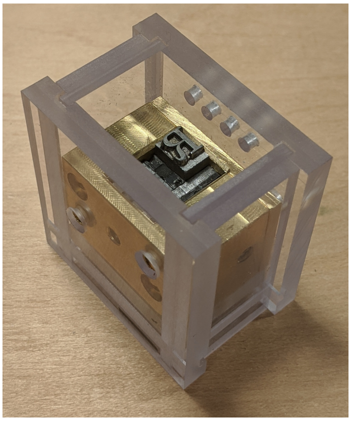
Workshop Notes on

Electroforming Matrices

(Dunker Method)

Dr. David M. MacMillan



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1• Introduction

1.1• Basic Definition

Matrix Electroforming is the process of making a typecasting matrix by electrolytic deposition over an existing type-like object. The original object may be something which resembles the printing end of a type, cut in soft metal[1] or in brass[2] (rather than steel) either by hand cutting with files and gravers or by machine cutting with a rotary-spindle pantograph engraving machine[3] In these Workshop Notes, I will call such a "new original" a **patrix**. The original may also be an existing printing type. In this case, although it is still functioning as a patrix, I'll tend to call it a **pattern type**.

The ability to duplicate existing types by electroforming matrices naturally led to a great deal of design piracy. This has given the process a bad name. However, as a better picture of the use of this technology emerges it is becoming clear, I think, that its use with original patrices to generate new types was far more important. A substantial portion of the 19th and 20th century types familiar to letterpress printers today were created not by punchcutting in steel or by direct matrix engraving but by patrix cutting in soft metal and matrix electroforming.

1.2• Brief History

Electroforming matrices seems to have originated at The United States Type Foundry of James Conner in New York City in the late 1830s.[4] A patent for the process, U.S. patent No. 4,130, was issued on August 4, 1845 to Thomas W. Starr.[5]

From the 1840s through the 20th century, matrix electroforming from hand or machine cut patrices was common both in the United States and in Europe. In sizes greater than 14 point, it was the preferred method.[6] In

[1] Bohadti says (in Duensing's translation) "a piece of type metal …but of an alloy somewhat softer" (Bohadti & Duensing 1968).

[2] In 1956, the Canadian typographer Carl Dair went to Enschedé to study type engraving under Rädisch. He said that "I had my choice of metals to start working on …[ellipsis in the original] steel, brass or "spacing" (lead)." (Dair 2015), Epistle 4. He began working in typemetal, but found steel more to his liking.

[3] Today one would use a CNC milling machine for machine cutting, but I do not think that anyone has yet done this for patrices.

[4] See (Saxe 2016), p. 51.

[5] Son of Edwin Starr, who was one of the great itinerant technicians behind much of the early American typefounding industry.

[6] Writing in 1930 in his translation of Fournier, Harry Carter (perhaps the greatest typographical authority of his day) said "Since …Starr …in 1845, large letters and ornaments are always cast from deposited matrices 'grown' upon originals cut in typemetal or brass. The

larger sizes, producing matrices by driving steel punches has always been difficult. Producing complex or highly ornamented types in larger sizes by punchcutting in steel would be *extremely* difficult. Hand or machine patrix cutting and matrix electroforming makes this undertaking much more tractable.[7]

Saxe has argued persuasively that patrix cutting and matrix electroforming, together with machine typecasting, were the pivotal inventions (pun intended) which enabled the creation of 19th century ornamented types. See (Saxe 2016) and (NSMH 2020).[8]

Unfortunately, for a variety of reasons this process was entirely forgotten by authorities on and historians of type in the United States, even when many of the types they were describing were so produced[9] In Europe, by way of contrast, published sources simply describe it alongside punchcutting in steel and direct matrix engraving as one of the three basic methods of matrix making. See, for example, (Bauer 1930s), pp. 6–7, and (Bauer 1950s), p. 16.

1.3 • Terminology

There is no standard terminology of this field (at least in English). The term that would have been used most commonly for a matrix of this kind is "electrotype" ("electrotype matrix," or just "electro"). However, this term has the significant disadvantage that much more commonly it was used for an entirely different thing: an electrotype as a printing plate. The term that would have been used most commonly for the type-like original is probably "pattern type." The problem with this term is that it emphasizes the potential use of this process for type piracy and neglects its more important use for originating new types.

Here I will adopt a standardized modern terminology. It is ahistorical,

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present practice is to cut letters larger than 14-pt. in soft metal ..." (Fournier 1930 EN), p. 40.

[7] Earlier solutions were less satisfactory, though many were tried. These included the direct sand casting of types (for which I don't have a proper reference yet; sorry). There was also a complex process of sand casting brass (not copper) matrices from lead strikes of steel punches (with the same steel punches used to clean up the brass mats after casting). This has been investigated by James Mosley and Stan Nelson. See (Mosley 2015). Stan has cut a magnificent large punch to demonstrate this process. Later there were cut-out and riveted matrices (called the "sanspareil" matrices, because of their size) in the late 18th century. See (NSMH 2020).

[8] For For a survey of the literature in English on patrix cutting, see (CR Patrix Lit).

[9] For example, in his entry for ATF's Wedding Text, McGrew writes that it was "cut in type metal [in 1901] ...instead of cutting punches or engraving matrices directly" and that this was a "new method of cutting delicate faces." In fact, this method was at the time a half century old (as a hand method) and Linn Boyd Benton had been employing it as at the pantographic engraving machine since the early 1880s. Few people knew more about type than Mac McGrew, but in 1993 he didn't know that patrix cutting had ever been historically important — even though a large number of the types shown in his book were made this way. (McGrew 1993), p. 333.

but rational and consistent. I'll call the process **electroforming**. This is the standard industry term for this process today. (Electroforming is a variation on electroplating where the plating thickness is enough to produce a freestanding object.) When working from a newly made original (as opposed to copying an existing printing type), I'll call the original type-like object a **patrix**. This term should be seen by way of analogy with matrix: a matrix is an intaglio form, a patrix is a relief form.[10] When copying an existing printing type, of course, the original is simply a **type**. The term **pattern type** is appropriate in this situation.

I do not know of any really good name for the intaglio letterform as a negative-space object. For lack of a better term, here I will call it the **casting cavity**. When only a small area around the casting cavity was electroformed (see below for more on this), this area was often called the **eye**.

1.4• Dunker's Method

In almost all variations of this process,[11] the method was to start with a matrix blank or **planchet**[12] with a hole in it. The casting cavity was electroformed into the hole in the blank (producing an "eye"). Starr's 1845 patent describes such a method.[13] Around the turn of the 20th century first the National Compositype Company and later the Lanston Monotype Machine Company used this method when producing their electro display matrices in volume.

In the second half of the 20th century, Andrew W. Dunker, a machinist in Jackson, Michigan who became interested in type making and typefounding, adopted a very different method. He electroformed the *entire* matrix as a single copper deposit. He then machined this to final matrix

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[10]My use of these terms has been influenced by two people. In conversation with Mike Anderson in 2010, I employed the term "electroforming." He thanked me for using the right word. Later I discovered that Jim Rimmer used the term "patrix" for his work in cutting them both by hand and machine. If the term is good enough for Rimmer, it's good enough for me.

However, it will prove impossible to avoid all confusion. In his authoritative work *Die Buchdruckletter*, Gustav Bohadti uses the term "patrix" for a steel punch: "Das älteste Verfahren zur Herstellung der Patrizen, der Stahlstepel, is der Stahlschitt." To add to this potential confusion, when Paul Hayden Duensing translated this work he captioned an illustration of a *counter*punch (which Bohadti had called "Punzenstempel," or, loosely, "punch punch"): "Patrix or Counterpunch." (Bohadti 1954), pp. 131–132 and (Bohadti & Duensing 1968), pp. 131–132

[11]Carl Schraubstadter, Jr. documents an early form of matrix electroforming in which the "eye" was grown free-form from a suspended type. After it was removed from the plating bath, a matrix body made of typemetal was then cast around this eye. He felt, however, that this method had "fatal defects." (Schraubstadter 1887).

[12]The term "planchet" comes from the field of coinmaking.

[13]In fact, Starr claims only this method. Dunker's method would not have infringed on Starr's patent.

dimensions.[14] To someone who knows both typemaking and machining, Dunker's matrices are startling and beautiful; objects worthy of considerable admiration. I was very fortunate to have had the opportunity to cast from some of them while I apprenticed at Skyline Type Foundry.

Dunker owned a Thompson Type Caster with an 0.043″ drive mold. His matrices were produced with this machine in mind. (However, he could produce matrices for the Monotype Type-&-Rule Caster, with their distinctive bevel corners. His milling fixture for Lanston Monotype style matrices survives.) Dunker's matrix electroforming equipment (or equipment based very closely on it) was also used by at least three other people: Paul Hayden Duensing, Pat Taylor,[15] and Mike Anderson.

To the best of my present knowledge, Dunker only employed this method to reproduce existing types (vs. new patrices). [TO CHECK: what about Homespun? Ask Rich] I do not know whether or not any of the others who used his equipment experimented with patrices (but I suspect that they did not).

Note also that Dunker was a machinist by profession, not a typefounder, and that he did not draw directly on the established / inherited practices of any type foundry. To the best of our knowledge, Dunker's method does not represent the methods used by professional typefounders.

Dunker's method also involves altering the shoulders of the pattern types. This precludes its use with historically important types. (But in general direct electroforming from pattern types always presents a real danger to these types and should never be used when they are of historic importance.) See the section later on "Cutting Away the Shoulder of the Type" in the chapter "Assembling with a Pattern Type" for further discussion of this.

Sill, Dunker's method and his matrices are remarkable achievements. These Workshop Notes are an attempt to re-create his method more or less as he practiced it, with only minor alterations to suit currently available materials.

[14] Dunker employed a now-unusual machine for this, a metalworking shaper.

[15] More specifically, we know that Duensing set Taylor the equipment and instructed him in its use. I have not verified that Taylor produced matrices using this equipment.

2• Sources

Information on matrix electroforming in general is scarce enough; information on Dunker's method is extremely rare. I have been fortunate in having been able to work with some of the few surviving primary sources. I would like, first, to express my deep appreciation for access to these to: the late Paul Hayden Duensing (whom I never met), the late Mike Anderson (whom I did meet), Richard L. Hopkins (for access to the Duensing material), and Sky Shipley (for allowing me to handle and cast Dunker mats).

I'll use extracts from these sources throughout. For more complete reprints of them, see the Appendices.

If any reader of these Workshop Notes knows of or has any other information on any aspect (historical or technical) of matrix electroforming by Dunker's method, I would be very interested in learning of it. I may be contacted at: `dmm@lemur.com`

2.1• Dunker's Deposition Case Drawings

The late Paul Hayden Duensing drew an overall view of the Dunker electroforming process and photocopied three pages of Andrew Dunker's original engineering drawings of his matrix deposition case.[1] These papers are currently in the Paul Hayden Duensing archive. In 2014 I had the opportunity to scan them, through the courtesy of Richard L. Hopkins.

Note: It seems clear that the page containing the overall view of the process was drawn by Duensing, as it appears on his letterhead. I am making an assumption in attributing the three technical drawings to Dunker. They bear the name "ANDREW W. DUNKER", but this could be an attribution as easily as a signature. It is possible that they were drawn by Duensing as well. The lettering in both instances is similar. I am not sufficiently skilled at handwriting analysis to resolve this question.

2.2• Duensing's Letter to Taylor

On 24 November 1974, Duensing wrote a two-page letter to Pat Taylor (Out of Sorts Letter Foundry) in which he described how to set up and use the Dunker matrix electroforming apparatus. (The letter probably accompanied this apparatus; if not, it would have arrived soon after.) A copy of

[1] The set of papers containing these also includes a single page showing matrix electroforming more schematically. This page has the look of a commercial illustration, but if Duensing did not draw it I have not been able to identify its source.

this letter is preserved in the Paul Hayden Duensing archive. In 2014, again through the courtesy of Richard L. Hopkins, I had the opportunity to scan this letter.

It is the only surviving information of which I am aware which discusses the operating procedure for the use of this equipment.

2.3• Duensing's Dunker Matrix Dimensions

In Duensing's *Matlas*, in the 1988 16-page version, there is a drawing of the dimensions of a Thompson-compatible matrix as used by Dunker. (The drawing may be by Dunker.)

For a collection of versions of *Matlas*, see the CircuitousRoot Notebook of "General Machine Typecasting Practices (Literature and Data)" at:

[URL... artifice/letters/press/noncomptype/literature/practices/index.html]

2.4• Anderson's Dunker Deposition Case

At the 2010 biennial Conference of the American Typecasting Fellowship, held by Gregory Jackson Walters in Piqua, Ohio, I was Mike Anderson's roommate. Anderson demonstrated matrix electroforming at the Conference using his own method (which involved piecing together a type holder from printing spaces and quads), but he also had with him what I believe was an original Dunker deposition case.

Anderson left at the end of the Conference proper, but I stayed on to attend one of the after-conference Workshops. Fortunately for me, he forgot his matrix electroforming equipment in our room.[2] Of course, I took this equipment home and mailed it back to him — but naturally I photographed everything.

When I took these photographs, I did not then entirely understand what I was looking at (and so now wish I'd taken some from other angles). Nevertheless, since Dunker's drawings can be difficult to interpret, these photographs have been invaluable to me in reconstructing the Dunker deposition case.

[2] I've always suspected that he "forgot" it on purpose so as to let me have a better look at it.

2.5• Experiences in Casting from Dunker Matrices

Finally, although it is less quantifiable, I have benefitted greatly from the experience of casting from Dunker-made electroformed matrices at Skyline Type Foundry.

3• Matrix Terminology and Alignment

[TO DO. Use drawings. This is important.]

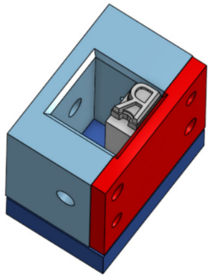
4• The Deposition Case

We are extremely fortunate to have Dunker's original drawings for his deposition case. However, I found these drawings difficult to understand on their own and had to make considerable reference to my photographs of Mike Anderson's Dunker deposition case while I reconstructed them in CAD.

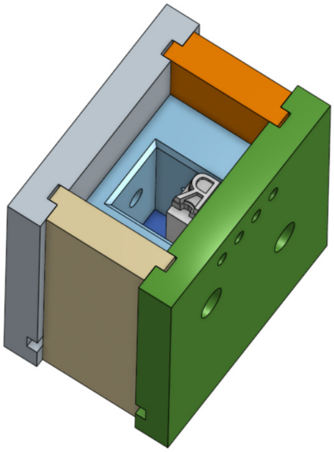
4.1• Overview

The Dunker **matrix deposition case**[1] is comprised of two nested structures.

The first is an inner structure made of metal and plastic which holds the **pattern type**. Duensing calls the metal part of this structure the **type holder**.[2] The inner structure also has an acrylic piece attached by screws to its bottom. Duensing calls this the **screwed-on bottom piece**.[3] In my drawings and discussion here I will adopt a slightly different terminology. I'll call the entire inner structure the **type holder** (or just **holder**).[4]



4.1: Type Holder
(with pattern type)



4.2: Deposition Case
(type holder + outer box)

[1]It is called by this name in Dunker's drawings. In Duensing's 1974 letter to Taylor he calls it the "Depositing Case."

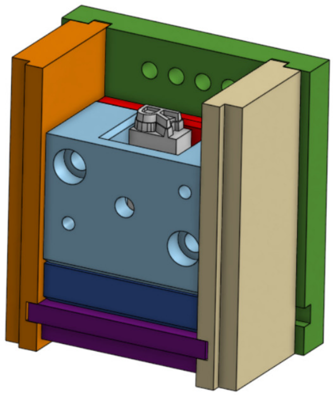
[2]In his overview drawing of the process accompanying Dunker's drawings.

[3]In his 1974 letter to Taylor.

[4]I'll call the "screwed-on bottom piece" the **type holder bottom**; more on that in the detailed discussions of the parts later.

The type holder is surrounded on five of its six sides by a plastic outer case. Duensing simply refers to this descriptively as the “non-conducting protective case for type holder”.[5] However, it seems to me to be confusing to use the term “case” for both the overall object and for parts of it. I’ll call this outer plastic structure the **box**. This is a five-sided box, open at the top. I’ll just designate the sides by letter: A, B, C, D, and E.

Note that the matrix deposition case has two bottoms, the type holder bottom and box side E (the box bottom).



4.3: Type Holder Bottom (blue) & Outer Box Bottom (purple)

The type holder is held together by itself with **brass screws**. (These are not shown in the CAD illustrations here.) The pattern type is held within the type holder by a combination of two brass set screws and, optionally, **printing spaces** to fill up the space around the pattern type. (These aren’t shown either.) The outer box is assembled around the type holder and is held to the type holder by brass screws.

In use, all exposed parts of the entire deposition case which are not to be plated are coated with **paraffin wax** as a nonconductive seal. This includes filling up any void remaining inside the type holder not occupied by the pattern type. The surface of paraffin wax on top of the type holder (which covers every part of it except the exposed pattern type) provides the surface on which the matrix is deposited. To render this particular surface conductive, it is covered in **bronze powder**.[6]

The deposition case is suspended by an **insulated wire** (not shown here) in the plating tank. This wire also serves as its electrical connection. (It makes an electrical connection through one of the brass screws to the main metal portion of the type holder. This in turn is touching and thus electrically connected to the pattern type.)

4.2• Orientation

We need a consistent terminology to indicate up/down, left/right, etc. There is ample room for confusion here, as the matrix is grown upside-

[5] In his overview drawing of the process.

[6] Bronze powder was used in printing as “artificial gold dust” for metallic color.

down in the holder, the foot of the pattern type is not the same thing as the foot of the matrix, etc.

I'll base everything around the standard terminology of the matrix. Look at a matrix with the letterform rightside-up.[7] The top of the matrix in this orientation is called the **head**. The bottom of the matrix (which is the nick side of American and English type) is called the **foot**.[8] The left side of the matrix is called, simply, the **left** and the right side is called the **right**.

Now flip this matrix upside-down into the position it will be grown in in the deposition case. Apply the terms of the matrix to the case. The matrix head is at the **head** of the case and its foot is at the **foot** of the case. Simple enough. But the matrix left side is now on the *right* side of the case if viewed from above with the head away from you. Following the conventional language of stage direction, I'll call this side of the deposition case **mat-left**. Its opposite is **mat-right**.

The side of the deposition case where the matrix is grown is the **top** and its opposite is the the **bottom**.[9]

In use, the pattern type is placed in the deposition case with its (type) foot toward the case bottom and its face toward the case top. The type's top side will be toward the case head and its bottom (nick) side toward the case foot. The type's right side will be toward mat-left and its left side toward mat-right. Confusing enough?

I'll try to be consistent and call dimensions in the mat left/right direction **widths**, dimensions in the head/foot direction **lengths**, and dimensions in the top/bottom direction **heights** or **depths**. This fits with the common terminology of "type height" and "set width" (but the use of "length" in this direction is not a part of the terminology of printing types).

4.3• Materials Used

In the discussion above, I referred to parts of the deposition case rather vaguely as being made of "metal." The reason I was so vague is that while Dunker is relatively specific the subject requires some clarification. Dunker specifies "tin-bronze" for the two major metal components (which I'll be calling the "frame" and the "plate"; see below). Now, while a dictionary might tell you that "bronze" is an alloy of copper and tin (vs. brass, an alloy of copper and zinc) and you might think that Dunker's "tin-bronze" is redundant, this is not necessarily the case. Some common alloys sold as

[7]Confusingly, this is the opposite of the way a printer views things. Printers read type upside-down.

[8]The foot of the matrix is unrelated to the foot of the type.

[9]This is simple enough, but it does mean that the top of the type and the top of the deposition case are unrelated.

“bronze” contain zinc rather than tin (e.g., “architectural bronze”, C38500, which has a nominal content of 57% copper, 40% zinc and 3% lead). Other ”bronzes” contain no tin or zinc at all (e.g., “aluminum bronze,” C95400, which has a content of 83% copper (minimum), 10 to 11.5% aluminum, plus some other elements, but with no tin or zinc).[10]

So Dunker’s specification of “tin-bronze” is not at all redundant. Unfortunately, it can be relatively difficult to find a tin-bronze in sufficiently thick bar stock (a quick check online just now indicates that alloy C95400, aluminum bronze, is the most common alloy stocked in this form). Actual tin-bronzes are more commonly supplied as round bar, and while you can certainly machine a rectangular part from a sufficiently thick round bar, this is wasteful.

It is also possible that Dunker was over-specifying this material. Only experimentation will tell. I’ll be making this part first using C36000 (CDA 360 yellow brass) because it is relatively inexpensive for a copper alloy and because I have some.

Dunker’s drawings specify “plexiglass” [sic, for Plexiglas] as the non-conductive plastic material. This is a trade name for acrylic.[11] Acrylic is available in cast and extruded forms. The cast version typically is more homogenous and dimensionally accurate. Neither Dunker nor Duensing specifies cast vs. extruded. If what you use works, then it works.

It might also be possible to use other materials if desired. The material must be non-conductive, must be resistant to sulfuric acid (the plating bath is a sulfuric acid bath), and must not absorb liquid (or at least must not change its dimensions because of this). One viable option might be polycarbonate.[12] Polycarbonate can be much nicer to work with than acrylic (it is much less brittle).

Other common machinable plastics may present issues. While it is tempting to a machinist to use delrin,[13] delrin is susceptable to acids. Nylon absorbs water and changes dimensionally,[14] so it is not a good substitute either. ABS also absorbs water and swells.[15]

Dunker’s drawings specify brass for all of the screws and vinyl-insulated wire for the electrical supply wire. I plan to use whatever insulated hookup wire I have at my electrical bench.

[10] Things are a little less confusing with brass, which seems always to be a copper-zinc alloy. “Tin brass” is a copper-zinc alloy with relatively small additions of tin.

[11] More specifically, PMMA or Poly(mythyl-amethacrylate). Aka Perspex (UK) and Lucite (duPont).

[12] Trade name: Lexan.

[13] POM, or polyoxymethylene, aka acetal.

[14] And is harder to machine, anyway.

[15] As anyone who has ever tried to use old ABS 3-D printer filament has experienced.

Duensing said to seal up the case using paraffin wax. Note that this is a well-defined substance which is to be distinguished from other uses of the word "paraffin."[16] Paraffin wax is a wax-like solid with a melting point generally in the range 115 to 154 degrees Fahrenheit (40 to 68 degrees Celsius). Earlier matrix electroforming practice also used beeswax (see (Nuernberger 1966)).

4.4• Screw Information

Dunker's drawings specify only screw thread and length. The counterbores for the screw heads are called out as "to suit screws." The screws are brass or bronze,[17] and those used on the Anderson Dunker Deposition Case seem to be fillister head.

For the screws with heads, I'm using "Brass Narrow Fillister Head Slotted Screws, High-Profile" from McMaster-Carr, as these are the most readily available similar screws.[18] But when you try to work them in to Dunker's design, it is clear that these "High-Profile" screws have a deeper head than those used by Dunker. This isn't really a problem, as it is easy to modify brass screws (and, indeed, Dunker already does so for two of them).

For the set screws, I'm using "Brass Cup-Point Set Screws." However, cup-point set screws will marr what they press against. It might be better to use a non-marring set screw. These are not available in brass (at least from McMaster-Carr), but could easily be made by trimming down a longer screw.

It is useful to know not only the threads and (possibly trimmed) lengths of these screws, but also the head depths and diameters.[19]

Thread	Length	Head Depth	Trim Length	Head Dia.
#4-40 UNC	3/8 (0.375)	0.107	n/a	0.183
#4-40 UNC	1/2 (0.5)	0.107	n/a	0.183
#6-32 UNC	3/8 (0.375)	0.132	≤ 0.35	0.226
#6-32 UNC	5/8 (0.625)	0.132	≤ 0.615	0.226
#8-32 UNC	1/8 (0.125)	(set screw)	n/a	n/a
#8-32 UNC	1/4 (0.25)	(set screw)	n/a	n/a

[16] In the UK, "paraffin oil" is the term for kerosene. "Paraffin" is also used as a term for several kinds of mineral oil. Wikipedia notes that petroleum jelly is also called "soft paraffin." None of these things are "paraffin wax."

[17] Dunker's drawings specify "brass or bronze" screws. Suitable bronze screws are probably still available as specialty items, but McMaster-Carr carries them only as hex head screws in the sizes required. These would not work. So I'll use brass.

[18] Technically, these are not fillister head screws at all. A true fillister head screw head has vertical sides; it's basically a cheese-head screw with a rounded top. The screws supplied by McMaster-Carr have slightly tapered heads.

[19] This information is taken from the McMaster-Carr online catalog.

(Note that the table above is not a bill of materials for screws, but just a table of screw dimensions.)

The “basic” diameter of a #4 screw is 0.112. Dunker uses a 1/8 inch drill to provide clearance holes for these.

The “basic” diameter of a #6 screw is 0.138. Dunker uses a #29 drill to provide clearance holes for these. This may seem a problem at first, because a #29 drill is 0.136, but the actual diameters of screws are less than their nominal diameters.[20]

The “basic” diameter of a #8 screw is 0.164.

A #8 set screw takes a 5/64 inch hex wrench.

Dunker’s drawings actually specify #4-36 screws, not #4-40 UNC. The #4-36 thread was a part of the earlier American Society of Mechanical Engineers (ASME) screw thread standard (see (Machinery’s 1919), p. 1015). It was superseded in 1949 with the introduction of the Unified Thread Standard, but it would still have been common enough for a machinist of Dunker’s generation. Today it is a special part and an unnecessary cost.

4.5• Type Holder, Frame

The type holder consists of three pieces (plus screws): two of metal and one of acrylic. The larger of the metal pieces, shown in “Detail 1” on Dunker’s drawings but not named there, is a ’C’-shaped piece which forms the basis of the entire structure. Everything screws into it. Duensing does not name it in his 1974 letter to Taylor. It needs a name. “Body” is perhaps the most obvious name, but types also have bodies and this piece holds the type by its body. So that name is too confusing. Instead, I’ll call it the **frame**.[21]

4.5.1• Overall Dimensions

The length of the frame, from head to foot, is given in the Dunker drawing as 1.125 inches. This is a common length for Thompson matrices and the only length for Lanston Monotype display matrices. The width of the frame is 0.640 inches; this plus the thickness of the plate (0.110 inches, see below) is 0.750 inches, or the width of a regular[22] Thompson matrix or all Lanston Monotype display matrices. In simpler terms, the X-Y dimen-

[20] The definition of the range for the major diameter of a #6-32 screw thread is 0.131,2 to 0.137,2, so in theory a 0.136 drill might be too small. In practice, it should just give a nice snug fit.

[21] By the time I was done putting all of the holes in it, I was tempted to call it the Swiss cheese.

[22] Aka “narrow,” meaning not wide.

sions of the type holder are those of the Thompson or Lanston matrix to be grown.

4.5.2 • Plate Attachment Screw Clearance Holes

All of the screw holes on the frame are tapped except for the two **plate attachment screw** clearance holes. These holes must pass a #6-32 screw. Dunker uses a #29 drill (0.136) for this; as discussed above, this should provide a snug to slight interference fit. The heads of these screws are fully countersunk into the frame. The screw heads used have a depth of 0.132 and a diameter of 0.226. The counterbore for them should have a flat bottom, and so should be made by something like an actual counterbore (tool) or an end mill; a twist drill is not appropriate. $15/64^{ths}$ (0.235) would be the nearest fractional inch size to use. End mills in this size are readily available, but a counterbore would be a special item and probably isn't worth the trouble. I'll counterbore to a depth of 0.135, to give just a little bit of clearance for the 0.132 deep head.

This counterbore means that the maximum screw length so that the screw doesn't stick out of the plate (see below for the geometry of this) is: 0.750 - 0.135 = 0.615. We're using a 5/8 inch screw (0.625), so we need to trim down the length of the threaded part of the screw (not the head) to 0.615 or a tiny bit less. (Dunker didn't have to do this, because his screws had shallower heads.)

4.5.3 • Case Attachment Screw Holes (Left & Right)

Two #4-40 x 3/8 screws are used to attach the mat-right case side to the holder. These screw into one side of two through-drilled and tapped cross holes.

Two #4-40 x 1/2 screws are used to attach the mat-left case side to the holder (they must be slightly longer on this side because they must pass through the 0.110 thick type holder plate). These screw into the other sides of the two through-drilled and tapped cross holes.

4.5.4 • Case Attachment Screw Hole (Head)

A single #4-40 x 3/8 screw is used to attach the case side at the head of the frame. The hole for this screw is drilled completely through the upper 'C' of the frame.

4.5.5 • Type Pushing Set Screws

Two #8-32 set screws (1/8 and 1/4 long) press and hold the pattern type in position.

4.5.6 • Bottom Holes

The two screw holes on the bottom side of the frame are tapped for the attachment of the type holder bottom. Their location is given on Dunker's drawing but not their size or depth. The size may be deduced from the table of screws: they must be the #6-32 x 3/8 screws shortened to 11/32 (0.344) or less. Their length must be calculated from the model. The calculation here will differ slightly from Dunker's because of the different head depths of the screws used here. These screws' holes will intersect with the lower cross holes (one plate attachment screw hole and one case attachment screw hole).[23] The distance between the lowest point of these cross holes and the bottom of the frame is 0.254. To this must be added the length of the screw within the type holder bottom. The type holder bottom is 1/4 inch thick and the #6-32 screws we're using have a head depth of 0.132. So 0.250 - 0.132 = 0.118 for the length of the screw in the bottom. The overall screw length must therefore be 0.118 + 0.254 = 0.372. Curiously, this works out to slightly more than Dunker's 11/32.

So I'll drill these bottom screw holes up to somewhere at least at the midpoint of the highest of the cross-holes (turns out to be 0.31). Then I'll tap them up as far as I can with a taper, plug, and bottoming tap set. Into this I'll put #6-32 x 0.35 screws, which shouldn't interfere with the cross holes.

4.5.7 • Bevels

I believe that the features Dunker refers to as "bevels" are actually "chamfers" in modern terminology. (A chamfer cuts a corner. A bevel goes all the way to an edge, as for instance the bevel on the end of a woodworking hand plane blade.) But Dunker calls them bevels, so I'll do the same here.

I believe that the "outside" bevel at the bottom of the type holder frame (which continues on to the type holder plate) is just to break the edge and make assembly easier. I don't think that it needs to be particularly precise.

TO DO: purpose of the inside bevel. Do not cut it when making the frame. Instead, wait until you have made the plate and cut this inside bevel on both pieces while they are assembled. (See the section on the type holder plate, below.)

[23] It is ok for the holes to intersect so long as the bottom screws don't actually project into the cross holes.

4.6• Type Holder, Plate (Name & Dimensions)

The other metal component of the type holder is called by Duensing the "side-wall" because that's just what it is: a side wall which closes off the C shape of the frame. It is shown as Detail 2 on Dunker's drawings. Unfortunately, the term "side wall" has two other distinct meanings in matrix making.[24] Adding another here seems unwise. So I will once again take the liberty of changing Duensing's terminology and will call it, blandly, the **plate**.

The external dimensions of the plate are given on the drawing, but not its orientation relative to the frame (or its hole locations, which are located from the frame). This missing information must be deduced.

We are told its thickness (which will be its width in the orientation in which it is assembled): 0.110 inches. This corresponds exactly to the **left side bearing** of a Thompson matrix.[25]

Its length is given as 1.115 inches. This is 0.010 inches less than the corresponding dimension of the frame. If we assume that the plate is centered length-wise on the frame, this mean that it is located 0.005 inches in from the head and foot sides of the frame.

Its height is given as 0.857. This is 0.005 inches less than the corresponding dimension of the frame. Howver, it is *not* positioned at offsets 0.000 and 0.005 from the top or bottom of the frame. In the overview drawing page, a note by Duensing says that the top of the plate is 0.002 lower than the top of the frame.[26] This implies that the bottom is located 0.003 up from the bottom of the frame.

Note that these reduced dimensions and the consequent offset positioning of the plate relative to the frame mean that the bottom bevels on the plate will *not* line up with those on the frame. I don't think that this matters.

[24] In Linotype and Linotype-compatible matrices, the "side wall" is the portion of the matrix between each side of the casting cavity and the side of the matrix. Because of the nature of Linotype matrices, these side walls can often be thin and are easily damaged. The term "side-wall" was also introduced by the Wicks rotary type casting machine to describe the distance in the plane of a type's face between the edge of the printing area of the face and (measuring horizontally, set-wise) the side of the type body. See (Legros & Grant 1916), pp. 10–11. Harry Carter referred to (and disliked) this term when discussing Fournier's term "*approche*." See Carter's note on p. 93 of (Fournier 1930 EN), as well as the section "de l'approche" on pp. 153–163 of (Fournier 1764 FR), its translation as Chapter XX, "The Set" by Carter in (Fournier 1930 EN), and James Mosley's note about this matter on p. *349 of (Fournier 1995). Both of these uses of "side wall" are distinct from the term "side bearing" as used in matrix making.

[25] The side bearing of a matrix is the distance from the left or right edge of the type body as it is positioned on the matrix to the corresponding left or right edge of the matrix.

[26] Bear in mind that the front and back of the grown matrix (these are the bottom and top surfaces as grown in the case) will be entirely machined to size. The details of the top surfaces of the type holder were designed by Dunker to aid in electrodeposition, not to define finished matrix surfaces.

However, the drawings specify that the top ("inner") bevel of the plate (which is a part of the bevel which runs around the cavity where the pattern type is placed) is to be bevelled "in assembly." I believe that this means that the frame and

Note also that unless the frame and plate are either hand finished by filing or is constructed using really elaborate setups on the shaper (which is a reciprocating machine tool) then the inside corners of these bevels will be rounded. This probably doesn't matter.

4.7• Type Holder, Plate (Attachment)

The plate has four holes in it. Two are drilled and tapped #6-32 UNF. The plate is held to the frame by two screws from the *opposite* side of the frame.[27]

The other two holes in the plate are clearance holes, drilled with 1/8 inch diameters. Two #4-40 screws[28] will pass through these holes. The case and type holder are screwed to each other on two sides: the head side and the mat-left side. These are the two screws used to screw the case and holder together on the mat-left side.

4.8• Type Holder Bottom

This is Detail 3 in Dunker's drawing. As noted earlier, I'll call it the **type holder bottom** (or just **bottom**). It is screwed on to the bottom side of the type holder frame and it provides a surface on which the foot of the pattern type stands.

Like the type holder plate, the type holder bottom is slightly smaller than the side of the frame to which it is screwed. But with the bottom things are simpler. The bottom of the frame and plate together measure 0.750 wide by 1.125 long (3/4 inch x 1 1/8 inch, or the size of the mat). The type holder bottom measures 0.740 wide by 1.115 long. This is 0.010 less in either dimension, so assuming that it is centered its sides are 0.005 in from the sides of the frame and plate.

It is drilled and counterbored to pass two #6-32 screws which attach it to the frame. Dunker specifies brass 6-32 x 3/8 screws "shortened to 11/32

[27] Dunker specified two #6-32 x 5/8″ brass screws, with the heads to be countersunk into the frame "to suit." However, the most similar readily available screws that I could find are "brass high-profile narrow fillister head slotted screws" (McMaster-Carr part 90114A531 for the 5/8″ length). These have taller heads than the screws available to Dunker, with a head height of 0.132. This gives an overall length of 0.757, which is 0.007 over-length. It is a simple matter to file these down to a suitable length not exceeding 0.618.

[28] The drawing actually specifies #4-36, but this is not a standard modern thread. #4-40 UNC is the closest available.

or less.”

Note that the two screw holes are *not* centered on the lengthwise axis of this part (neither are they both the same distance in from the head and foot edges). As these screws are just holding the part in place, I don’t see that this placement really matters all that much so long as where you put them works.

Dunker’s drawings specify that the type holder bottom is to be made from acrylic,[29] but I do not see why it cannot be made out of metal. I will, though, make mine out of acrylic.

4.9• Box Side A (Matrix-Left)

The Type Holder is surrounded on five sides by a plastic box (open at the top). I’ll call the five components of this box **sides**. Rather than trying to identify them by location (head, mat-left, etc.) I’ll just give them letters: **box side A** through **box side E**

The part numbers of the three components of the type holder (1 (frame), 2 (plate), and 3 (bottom)) corresponded to the detail numbers of Dunker’s drawing. However, the part numbers of the case will not. Dunker went: bottom, mat-right, mat-left, head and foot. I’ll go: mat-left, head, mat-right, foot, bottom. Thus:

Here	Dunker	Location
Side A	Det. 6	mat-left (type-right)
Side B	Det. 7	head
Side C	Det. 5	mat-right (type-left)
Side D	Det. 8	foot
Side E	Det. 4	bottom

Of the five box sides, the most complex is A. In addition to being screwed to the type holder, and having slots to hold three other sides, it (uniquely) has a series of four tapered holes drilled through it above the level of the type holder. (The purpose of these holes is to aid in the electrodeposition. I’ll call them **flow holes**.)

This box side is held on to the type holder by two #4-40 UNC fillister head screws. Their heads measure 0.183 in diameter and 0.107 deep. The piece is counterbored so that they will be flush. Dunker was using slightly different screws (#4-36 ASME screws with an unknown head size) and simply says “counterbore to suit.” I’ll counterbore with a 7/32 end mill (0.219), which is perhaps a bit large but is the closest I can get without going to 64$^{\text{ths}}$ or decimal. I’ll counterbore this for 0.11 to give just a little bit of extra depth.

[29] “Plexiglass”, meaning Plexiglas.

4.10 • Box Side B (Head)

This box side is attached to the type holder frame with a #4-40 screw, so I'll use the same counterbore dimensions as I did for the #4-40 screws on side A: counterbore diameter of 7/32 (0.219) and counterbore depth of 0.11.

(Perhaps it is best to think of this attachment as being the other way around: the frame is pulled tight against side B by the screw. Side B defines the matrix head bearing and side A the matrix left side bearing. It is important that these be as close to intent as possible.)

The location of this screw's hole in Dunker's drawings contains the only error in dimensioning that I've found in his drawings. At least I think it's an error, but Dunker was a far better machinist than I'll ever be, so the error may be on my part. The distance of this hole above the bottom of the box side must be:

- The distance from the box side's bottom to the top of the slot for the box bottom: 5/16
- Plus the thickness of the type holder bottom: 1/4
- Plus the distance of the corresponding hole in the frame above the bottom of the frame. The hole in the frame is dimensioned from the top of the frame, so it's distance from the bottom must be the frame height less this distance: 0.862 - 3/8

Working this out we get 1.050. But Dunker's drawing of the part in Detail 7 calls out the value as 1 1/16 (1.063).

There are a total of five screws holding the box to the frame (two on each side plus this one). Of those five, this one is the only one for which the drawings do not say "locate in assembly" — but it is likely that Dunker was in fact locating them with the components assembled.

In practice, the exact location of this screw hole in box side B doesn't matter much, so long as it lines up with the corresponding tapped hole in the frame.

4.11 • Box Side C (Matrix-Right)

4.12 • Box Side D (Foot)

4.13 • Box Side E (Box Bottom)

5• Machining the Deposition Case

5.1• On Drilling Acrylic

Some years ago, a friend of mine who is a retired tool and die maker[1] told me a story about an experience he had in drilling acrylic. He had done an entire production run of acrylic parts, using WD-40 as a lubricant for drilling. It worked and looked great. But later every single part developed cracks from these holes. He had to re-run the entire job at his cost. When he did the job over, he used food-grade mineral oil as a drilling lubricant. This did not result in cracking.

[1] The aristocracy of machinists.

6• Assembly with a Pattern Type

6.1• Cutting Away the Shoulder of the Type

In his 1974 letter to Tayler, Duensing says:

"The shoulder of the type must be cut below the level of the holder, perhaps 4 points or so."

In general, electroforming should never be considered as an option with original types of historic significance, because there is always the possibility that the electrodeposited matrix will stick to the type (ruining it). It need hardly be added that Dunker's method, which involves cutting away the shoulder, precludes the use of important original types.

I am at present unaware of any reference in the literature of other matrix electroforming methods to the cutting away of the shoulder like this. However, my memory may be faulty and, in any case, the literature is meagre and insufficiently detailed. But in his relatively detailed 1954 book on type-making, *Die Buchdruckletter*, Gustav Bohadti illustrates schematically the process of electroforming a matrix eye into a planchet. Assuming that the pattern type and the resulting matrix are intended in his drawing to have the same depth of drive (as seems reasonable), then his pattern type's shoulders were *not* cut away. See (Bohadti 1954), p. 137 and (Bohadti & Duensing 1968).

As I write this (before having actually created a matrix), I am presuming that Dunker cut away the shoulders so as to give more electrodeposited material on the front of the matrix. This would lessen the chance of an incomplete deposition not sufficient to form a full matrix front.

6.2• Assembling the Pattern Type in the Type Holder

6.3• First Waxing (Type Holder)

6.4• Bronze Dusting

6.5• Assembling the Outer Box

6.6• Wire Connection

6.7• Waxing the Entire Deposition Case

7• Electrodeposition

[I have not done this yet.]

8• Milling the Matrix

[I have not done this yet. My guess is that it will be the single most difficult operation.]

A• Dunker's Deposition Case Drawings

These are reproduced in a separate volume: *Drawing Portfolio for Workshop Notes on Electroforming Matrices (Dunker Method)* (Mineral Point, WI: The Typemakers' Society, Inc., 2020). This Portfolio is freely available from the The Typemakers' Society website alongside these present *Workshop Notes*.

B• Dunker's Matrix Dimensions

[See Matlas 16 page version, p. 13. This drawing may be by Dunker.]

[Include a comparison with standard Thompson mats (same Matlas version, p. 5) and with Lanston Monotype display mats.]

C• Anderson's Dunker Case

D• Duensing's Letter to Taylor

In 1974, Paul Hayden Duensing wrote to Pat Taylor, a typefounder and proprietor of the Out of Sorts Letter Foundery. This letter appears accompanied a Dunker-style matrix case. (I know of no further details at this time as to the origin or eventual fate of this case.) It contains what is, at present, the only known set of instructions for Dunker's process.

Note: This letter is a typescript original which is preserved in Richard L. Hopkins' archive of Duensing material. As it is a letter from Duensing, it is not entirely clear how it ended up in his own papers.

Because of the importance of this source, it is reproduced in facsimile (rather than transcription) on the next two pages.

the private press and typefoundry of paul hayden duensing
2636 beethoven avenue · kalamazoo, michigan 49002 u.s.a.

24 November 1974 Dear Pat and T: Please pardon the long delay in getting the depositing case (as well as the rectifier) to you. I have been on the road a lot since Washington, and this is about the first opportunity I have had to think in depth about electroplating.

The Rectifier is probably self evident; you put AC in one side and get much reduced DC out the other end. The meter tells you how much.

The intensity of plating varies as the square of the distance between anode and cathode, so that a small plating bath is desirable. I used a pyrex baking dish about 4 inches deep and this worked rather well. It must be clean and rinsed a couple of time with distilled water to rid it of any latent mineral deposits. (Your bath can be smaller than this to start, if you like). Next dissolve as much C.P. Copper Sulphate as possible in warm distilled water in the bath. It should represent a saturated solution, since you want all the carrying capacity possible. Next add concentrated sulphuric acid H_2SO_4 a few drops at a time (so you don't have an explosion from all the heat generated when the H_2SO_4 goes into solution). About 30 to 50 drops should be good for a start.

Now you need some sort of anode. A bar of C.P.Copper is ok; but I have found that the depositing goes more quickly when there is more surface area exposed and this can be done by putting in a small walled dish (I have used the plastic top to a butter dish) filled with copper chips or shavings. Now the lead from the rectifier (the +) is contacted with the copper source (either by leading a wire into the copper chips, or, if using a bar of copper, attaching an alligator clip to it). Now the anode (+) is ready.

Next take apart the depositing case, noting the order in which the side walls come off first, then the screwed-on end-piece, then the loose bottom-piece, then the screwed-on bottom-piece, and finally the metal side-wall. I have put a piece of type in the holder to show where the nick goes. The shoulder of the type must be cut below the level of the holder, perhaps 4 points or so. If you are plating pieces of less than 24 point quad size, put the type in the outside corner (next to the removable side-wall) and put any necessary spaces on the nick side of the type (this is necessary because of the fixed head-bearing and side-bearing of the Thompson). With type and spaces in position, put on the removable side wall, then tighten the two set-screws (the smaller screw-heads) to firmly hold the type and spaces in place.* You are now ready to start waxing-in the type and holder. I use an old wood-burning pencil, which I have to keep plugging and unplugging to keep the right temperature, but there would be a lot of advantage in putting something like a train transformer in the circuit. With some paraffin made just-barely-fluid you seal up the three screw heads on the sides and the one in the end of the depositing (metal) block. Next put paraffin into the well, formed around the type (if smaller than 24 pt., the well is where the spaces are; if it is a 24 pt. quad, it's where the shoulder has been cut back. Bring the level of wax up to slightly above the upper surface of the block, and with a doctor blade (I use the squared-off

* See next page

D.1: Duensing's Letter to Taylor (p. 1 of 2) end of an old hack-saw blade) scrape off the surplus wax. The wax should now be flush with the upper surface and up to the character, which is sticking up about .055" above the surface. With a fine brush, dust artificial ~~gold~~ gold-dust (actually finely powdered bronze) onto the waxed areas to make it electrically

* conductive. *(I think I forgot to mention that you should have put on the screwed-on bottom-plate before the type was inserted, to give it a stable base on which to stand).

Now re-assemble the rest of the depositing case (plastic pieces). With the waxing iron (the wood-burning pencil) seal all the screw holes, but one, and also seal all the joints where two pieces come together (this is to keep the plating solution from seapaing in and plating what you don't want plated). On the remaing screw that you have not yet sealed, back it out a bit, and put the loop [of the lead-wire] around the shaft of the screw. Re-tighten the screw and now seal the screw and lead with plenty of wax, so that the tube is immobilized against the side of the plastic wall. If solution seeps in, copper will plate on the wire and around the screw-head, preventing its extraction later.

Now carefully set the case in the bath, which should cover the top of the case about $\frac{1}{2}$" to 3/4". If the bronze powder has been pressed slightly into the surface of the wax, it will not float off into the solution. If it floats off, you're in trouble. [Take it out and re-wax and re-dust it. And THIS TIME, press the dust into the wax, dummy.] Hook the alligator clip onto the cathode (-) pole and check carefully for any bubbles that may form around the type during the first few minutes of plating. This is important, as bubbles cause holes, and that ain't what you want. (On ~~the~~ ANY finished matrix, you'll see the results of one or two small bubbles.) Now adjust the current to 0.75 amp and 1.5 volt DC, get out your high-speed rosary to pray a lot, and have a drink nearby in case it doesn't work.

When plated (which depends on many things, including, I think, luck), take the case from the bath, rinse carefully in distilled water, dry, and take it apart. Be sure to get the solution out of the three little holes that go through the side of the case (these are important in contributing to the ~~fat~~ flow of solution over the face of the type). After you've taken the side wall off the block, the deposit should come away. Some times the type remains stuck in the deposit, or else the face tears off. Then you have to dunk the deposit in the melting pot to melt the type out. If you've gotten a good deposit, the thickness of the sample, the four edges of the deposit will need almost no treatment, except just a quick brush with a file to get any whiskers off. I don't know how you intend to ~~take~~ MILL the back off. At home, I use the pantograph, or else send them to Dunker. After you have taken the back down ~~f~~ [to a remaining] total thickness of about 0.1019 or 0.1020", flop the mat and check with a needle-guage for depth of "drive" which should be now 0.055". When you take 0.005" off the face to give a 50/1000s drive, the mat should now be 7 points thick (0.0969") which is what you want.

Plating time will vary with the number of cases in the tank, etc. It is better to start plating ~~slowly~~ slowly, which makes a much finer deposit. If you were to introduce a pump into the bath to keep it stirred up, and/or increase the temperature, the depositing time would be greatly diminished, but that's a lot of work.

That's it, dear boy. Good luck. Let me know what happens.

Cheers,

Paul

D.2: Duensing's Letter to Taylor (p. 2 of 2)

E• New Drawings and CAD Model

E.1• Size and Availability

The drawings are intended to be printed on US Letter paper in "landscape" format (11 x 8.5 inches). They wouldn't really be legible if reprinted within the margins of this booklet. They are available in a separate booklet, *Drawing Portfolio for Workshop Notes on Electroforming Matrices (Dunker Method)* (Mineral Point, WI: The Typemakers' Society, Inc., 2020). This Portfolio is freely available on its publisher's website at:

`http://www.TheTypemakersSociety.com/publications/index.html`

The 3-D CAD model was done using the Onshape CAD software. This is an online-online (i.e., "cloud-based") program. At the time of writing, Onshape offers a free version the only limitation of which is that your models must all be public.

The Onshape model of the Dunker Matrix Deposition Case is a public model. Whether or not you have an Onshape account, you can view it at the following impossibly long URL:

`https://cad.onshape.com/documents/0c412a5cb0e263a0c7c3711a/w/ae499bc626bab1ca697671e0/e/3dc0540e4ed9ffe5bfb65163`

If this URL isn't clickable for you (either because of PDF corruption or because you're reading this on real paper), it would be very annoying to type it in. Instead, search the Onshape public models for: Dunker Matrix Deposition Case

If you have an Onshape account, you can copy it into your own workspace and modify your copy.

For those using other CAD programs, I have exported the eight parts of the model as both STEP and STL files.[1] These exported CAD files are also available at the *Drawing Portfolio* booklet's URL.

E.2• Notes about the Drawings

In the dimensions, often I have included supplementary figures enclosed in [brackets]. These contain three things:

- Dunker's original fractional dimensions.
- Calculations showing how a particular dimension was derived.

[1] I don't really think that 3-D printing is the best technology for making this, but it's always nice to be surprised.

- Numbered drill sizes to identify drills where the CAD software insists on giving decimal hole dimensions.

Note that sometimes the decimal to fractional correspondences are quite simple. It isn't that I don't think that you know that 1/4 is 0.25. Rather, it is that I wish to indicate that this dimension was originally specified in fractional rather than decimal inches and its tolerances should be evaluated accordingly.

There are also several situations where I have conventional "reference" dimensions. These are dimensions as calculated in a perfect world which should not in fact be used because they'll conflict with the stack-up of tolerances. As is conventional in (at least some) modern practice, these reference dimensions are enclosed in parentheses.

F• Bill of Materials

Item	Qty	Description & Use
1	3	#4-40 UNC x 3/8 brass fillister head screw
		(2) attach box side C (mat-right) to the frame
		(1) attaches box side B (head) to the frame
2	2	#4-40 UNC x 1/2 brass fillister head screw
		(2) attach the box side A (mat-left) to the frame
3	2	#6-32 UNC x 5/8 brass fillister head screw
		(2) shorten to 0.615 and attach the plate to the frame
4	2	#6-32 UNC x 3/8 brass fillister head screw
		shorten to 0.31 and attach the bottom to the frame
5	1	#8-32 UNC x 1/8 brass set screw
		push the pattern type from the type-left side
6	1	#8-32 UNC x 1/4 brass set screw
		push the pattern type from the type nick side
7	12″	18 AWG solid PVC-insulated copper electrical wire
		suspend and power the deposition case
8	1	3/4 x 1 x 1.5 bronze or brass bar stock
		type holder frame
9	1	1/8 x 3/4 x 1 bronze or brass flat stock
		type holder plate
10	1	1/4 x 4 x 10 inch acrylic or polycarbonate flat stock
		type holder bottom & outer case parts
11	1	[SIZE?] flat tip screwdriver
		to fit the #4-40 fillister head screws
12	1	[SIZE?] flat tip screwdriver
		to fit the #6-32 fillister head screws
13	1	5/64 hex wrench
		for the #8-32 set screws
14	some	printing spaces and quads
		to pack the pattern type into the holder
15	some	paraffin wax
		insulate the assembled deposition case
16	some	powdered bronze
		make the case at the mat face conductive

Depending on your machining skills and the flatness and surface condition of your metal stock, it might be best to use 3/16 inch thick stock for item 9 (which is part 3, the type holder plate) rather than 1/8.

The overall thickness of the box sides is not critical, so it is possible to use stock thicknesses, even if they are slightly undersize. (The exception to this is the Type Holder Bottom piece, which should be fully 0.250 thick.)

I have discovered that even reputable vendors will supply arbitrary near-matches for stated stock thicknesses. For example, the TAP Plastics quotes decimal equivalents for its fractional inch sizes of acrylic and polycarbonate which are not really decimal equivalents but rather are ″soft″ conversions of nearby metric sizes (e.g., “1/4 (0.236)”, which is really 6 mm). The sizes actually supplied are nominal metric products which, further, run undersize. So their “1/4” (which you would expect to be 0.25) is not really 0.236 (as quoted) but in fact 0.225 as supplied. This presents an obvious problem if you really need 1/4 inch.[1] Other vendors must recognize this and will supply over-thickness metric products. For example, McMaster-Carr supplies nominal 6.0mm cast acrylic when 7/32 (0.219) inch is ordered. This gives you at least the amount you ordered, but is a problem if you were planning on relying upon the manufactured surface finish of the plastic and have to mill it to thickness instead.

It is also possible to 3-D print the plastic parts of the model (and indeed perhaps the metal parts, which don’t necessarily have to be metal. A friend has done this, but at the time of writing has not yet grown a matrix with it.

[1] The problem becomes more severe at greater thicknesses. TAP Plastics’ 1 inch (“0.944,” probably a soft conversion of 24mm) is, as supplied, 0.913. This turns engineering into scale modeling. But their 2 inch must come from a different supplier, because it is actually 2.02 inches thick.

G• Bill of Tooling

In addition to the following specific tools, making the deposition case will require the standard tooling to be expected in any small machine shop.[1]

- #43 twist drill (0.089): tap drill for #4-40
- 3/32 (0.094) twist drill: flow holes
- #36 twist drill (0.107): tap drill for #6-32
- #29 twist drill (0.136): clearance for #6-32 and tap drill for #8-32
- HSS end mill, 7/32:
  counterbore in plastic for #4-40 fillister head screws
- HSS end mill, 15/64, modified for cutting brass:
  counterbore in brass for #6-32 fillister head screws
- #4-40 UNC taper (i.e., regular) tap
- #6-32 UNC tap set (taper, plug, bottoming)
- #8-32 UNC taper (i.e., regular) tap
- 90 degree chamfer cutter capable of a 1/32 chamfer (bevel)
- ≤ 1/8 milling cutter for plastic
- # 4/0[2] (0.1142 to 0.0869) taper pin reamer[3]
- pin vise or tap handle to hold the 4/0 taper pin reamer
- (optional) food-grade mineral oil (if using acrylic)[4]
- 0.002 feeler gauge[5]

Although this Bill of Materials calls out end mills for plastic milling and counterboring, I have found that the router bits sold to woodworkers are quite well suited to this work. For plastics milled in the ways they will be here, 2-flute bits usually are best. However, I had success using O-flute bits[6] for cutting the 1/8 inch channels in a single pass. Buying higher quality

[1] Of course, some of the tools called out in this list *are* standard tools. Don't, for example, go out and buy individual #43, #36 and #29 twist drills. Instead, make the investment in a good set of numbered (#60 to #1), fractional (1/16 to 1/2 by 64^{ths}), and lettered (A to Z) HSS drills (115 pieces total, in a proper index case.) You'll always need it. But good drills are expensive and cheap drills aren't worth the price.

[2] Note that this is a # 4/0 taper pin reamer (that is, 0000, or "four-aught"), not a No. #4. It is the taper reamer suitable for reaming a hole for a #4/0 taper pin.

[3] Either a straight or a spiral flute reamer is ok.

[4] Actually, I found that cutting, drilling and counterboring both acrylic and polycarbonate worked fine dry.

[5] It is probably easiest to get a cheap automotive feeler gauge set rather than an individual piece.

[6] These are 'O' as in the letter O -flute bits. I presume they are so called because of their shape. They actually have a single cutting edge and are thus also 1-flute bits.

router bits from specialist manufacturers, rather than the mass-market bits available in the major home improvement centers, is worth the cost.

In addition, a standard small hobby-level copper plating setup will be required. This will include proper safety equipment (especially good laboratory googles), a power supply, a plating tank, distilled water, copper sulfate, sulfuric acid, copper for the anode, and various conductive and nonconductive bits and pieces to rig it all together. There is a considerable literature available on this subject now, especially within the jewelry making and automotive rebuilding communities. All of this equipment is commercially available to the hobby or artist plater.

IMPORTANT: Acquire your copper for the plating bath as a known alloy from a reputable source. Do not simply use any random bit of copper you find. There is a chance that it might be a beryllium copper alloy. While safe enough as an alloy, if you plate the copper out of it you'll be left with free beryllium, which is an exceptionally nasty toxic element. Copper isn't that expensive, really; don't risk this.

For milling the grown matrix to dimension a conventional hobby milling machine setup will suffice.[7] The one special tool needed is a matrix depth gauge. A dial comparator on a stand will work, provided that it is fitted with a tip which will reach the bottom of the casting cavity of the matrix.

[7] Files and patience should also work.

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This is Duensing's translation of (Bohadti 1954). Note that the date Duensing gives in the colophon for Bohadti's work, 1953, is in error. *Die Buchdruckletter* bears a copyright date of 1954. It is entirely possible that Duensing was working from a preliminary copy from Bohadti.

(CR Patrix Lit) CircuitousRoot Notebook "The Issue of Patrix Cutting in Soft Metal: A Survey of the Data." Online on 2020-01-7 at:

`http://www.CircuitousRoot.com/artifice/letters/press/typemaking/the-issue-of-patrix-cutting-in-soft-metal/survey-of-data/index.html`

(Dair 2015) Dair, Carl. Intro. William Ross. Notes by Rod McDonald. *Epistles to the Torontonians, with Articles from Canadian Printer & Pub-*

lisher. Toronto: Coach House Press with Sheridan College, and New Castle, DE: Oak Knoll Press, 2015.

This book also contains a DVD with a short film on it, *Carl Dair at Enschedé: The Last Days of Metal Type* (co-produced by Sheridan Colleg and Massey College). Introduced by Rod McDonald and narrated by Matthew Carter, it contains footage shot by Dair in 1957 at Enschedé. This film is now circulating on the Internet but, sadly, often has been stripped of all reference to its original publication.

(Fournier 1764) Fournier [le jeune], Pierre Simon [aka Simon Pierre]. *Manuel Typographique, utile aux Gens de Lettres*. Tome I. Paris: Imprimé par l'Auteur, rue des Postes, & se vend Chez Barbou, rue S. Jacques, M.DCC.LXIV.

This work is, of course, in French. It has been translated into English once, by Harry Carter in 1930. For various editions of this, see: (Fournier 1930 EN), (Fournier 1973 EN), and (Fournier 1995).

Tome I is the volume on making type. Tome II is a specimen book. Further projected volumes were never completed. A good digitization of Tome I is available in the Gallica digital library of the Bibliothèque nationale de France at:

`http://gallica.bnf.fr/ark:/12148/bpt6k1070584h`

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(Fournier 1930 EN) Fournier *le jeune*, Pierre Simon. Trans. & ed. Harry Carter. *Fournier on Typefounding: The Text of the Manuel Typographique (1964-1768) translated into English by Harry Carter*. London: The Soncino Press, 1930.

This is the original edition of the only English translation of Tome I of Fournier's *Manuel Typographique* (Fournier 1764 FR). Despite its title, it contains not only the text but also the plates. It is an excellent translation, but a comparison with the original shows that Carter omits some material and rationalizes or reorganizes other parts. See (Fournier 1973 EN) and (Fournier 1995) for reprints.

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This is the first of two reprints of the only English translation of Tome I of Fournier's *Manuel Typographique* (Fournier 1764 FR). It contains new introductory material by Carter. See (Fournier 1930 EN) for the original edition and (Fournier 1995) for a later reprint.

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(Legros & Grant 1916) Legros, Lucien Alphonse and John Cameron Grant. *Typographical Printing Surfaces*. London: Longmans, Green and Co., 1916.

Google has digitized the University of Michigan copy:

`https://books.google.com/books?id=cmjPAAAAMAAJ`

However, because no one appears to know the date of death of "England's Empire Poet" John Cameron Grant, there is some remote possibility that this work remains in copyright outside of the United States. The Google digitization will not display internationally. Acting entirely within the borders of the USA, where this work is in the public domain, CircuitousRoot has digitized a copy and uploaded it to The Internet Archive:

`http://www.archive.org/details/LegrosGrantTypographicalPrintingSurfaces1916`

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This is the definitive desk reference on the subject.

The first edition of McGrew (New Rochelle, NY: The Myriade Press, Inc., 1986) was a “preliminary edition” circulated as a bound typescript to solicit corrections and additions. Unless you’re as obsessive as I am, there is no need to track it down.

(Mosley 2015) Mosley, James “Big brass matrices: a mystery resolved?” In *Journal of the Printing Historical Society.* New Series, No. 23 (2015): 45–48.

(Moxon 1683) Moxon, Joseph. *Mechanick Exercises: or, the Doctrine of Handy-Works. Applied to the Art of Printing. The Second Volumne* London: Printed for Joseph Moxon on the West-side of Fleet-ditch, at the Sign of Atlas, 1683.

Understanding the “volumes” of Moxon is initially confusing. From 1678 (new style) to 1680, Moxon serially published works on blacksmithing, turning at the lathe, etc. He used the general title *Mechanick Exercises* for these; they were later published as a single volume (sometimes with additional sections on bricklaying (1700) and sundial construction (1703)). They did not address type or printing at all. Then, from 1683 to 1684 he published (again, serially at first) a “second volume” of *Mechanick Exercises* with the subtitle “Applied to the Art of Printing. The Second Volumne”. That is, they were the second volume of the *Mechanick Exercises* (in general), not the second volume on printing. There was never a “first volume on printing.”

The bibliographic history of Moxon is exceedingly complex (in the original editions, in partial reprints in the 18th through 20th centuries, and in digital and POD versions today). For a bibliographic study of these editions of Moxon, see:

`http://www.CircuitousRoot.com/artifice/machine-shop/ornamental-turning/literature/moxon/index.html`

However, for the typefounder or printer only one edition is necessary: that of the second volume on printing superbly edited by by Herbert Davis and Harry Carter and published under the title *Mechanick Exercises on the Whole Art of Printing*. See: (Moxon 1962).

(Moxon 1962) Moxon, Joseph. Ed. Herbert Davis and Harry Carter. *Mechanick Exercises on the Whole Art of Printing (1683-4)*. Oxford, UK: Oxford University Press, 1958 (revised 1962).

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This is the essential modern edition of (Moxon 1683).

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This booklet, edited, typeset and printed by Paul Hayden Duensing, contains the text of a letter from Philip G. Nuernberger to Archie Little in 1931. (It refers to Nuernberger as "Phil. T. Nuernberger," but we know from Nuernberger's patents that his name was Philip George Nuernberger.)

It has been digitized by CircuitousRoot:

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However, for the typefounder or printer only one edition is necessary: that of the second volume on printing superbly edited by by Herbert Davis and Harry Carter and published under the title *Mechanick Exercises on the Whole Art of Printing*. See: (Moxon 1962).

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This essay, with corrections, appears in (N/S/M/H 2020).

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This article has been reprinted by CircuitousRoot:

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The layout of this book was done using the XƎLaTeX
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