A Chronology of Typographical Pantographs

Dr. David M. MacMillan

Abstract

The history of the development and use of pantographic techniques in the making of metal printing type has never been recounted either comprehensively or accurately. This is a first step, necessary but necessarily incomplete: a raw chronology of events, together with references to the sources of our knowledge.

1 ◆ Introduction

While it is beyond question that the mechanization of the making of punches, patrices, and matrices for metal letterpress printing types in the late 19th century was one of the most important events in the history of type, most accounts of this are inadequate. They tend to oversimplify both history and technology and to reduce a complex technological transition to a myth of a lone genius. Moreover, most narratives today are seriously inaccurate in their details and their understanding of the technologies. They conflate different methods of type-making and often leave out important methods entirely. As a result, this is perhaps the least well understood of all of the technological transformations that have shaped our world.

This chronology is not a complete analysis of this history; it's just a first step. It lays out all of the presently known events in this history in order to provide a better, and better documented, context. It also identifies events which are still recounted as a part of this history but which never really happened.

This Chronology also includes non-typographical pantographs, particularly in its early sections. The purpose of this is to counter the tendency in typographical history to see the adaptation of pantographic technology to metal type-making as something that happened in isolation. It was, instead, an application of well-established industrial technologies.

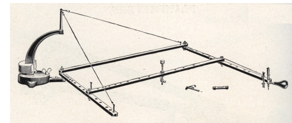
A "Plate Book" with larger versions of most of the illustrations accompanies this article.

The author may be reached at dmm@Lemur.com

Revision 11, 2018-03-23. The current version of this document is available at:
www.CircuitousRoot.com//artifice/letters/pantocut/index.html#pantochron

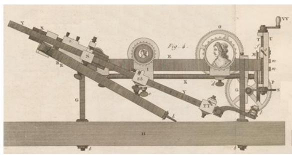
2• Technical Background

2.1• What is a Pantograph?



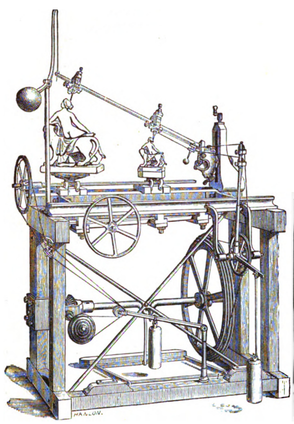
1. Drafting Pantograph

The true pantograph is a four-bar linkage which transmits the motion of a tracer to the motion of a drawing or cutting tool in such a way that the tool reproduces the motion of the tracer at some scale (smaller, equal, or larger). The motion of the tool is an exact scale duplicate of the tracer (unless deliberate measures are taken to modify the proportions of the copy).



2. Medallion "Lathe"

Another device which operates on completely different principles is often (but not always) called a "pantograph." This kind of device employs a single arm which is pivoted at one end. The motion of a tracer at some point along this arm is reproduced by a drawing or cutting tool at another point. This style of pantograph was used over a long period in various fields. It seems to have been introduced in the 18^{th} century in ornamental turning lathes for copying medallions in low relief. It saw significant use in the 18th and, especially, the 19th centuries adapted to three dimensions for copying sculptures.



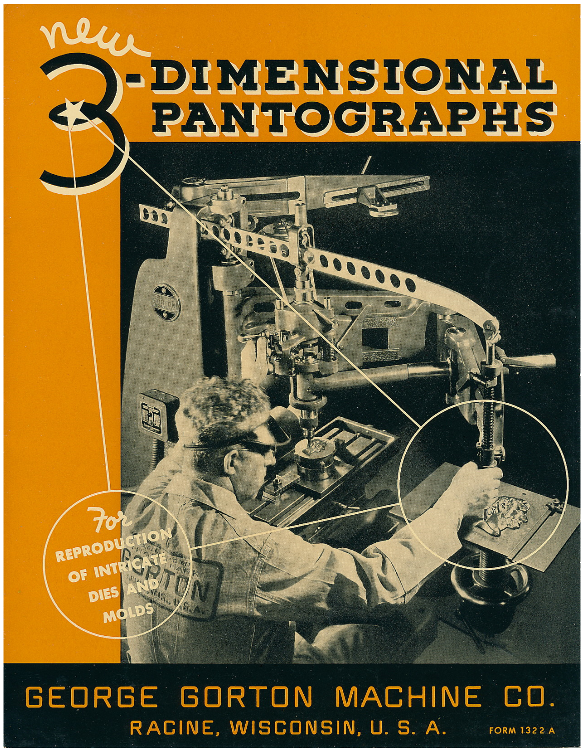
3. Sculpting "Pantograph"

4. Hollerith Card Punch

In the 19^{th} and 20^{th} centuries, various kinds of pantographs of the single– arm type were used for coining and die sinking. In 1891 a machine of the same principle was used by Hollerith for a hand-operated tabulating-card punch. From the lathe 19th century, Benton used this form of machine in his two vertical-format patrix, punch, and matrix engraving typographical pantographs. Following his lead, this style was adopted by the American and English Linotype, Monotype, and Intertype firms.

The four-bar pantograph operates without distortion (unless this is introduced deliberately, as in arrangements for slanting letters). The single-arm pantograph necessarily introduces distortion between pattern and workpiece; this must be compensated for in the pattern. This can be seen most clearly in the Hollerith pantograph for hand-punching tabulating cards, where the array of tracer locations must be curved in two dimensions in order to produce a rectangular grid of punches on a card.

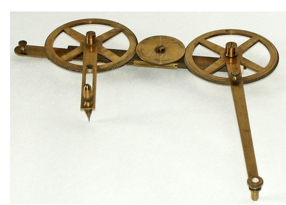
The four-bar pantograph is a two-dimensional machine. In drawing work it is used strictly in two dimensions. For typographical work and much coining / medallion work a simplified third dimension, cutting depth, may be added independently of the primary pantograph linkage. For true three-dimensional work with a four-bar pantograph, as in industrial diemaking, additional apparatus must be added.[1]



5. An Industrial 3-D Pantograph (1937)

The single-arm pantograph may be constructed as either a two-dimensional or three-dimensional machine.

There have also been machines which employ other mechanisms (e.g., gears, chains) to provide proportional movements like those of the pantograph. The "Storchenschnabel"[2] of the Austrian inventor Siegfried Marcus (1855) is a particularly clear example of one instance of this diverse category of machines.



6. Geared "Pantograph"

[1]For example, in their GK-21 Deckel simply pivoted the entire pantograph mechanism. This introduces some distortion. Gorton employed a more sophisticated method of proportional motion for the vertical dimension.

[2]The German word "storchenschnabel" literally means "a stork or crane's bill or beak." It is most commonly applied today to a kind of geranium. It was often used as a term for "pantograph" in the 19th century German literature. I have presumed that this was because the typical form of the framework holding the spindle in many horizontal-format European pantographs resembles the long neck of a crane, but this is a pure supposition on my part. It might just as well refer to the supporting arm of a suspended style of drafting pantograph. Words escape their origins, and Marcus' storchenschnabel does not have such a spindle holding neck.

3 ⬩ What is Not a Pantograph?

7. Not Our Kind of Pantograph

While the various mechanically diverse instruments described above are all reasonably called "pantographs" within the meaning of this term as understood here, there is another device called a "pantograph" which is unrelated both in its mechanism and purpose. The device called a "pantograph" as employed in electrical power transmission to streetcars and electric trains is not a pantograph in the present sense at all. Its mechanism differs: it is just an arrangement of springs and bars which bears a superficial resemblance to the four-bar pantograph. Its purpose also differs: it transmits electrical power rather than describing motion. This confusion of terms is now embedded in the language. It is perfectly correct to call this a pantograph when talking about trains or trams, but not when talking about drawing or engraving.

3.1 • How are Pantographs Used in Making Metal Type?

Cast metal letterpress printing type [3] is made by first making a "matrix" (plural "matrices") [4] which contains an individual letterform molded into a cavity and then using this matrix, together with further mold parts and equipment, to cast the types.

In the various processes for making matrices for metal printing type, the pantograph may be employed in two (or, perhaps rarely, three) distinct phases of the operations.

A. A pantograph may be used by the type drawing office to scale, expand, condense, incline, or otherwise modify type designs. Linn Boyd Benton himself describes this process (briefly); see {Benton 1906}: 32-33. A pantograph by Benton for this purpose is illustrated in Kaup's 1909 article "Modern Automatic Type Making Methods" {Kaup 1909}: 1042. But in general, the use of a pantograph at the design stage is not what people are thinking of when they talk about the revolutionary influence of pantographs on type production in the late 19th century. [5]

B. A pantograph is routinely used in the preparation of a durable metal "working pattern" from the final design drawings. Often a standard commercial machine may be used for this. For example: Frederic Goudy used a Deckel, in the 1940s American Type Founders used a modified Gorton 3-B, and the late Jim Rimmer used a Taylor-Hobson. [6] Sometimes a pantograph used at this stage cuts the pattern with a rotary cutting tool, but in other cases it may simply scratch the pattern through wax (from which the pattern is produced by electroforming).

C. A pantograph may be used in any of the three major processes for making matrices:

1. It may be used to cut a punch in steel. A matrix is then made by pressing this punch into a matrix blank ("planchet"). This is a mechanization of traditional hand punchcutting.

2. It may be used to cut a patrix ("pattern type") in soft metal. A matrix is then electroformed from this patrix. This is a mechanization of patrix

[3] By this I mean to exclude wood type (where each sort is cut individually), specialized metal type for hard service, typically in brass or steel (which is also cut individually), nontypographical punchcutting, and long obsolete processes employed in the 18th century and earlier for making very large types by sand casting.

[4] The use of "matrice" as a singular is in fact attested in the older literature (e.g., Moxon in 1683). However, when "matrice" is used as a singular today it is my impression that it has been constructed as an incorrect singular back-formation from the plural. So unless specifically citing pre-20th century literature, it is best to use the standard form "matrix" for the singular. The colloquial shortening of "matrix" is "mat" (plural "mats.")

[5] Depending on the machines used, modifications of this kind may also be made during later stages of matrix production. This would make the creation of variant drawings unnecessary.

[6] See the entries for "1920s–1940s Goudy's Deckel and E&PM Pantographs," "1939 Goudy's E&PM Pantograph for Working Patterns," "1940s ATF Gorton 3-B," and "[DATES?] Jim Rimmer's Taylor-Hobson for working patterns" for more information on these particular machines.

cutting as practiced by hand since about 1845.[7]

3. It may be used to cut a matrix directly. This was never done by hand.[8]

The use of a pantograph at this late stage in these processes is what most people are thinking of when typographical pantographs are mentioned.

All three of these processes were used simultaneously throughout the era of the machine production of metal type.

Pantographs have also been used in making wood type. This began in the 1830s and continues today. However in this use the pantograph is making the end product directly, one piece at a time. Interestingly, I can find no evidence that there was any direct influence of this well-established typographical use of the pantograph on the development of pantographs for metal type processes in the late 19th century.

4◆ Perspective and Credit

No single history of type yet written tells the story of the development of machine methods in matrix making either accurately or comprehensively. Most simply repeat earlier and frequently inaccurate reports, sometimes adding new and interesting misunderstandings.[9] This is not a new problem. For example, in 1948 the great American typographer Carl Purington Rollins said:

> ... the making of type was entirely a hand operation. Not the least exacting part of the work was the cutting of the punch on the end of a short bar of softened steel. It was not until the invention of the Benton pantograph punch-cutting machine in 1885 that any other method was known. All type made before 1885 was therefore dependent on hand punch cutting. {Rollins 1948}[10]

[7]For reasons both deliberate and accidental, knowledge of patrix cutting (first by hand, then by pantograph) and matrix electroforming has been erased from this history of type-making in American accounts. (In German accounts it was presented as one of the three basic methods.) From its introduction in 1845, patrix cutting by hand became an important method of type production and the dominant method of making display types. It was one of the two enabling technologies for 19th century ornamented types (along with the pivotal casting machine); see {Saxe 2016}. We have good reason to believe that Benton first used his first pantograph to cut patrices and that he continued to use this method until at least 1901. All of the brass display matrices manufactured by the Lanston Monotype Machine Company, which were the mainstay of independent typecasting in America in the 20th century, were made in this way.

[8]That is to say, I am aware of no instances of it. Cutting counters is the hardest part of punchcutting. Attempting to cut a matrix by hand would be “all cutting counters.” The 18th century “Sanspareil” matrices for very large types were made by hand, but this was done by cutting them out with a saw and riveting them onto a backing.

[9]One book by an author now deceased, but still in print, has Benton making wood type and brass punches.

[10]This essay appeared originally in the material accompanying a 1947 exhibition by the R. R. Donnelley & Sons printing firm at the offices of their prestige imprint, The Lakeside Press. It was reprinted in *Print*, Vol. 5, No. 4 (1948). This article by Rollins established the basic canon of American type designers and put the concept of a “type designer” on its modern footing.

Rollins was one of the great typographers of the 20th century, and this account would not raise an eyebrow today, yet every part of it is false.[11]

Much of this history as commonly told revolves around Linn Boyd Benton. The evidence in the present chronology indicates that little of this is actually true. It might be easy to think, therefore, that I'm simply "bashing" Benton. Nothing could be further from the case — he is a remarkable figure in the history of type technology and I admire him deeply.

But the story of the typographical pantograph is much, much more complex than this simple origin myth. It shaped our visual world, and deserves to be told more completely and, above all, more accurately. In this more complex story, Benton becomes one player among many, but he is not diminished. An understanding of his achievements in context allows us to see just how magnificent they were — as he developed not one but several different pantographs,[12] put the Linotype and Monotype companies on a sound technological path to punchcutting and, together with his son Morris Fuller Benton, reshaped the typographical presence of the largest type foundry in the world.

---

[11]It is true that punches are cut on the ends of short bars of un-hardened steel, but because he omits patrix cutting Rollins' point that this was the *only* method fails to be true.

[12]The count of Benton's pantograph designs is uncertain. If you had to boil it down to a single number, "five or more" would be a reasonable answer. He has been documented as responsible for three different machines in their entirety: the circa 1884 patrix/punch cutting single-arm vertical pantograh, the 1899 direct matrix engraving single-arm vertical pantograph, and the 1899/1905 horizontal four-bar "opto-mechanical" or drawing-room delineating pantograph. All three of these are extraordinary machines. It is likely that he designed the horizontal four-bar machine called here the "wax plate" pantograph by 1905 or 1906. This was a conventional machine which greatly resembled commercial drawing office pantographs. He also "built and enhanced" a "small number" of pantographs for matrix cutting use — this phrasing (from Rehak) implies that some of these machines originated with Benton and some originated elsewhere. See the section on the 1918–1919 "Ad-Cut" pantograph. Finally (or more precisely, initially) he may have constructed one or more other pantographs for pattern making using the "lead plate" method in the period 1884–1905, but nothing is known of these machines.

Patent claims, which by intent are expressed as broadly as possible, further confuse the question of the use of these machines. For example, Benton's 1885 patent (for the circa 1884 patrix/punch machine) does mention the direct engraving of matrices, but the machine seems much better suited to patrix/punch cutting. In another example, the 1905 patent for his "opto-mechanical" pantograph mentions the use of both drawing and cutting tools, but we know of this machine only in drawing-office use.

5◆ Conspectus

A first impression of the chronology which follows might be that it is very complicated. That's the point, actually: the real history *was* complicated and cannot be distilled into a single hagiographic sentence. But the problem is that it is easy to get lost in this detail and difficult to separate what is important in itself from what was important only because it shows how much was going on at the time.

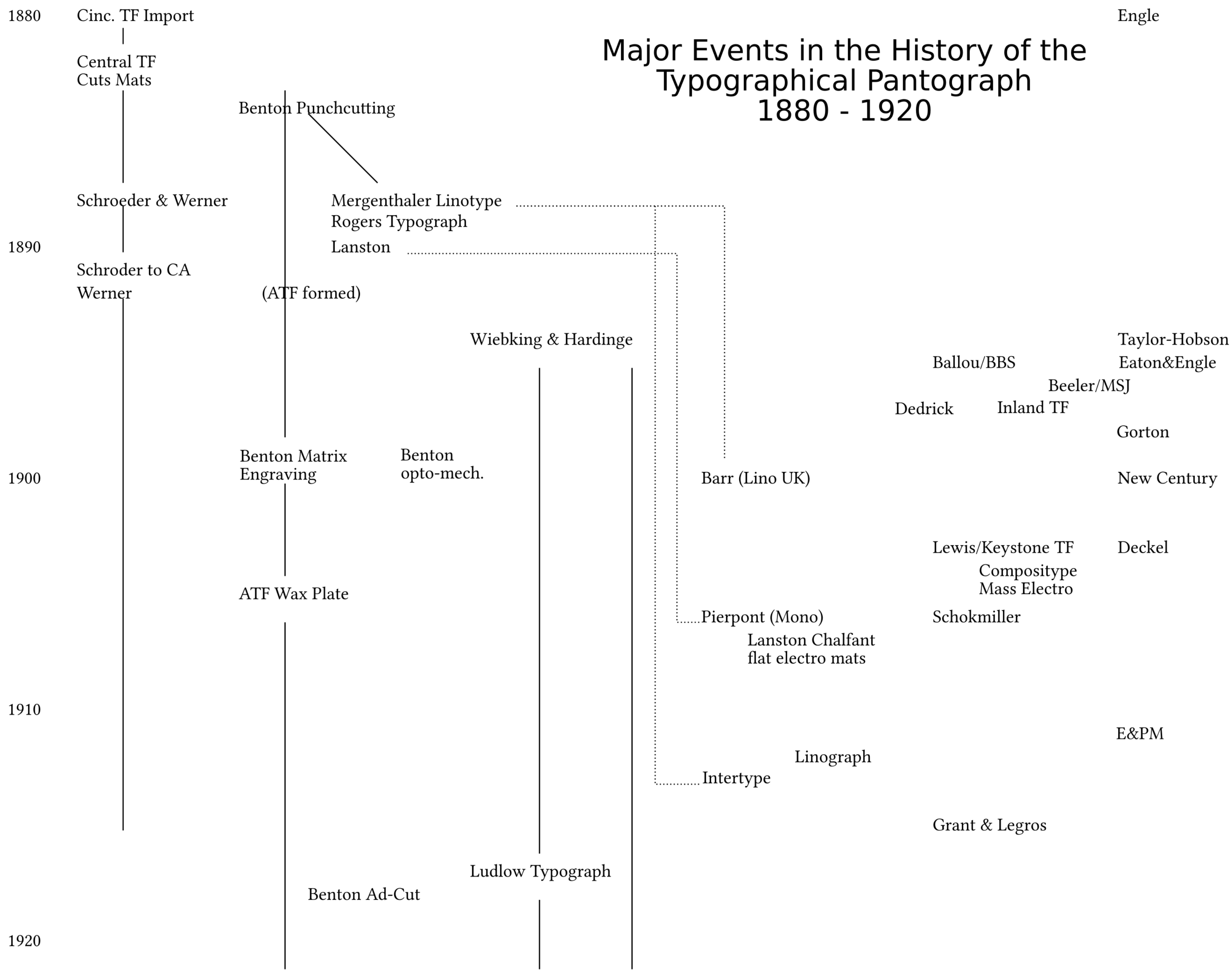
On the following page, then, is a simplified chart which shows the main events of typographical (only) pantograph development in the main period from 1880 through 1918. It is organized so as to show the main threads of development:

1. The Central Type Foundry pantograph (Schraubstadter, Schroeder, Werner)
2. Benton's two vertical pantographs (and thence ATF, the two Linotype firms, the two Monotype firm, and Tsugami)
3. Wiebking/Hardinge (and thence Ludlow)
4. (A consistent but still uncharted history of horizontal-format pantographs in European type foundries)

Many other items are included, but they played a lesser role.

I have also indicated, sketchily, the timelines through the period of this chart of several long-lived commercial pantograph makers whose machines were at times used typographically (Engle/Eaton/E&PM/Cronite, Taylor-Hobson, Gorton, Deckel.)

Major Events in the History of the Typographical Pantograph 1880 - 1920



6 ◆ Prehistory to 1880

This section covers items up to, but not including, the first documented successful commercial use of a pantograph in the making of matrices for metal type (which was at the Central Type Foundry in St. Louis, Missouri, in 1882 by a machine constructed in Germany not later than 1880). Most of the items in this section are just here for reference or orientation, or to identify "red herrings" or false trails. However, I have a gut feeling that there are pieces of this story missing, and that the real origins of the pantograph in metal type making are in Europe — probably in Germany — in the period after Leschot (1844) and before 1880.

Pantographs not directly related to typographical punch/patrix/matrix making are identified with the code "**[NT]**".

Please note that this section contains more references to the secondary and tertiary literature than I am comfortable with (though fortunately most of these are for nontypographical pantographs). Items supported only by nonprimary evidence should be considered as placeholders for further research, not as verified historical data points.

6.1 ◆ Why So Many Medallion Lathes?

It is reasonable to ask why this Chronology spends so much time on the "portrait lathes" or medal/medallion making machinery of the 17th and 18th centuries given that these machines were not (and probably cannot be) used for making typographical punches, patrices, or matrices. The reason is that the best known style of pantograph used typographically was single-arm; Benton started this trend with his patrix and punch engraving machine by 1884. Considered as a machine, this kind of single-arm pantograph is most closely related to the single-arm pantographic "reducing machines" which had long been used for engraving the stamping dies used in the making of coins in mints. By the late 19th century, these had reached a point of considerable refinement.

These single-arm pantograph "reducing machines" in turn were developed as improved machines to cut medallions (often portrait medallions). The machines they replaced were the "portrait lathes" or "medallion engines" of the 17th and 18th centuries. These earlier machines accomplished the same end (cutting a medallion from a larger hand-made pattern) using complex arrangements of shafts, gears, and chains.

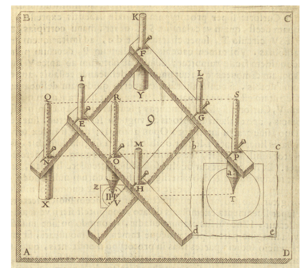
So while a "portrait lathe" from the early 17th century is not itself a typographical machine, there is a clear path of technological development from it to the mechanization of type-making in the late 19th century.

Conversely, a reader who discovered this Chronology while researching the early history of the fields of "ornamental turning" and "rose engines [lathes]" will be frustrated when the focus turns away from these fields in the 19th century. For this I can only offer my apologies.

6.2• Seventeenth Century

The original 4-bar pantograph was invented in the early 17th century. I have found little evidence for its use until the next century, however, and no evidence for its industrial use at this time. The first machines for medallion or portrait copying (a field in which pantographic machinery later excelled) seem to be built on other principles.

1631. [NT] *Christoph Scheiner* publishes a description of the *four-bar linkage pantograph*, invented by him some years earlier. It is at this time a machine for drawing and geometry. See {Scheiner 1631}, where it is shown in the frontispiece and elsewhere.



8. Scheiner, 1631

Circa 1677. [NT] *Senger. Machine-cut double-medallion.* In the Museo degli Argenti in the Pitti Palace, Florence, there is preserved a "Double Medallion with a Portrait of Cosimo III and His Monograph." This consists of two ivory medallions joined with an ivory chain (the whole, including the chain, cut from a single piece of ivory). Mosco dates this object to some point after 1670 (probably 1677) and feels that because of its "technical precision" it implies "the use of a pantograph" {Mosco 2004}, p. 153. It is illustrated in {Mosco 2004}, p. 154, and identified there as by Filippo Senger ("or Sengher"). Inventory Number: "Bg. [Bargello] 1879 no. 81."

Brookes is of the opinion that this double medallion was turned on a medallion lathe. It is the earliest item in his list of "landmarks" in the history of medallion turning. {Brookes 1991}, p. 174.

I am aware of no information on the machine, if any, used to produce this object or of any technical analysis of it which would confirm or refute its production on a medallion lathe.

1688. [NT] *Machine-cut medallions attested.* {Brookes 1991}, p. 174, says in his summary of the history of medallion turning that in 1688 "Landgrave Carl of Hesse-Kassel was producing medallions" [presumably with a medallion lathe]. At present I have no further details.

17th Century [NT] Note: There is more work to be done in researching the early history of copying lathes in the 17th and very early 18th centuries (that is, before Nartov; see below).

What we're looking for are mechanisms which simultaneously copy and scale an arbitrary original form (for example: cutting a relatively small medallion in some hard material by scaling down a larger pattern which has been hand-made in some easier-to-work material). This may be accomplished by four-bar or single-arm pantographs as we recognize them today, or by any of a wide range of other mechanisms.

These mechanisms must be distinguished from mechanisms for the production of geometric shapes and figures from other geometric shapes and figures (and in the case of Condamine, the transformation of geometric curves into arbitrary portrait figures). Mechanisms of this kind, using swash plates, rosettes, and so forth, are well known in this period and are documented in this history of ornamental turning and rose engine work.

Such copying-and-scaling devices certainly must have existed. Zagorskii, for example, claims that "copying lathes for making decorative articles had attained considerable complexity in the 17th century, as gan be judged from the surviving specimens" {Zagorskii 1982}: 74. But he does not give any information on the machines themselves.

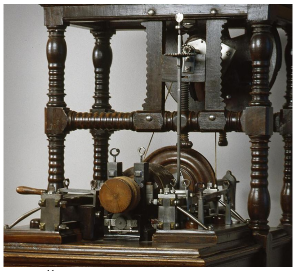
I have been unsuccessful in discovering concrete information. I can find no descriptions of copying-and-scaling devices in the better-known early sources on ornamental turning. There is nothing in Jaques Besson's *Theatrum Instrumentorum et Machinarum* (1578), Salomon De Caus's *Les raisons des forces mouvantes* (1615), the *Recueil d'ouvrages curieux de mathematique et de mechanique* of Grollier de Servière (who lived from 1596 to 1689), Moxon's *Mechanick Exercises* (1678 N.S. – 1680), or Plumier's *L'art de tourner en perfection* (1701). In the scholarly secondary literature, there is no mention of any such machine in Woodbury's *History of the Lathe to 1850* {Woodbury 1961}.

6.3⬩ Eighteenth Century

The 18th century saw the introduction of the single-arm "pantograph" both for medallion/portrait engraving in low relief and for full three-dimensional sculpture reproduction. It also saw the introduction of scale reproducing machines using other mechanisms; whether one wishes to call them "pantographs" or not is matter of opinion. The four-bar or true pantograph, however, seemed to see little use outside of drawing. By the end of the 18th century, the basic technology for fine machine engraving with single-arm pantographs was well established and in industrial production in public and private mints.

1701, 1749. [NT, negative instance] *Plumier.* Neither the 1701 or the 1749 edition of Charles Plumier's *L'art de tourner en perfection* describe a copying or portrait/medallion lathe (or a pantograph of any kind). This seems especially curious since Plumier is relatively comprehensive and it has been been presumed that such lathes exist.

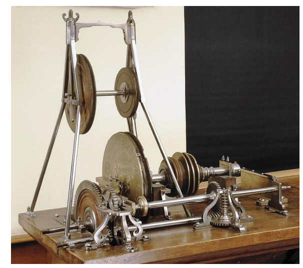
Plumier does describe a number of lathes for producing highly figured work geometrically, and the 1749 edition does reprint Condamine's essays (which include the generation of portrait figures from curves; see below). These are not, however, devices for copying and scaling originals. See {Plumier 1975} and {CR Plumier}.



9. "Turning Machine for Copying" (1711)

Early 18th Century [NT] *Portrait and medallion lathes.* There were other portrait / medallion / copying lathes in the early 18th century. I just don't know much about them yet. One example, shown here, is preserved in the collection of the State Hermitage Museum in St. Petersburg, Russia. They date it to 1711 and place its origins in Italy. Its mechanism isn't clear from the photograph.

1710s – 1730s. [NT] *Nartov. Medallion lathes.* From the 1710s through the 1730s, Andrei Konstantinovich Nartov in Russia constructed several ornamental turning lathes, some of which incorporated features for simultaneously copying and scaling low-relief patterns.



10. Nartov's Portrait Cutter Type 2 (1721)

So for example his "Portrait Cutter Type 2" included both the mechanism of a more or less conventional rose engine plus two more motions: (1) longitudinal motion of the lathe spindle, allowing a low-relief pattern at one end of the spindle to control the depth of cut at the other end,[13] and (2) coordinated and scaled motion of a tracer against this pattern and a cutting tool against the workpiece. This coordination and scaling was accomplished with chains, wheels, shafts and gears. The combination of these two motions permitted, for example, a portrait medallion to be cut by automatically scaling and reproducing a larger hand-carved model.

As far as I can determine, none of Nartov's copying lathes incorporated either a four-bar or a single-arm pantograph.

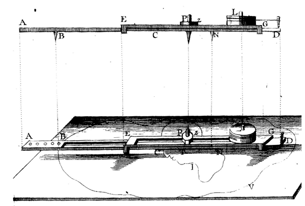
A lathe by Nartov probably survives in the collections of the CNAM in France, but I have not yet identified it with certainty. {Steeds 1969}, pp. 11–12, say that a lathe by Nartov was given by Peter the Great to "a Frenchman." He describes this lathe in some detail, but the illustration he gives for it (his Plate 1b) is identified in its caption as by Mercklein from 1767 (and would seem to be just that).

Unfortunately, while Nartov's work was remarkable, it was not influential. Some of his machines have survived, but his manuscript *Ясное зрелище машин* (literally "a clear view of machines," but commonly known today by the name later given to it, *Theatrum Machinorum*) was not published until the late 20th century.

For bibliography on Nartov, see the CircuitousRoot Notebook on Nartov {CR Nartov}. See also the discussions of Nartov's copying lathes in {Zagorskii 1982}: 74–95.

[13] The motion is inverted: Both the tracer and the cutter are constrained in slides perpendicular to the spindle. A raised portion of the pattern moves the spindle rightward against the cutter, and produces therefore a depression in the workpiece. A depression in the pattern similarly produces a raised portion in the workpiece.

1734. [NT, red herring] *Condamine. Rosette generation.* Charles Marie de la Condamine (1701-1774) published a two-part essay, "Recherches sur le Tour" [research on turning], in the *Histoire de l'Académie Royale des Sciences* for 1734. Since at least the 19th century, the second of these has been cited by reputable sources as the origin of the single-arm pantograph medallion or portrait "lathe" ("tour à portrait"). See for example the second edition of Bergeron, {Bergeron 1816v2}: Vol. II, Chap. VII, or Laboulaye's *Traité de cinématique*, {Laboulaye 1878}: 928. This is an error.


11. Condamine's Rosette Generator

Condamine, better known today as an explorer, was writing here as a mathematician rather than a practical turner. The first part of his essay described what was essentially a mechanical simulator for geometrical turning. The second part describes a non-pantographic single-arm device which he uses to transform an arbitrary figure, such as the silhouette of a human head, into a series of curves which could be used to form the rosette of a rose engine (rose lathe). Equipped with this rosette, the lathe would produce the silhouette on its workpiece. Neither of these devices, however, is a pantograph of any sort. A pantograph reproduces a model at scale; Condamine's devices deconstruct the model.[14]

See {Condamine 1734}. Condamine's essays were reprinted in Plumier's *L'art de Tourner* (1749). For a translation into English, see Ferraglio's translation of Plumier, {Plumier 1975}. Condamine's devices are discussed at length in {Zagorskii 1982}, pp. 96–117, but I believe that he is in error in thinking that Condamine considered "copying" lathes (when his work was in methods for generating figures on geometric principles).

1740. *Tuebers. Medallion lathe (shaft and chain style.)*

1743. [NT] *Dollond. Possible single-arm pantograph medallion reducing machine.* John Dollond (1706 – 1761) and his son Peter Dollond (1731–1820) were a well-known English makers of optical instruments. Cooper, writing in the context of coin-making technology and the "reducing lathes" which reached their full development with Janvier in the late 19th century, says:

> ... the first pantograph machine nearest in form to the present day reducing machines [that is, single-arm horizontal pantographs as made by Janvier] was made by Dollond in 1743, and it has been referred to as the "singe", meaning monkey or mimic. These machines were used for copying engraved designs onto softer material than the steel normally used for coining tools. {Cooper 1988}: 164.

[14] This device has often been cited, but was not in fact influential. It was an exploration of the geometrical basis of an arbitrary figure without recourse to simplistic geometries of lines and circles. In the world of type, this was not attempted again until Knuth's METAFONT(1979/1984).

He provides no illustration or further information. I do not yet understand the meaning of the final sentence quoted above. One further difficulty is that the Dollonds did not enter into the optical business until the early 1750s. If Cooper's date of 1743 is correct, then this reducing lathe must have been produced as an amateur project while both father and son were still engaged in the trade of silk weaving.

Circa 1780. [NT] *Dupeyrat, portrait lathes at the French mint.* Jean Baptiste Dupeyrat, circa 1780. Cooper claims that "About 1780 similar [to Dollond's, 1743] machines known as the 'tour à portrait', or portrait lathe, were introduced into the French Mint in Paris and were being manufactured systematically by Dupeyrat." {Cooper 1988}: 164.

Dupeyrat is also cited in {Johnson 2012}: 11 {Musson & Robinson 1969}: 221 claim that in 1790 Boulton bought a "lathe … which was kind of reducing machine" for the Soho Manufactory. These are secondary (Cooper, Musson & Robinson) and ternary (Johnson) sources; I have discovered no primary information concerning these machines, but given other developments in coining (Hulot, Janvier) they were probably horizontal-format single-arm pantographic medallion/portrait lathes.

1790. [NT] *Watt, "reducing machine" at the Soho Mint.* James Watt is said to have ordered a "reducing machine" (probably pantograhic) at Boulton & Watt's private Soho Mint in 1790 ({Cooper 1988}: 164; he does not give his source). Also cited in {Johnson 2012}: 11 (in entry on Hill, 1851).

1790s. [NT] *Watt's single-arm pantographs* for sculpture reproduction. These are preserved in the Science Museum (London). See {Dickinson 1929}. [TO DO: GET DATES; I've got Dickinson around here somewhere…]

After 1792, before 1816. [NT] In 1775, Hulot, père, published *L'Art du tourneur mécanicien*, an excellent work on plain or simple turning.[15] It does not discuss portrait/medallion lathes. In 1792, Louis-Georges-Isaac Salivet, publishing under the name of his friend Louis-Eloy Bergeron, published his comprehensive *Manuel du Tourneur* covering plain and ornamental turning. He made no reference to portrait/medallion lathes. But in 1816, Pierre Hamelin-Bergeron published a revised second edition of the *Manuel du Tourneur.* It illustrates a single-arm pantograph portrait or medallion reproducing lathe (see Bergeron 1816, below).

This 1816 volume incorrectly attributes the origin of this kind of pantographic lathe to Condamine (1734, see above). But it attributes the perfection of this machine to Hulot's son (deceased). At least one "Hulot Reducing Machine" survives.[16] It is illustrated in {Cooper 1988}.

[Aside? Discuss tantalizing but probably nonexistent link: Hulot (père) was involved with the project which became the Descriptions des Arts et

[15] Fans of Roy Underhill will recognize the senior Hulot's compact pole lathe.

[16] Or at least survived until 1988, at the Coin Cabinet of the Bibliothèque Royale Albert 1, Brussels.

Métiers. Tie in with Jaugeon / Bignon committee and the early documentation of type; and the development of the Romain du Roy - which was used to print a book of MEDALS honoring Louis XIV. Everything was in place for the introduction of pantographic techniques into type-making, but it did not happen.]

1794. [NT] *Droz for Breguet, pantograph for "secret signatures."* In 1794, in Geneva, Jean-Pierre Droz constructs a pantograph for the great watchmaker Abraham-Louis Breguet to allow him to engrave his so-called "secret signatures." {Daniels 1975}: 7, 32. (Daniels' book is still the standard reference on Breguet, and he wrote it with complete access to the firm's archives.)

Curiously {Johnson 2012}: 9 says that Jean-Pierre Droz was at Boulton's Soho Manufactory from 1789 to 1799. He could of course have produced work in both Geneva and Birmingham in the same decade. Daniels is the authoritative source.

The Breguet "secret signature" pantograph survives. It was sold in 2012 at the Sotheby's auction of the "George Daniels Horological Collection." Sotheby's has a good color photograph of it online at:

`www.sothebys.com/en/auctions/ecatalogue/2012/george-daniels-so-l12313/lot.68.html`

6.4• Nineteenth Century, First Quarter

The 19th saw the refinement of single-arm pantographs in their established fields (especially coining) and the more or less continuous introduction of pantographs of all kinds into a wide range of industries.

1819. [NT] *Pistrucci. Pantograph in London Mint.* {Cooper 1988}, p. 165 (writing in the context of single-arm pantographic "portrait lathes" says that "Pistrucci installed a pantograph machine in the London Mint in 1819. In Italy he had used one for cameo production."

Early 19th Century [NT] *Single-arm pantographic lathes in European mints.* {Cooper 1988}, p. 166, illustrates several single-arm pantographic lathes used as "reducing machines" for die engraving in European mints in the early 19th century. One by Braemt from the Brussels mint. One in Karlsruhe. Neither is dated.

1821. [NT] *Apograph. Vertical-format single-arm* [TO DO] Andrew Smith, 1821. For drawing. This is presently the earliest *vertical-format* single-arm pantograph of which I am aware.

There is no evidence (and no reason to suppose) that Benton was aware of the Apograph.

1821. [NT] *Wallace. Eidograph*

1822. [NT, not really related] *Blanchard. Gunstock reproducing lathe.* Blanchard's lathe for reproducing gunstocks from a pattern is a copying device, and it does scale from a pattern (though at a fixed proportion), but it isn't really a part of the history of pantographs. It is basically a tracer-controlled milling machine with coordinated rotary indexing fixtures for both the pattern and workpiece.

1824 (1830?) [NT] *Single-arm pantographic reducing machine at the London mint.* Cooper (writing in 1988) says that this machine was purchased in 1824, and that it was the machine in the collections of the Science Museum (london). It is a single-arm pantographic lathe / reducing machine. Identified as item "M.3720". {Cooper 1988}, p. 167 and Fig. 175.

The 1920 Catalogue of the Science Museum identifies an "Engraving Machine. Lent by the Deputy Master of the Royal Mint." {Science Museum 1920}: 48–49. It is not illustrated.

There is now a Royal Mint Museum; I haven't yet determined whether this machine is remains at the Science Museum or is at the Royal Mint Museum.

1826. [NT] *Benjamin Chevereton, "Machine for Reproducing Sculpture."* A horizontal-format single-arm 3-D pantograph. Unsurprisingly, one of

Cheverton's works is a portrait bust of Watt. This machine survives in the collection of the Science Museum, London. Inventory No. 3015520. See: collection.sciencemuseum.org.uk/objects/co47993/machine-for-reproducing-sculpture-machine

6.5• Nineteenth Century, Second Quarter

The second quarter of the 19th century saw the introduction of power cutting tools (wood routers by Leavenworth in 1834, metal drilling by Leschot in 1839). Previously the pantograph had excelled at fine work such as making coining dies or less precise but artistic work such as sculpture reproduction. Now it began to be applied to heavier industrial work and production work.

In other technologies, the end of this period saw the introduction of electroforming. [TO DO: Electroforming was used for preparing hard original patterns for use by single-arm pantographic reducing machines in coining. See {Cooper 1988}: 167.]

1829. [NT] *Pantographic Embroidery Machines, Europe* The German-language Wikipedia article on the "Handstickmaschine,"[17] or pantographically controlled hand-operated embroidery machine, indicates that from its invention in 1829 and maturity in the 1850s, through its decline in the early 20th century, it was widely used in Europe. The claim is made that by 1910 almost 20,000 of them were in operation in eastern Switzerland alone. While this information requires more careful examination of its sources, it does seem a good indication that throughout the 19th century the pantograph was an integral part of industrial technology rather than the isolated invention that is often portrayed in histories of type. See: `de.wikipedia.org/wiki/Handstickmaschine`.

1830. *Collas.*

The 1920 Catalogue of the collections of the Science Museum (London) says that "In 1830 Achille Collas, of Paris, ... brought out a new design in which distortion was reduced; with the a large amount of actual work was done." It goes on to discuss an item in their collection, an "Engraving Machine" received by them in 1857 (Inv. 1857–21). Unfortunately, while the Cagalogue describe the arrangement of this machine it does not illustrate it. {Science Museum 1920}: 46 (Item 110).

A machine of this type made by Joseph Saxton was lent to the Science Museum in 1899. {Science Museum 1920}: 47 (Item 113, "M.3071").

1832. *Bate, anaglyptograph.*

The 1920 Catalogue of the collections of the Science Museum (London) identifies an item called an "Anaglyptograph" and says of it that it is a "small example of the medal-engraving machine as modified by John Bate, and patented by him in 1832, so as to diminish the distortion which resulted from the ordinary machine [of the Collas type, see above]; this

[17] I am uncomfortable using tertiary sources such as this here. However, I lack the linguistic ability to drill down through the secondary sources it cites to discover the primary sources regarding this technology and its history. In this case, where the point is simply to show the general use of pantograph technology in the 19th century, the use of a tertiary source such as Wikipedia probably does little harm.

distortion, however, is only noticeable when the object being copied is in high relief." The example in their collections was received by them in 1909 and is identified as "M. 3633. S.M. 239, L.S." {Science Museum 1920}: 46–47 (Item 111).

1834. *William Leavenworth* (possibly in collaboration with an A. R. Gilmore, otherwise unknown) begins developing a *four-bar pantographic routing machine for making wood type.* This led to a long and successful history of wood type directly cut by machine. However, as far as I am aware there was no direct influence of this successful technology on the pantographs used in metal type making from the 1880s on.

1836. [NT] *Contamin. Rotary-cutter die-engraving pantograph.* {Johnson 2012}: 11 (a ternary source) claims that an 1836 pantograph by "Contamin" was the first die-sinking (coining, at this stage) pantograph to employ a rotary cutter. Johnson also says that Contamin's work was an adaptation of the circa 1788 engraving pantograph of Jean Baptiste Dupeyrat. I have not yet found a primary source to confirm these statements. It is interesting that this at about the same time that Leavenworth (1834) and Allen (1836) apply rotary "routers" to pantographs for the direct cutting of wood type.

At the June 22, 1837 "Monthly Conversation Meeting" of the Franklin Institute in Philadelphia, a "Portrait Lathe, made for the Mint of the United States" by Contamin (Paris). It says nothing about the technical details of this machine. {JFI 1837}: 131.

1836–1903 *Edwin Allen.* A pantograph for wood type developed independently of William Leavenworth's 1834 machine. See {Kelly 1969}.

1839. [NT] *Contamin. Improvements to the Reducing Machine.* [see Bio. Dict. of Medallists: A-D (1904); exhibited Paris 1839, sold to Munich mint.] Not to be conflated with Condamine of the 18th century.

1839–1844. [NT] *Georges-August Leschot*, in Switzerland, applies a four-bar pantograph to the drilling of holes in watch plates. [TO DO: Cite the sources. At least one Leschot pantograph survives, in the museum of the watchmaking firm Vacheron-Constantin.]

1848. [NT] *Roberts. Light industrial use of single-arm pantograph.* Richard Roberts, 1848. An adaptation of a horizontal-format single-arm pantograph reminiscent of medallion lathes (earlier) or the Janvier dies sinking pantographs (later) intended for drilling watch plates. Photograph in {Schaefer 1970}: 32. [TO DO: The photograph in Schaefer has a Science Museum crown copyright; track this machine down.]

6.6• Nineteenth Century, Third Quarter

By 1850. *[Future research; possible red herring]* Vol. 16 ("Stampfwerke, stereotypie und scriftgießerei") of Prechtl's *Technologische Encyklopädie* contains three references to bohrmaschinen (pp. 324, 327, and 331). I'm afraid that I can't read German and my skills at transliterating blackletter aren't very good, so discovering whether this is relevant or not (it might be a different kind of drill, or a milling machine used for something else) is a task for a better scholar.

Circa 1850 to early 20th Century. **[NT]** *Hope (Providence, RI), pantograph engravers for the calico printing industry. Also ruling machines.*

1850. [Red Herring] *Alfred Vincent Newton* is issued GB Patent No. 13,239 of Aug. 29, 1850. This is for a three-dimensional pantograph constructed by using a four-bar pantograph in the horizonal plane and another four-bar pantograph in the vertical plane. Although the patent mentions the cutting of "letters" it is really best adapted to cutting relief images ("tracery and gothic work" in "wood or stone"). Like Leavenworth's wood type pantograph, it cuts a final product, not a punch, patrix, or matrix. {Wilkes 1990}, p. 48, mistakenly cites it as a "matrizenbohrmaschine"; it was not. See: {Abridgments 1859}: 309. {Newton 1851}: 325–328 & Plate XIV.[18]

1851 [NT] *Hill, Wailes. Probably single-arm pantographic reducing machines for coining.*

Cooper dates the introduction of rotating cutters for reducing machines for coining to "by 1850". He mentions a reducing machine exhibited by C. J. Hill at the 1851 Great Exhibition. It was made by George Wailes & Co. Cooper says that Wailes also supplied a machine to the medal engraver John Pinches, but that later they were unable to supply another and Janvier did instead. Cooper does not illustrate these machines. {Cooper 1988}: 167.

Cooper clearly differentiates this earlier machine by Hill from Hill's machine of 1866 (see below). The 1866 machine (illustrated by Cooper) had vertically oriented spindles with a single pantograph arm in a horizontal plane. Presumably the 1851 machine (which I have not yet seen illustrated) was of the more conventional portrait/medallion lathe style with horizontal spindles and a single arm pivoted in a vertical plane.

There is now a Royal Mint Museum; I haven't yet determined whether this machine exists in their collection.

1855. [NT] *Marcus, geared pantograph.* Storchenschnabel by Siegfried Marcus, 1855. No known type application. It's a fine and simple example of a non-lever pantograph, though. Wikimedia Commons:

[18] A. V. Newton is not the same person as W. Newton, editor of {Newton 1851}.

https://commons.wikimedia.org/wiki/File:Pantograph_1855.jpg

1862 [NT] *Kennan & Sons, Dublin. Sculpturing machine.* A single-arm pantograph. [FINISH: See Clark 1862 pp. 227-228]

1862 [NT] *[TO DO: multiple-cutter production pantographs exhibited; see Clark 1862 pp. 228-229]*

1866, later [NT] *Hill. Probably single-arm vertical-spindle pantographic reducing machines for coining.* This is a single-arm pantographic reducing machine using rotary cutters. Unlike earlier and other medallion/portrait "lathes," its spindles are in vertical orientation and its pantograph arm moves in a horizontal plane (vs. horizontal spindles and an arm moving in a vertical plane). Cooper distinguishes Hill's 1866 machine from Hill's earlier machine as exhibited at the 1851 Great Exhibition (see above). He illustrates it with a photograph from the Science Museum. {Cooper 1988}: 169, Fig. 178

The 1920 Catalogue of the Science Museum identifies a "Die-Sinking Machine. Lent by the Deputy Master of the Royal Mint" in 1910. It was "patented by Mr. C. . Hill in 1866." Identified as item "M.3721". {Science Museum 1920}: 49–50. It is not illustrated.

There is now a Royal Mint Museum; I haven't yet determined whether this machine is remains at the Science Museum or is at the Royal Mint Museum.

Circa 1870s. *Hofer. Pantographic matrix milling machine.* H. Hofer, in Berlin, had from at least 1869 (probably earlier) been making pantographs for engraving lettering ("maschinen für schriftarbeit"). Several advertisements in the *Illustrirte Zeitung* from 1869 through 1874 attest this {IZ 1869–1874}. In 1881, Joh. Gabr. Nordin (Sweden) in *Handbok i Boktryckarekonsten* ("Handbook on the Art/Craft of Book-Printing") wrote:[19]

> "H. Hofer lärer hafva uppfunnit en matrisborningsmaskin efter samma princip som pantografen, hvilken skall göra stålstämplarne obehöfliga och hvarmed en matris kan göras på 15 minuter, men vi känna icke huruvida den motsvarat sitt ändamål." ({Nordin 1881}: 57)

This may be translated as:

> "H. Hofer is said to/supposed to have invented a matrix-engraving machine based on the same principle as the pantograph which is going to make steel punches redundant and by means of which a matrix can be produced within 15 minutes, but we don't know whether it actually fulfills its purpose."

[19] My thanks to Victor Thibout for discovering this important but obscure reference and for providing the English translation of it.

So we have firm contemporary evidence of matrix engraving in Berlin by 1881 (and probably therefore a few years earlier), though the level of its success is in question. It is suggestive that (a) Herman Wiebking, the father of the great American matrix engraver Robert Wiebking, experimented (unsuccessfully) with pantographic matrix engraving in Germany in the 1787–1889 timeframe, and (b) that the first pantograph to engrave matrices (or indeed to be used in any way in metal type) in the USA, at the Central Type Foundry in 1882, was made in Germany before 1880.

1875. [NT] *Lotz.* In at least two forms. For line engraving (e.g., in stone lithography).

1878–1880. *Herman Wiebking.* Robert Wiebking's brother, Adolf Wiebking, wrote of the matrix engraving of his father, Herman Wiebking, while in Germany. He said that Herman Wiebking's "engraving machine ... was made by somebody in Berlin, possibly during 1870 or even before." With it, in 1878–1880 Herman Wiebking engraved matrices, but did not manage to cast proper type with them. He ended up soldering them into door signs rather than using them as printing types. {Werner 1932}: 73.

In itself this is of limited importance. Its significance is twofold. First, it is evidence of pantograph construction in Germany in the general 1870s timeframe. Second, Herman Wiebking's son, Robert Wiebking, became one of the most important pantograph makers and matrix engravers of the late 19th and early 20th centuries.

7◆ 1880–1918: The Rise of Pantographic Methods

The first successful commercial use of pantographs in metal type making was the matrix engraving by William Schraubstadter at the Central Type Foundry, in St. Louis, in 1882. The types cut were monoline ornamental gothics. Things developed rapidly after that. Within a few years Linn Boyd Benton was cutting Roman types of considerable technical merit. By the late 1880s and mid 1890s commercial patrix and matrix engraving was a reality. Benton appears to have cut his first matrices in the very late 1890s, but was still cutting patrices as late as 1901. From these beginnings, pantographic methods spread rapidly; there were not one or two, but dozens of different machines and every conceivable combination of methods.

The terminal date of this section is geopolitical, not technical: the First World War.

I will continue include here instances of non-typographical pantographs, just to give a sense of the technological climate of the day. Benton was not a lone inventor. Pantographs were trendy high-tech in the 1880s. They were the 3-D printers of their era: relatively easy to make yet capable of mechanizing previously skilled hand techniques.

1880. The Cincinnati Type Foundry (headed by Henry Barth) *imports a pantograph from Germany* with the intent to use it typographically, but is unable to achieve results with it. This machine was then sold to the Central Type Foundry (St. Louis), where it engraved the first matrices by machine in America.

Here's the unsolved puzzle: Where and when was this machine made, and why? Did Barth of the Cincinnati Type Foundry (who had been born Hans Barth in Liepzig in the Kingdom of Saxony and who was active in the expatriate German community in Cincinnati) simply import an "ordinary" industrial pantograph from Germany in the hope of using it typographically? Or was there some as-yet-undocumented history of typographical pantographs in use in Germany in the 1870s? The fact that Herman Wiebking was involved with one in 1878–1880 (albeit unsuccessfully) and the existence of pantographs for use in the watchmaking industry in nearby Switzerland from the 1830s and 1840s suggests that there may be something here. But nothing is recorded about it in the Anglophone literature.

1880. *Allan E. Francis* patents a pantograph for lettering (not type-making) capable of considerable adjustment. US patent 238,882 issued March 15. 1881. Filed April 12, 1880. This machine was produced commercially (one turned up on Ebay in 2011).

1881. *Stephen D. Engle's single-point cutting tool pantograph.* US patent 246,737, filed April 4, 1881, issued September 6, 1881. This is an unusual machine which was not itself commercially successful. It is significant because it is the first machine in a long line of development which led through later machines by Engle (1883), Engle with Eaton and Glover, the commercially produced "New Century" pantograph, various machines by the Engravers' & Printers' Machinery Company (first in NY City, then in Sag Harbor, NY), and finally various models of the Cronite pantograph. The Cronite company is still in business and still sells these machines. The primary markets for these machines have been the commercial engraving and intaglio-printed engraved stationary industries, but their history is important to type-making because Frederic Goudy employed E&PM Model D rotary spindle pantographs for matrix cutting (and, temporarily and on an emergency basis, cutting working patterns). See {CR Eaton} for details of this history.

Engle's 1881 patent is also important because this was a vertical-format single-arm pantograph intended for use in lettering (if not typography). This is evidence in addition to 18th century sources that Benton did not originate this style of machine.

1882. At the Central Type Foundry in St. Louis, William Schraubstadter (one of the sons of its co-owner) *employs a pantograph in metal type making for the first time in America* by directly engraving matrices.[20] The patterns were made (by unknown methods) by Gustave Schroeder. The three types so made were all monoline ornamental gothics:[21] {Werner 1927}: 765. Geometric, Geometric Italic, and Morning Glory. Interestingly, the first of these faces, Geometric, dates to at least 1880.[22] It is possible that Werner's

[20]This claim that pantographic methods in type-making originated at the Central Type Foundry, rather than with Benton at the Northwestern Type Foundry, contradicts a century of received tradition. It rests entirely on the word of Nicholas Werner, writing some years after the fact. We should ask why we should trust this information, particularly when I suggest that we must discount anything said by Henry Lewis Bullen (the man in large part responsible for Benton's reputation, also writing some years after the events). It comes down to two things.

First, Henry Lewis Bullen consistently said things which were not true. This can be seen most clearly in the present context by looking at his completely fabricated story about Dodge of the Mergenthaler company causing Benton to cut his first steel punch. The damage done by false stories such as these to our understanding of typographical history is beyond calculation. By way of contrast, Werner may slip here and there in a detail, but, like Mark Twain, mainly he told the truth.

Second, Werner was an actual participant in these events. He was active at the Central when Schraubstadter cut these types. He became a partner with Schroeder when they took over this equiment. When Schroeder left for California, he went on to finish cutting DeVinne himself. He knew what he was talking about because he did it with his own hands.

[21]Werner, from whom we get this information, credits Benton with cutting the first *Roman* types. {Werner 1931}: [unnumbered page] 3.

[22]Geometric is attributed by Mullen to Gustav[e] Schroeder and William Jackson ({Mullen 2005}: 135). It was patented by James A. St. John, co-owner of the Central, in US Design Patent 12,123 of January 11, 1881 (filed December 14, 1880). The earliest showing I have found so far is a foreign one, in a journal in England in early 1883: {Hailing's 1883}: 1.

Mullen (p. 136) says that Geometric Italic was "designed and cut" by Gustav[e] Schroeder. US Design patent 14,011 to James St. John on June 23, 1883 (filed March 27, 1883) [but note that the USPTO version of this patent is missing the specimen page].

Mullen (p. 137) says that Morning Glory was "designed and cut" by Gustav[e] Schroeder. Its patent is not yet known. Mullen dates it to 1884, but it is earlier. A note in the *Printers' Circular*, Vol. 18, No. 10 (December 1883): 202 says: "The St. Louis *Printers' Register,* issued by the Central Type Foundry, states that the "Morning Glory" series was named after 'Miss Morning Glory Johnston, daughter of the renowned art printer, Mr. S. Reed recollection in 1927 was in error and that this event dates to 1880. It is also possible that the cutting of this face began using hand methods earlier than 1882.

Werner also notes that William Schraubstadter and Gustave Schroeder of Central cut their Typewriter face on this machine. {Werner 1927}: 765. A 1901 article in *Printers' Ink* dates the first casting of Typewriter to August 3, 1883. {Printers' Ink 1901} Mullen calls it their "all-time best selling advertising type" {Mullen 2005}: 138. Loy, in his biographical sketch of Schroeder, said that he also cut the patterns for Scribner, "of which matrices were cut in brass by machine." {Loy 1898–1900} and {Loy/Saxe 2009}: 73. Mullen dates Scribner to 1883. It is an irregular monoline face. {Mullen 2005}: 138.

The pantograph used was horizontal in format ({Werner 1931}: [unnumbered page] 3) It was made in German and had been imported into the US by the Cincinnati Type Foundry in 1880. They "had no one competent to operate it" and sold it to the Central Type Foundry in 1882. ({Werner 1932}: 72).

1883. *Stephen D Engle.* US patent 275,618 for a vertical-format lettering pantograph improving on his 1881 machine. This machine was produced commercially; it was illustrated in an 1891 *Popular Science* article in use in the glassmaking industry. See {CR Eaton} for further information and reprints of this patent and article. See the 1891 Eaton-Engle engraving machine for the next item in this historical thread.

Attested 1884. *Benton's first vertical-format pantograph.* Patent filed Feb. 29, 1884 (issued 1885). I am presuming his was working on it in 1883; it is unlikely that he was working on it in 1882.[23] In June 1884 he announced as a service the cutting of punches in steel by machine. Much later the ATF matrix engraver William Charles Gregan, recollecting conversations with Morris Fuller Benton, concluded that Linn Boyd Benton began by engraving patrices in soft metal. This makes perfect sense, but we have no direct evidence for it.[24] The patent for Benton's machine claims both cutting punches and matrices, but the 1884 machine seems particularly

Johnston, of Pittsburgh, Pa.' "

[23]Because his patents filed in that year indicate involvements with other matters, such as a mold resembling a sterotype casting box for casting printers' leads, US patent 254,792. By 1883 he was involved in his unit-set (confusingly termed "self-spacing") types (US patent 290,201 of 1883). Despite the wild inaccuracies in Bullen's accounts, it is likely that these provided an impetus toward the development of machine patrix and punch cutting.

[24]The discussion of Benton's pantograph in this period in {Cost 2011} reconstructs *two* successive machines, a first one for cutting patrices and a second one for cutting punches. This is probably not correct. The same machine was perfectly suitable for cutting both patrices and punches. There is no need to posit a second, punchcutting, machine, and no evidence for one. A big part of the confusion here is an attempt to reconcile two accounts. One is the reconstruction William Charles Gregan of Benton's early methods, with the conclusion that he was cutting patrices at first. This reconstruction is undoubtedly sound. The second is the story told in 1922 by Henry Lewis Bullen about a meeting between Philip T. Dodge of the Mergenthaler Linotype Company in which Dodge convinces Benton to try cutting punches on his patrix cutting machine. {Bullen 1922}: 62. Bullen's story is pure fiction. See the item "Did not happen, late 1887," below, for a discussion.

well suited for cutting the former. I am unaware of evidence that he cut matrices before the introduction of his second vertical format pantograph (patent filed Feb. 17, 1899).

Our *primary* and near-primary sources for information on this important machine are disturbingly meager.

The earliest reference we have is Benton's July 1884 trade note in *The Inland Printer* advertising the cutting of punches in steel. Given the importance (and brevity) of this note, it is worth quoting in full here:

> BENTON, WALDO & CO., of Milwaukee, claim to have perfected a machine for cutting punches for original characters for type foundries in steel, — an invention which will much cheapen the ordinary process of cutting by hand. It will cut from the largest to the smallest punch — even to half-diamond;[25] whileas a time-saver, we may state that a pice of work now requiring four hours to prefect by the hand process can, under its operation, be turned out in *half an hour.* [italics original] {Benton 1884}.

We have Benton's US patent, No. 332,955. Filed February 29, 1884 and issued December 22, 1885 to Linn Boyd Benton. Assigned to Benton, Waldo & Co. An equivalent patent was filed in England as No. 11,894 of 1885.[26]

An 1891 brochure advertising "Bentons's Punch Engraving Machine" survives. It is quoted from (and its cover with a photograph of the machine is shown) in {Cost 2011}: 68–19.

Rehak reproduces photographically a single page from the Benton, Waldo & Co. "day book" which identifies the first five machines leased {Rehak 1993}: Fig. 31, p. 109.

We have a line illustration of this machine in {DeVinne 1900}, p. 351[27] and a photograph in {Rehak 1993}: Fig. 36, p. 126.

As a close secondary source we have the reconstructions of Benton's early methods by William Charles Gregan, a master engraver at ATF. Gregan spoke with Morris Fuller Benton in the 1940s. Gregan's reconstructions are reported in {Cost 2011}: 60, 73.

Other material may survive in the archives from the Dale Guild, now in Antwerp, and in other private collections.

All other sources are distant secondary ones.

[25] The "diamond" body size was roughly equivalent to 4 1/2 points. I cannot find "half-diamond" as a standard pre-point-system body size.

[26] This GB patent does not seem to be available via the European Patent Office. I have scanned it from an original lent to me by Mark Knudsen (Elmwood Press). It is online on CircuitousRoot as I write this, but I'll be reorganizing this section and it will move. Contact me if you need it.

[27] DeVinne is an outstandingly accurate source. Still, care must always be taken when interpreting sources. There is no reason to suspect his illustration of Benton's pantograph, but his illustration of the Barth Typecaster has an important component cut out of it.

Circa 1884 – circa 1905 *Benton's pantographs for working patterns.* No primary sources of information survive for Benton's methods and machines for making working patterns in the period from circa 1883 to circa 1905 (when his early method was replaced with a wax-plate method).

One reliable secondary source exists: Theo Rehak's brief account on p. 108 of *Practical Typecasting*, {Rehak 1993}: 108. This account spans two generations of pantograph technology (the patrix/punch machine of 1883/4 and the matrix machine of 1899) and two variations in pattern materials.

Rehak tells us that "The patterns originally used by the Benton engraver for cutting punches or type charaacters on blank type bodies had to be raised (i.e., in relief)." {Rehak 1993}: 108. This fits with the design of Benton's 1884 vertical pantograph used as a patrix and punch cutting machine. He then says that "Later, the raised offset patterns were discarded for right-reading incised ones, first cut by tracing the design on a flat square of lead and firmed up by hand engraving." This fits with the design of Benton's 1899 vertical pantograph used as a direct matrix engraving machine.

He also says that at some point the lead plates were replaced by zinc ones.[28]

However, the details of this process remain unknown. He implies that the lead patterns were single-use, and that "After each use the thickness of the lead plates was reduced by shaving away the old surface, and a new one was prepared. When the plate was too thin to use further, it was discarded." Why this was done is not clear at all to me.[29] Similarly, the details of the process when used with zinc plates are unknown.

These lead and zinc working patterns were prepared pantographically. We know nothing of the pantograph(s) used in at least the first period from circa 1883 to circa 1899.

Rehak says that the "Benton Delineator" was used {Rehak 1993}: 108, that it has a 25:1 reduction ratio, and that no trace of it survives. But this may only be true of the later part of the period of these methods, and it may not completely describe the pantographs involved even then. It seems most likely that the "Benton Delineator" is the 1899 (patent filed; issued 1905) "opto-mechanical" pantograph (q.v.) Benton himself refers to it as a "delineating machine" ({Benton 1906}: 32). This pantograph was used for (a) copying existing types at a high enlargement ratio (1:25 seems possible), (b) enlarging original drawings made at a relatively small scale,[30] and (c)

[28]Not to be confused with the photoetched zinc plates used much later. See {Rehak 1993}: 134-135.

[29]Decades later, Jim Rimmer used typemetal blanks for his working patterns with great success; they appeared to be relatively durable and capable of multiple uses. This shaving of the plates also seems strange to me because casting a new lead plate would be trivial for a typefoundry, while shaving an existing one down requires a machining operation.

[30]In describing the early wax-plate method in 1906, Benton refers to using a "delineating machine" to enlarge the original drawings ("about an inch high") to a large scale. These enlarged drawings were used as input to the working pattern making step.

reducing large-scale original drawings so that they could be examined at type-size.[31] But the problem with envisioning the use of this pantograph for tracing/scratching designs on lead or zinc plates for working patterns is that the machine as shown both in its patent drawings and in Kaup's 1909 article would produce a plate which is too small.

In summary, we know absolutely nothing about the pantographs used by Benton for making working patterns in the period circa 1883 to circa 1899. From 1899 onward the 1899/1905 opto-mechanical "delineating machine" might or might not have been used, and of course earlier machines may have continued in use as well. This period spans two generations of working pattern technology (lead plates, zinc plates) and two generations of punch/patrix and matrix pantograph technology.

By 1887, probably slightly earlier. *Benton cuts Roman types as patrices by pantograph.* Werner notes that while the first use of the pantograph to make metal types was at the Central Type Foundry in 1882, the first *Roman* (vs. monoline gothic) faces were cut by Benton. He does not date this, but it must predate his own cutting of DeVinne (by 1892, patented 1893)[32] In fact Benton must have done this by at least March of 1887, because in that year Carl Schraubstadter, Jr. of the Central Type Foundry noted that "lately Mr. Benton has cut Roman type on metal [meaning soft metal; cutting patrices] with his engraving machine, having such a high finish that it is safe to say the even in this field … the electrotype matix will also drive out its copper rival" {Schraubstadter 1887}.

Did not happen, late 1887. *Dodge/Mergenthaler prompts Benton to cut his first punch in steel.* In his 1922 biographical article on Linn Boyd Benton in *The Inland Printer*, Henry Lewis Bullen tells an exciting story about a meeting between Philip T. Dodge of the Mergenthaler Linotype Company and Linn Boyd Benton in which Dodge convinces a reluctant Benton to try cutting punches for the first time. {Bullen 1922}: 62. This story is still being retold and it informs the discussions of the best modern academic studies of Benton. Sadly, it is not true.

If it had occurred, such a meeting would have had to have happened aroud late 1887 (or perhaps very early in 1888). It could not have occurred in 1886 or earlier, which was the year in which Mergenthaler (both the person and the company) introduced the "Blower" Linotype. This machine first used electroformed matrices and then, when these proved insufficiently durable, punched matrices from hand-cut punches. It is unlikely that contact could have occurred between what was then called the Mergenthaler Printing Company (in New York) and Benton through most of

[31] See {Kaup 1909}: 1043.

[32] DeVine was shown in 6, 12, 18, 24, 36, and 48 point by the Dickinson Type Foundery (then newly a part of ATF) in the April 1892 issue of *The Inland Printer.* It was patented Gustave F. Schroeder in US design patent 22,263 of March 7, 1893. This patent was assigned to V[alentine] J. A. Rey (the Palmer & Rey foundry in San Francisco was a part of the original 1892 ATF amalgamation, and it survived as a distinct branch until at least 1894).

1887. Relations between the NY-based Mergenthaler company and Ottmar Mergenthaler himself, in Baltimore, were strained. But Mergenthaler did not resign until March 15 1888[33] {Mergenthaler 1989}: 36, 39. At this time he had no knowledge of Benton's machine, and writes in his autobiography that he was "already well advanced" on his own "work designing an engraving machine" for punchcutting. {Mergenthaler 1989}: 30. There probably had been some communication between the Mergenthaler Printing Company and Benton, Waldo & Co. in late 1887, although this was not communicated to Ottmar Mergenthaler. We can presume this because very early in 1888, on January 10, Whitelaw Reid of the Mergenthaler Printing Company ordered 100 steel blanks to be sent to Benton, Waldo & Co. for cutting punches (Reid's correspondence is quoted in {Kahan 2000}: 48.) It was not until February 13, 1889 that Benton, Waldo & Co. actually leased a "Punch Engraving Machine," serial no. 3, to the Mergenthaler Printing Company.

But Benton's 1884 *Inland Printer* trade note proves that he was cutting punches in steel, and announcing it as a service, several years before the earliest possible date of Bullen's myth.

1888. *Mergenthaler (Linotype) has Benton, Waldo & Co. cut punches* On January 10, 1888 Whitelaw Reid of the Mergenthaler Printing Company (the name at the time of what became the Mergenthaler Linotype Company) ordered 100 steel blanks to be sent to Benton, Waldo & Co. for cutting punches (Reid's correspondence is quoted in {Kahan 2000}: 48.)

1888. *Schroeder & Werner, matrix engraving as a service.* Gustave Schroeder of the Central Type Foundry was trained as an engraver, and cut the working patterns for William Schraubstadter's matrix engraving at the Central Type Foundry in 1882. Nicholas Werner was trained as a printer and worked at the Central as well. In 1888 (according to {Werner 1927}: 765) or 1889 (according to Loy {Loy 1898–1900} / {Loy/Saxe 2009})[34] they formed a partnership, Schroeder & Werner, to engrave matrices commercially for several type foundries. Loy, in his article on Werner, says that in partnership they cut these faces for the Central Type Foundry:

- The first eight sizes of DeVinne.
- Eight sizes of Victoria Italic.
- Hermes (complete series).
- Jefferson (complete series).
- Novelty Script (complete series).
- Multiform (complete series).
- Johnston Gothic (lower case)

[33] Resignation accepted April 4, 1888

[34] Stephen O. Saxe notes that Werner was the co-editor of the 1889 and 1890 Central Type Foundry specimen books and the 1889 Boston Type Foundry specimen {Loy/Saxe 2009}: 110.

In addition, they cut Façade Condensed (lower case) for the Boston Type Foundry and Era (complete series) for Barnhart Brothers and Spindler.

In 1891, Schroeder moved to California and the partnership was dissolved.

It would be interesting to track down the dates for these several faces, as some of them do not seem to line up with the dates of this partnership (e.g., Novelty Script in 1893).

Circa 1888. *Schroeder-Boyer pantograph.* Built in St. Louis for Gustave Schroeder.[35] It was a one-off machine {Werner 1927}: 765. It is not clear whether this pantograph was used by him for cutting working patterns or cutting matrices. It is not clear if this machine was a copy of the Central Type Foundry pantograph. Nothing is known of its technical details, though it may be safe to presume that it was a horizontal-format machine like the Central T.F. machine.

This machine was made by the J[oseph] Boyer Machine Company in St. Louis. Boyer was also co-developer of the Burroughs adding machine.

1888–1898. *DeLittle, wood type.* One of their pantographs survives at the Type Archive. [TO DO]

1889. **[NT]** *Goodie (Scotland), multispindle pantograph for engraving on glass.* GB Patent 7,157 of 1889. US Patent 460,931 (1891).

1889. *Mergenthaler Printing Co. (Linotype) licenses a Benton pantograph.* The Benton, Waldo & Co. "Day Book," a single page of which is reproduced photographically in {Rehak 1993}: 109, indicates that on February 13, 1889 the Mergenthaler Printing Company (Brooklyn, NY) rented "Benton Punch Engraving Machine" serial no. 3.

1889. *Minneapolis Electro Matrix Co. licenses two Benton pantographs.* The Benton, Waldo & Co. "Day Book," a single page of which is reproduced photographically in {Rehak 1993}: 109, indicates that on May 1 and then June 28, 1889 the Minneapolis Electro Matrix Company rented two "Benton Punch Engraving Machine[s]" serial nos. 4 and 6. Nothing more is known at present about this company. The second of these machines was rented to them but delivered to the Ames Manufacturing Co. (Chicopee, MA).

The term "rental" is used in this entry (vs. "lease"); this difference is probably inconsequential.

1889. *The Linotype Co. Ltd. (UK) licenses two Benton pantographs.* The Benton, Waldo & Co. "Day Book," a single page of which is reproduced photographically in {Rehak 1993}: 109, indicates that on February 15, 1889

[35] Schroeder cut the patterns for the first matrices engraved in the US (by William Schraubstadter in 1882) and later worked with Werner to cut DeVinne.

the English Linotype firm (then called "The Linotype Company Limited") rented two "Benton Punch Engraving Machine[s]" serial nos. 8 and 9.

1890. *The Rogers Typograph Co. licenses two Benton pantographs.* The Benton, Waldo & Co. "Day Book," a single page of which is reproduced photographically in {Rehak 1993}: 109, indicates that on May 19, 1890 the Rogers Typograph Company rented "Benton Punch Engraving Machine" serial no. 10.

1891. *Hollerith, manual card punch* This is a single-arm pantograph used as a manually operated punched-card punching device by Herman Hollerith (developer of the tabulating equiment for the 1890 US census; this work led ultimately to the I.B.M. Corporation). In itself it has nothing to do with type. But it is a particularly clear illustration of the distortion inherent in a single-arm pantograph (it uses a template-plate curved in two dimensions to produce a rectangular punched card). US patent 487,737 filed March 10, 1891 and issued December 13, 1892.

1891. *Schroeder in California* Schroeder & Werner had set up in partnership in 1888/9 and engraved a number of faces by machine. Schroeder moved to California in 1891 and that partnership was dissolved. Schroeder continued cutting cutting types (for at least the Pacific States Type Foundry). It is not clear whether he did this by hand or by machine. He had been involved with pantographic matrix making for a decade, and had commissioned machine (see the Schroeder-Boyer machine, above). But he was also a trained engraver and could have been working by hand. {Loy 1898–1900} / {Loy/Saxe 2009}

1891. *Werner without Schroeder, matrix engraving for several foundries.* After the Schroeder & Werner partnership dissolved in 1891, Werner continued engraving. He must have been doing this by pantograph, because unlike Schroeder he was not trained as an engraver and did not have the skills to cut punches or patrices by hand. Loy says that for the Central he cut:

- DeVinne (the remainder of the series)
- Victoria Italic (the remainder of the series)
- DeVinne Condensed (designed, cut entire series)
- DeVinne Italic (designed, cut entire series)
- Midgothic (designed, cut entire series)
- Antique No. 6 (designed, cut entire series)
- Quentell (cut entire series, after designs by W. P.Quentell)

For Marder, Luse & Co. he cut "the four larger sizes of Caslon Bold."

He traveled to Europe to instruct the Genzsch & Heyse and the Stephenson, Blake foundries in the use of Schokmiller pantographs (q.v.) {Werner 1927}: 765. Presumably while there, for Stephenson Blake he cut Flemish Extended.

He joined the Inland Type Foundry[36] and for them "designed and partly engraved:

- Skinner [Saxe notes that this was renamed Menu Roman by BB&S]
- Extended Woodward
- Condensed Woodward
- Gothic No. 8
- (two unnamed faces nearly to market in 1899)

(For most of the information on faces cut by Werner, see {Loy 1898–1900} / {Loy/Saxe 2009}.)

By 1891 through the 1960s. *Lanston Monotype.* The Lanston Type Machine Company was incorporated in 1886; by 1892 it had reorganized into the Lanston Monotype Machine Company. After much development, the first production machine (the "Limited Font" machine) was introduced in 1897 and the Monotype Composition Caster as we know it followed in 1900. See {Hopkins 2012}: 19, 22, 74. Lanston composition matrices were punched from pantographically cut punches. Lanston display matrices ("flat mats") were introduced between 1903 and 1907. For many decades these were brass matrices electroformed from pantographically cut patrices.[37] At a later point punched aluminum matrices were introduced. After World War II the Lanston company declined in complex ways (see {Hopkins 2012}). In 1970 their matrix business was purchased by American Type Founders. It passed from them to Hartzell Machine Works, then to M&H Type Foundry (San Francisco), then to Gerald Giampa, and final met its end in storage during a flood due to a tidal surge on Prince Edward Island, Canada.

We know from a booklet published by Benton, Waldo & Co. in 1891 (quoted from in {Cost 2011} — I have not seen it) that the Lanston Type Machine Company had by that date leased a Benton punch-cutting pantograph. The little that we know of Lanston Monotype history after that point suggests that both this company and the English Monotype firm continued with vertical-format pantographs until they ceased matrix production.

1892–1902. *A Benton Puzzle.* One of the major historical points usually made about Benton's 1884 pantograph is that it enabled the Mergenthaler Linotype Company to mass-produce matrices successfully. This is undoubtedly true, and indeed the argument can be extended to the Lanston

[36]Which had been formed by Schraubstatdter's sons.

[37]The early history of Lanston display casting is still unclear. This capability seems to have been rushed to market in 1903 in response to the Compositype. See {MacMillan 2018}. The Lanston matrix equipment with which we are familiar dates to the patents of William Elmer Chalfant, filed in 1907. The date of issue of this patent, Nov. 24, 1908, will be familiar to every typecaster who has ever looked at the back of a Lanston flat mat.

Monotype Machine Company, which also leased one or more pantographs from Benton, Waldo & Co.[38]

But there is an unsolved puzzle, present both for the Lanston company and for the American and English Linotype companies. It is reported that part of Linn Boyd Benton's agreement at the amalgamation of American Type Founders in 1892 required him to "recover" the pantographs that he had leased.[39] Benton's 1885 patent would not expire until 1902. The earliest pantographs of which I am presently aware which were developed internally by either Linotype firm were those by Barr in England in 1900 (patented in the US in a filing in 1902, which is the year Benton's 1884 patent expired). The earliest pantographs developed internally by either Monotype firm date to 1906 (Pierpont). What were these companies doing in the period from 1892 to 1902? Is the information that Benton was required to reacquire his machines incorrect? Or was Benton unable to reacquire these machines within this time period? Or were there loopholes in Benton's 1885 patent allowing these companies to develop equivalent machines. We do not yet know the answer.

1894. *Robert Wiebking and H. H. Hardinge.* Robert Wiebking is one of the greatest underappreciated figures in the history of type in America. From the mid 1890s to his death in 1927 he was the premier independent matrix engraver in the country (responsible for, among other things, many of Goudy's early types). With his busines partner Henry H. Hardinge (yes, co-founder of the great Hardinge machine tool company) he developed his own pantographs (and also their own type casting machine). These became the basis of the punch engraving department of the Ludlow Typograph Company and thus were responsible for the making of some of the finest types of the 20th century.[40] Yet Wiebking was a secretive man, and his achievements are largely unknown. (See the CircuitousRoot Notebook "Robert Wiebking" for a collection of as much information as I could find about him {CR Wiebking}. Most of the references for the material in this section can be found there.)

Having trained from 1884 to 1892 as an engraver, Wiebking set up on

---

[38] The technical side of this argument may be articulated in two parts. First, punched matrices have been seen as more durable than electroformed matrices, especially in the heavy service of hot metal composition. We have evidence that this is true. Ottmar Mergenthaler began with electroformed matrices with the 1886 "Blower" Linotype, but several months later switched to punched matrices made using hand-cut punches. Second, the matrices for the Linotype and Monotype hot metal composition machines had to be mass-produced and mats for each sort had to be as nearly identical as possible. Yet punches can break in service. A machine-cut punch can be reproduced nearly exactly. This is not the case with hand-cut punches. So it wasn't just that pantographic punchcutting made the process cheaper and faster, but that it made it more repeatable. Still, though, it should be noted that on every Mergenthaler Linotype matrix there is a code composed of stamped dot, dash, 'x', or other marks. This code indicates the date of matrix production in six-month periods. The Mergenthaler Linotype Company requested that this code be reported when ordering replacement or supplemental matrices so that they could match the matrix production run. Many factors affect matrix accuracy beyond hand vs. machine punchcutting. See {CR Merg Mat}.

[39] Rehak cites this as one of Benton's three conditions to merge his foundry into ATF {Rehak 1993}: 105. See also {Cost 2011}: 81.

[40] And probably most of the headlines and grocery store ads.

his own in 1893. In 1894 he entered into a partnership with Hardinge and, we can reconstruct, built a pantograph and began offering matrix engraving services. We know nothing of the details of this machine; it may or may not have been based on his father (Herman Wiebking's) German machine from the 1870s.

Wiebking cut the matrices for several type foundries (BB&S, Inland, Keystone, Advance, and Western, and the Haddon and Stephenson, Blake foundries in England). He cut mats for some of Goudy's early faces. He cut the first mats for Rogers' Centaur. He designed a number of faces himself, including Artcraft. With Hardinge he, briefly, operated the Advance Type foundry.

While still more or less in startup mode in 1909, the Ludlow Typograph Company moved to Chicago. The first premises they leased were in Wiebking's building, and he began engraving punches for them by 1912. Eventually (probably around 1917), they persuaded him to build machines for their own use.[41]

1894. The optical firm of Taylor, Taylor & Hobson, established in England in 1886, *begins making pantographs under the brand name "Taylor-Hobson."* Their innovation was the separation of the heavy articulated arm supporting the cutting spindle from the lightweight pantographic linkage controlling it. In the United States, Gorton later began their pantograph manufacturing by licensing the Taylor-Hobson design (in 1898). Some Friedrich Deckel pantographs were also very similar. Decades later, Jim Rimmer used a Taylor-Hobson pantograph for making his working patterns.

By 1895. *Ballou.* Chicago. Purchased by Barnhart Brothers & Spindler for matrix engraving.

Between 1895 and 1912. *Inland Type Foundry.*

By 1896 *Beeler / MacKellar, Smiths & Jordan; pantograph for scaling to taste.* Often this history becomes archaeology — piecing together the broken shards to form the most likely whole. We have here two data points.

First, what appears to be a pantograph is shown incidentally in a photograph in the book *One Hundred Years* published under the name of MacKellar, Smiths & Jordan.[42] It is not mentioned in the text and no other information survives which we may be certain refers to it. It is a vertical-format machine, and it is clearly capable of altering proportions. It is also (and as I will argue, significantly) shown on the same bench as a craftsman engraving patrices in soft metal by hand.

[41] Four of these are known to survive.

[42] MSJ was a part of the original 1892 amalgamation of American Type Founders, and it did not in fact exist in 1896. It just thought it did. ATF consolidated rapidly into several manufacturing foundries in various cities. The Philadelphia branch, Foundry C, was for the most part the old MacKellar, Smiths & Jordan foundry. 1896 was the 100th anniversary of their oldest predecessor, Binny & Ronaldson. They published a beautiful folio volume to commemorate this while managing to avoid mentioning ATF almost entirely.

Second, in the 1899 biographical sketch by William Loy of the engraver and designer Charles H. Beeler we learn that Beeler had invented one pantograph by that date and was at work on another.[43] Loy says that Beeler is "the inventor of a simple and accurate form of pantograph, which changes the proportions of the letters according to taste, instead of following the one fixed template from six point to seventy-two point, as is usually done." If taste in type is guided by the eye, then this is perilously close to what would be called "optical scaling" today.

We also learn that Beeler "benefited and profited from the example and suggestions of Mr. [Ewdin C.] Ruthven" and that "they came to use the same methods in their work, and employed the same tools." Now, Ruthven is described in the same paragraph as "unquestionably the father of the art of letter-cutting, as now practiced in all American type foundries." The term "letter-cutting" at this point in history meant patrix cutting in soft metal as opposed to punchcutting in steel. And indeed, turning to the biographical sketch of Ruthven in Loy, we discover that Ruthven was an early practitioner and strong proponent of "cutting type on soft metal" for "electrotyping the matrices."[44] See {Loy 1898–1900} and {Loy/Saxe 2009}.

So it is very likely that the pantograph shown at MSJ in 1896 is a patrix-cutting pantograph by Beeler capable of changing the proportions of patrices depending on their size. But pending further evidence we may only regard this as a very plausible supposition.[45]

Beeler continued with American Type Founders, but there is no information about the fate of this pantograph after the consolidation of ATF into a single Central Plant with matrix engraving under the control of the Bentons. He later became the head of the Special Matrix Department at the Lanston Monotype Machine Company, where he was still employed at his death in 1934. See {Hopkins 2012}: 193.[46]

1896. [NT] *William S. Eaton multiple-spindle pantograph.* US patent 584,335, filed February 14, 1896, issued June 15, 1897. This is for a vertical-format multiple-spindle pantograph for rotary and drag engraving, intended for volume production of ornamental engraving. Although Eaton was an important part of the historical thread that leads from Engle (1881) through Cronite (to the present), this particular pantograph seems to stand apart from his other work. See {CR Eaton}.

1896. [NT] *William S. Eaton and William T. Goodnow.* This is a patent for minor improvements on the earlier (1881 and 1883) machines of Stephen D. Engle. This patent links Eaton to Engle. The machine was produced

[43] For this second machine, see the entry "Circa 1899. Beeler" below.

[44] This was after Ruthven came to America in 1846. Starr's patent for this process dates to 1845. This matter deserves further inquiry.

[45] It is likely that useful information may be found in {Beeler 1935}, but I have not yet had the opportunity to examine it.

[46] Lettepress printing enthusiasts may still be familiar with one of his works: the engraving of the Lord's Prayer on a 12-point body.

commercially as the "Eaton-Engle Engraving Machine." US patent 585,261, filed November 27, 1896, issued June 29, 1897. Assigned to the Eaton-Engle Engraving Machine Company. See {CR Eaton} for more details and for trade references in the 1897–1901 timeframe.

1896/7. *Dedrick.*

1898. *Gorton. Licenses Taylor-Hobson.* The George Gorton Machine Company of Racine, Wisconsin licensed the pantograph patents of Taylor, Taylor and Hobson (UK) on December 27, 1898. Digitizations of the original patent licensing agreement are online; see {Gorton 1898}

Gorton continued throughout the 20th century to manufacture pantographs suitable both for working pattern engraving (e.g., the Model 3-U and its successor, the P1-2) and matrix engraving (including the Models 1-A, 1-G, 3-G and the 3-K Precision Matrix Machine).

Circa 1899. *Beeler, patrix-engraving pantograph capable of cutting back-sloped letters.*

1899. *Janvier die-sinking / coining pantograph.* Dated to 1899 by {Johnson 2012}: 13 First purchase by the US Mint in 1907 {Johnson 2012}: 14. (These from a tertiary source.)

The Janvier machine was a horizontal-format single-arm pantograph widely used in coining/minting.

Cooper illustrates a Janvier reducing machine of about 1900. It shows clearly the double-cone belt drive for constant cutter speed characteristic of Janvier's machines. {Cooper 1988}: 168, Fig. 177.

[TO DO: lots more on Janvier in the minting and medallion engraving literature]

1899/1905. *Benton's "opto-mechanical" pantograph.* This is a complex and fascinating machine. It is the third pantograph design for which we can with certainty attribute the entire design to Linn Boyd Benton.[47] Benton's US patent for this pantograph was filed on July 21, 1899 but it was not issued until May 16, 1905. The patent calls it a "Tracing Apparatus." It may be described in several ways. First, although the patent admits the possibility of a cutting tool, it seems primarily a drawing instrument and its use is only attested in drawing. Second, it is a horizontal-format machine with a very large ratio of enlargement or reduction. It can be used either way, as an enlarger or as a reducer. At the small end of the pantographic lever, does not move a tracer but instead moves the entire pattern around a fixed tracing point. That tracing point is optical: a microscope and crosshair reticle. It is intended to enlarge either from a drawn design or from an

[47] The other two are the 1884 patent vertical patrix/punch machine and the 1899 patent vertical matrix machine. It is very likely that he was responsible for the "wax plate" machine attested by 1905/6. He was responsible in whole or in part for several other machines including the "Ad-Cut" machine; for these see {Rehak 1993}: 107.

example type. (In practice it seems to have been used for reduction only to drawings, though the patent does not require this.) It is capable of expanding/condensing and sloping/back-sloping type designs. Because this expanding and condensing is accomplished by tilting the pattern table, it is equipped with an additional mechanism to raise or lower the microscope to keep it always in focus. It is, in short, one of the most sophisticated pantographs ever made.

In his 1906 book chapter "The Making of Type," Benton describes the steps of his wax-plate method for making working patterns. He begins with original drawings "about an inch high"[48] These are enlarged using a "delineating machine" and made "so large that all errors are easily seen and corrected." This large drawing is then placed in another pantograph and used to mark a wax plate from which a working pattern will be made. {Benton 1906}: 32. Neither machine is illustrated.

In Kaup's 1909 article on "Modern Automatic Type Making Methods" in *American Machinist* this pantograph (the 1899/1905 "opto-mechanical" one) is illustrated. The caption says that it is "delineating the characters." Kaup's article gives it a range from 0 to 96 point. The description of its use corresponds to Benton's in 1906. {Kaup 1909}: 1042.

Kaup's article captions its illustration of the "wax plate" making pantograph: "Delineating on Wax Plate."

This isn't a problem, except that it uses the same word, "delineate," in describing two different pantographs.

Rehak, writing about the procedures used by Benton to make working patterns in the circa 1883 to circa 1905/6 lead/zinc plate era, says that "the Benton Delineator" was used to trace working patterns onto the sheets of lead or zinc. He also says that it operated at a 25:1 ratio. Benton's opto-mechanical pantograph does have a high enlargement / reduction ratio and Benton is clearly referring to it when he writes of a "delineating machine" in 1906. The patent filing date of 1899 does place its origins within the lead/zinc plate era of working pattern making. But the opto-mechanical pantograph does not seem to be suited for making working patterns. If used in reduction mode, the working pattern would be too small. If used in enlargement mode, it would either be too large or, if of a reasonable size, would require actual type-size original drawings.

The patent issue date of 1905 may be significant. Benton didn't trigger the issuing of the patent until the advent of the wax plate method of working patterns. It isn't certain, but it seems not unlikely that this opto-mechanical pantograph was used from 1905 onward in the wax plate pattern era, not earlier in the lead/zinc plate era. But we may never really know.

1899–1902. [NT] *William S. Eaton's ball-bearing pantographs.* In the 1902/1903 period, William S. Eaton filed three patents for vertical-format

[48] This size is relatively small, when compared to the practices of others.

pantographs which employed moving tables supported by either ball bearings or rollers. These do not seem to have been manufactured at the time, but they are interesting becase a similar ball bearing arrangement was used on the later Engravers' & Printers' Machinery Company pantographs (such as the Model D used by Goudy for matrix engraving). US patent 696,950, filed November 23, 1899 (renewed November 1, 1901) and issued April 8, 1902. US patent 696,951, filed November 27, 1899 (renewed November 29, 1901) and issued April 8, 1902. US patent 728,556, filed July 29, 1902 and issued May 19, 1903. See {CR Eaton}.

1900. *Barr (English Linotype), for punchcutting.* This is a curious machine. It was patented by Mark Barr of The Linotype Company Ltd. (he says "The Linotype Works" in his patent).[49] But it does not resemble Barr's vertical-format pantograph of 1902 which Legros & Grant wrote of as the Barr machine used by English Linotype. Instead, it is an arrangement of linkages with both vertical and horizontal components. It most closely resembles the 1895 Ballou machine purchased by Barnhart Brothers & Spindler (Chicago). US patent 655,750, filed January 4, 1900 and issued August 14, 1900.

1900. *Barr (English Linotype), for punchcutting.* By Mark Barr of the Linotype Company Limited (England). This is a vertical-format pantograph which appears to be derived from Benton's work. GB patent No. 22,106 of 1900. US patent 759,957 filed March 3, 2901, issued May 17, 1904. {Legros & Grant 1916} document this as the regular punchcutting machine used by the English Linotye firm.

1900– [at least] 1907. **[NT]** *Eaton & Glover "New Century" Engraving Machine* This was the next step in the historical thread that runs from Engle (1881) to Cronite (present), picking up Goudy along the way. The two patents for this machine are: US 663,563, filed September 17, 1900 and issued to William S. Eaton December 11 1900. US 729,758, filed September 7, 1901 and issued June 2, 1903 to William T. Goodnow and William S. Eaton. Assigned to the Eaton & Glover Company (NY). It is a vertical-format lettering machine which was produced commercially. I know of no evidence to indicate that it was used for type-making. See {CR Eaton} for further information and reprints.

19??. *Barr (English Linotype), for working patterns.*

1901. *Benton still cutting patrices.* We know from a comment in {McGrew 1993} that Benton was still cutting patrices in 1901. McGrew's comment, which comes in the context of his discussion of ATF Wedding Text (p. 333)

[49] This was the English Linotype firm, which was separate from the Mergenthaler Linotype Company. It later became "Linotype and Machinery Ltd."

is interesting because it indicates the completeness with which the knowledge of patrix cutting had disappeared by the late 20th century. McGrew was one of the most informed typographers of his day, and his book remains a daily standard reference, yet he wrote of patrix cutting and matrix electroforming as a "new method":

> "WEDDING TEXT ... designed by Morris F. Benton and cut by ATF in 1901. It is recorded that the 12-point size was cut in type metal in that year, instead of cutting punches or engraving matrices directly. Electrotype matrices were then made from these cuttings. It is uncertain whether this new method of cutting delicate faces resulted in unusual problems and delays, but the face was hailed as 'new' in 1907 and again in 1909."

Benton had, of course, been cutting patrices by machine since 1883/4.

By 1903. *Stephenson, Blake using a Gorton.* At some time after 1898 but before 1903, Stephenson, Blake in England acquired a Gorton No. 1 pantograph. Nothing is known of their use of this machine (we don't know if it was for working patterns or for patric/punch/matrix engraving). see {Gorton 1903}

(Around 1906, Stephenson, Blake acquired a Schokmiller pantograph for matrix engraving; see below).

1903–1906. *Lewis / Keystone Type Foundry.*

1904/5. *Compositype.* At some point around 1904/1905, John E. Hanrahan (late of the Ryan Type Foundry) and the National Compositype Company developed the first technology for volume production of electroformed matrices. We must presume that they were using pantographic methods for producing the patrices, but we have no information about the pantograph(s) they were using. See {MacMillan 2018}.

1905/6 *The Benton Wax Plate Pantograph.* This machine is shown clearly in two illustrations: Kaup's 1909 *American Machinist* article "Modern Automatic Type Making Methods" and the 1912 ATF specimen book. Benton describes its use (without ever giving it a name or illustrating it) in his 1906 chapter "The Making of Type." {Kaup 1909} p. 1042. {ATF 1912}: 4. {Benton 1906}: 33. It was never patented but it is almost certainly of Benton's design. {Rehak 1993}, p. 108, dates the wax plate process in which it was employed to "by 1905."

From the pantograph point of view, it is entirely conventional and not unlike any drawing office pantograph of the era. What distinguishes it is its use: it is designed to take an enlarged drawing produced by the Benton 1899/1905 opto-mechanical pantograph and to inscribe it at reduced scale on a wax plate. The wax plate is held inverted in a rectangular frame; the frame (without any plate in place) is clearly visible in both illustrations of the machine.

This wax plate was then electroformed to produce a working pattern. ATF working patterns made in this way were unusual in that they consisted of a line outlining the character. Tracing the outside of this line

This process was later adopted by the English Monotype firm, with some modifications (they peeled away unwanted portions of the wax after the tracing so as finally to make a relief pattern, not an outline one). It is shown very completely in their 1956 film *Type Faces in the Making*, {Monotype 1956a} (which, frustratingly, is not available and may not be reproduced) and in its companion treatment in *The Monotype Recorder*, {Monotype 1956b}.

1906. *Schokmiller.* Charles H. Schokmiller was a major, but now forgotten, figure in midwestern typefounding. He built typecasting machines and pantographs. He founded the Western Type Foundry and the Laclede Type Foundry. Earlier, he was associated with the Central Type Foundry and also the Burroughs adding machine company in St. Louis (perhaps significantly, this company grew out of the Boyer machine works — builders of the Schroeder-Boyer pantograph around 1888). Schokmiller's pantographs were sold to Genzsch & Heyse (Germany) nad Stephenson, Blake (England); Nicholas Werner traveled to Europe to instruct in their use. See: {Werner 1927}: 765. {CR Schokmiller} {Mullen 2005}

Before 1908. *Legros & Colebrook.* Lucian Alphonse Legros and "Mr. Colebrook." This was a one-off machine improvised out of bicycle tubing. It was associated with work on the high-speed Wicks Rotary Type Caster. There is no information on its intended use. See {Legros 1908}

1911–[probably]1934. *Engravers' & Printers' Machinery Company pantographs.* These were developments of the earlier machines by William S. Eaton (see the 1896 Eaton-Engle pantograph, Eaton's 1899–1902 ball-bearing pantograph patents, and the 1900 Eaton & Glover "New Century" pantograph, above). EP&M machines were produced in various models. Their primary markets were the commercial engraving industry and, especially, the intaglio-printed engraved stationary business. Most of their pantographs were drag-engraving machines (e.g., their Model C, attested from at least 1912). Their Model D, however, was a rotary spindle engraver. Eaton retired in 1920, and at some point, probably 1934, the company was purchased by the long-established Cronite company. Cronite pantographs developed from the E&PM machines remain available today.

The E&PM Model D pantograph is important in the history of type-making because Frederic Goudy used it for his matrix engraving work.[50]

[50]This machine is of course often shown in material on Goudy. It has never been correctly identified in the published print literature; often it is called a "Benton" pantograph. It is not.

(During a short period after his 1939 workshop fire, he also used a Model D for cutting working patterns because for a time he was unable to replace his larger horizontal-format Deckel pantograph in wartime conditions. The E&PM Model D was not well suited for this work. This is worth mentioning because {Boone 1942} reports on Goudy's work and shows this Model D as if it was Goudy's normal machine for making working patterns.

1912–WWII. *Linograph.*

1913–1970s. *Intertype.*

By 1914 – [END DATES?] *Monotype UK* [Maybe move to 1906? Check Slinn.] [Pierpont machine shown in The Engineer, 1914.] [TO DO: Check Slinn et. al. for dates of the English Monotype matrix operations. 1925 film shows both machines very like the 1899 Benton-style machines (but they were cutting punches) and Pierpont machines. It also shows both composition and display matrices being made. The 1956 film shows both more clearly.]

1916 [GET BETTER DATE]. *Grant & Legros.*

Circa 1917. *Ludlow acquires its own Wiebking pantographs.*

The late Paul Hayden Duensing acquired an ex-Ludlow pantograph from R. Hunter Middleton when Middleton was finding sympathetic homes for some of this equipment when Ludlow shut down. Middleton was of course the head of typeface design for the Ludlow Typograph Company. Relaying information from Middleton, Duensing wrote "The pantographs Ludlow used were originally designed by Wiebking. When Ludlow drew the contract with Wiebking, one stipulation was that they be housed in a special, locked room, to which only the head of the punch-cutting department had the key. " Of his own machine, he said "Bob Middleton gave me one with several attachments, one of which was an ancillary stylus head which fitted onto the machine stylus and raised the reduction capacity to 50:1 in stead of only 25:1 with the basic machine, a clever solution." {Duensing 1999a}

Duensing also provided one of the only descriptions of the process used by Ludlow. This is worth quoting in its entirety:

> Perhaps I can help with some hints on how Ludlow mats were made. The beginning of the cycle was Robert Hunter Middleton, Design Director for Ludlow. He met with the Sales Department and noted what they wanted. Then he came back with sketches. When all was approved, the type drawing office produced working drawings about 8" or 10" high. These were followed by a stylus on a pantograph to reduce them to about 4" working patterns as relief letters flopped left to right like type, in a brass

> plate. The final engraving was in a block or tablet of high quality, tempered (softened) steel. After these punches were inspected and approved, the punches were heated and oil quenched. They were then heated again to a lower temperature and allowed to be quenched more slowly. The first heating and quenching was to harden the punch; the second to relieve the internal stresses and reduce brittleness. The scaling was brushed off, and they were placed in a punch press with perhaps 10 or 20 tons of pressure and–viola!–a matrix in brass. The mats then went through various inspections, adding font codes on the back, ...

{Duensing 1999b}

8♦ 1918 to the Late 20th Century: Maturity

This was the great period of the machine production of type commercially, when printing rose to become one of the half-dozen largest industries in the world. Note that several major operations which began earlier continued through this period, including:

- American Type Founders
- The Mergenthaler Linotype Company
- The Lanston Monotype Machine Company
- The Monotype Corporation Ltd. (England)
- Linotype & Machinery Ltd. (the English Linotype company)
- The Intertype Corporation (and its English counterpart)
- The Linograph Company (terminated in WWII)

1903–1990. *Deckel pantographs.* The pantographs by Friedrich Deckel (Munich) are of typographical interest primarily because Goudy used one of them for cutting working patterns. Friedrich Deckel was a major producer of industrial pantographs throughout the 20th century. (Curiously, like Taylor-Hobson in England, they began making these machines as a sideline to a camera-related business; they made the famous "Compur" brand camera shutters. They ended up as a major manufacturer of machine tools.) The firm of Friedrich Deckel merged into MAHO AG and the resulting firm has since disappeared in further mergers. In 1950, a related firm which does still exist was founded, Feinmechanick Michael Deckel GmbH & Co, KG (Weilheim). I am unclear as to the relationship between the two firms. Michael Deckel still manufactures the Deckel cutter grinders, a fact which is of interest to those operating typographical pantographs today. See {CR Deckel Pantographs}.

1918–1919 *Benton's "Ad-Cut" Pantograph.* This pantograph is the representative in this chronology of an unknown number of otherwise unrecorded Benton pantographs.

Rehak says that "Benton also built and enhanced a small number of pantograph engraving machines, fitting them with his quill and cutting tool assemblies, which enabled them to produce engravings with the same precision as other machines."[51] He says that only one of these machines survives, the "Ad-Cut" machine used for producing the largest matrices for the "Hand-and-Steam" department (that is, ATF's pivotal type casting department as opposed to the "Automatic" or Barth type caster department). I do not know the present location of this machine and have not been able to discover a photograph of it or learn anything more about it. {Rehak 1993}: 107–108 and 107n41.

[51] In particular, the quill assemblies used would have permitted the use of Benton's cutter sharpening machine and given near-perfect reproducibility of depth-of-cut.

1920s–1940s. *Goudy's Deckel and E&PM pantographs.* Frederic Goudy was unusual among 20th century designers of types in that he took the trouble actually to learn how to make type. We should have the deepest respect for this achivement. His methods were also relatively well documented (although incompletely so). We must be grateful for this information. However, the methods that Goudy developed were not those used by any type foundry or matrix making company. They were methods well suited to a 20th century artist, at home with drawing instruments and sharp knives.

For his first decades as a type designer, Goudy's matrices were made commercially by independent contractors such as Wiebking (see "1894 Wiebking," above) and larger firms such as American Type Founders and the Lanston Monotype Machine Company. But from the early 1920s, in the studio he named "Deepdene" in Marlboro, NY, he began to make his own types. It appears that his process evolved over time, and we do not have all of the details. However, in its mature form by the early 1930s it involved the use of two different models of pantographs: He used a German-made Deckel pantograph of unknown model for making metal working patterns from cut-paper patterns. He then used a vertical-format pantograph made by the Engravers' and Printers' Machinery Company (of Sag Harbor, NY) to cut matrices. This machine was the E&PM "Model D" pantograph, which was the rotary-spindle version of their drag-engraving pantographs made for the engraved stationary trade.

Sources: His E&PM pantographs are shown indisinctly in the 1933 Kellerman film, {Goudy 1933b}. They are shown more clearly in {Goudy 1934} (*Ars Typographica*), {Boone 1942} (*Popular Science*), His Deckel pantograph for working patterns is shown (again, not well) in the 1933 Kellerman film and in a better view in {Lewis 1941}. The best public domain images of Goudy at work at both machines are in the 1939 article in *Advertising and Selling*, {Goudy 1939}. Goudy's *Typologia* shows his E&PM matrix engraving pantograph clearly and his Deckel working pattern pantograph poorly; it also shows his cutter sharpening equipment {Goudy 1940}. A poor view of the Deckel and a good, but small-scale, view of Goudy's studio showing the pantographs appear in {Lawson 1969}. Perhaps the best illustrations of his Deckel (and good ones of his cutter sharpening equipment) appear in {Bruckner 1990}. Goudy's explanation of his temporary use of an E&PM pantograph for cutting working patterns in the period 1939–1943 appears in his discussion of Scripps College Old Style in {Goudy 1946 v2}.

Circa 1934–Present *Cronite pantographs.* At some time around 1934, the Cronite Company purchased the assets of the Engravers' & Printers' Machinery Company of Sag Harbor, NY. They continued to manufacture pantographs based on the E&PM machines, in several models. They continue in business today, serving the intaglio-printed engraved stationary industry. They are significant in type-making history because they are the end-point of a continuous thread of development which began with the 1881 Engle pantograph and which included the E&PM Model D pantographs used by Goudy for matrix engraving. See {CR Eaton}.

1939–1943. *Goudy's E&PM Pantograph for Working Patterns.* After his catastrophic 1939 workshop fire, Frederic Goudy was able to replace his matrix engraving pantograph, a vertical-format Engraving and Printing Machinery Company (Sag Harbor, NY) Model D, with a machine of the same model which he had previously placed at Syracuse University. However, due to the war he was unable to replace his German Deckel pantograph. (Obtaining a Deckel from Germany clearly would have been impossible in 1939. There were equivalent American machines, such as the Gorton 3-U, but Goudy's account claims that he was unable to acquire a suitable equivalent.) So for a period of time he pressed his E&PM machine into service cutting working patterns. It was not ideal for this purpose. As it happens, one of the best contemporary accounts of Goudy's methods, Boone's 1942 *Popular Mechanics* article, was done during this period and implies, incorrectly, that this was Goudy's standard method for making working patterns. In 1943 Goudy was able to acquire a more suitable industrial pantograph for working patterns (he never says what model and I know of no illustrations of it). See Goudy's discussion of Scripps College Old Style in {Goudy 1946 v2} for an account of this incident See {Boone 1942} for a popular article on Goudy's practices during this period.

1940s. *ATF Gorton 3-B.* In the 1940s, American Type Founders employed a commercial pantograph made by the George Gorton Machine Company for cutting working patterns. The particular model they used was a Gorton 3-B, an industrial three-dimensional pantograph. In ATF's use, it was stripped down for two-dimensional use. {Rehak 1993}: 133 indicates that they began using this machine in 1941. This is the pantograph shown in the 1948 film *Type Speaks* {ATF 1948}. (Note that this machine is reported incorrectly as a Gorton 3-U in {Rehak 1993}: 133.)

[DATES?] *Ludlow Typograph (Chicago), large engraved matrices (Gorton pantograph).* Most matrices made by the Ludlow Typograph Company were punched using punches made by Wiebking pantographs (see above). However, in a 1999 posting to the LETPRESS discussion forum, the late Henry Weiland, a great collector of printing machinery and the person who acquired the Ludlow punches when they closed, wrote "I found the last superintendent of the mat department at Ludlow. This is what I was told. ... The very largest sizes, 120 point and alike where engraved on a Gorton pantagraph." {Weiland 1999}

It should be noted, however, that Ludlow did make 120 point punches. I have in my collection a few of these punches, and aluminum matrices punched with them.[52]

[TO DO: It should be possible to estimate approximate dates for this by identifying the dates at which 120 point sizes of various Ludlow faces were introduced.]

[DATES?] *Pantograph(s) for matrix engraving at Deberny & Peignot, France.* A horizontal-format pantograph which appears to be of a style appropriate for matrix engraving survives in the Musée Renaudot, Loudun, France. According to its placard, it came from the Deberny & Peignot foundry. It bears no indication of its maker.[53]

Post-WWII. *Tsugami (Japan).* [TO DO] A close copy of the Benton 1899 vertical matrix engraving pantograph. [Get information from {Rehak 1993} on the export of Benton pantographs to Japan.

Attested 1948. *Typefoundry Amsterdam, horizontal pantographs.* {Lane & Lommen 1998} reproduce a photograph dated April 1948 showing the engraving room at Typefoundry Amsterdam. It shows two horizontal format pantographs of the pattern conventional in Europe. They say that T.A. installed these "long before this date."[54]

[DATES?] *Service Engraving Co., matrices for several kinds of casting machines.* The late Henry Weiland said that matrices from this firm were engraved. He did not indicate the kind of pantograph used. He might or might not have known this from direct observation. {Weiland 1999}

[DATES?] *Modern Matrix, matrices for several kinds of casting machines.* This was an independent matrix engraving firm.

In a posting to the LETPRESS discussion forum in 2015, John Henry said "Many years ago I purchased a business called Modern Matix, which was located in northern Wisconsin, and moved the machinery to Mason City, Iowa." He indicates that he did not find the production of matrices to be financially feasible and that he later sold the equipment. {Henry 2015}

In a posting to the LETPRESS discussion forum in 1999 Zack Hamric wrote: "I bought the equipment that was originally owned by Modern Matrix. That included the Gorton Pantograph, the tool sharpener, a full set of the Ludlow Deep Engraved Mat Patterns, some punch cutting tools, and hundreds of jigs and setups for producing Linotype, Ludlow, or flat mats." He indicated that he was prepared to cut "[Lanston Monotype compatible"

[52]I acquired these from Paul Aken — thanks, Paul! — who in turn acquired them from Henry Weiland.

[53]My thanks to Patrick Goossens for bringing this machine to my notice.

[54]Interestingly, they also make an error which illustrates the dangers of forgetting technology. The photograph shows two pantographs. But in the foreground it shows seven people engaged in hand engraving. They are at a long bench equipped with lötzwerkzeug, and are clearly cutting patrices by hand. Lane and Lommen, however, say that because the pantographs were installed earlier they are "probably finish[ing] details that were difficult to make with a pantograph." Because patrix cutting was forgotten in the anglophone history of type, they both underestimate the capabilities of pantographic engraving and misidentify the occupations of seven of the nine engravers shown in this photograph.

flat mats, Ludlow, or Linotype [mats]." It is safe to presume that Modern Matrix could do the same. {Hamric 1999}

[DATES?] *Ludlow Typograph, late matrix manufacturing in England.* [TO DO - it's in ATF Newsletter 33]

Unknown – Circa 1995 *Henry Sheer [spelling?], Gorton-engraved mats.* Bill Simon (known to Ludlow operators and enthusiasts as the editor of *The Ludlow Quarterly*) posted a note in 1999 to the LETPRESS discussion forum in which he said: "Henry Sheer (sp) ?? in New York often made engraved mats for Ludlow and Lino to replace missing mats. (at about $10.00 each) (but he folded 4-5 years ago) I believe he used a Gorton engraver. It is a godzilla sized engraver, heavily built and weighs - 2,500 pounds?" This description would match the Gorton 3-K Precision Matrix Machine.

9 ◆ Preservation and Revival

1993– *Ed Rayher, Swamp Press* Ed acquired several 1899-style Benton pantograph matrix engraving machines in the 1993 ATF auction, and operates them to this day.

[DATES?] *The Dale Guild's "Gorton 2G1".* {Rehak 1993}: 135 says that the Dale Guild was using a Deckel model 2G1 for working patterns. I have not been able to discover any such Deckel model. Rehak says that it is the same kind of Deckel as that used by Goudy.

20th century. **[DATES?]** *Kampf.* Maschinenfabrik Michael Kampf. Four-bar linkage pantographs built for making coining dies. Kampf pantographs have been used for matrix engraving and continue today in this use (the Offizin Parnassia Vättis used one for their recutting of Morris' Troy type).

[DATES?] *The Dale Guild, Benton matrix pantographs.*

[TO DO: Micah Currier's article "Disciplines and Protocols" and his short film *Disciplines and Protocols*; photopolymer plate working patterns from digital artwork.]

[DATES?] *The Type Archive.* [TO DO. Acquired The Monotype Corp. composition punchcutting and matrix making equipment. They are still able to create new composition matrices to this day. The display punch and matrix equipment was scrapped.]

By 2001, probably earlier. *Jim Rimmer's Taylor-Hobson pantograph for working patterns.* Rimmer employed a 1915 Taylor-Hobson pantograph ({Rimmer 2008}: 67) for engraving working patterns. [TO DO: Ask Jason Dewinetz which model it is.] [TO DO: Find date of acquisition and first use. Earliest documented use so far: cutting patterns for the attempted patrix cutting of Cartier in 2001 {Rimmer 2003}: 18. A *terminus post quem* is 1984, because at that point he was still cutting by hand.]

The use of this machine is shown in much of the material on Rimmer, including the film *Making Faces* {Kegler 2011}. The Taylor-Hobson is very similar to the model of Deckel used by Goudy and to the more common (in the USA) Gorton 3-U and P1-2 pantographs.

2001 *Jim Rimmer's Wiebking/Ludlow pantograph for patrix cutting.*

At some point before 1999, Paul Hayden Duensing gave to Jim Rimmer the pantograph that had been given to him by R. Hunter Middleton at the demise of the Ludlow firm {Duensing 1999a}. In 2001, Rimmer began using this machine to cut patrices in typemetal for his cutting of Carl Dair's face "Cartier." This was not successful because the machine was too worn.[55]

[55]Personal communication from his friend Alex Widen [GET DATE]. This is also implied in his *DA* article "The Cutting of Cartier in Metal" {Rimmer 2003}: 19.

1999 *Zack Hamric, Two Swallows Press (Tennessee), announces matrix cutting capabilities.* In a posting to the LETPRESS discussion forum in 1999 Zack Hamric wrote: "I bought the equipment that was originally owned by Modern Matrix [q.v.] That included the Gorton Pantograph, the tool sharpener, a full set of the Ludlow Deep Engraved Mat Patterns, some punch cutting tools, and hundreds of jigs and setups for producing Linotype, Ludlow, or flat mats." He indicated that he was prepared to cut "[Lanston Monotype compatible" flat mats, Ludlow, or Linotype [mats]." He used working patterns made photographically from artwork onto photopolymer plates. {Hamric 1999}

[DATES?] *Jim Rimmer's Ogata pantograph for matrix cutting.*

Rimmer employed a 1973 Ogata model RS-260 pantograph for engraving matrices {Rimmer 2008}: 67.

He cut the matrices for his typeface "Quill" with it [DATE? anything earlier?] ({Rimmer 2008}: 67).

Little can be discovered about the Ogata. A 1964 publication[56] which I know only through a Google Books search result mentions "Ogata Seisakusho Ltd., Japan (Engraving Machines)". A 1970 Australian business publication[57], also known to me only through Google Books search results, reports the same company information. Ogata Seisakusho Co. Ltd. still exists (www.ogata-ss.jp), but they say they were founded in March 1970. They now manufacture and assemble electronic devices.

The Ogata Model RS-260 is mentioned in an exhibition catalogue for a 1965 machine tool exhibition in Sydney, Australia. Because information on this machine is so hard to discover, I'll quote it in full here:

> OGATA Bench Engraving Machine, Model RS-260. Surface of pattern table, 13in. x 16in.; surface of working table, 10in x 14in.; longitudinal feed of work table, 10 1/2 in.; cross feed of work table, 7in.; measurement of pantograph, 10 1/2in. x 10 1/2in.; smallest ratio, 1.1; largest ration, 1.20; spindle speeds, 8500–12,000 r.p.m.; max distance between table and spindle, 7 in.; motor 1/4 h.p., 240 volt. [On display by the firm of] Scruttons, Stand 3, Hall 1." ({Sydney 1965}: 18)

2010 *Flynn & McLean, laser-cut working patterns for the Type Archive's Monotype punchcutting pantographs.* Danny A. Flynn (a printer) and Flora McLean (a fashion designer) experimented with uses of laser cutting in letterpress printing. They demonstrated laser-cut wood type, laser-cut acrylic type, and a laser-cut acrylic pattern used as working pattern for an ex-Monotype punchcutting pantograph at The Type Museum (now the

[56] *Dean's Report to the Alumni* (Ann Arbor: University of Michigan School of Library Science, 1964), p. 400.

[57] Mullane, A. and D. G. King. *The Business Who's who of Australia.* ([location unknown, Australia]: R.G. Riddell, 1970, p. 420.

Type Archive). This was done because (the abstract of the article claims) the museum "can no longer undertake " the"copper electro deposition process" (that is the wax plate process for working patterns). {Flynn & McLean 2010}

2017– *Patrick Goossens, Letter-kunde Press, Antwerp.* Patrick preserved the physical assets of The Dale Guild after its tragic collapse. He is now operating both Barth Type Casters and 1899-style Benton pantograph matrix engraving machines in laboratory conditions.

10◆ Other 20th Century Nontypographical Pantographs

These are listed here mostly just to note that they were not used, and may or may not be suitable, for typographical work. Questions about them do come up, especially from people interested in making matrices.[58]

After 1939. *Alexander (UK).* George H. Alexander Machinery Ltd. They were the English agents for Deckel, and began manufacturing pantographs similar to some Deckel machines. I know of no typographical use of Alexander pantographs, but they could easily have been used for cutting working patterns (as Deckel, Taylor-Hobson and similar machines were).

Mid-20th Century – Present. [NT] *New Hermes / Engravograph* There are or were two styles of these machines. In one the cutter depth is regulated by a collar which rubs on the workpiece, and the entire pantograph frame pivots vertically. This style is not suitable for patrix, punch, or matrix engraving. In the other style the pantograph frame is fixed vertically and the cutter depth is better regulated, but in my opinion it would be an uphill struggle to adapt it to typographical work. There are other machines readily available which are better candidates. For their intended purposes (light duty engraving of desk and door signs, bowling trophies, etc.) these are all fine machines. Note however that the Preis, which was intended for the same market as the New Hermes, has been used successfully for type-making.[59]

1954. [NT] *Model Engineer* Duplex [pseud.] "Constructing an Engraving Machine." *Model Engineer.* - Vol 110, Whole Nos. 2758, 2760, 2762, 2764, 2766, 2768. Also followups by others in 2779, 2803, andmaybe 2781. (1854–1955) [This is really just a note to myself because I'd like to find this construction series.]

[58] If you are, then I will be so bold as to offer some advice: while I love my pantographs dearly, the future is CNC.

[59] The late Paul Hayden Duensing used it for matrix engraving. Today Scott Moore uses a Preis for cutting wood type.

11• Unknown Machines

The following companies or individuals employed pantographs for making working patterns. We just don't know what machines they used.

- Adler Traldi (Italy)
- Baltimore Matrix
- Bauer (Germany)
- Paul Hayden Duensing [he may have used optical methods, not pantographs]
- Intertype (US, UK)
- Lanston Monotype
- Linograph
- Ludlow Typograph
- Matrotype
- Mergenthaler Linotype
- Monoline
- Simoncini (Italy)
- Stempel (Germany)
- Stephenson, Blake (England)
- Rogers Typograph (Germany)
- Victorline

The following companies employed pantographs for making punches, patrices, or matrices. We just don't know what machines they used. It is emphatically not right to simplify and say that they used "Benton" pantographs.

- Adler Traldi (Italy)
- Baltimore Matrix
- Bauer (Germany)
- Intertype (US, UK)
- Lanston Monotype (post-Benton)
- Linograph
- Matrotype
- Monoline
- Simoncini (Italy)
- Stempel (Germany)
- Stephenson, Blake (England) (other than Schokmiller's?)
- Rogers Typograph (Germany)
- Victorline

In addition to "unknown machines," it may be relevant to identify cases of "unknown uses" of clearly suitable machines:

In particular, the George Gorton Machine Company of Racine, Wisconsin made several pantograph engraving machines well suited to punch, patrix, and matrix work, including the models 1-A, 1-G, 3-G, and the magnificent 3-K Precision Matrix Machine. {CR Gorton Pantographs}. Outside of example applications in Gorton advertising literature, the use of an unspecified Gorton pantograph to engrave very large Ludlow matrices, and the use of an unspecified Gorton pantograph by Modern Matrix, we do not yet know how or to what extent they were employed in this service.

12◆ Unidentified Machines

Keller-Dorian. The Bibliothèque nationale de France has a photograph of this multispindle machine online: "Atelier des pantographes de A. Keller-Dorian, à Mulhouse" `gallica.bnf.fr/ark:/12148/btv1b10217493h`

Leipzig Druckmuseum. Horizontal four-bar pantograph of substantial, but standard European, construction.

Linotype/Stempel (Gerstenberg) Schriftgießerei Rainer Gerstenberg, successor to, *inter alia,* Stempel, has a horizontal format four-bar pantograph. The placard on the photograph I've seen of it identifies its as a storchschnabel for is in "Linotype Matrizen-Herstellung" (Linotype matrix manufacturing). This would seem to describe the overall process in which it was employed; the pantograph itself is adapted for cutting working patterns, not matrices.

13◆ Nonexistent Machines

A few pantographs have been cited in the literature which have entirely resisted further research. In some cases I'm pretty sure they never existed. In other cases, it may be that I just haven't found them yet.

Dietrich. This is mentioned in {Legros 1908}. It would seem to have been a typo for the 1896/7 "Dedrick."

Little Pioneer. {Rehak 1993} mentions this (p. 100) as a machine employed by Goudy. To the best of my knowledge, Goudy employed no such machine. I have been unable to discover any other reference to a "Little Pioneer" pantograph.

Gem. Switzerland. {Rehak 1993} mentions this (p. 100). I have been unable to discover any other reference to a "Gem" pantograph.

A Note on Sources

In each case I have attempted to rely *only* on primary sources: documents and artifacts contemporary to the events, and the recollections of people who were there. Even these must be treated carefully. Artifacts may mislead because this technology can be difficult to understand. Documents may mislead because the writers were at that time misinformed or in error.

In a few cases I've relied upon, or mentioned, careful secondary research. A good example of this would be Gregan's reconstruction of Benton method of the early 1880s based on his (Gregan's) conversations with Benton's son, Morris Fuller Benton, in the 1940s and upon his own deep knowledge of the technology. I have also relied upon the writings of Theo Rehak, who made it his life's work to understand and preserve the typemaking technology of American Type Founders and who, through his position as the last matrix engraver and typecaster trained at ATF, had unparalleled access to its traditions. It is always important when citing secondary sources to be clear about their sources or the reasons for their beliefs.

In a very few cases, I've used tertiary sources. But I have tried only to do so in areas which are not really important to the present study (for example, German-language Wikipedia articles on European pantographic hand embroidery machines).

One source, which *could* in some cases have been considered primary, and which has shaped most of the secondary literature, is notably absent here: Henry Lewis Bullen. He was there, and both at the time and later he wrote extensively and passionately about the history of type and type technology. But, very regrettably, anything said by him must be discounted unless it is corroborated by independent evidence (which of course makes him completely useless as a source). So many of Bullen's stories are demonstrably false that he cannot be trusted as a source at all. This is a great loss to the history of type.

Other primary sources remain uninvestigated. These include:

- Surviving original matrices, which may be examined for many things, including their method of manufacture (electroformed, punched, engraved).
- Surviving original machines and ancillary items (such as patterns).
- Surviving documents in several private collections and university and public libraries.
- Individual data points hidden in obscure publications.[60] Thanks to bulk digitization by Google and others, it is now possible to search this material.

[60] For example, the location of Wiebking's offices in the 1890s can be traced in factory inspectors' reports from the State of Illinois.

There is a great need for more research.

Acknowledgments

My debts are uncountable. Nearly everyone I know in the typefounding and letterpress printing communities has helped me here, directly or indirectly. I cannot list you all here, but I'll name a few of you. My apologies if I've missed you here; the trouble is that my memory *is* what it used to be: always bad. My thanks to:

Paul Aken, for help with my Cronite pantograph. Luke Charsley, for perceptive questions. Jason Dewinetz, for giving me Jim Rimmer's Monotype keyboard, allowing me to photograph Rimmer's Ogata pantograph, and fine hospitality. Patrick Goossens, fellow Barth type caster custodian, for his continual help and for information on his Benton and Wiebking/Ludlow pantographs. Richard L. Hopkins, for co-founding the American Typecasting Fellowship and an infinite depth of information on matrices, casting, and Monotypes. John Johnson, for help with the Wiebking/Ludlow pantograph. Mark Knudsen (Elmwood Press), for his knowledge of matrix engraving and access to rare documents. The late Carl Schlesinger, for preserving information that would have been lost and for reverse-engineering Mergenthaler's electroformed matrices. Raymond Stanley (Stan) Nelson, who taught me how to cut punches by hand. Sky Shipley (Skyline Type Foundry), who taught me how to cast type by machine. Victor Thibout, who opened my eyes to the extent of type-making in Asia and also spotted the reference to Hofer in Nordin. Gregory Jackson Walters, for the 60 point Barth type caster and continual support. Alex Widen, for his insights into Jim Rimmer. Doug Wilson (PrintingFilms.com), for presenting information that would have been lost. Kylian and Sara Wrzesinski, fellow travelers on the path to the matrix.

Finally, none of this would have been possible without the 40-year tradition and wonderful community of the American Typecasting Fellowship.

Illustration Notes, Sources & Licenses

License Discussion

All of the illustrations used in this document have their own individual copyright status and bear their own individual licensing terms. These are indicated for each.

Public domain items remain in the public domain here regardless of the licensing terms of the rest of this document.

Most illustrations not in the public domain are used under Creative Commons or other free licensing terms which are compatible with the overall license of this document.

However, a few items (such as photographs from the Russian State Herminate Museum and images extracted from texts from the Bibliothéque nationale de France's "Gallica" digital library) are licensed only for noncommercial private study. This is the reason for the "NonCommercial" term in the overall document license. If you were to remove all of these images licensed only for noncommercial use, it would be fine by me if you were to consider the rest of the document as licensed under the Creative Commons Attribution - ShareAlike 4.0 International license.

The Illustrations

Fig. 1. This is a drafting pantograph sold by B. K. Elliott & Co. as their No. 61481. Suspended style with wooden arms. Scanned by the author from {Elliott 1943}: 148. Public domain.

Fig. 2. This is a single-arm pantograph in a horizontal arrangement for use as a medallion reproducing "lathe." Illustrated in the volume of plates to accompany *Manuel du Tourneur* published under the name of L. -E. Bergeron (but written by Louis-Georges-Isaac Salivet). {Bergeron 1816a} Public domain.

Fig. 3. This is a single-arm pantograph in a horizontal arrangement for use as a "sculpturing machine." By Kennan & Sons, Dublin, as exhibited at the 1862 as a "machine for copying scultpures ... in any scale." From the Google Books scan of the Harvard University copy of {Clark 1862}: 228. Public domain.

Fig. 4. A single-arm pantograph style tabulating card punch, as patented by Herman Hollerith in 1892 (filed 1891) and used by the United States Census Bureau. Shown here in use in a photograph from 1940. Public domain. From a US Census Bureau photograph, online at:
`https://www.census.gov/library/photos/card_punching_1940.html`

Fig. 5. This is a Gorton model 3-L 3-dimensional pantograph. From {Gorton 1937} Public domain.

Fig. 6. A geared device functioning as a pantograph. By Siegfried Marcus. Identified by the photographer as being from 1855. From a photograph by Wikimedia Commons user "newfoundlanddog" taken

on July 2006 and entitled "Storchenschnabel nach Siegfried Marcus, 1855."

https://commons.wikimedia.org/wiki/File:Pantograph_1855.jpg

Fig. 7. A railway "pantograph" (so called). Shown here on a Swiss-made locomotive on the Schynige Platte mountain railway. Photograph taken in 2007 by Audrius Meskauska and uploaded to Wikimedia Commons. License: Creative Commons Attribution-ShareAlike 3.0 Unported. Source:

commons.wikimedia.org/wiki/File:Schynige_Platte_diamond_pantograph.jpg

Fig. 8. The first pantograph, by Christoph Scheiner, shown in 1631 on p. 29 of his *Pantographice seu Ars Delineandi Res Quaslibet per Parallelogrammum Lineare seu Cavum, Mechanicum, Mobile.* {Scheiner 1631} The illustration here is from the digitization by the Getty Research Institute of their copy. Public domain.

Fig. 9. This photograph is of a lathe at the State Hermitage Museum, St. Petersburg, Russia. Inventory No. ЭРТх-648. They identify it as a "Turning Machine for Copying" and date it to 1711 (from Florence, Italy). This photograph is Copyright © by The Russian State Hermitage Museum and is licensed by them for noncommercial "personal, educational and information purposes." Please respect the terms of their licensing. The original image is online at:

https://www.hermitagemuseum.org/wps/portal/hermitage/digital-collection/
08.+applied+arts/495389

Fig. 10. This photograph is of a lathe from 1721 by A. K. Nartov at the State Hermitage Museum, St. Petersburg, Russia. Inventory No. ЭРТх-1531. They identify it as a "Copying Lathe for Making Medals and Guilloche Patterns." It is very similar to, and may be, Nartov's "Portrait Cutter Type 2." This photograph is Copyright © by The Russian State Hermitage Museum and is licensed by them for noncommercial "personal, educational and information purposes." Please respect the terms of their licensing. The original image is online at:

www.hermitagemuseum.org/wps/portal/hermitage/digital-collection/
08.+applied+arts/500114

Fig. 11. This image is taken from "Examen de la nature des Courbes qui peuvent se tracer par les mouvements du Tour," which is the second part of the two-part paper "Recherches sur le Tour" by Charles Marie de la Condamine. It appeared originally in *Histoire de l'Académie Royale des Sciences* [for year 1734] (Paris: l'Imprimerie Royale, 1736): 216–258 with accompanying Plates. The digitization from which this image is extracted is from the Gallica digital library of the Bibliothèque Nationale de France. It is licensed by them for noncommercial use only; please respect the terms of their license. The original document is online at:

http://gallica.bnf.fr/ark:/12148/bpt6k3531x/

Bibliography

{ATF 1912} ATF. *American Specimen Book of Type Styles.* Jersey City, NJ: American Type Founders Company, 1912.

The Internet Archive has digitized a University of California copy; it is online at:

archive.org/details/americanspecimen00amerrich/

Brigham Young University has digitized their copy. It is online at The Internet Archive at:

archive.org/details/americanspecimen00amer/

Higher-resolution scans of the images on page 4 of the ATF drawing office and the pantograph in it (which is identical to the Benton "wax plate" pantograph) are online in the section "ATF's Wax-Plate Pantograph" in the CircuitousRoot book *Making Matrices*, at:

CircuitousRoot.com/artifice/letters/press/typemaking/
making-matrices/specific-pantographs/
pantograph-atf-wax-plate/index.html

{ATF 1948} ATF. *Type Speaks!* Elizabeth, NJ: American Type Founders Sales Corp., 1948.

Film, 16mm, sound, color. Narrated by Ben Grauer. A digitization of it is online at:

www.PrintingFilms.com

{Abridgments 1859} *Patents for Inventions: Abridgments of Specifications Relating to Printing.* London: George E. Eyre and William Spottiswoode, 1859.

Google's digitization of the Harvard University copy is at:

books.google.com/books?id=zJAhbHXjyqQC

{Beeler 1935} "Beeler, C. H., Artist & Engraver, examples of work and brief biography." Rare Books and Manuscripts Library, Columbia University, Cabinet J, Shelft 2, No. 43. Now, box 2.

I have not yet had the opportunity to read this. I know of it through the Bibliography in {Clouse 2008}: 83.

{Benton 1884} [Trade note by Benton, Waldo & Co.] *The Inland Printer,* Vol.1, No. 10 (July 1884): 21.

This is quoted in full in {Cost 2011}: 61.

I have had a scan of this from an original online for some time, from the University of Wisconsin original, but I need to review and reorganize those web pages so it will probably move. It is quoted in full in the item above on Benton's 1884 vertical pantograph.

{Benton 1906} Benton, L[inn] Boyd. "The Making of Type." [the fifth chapter, pp. 31–40, in] Hitchcock, Frederick H., ed. Intro. Theodore L. DeVinne. *The Building of a Book.* NY: The Grafton Press, 1906. [No illustrations.]

The Internet Archive has digitized a University of California copy. This is available online at:

`archive.org/details/buildingofbookse00hitc`

The digitization of the Cornell University copy is online at The Internet Archive at:

`archive.org/details/cu31924029482167`

The Google digitization of the Harvard University copy is online at:

`books.google.com/books?id=D3F-7E08cdgC`

The Google digitization of a University of California copy is online at:

`books.google.com/books?id=bddAAAAAIAAJ`

A plaint-text Project Gutenberg digitization is online as their book 23754 at:

`www.gutenberg.org/ebooks/23754`

{Bergeron 1816v2} Bergeron, L.-E. and P. Hamelin-Bergeron. *Manuel du Tourneur.* Tome Second. Paris: J.-M. Eberhart, 1816.

This is the second edition (1816) of the *Manuel du Tourneur* published under the name of L. -E. Bergeron (but written by Louis-Georges-Isaac Salivet).

The Google digitization of the University of Ghent copy is online at:

`books.google.com/books?id=aygPAAAAQAAJ`

The Google digitization of the Lausanne copy is online at:

`books.google.com/books?id=gxA1AAAAQAAJ`

A translation of this volume by many hands, edited by Jeremy Soulsby, was published by the Society of Ornamental Turners in 2010.

{Bergeron 1816a} Bergeron, L.-E. and P. Hamelin-Bergeron. *Atlas ou Manual du Tourneur.* Paris: Hamelin Bergeron, 1816.

This is the volume of plates to accompany the second edition (1816) of the *Manuel du Tourneur* published under the name of L. -E. Bergeron (but written by Louis-Georges-Isaac Salivet).

The Google digitization of the University of Ghent copy is online at:

`books.google.com/books?id=icVZAAAAcAAJ`

A better digitization, with good scans of the plates, is online at the ETH-Bibliothek Zűrich at:

`dx.doi.org/10.3931/e-rara-9982`

For more on Bergeron, see
`www.circuitousroot.com/artifice/machine-shop/ornamental-turning/literature/bergeron/index.html`

A beautiful edition of this Atlas, edited by Jeremy Soulsby, was published by the Society of Ornamental Turners in 2010.

{Boone 1942} Boone, Andrew R. "Type by Goudy." *Popular Science.* Vol. 140, No. 4 (April, 1942): 114-119.

This is available for free viewing (but not downloading) by arrangement with the publisher on Google Books at:
`books.google.com/books?id=CCcDAAAAMBAJ`

{Brookes 1991} Brookes, E. M. "Medallion Turning: Some Notes by E. M. Brookes." *The Bulletin of the Society of Ornamental Turners.* Vol. 17, Whole No. 84 (Spring 1991): 174–178.

The early numbers of the *The Bulletin of the Society of Ornamental Turners* are available in digital form to members of the S.O.T.

{Bruckner 1990} Bruckner, D. J. R. *Frederic Goudy.* NY: Harry N. Abrams, 1990.

{Bullen 1922} Bullen, Henry Lewis. "Linn Boyd Benton — The Man and His Work." *The Inland Printer.* Vol. 70, No. 1 (October 1922): frontis., 60–64.

An extract of this article, taken from the Hathi Trust presentation of the Google digitization of the University of Michigan copy of this volume of *The Inland Printer* is online in the CircuitousRoot Notebook on "Henry Lewis Bullen" at:
`www.circuitousroot.com/artifice/letters/press/typemaking/history/type-scholars/bullen/index.html`

{Clark 1862} Clark, D. K. *The Exhibited Machinery of 1862: A Cyclopædia of the Machinery Represented at the International Exhibition.* London: Day & Son, 1862. The Google digitization of the Harvard University copy is online at:
`books.google.com/books?id=i9EOAAAAYAAJ`

{Clouse 2008} Clouse, Doug. *MacKellar, Smiths & Jordan: Typographical Tastemakers of the Late Nineteenth Century.* New Castle, DE: Oak Knoll Press, 2008.

{de la Condamine 1734} de la Condamine, Charles Marie. "Recherches sur le Tour" in *Histoire de l'Académie Royale des Sciences, Année MDCCXXXIV.* Paris: l'Imprimerie Royale, 1736.

First part: "Description et Usage d'une Machine qui imite les Mouvements du Tour," pp. 216-258 with seven additional plates.

Second part: "Examen de la nature des Courbes qui peuvent se tracer par les mouvements du Tour," pp. 295-340 with six additional plates.

This volume of the proceedings of the French Royal Academy has been digitized in the Bibliothéque nationale de France's "Gallica" digital library at:

gallica.bnf.fr/ark:/12148/bpt6k3531x/

de la Condamine's essays were reprinted in Plumier's *L'art de Tourner* (1749). For a translation into English, see Ferraglio's translation of Plumier, {Plumier 1975}.

{Cooper 1988} Cooper, Denis R. *The Art and Craft of Coinmaking: A History of Minting Technology.* London : Spink & Sons, 1988.

{Cost 2011} Cost, Patricia A. *The Bentons: How an American Father and Son Changed the Printing Industry.* Rochester, NY: RIT Cary Graphic Arts Press, 2011

{CR Deckel Pantographs} "Deckel Pantographs." CircuitousRoot Notebook at:

www.CircuitousRoot.com/artifice/letters/pantocut/deckel/index.html

{CR Eaton} "Eaton and Related Pantographs (Engle, Glover, Cronite)." CircuitousRoot Notebook at:

www.CircuitousRoot.com/artifice/letters/pantocut/eaton/index.html

{CR Gorton Pantographs} "Gorton Pantograph Engraving Machines" CircuitousRoot Notebook at:

www.CircuitousRoot.com/artifice/letters/pantocut/gorton/index.html

{CR Merg Mat} "Mergenthaler Linotype Matrix Identifiation." CircuitousRoot Notebook at:

www.CircuitousRoot.com/artifice/letters/press/compline/typography/matrix/mergenthaler/index.html

{CR Nartov} "Nartov: Ornamental Turning in Early 18th Century Russia." CircuitousRoot Notebook at:

www.CircuitousRoot.com/artifice/machine-shop/ornamental-turning/literature/nartov/index.html

{CR Plumier} "Plumier." CircuitousRoot Notebook at:

www.CircuitousRoot.com/artifice/machine-shop/ornamental-turning/literature/plumier/index.html

{CR Schokmiller} "Mergenthaler Linotype Matrix Identifiation." CircuitousRoot Notebook at:

www.CircuitousRoot.com/artifice/letters/press/typemaking/

history/engineers-and-works-managers/schokmiller/index.html

{CR Wiebking} “Robert Wiebking” CircuitousRoot Notebook at:

www.CircuitousRoot.com/artifice/letters/pantocut/

wiebking/index.html

{Daniels 1975} Daniels, George. *The Art of Breguet.* London: Sotheby Parke Bernet, 1975.

{DeVinne 1900} DeVinne, Theodore Low. *The Practice of Typography.* NY: The Century Company, 1900 [copyright 1899].

The Internet Archive has digitized a University of California copy of the first edition (1900); this is online at:

archive.org/details/practiceoftypogr00devirich

A digitization by the University of Toronto of their copy of the Second Edition (1902) is online at Internet Archive at:

archive.org/details/practiceoftyppla00deviuoft

The Google digitization of the University of Minnesota’s copy of the 1914 Oswald Publishing Company reprint is online at:

books.google.com/books?id=9tsvAQAAMAAJ

{Dickinson 1929} Dickinson, Henry Winram. *The Garret Workshop of James Watt.* London: His Majesty’s Stationery Office, 1929.

{Duensing 1999a} Duensing, Paul Hayden. “Re: Wiebking Pantographs.” [Posting to the LETPRESS discussion forum, June 30, 1999.]

{Duensing 1999b} Duensing, Paul Hayden. “Re: Ludlow Mats.” [Posting to the LETPRESS discussion forum, October 22, 1999.]

{Plumier 1975} Plumier, Charles. Trans. Paul Ferraglio. *L’art de Tourner.* (1749) NY: [By the translator], 1975.

Plumier reprinted the essays of {de la Condamine 1734}, and this translation includes them.

{Elliott 1943} *Catalog and Price List* No. 6. (Pittsburgh, PA: B. K. Elliott & Co., [undated, with 1943 price list in back pocket]).

{Flynn & McLean 2010} Flynn, Danny A. and McLean, Flora. “Laser Cutting for Letterpress Printing: New Uses of Matrices and Techniques.” *The International Journal of Technology, Knowledge and Society.* [it’s either Vol. 6, No. 6 or just annual volume no. 6; I’m not sure] (2010): 103-112.

“Originally presented at the 6th International Conference on Technology and Society, held in the Free University, Berlin on 15th–17th January 2010.”

{Goble 1984} Goble, George Corban. *The Obituary of a Machine: The Rise and Fall of Ottmar Mergenthaler's Linotype at U.S. Newspapers.* Ph.D. Dissertation, Indiana University, 1984.

{Gorton 1898} "Agreement for License. Engraving Machine Patent (American)." [Licensing agreement between Taylor, Taylor and Hobson (England) and the George Gorton Machine Company (US)]

A digitizations of the original document is online at:

`gorton-machine.org/archives/TTH_license_1898/index.html`

{Gorton 1903} George Gorton [II], ed. "They Tell their Own Story." [A scrapbook assembled by George Gorton [II] for his newborn son George Gorton, Jr. [III] of business and technical material illustrating the nature and success of their firm.] October 27, 1903.

The document contained in this scrapbook which identifies Stephenson, Blake as a customer is *The Whereabouts of 230 Engraving Machines* (otherwise undated). A digitization of this composite document is online at:

`gorton-machine.org/corporate/g3birth/index.html`

{Gorton 1925} *Gorton Patent Engraving Machines* [Gorton Machine C. Form 933] Racine, WI: George Gorton Machine Co., 1925.

This 1925 catalog contains information on the Gorton No. 1-A Matrix Engraving Machine, Tool No. 237-1 Matrix Cutter Head, No. 1-G Matrix Engraving Machine, Tool No. 236-1 Matrix Cutter Head, and Gorton Tools Nos. 267-1 and 334-1 for the No. 265-1 Engraving Machine Cutter Grinder (these two attachments hold the No. 1-G [267-1] or 1-A [334-1] "matrix engraving machine **cutter barrel with its spindle complete**, so that the cutters may be accurately ground while in place." [emphasis original]

A digitization is online at:

`gorton-machine.org/forms/form_933/index.html`

{Gorton 1937} George Gorton Machine Co. *New 3-Dimensional Pantographs.* Racine, WI: George Gorton Machine Co., 1937.

A scan of this manual by Joel Havens is online on the VintageMachinery.org site at:

`vintagemachinery.org/pubs/detail.aspx?id=17768`

{Gorton 2015} Gorton, Richard. "The George Gorton Machine Company." 2004–2015.

`gorton-machine.org/corporate/index.html`

{Goudy 1933a} Goudy, Frederic. "On Designing a Type-Face." *The Dolphin.* No. 1 (1933): 3-23.

A scan of *The Dolphin* is online at Carnegie-Mellon University's Posner Library at:

posner.library.cmu.edu/Posner/

{Goudy 1933b} Goudy, Frederic and Maurice Kellerman (director). *Creation of a Printing Type: From the Design to the Print by Frederic W. Goudy* "A Paramount Picture presented by Adolph Zukor." 1933.

A tiny-format version of this film is online at:

http://typeculture.com/academic-resource/videos/the-creation-of-a-printing-type/
which in turn really links now to its presentation on Youtube at:

www.youtube.com/watch?v=gBeFZ4b7hZU

This film formerly was available from the late Carl Schlesinger. His film collection has been donated to The Museum of Printing (in Massachusetts). For those who might still have a copy of Carl's catalog and/or a version distributed by him, note that in this catalog he called this film "Type designer in Action." On the DVD itself, he called it 'Frederick [sic] Goudy "Designing Type"'. It's all the same film.

Finally, this film is also available as one of the "extras" on the DVD of the film *Making Faces*, about the late Jim Rimmer. See {Kegler 2011}.

{Goudy 1934} Goudy, Frederic W. "Type Design: A Homily." In *Ars Typographica.* Vol. 1, No. 4 (Autumn, 1934): 3-27.

This article is in three parts, "I. The Force of Tradition." "II. Type, What It Is." "III. The Technique of Type Engraving." Although this article is similar to Goudy's 1933 piece for *The Dolphin*, and contains some text in commmon with it, it is not the same. Neither does it have the same illustrations.

For a reprint (and a more detailed explanation of the confusing bibliography of *Ars Typographica*, see the "Goudy" section of the CircuitousRoot Notebook of "General Literature On Making Printing Matrices and Types":

CircuitousRoot.com/artifice/letters/press/typemaking/literature/
general/index.html#goudy

{Goudy 1939} "Type: Frederic W. Goudy Here Demonstrates the Design of One of Advertising's Oldest Devices, a Type Face." *Advertising and Selling.* Vol. 32, No. 6 (May, 1939): 38-39.

For a reprint see the "Goudy" section of the CircuitousRoot Notebook of "General Literature On Making Printing Matrices and Types":

CircuitousRoot.com/artifice/letters/press/typemaking/literature/
general/index.html#goudy

{Goudy 1940} Goudy, Frederic. *Typologia: Studies in Type Design and Type Making.* Berkeley, CA: The University of California Press, 1940. Reprinted in paperback by the UC Press in 1977.

This book is available for free viewing (but not downloading) via Google Books at:

books.google.com/books?id=s5Js_NPRflwC

{Goudy 1946 v2} Goudy, Frederic W. *A Half-Century of Type Design and Typography: 1895-1945.* Volume 2. [Typophile Chap Books: XIV.] NY: The Typophiles, 1946.

For a reprint see the "Goudy" section of the CircuitousRoot Notebook of "General Literature On Making Printing Matrices and Types":

CircuitousRoot.com/artifice/letters/press/typemaking/literature/
general/index.html#goudy

{Hailing's 1883} "Another Novelty." [Showing of the Central Type Foudryy typeface "Geometric"] *Hailing's Circular.* Vol. 2, No. 13 (Spring 1883): 1.

The Google digitization of an Oxford University copy is online at:

books.google.com/books?id=C7ZbAAAAQAAJ

{Hailing's 1884} "Another Novelty." [Showing of the Central Type Foudryy typeface "Morning Glory"] *Hailing's Circular.* Vol. 2, No. 16 (Spring 1884): 38.

The Google digitization of an Oxford University copy is online at:

books.google.com/books?id=C7ZbAAAAQAAJ

{Hamrick 1999} Hamric, Zack. "Mat Engraving." [Posting to the LETPRESS discussion forum, March 28, 1999.]

{Henry 2015} Henry, John. "Re: LETPRESS Digest - 19 Jul 2015 to 20 Jul 2015 (#2015-197)". [Posting to the LETPRESS discussion forum, July 21, 2015.]

{Hopkins 2012} Hopkins, Richard L. *Tolbert Lanston and the Monotype.* Tampa, FL: University of Tampa Press, 2012.

{IZ 1869–1874} *Illustrirte Zeitung.* Leipzig, from 1843.

This publication, which begain in Liepzig in 1843, was not the later and now better known *Berliner Illustrirte Zeitung,* which began in 1892. The following volumes (with digitizations by Google from copies in the Bavarian State Library, as indicated) contain advertisements for "maschinen für schriftarbeit" or related work by Hofer:

Vol. 53, Whole No. 1364 (August 21, 1869): 158.

books.google.com/books?id=0K5LAAAAcAAJ

Vol. 58, Whole No. 1488 (January 6, 1872): 20.

books.google.com/books?id=dzBTAAAAcAAJ

Vol. 62, Whole No. 1610 (May 9, 1874): 363.

books.google.com/books?id=MnlfAAAAcAAJ

Vol. 63, Whole No. 1638 (November 21, 1874): 407.

books.google.com/books?id=SHlfAAAAcAAJ

See also:

https://de.wikisource.org/wiki/Illustrirte_Zeitung

{JFI 1837} *Journal of the Franklin Insitute.* Vol. 19, [August number] (1837).

The Google Books digitization of the University of Michigan copy of this volume is online at:

books.google.com/books?id=4elIAAAAMAAJ

{Johnson 2012} Johnson, D. Wayne. "Art Medal Timeline: Notable Medallic Art Developments." *MCA Advisory.* Vol. 16, No. 6 (November–December 2012): 7–17.

The MCA is "Medal Collectors America."

{Kahan 2000} Kahan, Basil. Intro. Carl Schlesinger. *Ottmar Mergenthaler: The Man and His Machine.* New Castle, DE: Oak Knoll Press, 2000.

{Kaup 1909} Kaup, W. J. "Modern Automatic Type Making Methods." *American Machinist.* Vol. 32, (December 16, 1909): 1042–1046.

The Google digitization of the Stanford University copy of this volume of *American Machinist* is online at:

books.google.com/books?id=zr9MAQAAIAAJ

I cannot seem to find Google's digitization of the University of Michigan copy of this half-volume through Google Books. The Hathi Trust presentation of Google's digitization is at:

hdl.handle.net/2027/mdp.39015080284717

Nor can I find Google's digitization of the University of Minnesota copy. The Hathi Trust presentation of this digitization is at:

hdl.handle.net/2027/umn.319510007644626

Nor can I find Google's digitization of the Princeton University copy. The Hathi Trust presentation of this digitization is at:

hdl.handle.net/2027/njp.32101048918864

An extract of Kaup's article, taken from the Hathi presentation of the Princeton copy, is online in the "ATF" section of the CircuitousRoot Notebook of "General Literature On Making Printing Matrices and Types":

CircuitousRoot.com/artifice/letters/press/typemaking/literature/
general/index.html#atf

{Kegler 2011} Kegler, Richard (director). *Making Faces: Metal Type in the 21st Century.* Aurora, NY: P22 Films [P22 Type Foundry], 2011.

This film is available on DVD, with "extras," from the P22 Type Foundry:

p22.com.

It is also available for digital purchase (streaming and download) from P22 via Vimeo. The most interesting link to this is via Richard Kegler's Vimeo user page:

vimeo.com/user4883647

{Kelly 1969} Kelly, Rob Roy. *American Wood Type: 1828–1900.* NY: Van Nostrand Reinhold, 1969.

Reissued in 2010 by Liber Apertus Press, Saratoga, CA.

{Laboulaye 1878} Laboulaye, Charles. *Traité de cinématique théorique et pratique ou théorie des mécnismes.* Paris: Librairie du Dictionnaire des arts et manufactures, 1878.

The Google Books digitization of the University of Michigan copy of this volume is online at:

books.google.com/books?id=jO1IAAAAMAAJ

A better digitization is online in the Bibliothéque nationale de France's "Gallica" digital library at:

gallica.bnf.fr/ark:/12148/bpt6k287127

{Lane & Lommen 1998} Lane, John A. and Matthieu Lommen. *Letterproeven van Nederlandse gieterijen / Dutch Typefounders' Specimens.* [bilingual] Amsterdam: De Buitenkant, 1998.

{Lawson 1969} Lawson, Alexander. *Typographer's Digest.* No. 27 (Spring 1969).

(The entire issue is devoted to Goudy.) For a reprint see the "Goudy" section of the CircuitousRoot Notebook of "General Literature On Making Printing Matrices and Types":

CircuitousRoot.com/artifice/letters/press/typemaking/literature/general/index.html#goudy

{Legros 1908} Legros, Lucien A[lphonse]. "Typecasting and Composing Machinery." *Proceedings* [of the Institution of Mechanical Engineers]. Vol. 75, parts 3 and 4 (1908): 1027–1221& Plates 32–46.

This is a very long paper which was later greatly expanded into {Legros & Grant 1916}. It was printed twice in 1908: as part of the *Proceedings* and standalone as an "Excerpt Minutes of Proceedings of the Meeting."

Google's digitization of the original version from the *Proceedings*, from the University of Michigan copy (with poorly and incompletely scanned plates) is at:

books.google.com/books?id=7kNJAAAAMAAJ

Google's digitization of the standalone excerpted version, from the Harvard University copy (with better scans of the plates), is at:

books.google.com/books?id=GNIoAAAAYAAJ

Both of these digitizations are cached in the "Legros & Grant" section of the CircuitousRoot Notebook of "General Literature On Making Printing Matrices and Types" at:

CircuitousRoot.com/artifice/letters/press/typemaking/literature/general/index.html#legros-grant

(I also have an original printing of the standalone version, should anyone for any reason need a higher-resolution scan from it.)

{Legros & Grant 1916} Legros, Lucien A[lphonse] and John Cameron Grant. *Typographical Printing Surfaces.* London: Longmans, Green, and Co., 1916.

This book is clearly in the public domain in the United States. Google's digitization of the University of Michigan copy is at:

books.google.com/books?id=cmjPAAAAMAAJ

However, this digitization will not display outside the US. This is because there is no record of the exact date of death of the once famous "poet of empire" John Cameron Grant. If he lived to an extraordinary age, it is still remotely possible that this book might be in copyright in England. Google is just playing it safe. So I've put a version of my scan of the University of Minnesota copy online at The Internet Archive, at: archive.org/details/LegrosGrantTypographicalPrintingSurfaces1916

(I now, finally, have my own real copy of this book, should anyone for any reason need a higher-resolution scan from it.)

{Lewis 1941} Lewis, Bernard. *Behind the Type: The Life Story of Frederic W. Goudy.* Pittsburgh, PA: Department of Printing, Carnegie Institute of Technology, 1941.

For a reprint see the "Goudy" section of the CircuitousRoot Notebook of "General Literature On Making Printing Matrices and Types":

CircuitousRoot.com/artifice/letters/press/typemaking/literature/general/index.html#goudy

{Loy 1898–1900} Loy, William E. "Designers and Engravers of Type." *The Inland Printer.* [In 28 installments from 1898 to 1900.]

For reprints of these, see the CircuitousRoot Notebook on Loy's "Designers and Engravers of Type" at:

www.CircuitousRoot.com/artifice/letters/press/typemaking/literature/general/loy/index.html

Really, though, you should acquire a copy of {Loy/Saxe 2009}.

The articles of greatest relevance to this chronology are:

No. 11. Gustav[e] F. Schroeder. Vol. 22, No. 3 (Dec. 1898): 338.
No. 15. Edwin C. Ruthven. Vol. 23, No.1 (Apr. 1899): 64.

No. 19. Nicholas J. Werner. Vol. 23, No.5 (Aug. 1899): 595.
No. 21. John E. Hanrahan. Vol 24, No. 1 (Oct. 1899): 95.

{Loy/Saxe 2009} Loy, William E., ed. Alastair M. Johnston and Stephen O. Saxe. *Nineteenth-Century American Designers and Engravers of Type.* New Castle, DE: Oak Knoll Press, 2009.

This is a reprint of {Loy 1898–1900} with an introduction by Johnston and extensive typographical illustrations and research by Saxe.

{MacMillan 2018} MacMillan, David M. “Compositype: The Success of a Failed Machine.” *American Typecasting Fellowship Newsletter.* No. 42 (January 2018): 29–33.

At some future point this issue will be presented digitally on the CircuitousRoot “ATF Newsletter” Notebook at:

`www.CircuitousRoot.com/artifice/letters/press/typemaking/atf/newsletters/index.html`

{McGrew 1993} McGrew, Mac. *American Metal Typefaces of the Twentieth Century.* Second Edition. New Castle, DE: Oak Knoll Books, 1993.

This “second” edition is the first complete edition. The first edition was circulated privately by McGrew to solicit comments and additional material. This book is still the daily go-to desk reference for real type in America.

{Mergenthaler 1989} Mergenthaler, Ottmar, and Carl Schlesinger, ed. *The Biography of Ottmar Mergenthaler, Inventor of the Linotype.* New Castle, DE: Oak Knoll Books, 1989.

Mergenthaler dictated his autobiography in the third person while convalescing in Deming, New Mexico. It was published anonymously as *Biography of Ottmar Mergenthaler and History of the Linotype, Its Invention and Development.* (Baltimore, MD: 1898). Schlesinger’s edition was the first modern reprint of this now rare book.

{Monotype 1956a} Monotype Corporation Limited. *’Making Sure’ At the Monotype Works: Type Faces In the Making.* Film. Peak Film Productions [from photograph by Dan Rhatigan of an original film canister]. Commentary by Bob Danvers Walker. Directed by R. C. B. Holton. 1956.

{Monotype 1956b} Monotype Corporation Limited. ”’Monotype’ Matrices and Moulds in the Making” [the full issue of] *The Monotype Recorder.* Vol. 40, No. 3 (Autumn 1956).

{Mosco 2004} Mosco, Marilena and Ornella Casazza. *The Museo degli Argenti: Collections and Collectors.* Florence, Italy: Giunti Editore, 2004.

The chapter by Mosco, “Cosimo III and ‘Gran Principe’ Ferdinando: From Sacred to Profane” (pp. 152–167), is the one illustrating the circa 1677 double medallion probably engraved by machine.

{MSJ 1896} MacKellar, Smiths & Jordan. *One Hundred Years.* Philadelphia, PA: MacKellar, Smiths and Jordan [at that time legally the Philadelphia branch of American Type Founders Company], 1896.

For more on this book see the "MacKellar, Smiths & Jordan" section of the CircuitousRoot Notebook of "General Literature On Making Printing Matrices and Types":

`CircuitousRoot.com/artifice/letters/press/typemaking/literature/general/index.html#msj-1896`

{Mullen 2005} Mullen, Robert A. *Recasting a Craft: St. Louis Typefounders Respond to Industrialization.* Carbondale, IL: Southern Illinois University Press, 2005.

{Musson & Robinson 1969} Musson, Albert Edward and Eric Robinson. *Science and Technology in the Industrial Revolution.* Manchester, UK: Manchester University Press, 1969.

{Newton 1851} Newton, W. *The London Journal of Arts, Sciences, and Manufactures and Repertory of Patent Inventions.* Conjoined Series, Vol. 38 (1851)

Google's digitization of the University of Michigan copy (plates digitized incompletely) is at:

`books.google.com/books?id=1jI1AAAAMAAJ`

Google's digitization of the Bodleian Library copy (plates digitized incompletely) is at:

`books.google.com/books?id=8EsEAAAAQAAJ`

{Nordin 1881} Nordin, Joh. Gabr. Nordin. *Handbok i Boktryckarekonsten.* Stockholm: P. A. Norstedt & Söners Förlag, 1881.

A low-resolution digitization by Google of the NY Public Library copy of this volume is at:

`books.google.com/books?id=NshaAAAAcAAJ`

A better, but less convenient, digitization is has been done by Project Runeberg and is online at:

`runeberg.org/download.pl?mode=work&work=njgboktr`

{Prechtl V.16 1850} von Prechtl, Johann Joseph, Ed. *Technologische Encyklopädie.* Vol. 16 ["Stampfwerke, stereotypie und scriftgießerei"]. Stuttgart: Im Verlage der J. G. Cotta'schen Buchhandlung, 1850.

Google's digitization of the Bavarian State Library copy of this volume (no plates) is at:

`books.google.com/books?id=NshaAAAAcAAJ`

{Printers' Ink 1901} "Typewriter Type." *Printers' Ink.* Vol. 34, No. 7 (February 13 1901): 13.

Google's digitization of the Columbia University copy of Vols. 33–34 of *Printers' Ink* is at:

books.google.com/books?id=qhHovx5O964C

Google's digitization of the Pennsylvania State University copy of Vol. 34 of *Printers' Ink* is at:

books.google.com/books?id=P6g9AQAAMAAJ

{Rehak 1993} Rehak, Theo. *Practical Typecasting.* New Castle, DE: Oak Knoll Books, 1993.

{Rimmer 2003} Rimmer, Jim. "The Cutting of Cartier in Metal." *DA: A Journal of the Printing Arts.* No. 52 (Spring/Summer 2003): 15–20.

{Rimmer 2008} Rimmer, Jim. *Pie Tree Press: Memories from the Composing Room Floor, with Illustrations and Type Designs by Jim Rimmer.* Kentville, Nova Scotia, Canada: Gaspereau Press, 2008.

{Rollins 1947} Rollins, Carl Purington. "American Type Designers and their Work." [Material to accompany an exhibition of the same name by R. R. Donnelley & Sons Company in 1947 at The Lakeside Press, Chicago.]

This was reprinted as {Rollins 1948}. Both are online on the CircuitousRoot Notebook "Carl Purington Rollins" at:

www.CircuitousRoot.com/artifice/letters/press/
history-of-printing/heroic-age/rollins/index.html

{Rollins 1948} Rollins, Carl Purington. "American Type Designers and their Work." *Print*, Vol. 5, No. 4 (1948): 1-20.

This was a reprint of {Rollins 1947} Both are online on the CircuitousRoot Notebook "Carl Purington Rollins" at:

www.CircuitousRoot.com/artifice/letters/press/
history-of-printing/heroic-age/rollins/index.html

{Saxe 2016} Saxe, Stephen O. "The Bruce Pivotal Typecaster and its Influence on Nineteenth-Century Typography." *Journal of The Printing Historical Society.* New Series, No. 24 (2016): 37–62.

{Scheiner 1631} *Pantographice seu Ars Delineandi Res Quaslibet per Parallelogrammum Lineare seu Cavum, Mechanicum, Mobile.* Rome: Typographia Ludouici Grignani, 1631.

This book has been digitized many times. Google's digitization of the Bavarian State Library copy is at:

books.google.com/books?id=Bw5BAAAAcAAJ

The much better digitization by the Getty Research Institute from their copy is online at The Internet Archive at:

books.google.com/books?id=Bw5BAAAAcAAJ

{Schraubstadter 1887} Schraubstadter, Jr., Carl. "Electrotype Matrices." *The Inland Printer,* Vol. 4, No. 6 (March, 1887): 382.

This brief article, extracted, is reprinted in the CircuitousRoot Notebook of "Literature on Electroforming Matrices" at:

`CircuitousRoot.com/artifice/letters/press/typemaking/literature/electroforming/index.html`

{Science Museum 1920} *Illustrated Catalogue of the Collections in the Science Museum, South Kensington: [unnumbered volume] Machine Tools.* London: His Majesty's Statinery Office, 1920.

Items 110 through 116 are engraving machines (p. 46–50). Unfortunately, none of them appear in the illustrations (which are not as numerous as the title might suggest).

A digitization of a University of California copy is online in The Internet Archive at:

`archive.org/details/illustratedcatal00scierich`

{Shaefer 1970} Schaefer, Herwin. *Nineteenth Century Modern: The Functional Tradition in Victorian Design.* NY: Praeger Publishers, 1970.

{Simon 1999} Simon, Bill. "Ludlow Mats." [Posting to the LETPRESS discussion forum, October 22, 1999.]

{Steeds 1969} Steeds, W. *A History of Machine Tools: 1700–1910.* Oxford: At the Clarendon Press, 1969.

{Sydney 1965} *Official Catalogue: Third Machine Tool Exhibition.* Sydney, Australia: The Machine Tool Merchants' Division of the Sydney Chamber of Commerce, 1965.

A digitization of this is online at:

`users.beagle.com.au/lathefan/1965 machine tool exhibition.pdf`

{Warde 1935} Warde, Beatrice L. "Cutting Types for the Machines: A Layman's Account." *The Dolphin.* No. 2 (1935): 60-70.

A scan of *The Dolphin* is online at Carnegie-Mellon University's Posner Library at:

`posner.library.cmu.edu/Posner/`

{Weiland 1999} Weiland, Henry. "Ludlow Mats." [Posting to the LETPRESS discussion forum, October 21, 1999.]

{Werner 1927} Werner, Nicholas J. "Saint Louis' Place on the Type-Founders' Map." *The Inland Printer.* Vol. 79, No. 5 (August 1927): 764-766.

This article, extracted, is reprinted in the CircuitousRoot Notebook on "Nicholas J. Werner" at:

CircuitousRoot.com/artifice/letters/press/typemaking/history/
/punch-patrix-matrix-makers/werner/index.html#
inland-printer-vol-079-no-05-1927-08-werner-
st-louis-place-on-the-type-founders-map

{Werner 1931} Werner, N[icholas] J. "An Address by N. J. Werner of St. Louis." St. Louis: [St. Louis Club of Printing House Craftsmen, 1931.

This article, extracted, is reprinted in the CircuitousRoot Notebook on "Nicholas J. Werner" at:

CircuitousRoot.com/artifice/letters/press/typemaking/history/
/punch-patrix-matrix-makers/werner/index.html#
werner-1931-an-address-st-louis

{Werner 1932} Werner, Nicholas J. "Wiebking Created Popular Faces in Chicago, Friend Discloses." *The Inland Printer.* Vol. 90, No. 2 (November 1932): 71-73.

This article, extracted, is reprinted in the CircuitousRoot Notebook on "Robert Wiebking" at:

CircuitousRoot.com/artifice/letters/press/typemaking/history
punch-patrix-matrix-makers/wiebking-robert/
index.html#werner-1932

{Werner 1941} Werner, N[icholas] J. "St. Louis in Type-Founding History." *Share Your Knowledge Review.* Vol. 22, No. 3 (January 1941): 21-26.

This is a reprint of {Werner 1931}. It is in turn reprinted in the CircuitousRoot Notebook on "Nicholas J. Werner" at:

CircuitousRoot.com/artifice/letters/press/typemaking/history/
/punch-patrix-matrix-makers/werner/index.html#
share-your-knowledge-review-v22n03-1941-01-
werner-st-louis-in-type-founding-history

{Wilkes 1990} Wilkes, Walter. *Das Schriftgießen: Von Stempelschnitt, Matrizenfertigung und Letterguss: eine Dokumentation von Walter Wilkes.* Darmstadt, Germany: Technische Hochschule Darmstadt, 1990. Also Stuttgart, Germany: Hauswedell, 1990.

ISBN: 3-7762-0311-0 (same for both Darmstadt and Stuttgart editions). ISBN-13: 978377620311.

{Woodbury 1961} Woodbury, Robert S. *History of the Lathe to 1850: A Study in th Growth of a Technical Element of an Industrial Economy.* Cambridge, MA: The M.I.T. Press, 1961.

Reprinted in Woodbury, Robert S. *Studies in the History of Machine Tools* (Cambridge, MA: The M.I.T. Press, 1972).

{Zagorskii 1982} Zagorskii, F. N., edited by Edwin A. Battison. *An Outline of the History of Metal Cutting Machines to the Middle of the 19th Century.* New Dehli, India: Amerind Publishing Co. Pvt. Ltd., 1982.

This is a translation, with additional material, of Zagorskii's *Ocherki po Istorii Metallorezhushchikh Stankov do Serediny XIX Veka.* (Moscow and Leningrad: Akademiya Nauk SSSR Publishers, 1960.)

To Do

- Cross-check against material in *Making Matrices*
- Pierpont (see also photo in Wilkes)
- A closer look at Lanston patrix engraving machines
- Fill in various placeholders and “TO DO” and “DATES?” items.
- Doublecheck Brocading Engine technology to identify its relationship to pantographs
- Expand medallion lathe overview. Get sources: Nartov? Bergeron.
- Get exact dates for Watt, from pamphlet
- Other nontypographical 19th century pantographs, to illustrate how widespread they were.
- German pantographs; Wernicke 1909; go through Wilkes.
- Intertype and Linotype still and video images
- Beatrice Warde article; other 1920s/30s pop sources?
- Check Rolt’s History of Machine Tools for die sinking / reducing machines.
- Go through the early scientific instrument section of my library to find examples of NT pantographs through the 18th c.
- Above all, go back now and fix errors in existing CircuitousRoot Notebooks.