

The Durability of Fifteenth-century Type

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From a review of references to early typecasting and typesetting practices, the author computes the amount of labor required to handcast 1,000 pieces of type in the fifteenth century, and reaches a figure of fourteen man-hours. As a means of determining the ability of the type to withstand succeeding blows of the platen and the other wear brought about by setting, cleaning, and distributing the type, he applies this labor cost to the publication of a fifteenth-century book, the works of Flavius Josephus printed at Venice in 1486, postulating different sizes of editions. Working on the assumption that excessive labor costs per copy would have made this book and others like it uneconomical to produce, he concludes that incunable type was able to withstand at least 10,000 to 20,000 blows of the platen but suggests that its life expectancy was actually much higher. He supplements his cost analysis by citing other evidence to show that incunable type was fairly durable.

No specimen of type metal, authoritatively identified as having been manufactured during the first few decades following the invention of printing, has yet been discovered. Maurice Audin, it is true, has concluded that certain type characters recovered from the bed of the Saône River at Lyons about 100 years ago are of either late fifteenth-century or early sixteenth-century origin [1, pp. 9–10]. The fact remains, however, that today there is absolutely nothing we can see, touch, or feel with the complete assurance that it is really one of the many millions of pieces of type cast for the 1,700 or more printing plants which flourished at one time or another during the incunable period. And even if we are fortunate enough to unearth a cache of unused fifteenth-century type some day, only a breakdown test of the unique find on a wooden handpress, using paper and ink similar to those of the incunable era, could provide us with a meaningful estimate of the durability of fifteenth-century type—which is to say, the number of impressions incunable type was capable of withstanding before it became too worn to continue producing work of acceptable quality.

The significance of the matter lies in the fact that the number of copies of a book which could be printed depended greatly upon the life expectancy of the type available to the printer. If type was so soft that it would wear out quickly, then a large edition was possible only if the printer could provide an immense quantity of type with which to do the job, or if he could replenish the type as it deteriorated. If, on the other hand, type was fairly durable, a printer who owned only a modest stock of characters could compose enough pages of text to fill a few forms, print those forms, clean the used type, distribute it back into the cases, and then repeat the process as many times as necessary, until he finished printing the edition. The ultimate selling price of a book, it must be stressed, was materially affected by the durability of the type used in its manufacture, for the cost of casting and finishing new type was very high [2, pp. 76–78]. Consequently, the direct and significant relationship between the life expectancy of type and the retail price of early printed books is a matter which merits investigation.

Quite obviously, the fledgling printing industry could not have survived very long as a self-sustaining economic entity unless it could meet and overcome the competition of the scribes, and then reduce the price of books sufficiently to create a broad and receptive market for them. Bühler has suggested that the products of the press may have been as expensive as manuscript work in the very early days of printing [3, p. 150 n]. If this is true, the high cost of type, prorated on a per-copy basis, must surely have played an important role in the establishment of the correspondingly high selling price for the printed book. Similarly, the decrease in the price of printed books in succeeding years should be attributed in great part to improvements in production techniques, including those pertaining to the durability of type.

We are handicapped in the investigation of early type, not only by our inability to study the type itself at first hand, but also by a scarcity of records from the incunable period which might throw light upon the subject. We know that lead, tin, and antimony were commonly employed in the manufacture of the metal,¹ and that other

1. It is not certain that antimony was used in the type alloy mix in the early part of the incunable period.

elements, such as silver and iron, were also used on occasion, although it is possible that the iron (or, at least the iron found in the types examined by Audin) existed only in traces, as an impurity [4, p. 92]. There appears to have been no uniform standard of procedure from plant to plant either in the metallurgical techniques employed or in the determination of the proportions of ingredients making up the type alloy. Accordingly, we cannot expect that all types manufactured in the incunabular era would bear up equally well in pressroom use.

No meaningful attempt can be made to provide a solution to the problem of the durability of early type until certain questions are taken into consideration. How do we define the point at which type becomes sufficiently worn so that we can say that it is no longer capable of yielding impressions of "acceptable" quality? Are we speaking of thin-faced types or bold-faced types, of small sizes or large sizes? Is the platen of the press made of wood alone, or is its underside sheathed in metal? Is the press equipped with some kind of mechanical stop to limit the downward travel of the platen, or will the platen come down crushingly onto the form if the pressman swings the lever somewhat too zealously? Is any packing material (blanketing) interposed between the platen and the paper lying on the type? What kind of paper and ink are being employed? Are the individual press runs so large that the type will undergo only a limited number of "wash-ups," distributions, and resettings, or are the runs so small that the type will be subjected repeatedly to the risk of damage and the increase in wear inherent in these off-press phases of the work? And, of course, how carefully is the type being handled by the workmen from the time it is removed from the cases until the time it is distributed back into the cases?

Even if we were able to provide specific answers to all of these questions, a precise determination of the durability of primitive type would still not be possible. If we were to ask a number of modern pressmen how many impressions may be anticipated from a font of new foundry type being used on a small platen press, the answers would vary widely. I asked several pressmen for such estimates, specifying a 10-point Futura Medium typeface on a small "snapper" press being operated under ordinary shop conditions, and received replies ranging from 25,000 to 100,000 impressions, although it was agreed that much larger runs could be expected if great care was

exercised throughout all phases of the work. Jackson says that type “will print, if not abused, hundreds of thousands of clear impressions before it wears out,” offering this as a rather broad estimate for modern power-driven letterpress work [5, p. 11]. Kubler reprints a document, dated March 11, 1806, entitled *Arbitration between the University of Cambridge and Andrew Wilson*, which states that “it is determined by the experience of the University of Oxford that a work entirely composed with moveable types, and kept standing, will print tolerably fairly 120,000 copies. Had this font of letter been subject to repeated distribution, repeated composition, repeated correction, repeated planing-over, and all the consequent damage that accompanies these destructive operations, it is fair to infer that not more than 100,000 impressions per form would have been obtained from it” [6, p. 39]. A year or two later, however, the printer and author, Thomas Hodgson, projected a much higher figure for type which is kept standing, “I have heard from good authority,” he wrote, “that from forms of a bible, or a testament, the types of which are kept constantly standing, at the University of Cambridge, no fewer than 500,000 copies have been printed” [6, pp. 65–66].

If we cannot arrive at a fairly exact figure concerning the life expectancy of type in our own times, or in comparatively recent times, how can we expect to do so for the type of half a millennium ago? Quite obviously, the best we can hope for is to ascertain whether early type was so soft that it would produce only a few hundred to a few thousand impressions, or whether it was hard enough to make as many as 10,000, 20,000 or 30,000 impressions possible—or even considerably more. It comes as no surprise, therefore, that some confusion exists today concerning the durability of fifteenth-century type.

“The type metal used in the fifteenth century,” reports the British Museum Catalogue, “appears to have been very soft, and the printer who desired to go on using the same fount was obliged to provide for its renewal. This could be effected either by a periodical recasting of the type in bulk, or by frequent additions to the fount supplementing a diminishing stock of any particular sort” [7, pt. I, p. xv].

Febvre and Martin express an opposing view as they open their discussion of type usage, asserting that incunable types (and also those of the next three centuries) were unquestionably durable,

although not, possibly, to the same degree as modern types [2, p. 74]. Yet they immediately follow this statement by informing us that Ambroise Firmin-Didot [8, pp. 99–101] had determined, in a study of the post-incunable Aldine Greek texts, that the type characters used in these edition wore out quickly, so much so that in 1570 Paul Manutius was still having problems with type, and was asking that fresh characters be cast for him every time he put a new book into production. If this were not done, Paul Manutius is reported to have written, the type would be worn out in four months, possibly in the middle of the printing of the book.

The reader is left with the impression that Febvre and Martin do agree basically with the contention made in the British Museum Catalogue that type was soft, in spite of their initial assertion to the contrary, for they reaffirm in the very next paragraph that “types wore out rapidly. The printers, therefore, had to replace them frequently; in this area they were faced with many problems for a long time” [2, p. 76].

In a previous paper dealing with production costs in early printing [9] I examined two copies of the works of Flavius Josephus, printed for Octavianus Scotus at Venice in 1486 by Joannes Rubeus Vercellensis [10, p. 360, item J-486],² and attempted to arrive at the costs (expressed in terms of hours of labor) for the printing of editions of 200, 300, 500, and 1,000 copies of the book. This earlier study did not analyze the cost of manufacturing the type needed by Joannes for the project. The present paper will investigate this aspect of the production of the book by Joannes, again expressed in terms of hours of labor. The purpose will be to establish, in broad terms, how durable early type was, primarily by computing how long-lasting it had to be before it would be financially feasible to print a book with the typographic characteristics of the Josephus volume—or, by extension, any other book.

The Josephus work is in folio. It consists of 274 printed leaves and 4 blank leaves (548 printed pages and 8 blank pages), each leaf measuring in excess of 310 mm × 212 mm. The type is set in one column of 56 lines per page, and the type area on the typical page is

2. One of the copies examined belongs to the Bridwell Library, Southern Methodist University; the other is the property of the author.

about 54 picas high by 34 picas wide. The bound book is made up of three separate works by Josephus: *De Antiquitate Judaica*, *De Bello Judaico*, and *Contra Appionem*. A single style of type, in one size only, designated as Proctor 82 R [7, pt. V, *Venice*, Facsimiles, pl. 36], is used throughout the book. This type corresponds fairly closely in size and weight, although not in appearance, to the 12-point Century type of our times. Each page of the book is estimated to contain, on the average, some 5,250 units of type, counting characters, spaces, and quads.

The bound volume is made up of 35 sections.³ Two of these sections contain 12 pages each, while one contains 20. The remaining 32 sections have 16 pages apiece. In order to simplify our calculations and minimize confusion, it will be assumed henceforth that each of the book's 35 sections contains 16 pages of printed text. The liberties which are being taken will yield results only slightly at variance with those which would be obtained if we adhered rigidly to the conditions actually existing in the book. The minor discrepancies involved will be of no practical importance.

Since each page contains approximately 5,250 characters, a section of 16 pages would require 84,000 pieces of type. The entire book of 35 sections would thus call for 2,940,000 characters.

There is no way of knowing how much type Joannes had available in his shop when he printed the Josephus work, but we can be certain that he did not own enough to be able to compose the entire book in one fell swoop.

Since type was so expensive, it was imperative that the acquisition of new type be limited quite severely. Although printers generally did their own type casting, the high cost factors imposed rigid restrictions upon the quantity of type they could economically manufacture and store in the plants. Febvre and Martin state that when, later on, it became commonplace for printers to buy type, the practice developed of purchasing only minimal quantities, and that a font of type usually included between 60,000 and 100,000 pieces [2, p. 78]. Such a font, Febvre and Martin explain, would generally be adequate for the composition of no more than a few dozen pages at a time.⁴ The printer

3. The collation is as follows: A-L⁸M⁶a¹⁰b-r⁸f⁸s-x⁸y⁶.

4. The typical page in the Joannes-Josephus contains many more characters than

was accordingly obliged to reset and reuse the same characters in the printing of a book, so that the font wore out rapidly. Febyre and Martin refer to a contract written during 1637 in which a typesetter sold a font, *très complète*, of more than 180,000 pieces [2, p. 170]. Even as late as 1637, apparently, a transaction involving so large a font was rather unusual.

Our calculations pertinent to the analysis of the durability of Joannes's type can be simplified considerably by making the following assumptions, unrealistic though they are :

1. Joannes owned about 84,000 characters, just enough to set the type for one section of 16 pages.

2. Each section required exactly the same number of *a*'s, *b*'s, *c*'s, etc. as every other section.

3. Joannes's font of 84,000 characters coincided sort for sort with the type requirements of every one of the 35 sections in the book.

4. The first section of the Josephus edition was composed and printed, the type therein was distributed, the second section was composed and printed, its type was then distributed, and so forth.

5. Not a single piece of type was destroyed or mislaid during the entire operation, there were no mistakes in the presswork, and no overruns or underruns of the press were required.

These assumptions are very far from being realistic. Nevertheless, they can be employed quite logically for our purposes. Joannes obviously must have owned considerably more than 84,000 characters in order to print anything of the magnitude of the Josephus work with any reasonable measure of economy and efficiency; but even if he had used several times 84,000 characters, it still would not have affected the durability of the individual pieces of type. What we are interested in determining, after all, is how many blows of the platen could be withstood by the type. Those pieces of type which were utilized to the extent of, let us say, 60 percent of their life expectancy would still have had 40 percent left for subsequent use by Joannes. The assumptions we are making at this point simply eliminate the need for the repeated application of correction factors to many of the figures which will be encountered as we proceed with our computations.

most incunable pages. A font of as many as 100,000 characters would not have been adequate for more than about one and one-half dozen Josephus pages.

For a 16-page section printed in folio the imposition requirements are that Form No. 1 (pages 1 and 16) back up with Form No. 2 (pages 2 and 15); Form No. 3 (pages 3 and 14) with Form No. 4 (pages 4 and 13); Form No. 5 (pages 5 and 12) with Form No. 6 (pages 6 and 11); and Form No. 7 (pages 7 and 10) with Form No. 8 (pages 8 and 9).

Theoretically, Joannes could have produced a book of 35 sections, each of 16 pages, by composing pages 1 through 9 of each section as its turn came up for processing. He could have locked up pages 8 and 9 as Form No. 8, and printed this form. The type in these two pages could then have been distributed back into the cases. He would now have had enough type on hand to compose pages 10 and 11 for locking up with their conjugates, pages 7 and 6 respectively. The two forms thus created, Form No. 7 and Form No. 6, could then have been printed (on one or two presses) and the type distributed and set again as needed, until the book was finished. Such a procedure could have been carried out economically only in a plant operated at an awesome level of efficiency, and would have reduced the minimum number of characters required from our hypothetical (and unrealistic) figure of 84,000 to a mere 47,250 (an even more unrealistic quantity, representing enough type for nine pages, at 5,250 pieces per page). However, the life expectancy of each piece of type would still have remained the same.⁵

It is regrettable that today we have no fifteenth-century sources to consult for detailed information regarding early printing technology. Although a few scattered remarks on the subject are found in the colophons and within the texts of various incunable works, they are

5. In the earliest part of the incunable period, printing was done one page at a time, so that a printer who operated one press could get along with a very small stock of type characters, enough essentially to compose one page at a time. When the press run for one page was completed, the type could be distributed and then reset for the page immediately following it in the book. We may suppose, however, that a printer would prefer to own enough type to be able to compose at least one page while its predecessor was still on the press, in order to prevent his press from lying idle during the distribution and composition processes. The development of the technique of printing two or more pages on one form for subsequent inclusion in a section of the book created imposition problems which had not previously existed for the printer, and which made it necessary for him to own comparatively large quantities of type.

generally brief, and of limited value from the technical point of view. We do not encounter any mildly serious attempts to describe the mechanics of the craft until well into the sixteenth century, but even these are abbreviated and inadequate. The first edition of Vannoccio Biringuccio's *Pirotechnia*, a treatise dealing with the entire field of metallurgy as then known, appeared in 1540; it allocated only a few sentences to printing and typefounding [11, pp. 374–76]. Although this material was slightly enlarged beginning with the second edition, issued in 1550 [11, p. 374 n], the *Pirotechnia* contains, all told, no more than a few hundred words on the art of printing; and, except for giving us a breakdown of the ingredients of the type alloy mix, yields little of value in the study of the durability of early type. Nor is there much to be learned in this connection from the other sixteenth-century works which deal peripherally, or rather sketchily, with printing, such as Leonardo Fioravanti's *Dello Specchio di Scientia Universale*, published in Venice in 1567, and the *Eygentliche Beschreibung aller Stände*, with text by Hans Sachs and woodcuts by Jost Amman, a curious compendium of contemporary vocations, issued in Frankfurt in 1568. A pamphlet devoted completely to the related subjects of calligraphy and printing, attributed to Christopher Plantin and published by him in 1567, also provides only skimpy details [12]. There are a number of woodcuts, the earliest of which appeared in 1499, depicting print-shop employees at work, but these are of little worth for our purposes in this study, and some are of dubious accuracy. Here and there, from correspondence and contracts, it is possible to glean a few pertinent and enlightening facts. However, we are compelled to depend upon the work of that energetic Londoner, Joseph Moxon, for most of the technical information available concerning early printing methods—although Moxon's book did not appear until 1683–84, two centuries after Joannes had printed the Josephus volume [13]. It is therefore imperative that we proceed gingerly as we examine Moxon's description of printing practices, and try to apply the seventeenth-century techniques he describes to a shop of the period of Joannes.

Actually, there had not been many significant improvements in printing equipment from the incunable decades until Moxon's day. Most of the progress could be classified as belonging in the "tricks of the trade" category. If, by some miracle, Joannes Rubeus Vercellensis could have been transported over the intervening 200 years to

re inquit in montibus abscondas: arbutus fortitudinem te habere: sed si confidas tuæ uirtuti
descende: quatenus per caput nostri milites configant: & fortissimi belli euentus demonstrerit ui-
diorum meis uel tuis. Scito tamē optimos ab unaquaque ciuitate mihi cōmittentes iustosq; sen-
tus tuos proauos euicerunt. Contra nos alias nobis aut in tali terra certandū est: ubi non lapidi-
bus sed armis decet fortissime præliari: ne sit locus tibi quo ualeas deuidus esfigere. His inci-
perat ionathas: decem milia militum eligens: ab hierosolymis egreditur cum fratre symone: per-
uenitque ad ioppem: castra iuxta ciuitatem disposuit. Nam ioppenses portas concluderant: in-
tra habentes custodias ab appollonio constitutas. Cūq; ionathas obsidere parasset eos: timētes
ne suam ciuitatem deualaret portas aperit. Appollonius uero captam audiens ioppem a iona-
tham: tria milia equitum sumens: & octo milia pedum ad azotum peruenit: & exinde tacite pau-
latimq; uiam sibi perfecit. Cum ergo uenisset i ioppem tanquā recedēs: ionatham trahit ad cam-
pum: confidens equitibus & spē in eis habens suæ uictoriæ. Cūq; processisset ionathas: sequen-
tur usq; ad azotum appollonius: qui cum ad campum uidisset hostem uenisse: conuersus pugna-
cum eo cōmisit. Mille itaq; equites appollonius ad insidias in aliquo torrente disposuerat: qui re-
tro inimicis insisterent. Quod sentiens ionathas: non est turbatus: sed ordinans in quadro exer-
citurum: per ambas partes inimicos exciperent: hortatus est: ut fortiter ante uel retro pugnantibus
ubiq; resisteret. Prælio aut usq; ad uesperam procedente: dāns fratri symoni partem exercitus
iussit aduersarioq; eum aciem inuadere: suisq; preceptis: restudine facta sagittas equitū exci-
pere. Qui cum præcepta fecissent nihil letebātur: quāuis hostes super eos frequentia tela libraret:
usque quo suas euacuasent pharetras. Nam sagitte corpora clipeis septa: minime cōtingebant:
cum conspatione restudinis tela uenientia refugarentur. Cum uero a primo mane usq; uespe-
re iaculantes aduersarii descensissent: intelligens symon lassos eos: inuadit aciem: fortiterq; eū suis
militibus dimicans: fugauit inimicos. Vidēs aut equites pedites ad fugā conuersos: & spē corū
decepti sine decore & turpiter abscesserunt: & per oēm campum dispersi fugierunt. Quos secu-
tus ionathas usq; ad azotum multos occidit eorum. Qui de sua salute deperantes: ad templum
dagonis cōfugerunt: qd erat in azoto. Captiens aut incurisione sua ciuitatē ionathas: incēdit eā:
omnes circa eam uicos: neq; peperit templo dagonis: sed etiam flammis consumpsit: & eos q;
sibi confugerant interfici. Multitudo uero quæ in illo concidit prælio una cum illis qui in templo
confugerant: octo milia fugerunt. Vincens ergo tantū ionathas exercitum: ab azoto discessit: &
ad ascalon uenit: & foras ciuitatem castra constituens: terni ascalonite: in occursum ei exierunt
dona portantes. Qui laudans eorum uoluntatem reuersus est ad hierosolymam: multa prædā fe-
rens: qui uidebatur a uictis hostibus abstulisse. Alexander autē deuidus audiens ducem suum
appollonium: simulauit gaudium: q; præter eius sententiā cum ionathā confuisset: qui eius ami-
cus erat: mitititq; testimonium ionathæ: præbēs præmium & honorem: & torquē aureum: sicut
solet affinis regis dari: eiq; commisit accaronis prouinciæ magistratum.

Capitulum VII.

Odem tempore: rex ptolomeus philometor dicitur naualem ducens exercitum & pe-
dites: ad syriam ueniebat: alexandro suo genero solatia præbiturus. Quæ omnis ciui-
tates studiose alexandro præcipiente suscipiebant: & deducebant usq; ad gazorum:
ubi oēs clamabant: acculantes ionathan q; templū incendisset & destruxisset: pun-
ciamq; uastasset: multosq; eorum interemisset. Quæ ptolomeus audiēs tacuit: ionathas aut i iop-
pen occurrit ptolomeo dona clarissima uel honorem ab eo percipiens: & producens eum usq;
ad flauium qui cleutherus appellatur: ad hierosolymam remcauit. Perueniens ergo ptolo-
maidem: præter omnē spem paulominus habuit interfici ptolomeus insidiis alexandri: quas ei
per ammoniū amicum parauerat. Manifestis aut factis insidiis ptolomeus alexandro scribitur: quas ei
nam ammoniū petens: & dicens insidias se ab eo passum: & uindictā sumere iussit esse. Alexandro
uero non concedente ptolomeus intellexit illum causam insidiarū extinxisse. Quapropter ei sa-
ctus est odiosus. Antiochenis autē prius erat odibilis alexander propter ammoniū: multa nūq;
per eum passi fuerat: & poenā quidē ab ammonio pro eius delictis exegerunt: occidentes eū qui
tanquā mulier se pperabat abscondere habitu circumdatus femineo: sicut alibi dictū est. Ptho-
lomeus itaq; acculans eum ut patrem nuptiæ filiz suæ: transgressorēq; auxilii quod ei con-
tra demetrium deduxisset: soluit affinitatē. Nam & auferens suam filiam: ad demetrium legatio-
nem direxit: amicum cum eo cōponens: sicutq; daret se illi uxorem: & restituere paterno cum
principatu cōpromittens. Demetrius uero gaudēs: suscepit legationem & nuptias. Tum nimis
iām ptolomeo labor restabat: flelere antiochenos: ut demetriū susciperent: nam inimici eius
fugerunt: eo q; a parte eius demetrio multa pessima passi fuissent: & alexandro tamen antiocheni

propter ammoniū irascebatur: ut prædiximus. Qui pulsus ab antiochia: in ciliciam usq; puenit. Ptolomeus ergo ad atiochenos ueniens: rex ab illis & militibus ordinatur: coactusq; duo sibi diademata superposuit: unū asyæ: alterum egypti. Benignus autē & iustus existens: nec concupiscens aliena: sed & futura prouidens: regulare regnū decreuit: ne romanos offenderet: ideoq; antiochenos in contōne congregans: flecit eos ut demetriū susciperent: dicens eum nequū pro patre dolorem seruaturū: si bene mereretur ab eis: doctore autē i bonis & ducē se illi esse: nec se fallacibus negociis immiscere: sibi autē dicebat egypti regnū sufficere. Quæ differens flecit antiochenos: terramq; atiochenosq; pdāte ptolemeus cū genero cōtra eū duxit exercitum. nā iam filiā suā matrimoniali iure demetrio contradiderat: & uincens alexandriā: ad arabia fugauit eū. Cōgrit autem in phouat equus ptolemei uocē elephātis audiens: ptolemeū iactaret. Quod eū uidit illi hostes: impetum sup eū fecerūt: multisq; uulneribus caput eius pforātes: ad piculū mortis eum adduxerunt. Sed custodes corporis eius rapientes eū liberauerunt: & ita p quatuor dies defechus iacuit: ut nec loqui nec intelligere potuisset. Alexandri uero caput arabū potentissimus zabilus abicidens ptolemeo transmisit. Qui die quinto releuatus: a uulnere dolore: suauē sibi rem summuq; spectacula alexandri morte simul & capite uidit: qui tamen paulopost uitā finiuit: pro alexandri morte gaudio summo cōpletus. Regnauit ergo asyæ alexander qui dictus est balans: annis quinq;: sicut i aliis demōstratū est. Suscipiens uero picipatū demetrius qui nicanor appellabatur: fraudibus corrupē cepit ptolemei militiā oblitus: & q; focer eius & auxiliator fuisset: & affinis per connubiū cleopatæ. Quapropter milites ptolemei ad alexandriā cōfugerunt: elephātes autē demetrius comprehendit. Ionatas interea princeps sacerdotū ex omni iudea sibi milites cōgregās: arcem hierosolymog; obfidebat: ubi custodia macedonū: & transgressoz; multitudo locata uidebatur. Et hi quidē contēbant ionathan facientē machinamenta: confidentes loci munitionibus. Noctū uero quidē multiuoli iudei exeuntes: uenerunt ad demetriū: arcis obfidiōē nūciantes. Qui nūcio incitatus: exercitū contra ionathan ab antiochia eduxit. Cūq; ad ptolemaidem peruenisset: scripsit ionathæ: picipiens ad ptolemaidē eū citius occurrere. Ionathas autē obfidiōē quidem minime soluere decreuit: seniores uero populi & sacerdotes congregans: & aux; & argētū & uesticū multitudine donoz; deportans: ad demetriū usq; puenit. Quæ cū obtulisset: irā eius moluit: & honoratus firmū ab eo principatū sacerdotū suscepit: quē a regibus ante ipsum donatum possidebat: accusantibusq; eū transfugas: demetrius eis non credidit: sed & petriū quatenus pro omni iudea: uel tribus prouinciis: samaria: uel ioppe: uel galilea: trecenta tantum daret talenta: fratris gentiq; iudeoz; salutē. Exemplum epistolæ quā lasteni cognato nostro scripsimus: transfugissimus uobis: ut eam noueritis. Rex demetrius lasteni patri salutē. Iudeoz; genti uobis nostraq; iustis seruanti: pro fide decreui dona pberē: & tres possessiones afferem: bescleda: uel ramathe: quæ additæ sunt iudeis de samaria: & his arrentia: & quantacūq; ab immobilibus hierosolymog; reges accipiebāt ante me: uel quæcūq; de fructu terræ: uel patatis: & omiaq; alia quæ nostro competunt iuri: uel paludes salis: uel pro coronis quæ nobis offerebantur eis cōcedo: & nihil extorqueatur ab his ammōdo & ipostez;. Cura igitur ut huius epistolæ fiat exēplar: & detur ionathæ: quatenus in nobili loco tēpli reponatur. Hæc scripta fuerant. Videns ergo demetrius pacē nullūq; supesse periculū: nec belli timorē: soluit exercitū stipendiisq; eoz; iminuit: & solis illis sumptus pbebat: qui cū eo a creta uel aliis insulis uenerāt. Vnde odiū uel inimicitia militum cōtra eū cōhatæ sunt: quibus ipse quidē nihil pbebat: reges uero ante ipsum eis ānonas etiā in pace submittrabant: ut eos in certaminibus si oporteret pro se fideles & pronos hēnt: atq; paratissimos in re bellica & pacis cū omni haberent confidentia expetere.

Capitulum. VIII.

Nrelligēs itaq; odiū militū circa demetriū alexandri qdā dux apamēnus genere: diodotus nomine: qui & trison dicebatur: uenit ad malchū arabū: qui filiū alexandri antiochū nūtrierat: manifestansq; ei inimicitias exercitus quas contra demetriū habebāt dari sibi petebat antiochū: nā regē eū facere: uel paternū principatū ei se restituere dicebat. Qui primū resistebat: minie credens: post uero multo tpe trifone petere: uincit malchus: flexusq; uolūtate sua est ad ea q; trison petebat. Princeps autē sacerdotū ionathas capere uolens arcē hierosolymog;: & iudeos transfugas: uel ipsos oēs; qui p totā puincia custodes erant: transmitrēs ad demetriū legaros cū donis: rogabat ut de castellis iudeæ custodes eiecet. Cui rex nō hæc tātū se pberē: sed etiā his maiora pmittebat: post finē belli qd præ mātibus habebat: petebat uero eū & auxilia trāsmittre: mādās q; exercitus suus ab eo recelisset. Tūc ionathas tria milia militū eligēs destinauit.

the shop of Joseph Moxon, he would surely have been greatly impressed by the procedural advances which had been made in that long span of time, but he would have seen very little in the way of tools and machinery that was completely strange to him. Nevertheless, the improvements in foundry techniques, press operation, and the other activities carried on routinely in printing shops had been substantial. We must assume, therefore, that a printer in Joannes's time could not perform his functions as rapidly or as efficiently as a printer in Moxon's day. It is essential that we bear this in mind as we read Moxon.

The cutting of a full set of punches was in itself a very costly affair. From such a set it was then necessary to strike rough matrices (one for each punch in the set) and to justify, or finish, them, procedures which added greatly to the already high costs. On January 16, 1576, ninety years after the publication of the Joannes-Josephus, according to Voet [14, pp. 44–45], the punchcutter Hendrik van den Keere wrote a letter to his customer, the eminent printer Christopher Plantin, concerning the “jolye romain” type font which he was preparing for Plantin [15, vol. 5, p. 698]. In this letter, van den Keere explained that it took him more than a full day to cut each character in a font, and that the making of five or six matrices required an additional day. He estimated that he could complete the cutting of the punches in about three months, and that the processes of striking and justifying the matrices and making the molds would take four more weeks. Having thus prepared the ground, van den Keere then explained why it was going to take even more than four months to complete the work. If Plantin wanted to be sure that proper care could be given to all the details of the job, van den Keere cautioned, he would be well advised to allow two more months for that purpose. In other words, van den Keere was figuring on about six months of his time (plus the time of the people who may have been helping him) to prepare a set of punches and the necessary appurtenances.

A cursory survey of van den Keere's computations will reveal that the font he was cutting for Plantin could not have exceeded five or six dozen characters in number and was, consequently, a comparatively small font, for it could not have included much more than an alphabet in upper- and lower-cases, the numerals, and a few points and ligatures. An incunable font generally required many abbreviations,

ligatures, contractions, and points, so that an average-sized font in Joannes's time contained more than 100 units, and would therefore have taken much more time to cut than the font which van den Keere made for Plantin.

It is perhaps not out of order to suspect that van den Keere did not want to be rushed by his customer, and was tacking on two months to his normal schedule for reasons which had less to do with quality control than with keeping Plantin from pressing him unduly for early delivery. Of course, whether it took four months or six months, the job was very expensive, all the more so since it called for craftsmanship of the highest order.

One set of punches could have been the source for the creation of an indeterminate number of matrices. Vervliet states that "several dozens of strikes can be made with one set of punches" [16, p. 7], but an incunable printer who was more interested in keeping costs down than in producing work of quality could readily have gone well beyond the limits set by Vervliet. Each set of matrices could, in turn, have been used for the casting of a large number of characters. How much of the time devoted to the making of a set of punches and its auxiliary items should be apportioned as a labor cost to each thousand impressions of the type derived from these punches, should now be considered.

Let us begin by returning to van den Keere's estimate of six months for the cutting of a set of punches and the preparation of the accompanying matrices and molds, but let us also assume that in these six months he made a full-sized font rather than the smaller one he actually prepared. This will serve to compensate, to some degree, for the possibility that he was exaggerating his time requirements in the letter to Plantin. Let us also assume that van den Keere, like his contemporaries in the printing trade, observed the many holidays then in vogue. He would thus have worked, according to Oswald [17, p. 365], about 120 days in the six-month period.

When the typesetters eventually received the matrices from van den Keere, they naturally cast more of the frequently used characters than those which appear less often, so that the degree of wear incurred by the individual matrices within a set differed in proportion to their use by the typesetters. Unless replacements for the worn-out matrices were then struck from the punches, the first matrix to be

come no longer usable would put an end to the value of the entire set. The remedy was to strike new matrices as the need arose. Consequently, the individual punches in a font also wore out at varying rates.⁶

To attempt to compute the number of type characters which could have been derived from a set of punches would constitute an exercise in futility; to attempt to determine the number of man-hours required to cut punches and strike matrices for, let us say, each 100,000 pieces of type made would be an equally unrewarding experience, unless we knew the total number of characters which were actually produced from these punches. If we accept the van den Keere figures, it can be stated that in the case where only 100,000 units of type were made from a set of punches, the labor cost of that set of punches and its accessories was 120 man-days, or 1.20 man-days per 1,000 characters—conversely, 1,000 characters in 1.20 man-days, or 833 characters in one man-day. If 200,000 characters were produced from the one set of punches, one day of the punchcutter's time would have to be applied as a labor cost figure to the casting of each 1,667 characters, and so forth. No labor cost allowance is being made here for the restriking of matrices.

We may assume that the efficient printer tried to squeeze out as much use as possible from his punches, so that the number of characters eventually obtained from each set of punches would probably have run into many hundreds of thousands, if not into millions. It appears safe to assert that while punch (or matrix) deterioration did, of course, represent a necessary expense to the printer, it was not *critically* significant in the calculation of the cost of type and, consequently, in the cost of each thousand impressions produced with the type. This would have been true, of course, only if the type was utilized quite extensively. However, in the case of a type which received very little actual use, such as a type employed exclusively for headings, the cost of cutting the punches from which this type was ultimately derived must have been fantastically high in relation to the number of pieces

6. The rate of deterioration of punches and matrices would also be affected, of course, by other considerations, such as the size and design of the letter, the kind of metal of which the matrices were made, the care exercised by the workmen, and so forth.

cast and the number of impressions to which these pieces were subjected. Nevertheless, even when a type received substantial use, the factor of punch and matrix wear could not be ignored completely, for if, let us say, a million pieces of type were cast from one set of punches, the punchcutter's time outlay would have amounted to nearly one-eighth of a man-day for each 1,000 of these characters.

The labor costs for the cutting of the punches for Proctor 82 R, the type in which the Josephus work was composed, must have been rather low in relation to the number of pieces of type eventually derived from these punches, for Type 82 R underwent very extensive use over a period of many years. Information extracted from the British Museum Catalogue [7, V, pp. xxxviii, 414–22; VI, pp. 896–97], Goff [10, p. 711, and items referred to therein], and the British Museum *Short-Title Catalogue* [18, pp. 931–32, 978] indicates that Joannes Rubeus Vercellensis was engaged in the printing business, first at Treviso and then at Venice, from 1480 to 1519, that his brother Albertinus Vercellensis was his partner for some time, and that he also printed a number of books in association with Bernardinus Vercellensis. During this period of four decades, the Vercellensis brothers had a hand in the printing of at least 100 books. The British Museum Catalogue, which limits itself to works published during the fifteenth century and which provides typographic data concerning these works, lists forty books printed by Joannes and Albertinus. Of these forty, thirty were composed, either entirely or substantially, in Type 82 R; at least one other printer, Matteo Capcasa [7, V, p. 482], used the Vercellensis 82 R for the production of several books.

Those editions listed in the British Museum Catalogue in which 82 R is the only, or predominant, type contain some 10,000 pages of crowded text including, I estimate, nearly as many characters on the average page as there are in the Josephus work. I have not attempted to determine whether 82 R was used in the composition of those Vercellensis (or Vercellensis-related) books which do not appear in the British Museum Catalogue; and I have also disregarded the fact that 82 R almost surely occurred frequently in other products of the Vercellensis shops, such as ephemera and books of which no record exists today. Nevertheless, even if we restrict our computations to the 10,000 pages of 82 R noted by the British Museum Catalogue, we conclude that the Vercellensis compositors must have set, during the last

two decades of the fifteenth century, some 50,000,000 pieces of that type alone. This achievement, equivalent to composing seventeen volumes, each of the size and typographic specifications of the Josephus work, makes it obvious that the Vercellensis inventory of Type 82 R was replenished frequently. The typefounders must have been kept very busy casting enough sorts to see to it that the compositors' cases were properly stocked.

The fact that 50,000,000 characters of 82 R were composed does not mean, of course, that 50,000,000 characters were cast. Type was made, used for setting a number of pages of text, put on the press for whatever run was specified, washed, distributed, and then set again. New type was manufactured as needed; the total amount of type eventually cast to meet the requirements of the compositors was a function, in the mathematical sense, of the life expectancy of that type.

It would appear that Joannes obtained a set of punches in 82 R during or before 1480, struck matrices from these punches, and made his original font. Time and again, as the years passed, his typefounders cast replacement and additional type from the matrices, striking new matrices as the old ones wore out. When a punch was no longer up to the standard of quality demanded by Joannes, a substitute was cut. The possibility also exists, in light of the evidence accumulated by Harry Carter regarding the type acquisition practices of the early printers, that all, or part, of the type manufacturing processes—from the cutting of the punches to the casting and finishing of the characters—could have been contracted out to others [19, chap. 5]. In either case, the labor costs for the cutting of the punches and the making of the matrices, we may surmise, could not have been very significant when a type was used as thoroughly as the Vercellensis 82 R.

No attempt will be made in this study to estimate the amount of labor which went into the preparation of the type alloy needed by the typefounder for casting the type, although this operation, according to Moxon, was “labour would make *Hercules* sweat” [13, p. 167]. So grueling was the work, we are told, that its completion was gratefully marked by a time-honoured ritual which unquestionably took priority over all the other activities in the plant, and which was supposed to help the workmen gird themselves for the exertions which

still lay ahead. Moxon describes this essential step in the manufacture of type in sympathetic detail, telling us that “Now (according to Custom) is Half a Pint of Sack mingled with Sallad Oyl, provided for each Workman to Drink; intended for an Antidote against the Poysonous Fumes of the *Antimony*, and to restore the Spirits that so Violent a Fire and Hard Labour may have exhausted” [13, p. 167].

The flagging energies of the foundrymen having been revived, the casting of the type followed. The alloy was melted, and the type-founder then poured the molten metal into the mold, a technique requiring a great deal of skill. A separate casting was needed to make each and every letter. Legros and Grant describe the procedure in this manner: “In the early days of typefounding the metal was first melted into a pot from which it was taken in a ladle and poured by hand into the mould. This was jerked upwards by the founder with a peculiar and dexterous motion, so as to cause the liquid metal to reach the matrix at its end and so obtain a cast of the impression previously made by the punch” [20, pp. 16–17].

The speed at which this work could be accomplished is specified by Moxon. “A Work-man,” he says, “will *Cast* about four thousand of these Letters ordinarily in one day” [13, p. 173.]. However, P. S. Fournier *le jeune*, writing in 1764, about eighty years later than Moxon, puts the number at 2,000 to 3,000 a day [13, p. 173 n]. The discrepancy between the two estimates is substantial, and the fact that the figures presented at the later date show a lower daily production capacity is rather surprising. One would expect that with the passage of time and the growth of technical expertise, Fournier’s contemporaries would have been able to make at least as much type in a day as the foundrymen of Moxon’s time. It may be, however, that the craftsmen of Fournier’s acquaintance worked fewer hours each day than the men Moxon knew, or that they simply did not work as hard, or as well. It may also be that neither Moxon nor Fournier kept precise figures on foundry production, but that each was merely quoting rather general estimates of the number of type characters which, in his opinion, could be expected from each man-day of labor. It appears reasonable to assume that the daily production rate lay someplace between the lower limit of 2,000 characters proposed by Fournier and the higher quota of 4,000 advanced by Moxon. This assumption is lent credence by a statement made in

1750, in the *Universal Magazine* [21, p. 278], that a man could cast 3,000 letters in a day. Since this figure coincides with the average of the two extremes provided by Moxon and Fournier, it is being accepted as the basis for further computations in our analysis of type manufacture costs. However, a caveat should be noted here—the typefounder in the very early years of printing must surely have produced fewer pieces for each hour he worked than his successors in the craft two or three centuries later. This lower hourly rate, on the other hand, could have been offset by the fact that the incunable craftsmen may have worked more hours per day than did the later generations plying the same trade.

The rough casting which emerged from the typefounder's mold had to be converted into the finished character which the typesetter could place into his composing stick. This metamorphosis was effected by routing the casting through a series of operations which, in total, consumed much more working time than the process of casting itself.

The steps by means of which the rough castings were transformed into usable type characters are painstakingly detailed for us by Moxon [13, pp. 173–90]; it becomes obvious from reading his description that the necessary finishing work on the castings was tedious and time-consuming.

The length of the working day during the fifteenth century varied from place to place, but it appears that it consisted, in the average print shop at least, of about fourteen hours.⁷ The casting of 3,000 characters per day would thus represent a rate of one piece every sixteen or seventeen seconds. Moxon's description of the steps following the casting process indicates that it must have taken considerably more time to finish each character than it did to cast it. The reader who wishes to pursue this matter more thoroughly is referred to the Moxon account; and it is suggested that he try to estimate how

7. Febvre and Martin have listed four examples of daily working hours in print shops during the first two centuries following Gutenberg. The average working day appears to have been about fourteen hours long [2, p. 198], although by the time of Moxon and Fournier the working day may not have been as long as it was when Joannes was operating his shop. In fact, one of the major objectives of the workers in the numerous strikes which took place in the printing industry during the post-incunable period was the reduction of the length of the working day.

much time it would have taken, per character, to carry out each of the operations which Moxon describes. The total of the time consumed by all these operations will be substantially greater than the sixteen or seventeen seconds which have been computed for the casting of each piece of type. It should also be remembered that this estimate of sixteen to seventeen seconds has been calculated backward, so to speak. We accepted 3,000 pieces as the total output for a day of fourteen hours, during which there must surely have been quite a few interruptions in the work, such as pauses for refreshment and chatting with fellow-workers, stoppages while waiting for materials, and all the other time-consuming breaks which inevitably crop up in a long working day. To the time estimates made by us for each step in the finishing processes listed by Moxon, we should, accordingly, add a bit more in order to make up for such stoppages during the day.

I believe that it must have taken at least twice as much time to finish the type and put it into the cases (or package each sort separately for shipment elsewhere) than it did to perform the casting work itself.⁸ If this is correct, then the time required to process each 1,000 pieces of type from beginning to end would have been at least fourteen hours of labor, a figure which represents a rate of seventy-one pieces per hour, or somewhat more than one unit of type per minute. I am inclined to the opinion, I should add, that the work actually proceeded much more slowly than this, so that the cost of type characters, expressed in terms of man-hours of labor, was greater than the fourteen hours which have been allocated per 1,000 pieces. Nevertheless, this figure, inadequate as it appears to be, will be used here.

If we assume, accordingly, that Joannes owned 84,000 pieces of type, and that it took one man-day of fourteen hours to cast and finish each 1,000 units of this type, then the manufacture of Joannes's inventory of 84,000 characters required eighty-four man-days, or 1,176 man-hours of direct labor.

It should be emphasized that the direct labor which has been

8. I discussed this matter with Roger Levenson, lecturer in librarianship, University of California, Berkeley, and proprietor of Tamalpais Press. Mr. Levenson, who has personally done a good deal of handcasting and finishing of type, agrees that the finishing processes consume at least twice as much time as the casting work.

considered here has not included any allowances for the time devoted to the making of the punches, matrices, and molds, or to the melting and mixing of the ingredients which made up the alloy. We have also failed to allot any time for such indirect labor items as the hauling, delivery, and storage of the fuel and raw materials used in the manufacturing of the alloy, running errands, cleaning furnaces, starting and feeding fires, maintenance work, supervisory labor, labor resulting from inefficiency, waste, and human error, and so forth. I am, therefore, adding one-third more labor time to the direct labor figure of 1,176 man-hours which has been computed, so that the adjusted labor charge for making 84,000 pieces of type now becomes 1,568 man-hours. Although this adjustment of $33\frac{1}{3}$ percent is completely arbitrary, I believe that it is, in fact, much too low. (It will be recalled that the punchcutter's time expenditure for the cutting of punches, in the case where a million characters were ultimately derived from these punches, was by itself computed at nearly one-eighth of a man-day for each 1,000 characters—which is to say, that this item alone could have accounted for about 12 of the $33\frac{1}{3}$ percent being proposed here as the appropriate increment.)

To facilitate our computations, we have postulated that Joannes used the same 84,000 pieces of type thirty-five times in printing thirty-five sections of the Josephus volume. Consequently, each piece underwent exactly thirty-five impressions in the printing of each copy of the book. Since it required 1,568 man-hours of labor for the manufacture of 84,000 units of type, it follows that if this type was so soft that it would withstand only (let us say, for the sake of illustration) thirty-five blows of the platen, then all of these 1,568 man-hours would have had to be charged to the printing of one copy of the Josephus. It is also evident that it would have been possible to print about twenty-nine copies of the book for each 1,000 impressions which the type was capable of withstanding ($1,000 \text{ impressions} / 35 \text{ impressions per copy} = 28.6 \text{ copies}$).

We are now able to write a simple mathematical equation to demonstrate the relationship—under the conditions postulated in this study—between (1) the life expectancies, at various levels, which Joannes's type could have been capable of sustaining in the printing of the Josephus work (the number of impressions which the type could withstand at any level being designated as N); (2) the number of

books which Joannes could have produced with his 84,000 pieces of type at each of these levels ($N/35$); and (3) the prorated labor costs per copy (expressed in man-hours, and designated as L) at such levels:

$$L = \frac{1,568}{N/35}$$

Table I has been constructed by substituting quantities ranging from 1,000 to 50,000 for N . All figures have been rounded out to the nearest full number.

Column $N/35$ in Table I includes listings for edition sizes of 200, 300, 500, and 1,000 copies, since these were the edition size figures which were analyzed in the earlier paper on the labor costs involved in the production of the Josephus work. The corresponding N and L quantities have been entered in their appropriate positions in Table I.

Table II has been abstracted from the earlier study, and lists the number of man-hours of labor—including an augmentation of one-

TABLE I. *Labor Requirements for the Manufacture of Type in the Production of the Joannes-Josephus at Various Levels of Type Life Expectancy*

<i>Number of Impressions Type Is Assumed To Be Capable of Withstanding</i>	<i>Number of Copies of the Book Which Could Be Produced at Each Level of Type Life Expectancy</i>	<i>Number of Man-Hours Needed to Manufacture Type for Each Copy Produced</i>
(N)	($N/35$)	($L = \frac{1,568}{N/35}$)
1,000	29	55
2,000	57	27
3,000	86	18
4,000	114	14
5,000	143	11
7,000	200	8
10,000	286	5
10,500	300	5
17,500	500	3
20,000	571	3
30,000	857	2
35,000	1,000	2
40,000	1,143	1
50,000	1,429	1

TABLE II. *Labor Requirements for Composition, Presswork, and Bindery Work in the Production of the Joannes-Josephus in Various Edition Sizes*

<i>Processes</i>	<i>Number of Man-Hours by Size of Edition</i>			
	200	300	500	1,000
Number of man-hours required for composition, presswork, and bindery work	9,969	12,488	17,525	30,119
Number of man-hours per copy produced (to nearest man-hour)	50	42	35	30

third to allow for indirect labor, at least in part—which Joannes would have had to expend for composition, presswork and bindery work (exclusive of the actual covering of the book) for editions of 200, 300, 500, and 1,000 copies.

If we now draw up Table III by adding the appropriate figure from column *L* of Table I to each of the figures on the bottom line of Table II, we will obtain the per-copy number of man-hours of labor needed in edition sizes of 200, 300, 500, and 1,000 copies to perform all the work described in the earlier study and, in addition, to cover the manufacturing of the type. The number of impressions which the type would have had to be able to withstand in order to produce each edition size (column *N*, Table I) is also indicated in Table III, as is the percentage of the overall labor time attributed to the manufacture of the type.

An edition of 300 copies was fairly common in the 1480s, the decade during which the Josephus volume was printed by Joannes. If Joannes wore out his font of type by producing an edition of this size, then the labor expenditure for each of the 300 copies amounted to forty-seven hours.

This figure of forty-seven man-hours by no means represents the total cost of producing each copy of the book. We have ignored all overhead and editorial expense, as well as the many other outlays which occur in commercial ventures of all kinds. And, above all, we have not even mentioned the expenditures for materials—fuel, metal, ink, and, most important, paper.

Hirsch concludes that “the permissible generalization . . . is that in the earliest period the cost of material probably equalled or slightly exceeded the cost of labor, that it decreased at a slow rate, but may

TABLE III. *Labor Requirements for the Production of the Joannes-Josephus in Various Edition Sizes*

	<i>Number of Man-Hours by Size of Edition</i>			
	200	300	500	1,000
Number of impressions type is able to withstand (table I, col. <i>N</i>)	7,000	10,500	17,500	35,000
Number of man-hours required per copy for composition, presswork, and bindery work (from table II)	50	42	35	30
Number of man-hours required per copy for manufacture of type (table I, col. <i>L</i>)	8	5	3	2
Totals	58	47	38	32
Percentage of overall labor costs attributable to type manufacture	14%	11%	8%	6%

have been reduced to a third of the total cost some time during the second half of the XVI century” [22, p. 40]. Although, as Hirsch points out, this is no more than a generalization, it nevertheless indicates that the cost of furnishing the paper for, and printing, each copy of a 300-copy edition of the Joannes-Josephus must have been very high, quite likely equivalent to the earnings of a skilled printing craftsman over a period substantially greater than a full week. The retail price of the book would, of course, have been considerably more than that, for it would have had to take into account many other costs—overhead, transportation, sales expenses, allowances for bad debts, and so forth. Moreover, the businessmen who had invested their funds in the printing and selling of the book would have had to set the market price high enough to enable them to make a profit. It would thus appear that a book of the typographic characteristics and size of the Josephus must have sold for a sum equivalent to the earnings of an artisan over a period of several weeks. Even in the fifteenth century, when wages were low, this must have represented a tidy outlay on the part of the purchaser. Printed books were obviously cheaper than manuscripts, but they were still quite expensive.

It was stated earlier in this study that the best we could hope to achieve in our investigation of the durability of early type would be

to ascertain whether this type was so soft that it could provide only a few hundred to a few thousand impressions, or whether it was hard enough to allow 10,000 or more impressions be made from it.

We can, at this point, reject as untenable any assertion that early type was so fragile that only a few hundred to a few thousand impressions could be expected from it. In Table I we see that when N (the number of impressions type is able to withstand) is 1,000, an edition of only twenty-nine copies could be produced from our hypothetical font of 84,000 characters, and that L (the number of man-hours which have been spent in making this type, prorated on a per-copy basis for this edition of twenty-nine copies) would have been fifty-five hours, a forbiddingly high figure. The reader is reminded that if the edition had been large—say, 1,000 copies—the L cost would still have been fifty-five hours of labor per copy, since Joannes would have had to keep casting new type repeatedly (at the cost of 1,568 man-hours per 84,000 characters) in order to keep his pressmen working. In fact, in an edition of 1,000 copies, with a type life expectancy of only 1,000 impressions, Joannes would have been able, in theory, to print exactly 1,000 copies of each form with the type before it wore out. Since he had thirty-five forms to complete, he would have had to cast, in all, $35 \times 84,000$ characters, or 2,940,000 pieces. This would have entailed $35 \times 1,568$ man-hours (54,880 man-hours) simply to make the type for the printing of this one edition. If we divide the last figure by the number of copies in the edition, 1,000, we come back to our previously determined cost of fifty-five man-hours per copy for the manufacture of the type in an edition of this size. (A small offsetting factor would have been introduced under these conditions—the time for washing and distributing the type after printing each form would have been eliminated.)

We can, accordingly, assume that it would have been financially impractical for Joannes to have printed the Josephus work if type was so soft that it would yield only as few as 1,000 impressions. It also seems unlikely that the type's life expectancy was limited to as few as 7,000 impressions (permitting an edition of only 200 copies, with the cost of type manufacture running to eight man-hours per copy). I think that the information currently available to us permits us to assume that type was probably usable, on the average, for at least 10,000 to 20,000 impressions. This would have permitted edition

runs of the Joannes-Josephus of between 286 and 571 copies with labor costs for type manufacture ranging from five to three man-hours per copy (Table I). I suspect, however, that the incunable printer could normally expect that his type would last for several tens of thousands of impressions.

Above the financial considerations analyzed here, there are other grounds for believing that incunable type was moderately durable. (I use the word “moderately” to indicate that, on the one hand, the type was not so soft that it could be subjected to only a few thousand blows of the platen, while, on the other hand, it was not as durable as modern type.)

We must concede that the alloy from which the type was made had to be reasonably tough. Had the characters consisted of lead alone, they would have been very soft, of course, and would not have been able to survive as many impressions as the process of alloying made possible.⁹ Nevertheless, it is quite feasible to produce a press run of respectable size using type characters made of nothing but pure lead. William Blades proved this more than a century ago, describing his purpose and method in these words [23, p. 108]:

The metal of which Caxton’s types were cast can only be conjectured. The probability is that it was soft, and if even so soft as lead it would have been sufficiently durable to have performed the work for the small impression required of each book. In demonstration of this, the author procured, by the kindness of Messrs. Figgins, a fount of their Caxton types in pure lead, and composed a page of Caxton’s “Chess Book,” working it in the usual way, at a common hand press, and numbering each impression as it came from the tympan in order to note its gradual wear. The paper was a royal cartridge of the common rough quality, and was worked dry. After 500 pulls, perceiving no appreciable wear, the author stopped the experiment, being sufficiently satisfied.

9. The use of an alloy, rather than lead alone, not only increases the durability of type but also provides other noteworthy advantages. The modern type alloy is made of lead, tin, and antimony, and may also include small percentages of copper and/or other metals. Its melting point is approximately 475°F, much lower than that of lead (621°F). The alloy’s fluidity is superior to that of lead, as are its expansion and contraction characteristics in the mold during the processes of cooling and solidification. Type made of lead alone will produce fewer impressions by far than type made of the alloy, and the quality of these impressions will be decidedly inferior [5, pp. 15–16].

Blades considered it likely that Caxton's type was soft. But, how soft? He says that he used a rough paper and ran it dry. The incunable printer, more often than not, also used what might be termed a rough paper, but ran it wet. The dry paper which Blades ran was, of course, harder on his type than wet paper would have been. He stopped the experiment at the 500th impression, although it is obvious that he could have printed many more sheets, had he chosen to do so. Hence, if type made of pure lead alone can yield more than 500 impressions on dry paper—and probably a number of multiples of that figure—how many more impressions could have been gotten if wet paper had been used and if the type had been cast from the much tougher alloy which we know to have been available in incunable days? The evidence provided by Blades's experiment surely establishes the *minimal* figure for incunable type durability at several thousands of impressions.

Moreover, had fifteenth-century type not been capable of withstanding many thousands of impressions, virtually every page of incunable print which has come down to us would include a distressingly large number of broken and fuzzy characters. Much of incunable printing is poorly done, it is true, and there is no shortage of pages of text in which many defective characters may be seen. It is an indisputable fact that more than a few incunable printers continued to use type long after it should have been discarded. However, if we restrict our investigation to the output of the better printers of the time, we find that the condition of the individual type characters on the pages is uniformly good. Would this be true if type was forever breaking down?

Horatio Brown, having studied the craftsmanship of the master printer Nicolaus Jenson, makes this comment [24, pp. 17–18]: “The characteristics of the Jenson type are maintained all through his work; and if we note a marked difference in the freshness and sharpness of the print of one year as compared with that of another, this is to be attributed to the fact that the more brilliant print is the result of a fresh casting from the old matrices, or possibly even from fresh matrices newly stamped from the original punches.”

Brown, it will be noted, does not say that he has found numerous cases in which individual pieces of type (or even lines or islands of type) within a page had broken down. He speaks, on the contrary, of

a uniformity of freshness and sharpness, implying that the wear which inevitably took place did so on a broad basis. Had type been breaking down after comparatively short runs of the press, such a uniformity could not have prevailed for very many impressions unless Jenson had been casting replacements for *entire* pages repeatedly—that is, every time a type breakdown occurred within those pages. If Jenson had been doing this, textual examination of specific pages from copy to copy within any edition of his would reveal the fact very quickly, and the year-to-year comparison which Brown makes would be totally inappropriate.

No printer, not even as meticulous a craftsman as Jenson, could have permitted himself the luxury of examining each sheet for defective characters as it came off the press and, if he found such characters cropping up, stop the press, take the form off the press, remove and discard the offending type, and then set up replacement type, lock it into position in the form, put the form back on the press, and start printing again. While such stoppages did occur from time to time, it would have spelled financial ruin to a printer to have been compelled to close down his press operation repeatedly during the course of each working day for the purpose of replacing worn-out type. How much more calamitous would it have been if the printer had been forced to set up an entire page when a breakdown took place in only a small portion of that page!

It seems apparent that when the incunable printer put a form on the press he must have known that the type could be expected to last for a run of quite a few thousand impressions. If, at the end of the press run of any particular form, it was noticed that certain characters were showing signs of wear, they could be culled out as the type was being distributed into the cases, so that no interruption of the press operation would be required.

An objection may be raised at this point. Reference was made earlier in this study to the assertion of Paul Manutius, in 1570, that type would wear out in only four months, and that it was desirable to cast fresh type before starting work on any new book in order to lessen the risk of having the characters go bad in the middle of the printing of the book. The inference to be drawn, it would appear, is that early type was not very durable. Such a deduction, however, is not necessarily valid.

To begin with, it is not at all unlikely that Manutius was exaggerating his difficulties with type, in which case his complaints should not be taken too seriously or too literally. He would not be the first printer, nor the last, to find fault with materials and equipment, justifiably or not. Moreover, even if the Manutius figure of four months is taken to be correct for the life expectancy of early type, we have no way of knowing how many impressions were actually made with the type during that period. How many characters were available at the start of the work? How many presses were used on the job, and how much work did they produce? How many times, in essence, did the average character print an image of itself on paper during those four months?

Finally, Haebler cites a contract, dated December 19, 1483, which may be construed as presenting a position differing radically from that of Manutius [25, p. 19]. In this document, Domenico Caraffa agrees to lease equipment and type to a printer who, according to Haebler, “was designated as Justo [T]heotonico, probably identical with the Neapolitan printer Jodocus Hohenstein.” Haebler says that the contract stipulates “that the weight of the type leased by Hohenstein for nine months at the price of 10 ducats was 122 lbs.” Haebler also deduces from other documentation that this type had in all probability already been used for eighteen months by two previous associates of Caraffa, Johann Steingamer of Landsburg and Werner Raptor of Marburg.

If a printer paid as much as ten ducats for a nine-month lease of type, at a time when the earnings of the average Italian printing craftsman for an entire month amounted to only four ducats [22, p. 38], he must surely have planned to get his money’s worth by utilizing the type rather thoroughly. In addition, this type, as has been noted, may already have seen eighteen months of use. That it was being leased instead of sold would indicate either that Caraffa did not expect it to be completely worn out when Hohenstein had finished with it, or that he simply wanted to retain ownership of the metal.

The fact remains that in both cases—Caraffa’s type and that of Manutius—we still do not know how many impressions were involved. The evidence is not conclusive, of course, but it does appear that Caraffa’s estimate of type durability, in 1483, was substantially higher than Manutius’s, in 1570.

Conclusion

If type life expectancy during the incunable era had been limited to only a few thousand impressions, the excessive labor costs inherent in the manufacture of the type characters would have raised the production costs of the printed book very substantially. It is difficult to believe that printing could have been carried on extensively on a commercial basis during the fifteenth century had type life expectancy been very low. Moreover, the fact that we do not find large numbers of defective characters in the works of the better printers of the time tends to reinforce this point of view, as does the prevalence of the "freshness and sharpness of the print of one year as compared with that of another," pointed out in the works of Jenson by Brown.

Still another indication that incunable type was sturdy enough to last for quite a few thousand impressions is furnished by Blades's experiment with type made of pure lead.

The lines of reasoning which have been pursued in this study lead to the conclusion that incunable type was fairly durable, probably to a substantially greater degree than has been suggested by either the British Museum Catalogue or Febvre and Martin. It would appear that the number of "acceptable" impressions which the early printer could expect to obtain from his type must have been on the order of several tens of thousands.

REFERENCES

1. Audin, Maurice. *Les types lyonnais primitifs conservés au Département des Imprimés*. Paris: Bibliothèque nationale, 1955.
2. Febvre, L., and Martin, H.-J. *L'apparition du livre*. Paris: Éditions Albin-Michel, 1958.
3. Bühler, Curt F. *The Fifteenth-Century Book: The Scribes, the Printers, the Decorators*. Philadelphia: University of Pennsylvania, 1960.
4. Audin, Maurice. "Types du XV^e siècle." *Gutenberg-Jahrbuch* (1954), pp. 84-100.
5. Jackson, Hartley E. *26 Lead Soldiers*. Stanford, Calif.: Stanford University Press, 1937.
6. Kubler, George A. *The Era of Charles Mahon, Third Earl of Stanhope: Stereotyper, 1750-1825*. New York: J. J. Little & Ives, 1938.
7. British Museum, Department of Printed Books. *Catalogue of Books Printed in the XVth Century Now in the British Museum*. Pts. 1-9. London: Trustees of the British Museum, 1908-62. Lithographic reprint, 1963.
8. Didot, Ambroise Firmin, *Alde Manuce et l'hellénisme à Venise*. Paris: A. Firmin-Didot, 1875. Cited by Febvre and Martin (see [2, p. 74] above).

9. Pollak, Michael. "Production Costs in Fifteenth-Century Printing." *Library Quarterly* 39 (October 1969): 318-30.
10. Goff, Frederick R., ed. *Incunabula in American Libraries*. New York: Bibliographical Society of America, 1964.
11. Biringuccio, Vannoccio. *The Pirotechnia*. Translated by Martha Teach Gnudi and Cyril Stanley Smith. New York: American Institute of Mining and Metallurgical Engineers, 1942.
12. *An Account of Calligraphy and Printing in the Sixteenth Century*. From dialogues attributed to Christopher Plantin. Printed and published by Plantin at Antwerp in 1567. Translated by Ray Nash. Cambridge, Mass.: Department of Printing and Graphic Arts, Harvard College Library, 1940.
13. Moxon, Joseph. *Mechanick Exercises on the Whole Art of Printing, 1683-84*. Edited by Herbert Davis and Harry Carter. London: Oxford University Press, 1958.
14. Voet, L. "The Making of Books in the Renaissance as Told by the Archives of the Plantin-Moretus Museum." *Printing and Graphic Arts* 10, no. 2 (December 1965): 33-62.
15. *Correspondance de Christophe Plantin*. 9 vols. Antwerp: J. E. Buschmann, 1883-1918.
16. Vervliet, H. D. *Sixteenth Century Printing Types of the Low Countries*. Translated by Harry Carter. Amsterdam: Menno Hertzberger & Co., 1968.
17. Oswald, John Clyde. *A History of Printing*. New York: D. Appleton & Co., 1928.
18. *Short-title Catalogue of Books Printed in Italy and of Italian Books Printed in Other Countries from 1465 to 1600 Now in the British Museum*. London: Trustees of the British Museum, 1958.
19. Carter, Harry. *A View of Early Typography Up to About 1600*. Oxford: Clarendon Press, 1969.
20. Legros, Lucien Alphonse, and Grant, John Cameron. *Typographical Printing-Surfaces*. London: Longmans, Green & Co., 1916.
21. A. B. "The Art of Cutting, Casting, and Preparing of Letters for Printing." *Universal Magazine*, vol. 6 (1750). London: Published for J. Hinton, 1747-1815. Cited by Rollo G. Silver in *Typefounders in America, 1787-1825*. Charlottesville: University Press of Virginia, 1965.
22. Hirsch, Rudolph. *Printing, Selling, and Reading, 1450-1550*. Wiesbaden: Otto Harrassowitz, 1967.
23. Blades, William. *The Biography and Typography of William Caxton, England's First Printer*. 2d ed. London: Trübner & Co., 1882.
24. Brown, Horatio R. F. *The Venetian Printing Press, 1469-1800*. London: J. C. Nimmo, 1891.
25. Haebler, Konrad. "Typefounding and Commerce in Type during the Early Years of Printing." *Ars Typographica* 3 (July 1926): 3-35.

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