

PRINTING WITH GOLD IN THE FIFTEENTH CENTURY

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with photographs by JANE MULLANE

SEVERAL years ago, concern about the technique of gold printing—had gold leaf or pigment been used?—instigated the research described in the present article.

Victor Carter, head of the manuscript conservation workshop, suggested that the flecks of gold visible with the help of a high-magnification microscope were the remnants of superfluous gold, not bonded to the page, and dispersed with a brush. His flash of insight was followed by deliberations about the technical possibilities of the fifteenth century, weighing of alternative explanations, reasoning on the basis of the available evidence, and, most of all, by attempts to repeat the experiment.

It is for his co-authors a cause of sad satisfaction that Victor Carter, who had been their leading spirit, did approve the final version of this article, and that during the last weeks before his death the questions posed in it occupied his mind and continued to rouse his enthusiasm.

I

Gold printing in the fifteenth century is very rare. There are only two printers who are known to have applied this technique. One of them was Erhard Ratdolt who first used gold for printing a gloriously spectacular full page of dedication in a number of copies of his *editio princeps* of Euclid. The book was completed a little over 500 years ago, on 25 May 1482. The British Library owns a particularly fine copy on vellum, which was given by the printer to Giovanni Mocenigo, Doge of Venice from 1478 to 1485, to whom he had dedicated the book. It bears the arms of the Doge and his portrait on the page facing the dedication in gold (fig. 1). This copy formed part of the *en bloc* collection of books which King George III acquired in 1765 from Joseph Smith, the English consul in Venice who is better known to posterity as a collector of art and a dealer in paintings. Smith had brought together a collection of very fine books, especially of first editions printed in Italy which were to become the foundation of the king's library. The exceptional copy of the Euclid had no doubt been found by Smith in Venice. It is now on permanent exhibition in the King's Library.¹ There are other copies recorded which have the dedication page printed in gold: two in the Bibliothèque Nationale in Paris (one on vellum and one on paper), two in the Bayerische Staatsbibliothek in Munich, one in the University Library in Budapest,

and one in the Stadtbibliothek in Augsburg. They have this feature in common: the dedication page in gold is printed in a different typesetting from that used in the other known copies printed in black.²

Ratdolt repeated this experiment after his return to his native city of Augsburg where in 1488 he printed the *Chronica Hungarorum* by Johannes Thuróczy. Two copies preserved in the National Museum in Budapest have some gold printing.³ The three copies in the British Library belong to the large group of plain ones that have survived.⁴

The other printer to apply a technique for gold printing was the Cretan Zacharias Callierges whose first publication, the *Etymologicon Magnum Graecum* (GW 9426), was completed in Venice on 8 July 1499. The books of Callierges are outstanding specimens of Greek printing. It had taken five years to prepare his type which in all likelihood was his own work. It is one of the most elegant Greek typefaces ever designed, which is partly due to a technical innovation devised by him.⁵ Callierges decorated his books with metal borders and initials of almost oriental design. To add splendour to a number of copies the border and initial on the first page of text were printed in gold (fig. 2). Gold borders and initials are found most frequently in the second book printed by him, Ammonius Hermeas, *Commentarii in quinque voces Porphyrii*, in Greek, completed on 23 May 1500 (GW 1618). Not fewer than eight copies of this book with a first text page decorated in gold printing can now be traced;⁶ of Callierges's third book, and the last printed in Venice in this phase of his activities as printer, the Simplicius, *Commentarii in Aristotelem*, two copies with gold printing are known to have survived.⁷

There is, of course, nothing unexpected in finding an inclination to embellish printed books with gold in the fifteenth century. In manuscripts gold was widely used with a purely decorative function. Gold script is not quite so common, but there are famous examples. Occasionally one encounters attempts to apply gold by hand to printed books, and to make it conform to typography. There are copies of incunabula in which headings, initials, or capitals are written in gold or traced over in gold. An example of the former was quoted by Dr F. R. Goff. It is the Lessing J. Rosenwald copy, now in the Library of Congress, of Cicero's *De Officiis*, printed in 1465 at Mainz by Fust and Schoeffer,⁸ in which the headings are supplied in gold writing, whereas they are printed in red in other copies. There are other books in which initials are painted in gold, while letters printed in black ink were carefully traced over in gold. One of them is the fine copy of Cornelius Celsus, *De Medicina*, printed in 1478 at Florence by Nicolaus Laurentii, now at the Royal College of Physicians.⁹ In the British Library there is a good example in a copy of the Dante edition printed by Johann Neumeister at Foligno in 1472.¹⁰

It is therefore a natural development that printers sought to achieve this effect by mechanical means. The fact that only on a very few occasions gold printing was carried out in the fifteenth century (and that it was rare in the centuries thereafter), in contrast with its lavish occurrence in manuscripts, should perhaps suffice as an indication that this could not have been a simple printing technique. The two printers who did print with gold in the fifteenth century both did so to herald a very notable technical innovation. Ratdolt explains in his dedicatory letter to the Doge that so far it had been impossible to print

mathematical works, because the difficulty of printing mathematical figures, 'without which nothing in this science can be well understood', had not yet been overcome. 'Having perceived', Ratdolt continues, 'that it was this alone that formed an obstacle to something that would be useful to all, I have achieved, by applying myself to the problem and not without putting in much hard work, that geometrical figures can be composed with the same ease as movable type.' Ratdolt had devised elementary geometrical forms in type metal which could be combined to form figures which, being in metal, could be printed at the same time as the typeset page. He has become famous for his illustrations and ingenious tables for calendars and astronomical works which are all variations on this particular skill. Ratdolt was a superb and inventive craftsman.

Callierges is hardly less famous for his Greek type which he had developed with much ingenuity and patience and for which he received ample praise. In the Greek type that makes its first appearance in the *Etymologicon Magnum* of 1499 he had found the solution for a difficult problem of typefounding.¹¹

Incunabulists have so far paid hardly any attention to the question by what technical means Ratdolt and Callierges applied their gold to print, although especially Ratdolt's Euclid is well known for this feature. The first reports of copies of the Euclid with gold printing were based on successive catalogues of the ancient library at Augsburg. They were dismissed with utter disbelief by Prosper Marchand, one of the early authorities on the history and spread of printing: 'ce n'est-là qu'une imagination frivole, absolument dénuée de tout fondement . . .' he wrote in his *Dictionnaire* of 1758-9.¹² However, at about the same time the Smith copy emerged, and its existence was made known in the catalogue of the *Bibliotheca Smithiana*, first issued in 1755, where it was described as 'Est autem Epistola Dedicatoria litteris aureis impressa' (p. clxi). Hence Gerard Meerman, a tireless investigator of the invention of printing, reproved Marchand in a lengthy note on the invention of printing ink in his *Origines Typographicae* of 1765.¹³ Meerman's terminology shows that he thought that the gold was applied in some sort of ink: 'Novum tandem impressioni decus adjecit Erhardus Ratdolt . . . compositione atramenti aurei impressorii, quali superbiunt exempla membranacea . . .' [Finally Erhard Ratdolt added new beauty to the art of printing . . . by composing gold ink for printing . . . which gave an outstanding quality to copies on vellum]. From then on the existence of gold printing was never challenged again, nor the statement that printing was carried out with gold ink, although this opinion may have derived from independent observations. K. Falkenstein devoted a chapter of his *Geschichte der Buchdruckerkunst* (1840) to gold printing, but did not comment on the technique.¹⁴ Konrad Haebler's *Handbuch der Inkunabelkunde* (1925, English translation 1933) is vague. It uses the term 'in Golddruck' in the German version, 'used gold' in English.¹⁵ In the general context one may expect that Haebler was thinking of some form of printing with ink. Bibliographers who concentrated on Ratdolt in particular, G. R. Redgrave and R. Diehl, expressed themselves in the same terms, as did C. Thomas-Stanford in his bibliography of early editions of Euclid. Proctor on Callierges was equally non-committal.¹⁶ More recently F. Geldner stated in his handbook *Inkunabelkunde* (1978) that Ratdolt had invented a suspension of gold ('Goldlösung'),¹⁷ a

theory that can also be found in Maggs's *Catalogue One Thousand* (1980). Maggs's catalogue refers to the Greek scholar Ambroise Firmin Didot for the opinion that Callierges 'did not powder gold but mixed [it] with varnish at boiling point, thus preserving its lustre'. Firmin Didot had used the phrase 'l'or n'est point sapoudré, mais fait corps avec le vernis auquel il est mêlé par la cuisson',¹⁸ a notion which is far from clear in itself but probably harks back to the printer's manual written by M. A. Brun which was printed and published in 1825 by the ancestral firm of Firmin Didot. When read in conjunction with Brun's explanation (see below) Firmin Didot's words take on a different meaning.

Recent literature, scant as it is, suggests that there is now a tendency to assume that Ratdolt used some mixture of gold (flaked gold, apparently) and varnish. This theory is probably influenced by the later methods of gold printing, using gold substitutes such as bronze powders, which were developed from the late seventeenth century on.¹⁹ Whether an exhibition label in the King's Library (now replaced) contributed to the dissemination of this theory remains a matter for speculation. A visitor to the King's Library with expert knowledge of early colour printing queried a few years ago the very positively stated contents of this label.²⁰ It was his comment, rapidly followed by two other enquiries reflecting the rising interest in early printing techniques, which led us to examine in the manuscript conservation workshop those instances of fifteenth-century gold printing which are represented in the British Library. The results of this investigation, given below, show that not only was gold printing used to inaugurate two technical innovations in printing, but that it was a delicate and complicated process which, as applied to typography, was a technical achievement in itself.

II

When studying manuscripts, early printed books, and bindings we can distinguish nowadays several methods of applying gold to paper, vellum, or leather. Flaked gold can be suspended in a binding medium (varnish or gum) and then be applied to all kinds of surfaces; powdered gold can be dusted over designs previously painted with an adhesive (this method was applied after the fifteenth century and is therefore not discussed in this article); gold leaf can be laid onto a coating of glaire or gum; and gold can be bonded to a surface with the help of a dry bonding agent, i.e. ground resin or dried egg-white, combining a slight rise in temperature with the pressure of a press. Under magnification the results of these methods show a great deal of difference.

Two of these methods can be seen together on a page of the Dante edition printed by Johann Neumeister at Foligno in 1472 (B.L., G.11346). The first page of this book is richly decorated with a colourful border on a gold background, and the capitals are gilded (figs. 3, 4). The printed capitals were painted over with gold pigment which consisted of a suspension of flaked gold. The surface of the capitals looks slightly grainy and shows no cracks at all. The thickness of the pigment caused a somewhat raised effect which was photographed with lighting at an oblique angle (fig. 5).

In the border the effect was achieved by entirely different means. Gold leaf was laid on a coating of glaire or gum and left unburnished. This gave a very flat and even effect which was suitable for decorations later to be painted onto the gold surface. As can be seen in fig. 3 the gold surface in the border shows numerous hair-line cracks. Gold laid on paper cracks easily because it forms a second surface which bends differentially. Moreover, it is difficult to lay onto an adhesive and it usually creases in the process.

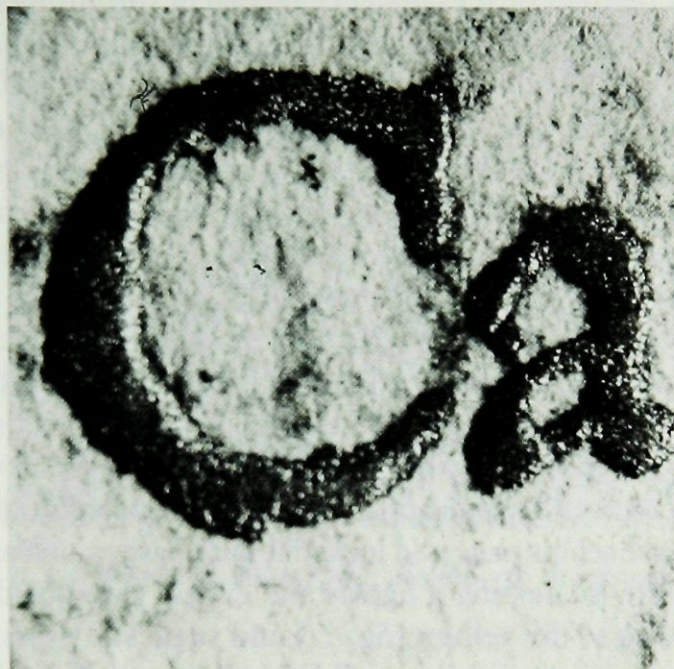


Fig. 5. Foligno Dante: the suspension of gold pigment causes a raised effect

However, the two instances of gold printing in the fifteenth century that we propose to examine here, Ratdolt's and Callierges's, do not conform to either of these methods. There is much evidence to suggest that their method was very much closer to the tooling technique used by bookbinders. In figs. 6 and 7 we can see that the gold surface shows pronounced cracks which are quite distinct in appearance from the hair-line cracks in the laid-on gold. These can be explained by the fact that gold leaf when applied to a surface rarely lies perfectly flat, but more usually creases. When pressure is applied to these slight elevations by a platen they break off, thus causing the sharp fissures in the surface which under high magnification can readily be distinguished from hair-line cracks. That these large cracks are not due to imperfections in the typographical material is demonstrated by a comparison of figs. 7 and 8 which show the same section of the border, one printed in red ink, the other printed in gold. The absence of cracks in the red impression shows that the border was quite intact.

Direct evidence that pressure was used is shown in fig. 9, a photograph which was also taken under oblique lighting. It shows deep indentation of the type. In fact the pressure was quite exceptionally heavy. The other side of the leaf (recto) which was left blank shows

clear risings. The blind bearer type at the bottom of the page of gold printing is also deeply indented in the vellum and provides further evidence for exceptional pressure. We may therefore conclude that gold leaf was used and not a gold pigment, and that it was applied by pressure, in the same way as a binder would use pressure to achieve an impression of his decorative tools on leather.

A further series of observations tells us a great deal more about the way the two printers in Venice set about the use of gold in typography. In what follows, these observations are interpreted in view of the practical experience of two of the authors with gold tooling of book bindings, but let it be emphasized that the observations come first and the question 'How could this be done?' a deliberate and distinct second.

In the first place we can see that Ratdolt set up a page in his ordinary text types which he also used for the rest of the book. His intention must have been to pull a limited number of copies with gold printing, of which there are now eight known to have survived. It is remarkable that one typesetting was used for the dedication page in the copies printed with gold, which measures 185×118 mm, whereas the ordinary print run of the page was printed in a different typesetting (although it had exactly the same contents), without the headline in larger type, and measuring 175×117 mm. That Ratdolt used the same typographical material for his gold printing as for his ordinary printing in black ink is self-evident by the identity of the typeface. It is moreover shown by an occasional smudge of black ink on the gold, where the type apparently had not been quite clean (fig. 10).

Ratdolt must first have set his page and locked it in a chase, much as usual. He then must have prepared the vellum by dusting it lightly and evenly with powdered adhesive. A few stray particles have clung to the vellum (fig. 11) and suggest by their appearance that the powdered substance may have been rosin. Experiments with gold techniques in the laboratory using rosin gave perfectly satisfactory results, suggesting that this material might indeed have been used. Another possibility is dried and powdered egg-white. The next step in the process was probably the slight heating of the typeface. It is worth noting that among adhesives rosin has a very low melting-point (about 100°C). Ratdolt's block of type could have been heated by placing metal bars on it which were then removed. If the type had been overheated there would have been traces of scorching of the vellum. In the copies of Ratdolt's gold printing that were examined no such traces were visible. This can be interpreted that Ratdolt either used no heat, or was adept at judging the heat required.²¹

Subsequently, the gold leaf was applied to the typeface. Transferring gold leaf is tricky. The process is described in considerable detail by Edward Johnston in his chapter on 'Laying & burnishing gold' in *Writing & Illuminating, & Lettering*. The method he suggests of cutting the gold leaf with sharp scissors as it is lying on a sheet of paper could have been applied in the fifteenth century.²² Experience tells us that gold leaf clings very easily and evenly to a metal surface that has been greased very lightly. The next step would be to press the type onto the vellum (or paper), and finally, after the heat had melted the powder and the pressure had fused the gold to the vellum wherever type met gold, bonding agent, and vellum, the last step would be to brush off the superfluous gold. For this last action there is an abundance of evidence. Under magnification ($40\times$) we see that

the vellum of the Ratdolt book is speckled with very tiny flecks of gold (not photographed). Occasionally larger fragments of gold have clung to the page, both in Ratdolt's and in Callierges's printing (see figs. 12, 13, 14).

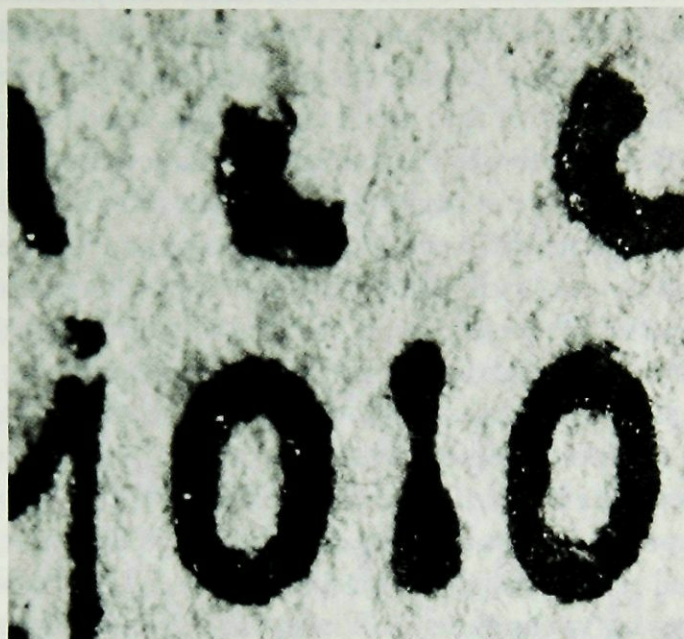


Fig. 13. Callierges: specks of gold clinging to the printing ink

It does not seem possible, however, to deduce with absolute certainty from the present material what kind of press was used. It was either a printing press or a bookbinder's press. On a printing press the typeset page would have rested on the bed of the press, and the paper or vellum was brought into contact with the type by means of a frisket. It is difficult to reconcile this folding movement with the fact that the vellum or paper must have been powdered with the bonding agent. Moreover, it is practically impossible to lay gold leaf flat on vellum or paper unless the surface is greased, which would have left marks. It is therefore easier to visualize the use of a binder's standing press where the vellum or paper would lie flat and the metal was put upside-down with the gold-leaf adhering to it. The fact that Ratdolt gave his page of gold printing a different dimension from the ordinary print run of this page may be relevant here. It was proved by experiment that gold leaf clings easily to type metal.

At this stage it seems more fruitful to return to direct observations. Ratdolt's result was close to perfection; a magnificent page of sharply imprinted type that does full justice to the two beautiful typefaces. Raised temperature and high pressure together would suffice to melt the powdered adhesive, punch out the shapes of type, and bond the gold to the vellum. The very slight unevenness in colour may be due to varying concentrations of the bonding powder (see, for example, the n in fig. 6), but this is not noticeable in the overall effect. Nevertheless, a few letters did not print well (see fig. 15). Perhaps there was not

enough bonding powder or the type may not have been hot enough. In the two copies examined in the Bibliothèque Nationale the i's were printed perfectly: unevenness in typesetting can therefore be ruled out as the cause for this defect.

Callierges was not quite as successful, and his pages may tell us therefore even more. The task he set himself was slightly different and more complicated. He wished to print a page of Greek type in black and white and to combine it with a border and an ornamental initial which are both red in most copies, but printed in gold in a few. His typographical decorations probably consisted of thin metal clapped on wood.

We compared the British Library's two copies of Ammonius that have gold printing with the illustration in Maggs's *Catalogue One Thousand* (1980), and noticed that between the three copies there are slight differences in the alignment of border with title and initial in relation to the page of type. From this we can deduce that there were three separate operations: the printing of the page of type, the printing of the border with the title, and the printing of the initial. It is quite clear that the gold printing took place after the printing of the type, as gold can be seen on top of the impression of black type (figs. 13, 16). The red printing was carried out before the black printing, as is proved by black showing over red, as can be seen for example in the copy IB.2474I on E 1 recto, E 1 verso, and E 2 verso. Therefore the printer's sequence was red, black, gold.

Callierges combined thin metal strips for his border and initial with the much thicker metal for the three lines of type in the title. These three lines of capitals belong to the same typeface as that used throughout the book. Lines of type react to heating in a way different from a shallow metal border, and retain heat for a longer period because of their larger volume. We can see in fig. 17 that the capitals got clogged and show a dark colour, in particular in the copy IB.2474I. This 'blocking' of the design was probably caused either by overheating or by maintaining the pressure for too long. In this case overheating is the likelier cause of the darker colour. The bonding agent bled through the gold on overheating and caused discoloration. The other copy is printed more successfully (fig. 18) but even here the result cannot match the relatively clear, although not perfect, outline of the same letters printed in red (fig. 19). Although the overall effect of the border and initial is very striking, scrutiny under magnification shows that the impression is far from perfect. Fissures in the gold surface, explained above (figs. 6, 7), combined with only partially complete bonding, caused some areas to peel off in the copy IB.2474I (fig. 20). For comparison the same area is shown in the other copy printed with gold (fig. 21) and in red (fig. 22). The 'blocking' of the red ink visible in fig. 22 is an indication of the shallowness of the metal border. In fig. 20 the presence of a dark yellow, almost brown substance underneath the gold is plainly visible. This can again be explained by overheating, just as in the case of the lines of capitals in the same copy. Overheating caused the bonding agent to singe slightly and to discolour. The same effect is visible in fig. 12 which shows another detail of the border of the same copy. Overheating, apparently, did not improve the quality of the bonding of the gold, but in fact could be one of the factors which contributed to the damage of the surface.

Finally, all three copies of Callierges's Ammonius show in yet another way evidence for

the application of heat. There was very little space between the initial and the type. The two B.L. copies, and also the Maggs copy, show abundant traces of gold just below and on the right-hand side of the initial (fig. 16). The gold forms a straight demarcation line. This is very different from the specks of gold visible on the type lower down the page (fig. 13) and the random gold flecks occasionally visible in the border (fig. 12). The rim of gold round the initial can be explained if we visualize that one or more strips of leaf gold were cut to size and applied to the initial with a very slight overlap. There was, of course, no bonding agent applied to the printed type, but the heat transmitted through the paper was sufficient to make the ink of the printed type tacky again and cause it to act as an adhesive. No pressure was applied to this type-printed area, yet it must have been impossible to rub off the gold altogether. The fact that there is not the slightest sign of smudging caused by rubbing off the gold shows that the black ink on the sheets had otherwise dried perfectly.

There is no mark of any great pressure used by Callierges. The capitals are only slightly indented. This may perhaps partly account for a result which under close scrutiny cannot quite match the precision of Ratdolt's work. Furthermore, Ratdolt's solid block of type retained heat more evenly than Callierges's combination of metals.

Although we can discern some difference in the application of the technique of gold printing by the two printers who practised it in Venice in the fifteenth century, there is no doubt that the similarity of what they did is striking. It is more than likely that, independent of each other, they both adapted the technique of gold tooling on leather that was known to bookbinders in Venice.

III

After these direct observations, and after considering what can be deduced from them, it is useful to see what printers' manuals had to say about gold printing during the handpress period. The gap in time of over two hundred years between the incunable period and the earliest information on gold printing is too long to be sure that any later technical description is relevant to what happened in 1482 or 1499-1500. Besides, very few handbooks went into details of gold printing. Joseph Moxon described in *Mechanick Exercises* (1683/4) the printing in gold of only a few words at a time.²³ They would be 'inked' in the composing stick with varnish, the stick would be reversed to stamp the words on paper which was placed on the correcting stone and gold leaf (or silver leaf) would then be applied to the surface with the sticky letters printed in varnish. The metal would adhere to the varnish and was gently pressed on with a piece of cotton. It would, of course, not adhere to the paper itself, and therefore the superfluous metal could be gently brushed off after drying. As Moxon deals only with the printing of a small surface it has certainly no bearing on Ratdolt's printing, and it is also unlikely, from what we have seen, to have had much similarity to the method employed by Callierges.

There is one source at the very end of the handpress period that goes a long way to confirm our observations and that adds some significant details. It is M. A. Brun, *Manuel pratique et abrégé de la typographie française* (Paris, 1825), which was printed and

published by the firm Firmin Didot. It deserves to be quoted in full, even if this account was dismissed not many years later as being too fiddling and impracticable in P. M. van Cleef's *Handboek ter beoefening der boekdrukkunst in Nederland* of 1844, which used Brun as its most important source.²⁴ Not every printer had the high ambitions of Ratdolt or Didot:

1. *Impression en or.* Ayez du blanc d'œuf séché au soleil et réduit en poudre impalpable. Sapoudrez légèrement le papier à l'endroit où vous voulez imprimer, et y appliquez l'or avec précaution, comme font les relieurs. La forme, composée en caractères neufs, épaulés exprès le plus à vif possible, doit être chauffée à un degré convenable, bien sèche, bien propre, et assez serrée pour que les espaces ne bougent pas.

2. Posez sur la marbre de la presse une feuille de carton à satiner bien lisse, par-dessus une feuille de papier vélin humide, ensuite la feuille que vous venez de préparer et qui doit être sèche. On présente la composition au-dessus de la feuille à imprimer l'œil en-dessous; mais elle y reste suspendue sur quatre ressorts qui l'empêchent de toucher au papier, et entre dans des repères, ou pointures, qui font un registre, afin de marger droit et de pouvoir ensuite imprimer en une autre couleur s'il y a lieu.

3. Mettez un blanchet sur le cul de lettre.

4. Dans cet état, roulez doucement le train sous la platine, tirez le barreau et restez un instant sur le coup.

5. Il faut que l'opération se fasse assez promptement pour ne pas donner à la feuille dorée le temps de prendre l'humidité de la feuille de-dessous avant l'impression. Enlevez ensuite le superflu de l'or et de la préparation avec une étoffe de laine sèche ou une petite brosse de blaireau.

6. Il faut avoir soin de changer le carton et la feuille humide à chaque exemplaire qu'on veut exécuter.

1. Take egg-white, dried in the sun, and reduce it to a very fine powder. Very lightly powder the surface of the paper where you intend to print, and carefully put the [transfer-]gold on top in the way binders do. The forme of type, set with newly cast type with shoulders as sharp as possible, should be heated to the appropriate temperature; the forme should be dry, clean, and compactly set for the spaces should not move.

2. Place on the press stone a smooth sheet of cardboard, and on top of this a damp sheet of wove paper, and finally the sheet you wish to print which you have just prepared and which should be dry. Bring the typeset page upside down over the leaf you wish to print; the forme will hang suspended over the paper from four springs which will prevent it from touching the paper, and [the paper] has to enter into points, in order to make register for a well-aligned margin and for printing in another colour [in a second pull] if desired.

3. Mask the lower margin with a patch of paper.

4. Gently run in the carriage under the platen, pull the bar, and dwell for an instant on the pull.

5. This operation should be carried out rather fast, to prevent the leaf printed with gold getting any of the moisture from the sheet placed below it before it is printed. Finally brush off the superfluous gold with a dry woollen cloth or a small brush of badger hair.

6. One has to change the cardboard and the dampened sheet for each sheet that one has to print.

**Erhardus ratdolt Augustensis impres
sor Serenissimo Almae urbis venetae
Principi Joanni Mocenico .S.**

Solebam antea Serenissime Princeps mecū ipse cogitans admi-
rani quid causae esset: q̄ in hac tua praepotenti ⁊ fausta vrbe cū varia
anctorum veterū nonorūq; volumina quottidie imprimerent. In
hac mathematica facultate vel reliquarum disciplinarū nobilissima
aut nihil aut parua quaedam ⁊ frivola in tanta impressorū copia qui
in tua vrbe agunt: videntur impressa. Haec cum mecū saepius discu-
terem: inueniebam id difficultate operis accidisse. Non enim adhuc
quo pacto schemata geometrica: quibus mathematica volumina sca-
lent: ac sine quibus nihil i his disciplinis fere intelligi optime potest
excogitauerant. Itaq; cum hoc ipsum tantūmodo cōmuni omnium
utilitati quae ex his percipitur obstarer: mea industria nō sine maximo
labore eff. ci. ut qua facilitate litterarum elementa imprimuntur. ea
etiam geometricae figurae conficerent. Quamobrem ut spero hoc
nostro inuento hae disciplinae quas mathematica graeci appellant
voluminū copia sicuti reliquae scientiae breui illustrabūf. De quaz
laudibus ⁊ utilitate possem multa impraesens adducere ab illustribus
collecta auctorib⁹: nisi studiosis iam omnib⁹ haec nota essent. Illud
etiam plane cognitū est caeteras scientias sine mathematib⁹ imper-
fectas ac veluti mancas esse. Neq; hoc profecto negabūt Dialectici
neq; Philosophi abnuent: in quoz libris multa reperiunt: quae si-
ne mathematica ratione minime intelligi possunt. Quam diuin⁹ ille
Plato moere veritatis arcanū. ut adipisceretur cyrenas ad Theo-
dorum summum eo tempore mathematicū ⁊ ad egyptios sacerdotes
enavigavit. Quid q̄ sine hac vna facultate viuendi ratio nō perfecte
constat. Nam ut de musice taceam: quae nobis muneri ab ipsa natu-
ra ad perferendos facili⁹ labores p̄cessa videtur: ut astrologiā prae-
teream qua ex cultu caelū ipsum veluti scalis machinisq; quibusdā
conscendentes verum ipsius naturae argumentum cognoscimus: sine
arithmetica ⁊ geometria: quarū altera numeros altera mēsuras do-
cet: cuiusmodi comodeq; viuere qui possum⁹. Sed quid ego i his mo-
ror: quae iam omnibus ut dixi: notiorū sunt q̄ ut a me dicantur. Eu-
clides igitur megarensis serenissime princeps qui. xv. libris omnem
geometriae rationem p̄summatissime complexus est: quem ego sum-
ma ⁊ cura ⁊ diligentia nullo praetermisso schemate imprimendū cu-
raui: sub tuo numine ratus foelixq; prodeat.

Fig. 1a. Ratdolt: the dedication to the Doge Giovanni Mocenigo, printed in gold



Fig. 1b. Ratdolt: the opening page of Euclid, *Elementa* (1482)



Fig. 3. Foligno Dante: gold leaf laid onto a coating results in a flat surface with hair-line cracks



Fig. 4. Foligno Dante: a printed capital painted over with a suspension of flaked gold



Fig. 9. Ratdolt: type and bearer type show heavy indentation in the vellum



Fig. 6. Ratdolt: pronounced cracks where the platen has broken the creases in the gold leaf



Fig. 7. Callierges: imperfections and cracks in the surface



Fig. 10. Ratdolt: the type was not new as a smudge of printing ink shows



Fig. 8. Callierges: the same section in red shows that the typographical material was perfect

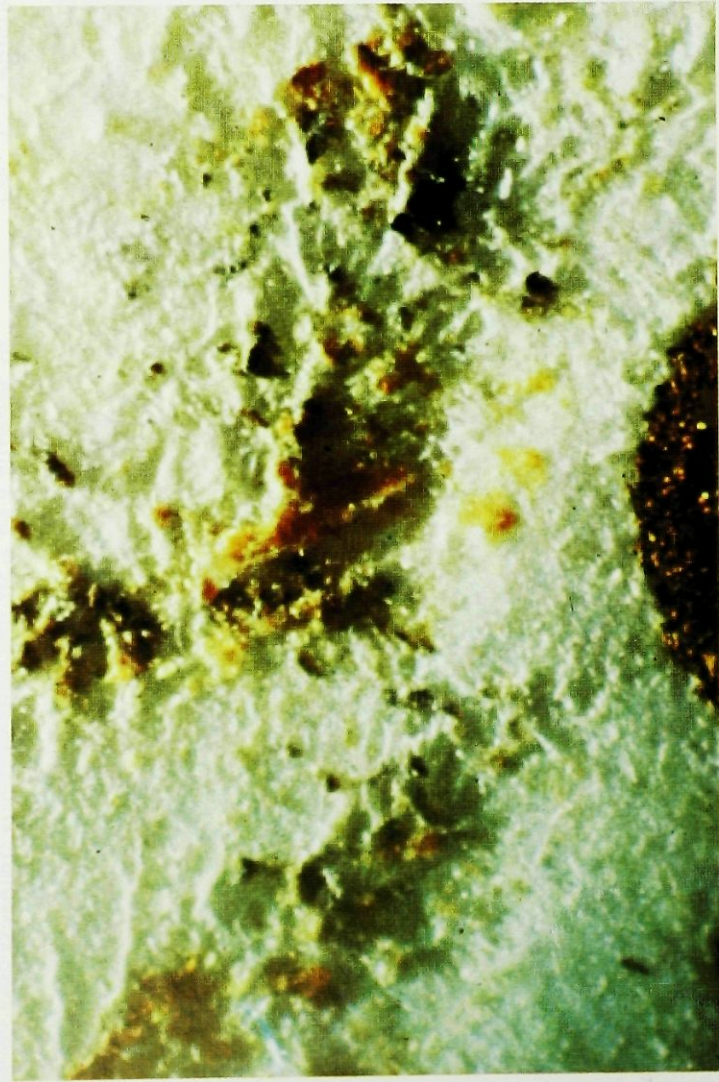


Fig. 11. Ratdolt: the adhesive was probably powdered rosin, as a stray crystal shows

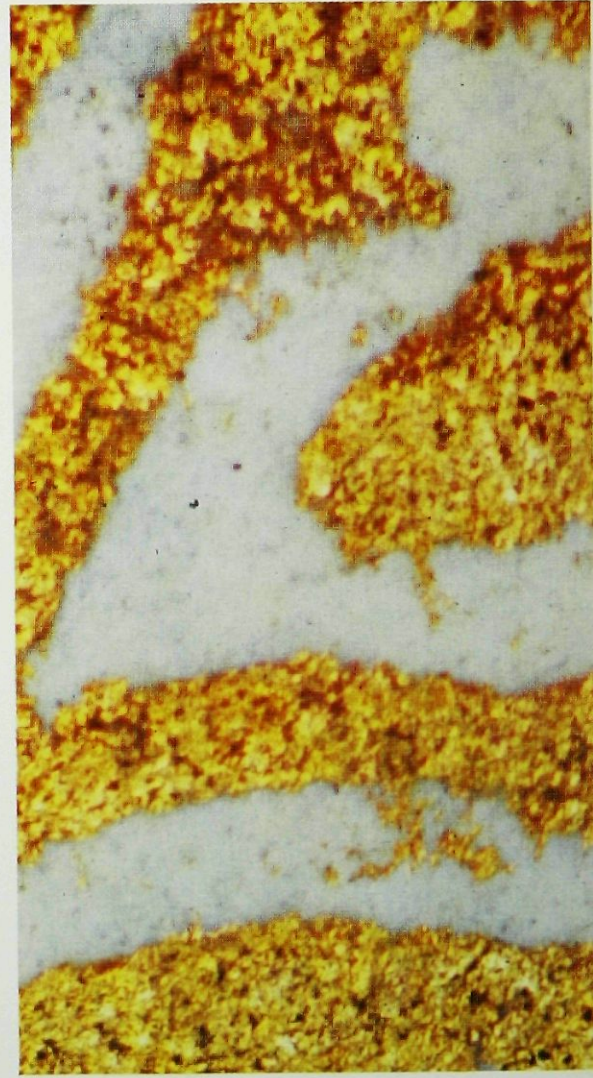


Fig. 12. Callierges: particles of gold remain on the paper



Fig. 14. Ratdolt: a fleck of gold remains in the middle of the letter n

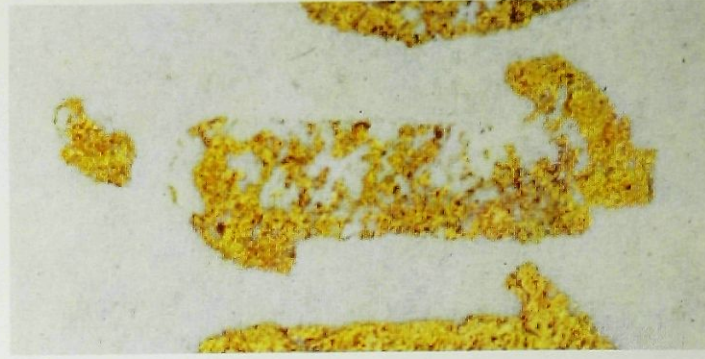
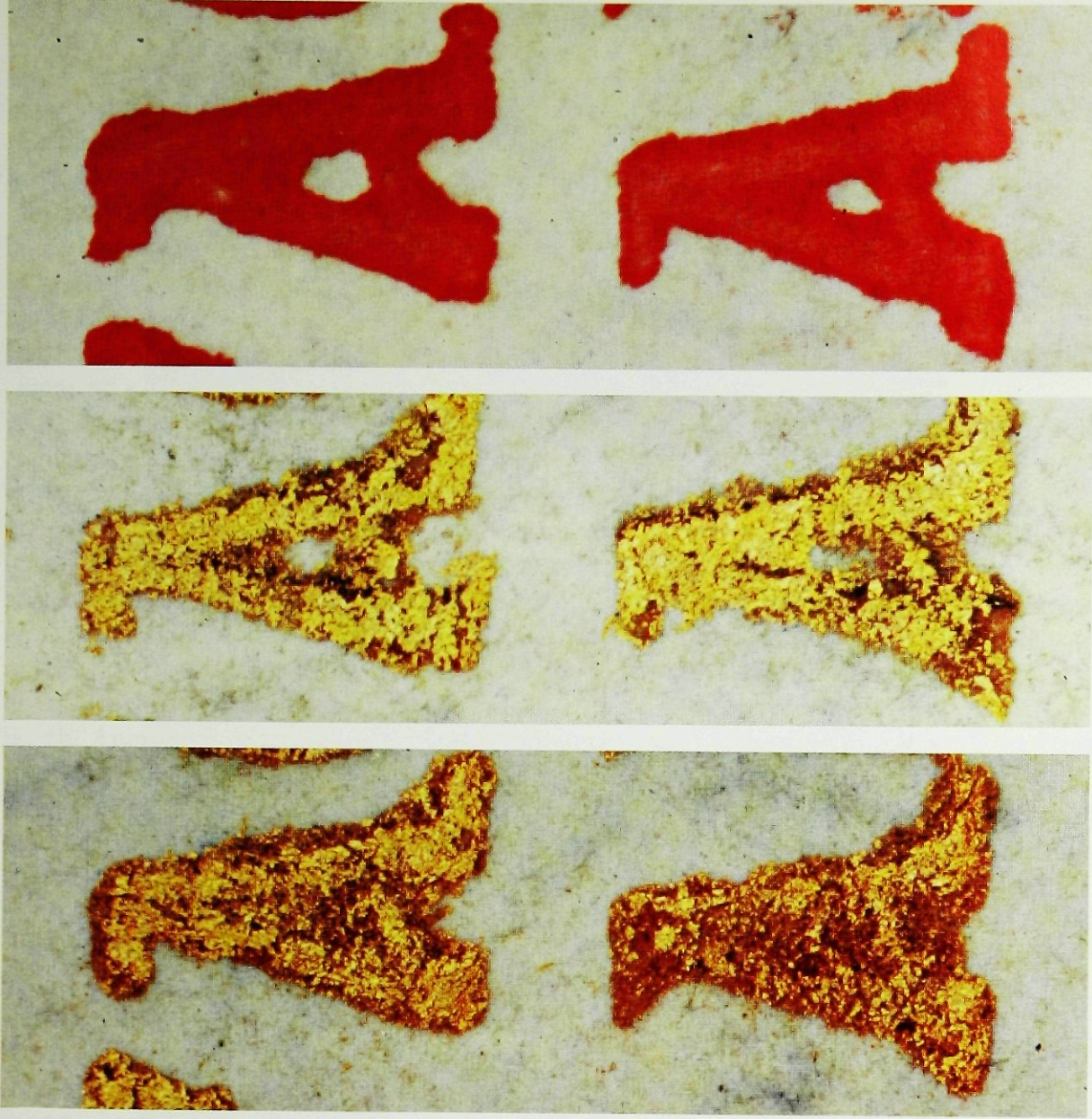


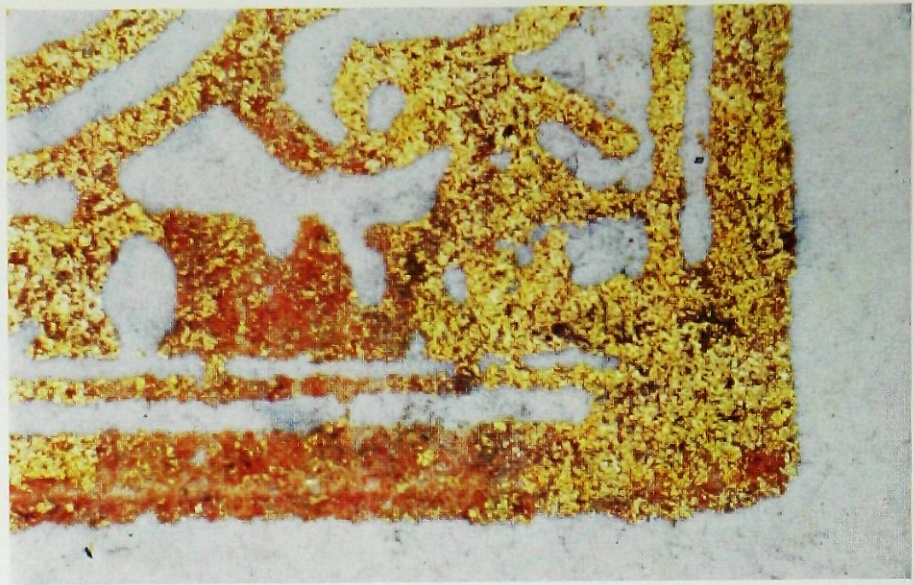
Fig. 15. Ratdolt: a letter (i) printed imperfectly



*Fig. 16. Callierges: gold on the first line
of type below the gold initial*



Figs. 17-19. Callierges: different impressions of the same letters in three copies: 17. clogged and dark (overheated); 18. a sharper impression and lighter; 19. a clear outline in red



Figs. 20-22. Callierges: different impressions of the same border detail: 20. a dark substance shows beneath the gold, where it has peeled off; 21. a good impression remains intact; 22. the clogging of the red ink indicates the shallowness of the metal border

Further details of the illustrations

- Fig. 1a-b. Euclid, *Elementa* (Venice: Erhard Ratdolt, 25 May 1482) C.2.c.1, fols. a 1^v and a 2^r
- Fig. 2. Ammonius Hermeas, *Commentarii in quinque voces Porphyrii* [Greek] (Venice: Zacharias Callierges, 23 May 1500) IB.24741, fol. A 2^r
- Fig. 3. Dante Alighieri, *Divina Commedia* (Foligno: Johann Neumeister, 11 April 1472) G.11346, fol. a 2^r (enlargement 9 ×)
- Fig. 4. Dante Alighieri, *Divina Commedia* (Foligno, 1472) G.11346, fol. a 2^r, l. 26 (enlargement 10 ×)
- Fig. 5. Dante Alighieri, *Divina Commedia* (Foligno, 1472) G.11346, fol. 92^r, l. 4 (enlargement 10 ×)
- Fig. 6. Euclid, *Elementa* (Venice, 1482) C.2.c.1, fol. a 1^v, l. 24 (enlargement 18 ×)
- Fig. 7. Ammonius Hermeas, *Commentarii* (Venice, 1500) IB.24741, border section (enlargement 10 ×)
- Fig. 8. Ammonius Hermeas, *Commentarii* (Venice, 1500) 167.e.10(2), border section as in fig. 7 (enlargement 10 ×)
- Fig. 9. Euclid, *Elementa* (Venice, 1482) C.2.c.1, fol. a 1^v (enlargement 3 ×)
- Fig. 10. Euclid, *Elementa* (Venice, 1482) C.2.c.1, fol. a 1^v, l. 5 (enlargement 13.5 ×)
- Fig. 11. Euclid, *Elementa* (Venice, 1482) C.2.c.1, fol. a 1^v, l. 11 (enlargement 35 ×)
- Fig. 12. Ammonius Hermeas, *Commentarii* (Venice, 1500) IB.24741, fol. A 2^r (enlargement 22 ×)
- Fig. 13. Ammonius Hermeas, *Commentarii* (Venice, 1500) IB.24741, fol. A 2^r (enlargement 12 ×)
- Fig. 14. Euclid, *Elementa* (Venice, 1482) C.2.c.1, fol. a 1^v, l. 4 (enlargement 14.5 ×)
- Fig. 15. Euclid, *Elementa* (Venice, 1482) C.2.c.1, fol. a 1^v, l. 3 (enlargement 20 ×)
- Fig. 16. Ammonius Hermeas, *Commentarii* (Venice, 1500) IB.24741, fol. A 2^r, l. 12 (enlargement 13 ×)
- Fig. 17. Ammonius Hermeas, *Commentarii* (Venice, 1500) IB.24741, fol. A 2^r (enlargement 9 ×)
- Fig. 18. Ammonius Hermeas, *Commentarii* (Venice, 1500) G.8015, section as in fig. 17 (enlargement 9 ×)
- Fig. 19. Ammonius Hermeas, *Commentarii* (Venice, 1500) 167.e.10(2), section as in fig. 17 (enlargement 9 ×)
- Fig. 20. Ammonius Hermeas, *Commentarii* (Venice, 1500) IB.24741, section of border on fol. A 2^r (enlargement 8 ×)
- Fig. 21. Ammonius Hermeas, *Commentarii* (Venice, 1500) G.8015, section as in fig. 20 (enlargement 8 ×)
- Fig. 22. Ammonius Hermeas, *Commentarii* (Venice, 1500) 167.e.10(2), section as in fig. 20 (enlargement 8 ×)

Equipment and method used to obtain photomicrographs

35 mm camera, stereo-microscope with photo-tube, LS 10 light source, fibre-optic cables and beam spreaders, ring flash unit, flash meter.

The camera was coupled to the photo-tube of the microscope by using an adaptor which replaced the camera lens. The ring flash unit was clamped underneath the objective lens of the microscope in order to give a flat, even light which was triggered from a flash meter.

When an oblique light was required a different approach was used. The volume from which the photograph was to be taken was placed below the camera microscope as usual, but instead of the flash unit, up to three variable light sources with fibre-optic cables attached were used, so that (due to the flexibility of the cables) the light could be moved around to obtain the best angle for illuminating the leaf. For example, fig. 9 was photographed by using three cables directed carefully

onto the surface, two to give background light and a third to show up the indentation of the bearer type.

Magnification and focusing were assessed through the microscope. Exposures were bracketed in the range of $\frac{1}{15}$ – $\frac{1}{2}$ sec.

A daylight-balanced colour transparency film was used with the ring flash and a tungsten-balanced film was used with the LS 10 fibre optics. The black-and-white photographs were taken on a medium-spread fine-grain film.

- 1 C.2.c.1, BMC v. 285. *Bibliotheca Smithiana* (Venice, 1755), p. clxi.
- 2 GW 9428. M. B. Stillwell, *The Awakening Interest in Science During the First Century of Printing 1450–1550* (New York, 1970), ii, no. 163. The printing of this book was a complicated procedure, as appears from the variant states of the first nine leaves, and other variants. The copies with gold printing and the other vellum copies seem to belong to the early state of the edition. Curt F. Bühler has shown that it is likely that normally a few sheets of paper were run off before vellum sheets were put on the press. He proved this in any case for sheet 01.8 where the vellum copies all have the second correction state, like the great majority of paper copies. See C. F. Bühler, 'A Typographical Error in the Editio Princeps of Euclid', *Gutenberg-Jahrbuch* 1966, pp. 102–4. The page in gold was set by a compositor who was not the same man as the compositor who set this page for printing in black. This appears from consistent differences in spelling (e.g. egyptios/egiptios, foelix/felix, moere/mere). The measurement of the page in gold is 185 × 118 mm (204 × 118 mm if one includes the bearer type at the bottom); in black the page measures 175 × 117 mm. The gold page is conjugate with a¹⁰ in all copies examined.
- 3 Hain *15518. Géza Sajó and Erzsébet Soltész, *Catalogus incunabulorum quae in bibliothecis publicis Hungariae asservantur* (Budapest, 1970), no. 3324. Cf. J. Fitz in *Gutenberg-Jahrbuch* 1937, pp. 97–106, and I. Hubay in *Gutenberg-Jahrbuch* 1962, pp. 390–9. Cf. note 19.
- 4 BMC ii. 381.
- 5 The technical innovation has recently been re-examined and discussed by N. J. Barker, *Aldus Manutius and the Development of Greek Script and Type in the Fifteenth Century* (forthcoming).
- 6 Aberdeen University Library, Inc. 132, see W. S. Mitchell, *Catalogue of the Incunabula in Aberdeen University Library* (Aberdeen, 1968), p. 49. Athens, National Library of Greece, two copies, see D. E. Rhodes, *Incunabula in Greece. A First Census* (Munich, 1981), no. A6. London, British Library, G.8015 and IB.24741 (BMC v. 580). Rome, Biblioteca Corsiniana. Biblioteca Apostolica Vaticana, see T. Accurti, *Editiones saeculi XV pleraeque bibliographis ignotae* (Florence, 1930), p. 123. Maggs Bross. Ltd., *Catalogue One Thousand* (London, 1980), no. 3. There are no copies of the *Etymologicon Magnum* with gold printing known to survive. A. Firmin Didot, *Alde Manuce et l'hellénisme à Venise* (Paris, 1875), p. 599 note 1, mentions a copy in the National Library in Athens, but he must have confused this with the Ammonius. He had also seen a copy with gold printing of the Ammonius, then in the collection of Prince Mavrocordatou. We are most indebted to the Director of the National Library of Greece and to Mr L. Hoffmann of the *Gesamtkatalog der Wiegendrucke* for information on this point.
- 7 Hain *14757. F. R. Goff, 'A Few Footnotes to Konrad Haebler's "Handbuch der Inkunabelkunde"', D. E. Rhodes (ed.), *Essays in Honour of Victor Scholderer* (Mainz, 1970), p. 177, mentioned the Heber copy which was offered for sale by E. Ph. Goldschmidt & Co., *Catalogue* 134 (1966). It is now in the University Library, Amsterdam (Inc. 411) after passing through Internationaal Antiquariaat Menno Hertzberger. We are most grateful to the late Mr Menno Hertzberger, Mr Jacques Vellekoop, and Dr A. K. Offenbergh for this information. One of the two copies in The National Library of Scotland, Edinburgh (Inc.205.61) also contains gold printing on A2 (ornament); the copy Inc.205.6 has the ornament in red.
- 8 GW 6921. F. R. Goff, *Incunabula in American Libraries. A Third Census* (1964), C-575. F. R. Goff, 'A Few Footnotes to Konrad Haebler', p. 177.
- 9 GW 6456. Dr D. E. Rhodes kindly drew my attention to this copy.
- 10 BMC vi. 599–600; G.11346, GW 7958.

- 11 See note 5 above.
- 12 Prosper Marchand, *Dictionaire historique, ou Memoires critiques et litteraires, concernant la vie et les ouvrages de diverses personages distingues, particulièrement dans la Republique des lettres*, 2 vols. (La Haye, chez Pierre de Hondt, 1758-9), vol. ii, p. 158 note B. An attempt to follow up Marchand's reference to a page in his own *Histoire de l'Imprimerie* (1740) was unfruitful.
- 13 Gerardus Meerman, *Origines Typographicae*, 2 vols. (Hagae Comitum, Nicolaus van Daalen, Parisiis, G. F. de Bure, and Londini, Th. Wilcox, 1765), vol. i, I ac (p. 12).
- 14 K. Falkenstein, *Geschichte der Buchdruckerkunst* (Leipzig, 1840), pp. 366-8.
- 15 K. Haebler, *Handbuch der Inkunabelkunde* (Leipzig, 1925), p. 109. Translated into English by L. E. Osborne with the title *The Study of Incunabula* (New York, 1933). Gold printing is mentioned on p. 133.
- 16 G. R. Redgrave, *Erhard Ratdolt and his Work at Venice* (London, the Bibliographical Society, 1894), p. 16; R. Diehl, *Erhard Ratdolt, ein Meisterdrucker des XV. und XVI. Jahrhunderts* (Vienna, 1933), p. 16; C. Thomas-Stanford, *Early Editions of Euclid's Elements* (London, the Bibliographical Society, 1926), pp. 4, 5, no. 1. R. Proctor, *The Printing of Greek in the Fifteenth Century* (London, the Bibliographical Society, 1900), p. 119. Proctor surmised that the gold was added by hand after the type had been inked, and that the whole was then printed at one pull. He observed that the letters adjoining the initial were 'gilded'. He did not give any indication what, in his opinion, the substance of the gold was.
- 17 F. Geldner, *Inkunabelkunde. Eine Einführung in die Welt des frühesten Buchdrucks* (Wiesbaden, 1978), p. 56.
- 18 A. Firmin Didot, op. cit., p. 559 note 1.
- 19 C. H. Bloy, *A History of Printing Ink, Balls and Rollers 1440-1850* (London, 1967), pp. 92-3. See, however, C. W. Gerhardt, 'Goldbronze von der Antike bis zur Gegenwart', *Wolfenbütteler Notizen zur Buchgeschichte*, iv (1979), p. 54, stating that bronze inks were first used in 1556, and G. Borsa, 'Az első, aranyfestéssel készült nyomtatvány és annak magyar vonatkozásai', *Magyar Könyvszemle*, xcvi (1980), pp. 217-29; the author examined the Budapest copies of the *Chronica Hungarorum* (see note 3) and established that they were printed with gold ink.
- 20 We are grateful to Dr Michael Bury, Department of Fine Arts, Edinburgh University, for his comments on the exhibition label. Later we received requests for information from Dr C. W. Gerhardt, Mainz, and Dr Gideon Borsa, Budapest. We are grateful for their stimulating remarks.
- 21 Two copies were superficially examined in Paris, Bibliothèque Nationale, without optical aids other than a magnifying glass. Neither copy shows any sign of scorching. In the paper copy, Rés.g.V.34, the gold seems a little darker than in the B.L. copy. The impression is strong and the bearer type is well visible, but the impression is not quite as pronounced as in the B.L. copy. The page is splendid and quite intact. The S in line 3 has printed much better than in the B.L. copy. The paper is the same as noted in other parts of the book (watermark: scales). The other copy, Rés. vélins 1027, also shows a strong impression, but again not quite as strong as the B.L. copy. A few letters have printed defectively. There is a little more flaking of the gold visible than in the copy on paper.
- 22 Edward Johnston, *Writing & Illumination, & Lettering* (London, 1906), p. 118, fig. 99.
- 23 J. Moxon, *Mechanick Exercises on the Whole Art of Printing* (ed. H. Davis and H. Carter, second edition, London, 1962), pp. 301-2.
- 24 P. M. van Cleef Jzn., *Handboek ter beoefening der boekdrukkunst in Nederland voorafgegaan van eene beknopte geschiedenis dezer kunst* ('s-Gravenhage, 1844; ed. F. A. Janssen, Amsterdam, 1974), p. 146.

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