JOURNAL

of the

American Research Center In Egypt

VOLUME XXXV

1998

Published by

THE AMERICAN RESEARCH CENTER IN EGYPT

Digital Epigraphy: An Approach to Streamlining Egyptological Epigraphic Method

PETER DER MANUELIAN

Introduction

It is no secret that the rate of deterioration of Egyptian monuments has long since reached a crisis phase. Despite the best efforts of many, the annual loss of Egypt's ancient cultural heritage proceeds at such an accelerated pace that many of the monuments taken for granted by the current generation will not survive into the new millennium (figs. 1–2).[1] The focus of this paper is not the physical protection and conservation of the monuments, although this is of course of paramount importance, but rather their facsimile "conservation." It is suggested that the time has come to take advantage of new technologies in re-evaluating some of Egyptology's traditional documentation methods (see fig. 3). The remarks below consider the case for streamlining the epigraphic process as currently practiced in Egyptology.

I hope to avoid excess discussion here of computer terminology, specific hardware and software products, or their prices.[2] This is intended to keep the focus on epigraphy and eliminate the clutter of unnecessary technical jargon, or of emphasis on a particular brand of hardware or software. Although each user might have his or her own equipment preferences, satisfactory results are attainable with most of the major brands of computer platforms currently available. Moreover, due to the daunting pace of current technological developments, detailed descriptions of specific equipment, and indeed the state of the art in general, will most likely be out of date by the time these remarks appear in print. The underlying epigraphic principles, however, will not.

Epigraphy Then and Now

A number of documentation procedures have evolved over the decades since the first great epigraphic campaigns of the last century (Champollion, Rossellini, Lepsius),[3] but each procedure—taken by itself—almost always leaves something to be desired in comparison to the original monument. Published photographs provide the truest reproduction of the ancient wall, but are often marred by difficult lighting conditions, cracks and other types of damaged areas; these can be misread as carved or painted lines. Facsimile line drawings are an indispensable part of proper documentation, but these can introduce potential bias and/or oversight on the part of the modern artist. The best examples of Egyptological epigraphy have always combined the expertise of several specialists—photographers, epigrapher/artists and Egyptologists—in the conviction that the combined

[1] For some sobering images of deterioration at Saqqara, see N. Kanawati and A. Hassan, *The Teti Cemetery at Saqqara II, The Tomb of Ankhmahor*, Australian Centre for Egyptology Reports 9 (Wiltshire, 1997), pls. 26–28. The situation with the Theban tombs has been recently discussed by Arpag Mekhitarian, *La misère des tombes thébaines*, Monumenta Aegyptiaca VI (Brussels, 1994).

[2] A short summary of the equipment required for digital epigraphy is provided in the appendix at the end of this article.

[3] See Champollion, *Monuments de l'Egypte de la Nubie* 1–4 (Paris, 1835–45); I. Rossellini, *I monumenti dell'Egitto e della Nubia* (Pisa, 1832–44); C. R. Lepsius, *Denkmaeler aus Aegypten und Aethiopien* 1–12 and *Ergänzungsband* (Berlin, 1849–58, Leipzig, 1913).

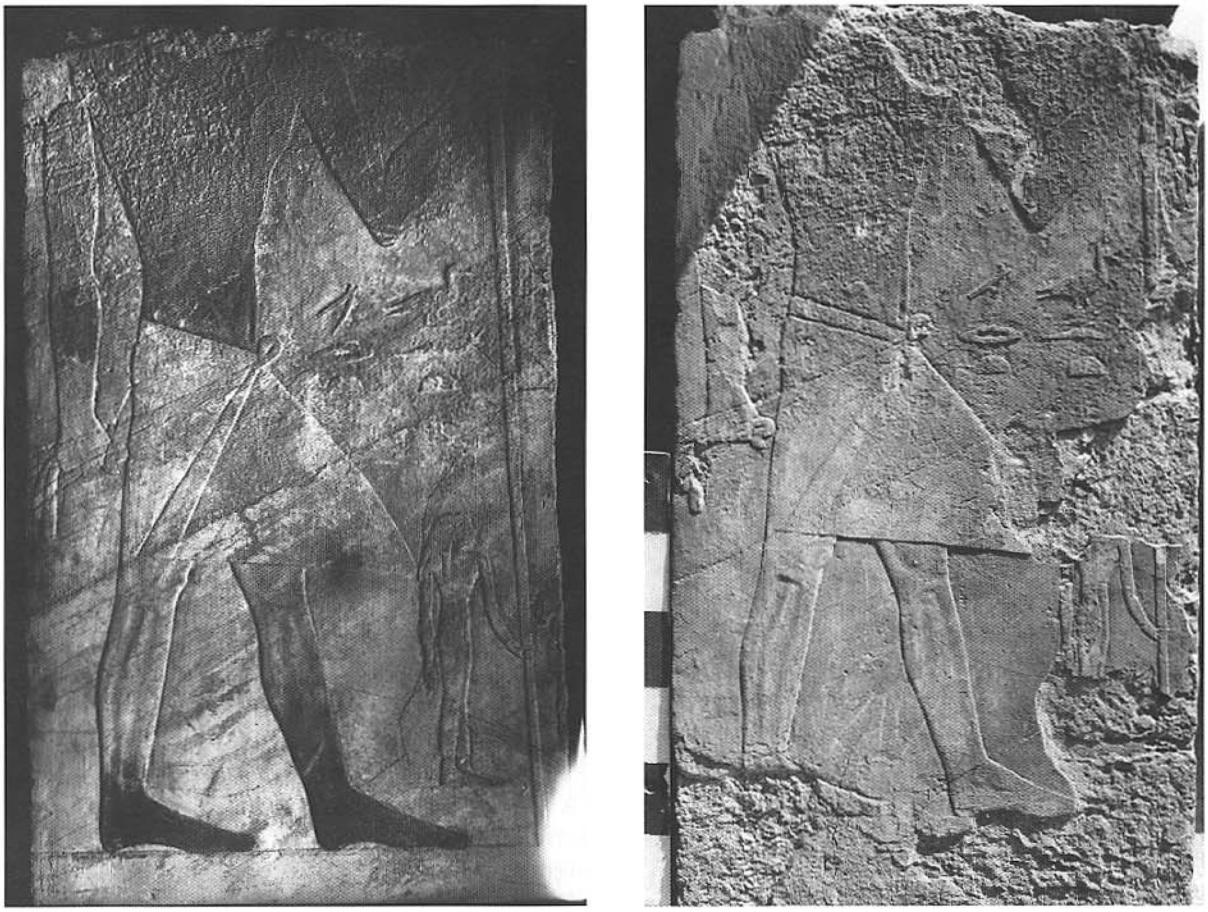

Fig. 1. Damage at Giza between 1938 and 1989. Cf. A. M. Roth, Giza Mastabas *6, pls. 19a, 19c.*

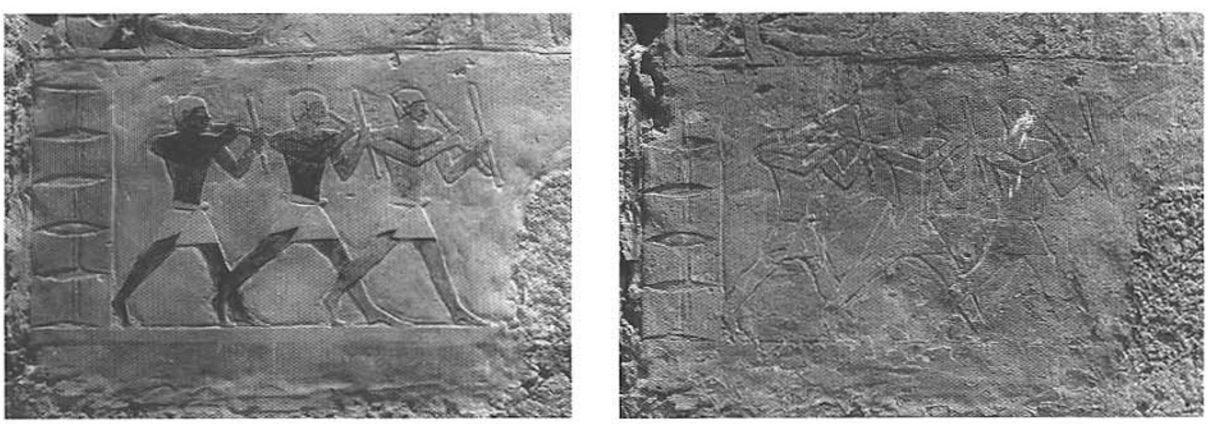

Fig. 2. Damage at Giza between 1936 and 1989. Cf. A. M. Roth, Giza Mastabas *6, pls. 74a–75b.*

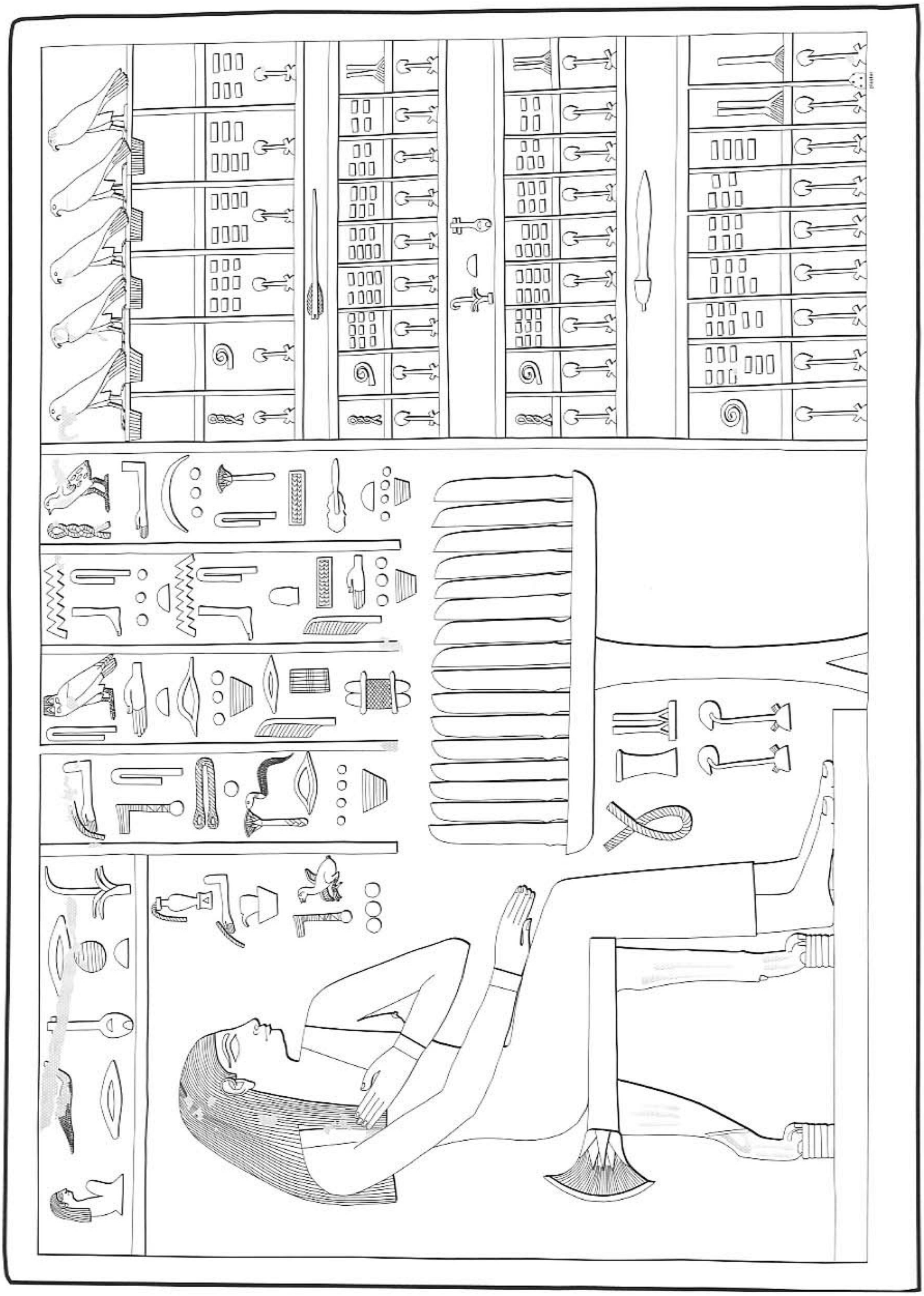

Fig. 3. Digital line drawing of a Giza slab stela by means of the computer; no ink was used.

result is far more useful than any of the individual elements by themselves.

Egyptologists and epigraphers have employed many different methods in the production of facsimile line drawings of Egyptian tomb and temple walls. Probably the two most common are direct 1:1 tracing at the wall, and tracing of photographic enlargements. It is far beyond the scope of these pages to describe all of the different practices or provide a history of epigraphic methods.[4] Instead, the approach outlined below grew out of the author's search for an efficient system that would allow the most time- and cost-efficient recording possible, yet in a scientifically responsible manner. This epigraphic approach therefore attempts to combine the high quality and accuracy of such methods as are employed by the Epigraphic Survey of the Oriental Institute, University of Chicago ("Chicago House"),[5] while accelerating the process to allow for the documentation of more monuments in less time. We might call this process "digital epigraphy" for lack of a better term.

In preparing future volumes for the *Giza Mastabas* Series, much of the work has come to involve the computer as a vital part of the epigraphic process. This machine is far from a replacement for human Egyptological, epigraphic or artistic talent or creativity, but rather just another tool for use in the epigraphic process. Moving from ink to the computer screen might best be understood as analogous to the way the rapidograph technical pen replaced the crowquill point as a better drawing tool. In other words, none of the intellectual aspects of epigraphic practice (scene and content analysis, inscriptional expertise, reconstruction of fragments and lacunae) is "automated," outmoded or eliminated by the computer.

As applied to Egyptological drawing, digital epigraphy consists of the following two steps, to be briefly discussed in turn below:

1) preparation of digital or digitized (scanned) photographs of the ancient wall as the base or template for "on-screen tracing;"
2) use of vector-based (rather than pixel-based; see fig. 4 below) computer software to trace the digital photographic image on the computer.

1) The photographic base

Due to the often fragile condition of ancient monuments, the avoidance of excessive physical contact through direct wall tracing (affixing tracing papers directly to the ancient wall surface) is always desirable. Other inconveniences of direct wall tracing include the partial opacity of some drawing papers and films, often obscuring the ancient carved lines, and the misalignment and shifting of the drawing film during the tracing process due to wind or adhesion problems. Photograph-based tracing offers a number of advantages, among them working on a more manageable scale (especially where long temple walls are concerned), ease of handling and transportation of drawing materials (versus large rolls of 1:1 tracings) and, perhaps most important, optimum epigraphic "chronology." While direct wall tracing limits the epigrapher to one specific moment of the wall's preservation in time, photographs taken in different years provide the

[4] For just a few references on the subject, see Henry G. Fischer and Ricardo Caminos, *Ancient Egyptian Epigraphy and Palaeography*, 3rd edition (New York: The Metropolitan Museum of Art, 1987); and Lanny Bell, "The Epigraphic Survey: Philosophy of Egyptian Epigraphy after Sixty Year's Practical Experience," in Jan Assmann, Günter Burkard and Vivian Davies, eds., *Problems and Priorities in Egyptian Archaeology* (London: Kegan Paul International, 1987), 43–55; Edward Brovarski, "Epigraphic and Archaeological Documentation of Old Kingdom Tombs and Monuments at Giza and Saqqara," in Nancy Thomas, ed., *The American Discovery of Ancient Egypt. Essays* (Los Angeles, 1996), 25–43; and Lanny Bell, "New Kingdom Epigraphy," ibid., 97–109, with important bibliography; Christian E. Loeben, "Anmerkungen zu jüngsten Arbeiten ägyptischer Epigraphik," *Arcus, Berichte aus Archäologie, Baugeschichte und Nachbargebieten* 3 (Berlin, 1996), 15–27. For a few descriptions of epigraphic practices as applied to specific projects, see Klaus-Peter Kuhlmann and Wolfgang Schenkel, *Das Grab des Ibi* I (Mainz, 1983), 12–13, and Ann Macy Roth, "The Testing of an Epigraphic Method," *NARCE* 141 (Spring, 1988), 7–13.

[5] I am indebted to a number of individuals for sharing their own epigraphic expertise with me over the years, in particular Lanny Bell and W. Raymond Johnson. Digital epigraphy borrows much from and thus owes much to the Chicago House method. For helping to bring the computer into the Egyptological epigraphic process, and overcoming many of the initial technological challenges, I wish to acknowledge the technical brilliance and generosity of the late William Riseman. I also thank Lanny Bell for his insightful comments on a preliminary version of this paper.

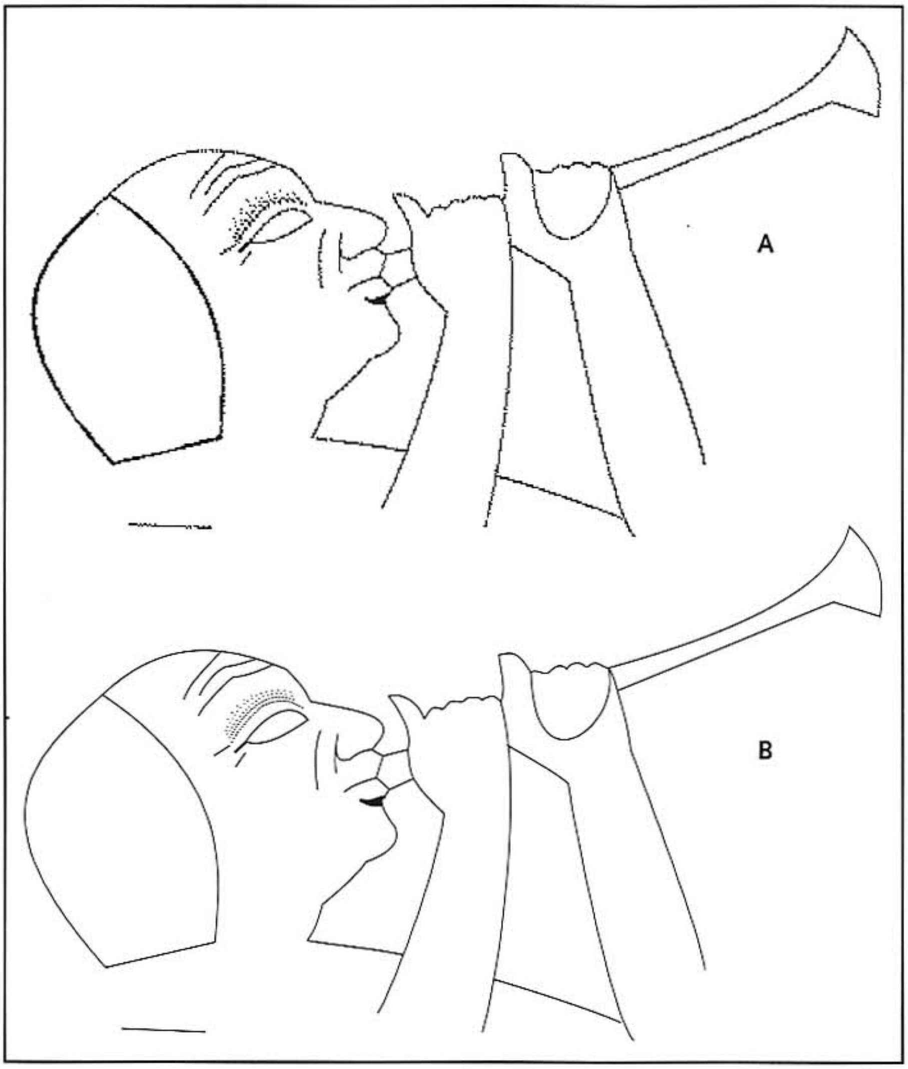

Fig. 4. The two principle types of computerized line art: bitmap (A) versus vector (B).

option to choose the best state of preservation available. Suitably prepared photographs from earlier generations[6] often reveal much more wall decoration than is preserved now, and thus provide a far better primary source for epigraphic work than the actual monument as it stands today (see figs. 1–2). In fact, the older the photograph, the better the preservation is likely to be. Moreover, the large format cameras of the past produced spectacular negatives that contain far more information than today's standard 35mm image.[7] It is a wasted opportunity to trace a damaged wall directly today when a suitable

[6] Examples include the 60,000 glass plate negatives of the Museum of Fine Arts, Boston-Harvard University Expedition under George A. Reisner; the expedition archives of the Metropolitan Museum of Art, the University of Pennsylvania, the Oriental Institute, University of Chicago, the Griffith Institute, Oxford, the various Junker expeditions (partially preserved in Hildesheim, Vienna and Leipzig), and many others.

[7] For a description of one approach to large format expedition photography, see "George Andrew Reisner on Archaeological Photography," *JARCE* 29 (1992), 1–34.

early expedition photograph exists that shows twice as much surface preserved. Thus, wherever possible and affordable, early photography and/or large format modern photography provide great advantages to Egyptological epigraphy.

2) Vector-based line art

Computer-drawn lines may be broadly divided into two types, one of which is unacceptable for Egyptological facsimile work, while the other is very well-suited for it. Fig. 4 shows the two modes of line art. Above (fig. 4A) is a "bit-mapped" rendering of a bugler from Luxor Temple. The lines consist of individual, unconnected black squares (called pixels), and the result has a distracting jagged effect that does the ancient relief an injustice and should not be used for serious epigraphic work. The version below (fig. 4B) is a "vector" line drawing, consisting not of individual squares or dots, but of vectors, mathematically calculated lines and curves between specific points placed on the screen by the epigrapher. The result is a smoothly rendered line that is infinitely adjustable, and well-suited to epigraphic reproduction. Its final quality is dependent only on the quality of the output device upon which it is printed (from office laserprinters to high end imagesetters used in the publishing industry). It is the technique of producing vector-based line art that is discussed below.

The Digital Epigraphy Procedure

The techniques listed below have evolved considerably over the past decade with accumulated experience in traditional epigraphy, changes in technology and simple trial and error.[8] There are no doubt further developments and advances still to come. But although computer processor speeds have risen, and digital storage media have grown in capacity while shrinking in size, and although software programs continue to be revised and enhanced at an exhausting pace, the basic principles underlying the computerized documentation of an ancient Egyptian wall surface have remained remarkably constant.

For the project at hand (the documentation of the Giza mastabas), use is made of photographic prints from original Museum Expedition (Reisner) negatives, a professional publisher's flatbed scanner, a computer, and a laserprinter for drafts and proofs (see appendix below for additional notes on equipment). As is outlined in the working flowchart in fig. 5, photographs are first scanned at as high a resolution and file size as possible; the higher the resolution and larger the file size (in megabytes), the greater magnification of details will be available to the epigrapher on the computer screen (fig. 6). (Low resolution scans begin to "break up" and become unreadable very quickly on screen as soon as one attempts to zoom in on a particular area, such as the curve of a hieroglyph, or the nose of an offering bearer.) Then the scanned (digitized) image[9] is imported into a vector drawing program.[10] Such programs provide the useful ability to create multiple drawing "layers" on the screen; it is at this point that some new thinking must be applied to the process of producing a facsimile line drawing.

With the scanned photograph in place on the computer screen on one layer (fig. 6), a second layer is added "on top of" the photograph, and this layer will bear the traced lines. A digitizing tablet and cordless pen[11] are the most natural tools for emulating the traditional tracing process. The term "on-screen tracing" used here is actually slightly inaccurate, since one does not touch or trace the computer screen physically, but rather uses the drawing tablet to deter-

[8] The evolution of the method currently employed was built upon the following steps to date:
1) 1:1 direct tracing with herculene (sheets of plastic drawing film) affixed to wall (1978–1983);
2) traditional Chicago House method (1984–1987);
3) tracing of 16 × 20 inch (40.6 × 50.8 cm) photographic enlargements with pencil and ink (1988–1993);
4) desktop quality scanning of 16 × 20 inch photographic enlargements for on-screen tracing (1993–1995);
5) professional quality scanning of original-sized photographs for "on-screen tracing" (1996–present).

[9] The scanned image may be saved on disk in a wide variety of computer formats, depending on which one can be understood and imported on screen by the drawing program used. A common current image file format (used for our purposes) is TIFF.

[10] Just a few popular vector drawing programs include Deneba Canvas, Adobe Illustrator, Macromedia Freehand, and CorelDraw.

[11] Less convenient or natural input devices include a trackball, or a regular computer mouse.

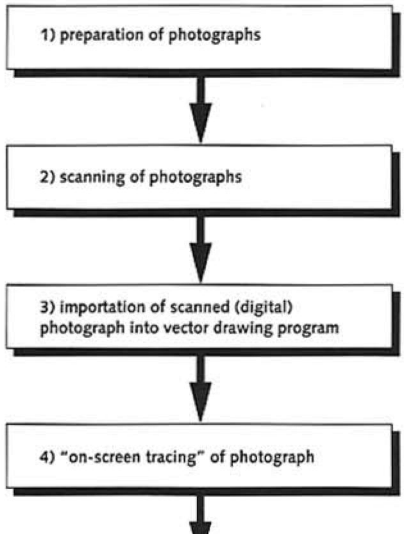

Fig. 5. Workflow of the epigraphic process for creating a digital facsimile line drawing.

mine the position of the cursor on the screen. Since black drawing lines are often difficult to see against the underlying black and white (or color) image, all lines on the drawing layer may be temporarily colored red, yellow, or other bright hue for maximum contrast. Similarly, any layer may be "turned off" or "on," that is, made invisible or visible, at any time for purposes of comparison or clarity or collation, and for print-

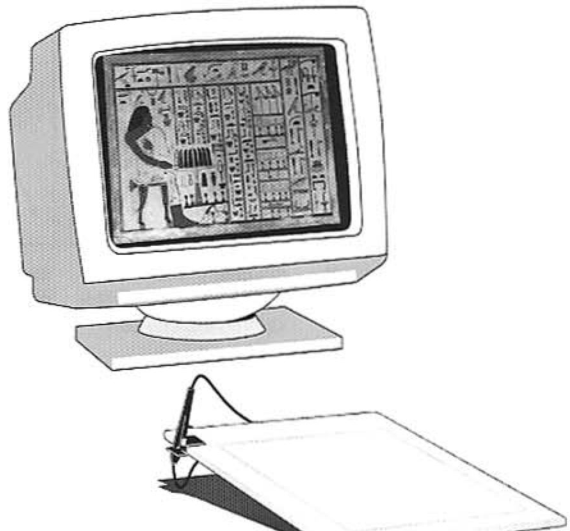

Fig. 6. The basic setup for digital epigraphy, consisting of a scanned photograph on the screen, "traced" on a drawing tablet and pen that replaces the computer "mouse."

ing out proofs of selected areas to check the epigrapher's progress. Anyone who has struggled to peer through partially opaque plastic film tracing papers to see the carved wall surface underneath will appreciate these features immensely.

In drawing lines with the computer, the most important point to grasp here is that the epigrapher/artist is not tracing in the traditional sense, that is dragging the pen over the entire length of an ancient carved line—this would be an awkward process to simulate on either the digitizing tablet or the computer screen. The drawn lines that appear on the screen are not individual squares (bitmapped "pixels," see fig. 4 above), but are vector lines—lines connected by the computer—between two anchor points that are set down by the artist (see fig. 7). Each anchor point displays non-printing direction lines, handles that are used to adjust the paths of drawn lines. The slope of the direction lines determines the slope of the actual drawn curve, and the length of each direction line determines the height, or depth, of the curve. The resulting lines and curves are thus infinitely adjustable; the non-printing anchor points and direction lines are available for every curve and line, editable at any time during the course of drawing.

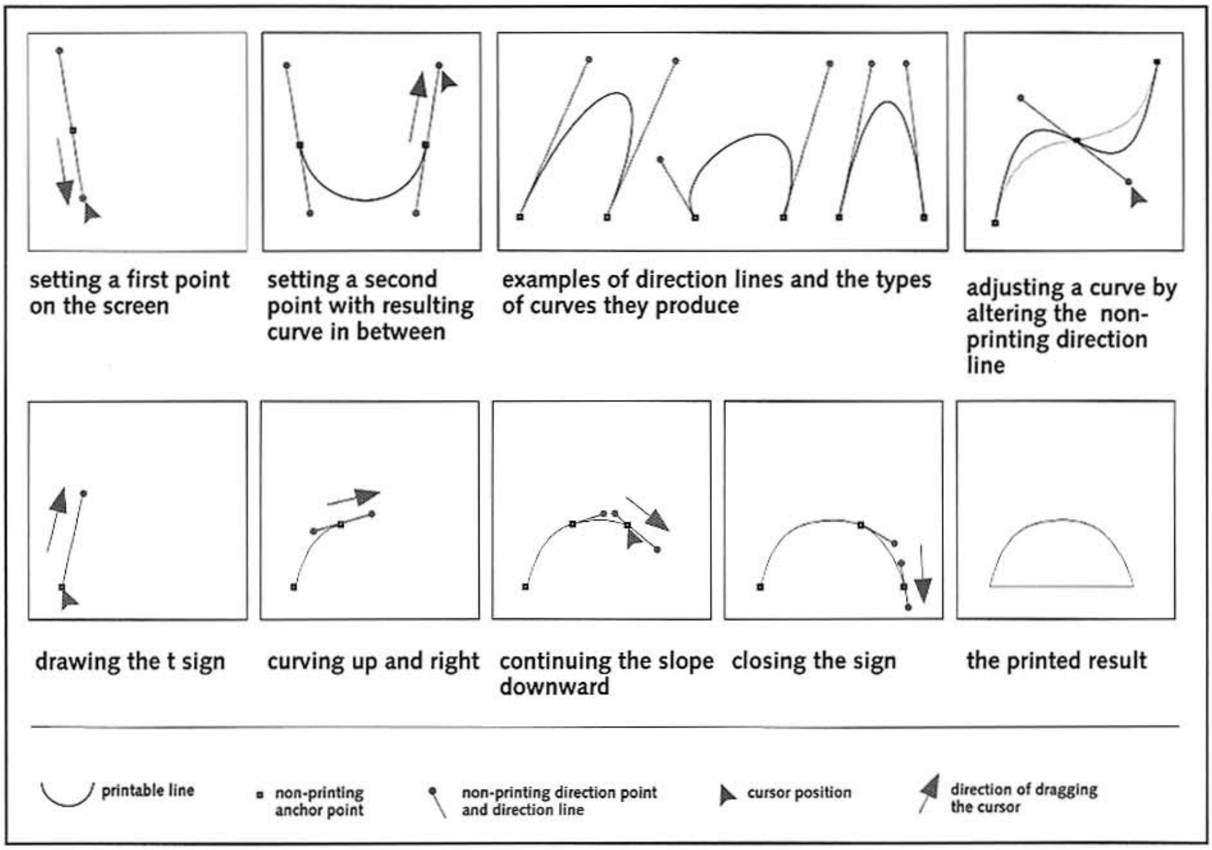

Fig. 7. The process of creating lines and curves using a vector drawing software program.

In other words, rather than "trace," the epigrapher/artist actually manipulates the curve between two anchor points until it "matches" the contour of the ancient carved line. The more detail and flexibility one needs for a line, the more anchor points one uses. Thus the swoop of an eyebrow, shape of a wing, or curve of a cartouche can be meticulously controlled and endlessly improved. Fig. 7 shows how curves are drawn and adjusted, and demonstrates the steps involved in creating a hieroglyphic *t* sign.

During the course of the drawing process, one immediate advantage that the computer offers over all other epigraphic methods is the ability to magnify the image on the screen for analysis of minute details. Depending only on the quality of the original photographic scan (resolution, file size), the tiniest details may be magnified hundreds or even thousands of times the original size of the element in the image. While constant access to the original wall surface for collation is of course the ideal, it is not always possible, and peering through a lupe at tiny details on a photograph can be a frustrating substitute. By contrast, a magnifiable digital photograph allows for virtually unlimited attention to the subtlest of details.

When all the lines have been drawn, proofs are printed on a standard laserprinter,[12] and are then collated and annotated at the original monument just as with traditional epigraphy. Corrections are made subsequently to the drawing on the computer, and the collation process is then repeated as many times as necessary (see fig. 5 above). Upon completion of the

[12] Laserprinters able to print at 600 dots per inch (dpi) will produce proofs that are true to the quality of the final output of the drawing—on professional imagesetters that normally operate at 1200 or 2400 dpi. Simpler laserprinters using 300 dpi will tend to melt together tightly spaced lines in detailed areas, but can still be used for basic collation purposes.

drawing, the final output is produced on a high-quality imagesetting device.[13] The actual final output product can be a positive (black lines on a white, resin-coated photographic paper, identical to reprographic camera-ready artwork, called in some countries bromide), or negative film, saving the step of additional camera-ready photographic fees for publication. The drawing file can also be imported directly into a page layout or book design program and placed on-screen on the final page mockup of the publication, surrounded by text or other elements. An entirely digitally produced publication, avoiding costly stripping and manual paste-up fees, thus becomes a very practical and cost-effective reality.

This process of digital epigraphy streamlines some of the cumbersome aspects of traditional pen and ink epigraphy. For example, any number of collation proof sheets may be printed out, thus eliminating the traditional expense of photographic reductions from large-scale 1:1 drawings, or of producing "blueprint proofs" (or struggling with low-quality photocopies) made from preliminary drafts of inked drawings. Unclear or problem areas of the drawing may be isolated and printed at an enlarged scale for separate collation. In addition, off-site epigraphy becomes much more time-efficient. As was already mentioned above, when the ideal epigraphic scenario of 100% proximity to the original monument (either in Egypt or a foreign collection) proves impossible, a premium is placed on the often limited time at the original. With digital epigraphy, a first draft of the majority of the drawing may be prepared off-site, while problem areas are flagged for particularly intensive collation on-site at a later time.[14] In other words, one need not waste valuable on-site expedition time drawing the preliminary outline of a perfectly clear, uncomplicated hieroglyph; such clearly visible areas may be drawn ahead of time, allowing for better use of critical collation time later at the actual monument.

Sun and Shadow Lines

Egyptological epigraphy is produced in some cases using a single line weight for all carved lines, and in others using varying line weights to indicate the nature of the relief carving. Single line weights represent the easier, more abbreviated approach; the digital procedure outlined above is complete as described thus far for producing this type of line art (see fig. 8A). By contrast, drawing with varying line weights, often called sun and shadow lines, indicates immediately to the reader the presence of raised versus sunk relief, and forces a more thorough analysis and understanding of the scene at hand (see fig. 8B).[15] For example, for a single line weight drawing, a group of overlapping offering bearers' or animals' legs need not be epigraphically "disentangled" by the epigrapher since all lines are of equal thickness (fig. 9A). With sun and shadow line drawing, all lines must be understood by the epigrapher, for the fronts and backs of legs will receive different line thicknesses according to the nature of the relief (fig. 9B).

Producing epigraphic drawings digitally eliminates the traditional pen-and-ink complications of switching between rapidograph sizes, and coping with changes regarding line thicknesses that forces either the scraping away or the addition of ink across an entire drawing. To produce sun and shadow lines with the digital procedure, one need only expand upon the same layering principle described above whereby the photograph on the screen is on an underlying layer, separate from the epigrapher's drawn lines on the "overlying" layer. One simply stacks additional copy layers of signs and figural representations, which are then offset slightly from the originals to create "sun" and "shadow" lines. The process of creating sun and shadow lines (in which Egyptological convention assumes the light originates

[13] Such devices are usually too expensive for individual or institutional purchase; print houses and service bureaus offer printing services for nominal per-page fees. This process is similar to sending a large, 1:1 pen-and-ink drawing off to a reprographic house for reduction photography and final print that is then submitted for publication.

[14] Although this fact is also true of tracing photographs by traditional methods, the correction of drawn lines after on-site collation is much easier with the "virtual ink" on the computer than with paper and actual ink. The only solution using traditional methods requires preparing preliminary drawings in pencil only, but this leaves the bulk of the final work to post-collation, a more time-consuming procedure.

[15] For an example of ancient raised and sunk relief on the same monument which is not reproduced in the single line weight epigraphic drawings, see W. K. Simpson, *Mastabas of the Western Cemetery Part I*, Giza Mastabas 4 (Boston, 1980), pl. 61a and fig. 47 (stela of Setju).

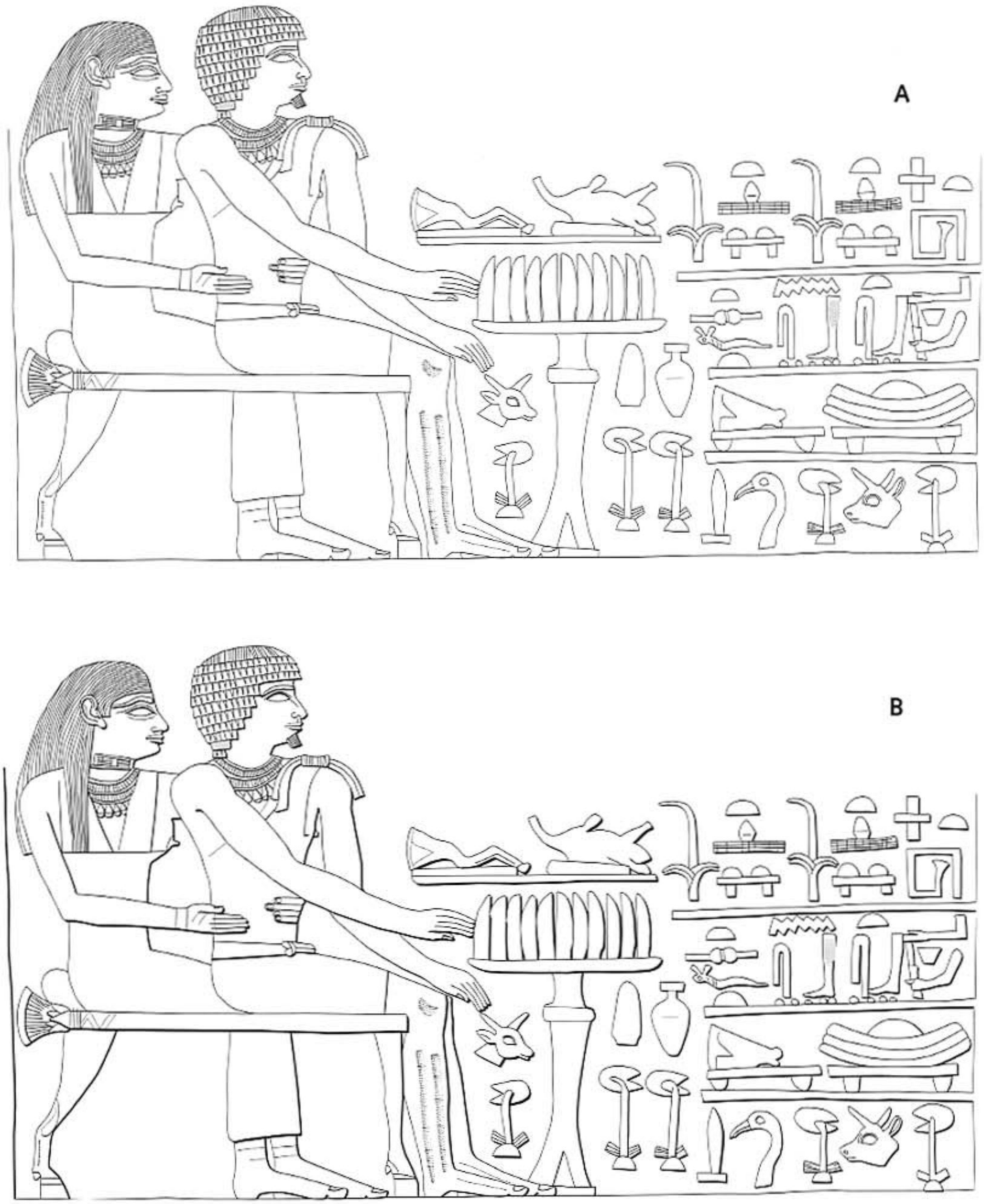

Fig. 8. Single line weight drawing (A) versus a drawing with sun and shadow lines (B).

in the upper left of the image, shining down at a 45° angle) thus essentially duplicates all the carved elements of the drawing, offsetting one copy slightly to provide a smooth drop shadow. For example, in fig. 10 a raised relief scribal sign (Sign List Y3) has been traced and the underlying photograph made invisible. The sign is "painted" on-screen with a white fill, that is, made opaque. Then it is copied, "painted" with a black fill, and placed "underneath" the white-filled original sign. One can offset (at a 45° angle) the underlying black sign slightly, either down and to the right to indicate raised relief (as in fig. 10), or up and to the left to indicate

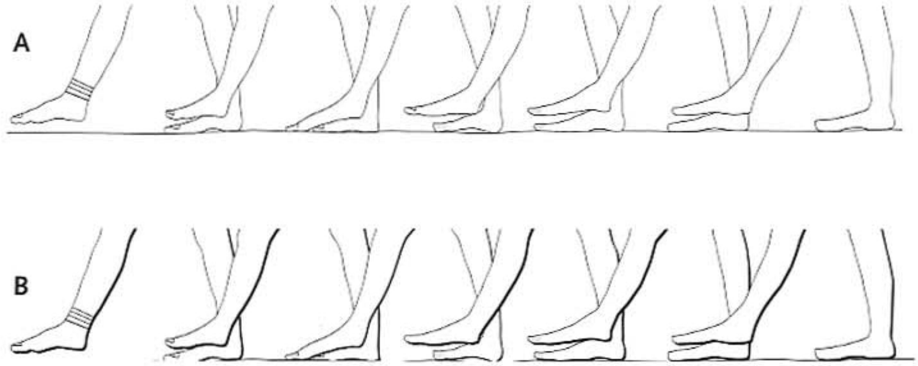

Fig. 9. Detail of grouped individuals, represented in single line weights (A) and with sun and shadow lines (B).

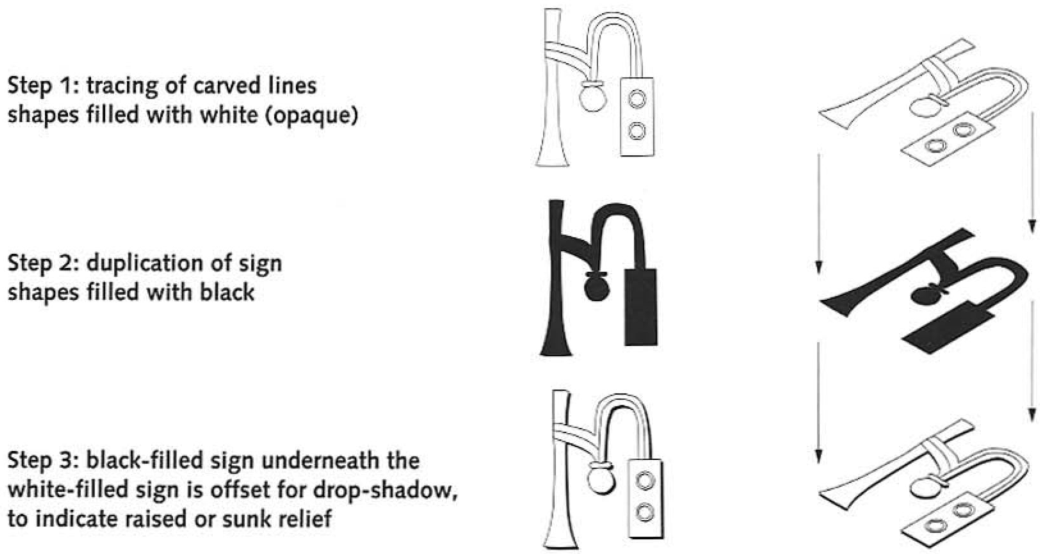

Fig. 10. The layering of "white-filled" and "black-filled" copies of a hieroglyph to simulate the appearance of raised relief.

sunk relief. The drop shadow process creates the sun and shadow lines as needed with a seamless blend of line weights.[16] This principle is applied to the entire drawing to produce consistent sun and shadow lines. Fig. 11 shows an exploded view of all the layered elements contained in a digital facsimile line drawing: original computer tracing of the photograph, drop-shadow black-filled signs, outlines of preserved surface area, and architectural block lines.

While making copies and playing with layers and offsets may seem in verbal description like a tedious and unnatural way to draw, most software program's commands help streamline the process immensely. All the elements of a drawing (hieroglyphs, figures, objects) may be treated together as a group, copied, and offset simultaneously to predetermined specifications with

[16] For areas such as the lower left corner of rectangular raised relief signs and shapes, the sharp corner of the white-filled sign might on occasion appear too distinctly separate from the sharp corner of the underlying black-filled sign. Depending on the scale of the final product, this discrepancy is often invisible to the naked eye, thus any adjustments represent unnecessary overkill. But additional filler lines or shapes are easily added to hide the distinction.

just a few keystrokes or clicks of a mouse.[17] The one prerequisite of this procedure that is foreign to the artist trained with pen and ink is conceiving of the drawing in terms of its layers. In order to fill signs and figures with white and black, they should in most cases be closed paths; lines that are left open and unconnected at the ends can produce unexpected results when filled with white or black. The phenomenon is especially important where figures are broken across multiple blocks of relief, or when signs contain intertwining lines or overlapping detail. In most cases, following the exterior outlines first, and then adding interior detail solves the problem (see fig. 12).

Digital epigraphy may also be applied to wall surfaces that contain painting only, such as are commonly found in the Theban necropolis. One has the option here of producing uniform line weights or effectively simulating the painted surface by outlining the contours of uneven brush strokes. Fig. 13 shows such a painted figure, with just a few options for indicating elements painted in different colors and damaged areas. There is virtually no limit to the gradations or colors available for indicating polychromy.

The addition of various shading conventions to simulate damage, recarving, ancient plaster repairs, block edge erosion, traces of paint or modeling, is a critical carrier of information in interpreting an epigraphic drawing, and should always be included in some form. Such conventions are available in a wide variety with the computer. There are a number of preformed hatching, stippling and shading patterns included with most drawing software programs, as well as the possibility of creating one's own custom patterns. These can be applied to the various layers of the drawing as desired (fig. 14). Alternatively, one could even allow the original scanned photograph to "show through" the drawing in damaged areas, although the combination of black-and-white line art and gray-scale photographic images might prove too jarring to some readers. In all cases, shading and other conventions can be lightened as much as desired so as not to distract the eye from the rest of the carved or painted decoration.[18] Fig. 15 shows some of the options for indicating modeled areas (such as leg musculature), including stippling, gray fills, blends and light outlines.

Advantages of Computerized Epigraphy

Some might question why we should bother with the expense of computerizing what, at face value, appears infinitely easier to do with simple pen and ink? To consider an analogy for a moment, most of the advantages of using a word processor versus a simple typewriter can be applied to using digital epigraphy instead of traditional ink-based epigraphy. For example, correcting errors and making fine-tuned adjustments is simplified. Gone are the worries of scratching away ink with a scalpel blade, and wondering if the scraped fibers of the paper will cause newly applied ink to bleed all over the drawing. Unexpected changes of approach midway through a project, such as scale alterations, global changes to all line widths and revisions of final publication formats, no longer pose insurmountable challenges. And the alteration and reuse of previously completed work is also made easier; individual drawings that form part of an entire wall can be combined, separated, rotated, resized for different publications etc., all without incurring the additional photographic and reproduction costs that accompany such repurposing of traditionally inked artwork. The same drawing can be used as a miniature "key plan" for overview purposes, or as an enlarged view of the minutest carving details. Because the lines are vector-based, rather than bitmap (pixel-based; see fig. 4),[19] line quality and integrity

[17] "Grouping" objects is a convenient computer feature that applies the same changes made to any single member of the group to all the rest of the members. Hieroglyphs, human and animal figures, block lines, etc. may be "grouped" or "ungrouped" as often as is necessary for convenient editing.

[18] It is important to remember that the gray fills resulting from a laserprinter proof are always darker and coarser than those produced by high quality professional imagesetting devices. Thus, a damaged area that might appear too dark and distracting in the proof stage might be perfectly light in the final output.

[19] Unlike artwork based on individual bitmaps, vector-based artwork utilizes the computer language called "postscript" to retain and communicate the quality of the linework to any output device that understands this page description language.

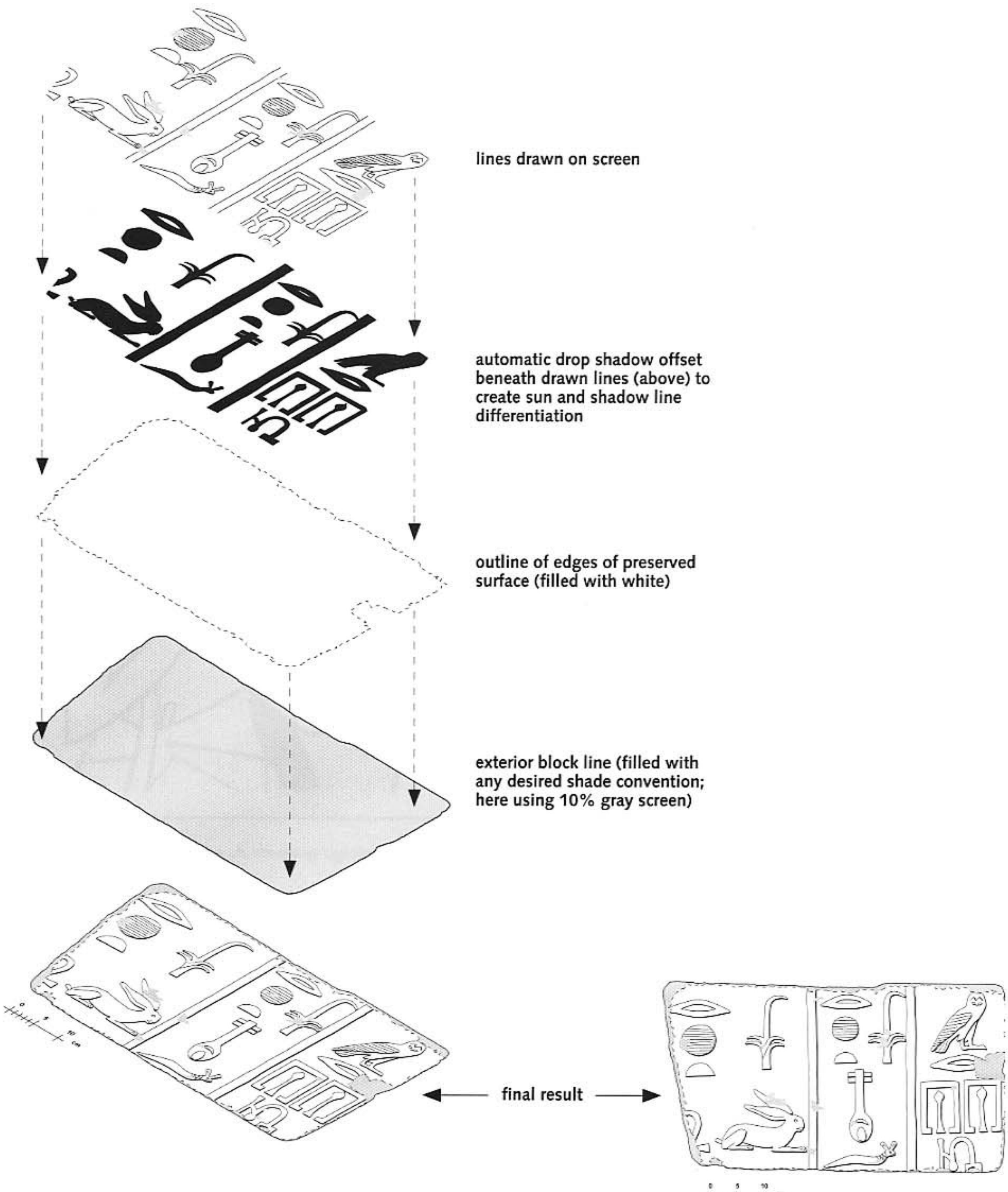

Fig. 11. Exploded view of the various layers that make up a digital facsimile line drawing.

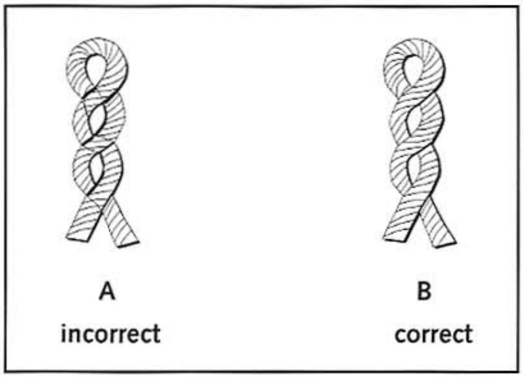

Fig. 12. Some of the problems that can occur in drawing overlapping lines filled with white or black (A); the solution involves drawing the outlines first as a closed path, before proceeding to the interior details (B).

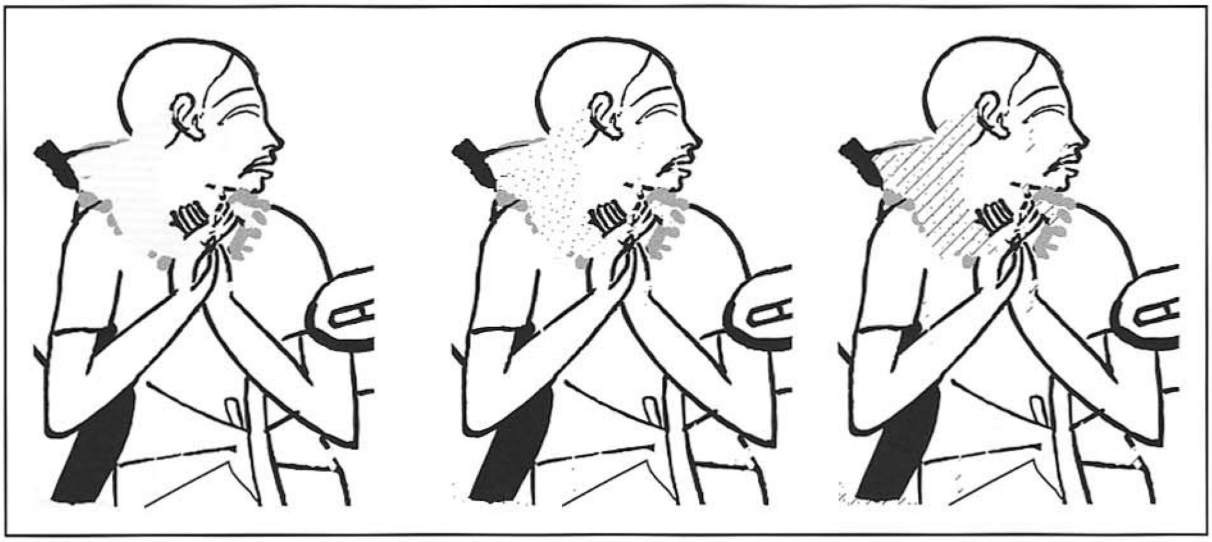

Fig. 13. Samples of digital epigraphy applied to wall painting instead of relief carving; compare A. and A. Brack, Das Grab des Haremhab (Mainz, 1980), pl. 10.

remain constant despite infinite resizings, either up or down. When a particular scene or inscription is under investigation, individual hieroglyphs or other elements may be copied or "removed" from the drawing and placed in comparison charts such as palaeographies. Moreover, some projects can only be completed in a cost-effective manner using a digital approach. For Egyptian monuments whose wall reliefs are inaccessible or are spread throughout the world, and whose photographs were taken at a wide variety of scales, scaleable digital photographic montages and on-screen drawing provide the only solution short of paying a small fortune in copy photography and photographic printing fees.

Finally, there is the issue of speed. While it takes some time at first to master the new technology and the various approaches to layering the lines of individual signs and figures, there quickly follows a tangible boost to the speed with which one can produce epigraphic drawings. By comparison, it might be suggested that even today's best traditional epigraphic methods are not wholly successful if they require decades of work on a single monument, while many other monuments in the vicinity disintegrate for lack of attention. For this and other reasons touched on above, it is worth considering digital epigraphy over tracing the wall or photograph with pencil, pen and ink.

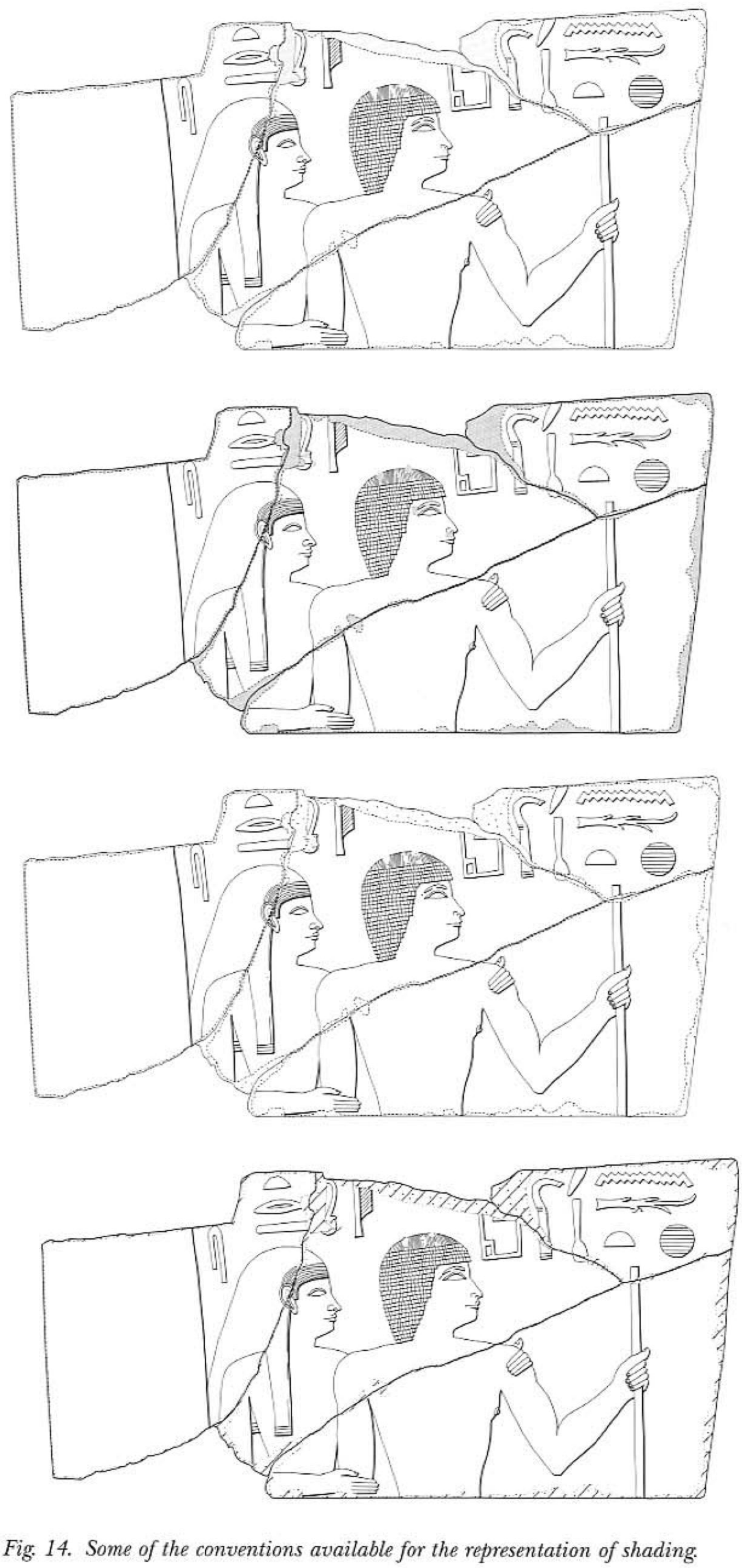

Fig. 14. Some of the conventions available for the representation of shading.

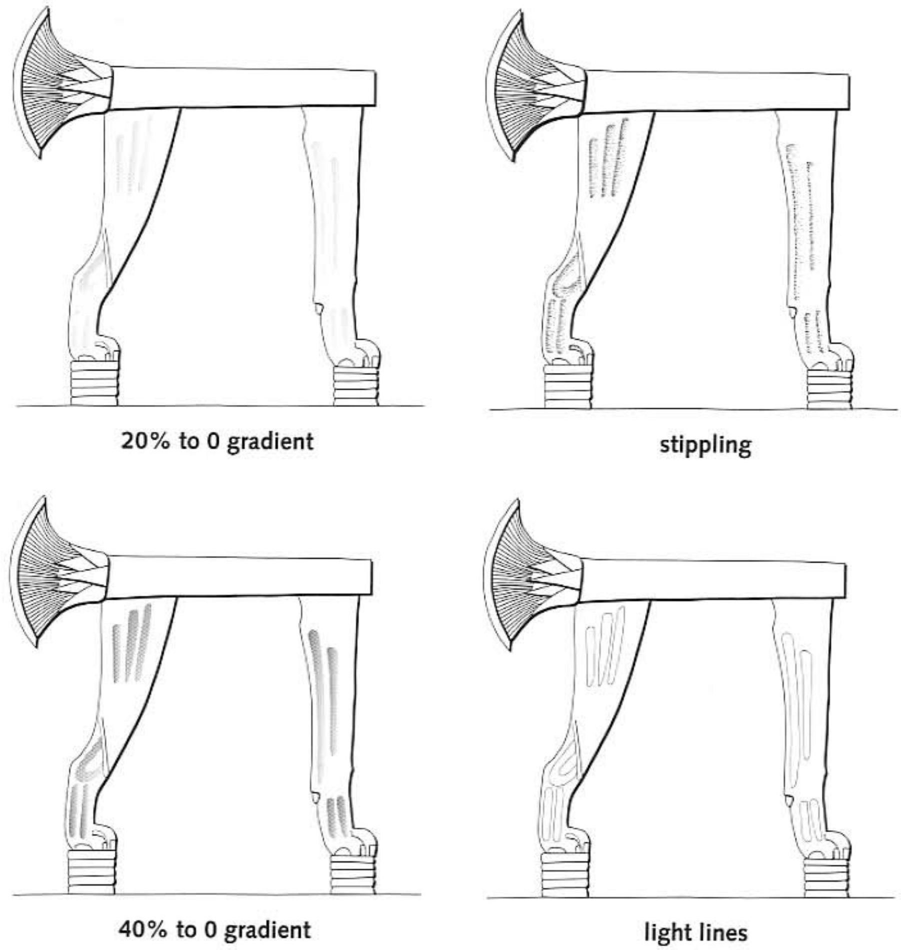

Fig. 15. Some of the conventions available for the representation of modeled surfaces.

New Application Potential for Egyptian Epigraphy

A number of new ways to describe and represent archaeological data become available once one takes advantage of digital epigraphy. Many of these have yet to find their way into traditional (paper-based, black-and-white) academic avenues of publication, but technology is changing some of these avenues as well. It is far beyond the scope of these pages to elaborate on the more advanced possibilities for archaeological reconstruction using digital epigraphy and computer technology, but a few examples might briefly be mentioned.

Some of the new uses to which digital epigraphy may be put include the (re)colorization of ancient wall decoration. Just as individual human figures, hieroglyphs and objects may be filled with white or black to create raised and sunk relief, so too can they be colored with any hue occurring in the ancient Egyptian palette.[20] After computerizing a wall relief, then reconstructing its original colors, the next step in this logical progression is to reassemble the walls and the ancient monument in three-dimensional space using computer-aided design (CAD). From here, perspective renderings, animated walkthroughs, virtual reality motion and panoramic viewing are all tools that can help us better simulate and understand Egyptian environments. Such tools are well on their way to evolving beyond the mere

[20] For an interesting discussion of ancient Egyptian color, see Jochen Kahl, "Die Farbgeben in der frühen Hieroglyphenschrift; *ZÄS* 124 (1997), 44–56, with additional bibliography.

"computer game" level into becoming serious scholarly research tools that can lead to new discoveries. The reconstruction of ancient monuments thus takes on new dimensions, available in hard copy through traditional paper and publication output, or in on-line form through various disk-based media and the internet.

As far as further streamlining the actual digital epigraphy process is concerned, one might consider the day when the paper-based portion of the photographic process may be avoided altogether through the use of digital cameras. At this writing, however, the high-quality digital cameras required for epigraphically suitable images are beyond the means of most expeditions, and none has so far come close to matching the information quality contained in a 100 year-old 8 × 10 inch glass negative. It also remains to be seen whether digital epigraphy will eventually be liberated from the drawing or computer studio altogether, and one will be able to practice digital epigraphy in "portable form." If future generations of laptop computers provide sufficient screen quality, appropriate input devices, and resistance to the elements, epigraphers might eventually be able to draw digitally in the field, at the tomb or temple wall, bringing almost the entire epigraphic process to the monument.

The preceding remarks have demonstrated that a digital approach to Egyptian epigraphy provides a number of financial, speed and consistency advantages over traditional direct wall- or photograph-tracing, and allows for archaeological data to be interpreted and presented in a number of new ways. There will most likely always be a place for traditional tracing methods,[21] but scholars must explore any and all responsible systems that would help document the ancient monuments before their complete deterioration. For purposes of documentation in the broadest sense of the word, digital epigraphy has much to offer.

Appendix: Some Logistical Considerations

It is certainly true that the procedure outlined above requires some powerful computer hardware and software for optimal working conditions. However, there is nothing customized about the procedure; the software used is completely commercially available, and no specialized programming skills are required on the part of the Egyptologist or epigrapher. Some of the equipment required for digital epigraphy includes:

- access to a high-resolution flatbed scanner
- a powerful processor inside the computer (central processing unit)
- as much computer RAM as possible
- as large a screen as possible
- large amounts of digital storage space for large file sizes required by high resolution images (and sufficient backup capabilities)
- a comfortable input device, such as a digitizing tablet and cordless pen, in place of a regular mouse or trackball
- photographic image-editing software
- vector-based drawing software
- access to a 600 dots-per-inch or better laser-printer for proofing purposes
- access to professional quality imagesetting device (2400 dots-per-inch) for final output of digital facsimile line drawings.

While this financial outlay is certainly not inexpensive, many scholars already own or have access to parts of the equipment outlined above within the context of their other academic work. What is often required, then, is merely the addition or upgrade of certain components, rather than the purchase of entirely new computer systems. Some purchases help pay for themselves in time saved and in traditional epigraphic materials that are no longer necessary, such as photographic supplies, printing and processing, tracing/drawing paper, rapidographs and ink. Moreover, much of the equipment need not be purchased; many services, such as one-time scanning or high-quality printing of final drawings, are available from graphics prepress and publishing houses, service bureaus and institutions that own the high quality equipment.

Museum of Fine Arts, Boston

[21] Curving surfaces, such as temple columns, and tiny, cramped decorated chambers, come to mind as examples of difficult challenges for photograph-based epigraphy.