repair because the pulleys and gears were rigidly fastened in position by driving iron wedges between the polygonal shafts and the matching hubs. These pulleys and gears could be removed from a broken shaft and fixed on the replacement part only with great difficulty.

About 1840, American power transmission systems were improved again by the introduction of the English plan of substituting malleable wrought-iron shafting for its brittle cast-iron counterpart. Improved methods for fastening pulleys and gears to shafts and for connecting one shaft to another were adopted simultaneously. Cast iron power transmission equipment, which was widely used until that date, disappeared overnight. Today, only fragments of the old cast iron systems can be found. The Gillette Grist Mill provides the opportunity to observe a complete cast iron power transmission system. We can study the details of the casting and machining operations used to manufacture the shafting, the way in which connecting shafts were coupled together, and the bearings employed to support the equipment. This artifact-system preserves a wealth of technological information unavailable elsewhere. Public records similar to those cited for the Phoenix Mill can then be utilized to place the grist mill in its economic and sociological setting.

As Hawkes and Wainwright have suggested, artifacts are capable of supplyng economic information, but that is not the case in the example of the early turning lathe or the cast iron power transmission system. Little documentation is available to interpret and explain mechanical equipment found in the Phoenix Mill or the Gillette Grist Mill but, as described above, artifacts can supply that sort of technological information directly to take us beyond the point where the written record ends. Economic information, on the other hand, was available in written form for both mills but could not be recovered from the artifacts. Presently, not enough is known about the location, materials, and chronology of comparable physical objects to allow inferences about the economics of the artifacts discussed in the preceding pages to be drawn from the physical record.

Industrial archeologists face similar problems on both sides of the historical coin. To date, very little is known about the actual artifacts of early industry and how they evolved and diffused with time. Typologies exist for the potsherds and pipe stems of the historical archeologist, but not for the nuts and bolts, gears and bearings of the industrial archeologist. Also, American historians have not involved themselves in the sort of local history studies that are useful to interpreting industrial sites. They do not have the comparative information needed to make sense of the archeological or historical evidence for industrial archeology; lacking is a sense of context and pattern in what is observed. A sense of context and pattern will improve, however, as more descriptive studies of machines, sites, and other artifacts are undertaken and completed.

Context and pattern are essential concepts for both the archeologist and historian. Context signifies the concern for the relation of a bit of information to other adjacent bits of information that are not necessarily similar, but in close proximity to each other. Pattern signifies the concern for the relation of a bit of information to other similar bits of information that are not necessarily in close proximity to each other. Historians usually experience difficulty with material evidence for the same reason that archeologists have trouble with historical evidence: each asks questions of the unfamiliar evidence that it cannot answer properly.

Historians are vitally aware of the relationship of documentary evidence to context and pattern but do not hesitate to lift artifacts out of context or disregard pattern in the artifactual record. Archeologists, on the other hand, recognize the relationship of artifactual evidence to context and pattern but are quick to remove written evidence from context or disregard pattern in the documentary record. Our task, as industrial archeologists, is to interpret the material culture of industrial life and activity to learn everything we can about the human behavior embodied in those remains. We must struggle to understand what can and cannot be learned from documentary and physical evidence and search for ways to maximize our knowledge of past industry through the integration of historical and archeological information.

FOOTNOTES

1. Brooke Hindle, "How Much is a Piece of True Cross Worth," in Material Culture and the Study of American Life, ed. Ian M.G. Quimby (New York: W.W. Norton, forthcoming).

2. Webster's New International Dictionary of the English Language, 2d. ed., unabridged, S.V. "archaeology."

3. D.P. Dymond, Archaeology and History, a Plea for Reconciliation (London: Thames and Hudson, 1974), p. 43.

4. Christopher Hawkes, "Archeological Theory and Method, Some Suggestions from the Old World." American Anthropologist 56 (1954): 155-68; F.T. Wainwright, Archaeology and Placenames and History, an Essay on Problems of Coordination (London: Rutledge and Kegan Paul, 1962).

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4 THREE DIMENSIONS REDUCED TO TWO: USING MEASURED DRAWINGS AS A MEANS TO RECORD I A SITES

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There is no set formula to follow when producing measured drawings of industrial archeological sites, nor should there be.* The recording process is too complex to be reduced to a list of requisite site maps, plans, elevations, sections, and details. And it is too complex to be reduced to the sophomoric tenet that you "draw it as it exists." Different industrial or structural types demand different treatments, and even structures of the same type often require individualized attention. Surely two locomotive erecting shops should not be drawn in the same fashion, if one is in ruins, while the other is intact and filled with original machinery.

Although a recording team cannot be sent out into the field with a set formula to follow, it can be provided with an over-riding rationale for its work and with a certain modus operandi. Armed with these, and with their own graphic, detective, and research skills, team members should produce drawings that are informative, accurate, and useful.

Rationalizing the recording process can be compared with the acquisition and preservation of technological artifacts as practiced by better museums. Above all else, an artifact is seen as a three-dimensional data source that informs of the culture that made it and used it. This information may be very diverse. Artifacts contain evidence of cultural styles and tastes, of the availability of materials, of manufacturing methods, of acquired scientific and technical knowledge, and of the ways of organizing and doing work. Because the artifact contains this information, it is valuable as a document of past human behavior, so it is acquired, preserved, and made accessible to the general public and to scholars.

IA sites also contain diverse cultural information and are therefore valuable as documents. But these sites and their attendant structures are generally fixed and immovable. If they are moved, it is usually not by the hands of a solicitous curator, but by a wrecking ball. A few IA sites will be physically preserved as museums unto themselves, and a number will be "preserved" through adaptive reuse.[1] But the vast majority of industrial and engineering structures will ultimately come down, and like Humpty-Dumpty, they will never to be put back together again.

Since the typical IA site cannot be shipped off to the Smithsonian, the Henry Ford Museum, or to Old Sturbridge Village, it is important to record it graphically. The recording of an industrial site can be seen as the functional equivalent of physically removing an artifact from the culture at large and sheltering it in a protected place, where it is to be kept in perpetuity. Drawings, like artifacts in a museum, store information. That is always a drawing's primary function--TO STORE INFORMATION.

In a sense, a drawing has two advantages over the real thing it represents. The site itself often stands like the door to the robbers' cave in Arabian Nights. It does not open to just anybody. The magic words must be known. Unless investigators have the experience and expertise to ask it the right questions, it provides too few answers. The abandoned factory complex does not broadcast the functions of its various buildings and their many compartments; it does not declare that the steam engine was added in 1885; or that a vertical boring mill once stood on a particular concrete pad; or that workpieces were finished as they moved up the building, rather than down.

The IA site--perhaps shut down, perhaps in ruins, or perhaps too complicated for the average viewer--may hide or camouflage all kinds of information. Through careful, probing research on the part of a recording team, this information can be retrived and brought forward. Drawings--with judiciously selected views, notes, symbols, keys, flow charts, and the like--can often impart information more readily than the site itself. So another function of measured drawings--besides storing information--is to make a site or structure more understandable: THE DRAWINGS ARE INTERPRETIVE TOOLS.

The second advantage that drawings have over the real thing is their reproducibility. They can be copied and easily transported to anyone who has any interest in them. This advantage is often overlooked, or even disparaged. Some people see no reason, for example, to graphically record an IA site that has been stablized, restored, or turned into a museum. But the fact remains that the site, in all its glory, stays put and is therefore inaccessible to most because of considerations of time, money, and distance. Drawings can spread knowledge of a site further and faster than the practice of visitation. Also, the site that appears so well protected today could be gone tomorrow. Present protection is no guarantee of long-term survival.

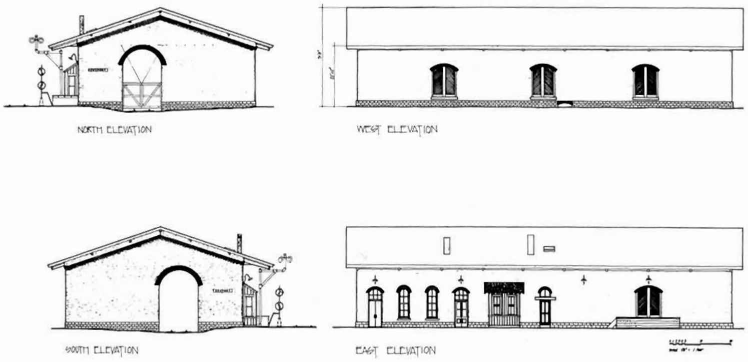
Having recognized two advantages of measured drawings, their limitations must be discussed vis-à-vis the real thing, photographs, and the written word.

The real thing can be a veritable treasure trove of information, containing an infinite amount of data. It can be revisited again and again, each time to investigate a new turn or twist. Both major and minor questions can be asked of it, and if skilled enough in historical research and in reading material culture, investigators can get the answers.

The first trip through an intact 19th century machine shop might be to examine its structural components--the brick masonry, the wooden-block floor, the trussed roof, the windows, and the clerestory monitor. The next visit might be to study all the machine tools and the way in which they were driven. On subsequent trips, the tool room might be explored to discover how cutters and gages were stored to protect sharpened edges or precision surfaces. Yellowed sheets show how each machinist signed out for the tools he used. Later, the lathes might be compared to see if the carriages were gibbed or counterweighted to prevent tool chatter. Kicking over an old can whose bottom is caked with the residue of an evaporated mixture of spit and tobacco juice could reveal that at least one machinist was fastidious; he didn't foul the floor.

The shop has a feeling of space. It has texture, color, heat, light, odors, and sounds. It contains thousands of artifacts, ranging from drawersful of taps, dies, nuts, and bolts to large machine tools and a steam engine. These artifacts, taken together with the structure itself, compose the shop's "visible" history--and it is impossible for drawings to capture all that history. For example, in the corner of a tool crib stands a cabinet that stores measuring and gaging tools. Within it are micrometers of varying size; inside, outside, and vernier calipers; ring, plug, limit, and thread gages; and steel rules. The cabinet has its own history, and so does each tool inside it. These artifacts are important resources for studying, if you will, "machine shop culture." Yet, a floor plan of the shop simply cannot cope with the complexities of this well-stocked, important cabinet. On the plan, it becomes, of necessity, a mere rectangle, perhaps a half-inch long and quarter-inch wide, labelled "Tool Cabinet." The real thing, in this instance, is infinitely superior to its graphic representation.

To complicate matters, there is an entire "invisible" history of the mill, one that cannot be perceived directly by a visitor. There are ghosts. Numerous historical agents--people, machines, and tools--are no longer there. They have long since vanished, and they cannot be resurrected solely by studying the shop's physical remains. The boiler room shows evidence of having been altered considerably, but it does not tell why. It does not tell that the alterations followed a boiler explosion in 1873 that killed two men. Many historical and economic questions that the industrial archeologist should ask of this shop simply cannot be answered by using material



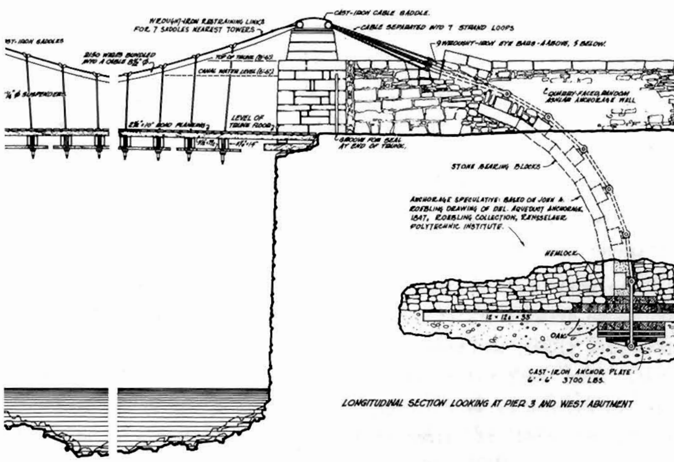
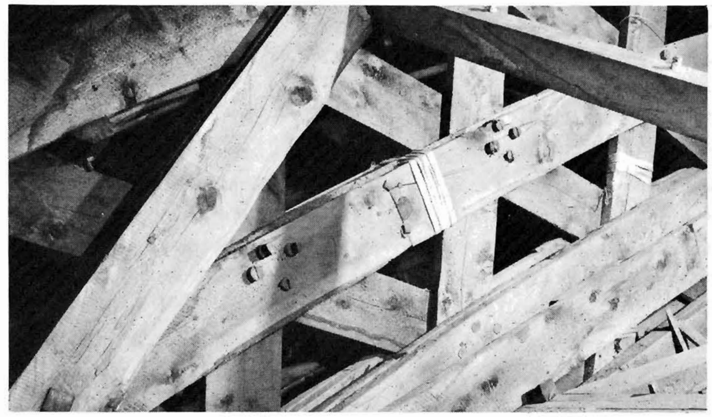


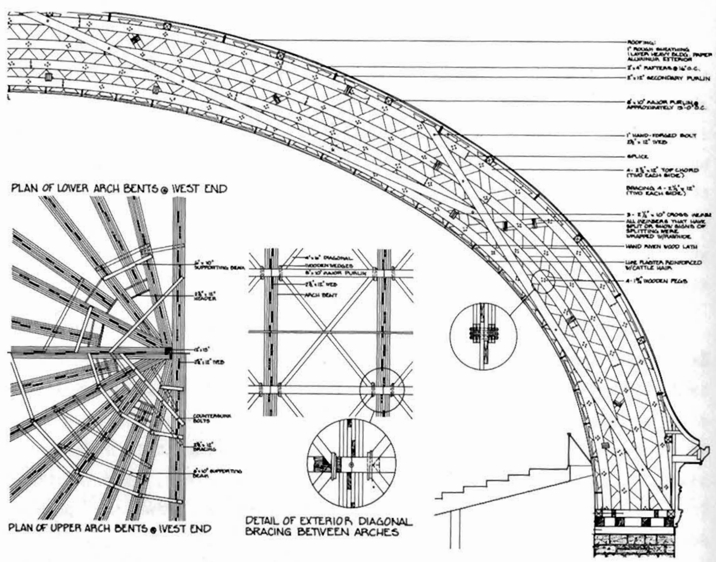
Figure 1. (top) Gosport (Indiana) Station exemplifies the "train barn" style of railroad architecture; one set of tracks passes through the station. Such a feature is best shown on a floor plan or perhaps a longitudinal section--either drawing would show more than could be captured with a camera. These elevations, however, are largely superfluous, because they store far less information than do photographs of the four sides of the station. For example, can you readily identify the various building materials? Can you find the wall anchors? Can you tell if the structure was built in a slip-shod manner or well-constructed? This sheet also typifies the strong aversion that many architects have towards "violating" elevations with any notes or keys. They like their elevations as pristine as possible. Consequently, elevations of historic engineering and industrial structures too often raise far more questions than they answer.

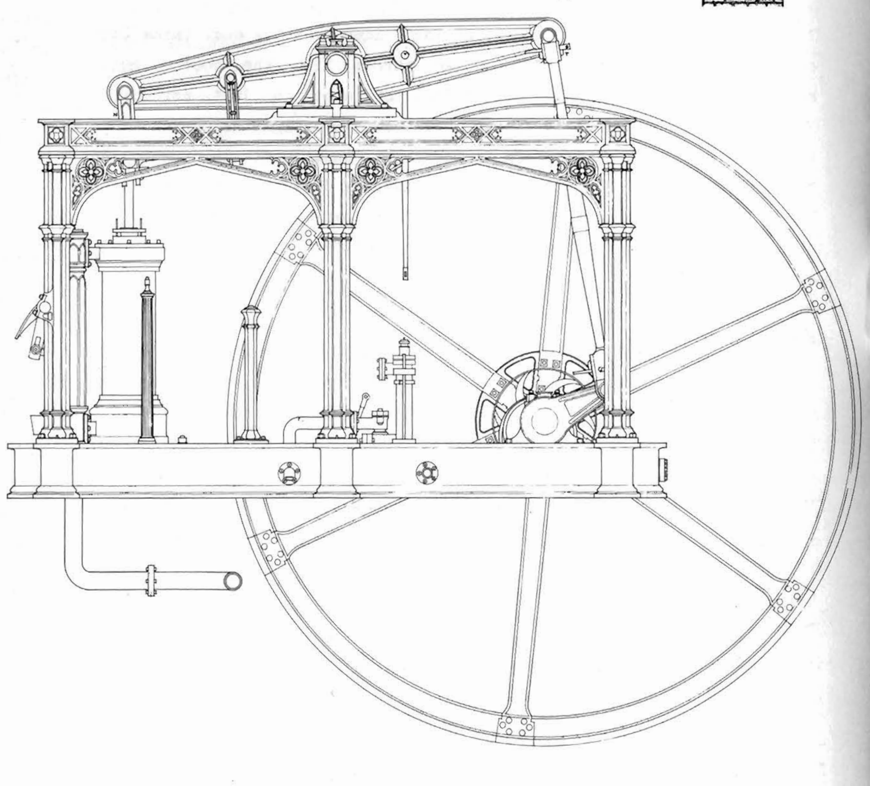
Figure 2. (above) This view illustrates the use of speculative drawings to "reconstruct" or "uncover" historic technology. As shown here, the buried anchorage of the Delaware Aqueduct was "uncovered" by historical research and a delineator's skill. The drawing makes heavy use of documentary information, permitting materials, dimensions and proper nomenclature to be shown.

Figure 3. (right) Obviously a skilled and delicate hand created this drawing of an 1861 West Point Foundry beam engine located in Puerto Rico. Here the delineator successfully combined "art" and "information." Still, the delineator (an architect) could have improved his drawing if he had been more familiar with machinery and the conventions of engineering (as opposed to architectural) drafting. By drawing only an "elevation" of the engine's "facade," he failed to take full advantage of the "magic" that drawings can perform. He could have shown us, for example, cross sections of the beam, flywheel rim, and spokes. He could have broken away part of the front of the engine bed to show us internal construction and piping. And--if he had had the heart to do so--he could have broken away the left side of the elaborate Gothic frame to expose the parallel motion, steam chest, and valves. Finally--and this is definitely a stylistic matter--he could have decided that a large, cast-iron engine called for heavier lines and a bolder approach. The drawing is light and airy. The engine most definitely is not.



Figures 4 and 5. Working in cramped quarters in the dome of the Salt Lake City Tabernacle, a photographer cannot capture enough of the roof trussing to show the viewer how it really looks or works. For an overall view, a drawing is an absolute must. Still, the photograph complements the drawing showing us details. Note the circular-saw marks, the mortise-and-tenon construction, the iron fasteners, and the rawhide wrapped around split truss members.





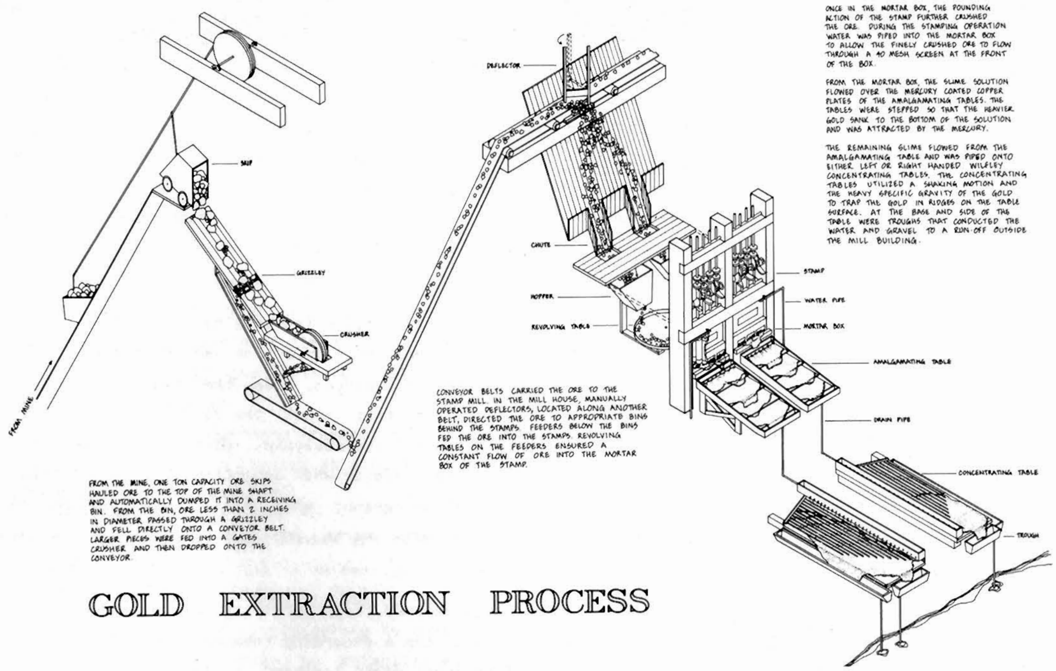


Figure 6. Plans, elevations, and sections of the Coggins Gold Mill simply cannot communicate, in a concise and readily understandable way, the processes carried out at this site. To record work (as opposed to design and construction), it often is necessary to reject standard architectural drawings in favor of interpretive flow charts. This flow chart is particularly good, because while documenting processes, it also succeeds in giving the user some idea of shapes, sizes and spatial relationships.

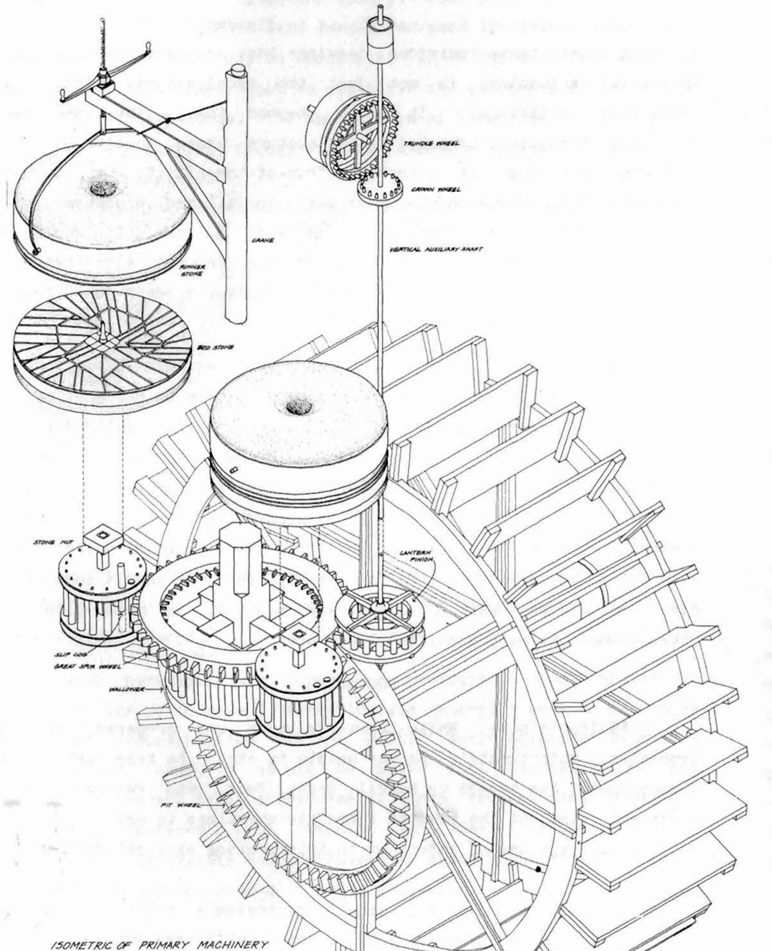
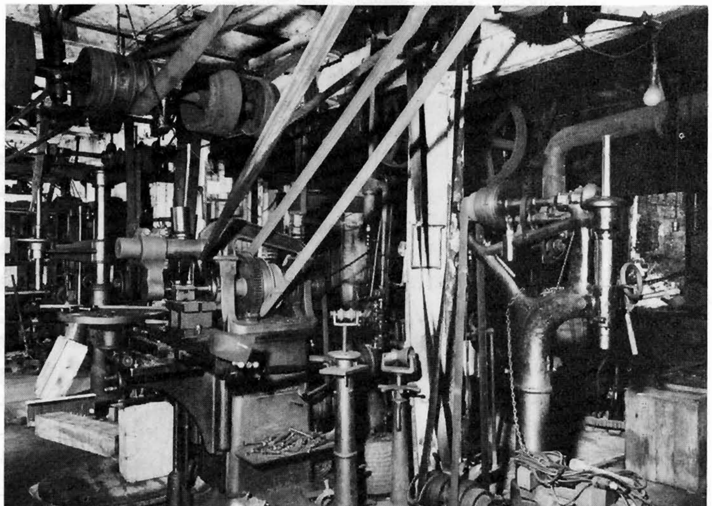


Figure 7. (left) This drawing performs "double magic." First, based on documentary and physical evidence, it reconstructs the missing undershot wheel and its pit wheel. Second, it peels away barriers (both floors and walls) to allow us to see a train of machinery and motion. Photographs of this mill could only show disconnected bits and pieces of the power and milling system.

Figure 8. (below) The Appomattox Iron Works could pass for the "hypothetical machine shop" discussed in the text. There is no way for drawings to capture all that can be seen in the shop. This view admirably illustrates the "inclusive" nature of photography. The purpose of this photograph was to record the horizontal milling machine and the drill press in the foreground. But these machines could not be isolated. They were captured on film in the context of all the material culture that surrounded them.



All drawings and photographs on these two pages are from Historic American Engineering Record recording projects.

culture. They can be answered only by researching other data sources, such as the written record. The shop itself will not tell who worked there, and whether they were content, well-paid, and well-fed, or whether they were rebellious, exploited, and hungry. This type of historical information--that cannot be gotten from the site itself--certainly cannot be stored by any line drawings representative of the site.

Drawings take considerable time and money to produce. Consequently, it is rare for a single structure to be documented by more than 10 sheets of drawings. But how, in 10 sheets or less, can you best cover the complexities of a structure such as our hypothetical machine shop? It is best to dispense with the idea of simply "drawing what's there." Due to necessity, and often due to chioce, a great deal will have to be left out. The drawings, as illustrated by the case of the tool cabinet, will never capture everything. The graphic record must be fleshed out with photograhs, and this graphic record must also be supplemented by a strong written report.

Photographs--both historic and modern--have several advantages over drawings. For members of our modern "Kodak culture," who are more familiar with cameras than with drafting tools, photographs are generally much easier to read and understand. Photographs often convey a sense of human-scaled space better than dimensioned floor plans, and they will certainly capture textures and materials better than any line drawings. Photographs are much less expensive to produce, so they are usually the best way of documenting numerous architectural or mechanical details. Also, photographs are more comprehensive, more inclusive. A delineator starts with a blank sheet, and the finished drawing stores only the data consciously inked onto it. The photographer, on the other hand, shooting the interior or exterior of a structure, may focus on a particular feature, but more often than not, the film will also capture the images of surrounding features and background details. A photograph, in short, may show us more than its originator intended, while a drawing seldom does.

Photographs, too, have their limitations. It is the camera, more than the drawing, that records a site, for better or for worse, "as it is." The photographer is stymied by the underbrush, trees, and walls that block their line of sight. No filter can make all obstructions disappear. No photographer can use their camera to take a machine or structure apart. Nor can they use it to put together pieces of a machine or structure that were separated long ago, and which are found at a site in a jumbled pile.

Drawings, in contrast to more reality-bound photographs, can perform magic. That is their strength, and it must be exploited more and more. Delineators are tied to the physical characteristics of a site, and are not allowed to fantasize. Yet they can creatively warp reality. They can make a wall disappear to show us what is behind it; cut any structure in half, horizontally or vertically; explode an assembly, to show us important pieces; take the parts of a demolished or disassembled mechanism and reconstruct it as a whole; take a complex manufacturing process and its attendant machinery, and reduce it to a readily understandable flow chart; and when confronted by barriers that block accesss to the internal parts of a machine, they can nevertheless represent those parts and their motions schematically.

But in a real sense, the success of the drawings meant to represent a three-dimensional site is determined long before any ink hits mylar. It is determined even before the recording team pulls out its 100-foot tape and begins taking field measurements. Before the tape and field notebooks are brought out, the delineators and historical researchers should go over the site or structure carefully, looking into all its nooks and crannies. They have to be inquisitive and adventuresome. They have to ask questions of everything they see. They must read the site; identify artifacts and structural parts; follow processes; and be cognizant of changes that may have occurred over time. When confronted by a puzzle--something they do not understand at first--they have to meet it head on. Only in this manner can they truly come to understand a site. And only if they understand a site, can they draw it properly.

Once a recording team has done its on-site homework, and once the researchers have shared their expertise and the fruits of their investigations into other data sources, then the team is ready to decide what is truly important about the site-- what information should be stored, interpreted, and analyzed. Once this judgement is made, then the team can decide what aspects of the site should be treated in the historical monograph; what parts should be recorded photographically; and what parts and processes would be best illustrated by drawings.

If the site or structure truly merits it, and if time and money are available for it, then a recording team may decide to do a full set of drawings. Such a set might include: a site location map; a site plan; floor plans; elevations; longitudinal and transverse sections; details; isometrics; process and flow charts; and schematics. In many cases, however, the idea of doing such a comprehensive "set" of drawings should be dispensed with, in lieu of choosing just those individual drawings that are deemed most useful. Industrial archeology is not just the architectural history of industrial buildings. It goes beyond that. The industrial archeologist may be interested in a structure whose architecture or building technology is literally "run-of-the-mill." They may be interested only in the people, machines, tools, and processes that operated within the structure. In such a case, it would be extravagant to record the structure's architecture with numerous drawings, when far less expensive photographs would serve just as well to document facades and the like.

When a field team has decided upon those views that will best show the site--on those views that will contribute the most to our knowledge and understanding of the site--then they can pull out the 100-foot tape and begin taking field measurements and notes. Adherence to this regimen will never guarantee success, but it will help minimize failure and disappointment. The drawings produced by the most skilled and experienced field teams will never show everything to be seen at the site itself. But they should show, in a clear and bold way, what the field team members, intimate with the site, deemed its most significant features.

FOOTNOTES

*Editor's Note: While Lankton's paper was prepared for the Symposium, unfortunately he was unable to attend to take part in the discussions. See papers by Newell, Brown, Penn, and Packard for a different view of the need to formulate questions to ask of physical remains, and the use of inference in interpreting physical data.

1. Adaptive reuse is an aid to preserving a built environment that is visually diverse, and it may well serve as an economic stimulus to a community. But it is far less successful in terms of preserving the cultural evidence to be found at any IA site. The boutique-laden roundhouse and the train station-restaurant are uncomfortably reminiscent of the surveyor's transit and duck decoy that have become the bases of lamps in someone's living room.

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