4.0 MEASURED DRAWINGS

4.1 INTRODUCTION

The role of the architect, architecture technician, industrial designer or illustrator on a HAER project is multi-faceted. References to "architects" in the following pages should be treated as referring to anyone delineating HAER drawings. HAER documentation is an interdisciplinary effort which requires *teamwork.* The architects need the expertise of the historians and photographers just as much as these team members need the architects' talents; *architects cannot work in isolation.* Working with historic engineering or industrial sites may present architects with unfamiliar technologies, building structures, materials, and processes. Be sure you get team historians to properly identify site features and help you understand their significance and function. Similarly, if you discover features and dimensions in your field work which do not fit with the historic information you have been given, bring them to the historians' attention immediately. The data will fill in gaps, challenge certain conclusions, or confirm tentative hunches about the historic record. *All* team members should develop an open give-and-take among themselves and share data, discuss ideas, interpret data, and determine the best medium for recording various aspects of the site to the *Secretary's Standards.*

To meet those standards, you must concentrate on documenting what is specifically significant and valuable about your site (including context), prepare your preliminary drawings from accurately recorded field work (or other verified sources), and ink your final drawings on archival HAER Mylar sheets so that the significant features of your site come across "clearly and concisely". (See the Appendix, Section 5.1 for the text of the *Secretary's Standards.)*

4.2 PLANNING DRAWINGS

Documentation is necessarily a selective and interpretive process, so you cannot plan a drawing set without having some idea what is significant about your site, and what combination of media will do the best recording job. The entire documentation package must be developed as an integrated whole. Your site's significance will have been outlined by the HAER office sufficiently to direct your general field work at the very beginning of the project. Consult all materials sent the team by WASO staff, and prepare to spend a few days examining pre-existing documents and exploring the site in earnest.

Drawing Sets

Below is a checklist of drawings--there are no "standardized" sets of drawings, since every site has its own combination of significant features to record, and its own peculiar collection of surviving records.

- **Title Sheet.** This sheet always contains the name of the structure in bold lettering, a short synopsis of the site's history, site location maps, a site plan, and project credits. Sometimes a significant elevation, detail, or perspective view is presented. A drawing index is essential for large sets. More details are given in Section 4.7.

- **Site Plans.** These should show existing site conditions. (Historic conditions may also be required.) Site plans should feature plat boundaries, transportation systems, influential geography (rivers, valleys), and significant site structures and services. Topography may need to be included, and if botanical materials (trees, shrubs, plants) are significant, they should be shown and identified by their Latin and common names.

• **Historic Site Plans.** A series of dated site plans may be needed to show the development of a building, industrial complex or large civil engineering system.

• **Site Sections.** These are needed to show the way an industrial site or bridge was built to adapt to special topographic conditions. Relationships between buildings or functions at different levels can be displayed this way.

• **Floor Plans.** These must show wall materials and openings, floor configurations and finishes, and significant structural members. Machinery, transportation routes, piping, line shafting, and the like should be included. Plans may also trace the flow of a process or product through a building or site. Cutaway plans may be used in some cases (such as bridges or other modular structures) in order to show typical internal or underlying structure.

• **Reflected Ceiling Plans.** These show significant *overhead* architectural and mechanical details, such as line shafting, ducts, tramways, etc. They may also show structural systems.

• **Elevations.** These show the principal facades of a structure (but not necessarily all sides).

• **Sections.** Sections show significant interrelationships among spaces and equipment on different floors or in relation to other features on site. Sections may be longitudinal, transverse, or even one-point perspectives. Sections are often jogged, that is, a single section plane is woven through a structure in order to avoid structural members or objects that would obscure more significant things in the view.

• **Details.** Detail views show significant architectural and engineering features whose relationships cannot be clearly displayed at small scales. Details can include orthographic views and sections of machinery, structural joints, and special site conditions; they also may include significant architectural details, such as molding profiles, cornices, columns, door and window cases.

• **Interpretive Drawings.** Interpretive drawings go beyond orthographic views to clarify, explain and emphasize distinctive relationships between physical features of the site and its functions. Such drawings may range from reconstructed historical perspective views of a site (when no historic graphic views survive); exploded axonometrics, cutaway views, flow charts of industrial processes, or step-by-step schematics illustrating how a crucial machine or process functions.

Choice of these views, or combinations, will be governed by the nature of your site and the specific features which you are recording. In planning a series of drawings, you must decide in conjunction with your team where drawings do the best documentary job, and where photographs and histories would be more appropriate. Expect many details of a drawing set to change depending on the evolution of historical research and field work at the site itself.

Unless the WASO office has already developed a complementary drawing list and sheet layouts in advance, team architects are expected to develop them within the first week.

Thumbnail Sketches

The team should make thumbnail sketches of prospective drawings as thinking and talking points (see Fig. 4.1). As you discuss significant features of the resource, think about several ways to constructively present them and use the thumbnail sketches to test their effectiveness.

> **TIP:** For very complex structures, building a scale *schematic* model with cardboard, balsa wood, or scrap materials may be a considerable help to visualizing how processes operate, and to making decisions about documentation. It can also contribute considerably to team communications.

As ideas occur to the team for research, scheduling, and field work, jot them down on the sketches. Consider what you will base your drawings on in order to meet Standard II. Rigorous hand measurements and photography? Pre-existing drawings, historic photos, and published materials? Written data? Rectified photography? Photogrammetry? Electronic surveying? Disassembly of components? In all likelihood, you will depend on some combination of these sources and methods Annotate your thumbnail sketches with the collage of information you assemble, and begin to sort it out, and pull useful records. You will need to plan your work so that its accuracy and verifiability are appropriate to the significant features you are documenting. *The whole team will need to check each kind of source against the others and with the site itself* in order to ferret out contradictions and agreements. (Report these procedures and their results in your final products.) You should also read the following sections on field measurement and photographic techniques to help you select and use the appropriate media at your site.

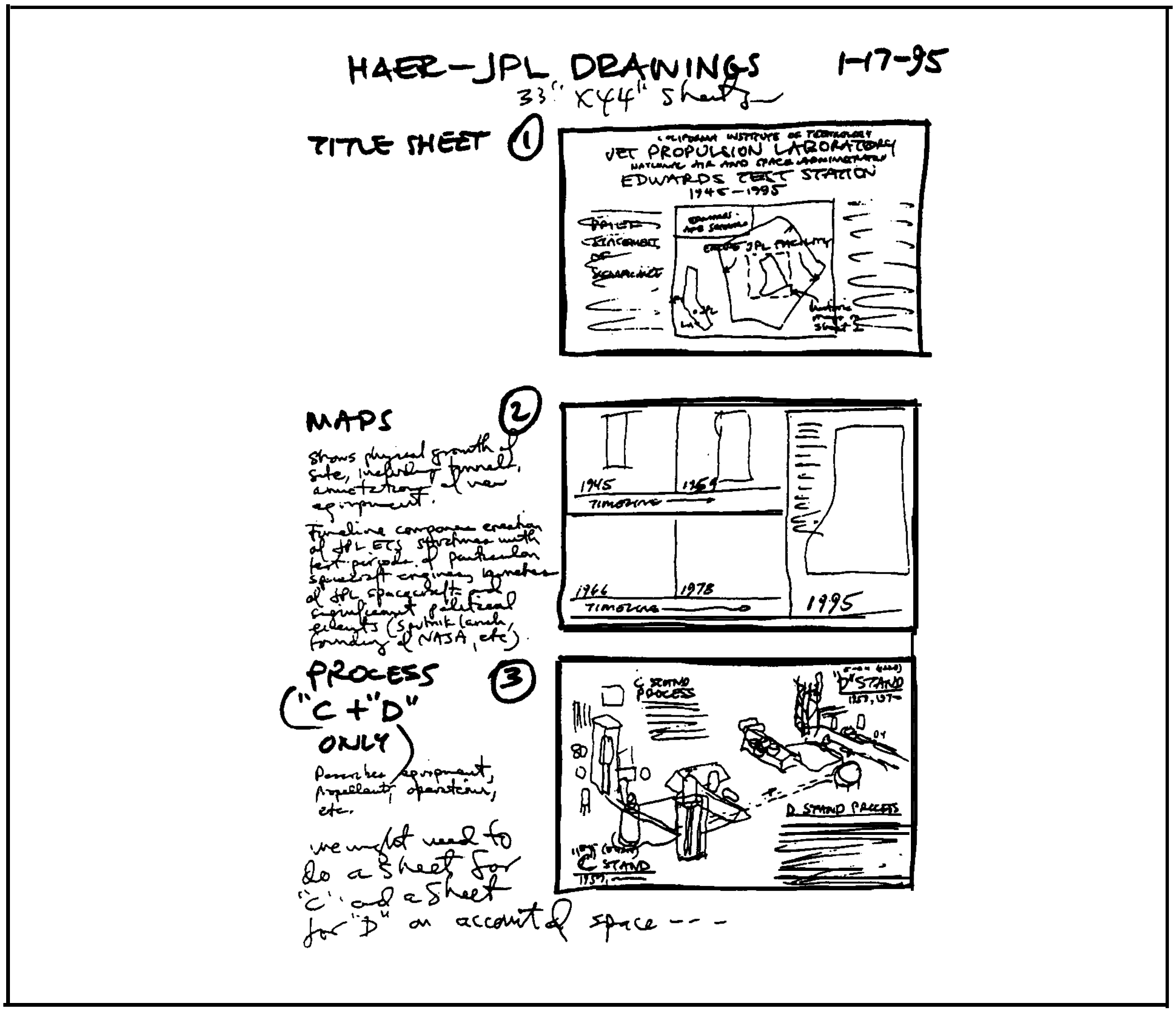


Fig. 4.1
Preliminary set of thumbnail sketches for a small drawing set

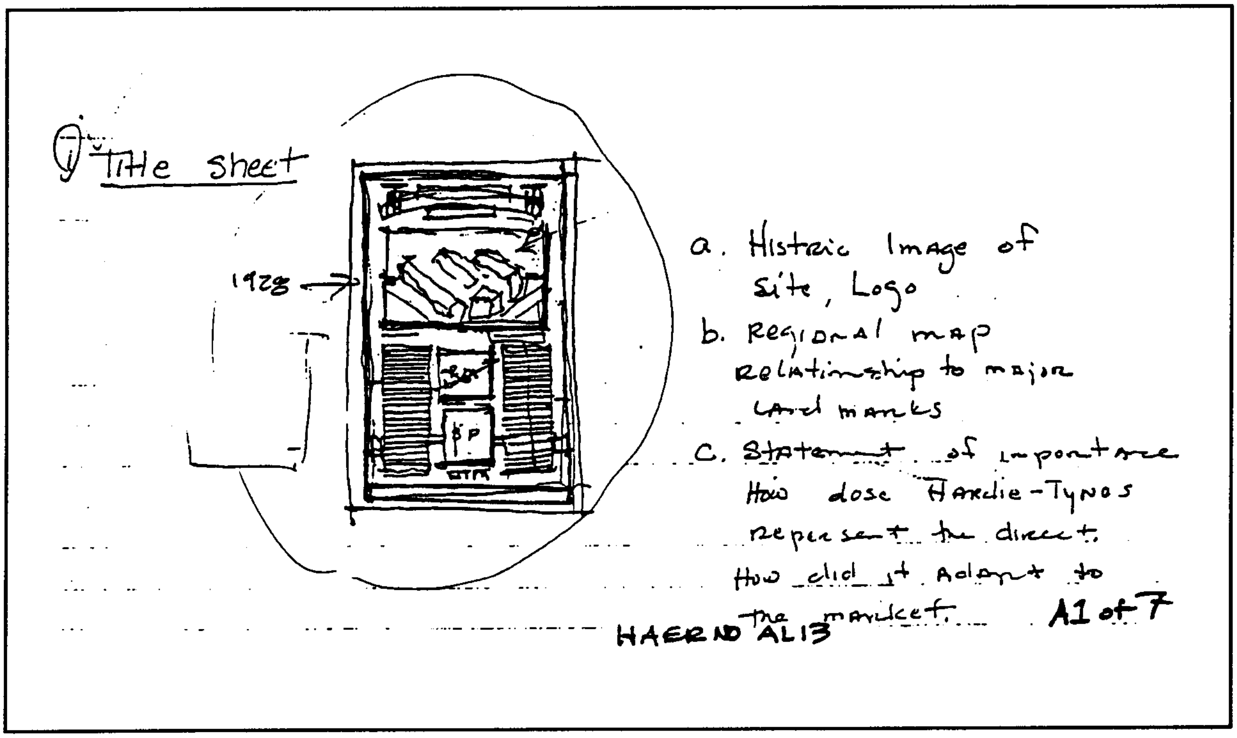


Fig. 4.2
Further developed thumbnail sketch and notes for the Hardie-Tynes title sheet

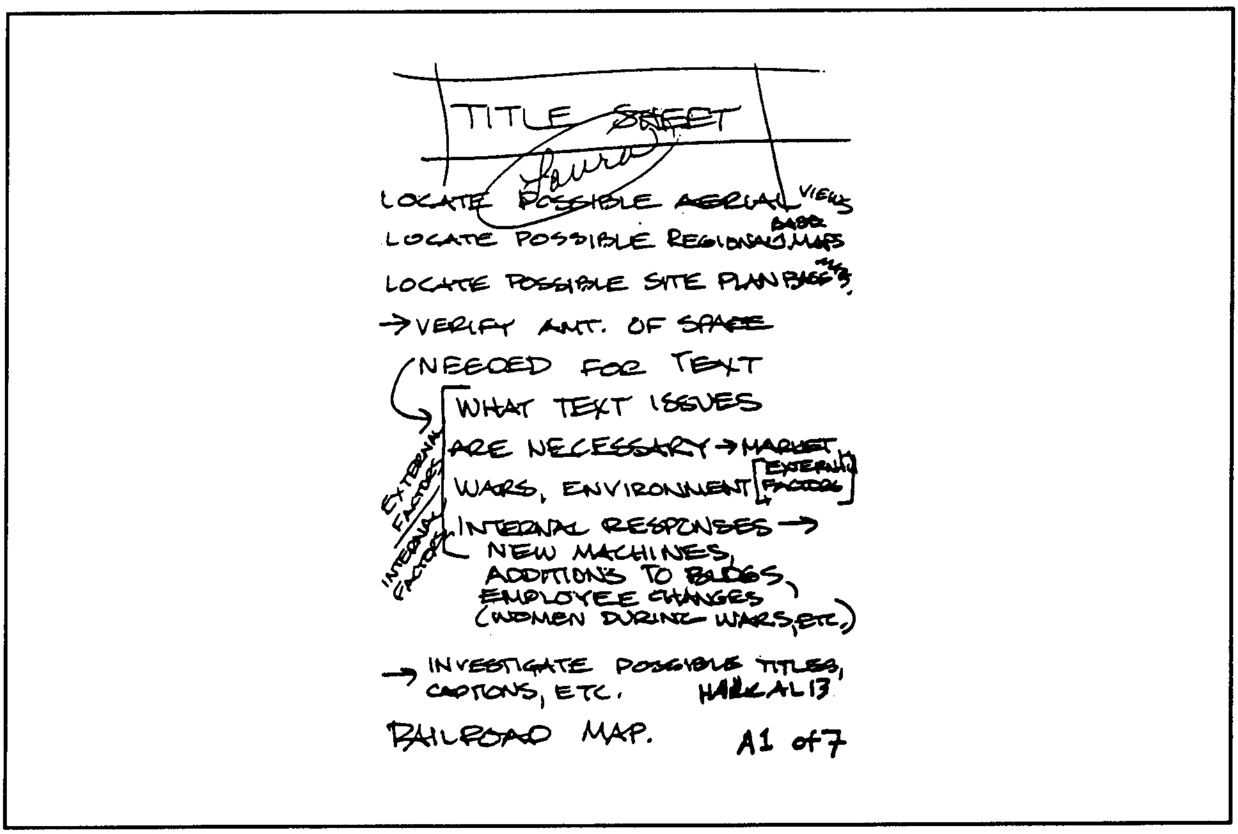


Fig. 4.3
List of preliminary questions and sources for the Hardie-Tynes title sheet

SHEET TITLE: "Hardie-Tynes Manufacturing Company"

ARCHITECT: Laura Letton

I. **Title Sheet:**
Through an illustration, maps, and written text the title sheet serves as the introductory sheet for the set of architectural drawings of the Hardie-Tynes Manufacturing Company.

A. **Illustration:** The title sheet will show the Hardie-Tynes Manufacturing Company site in a two-point perspective north-easterly view. This illustration will show the site as it was circa 1912. With a tilted ground plane the illustration will show all of the major buildings of Hardie-Tynes that existed at this time.

B. **Location Maps:** The title sheet will include two location maps.

1. **Regional Map:** The first map will show a birdis eye view of the Birmingham area with a smaller Alabama State map superimposed for contextual placement. The Alabama State map will show the five-county Birmingham District.

2. **Vicinity Map:** The vicinity map will show a nine-block area with the one block Hardie-Tynes site as the central focus. Structures at the Hardie-Tynes site will be identified, as well as rail lines which function as the connecting infrastructure for incoming materials and out-going products.

C. **Annotation:** The illustration and maps will be titled with brief captions indicating what information the respective graphic contains as well as the source of materials presented. Maps will be labeled as deemed appropriate for clarity. UTM numbers will be indicated on the vicinity map.

D. **Text:** The text will include a statement of significance, a brief history of the evolution of the Hardie-Tynes Manufacturing Company, and a brief explanation of the operations of the machine shop and foundry. The text will conclude with a list of credits which will include thanks to the Hardie-Tynes Manufacturing Company, the Birmingham Historical Society, the Birmingham Industrial Corridor Advisory Board, and/or all individuals and associations who will have facilitated the execution of this documentation project. Also included in the credits will be a list of names of HAER recording team members.

Fig. 4.4
Typed list of objectives, content, sources and annotations for the Hardie-Tynes title sheet

INDEX TO DRAWINGS, PHOTOGRAPHS & REFERENCES

Structure: **Hardie-Tynes Manufacturing Company**

Sheet Title: **"Hardie-Tynes Manufacturing Company" (Title Sheet)**

HAER Number: **AL-13**

Address: **800 28th Street North**

City/Town: **Birmingham**

County: **Jefferson**

State: **Alabama**

Measured By:

Field Notebook Number	Description	Date
A1 of 7	Preliminary outline, Evelyn Green	JUN 1992
A2 of 7	Half-size preliminary layout	JUN 1992
A3 of 7	Richard Anderson Red-line	JUL 1992
A4 of 7	Hardie-Tynes Manufacturing Company, Advertising Brochure	JUL 1912
A5 of 7	"Bird's Eye View of Birmingham," from Designs on Birmingham, courtesy Birmingham Historical Society	1989
A6 of 7	Ownership Map (Tax Map), Jefferson County, Alabama Department of Revenue, Numbers 22-25-4 and 22-25-1	1976
A7 of 7	Aerial Photographs, Hardie-Tynes Manufacturing Company Archives	

Fig. 4.5
Architect's schedule and sources for the Hardie-Tynes title sheet

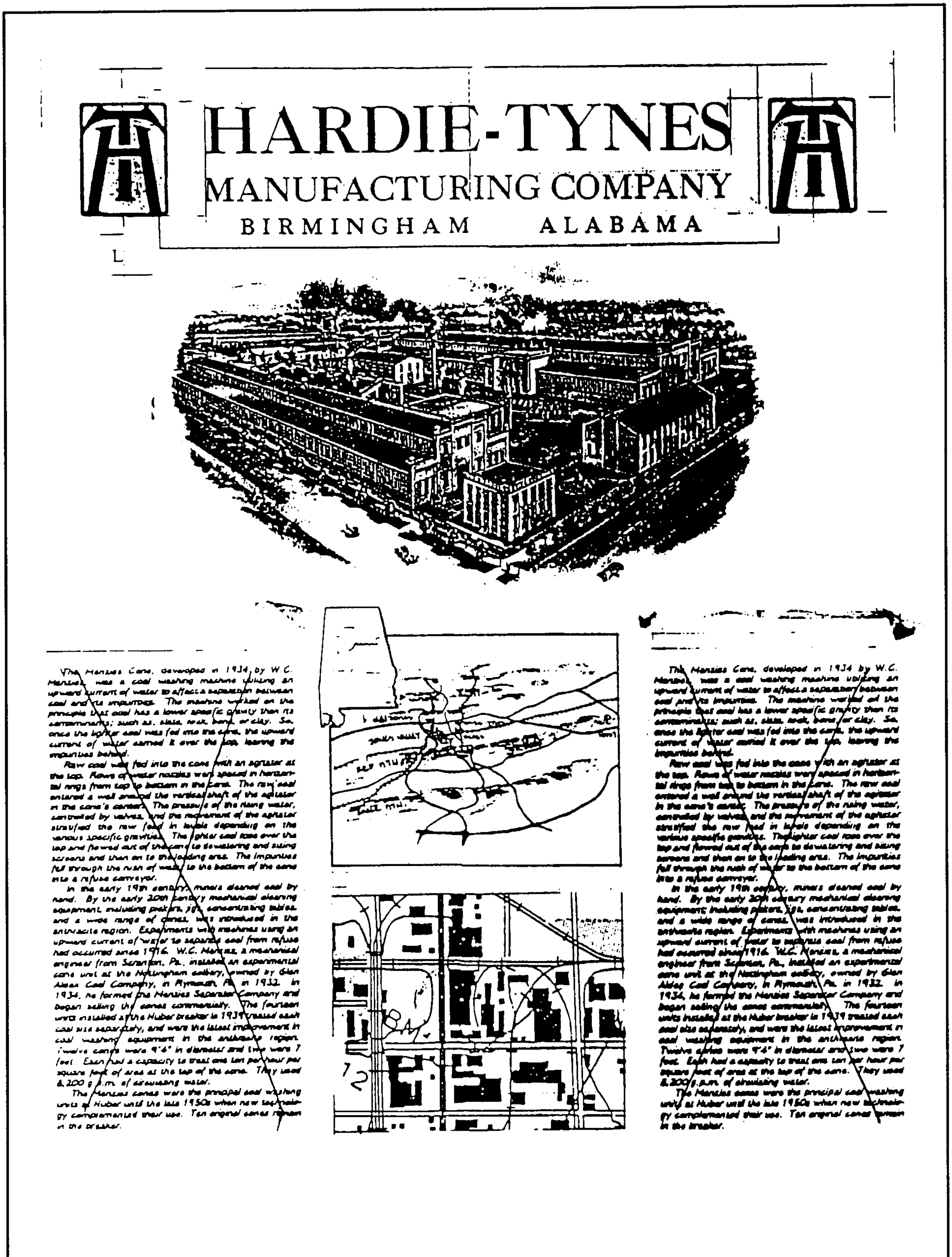
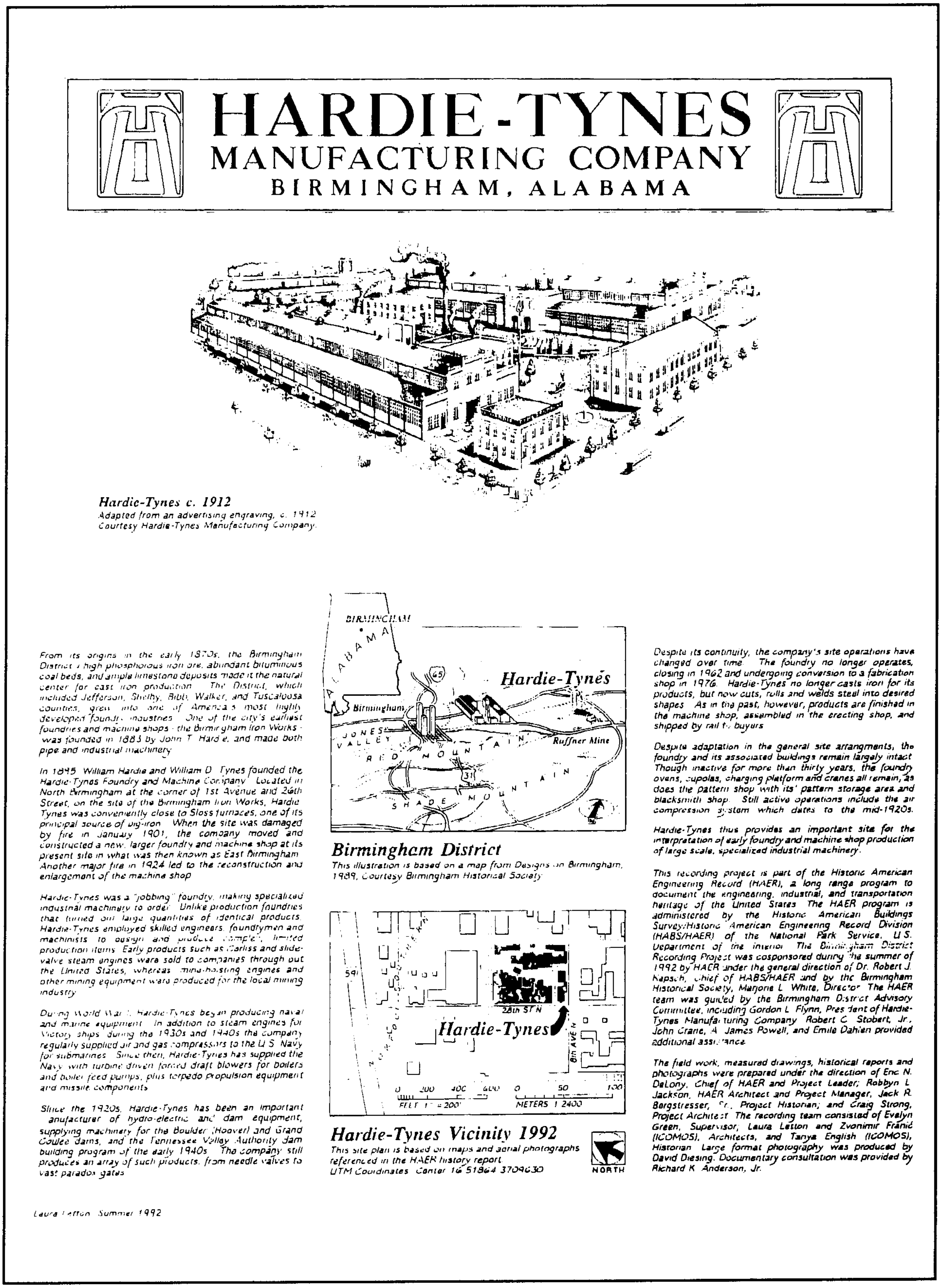


Fig. 4.6

Reduced view of a half-sized mock-up for the Hardie-Tynes title sheet. Note that the title lettering, graphics, and maps are set out, while the text is simply a visual filler copied from another drawing



HARDIE-TYNES
MANUFACTURING COMPANY
BIRMINGHAM, ALABAMA

Hardie-Tynes c. 1912
Adapted from an advertising engraving, c. 1912
Courtesy Hardie-Tynes Manufacturing Company.

From its origins in the early 1870s, the Birmingham District's high phosphorous iron ore, abundant bituminous coal beds, and ample limestone deposits made it the natural center for cast iron production. The District, which included Jefferson, Shelby, Bibb, Walker, and Tuscaloosa counties, grew into one of America's most highly developed foundry industries. One of the city's earliest foundries and machine shops - the Birmingham Iron Works - was founded in 1883 by John T. Hardie, and made both pipe and industrial machinery.

In 1895 William Hardie and William D. Tynes founded the Hardie-Tynes Foundry and Machine Company. Located in North Birmingham at the corner of 1st Avenue and 26th Street, on the site of the Birmingham Iron Works, Hardie-Tynes was conveniently close to Sloss furnaces, one of its principal source of pig-iron. When the site was damaged by fire in January 1901, the company moved and constructed a new, larger foundry and machine shop at its present site in what was then known as East Birmingham. Another major fire in 1924 led to the reconstruction and enlargement of the machine shop.

Hardie-Tynes was a "jobbing" foundry, making specialized industrial machinery to order. Unlike production foundries that turned out large quantities of identical products, Hardie-Tynes employed skilled engineers, foundrymen and machinists to design and produce complex, limited production items. Early products such as Corliss and slide-valve steam engines were sold to companies through out the United States, whereas mine-hoisting engines and other mining equipment were produced for the local mining industry.

During World War I, Hardie-Tynes began producing naval and marine equipment. In addition to steam engines for Victory ships during the 1930s and 1940s the company regularly supplied air and gas compressors to the U.S. Navy for submarines. Since then, Hardie-Tynes has supplied the Navy with turbine driven forced draft blowers for boilers and boiler feed pumps, plus torpedo propulsion equipment and missile components.

Since the 1920s, Hardie-Tynes has been an important manufacturer of hydro-electric and dam equipment, supplying machinery for the Boulder (Hoover) and Grand Coulee dams, and the Tennessee Valley Authority dam building program of the early 1940s. The company still produces an array of such products, from needle valves to vast paradox gates.

Laura Letton Summer 1992

Birmingham District
This illustration is based on a map from Designs on Birmingham, 1989. Courtesy Birmingham Historical Society.

Hardie-Tynes Vicinity 1992
This site plan is based on maps and aerial photographs referenced in the HAER history report.
UTM Coordinates Center 16 518640 3709630

Despite its continuity, the company's site operations have changed over time. The foundry no longer operates, closing in 1962 and undergoing conversion to a fabrication shop in 1976. Hardie-Tynes no longer casts iron for its products, but now cuts, rolls and welds steel into desired shapes. As in the past, however, products are finished in the machine shop, assembled in the erecting shop, and shipped by rail to buyers.

Despite adaptation in the general site arrangments, the foundry and its associated buildings remain largely intact. Though inactive for more than thirty years, the foundry ovens, cupolas, charging platform and cranes all remain, as does the pattern shop with its' pattern storage area and blacksmith shop. Still active operations include the air compression system which dates to the mid-1920s.

Hardie-Tynes thus provides an important site for the interpretation of early foundry and machine shop production of large scale, specialized industrial machinery.

This recording project is part of the Historic American Engineering Record (HAER), a long range program to document the engineering, industrial, and transportation heritage of the United States. The HAER program is administered by the Historic American Buildings Survey/Historic American Engineering Record Division (HABS/HAER) of the National Park Service, U.S. Department of the Interior. The Birmingham District Recording Project was cosponsored during the summer of 1992 by HAER under the general direction of Dr. Robert J. Kapsch, Chief of HABS/HAER and by the Birmingham Historical Society, Marjorie L. White, Director. The HAER team was guided by the Birmingham District Advisory Committee, including Gordon L. Flynn, President of Hardie-Tynes Manufacturing Company. Robert C. Stobert, Jr., John Crane, A. James Powell, and Emile Dahlen provided additional assistance.

The field work, measured drawings, historical reports and photographs were prepared under the direction of Eric N. DeLony, Chief of HAER and Project Leader; Robbyn L. Jackson, HAER Architect and Project Manager, Jack R. Bergstresser, Sr., Project Historian; and Craig Strong, Project Architect. The recording team consisted of Evelyn Green, Supervisor; Laura Letton and Zvonimir Franić (ICOMOS), Architects, and Tanya English (ICOMOS), Historian. Large format photography was produced by David Diesing. Documentary consultation was provided by Richard K. Anderson, Jr.

Fig. 4.7
Final inked title sheet, shown for comparison to earlier stages of development

Outline for Drawings

Eventually you will arrive at a sequence of sketches, each covered with notes on what to go after on the site and in the records (see Figs. 4.2 and 4.3). Refine these images and verbal notes to produce a written outline for each sheet containing a statement of objectives, list of views to be drawn, and a preliminary concept of annotation (Fig. 4.4).

Index to References

List potential secondary sources for each drawing and set a written schedule for each architect (Fig. 4.5).

> **NOTE:** Don't assume the preliminary drawing list is ironclad--research progress may point to a need for further drawings, or for revising some of the previously scheduled ones in order to meet Standard I.

Half-size Layout Sheets

Within the first two weeks of your project, you should develop a scale mock-up of each sheet. Fig. 4.6 shows a reduced example. (The final inked sheet is shown in Fig. 4.7 for comparison.)

Production Phases

Production of measured drawings by hand occurs in four overlapping phases: preparation, field work, preliminary drawings, and finished ink-on-Mylar drawings. HAER projects usually run for 12 weeks during the summer. Team size is determined by how many people are needed to get the job done within that time.

Experience indicates you should budget one-third of your time for field work (including preparation), one-third for preliminary drawings, and one-third for inking Mylar sheets. The following sections are organized by these phases and explain how to meet the ***Secretary's Standards.***

4.3 FIELD WORK

Field work encompasses any activity which collects data about a site. The objective of field work is ***accurate gathering of significant dimensional and representative data*** (Standards I and II). It includes shooting field photographs and checking various records against the site, but it rarely involves any destructive investigation or archeological excavation. The means for clearly recording this data to meet Standards II- IV.

Field work should be conducted according to the level of accuracy required, schedule, project budget, and the nature of the resource being recorded. HAER sites present challenges to recorders, who are often armed with nothing more than paper, pencils, cameras and hand measuring tools.

Safety

Few sites present openly dangerous conditions, however, even the safest will not prevent injuries stemming from plain carelessness. It is always your responsibility to look around, think ahead, and use common sense. A few reminders are listed below:

- **Apparel.** Work clothes such as jeans, sweatshirts and sturdy shoes or boots are protection against dirt and abrasion. Metallic materials exposed to sunlight get hot; work gloves should be kept nearby. Hard hats should be worn when in operational facilities or in deteriorating structures where overhead materials have been falling.

- **Deteriorated Structures.** Don't go out onto structures that are obviously deteriorated and unsound. Check the underlying structure in unused or abandoned buildings before going out onto (or under) floors, beams, roofs, walls. If necessary use ladders, scaffolding and safety lines. Photography (rectified photos or even photogrammetry) may be the safest way to "measure" unsound portions of a structure.

Never enter dilapidated buildings alone, and always use lights in darkened areas. Don't assume old wiring is "dead".

- **Ladders.** Always plant ladders on a firm footing and tie them down (top and bottom) or have team members hold them. Ladders are best for heights under 20 feet. For heights greater than 20 feet, scaffolding or cherry pickers are recommended when there is no other means to measure a facade.

- **Poison Ivy and Critters.** On overgrown or neglected sites, keep an eye out for irritating plants such as poison ivy and poison oak. Wash any affected skin immediately with soap and water. Be careful in high weeds and underbrush, since they can conceal thorns or snakes. Bees and wasps sometimes build hives in abandoned structures. Mice and rats should be expected, especially around foodstuffs (grain elevators, grist mills).

- **Exposure.** Use a sunscreen and wear a hat if you are outdoors a lot. Drink plenty of water in the summer to avoid dehydration.

- **Animal Droppings.** If you encounter accumulations of bird or animal droppings, avoid stirring up dust from them or contacting them directly. Illness from them is unusual, but can be serious. If you are going to work for extended periods of time in fouled areas, wear a mask and protective clothing.

- **Asbestos.** Asbestos is a white, fibrous, noncombustible and potentially carcinogenic mineral. Historic industrial sites are very likely to contain pipes, boilers and other heated equipment insulated with asbestos or constructed with asbestos-bearing materials (such as floor tiles, shingles, cements, gaskets, etc.). Normally these materials present no danger to you if the site is well-maintained and insulation coverings are intact. Loose asbestos is not a serious hazard to work around briefly if you do *not stir it into an airborne dust cloud. If you should encounter loose asbestos, do not touch it or attempt to remove it.*

Locating Existing Records

Before you blanch at the prospect of measuring large or complicated things, see if you can find any existing maps, site plans, architectural and engineering drawings, erection plans, textbooks, repair manuals, or other graphics having to do with your site's layout, buildings and equipment. These may save you a lot of time and effort. Drawings usually survive for large utilities (hydroelectric stations, municipal pumping or electrical stations), major civil engineering works (dams, aqueducts, bridges, tunnels, canals) and large industrial sites with a lengthy period of operation. They are least likely to survive (if they ever existed at all) for small industrial and rural operations, such as grist mills, blacksmith shops, and the like. Information for and drawings of mass-produced structural members, machinery, and equipment can often be found in period advertisements, catalogs, trade journals, technical manuals or patent data. In some cases, documentary information may be the only way you can conveniently and economically get at the historically significant inner structures of buildings or machinery without dismantling or destroying the features you are recording. Placement of concrete reinforcement and the internal arrangement of a steam engine are some examples of this situation. Even if drawings do not show all the latest changes or cover more than a few buildings or machines, they may save you considerable measuring time.

IMPORTANT CAUTIONS:

1) Older drawings should always be checked against the objects documented by or built from them, since construction errors or changes may have occurred.

2) Be very careful to check older drawings and reproductions for scale distortion. Most reproductions (blueprints, electrostatic prints, etc.) introduce distortions in the direction of travel of the original document through the copying apparatus; multiple copy generations only magnify the problem. Paper also expands and contracts across its grain with age, temperature and humidity changes.

3) Most engineering drawings are governed by their <u>written</u> dimensions, not the scale of the image; where the two conflict, the written dimensions rule. So be very careful to check the image scale against written dimensions before using old drawings for underlays. Distorted or not-to-scale images may require you to rework or redraw reproductions rather than trace from them.

> TIP: Electrostatic (Xerox@ or equivalent) copies of existing drawings can serve as field sketches on which to put check measurements and any additional field notes (building additions, changes) that you may need to record. You can use them to make additional notes about existing materials and conditions, jotting down any questions or references that arise.

Explore your site for telltale signs of historic use, adaptation, repair and demolition. Smells and sounds can help as much as sight and touch. Inconsistencies in materials, alignment of features, or changes in surface finishes and colors can be valuable clues (see *Appendix 5.5 for clues identifying metals).* Bricked-in windows and doors, changes or splices in moldings, partially buried foundations, even stray bricks and stones of unusual color or size should be examined as clues to possible additions or changes. Wear patterns in floors can be clues to age, to human and mechanical traffic patterns and to the organization of work areas. Some irregularities can be subtle, revealing themselves best in a light held at a grazing angle to a wall or floor. Unexplained holes, straight or parallel cracks, patches of oil or soot, rust stains, indentations in floors for machinery bases, anchor bolt holes, nail holes, abrasion, rows of empty brackets, “shadows” or holidays in paint finishes--all these should be examined and noted. Look for patterns of clues, and see if a geometric form appears, or if clues follow an axis, or lead to other patterns. Sight down the edges of walls, lines of columns, holes in walls, rows of trusses, to see if anything unexpectedly regular or irregular shows up. Look at graffiti--some of it may reveal dates, employee names, work procedures, employee attitudes, or even work space organization. Examine the topography of a site--unusual hollows or hills, even weeds and brush, can be the “X that marks the spot”. Does a room smell particularly of paint solvents or ammonia, diesel fuel or smoke? You might also listen for sounds as you walk through a site or structure--does the floor or ground suddenly change from hollow- to solid-sounding? from masonry- to metallic-sounding? What could be the reasons?

These are only a few of the kinds of clues abandoned and operating sites contain. You will find dozens more.

As you go about your field work, keep your drawing list and layout sheets in mind so that you gather dimensions relevant to them and don’t waste time on unnecessary features. It is necessary to rank the significance of various features and details, so that a reasonable trade-off between significance, recording methods, schedule, and budget can be made when necessary.

Hand Measuring Tools

Below is a list of basic hand-measuring equipment recommended for field work, some of which is used to establish reference planes. Tapes and rules should be graduated in the English system, not the metric (routinely used in classical archeology), since most American industrial sites were built using the English system of feet and inches. (Site plans and plats may have been laid out in 66-foot surveyor's chains or in decimal feet, depending on their era--be careful here when comparing modern measurements with historic records.)

TIP: However, if you encounter equipment built to metric dimensions, use metric instruments to measure it. Objects should be recorded in the dimensional systems in which they were designed in order to best understand design ideas and interrelationships.

Storage containers:
- Toolboxes

Reference Devices:
- Transit (with tripod)
- "Torpedo" level (8-inch length)
- String level
- Plumb bobs
- Braided mason's or surveyor's twine

Measuring Devices:
- 300-foot tapes, l/8" graduations
- IOO-foot tapes, l/8" graduations
- 50-foot tapes, l/8" graduations
- 6-, 12-, 16-, 25-foot retractable tapes, l/ 16" graduations
- 6-, 8-foot folding carpenter's rules l/ **16"** graduations

WARNING! Most tapes (especially retractable ones) are metallic. Fiberglass tapes should be used around energized electrical equipment to prevent electrocution ***or fire.***

Marking Devices:
- Lumber crayons (red, black, yellow)
- Chalk sticks (white, blue, red, yellow)
- Chalk line reels (with bottles of powdered chalk for refills)
- Felt markers
- Ballpoint pens
- Pencils

Holding Devices:
- Masking tape
- Nails and hammer

Gauges:
- Contour gauge ("molding comb")

Hand Tools:
- Hammer
- Pliers
- Screwdrivers
- Utility (or mat) knife and blades
- Flashlights and batteries

Apparel:
- **Gloves**
- First aid kits
- Dust Masks

Data Storage:
- Clipboards 9"x 12" and 18"x24")
- 17"x22" field paper, 8 x 8 gridded
- Field notebooks
- Pencils (No. 2 black)
- Erasers
- Pens (red, blue)

Other:
- Drawing compass

Other tools that might be utilized by a field team include a carpenter's square, strong magnets (for temporarily securing tapes, plumb lines, etc. to steel structures), **2-** or 4-foot mason's levels, protractor level, digital level (e.g. "SmartLevel"TM), calculators, spring and jaw calipers, vernier calipers, a magnetic compass, and binoculars.

Reference Planes (Datum Lines)

Before measuring any site or structure, it is imperative that independent horizontal and vertical reference planes (often loosely called "datum lines") be established and marked on the structures.

> *WARNING! You* should *never* assume that a structure is level, plumb, or square and then try to use the structure's walls and floors as your overall reference frame.

Reference planes are necessary to help your work meet the *Secretary's Standards.* They are essential to accurately establishing where the heights of different features within a structure lie for recording plans, sections and elevations. They are also vital to establishing what the inclination of sloped areas is (they are sloped for a reason). Vertical reference planes are less critical, but will be necessary to establish vertical orientations of walls, and whether interior features lie over each other floor-to-floor or not.

1) Datum planes should be set at heights as convenient as possible for access throughout a building or site.

2) Once a beginning point is selected, try to transfer the level of that point to as many other places within your site as possible. This will aid you considerably in the drawing phases.

3) Mark the datum plane on structures. Make marks no more than 15 feet apart, using some recoverable method. (On some highly finished structures you may have to make these marks unobtrusive or put them on removable tape in order not to damage important finishes.)

> *WARNING!* Failing to leave marks behind will make it difficult to recover the datum plane to check conflicts, errors, and omissions later.

4) When it is time to measure something relative to the datum plane, team members can stretch a string between marks, and use the string as the datum plane indicator.

Horizontal Reference Planes

There are four major devices for setting horizontal reference planes:

1) Water Level: This device is extremely simple, cheap, effective, and nearly foolproof for setting level reference planes at a site or structure. It probably antedates the Egyptians, and operates on the elementary principle that water seeks its own level (see Fig. 4.8). If it were practical, you could set a horizontal datum plane at your site by filling the site with water, and marking where the water surface intersected the structures on a calm day. The water surface would be dead level due to water's response to gravity. A water level performs the same function without the flood. If you put water in a tube of any practical length with open ends, and hold the ends in the air, will be level with each other regardless of intervening terrain. (You will need to allow some time for water to settle from inertia and friction in the tube). Add some means of closing the tube ends so the water won't spill when the level is stored, and perhaps a coloring agent for easier visibility, and you have a very versatile tool.

Once a beginning point for a datum plane is selected, you can transfer the level of that point as far as the hose will reach.

There are two ways to use a water level (see Fig. 4.9):

(a) The first is to raise/lower the hose end at the initial mark until the water column (A) is aligned with the mark, while another person holds the other end (B) absolutely still. When water column A is aligned, signal the other operator to make a mark at the top of the water column at B. The person at A can speed the process tremendously by waiting for the water column to settle (no matter where that may be relative to the initial mark), noting how far above (or below) the water column top is from the initial mark, then moving the hose *twice* that distance in the *opposite*

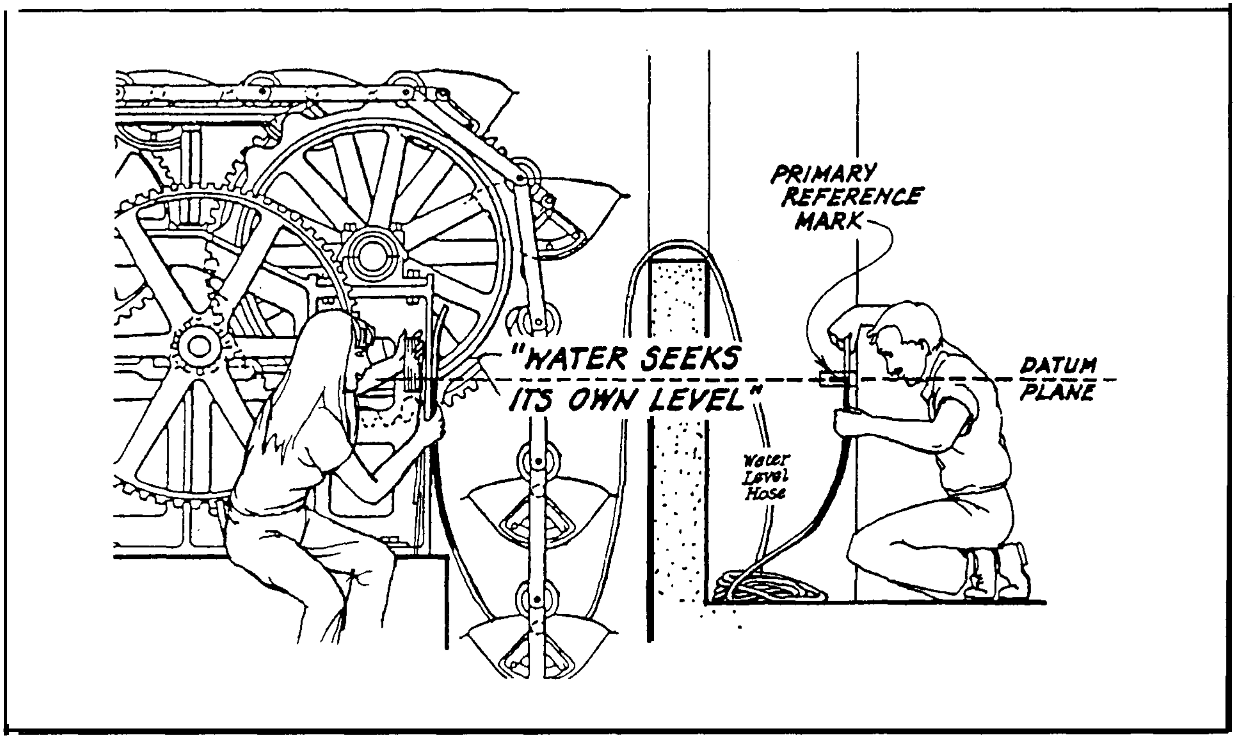


Fig. 4.8
Using a Water Level

direction. The water column should "split the difference" and settle very closely to the mark. Repeat this until the mark and water column are aligned.

(b) Here both hose operators wait until the water columns settle. Then the person at the initial mark A measures how far above or below the water column is from the initial mark, and tells the second person what this measurement is, and where it is relative to the water column. The second person then makes a mark at the proper measurement. The two marks should be level with each other since they are both the same distance in the same direction from the level ends of the water column. While this procedure eliminates adjusting the hose, the second person may measure the wrong direction for the second mark and introduce considerable error, especially when you can't visually double-check their relative levels because of an intervening obstacle.

For a one-person operation, both procedures take similar times. Both ends of the hose should be taped to the structure, and then the water column either adjusted or measured at the initial mark before setting the second.

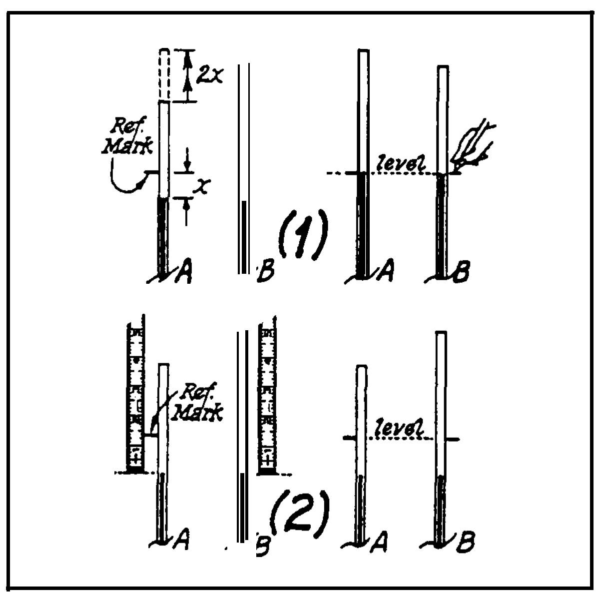


Fig. 4.9
Transferring Datum Plane with Water Level

CAUTION: Set as many marks as possible from your initial mark. “Chaining” level marks (using the second mark as the initial mark for the third, etc.) can result in significant cumulativc errors. This problem is analogous to that with additive (or cumulative) measurements discussed later.

2. **String Levels.** A string level consists of a bubble level with hooks on each end hung on a strong string. The bubble level should be equidistant between suspension points so the level and the string ends are parallel despite the sag induced by the level’s weight. Set one end of the string to an initial mark, and raise/lower the other end until the bubble in the level is centered. Remove the level from the string, and mark the string ends and points between along the string. This procedure works best with three people, though it can be done by one person with a way to secure both ends of the string while checking level and making marks.

This device depends on its hooks for accuracy. If they are bent or damaged, check the bubble level against itself by reversing its position on the string. If the bubble settles at the same relative position towards a marked end of the vial, then the string is level, even though the bubble may no longer lie between the centering marks (see Fig. 4. 1O).

The string level works best over distances less than 20 feet. Other reference plane devices are more consistently accurate and faster to use for longer distances.

3. **Laser Levels.** Once properly leveled, these devices project a visible red or infrared (invisible) laser beam horizontally, rotating it to describe a datum plane with a beam of light. You can then mark a structure using the beam as a guide or measure from features to the light plane, recording the dimension where the beam crosses your scale. The chief advantages of a laser level are speed of setup and ease of use; one person can make measurements to the reference plane with it. (All other instruments are most efficiently operated with at least two people.) In bright sunlight, both types, visible red and infrared need a detector to find the beam, but in shady or dark places indoors, the visible beam is easily seen. Laser units are sold as self-leveling or non-self-leveling units. The self-leveling variety typically have an average level accuracy of $^1/_2$" in 100 feet. The non-self-leveling kind can be adjusted with better precision; in addition, many can be set up to project vertical planes, or stationary lines. New laser units cost about as much as a Category 1 transit. Many are battery powered, which limits their time at a given set-up; some have 120v adapters.

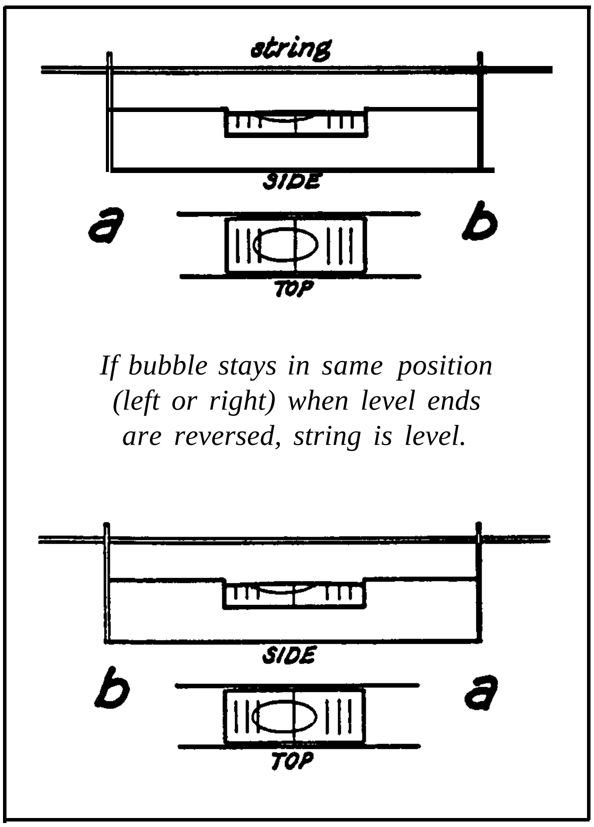


Fig. 4.10
Using a string Level

CAUTION: Visible light lasers operate at a very low power (about 3 milliwatts, or 3/1000 this the power of a flashlight bulb), so the ability of a fast-rotating beam to "zap" things or damage your eyes is minimal. (The same lasers power bar code scanners in grocery stores and are used by workers to align and hang dropped ceilings). However, danger does lie in staring for a *prolonged* time into a *stationary* laser beam. Your eye will focus the energy onto a very small spot, and time only multiplies the energy delivered. So be careful! In the absence of a detector, a visible laser beam can be seen in bright sunlight by looking back toward the laser unit from the point at which you wish to mark the reference plane. With the laser rotating at I50 RPM at a distance of 50 feet, you will see flashes of two-millionths of a second 150 times a second. If you are still concerned about damage to your eyes, use a small piece of clean window glass for a reflector/detector. Glass reflects about 5% of the light striking it within 20" of a line normal to its surface.

4. **Transits and Theodolites.** Regardless of their technology, these instruments measure angles (horizontal and vertical) and distances (range from the instrument station). However, in order to operate properly, they must be leveled (see the Appendix if you are not familiar with leveling procedures). Once leveled, they can be used to set a datum plane on structures through the telescope reticle (cross hairs). Simple mechanical transits (Category 1 instruments) require no power supply and can set a plane level to within $^1/_8$" or better for each 100 feet of distance. (As long as the instrument is set up, you can also record the heights of features above or below the datum plane described with the telescope.) Optical or electronic theodolites can be set level more precisely, but they are too expensive to use if all you are planning to do is set a level datum plane with them.

TIP: If all you plan to USC a transit for is setting level planes, a builder's level (commonly called a "dumpy" level) may be all you need. These instruments are easier to set up, but they have no vertical circle, and the horizontal circle cannot measure turns as precisely as a Category 1 instrument.

Electronic theodolites with EDM (Electronic Distance Measurement) capabilities are only practical if you need to record dozens or hundreds of control points and plot them in addition to a datum plane with a CAD system in a very limited time. Short battery life limits these units to between 2 and 6 hours continuous operation without access to a 120v outlet, and if you shut them off, you lose all your settings. Nearly all these instruments require at least two people to operate them effectively--a transit operator and someone to mark a point, or hold a measuring tool or prism rod in alignment with the telescope.

Setting Reference Planes with a Transit. A transit can set planes two ways:

(a) The transit operator can signal a second person at the structure to move a marker up or down until he/she can make a mark in line with the cross hair in the telescope reticle. This can produce a lot of hand-waving.

(b) The second person at the structure can firmly hold a tape or folding rule against the structure where the transit operator can read it through the telescope (Fig. 4.11). The operator then reads the rule where the horizontal cross hair intersects it and calls out the reading to the person at the structure who makes a mark by that reading on the rule. This is much faster than hand-waving.

Once you begin to set reference marks, make sure you set all you will need or can see from the instrument station. Unlike the water level or most laser levels, once you move a transit and tripod, it is impossible to set the instrument up at exactly the same datum plane again. Try to set a station at a building corner where you can spot at least two elevations from one point, or even see into or through buildings to others beyond. Inside structures, try to shoot as far as you can down hallways or into adjacent spaces; don't set up a station on easily deflected floors--anyone walking around the instrument will upset the instrument's level plane.

TIP: In some cases you may find it useful to erect a pole or two at a site on which to set datum marks in order to pick up the plane from another instrument station.

On most sites, you will need at least two transit stations (and perhaps many more) to set a horizontal reference plane. Since you cannot set the instrument up twice in the same plane, there are two ways to continue a datum plane:

(c) After the instrument is leveled, set your next series of marks at the second horizontal reference plane, *but be sure you measure and record the distance between the two planes* in your field notes. This method is faster than the second one below, but it can cause confusion in field notes and drawings if the various datum planes are not clearly labeled and distinguished from each other.

(d) After leveling the instrument, measure and record the distance between the new instrument height and the original reference plane. Each subsequent sighting indicates where the new plane lies, but you measure the recorded distance back to the original plane and mark it on the structure. This takes more time, but continues the original plane uninterrupted.

Vertical Reference Planes

There are three major devices for setting vertical reference planes:

1. Plumb Bobs. The plumb bob is the simplest and most foolproof vertical reference line instrument. Its truth is with two plumb lines by sighting across the visually superimposed strings and aligning them equidistantly from a vertical surface (or other reference points). The line-of-plane can then be used to read swing ties to features (see Fig. 4.12). The plumb lines could be set up over a grid line or reference line pulled along the ground in order to take horizontal dimensions with reference to the plane.

TIP: Wind effects can be greatly reduced by immersing suspended plumb bobs in containers of water.

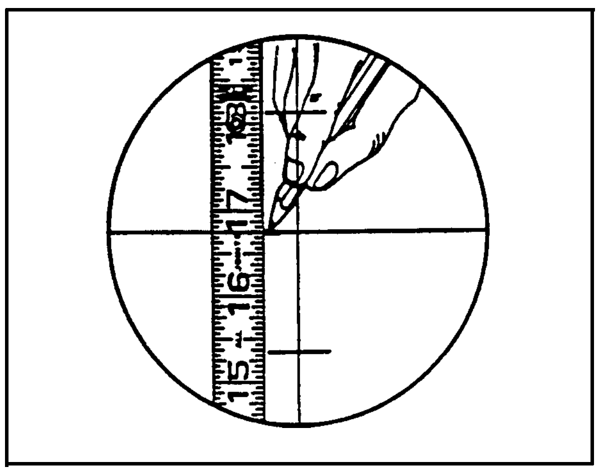


Fig. 4.11
Using a rule to mark a Datum plane

2. **Laser Levels.** As mentioned above, some laser levels can be mounted to project vertical planes. They can be set or double-checked by hanging plumb lines in the laser plane (the string will brightly reflect laser light). To align the laser plane with a wall, adjust the laser plane until it crosses two rules set at the

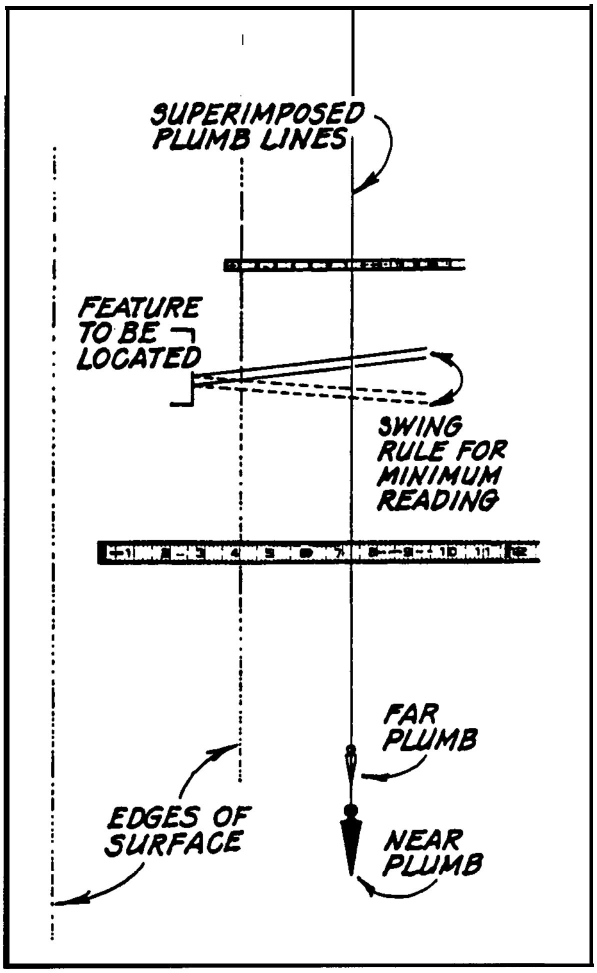


Fig. 4.12
Vertical planes set with plumb lines

ends of the wall at an equal dimension (similar to setting a plane with plumb lines, see Fig. 4.12). Use swing ties to measure from features on the wall to the laser plane.

3. **Transits.** Transits and theodolites contain precise circles whose aligned by the instrument frame and the leveling process. Just as the horizontal circle is used to set horizontal reference planes, the vertical circle can be used to set vertical reference planes. Move the telescope until equal measurements are sighted through the reticle on two rules set at the base of a wall (or whatever feature is to be measured), similar to Figure 4.12. Lock the horizontal circle and take swing ties from features to the plane of the vertical circle; read dimensions with the telescope.

Hand Measuring Methods

There are two approaches to systematic measurement: additive (or cumulative) and running (or consecutive) methods.

- **Additive measurements.** Additive measurements are "chained''--each succeeding measurement begins where the last one ended (see Fig. 4.13). Grouped and overall measurements are obtained by adding individual measurements. While this method reduces a lot of measurements to a size that an unassisted person can make with a tape, tolerances/errors accumulate. If you add six measurements, each with a $\pm 1/8$" tolerance, the sum has a tolerance of 6 x $\pm 1/8$" or $\pm 3/4$". Adding dimensions with different tolerances gives a total with a final tolerance that is the sum of all the individual tolerances, regardless of their size. In the end, reasonably careful measuring leaves you with an unreasonable amount of error. (For example, individually measuring the widths of fifty successive floorboards in a mill to $\pm 1/16$" will leave a final tolerance of $\pm 3\,1/8$"!) You may also make errors summing fractions, and a recording error in one measurement affects the total.

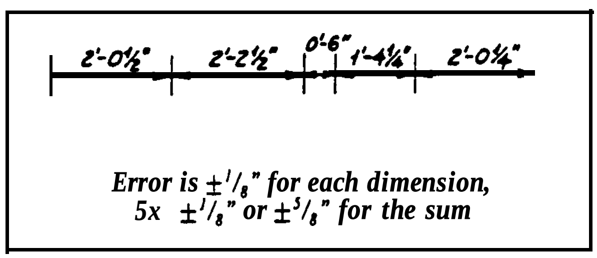


Fig. 4.13
Additive measurements

- **Running measurements.** Running dimensions reduce these problems by using the same starting point for all measurements made in a common direction (see Fig. 4.14), so they help your work meet Standard II. For example, to measure the window openings in a building facade, you would hook the tape at one corner, and continue (or "run") down the

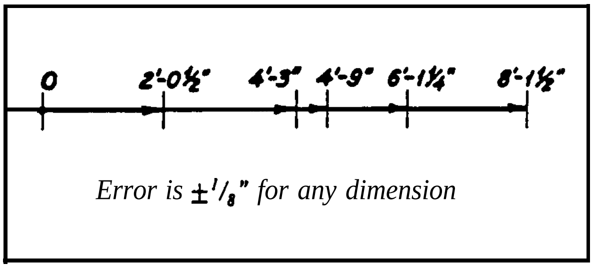


Fig. 4.14
Running Measurements

facade, taking the measurement of each opening edge as it is read from the tape. Each successive dimension is larger than the one preceding it, but if you hold a tolerance off'/ $_8$" for each dimension, that tolerance is the same for any individual measurement, independent of all others. Tolerances/errors do not accumulate. Note, however, if you subtract one running dimension from another, the tolerances *add, you* cannot subtract your way into a zero or negative tolerance.

In practice, additive measurement errors average out in many cases, but the total tolerance cannot be reduced mathematically. Use *running dimensions whenever possible.*

Be aware of the following in reading tapes, or recording and plotting dimensions:

Write dimensions in standard U.S. feet-and-inches with a single tic (') for feet and a double tic for inches ("). Insert "0" when a foot or inch dimension is less than one. Often common sense or "fit" to a drawing is not enough to interpret a dimension like 6'- ". Is it "6 feet and one-half inch", "6 and one-half inches" or "6 and one-half feet"? Did you forget an inch figure? Avoid ambiguities and ensure clarity (Standard IV) by writing this as 6'-0 ".

Take care in reading upside down scales; don't confuse 6 for 9 or mix up other numerals.

If you read scales opposite to their numerical progression, don't associate a fraction with an integer an inch too high or too low--i.e., misread $7^1/_2$" as $8^1/_2$", or 1 $0^7/_8$" as 1 $1^1/_8$".

Don't associate a fraction incorrectly with the nearest integer inch--i.e., misread $4^3/_4$" as $5^3/_4$".

Take care not to associate a reading incorrectly with the nearest integer foot--don't misread 21 "-$8^3/_4$" as 22'-$8^3/_4$".

Record dimensions as they appear on the tape you are using so you don't make mathematical conversion errors. (Some tapes are in inches only, some feet and inches-- others feature both systems.)

TIP: Plotting errors will be less frequent if all your dimensions are taken in feet and inches, since architectural scales are graduated that way. Converting inches to feet/inches can result in plotting errors.

Lastly, be sure you know where the "zero" is on the tape you are using. The "zero" for carpenter's tapes is at the tip end with the hook *closed.* (Some surveyor's tapes end four to six inches *beyond* the tape "zero"; the end is used as a handle.)

. **Swing Ties to Lines.** The correct distance from a point to a line lies along a second line running from the point square to the first line (see Fig. 4.15). You do not need to establish this connecting line with a square in order to measure it. All you need to do is put the zero end of your tape or rule on the point (feature whose location you are measuring), and swing the tape by the reference line. The *minimum* measurement on the tape is the true dimension. This type of measurement is called a **swing tie.** If it were worth your time to check it, you would find that the point of minimum measurement on the reference string would lie at the intersection of the squared connecting line going to the point on the feature. (Ordinarily the face of rule shown in Fig. 4.15 would be turned 90” so that swinging the rule will not introduce error from “rocking” the wider end on its corners.)

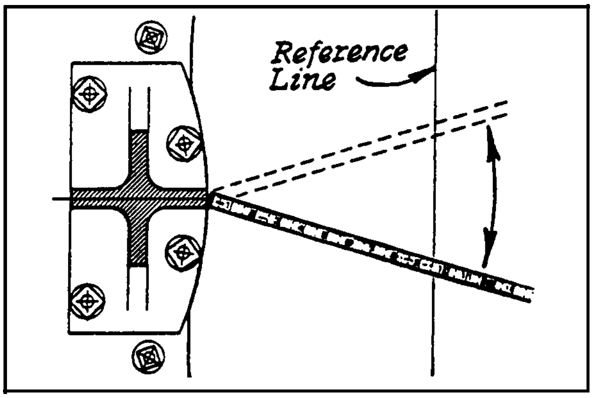


Fig. 4.15
Swing-tie from point to reference line

. Swing **Tie Measurements to Reference Planes.** A similar swing tie is used when measuring heights or depths to a horizontal reference plane over a broad area (deflected floors, foundations, remains, etc.). To measure the depth of a feature beneath a datum plane set by a transit, place the zero end of a rule on the feature, then sight the scale through the telescope. The rule should be swung towards and away from the transit, then left to right. A minimum measurement should be sought in both directions, and the procedure repeated until a minimum is found (see Fig. 4.16). As with the previous example, this minimum is the true distance between the feature and the reference plane. Sighting the rule through a transit telescope takes more time than measuring to a visible laser level plane. The laser beam indicates the location of the plane directly, and you find a minimum measurement quickly. This kind of swing tie will work as well with and vertical reference planes (see Fig. 4.12), but it does not work easily at all with a water level or string level.

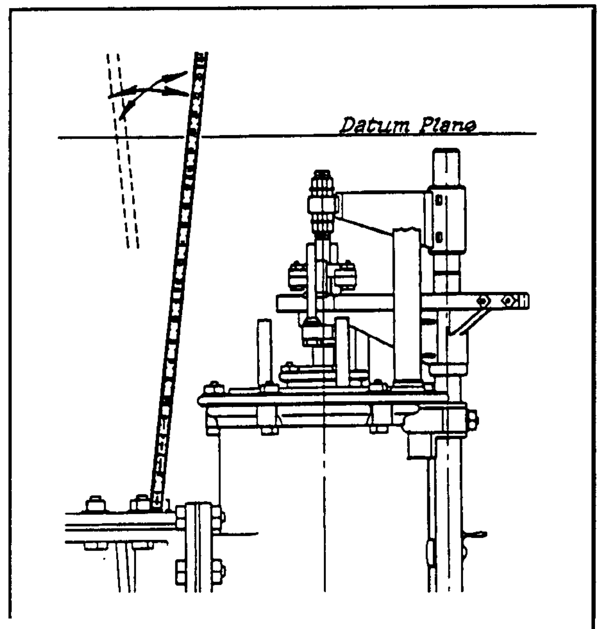


Fig. 4.16
Swing-tie from point to reference plane

. **Trilateration.** Hand trilateration is simple, powerful, and relatively foolproof for locating points and determining the shape of just about anything, so long as measurements are carefully taken, recorded, and plotted. No trigonometry is required. Trilaterated points are easy to reconstruct at the drawing board with a scale and compass.

Use trilateration to measure small site plans, building plans, layouts of columns or machinery, and the shapes of curves and irregular features. It can also be used to measure elevations and bridge arches (see Fig. 4.17 through 4.19)

• **Reference Strings.** In complex site or room plans, trilateration should be supplemented with a reference string and swing ties, especially where the measured area is slender (see Fig. 4.20). Be sure to measure and annotate the locations of the string ends on your notes. In cases of conflicts between the reference string and trilaterations, the reference string data is probably more reliable.

Reference strings can also be used as bases for trilateration. Points can be set along the line at *measured* locations (integer feet are convenient), and trilaterations made from these points to features (see Fig. 4.2 1).

• **Poles.** For conveniently reaching features up to 20 feet from you with a tape or plumb line, poles are excellent "extenders" for your arms. Poles should be made from one or more 8-foot pieces of clear (knotless, crackless) 1 "x2" lumber. (Knots or cracks can lead to fractures.) A series of measurements from vertical features to horizontal datum lines can be made very quickly by hooking the zero end of a tape on a pole and holding the end to the feature you wish to measure. This procedure is faster than repeatedly moving a heavy ladder.

> SAFETY NOTE: Poles made up from a series of l"x2"s should have joints that overlap at least 12", glued and nailed together.

• **Measuring Diameters.** The diameters of small piping and round decorative features can be measured with jaw or spring calipers. Measure the diameters of tanks, penstocks, etc. by taping their circumferences and dividing by π (3.1416). An architectural column must have circumferences taken at numerous measured locations along the shaft in order to determine the column entasis.

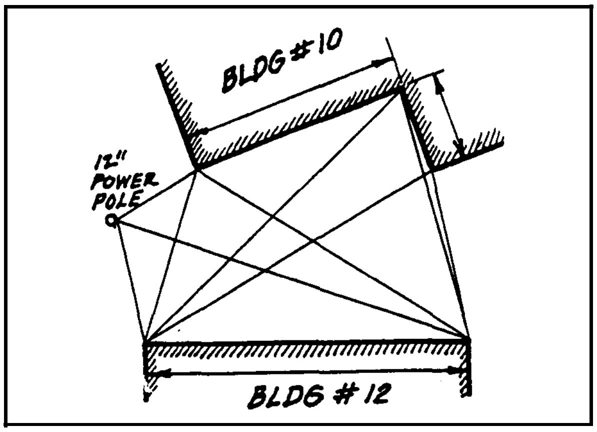


Fig. 4.17
Triangles and trilateration at work

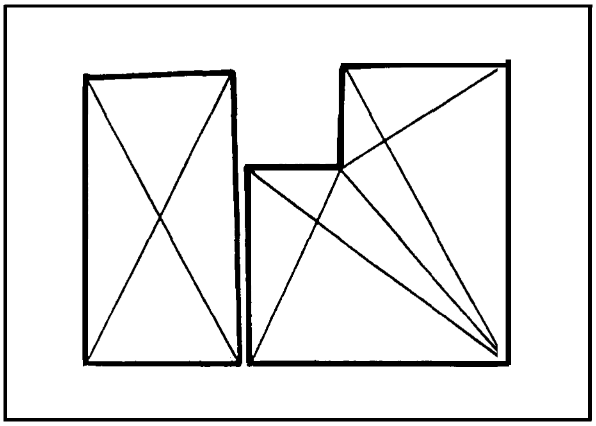


Fig. 4.18
Triangles capture room shape
(measure all sides and diagonals)

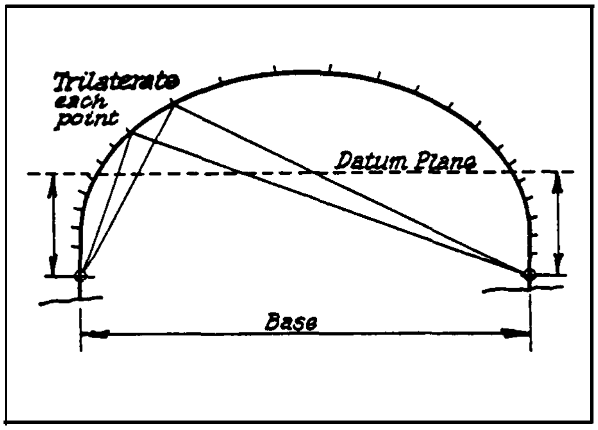


Fig. 4.19
Triangles map arches
(and other various curves)

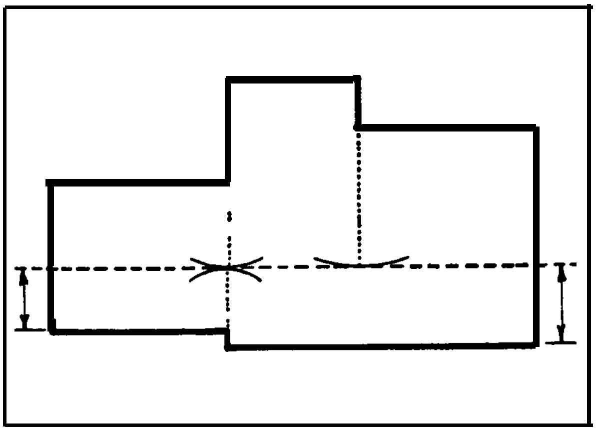


Fig. 4.20
Swing ties to reference string

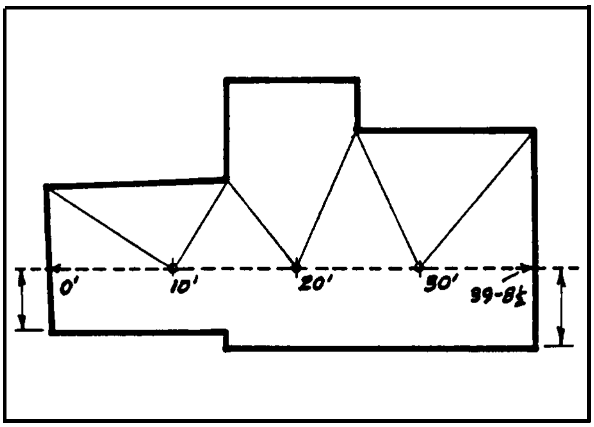


Fig. 4.21
Trilateration from points
on reference string

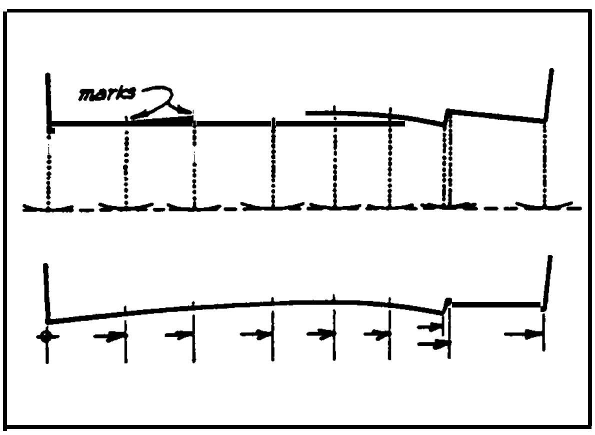


Fig. 4.22
Reference string for
bowed and irregular features

NOTE: This procedure ***assumes the*** object is truly circular in section. Tanks, piping, and other "round" shapes in engineering structures typically have to resist internal or external pressure--a circular section does this best, aside from being easier to manufacture than non-circular shapes. You are fairly safe assuming round objects are circular, unless visual inspection or drawing board concts suggests otherwise

<u>Measuring Site Plans</u>

Site plans can be measured using several different systems: 1. trilateration with tapes 2. bearing and distances with transit and stadia rod 3. rectangular grid system 4. topographic surveys 5. GPS (Global Positioning Systems). Since most site plans are drawn by HAER at scales of 1"=20' (1:240) or smaller, the precision of field measurements is looser than for hand-measurement of structures.

1. Trilateration. Before measuring a site plan, a horizontal reference plane should be struck on all structures, especially if the site has notable topography. Trilaterations should be done in level planes in order to plot them correctly in plan.

TIP: Over a distance of 50 feet, a difference in endpoint elevation of 3" or 4" (1 in 200 slope) for a horizontal measurement will have a negligible effect on the measured length. A tape **could** be leveled with a string level for this precision.

To begin measuring a site plan, two points "A" and "B" are established as starting points--conveniently the ends of a building wall or the corners of two buildings. The distance between A and B is measured and recorded. The locations of other points (such as the corners of other buildings or site features) are measured from A and B and recorded as pairs of dimensions in tabular form to keep notes neat (see Fig. 4.23). There must be two measurements for each new point in order to locate it. At the drawing board, A and B are located to scale. To draw each point, adjust a compass to the scale lengths of the legs A and B, and strike arcs. The result will be a plot with arc crosses, all representing locations of points from A and B.

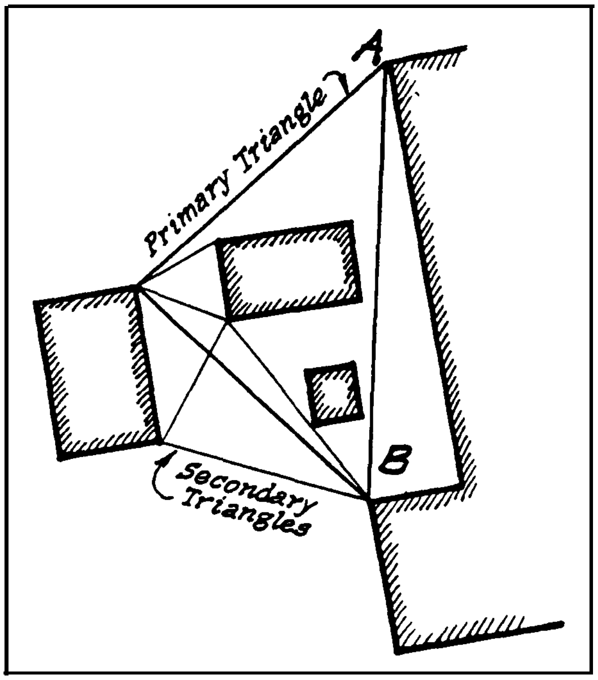


Fig. 4.23
Site plan trilaterations

Eventually you will want to measure two or more triangles per point in a site plan, both as checks against errors and as reinforcement for the accuracy of the job.

> **TIP:** For large sites, begin with large overall triangles and work smaller ones within them to hold error under control. If you try to construct a site plan from a web of small triangles, cumulative errors will introduce distortions, just as additive measurements accumulate error.

2. Transit and Stadia Rod. All this entails is reading precisely the horizontal circle of the transit, and reading precisely the numbers on a stadia rod through the telescope. Every point recorded will have a unique pair of numbers consisting of an angle (bearing) and range (distance) from the transit station.

a. Mark the Station Location. When setting up the transit, be sure to mark the instrument station by suspending a plumb bob beneath the instrument and setting some kind of reasonably permanent mark on/in the ground or other surface beneath the plumb bob tip. This way, you can recover the station if certain measurements prove to be in error.

> **TIP:** Trilaterate the station mark to nearby building or permanent features and record this data in case the mark is disturbed.

b. Align the Horizontal Circle. Before you can begin to record bearings, you need to decide where the zero (north) of the horizontal circle will point. In some cases, aligning it with magnetic north will be useful, at other times, aligning it with the corner of a building, or an axial orientation (centered on railroad track or smokestack) will be more helpful.

c. *Reading Stadia Rods and Computing Range.* As you look through most transit telescopes, you will notice two small cross hairs on the vertical line of the reticle--one above and one below the horizontal line (see Fig. 4.24). These hairs are used to read figures on stadia rods for computation of range. Stadia rods come graduated in decimal feet (tenths and hundredths of a foot) or feet and inches (12 inches to the foot). Before you proceed, examine your stadia rod to see which kind you have, or your results will be erroneous.

When a stadia rod is held against a building corner or set vertically over a point whose distance is to be measured, the stadia cross hairs in the telescope will permit you to read an upper and a lower figure on the rod. (To plumb the rod, try to balance it vertically between your fingers, or use a rod level.) Record these two figures, subtract the lower from the upper, and multiply the result by 100. The product is the distance in feet from the transit to the stadia rod. This calculation is much easier with decimal feet than feet and inches.

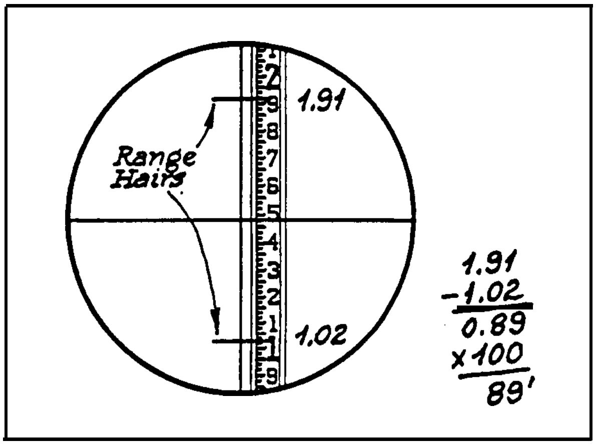


Fig. 4.24
Range reading with stadia rod

TIP: If for some reason you have to incline the telescope from horizontal to read the stadia rod, a correction factor must be introduced into your calculations, or you will arrive at artificially longer range figures. To obtain the correction factor, record the inclination angle on the telescope's vertical circle, and multiply the range by the cosine of this angle.

In distance measurement, the accuracy of a transit used with a stadia rod depends on the distance measured; as long as you can read ± 0.01 foot through the telescope, your tolerance is ±1 foot.

Total Stations. Total stations are complete electronic instruments for taking bearing and range data and converting it to plottable coordinates with automatic corrections for telescope inclination. They can also calculate and plot elevations for use in topographic surveys. The time savings and reduction in errors from hand calculations can be considerable for complex sites. Instrument memory can be downloaded to a computer for data printout (for hand plotting), or creating a CAD plot.

NOTE: It is wise to make a hard-copy printout of coordinates in case something damages data storage media.

Advanced total stations have accuracies up to ± 1 second of arc (a Category 4 instrument, or theodolite). Total stations use EDM (Electronic Distance Measurement) devices capable of accuracies of 2 or 3 parts per million; at a range of 1,000 feet, you can measure range theoretically to within about $^{36}/_{1000}$ths of an inch (0.036"), greatly exceeding any accuracy requirements in the *Secretary's Standards.* In most cases, a Category 1 transit is sufficient for HAER site work; it requires a little training to level the instrument properly, set it over a station point, and read the vernier scales correctly. In addition the instrument requires no electric power, and is relatively inexpensive. All data must be read and taken down by hand from a transit, and then you must reduce the data by hand (with a calculator) to coordinates or range-and-bearing measurements in order to plot points. If run on batteries, total stations may only operate for a short time before battery recharging is necessary; check your model to see if field data will still be saved if the battery should run down before you finish a day's work.

3. **Rectangular Grid.** Many people are familiar with photographs of archeological excavations which show strings pulled over the ground in a rectilinear pattern. This system aids archaeologists in cataloging and mapping locations of artifacts. A similar but larger grid system may be an advantage in recording some site plans where the ground is relatively level. The grid could be squared with a transit (or 3-4-5 taped triangle) and marked off with tapes at intervals of 20 or 50 feet. Use the grid intersections as trilateration points for site features, or take swing ties from features to grid lines.

4. Topographic Surveys. HAER normally relies on pre-existing topographic surveys of sites, or the topography in **USGS** 7.5 minute topographic maps for site topography. A topographic survey would only be required where these records do not exist or are inadequate to adapt for the display of significant topographic data. If time or budget do not allow for a topographic survey, some older graphic conventions for maps should be employed to at least indicate the subjective relative differences in level observed at the site (see Field Notes, Section 4.4).

5. **GPS or Global Positioning Systems.** The advent of satellite-based navigational systems has led to the development of very precise land surveying instruments that rely on satellite signals to determine location. Many of these instruments can resolve land coordinates in three dimensions to within an inch, but it takes the instrument about 5 minutes per station to determine the figures. These systems also operate well only in open areas. Significant tree cover attenuates the satellite signals too much for accurate work.

Measuring Building Plans

In general, measure plans from the outside in. Angles at corners and between wings can be determined by trilateration. ***Never assume buildings are square.*** When an exterior corner exceeds 180°, one wall can be extended by line of sight to a stake, and the stake position trilaterated to the second wall (a similar approach works on interior corners of this kind). Plotting these dimensions will establish the corner angle (see Fig. 4.25). Use of reference strings and swing ties may be called for where there are significant irregularities. After the building perimeter is established, move on to wall thicknesses (obtained from doors and windows, or accessible holes), then to interior spaces.

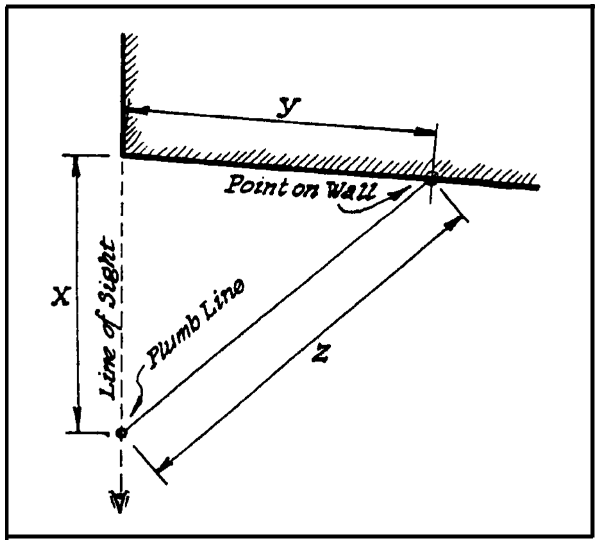


Fig. 4.25
Trilaterating exterior comer

Interior plans may require a variety of approaches depending on the geometry of spaces, access to walls and comers, and the presence of columns, large machinery or other large objects (such as tanks, bins, furnaces, boilers). Don't forget to set reference planes first. In subdivided spaces, every wall should be measured room by room, with at least one diagonal taken in each space. If obstructions prevent your taking diagonals in one space, you may have to rely on swing offsets and trilaterations from a reference string or use the geometries of surrounding rooms to establish the shape of the less accessible space. Reference strings may be needed to tie a series of adjacent irregular spaces together accurately.

> NOTE: While measuring for plans, keep in mind measurements that will serve double use in sections.

Features located high above floors may be approached in several ways; these features may be pipes, ducts, beams, trusses, catwalks, conveyors, decorative features, etc. Look for access by catwalks, mezzanines, windows, fire escapes, traveling cranes and the like. Plumb lines can be lowered from these features and their locations marked on floors for dimensioning, or for trilateration and swing ties to room walls, corners, or reference strings. The plumb line creates a precise projection of overhead features onto the floor below.

Measuring Facades

Before you resort to ladders and scaffolding to scale elevations for measurements, consider using a building's floors, windows, and fire escapes as de facto scaffolding. Tapes can be dropped from the roof parapets or from windows to datum lines for vertical measurements; tapes can also be rigged horizontally from window to window. Binoculars are useful for reading tapes suspended in this manner.

Ladders are best for heights under 20 feet. Above this, scaffolding or cherry pickers are recommended for safety when there is no other means to lay tapes on a facade.

Poles can be used to hold tapes to features high above datum lines. A series of high vertical measurements can be made much more quickly with poles than ladders.

Make sure you set and mark reference planes on the structure(s) first. These will be your best (often only) means to sew together a complex structure accurately. (Remove these marks at your project's end, especially in finished public spaces.)

Always obtain overall measurements first, and work down to smaller levels of detail. That is the way you will draw it, so it makes sense to measure and record it that way. Repetitive features (columns, windows, details) can be drawn once and any variable measurements recorded in a table. Ask yourself if the variations are significant enough to spend time measuring them compared to other priorities. Note down your decisions and tolerances for verifiablity (Standard II).

Some buildings and structures are too large or too dangerous to measure by hand. Interior spaces may be very high and offer little or no access to exteriors high above the ground. If pre-existing drawings are not available in these cases, a transit may be the solution. A plumb bob should be hung beneath the instrument, and its location in plan carefully triangulated from the building facade. Its vertical location relative to the datum plane should be determined after the instrument is leveled. Facades can then be measured by reading a combination of angles from the horizontal and vertical circles and reducing the data trigonometrically to coordinates for plotting at the drawing board or computer.

The above method works best with planar surfaces. Projections and recessions from the facade plane will yield errors unless the projections and recessions are measured. Tilted walls will also yield errors, unless you determine compensation factors. In some cases projections can be plumbed for location relative to the transit or building facade. However, if space permits you to set your transit up at two different points, the method in Fig 4.26 will address all problems of projection, recession and/or tilting. This method requires some basic trigonometry. The baseline dimension between the two instrument stations is ***critical*** to success (whether it is inclined or level). See Section 5 for relevant mathematical formulas.

Total stations hold out the prospect of measuring elevations without the tedium of reducing hand-recorded data. However, the EDM in a total station requires the placement of a prism or reflector at points whose coordinates are sought. If you cannot gain access to place the prism, the total station cannot record the point. As with Category 1 transits, anything that interferes with line-of-sight from the instrument will make it impossible to gather data from the hidden areas.

Photogrammetry is a photographic technique for measuring elevations. While acceptable for HAER documentation, it is not used by summer teams due to expense of equipment and need for highly trained operators. Photogrammetry must be supplemented by hand measurement in areas that cannot be covered by cameras.

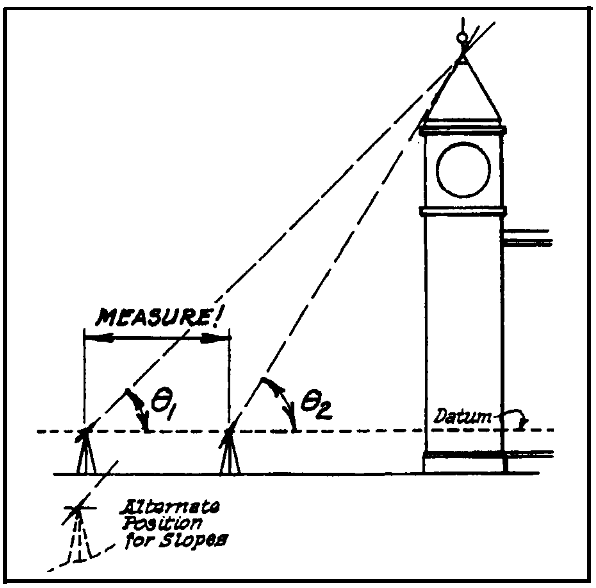


Fig. 4.26
Measuring any height with two transit stations

Measuring Internal Elevations and Cross Sections

Measuring plans gives you half the dimensions for cross sections and internal elevations--you have horizontal but not vertical coordinates. Horizontal dimension strings taken for constructing a section for multiple floors must be coordinated vertically by relating each string to a common vertical datum line (such as might be established by a plumb line). Vertical coordinates can be established from one or more horizontal datum planes. The shape of odd or deformed geometries in section or elevation can be determined by trilateration.

Elevations of repetitive features like roof trusses usually require that you measure one and assume the others are the same when no obvious differences appear to the eye or are required by function. (Take advantage of symmetry to reduce measuring time.) Lower chord joints in trusses can be located by raising a pole with a plumb line to the joint centerline, or tossing a ball of string over the joint. A plumb line or measuring tape can then be tied to the string and raised to measure vertical heights or establish plan dimensions. A transit, plumb lines and tapes can be used to advantage also, although for every point you sight you must derive three coordinates for the data to be useful. These measurements must be observed directly or calculated trigonometrically. Tapes may also be stretched over high features and dimensions read from the ground with the aid of binoculars.

Floor-over-Floor Position. To accurately position floors over ones beneath, try looking for holes in floors through which to drop plumb lines, or hang them in stairwells or pipe chases. Measure the locations of the suspension point on the upper floor and of the plumb bob tip on the floor beneath and plot these points in the plans of the two floors being checked. Two such plumb lines are needed to "lock" the two floors together. This relationship will also help in plotting and checking sections.

Measuring Trussed Structures

Metal and wooden truss structures are distinctive features of American engineering history, and they are frequently recorded for HAER. The following procedures will apply equally well to truss bridges, roof trusses, towers, and other trussed structures.

Try to locate engineering drawings before resorting to complete measurement, especially if the trusses are large, or consist of multiple spans. Drawings will often be your only clue to rivet sizes and internal joint construction. (Rivet are sized by their shank diameter, not head diameter.) A chart of common truss types and bridge part terminology is provided in Figure 5.15.

Truss Components. If field measurement is required, the measurements needed to record a truss break down into several easily defined groups, regardless of the truss type (see Fig. 4.27). On bridges, the span between the center line of the truss bearing points must be measured first (a), followed by the distance between the center line of the truss planes (b), then the distance between the center line of the top and bottom chords (c) (if the truss has parallel chords). If a bridge is skewed in plan, the relative position of the trusses can be obtained by trilateration in plan. You should also sight along upper and lower chords to check for vertical camber; if any exists you may need a transit or water level to measure it.

Symmetry. Considerable time can be saved measuring a metal bridge by taking advantage of its numerous symmetries. First, the two trusses of a simple bridge span are usually the same, even if the bridge is skewed in plan. Second, an individual truss is usually symmetrical about its centerline between ends. Third, these same observations apply to decks and upper chord bracing. In effect, you might measure only l/4 of the bridge after overall dimensions are obtained.

> **WARNING: These** observations may *not* apply to "vernacular" bridges.

Panels. After obtaining overall dimensions, the dimensions of truss panel points must be taken and recorded (see Fig. 4.28). In most bridges, the panel points are evenly spaced along the top and bottom chords, but this is not always the case.

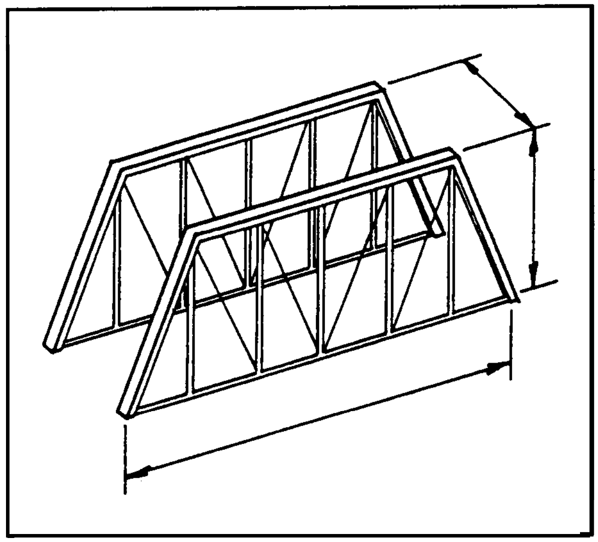


Fig. 4.27
Basic truss measurements

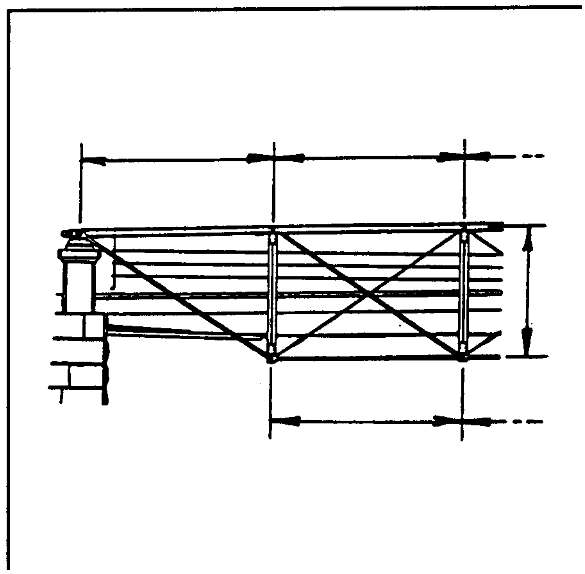


Fig. 4.28
Panels of pin-connected truss

Measuring between panel points of a metal truss bridge is easy if the bridge is old enough to be pin-connected--dimensions are simply taken between the centerline of each pin along the chords and for all diagonals and verticals. (The pin centerline is frequently marked in the ends by dimples or countersunk holes used to turn the pin in a lathe.) If your bridge is wooden or has riveted joints, you are better

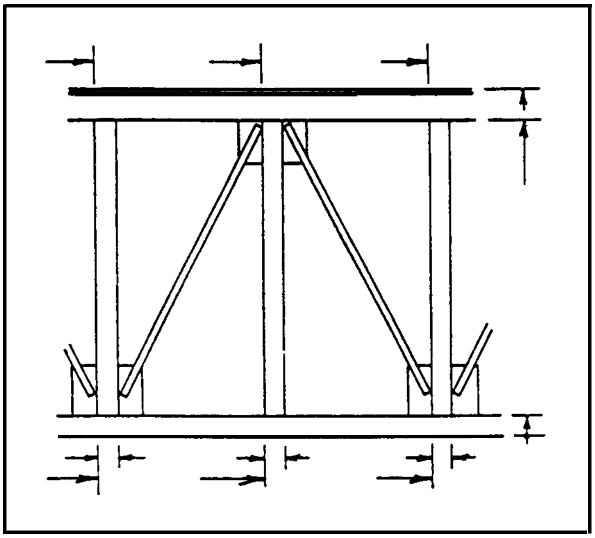


Fig. 4.29
Measuring riveted panels

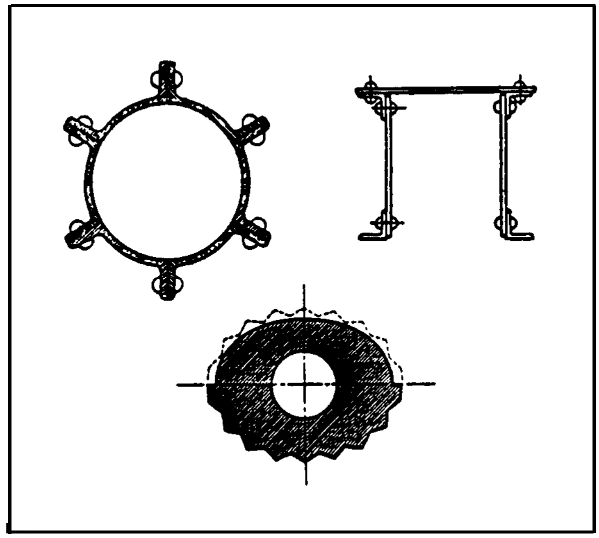


Fig. 4.30
Examples of Built-up and cast sections

off measuring between the edges and joints of members (see Fig. 4.29). The lines of action are difficult to determine in the field for these structures. Pin-connected bridges usually had members with symmetrical cross sections, so lines of action were the same as the geometric centerline of each member. Determining the location of lines of action in a riveted truss with asymmetrical cross sections will require you to refer to original drawings, engineering handbooks, or structural steel catalogs.

Member Cross Sections. Engineers and historians of technology will be particularly interested in the forces acting through the bridge members, so it is imperative that you measure not only member lengths, but their cross sections as well (to at least $\pm^{1}/_{16}$" or better). This is especially so for built-up members. Cast iron members are often hollow, and the dimensions of their cores may be hard to obtain unless you can see into an end. Look for manufacturers' names rolled or cast into bridge members; this information may be key to obtaining original cross-section information from makers catalogs, especially if rust or paint prevent accurate field dimensions.

Joint Assemblies. It is important to make notes and take dimensions that help you analyze joint assemblies in a bridge (see Fig. 4.3 1). Typical joints are shoes and panel points, but there may be other specialized connections depending on the truss design.

<u>Measuring Bridges</u>

On of the most common applications of truss structures is in the construction of bridges. The materials used in bridges should also be recorded. Determination of wood species in wooden bridges or the minerals in stone bridges may require the services of a specialist. For metal bridges, the age of a bridge, type of joints, and the stresses acting in various members are strong indicators of materials used. Wrought and cast iron were used exclusively in metal bridges until the 1860s when Bessemer steels became available. By the 1880s wrought iron was still the more widely used material, but by 1900, it had been completely supplanted by steel. Cast iron, being brittle, was used only for compression members and fittings (such as joint blocks, shoes, builder's plates and decorative finials) where no bending occurred.

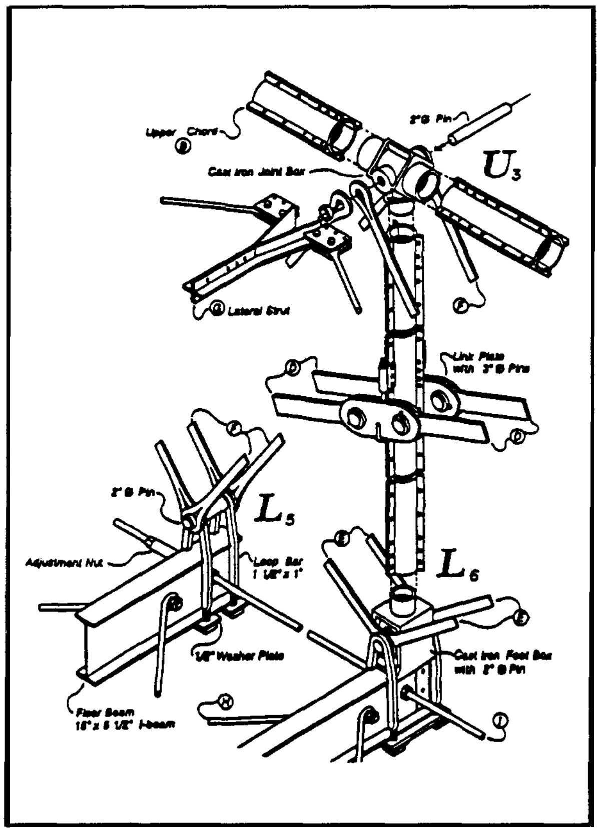


Fig. 4.31
Example of joint assemblies

Built-up wrought iron and steel shapes often served for compression members as truss bridge engineering matured; they were always used for tension members and members subject to bending loads (such as floor beams and stringers). HAER has recorded a handful of bridges with cast iron floor beams, but these are very rare survivors.

Anomalies. Deformations, deterioration, asymmetries, (and even missing members) should be recorded since they may be important clues to the success or weakness of the bridge's original design, detailing, and construction.

Decorative Features. Builders' plates, dedication plates, and decorative features should be recorded.

Masonry Bridges. The exterior shapes of masonry bridges can be recorded by methods used for buildings. Internal construction is very difficult to infer without original drawings, photographs, or some convenient damage that allows you to look into a cross section of arches or piers. Arch shape can be recorded by trilateration from spring points or bridge piers. Very large spans can be recorded with a transit.

Concrete Bridges. Discovery of original construction drawings is vital to properly document reinforcing bar type, sizes, and placement. Without this information, all you can measure are the architectural appearance and outer dimensions of these structures.

Suspension Bridges. This distinctive bridge type will involve you in the documentation of trusses (roadway stiffening trusses, perhaps towers), as well as cables, anchorages, saddles, and specialized joints. An important thing to remember in recording and drawing the main cables is that their shape follows a catenary curve, not an elliptical or circular arc.

TIP: A catenary curve can be duplicated in a drawing by putting the drawing on a wall, suspending a fine beaded chain between the tower tops and the plotted bottom of the cable span, and marking the centerline of the chain every inch or two. These marks can then be connected by flexible curves. The beaded chain hangs in a catenary curve.

Cable construction should be carefully determined. The use of engineering handbooks and manufacturers' catalogs is encouraged.

Measuring Machinery

Machinery is a much broader category of resource to measure than bridges.

Nonetheless, there are some basic rules for measuring mechanical devices. You will need to use your ingenuity in special cases.

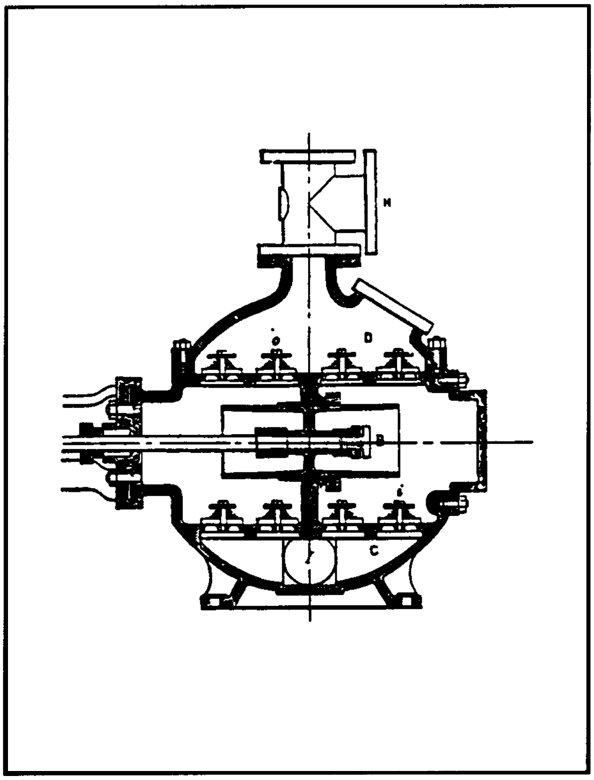


Fig. 4.32
Aid from old drawings and publications

These procedures apply even to some large industrial buildings which are machines enlarged to titanic scales.

As with other objects, finding engineering drawings will save you much sketching and measuring time. They will not only provide critical external and design dimensions, but important internal sections and arrangements that you would be unable to get without disassembling the machinery, a logistical impracticality on most HAER teams (see Fig. 4.32). In some cases, photocopying selected blueprints may be sufficient to document equipment to the Secretary's Standards, thus freeing the team to concentrate on other site features. Reproductions of suitable drawings can serve as underlays for inked drawings or be scanned for CAD work.

As with structures, you should check blueprints against the subject machinery to be sure drawing scale and dimensions coincide and whether any modifications have been made. If blueprints are not available, check trade journals and catalogs for technological insights; these frequently feature drawings detailing special features, etc.

Machinery is, in many respects very easy to record, no matter how intricate it is. This is because *most machinery has been designed and built along* center lines (shafts, pins, pipes, tanks, pulleys, gears, rods, frames, fasteners, etc.). If you locate these center lines and measure everything else with respect to them, many of your measurement problems will diminish or disappear in both the field and at the drawing board (see Fig. 4.33). Most *machinery parts are either rectangularl prismatic or circular1 cylindrical in shape;* break down equipment in terms of these shapes before you begin to sketch and measure it. *Look for symmetry and repetition.*

These characteristics can save you time, since you won't have to duplicate measurements. You may need only one side of a frame if both sides are the same; asymmetrical features are all that will need measurement on a matching side. Multiples of the same part mean you only need to dimension one of them.

All machinery has a base or frame which supports and aligns its active parts. These frames and bases provide built-in datum planes from which you can measure to other features or to centerline of shafts, and the surfaces of rotating and sliding parts. The bottoms of bases are usually level, unless foundations have deteriorated or some special condition dictates an unusual mounting. Most active machinery parts either slide, rotate, or reciprocate, and those that won't are usually power transmission devices like belts, chains, shafts, or connecting rods. Study each machine and figure out how it operates, if you cannot observe it in motion. An understanding of its operation will help you simplify your notes and avoid taking misleading or unnecessary measurements. It is more important to measure the configuration of parts whose relationship does not change as a machine operates rather than dimension changing relationships. For example, on a reciprocating steam engine, it is more important to have the length of the connecting rod from the wrist pin to the crank pin and the throw of the crankpin, than it is to measure the distance of the wrist pin from the cylinder head. The connecting rod and crankpin dimensions never change; the position of the wrist pin is always changing as the engine runs, although the possible positions are limited by the geometry of the rod length and crank throw.

Always record center lines before details. Locate major center lines of bases, shafts, cylinders, motors, gears, etc. from each other and from primary reference surfaces such as bases or datum planes. Your first sketches and dimensions should address ***only*** these center lines in elevation, plan, and section (see Fig. 4.33). Look for physical features which define the centers of shafts, cylinders, and bases (such as center holes in shaft ends, bolts at frame center lines, joints in casings, bearings, castings). Where no physical indications are apparent, you will have to mark center lines by halving the widths of round and rectangular elements. Datum surfaces like bases can be artificially extended by placing a straight 2” x 4” or long mason’s level under the edge and leveling the level to it (check that the machine base is level first). Having done this, you can then measure up from the level to various center lines, swinging the level as needed to get in position. Plumb lines will “drop” center lines to a datum plane for horizontal position measurements (you can also use the vertical vials in a mason’s level). Magnets can be used to hold tapes in place on iron or steel machinery. Once the defining center lines are documented, you can proceed to measure principal parts like pulley and gear diameters, and bearing sizes. Leave small (but important) details such as nuts and bolts, pulley spokes, and piping for last. See sections on field notes and field photography for further instructions.

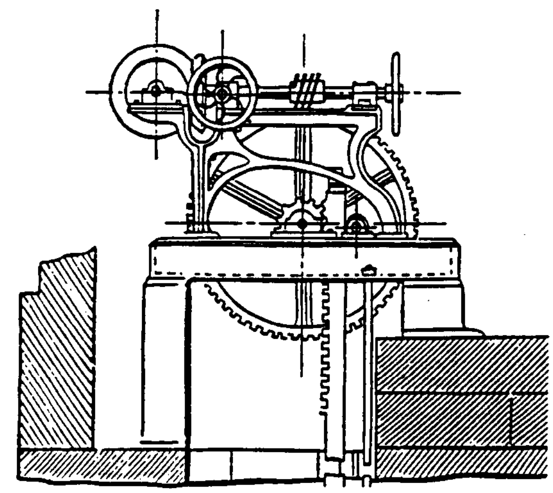


Fig. 4.33
Machinery designed around center lines

Pay particular attention to the angular or radial alignment of keys, spokes, part lines, molding lines, pins, bolts and other features of different parts around a common shaft (see Fig. 4.34). These can be measured using a level and protractor, or a combined protractor-level.

TIP: Many parts such as fasteners, pipes, valves, structural steel sections, rails, chains, and cables come in standardized sizes dimensioned in engineer’s handbooks or other references. These will save you time in dimensioning and labeling. Avoid measuring worn areas for principal cross sectional dimensions.

Almost all machinery comes with basic information cast into frames or embossed on manufacturer's plates mounted in a prominent place. ***All*** the information on these plates should be copied into your field notes. This data records the manufacturer's name, address, dates, serial numbers, model numbers, and often patent numbers. Further information pertinent to the machine may also be given, such as cylinder sizes, horsepower, voltage and amperage, pumping capacities, pressures, temperatures, lubrication and operation instructions, and safety procedures. Beyond this, recording of numbers and verbal information depends on its significance to the machine and the site. Numbers and letters cast into frames or embossed into parts may be part of a system of part numbers, mold numbers, or even serial numbers. Some may be match numbers used to show which parts should be joined after they have been disassembled for repair.

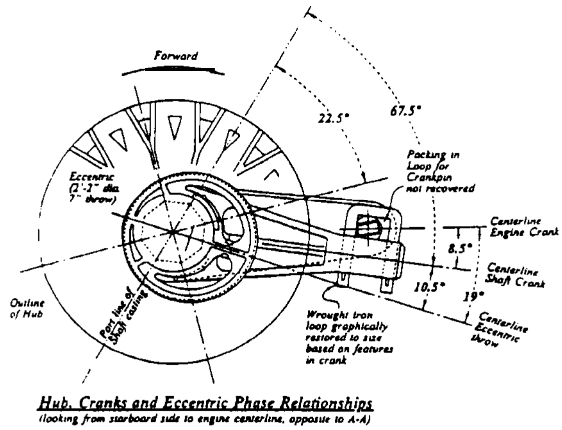


Fig. 4.34
Radial location of parts

<u>Interureting Industrial Processes</u>

Frequently the significance of a site lies as much in the industrial process going on inside the buildings as it does in the buildings themselves or their machinery. You should carefully note the steps in manufacture of a product, or the way equipment is oriented and operated. You may need to trace pipes, belts, conveyors, tracks, shafts, canals, tunnels and wires in order to understand where, how and why materials and energy moved throughout the site. Specialized machinery and materials should be noted. Chemical reactions, quantities, temperatures, sequences, and byproducts should be determined where they are significant to a site's function. Electrical, mechanical, and hydraulic data should be recorded for systems where voltages, amperages, horsepower, pressures, and volumes are significant to operations.

Points of wear on floors, equipment, or structures can offer meaningful clues to work patterns and flows of material and products. The age of equipment, manufacturing methods used, and working conditions will be of great interest to historians. The team historians' research and insights will be critical when the business has closed down, or the site has been partially dismantled. You will have to call on your imagination to piece operations together from holes in walls, "ghosts" on floors where machines once stood, structural alterations, and other silent features.

4.4 FIELD NOTES

Field Note Material

HAER uses 17"x22" gridded bond paper (sometimes called "layout paper" or "cross-section paper"). This size folds conveniently to 8 " x 11" for storage in field notebooks and later filing at the Library of Congress (Standard III). These sheets may be glued together with a white glue (1ike"Elmer's Glue-all" or similar polyvinyl acetate (PVA) glues) for larger sheets, just so the notes fold conveniently to 8 " x 1 1" format. Tape is unacceptable because its adhesives fail quickly. Scraps of paper snatched from notepads, "post-ems", backs of envelopes and the like are unacceptable because they are easily lost. Torn or abraded field notes should be repaired with glued on strips of field note paper for permanence.

There is an important exception to Standard III as applied to field notes: they need not be on archivally stable paper, because field notes are inevitably contaminated with dirt, perspiration, oils and other substances at industrial sites. If archival stability is an absolute must, notes should be copied over by hand onto clean archivally stable gridded paper, or reproduced electrostatically. Original notes must always be submitted to the Library of Congress.

Sketches should be made in No. 2 pencil. Changes are easy to make, and graphite does not fade with time nor run if accidentally exposed to water (rain, etc.). Dimensions, dimension strings, and witness lines should always be recorded in red in order to ***clearly*** distinguish them from black pencil lines that denote structure (Standard IV). Use a red pencil or a pen with a good non-dye based ball-point ink. (Imagine how even Fig. 4.38 would be improved with dimensional data in red!) Large mistakes should be crossed out rather than erased. Paper is cheap compared to your time. If erasures thin a spot in your paper, or there is too much pencil or ink to erase without tearing the paper, glue a patch of gridded paper over the spot.

In order to meet the ***Secretary's Standards,*** every sheet of field notes should be clearly labeled with the following:

1) Site name and location
2) HAER Number (if known)
3) Specific view in the note
4) Names of note makers
5) Date

The field notes and photographs you make are the primary sources for your drawings (Standard II), hence they must be clear and legible (Standard IV). Field notes are transmitted to the Library of Congress along with your measured drawings; without the notes, your drawings have no back-up, and will be stamped with a disclaimer stating that your drawings cannot be verified. This chapter will give you time- and field-tested approaches which conserve time in the field and at the drawing board.

First, think of your field notes and photographs purely as data storage systems. Their primary function is to record significant ***dimensional*** and ***relational*** data about your site (Standard I). All other purposes and expressions are secondary. The sketches you produce for field notes are merely a framework for presenting dimensional (not artistic) data, and showing the spatial relationships among various dimensions you record there. Rendering and shading should only be used where they are necessary for clarity (distinguishing various materials in section, making clear which side of a section line is solid, etc.).

The following approach to field notes not only promotes clear and concise presentation of significant dimensions, but also is very easy to use at the drawing board or CAD station. The production of field notes should parallel the production of drawings. When you begin a preliminary drawing of an elevation, the first lines you draw should be the horizontal and vertical reference planes; all other dimensions should relate to them. Following this, the normal procedure is to block out the structure by drawing outlines of walls, foundations, column centers, or similar determining structural features. Detailed items like windows, columns, machinery, etc. aren't placeable without these steps. From this point, you usually work in progressive stages from larger "blocks" or determinant features of the drawings down to the details. The details are not placeable until the larger context for them is drawn.

The production of field notes and measurements should follow a similar progression. The first notes should show nothing but instrument set-ups and reference plane locations (see Fig. 4.35). The sketch of the structure or site plan need only have an outline--no windows or internal details are necessary unless they provide some non-verbal orientation that is faster or clearer to interpret than written notes. Written documentation of instruments used (even hand tools) and procedures are necessary to meet Standard II. Be sure you include a north arrow in plans.

Field sketches may be thought of as bordering on the schematic (see Fig. 4.36). This is not meant to encourage sloppy work. Crudeness does not promote clarity (Standard IV). Nor should you treat field notes as cryptic shorthand reminders for your use only--notes *must* be intelligible to other users (including your team members) to meet the *Secretary's Standards* and enable the work of the team to proceed smoothly! Very often your notes will be used by another team member to produce a drawing.

Field Note Organization

Sketches should be made on *only one* side of a field note sheet, and sketches on a single sheet should be related. For example, if you begin a note on the elevation of a building, don't include plans of machinery in the building on the same sheet when details of the elevation would make more organizational sense. Floor plans should cover just floor plans, not other objects that don't appear in plans. This saves a great deal of time shuffling notes in search of scraps of information to produce a drawing.

Types of Field Notes

Each note should be devoted to a "layer" of detail or to the dimensions and locations of a similar class of features (such as windows, valves, pulley wheels, trestle bents, etc.). Repetitive details can be drawn once in field notes, and if necessary, a table of dimensions keyed to the sketch can record variations (see Fig. 4.42).

The tendency among beginers is to try to cover everything for a final drawing in a single field sketch. Much time is spent drawing a view that looks similar to what is envisioned for the final ink drawing, right down to rivets, gear teeth, bricks and doorknobs. Architects love to draw and sketch, and field notes seem to be a wonderful outlet for their skill and training. However, artistic or architectural effect is not the point of field notes; complete, detailed sketch views are a waste of time. They are useless for dimensioning, because they are too crowded with line work to add many dimensions without turning the notes into a confusing mass of lines. Overworking sketches not only takes valuable time, it will slow you down during the drawing phase as you filter dimensions from complex line work (see Fig. 4.38). You will be far better off breaking a machine, such as appears in Fig. 4.38, into layers of distinct information, as Fig. 4.39 begins to demonstrate. Overworked sketches also have a tendency to give the false impression of completeness in the field. Only when you reach the drawing board do you discover that they are riddled with numerous omissions, errors, and confused markings.

You will also find that you run out of room in complex sketches for all the dimensions you will need in order to make use of everything you drew, and then you will have to start another note in any case. Don't fall for the seduction that you are saving time by crowding notes; what time you save will be lost several times over rechecking measurements and puzzling over scribbles at your desk. If you think you need an overall picture to capture details, take a photograph!

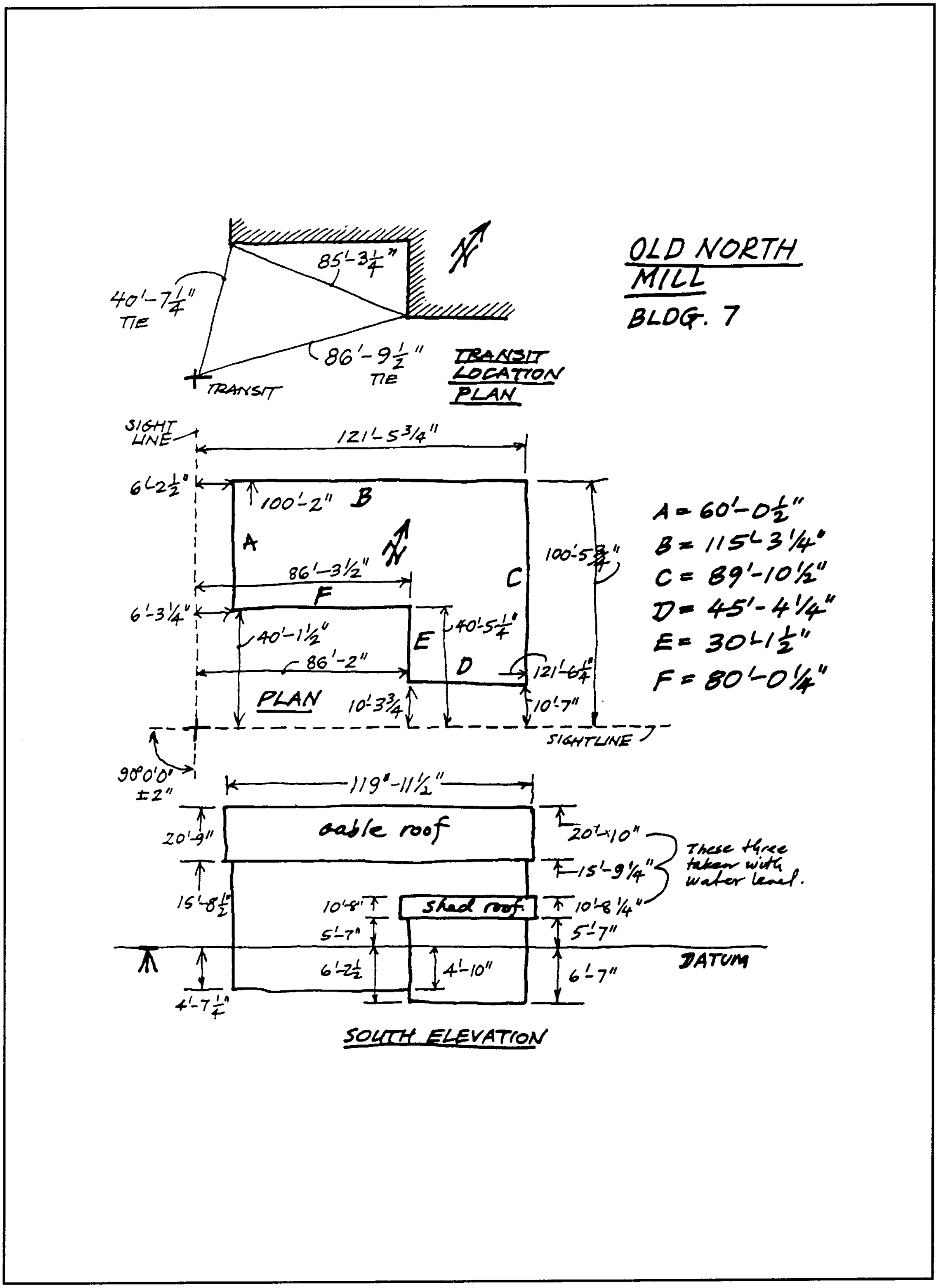


Fig. 4.35
Example of initial field note of a structure

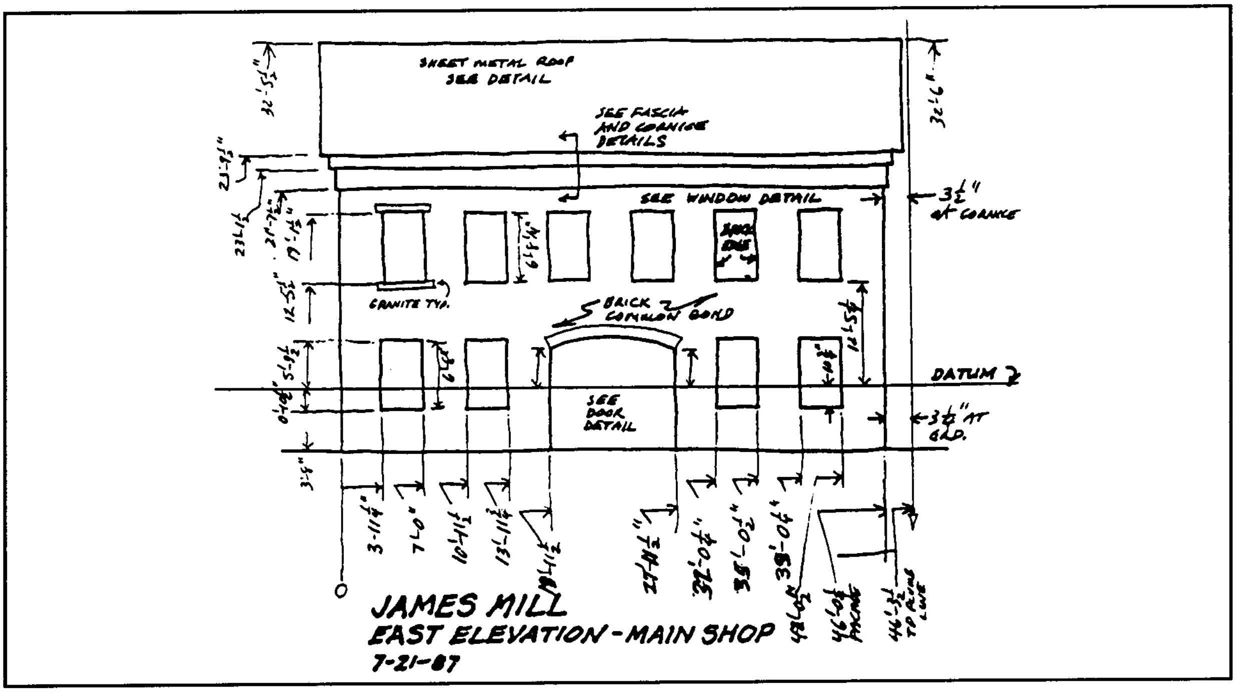


Fig. 4.36
Schematic note of an elevation

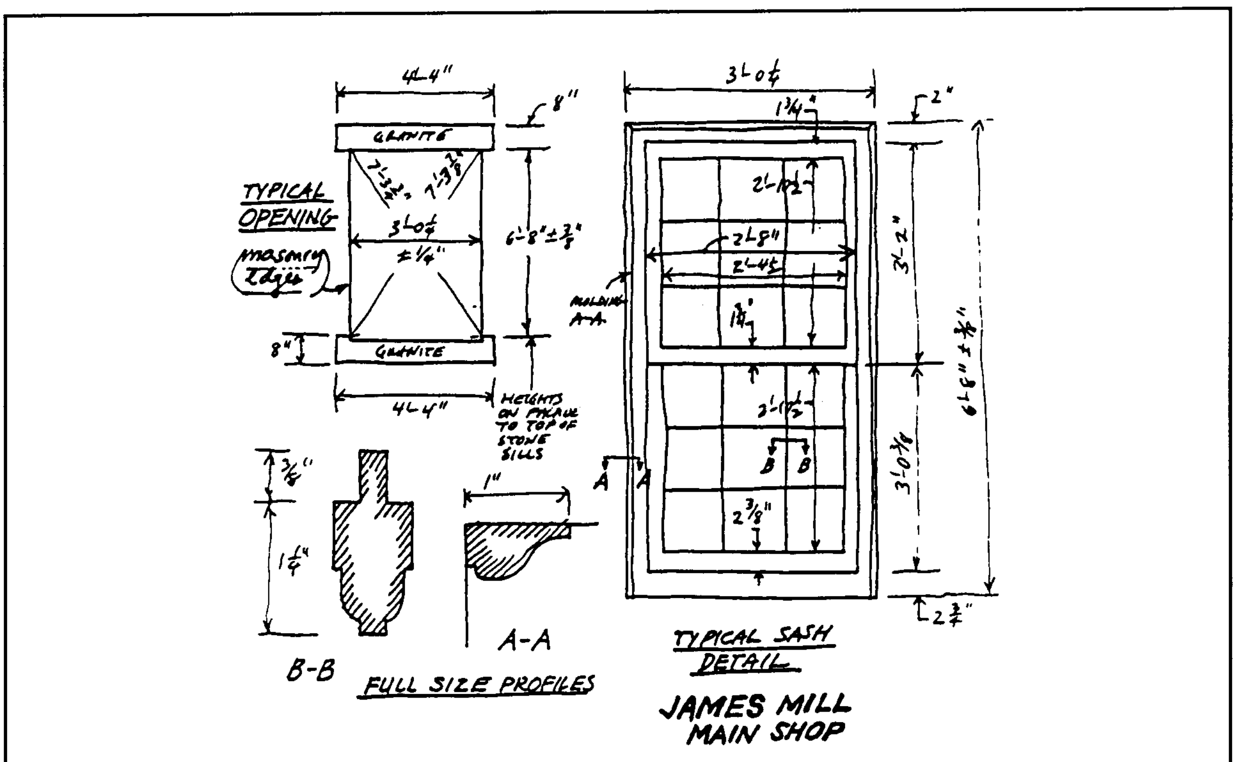


Fig. 4.37
Elevation Details: How to handle repetitive details

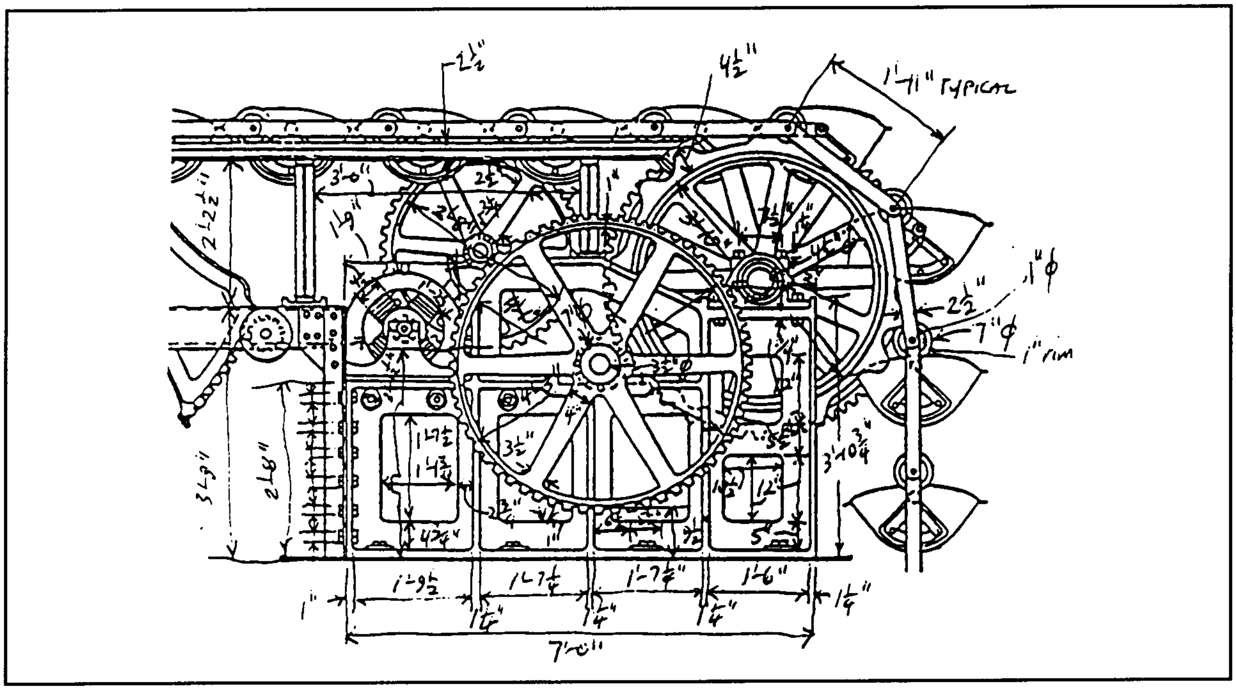


Fig. 4.38
An overworked sketch is useless for dimensioning

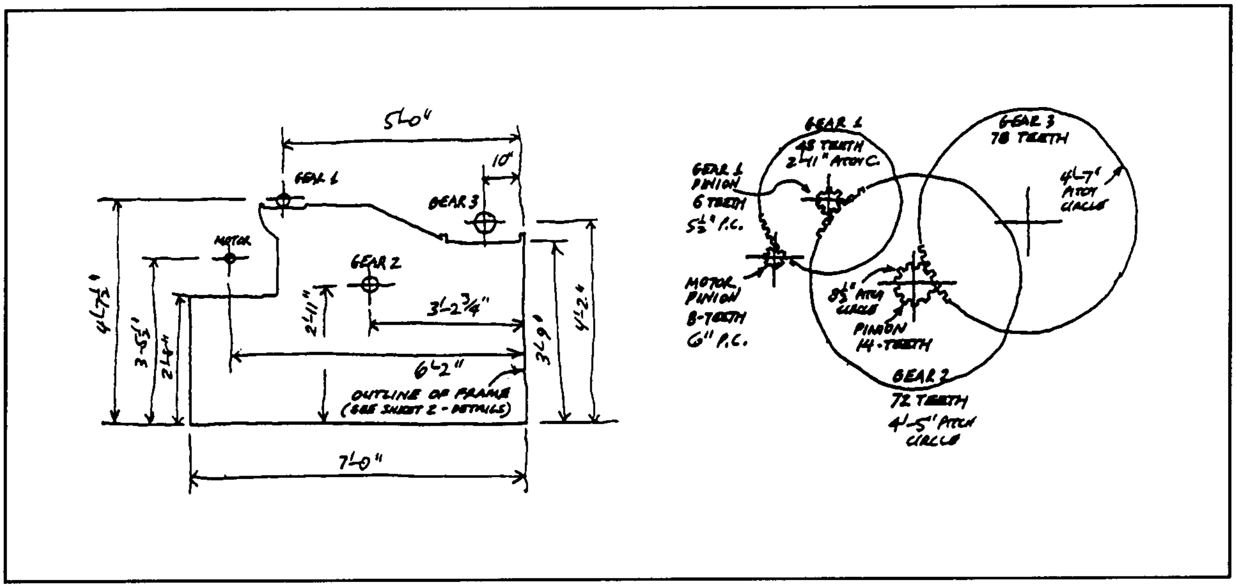


Fig. 4.39
Simplified notes that break machinery down are easier to read and faster to execute.

Use the grid on the field notes to draw things square, and use a cheap drugstore compass for circles. Take advantage of the symmetry typical of machine parts when you make sketches and record dimensions (see Fig. 4.40). On occasion, deliberate exaggerations may be made in notes in order to record dimensions efficiently (see Fig. 4.41). Some long features may be foreshortened, for example, when ail that is important is length--the dimension will take care of that significant factor. In field notes, dimensions rule, not the proportions of sketches. Sketches drawn to scale are not recommended in most circumstances except for full-size profiles of moldings and certain sorts of rubbings.

There are times when multiple sections, exploded sketch views, and perspectives will go far to clarifying the significant aspects of a site feature. Don’t hesitate to dimension these sorts of sketches when appropriate.

For highly complex planar detail (castings, gear teeth, lettering, architectural carvings, curvilinear features, etc.) consider making full-size rubbings of them. Rubbings capture shape and dimension simultaneously and edit out distracting details. The final note can be

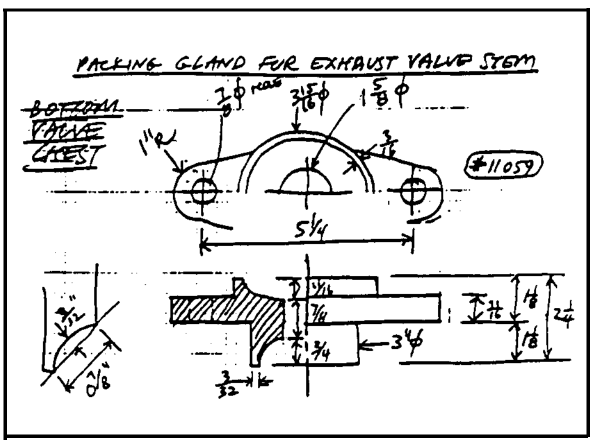


Fig. 4.40
Using symmetry efficiently

scanned or electrostatically reproduced to the scale of your preliminary drawings, thus saving drawing time. Rubbings should always be accompanied by overall measurements made directly from the object (not the

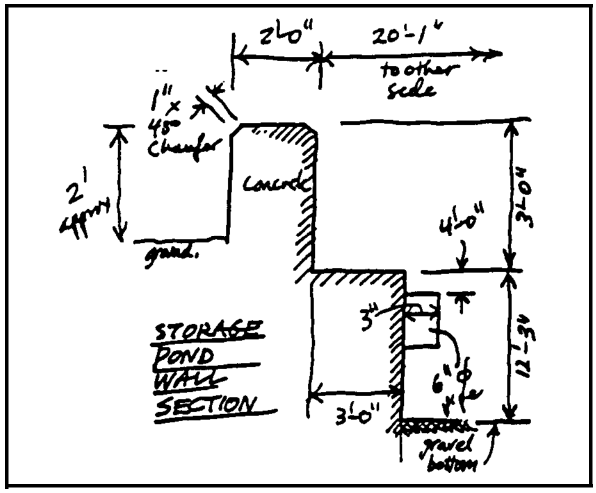
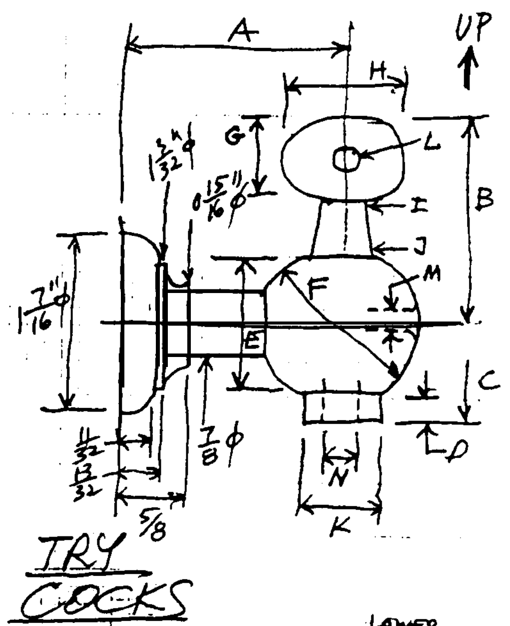


Fig. 4.41
Foreshortening sketch to record long dimensions.

rubbing) as a check against the rubbing being distorted by slippage. The field note grid helps with distortion correction or hand digitization for CAD drawings. This rubbing (see Fig. 4.43) was made from one of four flat legs of a valve spindle guide in the valve chest of a steam engine. In five minutes it captured the complex shape of the leg on a gridded reference while eliminating the overwhelming tedium of trying to accurately capture the curves with measurements. Photography was impossible due to the confines of the valve chamber. Once made, the rubbing was immediately traced onto a field note sheet, and supplementary details added to complete the field note (see Fig. 4.44).

The accuracy of rubbings is greatly improved by carefully creasing the field note paper along the edges of the object with your fingernail or firm tool. The crease remains in the paper, and it can be traced with a pencil, thus avoiding the blurry mess caused by applying a crayon or graphite stick directly to the sheet over the object. (If one side of the rubbing becomes unusually dirty in the process, perhaps tracing the edges in pencil can be cleanly done on the reverse side of the field note.) Be careful not to depress the paper when you make creases, or the rubbing will be artificially stretched. Most rubbings can be held to tolerances of $\pm{}^{1}/_{16}$” or $\pm{}^{1}/_{8}$”.



	UPPER CHEST I	UPPER CHEST II	LOWER CHEST III
A	2 5/8	2 11/16	2 3/8
B	2 5/16	2 1/16	2 1/4
C	3 3/16	3 1/8	3 1/8
D	0 3/16	0 3/8	0 1/8
E	1 5/16	1 11/32	1 3/8
F	1 1/2	1 1/2	1 5/8
G	0 7/8	0 15/16	0 15/16
H	1 1/4	1 1/4	1 1/4
I	0 23/32	0 23/32	X
J	0 3/4	0 23/32	—
K	0 5/8	0 5/8	—
L	0 3/8	0 3/8	—
M	0 5/16	0 5/16	—
N	0 1/4	0 1/4	—

Fig. 4.42
Tabulated dimensions

Annotations. Efficient field notes are a mixture of line sketches, dimensions and verbal annotations. ***Always*** label parts, rooms, materials, and special measurement conditions in order to meet Standards II and IV.

> Note: Remember that field notes are not private reminders but ***public records*** which must be intelligible to anyone.

Make references to other sketches (e.g. "see section A-A"), include dates and historical facts, or call attention to special conditions in your notes ("shape exaggerated for clarity", etc.). Record significant color attributes with the ***Munsell Book of Color.***

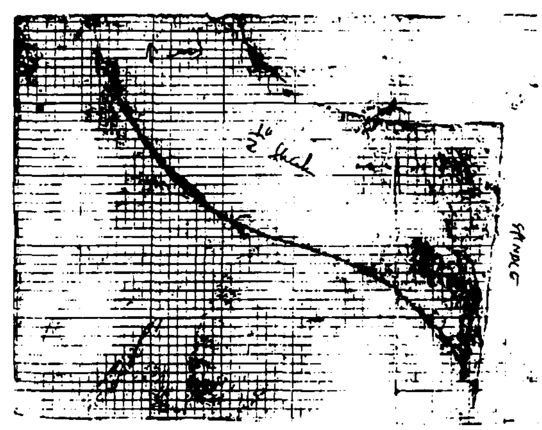


Fig. 4.43
Original rubbmg of spindle leg

Color

The ***Secretary's Standards*** make no provision for the documentation of color, but it is occasionally a very significant factor in an industrial/architectural environment and should be documented under Standard I. Because archival color photography is not perfected, and accurate reproduction of color images is technically difficult, the problem can be solved by using the *Munsell®* ***Book of Color,*** an internationally accepted scientific color reference system. Color is recorded by comparing numbered color chips to a subject and recording the color numberwhen the proper chip is found. Color numbers can be

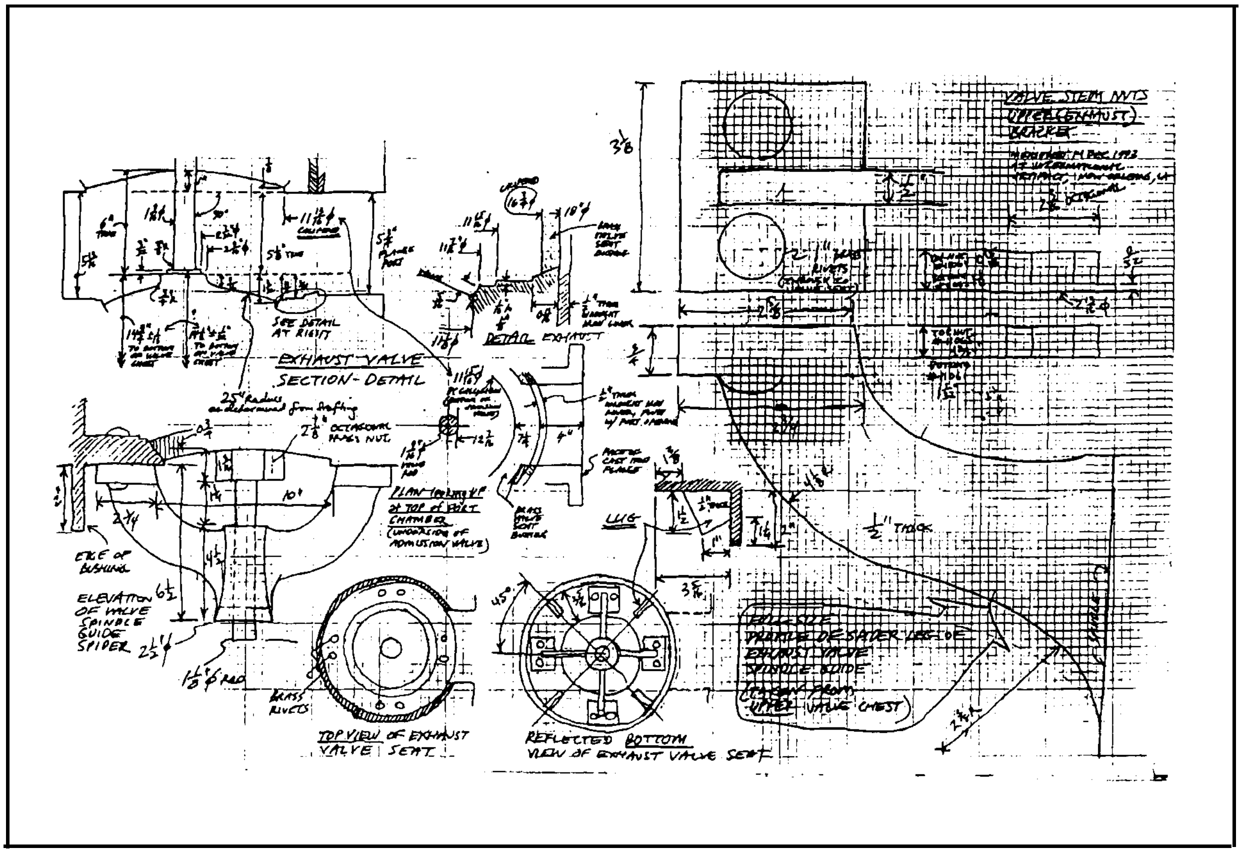


Fig. 4.44
Final field note on gridded paper for valve spindle spider

designated in field notes and final drawings. The problem of recordation and reproduction is at once simplified, but not entirely solved. The *Munsell Book of Color* and information on its use can be ordered from Macbeth, Division of Kollmorgen Instruments Corp., P.O. Box 230, Newburgh, NY 12551-0230; phone (9 14) 565-7660.

Clarity is achieved by recording what you did *not* do as well as what you accomplished. This applies particularly to situations where data might be expected; note what areas are inaccessible and why. Also annotate dimensions with an atypical error tolerance.

4.5 FIELD PHOTOGRAPHY

Like field notes, field photographs are data storage media. In addition to verifying dimensional data, they capture in minute detail the actual on-site appearance of an object. Most efficient field work will require a balance between dimensioned sketches and thoughtfully taken field photographs. The relative significance of each object and feature you document should guide how much you rely on either tool. The applications for field photographs are numerous. Aside from general survey photography at the site, photographs capture data about materials, textures, form, massing, condition, cracks, deformations, relative placement, quantities of objects (rivets, windows, spokes, and so on) far more quickly and concisely than could ever be done by sketching and measuring. At the drawing board or computer, they can be used to double-check and straighten out confusion in field notes without going back to the site.

Your time is at a premium, so photographing secondary contextual details needed for documentation can save you much time over hand-recording them. You can reserve dimensioned sketches for more significant things, and fill in minor details from photos. Field photographs should never be taken as *substitutes* for measured field notes on features of primary significance.

Aside from verifying measurements (Standard II), photos can be used to document and count things like clapboards, steps, line shaft bearings, insulators, brick courses, wall infill, bridge member webbing pieces, gear teeth, and the like. Photography is obviously far faster than sketching and measuring objects, but keep in mind that using photographs effectively to check field notes or derive dimensions will take time in your office. Due to the inevitable kinds of distortions in images, any derivation of measurements must be done carefully, and the process begins with appropriate set-ups in the field (see Types of Field Photography")

NOTE: Often two or more photographs must be compared to narrow down tolerances.

Any corrections or additions made to your field notes based on your field photographs should be so noted in your field notes (Standard II). If you derive a substantial number of dimensions of a feature from field photographs, you should make a dimensioned field sketch, and annotate it with references to field photographs you used (by roll number and image frame number).

Eauinment

Camera equipment must be supplied by HAER team members. HAER supplies film and processing for HAER administered teams. Basic equipment is listed below:

35mm camera
assorted lenses (35- 150mm zoom lens, or 35mm, 55mm normal, and 135mm telephoto lenses are suggested)
flash unit
cable release
tripod

A flash or photo flood lamp will help fill in shadows on bright days or light up dim interiors. Tripods and cable releases are needed for time exposures or photos taken with telephoto lenses.

Lenses shorter than 35mm are discouraged because of the distortion they introduce into images, despite their greater covering power. (Exceptions would be made in the case of extremely cramped, spaces where restrictions won't allow longer lenses to "pull in" a view.) A 35mm lens tends to cover most of what the eye sees looking at a scene, but the edges of the camera image are distorted and are not as suitable for measurement as longer lenses. A 55mm (or normal) lens introduces the least distortion across an image and it can be used for many measurement checking purposes. Longer lenses produce progressively flatter images, and if your camera is properly set up, they yield more useful pictures for scaling purposes. However, long lenses magnify camera shake and require higher shutter speeds or faster film to avoid blurred images.

All field photography is done with black-and-white film. HAER teams are supplied with 36-exposure rolls of Kodak Tri-X (IS0 400) or equivalent. This film can record detail in dim areas without a flash, but with some sacrifice of detail in enlargements. Slower films are sometimes useful because of their finer grain and resolving power, but they are better used in bright light.

Color Films. On some projects, a limited supply of color slide film will be provided for publicity or lecture purposes. This should not be used for field photographs.

WARNING! Store all firm and cameras in a cool place. Don't leave photo equipment in vehicles or tool boxes standing in direct sunlight. Excess heat alters film shelf life and exposure characteristics. Batteries and electronic camera mechanisms can also be badly damaged.

Digital cameras and image formats are not accepted by HAER because of archival permanence and long-term data accessibility problems. Black-and-white film should be processed locally as soon as is practical.

Team members are discouraged from attempting their own processing because of the time consumption.

Contact sheets are required for field notebook filing. An 8-power eye loupe makes viewing easy. Enlargements should be ordered selectively.

Types of Field Photography

Oblique Photographs. Oblique photos are two- or three-point perspectives intended primarily for contextual coverage and only secondarily for any dimensioning purposes. In addition to general survey images, oblique photos are taken of specific features from several angles in order to record the relationships of significant details. Such photos enhance the use of field notes at the drawing board.

Rectified Photographs. Sometimes a mechanical or architectural detail is so complex that hand-measurement is both time consuming and unsatisfactory in the number of plottable measurements obtained. If a rubbing is impractical because of the object's size, condition, or extent of projections and recessions from a flat plane, a rectified photograph can capture dimensional data quickly and with reasonable error tolerance--in fact, the photograph would probably be more reliable than a rubbing for dimensional purposes. The image scale on a rectified photo's horizontal and vertical axes is equal and uniform. For features il a plane parallel to the film plane there is little optical distortion, and measurements or tracings can be made from the image. For the most reliable and verifiable results, vertical and horizontal scale sticks should be placed on the subject (Standard II). You should also make a general overall field note with some key measurements to double-check against photographic distortion.

Rectified photos can save a lot of hand sketching and dimensioning of extremely complex or detailed features. For example, smooth-faced or slightly rough rubble stonework in a mill building or canal lock wall could be recorded this way and transferred to a measured drawing. (Successive overlapping photos are needed for long horizontal objects.) Complex iron castings, gears, door hardware, and the like are fair game!

Rectified photos are best limited to things that lie in fairly flat planes, since parallax errors unavoidably introduced by perspective effects can cause scaling problems and unacceptable distortions in objects that project or recede from the subject. The longer the lens you use, however, the more compressed a photo's foreground and background will appear. Projections and recessions gradually approximate the same scale as focal length increases (see Fig. 4.45).

> WARNING: Avoid scaling round objects like tanks from any photographs--parallax effects almost inevitably lead to errors except with small piping.

A fast and accurate way to set up a rectified photograph only requires a mirror fixed in the plane of the subject whose image you wish to record. Your camera must be an SLR (single lens reflex) mounted on a tripod. As you look through the viewfinder, center the *reflected image of the camera lens in the mirror* in the center of the split-image (or microprism) focussing zone in your camera's viewfinder (see Fig. 4.47 for a schematic view). This will position the lens axis normal to the mirror plane and to the surface to which it is attached. The larger the mirror, the better its parallelism to the subject's surface can be assured. This method results in an undistorted image for the plane in which the mirror lies. (The mirror can be removed before tripping the shutter once the camera set-up is complete.)

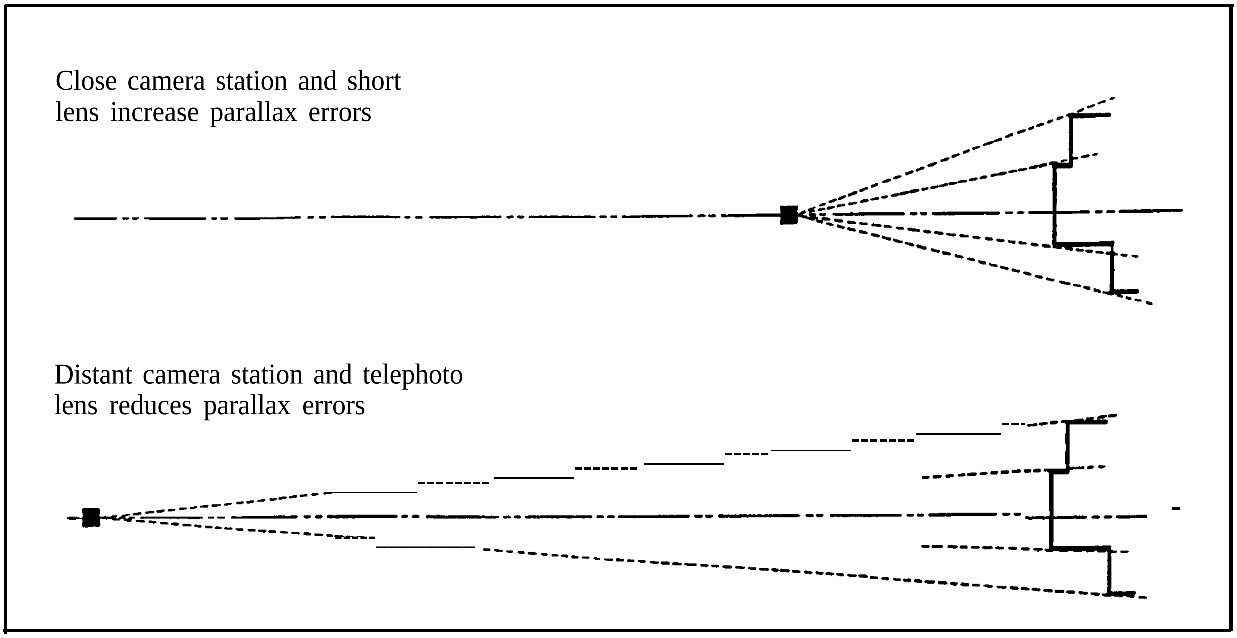


Fig. 4.45
Camera position and parallax errors

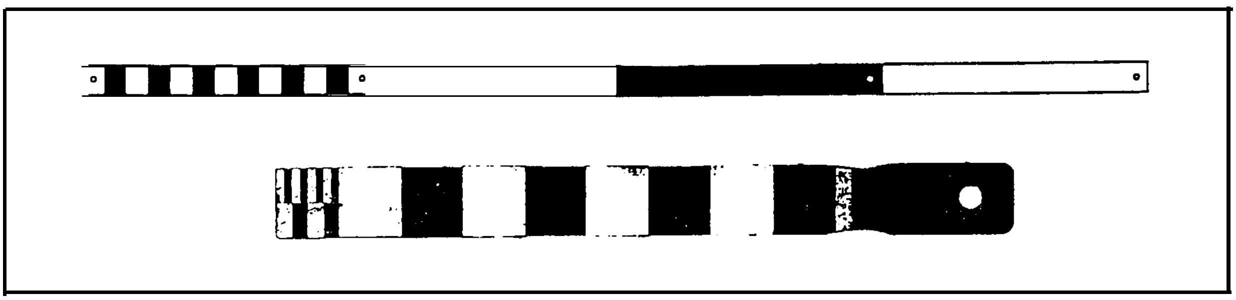


Fig. 4.46
Scale sticks

Scaling and Plotting Dimensions from Field Photographs

Scale sticks in each image enhance verifiability (Standard II), even though you have recorded the dimensions of photographed subjects in your field notes.

The best scale stick is one painted in alternating black and white stripes (each a foot long) on lattice wood strips (about 3/8" x 11/4" in section) available from a hardware store. For small details, a stick painted in inches or fractions of an inch will be useful (see Fig. 4.46). The numerals and graduations of folding rules and tapes are useable in close-ups, but they are impossible to read when the camera is more than 10 feet away. Two or more legible scale sticks in the plane(s) of the object you wish to record is highly recommended for verifiability.

TIP: If a horizontal or vertical datum plane passes through the photo field, you would do well to mark it (tight string or chalk line) and lay a scale stick near it for photos.

Photos can solve a lot of dimensional confusions or conflicts in field notes without revisiting a site. Field photos are either rectified ("squared" or one-point perspective) photographs, or oblique views which have two- or three-point perspectives. Rectified or one-point perspectives are best for scaling, but oblique views can provide relative measurements or check measurements (of more or less accuracy) depending what information you want, and how you go about obtaining it.

TIP: In some cases you may find more information in negatives than prints. If you have problems seeing important details in an unexpected shadow of your contact print or enlargement, examine the negative under an 8x eye loupe. Be sure to protect the negative strip from fingerprints and scratches by enclosing it in a temporary transparent plastic negative sleeve.

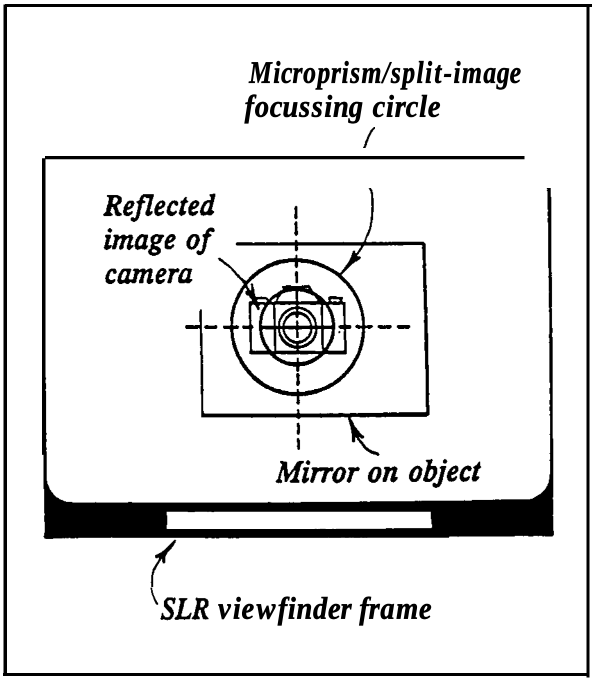


Fig. 4.47
Schematic "Camera's Eye" view of rectified photo set-up with mirror

A qualitative way to derive measurements from photographs is to count standardized or regularly spaced objects (bricks, clapboards, ceiling joists, structure bays, etc.). Dimensions of nearby features can be estimated by using these items as "measuring sticks". A brick facade virtually includes it's own scales on all axes no matter whether a photo of it is rectified or oblique, since the brick grid is based on repeated unit lengths. Remember that your error tolerance is higher than for direct field measurements. and annotate your final drawings accordingly. This technique is especially useful for inaccessible heights or features whose significance does not justify the time and effort to physically measure them.

There are two ways to scale a rectified image:

1) From a bar scale included in the image: measure the bar scale in the image with an architect's or engineer's scale, and calculate the image scale. The image scale in Fig. 4.48 is 0.9 1 5"=1'-0" (or 1" in the image equals 1 "- 1 $^{7}/_{64}$" on the original object). From here, you obtain other dimensions by simple proportions. You also may use a pair of dividers to pick the dimension desired from the image and compare it to the scale included in the image (see Fig. 4.48). *This works with confidence only if you obtain measurements within the same plane as the one in which the scale appears.*

2) For photos that do not include a bar scale, use a known dimension from field measurements to calculate the scale of the image, then derive other dimensions by simple proportions. If you have field measurements of several features from different planes within a photo, you may be able to scale other things.

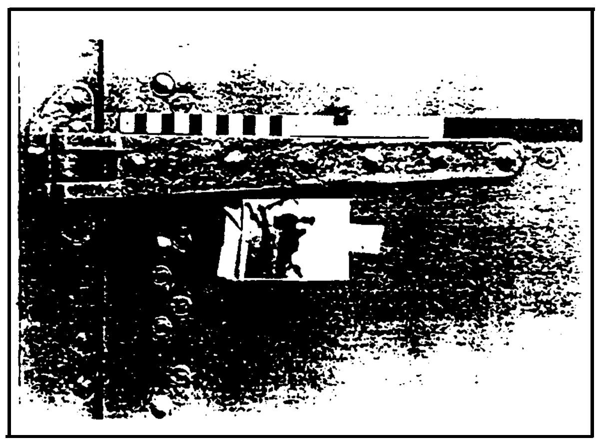


Fig. 4.48
Rectified photo with scale: set up with mirror, shot with 200mm lens

A planar feature in a truly rectified photo (like Fig. 4.49) can be traced, and the line drawing reduced to your preliminary drawing scale (see Fig. 4.50). Do not go to the trouble of trying to order an enlargement of the field photograph to a specific scale (something most photo labs will not do, or won't do accurately or cheaply!). This can help particularly with complex curves, scrollwork, ironwork, windows, signage, stonework, and so forth

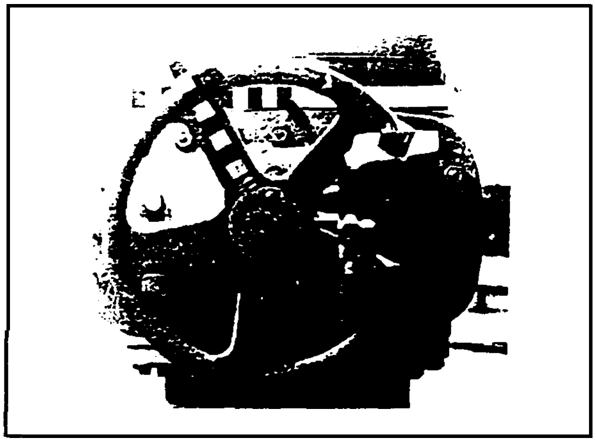


Fig. 4.49
Compound curves in flange of this water valve can be traced to scale

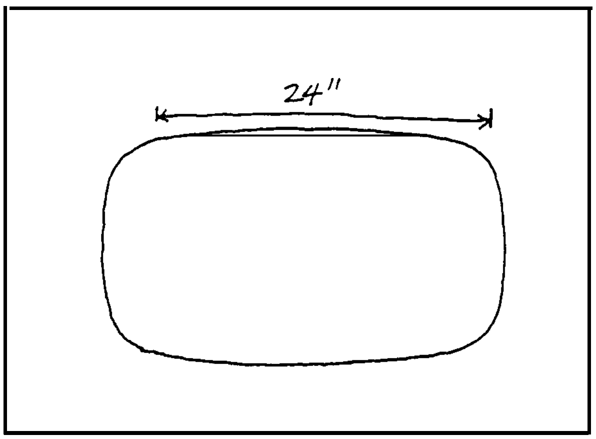


Fig. 4.50
Outline of flange with ends of 2-foot scale marked, ready for reduction.

Oblique views are more difficult to scale because perspective convergence is always changing the image scale. If an image is a two-point perspective (all verticals are parallel), then the easiest dimensions to scale are vertical ones. If you trace the converging lines of the image to the vanishing points, you can use the points to transfer vertical scales from a known plane "forward" or "backward" into other planes along the vanishing lines. Heights of other features can be calculated by simple proportions (see Fig 4.5 1). Scale approaching the vanishing points, however,is progressively more difficult to determine since convergence of parallel lines shortens image scale dramatically (increasing error). Grazing views are useless. Scale (or relative proportions) can be stepped off along a vanishing line using various laws of perspective (e.g. proportions of similar triangles, Fig. 4.52). Under some circumstances plans or elevations can be derived from oblique views if vanishing points can be determined accurately (reverse perspective analysis), and there are one or more known dimensions for features in the photo. For best results, the camera lens focal length should be known.

Some measurements from photos should be added to your field notes. If drawing a particular feature is based significantly on dimensions from field photos, a special field note should be drawn in which those dimensions are recorded.

The techniques mentioned above apply equally well to historic photographs. Dimensional analysis of historic photos may yield significant information about a structure or site. You may be able to date the photograph or the structure, depending on what you know of the site's construction history, for example. You may be able to fill in gaps in the written record from data obtained from a photo.

4.6 SUBMITTING FIELD NOTES and FIELD PHOTOGRAPHS

All field notes must be filed in printed HAER field note folders (see Fig. 4.53). Field notes should be organized in a manner appropriate to the site you are recording (e.g. by building, floor, machine, elevation, etc.). ***Fill in every blank on every folder.***

In order to meet the ***Secretary's Standards,*** every sheet of field notes should be clearly block lettered in pencil as follows:

1) Site name
2) Site location
3) HAER Number (if known)
4) Specific view(s) in the note
5) Names of note makers
6) Date notes were made

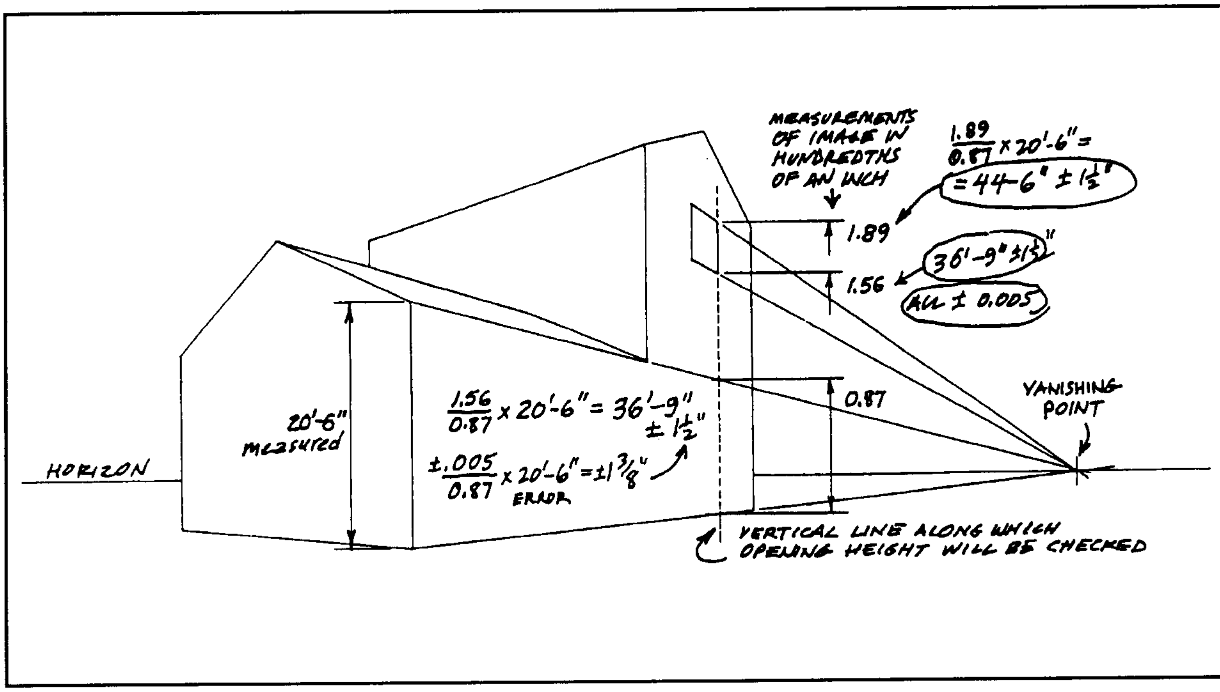


Fig 4.51
Using perspective convergence and simple proportions to calculate heights

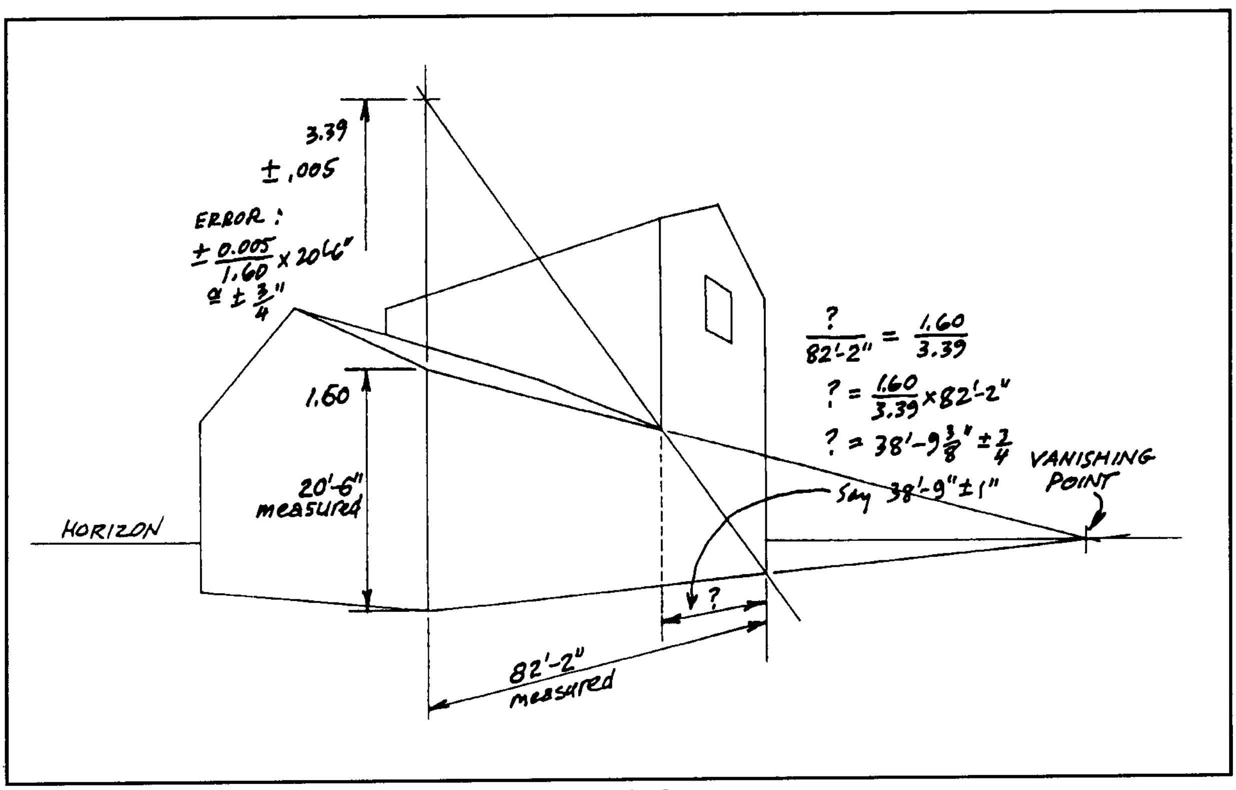


Fig. 4.52
Calculating lenghts using simple proportions and similar triangles

A Field Photo Identification Sheet must be filled out by the recording team for each roll of film in order to meet the Secretary's Standards (see Fig. 4.54). Unidentified photographs fail to meet Standards II and IV. The blanks on each sheet must be completely filled out with site name, project number, photographers' names and dates, etc. Each image should be numbered according to the frame numbers on the negative strips. If certain exposures did not turn out, caption them as "blank", "underexposed", etc. Be sure to give particulars such as building names, compass directions, names of objects and specific reasons why the image was taken.

You know your site and field procedures better than anyone else; HAER staff in Washington or regional offices cannot do this task for you.

After processing, every contact sheet and its corresponding film strips must be identified by a HAER number and film roll number (see Fig. 4.55). Film strips should be labeled on the shiny side with drafting ink and a #0 [.35mm] pen, each letter or numeral between a sprocket hole (never in the image area). Individual film strips should be stored in separate acid-free archival envelopes labeled in No.1 pencil with the HAER number and roll number. Contact sheets and film envelopes shall be filed in labeled HAER field note folders.

Consult *HABSIHAER Transmittal Guidelines* for further transmittal details.

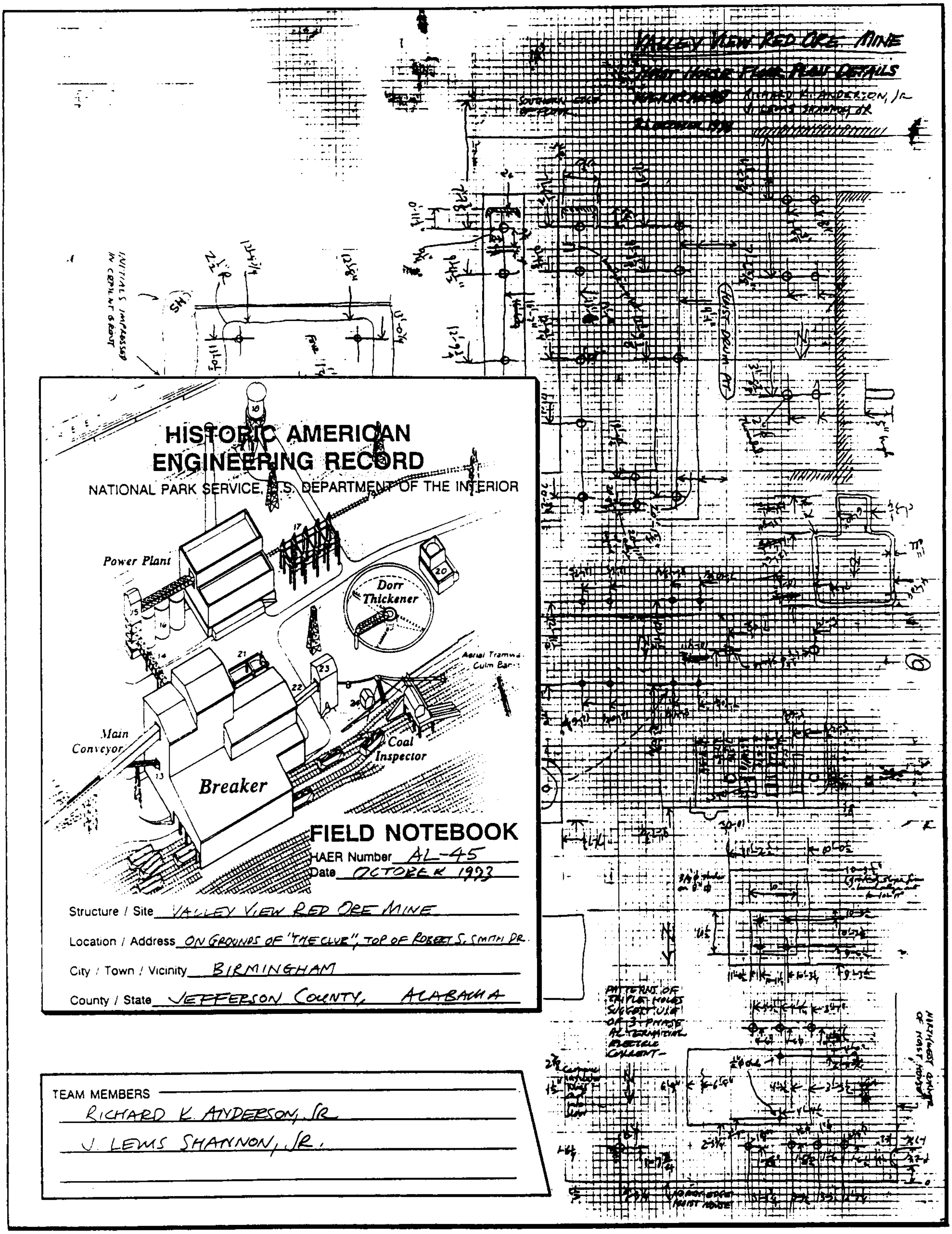


Fig. 4.53
Properly labeled field note folder and field note

National Park Service
Photo Identification Sheet

PHOTOGRAPHER	Date	HABS #
	Field Film #	HAER #

Location	Building	Elevation/View

WASO-29

Fig. 4.54
Field photo identification sheet

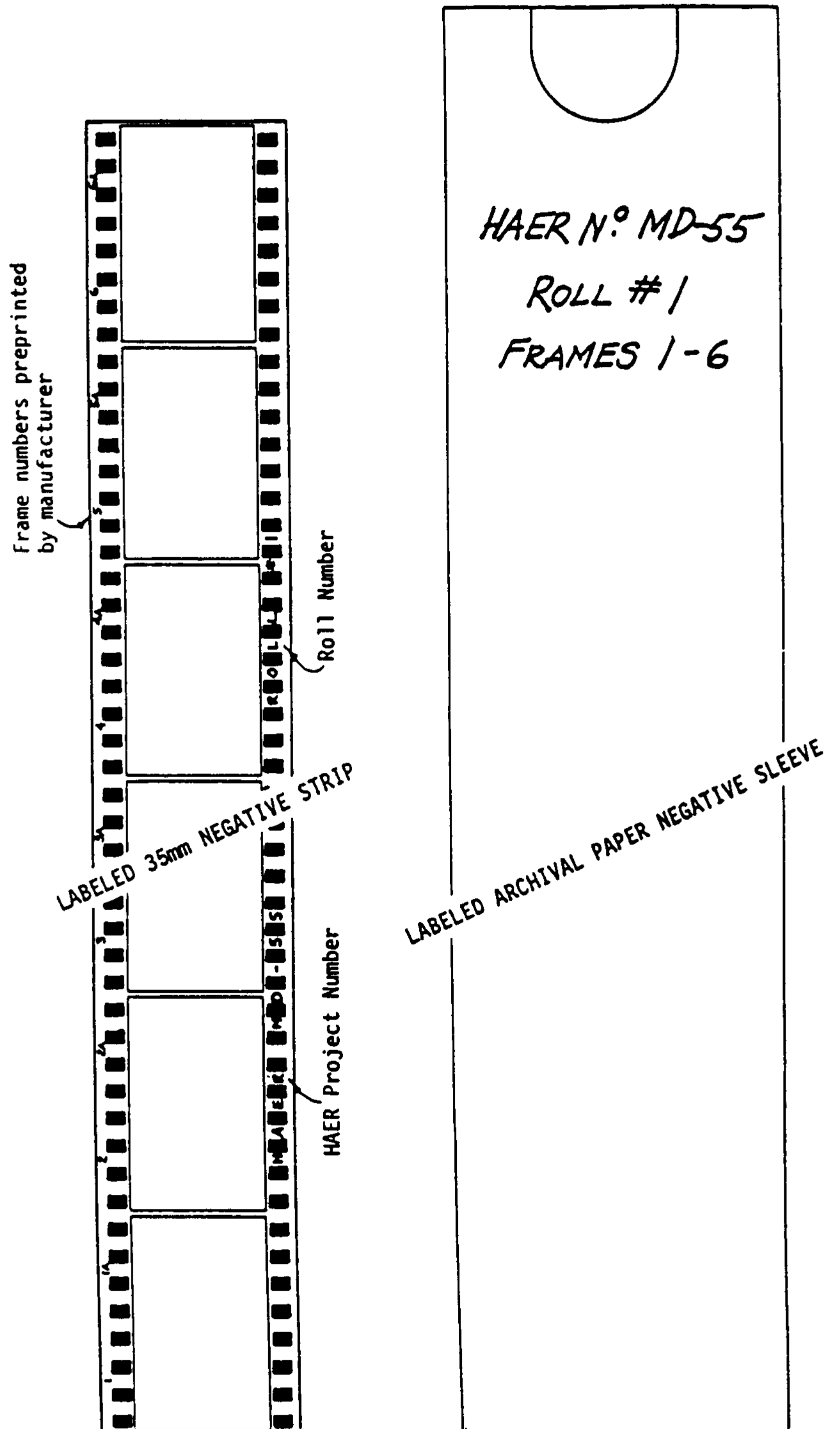


Fig. 4.55
Labeled 35mm film strip and labeled archival paper negative sleeve

4.7 PRELIMINARY DRAWINGS

In hand-drawn measured drawings, preliminary drawings are the underlays from which final ink drawings are traced. In this phase, the final details of sheet content and composition are worked out for each sheet in a project. It is assumed by this point that you have already finalized the drawing schedule for your project.

Preliminary drawings are more than just a development tool for final drawings, however. ***They are the proving ground for your field work.*** If your notes, measurements and photographs were properly and thoroughly taken, your preliminary drawings should proceed smoothly. Errors and omissions will become evident when points refuse to plot, dimensions conflict or don't add up, and spaces refuse to close. ***Because preliminary drawings test the validity of your field work, it is imperative to begin them as soon as possible.*** Don't wait for one-third of your project schedule to pass before you begin them just because field work is estimated to take one-third of the total hours available!

> NOTE: Preliminary drawings provide invaluable feed-back for directing and correcting your field methods and note taking procedures, thus leading to good field notes and final drawings. Begin them as soon as you have notes complete enough to plot.

Strategy. Preliminary drawings are somewhat analogous to the form work and scaffolding for concrete construction. They don't have to be pretty, but they do have to be accurate (Standard II), since final drawings are traced from them. There are several materials and techniques which can be used to preserve accuracy and save you time in this phase; you may think of others. ***Be sure to read Sections*** 4.8-4.9 ***since they contain many drawing guidelines which apply also at the preliminary drawing phase.***

Preliminary drawings may be spliced or layered at will to arrive at accurate results. Repeated features whose dimensions do not vary can be electrostatically copied and taped to their locations instead of laboriously redrafted. Electrostatic and photographic images of other kinds (e.g. reductions of rubbings or traced rectified photographs) can be spliced into preliminary drawings to speed production. This is where preliminary drawings function like form work for "molding" each final drawing. Lettering for text composed by team historians can be laid out in draft form by hand (or word processor) and moved about each drawing to find the best size, weight, and layout for meeting Standard IV and the stipulations set out in Section 4.7. Reference lines and grids can be drawn on the back of the sheet to avoid damage when line work on the front needs erasure.

Always check the accuracy of your drawing set by occasionally overlaying preliminary elevations, plans and sections and looking for mismatched datum lines, windows, walls, columns, machinery, and other features.

While you are drawing, allow yourself time to write down notes and labels on the sheets as you think of them for possible inclusion in final drawings. Copy principal dimensions from field notes onto your preliminary sheets so you don't have to search for them again later. Keep a separate list of conflicts and questions to resolve back at the site.

Preliminary drawings are transmitted along with field notes to the Library of Congress. Two media are recommended for preliminary drawings: drafting vellums and polyester films (commonly called Mylar@). The surfaces of drafting vellums are designed for clean drawing in pencil and ink, unlike bond papers. However, vellums (like most papers) expand and contract with humidity changes, sometimes as much as 5%. While more expensive, polyester films are immune to humidity fluctuations, and change dimension only very slightly on exposure to heat (as from a hot drafting lamp bulb). Preliminary drawings should never be done on HAER Mylar sheets.

Drafting Equipment

Teams administered by HAER are usually sent the drafting tools listed below (this does not mean team members may not bring or use their own). Most of this equipment is widely available and would be needed by anyone producing measured drawings by hand.

Parallel bar
12" architect's and engineer's scales
Wangles, ranging from 3" to 12" sizes, in both 30°/60° and 45°/45°
Adjustable triangles, in **8"** and 12" sizes
Protractors
Ames lettering guides
Templates with graduated sizes of circles, ellipses, or specialized shapes
French curves
Bow compasses
Beam compasses
Universal compass adapter (for using pencils and pens with various compasses)
Drafting lead holders and graphite leads (2H to 9H hardness) for preliminary drawings only
Lead pointers
Technical pens (for ink) in the following sizes (These pen sizes vary slightly among manufacturers):

6x0	(0.13mm 0.005 in)*
4x0	(0.18mm 0.007 in)
3x0	(0.25mm 0.010 in)
2x0	(0.30mm 0.012 in)
0	(0.35mm 0.014 in)
1	(0.50mm 0.020 in)
2	(0.60mm 0.024 in)
2-112	(0.70mm 0.028 in)
3	(0.80mm 0.03 1 in)
4	(1.20mm 0.047 in)

**rarely used*

Acetate ink (black, e.g. Pelikan-FT®)
Erasers (vinyl or plastic for both vellum and mylar)
Erasing shields
Drafting tape
Table brushes
"X-Acto" knife and blades (or equivalent)
Mechanical lettering set (K&E "Leroy" or equivalent)
Roll of polyester film or drafting vellum
HAER mylar sheets

A calculator (with trigonometric functions) is recommended but not supplied by HAER.

It is good practice to check architect's (and engineer's) scales against one another-it occasionally happens that one or two scales are inaccurate and do not match the others. Failure to find these nonconformists can lead to problems when an inaccurate scale is used with accurate ones on the same drawing. Parallel bars should be checked for straightness and triangles for squareness.

> TIP: To check a parallel bar, draw a line the length of the bar using one edge; then turn the bar end-for-end (same side up) and draw another line close to the first using the same edge employed earlier. Any bowing between the lines is an indication that the bar is bent. To check a triangle for squareness, set it on a straight parallel bar and draw a line at right angles to the bar; then flip the triangle to the other side of the line and draw a second line close to the first. If the lines diverge, the triangle isn't square and should be discarded.

Adhesive-backed lettering and rendering materials such as LetratoneTM and Kroy® are ***prohibited*** on final ink drawings submitted to HAER because their adhesives are not archivally stable. However, if their use in preliminary drawings will save time, enhance accuracy and solve problems, by all means use them. You may find it faster or cheaper to electrostatically copy some forms of rendering you find effective and attach it to your drawings as needed.

HAER Mylar

HAER Mylar™ is produced in three different sheet sizes with a standard HAER preprinted border. The sheet size and actual drawing area are given below:

19"x24" (15-3/4" x 20-l/8")
24"x36" (21-3/4" x 3 l-3/4")
33"x44" (3 l-3/4" x 39-7/8")
IMPORTANT NOTE: *All sheets in a drawing set must be of the same size.*

HAER sheets are only for final ink drawings. ***All*** preliminary pencil work should be done on separate materials.

Only two orientations of the HAER drawing sheet are permissible:

1) HORIZONTAL with title block to the RIGHT

2) VERTICAL with title block at the BOTTOM

Borders may be broken when the orientation, scale, or presentation of a subject requires it, but this is not an excuse for contrived effects or cramming views onto single sheets which would fit better at a smaller scale. or onto two sheets.

Do not trim the HAER sheets at the "Trim Line" marks. The Trim Line is a guide for trimming ***reproductions*** for presentation, not the standard size original sheets.

> CAUTION: Do not "start" pens on the edges of the mylar beyond the Trim Line. Since the edges will remain, these stray marks will have to be removed before a drawing will be accepted for transmittal.

HAER sheets have a drawing surface on each side (double-matted).

> NOTE: Reserve the front side for all line work and labeling, and use the back for center lines, grids, pochés, and rendering (e.g. clapboards, brick, etc.). This way, rendering mistakes can be erased without disturbing line work, and vice versa.

Oily fingerprints, perspiration, and smudges cause ink lines to "bead" and fail to adhere. These can be quickly removed with ***naphtha*** (lighter fluid) or a chamois cloth without removing previously inked lines.

> ***WARNING! Never use acetone or aromatic solvents like toluene--these destroy the drawing surface.***

HAER sheets should be stored flat, or in a roll, ***never folded*** (creases are structurally weak, collect dirt, and spoil the image). Avoid kinking or crinkling sheets.

<u>Sheet Organization</u>

Generally a drawing set should be organized as follows:

Title Sheet (with location maps)
Site Plans
Site Sections
Building or Structure Plans
Elevations
Sections
Details (plans and elevations, sections, exploded views, isometrics)
Process Diagrams (isometrics, flow charts, schematics, etc.)
Other interpretive views

Not all sites will receive coverage as complete as the list above, nor is it necessary to devote a minimum of a single sheet to each view or subject listed. The extent of documentation should depend first on the site's significance and the importance and number of specific features there, although other planning factors in your project's goals may affect the content of the drawing set.

<u>Title Page Layout.</u>

Each set of drawings must have an introductory title sheet, containing a brief historical summary, project credit statement, a graphic (historical view of the site) or major map or site plan, and location maps showing regional and local orientation.

Heading. The record name of the site should go at the top of the sheet in letters at least 3/4" to 1-1/2" high. This name should match the record name listed on the Data Entry Sheet.

> TIP: Consider adapting the heading from an old company letterhead, signage, advertising, or other associated source if the style is sufficiently distinctive or attractive.

Remember to note your source of the lettering style in such cases. If you have created a graphic which might be mistaken for something historical, be sure to state that it is ***not*** drawn from anything associated with the site. Examples appear in Section 4.8.

Site Location. (City and state, no county) Letters 5/8" to 1" high, all capitals or upper and lower case, underneath title lettering.

Construction Year(s). Numerals 3/4" to 11/4" high, usually smaller than the title.

Statement of Significance. A historical abstract highlighting the site's historic and/or engineering significance and important aspects of its history is hand-lettered on the title sheet. This statement is written by the project historians and its length should be coordinated with the architects. It should agree with the findings reported in the historians' final draft and should contain the essence of the report in not more than 200 to 400 words.

Project Credit Statement. A project credit statement will be worded identically on all title sheets produced by a single recording team. Follow the model below:

THIS RECORDING PROJECT IS PART OF THE HISTORIC AMERICAN ENGINEERING RECORD (HAER), A LONG-RANGE PROGRAM TO DOCUMENT HISTORICALLY SIGNIFICANT ENGINEERING, INDUSTRIAL, AND MARITIME WORKS IN THE UNITED STATES. THE HAER PROGRAM IS ADMINISTERED BY THE NATIONAL PARK SERVICE, U.S. DEPARTMENT OF THE INTERIOR. THE [name of project] RECORDING PROJECT WAS COSPONSORED DURING [THE SUMMER(S) OF (years)] BY HAER UNDER THE GENERAL DIRECTION OF [...] AND BY [list of all cosponsors] .

THE FIELD WORK, MEASURED DRAWINGS, HISTORICAL REPORTS AND PHOTOGRAPHS WERE PREPARED UNDER THE GENERAL DIRECTION OF [...], CHIEF, HAER, AND BY [name], HAER PROJECT LEADER; [name] HISTORIAN FIELD TEAM SUPERVISOR; AND [name], ARCHITECT FIELD TEAM SUPERVISOR. THE [project name] TEAM CONSISTED OF [name, team title, school, for each team member] . LARGE FORMAT PHOTOGRAPHY WAS DONE BY [name, school] .

The affiliations and professional status of the historians and delineators should be included as appropriate (e.g., name of university, or other organization from which the person came).

Location Maps. Inclusion of location maps for the site is a requirement. The purpose is to clearly indicate where the site lies. Extraneous information should be avoided. It takes time to ink and confuses users.

Typically, the site is pointed out within a state or region in a schematic map at a scale of 1"=100 miles or more. Major cities are labeled, with the site name itself in the largest, boldest lettering. Major geographic features (such as mountains or rivers) or the interstate highway system are not shown unless they have some crucial bearing on siting. Some sites are systems that cross state lines or connect numerous cities, in which case, the first location map is drawn at a larger scale to show more detail.

The second location map is more detailed and is usually based on a USGS 7.5 minute quadrangle topographic map (scale 1"=2,000'). The information in the USGS map must be carefully "edited" so that the site location is readily apparent without a glut of detail or radical loss of context. Do not trace topographic lines unless topography is critical historically to siting. Rivers, lakes, and other major geographic features must be shown. Trace and name only major streets in a town. Do not copy all the dots for individual buildings; such detail should be reserved for the site only, assuming it contains multiple structures in an area large enough to show at 1"=2,000'.

In addition to location maps some sites merit a large overall site plan on the title page to orient the user to a building complex, localized industrial system, or the surrounding community context. Scales should range between 1"=400' to 1"=100' depending on the site and its complexity.

UTM Numbers. The UTM (Universal Transverse Mercator) coordinates for the site must be determined, and lettered on the site location map. Add a prominent cross hair, a bold arrow and the site name to further clarify location in the map. See Section 5 (Appendicies) for directions deriving UTM coordinates.

Pictorial Graphic. Where a useful site plan would be too extensive to include on a title sheet, move it to the second sheet and substitute a principal elevation or an aerial view of the site. Pictorial views can be derived from photos (historic or current) and combined with well-designed graphics.

Index to Drawing Set. This is only necessary for sets of 10 or more sheets. An index on the title sheet helps a user quickly locate particular views. If for some reason an index cannot be included on the title sheet indicate on the title sheet where it can be found (e.g., "Index: see Sheet 2").

4.8 ANNOTATING DRAWINGS.

The following section has been developed to assist delineators in incorporating titles, notes, descriptions and other written data into their sheet layouts. The following examples are to be used as a guide for the size, quality, clarity and readability of drawings (Standard II).

A hierarchical system of lettering sizes and weights will distinguish various types of verbal information and their relative significance. In general, large lettering with heavy line weights should be reserved for sheet titles and drawing titles, small lettering should be reserved for short labels and notes appearing on or near the drawings. Creativity with font styles is acceptable, especially with the project title on the title sheet where historic logos and typefaces can provide additional information. However, the font styles must not violate the principles of quality and clarity that the *Secretary's Standards* set forth and must be approved by a project leader in the Washington office before being used.

NOTE. Mechanical block lettering, such as Leroy™ lettering templates or similar must be used in HAER sheet title blocks. See Figs.4.72-4.73 for further instructions.

Computer Underlays

With the wide variety of font styles and sizes that can be generated from the personal computers and printers today, it is recommended that "mock-ups" and underlays of text be generated and incorporated into the preliminary sheet layouts as soon as possible. These computer generated fonts can also serve as underlays for the final ink-on-Mylar drawings.

Computer generated text, used as an underlay, will also assist the delineators in keeping font styles and sizes consistent and uniform throughout a set of drawings. This consistency contributes to the visual effectiveness and sense of unity in a drawing set. Other items that must remain graphically consistent throughout a project include graphic scales, diagrams and north arrows. Items such as these should not only be consistent but also be practical and sensible. They should contribute to the overall composition of a sheet and not be visually distracting.

The following pages give examples of HAER drawings which remain clear and readable after reduction to 8 " x 1 1". The pages preceding the examples give the font sizes used to achieve this clarity. The font styles can change to suit the project, but minimum sizes must be strictly followed to ensure legibility at any size.

In order to meet Standards II and IV, *all keys and labels should use arrows pointing directly to denotedfeatures.* Putting a label in the vicinity of a feature does not guarantee unambiguous association in the minds of users who don't know your site.

Lettering Standards

Lettering can make or break a drawing visually. Poor lettering is distracting and may unfairly reflect on the quality of your documentation. If you cannot letter well by hand, improve your technique or use a mechanical lettering system in order to meet Standard IV.

Sheet Titles. (Not to be confused with Title Blocks or Title Sheets.) Every view must have a clear, thorough, unambiguous title: "Site Plan- 1882," "North Elevation," "Section A-A," etc. It should be in large lettering, prominently placed for recognition by users. Follow the lettering sizes and weights in Figs. 4. 56. If necessary, underline titles to add visual emphasis.

Blurbs, Notes, Labels, and Keys. Blurbs, notes, labels, and keys should be composed by team historians. Important information should be conveyed and proper terminology used. Architects are responsible for graphically integrating these elements into the sheets.

Blurbs should be limited in length and contain only the most important facts and observations. They should help the drawing document and interpret the resource.

Notes. These are phrases or brief statements used to supplement graphic information. They may make a historical statement, describe a material or function, or give pertinent information on a piece of mechanical equipment (builders, patent numbers and dates, model numbers, serial numbers; mechanical specifications such as sizes, pressures, horsepowers, capacities, etc.) Notes also call attention to important documentary qualifications or field conditions, record bibliographical data, give Munsell color numbers, make observations, point out important speculations, or account for the accuracy of questionable-looking features in a drawing.

Labels and Keys. These two methods cite or describe different parts or features of a drawing. They may be used separately or together as the graphic layout of your sheet demands. Labels are best, since they directly name a part and point it out with an arrow. A key associates a numbered or lettered label in a list with a number-tagged (or letter-tagged) feature in a drawing. Keys are usually used where space is too cramped to permit labels. Use Arabic, not Roman numerals for number tags.

Labels vs. Line work. Do not label or dimension over line work--it impairs clarity. Keep lettering outside of line work. If you have to letter across pochés or other detailed areas of a drawing, erase enough line work to accommodate your label (Standard IV).

Map Lettering. Maps are required for every HAER project. They range from small schematic maps of a state or region to detailed plans of a site and its context at scales as large as 20 feet to the inch. Different lettering sizes and styles should be used to distinguish various layers of information in a map. Keep Standard I firmly in mind when generating a map, concentrate on the significant factors and delete most other detail. Always label such things as state, county and city lines, rivers, and major highways to provide overall orientation. Stippling, solids, and water lines can be used to good effect, especially since HAER maps are black and white. Examples of proven mapping graphics can be found in Section 4.9. Examine maps from the U.S. Geological Survey, National Geographic Society, or major publishers like McNally for further lettering and line work ideas.

TITLES

1. Titles for sheets should be 1 inch high and all upper case lettering.
   (suggested font - Times Bold 108pt)

Sub-Titles

2. Sub-Titles for drawings should be 3/4 inch high and upper/lower case lettering.
   (suggested font - Times bold 78pt)

Main Labels

3. Main labels for drawings should be
   3/8 inch high and upper/lower case lettering.
   (suggested font - Times bold Italic 38pt)

Minor Labels

4. Minor labels for drawings should be
   1/4 inch high and upper/lower case lettering.
   (suggested font - Times bold Italic 24pt)

General Text, Notes and Small Titles

5. General text, notes, and small titles should
   be 3/16 high inch and upper/lower case lettering.
   (suggested font - Universal Italic 20pt)

DIMENSIONS AND SECONDARY KEYS

6. Dimensions and secondary keys should be 1/8 inch high and all upper case lettering. (suggested font - Universal Italic 16pt)

See Drawing on the next page for an example of a 24" x 36" drawing reduced to 8 ½"x 11".

The lettering styles may change to suit the project, but the sizes of lettering should not be changed.

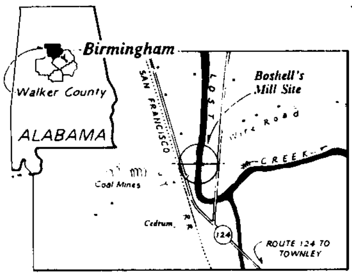
ABSOLUTELY NO LETTERING LESS THAN 3/16" HIGH.

Fig. 4.56

BOSHELL'S

SAW AND GRIST MILL

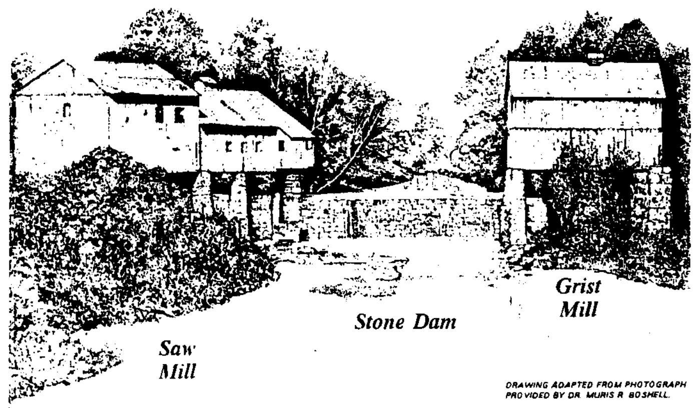
WALKER COUNTY, ALABAMA



Site Location Map

UTM REFERENCE: 16.458600 3745440

ABOVE MAP ADAPTED FROM USGS 7.5 MINUTE SERIES. TOWNLEY QUADRANGLE 1949, PHOTO REVISED, 1981.

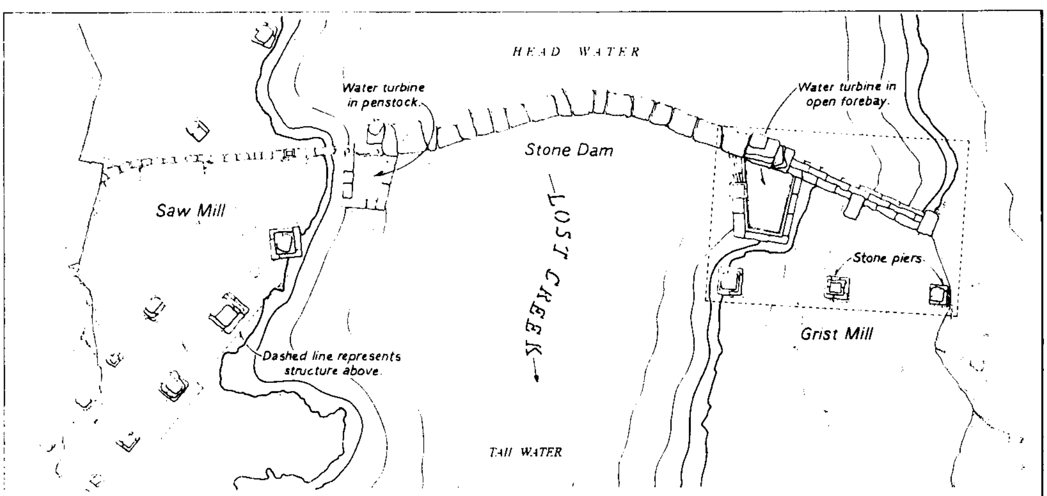


DRAWING ADAPTED FROM PHOTOGRAPH PROVIDED BY DR. MURIS R. BOSHELL.

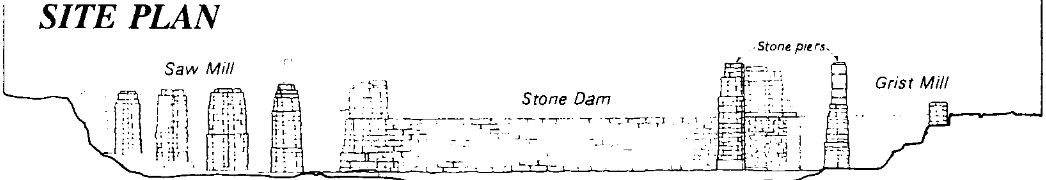
In 1901 W. R. Boshell began work on this stone mill dam, designed to power his mill operations through the use of water turbines. The new sawmill began production in October of 1902, followed by the addition of a gristmill in 1903. Production continued until 1963. The gristmill was destroyed by fire in 1976, and the sawmill fell to the same fate in 1986. Both buildings were constructed with large cylindrical beams, board and batten siding, and sheet metal roofing. The supporting piers, made of sandstone quarried on site, still stand.

This recording project was executed under the Historic American Engineering Record (HAER), a program to document historical industrial and transportation resources in the United States. The HAER program is administered by the Historic American Buildings Survey/Historic American Engineering Record Division (HABS/HAER) of the National Park Service, U.S. Department of the Interior. The Birmingham District Recording Project was cosposored during the summer of 1992 by HAER under the general direction of Dr. Robert J. Kapsch, Chief of HABS/HAER, and by the Birmingham Historical Society, Marjorie White, Director. The Birmingham District HAER Advisory Committee served this recording project. Assistance was provided by Dr. Muris R. Boshell, Professor Winfred Sandlin and Mr. Eddie Key.

The field work, measured drawings, historical reports and photographs were prepared under the direction of the Chief of HAER and Project Leader Eric DeLony; HAER Architect and Project Manager Robbyn Jackson; Project Historian Jack Bergstresser; and Project Architect, Craig Strong. The Roving Team Survey consisted of Architect Supervisor Kyle M. D'Agostino and Architects Robert Martin and Catherine Kudlik. The historical report was produced by Lewis Shannon. Formal photography was done by David Diesing. Additional consultation was provided by Richard Anderson Jr.

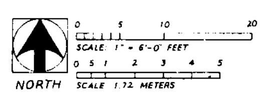


SITE PLAN



ELEVATION

Above plan and elevation produced from site survey and fieldnotes.



DELINEATED BY: *Kyle M. D'Agostino, Catherine Kudlik and Robert Martin, Summer 1992 Supervised By Craig Strong*

BIRMINGHAM DISTRICT RECORDING PROJECT NATIONAL PARK SERVICE UNITED STATES DEPARTMENT OF THE INTERIOR	TOWNLEY	BOSHELLS MILL LOST CREEK AT ALABAMA ROUTE 124, 1.7 MILES SOUTH OF U.S. ROUTE 78 WALKER COUNTY	ALABAMA	SHEET 1 of 1

HISTORIC AMERICAN ENGINEERING RECORD	AL-18

IF REPRODUCED PLEASE CREDIT: HISTORIC AMERICAN ENGINEERING RECORD, NATIONAL PARK SERVICE, NAME OF DELINEATOR, DATE OF THE DRAWING

TITLES

1. Titles for sheets should be 1 1/4 inch high and all upper case lettering.
(suggested font - Times Bold 134pt)

Sub-Titles

2. Sub-Titles for drawings should be 3/4 inch high and upper/lower case lettering.
(suggested font - Times bold 78pt)

Main Labels

3. Main labels for drawings should be
1/2 inch high and upper/lower case lettering.
(suggested font - Times bold Italic 54pt)

Minor Labels

4. Minor labels for drawings should be
3/8 inch high and upper/lower case lettering.
(suggested font - Times bold Italic 42pt)

General Text, Notes and Small Titles

5. General text, notes, and small titles should
be 1/4 high inch and upper/lower case lettering.
(suggested font - Universal Italic 24pt)

DIMENSIONS AND SECONDARY KEYS

6. Dimensions and secondary keys should
be 3/16 inch high and all upper case lettering.
(suggested font - Universal Italic 18pt)

See Drawing on the next page for an example of a 34" x 44" drawing reduced to 8 1/2 "x 11".

The lettering styles may change to suit the project, but the sizes of lettering should not be changed.

ABSOLUTELY NO LETTERING LESS THAN 3/16" HIGH.

HARDIE-TYNES
MANUFACTURING COMPANY
BIRMINGHAM, ALABAMA

Hardie-Tynes c. 1912
Adapted from an advertising engraving, c. 1912. Courtesy Hardie-Tynes Manufacturing Company.

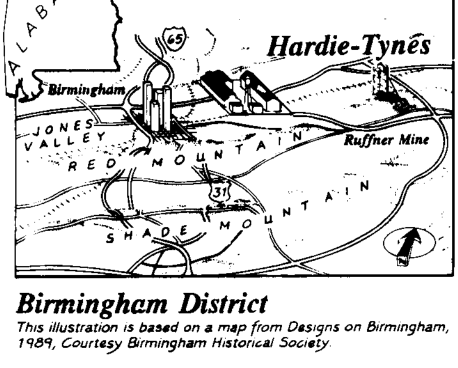
From its origins in the early 1870s, the Birmingham District's high phosphorous iron ore, abundant bituminous coal beds, and ample limestone deposits made it the natural center for cast iron production. The District, which included Jefferson, Shelby, Bibb, Walker, and Tuscaloosa counties, grew into one of America's most highly developed foundry industries. One of the city's earliest foundries and machine shops - the Birmingham Iron Works - was founded in 1883 by John T. Hardie, and made both pipe and industrial machinery.

In 1895, William Hardie and William D. Tynes founded the Hardie-Tynes Foundry and Machine Company. Located in North Birmingham at the corner of 1st Avenue and 26th Street, on the site of the Birmingham Iron Works, Hardie-Tynes was conveniently close to Sloss furnaces, one of its principal source of pig-iron. When the site was damaged by fire in January 1901, the company moved and constructed a new, larger foundry and machine shop at its present site in what was then known as East Birmingham. Another major fire in 1924 led to the reconstruction and enlargement of the machine shop.

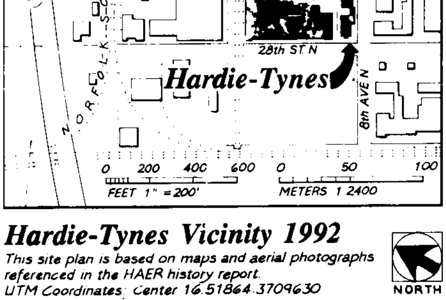
Hardie-Tynes was a "jobbing" foundry, making specialized industrial machinery to order. Unlike production foundries that turned out large quantities of identical products, Hardie-Tynes employed skilled engineers, foundrymen and machinists to design and produce complex, limited production items. Early products such as Corliss and slide-valve steam engines were sold to companies through out the United States; whereas, mine-hoisting engines and other mining equipment were produced for the local mining industry.

During World War I, Hardie-Tynes began producing naval and marine equipment. In addition to steam engines for Victory ships, during the 1930s and 1940s the company regularly supplied air and gas compressors to the U.S. Navy for submarines. Since then, Hardie-Tynes has supplied the Navy with turbine-driven forced draft blowers for boilers and boiler feed pumps, plus torpedo propulsion equipment and missile components.

Since the 1920s, Hardie-Tynes has been an important anufacturer of hydro-electric and dam equipment, supplying machinery for the Boulder (Hoover) and Grand Coulee dams, and the Tennessee Valley Authority dam building program of the early 1940s. The company still produces an array of such products, from needle valves to vast paradox gates.



Birmingham District
This illustration is based on a map from Designs on Birmingham, 1989, Courtesy Birmingham Historical Society.



Hardie-Tynes Vicinity 1992
This site plan is based on maps and aerial photographs referenced in the HAER history report.
UTM Coordinates: Center 16.518643709630

NORTH

Despite its continuity, the company's site operations have changed over time. The foundry no longer operates, closing in 1962 and undergoing conversion to a fabrication shop in 1976. Hardie-Tynes no longer casts iron for its products, but now cuts, rolls and welds steel into desired shapes. As in the past, however, products are finished in the machine shop, assembled in the erecting shop, and shipped by rail to buyers.

Despite adaptation in the general site arrangments, the foundry and its associated buildings remain largely intact. Though inactive for more than thirty years, the foundry ovens, cupolas, charging platform and cranes all remain, as does the pattern shop with its' pattern storage area and blacksmith shop. Still active operations include the air compression system which dates to the mid-1920s.

Hardie-Tynes thus provides an important site for the interpretation of early foundry and machine shop production of large scale, specialized industrial machinery.

This recording project is part of the Historic American Engineering Record (HAER), a long range program to document the engineering, industrial, and transportation heritage of the United States. The HAER program is administered by the Historic American Buildings Survey/Historic American Engineering Record Division (HABS/HAER) of the National Park Service, U.S. Department of the Interior. The Birmingham District Recording Project was cosponsored during the summer of 1992 by HAER under the general direction of Dr. Robert J. Kapsch, Chief of HABS/HAER and by the Birmingham Historical Society, Marjorie L. White, Director. The HAER team was guided by the Birmingham District Advisory Committee, including Gordon L. Flynn, President of Hardie-Tynes Manufacturing Company. Robert C. Stobert, Jr., John Crane, A. James Powell, and Emile Dahlen provided additional assistance.

The field work, measured drawings, historical reports and photographs were prepared under the direction of Eric N. DeLony, Chief of HAER and Project Leader; Robbyn L. Jackson, HAER Architect and Project Manager; Jack R. Bergstresser, Sr., Project Historian; and Craig Strong, Project Architect. The recording team consisted of Evelyn Green, Supervisor; Laura Letton and Zvonimir Franić (ICOMOS), Architects; and Tanya English (ICOMOS), Historian. Large format photography was produced by David Diesing. Documentary consultation was provided by Richard K. Anderson, Jr.

Laura Letton, Summer 1992

BIRMINGHAM DISTRICT RECORDING PROJECT	BIRMINGHAM	HARDIE-TYNES MANUFACTURING COMPANY 800 28TH STREET NORTH JEFFERSON COUNTY	ALABAMA	1 OF 5	HISTORIC AMERICAN ENGINEERING RECORD AL-13

HAND LETTERING
Unacceptable Styles

HAER drawings are public records intended for 500 years' use. Lettering that is too stylized, elongated or badly formed falls into the **"unacceptable"** category because it is not very legible to the general public and does not reproduce well. It thus fails Standard IV.

THE LAND THAT FORMED THE HACIENDA
HE WAS A SPANISH EMIGRE FROM VENEZUELA,
HIS VENEZUELAN-BORN SON, DON
1845, AND SUBSEQUENTLY FOUNDED THE

Too Vertically Elongated, middle horizontals are too high and the letter S is too stylized.

THIS RECORDING PROJECT
HGE PROGRAM OF THE HISTOR
RECORD (HAER) TO DOCUMENT
INDUSTRIAL SITES THROUGHOUT
WAS CONDUCTED BY HAER PUES

S,O,R,P and Ns are too compressed, they will blur and run together when they are reduced.

1 FREIGHT SHOP
2 TRUCK SHOP
3 MATCHING ROOM
4 HAMMER SHOP
5 WATER TOWER
6 GEN'L STORE NO
7 HOT AIR DRY
HOUSES (KILNS)
8 OIL HOUSE
9 IRON WAREHOUSE
10 REAR ERECTING
SHOP
11 REAR ERECTING
SHOP
12 REAR ERECTING
SHOP

Very eccentric, hard to read, much too elongated. The letters U,O,A,R,P,H,N and W will run together and become illegible blobs when reduced.

FIRST FLOOR PLAN

Just plain sloppy!

Fig. 4.58

HAND LETTERING
Acceptable Styles

Acceptable styles have well-rounded letters free of stylistic exaggerations. They read easily at full size and at a reduced scale and are adequately spaceed. Labels and blurbs should be laid out before inking to check placement, spacing, spelling, hyphenation, and visual effect on drawing composition. A word processor will speed layout.

A B C D E F G H I J K L M N
O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n
o p q r s t u v x y z

Lettering traced with No. 2 pen from computer generated underlay.
(Suggested font: Universal Italic 36pt)

A B C D E F G H I J K L M N
O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n
o p q r s t u v x y z

Lettering traced with No. 1 pen from computer generated underlay.
(Suggested font: Universal Italic 24pt)

A B C D E F G H I J K L M N
O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n
o p q r s t u v x y z

Lettering traced with No. 0 pen from computer generated underlay.
(Suggested font: Universal Italic 20pt)

Fig. 4.59

TITLE SHEETS
Title and Subtitle Lettering

Acceptable styles of titles and subtitles can be generated from existing company letterheads, logos, advertising and newsletters. Lettering can also be traced from computer-generated fonts or generated by Leroy lettering templates (or equivalent). Cite sources for graphics used in titles (Standard II) to avoid confusion about their origin and authorship.

THE BEEBE WINDMILL - 1820
BRIDGEHAMPTON, LONG ISLAND, NEW YORK

Uneven spacing

LAUREL VALLEY SUGAR
PLANTATION

Even spacing
(keep *areas* between letters constant for even spacing)

New titles can be generated by Leroy lettering templates (or equivalent). Such titles should be laid out in ink on vellum before inking them on mylar. Cut and tape vellum titles to adjust letter spacing, correct misspellings, and check visual composition.

Fig. 4.60

This page intentionally left blank.

4.9 INKING FINAL DRAWINGS

Inking Techniques

General Remarks. High-quality drafting is essential. To meet Standards II and IV drawings should be free of defects such as overrun or incomplete corners, mismatched meetings of curves and tangents, unfair curves, blobby, sloppy or streaked lines, irregularly spaced poche hatching, inconsistencies in repeated or concentric features, and poorly executed lettering.

Only permanent, waterproof, carbon-based black inks formulated for drafting films (“acetate inks”) are permitted. Latex-based inks, while darker, deteriorate. (Acceptable inks include Pelikan-FT™, Koh-I-Noor™ “Universal Drawing Ink” or Pentel® “Ceran-0-Matic”.)

Never use the following: Diluted ink, color inks or washes, markers, pencil, or adhesive-backed products (e.g. dry transfer lettering or toning materials).

CHART of RECOMMENDED LINE WEIGHTS

Pen Tit,	Line Width	Application
6 x 0	(0.13mm, 0.005 in.)	Extreme detail *(paired lines for window mullions, I-beam flange edges, other details in ” scale drawings)*
4 x 0	(0.18mm, 0.007 in.)	Small details (joints, brickwork and corrugations, patterned decking, floorboards, handrails, small bridge members, window sash, door panels, etc.) Poché patterns, stippling; dimension strings, witness lines, center lines, arrow lines
3 x 0	(0.25mm, 0.0 10 in.)	Small details *(small piping and shafting, wires, small bridge members and machinery parts)*
2 x 0	(0.30mm, 0.0 12 in.)	Outlines and edges of small areas and objects *(window and door openings, small motors and machines, bridge truss diagonals, sections of steel structural members, dimension line arrow heads)*
0	(0.35mm, 0.014 in.)	Outlines of medium-sized machinery, small wings of structures at $^{1}/_{4}$" scale, projecting architectural details *(roof overhangs, beltcourses),* edges at $^{3}/_{4}$” scale and larger
1	(0.50mm, 0.020 in.)	Edges of walls in plan at $^{1}/_{4}$” scale, edges of moderately sized structures and objects in section; small lettering ($^{1}/_{8}$” to $^{3}/_{16}$” high), dimensions
2 -	(0.60mm, 0.024 in.)	Edges of walls in plan at $^{1}/_{4}$” or larger scales, outlines of substantial building wings or entire structures; small lettering ($^{3}/_{16}$” to $^{5}/_{16}$” high), dimensions
2 -	(0.70mm, 0.028 in.)	Outlines and section lines; medium sized lettering ($^{5}/_{16}$” to ” high)
3 -	(0.80mm, 0.031 in.)	Section and ground lines; large lettering (3/8” to 3/4”)
4 -	(1.20mm, 0.047 in.)	Ground lines; very large lettering (” and larger)

Fig. 4.61

Most erasures can be made very easily with a slightly moistened vinyl drafting film eraser. Use rubbing alcohol to remove large inking errors and to clean pens.

Line *Weights.* Use a variety of line weights to reflect the significance of various features (Standard I). Fig 4.61 gives baseline recommendations. Standards I and IV call on you to create a hierarchy of information with line weights so that users can clearly distinguish overall structure and form from substructures and details. Foreground and background can be conveyed by appropriate graduations of line weights. Drawings with a single line weight look dull and have very little visual organization; figure-ground effects create confusion.

> **TIP:** Make your own templates for specialized but frequently repeated features--the improvement in consistent appearance and rapid execution will pay you back for the time invested.

> TIP: test your delineation techniques by reducing a portion of your drawing to 25% size on an office copier.

Ink Line "Joints". If a line stroke is interrupted, don't back up and restart it over the old line. Avoid blobs and put the pen tip down just beyond the end of the last stroke and continue inking.

Views without outtlining tend to look "flat" and may introduce confusing figure/ground effects. Outllining is commonly misused to emphasize only the extreme edges and open spaces of a structure or object; this misuse often makes an element or feature appear to be in several different planes simultaneously. It is better to outline *individually* separate components of a structure or object which lie in different planes. As a rule, the must emphasis should be given to the largest, most important or most defining parts, or to those which lie in the foreground. Less dominant parts recieve less emphasis, while some recieve none at all. The overall drawing will be much more consistent and readable in its graphic logic.

Similar rules apply to isometric and perspective drawings.

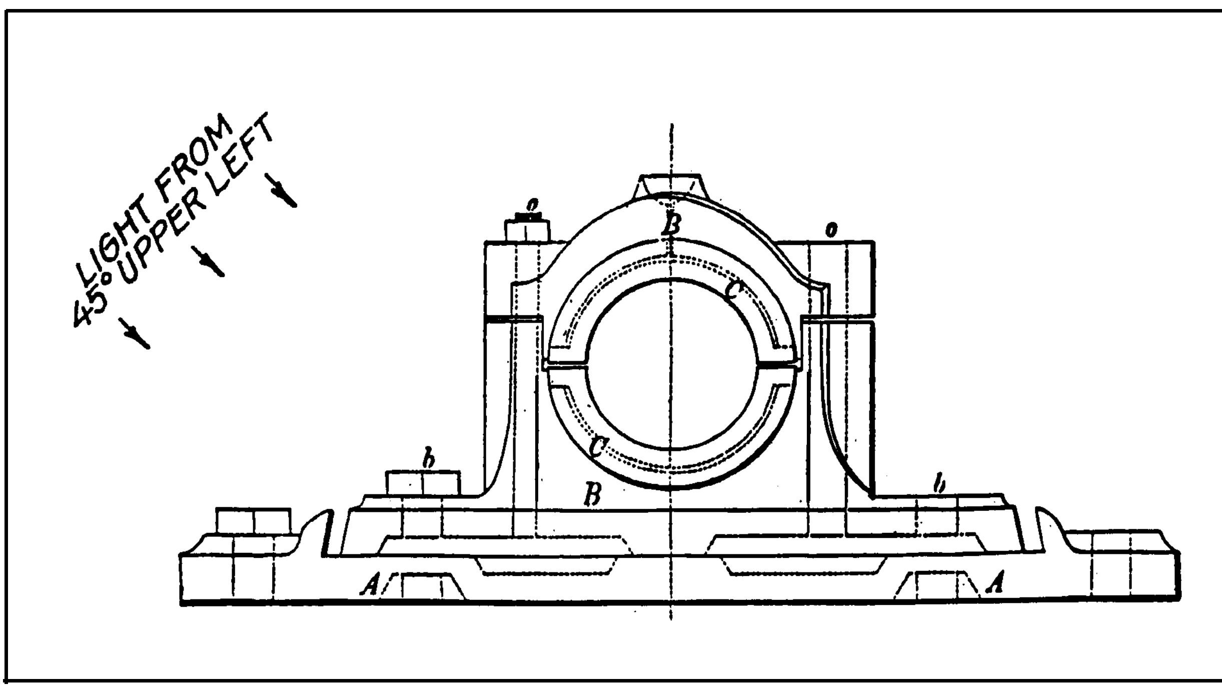
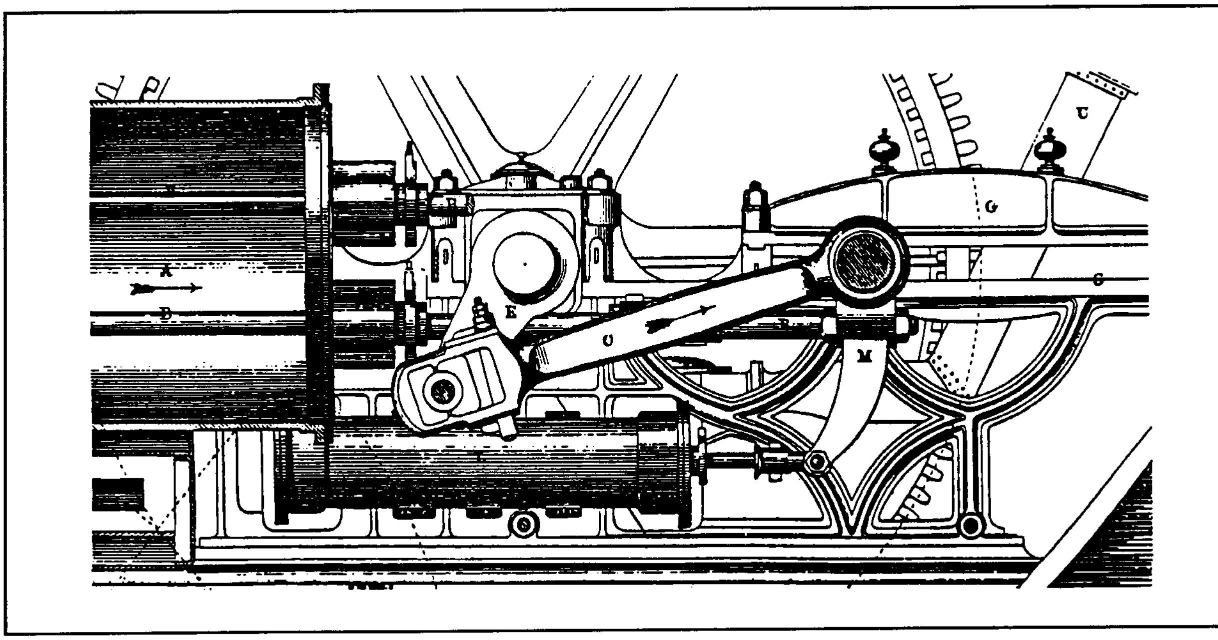


Fig. 4.62

Line Shadowing is a drafting convention that lends a third dimension to a drawing and helps clarify rrelationships between solids and open areas. It an also distinguish recessions and projections in plans, elevations and isometrics.



4.63

Line Shading, like shadowing, is a convention used to convey the "roundness" of parts like tanks, pipes, shafts, castings, etc. It is time consuming but effective. Do not use it where it might be confused for structure, such as barrel or tank staving.

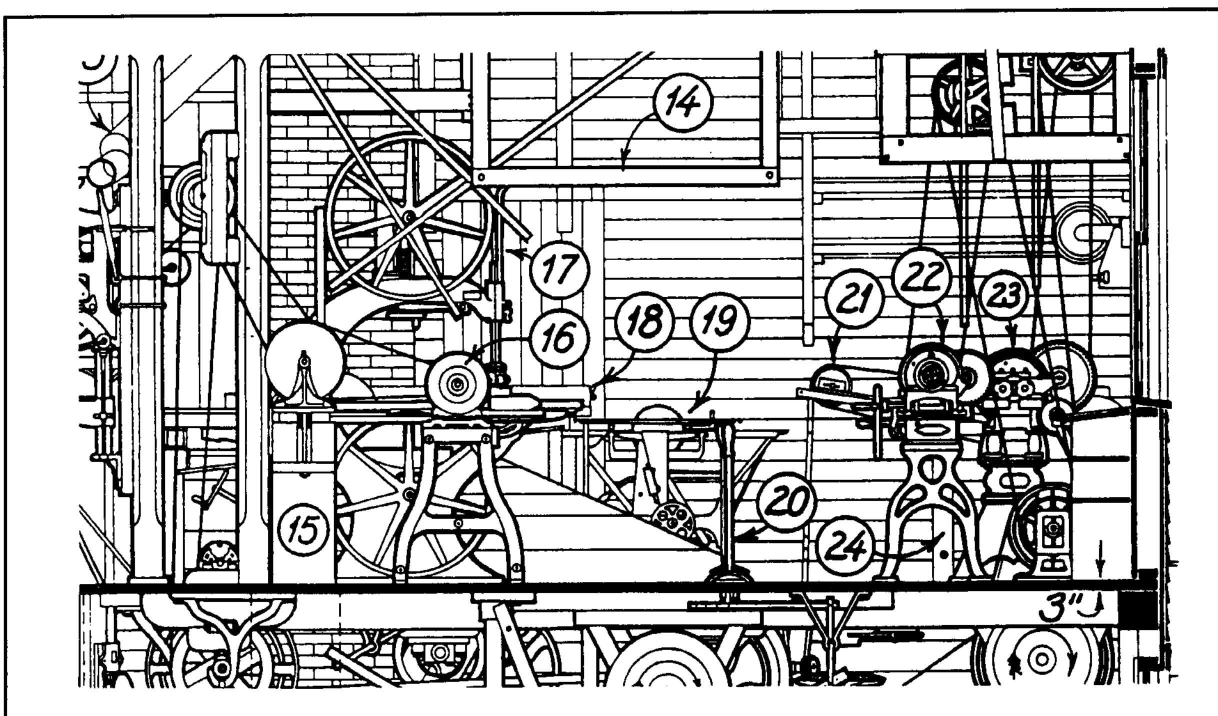


Fig. 4.64

Outlining is a more contemporary technique than line shadowing for giving a three-dimensional aspect to the drawing. It creates depth by surrounding feeatures with heavier (or lighter) lines in order to make features stand out from (or fall back into) the drawing plane.

4.10 STANDARD SYMBOLS

Pochés and Rendering. Pochés and rendering are necessary to distinguish materials in plan and section (Standards I, II and IV); see Fig. 4.65. CONVENTIONAL BREAKS in structure and materials are shown in Fig. 4.66. Rotated sections show sectional information without drawing a separate view. STIPPLING can highlight features or create a sense of depth or roundness, but it is chiefly reserved for rendering masonry or concrete. Airbrush techniques are acceptable, though not often used by HAER.

Linear and Axonometric Graphic Scale Bars. Direct scale references for reproductions, important to verification (Standard II). See Figs. 4.68 and 4.69 for standard HAER formats.

North Arrows. All site and structure plans must have unambiguous north arrows to indicate compass direction.(see Fig. 4.70).

Locator Diagrams. In multiple sheets, clarity and convenience are promoted by including on each sheet a small schematic diagram where a plan, elevation or section is highlighted (see Fig. 4.71).

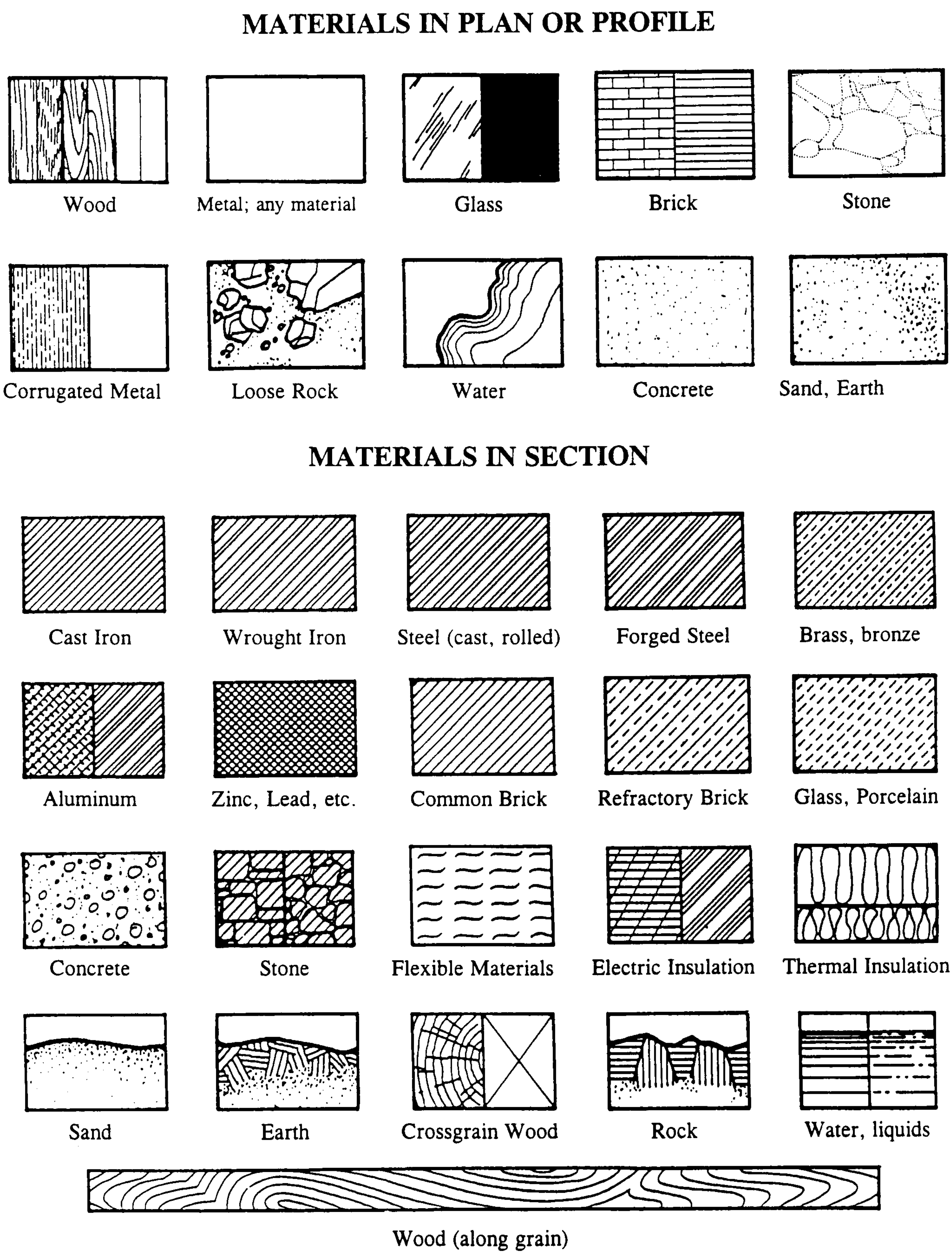
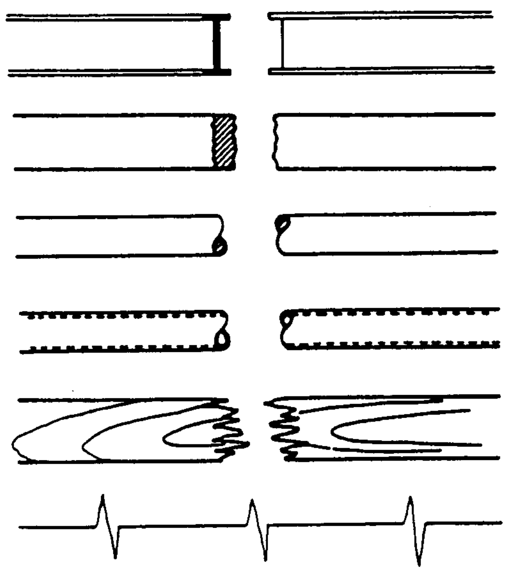

MATERIALS IN PLAN OR PROFILE
Wood
Metal; any material
Glass
Brick
Stone
Corrugated Metal
Loose Rock
Water
Concrete
Sand, Earth
MATERIALS IN SECTION
Cast Iron
Wrought Iron
Steel (cast, rolled)
Forged Steel
Brass, bronze
Aluminum
Zinc, Lead, etc.
Common Brick
Refractory Brick
Glass, Porcelain
Concrete
Stone
Flexible Materials
Electric Insulation
Thermal Insulation
Sand
Earth
Crossgrain Wood
Rock
Water, liquids
Wood (along grain)

Fig. 4.65

CONVENTIONAL BREAKS



Structural Shapes

Rectangular Section

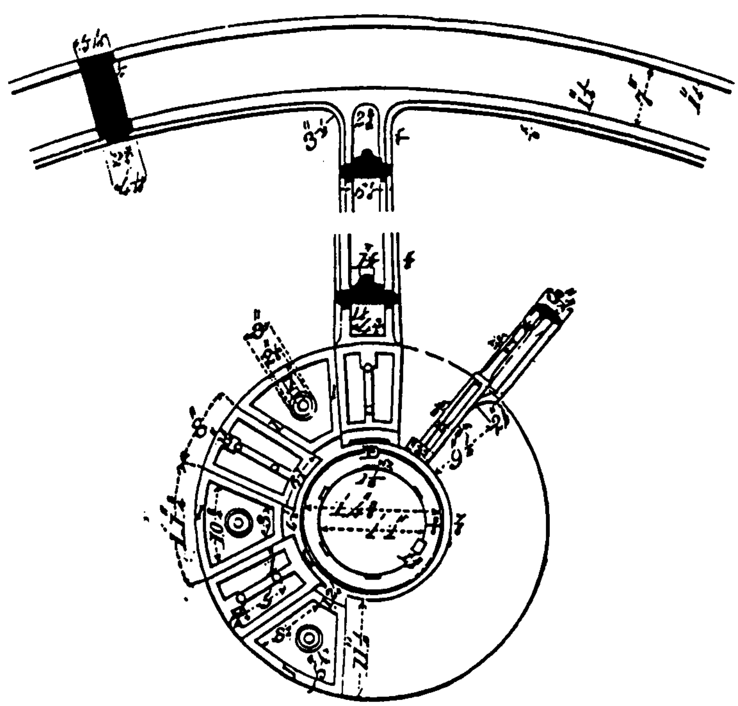
Round Section

Piping

Wood

Long Break (any material)

ROTATED SECTIONS



DIMENSIONING

1. Use a 3x0 (0.35mm) pen on 33"x44" sheets, 4x0 (0.18mm) on smaller sheets

2. Minimum heights for numerals: $^{7}/_{32}$" on 33"x44" sheets, $^{5}/_{32}$" on 24"x36" sheets, $^{3}/_{32}$" on 19"x24" sheets

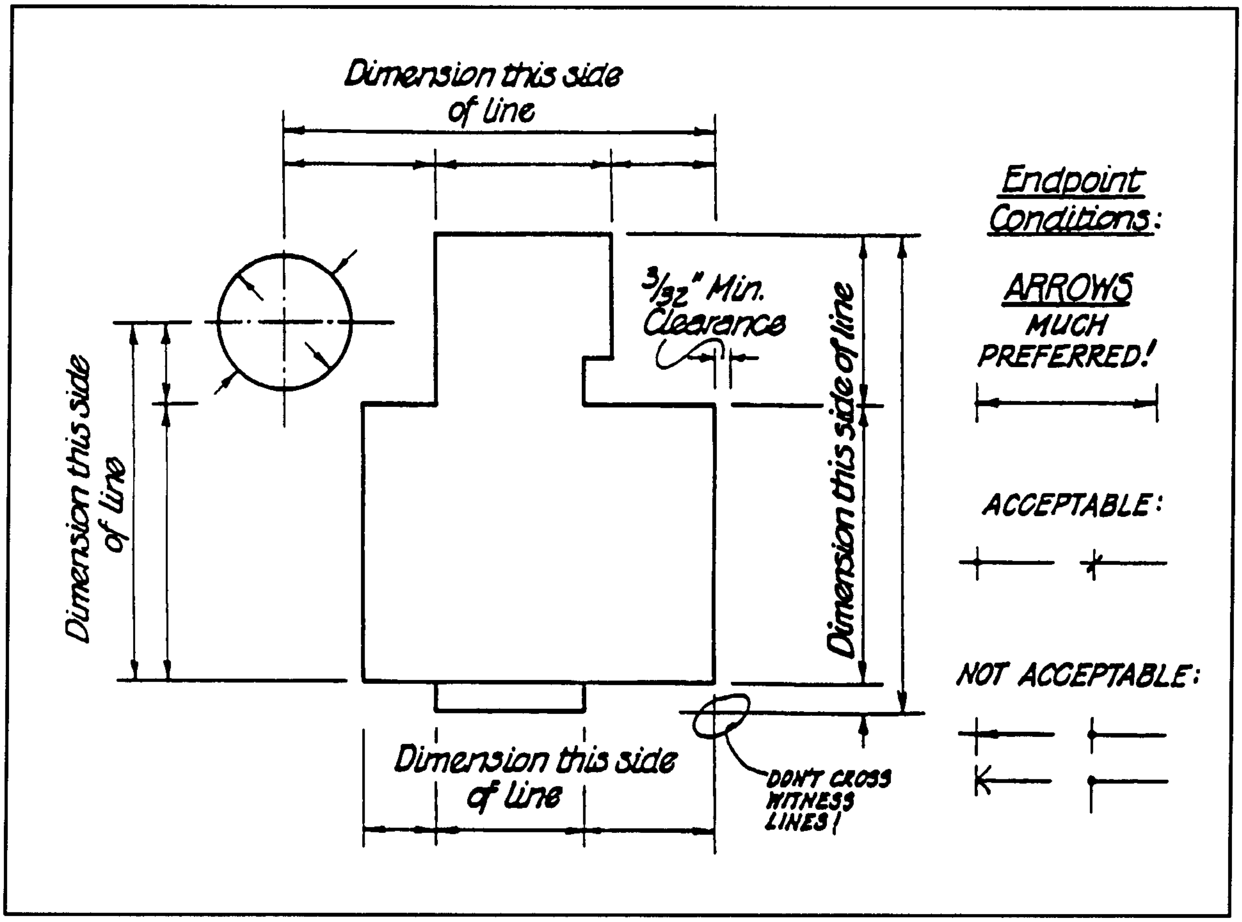


Fig. 4.67
Dimensioning conventions

3. Do not dimension across line work; move the dimension or erase the line work before lettering.

4. Place metric measurements inside parentheses after English ones, e.g. 12'-0" (3.66M); always round off metric figures to the nearest 0.01 meter.

5. Conversion factors: one meter = 3'-3$^{3}/_{8}$", one foot = 0.3048 meter.

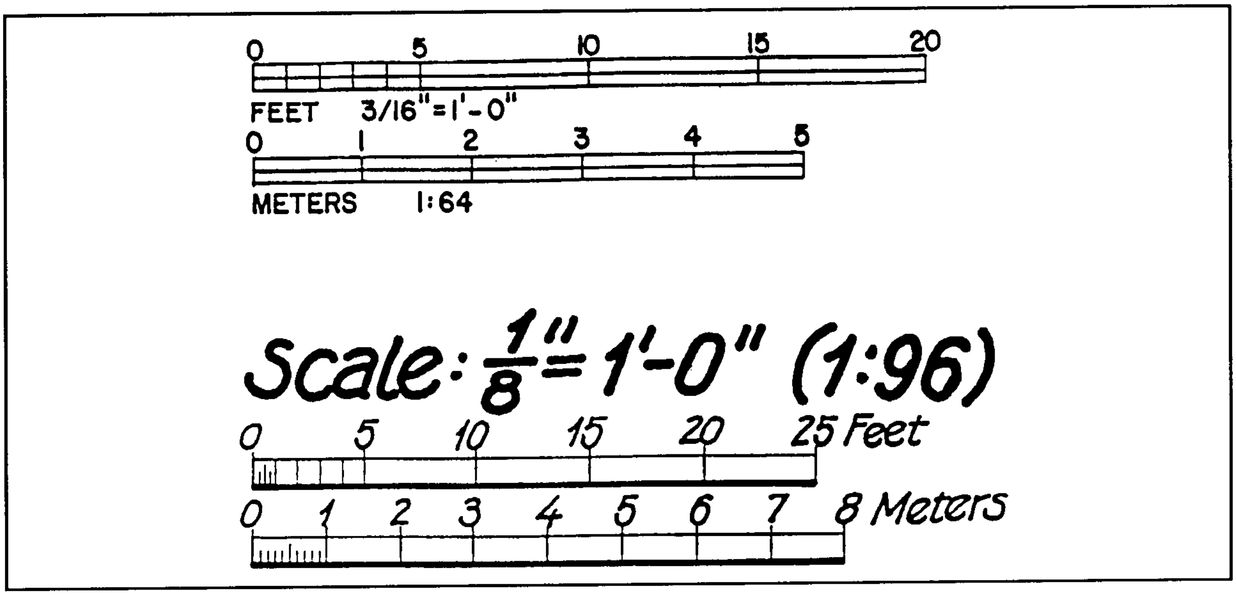


Fig. 4.68

Graphic bar scales should be simple. Vertical lines ticking off distance are most significant-ink these with a 4x0 pen for sharpness and accuracy: 1'-0" = 0.3048M, 1M = 3'-3 3/8" to plot meteric scales at the same scale ratio as English scales.

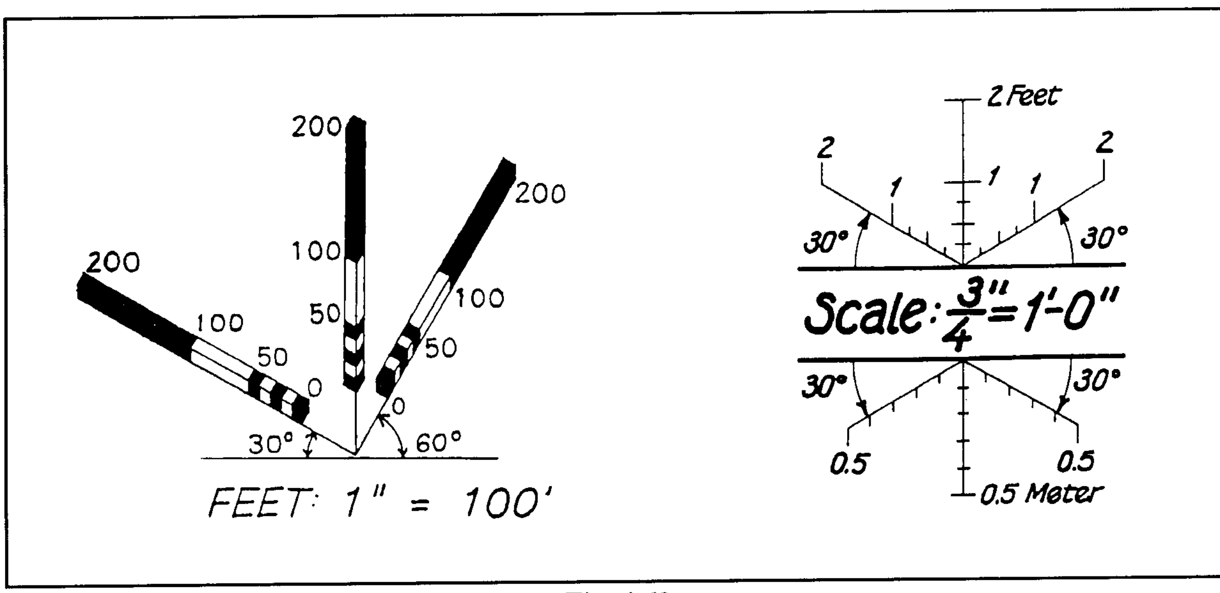


Fig. 4.69

Axonometric (and isometric) scales must show scales and angls of all three axes in both English and Metric systems. There are various formats depending on space

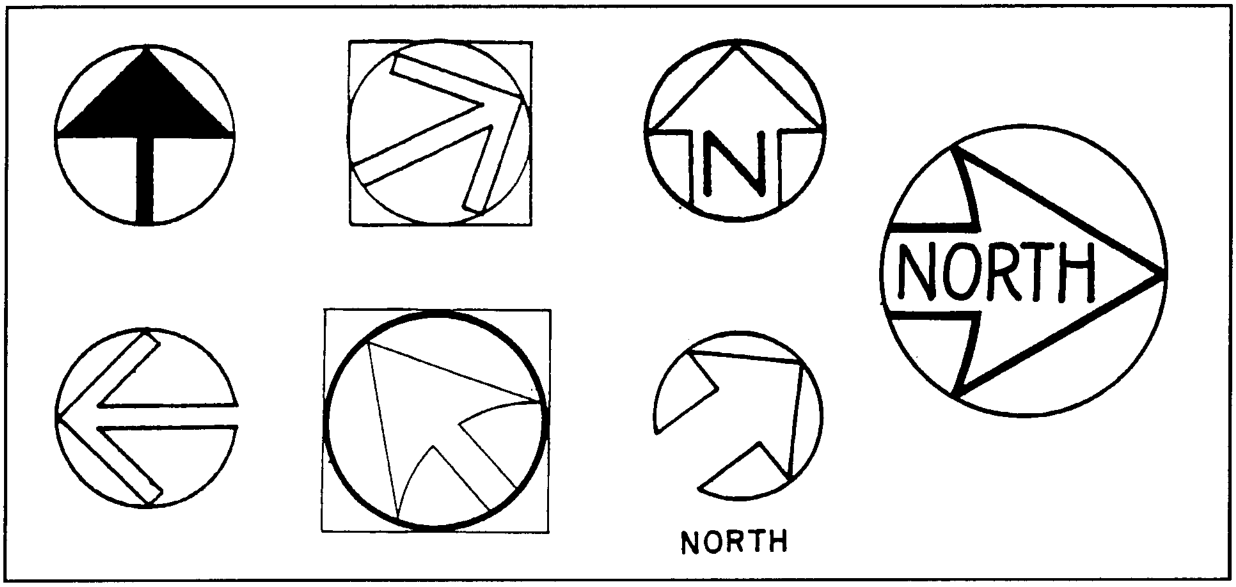


Fig. 4.70
North arrows should be clear and a consistent size on all sheets where they appear. No arrow circles should be less than 1" diameter on 24' x 36" sheets, or 1 1/2" on 34" x 44" sheets. Clarity is best met if the letter "N" or the word "North" is included

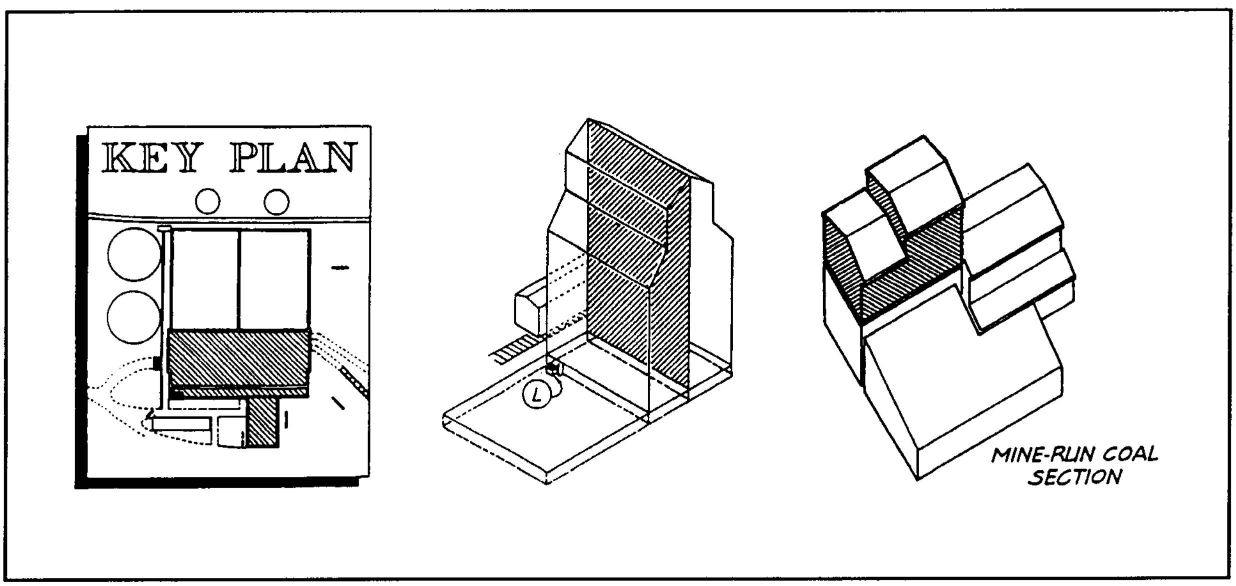


Fig. 4.71
Location diagrams are schematics which show the user where a plan, elevation, or section lies in a large building or complex documented on multiple sheets.

4.11 HAER SHEET TITLE BLOCKS

Standard Sheet Title Blocks

Preprinted title blocks on HAER sheets must be filled in using a Leroy lettering system (or equivalent) *no hand lettering* in accordance with directions below. Data Entry Sheets provide all necessary data. Lettering sizes are shown in Fig. 4.73.

LEFT CORNER BLOCK

The official name of the recording project, such as AVERY ISLAND SALT WORKS RECORDING PROJECT, is to be lettered here in capital letters.

CENTER BLOCK

Name of Site (Record Name): The record name is centered here (including date). The record name should be completely consistent with the one on the historical report and the DES form. For complexes and unusual circumstances, contact your HAER project leader. See also the *HABSIHAER Transmittal Guidelines.* ***NO drawing view titles (e.g. "West Elevation") go here.***

Date: The year of the site's construction should follow the record name on the same line, set off by two spaces. Years of significant modification may be required in addition, set off by commas.

Address: For urban areas, enter the number and street on which the site is located; if the site is extremely large, use boundary streets, but do *not* use "corner of'. For rural areas, use only a road, route, river or other significant landmark. Do *not* use mileage or UTM coordinates. Use "Vicinity of' if the site is best located near a town or other recognizable landmark. For bridges, use "Spanning [river, street, etc.] at [street, highway, railroad, etc.] ", If there is no address, leave this area blank. Do not abbreviate "Road", "Route", "Street" etc.

Location: Letter the name of the city (or vicinity) at the lower left of the block. Center the name of the county (or "independent city"), and letter the state at the lower right. All words are to be spelled out--no abbreviations for "county", or state.

RIGHT CORNER BLOCK

Record Number: This number is assigned by the HAER office. If you do not receive it, leave this space blank. It will be filled in later.

Sheet Numbers: Indicate which sheet out of total number of sheets for the set.

Library of Congress Number: Leave this space blank. It will be filled in by the Library of Congress.

TITLE BLOCKS MUST BE THE SAME ON ALL SHEETS HAVING THE SAME HAER NUMBER

Fig. 4.72

HAER SHEET TITLE BLOCKS

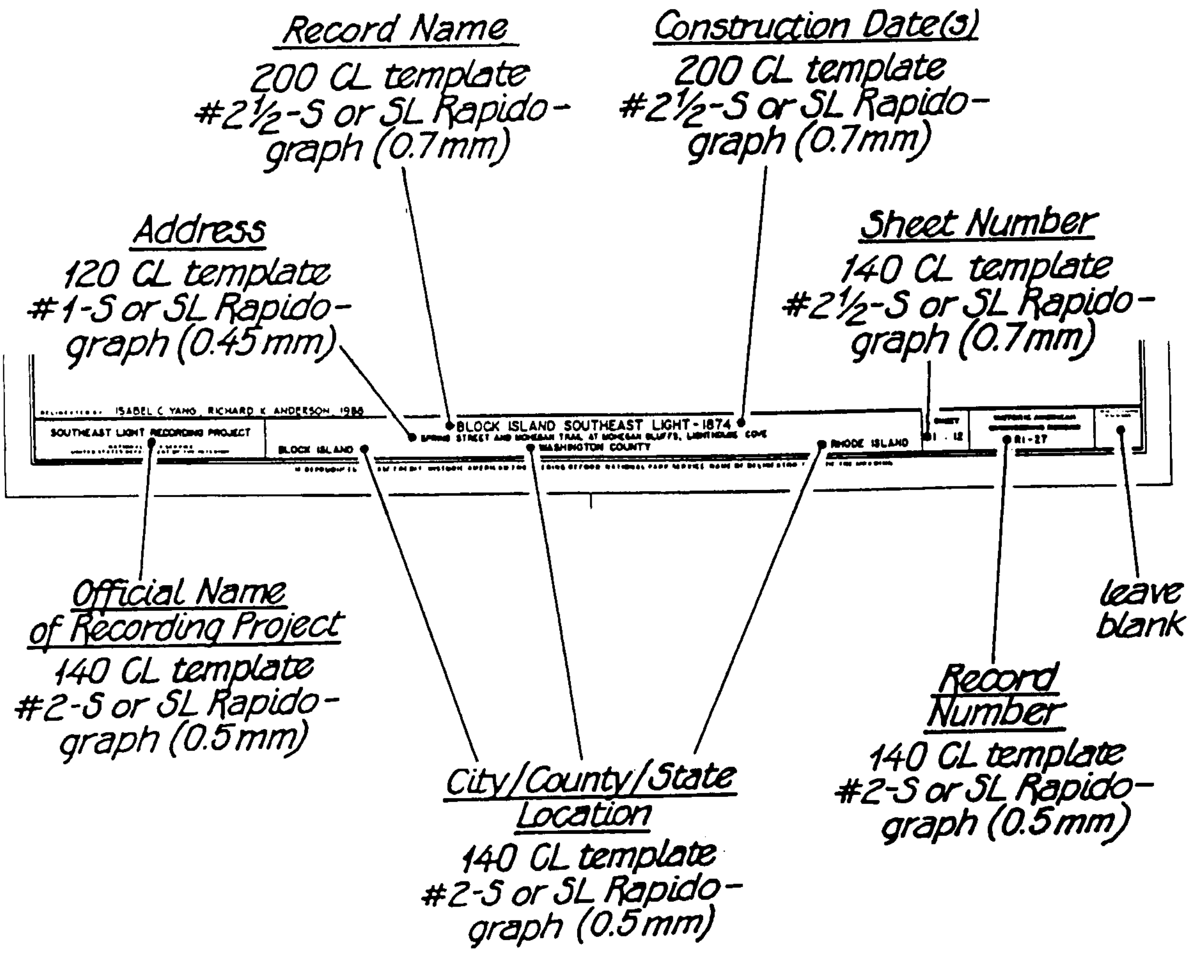


Fig. 4.73