Tools of the Imagination

Drawing Tools and Technologies from the Eighteenth Century to the Present

Tools of the Imagination: Drawing Tools and Technologies from the Eighteenth Century to the Present

Susan C. Piedmont-Palladino, editor

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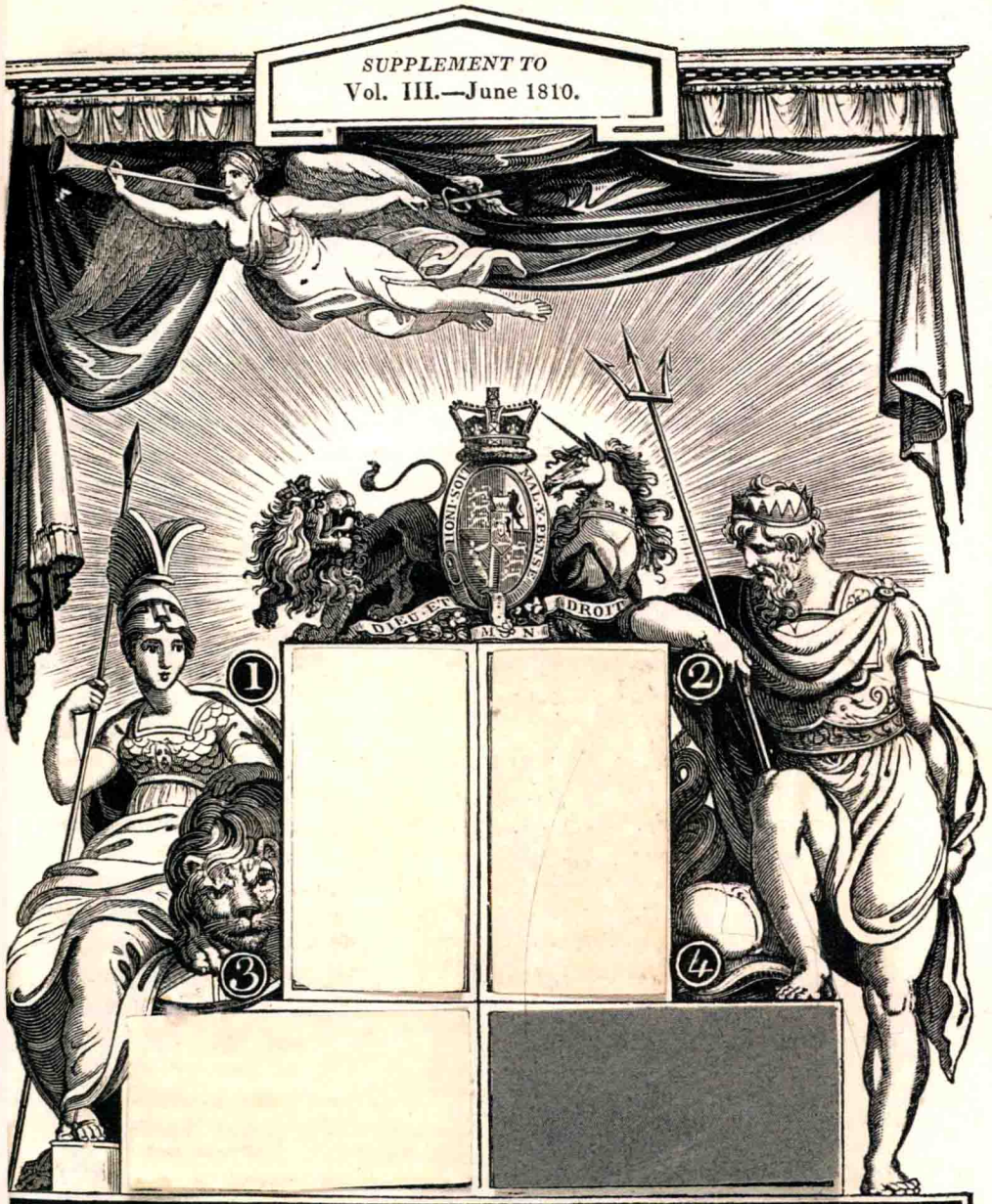
Tools of the Imagination

To Joseph Donlan Piedmont, 1928–2005



The Repository

Of Arts, Literature, Commerce, Manufactures, Fashions, and Politics,

SPECIMENS OF DRAWING PAPERS.

R. Ackermann, 101, *Strand, London.*

Foreword

Tools are among the most reliable gauges of human progress. The broad stages of early human history, in fact, are identified primarily by the types of tools developed and used during each cultural period, such as the Stone Age and the Bronze Age. The tools of a given age are revealing indicators not only of a society's achievements but also of its aspirations and limitations.

The National Building Museum's exhibition TOOLS OF THE IMAGINATION was conceived as an exploration of the architectural design process and the varied implements employed in that practice. The result was an engaging survey of items—from simple pencils, to elaborate devices for constructing perspectives, to astonishingly powerful software—whose qualities and significance were illuminated through the presentation of drawings, digital renderings, and models that they made possible. Visitors to the exhibition emerged with a clearer understanding of how architects and other designers cultivate, test, and express complex ideas.

This book uses the exhibition as a springboard for deeper exploration of several issues. In his essay, Paul Emmons brings a fresh perspective to the humble pencil, celebrating its unparalleled utility as a communication tool. David V. Thompson offers the unique viewpoint of the avid collector of drawing tools, reminding us that such devices often have remarkable personal significance to an architect. Phillip Bernstein's essay focuses on revolutionary new tools and strategies in the design industry, such as Building Information Modeling (BIM), in which the mere representation of a building as lines on paper is superseded by a fully integrated database, of which the "drawing" is just a legible expression. William J. Mitchell offers some final thoughts on the nature of drawing in both the analog and the digital realms.

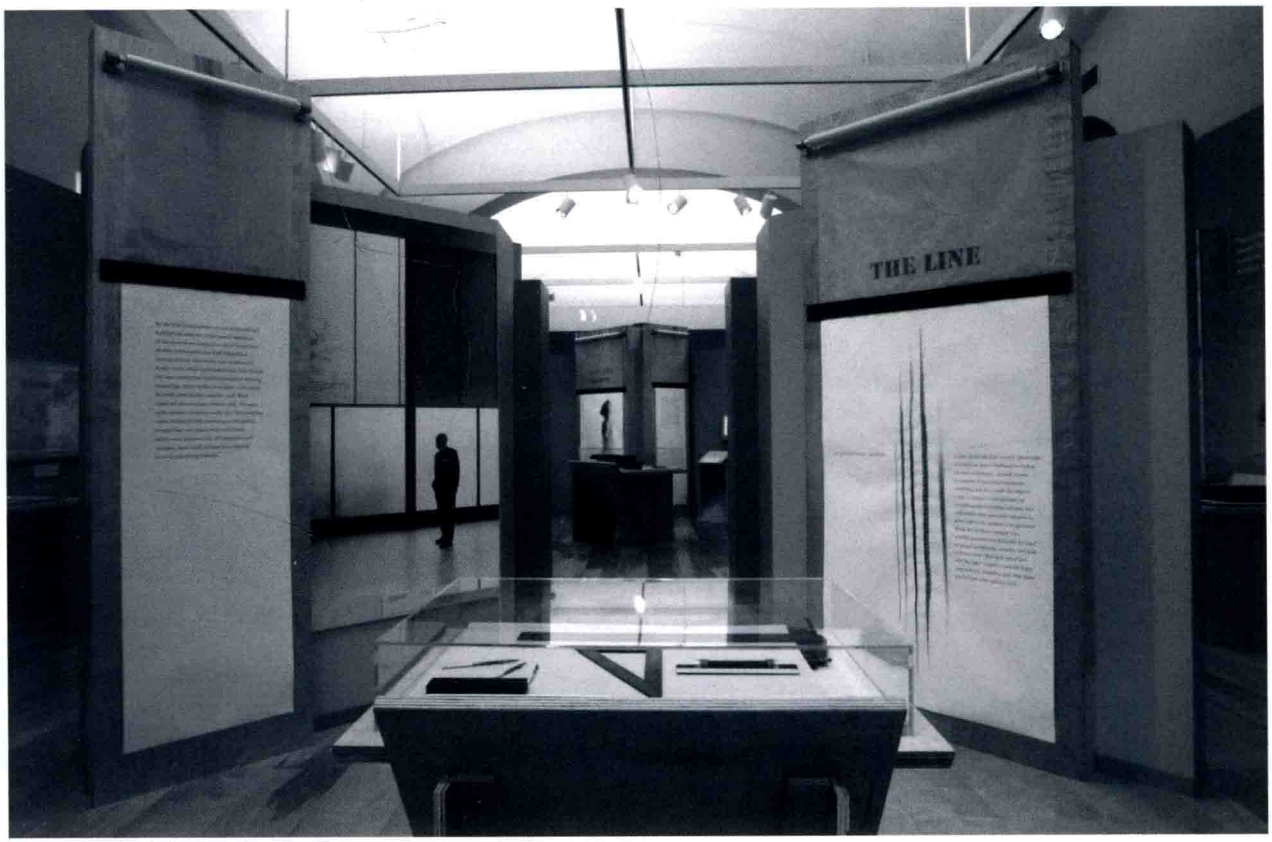
In addition to these essayists, the National Building Museum thanks all of the people who contributed to the exhibition and this book. The exhibition content was masterfully developed by Susan Piedmont-Palladino, an architect and professor at Virginia Tech's Washington-Alexandria Architecture Consortium, who served as guest curator on this and other projects for the Museum. She worked closely with curatorial associate Reed Haslach. Piedmont-Palladino and Haslach brought the subject matter to life in the Museum's galleries and managed its transformation into book form. The exhibition was designed by Andrew Pettiti of Knowtis Design and was constructed by the Museum's exhibition team, led by Hank Griffith. The book was designed by Stephanie Church of mgmt. design and published in cooperation with Princeton Architectural Press.

The Museum enjoyed excellent guidance on this project from an Advisory Committee led by co-chairs Carol Bartz, executive chairman of the board of Autodesk, Inc., and Greg Bentley, chief executive officer of Bentley Systems, Inc.

Projects such as these are not possible without significant outside financial support, and the Museum is grateful to all its contributors. In particular, the Museum thanks Autodesk, Inc., for its generous support of this publication.

On behalf of the National Building Museum, I thank all of the dedicated and, yes, imaginative team members who made TOOLS OF THE IMAGINATION possible.

Chase W. Rynd, Executive Director
National Building Museum



Installation view of the TOOLS OF THE IMAGINATION exhibition at the National Building Museum, Washington, D.C., March 5 through October 10, 2005

Preface

We all use tools every day of our lives—coffeemaker at breakfast, cell phones throughout the day, perhaps a computer or a pipe wrench at work, and then a corkscrew for the evening wine with supper or a spoon for our bowl of soup. Tools are the means by which we attain the results of our imaginings. A thought or dream occurs to us, and we reach for our tools to transform that wish into reality.

TOOLS OF THE IMAGINATION began as an attempt to gain access to the relationship between the physical world we shape and build and the desires that motivate us. How do architects record their visions, develop them, and ultimately instruct others in their construction? How have architect's tools shaped the buildings we inhabit, and how have architects' visions shaped their tools? In the pages that follow, you will see architects' tools across time and understand the tasks that they were intended to accomplish.

In the past, each building was a custom-made object because the tools to reproduce objects—or drawings—were very limited. The architects, or master stonemasons, who envisioned a sheltering structure, did not often make elaborate drawings with sophisticated tools. Instead, they relied on canons of proportion, systems of order, and ornament that could be written or orally passed between generations.

The industrial age brought with it machines capable of reproducing objects and greater availability of tools to achieve more advanced operations. First the pencil, then the ubiquitous tracing paper and duplicating tools began to emerge, so that information could be reproduced and more widely transmitted. Other tools, aimed at drawing certain kinds of lines or types of ornament, joined the toolbox as well. By the beginning of the twentieth century, American cities and towns were exploding in scale and population. The demand to design and build to accommodate this rapid growth was strong, and the architect's toolbox and tool technology increasingly serviced the frenzy of construction.

Historically, architects used one version or another of a reiterative process: sketch, overlay transparent paper, resketch, and revise. Repeat this over and over until the drawing and the vision touch one another. Instructing others on how to build the dream involved the use of transparent paper or, later, sheets of nearly clear Mylar plastic to ensure that the object was precise and consistent in plan, elevation, and section. By the last quarter of the twentieth century, architects had, in addition to the familiar blueprinting machines, large-scale copiers capable of rapidly making copies of full-sized drawing sheets. But the real change came with the advent of the computer.

It is the computer and computer-aided design (CAD) that have radically transformed the practice of architecture. Now, we seem to have come full circle: from a time when all buildings were custom made, to the standardization and mass production of the industrial age, and now, with digital technologies, back to the customization of each building or object. The computer, coupled with the Internet, allows the instantaneous transfer of particularized information among project teammates, clients, builders, and building managers. In so many ways, architects can work almost anywhere, hooked together in the ether of cyberspace.

Now the boisterous forms of bold, curving, crumpled architecture can easily be managed with computers. What were once only two-dimensional tools to describe three-

dimensional architecture have now become electronic tools that allow architects to work throughout the entire process fully in three dimensions. It seems as though the limits of what we can imagine, and construct, have been radically expanded because of our tools.

New tools have brought new questions. Historians ask, if we no longer have drawings on paper, how do we preserve the architect's work? How can any of us see the development of ideas across time when the reiterative process has been superseded? Can the hand of the designer still be detected in the drawings? We mount the beautiful pencil drawings of Frank Lloyd Wright or Mies Van der Rohe on the walls of our museums, admiring them as the beautiful objects they are. Now what?

Other questions also come to mind. How do we understand the difference between what our tools allow us to do and what we *should* do to make and remake our buildings, and our cities and towns? Do our new tools allow us to build more sustainably, more humanely, creating better places to live and work? TOOLS OF THE IMAGINATION succeeds in provoking these questions and invites us to search for answers. Tools of any trade are windows into that world and take us behind the scene. We can examine how tools make the seemingly effortless possible. TOOLS OF THE IMAGINATION shows us how architects turn dreams of once-unimagined worlds into the places where we lead our daily lives.

Howard S. Decker, FAIA

Contents

Introduction

"I've always wanted to be an architect, but I just couldn't draw a straight line." Many would-be architects have been discouraged from the design professions because of their perceived inability to draw a straight line, a circle, a convincing perspective, or realistic shadows. The architect's ability to put compelling images of future buildings and cities on paper, or on screen, is remarkable, but it is not magic.

It is fascinating to watch the construction of a building, but one rarely sees its design. On the construction site, every component has its craftworker, and every worker has a set of appropriate tools—from hammers to cranes—to turn piles of parts of materials into a work of architecture. Like the builder, the architect needs the right tools for the job. Before the tools of construction ever arrive on the scene, the architect deploys a different set of tools to design, develop, and document the building-to-be. These are the tools of the imagination. The architect's work takes place out of public view on the pages of sketchbooks, drawing tables, and computer screens of the studio. The newest tool, the computer, is really an entirely new toolbox full of software to solve old and new problems.

These challenges have been solved manually, mechanically, sometimes chemically, and, now, electronically. Problems of geometry are fundamental to drawing, and some of the most familiar tools are directed toward their solution: compasses, straightedge rulers, measuring devices, to name a few. But making a convincing drawing, one that allows the viewer see what is possible, demands another set of tools that assist in the representation of perspective space, light, and shadows. Finally, the architect needs tools to produce, reproduce, alter, and document the information as it becomes a set of instructions for building.

Every tool was at one time the new thing, the high-tech solution to a persistent problem. Before long, what once was high tech becomes standard, and we begin to look for the next new thing. While our current new thing, the computer and its suites of software, has radically changed how architects work, to view the present as completely severed from the past obscures the thread of continuity in our relationship with technology. That relationship is played out repeatedly as the new becomes old, the indispensable useless, the special ordinary, and the ordinary special, as need and desire coax tools from our imaginations that in turn serve our imaginations. No doubt our workstations and laptops, loaded with the newest visualization software, will someday appear as quaint to our descendants as pantographs, perspectagraphs, and blueprints do now.

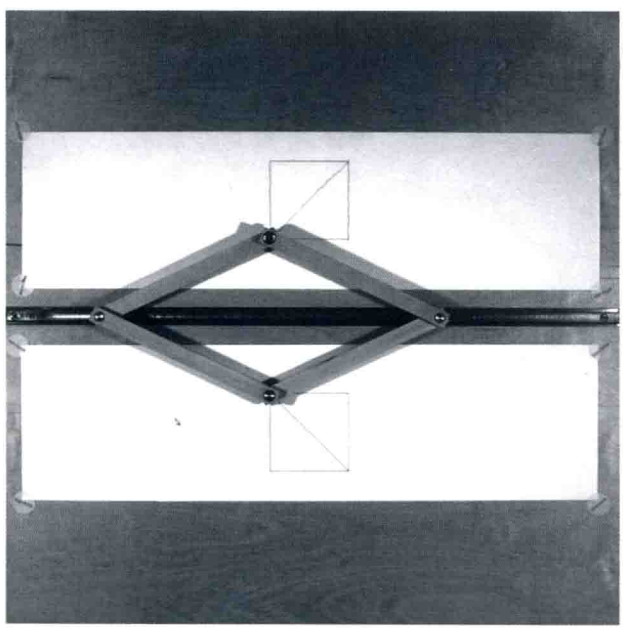
This volume, a companion and sequel to the exhibition of the same name held at the National Building Museum between March and October 2005, reveals how architects, engineers, and designers create the images that they do. Some of these artifacts, like the ellipsograph, are now more beautiful than useful; some, like computer stations, are too useful to be seen aesthetically. Others, like Thomas Jefferson's gridded paper and Paul Rudolph's colored pencils, are so remarkably unremarkable that we wonder how they escaped the trash heap. Still others, from our recent past, straddle the strange boundary between nostalgia and nuisance. Architects of a certain age will recognize this quality in the tools from the office of Tod Williams Billie Tsien Architects (TWBTA), just swept off the drawing boards to make room for the new screen. It is through the mastery of the full range of tools that the images in the architect's mind are translated into drawings and models, and from the drawings and the models into buildings. Whether a simple pencil or computer software, these tools give form to the wishes and the instructions of the architect, but they are also active shapers of what is possible.

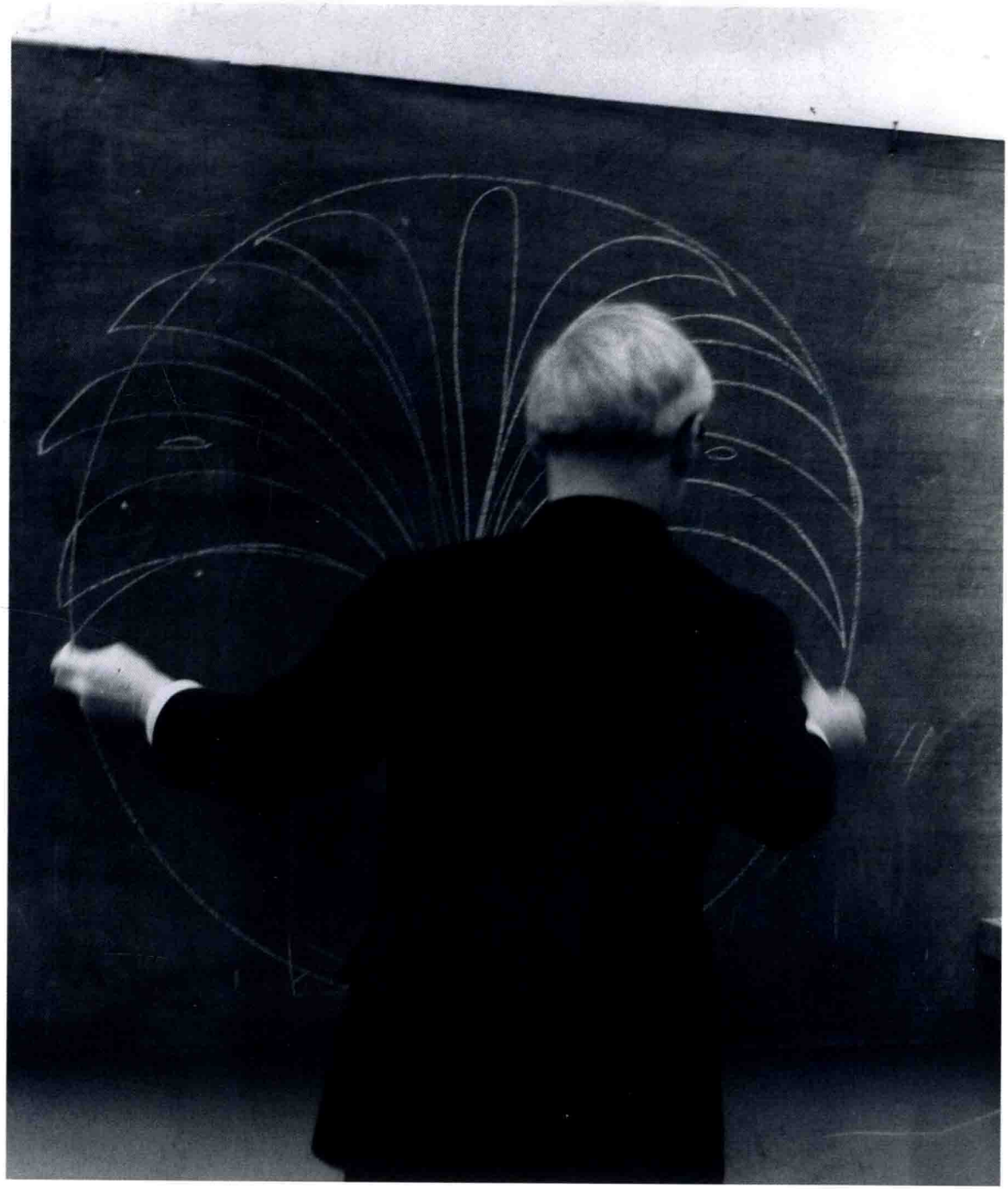
Susan Piedmont-Palladino

Not all of us can draw two figures, mirror images, using both hands, as architect Louis Kahn does. Yet the desire for symmetry—whether at the scale of ornament or building mass—has been a constant in architecture. The evolution of tools to make a reverse image of a drawing is indicative of the evolutions of all drawing technologies. "The antigraph is the only instrument for drawing parts of a figure the reverse hand to the original," claimed prolific toolmaker William Ford Stanley in 1888. Stanley's invention, the antigraph, did mechanically what Kahn could do by hand. The principle of the antigraph is simple enough, but its use actually requires a bit more ambidexterity than most of us have. Far easier is the keystroke that instructs the computer to copy_mirror.

left
Reproduction of a nineteenth-century antigraph

opposite
Louis I. Kahn
ca. 1965. Photograph by Martin Rich.





Timeline

1400

1400s
Paper becomes common in Europe.

1500

1560
Graphite is first mined in England.

1600

1600
Origin of orthogonal drawings

1600
Elliptical trammel, simplest of the ellipse tools, is invented.

1603
Pantograph is invented.

1662
Friedrich Staedtler, a carpenter in Nuremberg, gives birth to the modern pencil.

1669
Sir Christopher Wren invents a perspectograph.

1700

1700
Screw-adjustable ruling pens are invented.

1700
Scissor-jointed parallel rule is invented.

1720s
T-square and drawing board become standard drafting tools.

mid-1700s
London becomes center of mathematical- and drawing-instrument making.

1760
Volute compass is invented.

1761
Founding of Faber-Castell, makers of pencils

1765
Inventor James Watt designs a portable and foldable perspectograph.

1767
First use of gum or rubber eraser, discovered by Joseph Priestly

1771
Rolling parallel rule is invented.

1790–1810
Ellipsograph is invented.

1791
Helicograph illustrated in George Adams's *Geometrical and Graphical Essays*

1795
French chemist and inventor N. J. Conte (France) develops the process for hardening graphite by adding clay.

1800

1814
British architect and mathematician Peter Nicholson invents the centrolinead.

1816
Metric measuring is adopted by Holland.

1819
John Farey invents Mr. Peacock's Delineator, a perspective aid.

1825
Laid paper first manufactured by machine

1830
Edinburg Encyclopedia describes the familiar grades of graphite.

1840
Tracing paper becomes common.

1840
Specialized ruling pens invented for cartographers and railway engineers

1840s
Wood pulp introduced into paper production

1848
Immigration of skilled instrument makers to United States from Germany and England.

1853
W. F. Stanley manufactures wood "set squares," now known as triangles.

1857
H. Johnson patents the volutor.

1860
Slopes and batters, specialized triangles for railway embankments, are invented.

1860
W. F. Stanley markets the French curve, based on sixteenth-century ship makers' curved templates.

1866
Weighted flexible curves, weights, and splines appear in W. F. Stanley's catalog.

1866
Conchoidograph, which draws flutes on a classical column in entasis, is invented.

1866
W. F. Stanley publishes *Mathematical Drawing & Measuring Instruments.*

1867
William Keuffel & Hermann Esser (K&E) sets up shop in New York.

1867
Faber-Castell improves pencils with encased and refillable holders.

late 1800s
Parabolagraph, a rare instrument for drawing parabolas, is invented.

1880
Blueprinting becomes commercially available.

1900

1900
Last sighting of a sector, which gave way to the slide rule.

1900
Retailers start to sell tools, office supplies, reprographic services.

1920
Adjustable triangle first appears in clear celluloid.

1924
W. F. Stanley's catalog shows a parallel motion rule strung on piano wire.

1932
Graphos develops the first technical pen with twelve interchangeable ruling blades.

1932
Inventor Arthur Dremel of Racine, Wisconsin, invents the electric eraser.

1940
Drop-action clutch pencil is invented.

1952
Wilhelm Riepe of Hamburg, Germany, founder of Rotring Pens, introduces Rapidograph pens with cylindrical nibs.

1952
Dupont develops Mylar polyester drawing film.

1953
Technical compasses and accessories are mass marketed and produced.

1960
British manufacturing of drawing instruments comes to an end.

1960
Quick-set compass with wing arc or horizontal screw to set and hold is invented.

1960
Compass with attachments for technical pens instead of ruling pens is invented.

1963
Ivan Sutherland develops Sketchpad.

1960s
The beginnings of commercially available computer-aided design (CAD) systems.

1970s
Staedtler and Faber-Castell produce inexpensive mass-market tools.

1972
Metric line thicknesses are introduced by Rotring.

1977
Special moisture-holding cap for technical pens is invented.

1980
Nonclogging inks, tungsten, and ceramic tips for technical pens are invented.

1980s
Pen plotter is invented.

1980
Haff manufactures the last-known acrylic ellipsograph.

1982
First release of AutoCAD, called AutoCAD 80, by Autodesk.

1983
Introduction of the laser plotter.

1986
First release of MicroStation by Bentley Systems.

1987
First release of AutoCAD10 with three-dimensional capability.

1988
3D Systems introduces commercial stereolithography, otherwise known as "3D printing."

1991
Chris Yessios and Dave Kropp develop Form Z.

1997
Irwin Jungreis and Leonid Raiz develop Revit.

1999
W. F. Stanley goes out of business.

2000

2000
Brad Schell develops SketchUp.