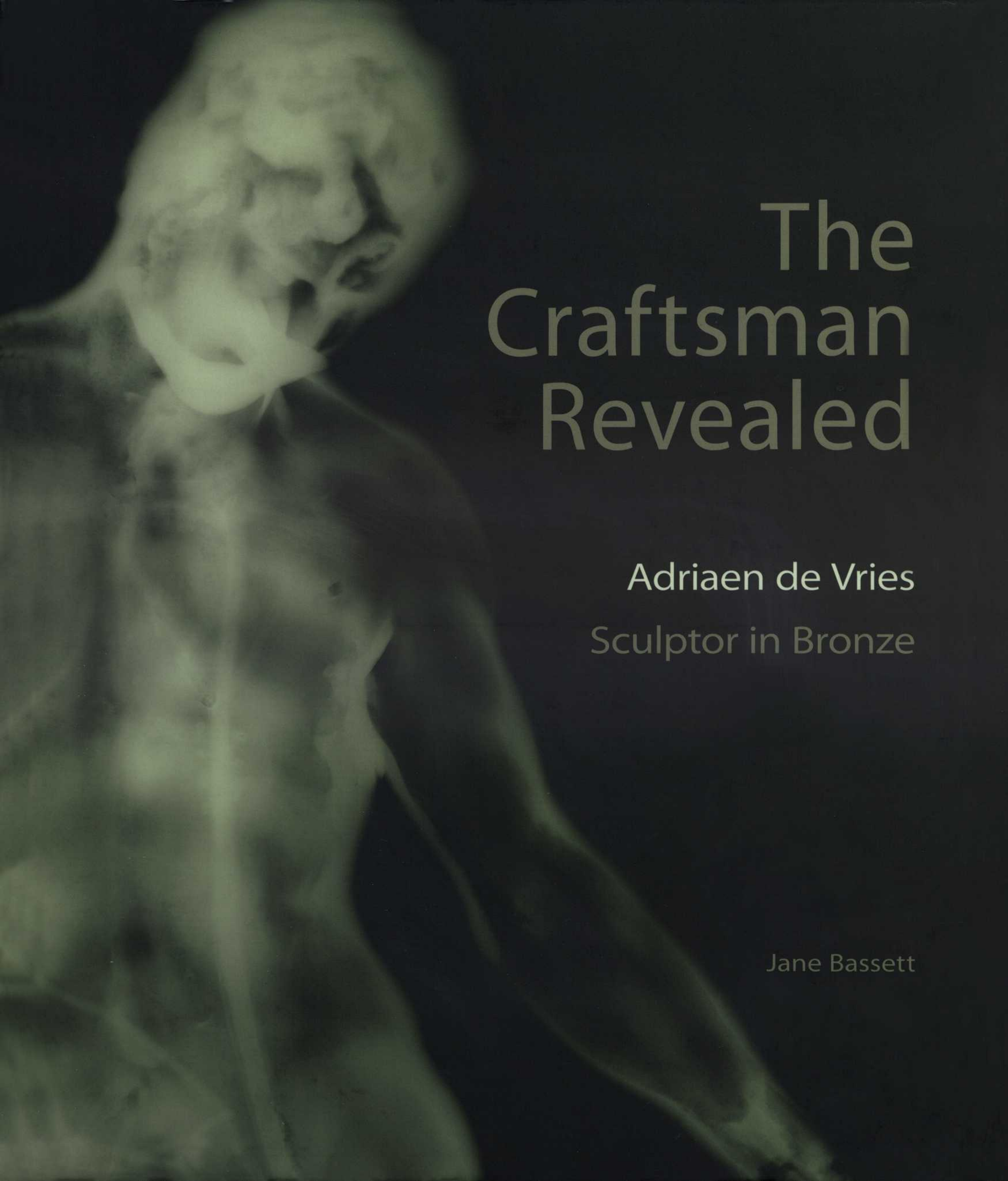

The Craftsman Revealed

Adriaen de Vries

Sculptor in Bronze

Jane Bassett

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Adriaen de Vries Sculptor in Bronze

Jane Bassett

with contributions by Peggy Fogelman, David A. Scott, and Ronald C. Schmidtling II

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CONTENTS

vii Foreword

ix Acknowledgments

xi Introduction: The Sculptural Personality of Adriaen de Vries (Peggy Fogelman)

PART I METHODOLOGY

3 Chapter 1 Project Method and Scope

11 Chapter 2 Casting Techniques

17 Chapter 3 Visual Examination and X-Ray Radiography

21 Chapter 4 X-Ray Fluorescence Alloy Analysis (David A. Scott)

35 Chapter 5 Core Analysis (Ronald C. Schmidtling II)

45 Chapter 6 Thermoluminescence Dating

PART II CASE STUDIES

53 Chapter 7 *Psyche Borne Aloft by Putti,* Nationalmuseum, Stockholm

63 Chapter 8 *Faun and Nymph,* Staatliche Kunstsammlungen, Dresden

73 Chapter 9 *Crucifix,* Kirchenstiftung Mariä Verkündigung, Wullenstetten

81 Chapter 10 *Venus* or *Nymph,* Herzog Anton Ulrich-Museum, Braunschweig

89 Chapter 11 *Bust of Emperor Rudolf II,* Kunsthistorisches Museum, Vienna

97 Chapter 12 *Bust of the Elector Christian II of Saxony,* Skulpturensammlung, Staatliche Kunstsammlungen, Dresden

103 Chapter 13 *Hercules, Nessus, and Deianeira,* Musée du Louvre, Paris

113 Chapter 14 *Allegory of the War against the Turks in Hungary,* Kunsthistorisches Museum, Vienna

119 Chapter 15 *Rearing Horse,* J. Paul Getty Museum, Los Angeles

127 Chapter 16 *Horse,* Národní Galerie v Praze, Prague

135 Chapter 17 *Vulcan's Forge,* Bayerisches Nationalmuseum, Munich
141 Chapter 18 *Cain and Abel,* University of Edinburgh, Torrie Collection
151 Chapter 19 *Juggling Man,* J. Paul Getty Museum, Los Angeles
159 Chapter 20 *Farnese Bull,* Schlossmuseum, Gotha
169 Chapter 21 *Christ at the Column,* Kunsthistorisches Museum, Vienna
175 Chapter 22 *Lazarus,* Statens Museum for Kunst, Copenhagen
181 Chapter 23 *Putto with a Goose,* Nationalmuseum, Stockholm
187 Chapter 24 *Cain and Abel,* Statens Museum for Kunst, Copenhagen
197 Chapter 25 *Laocoön and His Sons,* Nationalmuseum, Stockholm
207 Chapter 26 *Hercules Pomarius,* Muzeum hlavního města Prahy, Prague
215 Chapter 27 *Mercury* (Tetrode), Los Angeles County Museum of Art
223 Chapter 28 *Mercury and Psyche* (artist unknown), Huntington Art Collections, San Marino
231 Chapter 29 *Christ Mocked* (artist unknown), Los Angeles County Museum of Art
239 Chapter 30 *Hercules, Nessus, and Deianeira* (attributed to Crozatier), Nelson-Atkins Museum of Art, Kansas City
251 Chapter 31 *Hercules, Nessus, and Deianeira* (attributed to Crozatier), Rijksmuseum, Amsterdam

259 Conclusion: Adriaen de Vries, Sculptor
273 Appendix A. Glossary
289 Appendix B. Summary Tables
299 Appendix C. Signatures
301 Bibliography
307 Illustration Credits
309 Index

FOREWORD

Working almost exclusively in bronze, Adriaen de Vries (1556–1626) was one of the most progressive northern European sculptors of his time. His innovative compositions and modeling techniques foreshadow the power and movement of the Baroque style and anticipate the work of future artists such as Auguste Rodin. De Vries was also a technical master, successfully casting even his large and complex compositions in a single pour, a feat attempted by many bronze artists of the time but only rarely achieved.

In 1999 and early 2000 the J. Paul Getty Museum had the honor of presenting the exhibition *Adriaen de Vries: Imperial Sculptor.* Recognizing the increasing importance of technical studies in the scholarship relating to bronze sculpture, the Museum's Department of Decorative Arts and Sculpture Conservation, in collaboration with the Getty Conservation Institute's Museum Research Lab, followed the archival and technical studies done in preparation for rhe exhibition catalogue with a comprehensive study of twenty-five bronzes included in the Los Angeles installation. The Getty Museum and the GCI have long been dedicated to the scientific examination of works of art, seeking to illuminate both preservation issues and the social and cultural context in which the works were created. Both institutions are also committed to the dissemination of information gained through such study, and we are pleased to present the results of this project here.

In its examination of de Vries's work, this book explains how and why technical studies are undertaken, illustrates how bronzes are cast, and makes available to art historians, collectors, conservators, and conservation scientists a detailed description of the techniques and materials employed by this important artist. The study has allowed reconsideration of the attribution of some of the casts and makes an important addition to the body of knowledge on de Vries.

We are grateful to Peggy Fogelman, Ronald E. Schmidtling II, and David A. Scott for their important contributions to this volume. In addition, we would like to acknowledge a debt of gratitude to Francesca Bewer for her technical expertise and advice throughout the life of the project. Finally, we would like to thank the principal author, Jane Bassett. As a conservator in the Getty Museum's Department of Decorative Arts and Sculpture Conservation since 1991, Jane has been responsible for the technical examination of a broad range of materials, specializing in bronzes from the Renaissance to the late eighteenth century. She took the lead in this projecr from its inception, and it was her commitment to ensuring that the exhibition had an afterlife that has resulted in the publication of this volume.

Timothy P. Whalen
Director
The Getty Conservation Institute

Michael Brand
Director
The J. Paul Getty Museum

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Undertaking a detailed study of bronzes of such beauty and technical virtuosity has been a privilege beyond measure. I am grateful to the lending institutions that generously agreed to allow their bronzes to undergo examination and core sampling for this project. I want to thank Deborah Gribbon, former director of the J. Paul Getty Museum, who offered early support of this publication, as well as Michael Brand and David Bomford of the Museum and Timothy Whalen, Kristin Kelly, and Giacomo Chiari of the GCI for their continued support. The results of the study are built on the foundation provided by the excellent exhibition catalogue written and edited by Frits Scholten of the Rijksmuseum, as well as the early technical research on de Vries carried out for the exhibition by Francesca Bewer of the Harvard University Art Museums. I gratefully acknowledge Francesca's help with the interpretation of the radiographs and her invaluable advice on this volume. Christian Goedicke, previously of the Rathgen-Forschungslabor Berlin, worked tirelessly on the thermoluminescence dating of the cores and offered invaluable assistance in the interpretation of the results. I am grateful to have had the opportunity to work with the superb group of sculpture curators at the Getty Museum during the time of the exhibition: Peter Fusco, Peggy Fogelman, Marietta Camberari, and Denise Allen.

For their help throughout the examinations, I gratefully acknowledge chief preparator Bruce Metro and the art moving team headed by Kevin Marshall; essential support was also provided in the Registrar's office by Cory Gooch and chief registrar Sally Hibbard. I would like to express my thanks to Laramie Hickey-Friedman, then graduate intern in decorative arts and sculpture conservation, who worked closely with me throughout the initial examination phase of the project. Stephanie Sheerer, then a GCI graduate intern, spent many long hours running the X-ray fluorescence instrument, and Jeffrey Maish of the Getty Museum Antiquities Conservation Department assisted in the radiography of some of the larger sculptures.

I owe a debt of gratitude to my colleagues and contributors to this volume, Peggy Fogelman, Ronald C. Schmidtling II, and David A. Scott, all of whom generously shared their research and insights with me. Anne Boulton of the Baltimore Museum of Art, Chandra Reedy of the University of Delaware, and Karen Trentelman of the GCI kindly offered generous editing advice. I am very grateful to Antonia Boström, current curator of sculpture and decorative arts, for her continuing encouragement of the technical study of bronzes, and Eike Schmidt, associate curator, for his helpful guidance and translations. Valerie Greathouse, reference librarian in the GCI library, provided invaluable research and bibliography formatting support. At Getty Publications, I would like to extend my appreciation to Mark Greenberg, editor in chief, and the staff and consultants for their work in bringing this book to light: Sheila Berg, copy editor; Pamela Heath, production coordinator; Dominique Loder, photo researcher; and Hespenheide Design, for the beautiful final product. I gratefully acknowledge the seasoned advice and gentle prodding of Tevvy Ball, editor at Getty Publications, and Cynthia Godlewski, GCI senior project manager, both of whom helped to keep the project on track and led me out of the corners I had worked myself into.

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And finally, I want to express my heartfelt love and appreciation to Mike, Madi, and Marley Fair for first enduring, then forgiving my absences and preoccupations. This book is dedicated to you.

The Sculptural Personality of Adriaen de Vries

by Peggy Fogelman

On December 7, 1989, when Adriaen de Vries's *Juggling Man* (now owned by the J. Paul Getty Museum) sold at auction for $10.7 million, at that time the highest price ever recorded for sculpture, the general public could be forgiven for never having heard of the artist.[1] As the scholar Frits Scholten has noted, de Vries's reputation and fame had fallen into obscurity by 1688, not much more than fifty years after his death.[2] De Vries's relative anonymity in the history of art changed radically with the organization of an international, monographic exhibition in 1999. A collaboration among the Rijksmuseum in Amsterdam, the Nationalmuseum in Stockholm, and the J. Paul Getty Museum in Los Angeles, the exhibition afforded a unique opportunity to gain new understanding of the artist's work and locate him within the sculptural canon by means of archival research, visual examination, and technical analysis.

The use of conservation science to determine condition, authenticity, and techniques of manufacture is not new to the study of sculpture, and it was undertaken along with art historical considerations for those purposes by Francesca Bewer of the Straus Center for Conservation and Technical Studies at the Harvard University Art Museums, in preparation for the exhibition and catalogue. The arrival of de Vries's sculptures at the Getty, however, provided a rare chance to examine a large number of bronzes by one artist, gathered from collections throughout Europe and the United States, using the same equipment, under the same conditions, and with a consistent group of conservators and scientists to interpret the results. Jane Bassett's in-depth technical analyses of twenty-five bronzes (seventeen of which are securely attributed to de Vries) not only confirmed the identification of his casting methods, alloy compositions, and surface treatments but also resulted in additional insight into his artistic personality and preferences. The personality that emerges is highly enigmatic. As far as is known, de Vries worked almost exclusively in bronze, at a time when Michelangelo's legacy still privileged marble over any other sculptural material to demonstrate the true virtuosity of the artist of three dimensions. Even Cellini, the self-proclaimed protagonist of legendary bronze casting feats, undertook a marble crucifix to prove his superiority over other sculptors. Although de Vries was certainly beholden to the requirements of each commission, his consistent choice of bronze as a medium would seem to signal intentionality. Having worked from 1581 to 1586 in the Florentine studio of Giambologna, one of the most advanced training grounds for sculptural mass production in the form of reproducible, small-scale indirect casts, de Vries went on to become a master of unique, directly cast bronze sculptures.[3] Also characteristic of Giambologna's statuettes was the removal of all casting evidence and the exquisite, meticulous detailing of surface, often done by expert assistants in the cold bronze during the chasing process. Whereas de Vries was equally concerned with the surface of his bronzes, he seems to have done much of his detailing in the wax model and either incorporated into his composition or left visible the remnants of casting in the form of sprues. Especially in his later work but also in passages of his earlier bronzes, de Vries maintained a sketchy, impressionistic handling of facial features and other major elements while carefully articulating such textures as the scales of snakeskin, the veining of leaves, and the curly strands of human hair.

The artist that emerges from the technical studies is someone of remarkable consistency, regardless of the degree of conformity to or departure from the sculptural practices of his era. De Vries repeatedly chose a relatively pure mixture of copper and tin for his bronzes. Whereas a consistency of alloy marks other workshops and foundries active in the sixteenth century, bronze alloys more typically combine copper with tin, zinc, and lead. De Vries's preference yields an extremely hard metal, resistant to corrosion, that lends itself to crisp detailing, but whether his choice was guided by these inherent qualities or by other considerations is unknown.[4]

Another practice evident from the technical examinations is de Vries's use of the wax model to work out final, sometimes significant elements of his compositions. In the direct lost wax casting process, the sculptor begins by building a roughly modeled clay core over a metal armature and then applying a relatively thin layer of wax that receives the detailing of anatomy, texture, and facial features. De Vries frequently developed elements of his figures in the wax itself—seen in radiographs as solidly cast bronze—allowing him to modify compositions as he worked. A comparison to Michelangelo's approach to the marble block is not altogether irrelevant. By gradually excavating the figure from one primary angle rather than roughing out the block from all four sides, Michelangelo retained a mass of stone to accommodate further changes in composition. That this method also supported a concomitant symbolism of releasing the "living" figure trapped within the obdurate stone made the method even more attractive in wedding pragmatism with poetry. De Vries similarly developed a process in which he could allow his inventive powers free rein until the actual casting, although perhaps without asserting the same emblematic construct.

Considering the importance of de Vries's modeling process in manifesting his compositional decisions and recording the textures of the final sculpture, it may seem surprising that the riskiest approach to casting, in which the original model is destroyed—a bronze directly cast in a single pour—predominates in de Vries's oeuvre. Of the securely attributed de Vries sculptures included in the exhibition that were X-rayed, nearly two-thirds were directly cast. The size and purpose of a bronze—for instance, a smaller, marketable composition versus a specifically commissioned monumental sculpture that is unlikely to be replicated—may offer practical reasons for casting directly even when the technologies for indirect processes exist. However, such qualifications cannot be consistently applied to de Vries's work. For example, the *Hercules, Nessus, and Deianeira* multifigure group in the Musée du Louvre, measuring 81.7 centimeters, was cast indirectly, but the only slightly larger British royal collection's *Theseus and Antiope,* a two-figure group with comparable potential for reproduction and sale, is a unique, direct cast (Scholten 1998a: nos. 8, 14). Nor do the dates of de Vries's sculptures substantiate speculation that bronzes done earlier in his career, when he was presumably closer to the influence of Giambologna, have greater tendencies to be indirectly cast, since in the present example *Theseus and Antiope* probably predates the Louvre composition by several years.

The circumstances of de Vries's career and the conditions of patronage under which he worked do not fully account for his practices, either. The sculptor left Florence for Milan in 1586 to work as the chief assistant to Pompeo Leoni on the high altar for the Escorial. There he must have acquired or refined his experience in modeling over life-sized figures and preparing them for casting. In 1587 or 1588 he was appointed court sculptor to the duke of Savoy in Turin, where he stayed for eighteen months but left no known surviving works. He was at the Prague court of Rudolf II from 1589 to 1594, producing two extraordinary monumental bronzes, *Psyche Borne Aloft by Putti* and *Mercury and Psyche.* After traveling to Rome in 1595–96, de Vries accepted a major commission for two bronze fountains in the city of Augsburg. He was appointed official sculptor to Rudolf II in 1601 and remained in Prague for the rest of his career, relying on commissions from patrons outside the court after the death of Rudolf in 1612.

There is evidence, based on engravings, that de Vries was actively producing small bronze statuettes up to and during his Augsburg period, and some of his indirectly cast compositions, such as the *Apollo* from the Metropolitan Museum of Art, probably date from that time (Scholten 1998a: 21, 115–17). Once he officially entered the service of Rudolf II in 1601, his work was oriented toward the emperor's *Kunstkammer*. With consistent patronage secure and monopolizing de Vries's production, one might expect all his bronzes to be unique, direct casts unless specifically ordered as reproducible, diplomatic gifts. However, to cite just one example, the Getty's *Rearing Horse*, almost certainly made for Rudolf, is indirectly cast. If de Vries was, on the other hand, indirectly casting those compositions he knew to be marketable in the event that his patronage ended, a proliferation of second casts might be anticipated in the years after the emperor's death. The only imperial bronze known to have been replicated, however, was the *Cain and Abel*.

If size, function, and patronage cannot entirely explain de Vries's preference for direct, single-pour casts, might there be another reason? The scholarly literature on sculpture includes extensive discussions on the carving of complex monumental works out of a single block of marble as a heroic act of artistic virtuosity connecting Renaissance sculptors to the past—antiquity and its aspirations—and ensuring their immortality for the future. As Leonard Barkan has shown, Pliny's daunting description of the *Laocoön* as a three-figure composition carved from one block established a threshold for sculptural heroism that, on discovery of the actual ancient work in 1506, was understood to be as yet unachieved. According to Barkan, "Pliny's claim . . . defines the supreme goal for marble working at the same time as the real experience of the unearthed antiquities demonstrates that this goal has been left to the moderns" (1999: 337). It also establishes the ignominy of attaching, or piecing in, stone from another block to achieve a complex composition.

More recently, Michael Cole has argued that Cellini, in his autobiographical account of making the *Perseus*, posits casting, specifically the single pour, as an equivalent act of heroism: "The act of metallic fusion . . . offered Cellini a way to emulate the accomplishment of a monumental [marble] piece without joins" (Cole 2002: 49).[5] Cole proceeds to examine the alchemical and emblematic implications of the modeling and casting process—with its loaded terminology describing the armature as a skeleton, the core as a soul, or *anima*, the casting cup as the mouth, and the pour as giving life to the earthen form. Direct, single-pour bronze casting in the sixteenth century could be seen not only as an act rivaling marble sculptors but also as a divine, transformational process.

De Vries's relationship to casting was very different from Cellini's assertion of direct involvement in the actual pour of the molten bronze. Wolfgang Niedhart, the Augsburg founder who produced de Vries's fountains, specifically noted in a letter of 1620 that the sculptor "does not take on the casting," and the majority of de Vries's work in Prague was probably cast in the Arsenal foundry within the walls of Rudolf's castle.[6] Nevertheless, there are many reasons to believe that de Vries was highly engaged with every aspect of bronze casting at least up to the point of pouring the metal into the mold. His contracts in Milan and Augsburg specified his obligation to deliver the models "ready for casting" and to supervise lowering the molds into the casting pit (cited in Bewer 1998: 71). There is also no evidence that de Vries used assistants to chase the bronze after casting. His conscious incorporation of sprues as vines or other compositional elements both demonstrates his knowledgeable engineering of the channel system needed for the pour and declares the casting process as integral to the sculpture's form and perhaps meaning (Bewer 2001: 182).

There is no substantial biographical or literary documentation with which to construct a topos of divine artistry for de Vries, as there is for Michelangelo or Cellini. De Vries's work must, therefore, speak for itself. His relief of *Vulcan's Forge*, a powerful and exemplary study of the male nude in action, has self-referential overtones since de Vries, through the placement of his signature on the pedestal of the anvil, seems to associate himself with Vulcan, the divine metalsmith. A background figure of Fame declares his immortality (Scholten 1998a: 187). The Getty's *Juggling Man* may be a complicated allegory of alchemy, or artistic virtuosity, or both. The figure may relate to the three crucial components of the philosopher's stone, or Son of Wisdom: the sun, moon, and wind (symbolized in the bronze by the two plates and the bellows).[7] The act of juggling itself was known by the same term used to describe artistic virtuosity, *Kunststücke machen,* perhaps specifically the artistry of the bronze sculptor, as the bellows is easily associated with stoking the fires needed to melt wax from the mold and prepare the metal for casting. De Vries's figure may illustrate a sophisticated pun in which the adroit juggler and the masterful artist are one and the same. In both cases, de Vries seems to link himself and his art to a metaphoric framework.

The *Juggling Man* is an inventive variation of a famous ancient statue of the *Dancing Faun*. De Vries executed several other reinterpretations of the most famous antiquities of Rome, including the *Laocoön* and the *Farnese Bull,* in direct rivalry with both ancient sculptors and their modern heirs, such as Baccio Bandinelli and Antonio Susini, who had copied the excavated marbles. In the *Farnese Bull,* a number of round sprues were left in place (for instance, connecting the top of Dirce's head to the bull's belly), perhaps referencing marble struts but also clearly evidencing the casting process. As signposts tracing the flow of bronze through the mold, these sprue remnants broadcast de Vries's ability to cast this highly complex group as one whole (Bewer 2001: 180–81). When the buyer, alleging that the bronze was inadequately finished, complained about the price, de Vries declared his sculpture to be worth as much as the ancient marble in Rome—a value judgment with equal significance for the artist and his medium (Bruck 1917: 81). In the case of the *Laocoön,* de Vries invented a completely original composition to be viewed from all sides, assimilating not only the antique precedent but also the forms of Michelangelo's unfinished *Samson Slaying the Philistines.*[8] Moreover, he achieved in his medium what the ancients did not—a three-figure monumental group executed in one piece. As with Cellini, de Vries's use of the single pour had symbolic significance in relation to the marble block, and by applying it to this subject specifically, the sculptor declared his own sculptural heroism.

As Malcolm Baker (1998) has noted, it was relatively recent and rare in the art historical literature on sculpture that materials and techniques—and their potential to bear meaning—had been given any primacy. Baker's assessment is still relevant nearly ten years later. The preoccupation with process and medium in publications by sculpture conservators, aimed primarily at a peer audience of conservation scientists and practitioners, has had a substantial impact on curators and the way they understand the works in their care. However, it has only just begun to influence theorized art history in the area of sculpture. The technical analyses of de Vries's bronzes presented in this volume are significant precisely because of their ability to stimulate speculation regarding the meaning of his working methods and his place within the theoretical debates of his time. Through careful examinations, a more profound understanding of de Vries as a sculptor has emerged. And, in revealing the daring innovations of his bronzes, these studies should continue to reverse the unwarranted obscurity that befell de Vries's work so soon after his death.

NOTES

1 Sotheby's, London, December 7, 1989, lot 65. This introductory essay is dedicated to Peter Fusco, former curator of European sculpture and works of art at the J. Paul Getty Museum, whose expert connoisseurship and passion for sculpture guided the Museum's acquisitions from 1984 to 2000, including the purchase of two important works by Adriaen de Vries.

2 Scholten 1998b: 13, citing an entry in the unpublished travel diary of Robert Worsley in the Lincolnshire Archive Office, Lincoln.

3 The biographical information on de Vries included in this essay is derived primarily from the exhibition catalogue and the excellent research contained therein by Frits Scholten and others (Scholten 1998a). That de Vries was well versed in Giambologna's studio practices is evidenced by the technical similarities between such statuettes as the *Apollo* in the Metropolitan Museum of Art and small bronzes from Giambologna's workshop. See Bewer 2001: 172.

4 Bewer (2001: 178–79) considers the consistency of alloy further evidence of de Vries's extensive involvement in determining the technical aspects of casting his bronzes.

5 The association between casting in one piece and carving a composition from a single marble block as equivalent artistic challenges has also been made by Bewer (2001: 162–63).

6 Letter to Abraham van den Bloocke, January 30, 1620, cited in Bewer 1998: 72.

7 This interpretation, based in part on the resemblance of the pose of the *Juggling Man* to an engraving from the 1618 *Atalanta fugiens,* an alchemical emblem book by Michael Maier, was suggested by Scholten 1998a: no. 32.

8 The association with Michelangelo's composition was suggested by Larsson 1998: 54.

PART I

Methodology

CHAPTER 1

Project Method and Scope

THE TECHNICAL EXAMINATION OF RENAISSANCE BRONZES

For scholar and amateur alike, enjoyment of a sculptural work greatly increases with an understanding of its creation. In addition, understanding the materials and processes used to make a sculpture can help us to address important issues such as attribution and historical context. For the art conservator, knowing how a work was made as well as what has happened to it over time is an essential step in the proper care of the work. Art historians and connoisseurs have long relied on the study of style for the attribution of bronze casts.[1] The attribution of bronzes presents a particular challenge, though, as the methods used to cast sculpture are by nature reproductive, in certain circumstances allowing the production of a series of nearly identical autograph replicas, followed by aftercasts or copies that may or may not be authorized.[2] The technical examination of Renaissance bronzes owes much to earlier published studies of classical bronzes, including numerous papers from the 1967 colloquium on the subject found in *Art and Technology: A Symposium on Classical Bronzes* (Doeringer, Mitten, and Steinberg 1970). Carol Mattusch (of George Mason University) has made many important contributions to the study of Greek and Roman bronze production (Mattusch 1996).

The use of technical studies for the authentication of bronzes is based on the premise that artists or workshops consistently used specific and distinctive materials and approaches to technique. In 1981 Richard Stone of the Metropolitan Museum of Art demonstrated the validity of this premise with the publication of a seminal article describing casting techniques in late-fifteenth-/early-sixteenth-century Italy, concentrating on the work of Antico (ca. 1460–1528) and Riccio (d. 1532) (Stone 1981). By successfully identifying specific working patterns, Stone demonstrated the usefulness of technical studies for distinguishing works of a certain artist. The interpretation of the features he observed on the bronzes is supported by the contemporary treatises that address mold making and lost wax casting, including *The Madrid Codices* by Leonardo da Vinci, *Il libro dell'arte* by Cennino Cennini, *Vasari on Technique* by Giorgio Vasari, *De la pirotechnia* by Vannoccio Biringuccio, and the *Autobiography of Benvenuto Cellini,* as well as *The Treatises of Benvenuto Cellini on Goldsmithing and Sculpture.* The treatises provide detailed background for an understanding of the techniques used by both Antico and Riccio and remain the cornerstone of technical studies of Renaissance bronzes.

Concurrent with and following Stone's work on Antico and Riccio, a small group of museums in the late 1970s through early 1990s undertook detailed studies of their Renaissance bronzes, including the Victoria and Albert Museum in London, the Cleveland Museum of Art, the National Gallery of Art in Washington, D.C., the Los Angeles County Museum of Art (LACMA), and the J. Paul Getty Museum.

The J. Paul Getty Museum has been involved in the technical examination of Renaissance and later bronzes in many different phases since 1987. In that year a joint project between Billy Milam, associate conservator at the Getty Museum, and Chandra Reedy, associate research scientist at LACMA, was undertaken to study sixty-four bronzes from the Kunsthistorisches Museum, Vienna, brought to LACMA as part of the exhibition *Renaissance Master Bronzes.* A small number of bronzes from the Getty collection were also taken to LACMA for simultaneous study, including X-ray radiography, petrographic analysis of core samples, and atomic absorption alloy analysis of some of the casts.[3] Using a check form, the results were subjected to statistical analysis, in an approach similar to Reedy's 1997 study of Himalayan bronzes.[4]

Following this successful pilot project, the Getty Museum, in collaboration with the Getty Conservation Institute (GCI), established a term position dedicated to the technical study of Renaissance bronzes.[5] This post was held by Francesca Bewer from 1991 to 1995.[6] Bewer further refined and standardized a methodology for the study of Renaissance cast bronzes based on visual examination combined with X-ray radiography, core analysis, and alloy analysis. She developed a detailed examination worksheet that emphasizes written observations. Like Stone's 1981 work on Antico and Riccio, Bewer's interpretations of her observations are based in the technical processes described in period literature. Using this methodology, she then examined all thirty-eight bronzes in the Getty Museum in what was referred to as the "Renaissance Bronze Project," which resulted in reports illustrated with annotated radiographs and photographs.[7] In 1996 Bewer completed her Ph.D. dissertation at the University of London, "A Study of the Technology of Renaissance Bronze Statuettes," which presents two different types of case studies: one is an examination of a museum collection of diverse Renaissance bronzes; the second, a more concentrated study of works by a single artist. The first case study, of fourteen bronzes in the Huntington Art Collection in San Marino, California, was of sculptures of varying authorship, revealing variations in how bronzes are made by different workshops. The second case study included forty statuettes by or after Giambologna from European and U.S. collections. This comprehensive study of a wide range of works by a single author identified distinct and consistent methods, which has allowed a clear description of the artist's working methods.[8] Stone's earlier study of Antico and Riccio, together with Bewer's study of Giambologna, clearly demonstrated the potential of using technical studies combined with art historical information to further provenance determinations for Renaissance bronzes.

Although many of the early concentrated studies carried out by the institutions listed above remain unpublished, the past ten years have seen an increase in the number of publications that incorporate technical studies of Renaissance bronzes, including articles or papers,[9] as well as contributions to both permanent collection and exhibition catalogues.[10] Monographic exhibitions in particular offer the opportunity for in-depth comparisons of developments or patterns in techniques and materials in an artist's oeuvre.

PROJECT SCOPE

The present study was undertaken at the J. Paul Getty Museum in conjunction with the exhibition *Adriaen de Vries: Imperial Sculptor.* The exhibition opened at the Rijksmuseum, Amsterdam, in 1998, and then traveled to the Nationalmuseum, Stockholm, and the Getty Museum in Los Angeles. In preparation for the exhibition catalogue, Bewer (while working at the Straus Center for Conservation) examined thirty of the bronzes at their home institutions, collecting metal and core samples for analysis and undertaking X-ray radiography where possible. The results were summarized in the catalogue entries and were the basis of two technical essays on the artist's materials and techniques (Bewer 1998, 2001).

Thanks to Bewer's early studies, when the exhibition arrived at the Getty Museum, a considerable amount was already known about de Vries's working preferences. The possibility of carrying out a further systematic and in-depth study of a select group of the bronzes in Los Angeles presented the opportunity to build on the earlier study by broadening the database. It was anticipated that these results would expand our understanding of the artist's methods, at times confirming the earlier findings, at times broadening them as new variations came to light. With the advice of Bewer and Peter Fusco, then curator of European sculpture and works of art at the J. Paul Getty Museum, twenty-five of the fifty bronzes exhibited at the Getty were chosen for the present study. These bronzes had not been previously examined in detail. With three exceptions, the bronzes had not been previously radiographed.[11] Most had not had their core materials analyzed, and alloy analysis had not been carried out for many of them. Priority was also given to those works whose authorship had been questioned over the years or those that presented specific art historical or technical questions.

This volume presents the results of the technical examinations for these twenty-five bronzes, in chronological order: twenty-one sculptures from the international traveling exhibition and four bronzes included only in the Los Angeles installation (*Bust of the Elector Christian II,* the Tetrode *Mercury,* the small *Mercury and Psyche,* and *Christ Mocked*). Date, inventory number, and provenance for the twenty-one traveling bronzes were taken from the catalogue, which contains a wealth of information on interpretation and contextual perspectives (Scholten 1998a).

The goals of this technical study were twofold: to further our understanding of de Vries's methods and materials by examining a select group of securely attributed sculptures; and to reconsider a smaller group of objects of less certain authorship, allowing a new assessment of these sculptures in direct comparison with the larger group of de Vries objects. The comparison bronzes include three sculptures in the catalogue that have had a variety of attributions over the years (*Faun and Nymph, Crucifix,* and the Braunschweig *Nymph*), three comparative bronzes related to de Vries that were included in the Getty installation but are not in the catalogue (the Tetrode *Mercury,* the small *Mercury and Psyche,* and *Christ Mocked*), and, finally, two aftercasts of the *Hercules, Nessus, and Deianeira* group that are examples of later nonautograph de Vries casts. Figure 1.1 lists the bronzes that were examined and the analytical steps taken for each.

EXAMINATION PROCEDURE

An initial review was made of the provenance, art historical context, and any previously acquired technical information for each piece. Each technical study began with a general visual examination of the exterior, relying on good lighting with the unaided eye or low-power optical viewers. As each step of the examinations progressed, the surface was studied in more detail, often using a binocular microscope. Features such as surface texture, original and later repairs, joins between separately cast sections, surface staining due to the presence of rusting core pins or armature rods, remaining sprues, or other evidence of the casting process were recorded on a form. The use of a form helped to ensure uniformity in the investigations, yet its narrative format allows considerable flexibility.[12] It was then possible to view the interiors of the bronzes by laying the smaller ones on their sides or raising the larger ones with a gantry or forklift. Observations such as the presence or absence of core material, the general character of the bronze walls, and the presence of core pins or repairs were made of the interior.

Core samples were then removed for both petrographic analysis and thermoluminescence (TL) dating, taking care to avoid any contamination from restoration or mounting materials. As the exposure to the high-energy X-rays used to penetrate the bronze walls will complicate or disallow future TL dating, the core samples were removed before radiography. X-ray radiography was undertaken for all but two of the bronzes: the nymph in the *Faun and Nymph* group and the *Allegory of the War against the Turks.* The nymph was not radiographed as the interior and any core that may remain were inaccessible due to the presence of wooden blocks secured across the bottom of the sculpture. By not exposing the core to X-rays, it will be possible to more accurately date any core that may remain using TL, should it be desired in the future. The *Allegory* relief was not radiographed, as most of the core has been removed from the back, allowing direct viewing of the primarily low-relief features.[13]

Once the structure of the sculpture was determined through X-ray radiography, analysis of the alloy was undertaken using X-ray fluorescence (XRF).[14] XRF was chosen because it is a nondestructive technique (no sample is taken), yet yields an accurate semiquantitative measurement. The emphasis of the metal analysis was to determine the alloy of the bulk cast. Because no sample was taken, it was possible to analyze multiple locations on the surface (as time permitted), including separately cast elements and repairs.

The organic patinas were not analyzed because of the anticipated difficulty of correctly identifying their components.[15] Until a proven method of analysis has been

FIGURE 1.1 Bronzes studied at the J. Paul Getty Museum: Analytical steps

Chapter	Title/Collection	Artist	Core Analysis	TL Dating	X-Ray Radiography	XRF Alloy Analysis
7	*Psyche Borne Aloft by Putti* Nationalmuseum, Stockholm	Adriaen de Vries	X	X	X	X
8	*Faun and Nymph* Staatliche Kunstsammlungen, Dresden	After de Vries	X (faun only)		X (faun only)	X
9	*Crucifix* Kirchenstiftung Mariä Verkündigung, Wullenstetten	Authorship uncertain			X	X
10	*Venus* or *Nymph* Herzog Anton Ulrich-Museum, Braunschweig	Authorship uncertain	X	X	X	X
11	*Bust of Emperor Rudolf II* Kunsthistorisches Museum, Vienna	Adriaen de Vries	X	X	X	X
12	*Bust of the Elector Christian II of Saxony* Staatliche Kunstsammlungen, Dresden	Adriaen de Vries	X	X	X	X
13	*Hercules, Nessus, and Deianeira* Musée du Louvre, Paris	Adriaen de Vries	X	X	X	X
14	*Allegory of the War against the Turks in Hungary* Kunsthistorisches Museum, Vienna	Adriaen de Vries	X	X		X
15	*Rearing Horse* J. Paul Getty Museum, Los Angeles	Adriaen de Vries			X	X
16	*Horse* Národní Galerie v Praze, Prague	Adriaen de Vries			X	X
17	*Vulcan's Forge* Bayerisches Nationalmuseum, Munich	Adriaen de Vries	X	X	X	X
18	*Cain and Abel* University of Edinburgh, Torrie Collection	Adriaen de Vries	X	X	X	X

developed, precious old or original coatings are not being sampled. Additional small samples were taken of *Psyche Borne Aloft by Putti* (chapter 7), including a number of the soft fill materials, which were examined to determine a possible timetable of their application. A sample was also removed from a loose section of Psyche's armature rod. The rod was subjected to metallographic analysis to determine how it was formed.

Overall dimensions were taken using large, wooden, right-angle rulers.[16] The thickness of the bronze walls was occasionally recorded using calipers at the open bases or the edge of large lacunae, although the extreme variations in the metal thickness at the edges often suggested that these measurements were not indicative of the casts overall. Measurements of features such as repair plugs, armature rods, and core pin holes were taken directly off the radiographs and should be considered approximate.

Once these steps were taken for each bronze, the data recorded, and the sculptures returned to their home institutions, the reevaluation of the results and refinement of

FIGURE 1.1 cont.

Chapter	Title/Collection	Artist	Core Analysis	TL Dating	X-Ray Radiography	XRF Alloy Analysis
19	*Juggling Man* J. Paul Getty Museum, Los Angeles	Adriaen de Vries	X		X	X
20	*Farnese Bull* Schlossmuseum, Gotha	Adriaen de Vries	X	X	X	X
21	*Christ at the Column* Kunsthistorisches Museum, Vienna	Adriaen de Vries	X	X	X	X
22	*Lazarus* Statens Museum for Kunst, Copenhagen	Adriaen de Vries	X	X	X	X
23	*Putto with a Goose* Nationalmuseum, Stockholm	Adriaen de Vries	X	X	X	X
24	*Cain and Abel* Statens Museum for Kunst, Copenhagen	Adriaen de Vries	X	X	X	X
25	*Laocoön and His Sons* Nationalmuseum, Stockholm	Adriaen de Vries	X	X	X	X
26	*Hercules Pomarius* Muzeum hlavního města Prahy, Prague	Adriaen de Vries	X	X	X	X
27	*Mercury* Los Angeles County Museum of Art	Willem van Tetrode	X		X	X
28	*Mercury and Psyche* Huntington Art Collections, San Marino	Authorship uncertain			X	X
29	*Christ Mocked* Los Angeles County Museum of Art	Authorship uncertain	X	X	X	X
30	*Hercules, Nessus, and Deianeira* Nelson-Atkins Museum of Art, Kansas City	Attributed to Charles Crozatier, after de Vries	X		X	X
31	*Hercules, Nessus, and Deianeira* Rijksmuseum, Amsterdam	Attributed to Charles Crozatier, after de Vries	X	X	X	X

their interpretations was undertaken. The primary author had the opportunity to view a number of the bronzes again, including the installation of these and other important de Vries casts and related bronzes in the 2000 exhibition *Adriaen de Vries, 1556–1626,* at the Städtischen Kunstsammlungen, Augsburg. These follow-up visits have proven vital to this volume as they offered the opportunity to reflect on the remarkable coherence of the artist's productions and allowed a more focused reevaluation of the comparison bronzes.

THIS VOLUME

In addition to illustrating the techniques and materials used by the master sculptor Adriaen de Vries, this volume attempts to offer insight into the procedures involved in the technical examination of cast bronze sculpture, as well as the process of interpreting the results. The inclusion of related but not autograph bronzes offers the opportunity for comparisons and contrasts.

The remainder of this volume is organized as follows. Chapter 2, "Casting Techniques," describes the processes observed on the bronzes studied: direct lost wax casting, indirect lost wax casting, and sand casting. Whereas lost wax casting was the technique most commonly used for bronze sculptures beginning in the fifteenth century in Europe, it is likely that sand casting began to be used for figural sculpture in the eighteenth century, its use peaking in France in the nineteenth century. Reflecting this trend, the twenty-three bronzes once or now attributed to de Vries were cast using the lost wax process. The two remaining bronzes, both of which are aftercasts of de Vries's composition *Hercules, Nessus, and Deianeira,* date to the nineteenth and twentieth centuries and were made using the sand casting technique. The relative ease with which multiple sand cast copies can be made suggests the importance of at least a rudimentary understanding of the technique when undertaking authenticity studies of cast bronzes.

Chapter 3, "Visual Examination and X-Ray Radiography," describes the two complementary processes that provided the most data for this study. Chapter 4, "X-Ray Fluorescence Alloy Analysis," and chapter 5, "Core Analysis," describe the analytical techniques used to identify the composition of the metal and the casting cores and discuss the results. Chapter 6, "Thermoluminescence Dating," discusses the use of the technique for the direct dating of European bronze casting cores in the context of this study.

Chapters 7 through 31 present the technical reports for each bronze. Each of these chapters opens with an overview that briefly describes the subject and provenance of the sculpture, followed by the specific questions the examinations sought to answer. An examination section that contains the results of each study follows. To allow more immediate access to these details for readers researching a particular aspect of the construction, the text is presented in the format of the examination form. Each sculpture chapter then closes with a summary that presents the highlights of the technical study and places the sculpture in the context of de Vries's work or—for those sculptures whose authorship is questioned—examines other possible attributions.

To the extent possible, diagnostic or distinctive features discussed in chapters 7 through 31 are illustrated by photographs, annotated X-ray radiographs, and sketches. The more descriptive radiographs are included in this volume either as the best summary for the internal features of a certain sculpture or as a clear illustration of a repeating characteristic seen in many of the casts. The annotations point out features detailed in the text. As all the radiographs are not included here, information gathered through surface examination as well X-ray radiography is summarized in the "Structural Summary" sketches. These sketches illustrate the number of pieces the sculptures were formed or cast in, as well as the structure of the remaining internal iron supports—both suggestive of the methods used to cast each bronze. Structural summaries have not been included for the *Bust of the Elector Christian II of Saxony* and *Putto with a Goose* due to the removal of nearly all the armature rods and the absence of either wax or metal joins.

The final chapter, "Conclusion," offers an overview of the results of the technical studies, allowing a summary of de Vries's working techniques, at times contrasted with the comparison bronzes.

Appendix A, "Glossary," defines the terms specific to the art of casting that are encountered in this volume. Appendix B is a compilation of the data accumulated during the examinations. The signatures are listed in Appendix C. The data in Appendix B, drawn from the technical reports, are presented in table format so as to allow immediate access to much of the quantifiable information. This format allows a quick summary of the physical qualities that define a de Vries cast, illustrating the consistency of the artist's materials and techniques, as well as the variation observed in the comparison bronzes. We hope that the data will invite other interpretations.

The primary goal of this volume is to add to the growing body of knowledge on Renaissance and later bronzes. It is hoped that the success of this and similar studies in furthering our ability to determine attribution, as well as our overall understanding of the sculptor's working processes, will encourage other researchers. Toward this end, this volume includes an overview of the technical examination methodology and why such studies are undertaken. Illustrations in the sculpture chapters and in the glossary are presented as examples of how to interpret features observed on the surface and in the radiographs. In addition, we wish to encourage the collaboration of art historians, museum curators, scientists, connoisseurs, and conservators in the study of these wonderful sculptures captured in bronze.

NOTES

1 The term *bronze* is used here, as in art historical literature, to refer to fine art sculptures cast of metal alloys that contain primarily copper. Technically, this may include a broad range of alloys, such as brass (a mixture of copper and zinc), bronze (a mixture of copper and tin), or leaded brass or leaded bronze (the addition of lead to either alloy), which can be determined with certainty only through analysis.

2 Appendix A, "Glossary," defines many of the terms used in this volume, including *replica* and *aftercast*.

3 X-ray fluorescence analysis of the metal alloy had been undertaken before the Vienna bronzes arrived in Los Angeles by Lisha Glinsman at the National Gallery of Art, Washington, D.C.

4 "Renaissance Bronze Pilot Project," unpublished report in the files of Decorative Arts and Sculpture Conservation, J. Paul Getty Museum.

5 Under the guidance of Peter Fusco, curator of sculpture and works of art, together with David Scott, chief scientist of the GCI Museum Research Laboratory, and Brian Considine, conservator of decorative arts and sculpture.

6 Bewer's experience prior to taking the position included a 1985 M.Phil. dissertation titled "The *De la pirotechnia* of Vannoccio Biringucci (1480–1533) and Bronze Sculpture" at the University of London, Faculty of Arts, Warburg Institute, London (unpublished). She is currently associate curator of research at the Straus Center for Conservation and Technical Studies at the Harvard University Art Museums.

7 F. Bewer, "Renaissance Bronze Project 1995," unpublished volumes in the files of the Decorative Arts and Sculpture Conservation Department, the J. Paul Getty Museum. Data from the examinations were incorporated in the "Technical description" for the bronzes in Fogelman et al. 2002.

8 For this study on Giambologna, Bewer relied heavily on visual material (X-ray radiographs) as well as core samples provided by Jonathan Ashley Smith and Anthony Radcliff of the Victoria and Albert Museum, London. A summary of the results from this research can be found in Bewer 1995b.

9 Bewer 2001, on de Vries; Sturman 2001, on Giambologna; Stone 2001, on Donatello and Verrocchio; Ozone and Sturman 2003, on two large sixteenth-century Italian bronzes; Marsden and Bassett 2003, on Cellini; Stone 2006, on Severo da Ravenna; Bewer, Stone, and Sturman 2007, on Ghiberti.

10 Bewer 1998, on de Vries; Bewer on Algardi, in Montagu 1999; Brendel and Mach 2000, on de Vries; Motture, Martin, and Victoria and Albert Museum 2001, on Italian bells and mortars; Dillon 2002, on Fitzwilliam Museum bronzes; Bewer et al. 2003, on Tetrode; Sturman, on the Robert H. Smith Collection, in Radcliffe and Penny 2004; Sturman, on the Quentin Collection bronzes, in Leithe-Jasper and Wengraf 2004; van Langh and Visser, on Rijksmuseum bronzes, in Scholten and Verber 2005; Bassett, on French bronzes, in Bennett, Sargentson, and Huntington Library 2007.

11 The exceptions were *Hercules, Nessus, and Deianeira* from the Nelson-Atkins Museum and the Getty Museum *Juggling Man* and *Rearing Horse*.

12 The form used for this project is an adaptation of the one developed by Bewer for the Renaissance Bronze Project, proceeding from the inside to the outside in the order of the steps that de Vries would have taken when constructing the majority of his bronzes.

13 In comparison, the other relief included in the examination, *Vulcan's Forge*, was radiographed due to the presence of numerous free-standing elements modeled in the round.

14 As the energy of the X-rays used for XRF is comparatively low, with minimal penetration into the bronze, it will not affect future TL dating of the core of a bronze that has been analyzed using the technique.

15 As described by Stone, White, and Indictor 1990, the components of organic patinas are especially difficult to analyze because of their relatively thin application and extensive oxidation. Current studies of organic patinas on bronzes using GC-MS are showing promise (Pittard 2007).

16 In some cases, additional measurements of exterior features such as circumference were taken with a cloth measuring tape. Measurements are most useful in comparing multiple versions of a model. As both wax and bronze shrink when they cool, a copy will be smaller than the original. Comparing the dimensions of two casts can be deceiving, though, as the amount of shrinkage will depend on many factors, and casts with joins can be constructed in slightly different ways, complicating comparisons.

CHAPTER 2

Casting Techniques

In the past six centuries in Europe, two very different methods have been used for the casting of bronze sculptures: lost wax casting and sand casting. Lost wax casting predominated during most of this period, as it gives the artist considerable freedom to cast complex forms in one piece with fine surface detail. In basic terms, lost wax casting (also known as *cire perdue*) involves the formation of a mold around a wax model. The model is heated, which removes the wax and creates a space into which molten bronze is poured. There are two distinct variations, direct and indirect lost wax casting, determined by the method used to form the wax model around which the mold is made (referred to as the casting model). In sand casting the mold is formed around a rigid model. The mold must be opened to remove the model before the bronze is cast.

A basic understanding of the steps involved in the three processes is an essential tool for distinguishing them. The diagrams in this chapter describe the techniques used to cast the sculptures in this study. All the bronzes in the project were hollow-cast around an internal core. Although small solid-cast bronzes were made in the early Renaissance (Stone 1981: 93), there are many advantages to casting hollow. Less metal is used, which decreases the cost of the materials and the weight of the sculpture and makes it easier to transport and to hold in the hand to admire. More important, a solid-cast bronze is more likely to be flawed as a result of trapped gases and shrinkage porosity. The core helps to absorb gases as the bronze cools and allows for even thickness of the bronze walls, avoiding the variations in wall thickness and resultant uneven shrinkage of the metal that can lead to surface flaws. For these reasons, great effort was put into creating hollow casts with walls of relatively even thickness.

LOST WAX CASTING

Direct Lost Wax Casting

The more straightforward method of lost wax casting, the direct lost wax technique allows the artist to cast directly off of the original model, and is ideal for wax models with complex surface textures as well as large and complex compositions.[1] Because the original full-scale model is lost during the casting, the artist must start from scratch should there be a problem during the pour—a considerable disadvantage of the technique (figs. 2.1–2.3).

Direct Lost Wax Casting

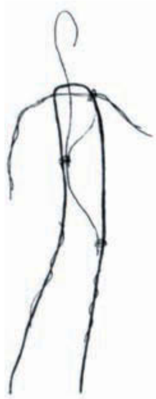


FIGURE 2.1 De Vries began by building an armature of iron wires and rods strong enough to support the model during construction. For larger sculptures in which heavy-gauge rods were used, proper layout was essential as bending or altering the rods would be difficult once the next steps began.

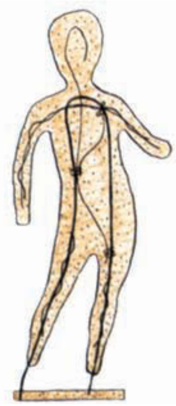


FIGURE 2.2 A fire-resistant clay and sand mixture was modeled over the armature. The clay form was built up until it looked like a simplified and slightly smaller version of the final sculpture. The clay with its armature then acted as the inner mold, or core. The clay core was then baked to harden it and drive off moisture.

FIGURE 2.3 De Vries then modeled wax over the clay core. The flesh was smoothed and the fine details refined, including the application of the signature and surface texture. The completed, original wax model was then ready to be prepared for casting.

Indirect Lost Wax Casting

In indirect lost wax casting, the artist is free to use a range of materials, for example, wood, clay, or solid wax, to sculpt the original model.[2] A mold is then made of the original model and duplicate wax models (referred to as *intermodels*) are made in the mold. These duplicate models are used for the casting, thereby preserving the original model. Numerous intermodels can be made from the molds. They can be virtually identical, or, with reworking, numerous slightly different replicas can be made. In addition, an intermodel lost due to a fault in the casting can be replaced with relative ease. Because the original model is preserved, it can be used as a guide for workshop assistants to carry out the final chasing of the bronze, freeing the artist from this laborious task. Because of the tremendous amount of time and materials needed to create a piece mold and a separate model for casting, the indirect technique may be impractical for large sculptures or those with complex compositions that include deep undercuts (figs. 2.4–2.8).

Indirect Lost Wax Casting

FIGURE 2.4 De Vries began his indirect casts by making a full-scale original model in solid wax or clay. A plaster piece mold was then made of the model. To facilitate the later steps, de Vries made his molds in sections. The sections could be made by leaving the model intact, as illustrated here, or by cutting the model into parts. For a small figure such as this, de Vries seems to have preferred making the limbs and the base in separate mold sections.

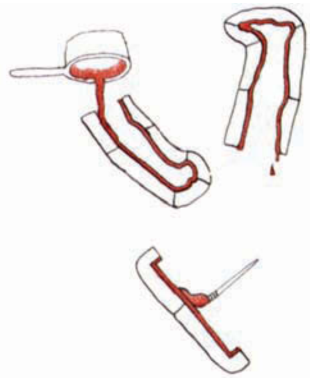


FIGURE 2.5 The molds were then used to form the separate parts of the wax intermodel. For the limbs and torso, de Vries used the slush molding technique. Molten wax was poured into the dampened mold, which was turned until the wax evenly coated all surfaces. When the desired thickness was achieved, the excess wax was poured out of the mold. For open forms such as the base shown here, the wax was applied by brush. Drips and brush marks left in the wax are transferred to the bronze and remain as telltale signs seen on the radiographs that allow for the identification of casting technique.

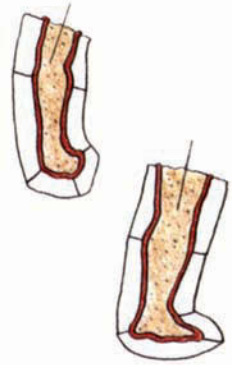


FIGURE 2.6 De Vries then packed clay into the hollow wax to form the core. Sections of iron rod or wire were then positioned partway into the joins as core supports. Sometimes de Vries used longer core supports extending farther into the limbs.

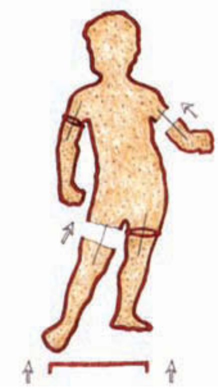


FIGURE 2.7 The separate wax sections were then assembled. A hot tool was used to "weld" the wax edges together, forming the distinctive wax-to-wax joins often seen in the radiographs of indirect casts. The core supports spanned the joins. At the join between the closed bottom of the feet and the top of the base, solid wax meets solid wax, forming a strong bond that de Vries did not support with rods.

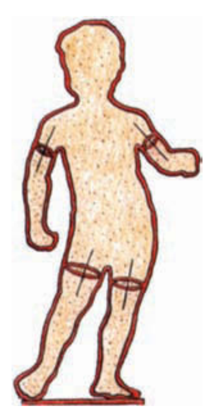


FIGURE 2.8 Once the model was fully assembled, imperfections on the exterior were removed. The surface details were then sharpened, modified, or added, and the completed wax intermodel was then ready to be prepared for casting.

Casting the Wax Model

Regardless of the technique used to prepare the wax casting model, the steps followed for casting it were the same (figs. 2.9–2.12).

FIGURE 2.9 The same steps were taken to cast the wax model (direct lost technique) or intermodel (indirect technique), independent of how it was formed. Short, tapering iron core pins were inserted through the wax and into the core. Round sectioned wax rods, referred to as sprues, were attached to the wax model.

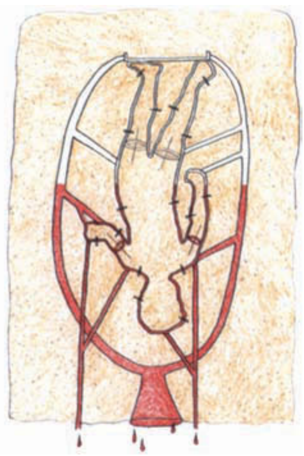


FIGURE 2.10 The artist applied layers of clay to the wax, forming the outer mold (also known as the investment). Once completed, the invested wax model was turned upside down in a kiln and heated to burn out the wax and drive all moisture from the core. The core pins kept the core in alignment once the wax was gone. The melted sprues created channels to bring the bronze into the investment and to carry away escaping air and released gases.

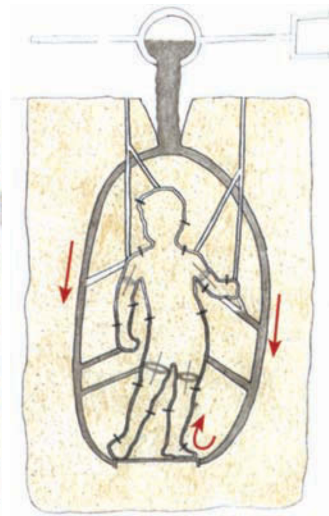


FIGURE 2.11 The investment was then buried right side up in a casting pit. The molten metal was poured into the cup at the top of the mold. The artist would have known that the mold was completely filled when the risers adjacent to the pouring cup filled with bronze.

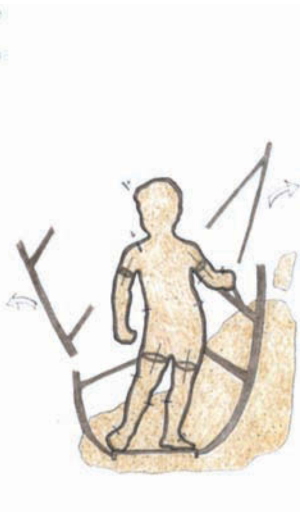


FIGURE 2.12 Once cooled, the outer investment was removed. If all went well, everything that had been wax was converted to bronze. At this point, the time-consuming steps of fettling and chasing began. The sprues and flashes were chiseled or filed off (although at times de Vries left sprues intact), the fire scale was removed with dilute acid or by scraping, the core pins were pulled out or were cut off and pushed into the bronze, and the casting flaws and core pin holes were repaired. De Vries removed the core from the hollow base, but the core and armature rods were often left inside the figures. Repairs as well as spots where the sprues and flashes were removed were chiseled, polished, and textured as needed. The flesh was polished, and minimal texture was applied to the metal with punches. As a final step, the bronze was coated with an organic lacquerlike patina.

SAND CASTING

Sand casting allows the relatively straightforward creation of replicas.[3] For centuries, the technique was most often applied to simplified forms such as medals, furniture mounts, or flat metalwork. Complex forms are difficult to sand cast. Once a sand mold is formed around a model, it must be disassembled to take the model out. If there are undercuts in the model, the mold must be made in pieces. For this reason, sand cast sculptures tend to be cast in parts that necessitate assembly and reworking of the metal to hide the joins. Although the technique is at times maligned both for the amount of reworking and for the poor quality of the surface, reproduction of very fine detail can be achieved in the highest-quality casts (figs. 2.13–2.19).

The two sand casts in this study, aftercasts of de Vries's *Hercules, Nessus, and Deianeira* composition, are included here for the purpose of comparison. As with lost wax casting, remnants left on the interior of a bronze can be used to identify the sand casting process.

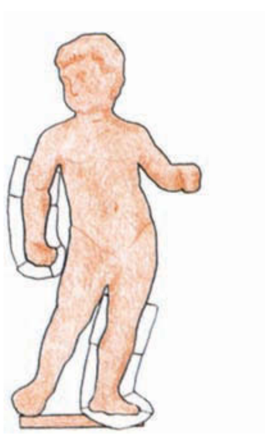


FIGURE 2.13 The process begins with a completed sculpture or model made in any medium such as clay, wood, plaster, bronze, or wax. A mold, most commonly a plaster piece mold, is taken from the original sculpture.

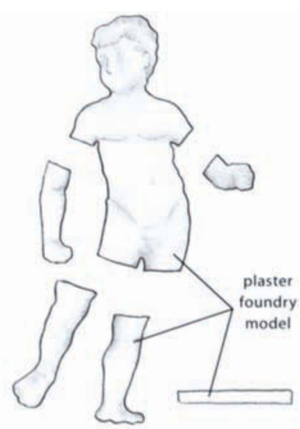


FIGURE 2.14 Using the piece mold, a solid replica, called a foundry model, is cast in sections in a hard material such as plaster.

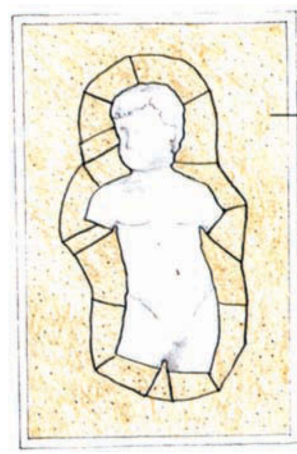


FIGURE 2.15 The mold for each section of the foundry model is made inside a box frame called a flask. The mold is made in sections by compacting sand (actually a mixture of sand and clay) against the plaster foundry model. These sections are held in place inside the flask in an outer bed of sand. Once the entire sand piece mold has been made, the plaster foundry model is removed from the flask. Because the sand mold was formed in pieces, the rigid model can be removed without damaging the piece mold. To speed the molding process, the foundry models are sometimes cut into sections, resulting in bronzes cast in numerous parts.

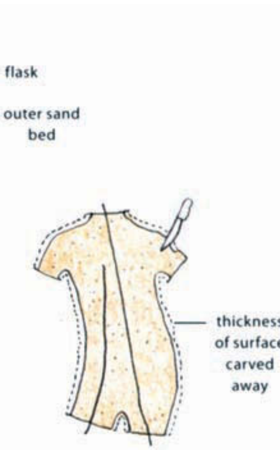
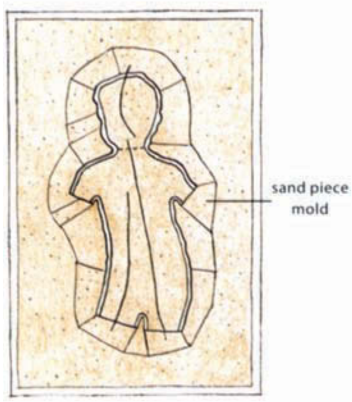


FIGURE 2.16 The inner mold, or core, is then prepared. A simple iron armature is made and placed within the hollow left in the sand mold when the plaster foundry model was removed. Sand is packed around the armature until the mold is filled. The core is then removed from the mold, and the surface is carved down by an even amount, equal to the desired thickness of the metal to be cast. In this example, the core is made in two sections, the head and the torso.



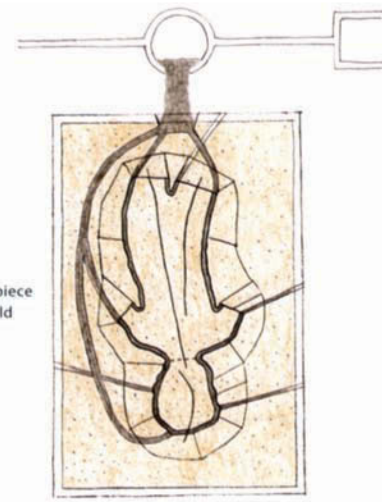


FIGURE 2.17 Both sections of the core are then placed back inside the sand piece mold. The core is held in suspension within the mold by the armature rods.

FIGURE 2.18 The sand mold is then prepared for casting. A pouring hole and gates are cut into the sand to allow bronze into the mold, and vents are cut to allow air and gasses to escape. The mold is then heated to drive off moisture and harden the sand. The bronze is poured. The gates feed bronze into the gaps between the core and the outer piece mold. The founder knows that the mold is full when bronze fills the vents.

FIGURE 2.19 When cooled, the bronze cast is removed from the sand mold, destroying the mold in the process. The surface is then fettled, including removal of bronze fins that formed between sections of the piece mold. Armature rods are cut off at the surface or removed. Much of the core is removed. The separately cast arms and legs are pinned to the torso using sleeves cast with the limbs; the feet are secured to the base with screws. The final chasing is undertaken to hide the metal-to-metal joins, fill the armature rod holes and any surface flaws, and enhance the surface with applied texture. A final patina is applied to the surface. In the nineteenth century, a wide selection of both organic lacquerlike coatings and chemical patinas were available.

NOTES

1 The armature construction illustrated in the direct process is based primarily on the technical studies of the *Juggling Man*, *Christ at the Column*, *Lazarus*, and *Hercules Pomarius*, detailed in chapters 19, 21, 22, 24, and 26 respectively.

2 Steps in the indirect process are based primarily on the technical studies of the Louvre *Hercules, Nessus, and Deianeira* (chapter 13), as well as the *Apollo* from the Metropolitan Museum of Art, New York, and the *Mercury* in the Stift Lambach, Lambach. The latter two bronzes are discussed in Bewer 2001: 170–71.

3 There are many different ways to prepare sand casting molds. Just one of those methods has been included here, based on the process used to cast the *Hercules, Nessus, and Deianeira* aftercast from the Nelson-Atkins Museum (chapter 30). More detailed descriptions of the sand casting process can be found in Rama and Berthelot 1988 and Shapiro 1985.

CHAPTER 3

Visual Examination and X-Ray Radiography

The backbone of any technical examination is observation. Provenance and art historical research, materials analysis, and experimentation with technique may all contribute to the understanding of a work of art, but detailed observation of the object itself is the foundation on which a study is built. Examination of the outer surface of a bronze will yield a certain amount of information about how it was made, yet the artist has often carefully removed many of the most telling remnants of the casting process from the outside of the bronze. For this reason, one must often turn to the inside of a sculpture, which may retain a host of evidence regarding the specific techniques used to cast and repair it. When the interior is inaccessible because of the closed composition of the form, or the presence of core material, X-ray radiography is an indispensable tool: it allows the production of high-resolution images that record detailed information about features that are present on all surfaces of a bronze.

Visual examination and X-ray radiography can yield a tremendous amount of raw data, yet the information acquired using either technique alone can be difficult to interpret. It is often only by combining visual examination with radiography that one is able to make meaning of the observations. The inside and outside surfaces of a bronze can retain evidence of how the wax was worked, how much cold work was applied, and the presence of joins, repairs, corrosion, or applied patina. Armed with a good light source, one can discern many of these details with the naked eye. Increasing the magnification with a 10× hand loupe or a microscope is especially useful for examining signatures, punched texture, modeling tool marks, and patina layers.[1] Ultraviolet light can be helpful for identifying repairs or surface alterations, as partial repatination or retouching of the organic patina to hide such repairs will often have a different appearance under ultraviolet illumination from the surrounding surfaces. As with the surface examination, good lighting is essential for viewing the hollow inside of a sculpture. A small mirror can be a useful way to see interior surfaces that are just beyond the direct line of sight. A borescope—a long, thin optical device with an internal light source—can be a useful tool for examining bronzes that offer only small access holes to the hollow interior. The presence of core material on the interior, as occurred in many of the bronzes in this project, limits any type of direct viewing of the inside surfaces, for which we can turn to X-ray radiography.[2]

X-ray radiography of bronzes is a relatively straightforward process similar to that used in the medical field, except that considerably higher energy is necessary to penetrate the metal walls. The X-rays are generated in a vacuum tube by bombarding a metal target with electrons. The X-rays are directed into a beam that, when pointed toward a bronze, is either absorbed by or passes through the different materials present in the sculpture. A sheet of film placed behind the bronze will be exposed by the X-rays that are not absorbed by the sculpture, capturing the very finest structural details.[3] The film is then chemically developed in a manner similar to that used for black-and-white photographic film, yielding an image (radiograph) with high resolution and a wide range of gray values. The ability of a material to absorb X-rays depends on its density and thickness. The more dense and thicker a material is, the more X-rays it will absorb and the fewer that will pass through the sculpture. Denser components in a sculpture, such as solder repairs and solid-cast elements, appear light gray or white on a radiograph. Less dense areas, such as porosity voids and hollow-cast elements, appear darker on the film. Radiographs can include details of elements such as wall thickness, flaws, joins, repairs, and internal rods and wires, as well as later alterations. X-ray radiography can aid in the examination of all surfaces—inside and out. Surface details hidden under repairs or coatings, as well as flaws or gaps within the bronze walls themselves, will be captured on a radiograph. The radiographs will also contain details of the interior surface, where most casting evidence often remains.

The bronzes in this study were radiographed using a Phillips 450 kilovolt (kV) tube. This powerful unit is ideal for imaging larger bronzes, particularly those containing core material, such as the *Bust of Emperor Rudolf II,* which was shot at near the unit's capacity.[4] The fine-grain, high-contrast radiographic film used for the project was held in cassette envelopes with lead sheet measuring 0.01 in. in front of and 0.005 in. behind the film.[5] To achieve a crisp, high-contrast image, the film was placed as close as possible to the sculpture. The lead-lined film cassettes were positioned near the top of the larger sculptures using a tripod support (fig. 3.1).

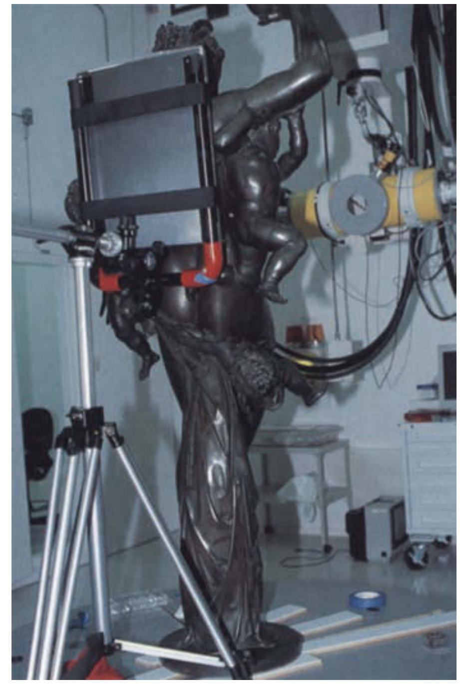


FIGURE 3.1 The life-size figure of Psyche in the lead-lined X-ray radiography lab in the Museum Research Laboratory of the GCI. X-rays are emitted from the yellow and gray X-ray tube positioned in front of the sculpture. The tripod in the foreground helps to hold the radiographic film as close as possible to the sculpture.

Correctly reading a radiograph is an art learned through experience, as features can often be interpreted in different ways. A number of factors can complicate the reading of radiographs. Features can be hidden by excess metal on the interior from flaws during the casting or later repairs. Corrosion can greatly reduce the density of components, reducing their ability to absorb X-rays, making them harder to see on the radiograph (such as the iron armature rods in this study). In addition, deciphering exactly where features are located inside a bronze can be difficult as all parts of the sculpture between the X-ray beam and the film will be superimposed on a single sheet of film. This is especially true in complex compositions in which figures or limbs overlap.[6] Extreme variations in density within adjacent features also present challenges for finding one exposure that will work for all areas; the extra density of overlapping forms or particularly thick sections necessitates higher-voltage exposures that will overexpose single thickness or thinner components. Many of these problems can be addressed by taking multiple exposures whenever possible, varying the angle at which the X-rays enter the sculpture, as well as the exposure times and energy of the X-rays. Time constraints may dictate that a bronze is radiographed from one or two angles and the images examined and interpreted later, but this situation is less than ideal. Whenever possible, radiographs should be compared to the bronze during the radiography session, allowing additional images to be taken when necessary for the sake of clarity.

Visual examination and X-ray radiography were used in this study to answer three basic questions about each bronze: How was it made? What was the quality of the casting? What alterations have occurred over time? Some of the features that help answer these questions for this specific group of bronzes are briefly discussed below. (See Appendix A for definitions and illustrations of terms.)

How was the bronze made? Determination of the methods used to cast a sculpture is important in that it indicates the possible nature of the commission (whether for a single unique cast or for a series) and can be useful in dating, as sand casting was not used extensively before the nineteenth century. The specific way in which the casting technique was approached (e.g., the number or locations of wax-to-wax joins, the design of the armature, the placement of the core pins) may be distinctive for a particular artist or foundry, adding considerably to the attribution studies for a bronze. Distinctive features for *direct lost wax bronzes* include a continuous armature, bronze walls that are often quite thick and not distinctly conformal with the exterior surface, and evidence of tool marks used to shape the core. In addition, directly cast bronzes are generally cast in one, rather than multiple, pieces. *Indirectly cast bronzes* may be cast in one or many pieces. The inside of indirect casts may contain evidence of the wax model in the form of drips, fingerprints, brushmarks, and wax-to-wax joins where separately formed sections of the casting waxes were joined. Rods and wires inside indirect casts tend to be in short sections that do not run continuously through the bronze and often support wax-to-wax joins. Indirect casts also tend to have relatively thin and even walls in which the inner contour conforms well to the outer contours. *Sand cast bronzes* often exhibit poor conformity between the inner and outer contours and can be most easily identified by the stepped and geometric contours of their inner surfaces, although attribution based on this characteristic can, in unusual circumstances, be incorrect.[7] Sand casts are often made in numerous sections, as evidenced by gaps visible on the surface or in the radiographs, solder or pins around a join, extra density from cast-in metal joins, or fittings such as pins from mechanical joins. Comparatively few flashes appear on the interior of sand casts, although fine, straight fins may be present if the core was formed in sections.

What was the quality of the casting? Observing the number and types of flaws in a cast will tell us something about the proficiency of the foundry. The presence of unrepaired porosity and miscast elements may also offer hints as to the artist's personality and intentions for the appearance of the cast. The presence of fluid and waxy modeled details on the surface of a bronze as revealed through visual examinations suggests not only the material used to make the model but also that the surface has remained as cast, without extensive chiseling in the metal. Determining whether the applied texture was added in the wax or the metal can be difficult. Although it is tempting to assume that indistinct texturing originated in the wax—due to the soft texture of the wax itself, with some loss of detail in the casting—and that sharp texture originated in the metal, it can be more complicated than this. Weathering, handling of the bronze over time, and repatination will soften surface details whether cast-in or applied in the metal. Alternatively, lost wax casting may allow the crisp transfer of very fine surface details formed in the wax, incorrectly appearing as cold work applied in the metal. Ultimately, a broad picture of the overall condition of the surface must be combined with any small remaining clues to determine how the punched and linear details were applied. Chiseling or the application of texture after casting may be suggestive of the artist's aesthetic vision for the final product, or may have been necessary as a result of surface flaws and repairs. Either way, the application of such cold work is extremely time-consuming, suggesting the participation of workshop assistants. An artist such as de Vries, who tended to avoid cold work, may have appreciated the close relationship of the as-cast surface to his original model, or he may have been motivated by more practical reasons, or both.

Repairs may be clearly visible on the surface of a bronze due to gaps at their edges or the different color of the cast-in or set-in metal. Set-in patches are generally geometric in shape and may be thinner than the surrounding bronze (therefore less dense in a radiograph). Cast-in repairs may be distinctive for their irregular shape and extra radiographic density compared to the surrounding bronze. The higher density of solder joins will be visible in radiographs, and the whitish color of solder metal may also be visible on the surface. Distorted surface features may be due to hammering to hide flaws. Porosity holes can generally be differentiated from core pin holes as the latter always extend through the entire thickness of the bronze and can be relatively uniform in size and shape.

What changes have occurred over time? Determination of what changes have occurred and why allows a clearer understanding of the artist's techniques and intentions, as well as insight into a sculpture's history of use, exhibition, and repair. It is important to understand the type and extent of corrosion, restoration, or other alterations that have changed the artist's original intentions for the appearance or structure of a work. Corrosion or surface abrasion from misguided cleanings can soften surface details, making them difficult to decipher. Corrosion may remove all evidence of the original patina. Repatination of a bronze may be difficult to determine, although a characteristic thin and even brownish chemical patina on a sixteenth- or seventeenth-century bronze (before this technique was commonly used) clearly suggests a later repatination. Expansion of iron elements inside a sculpture due to corrosion may cause splitting or staining of the bronze, leading to surface repairs and removal of the iron. Surface examination can help to determine whether or not all of the separately cast parts, including bases, are original; surface examination permits assessment of the different colors of the metal, the different handling of the modeled surface, and the different conditions of the parts. Recent repairs may be identified visually if they were made using techniques not typical of the artist or materials (such as machine screws) not available at the time.

All the bronzes discussed in this volume were carefully examined visually and through X-ray radiography for hints as to how they were created and why they look the way they currently do. The results can be found in chapters 7 through 31, which provide the bulk of the data on which the concluding chapter is based.

NOTES

1 A Zeiss binocular microscope with a 200 mm secondary objective and a 6× to 40× primary objective was used for this project. The microscope is mounted on a rolling stand with an extendable arm that allows swiveling of the head from a vertical to a horizontal position.

2 The full term *X-ray radiography* is used here to distinguish the technique most commonly used in the examination of bronzes from other imaging techniques, including neutron radiography, beta-radiography, and gamma-radiography. A brief description of the use of these additional techniques for the examination of cultural materials can be found in Lang and Middleton 2005: 2–5.

3 Digital capture of X-rays, now used almost exclusively in medicine, has great potential for the examination of sculpture once issues such as the long-term accessibility of the data have been solved.

4 Large bronzes can also be radiographed using gamma-radiography, in which solid columns of radioactive sources such as Iridium 192 and Cobalt 60 produce radiation on the order of 600 kV and 1,300 kV, respectively. Gamma-radiography was used in the examination of two life-size bronzes in the collections of the National Gallery of Art, Washington, D.C. (Ozone and Sturman 2003: 206). The disadvantages of radioactive sources include safety considerations and comparatively low-contrast images.

5 Kodak Industrex MX-125 film in two sizes, 14 × 17 in. and 8 × 10 in.

6 Techniques such as real-time radiography and tomography, in which the sculpture is placed on a turntable and multiple or continual images are captured, allow for clarification of the exact location of features inside a structure. An example of the use of neutron radiography and tomography for the examination of Renaissance bronzes can be found in Visser 2005. An example of tomography using X-rays can be found in Bettuzzi et al. 2004 and Casali et al. 2005a, 2005b.

7 It should be kept in mind that the core of an indirect lost wax cast can be made in a method similar to that often used in sand casting, confusing the determination of the casting method that was used. In this variant of the indirect process, the core is formed inside the plaster piece molds, producing a replica of the model in refractory material. The core is then cut down to the desired size. This process of paring down the core will give the interior of the bronze the appearance of a sand cast. This technique is described in Biringucci, Smith, and Gnudi 1990: 230. It is currently in use in the Fonderie de Coubertin in Paris as one method of indirect lost wax casting.

CHAPTER 4

X-Ray Fluorescence Alloy Analysis

by David A. Scott

The composition of the alloys used to cast the seventeen de Vries bronzes and eight comparative pieces included in this study was determined using X-ray fluorescence analysis. This technique allows the immediate determination of a wide range of elements without removing a sample from the artifact. Alloy analysis was undertaken in order to add to the existing data for de Vries bronzes,[1] as well as to further our understanding of the attributed casts and those of unknown authorship. Although a range of alloys are found in Renaissance and later bronzes, de Vries consistently cast in a bronze alloy containing primarily copper and tin, with less than 1 percent zinc and lead. Due to this relatively narrow alloy range, a comparison of metal compositions can be useful in authentication studies for bronzes attributed to Adriaen de Vries.

The term *bronze* is often used generically in art historical contexts to describe sculptures cast of a copper alloy of unknown chemical makeup. In technical nomenclature, *bronze* refers to a mixture containing primarily copper and tin; *brass*, primarily copper and zinc. When metals are alloyed, changes in the atomic structure result in radical alteration to the mechanical and chemical properties of the resulting alloy. For example, the color of pure copper is a pale red. Addition of about 12 percent tin makes the alloy color very golden, and the microhardness of the resulting alloy, even in the cast condition, is increased from about 60 Hv to about 140 Hv.[2]

Trace elements found in ancient and historic copper alloys enter the mix in a variety of ways. First, the copper that is smelted from the ores may contain impurities such as antimony, arsenic, silver, gold, selenium, iron, cobalt, nickel, lead, and zinc. The concentrations of these impurities are generally quite low, in the parts per million (ppm) range. For example, silver may be present but in the range of 30 to 500 ppm. Next, elements may be gained or lost in the process of ore beneficiation processes, such as roasting. Here, more volatile elements such as arsenic or sulfur may be partially lost before smelting. In the case of sulfur, this is beneficial, since it is far easier to smelt partially oxidized ores than the copper sulfide raw material. Elements may be lost or exchanged from furnace linings or fuel ash during the smelting process. Elements may be contributed by deliberate alloying as well, which is the case with the de Vries bronzes, in which addition of tin would have brought another suite of trace elements that could be accumulated with the trace elements derived from the copper itself. Thus, nickel may originate principally from the copper ore used by the smelters who supplied the foundry with the copper metal used in the sculptures. Lead may be partially introduced by the tin and the original copper alloy, since it is quite possible that the tin used would have contained accompanying small amounts of impurities, such as lead or zinc.

INSTRUMENT AND PROCEDURE USED IN THE ANALYTICAL STUDIES

X-ray fluorescence analysis has a long and significant history in its application to the analysis of works of art (Hall 1959; Hall, Banks, and Stern 1964; Hall, Schweizer, and Toller 1973). The technique is now a standard method of analysis available as hand-held portable instruments, bench-top models, and free-standing instruments operated in lead-lined rooms. X-ray fluorescence spectrometers can be divided into wavelength dispersive systems, which are generally more demanding but are better able to detect trace amounts, and energy dispersive systems, which are easier to use but do not have the sensitivity of wavelength dispersive instruments. Developments in detector technology have resulted in the increasing use of hand-held instruments as they now provide good resolution and are portable. The instrument used at the Museum Research Laboratory of the Getty Conservation Institute for this study of bronzes was a Kevex 0750A secondary-target X-ray fluorescence spectrometer (STXRF).

The advantages of STXRF are that the overall background radiation in the spectrum is kept very low due to the use of the secondary target, which is energized by the primary X-ray beam. The disadvantage of using secondary target excitation is that the energy of the primary beam is much reduced due to the secondary nature of the excitation. The larger power requirements usually prevent the secondary targets from being used in portable, hand-held units. The barium/strontium (Ba/Sr) secondary target used during this study was made up of three parts of strontium carbonate and one part of barium carbonate by weight, pressed into a pellet. Barium-strontium STXRF was employed specifically for bronze alloy analyses, since the barium provides excellent excitation of antimony, tin, and silver Ka lines, and strontium provides very good excitation of lead, gold, zinc, copper, nickel, arsenic, iron, platinum, cobalt, and manganese, all of which could be potentially of importance in the analysis of Renaissance and later bronze alloys. The X-ray beam was focused with a collimator measuring 6 mm on the detector and 2 mm on the X-ray tube.

The Kevex X-ray fluorescence instrument operates in free-standing mode in a lead-lined room with a laser and light combination spot finder that is adjusted to the position where the beam hits the object surface (fig. 4.1).

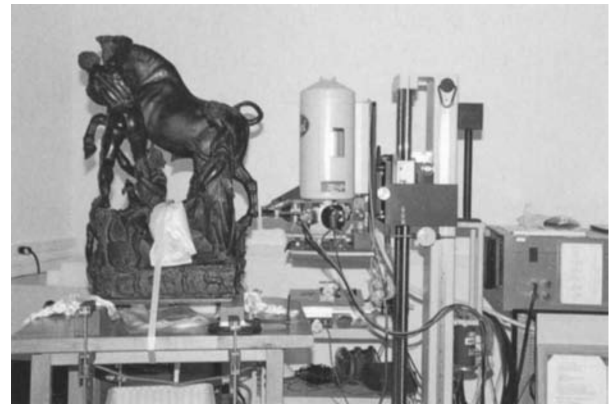


FIGURE 4.1 The *Farnese Bull* undergoing secondary target XRF analysis in a lead-lined room in the Museum Research Lab of the GCI. The beam is focused on the bull's right rear leg.

MEASUREMENT PROTOCOL

XRF spectra were acquired for 200 seconds at 50 kV 30 mA with the Ba/Sr secondary target and the results were calibrated against a standard that closely approximates the composition of the bronze alloy customarily used by de Vries.[3] This standard used for calibration contained copper, lead, tin, nickel, zinc, and iron but did not contain any silver or arsenic, which consequently had to be determined separately.[4] The results of the analyses were always normalized to 100 percent to counteract the variations that result from analyzing surfaces that are not flat (Carter 1978; Lal and Narang 1989).

Ideally, the surfaces of the object to be examined by X-ray fluorescence analysis must be ground flat to remove any contribution from the corrosion or patina that may be present (Milazzo and Cicardi 1997). This is rarely practicable with very valuable Renaissance bronzes whose patina is an integral part of the artistic finish of the bronze itself, and therefore in this study, apart from the occasional analysis of the bottom of bases, the STXRF was conducted on patinated areas of the bronze. Renaissance bronze patinas tend to be quite thin compared with those found on ancient or buried bronzes, and therefore the degree of error introduced by analyses through the patina is assumed to be relatively slight (Carlson 1989; Mortimer 1993).[5]

Studies of the organic composition of bronze patinas have been incomplete and are lacking here, due in part to the fact that the objects were on loan and and to time constraints. Further information for general application to Renaissance sculpture can be found in Stone, White, and Indictor (1990).

It is important to obtain readings from different parts of the same sculpture to assess variability, if possible, when using any analytic technique, and this is especially important and practicable in the case of the study of bronze surfaces by XRF analysis. Since the analysis is completely nondestructive, one can study as many parts or regions of the surface as desired. In many of the bronzes discussed here, where time allowed, we were able to carry out four or five different analyses on the bulk alloy of a bronze, which has often provided very useful information. Different parts of the bronze may be cast separately or have different surface features and appearance, which can be examined very effectively by XRF analysis.

The presence of lead in an alloy may produce a segregated microstructure in which lead is either drawn toward the bottom of the casting through gravity segregation or present in large globules that will produce unpredictable variations in the quantitative results of the STXRF. In general, the fact that lead is present in copper alloys at casting temperatures in the form of two emulsions helps to keep the lead randomly distributed in the copper alloy when it cools down from the melt. The results of STXRF analysis on leaded copper alloys are therefore not as variable as might be supposed. Once it enters the bronze, the X-ray fluorescence beam will spread in a lightbulb-shaped volume that is dependent on the size of the collimator, the angle of incidence of the beam, and the nature of the alloy matrix. The volume of the space sampled nondestructively is therefore much larger than the small size of the X-ray beam that impinges on the sample surface.

X-RAY FLUORESCENCE STUDIES OF DE VRIES BRONZES

De Vries appears to have been generally quite particular in his specifications regarding alloy composition. The results of the X-ray fluorescence studies, in approximate terms, revealed that the bronzes are consistently cast in a tin bronze with low levels of lead and zinc, often with a little antimony, nickel, iron, and arsenic and a trace of silver. The overall results of the many X-ray fluorescence analyses carried out in the course of this study are shown in table 4.1. This consistency in alloy contrasts markedly with the variation in elemental composition found in the work of such artists as de Vries's contemporary Hubert Gerhard (ca. 1540/50–before 1621), who worked in Augsburg, Munich, Mergentheim, and Innsbruck. Published data on Gerhard's large sculptures reveal varying amounts of tin, zinc, and lead, yielding a range of alloys from bronze to leaded brass to leaded bronze (Diemer, Gerhard, and de Cesare 2004). This variation would be expected from the variety of copper alloys and recycled scrap that were available to foundries and workshops in the Renaissance. It is therefore quite surprising to discover that de Vries preferred to work within rather closely defined compositional parameters; that is, he preferred to cast his sculptures in a tin bronze rather than a range of different compositions that would have been available. The relative uniformity of de Vries's casts compared to those of Gerhard, as an example, are illustrated in figure 4.2.[6] This consistency in de Vries's alloy composition was observed for bronzes dating from the earliest casts attributed to him in the 1590s through the end of his life in 1626, suggesting that de Vries must have exercised control or given precise instructions concerning the nature of the alloy with which his bronzes would be cast (Bewer 2001: 179).

Giambologna, with whom de Vries worked early in his career, also cast in a bronze alloy composed primarily of copper and tin, although, as illustrated in figure 4.3, lead and often zinc were added to Giambologna's alloys, again setting them apart from the relatively pure mixture of copper and tin preferred by de Vries.

Aside from the issue of the control of alloy composition, we have to wonder what advantages a tin bronze may have offered, over, say, brass or leaded brass and leaded bronze alloys. One possibility is that de Vries preferred the kind of patina that would result from use of this kind of alloy. If the bronze was intended to be displayed outdoors, then the presence of lead and zinc may have resulted in a darker or less controllable patina developing on the sculpture, and this could have been an influence on the choice of a tin bronze. De Vries may also have preferred to work in a tin bronze that at a tin content of 10 percent melts at about 1,000 degrees centigrade but does not become fully solidified until 850 degrees centigrade. But leaded tin bronzes and brasses have low melting points too, so what would

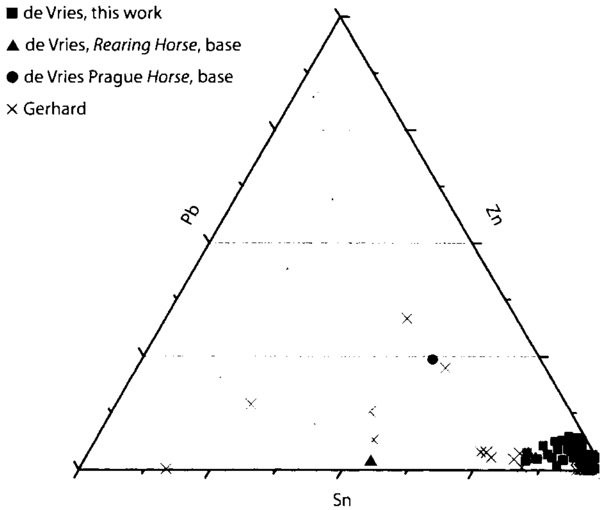


FIGURE 4.2 Spectra for the *Putto with a Goose* have been omitted due to contamination with repair lead. The two outliers are the separately cast bases of the *Rearing Horse* and Prague *Horse*. Source for de Vries data, table 4.1; source for Gerhard data, Diemer, Gerhard, and de Cesare 2004.

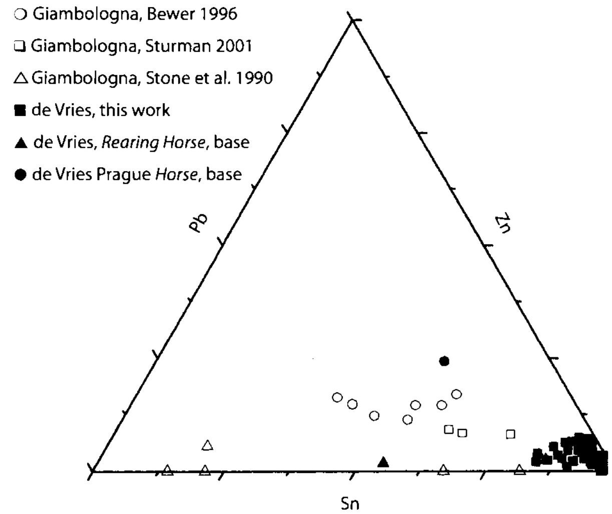


FIGURE 4.3 Source for de Vries data, table 4.1; source for Giambologna data, Bewer 1996; Stone, White, and Indictor 1990; Sturman 2001.

be that special about a 10 percent tin bronze by comparison? Perhaps de Vries liked the hardness of the alloy; he often appears to have used even more than 10 percent tin in his castings, which would make the surface even harder. Does that suggest it was the purity of the conception of his alloy that de Vries wanted, despite the fact that tin is more expensive than lead or zinc, or the patina that he was particularly concerned with?

The patina that develops on bronzes containing lead and zinc may become darker with time than that on bronzes that contain only tin as the major alloying element. This is due to the greater ease with which lead and zinc are corroded compared to tin, whose compounds are more likely to directly influence the patina in a predictable manner (Scott 2002). Indeed, in the case of the *Juggling Man* in the collections of the Getty Museum, which was exhibited outdoors for many years, the patina was found to contain substantial amounts of tin oxides, including romarchite and hydroromarchite (Scott 2002: 221). These hydrated tin oxides are part of the very insoluble patina that tin bronzes may accrue over years of exposure, producing a relatively stable surface with comparatively minimal loss of surface detail.

The general consistency of the elemental composition data can provide some basis for the authenticity of a de Vries bronze when there are art historical problems in attribution, or issues of later repairs. In the case of the *Mercury and Psyche* in the Huntington Art Collections (chapter 28), once attributed to de Vries, the alloy is a brass, a composition that appears to be entirely anomalous in terms of the artist's oeuvre. In such a case, the art historical evidence would have to be very strong indeed before the sculpture would be attributed to de Vries himself.

Some typical histograms showing elemental variation in the same bronze object, taken from different areas, and results for some of the objects examined in this study are shown in figures 4.4 and 4.5. Figure 4.4 shows the results obtained from different areas of the surface of the *Psyche Borne Aloft by Putti* in the Nationalmuseum, Stockholm. Note the slight variation in the results obtained. This degree of variation is quite typical but represents only a minor degree of fluctuation in the overall results for this sizable sculpture. Different types of composition of the same object are clearly revealed in the histogram shown in figure 4.5 for the *Lazarus* in the Statens Museum

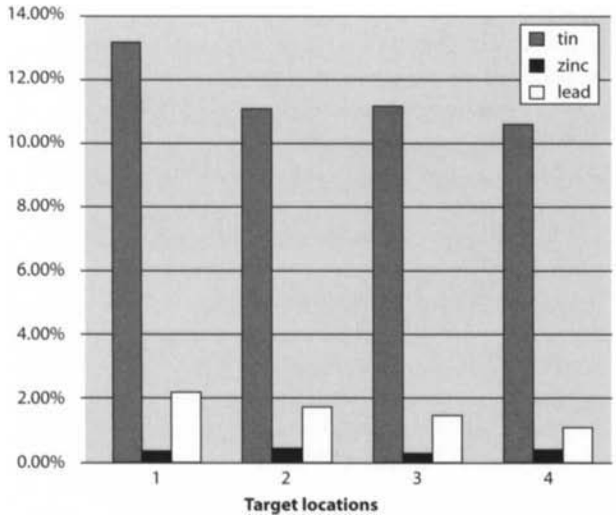


FIGURE 4.4 Histogram of *Psyche Borne Aloft by Putti*, Nationalmuseum, Stockholm.

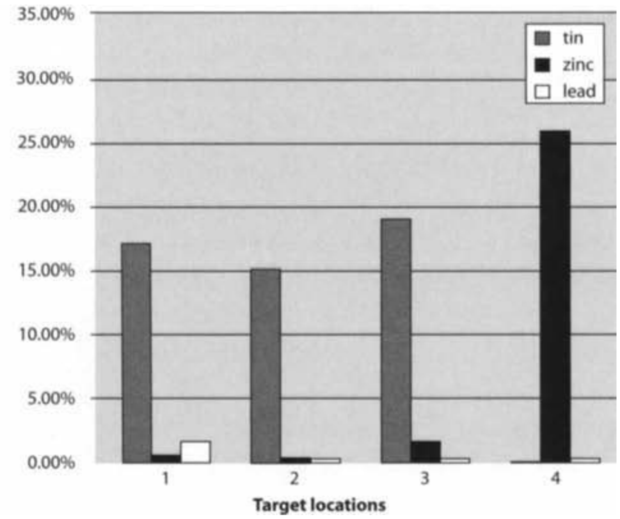


FIGURE 4.5 Histogram of *Lazarus*, Statens Museum for Kunst, Copenhagen.

for Kunst, Copenhagen. Here, one of the XRF analysis locations reveals a very much higher concentration of zinc, over 20 percent, compared to less than 1 percent in other locations. This, in fact, is the location for the right ring finger, made in a brass alloy, which is clearly a replacement.

The tin content of the de Vries casts was found to usually range from 6 to 17 percent.[7] Binary bronzes above 17 percent present a particular challenge once the bronze is cast, as the elevated tin causes the alloy to be very hard and brittle and will not allow cold working (Scott 1991: 26). Considering the tremendous expense involved in the fettling and chasing of a bronze, it is of note that a tin content at or above 17 percent was found on five of the de Vries casts: *Cain and Abel* from Edinburgh, *Farnese Bull, Lazarus, Putto with a Goose,* and *Laocoön.* Individual analysis sites on these bronzes contain as much as 66 percent tin. The elevated tin content on all these bronzes is likely a result of inverse segregation, in which the tin-rich phases of the alloy rose to the surface of the casts as they cooled, and is reflective of the surface content only, not of the overall bulk alloy.[8] The silvery patches in the patina of the *Laocoön* showed about 30 percent tin content in an area on the cheek of the supine son (see fig. 25.3), which is almost certainly due to inverse segregation of the bronze alloy, so that in this case the variation in tin concentrations ranged from 19 to 30 percent tin as measured on the surface. Bewer (2001: 166–67) reports the results of alloy analysis of twenty-eight de Vries casts using techniques in which the samples were removed by drilling, with resulting tin content of between 5 and 12 percent. Drilling ensures that the alloy measured is more representative of the bulk, avoiding the effects of surface patination, contamination, or, as in this case, enrichment. The results produced using a drilled sample should be considered more reliable for the overall alloys. Due to extensive inverse segregation, this comparison is an extreme case, highlighting the care that must be taken in interpreting the results of surface analysis techniques.

The comparison factor is an important one here. The results should be internally consistent within certain parameters, which allows the individual sculptures to be compared with each other, even if the absolute values of the analytical results are not completely reliable because of problems associated with the surface analysis technique employing STXRF analysis. Because of the relatively narrow alloy range used by de Vries, metal analysis proved useful in the study of the eight comparison bronzes included in this project. Of the three casts attributed to de Vries in the exhibition catalogue whose attribution is now questioned based on the technical studies (*Faun and Nymph, Crucifix,* and the Braunschweig *Venus*), the first two fall just outside de Vries's range of alloys—with a small amount of added zinc and lead in the *Faun and Nymph* and a bit of added zinc in the *Crucifix.* The leaded brass alloy used to cast the Braunschweig *Venus* falls completely out of the range. The alloy comparisons are just one additional piece of information leading to the determination that the attribution for these three bronzes should be reconsidered.

Two of the comparison pieces, *Mercury,* attributed to Willem van Tetrode, and *Mercury and Psyche,* for which attributions to both Hubert Gerhard and Casper Gras have been posited, are both brasses, reminding us of the preference for this alloy in foundries with Northern influences. *Christ Mocked* was cast in a relatively pure copper alloy, with a small amount of added tin, zinc, and lead, a result that gets us no closer to an attribution for this casting. The two *Hercules, Nessus, and Deianeira* aftercasts are both brasses, with approximately 13 percent zinc in the Nelson-Atkins version and 25 percent zinc in the version in the Rijksmuseum. A comprehensive study of the alloys of French eighteenth- through twentieth-century cast copper alloy sculptures has yet to be published but may one day help in the dating of these two bronzes.

NOTES

1 Bewer 1998; Bewer 2001: 166–67. The latter publication lists alloy content for thirty de Vries bronzes, many of which were analyzed in preparation for the exhibition catalogue (Scholten 1998a).

2 "Hv" refers to the Vickers diamond pyramid indentation hardness, which is a good example of how the alteration in mechanical properties of the alloy can be measured.

3 The appropriate standards to be used for an unknown alloy can be determined by first performing qualitative analysis of the surface in order to identify the individual components of the metal and their approximate concentrations. In this instance, previous work on de Vries's alloys was available from the two de Vries bronzes at the J. Paul Getty Museum, as well as the results published in Bewer 1998: 72.

4 Silver and arsenic standards were used for this purpose and employed for making a calibration curve. These were made from standards of silver, over the range from about 0% silver to 0.5% silver and from 0% arsenic to 2% arsenic. The percentages of any silver and/or arsenic that was determined to be present were subtracted from the overall copper content. Since the copper content is so high, the amount of error in adding in the silver and arsenic and subtracting the 0.1% to 0.5% from the copper total is very small and is insignificant in terms of the overall copper content of these alloys.

5 It should be noted that the effects of surface patina on the results are relatively slight when using the high voltage and current of units such as the Kevex XRF system. Units with lower voltage and current will show a greater effect from the patina, as the less intense X-rays are stopped more effectively by the patina.

6 It should be noted that the only de Vries casts that fall outside this cluster are the only separately cast bases in the study—those from the two horse compositions.

7 Here we should make a careful distinction between "high-tin bronzes" and "low-tin bronzes." High-tin bronzes are those binary alloys that contain over 20% tin and that often possess special working properties if quenched (Scott 2002). Low-tin bronzes are alloys that possess less than 20% tin, usually from 1% to 14%, since 14% generally marks the ordinary limit of the possible solid solution of tin in copper, known as the alpha phase. While the tin content of some of de Vries's bronzes is quite substantial, they should not be referred to as high-tin bronzes for the reason stated above.

8 Inverse segregation arises when a lower melting point phase, here the delta phase, is extruded to the surface through interdendritic channels in the bronze as the alloy cools down from the melt. Inverse segregation is an inadvertent effect and likely could not have been controlled using the available technology. The possibility that inverse segregation of tin will occur increases as the tin content is increased.

TABLE 4.1 Alloys: Overall Results of XRF Analyses

Chapter	Title	Target	Cu	Sn	Zn	Pb	Sb	Ni	Fe	As	Ag
7	*Psyche Borne Aloft by Putti*	Proper left knee of uppermost putto	81%	13%	<0.5%	2%	1%	<0.5%	<0.5%	1%	<0.5%
7	*Psyche Borne Aloft by Putti*	Proper left shin of lowermost putto	84%	11%	<0.5%	2%	1%	<0.5%	<0.5%	1%	<0.5%
7	*Psyche Borne Aloft by Putti*	Proper left knee of Psyche	84%	11%	<0.5%	1%	1%	<0.5%	<0.5%	1%	<0.5%
7	*Psyche Borne Aloft by Putti*	Outer edge of Psyche's proper right hand	85%	10%	<0.5%	1%	1%	<0.5%	<0.5%	<1%	<0.5%
8	*Faun and Nymph*	Faun—proper left shoulderblade	91%	6%	2%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
8	*Faun and Nymph*	Faun—proper right inside of calf	88%	7%	3%	1%	<0.5%	<0.5%	<0.5%	<0.5%	trace
8	*Faun and Nymph*	Faun—bottom of proper right foot at heel	81%	9%	4%	4%	<0.5%	1%	<0.5%	<0.5%	<0.5%
8	*Faun and Nymph*	Nymph—back of pedestal	89%	7%	2%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	trace
8	*Faun and Nymph*	Nymph—proper left buttocks	88%	7%	2%	1%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%
8	*Faun and Nymph*	Nymph—proper left side of head, headband	89%	6%	2%	1%	<0.5%	<0.5%	<0.5%	<0.5%	trace
8	*Faun and Nymph*	Faun—top of head solder around plug	33%	41%	<1%	24%	trace	<0.5%	<1%	<0.5%	trace
8	*Faun and Nymph*	Faun—top of head, plug	80%	11%	2%	5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
9	*Crucifix*	Proper right hand below thumb	87%	10%	1%	0.5%	<0.5%	<0.5%	<0.5%	trace	nd
9	*Crucifix*	Proper left breast	86%	9%	1%	<0.5%	<1%	<0.5%	trace	2%	<0.5%
9	*Crucifix*	Lower abdomen center	88%	10%	1%	<1%	0.5%	<0.5%	trace	<0.5%	<0.5%
9	*Crucifix*	Proper right hip, non-tarnished area	88%	10%	1%	<0.5%	<0.5%	<0.5%	trace	<0.5%	<0.5%
9	*Crucifix*	Titulus: between R and I	89%	10%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
9	*Crucifix*	Proper left shin repair	86%	9%	4%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%
9	*Crucifix*	Top of right foot repair	86%	8%	4%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%
10	*Venus* or *Nymph*	Left knee	82%	3%	11%	2%	<1%	<1%	<1%	<1%	<0.5%
10	*Venus* or *Nymph*	Back of right hand	80%	3%	11%	3%	1%	<1%	<1%	<1%	<0.5%
10	*Venus* or *Nymph*	Base in back	80%	3%	12%	2%	<1%	<1%	<1%	<1%	<0.5%

TABLE 4.1 cont.

Chapter	Title	Target	Cu	Sn	Zn	Pb	Sb	Ni	Fe	As	Ag
11	*Bust of Emperor Rudolph II*	Proper left side, fringe on scarf	84%	14%	<0.5%	<0.5%	0.5%	<0.5%	<0.5%	<0.5%	trace
11	*Bust of Emperor Rudolph II*	Bottom of skirt, proper right side	85%	13%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
11	*Bust of Emperor Rudolph II*	Proper left knee of figure on proper right side	83%	15%	<0.5%	<0.5%	<0.5%	<0.5%	trace	<0.5%	<0.5%
12	*Bust of the Elector Christian II of Saxony*	Outer drape on proper left figure	91%	6%	<0.5%	<0.5%	2%	<1%	<0.5%	<0.5%	trace
12	*Bust of the Elector Christian II of Saxony*	Back of head, flat area	91%	6%	<0.5%	<0.5%	2%	<1%	<0.5%	<1%	<0.5%
12	*Bust of the Elector Christian II of Saxony*	Curl on left side	91%	5%	<0.5%	<0.5%	2%	<1%	<0.5%	<1%	<0.5%
12	*Bust of the Elector Christian II of Saxony*	Chin	90%	6%	<0.5%	<0.5%	2%	<1%	trace	<1%	<0.5%
13	*Hercules, Nessus, and Deianeira* (Louvre)	Base under Nessus's proper left front leg	86%	13%	<0.5%	<0.5%	<0.5%	<0.5%	trace	<0.5%	trace
13	*Hercules, Nessus, and Deianeira* (Louvre)	Base below Hercules' proper left foot	85%	13%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
13	*Hercules, Nessus, and Deianeira* (Louvre)	Nessus's proper right haunch	86%	13%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
13	*Hercules, Nessus, and Deianeira* (Louvre)	Hercules' outer proper left thigh	85%	14%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
13	*Hercules, Nessus, and Deianeira* (Louvre)	Deianeira's proper right buttocks	85%	13%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
13	*Hercules, Nessus, and Deianeira* (Louvre)	Top of Nessus's tail	86%	12%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
14	*Allegory of the War against the Turks in Hungary*	Forehead of the female figure personifying the Danube	89%	9%	<0.5%	<0.5%	<1%	<0.5%	trace	<0.5%	<0.5%

TABLE 4.1 cont.

Chapter	Title	Target	Cu	Sn	Zn	Pb	Sb	Ni	Fe	As	Ag
14	*Allegory of the War against the Turks in Hungary*	Center of banner above Discordia, chained woman in center background	89%	10%	<0.5%	trace	<1%	<0.5%	trace	<0.5%	<0.5%
14	*Allegory of the War against the Turks in Hungary*	Proper left knee of the personification of Hungary, the seated woman next to fortress	90%	9%	<0.5%	trace	<1%	<0.5%	trace	<0.5%	<0.5%
14	*Allegory of the War against the Turks in Hungary*	Proper left bottom corner repair	90%	9%	<0.5%	<0.5%	<0.5%	<0.5%	trace	trace	<0.5%
14	*Allegory of the War against the Turks in Hungary*	Proper left bottom corner, lower rivet on repair	85%	3%	12%	<0.5%	<0.5%	<0.5%	<0.5%	trace	trace
15	*Rearing Horse**	From sprue	na	9%	nd	<0.5%	<0.5%	trace	nd	trace	trace
15	*Rearing Horse**	Polished base mid-right side	87%	7%	<0.5%	1%	<0.5%	<0.5%	<0.5%	<0.5%	trace
15	*Rearing Horse**	Polished base	86%	6%	<0.5%	5%	<1%	<0.5%	<0.5%	<0.5%	trace
15	*Rearing Horse**	Polished base front left side	88%	7%	<0.5%	1%	<0.5%	<0.5%	<1%	<0.5%	trace
16	*Horse*	Proper right side toward foreleg	89%	10%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
16	*Horse*	Proper right haunch	87%	10%	<0.5%	1%	<0.5%	<0.5%	<0.5%	<0.5%	trace
16	*Horse*	Top of tail	88%	10%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
16	*Horse*	Proper right side toward haunch	89%	10%	<0.5%	<0.5%	<0.5%	<0.5%	trace	<0.5%	trace
16	*Horse*	Proper right side of base	85%	7%	3%	3%	<1%	<0.5%	<0.5%	<0.5%	trace
17	*Vulcan's Forge*	Figure 1, proper right upper arm	92%	7%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	trace	trace
17	*Vulcan's Forge*	Figure 1, proper right thigh	92%	7%	<1%	trace	<0.5%	<0.5%	trace	trace	trace
17	*Vulcan's Forge*	Cuirass	89%	9%	<1%	<0.5%	0.5%	<0.5%	<0.5%	<0.5%	trace
17	*Vulcan's Forge*	Figure 5, proper left thigh	92%	7%	<0.5%	trace	<0.5%	<0.5%	trace	trace	trace
18	*Cain and Abel* (Edinburgh)	Abel's proper right elbow	81%	17%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%
18	*Cain and Abel* (Edinburgh)	Abel's proper right outer thigh	82%	17%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%

TABLE 4.1 cont.

Chapter	Title	Target	Cu	Sn	Zn	Pb	Sb	Ni	Fe	As	Ag
18	*Cain and Abel* (Edinburgh)	Cain's back under proper right shoulder blade	81%	17%	0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
18	*Cain and Abel* (Edinburgh)	Corner under base, to the outside of Abel's left foot	79%	18%	<1%	<1%	<0.5%	<0.5%	<1%	<0.5%	<0.5%
18	*Cain and Abel* (Edinburgh)	Core pin plug on proper right shoulder	81%	16%	<1%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%
19	*Juggling Man***	Under base	na	11%	nd	<0.5%	trace	<0.5%	nd	nd	trace
20	*Farnese Bull*	Antiope's drape, 12.5 cm up from base	39%	58%	<0.5%	0.5%	1%	<0.5%	trace	<0.5%	trace
20	*Farnese Bull*	Side of base, in tree located in front of a deer	81%	17%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
20	*Farnese Bull*	Back of proper right rear leg of bull	82%	16%	<0.5%	<0.5%	<0.5%	<0.5%	<1%	<0.5%	trace
21	*Christ at the Column*	Proper right knee	82%	16%	<0.5%	<1%	<0.5%	<0.5%	<1%	<0.5%	trace
22	*Lazarus*	Below proper right rear foot of dog on under-side of base	78%	17%	<0.5%	1%	0.5%	<0.5%	2%	<0.5%	trace
22	*Lazarus*	Lazarus's proper right forearm	83%	15%	<0.5%	<0.5%	<1%	<0.5%	<0.5%	<0.5%	trace
22	*Lazarus*	Lazarus's lower back: smooth bright gold surface	78%	19%	1%	<0.5%	<1%	<0.5%	<0.5%	<0.5%	nd
22	*Lazarus*	Repaired third finger on Lazarus's proper right hand	74%	trace	26%	<0.5%	trace	<0.5%	trace	trace	trace
23	*Putto with a Goose*	Base under left foot—polished corner	75%	13%	2%	5%	<0.5%	<0.5%	3%	<0.5%	<0.5%
23	*Putto with a Goose*	Curl on putto's head—patina partially abraded	80%	17%	<0.5%	<1%	<0.5%	<0.5%	1%	<0.5%	trace
23	*Putto with a Goose*	Right outer forearm near elbow—green patina partially abraded	75%	21%	<0.5%	<1%	<0.5%	<0.5%	1%	<1%	<0.5%
23	*Putto with a Goose*	Back of proper right shoulder near armpit	31%	66%	<0.5%	<1%	1%	trace	<0.5%	<1%	<0.5%

TABLE 4.1 cont.

Chapter	Title	Target	Cu	Sn	Zn	Pb	Sb	Ni	Fe	As	Ag
23	*Putto with a Goose*	Front tip of upper beak	73%	17%	<0.5%	7%	<0.5%	<0.5%	<1%	0.5%	trace
23	*Putto with a Goose*	Dovetail repair on base—polished bottom edge	53%	7%	1%	33%	3%	<1%	<1%	1%	trace
23	*Putto with a Goose*	White metal repair below goose tail	nd	34%	nd	66%	nd	nd	nd	nd	nd
24	*Cain and Abel* (Copenhagen)	Below Abel's proper right elbow, gold-colored area	85%	11%	<1%	1%	<0.5%	<0.5%	<0.5%	<0.5%	trace
24	*Cain and Abel* (Copenhagen)	Abel's proper right outer thigh, in green tarnish area	85%	12%	<1%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	trace
24	*Cain and Abel* (Copenhagen)	Abel's proper right buttock in dark area	86%	12%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
24	*Cain and Abel* (Copenhagen)	Cain's proper left outer thigh in gold area	86%	12%	<1%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	trace
24	*Cain and Abel* (Copenhagen)	Cain's proper right shoulderblade in gold area	86%	12%	<1%	<1%	<0.5%	<0.5%	<0.5%	<0.5%	trace
25	*Laocoön and His Sons*	Laocoön's proper left thigh, front	72%	24%	<0.5%	<1%	<1%	<0.5%	<1%	<0.5%	<0.5%
25	*Laocoön and His Sons*	Supine son, silver area on cheek near left ear	65%	29%	<0.5%	3%	<1%	<0.5%	1%	1%	<0.5%
25	*Laocoön and His Sons*	Supine son, black area on cheek below chin	76%	21%	<0.5%	<1%	<0.5%	<0.5%	1%	<0.5%	trace
25	*Laocoön and His sons*	Kneeling son—proper right outer shoulder	66%	30%	<0.5%	<1%	<1%	<0.5%	1%	<1%	trace
25	*Laocoön and His sons*	Laocoön's proper left thigh, front—odd patch of patina	78%	19%	<0.5%	<1%	<0.5%	<0.5%	<1%	<0.5%	trace
25	*Laocoön and His Sons*	Laocoön's left thigh, front—on rhomboid-shaped repair	81%	<1%	13%	3%	trace	<0.5%	1%	<0.5%	trace
25	*Laocoön and His Sons*	Laocoön's proper left thigh, front—rectangular repair center	94%	trace	10%	3%	trace	<0.5%	<0.5%	<0.5%	trace
25	*Laocoön and His Sons*	Laocoön's proper left thigh, front—small rectangular repair	76%	19%	<0.5%	3%	<0.5%	<0.5%	<1%	<0.5%	trace
26	*Hercules Pomarius*	Outer proper right thigh	83%	14%	<0.5%	<0.5%	<1%	<0.5%	<0.5%	<0.5%	trace

TABLE 4.1 cont.

Chapter	Title	Target	Cu	Sn	Zn	Pb	Sb	Ni	Fe	As	Ag
26	*Hercules Pomarius*	Lower proper right forearm	83%	15%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	<0.5%	trace
26	*Hercules Pomarius*	Proper right side—grape leaf addition	78%	2%	17%	2%	0.5%	<0.5%	<1%	<0.5%	trace
27	*Mercury* (Tetrode)	Proper left hip	84%	3%	8%	1%	1%	<1%	<1%	<0.5%	trace
27	*Mercury* (Tetrode)	Lower abdomen	77%	5%	10%	5%	1%	<1%	<1%	<0.5%	trace
27	*Mercury* (Tetrode)	Proper left arm	81%	1%	13%	2%	1%	1%	<1%	trace	trace
27	*Mercury* (Tetrode)	Proper left calf (repair soldered in place)	85%	2%	9%	1%	<1%	<1%	1%	<0.5%	<0.5%
28	*Mercury and Psyche* (artist unknown)	Psyche's proper right hip	72%	1%	25%	<1%	trace	<0.5%	<0.5%	<0.5%	trace
28	*Mercury and Psyche* (artist unknown)	Mercury's back, proper right side	72%	<1%	26%	<1%	trace	<0.5%	<0.5%	<0.5%	trace
28	*Mercury and Psyche* (artist unknown)	Inside of proper right wing on Mercury's head	77%	<1%	19%	2%	<0.5%	<0.5%	<0.5%	trace	trace
28	*Mercury and Psyche* (artist unknown)	Mercury's proper left hand	73%	<0.5%	25%	0.5%	trace	<0.5%	<0.5%	<0.5%	<0.5%
28	*Mercury and Psyche* (artist unknown)	Solder repair on Mercury's proper left forearm	16%	22%	8%	44%	<0.5%	trace	10%	<0.5%	trace
29	*Christ Mocked* (artist unknown)	Proper left shoulder	93%	2%	2%	2%	<0.5%	<0.5%	<0.5%	<0.5%	trace
29	*Christ Mocked* (artist unknown)	Polished area under base	94%	1%	2%	2%	<1%	<0.5%	<0.5%	<0.5%	trace
29	*Christ Mocked* (artist unknown)	Front of base	92%	1%	2%	2%	<1%	<0.5%	<1%	<0.5%	trace
30	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Nelson-Atkins	Front of Hercules' proper right shin	84%	2%	13%	<1%	trace	<0.5%	<0.5%	<0.5%	trace
30	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Nelson-Atkins	Deianeira's proper right elbow	84%	2%	13%	<1%	trace	<0.5%	<0.5%	trace	trace

TABLE 4.1 cont.

Chapter	Title	Target	Cu	Sn	Zn	Pb	Sb	Ni	Fe	As	Ag
30	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Nelson-Atkins	Back of Hercules' head	87%	2%	10%	<1%	trace	<0.5%	<1%	nd	nd
30	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Nelson-Atkins	Middle plug of five in Hercules' proper left outer thigh	70%	<0.5%	29%	<0.5%	trace	trace	<0.5%	trace	trace
30	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Nelson-Atkins	Nessus's proper left rear haunch	83%	2%	13%	<1%	trace	<0.5%	<0.5%	trace	trace
30	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Nelson-Atkins	Underside of base, polished area	84%	2%	13%	<1%	trace	<0.5%	<0.5%	trace	trace
31	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Rijksmuseum	Front of Hercules' proper right shin	71%	1%	26%	1%	trace	<0.5%	<0.5%	data lost	trace
31	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Rijksmuseum	Outside of Deianeira's proper left forearm	70%	1%	26%	2%	trace	<0.5%	<0.5%	data lost	trace
31	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Rijksmuseum	Back of Hercules' head	75%	1%	23%	<1%	trace	<0.5%	<0.5%	data lost	trace
31	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Rijksmuseum	Hercules' proper left shoulder	71%	1%	26%	1%	trace	<0.5%	<0.5%	data lost	trace
31	*Hercules, Nessus, and Deianeira* (attr. Crozatier), Rijksmuseum	Rear of Nessus's proper right haunch	73%	1%	24%	1.00%	trace	<0.5%	<0.5%	data lost	trace

trace: less than 0.1%.

nd: none detected.

* XRF analysis by Michael Schilling of the Getty Conservation Institute in 1986.

** ICP-MS analysis by West Coast Analytical Lab in 1995.

Major elements are accurate to approx. 5%, minor elements with less than 1% concentration to 30–40%.

[hatched box] shading indicates repairs or later addition.

[blue box] shading indicates a sculpture whose attribution is in question.

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CHAPTER 5

Core Analysis

by Ronald C. Schmidtling II

Analysis of the material used to form the inner mold—the core—was carried out for all of the bronzes examined at the J. Paul Getty Museum for which samples were available: fifteen de Vries bronzes and six comparison pieces of less certain authorship. Four additional bronzes that were included in the study did not receive core analysis, as there is no access to the interior cavity where the core remains (a list of these bronzes as well as those that were analyzed can be found in fig. 1.1). With the exception of the two sand casts, the cores examined here contain either clay or plaster as the primary constituent and are therefore categorized as either clay cores or plaster cores.[1] A mold used for bronze casting must be able to withstand the heat and turbulence of casting without burning, crumbling, excessive shrinkage, or cracking. For this reason, cores often include a variety of other materials, such as sand (primarily composed of quartz and feldspar), metal filings, or organic material (e.g., plant fibers). A variety of minerals that originate as natural inclusions in the clay are also found in core material.

Core analysis is undertaken in order to learn more about the specifics of the casting technique used for a particular bronze. In certain circumstances, the core composition may be one of the strongest indicators of casting method. A bronze with a plaster matrix was likely cast using the indirect lost wax technique. Although the components of a clay-based lost wax casting core can be quite similar to those in a sand casting core (basically clay and sand), the appearance of the latter is quite distinct when examined under magnification and can be an important aid in identifying the technique. Core analysis is also undertaken in order to gather data that may aid in the authentication of a bronze or a group of bronzes, based on the assumption that an artist or workshop is consistent in the materials used to make the core. In the course of this study and Bewer's earlier study of de Vries bronzes (2001),[2] it was determined that the artist used cores with a clay matrix, regardless of whether he was casting directly or indirectly. In contrast, the four comparison bronzes for which the lost wax process was used were cast with plaster-based cores; two additional bronzes are sand casts. Core analysis may sometimes be useful for determining the location where a bronze was cast. Although the minerals in a clay source may vary somewhat, providing some variation in the mineral contents of the cores made with that clay, the types of minerals will be determined by the geology surrounding the clay source.

RELATED WORK

The study of core materials is a relatively recent pursuit but shares many characteristics with studies dedicated to the petrographic analysis of ancient ceramics. Techniques used in these studies include microchemical testing, thin section analysis under polarized light microscopy, X-ray diffraction, and elemental analysis (Danson and Wallace 1956; Hodges 1962; Begg and Riley 1990; Jordan, Schrire, and Miller 1999).

Among the early studies of core material (Gettens 1969; Schneider 1989), the comprehensive work by Reedy (1991) established the foundation for the study of bronze casting cores. Her study included core materials from Himalayan bronze sculptures as well as some cores from European Renaissance bronzes. She reported that Himalayan cores almost always contained a high amount of carbon from burned plant material and tended to have rounded sand, whereas Renaissance cores contained more subangular sand and clay. Reedy also studied the quartz and feldspars in detail, to characterize the cores more fully.

Ron Schmidtling, in collaboration with Francesca Bewer, undertook thin section analysis of the cores of the Renaissance sculptors Giambologna and Susini and then a study of Renaissance cores from the Huntington Art Collection (see Bewer 1996), as well as Renaissance and later cores from the Getty Museum.[3] This led to further analyses of clays from the Getty *Aphrodite,* a Greek stone sculpture from the fifth century B.C.E. (Schmidtling 1997); cores from the analysis of a de Vries preexhibition study (Bewer 2001); and core materials from the Roman site of Francavilla (Scott 2003) and El Brujo (Schmidtling 2000). Further studies include that of casting cores of the late-eighteenth-/nineteenth-century sculptor Houdon (Schmidtling 2003) and the postexhibition study on Adriaen de Vries and related bronzes undertaken at the J. Paul Getty Museum and reported here. De Bari (2003) also studied a small group of Renaissance bronze cores, revealing differences in their composition. Each study has led to a deeper understanding of core materials, as well as a refinement of techniques for studying European casting cores.

METHODOLOGY

Four techniques were used to characterize the core materials in this study: visual analysis, microchemical analysis, X-ray diffraction (XRD), and polarized light microscopy (PLM). Each technique has its proper application and its limitations. Visual analysis allows one to determine texture, color, and overall structure without destroying a sample; however, the scale is limited to millimeters. Microchemical analysis uses wet chemistry to understand the makeup of core material that is too fine-grained to determine visually, but the sample is completely destroyed. X-ray diffraction uses X-rays to determine crystalline minerals in the core, and again the sample is destroyed. Polarized light microscopy uses a thin section of the core to characterize the minerals, their shape and size, and the microstructure of the core. In the latter case, the thin section presetves the core material on a slide. Statistical analysis of the data was also attempted, in order to achieve a visual comparison of the differences of the cores.

Samples of the cores (at least 20 mg) were removed with a scalpel or drill from the open bottoms or backs of the bronzes. Under a harder crust, the cores generally crumble easily when probed with a sharp tool. Portions of each sample were ground into a fine powder and used in microchemical testing and X-ray diffraction analysis. Another portion was impregnated in epoxy and made into a thin section for polarized light microscopy analysis. These three tests alter or destroy the sample, so care was taken to avoid using all of the material, if possible. However, some samples were rather small, and priority was given to the polarized light microscopy analysis.

Visual Analysis

Each sample was initially examined under low-power magnification in order to determine overall characteristics such as color and texture. Color may suggest the makeup of the core (e.g., a gypsum-based core will generally be white). The color of the clay in a core will give some indication of the conditions during firing, as an iron-containing core will turn red when heated under oxidizing conditions. A dark gray core sample removed from the *Farnese Bull* (2.5Y 4/1 "dark gray") was heated in a kiln for one hour at 1,000 degrees Celsius. The sample oxidized to a reddish color (7.5YR 6/6 "reddish yellow"), suggesting that the variable color of the cores may be due to the conditions within the bronze during heating. Munsell Soil Color Charts (1994) were used to record the color of many of the cores. Samples were photographed under 12× magnification and identical lighting conditions (fig. 5.1A–D), using a Leica MZ6 microscope. The study of texture may aid in the characterization of the material (e.g., is it crumbly or vitreous?).

Observation of the core materials under a Leitz Orthoplan microscope revealed that most cores were composed of clay with very fine sand, sometimes in chunks (fig. 5.1A) and sometimes as friable loose soil (fig. 5.1B). The cores ranged in color from pink to brown within the "Yellow Red" (YR) charts from Munsell (fig. 5.2). Core materials that lay outside the YR Munsell charts were from the Rijksmuseum

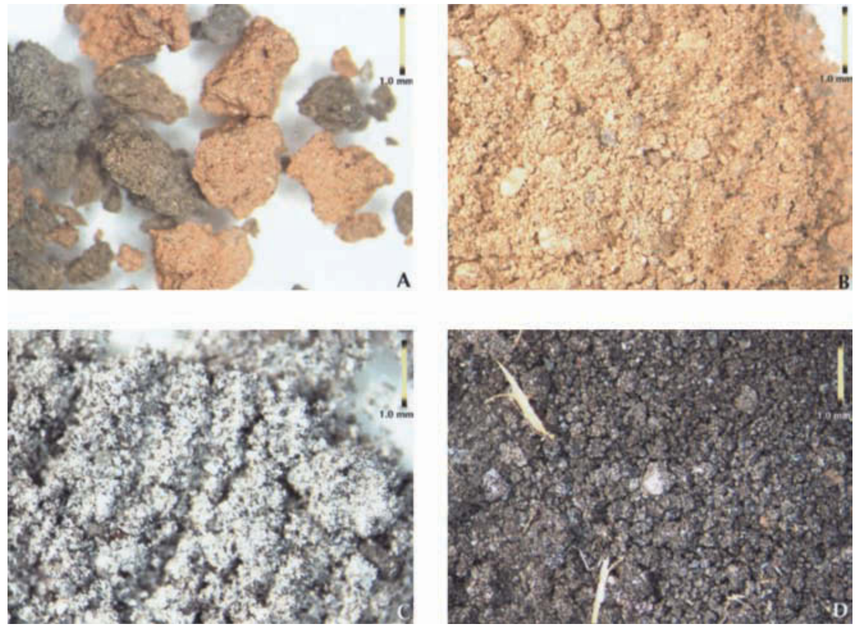

FIGURE 5.1 Dissecting microscope view of samples of core material showing the natural fine-grained condition of the samples. A: Core material from the *Bust of the Elector Christian II* (bust c). Note reddish and gray clay chunks with very fine angular sand grains that vary in size. B: Core material from *Hercules Pomarius* (vp 400). Note the orange color and the unconsolidated powdery texture, with large grains. C: Core material from *Venus* (bro 93), showing mainly white powder with dark specks of metal. D: Core material from the Rijksmuseum *Hercules, Nessus, and Deianeira* (bk 1957), showing loose sand grains covered by a thin coating of dark clay, with some yellowish wood fibers (postfiring contamination).

Hercules, Nessus, and Deianeira attributed to Crozatier (bk 1957) and the Copenhagen *Cain and Abel* (5492), and the Braunschweig *Venus* (bro 93), one of the two samples from *Laocoön* (sk68f), and the Nelson-Atkins *Hercules, Nessus, and Deianeira* attributed to Crozatier (Kcha). Detailed results for each core are given in section 2c of chapters 7 through 31.

Microchemical Analysis

Core materials historically are composed of primarily clay and sand, although other materials are frequently present.

FIGURE 5.2 Color chart of core materials (from Munsell Soil Color Charts 1994). The position of the sample names indicates value; the colors of the sample names are derived from the color charts. Most cores lie in the YR series, except for two in the Gley series and three in the Y series.

Visual analysis alone is often insufficient to identify the various components. Microchemical analysis allows one to distinguish, in a homogeneous matrix, clay from sulfate and carbonate. Although gypsum is generally white, identification by visual means can be deceiving as there could be rust staining or a dark color of added temper. Microchemical tests (MC) may determine the presence of calcium sulfate (gypsum, hemi-hydrate, or anhydrite) and calcium carbonate (calcite, aragonite, or dolomite). MC is a type of testing that is generally low-tech and thus is accessible to those who may not have elaborate laboratory equipment. However, MC results only indicate presence or absence of these components, and since a minute sample is used (often less than 1.0 mm^3), MC may not give an accurate expression of the whole core material. Other techniques, such as polarized light microscopy, can give a closer understanding of the proportions of each component.

In the core samples studied, three microchemical tests were done to determine the presence of calcium, carbonate, and sulfate ions. A very minute portion (approximately 1.0 mm^3 of sample) was immersed in dilute 0.1 M HCl to test for carbonate and to dissolve the sample. Fizzing indicated the presence of carbonate. The dissolved sample was separated into two parts. A drop of barium chloride solution was then added to one part, and a granular precipitate indicated the presence of calcium. In the other part, a drop of 72.5 percent sulfuric acid was added, and the growth of tiny needle-like selenite (gypsum) crystals indicated the presence of sulfate.

Microchemical analysis revealed the presence of calcium carbonate in most samples except the Nelson-Atkins *Hercules, Nessus, and Deianeira; Hercules Pomarius; Laocoön* e; and the *Allegory* relief. Calcium carbonate and calcium sulfate in combination were detected in *Christ Mocked;* the Louvre *Hercules, Nessus, and Deianeira; Christian II; Faun* sample "b"; and *Psyche.* Calcium sulfate without carbonate was detected in the Tetrode *Mercury;* the Rijksmuseum *Hercules, Nessus, and Deianeira; Venus;* and *Faun* sample "a." Although this microchemical test could not reveal the quantities of the materials present, it offered a glimpse into what would appear in later analyses.

Polarized Light Microscopy

Polarized light microscopy was the most telling of the analyses because large portions of the cores could be examined, instead of trying to describe the cores based on a tiny portion. PLM analysis not only yielded percentages of materials present but also confirmed what the microchemical tests and XRD analyses suggested.

Mounted and polished portions of the samples were analyzed using polarized light microscopy (fig. 5.3). PLM is a standard technique that geologists use to study the structure and composition of rocks. Usually, the rock is a solid, coherent object and thus easily polished. However, in the case of core materials, many are friable chunks of unconsolidated clays and sands. In order to consolidate the samples, they were impregnated with Petropoxy 154 (a type of epoxy resin) and mounted on a glass slide. The samples were then polished down to a thickness of 30 μm (Kerr and Rogers 1977).[4]

There were three major types of core materials identified by PLM. First, the majority of core materials analyzed had a dark red to gray clay matrix with fine angular sand. The sand grains ranged in size from 0.01 mm to 0.25 mm and included andesite rock fragments, metamorphic rock fragments, albite feldspar, hematite, and lamprobolite. The sec-

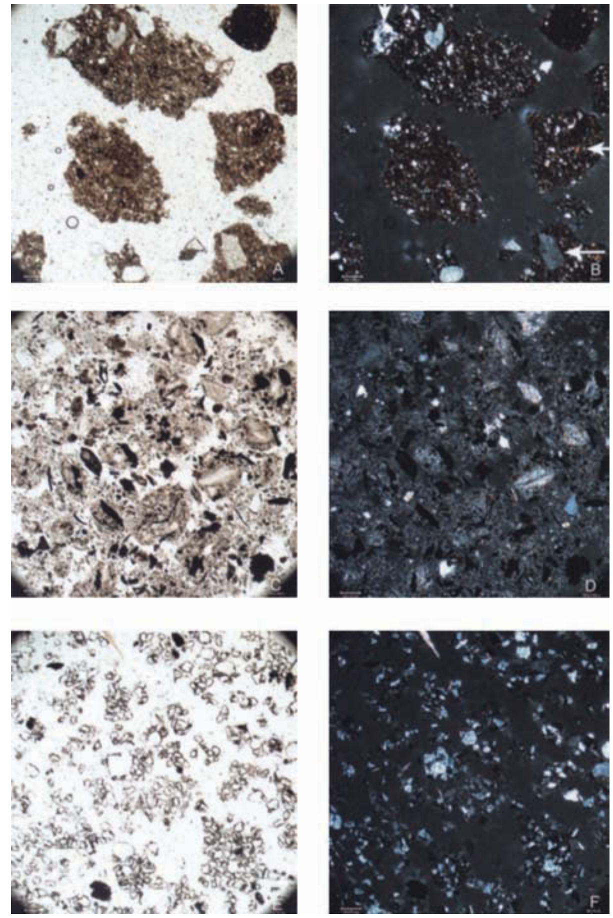

FIGURE 5.3 Thin section views of core materials (scale bar = 200 microns). A: Core material from the *Bust of the Elector Christian II.* Note reddish clay chunks with angular sand grains that vary in size. B: Same view as A under crossed polars, revealing a metamorphic rock fragment in the upper left, a large albite grain in the lower right, and a small oxy-hornblende (lamprobolite) grain shining bright red in the center right. C: Core material from *Venus,* showing mainly gypsum amid dark bits of carbon black and metal fragments. D: Same view as C under crossed polars, showing gypsum and anhydrite bright amid the dark metal and carbon fragments. E: Core material from *Hercules, Nessus, and Deianeira* attributed to Crozatier (Rijksmuseum), showing loose sand grains of roughly equal size, each outlined by a thin layer of dark clay. F: Same view as E under crossed polars, revealing homogeneous quartz sand with a bright yellowish splinter of wood in the top central edge of the frame.

ond type of core was gypsum-based, with very little sand. The third type was composed of mainly rounded sand that had dark rims of clay on each grain.

Most carbonates, like calcite (e.g., limestone) and dolomite (e.g., dolostone, a limestone with a high magnesium component), have very similar characteristics under the polarized light microscope. Sometimes, telltale structures give clues that can be tested with staining of the thin section itself. For example, in some of the core thin sections of this study, the carbonate grains had a dolomite-like ring structure. Staining techniques were done on the *Juggling Man* thin section to determine the carbonate portion. The Alizarin Red S test differentiating calcite, dolomite, and brucite and the Bromthymol Blue test differentiating calcite and dolomite were applied.

Among the most common material found in the de Vries cores besides the clay matrix is quartz (found in all cores included in this study). Quartz is the most common component in most sands around the world, because it is a very hard mineral and does not readily dissolve in water. Most quartz grains start off in solid rock and are broken free by weathering. As the grains are carried by wind and water from their source, their edges become more and more rounded. Thus the shape and size of the quartz grains tells the geologist how far from their source they have traveled.

Quartz grains were characterized by quantity, shape (angular or rounded), and size (diameter). Reedy (1991) further qualified quartz into many other categories, such as undulose extinction and multicrystalline structure. In this study, however, undulose extinction and multicrystalline structure were ubiquitous in all the samples. However, chert, a kind of multicrystalline quartz found in sedimentary rocks, was identified as an important distinct component.

The angularity of the quartz was determined much in the way of Hutchison (1974). The degree of angularity was determined under the microscope and counted, and then the ratio of angular (A) + subangular (sA) grains to rounded (R) + subrounded (sR) grains was derived, giving the subangular and subrounded grains 0.5 of their number:

$$A + sA(0.5)/R + sR(0.5)$$

Size was determined using the Udden-Wentworth scale (Adams, MacKenzie, and Guilford 1984).

Quantitative analysis (Hutchison 1974) of the thin sections at 400× magnification, sometimes called point-counting, was achieved by moving the stage a uniform distance and counting whatever appeared in the crosshairs of the eyepiece. This was repeated two hundred times. In addition to getting a quantitative measure of the composition of the core material, it provided the observer time to perceive the nature of the core material beyond a basic list of components, such as large-scale structures and any trace minerals or components that may not be encountered in the point-counting. Although this is an accurate way of determining the percentage of components in the sample, core material is not always uniform, and some minor components may be inaccurately represented. Combining different techniques allows for the best determination.

Point-count analysis defined the major components of each core quantitatively. After point-count analysis, the samples were plotted on a ternary diagram to better visualize the differences noted (fig. 5.4). The three end members of the ternary diagram were sand, clay, and gypsum/anhydrite. The de Vries cores cluster close to the clay end-member. The sand casting cores of both the Nelson-Atkins and the Rijksmuseum *Hercules, Nessus, and Deianeira* lay closer to the midpoint between sand and clay, and the plaster-based Tetrode *Mercury, Christ Mocked,* the Braunschweig *Venus,* and the two samples from the Dresden *Faun* all clustered near the gypsum/anhydrite end-member.

Comparing the quartz and feldspar grains revealed part of the character of the sand component of each core. Size and angularity from the thin section analysis were determined (fig. 5.5). The size and angularity of the sand were consistent in the majority of cores examined. The ratio of size to angularity was derived. The average was 0.05. Five cores were exceptions—*Christ Mocked,* the Nelson-Atkins *Hercules, Nessus, and Deianeira,* the Rijksmuseum *Hercules, Nessus, and Deianeira,* and the Braunschweig *Venus*—with a ratio above 1.0; the Tetrode *Mercury* had too few grains to measure.

When it is mined, all clay contains some component of sand or silt. Some clay-based materials need additional

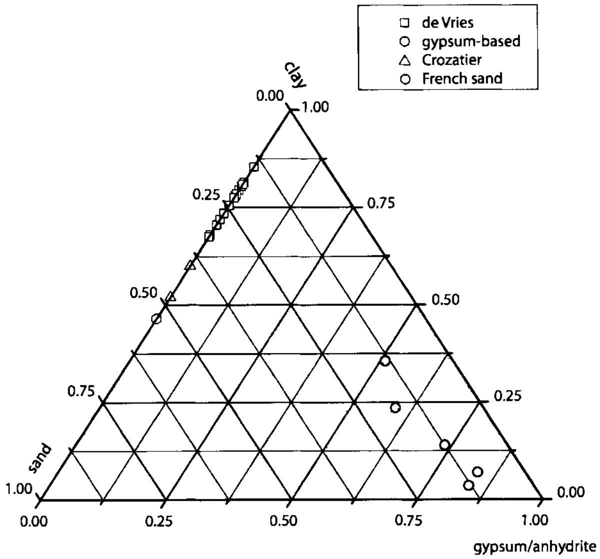

FIGURE 5.4 Ternary diagram plotting core material components of clay, sand, and gypsum/calcite. The de Vries cores (squares) cluster near the clay end-member, with exceptions being the gypsum-based cores (circles) Dresden *Faun,* Braunschweig *Venus, Christ Mocked,* and Tetrode's *Mercury.* Crozatier cores plot closest to 50% sand content (triangles) and are comparable to a modern French sand-casting core (hexagon).

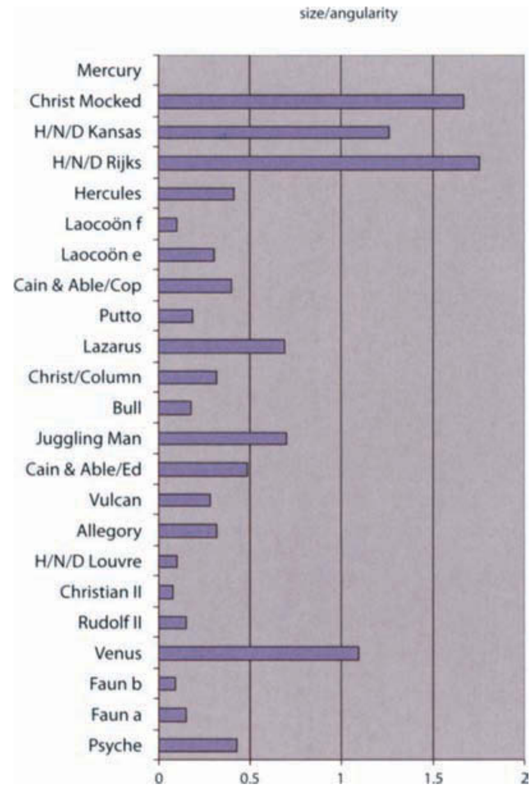

FIGURE 5.5 Plot of size/angularity of core materials. Most core materials are below a value of 1.0, except for *Christ Mocked,* the Nelson-Atkins and Rijksmuseum *Hercules, Nessus, and Deianeira,* and the Braunschweig *Venus.* The Tetrode *Mercury* does not graph due to the absence of measured grains.

temper, and sand may be added. The size and angularity of the grains within each core of this study were consistent, transitioning in size from fine silt size to very fine sand, and thus sand in cores by de Vries appears to be simply a natural component of the sediment. Had the sand been an added component, the angularity might have been different from the silt-sized particles, there would probably have been an abrupt change in size, and the mineralogical components of the sand may have varied.

Almost all clay contains a minor component of minerals besides quartz and feldspar. The de Vries cores contained angular quartz and albite feldspar, as well as the minerals lamprobolite and calcite (sometimes as fossil foraminifera) (fig. 5.6). In a previous study (Bewer 2001), Schmidtling reported the presence of aegerine (a type of pyroxene) in de Vries cores due to strong pleochroism and low extinction angle. However, closer examination and support from XRD (see below) revealed that lamprobolite (a volcanic variety of hornblende with a low extinction angle) is the actual constituent. Other minerals found in the core material sand were microcline, muscovite, biotite, and hematite. The minerals were not added intentionally but were simply present in the sediment. Metal fragments occasionally found in the de Vries cores were determined to be so uncommon as to most likely be incidental contaminants from the bronze or support rods.

X-Ray Diffraction

X-ray diffraction is a technique by which X-rays are projected through a sample. The crystalline components in the sample deflect some of the X-rays in patterns unique to each crystalline mineral. X-ray diffraction was carried out on all twenty-one cores, using a Siemens D5005, with a CuKα radiation and patterns obtained by step scan-

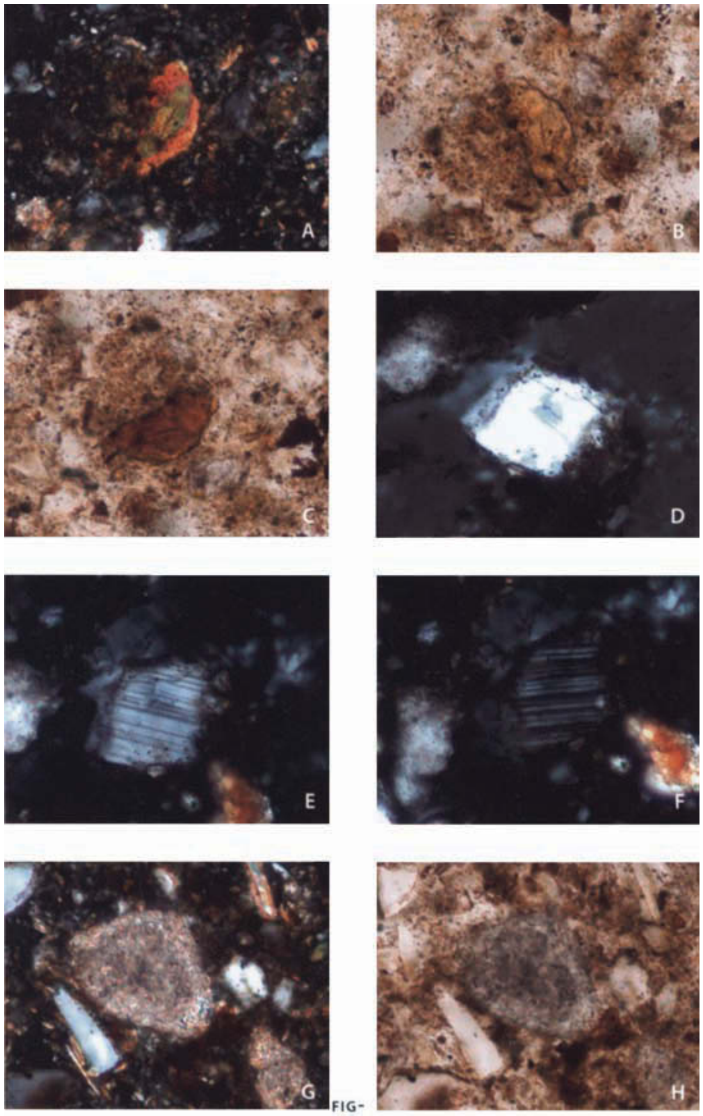

FIGURE 5.6 Components found most commonly in cores attributed to de Vries sculptures (magnification 200×). Lamprobolite (oxy-hornblende) (A) under crossed polars shows high second-order colors and is birefringent from yellow (B) to dark red (C). Unlike normal hornblende, oxy-hornblende shows parallel extinction under crossed polars. D: Subangular albite under crossed polars reveals twinning structure of feldspars that shows parallel extinction (E, F). G: Calcite and an elongate angular quartz grain. Under crossed polars, the calcite shows high third-order colors of pink, yellow, and lime green, whereas the quartz displays first-order blue-gray. H: The same view as G under plane polarized light shows the quartz as clear, and the calcite has a bluish tinge.

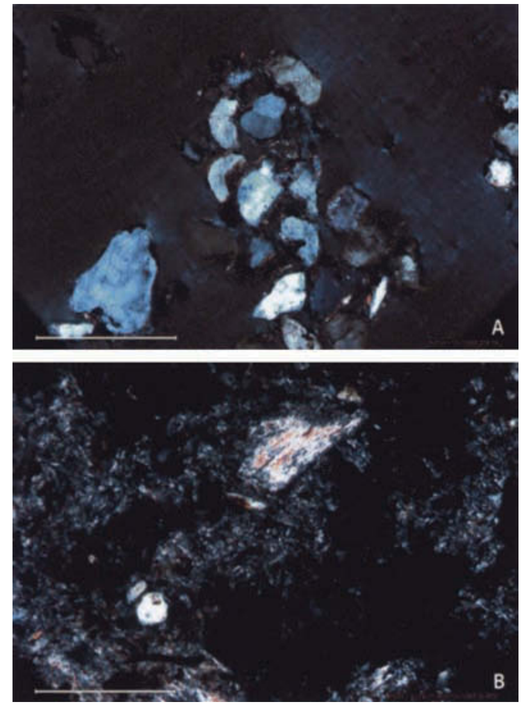

FIGURE 5.7 Components found in core materials of sculptors other than de Vries (magnification 200×). A: Rounded quartz grains surrounded by a thin black clay layer under crossed polars (Nelson-Atkins *Hercules, Nessus, and Deianeira* attr. Crozatier). B: Tiny assicular grains of gypsum, rounded grains of quartz, and a large chunk of fibrous gypsum under crossed polars (Braunschweig *Venus*).

ning from 10 to 2Θ with a count of 0.1 degree per step and a scan speed of 8 degrees per minute, and 40 kV and 30 mA in the X-ray tube.

Under PLM, some mineral grains do not show characteristic textural patterns that are usually associated with them. For example, lamprobolite can display cleavage (fracture) patterns and interference colors (colors visible under polarized light) similar to aegerine (both of which are black igneous minerals). Also, the extinction angle (under PLM, the angle at which no light is transmitted through a crystal) of feldspars, such as albite and oligoclase, can be misleading. De Bari (2003) used XRD to distinguish between core materials of de Vries,

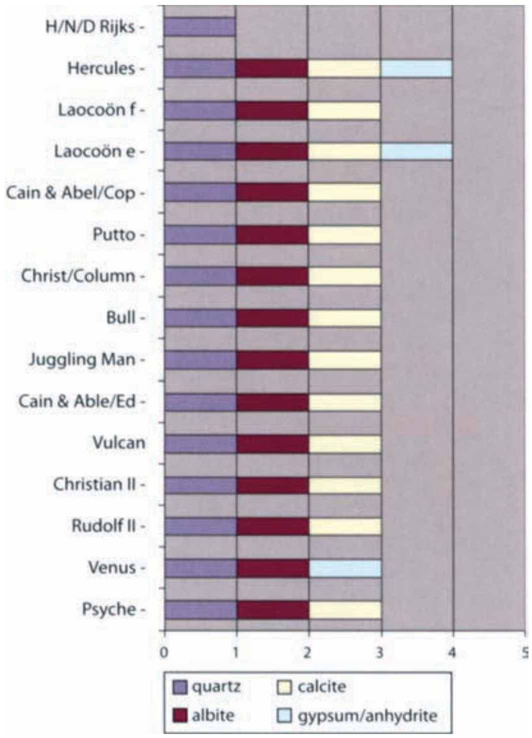

FIGURE 5.8 X-ray diffraction results indicating albite and calcite in most cores, except for the Rijksmuseum *Hercules, Nessus, and Deianeira* and the Braunschweig *Venus*. Due to the lack of sufficient sample, some cores were not examined using XRD.

Giambologna, Ghiberti, and Andrea del Verrochio. Her study showed that hornblende could be distinguished in XRD as well as PLM in de Vries cores, and different types of feldspars could also be determined.

The primary purpose of the XRD analysis (fig. 5.8) was to see if the feldspars were albite or oligoclase. Quartz, albite, and calcite were the main peaks in most samples tested, except for the Rijksmuseum *Hercules, Nessus, and Deianeira,* which showed no albite, calcite, or gypsum; and *Venus,* which lacked calcite and instead showed anhydrite/gypsum. Gypsum was detected in *Hercules Pomarius* and *Laocoön* as well; however, gypsum (calcium sulfate) was not detected in these two samples in microchemical testing. In contrast, in *Christian II* and *Psyche* no gypsum was detected, though it was detected in microchemical testing. Such results are probably due to the trace amounts of gypsum in these samples, confirmed with other analyses. It indicates that gypsum, though present, was not a major structural component of the core.

Metal fragments and corrosion products were sometimes encountered in the thin sections, and it was necessary to determine whether they were part of the core or simply fragments from the inside of the bronze or iron supports and thus not a purposeful constituent. For example, Biringuccio (1480–1539?) describes mixing rust or finely ground iron scale or bone ("ashes of a young ram's horn") with a weak core material to strengthen it (Biringuccio, Smith, and Gnudi 1990). When a substantial number of metal fragments were found, their composition was identified through X-ray fluorescence.

Statistical Analysis

Following visual, MC, XRD, and PLM analysis, the data were subjected to statistical analysis. Most data (besides trace elements) from the polarized light microscopy analysis yielded quantitative information. The ternary diagram of sedimentary rock types (fig. 5.4) showed a clear grouping of the different core types. However, some of the results from the visual analysis (fig. 5.2), microchemical analysis (fig. 5.3), and X-ray diffraction (fig. 5.8) were inconsistent with the results reflected in the ternary diagram. Factorial analysis was used to determine if there was structure in the relationships of the various components. Factorial analysis is a statistical technique used to combine large groups of data to determine how they correlate. Different forms of data are combined into "factors" in order to understand similarities in the group. In this case, the group was the core materials, and the forms of data were taken from the PLM study. Factorial analysis allowed the combination of angularity ratios, percentage of minerals, types of minerals, and clay content to be combined into one comparative matrix. The XLSTAT 2006 program was used in this study.

In the factorial analysis from the PLM data, the variance (amount of difference) shown by the first two factors is 40.7 percent. The highest data contributions to factor-1 are clay, quartz, and muscovite, with a negative correlation of gypsum. This negative correlation is understandable as cores are generally composed of either gypsum or clay as a matrix. The highest data contributions to factor-2 are hematite, calcite, biotite mica, and clay, with a negative correlation of metamorphic rock and muscovite mica. It is interesting to note that the hematite and biotite mica are components that are easily weathered and thus are found in sediments that are close to the source rock. Muscovite, a type of mica found in many metamorphic rocks, is more apt to survive weathering that would degrade biotite through time, and therefore is more apt to survive transport longer (Adams, MacKenzie, and Guilford 1984). All samples examined in this study were taken from bronzes cast in Prague, where de Vries most likely acquired his clay. The area surrounding Prague is mountainous, so any clay from that area would contain minerals indicating a nearby source, such as biotite.

Cores attributed to de Vries clustered in a line, with five outliers: the Tetrode *Mercury,* both *Faun* samples, the Braunschweig *Venus,* and *Christ Mocked.* Each of the five outliers contained a high content of gypsum. Although *Venus* and *Faun* have been considered possible de Vries cores, this analysis includes them with gypsum-rich cores, and no other de Vries cores contain more than a very small amount of gypsum.

The cores from the two *Hercules, Nessus, and Deianeira* aftercasts attributed to Crozatier clustered together at one end of the de Vries group, since clay and sand make up most of both cores. More of the de Vries cores have biotite mica and angular sand, and there is a range that is understandable given the variable nature of sedimentary rock sources. The higher muscovite and metamorphic rock content in Crozatier cores indicates a trend that can be more closely determined by including more Crozatier cores in future studies.

SUMMARY

The results of the core analysis project suggest that de Vries did not experiment with his cores; he found a material that worked and stayed with it.[5] It seems as if he used clay from one source only—practically from one batch of clay. The artist consistently used a basic mixture of natural iron-rich clay with fine to very fine angular sand, without the addition of organic components.

De Vries cores have a wide color range, from bright reddish to dark gray. However, on occasion, two distinct colors of the clay are found together in one sample, a reddish and a dull gray (see fig. 5.1A). It is likely that the different colors are due to different conditions within the sculpture during firing. For example, a portion of gray core from the *Farnese Bull* oxidized to a reddish color when heated, similar to the color of other portions of the core. Also of note, there is little difference in the mineralogical content of most of the de Vries cores, regardless of their color (see the section on polarized light microscopy).

There is a gradation from silt-sized (<0.0625 mm) to fine (<0.25 mm) sand, and the sand is evenly distributed throughout the core (see figs. 5.1A, B; 5.3A, B). The overall texture in thin section is similar to that of greywacke, a type of sandstone that has a high content of clay and fine-grained matrix (Adams, MacKenzie, and Guilford 1984), in which sand is a natural constituent in clay-rich sediment. In fact, with cores, one can use the same nomenclature that is used in sedimentary rocks, since they have not been properly fired. Sedimentary petrological classification (Greensmith 1989) reveals the de Vries cores to be lithic greywackes. Angular sand is created by fresh breaks in the source rock, such as a mountain range; and the farther away from the source, the more rounded the grains generally are. Angular sand in de Vries cores indicates close proximity to the sand source; however, the sand is not so angular as to have been recently crushed. In that case, an angularity of 10 would be expected, with a very uniform grain size. A natural source is considered, and Prague is an area with numerous local sources for sand and clay. Possible sources of clay are east of Prague, such as the marly (calcareous-clayey) Cretaceous sediments near Vysehorovice (Svoboda et al. 1966), which are still worked today. Such a calcareous clay would account for the foraminifera as well. Only partial fragments and recrystallized tests of foraminifera were found, so the different species cannot be ascertained from the thin sections. Andesite rock fragments and lamprobolite would be derived from volcanics in the region, which would find their way into such sediments.

Some of the minerals found in the cores that were used by Reedy (1991), for example, undulose quartz and quartz with inclusions, were found as traces in almost all cores in this study, both those cast by de Vries and those not, and therefore were not used as a criteria for determining characteristics specific to de Vries cores. Gypsum appears

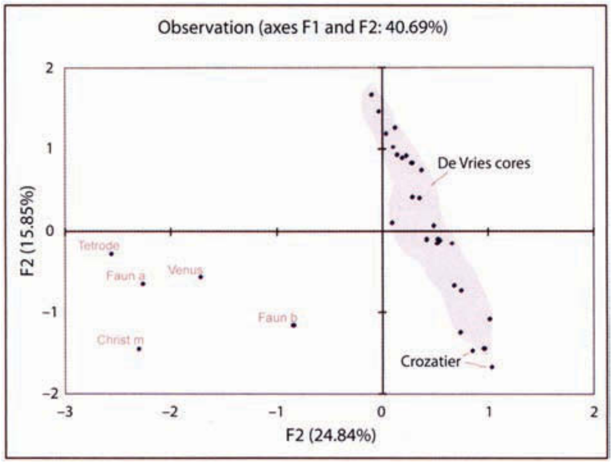

FIGURE 5.9 Factorial analysis of thin section data of the core materials. The samples with a high gypsum content are labeled in tan. De Vries core samples form an elongate structure (points not individually labeled). The two Crozatier core samples are labeled in light blue.

in some de Vries cores in XRD, for example, *Hercules Pomarius* and *Laocoön* sample "e" (see fig. 5.8); and in MC, for example, the Louvre *Hercules, Nessus, and Deianeira, Christian II,* and *Psyche.* However, detailed inspection and thin section analysis revealed that there is very little gypsum in these cores. Since gypsum was not a major component of the matrix of these samples, it may have been a natural inclusion in the sedimentary layers of the sand and clay, or an impurity picked up in the workshop.

The cores of the comparison pieces all differ considerably from the de Vries cores (fig. 5.9). It is clear from this study that the two Crozatier cores (the Nelson-Atkins and Rijksmuseum *Hercules, Nessus, and Deianeira*) share many characteristics, which are distinct from those of de Vries cores. Under magnification, the cores from the *Hercules, Nessus, and Deianeira* aftercasts have the appearance of rounded sand grains, each surrounded by a layer of clay (see fig. 5.7). Although categorized as a "sand," these cores are actually composed of more than 50 percent clay, which lends coherence to the mold when dry. Crozatier cores are different from de Vries cores in XRD, size/angularity ratio, clay/sand ratio, and Munsell color. Sedimentary petrological classification (Greensmith 1989) categorizes the Crozatier cores as subarkose sandstones.

The Tetrode core (*Mercury*), with its gypsum plaster matrix, contains iron shavings and charred plant material, no measurable clay, and very little sand, suggesting that iron was added as the primary temper. The Braunschweig *Venus* is different from de Vries cores in the following ways: color, the presence of metal as a component, plant material, gypsum plaster as matrix, lack of calcite, and size/angularity ratio of <1.0. The core material from the faun of the *Faun and Nymph* group is interesting in that although gypsum is one of the main ingredients, the size and angularity of the sand (fig. 5.5), as well as the inclusion of the mineral lamprobolite fits well within the de Vries characteristics, suggesting it may have been cast in Prague using a sandy clay temper. *Christ Mocked* revealed a gypsum-based heterogeneous core and a size/angularity ratio well above 1.0 (fig. 5.5). Sedimentary petrological classification categorizes the gypsum-rich cores as evaporites (sedimentary rocks made of salts and sulfates).

The results of the analysis present a strong clustering of de Vries cores in comparison with aftercasts and cores of other artists (fig. 5.9). The study has found that the artist was highly consistent in the materials used for each core, regardless of the casting technique used. It appears that de Vries used a clay containing sufficient sand so that he did not need to add additional temper. In fact, throughout his working life in Prague, de Vries may have used clay from a single source. The minerals identified in the cores correlate with sources of clay east of Prague, such as the marly (calcareous-clayey) Cretaceous sediments near Vysehorovice, which are still worked today.

NOTES

I wish to thank Karen Trentelman for assistance in Raman spectroscopy, Marc Walton for geophysics input, Giacomo Chiari for his knowledge of core materials and XRD techniques, Francesca Bewer, Jane Bassett, and David Scott.

1 The sand casting cores are simply referred to here as "sand cores."

2 Cores removed during the earlier (1998) de Vries study were also analyzed by Schmidtling, as summarized in Bewer 2001: 179.

3 The data from this study were published in Fogelman 2002.

4 Thin sections were prepared at the University of California, Los Angeles, by technician Rom Alkali.

5 All the de Vries cores were taken from bronzes that were likely cast in Prague. It would be interesting to compare the cores of bronzes the artist cast during his relatively brief stay in Augsburg.

CHAPTER 6

Thermoluminescence Dating

Using the thermoluminescence (TL) technique, the casting cores were tested to determine the approximate date the bronzes were cast.[1] The TL technique is based on the principle that certain components in casting cores absorb and store energy over time. Sources of this energy include unstable isotopes of uranium, thorium, and potassium present in clay that give off ionizing radiation as they spontaneously decay. Some minerals often present in clay, such as quartz and feldspars, absorb and store this energy in their crystalline lattice. When the clay is heated to approximately 500 degrees Celsius, the stored energy is released in the form of light. Clay in the earth absorbs this ionizing radiation from the time of its formation. But, during the casting process, the clay is heated above 500 degrees—to the point that the stored energy is released—reducing the stored energy to zero. The clay then begins the process of storing energy anew. In the laboratory, clay core materials can be heated again under controlled conditions, and the amount of light that is released can be measured. The relationship is linear: the more energy that is stored, the more light that is emitted when the clay is heated. The date since the casting can then be determined with the formula

$$\text{Age} = \frac{\text{Total amount of energy stored since casting}}{\text{Amount of energy stored each year}}$$

The amount of energy stored each year (the annual dose) comes from two primary sources: an *internal dose* from radioactive components within the clay core itself (potassium-40, thorium, and uranium) and an *environmental dose* from radioactive components in the environment that surrounds the artifact. In the case of archaeological objects, the source of the environmental dose is the radioactive components contained in burial soil. For historic objects, the environmental dose is determined by the relatively minor radioactive decay properties of the building materials or storage materials surrounding the object over time.

TL dating was included in the project for a number of reasons. First, we wanted to have a date on record before the bronzes were radiographed. As a form of ionizing radiation, X-rays increase the amount of energy stored in the quartz and feldspar, artificially increasing the age of the object undergoing TL dating. Although informal experiments have been done in the past to determine the number of years added to a TL date per X-ray exposure, these corrections have ranged from ten to one hundred years (G. Goedicke, pers. com.). According to recent research carried out by Castaing et al. (2002: 88), determining a formula to accurately predict the additional dose of energy acquired through each X-ray exposure is not practical.[2] When attempting to determine the authenticity of an ancient bronze, for example, an error due to one or two X-ray exposures will have minimal effect on the outcome. With objects that are only a few hundred years old, the error has a much larger impact. For this reason, a sample was removed from each piece before radiography, the exception being the bronzes with completely closed forms that offer no access to the interior (such as the Prague *Horse;* see chapter 16).

The second reason for TL dating the cores was to gain additional background information on the sculptures that presented intriguing curatorial questions, such as the two *Cain and Abel* groups (see chapters 18, 24), the only signed de Vries bronzes of which there are two versions, as well as on the five comparative bronzes included in the study.

The third and final goal for TL dating the bronzes—including those that are dated and have an excellent provenance—was to take the opportunity of the technical examinations to investigate the reliability of TL dating for European bronze casting cores. The J. Paul Getty Museum and many other institutions rely on thermoluminescence dating as one important step in the authentication of their collections as well as of potential donations and acquisitions. Although TL dating of archaeological materials was developed in the 1960s (Aitken 1985: 3), the majority of published accounts since that time address the dating of fired ceramics. No systematic study has been done on the use of the technique for dating European casting cores, which may present particular challenges, including the following:

1. Much of the core has often been removed from inside bronzes, with only small pockets remaining from which a sample can be removed. In such cases, the internal dose may be less than expected, as the surrounding source of radioactive material (the neighboring core) has been greatly reduced.
2. Due to shielding of the core by the bronze walls, the environmental dose that the core receives is assumed to be lower than that absorbed by ceramic materials, yet no calculations have been made to quantify this reduction.
3. It has been reported that bronze casting cores often exhibit characteristics (anomalous fading and spurious TL) (Martini et al. 1995) that must be recognized by the TL laboratory during analysis and, if present, necessitate taking special steps to avoid erroneous results.
4. Some Renaissance casting cores may contain a significant amount of gypsum in place of clay. The presence of plaster as a matrix presents a number of challenges. Although plaster itself generally cannot be used as a TL material due to its poor TL sensitivity, accurate dating of plaster-based cores may occasionally be complicated by the presence of thermoluminescent crystalline forms of gypsum. Further complications may arise as the conversion tables used for determining certain aspects of the internal dose are based on ceramic material (C. Goedicke, pers. com.). The main problem with dating plaster cores, though, may simply be the lack of clay and its radioactive components.
5. A final challenge to the accurate dating of bronzes is presented when they have been exhibited outside, as variation in water content of the core may be the single largest contributor to the error calculation (Goedicke, Slusallek, and Kubelik 1985: 6, 35 ff.), yet there is no certain way to determine the water content of the core over time.

With these many potential problems in mind, it was hoped that dating the bronzes with unquestioned provenance would help us to understand how often problems may occur in practice.

The core samples were removed from inside the hollow bronzes. At least 200 mg were removed either as chunks or by drilling.[3] In most instances, access to the inside was gained through the open bottom of the sculptures.[4]

RESULTS

As reported in figure 6.1, samples were submitted from eighteen bronzes. The TL dates were reported as a given year A.D. plus or minus a range of years. This ± value reflects the error limits or degree of uncertainty of the results, which ranged from 5 percent to 9 percent of the overall age. For example, *Lazarus* was given a TL date of 1645 ± 22 years (1623 to 1667), reflecting a 6 percent degree of uncertainty. In figure 6.1, the TL date for each bronze is reported, showing the results with one standard deviation as reported by the TL laboratory (gold section of bar) and with two standard deviations (gold and blue sections of bar). As with all the TL results in this study, the laboratory reports its results with one standard deviation, indicating that there is a 68 percent probability that the true date lies within this range of 1623 to 1667. Doubling the standard deviation to ± 44 years (1601 to 1689) increases the probability to 95.5 percent. Indeed, in this example, the inscribed date of 1615 falls within the TL date when reported with two standard deviations.

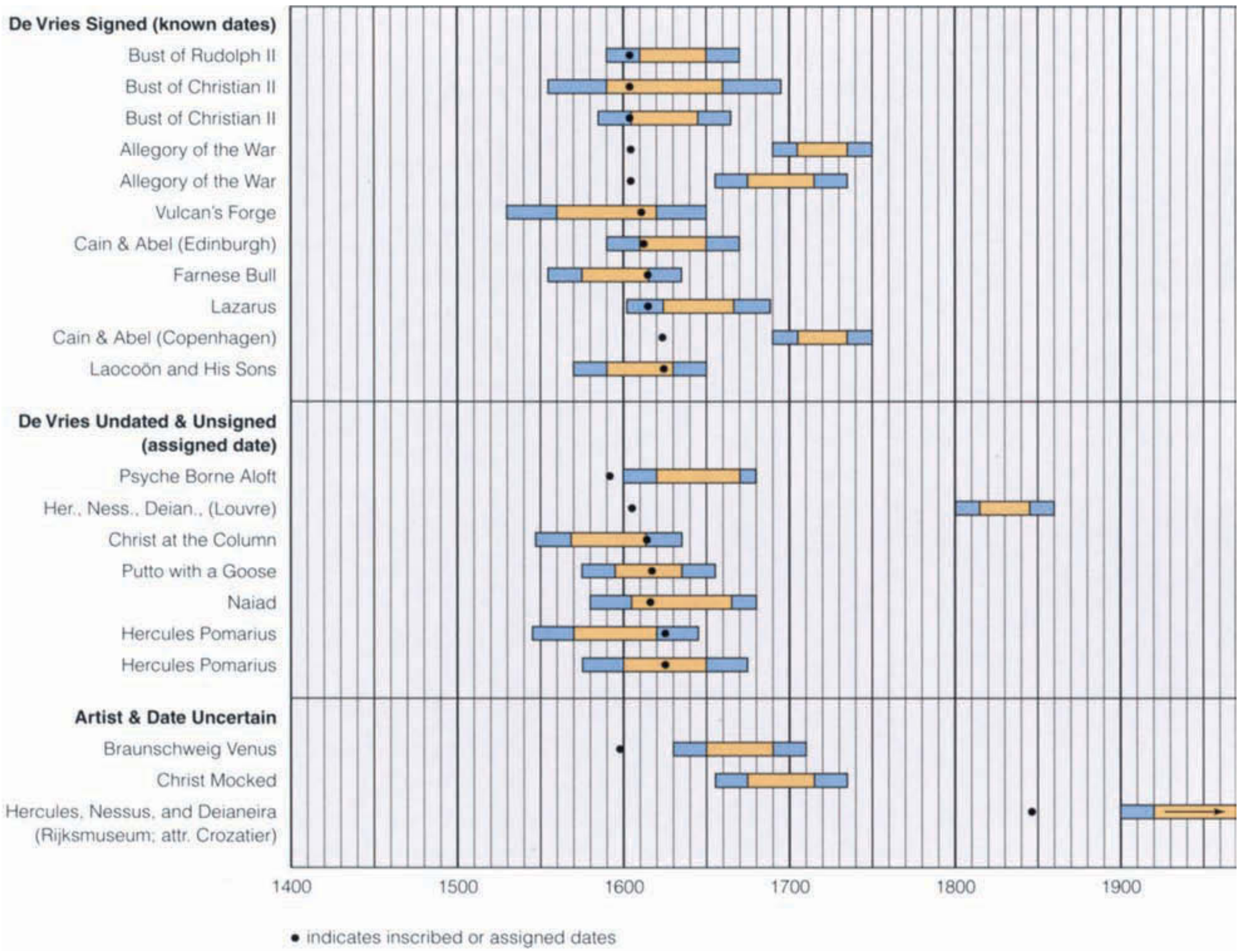

FIGURE 6.1 Chart comparing dates with TL results.

Undated Bronzes, Authorship Uncertain

Core material from three bronzes for which the artists and dates are uncertain was tested.

- Two TL dates were in the late seventeenth century (*Venus* in Braunschweig, chapter 10; and *Christ Mocked* in Los Angeles, chapter 29).
- The third was a twentieth-century date (*Hercules, Nessus, and Deianeira* aftercast from the Rijksmuseum, chapter 31).

Undated de Vries Bronzes

The results for six unsigned and undated de Vries bronzes were compared with the dates assigned to them based on stylistic or archival evidence.[5]

- With one standard deviation, the assigned dates for three of the bronzes correspond to the TL results.
- When reported with two standard deviations, four of the six dates correspond.
- A fifth sample falls just outside of two standard deviations (*Psyche Borne Aloft by Putti* in Stockholm, chapter 7), possibly due to the moisture content of the core during the time the bronze was exhibited outdoors.
- A sixth sample yielded a nineteenth-century date (*Hercules, Nessus, and Deianeira* from the Louvre, chapter 13). According to the laboratory, there was scatter in the light emission data for this sample and the results were not reproducible, throwing the

accuracy of the results into question. Due to specific characteristics of this core material, the thermoluminescence technique is therefore not a viable method for dating this bronze.

Signed de Vries Bronzes

Nine signed bronzes were tested; eight of the nine contain both a signature and a date.

- Four of the TL results correspond with the dates when the results are reported with a standard deviation of 1.
- When the standard deviation is increased to two, seven of the nine results correspond with the dates.
- Even when reported at a standard deviation of 2, two of the nine signed de Vries bronzes produced TL dates that are too recent. In one case, this lack of correspondence may be explained by a later heating treatment undertaken to remove the patina (*Cain and Abel* in Copenhagen, chapter 24).[6] The lack of correspondence in the second bronze remains unexplained (*Allegory of the War against the Turks in Hungary* in Vienna, chapter 14).

CONCLUSION

Two of the bronzes of uncertain authorship received late-seventeenth-century TL dates, as anticipated. Both of these bronzes contain gypsum-based cores, which apparently did not cause noticeable problems. The twentieth-century date for the Rijksmuseum *Hercules, Nessus, and Deianeira* suggests that the bronze may not have been cast by Charles Crozatier (1795–1855), a recent attribution that should be reconsidered.[7]

Six bronzes included in the TL study are attributed to de Vries but are without inscriptions. The published dates for the bronzes are based on a comparison with the artist's style as it evolved over time, as well as on documentary evidence. When the TL results are reported with one standard deviation, three of the six assigned dates fall within the range. Doubling the standard deviation increases correspondence to four out of six, with a fifth assigned date falling just outside the range. The core from the sixth bronze exhibits characteristics that render it undatable using the TL technique.

Core samples from nine signed bronzes were tested, eight of which are also dated. Increasing the standard deviation from 1 to 2 increases correspondence between the TL results and the inscriptions from four to seven, leaving two bronzes whose TL dates do not correspond with what are assumed to be the correct casting dates. For one of the bronzes, this may be due to reheating of the surface in the eighteenth century, which would have released the accumulated TL signal, yielding the date of the restoration rather than that of the original casting. The final bronze whose TL date appears to be too recent has a provenance dating back to the early seventeenth century. Two small samples from the bronze were tested. Although the bronze is dated to 1604–5, at two standard deviations the samples yield dates of 1655 and 1690. For both samples, the data were reported to be reliable and reproducible, yet they yielded results fifty and eighty-five years too recent. There does not appear to be an explanation for this inconsistency. As the bronze has been exhibited inside all of its life, the difference cannot be attributed to water content of the core, which, in any case, would likely not account for such a high discrepancy.

In summary, carrying out thermoluminescence dating for the three bronzes with uncertain authorship yielded useful information to include in their technical studies. When the TL dates are adjusted to two standard deviations, thereby increasing to 95.5 percent the likelihood that the date corresponds to the true date, twelve of the fifteen de Vries samples correspond, suggesting that a degree of uncertainty of between 10 and 18 percent is more realistic for TL dates of bronze casting cores.[8] Of the remaining three bronzes, a variety of problems were encountered. The Louvre *Hercules, Nessus, and Deianeira* produced a result that is unreliable as the data cannot be reproduced, indicating that the technique cannot be used to date this particular bronze. The TL date for the *Cain and Abel* group in Copenhagen does not correspond with its inscription, yet this may be explained by a later restoration treatment. Finally, the incorrect date for the *Allegory of the War against the Turks* relief (a bronze for which one would be hard-pressed to seriously question the attribution) reminds us that troubles with the technique can be difficult to anticipate.

Beginning in 2000, soon after the TL work for this project was completed, the Rathgen-Forschungslabor began to successfully use a related technique for the dating of cultural material. Referred to as optically stimulated luminescence (OSL), the technique uses light rather than heat for stimulating the stored energy. Given equal sample sizes, OSL offers greater accuracy and less error than TL. Although its use is not yet widespread, experience gained so far has shown that it may prove the preferred method for dating casting cores.

In investigating the authenticity of a work of art, there are very few techniques that will directly date an object. Thermoluminescence dating has been used for this purpose for over forty years. The results for this small group of bronzes suggest that although the technique can be a useful tool in the study of bronze casting cores, it must be undertaken with an understanding of the full range of problems that may be encountered. Most important, it should be remembered that thermoluminescence dating cannot be considered a technique for assigning a specific date to a bronze. Rather, it should be looked upon as a technique useful for specifying a period of time during which a sculpture was likely cast—results that must be considered together with art historical, archival, and other technical research.

NOTES

1 Thermoluminescence dating was undertaken by Ana Manzano, under the supervision of Christian Goedicke, at the Rathgen-Forschungslabor Staatlichen Museen zu Berlin. Dr. Goedicke has kindly and tirelessly offered further consultation on the interpretation of the results. Samples for TL dating were removed from nineteen of the twenty-five bronzes included in this study. For the six that could not be dated, there was either no core remaining or the core was inaccessible inside the closed form of the bronze.

2 Although attempts have been made to measure the amount of error in a TL date resulting from X-ray radiography, Castaing has shown that simple corrections are not feasible. Variations in the radiation received by the core may vary greatly depending on the parameters of the exposure. In addition, the absorbed dose will vary within an object due to absorption and scatter of the x-rays, the core situated closer to the X-ray source receiving a higher dose than the core located toward the back or away from the central focus of the beam. The author would like to thank C. Goedicke for describing and interpreting Castaing's 2002 presentation, the full text of which remains unpublished.

3 A full description of sampling techniques for TL dating can be found in Bassett 2008.

4 In one instance (the Tetrode *Mercury;* see chapter 27), the core sample was removed from the closed form with a thin steel probe through a small casting flaw in the foot.

5 The authorship of these bronzes is generally not questioned. These dates were taken from the exhibition catalogue (Scholten 1998a).

6 Temperatures as low as 300 degrees C will begin to erase the accumulated TL signal. At 500 degrees C the signal will be erased entirely (C. Goedicke, pers. com.).

7 For more details, see chapter 30.

8 In fact, as stated by Aitken (1985: 156), "in most cases it is possible to determine a TL age to an accuracy of around 20%." The low degree of uncertainty of the Rathgen-Forschungslabor results is due to the relatively large number of measurements taken in their standard procedure.

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PART II

Case Studies

CHAPTER 7

Psyche Borne Aloft by Putti

Nationalmuseum, Stockholm. Inv. no. NM Sk 352
Cast in Prague in 1590–1592
Dimensions: H: 187.5 cm × W: 97.1 cm × D: 76.5 cm
Marks and inscriptions: None

OVERVIEW

This inventive and playful composition represents Psyche as she is lifted from the ground by three putti, with just her falling drape connecting her to the small round base below (figs. 7.1, 7.2). Cast for Rudolf II, the bronze is first listed in the emperor's *Kunstkammer* in Hradčany Castle in Prague in 1621. The bronze was taken by Swedish troops in 1648, at the very end of the Thirty Years' War. It is recorded in the 1652 inventory of Queen Christina's collection. The sculpture then passed through the collections of Johan Gabriel Stenbock, Stina Lillie, Baron Eric Sparre, Carl Gustaf Tessin, Major Per Suther, and Anders Wahrendorff. It was donated to the Nationalmuseum, Stockholm, in 1863 by C. Holtermann-Wahrendorff.

The technical study was undertaken to add to our understanding of the artist's methods and materials. The earliest known large work cast by Adriaen de Vries as an independent artist, it was of particular interest to determine through the technical study what method was used to cast the sculpture and whether it was cast in one pour.

EXAMINATION

1. Alloy

The alloy was measured in four locations. The metal is composed of approximately 10 to 13 percent tin in a copper matrix with 1 to 2 percent lead and less than 1 percent zinc (results for all of the spectra can be found in table 4.1). Although the majority of the de Vries bronzes contain less than 1 percent lead, some variation was found in this study,

FIGURE 7.1 *Psyche Borne Aloft by Putti*
Nationalmuseum, Stockholm. Inv. no. NM Sk 352

FIGURE 7.2 *Psyche Borne Aloft by Putti*
Nationalmuseum, Stockholm, Inv. number NM Sk 352

including elevated lead content in *Laocoön* and *Putto with a Goose*, the latter likely due to contamination from the adjacent repairs. Lead is notoriously difficult to measure accurately using the X-ray fluorescence technique, as it is not soluble in the alloy, remaining as distinct globules.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

It can be assumed that substantial armature rods were used to help support the structure during the formation of the casting model and during the casting itself. If later large-scale compositions can be used for comparison, it is likely that the armature consisted of a central, large-diameter rod that would have extended up the drapery and then into the torso. Wires extending into Psyche's head, arms, and legs (some of which still remain) would have tied to this central armature. Similarly, as discussed below, evidence suggests that rods tied the two upper putti to the central armature. Many of these rods and the surrounding core material have been removed from the drape as well as the figure of Psyche. The rods that remain, as well as those that were removed but show evidence for their original locations, are illustrated in figure 7.3.

The material may have been removed in the foundry in order to reduce the overall weight of the sculpture and to allow recycling of the rods for other uses. The core and armature rods within the drape could have been removed from the open bottom of the base. Those inside the figure of Psyche must have been removed through openings before they were plugged, including the top of the head (fig. 7.4) and the raised arm; the core pin holes are rather small to have allowed much access to the interior.

A sample was taken from a loose fragment of an armature rod (the rod measures 0.8 cm wide × 0.2 cm thick). The sample was polished and examined under magnification and identified as extensively corroded wrought iron, suggesting that the bronze has been exposed to moisture or excessive humidity for a period, most likely due to outdoor exhibition. Rusting has lowered the X-ray opacity of all the original iron armature, making it difficult to discern in the radiographs.

Some of the armature remains inside the putti. The rods in the putti torsos and limbs are often in pairs; there are no rods in the putti heads. In two locations, evidence remains of armature rods that extended from Psyche into the adjacent figures. The presence of these rods furthers the argument that Psyche and the putti were modeled and cast at the same time. In the first example, an armature rod exited Psyche's left side and reentered the wax model in the adjacent putto's right hip (fig. 7.3). The rod then continued into the left leg, supporting the knee that kicks out, away from Psyche's body. The corresponding hole in Psyche's side is patched with gypsum, and magnetic attraction in the area suggests that a piece of armature still remains

FIGURE 7.3 Summary of armature rods and wires remaining on the interior. Dashed lines indicate the possible pathway of rods that have been removed.

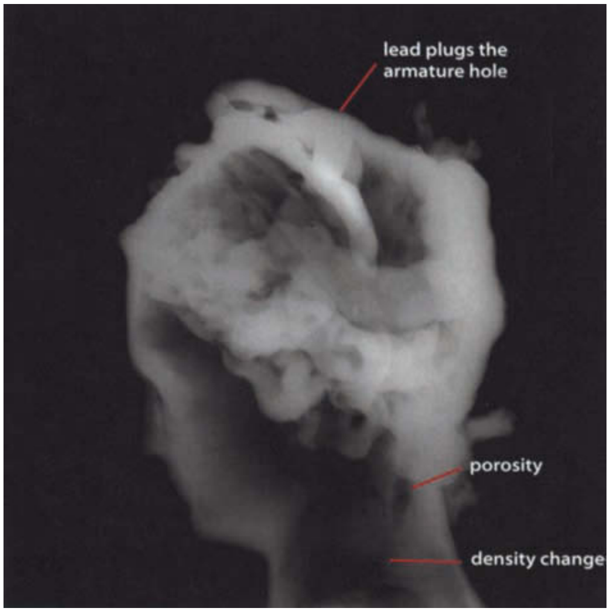

FIGURE 7.4 Radiograph of Psyche's head. Features such as the nose and braids were added in the wax over a generalized core. A density change in the back of the neck indicates where the core has been removed.

FIGURE 7.5 Plaster of paris fills the hole in Psyche's left side where an iron armature rod extended through the bronze.

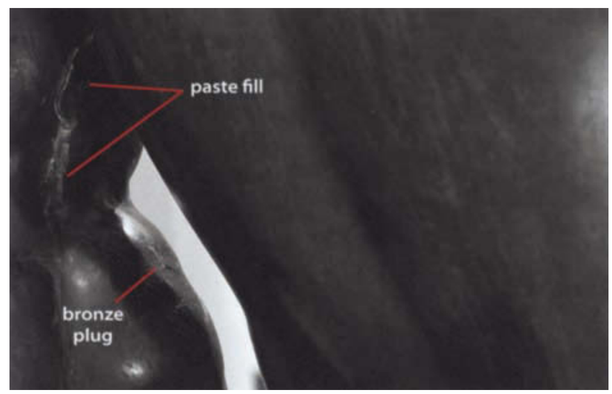

FIGURE 7.6 An armature rod passed outside the wax model from Psyche's left side into the putto's hip. When the rod was removed, the hole was patched.

inside (fig. 7.5). The hole in the putto's hip is plugged with bronze (fig. 7.6). This construction technique, in which a section of armature exits one part of the composition and reenters another, is found on many of de Vries's bronzes, for example, the *Farnese Bull* (see chapter 20).[1]

In a related but different example, the radiographs suggest that an armature rod connected Psyche's right hip to the putto that rests against it, again indicating that the figures were modeled and cast together. A wide (1.0 cm) gap runs straight through the remaining core in the putto's hips where the rod has been removed.

Three thin rods run from the repair in Psyche's left wrist into her upper arm (fig. 7.7). Unlike the other armature rods, which were formed of solid wrought iron, the long gaps along the length of the rods suggest that they are made of rolled sheet metal. They show no sign of corrosion. The upper ends of the shorter two rods appear to be embedded in the cast-in repair. The different appearance of these rods and their location suggests that they were added as part of the repair, although their function is unclear.

b. Core pins

Numerous square or rectangular core pin holes are visible throughout the radiographs. These holes measure roughly 0.3 cm to 0.5 cm on a side and have been filled with plugs that are thinner than the surrounding metal, leaving them easily visible in the radiographs. Approximately a dozen core pin holes can be seen on Psyche's torso, many of them in figure 7.9. The pins often appear to have been placed in pairs on the front and the back of the limb or body part. Many of the plugs are difficult to see on the surface of the bronze, although a plug on the back of Psyche's right arm is outlined in rust from corrosion of the remaining iron

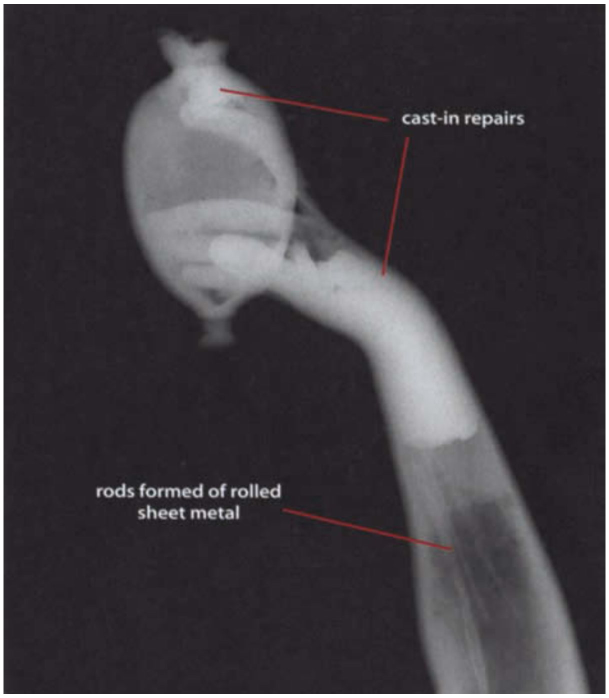

FIGURE 7.7 Radiograph of Psyche's left arm and vessel. The dense (white) areas in the wrist and vessel are cast-in repairs.

FIGURE 7.8 Open bottom of the base. The core extended from the base into the hollow drapery, but much of it was removed after casting.

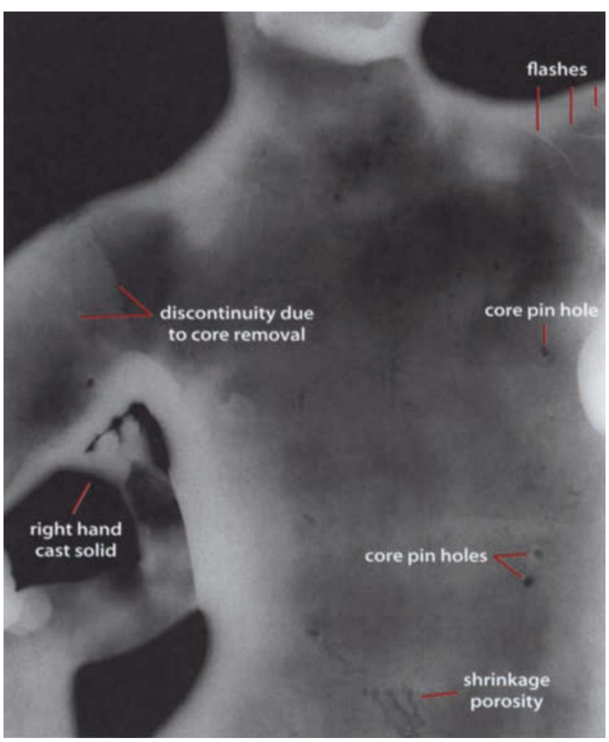

FIGURE 7.9 Radiograph of Psyche's torso.

core pin that was pushed into the inner cavity but remains in place below the plug.

c. Core material

The reddish-colored core is fairly soft and breaks off in chunks. Examination under the sculpture shows that most of the core has been removed from the base and drapery, although some remains in the recesses in these areas (fig. 7.8). The radiographs suggest that the core has also been removed from inside Psyche's torso and partway into her head and limbs. On Psyche's right side, for instance, the core remains in the arm. The extra density of the core has partially blocked the X-rays, yielding a whiter area on the radiograph. Even though the chest is thicker than the arm, removal of the core from the upper torso has allowed easier penetration of the X-rays and more exposure of the film in this area (fig. 7.9).

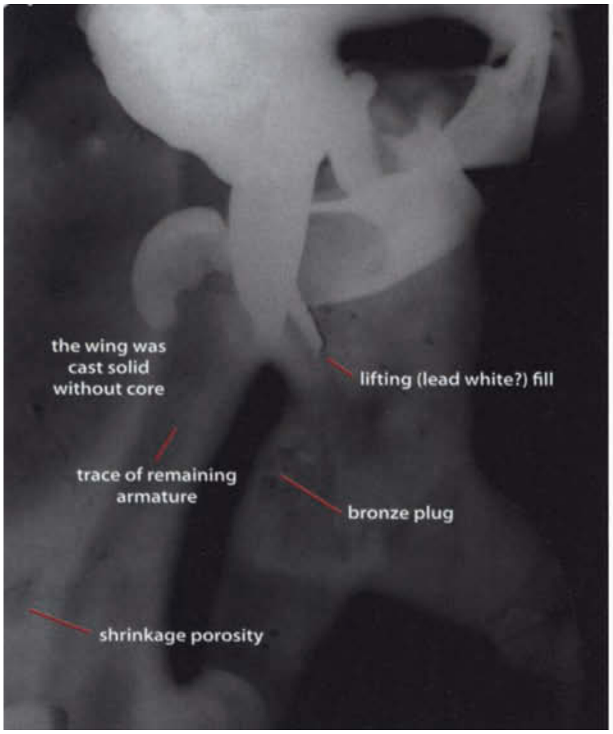

FIGURE 7.10 Radiograph of the putto under Psyche's left arm. The dashed line indicates the path of the armature rod (now removed).

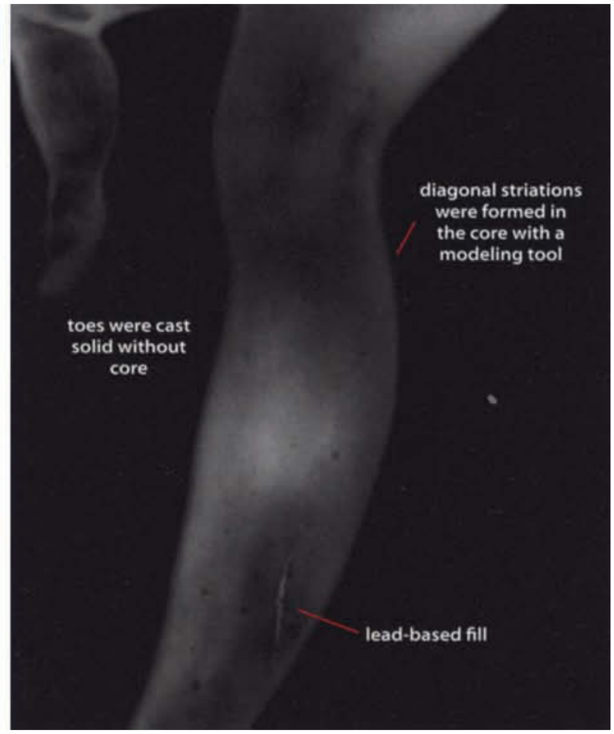

FIGURE 7.11 Radiograph of Psyche's left lower leg.

Quantitative analysis of the core yielded the following:

- 78 percent reddish clay
- 12.5 percent quartz
- 3 percent feldspar (albite)
- 3 percent hematite
- 1.5 percent calcite grains
- 1 percent oxy-hornblende (lamprobolite)
- 0.5 percent zircon

As described in chapter 6, the TL results for the project are best reported with two standard deviations, yielding a TL date for the core of 1640 ± 40 years (1600–1680). Still slightly outside the stylistic attribution (1590–92), the discrepancy may be due to the moisture contents of the core during the time the bronze was exhibited outdoors.

d. Internal surface of the bronze

The radiographs indicate that the figures of Psyche and the putti were cast hollow around an internal core. It is clear that de Vries paid particular attention to the layout and final finish of the core. The bronze walls are smooth and of an even thickness throughout Psyche's torso and limbs, suggesting that the artist carefully planned the overall composition such that the core closely resembled the appearance of the final cast. In the extremities, smaller sections were sculpted in solid wax, including the putti's wings, toes, and fingers or entire hands, as well as Psyche's nose and braids (figs. 7.4, 7.7, 7.9, 7.10).

As seen in the radiographs, diagonal striations on the inside surface of the metal on Psyche's left knee and lower leg were formed with a modeling tool as the core was being shaped; they are unusual on de Vries bronzes (fig. 7.11).

FIGURE 7.12 Putto under Psyche's right arm. No cold work was done after casting; the hair retains the loose and waxy feel of the model.

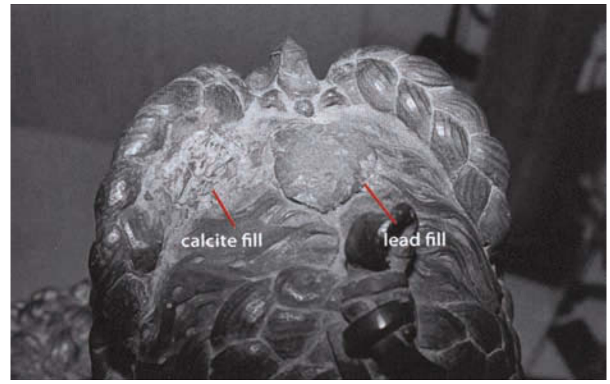

FIGURE 7.13 The top of Psyche's head. Repairs fill a casting flaw and the armature rod hole in the center of the head.

e. Method of assembly and joining of individual wax or cast bronze components

From study of the radiographs, the bronze surface, and the inside of the sculpture, it appears that the base and all of the figures were cast integrally; there is no indication of the metal-to-metal joins that would be present had the bronze been cast in sections.[2]

In keeping with all of de Vries's large compositions, *Psyche Borne Aloft by Putti* appears to have been cast using the direct lost wax method. Had the sculpture been constructed using the indirect lost wax method, wax-to-wax joins would be expected in areas where they appear on de Vries's other indirect casts, such as Psyche's neck, upper arms, and upper thighs, and possibly even her waist. The radiographs show that there are no such joins in these areas, strongly suggesting that the direct technique was used.[3]

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

With few exceptions, the surface was carefully finished both in the wax casting model and in the metal. The hard-to-reach transitions between the figures and the edges of the drapery were highly finished in the wax. After casting, the flesh and drape were polished overall, and any flaws such as flashes were carefully removed. Fine polish or scratch brush lines run parallel to the drapery; faint lines on the flesh run generally, although not exclusively, parallel to the limbs and may be partially due to later surface cleaning. The wings and hair were freely modeled in the wax and do not appear to have been reworked in the metal (fig. 7.12). The only punched surface texture on the entire sculpture is in the hair, where a single, finely textured, convex, oval punch was sparingly used. The texture is quite faint, perhaps partially due to wear. It is interesting to note that the texture was applied to the hair on top of Psyche's head, even though it would never be seen in normal viewing—which may be an argument for the texture having been applied in the wax when doing so would have been far easier (fig. 7.13). The left hand of the lowermost putto is only roughly formed as it is in a location that would have been inaccessible to tools.

g. Patina

The surface of the sculpture varies considerably from area to area, ranging from pale to dark bluish green to olive green to golden brown. The predominant surface colors are green, due to corrosion, and brown, due to an opaque, dark brown organic coating, both of which have been partially removed (fig 7.14). The applied dark brown coating is matte and grayish in color where deteriorated; in other areas, it remains translucent and brown in color. It is unclear when this coating was applied.

3. Casting Defects and Foundry Repairs

Very few flashes can be seen in the radiographs; and most are quite thin (fig. 7.9). Porosity occurs throughout the sculpture to varying degrees. Small- to medium-vacuole porosity is scattered over the sculpture (fig. 7.11), with a small amount of large-vacuole porosity, such as in the back of Psyche's neck (fig. 7.4). There is shrinkage (retraction) porosity in Psyche's torso (figs. 7.9, 7.10). Unrepaired porosity breaks through the surface in scattered areas throughout the sculpture.

A wide variety of repairs were used on the sculpture. The largest repairs fill casting flaws in Psyche's left wrist and in the vessel held in the left hand (fig. 7.7). The cast-in wrist repairs were done in a copper alloy, but flaws in the repairs themselves necessitated filling with a white metal alloy (the white color of the metal suggests that it is a lead alloy; identification of the alloys through XRF was not possible due to their locations above the reach of the instrument). The repair is currently quite noticeable on the surface of the sculpture due to rough scraping that removed any corrosion or patina that may have covered the surface in the past. The upper half of the vessel was also recast in a white metal alloy; the repair is roughly chased, perhaps because of its location nearly out of view (fig. 7.15).

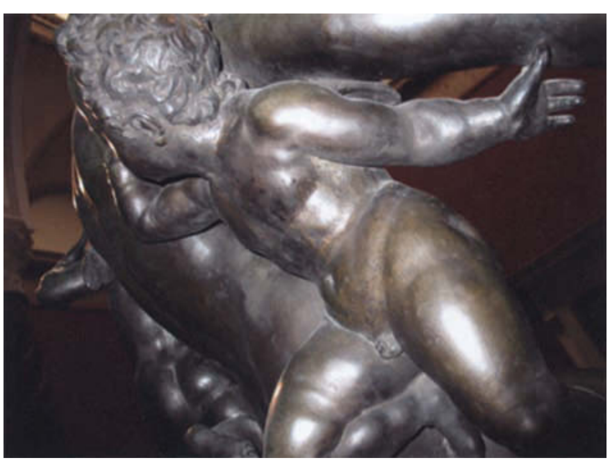

FIGURE 7.14 The organic patina on the chest of the putto under Psyche's right arm remains relatively intact. Note the later scrape marks in the stomach and groin that have removed the patina and the corrosion layer.

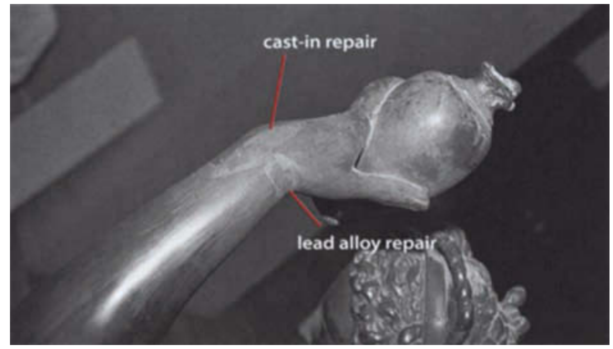

FIGURE 7.15 Repairs in the vessel and Psyche's left arm.

A white metal was also used to fill the hole in the top of Psyche's head that was apparently left when the central armature rod was removed (figs. 7.13, 7.4). A number of rectangular set-in bronze plugs were used, including one that fills the armature hole in the uppermost putto's right buttock (fig. 7.6).

Wax and various types of paste were used to fill a number of the holes in the bronze. Two rectangular core pin holes were filled with resin and/or wax. The fillers in three different types of paste fills were identified,[4] all of which were likely mixed with linseed oil or another type of drying oil: calcium carbonate (calcite) (fig. 7.13), calcium sulfate (plaster of paris) (fig. 7.5), and lead white. The lead white was identified on the fill in the leg (fig. 7.11) and down the spine of the uppermost putto (figs. 7.6, 7.11). It is unknown when these fills were applied; the use of organic fill is unusual in the artist's oeuvre.

4. Later Modifications/Restorations

The presence of four organic fills on the piece (whiting, gypsum, lead white, and wax/resin) suggests that there may have been one or more past restoration campaigns.

The thin green corrosion layer, which at one time must have covered the entire sculpture, has been partially removed using a straight-edged scraper. Some of the dark brown patina was also removed with scraping. The scraper caused fine scratch lines that run parallel to the limbs and chatter marks that run perpendicular to the limbs. They appear on prominent surfaces, such as Psyche's left lower arm, wrist, and shoulders; the entire right side of her right leg; and the left calf of the putto below Psyche's left arm. The scraped areas reveal the light brown color of the oxidized metal (fig. 7.14).

SUMMARY

Examination confirms that de Vries began his career with tremendous self-confidence and technical virtuosity. The lack of wax-to-wax joins in the figure of Psyche and the presence of tool marks made in the clay core and captured on the inside surface of the bronze strongly suggest that the sculpture was made using the direct lost wax technique. The large and complex composition was cast nearly flawlessly in a single pour, reflecting the extent of experience de Vries had gained while working in the workshops of Giambologna and Pompeo Leoni. As revealed in the radiographs of the *Psyche* group, the smooth and precise modeling of the inner core is reflected in the smooth and careful finish on the outside of the bronze. This approach is characteristic of de Vries's early career and creates an interesting contrast with the rougher modeling of the core and looser finish of the outer surfaces found in his later bronzes, such as *Laocoön and His Sons* (see chapter 25).

Details on the wings and hair were finished in the wax and generally left as-cast; the flesh was carefully polished overall after casting. Much of the iron armature and the reddish-colored clay core have been removed from the interior. A relatively small number of copper alloy, lead alloy, and organic fills have been used to fill casting flaws, armature rod holes, and core pin holes, including a large cast-in repair in Psyche's left hand and the vase it holds. Outdoor exposure at some time during the life of the sculpture has caused corrosion of the remaining armature rods and of the interior and exterior of the bronze. Over time, the sculpture has undergone a number of restorations, including the application and subsequent removal of coatings, the removal of corrosion products, the application of solder repairs, and the use of three different types of paste fills (whiting, gypsum, and lead white in unidentified binders).

NOTES

1 Inventory no. P50. In three locations on the *Farnese Bull*, the armature rods connect one part of the composition to another by running outside of one section of wax into another.

2 See Appendix A, Glossary. Separately cast elements can be joined with sleeves, threaded rods, solder, or other cast-in metal.

3 It cannot be absolutely confirmed with the present radiographs whether or not there are wax-to-wax joins between Psyche and the putti. The radiographs confirm the lack of metal-to-metal joins, but wax-to-wax joins cannot be ruled out. Regardless, the lack of wax-to-wax joins in the figure of Psyche is sufficient in this example to strongly suggest that the bronze was directly cast.

4 Raman analysis by Karen Trentelman and ESEM analysis by David Carson of the Museum Research Laboratory, Getty Conservation Institute.

CHAPTER 8

Faun and Nymph

Staatliche Kunstsammlungen, Grünes Gewölbe, Dresden. Inv. no. IX 36
After Adriaen de Vries
Possibly cast in Prague before 1621
Dimensions: *Faun* H: 48.2 cm; *Nymph* H: 34.6 cm
Marks and inscriptions: 54. is painted on the base below the nymph

OVERVIEW

The composition consists of two separately cast nude figures mounted on a wooden socle. The seated nymph turns sharply to her left and glances up at the second figure, a dancing faun, who turns back toward her, catching her gaze as he steps away (fig. 8.1). The group is documented in the 1621 estate inventory of the architect Giovanni Maria Nosseni. Johann Georg I, Elector of Saxony, acquired the group in 1622. It is then recorded in the 1640 inventory of the Grünes Gewölbe, Dresden.

Three versions of the *Faun and Nymph* group that had been in Nosseni's estate entered the electoral *Kuntskammer* in 1622 (Syndram and Scherner 2004: 277). The attribution for this version now held in the Grünes Gewölbe has varied over the years. In 1967 Larsson attributed the model alone to de Vries, questioning if the Grünes Gewölbe version may actually be an aftercast commissioned by Nosseni from an autograph group held in his own collection.[1] In 1995 Krahn gave the Grünes Gewölbe group full attribution to de Vries (Krahn 1995: 40). The most recent publication of the sculpture attributes the cast to de Vries but refers to archival documents indicating that the chasing was done at a later date.[2]

FIGURE **8.1** *Faun and Nymph*
Staatliche Kunstsammlungen, Grünes Gewölbe, Dresden.
Inv. no. IX 36

It was hoped that a detailed examination of the group would help to answer some of the questions posed by the presence of other contemporary versions of the composition. Although de Vries trained with Giambologna, he appears to have not acquired his teacher's specialization of casting in multiples. With only one other known exception, de Vries cast each of his compositions as single, unique pieces.[3] The aim of this study was to clarify the attribution, as well as the relationship between the different versions, by comparing to the extent possible the alloy and core materials, the casting model construction, and the repairs to those observed on other small casts in de Vries's oeuvre.

EXAMINATION

1. Alloy

Nymph and Faun: Three spectra were acquired for the bulk alloy of each of the figures. The figures were cast in a similar quaternary bronze alloy. The metal contains 6 to 9 percent tin in a copper matrix with 2 to 4 percent zinc and $<$0.5 to 4 percent lead. The zinc content is high enough to suggest that it was added intentionally to the alloy.

Composition of repairs: A small bronze plug on the top of the faun's head is composed of a copper-tin alloy with higher amounts of lead and tin than in the alloy used for the figures. The elevated lead and tin may be caused by the width of the X-ray beam used for the XRF analysis, which likely included the thin line of solder that surrounds the repair.

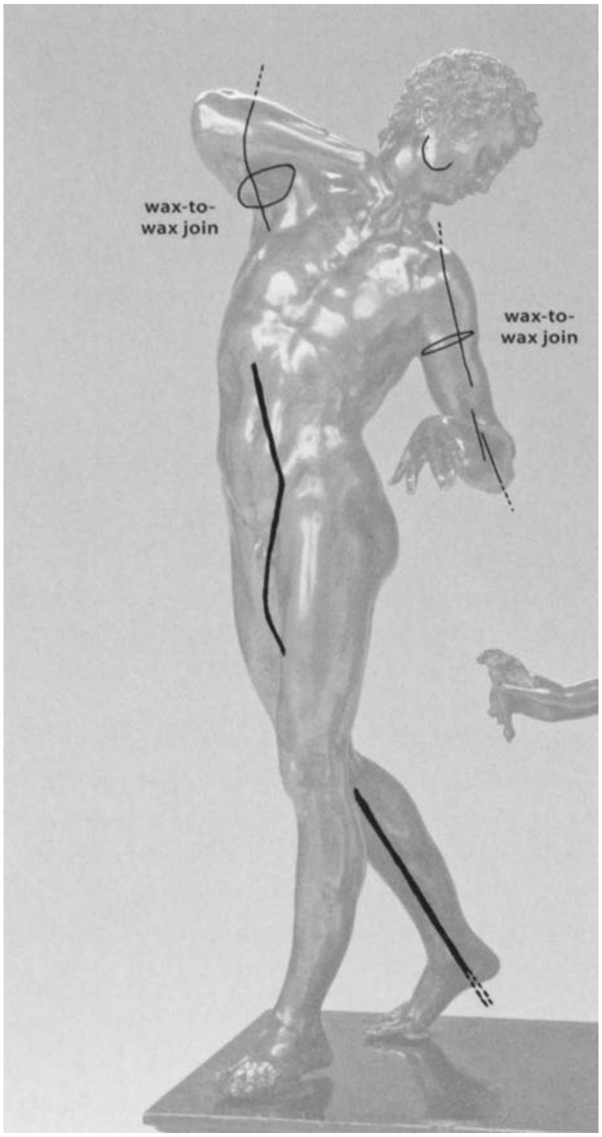

FIGURE 8.2 Summary of wax-to-wax joins and the remaining core supports. The dashed lines indicate where the core supports were cut off at the surface of the bronze.

White metal used to secure the plug in the top of the faun's head was roughly identified as a 60 percent tin, 40 percent lead solder. As with the spectra taken from the repair on the faun's head, interference from the bronze surrounding the thin line of solder precludes a more exact result. All the XRF spectra can be found in table 4.1.

FIGURE 8.3 Threaded sprue ends are used to mount the faun.

2. Evidence of the Technique of Fabrication

A summary sketch of the core supports and wax-to-wax joins in the faun can be found in figure 8.2.

The figures are mounted to a painted wooden base. The faun secures to the base using the casting sprues that extend below the feet (fig. 8.3); the nymph is mounted with a partially threaded iron rod. The internal cavity of the nymph is blocked by pieces of wood that cross the opening to the interior. The tightly wedged wood could not be removed for the examination (fig. 8.4). Because X-rays can interfere with thermoluminescence dating of core material and the core of the nymph was not accessible for sampling, the female figure was not radiographed, in the event core remains in the interior and dating is desired in the future. For this reason, radiographs were taken of the faun but not of the nymph.

a. Internal metal armature and core supports

Faun: Radiographs show wire core supports of two different dimensions remaining in the figure. A rod runs from the right heel up the right leg and into the torso, ending above the waist. Four smaller wires remain in the figure. Close examination of the radiographs shows that both ends of the thinner wires in the arms, as well as the bottom of the rod in the right leg, extended through the wax and into the investment material. In such a configuration, the wires acted as

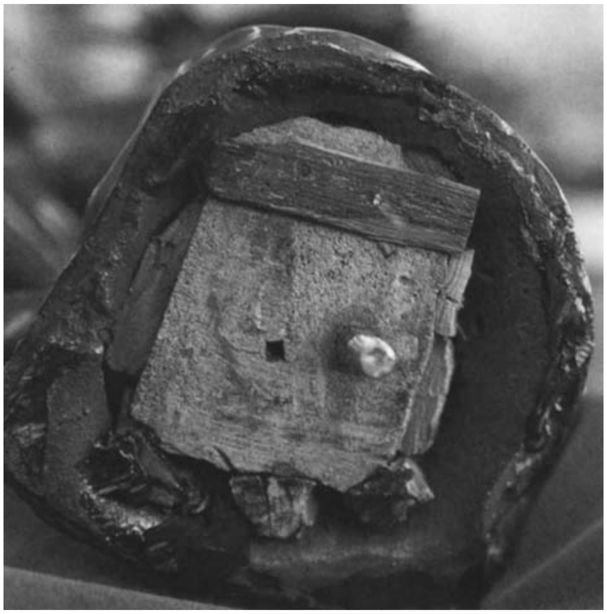

FIGURE 8.4 Wooden blocks close off the interior of the nymph.

both core supports (helping to keep the core together during the pour) and core pins (holding the core in alignment within the investment when the wax was melted out).

Nymph: There is no indication that the threaded rod used to mount the figure is part of the original armature. Removal of the wood plugs in the hollow base would help to determine if and how the rod secures to the bronze figure (fig. 8.4).

b. Core pins

Faun: As mentioned above, the core support wires also acted as core pins, holding the core in position during the casting. There are no core pin plugs discernible on the surface or remaining inside the bronze. The round holes visible in the radiographs appear to be porosity lacunae rather than core pin holes as they do not extend all the way through the bronze wall.

Nymph: Core pin plugs are not discernible on the surface.

c. Core material

Faun: By looking into the small casting flaws in the inside of the right elbow and under the feet, one can see that most of the core has been removed from inside the figure. Small samples were removed from each foot. Quantitative analysis yielded the following:

Right foot

- 83.5 percent gypsum matrix
- 5.5 percent red clay
- 1.5 percent gray clay
- 6 percent quartz
- 1 percent feldspar
- 1.5 percent opaque minerals
- 0.5 percent hematite
- trace of oxy-hornblende (lamprobolite)

Left foot

- 50.5 percent gypsum matrix
- 25.5 percent red clay
- 10 percent gray clay
- 11.5 percent quartz
- 0.5 percent feldspar
- 0.5 percent calcite (granular)
- 0.5 percent metamorphic rocks
- 0.5 percent opaque grains
- trace of muscovite

The results of the analysis show that the core is composed primarily of gypsum plaster with added clay and sand, suggesting that the core was poured into the wax as a slurry—another indication of the indirect lost wax technique. Variations in the ingredients added to the plaster suggest incomplete mixing before the liquid core was poured into the mold.

Sampling for thermoluminescence dating of the faun was not possible. A small amount of core could be coaxed out of the holes for microchemical and petrographic analysis, but additional sampling was not possible.

Nymph: The opening in the bottom of the figure is currently closed off by pieces of wood securely wedged in place, blocking examination of the interior surface. It is not known whether any core remains inside the figure.

d. Internal surface of the bronze

Faun: Radiographs suggest that the figure is hollow throughout. There is some variation in the thickness of the bronze, but overall the interior contour of the metal wall is smooth and the thickness is uniform. A large drip from slush molding of the wax model is preserved in the metal, suggesting that the sculpture was cast using the indirect process. The drip runs horizontally across the chest (fig. 8.5). Figure 8.6 shows a break across the core in

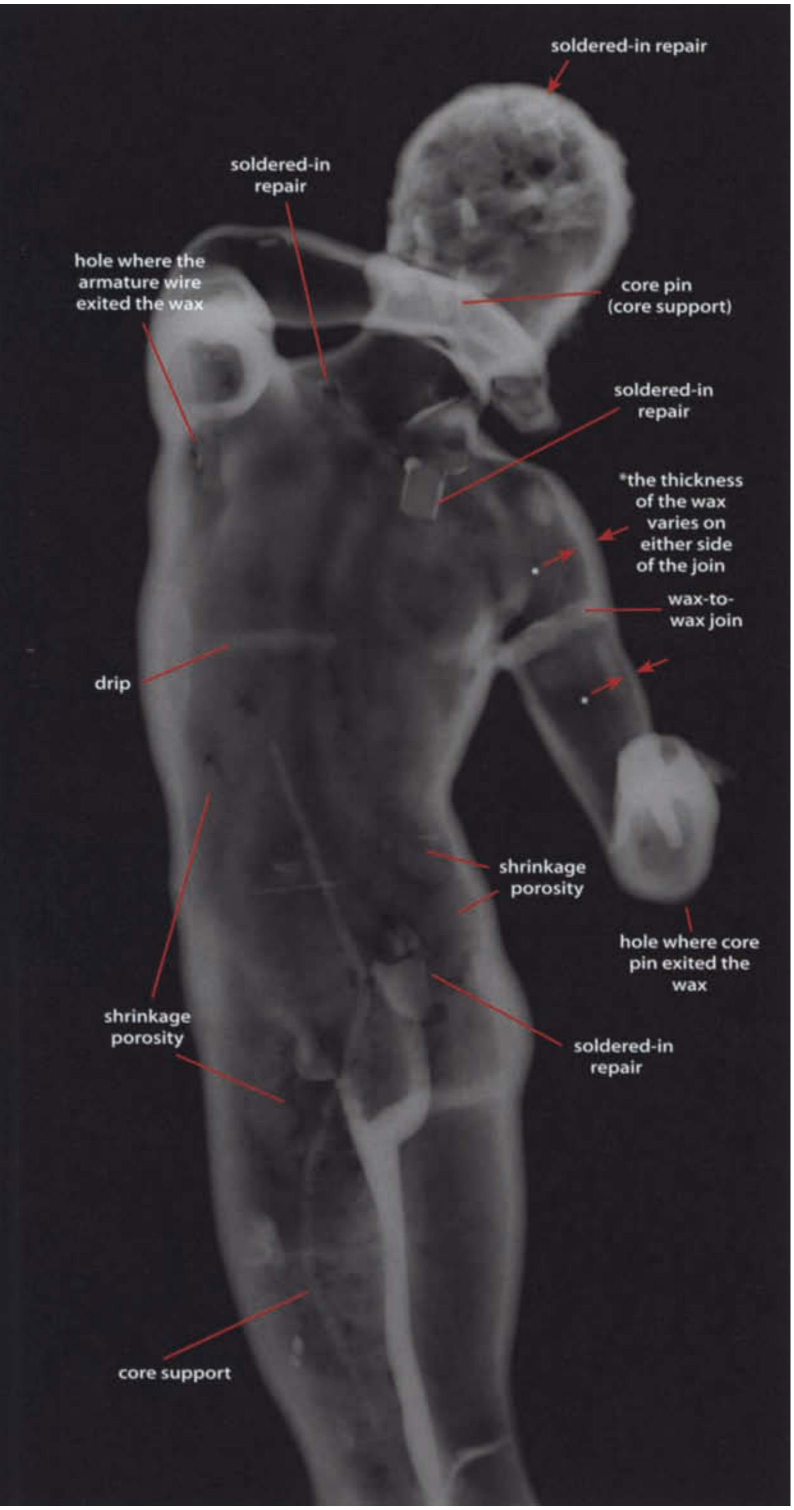

FIGURE 8.5 Radiograph of the faun.

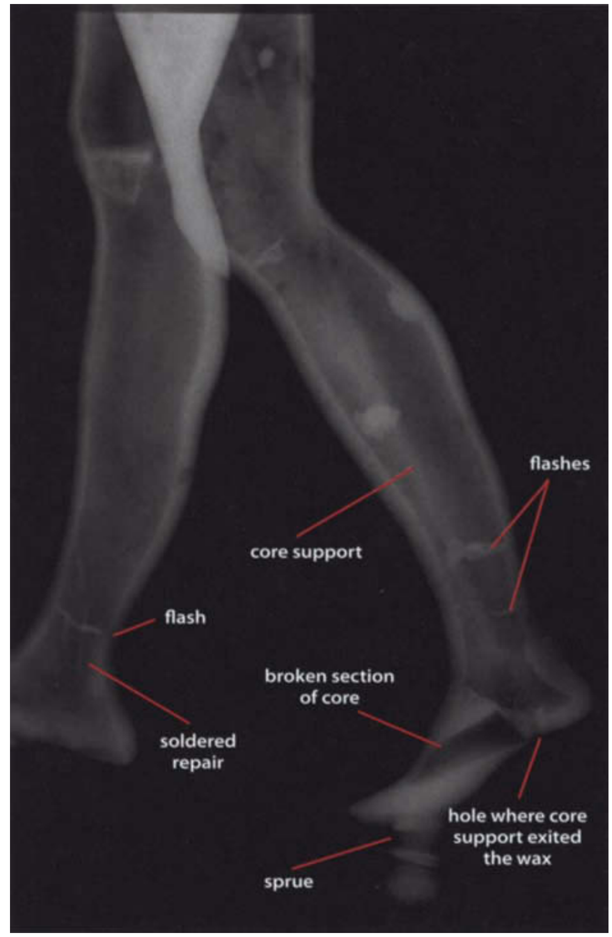

FIGURE 8.6 Radiograph of the faun's legs.

the right foot that may have occurred as the molten metal entered the mold.

Nymph: The interior was not examined.

e. Method of assembly and joining of individual wax or cast bronze components

The figures were cast separately.

Faun: As seen in the radiographs, rings of increased density across the upper arms indicate wax-to-wax joins where the separately molded wax arms were joined to the torso. As mentioned above, wires run through the upper arms, supporting these joins. Variation in the thickness of the metal on either side of the join in the left arm confirms

FIGURE 8.7 Side of the faun's head. The curls were deeply incised in the wax.

FIGURE 8.8 Photomicrograph of the faun's face with considerable cold work around the eyes.

that the wax arms were not made at the same time as the rest of the body, and were joined in the wax (fig. 8.5). These wax-to-wax joins are further evidence of the indirect lost wax casting technique. There is no indication of wax-to-wax joins in the thighs or neck. There are no metal-to-metal joins; the figure was cast in one pour.

The faun secures to the painted wooden base using the casting sprues that extend below the feet (fig. 8.3).

Nymph: There is no external evidence of metal-to-metal joins. If the wooden blocks are removed in the future, it may be possible to see wax-to-wax joins on the interior of the figure, or where the figure joins the pedestal on which she is seated.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

Faun: The flesh is polished, with short file or wire brush marks remaining in some areas. The curls in the hair and in the sideburns were deeply cut into the wax, and possibly also incised into the metal with a V-shaped chisel (fig. 8.7). The eyelashes, eyebrows, and pubic hair appear to have been punched into the metal with a straight chisel. The pupil was made with a round, convex punch stamped in the metal, yet the wavering line around the iris appears to have been cut into the wax (fig. 8.8).

Nymph: The flesh and drapery are polished. Short, haphazard file or wire brush marks remain in the polished areas. Figure 8.9, a photograph of the left hand, illustrates

FIGURE 8.9 The nymph's left hand is roughly finished.

FIGURE 8.10 Photomicrograph of the nymph's face. The chiseled details applied in the bronze are asymmetrical.

FIGURE 8.11 Photomicrograph of the faun's groin showing an area where an old organic lacquerlike patina protects a small spot of polished metal.

some of the casual finish of the details, such as the brusquely delineated nails and the rough finish between the fingers. As with the figure of the faun, the hair was deeply incised into the wax and was possibly sharpened in the metal. Fine parallel scratches in the nymph's headband and braids follow the contours closely and appear to have been applied in the wax. The details on the face were quickly applied: there are no brows or lashes on the right eye, and those on the left appear to have been cursorily applied in the metal in a manner seen in the figure of the faun. The lines around the eyes and lips were applied with an unsteady hand, likely in the wax. The pupils were applied with a round, convex punch (fig. 8.10).

g. Patina

The coatings on the faun and on the nymph appear to have been applied at the same time. The polished golden metal surface can be seen below small remnants of an old translucent reddish brown patina on the nymph's back and pedestal and on the faun's upper right thigh (fig. 8.11). A more recent dark brown, opaque patina remains in the recesses on both figures (e.g., fig. 8.9). A clear, organic coating appears to have been applied to both figures; through this coating the oxidized metal surface has a varied appearance from a warm golden brown to olive green.

3. Casting Defects and Foundry Repairs

Faun: Extensive shrinkage porosity, due to uneven cooling of the metal, plagues the right leg and torso (fig. 8.5). Unrepaired porosity mars the surface in many areas. Repairs were made using soldered-in copper alloy patches. The lead-tin solder is X-ray opaque and was used with the following repairs: one on top of the head, one on the left shin, one at the right shoulder, one below the tail, and one on the top and one on the bottom of the right arm (see Appendix A, fig. A.27).

The end of the left pinky finger appears to have been miscast. Rather than add a repair, a fingernail was simply chiseled into the metal at the end of the shortened digit.

Nymph: As with the faun, porosity flaws the surface, in some areas extending into the interior cavity. Unlike with the faun, which has none, there are numerous round copper alloy plugs on the body and drapery, and there appears to be a large copper alloy repair on the left side of the neck and cheek. The soldered-in repair on the top of the right upper arm is quite visible on the surface (see Appendix A, fig. A.26). Radiography of the sculpture would reveal more about the condition of the cast.

4. Later Modifications/Restorations

Faun: There are no later modifications/restorations.

Nymph: The early inventories mention that the nymph originally held a mirror, which is now missing.

SUMMARY

Although there may be little doubt that de Vries conceived the highly innovative and compelling composition of the *Faun and Nymph* group, the examination of the Grünes Gewölbe casts suggests that de Vries's involvement in the making of the casting model and the actual casting of the bronzes should be reassessed.

The wax-to-wax joins and wax drip preserved in the torso of the faun are characteristic of the indirect lost wax technique, in which the casting wax was slush molded in sections.[4] De Vries used the indirect technique for a number of his bronzes of small and medium size. Of the compositions clearly attributed to de Vries that were examined in detail as part of the exhibition, six were cast indirectly. Of those six, two besides the faun are small in scale: the *Apollo* in the Metropolitan Museum of Art, New York, and the *Flying Mercury* in Lambach Abbey, both of which are unsigned (Scholten 1998a: 115, 198). In comparing the radiographs of the faun with those of the *Apollo* and the *Mercury*,[5] it can be seen that the three were essentially constructed in the same manner, a manner typical of most indirect casts of this size (Stone 1981; Bewer 1995b). The casting waxes were made in sections using piece molds. The sections join at the limbs (so-called wax-to-wax joins) that are reinforced in the interior with core support wires. The core support wires on the faun are different from those of the other two, as they extended through the wax at both ends, doubling as core pins. There are other small similarities and differences, but this group of indirect casts attributed to de Vries is too small to make any definitive conclusions about whether or not the casting model for the faun was constructed in a manner typical of the artist.

Other evidence, though, shows considerable differences with the work of de Vries. The core of the faun was found to be plaster based. Plaster is often used as the matrix for the cores of indirect casts, yet de Vries seems to have preferred clay for all of his casts, indirect and direct. The one other de Vries bronze in this study found to contain a plaster core, the *Venus* in Braunschweig, contains numerous anomalies in its construction, leading to a reconsideration of the attribution (see chapter 10). This leaves the Grünes Gewölbe *Faun* as the only indirect cast—indeed, the only de Vries cast studied to date—that contains a plaster-based core. It should be noted, however, that certain aspects of the temper added to the Grünes Gewölbe *Faun* core are reminiscent of the "typical" de Vries compositions, including the color of the added clay, the small grain size, the grain angularity, and the presence of the mineral oxyhornblende (lamprobolite), suggesting that the casting model may have been constructed by another artist working in Prague.[6]

Up to 4 percent zinc was identified in the alloy of the *Faun and Nymph* figures, distinguishing it from other de Vries alloys. With only two exceptions, the other de Vries alloys studied to date contain zinc in quantities well below 1 percent, indicating that it occurs in the alloy as an impurity rather than an intentional addition. The two exceptions are also relatively small indirect casts: *Flying Mercury* in Lambach Abby, which contains 1.08 percent zinc (Bewer 2001: 166), and *Crucifix* in Augsburg, which has a zinc content of 0.5 to 1.5 percent. The attribution of the *Crucifix* is questioned (see chapter 9).

The treatment of the surface details on both the Grünes Gewölbe *Faun* and the *Nymph* differs from the rest of de Vries's oeuvre. The punched eyelashes, eyebrows, and pubic hair were added in the metal in a simplified and linear manner highly uncharacteristic of de Vries. Close examination of the surface details suggests that other uncharacteristic aspects of the form seem to derive from the handling of the wax *before* casting also. The distinctive parallel scratches decorating the headband, hair, and right ear of the nymph were applied in the wax; these marks are not seen on other de Vries casts. A second example can be seen in the modeling of the hair. In both the faun and the nymph, the hair is composed of curls and waves formed with deeply incised cuts. As seen in the artist's other early compositions such as *Psyche Borne Aloft by Putti* in Stockholm (fig. 7.12), as well as in other small compositions such as the *Apollo* in New York (Scholten 1998a: 117, fig. 5b), de Vries repeatedly approached the hair in a very different manner, in which the soft form of each tuft swells smoothly next to its neighbor in a very waxy, organic manner. This uncharacteristic modeling method on the *Faun and Nymph*, as well as the decorative surface scratches and the chisel work applied in the metal, suggests that de Vries was involved with neither the preparation of the casting wax nor the casting itself.

Larsson comments on the softer modeling of the version of the faun in the Skulpturensammlung, Dresden, as being more like the work of de Vries. While the hair on this second version displays less of the deep chiseling in the wax and the metal, and none of the fine parallel scratches made in the wax, to this researcher, the distinctly differentiated curls and stiff modeling in the mouth still do not have the quality of modeling expected of de Vries.

Soldered-in copper alloy repairs are not typical for de Vries. As the solder repairs on the *Faun and Nymph* are comparatively large and they appear to repair casting flaws rather than later damages, they were likely applied in the foundry. Soldered-in repairs were found on only three other sculptures in this study: *Laocoön*, the *Allegory of the War against the Turks* relief, and *Cain and Abel* in Copenhagen. The latter bronze was clearly repaired and chased after the artist's death (chapter 24). The date for the repairs on the *Laocoön* is unknown, although there have been numerous restoration campaigns on the bronze. The soldered-in section on the relief was carefully chased in attempts to hide the repair, in contrast to the clearly visible solder line around the repairs in the *Faun and Nymph*. Although it has not been examined in detail by the author, visual examination of the *Faun* in the Skulpturensammlung, Dresden, suggests that it too has two soldered-in repairs: one under the right forearm and one under the left knee.

One of the questions posed by the *Faun and Nymph* group is why multiple versions existed during de Vries's lifetime. The indirect technique, as observed on the figure of the faun, allows the casting of numerous, nearly identical bronzes, an approach to production not generally taken by de Vries. Yet was the artist directly involved in the casting of the Grünes Gewölbe version? The highly uncharacteristic handling of the wax suggests that someone other than de Vries reworked the wax models before casting. The type of core used for the cast has so far not been found in other casts by de Vries, a change in method unlikely for such a technologically consistent artist. Variations in the alloy from what is expected of de Vries, coupled with the uncharacteristic cold work and unusual repairs, also suggest that he was likely not involved in the casting or finishing of the figures.

In light of these observations, Larsson's opinion that the composition may be an aftercast of the version in the Skulpturensammlung may be correct. Yet there may be one more twist to the story. As stated above, although the details on the Skulpturensammlung *Faun* are softer than those on the Grünes Gewölbe version, neither is fully characteristic of de Vries. In addition, both versions carry similar, rather unusual soldered-in repairs, suggesting the same craftsman may have repaired both of them. Three versions of the *Faun and Nymph* composition entered the electoral *Kunstkammer* from Nosseni's estate, two of which were "unchased, raw casts" (Syndram and Scherner 2004: 277). It may be that both the Skulpturensammlung and the Grünes Gewölbe versions are aftercasts of the original version (whose whereabouts are now unknown). This third version may, in fact, be the single composition referred to in the Augsburg patrician Philipp Hainhofer's 1617 travel diary. In his visit to Nosseni's house in Dresden, he mentions seeing "a faun and nymph holding a mirror by de Vries" (in Larsson 1967: 13). It is possible, therefore, that Hainhofer saw the original de Vries composition, at that time the only one in the architect's collection. Sometime after that date, but before his death, Nosseni had two aftercasts made. These versions are now in the collections of the Grünes Gewölbe and the Skulpturensammlung, Dresden.[7]

NOTES

1 According to Larsson (1967: 13), the group in the Skulpturensammlung, Dresden, is the original autograph group. The nymph from this group is now lost. The faun is in the Skulpturensammlung, Dresden, inv. number ZV 3205; illustrated in Larsson 1967: pl. 8.

2 The distinction between the casting and actual chasing of the casts is presented in archival documents, as cited in Syndram and Scherner 2004: 244.

3 The other exceptions are the two signed *Cain and Abel* groups: one in Edinburgh (see chapter 18) and one in Copenhagen (see chapter 24). These bronzes are dated ten years apart.

4 As described in chapter 2, in the indirect lost wax casting technique the casting wax is formed inside of molds. For ease of handling, the wax is often made in sections that are joined to one another with a heated tool. These wax-to-wax joins remain visible on the interior of the bronze when radiographed. Drips are at times observed due to the method in which the molten wax is applied to the molds. Once the casting wax is formed, the core material is added. A plaster-based core can be poured into the cavity and sets through crystallization rather than through evaporation.

5 For views of the radiographs, see Bewer 2001: 171, illus. 16, 17.

6 Geologic features in an area will determine the minor elements found in the clay collected there. All the cores examined in detail in conjunction with this project were taken from bronzes cast in Prague, for which there is considerable consistency.

7 A technical examination of the *Faun* in the Skulpturensammlung would be of great interest, including determination of the casting method using X-ray radiography. If both versions are aftercasts made concurrently, they should exhibit wax-to-wax joins in the same locations and some consistency in the core supports. A comparison of the details in areas such as the hair may indicate whether variations are due solely to changes made in the wax. A comparison of the dimensions would also be of value, as an aftercast will be smaller than the bronze it copies, yet two aftercasts made concurrently should be quite similar in size. Measurements must be taken with care, as wax joins may cause slight differences in overall measurements, even in bronzes cast from the same molds. For this reason, internal features such as the distance between the eyes, or the length of the torso, may offer better comparisons than the overall height or the distance between an elbow and heel, for instance.

CHAPTER 9

Crucifix

Authorship uncertain

Kirchenstiftung Mariä Verkündigung, Wullenstetten

Dimensions: Corpus: H: 49.0 cm × W: 37.2 cm × D: approx. 10.5 cm ;
Titulus: H: 7.5 cm × W: 11.5 cm × D: 1.8 cm

Marks and inscriptions: None

OVERVIEW

The statuette represents a nude *Christo morto*, with the eyes nearly closed and the lips slightly parted (fig. 9.1). The *Crucifix* has long been attributed to Adriaen de Vries,[1] although it has received a recent attribution to Giambologna (Diemer 2006: 168). The nude depiction of Christ on the Cross is relatively unusual but was used by Cellini in his life-size marble (1556–62) and by Giambologna in his gilt bronze *Crucifix* (ca. 1590–1600).[2]

It was hoped that a comparison of the technical and stylistic details of the *Crucifix* with the work of Adriaen de Vries would help to clarify the attribution.

EXAMINATION

1. Alloy

Corpus: The corpus was cast in a bronze alloy containing approximately 9 to 10 percent tin in a copper matrix with just over 1 percent zinc and lead content below 1 percent. Repairs to the bottom of the legs were cast in a copper-tin alloy containing 3 to 4 percent zinc. Results for all of the spectra can be found in table 4.1.

Titulus: The titulus was cast in a bronze alloy containing approximately 10 percent tin in a copper matrix, with zinc and lead content below 0.5 percent.

FIGURE 9.1 *Crucifix*
Kirchenstiftung Mariä Verkündigung, Wullenstetten

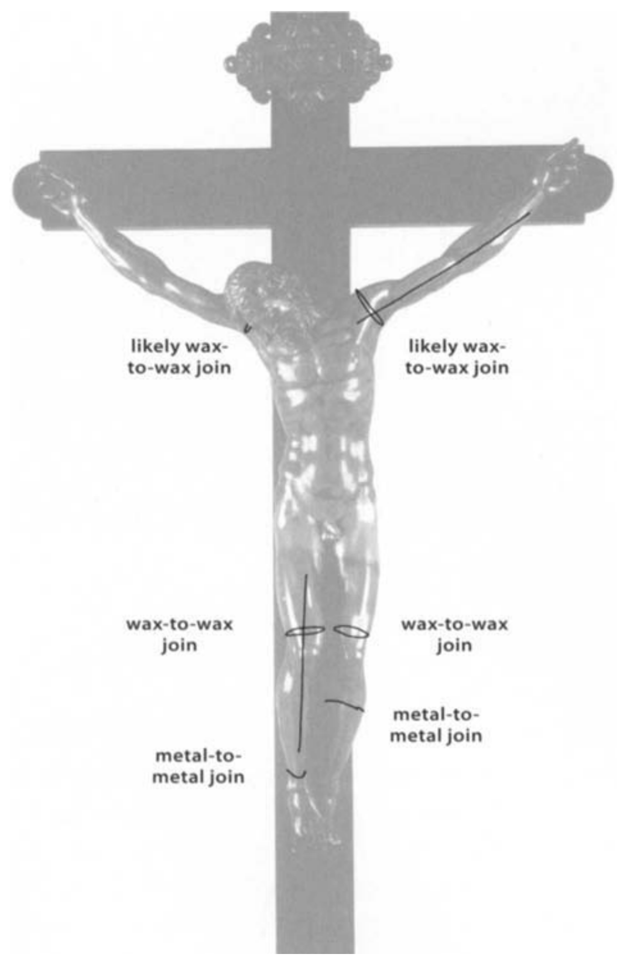

FIGURE 9.2 Summary of wax-to-wax and metal-to-metal joins with the remaining core supports.

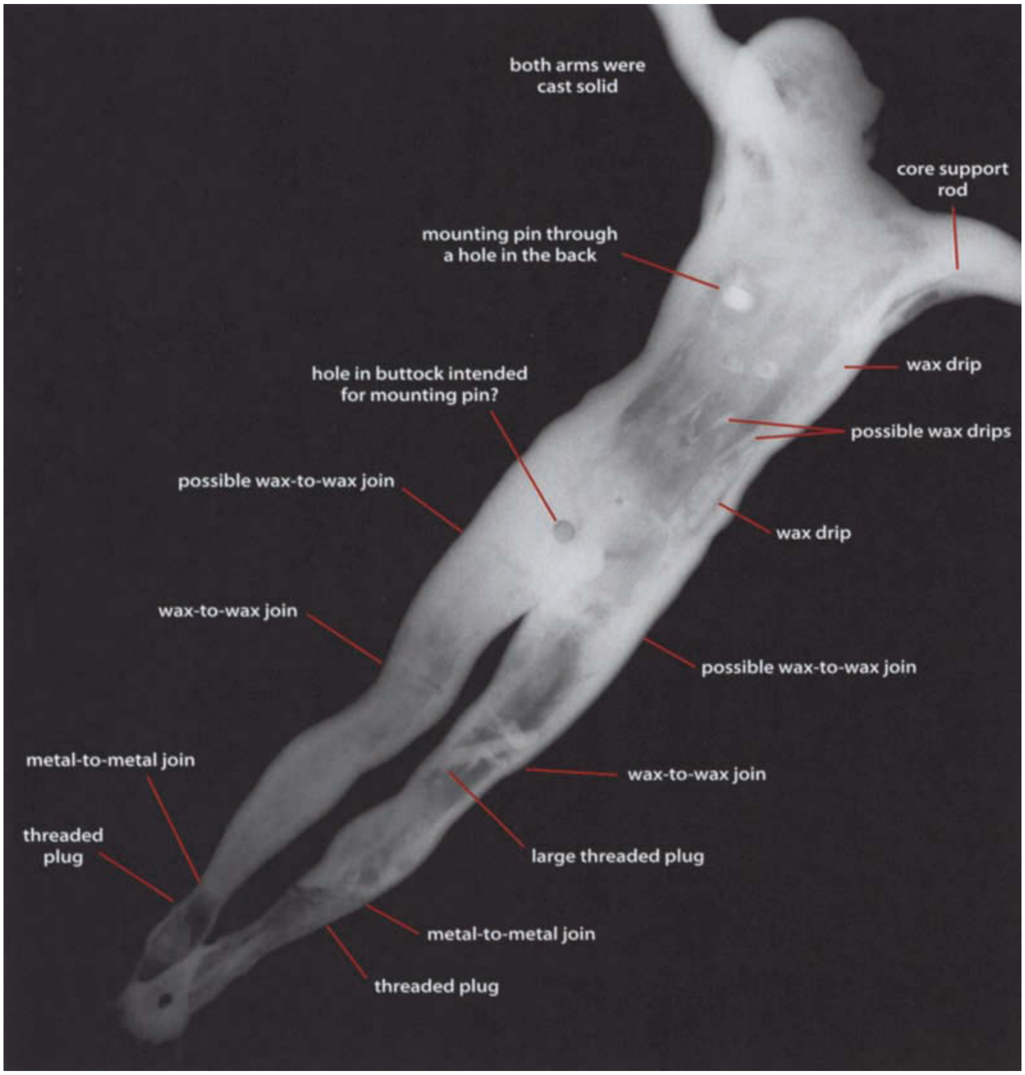

FIGURE 9.3 Radiograph of the corpus.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Corpus: Radiographs show that a support rod extended from the left wrist, up the left arm, and just into the chest (fig. 9.2). This rod would have acted as a support for the wax arm. There is no indication of a similar support in the right arm. The radiographs are difficult to read, but they suggest that a rod ran through the right leg from thigh to ankle (fig. 9.2).

Titulus: Not applicable.

b. Core pins

Corpus: Four sets of 0.3 cm diameter round plugs that are lighter in color than the surrounding surface appear along either side of the figure, indicating that they may be core pin plugs. These plugs appear in the following locations: under the armpits, on the hips, on the outer thighs, and on the upper calves (the latter three can be seen in fig. 9.4). As the holes in the armpits and hips are located across from one another, they may be remains from side-to-side core pins.

Titulus: Not applicable.

c. Core material

Corpus: As with all the bronzes included in this study, the radiographs show that the sculpture is hollow and was therefore cast with core material inside. A small hole in the left hip extends into the interior; shining a flashlight into the hole reveals that the core has been removed from at least this part of the torso; the entire core was likely removed from the interior before the repairs were made in the legs.

Titulus: Not applicable; the titulus was cast solid without any core material.

d. Internal surface of the bronze

Corpus: There is no direct access to the interior surfaces of the bronze. The torso, head, legs, and feet were cast hollow. The arms were cast solid without any core. The left arm was cast around a support rod. The radiographs show two vertical drip-like marks in the torso, an indication of the indirect lost wax technique (fig. 9.3).

There are unusual marks on the radiograph in the center of the belly in which a rough pattern of crossing lines, rather like checkmarks, is located. The marks may be drips (fig. 9.3).

Titulus: Not applicable.

e. Method of assembly and joining of individual wax or cast bronze components

Corpus: Variations in the thickness of the metal in rings above both knees are reminiscent of wax-to-wax joins (fig. 9.3). The solid arms were likely formed separately and attached to the torso with wax-to-wax joins. The wax drips now captured in the bronze along the proper left side of the figure may have formed when the left arm was secured to the torso with a hot tool (fig. 9.3). These wax-to-wax joins are further indication of the bronze having been cast using the indirect lost wax method.

As seen in the radiographs, the thickness of the bronze changes dramatically in the right ankle and lower left leg. In these lower sections, the bronze is much thinner than in the rest of the figure (fig. 9.3). Dark, recessed lines on the outer surface of the bronze confirm that the right foot and lower left leg were cast separately, then added on to the rest of the figure with metal-to-metal joins (fig. 9.2). It is not clear in the radiographs or through surface examination what type of join was used.

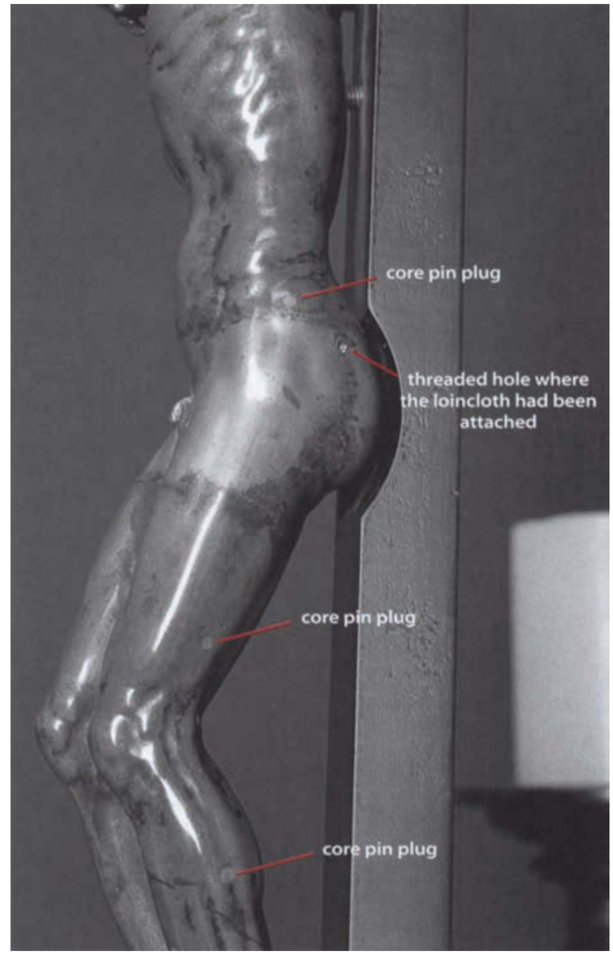

FIGURE 9.4 Side view. The cross has been cut back to fit the figure.

Titulus: Not applicable; the titulus was modeled and cast in one piece.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

Corpus: Fine details in the face and hair were fully modeled in the wax. Although the surface is difficult to read in areas as it is slightly worn and partly obscured by accumulated soil and coatings, there is no indication of chiseling in the metal to enhance or strengthen the lines in the

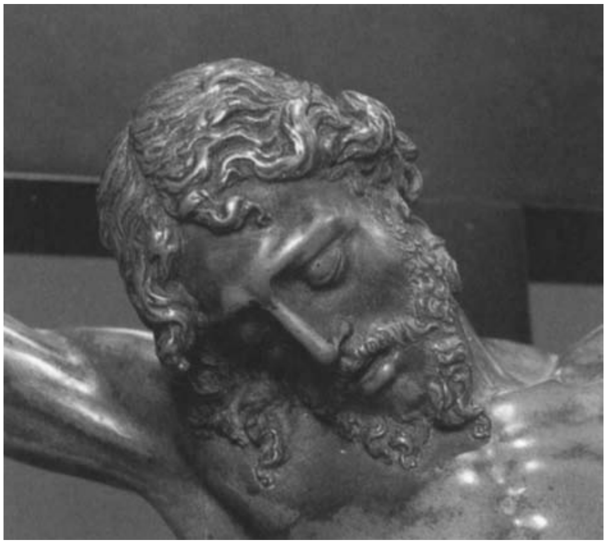

FIGURE 9.5 The careful and detailed modeling was done in the wax without reworking in the metal.

hair and beard. The eyes are almost closed, with carefully delineated lids. The mouth is slightly open, and no teeth are depicted (fig. 9.5). The genitals appear to have been fully modeled in the wax without any enhancement in the metal. The hair and beard were modeled more tightly on the left side of the head, which faces the viewer, and more freely on the right (figs. 9.5, 9.6). The flesh has been highly polished overall. There is no evidence of punched texture having been applied to the wax or metal.

Titulus: The titulus was modeled in wax and retains a waxy feel with little if any cold work in the metal.

g. Patina

Corpus: Where the loincloth has been removed, there is no coating; the golden color of the polished and lightly oxidized metal surface remains. The rest of the figure is browner in color, apparently due to a translucent brown organic coating that varies from light brown over most of the body to darker brown where the coating is thickest. A more recent, clear glossy coating has been applied overall.

Titulus: The surface is uncoated. The metal has oxidized to brown on the raised surfaces and to dark brown in the recesses.

3. Casting Defects and Foundry Repairs

Corpus: As the metal-to-metal joins indicate, the right foot and the lower left leg were apparently miscast in the original pour, and replacements were cast separately and added on in the metal. Due to the relatively small size and simple composition of the corpus, it seems likely that the added parts are repairs rather than an intentional part of the casting scheme. It is unclear from the radiographs, however, how the foot and lower leg are secured. Although the alloy of the repairs differs to a certain degree from that of the rest of the figure, the general appearance of the modeling and the condition of the surface suggest that the repairs are original to the sculpture.

Numerous round plugs, measuring 0.2 to 0.5 cm in diameter, can be seen on the surface of the bronze and in the radiographs. Some of these appear to be core pin plugs (see section 3b above), although the large number of them would suggest that some may plug casting flaws. The radiographs show that at least three of the repair plugs are threaded, including one in the right ankle, one in the lower left leg, and one that is 3.0 cm long just above the left knee (fig. 9.3). There is no indication of why such a long plug was used.

Two larger-diameter holes in the torso (measuring approximately 0.7 cm across in the radiograph) may have originally been used to mount the corpus to a cross. At present, only the uppermost hole is being used (fig. 9.3).

Titulus: None apparent.

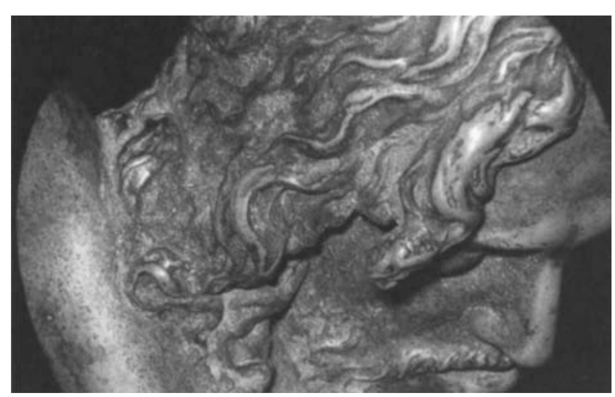

FIGURE 9.6 Photomicrograph. The sinewy curls on the right side of the head are more loosely defined.

4. Later Modifications/Restorations

Corpus: The cross is not original, nor is it of the proper design. The corpus attaches to the cross with a large iron screw that passes through the right side of the figure's torso; there are iron nails in the palms. In order to allow the hands and left foot to sit flat against the cross, the wood has been recessed at the buttocks (fig. 9.4). The hole in the crossed feet is not currently being used. It is likely that the original cross contained a shelf that supported the feet, lifting the figure slightly so that it would rest properly against the cross.

A 0.3 cm threaded hole in the left hip may be where the loincloth was attached (fig. 9.4). The careful finish of the bronze surface below the area hidden by the loincloth suggests that it was a later addition, covering what was intended to be seen.

Titulus: Originally, the two mounting holes on the sides of the plaque would have been used to secure it to a wider cross. The titulus attaches to the present narrow cross with a large screw in its center. When the hole was cut in the bronze to accommodate this screw, the letter *N* was distorted.

SUMMARY

The corpus and titulus were cast separately and are mounted to a cross that is not original. The corpus was rather thickly cast in bronze. Wax-to-wax joins and wax drips indicate that the figure was cast using the indirect lost wax technique. Details such as the face, hair, and genitals were carefully modeled in the wax without cold work in the metal. The right foot and the left leg from the calf down are foundry repairs that were cast separately and joined in the metal. A loincloth added to the sculpture at some point after casting was left in place when a translucent brown lacquerlike coating was applied. The loincloth was removed at some date, revealing the uncoated golden-colored oxidized metal surface that strongly contrasts with the adjacent patinated surfaces. The waxy appearance of the titulus suggests that the model was made in wax, but there is no further indication as to whether the casting wax for the titulus was formed in a mold using the indirect lost wax technique or was modeled and cast directly. The technical evidence does not clarify whether the titulus dates to the same time as the corpus.

Overall, many aspects of the technical examination, including the alloy, the refinement of the facial features and method of modeling the hair, the type of core pins, the thickness of the bronze walls, and the presence of substantial repairs, suggest that the attribution to de Vries should be reconsidered.

Wax drips and wax-to-wax joins in the corpus are characteristic of the indirect lost wax process, a technique used for two small de Vries bronzes with uncontested attributions: the *Apollo* in the Metropolitan Museum of Art and the *Flying Mercury* in Lambach Abbey. There is one important difference between the *Crucifix* and the other two casts, though. Whereas the *Apollo* and the *Flying Mercury* also contain similar wax-to-wax joins, they are notable for very thin walls that conform closely to the outer contours of the bronze.[3] In comparison, the walls of the corpus are quite thick overall and not particularly uniform.

At approximately 1.3 percent, the zinc content in the *Crucifix* is slightly higher than that found on most de Vries casts. Consistency in the modeling and surface appearance of the repairs in the lower legs suggests that they are original to the sculpture, but they have an elevated zinc content—3 to 4 percent—far above that found on the other de Vries bronzes.

Two aspects of the wax model itself distinguish this statuette from the workmanship observed in de Vries bronzes, regardless of their size or casting technique. The refined restraint of the facial features is not typical of de Vries, even at an early date. The precision of the lines delineating the eyelids and of the modeling in the nostrils and lips is not observed to this degree elsewhere in the artist's oeuvre. More important, the relatively sinewy curls in Christ's hair and beard differ considerably from the heavy tufts composed of individually delineated thick strands normally seen early in the artist's career (fig. 13.9).

The plugs located in pairs along the sides of the torso likely repair holes left from side-to-side core pins. No clear evidence of side-to-side core pins remains on any of the de Vries bronzes. Round plugs are relatively rare on de Vries bronzes. Those that have been identified are comparatively large and are not threaded (*Rearing Horse*, chapter 15; *Juggling Man*, chapter 19). According to Bewer et al.

(2003: 105), threaded plugs first appear in regular use in Florence for bronze repairs on Antonio Susini's casts made in Giambologna's workshop.

One further aspect of the casting separates this work from that of de Vries. The metal-to-metal joins in the right foot and the left lower leg were apparently made to repair casting flaws. Even in de Vries's largest bronze compositions, large miscast areas are rare; flaws of this size in a bronze of relatively small size and simple composition are not at all in character. This is particularly true as the corpus is an indirect cast. Should flaws of this dimension have occurred in his newly cast bronze, it seems highly likely that de Vries would have reused the molds to create another wax casting model, remelted the metal, and cast the composition again.

Admittedly, it is difficult to compare figures of different size and subject, yet anomalies in the surface details as well as the casting technique suggest that the composition was neither modeled nor cast by de Vries.

Diemer (2006: 168, 183 n. 54) reports that the Giambologna *Crucifix* in Vienna was made using the same model and cast in the same workshop as the Wullenstetten *Crucifix* considered here. The variations in the dimensions of the two are likely crucial, though, and should be considered further. Radiography of the Vienna *Crucifix* may be of value in confirming the attribution.

NOTES

1 Exhibition catalogue, Münchener Stadtmeseum, Bayern, Kunst und Kulture, Munich, 1972, as cited by Scholten 1998b: 122.

2 As mentioned in Scholten 1998b: 122.The Cellini marble is in El Escorial, Monastery of San Lorenzo, Madrid; the bronze is in the Kunsthistorisches Museum, Vienna.

3 X-ray radiographs of the *Apollo* and *Flying Mercury* can be found in Bewer 1998 and 2001: 171, illus. 16, 17.

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CHAPTER 10

Venus or *Nymph*

Authorship uncertain

Herzog Anton Ulrich-Museum, Braunschweig. Inv. no. Bro 93

Second half of seventeenth century

Dimensions: H: 45.5 cm × W: 23.4 cm × D: 26.6 cm

Smallest circumference around Venus's waist: 26.5 cm

Smallest circumference around plinth: 27.2 cm

Marks and inscriptions: None.

OVERVIEW

The bronze depicts a bathing *Venus* or *Nymph*. The seated figure washes her left foot and holds the remnant of a towel in her left hand (fig. 10.1). The sculpture is recorded in the collection of the Herzogliche Kunst- und Naturalienkabinett in 1753 (H 18).

It has been proposed that the bronze is a model for a seated nymph on de Vries's *Hercules* fountain in Augsburg, in which case the model would have been made between 1597 and 1600.[1] Berger and Krahn propose that the bronze is likely an aftercast of such a model, cast in the Netherlands and dating to the second quarter of the seventeenth century (Berger and Krahn 1994: 241). It was hoped that the examination might help to clarify the intent and authorship of the bronze.

The figure appears to have been cast using an unusual variant of the indirect lost wax technique:[2] A piece mold was taken off of the original model (this model could have been in clay or wax or even bronze) and the model removed from the mold. A rigid armature was then constructed. The armature was placed in the mold, and the plaster-based core was poured in. When the core had set, it was removed from the mold and pared down until it approximated the desired size of the internal casting core. In the narrow arms and lower legs, the plaster was simply cut off, eliminating what would have been very thin and brittle sections of core. The pared-down core was placed back inside the mold, and wax was poured into the void between the mold and the core. The outer piece mold was then removed from the solidified wax, the surface of the wax was touched up as needed (including the removal of fins or other flaws). The wax casting model was then embedded in investment material. The investment was heated to burn out the wax, and the bronze was poured into the void left when the wax was burned off.

FIGURE **10.1** *Venus* or *Nymph*
After Adriaen de Vries
Herzog Anton Ulrich-Museum, Braunschweig. Inv. no. Bro 93

EXAMINATION

1. Alloy

The figure and plinth were cast in leaded brass with a composition of approximately 11 to 12 percent zinc, 3 percent tin, and 2 to 3 percent lead in a copper matrix. The figure does not fit well on the plinth (the right foot hovers above the step), suggesting that it and the plinth were cast from unrelated models. Regardless, the alloys are similar enough that the figure and plinth may have been cast in the same workshop, possibly at the same time. Full alloy results can be found in table 4.1.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Figure: Much, if not all, of the armature remains in the interior (fig. 10.2). This includes five straight rods: two

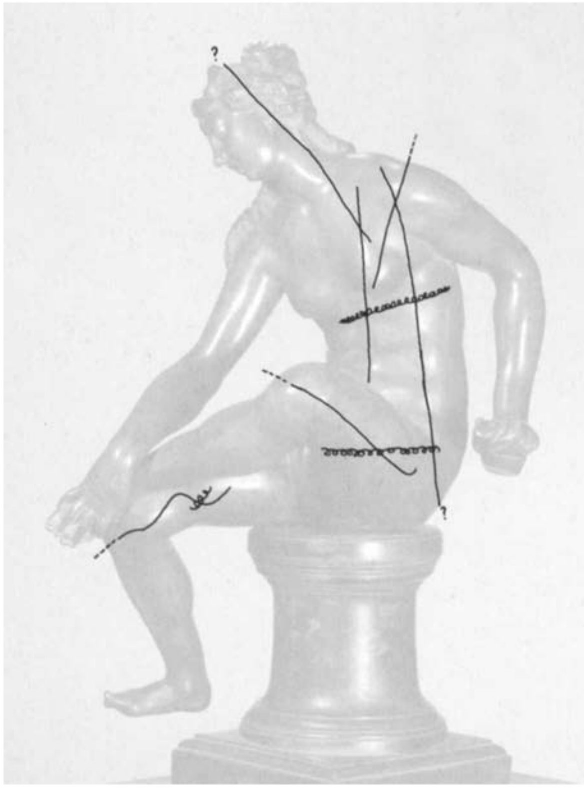


FIGURE 10.2 Summary of the remaining core support rods and wires.

run vertically through the torso; one runs from the chest into the head; and one runs through both of the upper legs. Three sets of tightly twisted double wires function as straight rods; two run horizontally through the body—one across the chest and one across the hips. A third runs diagonally across the right thigh. Where the twisted wires intersect the straight rods, the latter are held tightly in place between the twists, holding the armature together as an interconnected unit. The ends of many of the armature rods—including both ends of all three sets of twisted wires—extended out of the wax casting model and into the investment, helping to hold the core in place when the wax was melted out. The locations at which the wires passed through the wax are now visible as less dense areas in the radiographs where the round holes have been plugged (fig. 10.3).

Plinth: All of the core and armature have been removed from inside the plinth.

b. Core pins

Figure: As mentioned above, most of the armature rods also functioned as core pins, holding the core in place during the pour. There is no clear evidence of other types of core pins having been used.

Plinth: There is no evidence of core pins.

c. Core material

Figure: The powdery light gray–colored core crumbles easily and is fine in texture with a notable sparkle in the inclusions. The sample was removed from the central mounting hole in the buttocks (fig. 10.4). It appears that a lot more of the core still remains in the interior of the figure. Quantitative analysis yielded the following:

- 59 percent gypsum/anhydrite
- 22.5 percent sand particle–sized rusting iron fragments
- 7 percent quartz
- 3 percent feldspar
- 2.5 percent burned plant matter
- 1.5 percent plant fibers (uncharred)
- 1.5 percent opaque clay
- 1% greenish clay
- 1% hematite
- 0.5% biotite
- 0.5% metamorphic rock fragments
- 0.5% oxy-hornblende (lamprobolite)
- trace of othopyroxene

Under magnification, the iron fragments are quite distinctive as bright sand particle–sized bits of white metal surrounded by red rust. The relatively uniform size of the particles and their even distribution in the *Venus* or *Nymph* core suggests that they were added intentionally and are not present merely as flakes from rusting core supports. The core also contains sufficient charred plant material to suggest it was present during the casting and that it too was added intentionally.[3]

When plaster is used as a core material matrix, it is generally poured into the wax casting model, where it solidifies in situ. As such, a plaster core is indicative of the indirect lost wax technique. The sizable interconnected armature seen in

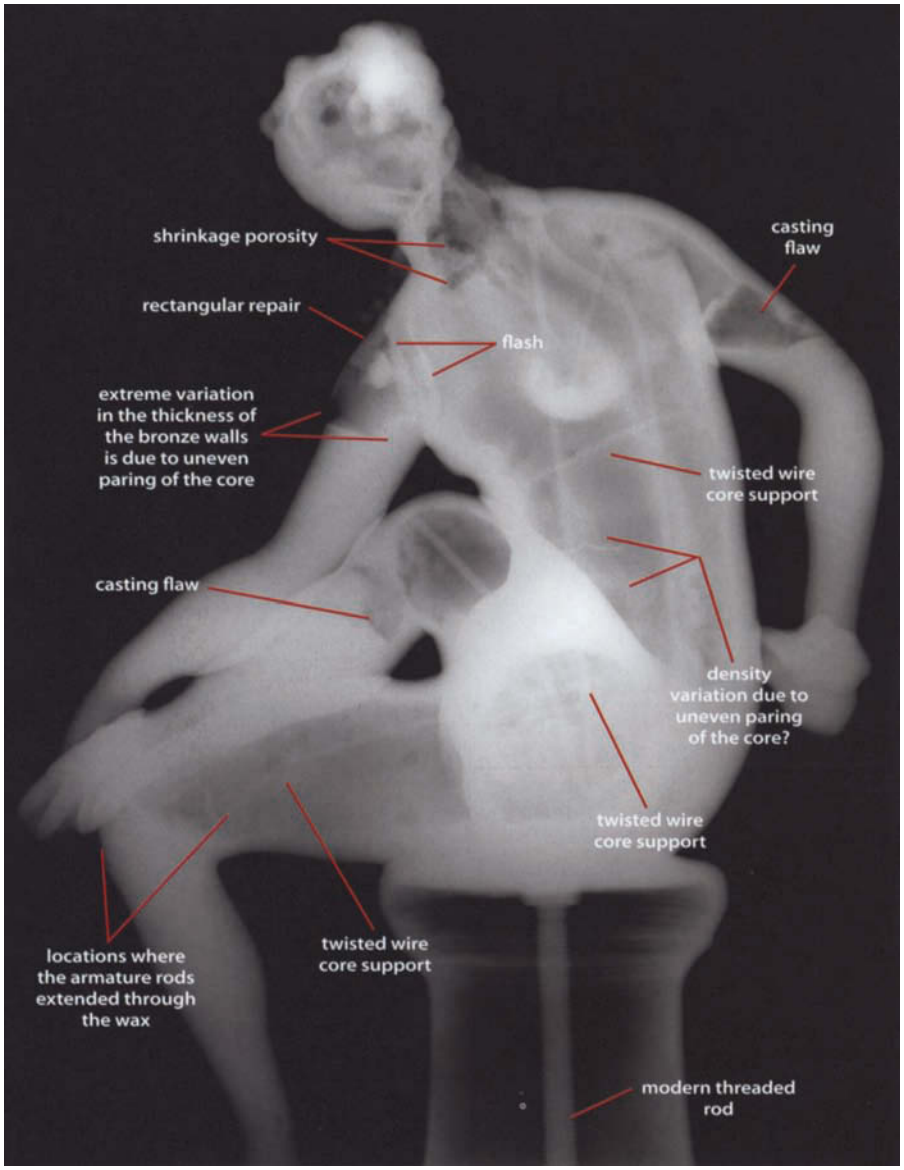


FIGURE 10.3 Radiograph.

this statuette, though, would have been impossible to insert into a preformed wax of this configuration. The lack of wax-to-wax joins confirms that the figure was formed all in one piece, further suggesting that there was no access for inserting the armature. This problem was evidently avoided by placing the armature inside the piece mold and pouring in the core through a hole left for this purpose (likely in the top of the head or the right shoulder where the surface has been repaired). Removed from the mold, the core was then pared down to its final shape.

An additional small chunk of core was dated to 1670 ± 20 years using the thermoluminescence (TL) technique. As described in chapter 6, a comparison of the TL dates with the signed and dated bronzes has shown that the results are best reported with two standard deviations. With this consideration, a TL date of 1670 ± 40 years may be considered

FIGURE 10.4 The figure and plinth are pinned to one another.

more accurate (suggesting the bronze was cast sometime between 1630 and 1710).

d. Internal surface of the bronze

Figure: There is no direct access to the interior surfaces of the bronze. The radiographs show that the head and body are hollow, yet the arms were cast solid from the biceps down, and the legs were cast solid from the knees down. The thickness of the bronze walls in the right shoulder is very uneven. This could be attributed to the core breaking in the shoulder after the wax was melted out, but the contours do not seem to fit this scenario. It could also be argued that the unevenness is due to uneven slush molding of the wax, but the extreme variation does not seem to back this up. Instead, it has the appearance of a core that has been inexpertly cut down, leaving an excess of space against the mold on one side of the shoulder and too little space on the other (fig. 10.3). In the sand casting process, where a similar technique is sometimes used in which the core is pared down, it is not unusual to find such unevenness in the walls due to imperfect shaping of the core.[4] Sand casting must be ruled out, however, primarily due to the composition of the core.

A line of increased density in the radiograph of the torso is likely a gouge formed in the core as it was being cut down (fig. 10.3).

Plinth: The hollow plinth is open at the bottom. The inside of the plinth is smooth, yet not polished. There is only minor porosity; the walls of the plinth are notably uniform in density (fig. 10.3).

e. Method of assembly and joining of individual wax or cast bronze components

Figure: The wax appears to have been formed in one piece and therefore with no wax-to-wax joins. Although thickening of the metal in a line across the left upper arm is reminiscent of a wax-to-wax join, further scrutiny of the radiograph suggests otherwise. The line appears to be the top of what should have been the solid-cast arm. Instead, extensive porosity occurred at the top of the solid section of the arm, forming the mottled surface of the void below the line, as well as the oddly sloping shape of the bottom of the void. These points are particularly clear when the left arm is compared to the right in the radiograph. A similar void appears in the left leg just below the knee (fig. 10.3). There are no metal-to-metal joins within the figure.

Plinth: There is no evidence of wax-to-wax or metal-to-metal joins in the plinth; it was modeled and cast in one piece. The figure attaches to the plinth with a modern threaded rod. A small copper alloy pin set into a small hole in the left buttock extends into a hole in the plinth, keeping the figure from rotating (fig. 10.4).

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

Figure: The flesh has been carefully smoothed with faint polish marks parallel to the limbs. The details appear to have been fully modeled in the wax, including the smooth transitions between the facial features. The towel or scarf in the left hand is truncated below the hand. The surface at the truncation is smooth, suggesting that it was present in the wax and smoothed over before casting. The hair strands

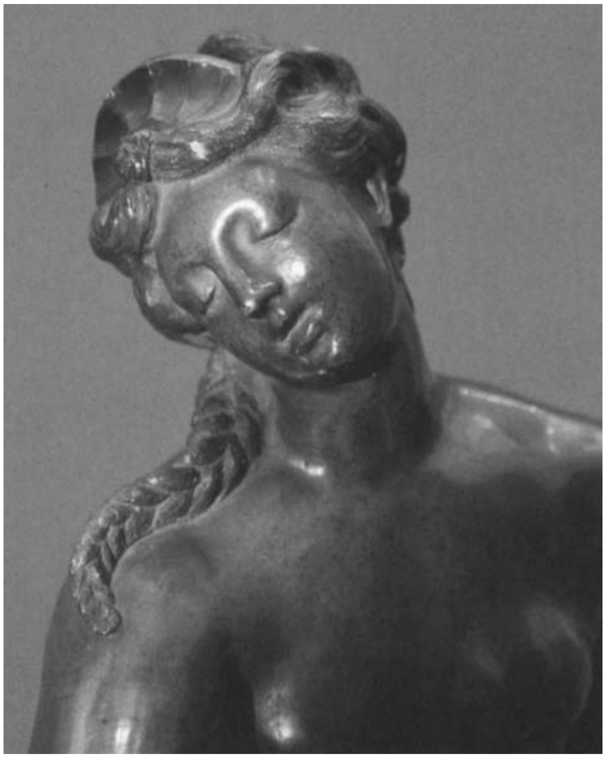


FIGURE 10.5 The features flow smoothly into each other. Strands of hair were scratched into the wax with a sharp tool.

were drawn into the heavy wax curls and braid with a fine pointed tool (fig. 10.5). The figure's sex was delineated with a quick stroke into the wax (fig. 10.4).

Plinth: Faint polish lines running horizontally around the exterior are visible where the patina has flaked off.

g. Patina

Figure: Traces of a translucent brown organic coating remain in areas. Most of this coating has worn away, exposing the brown oxidized metal surface. There appears to be a slightly yellowed clear coating overall.

Plinth: The plinth is quite a bit darker than the figure, due to remnants of a heavy, opaque dark brown paintlike coating over most of its surface. There are several large areas of loss where the brown oxidized metal surface can be seen. The clear coating found on the figure was also applied to the plinth.

3. Casting Defects and Repairs

Figure: The radiographs show both shrinkage and gaseous porosity in the metal. Shrinkage porosity occurs in the neck, head, left shoulder, and left upper arm. A small amount of small- to medium-vacuole gaseous porosity occurs in both the hollow-cast and solid-cast areas. Minor unrepaired porosity extends through to the surface in places.

There is a large set-in rectangular patch in the right shoulder and a cast-in repair on the top of the head. There are two threaded plugs in the torso and one on the top of the left knee (fig. 10.3).

Plinth: None apparent.

4. Later Modifications/Restorations

Figure: None apparent.

Plinth: Vertical scratches through the patina bisect the plinth and appear to be *surmoulage* lines. There are no traces of such lines on the figure.

SUMMARY

The artist was comparatively consistent in how he built and finished his wax casting models; many aspects of the method used for the *Venus* or *Nymph* have not been observed on any of the other de Vries bronzes. The "H"-shaped armature remaining in the sculpture is especially unusual for the artist, both in terms of the type of rods used and in terms of how the armature is constructed. Some of the core support rods are made of pairs of tightly twisted wires. These twisted wires run perpendicular to the solid rods and twist around them where they intersect, tying the armature together. Although de Vries often used wire to wrap parts of his armature, the wrapping was done in a less structured manner, often with loosely looped segments of wire; the careful twisting of two rods together has not been observed on other bronzes. It is clear that such a complex, interconnected armature could not have been inserted into a preformed wax figure, as one would generally find in an indirect lost wax bronze. It seems in this case that the armature was inserted into the mold and the plaster-based core was poured around the armature, hardening in place, a variation on the indirect lost wax process not seen before in de Vries bronzes. The limbs on the *Venus* or *Nymph* are cast nearly solid. With just one exception, all of the de Vries bronzes, whether cast using the direct or indirect method, are hollow-cast with only minimal solid sections, such as a hand, a foot, or a decorative element.[5] In no other instance is such a high percentage of the composition solid-cast.

Details in the hair are depicted in a manner completely antithetical to de Vries. In the *Venus* or *Nymph,* the hair is modeled in large billowing tufts with strands added as fine lines scratched into the wax (fig. 10.5). In contrast, de Vries relies on actual modeling of each tuft and strand, separating the strands by setting them at slightly differing angles. The strands are then often textured with a punch applied in the wax. The combination of modeling and texturing allows the light to play off of the forms and yields a varied, lifelike surface that contrasts with the more solid block forms seen in the hair of the *Venus* or *Nymph.*

In addition, the materials used to cast the *Venus* or *Nymph* differ from de Vries. Rather than the usual bronze, the metal is a brass alloy. The core in this example has a plaster matrix containing enough charred plant material and iron shavings to suggest that they were added intentionally. Of the cores from twenty-two de Vries bronzes examined in the scope of this project, this is the only one in which either intentionally added iron shavings or plant material was found.[6]

Although statistically the core of the *Venus* or *Nymph* falls outside of the de Vries cluster, the presence of lamprobolite in the core may be significant. Lamprobolite (also known as oxy-hornblende) is a relatively rare mineral found in igneous rocks. It is present in trace amounts in certain clays or sand and was found in all but one of the de Vries cores that were examined, all of which were cast in Prague. Its presence in the core suggests that the model could have been made in Prague, although an expansion of the database of core compositions is needed to make any definitive conclusions about the model's place of origin.

The unusual way in which the casting model was formed, the solid-cast limbs, unusual armature rods, plaster-based core, and brass casting alloy all differ significantly from the bronzes included in this study that are securely attributed to Adriaen de Vries. The technical examination supports the hypothesis that although de Vries may well have exerted stylistic influence over the artist in creating the statuette, de Vries himself was involved in neither the construction of the casting model nor the casting of the bronze. The unusual technique used to cast this bronze may one day help to link the *Venus* or *Nymph* to a particular school or artist.

NOTES

1 Scholten 1998a: 133. The nymph is illustrated on p. 131, fig. 10b.

2 The author would like to thank Francesca Bewer for first suggesting how this casting model may have been formed. A variation of the casting method observed on the *Venus* is briefly mentioned in Biringuccio, Smith, and Gnudi 1990: 230.

3 The addition of ground iron scale and organic material to casting cores is recommended in Biringucci, Smith, and Gnudi 1990: 219–20. Biringuccio recommends "rust or finely ground iron scale" as an addition to "weak clay," presumably as a temper to keep the core from shrinking or crumbling during the casting process. A variety of organic materials are also recommended, including cut straw and wool clippings. The heat of the casting process burns out the organic material, providing porosity to the core, which aids the escape of gases during the pour. The temper would have functioned similarly in a plaster-based core such as this.

4 This has been observed in unpublished radiographs taken by the author of French nineteenth-century sand cast bronzes belonging to the Huntington Art Gallery, San Marino, California.

5 The exception is the solid-cast arms of the Wullenstetten *Crucifix* (chapter 9), whose attribution remains in question. The arms on this bronze are so thin as to preclude the use of a core that would surely not withstand the pressures of casting.

6 Although both were found in the Tetrode *Mercury*, Los Angeles County Museum of Art (TR.10706.1.1), chapter 27.

CHAPTER 11

Bust of Emperor Rudolf II

Kunsthistorisches Museum, Vienna. Inv. no. K5506

Cast in Prague in 1590–1592

Dimensions: H: 111.5 cm x D: 39.6 cm x W: approx. 66 cm

Marks and inscriptions:

Inscribed on the back of the base: ADRIANVS FRIES HAGIEN FECIT 1603

Modeled in raised letters following from the left arm truncation to the right:

RVD:II• ROM:IMP• CÆS: AVG: ÆT:SVÆ LI•ANNO 1603

Written in white paint on the top of the base: 1012

Written twice in red paint on the top and side of the base: 5506

OVERVIEW

The portrait bust depicts Rudolf II in the round, truncated at the waist and upper arms. The emperor wears a cuirass embellished with figures and floral relief; two crouching nude figures (representing Jupiter and Mercury), an eagle, and a goat support the bust (fig. 11.1). The sculpture was likely one of the first commissions awarded to de Vries by Rudolf after the artist's 1602 return to Prague. The bust remained in the royal collections in Prague until 1648, when it was taken by the Swedes. It was then in the collections of Jan Stenbock, Stina Lillie, Erik Sparre, and Per Suther, from whom it was purchased in 1804 for the Kaiserliche Sammlungen in Vienna.

The technical study was undertaken to add to our understanding of de Vries's methods and materials, particularly during the early stages of the artist's second period in Prague.

EXAMINATION

1. Alloy

The metal is composed of approximately 13 to 15 percent tin in a copper matrix with zinc and lead contents below 0.5 percent. Full alloy results can be found in table 4.1.

FIGURE 11.1 *Bust of Emperor Rudolf II*
Kunsthistorisches Museum, Vienna. Inv. no. KK5506

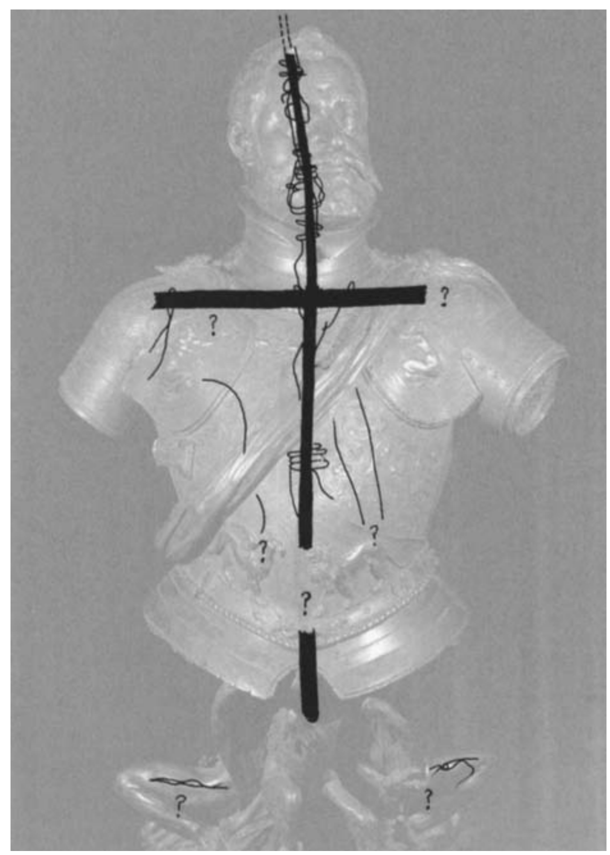


FIGURE 11.2 Summary of the remaining armature rods and wires. Question marks refer to areas that are not clearly legible in the radiographs. The dashed lines at the top of the head indicate where the armature rod was cut off at the surface of the bronze.

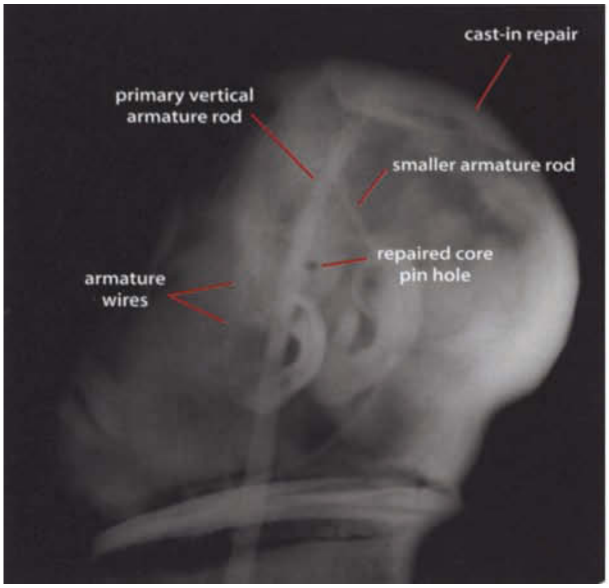


FIGURE 11.3 Radiograph of the side of Rudolf's head.

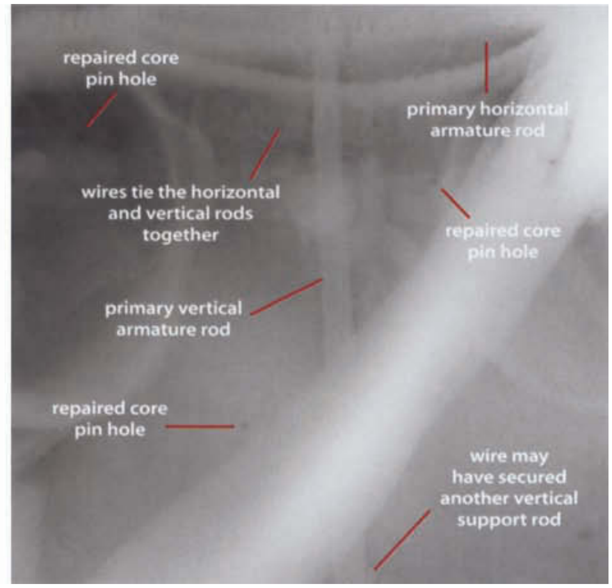


FIGURE 11.4 Radiograph of the center of the torso.

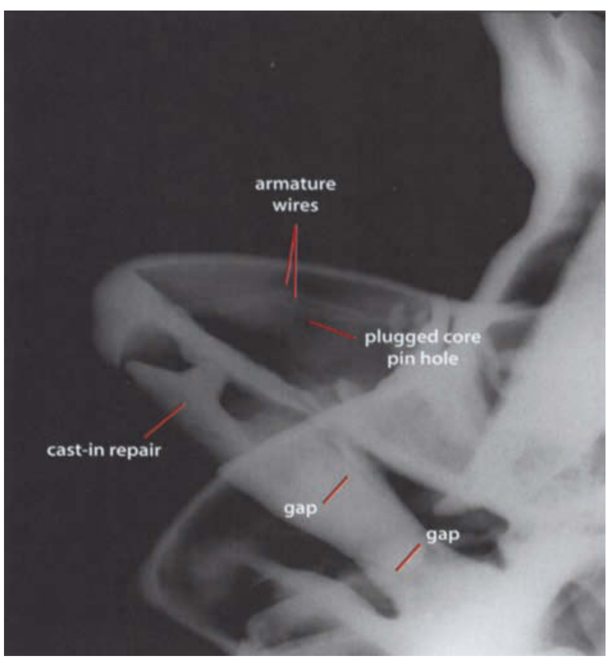


FIGURE 11.5 Radiograph of the proper right support figure's legs. The cast-in repair in the lower leg fills a large flaw. Note the gap formed where the cast-in bronze shrank away from the wall of the cast.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

The radiographs reveal the armature that remains on the interior of the sculpture, as summarized in figure 11.2. The armature is constructed around two crossing large-diameter rods. The vertical rod runs from the top of the head (fig. 11.3), straight down through the center of the torso, ending just below the cuirass. It is curious that this rod does not extend all the way down to the base, as would have been needed to support the model while under construction. As it would have been quite difficult to cut off the bottom of the rod, it seems likely that a second rod may have once been lashed to the bottom of it. Indeed, a looping wire around the vertical rod (center of the chest) likely held this second support, which was removed with core and other sections of the armature from the bottom of the bust. The relative lack of radiographic density of the horizontal member in the top of the torso suggests that it may be a flat bar (rather than square in section). These two major supports are secured to one another with wire (fig. 11.4).

Twisted armature wires remain in both of the supporting figures (fig. 11.5). The ends of twisted wires from inside the support figures can be seen below the open base (fig. 11.6).

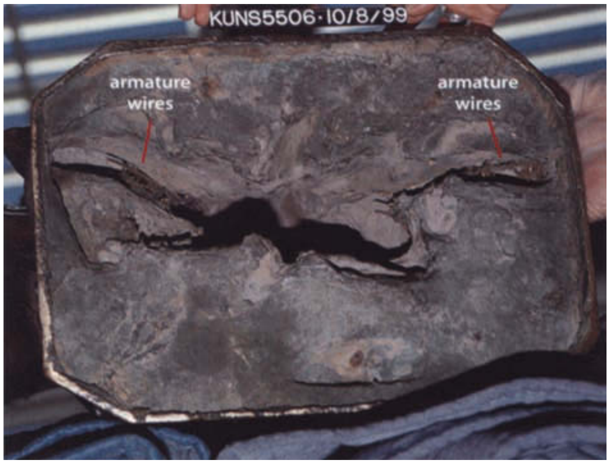


FIGURE 11.6 Open bottom of the base.

b. Core pins

The radiographs reveal what appear to be rectangular core pin holes in a few areas, including one measuring 0.4 × 0.45 cm in the center of the chest (fig. 11.4) and one (0.3 × 0.3 cm) in the center of the upper right thigh of the proper left support figure (fig. 11.5). The plugs that fill these holes are invisible on the surface of the sculpture, suggesting that they are of the same alloy as the rest of the cast (cut-off sprues or other metal removed during fettling may have been used). There are likely other core pin plugs that cannot be seen in the radiographs. One core pin that remains in the sculpture can be seen in the radiograph of the chest; it measures approximately 1.5 cm in length. A second core pin can be seen from the open bottom of the base. The iron pin extends into the interior cavity approximately 1.2 cm and is pointed at the end.

The central vertical armature rod appears to have extended out of the top of the head and into the surrounding investment, in which case it would have doubled as a core pin, helping to keep the core in place during the pour. There is no evidence that the horizontal rod exited the wax model in a similar manner.

c. Core material

The core is soft and crumbles easily. It varies in color from light gray to reddish tan. Examination of the open bottom of the sculpture shows that much of the core has been removed from the base and the supporting figures (fig. 11.6), but the radiographs suggest that core material remains in the emperor's chest and head. A core sample was taken for compositional analysis from below the base, inside the proper right supporting figure. Quantitative analysis yielded the following:

- 79.5 percent reddish clay
- 13 percent quartz
- 3 percent feldspar
- 1.5 percent calcite (0.5% of calcite is fossil foraminifera)
- 1.5 percent hematite
- 1 percent opaque minerals
- 0.5 percent muscovite
- traces of oxy-hornblende (lamprobolite) and biotite

An additional small chunk of core was dated to 1630 ± 20 years using the thermoluminescence technique. When the results are adjusted to two standard deviations (see chapter 6), the date of 1630 ± 40 years (1590–1670) corresponds with the inscription.

d. Internal surface of the bronze

Due to the thickness of the bronze walls and the amount of core contained in the chest, as well as the overlap of figures in the base, the radiographs are difficult to read—although some information can be gleaned from them. With the exception of the legs of the ram, the entire sculpture appears to have been cast hollow. The core in the proper right support figure's left thigh appears to have been quite abbreviated, with much of the modeling of the knee done in solid wax (fig. 11.5).

e. Method of assembly and joining of individual wax or cast bronze components

After studying the radiographs, the bronze surface, and the inside of the sculpture, it appears that the base and all of the figures were cast integrally; there is no indication of metal-to-metal or wax-to-wax joins.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

This bronze is notable for the large amount of very fine, carefully modeled and textured detail, particularly in the

FIGURE 11.7 Waxy modeling in the lion's head on the back of the armor.

FIGURE 11.8 Photomicrograph of a wreath held by the woman on the proper right side of the front of the armor.

ruler's head and armor. Very little, if any, reworking of the raised forms was done in the metal after casting; many of the details retain a loose and waxy feel (figs. 11.7, 11.8). In addition to the careful modeling, a considerable amount of surface texture was applied to the bust. A lightly textured rectangular-shaped punch with rounded corners was used to add a fine pattern and texture to the strands of Rudolf's hair and beard, as well as the ram's coat. A similar, but smaller, punch was used in Rudolf's sideburns. This punch was likely applied in the wax, where its convex shape created (or reinforced) the recessed contour of each strand, while simultaneously applying texture. This texture is relatively soft, with waxy edges between punch marks (fig. 11.9).

The drape on the base, the background of the truncation in the arms, and much of the eagle have been given a matte texture with a single oval, slightly convex, textured punch applied randomly. This texture is similar to that on the hair but without the secondary linear pattern achieved in the hair, where the texture is applied in lines. It is interesting to note on this early work that de Vries has already established a rule for applying texture that he adheres to throughout his career. In each area to which punched texture is applied, only one type of punch is used; he never mixes two different punches within a single area.

Further punched texture likely applied in the wax includes single, round- or oval-headed punches applied in two different ways: in fine lines to draw curvilinear outlines in the cuirass and in abutting lines to give an overall texture, as used on the stump below the eagle's claws. Deep, less carefully applied scratch marks were applied in the wax perpendicular to the folds in the sash (fig. 11.10). This method for depicting cloth is repeated throughout de Vries's career. In the course of this study, it was identified on the *Vulcan's Forge* relief in Munich; *Hercules, Nessus, and Deianeira* in the Louvre; the *Bust of the Elector Christian II* in Dresden; and *Lazarus* in the Statens Museum for Kunst, Copenhagen.

FIGURE 11.9 Photomicrograph of the texturing in Rudolf's left sideburn.

FIGURE 11.10 Photomicrograph detail of the deep and rather rough texturing in the sash over Rudolf's left shoulder.

Some of the linear details, such as the secondary feathers on the supporting eagle's neck, were applied in the wax with a relatively loose hand and do not appear to have been touched up in the metal. Other linear design elements, such as some on the cuirass, are quite crisp and may have been enhanced in the metal (fig. 11.11).

In contrast to the relatively soft texture in the hair and related surfaces, a deeply textured, flat-faced, rectangular punch was used to apply a very fine, deep texture to much of the background of the armor (fig. 11.11). The very sharply textured surface left by this tool suggests that it may have been applied in the metal after casting. This punch appears to be quite similar to, but perhaps a bit less finely textured than, the one used in the banners and foreground vases of the *Allegory of the War against the Turks* relief in Vienna, which also appears to have been applied in the metal, a relatively rare occurrence on de Vries bronzes (fig. 14.7).

Rudolf's pupils are flattened, without linear delineation. Although the eyelids and whites of the eyes are polished smooth, the pupils appear to retain their rougher as-cast surface, a subtle way of "coloring" the eyes with texture (fig. 11.12). Although the modeled details in the faces of the support figures appear to remain as-cast (fig. 11.13), the flesh on both the face of Rudolf and the support figures has been polished, with some fine parallel polish lines remaining (fig. 11.9).

The signature was carefully inscribed on the back of the base. What appear to be small casting flaws across the letters indicate that the signature was cut in the wax, perhaps with touch-ups in the metal, although the accumulation of soil and coatings complicates the reading of its facture (figs. 11.14, 11.15).

FIGURE 11.11 Photomicrograph of the crisp detailing in the lower section of the armor.

g. Patina

The surface is a golden brown color overall. A deteriorated dark brown organic coating remains in areas, primarily in the lower figural groups and in scattered sections of the head and armor (figs. 11.13, 11.14). A clear organic coating has been applied overall.

3. Casting Defects and Foundry Repairs

The sculpture was cleanly cast, with very few flaws and few subsequent repairs. There is some porosity, yet little internal flashing. Extensive pitting due to unrepaired small-vacuole gaseous porosity breaks through the surface of the bronze

FIGURE 11.12 Photomicrograph of Rudolf's right eye. The rough texture of the pupil catches the light in a different manner than with the polished whites and lids.

FIGURE 11.13 Photomicrograph detail of the support figure on the proper left side of the bust. The modeling in the face and hair has been left as-cast.

in areas. Perhaps because this porosity is quite fine and very high X-ray exposures were needed to penetrate the bronze, much of it is difficult to see in the radiographs. The following areas were miscast and not repaired: the tip of the epaulette buckle, several of the scarf tassels, and the straps that cross the right thigh of the proper left support figure.

The radiographs show that a large cast-in repair fills the right shin of the proper left support figure (fig. 11.5). What appears to be a large cast-in repair on top of the head corresponds to the spot where the armature likely protruded out of the top of the sculpture (fig. 11.3). With the exception of a small number of repair plugs that can just barely be seen on the support figures, the surface plugs visible in the radiographs are invisible on the surface.

SUMMARY

The sculpture was cast in bronze using the direct lost wax technique. The clay-based core was constructed over a cross-shaped armature composed of a single large-diameter vertical rod and a flat horizontal bar. The rod and bar and numerous smaller rods tie together with wire. Much of the core remains in the torso and head of the emperor. The surface details were carefully worked, both in the wax model and in the application of texture in the metal. The sculpture was cleanly cast, although some details were miscast and porosity extends through the surface in areas. The bust is golden brown in color with remains of a dark coating in areas. The bust is an exemplar of de Vries's expertise in creating a complex model cast in

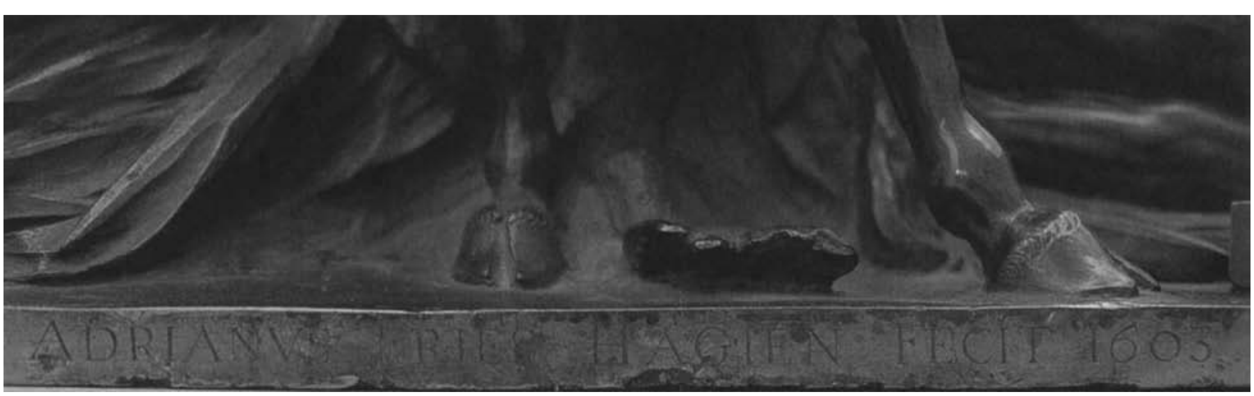


FIGURE 11.14 Signature on the back of the base.

FIGURE 11.15 The arrows highlight the minor casting flaws across the numbers, indicating that the signature and date were engraved into the wax.

a single pour with a minimum of flaws, a casting skill that warranted the tremendous amount of care expended on the detailed wax model.

There is a great deal of similarity in the treatment of the surfaces between this piece and the *Allegory of the War against the Turks*, also in the Kunsthistorisches Museum in Vienna. This blend of the lively and expertly modeled wax details, with the carefully applied textures, is seen throughout de Vries's oeuvre, even in the later monumental bronzes. However, nowhere is it brought to such extremes as in these two compositions.

CHAPTER 12

Bust of the Elector Christian II of Saxony

Skulpturensammlung, Staatliche Kunstsammlungen, Dresden. Inv. no. H4 1/4

Cast in Prague by Martin Hilliger in 1603

Dimensions: H: 94.2 cm × W: 62.3 cm × D: 38 cm

Outer diameter of truncated left arm: 48.2 cm

Marks and inscriptions:

Inscribed in the wax on the back of the base: ADRIANVS FRIES HAGENSIS FECIT 1603

Cast in raised letters cut into the wax on the medallion around Christian's neck:

RVD·II·ROM·IMP·CEÆ·AVG·

Painted on the proper left rear of the base and on top of the back of the plinth: H4 1/4

OVERVIEW

The portrait bust represents Christian II, Elector of Saxony. The figure is truncated above the waist and is supported by two female figures representing harmony between the emperor and the electors (fig. 12.1). The bust was commissioned by Emperor Rudolf II as a diplomatic gift for Christian II. Documentary evidence has shown that the bust was cast by Martin Hilliger of a well-known family of bronze founders. As *Zeugmeister-Bugengiesser* (arsenal master and cannon founder) of Prague Castle until 1622, Hilliger likely cast many of de Vries's sculptures (Scholten 1998a: 23). The bust was given to Christian in 1607 and has remained in the royal collections in Dresden ever since.

The technical study was undertaken to add to our understanding of de Vries's methods and materials and to compare this sculpture to the *Bust of Emperor Rudolf II,* which was also cast in Prague in 1603.

EXAMINATION

1. Alloy

The alloy was analyzed in four locations. The metal is composed of approximately 5 to 6 percent tin in a copper matrix with lead and zinc contents below 0.5 percent. Full alloy results can be found in table 4.1.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

All of the armature rods and wires have been removed from inside the bust (fig. 12.2). Armature wires remain inside the support figures. Those in the proper right figure can be seen in the radiograph (fig. 12.3). The ends of numerous

FIGURE 12.1 *Bust of the Elector Christian II of Saxony*
Skulpturensammlung, Staatliche Kunstsammlungen, Dresden.
Inv. no. H4 1/4

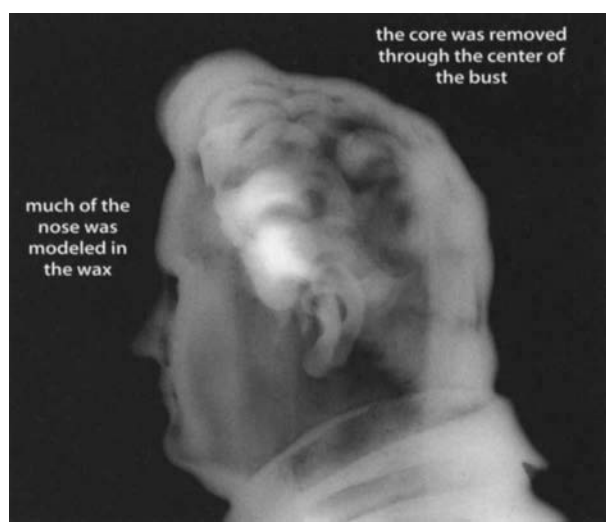


FIGURE 12.2 Radiograph.

rusting iron wires can be seen below both of the support figures from inside the sculpture (fig. 12.4).

b. Core pins

No core pins remain visible in the radiographs or up the hollow bottom of the sculpture. One square hole in the center of the chest is likely a core pin hole that has been filled with an oversized plug. Although the plug is not illustrated in the accompanying radiographs, the same type of plug was used in the *Horse* in Prague. Its construction is illustrated in Appendix A, figure A.24 (set-in repair). As measured from the radiograph, the core pin hole measures

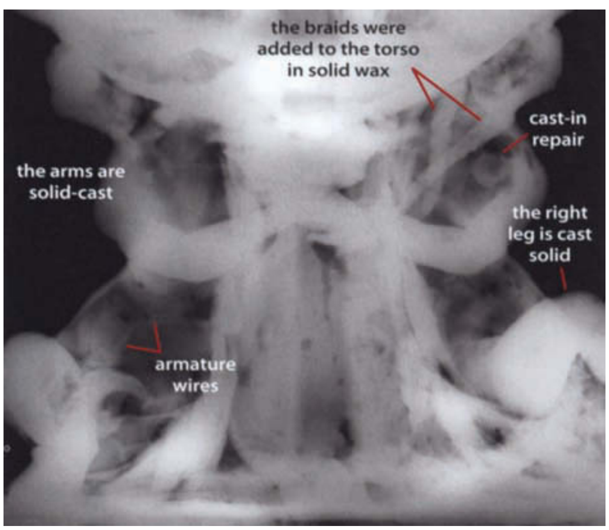


FIGURE 12.3 Radiograph of the support figures below the bust.

FIGURE 12.4 Open bottom of the base. The ends of the iron armature rods in the support figures are indicated with arrows.

0.5 × 0.5 cm; the thin set-in rectangular repair plug is larger, measuring about 0.75 × 0.75 cm. This plug is not visible on the surface of the sculpture. There are likely more core pin plugs that are not visible in the radiographs.

c. Core material

The core is a uniform pinkish tan color. Examination of the radiographs and the open bottom of the sculpture shows that the core has been removed from the base and partially removed from the supporting female figures. It has also been removed in a wide band in Christian's chest that narrows to the top of the head (figs. 12.4, 12.2, 12.3). The core may have been removed in order to reduce the overall weight of the sculpture and to allow reuse of the central armature, which seems to have extended from the base straight up into the head. A core sample was removed for compositional analysis from below the base, inside the proper left female figure. Quantitative analysis yielded the following:

- 52 percent reddish clay
- 15.5 percent gray clay
- 22 percent quartz
- 5 percent feldspar (albite present)
- 1 percent hematite
- 2 percent opaque minerals
- 1.5 percent metamorphic rocks
- 0.5 percent calcite
- 0.5 percent monazite
- traces of oxy-hornblende (lamprobolite) and muscovite

Two additional chunks of core that were taken from inside the proper left support figure were dated to 1625 ± 35 years and 1625 ± 20 years using the thermoluminescence technique.

d. Internal surface of the bronze

As seen by looking up into the bottom of the sculpture, the core ran continuously from the base, into the support figures, and into the portrait bust. No wax or metal joins can be seen in the walls of the bronze. The relatively smooth transition between the base, the female figures, and the bust indicates that they were modeled together over a premodeled core and that all were cast in one pour (fig. 12.4).

FIGURE 12.5 Head of Medusa on the front of the cuirass retains the waxy feel of the model.

FIGURE 12.6 The details were carefully rendered and finished, including texturing in the hair and high polish in the flesh.

The thickness of the bronze varies from area to area, apparently due to the generalized shape of the core on which the wax was modeled. See, for example, the thickness of the right support figure's neck and right shoulder compared with that of the left shoulder and upper arm of the proper left support figure (fig. 12.3). Many of the details were modeled in solid wax, including the end of Christian's nose, the arrows resting on the base, the arms of both female figures, the right leg of the proper left female figure, and the proper left support figure's braids (figs. 12.2, 12.3).

e. Method of assembly and joining of individual wax or cast bronze components

After studying the radiographs, the bronze surface, and the inside of the sculpture, it appears that the base and all of the figures were cast integrally; there is no indication of metal-to-metal or wax-to-wax joins. The lack of wax-to-wax joins, the continuous core, and the varying thicknesses of the bronze strongly suggest that the portrait bust was cast using the direct lost wax technique.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The elector's head and armor were carefully detailed in the wax model. The intricate relief elements on the armor retain a loose and waxlike feel (fig. 12.5). Christian's hair and facial features–including the concave irises–were crisply defined. The tufts and strands of the ruler's hair were modeled in the wax and textured with a single convex, oval, fine-textured punch (fig. 12.6). A variety of punches were used sparingly to add touches of detail to the floral relief in the armor. The ground surrounding these high-relief motifs was left rough in most areas, without polish or systematic texturing (fig. 12.7). It is difficult to say with certainty whether any of the texture on the armor was added in the metal.

FIGURE 12.7 Proper right side of the front of the armor. There is no applied texture in the flat background.

The portrait medallion of Rudolf II (approx. 4.5 cm high) was carved into the wax. Rudolf's hair, laurel wreath, and armor were quickly and expertly detailed with a pointed tool. A single oval, convex punch was applied in the metal to parts of the background of the portrait medallion, apparently to level casting flaws in front of the figure rather than to add texture (fig. 12.8).

Deep, haphazard scratch marks were applied in the wax model perpendicular to the folds of the sash that supports the portrait medallion, the same type of texturing seen on the sash in the *Bust of Rudolf II* (fig. 11.10).

The signature was inscribed in the wax on the back of the base. Fine horizontal lines scribed into the wax appear to have acted as guidelines for the letters, which are uniform in size (fig. 12.9).

The support figures are less highly finished than the figure of Christian, including unrepaired casting flaws at the back of the sculpture and cursorily resolved transitions between the forms. Although the flesh of the support figures has been polished, the facial features and hair appear to remain as-cast, without chiseling or texturing in the metal (fig. 12.10). Flat borders on the armor, as well as flat areas on the base, in the arm truncations, and on the back of the base, have also been polished, with rougher polish lines remaining.

FIGURE 12.8 Photomicrograph of the portrait medallion of Rudolf II. Great care was lavished on the intricate details.

g. Patina

There appear to be three coatings on the surface. Lowermost is an uneven organic coating that, where thin, is a translucent reddish brown color. This coating remains in areas on Christian's face and over much of the back of the sculpture. The golden color of the polished metal can be seen through the coating where it is thinnest, particularly in the sitter's face and in the flesh of the female figures. On the front, an opaque, uneven, greenish brown patina has been applied over the earlier coating. Remains of it can be seen below Christian's chin, in the hair, and on the front of the armor. The contrast between the golden glow of the flesh and the duller green-brown of the armor and hair is quite striking, yet seems to be the result of later surface treatments, rather than of the artist's original intent.

Where the coatings have worn completely off, the exposed bronze has oxidized to a gray color. More recently, a clear coating has been applied to the entire surface, giving a uniform degree of gloss overall.

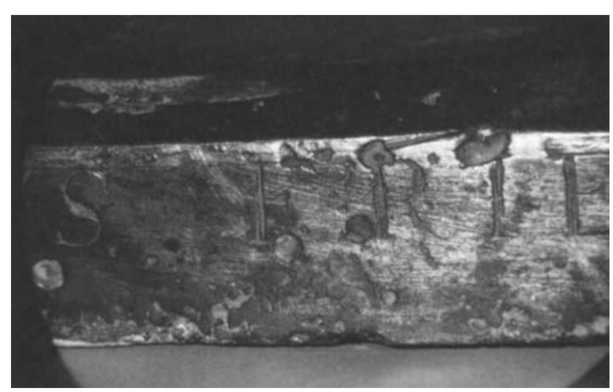


FIGURE 12.9 Photomicrograph of the signature. The letters were cut in the wax and the flaws left urepaired.

FIGURE 12.10 The flesh of the support figure has been polished, but the facial features and hair were left as-cast without chiseling.

3. Casting Defects and Foundry Repairs

The radiographs show a small amount of shrinkage porosity and extensive small- to large-vacuole gaseous porosity in the cast. Gaseous porosity is most severe in the lower section of the sculpture, particularly the arrows and legs of the female figures (fig. 12.3). The porosity breaks through to the surface in areas and is not repaired (see, for example, the hole above the bird in fig. 12.7 and the detail of the signature, fig. 12.9).

A very small number of repairs are visible in the radiographs, including a circular area of increased density in the left shoulder of the proper left female figure that appears to be a cast-in repair (fig. 12.3). There appears to be an oval set-in repair on the edge of the truncation of the proper right arm. It is likely that there are other repairs that are not visible in the radiographs, particularly in the very dense sections of the chest where the core still remains.

SUMMARY

The bust was cast using the direct lost wax technique. The armor is covered with rich surface details that remain essentially as-cast, with limited cold work. Although the sculpture was cast with extensive gaseous porosity, some of which breaks through the surface, there are very few repairs. The elector's face and the flesh of the support figures have been highly polished. The golden color of the polished metal shows through a translucent reddish brown coating on Christian's face and over much of the back of the sculpture. These lighter areas contrast with surfaces on the front of the armor and in the hair that are coated with a later, darker patina. There is a uniform gloss over the surface due to a more recent clear coating.

Both the *Bust of the Elector Christian II of Saxony* and the *Bust of Emperor Rudolf II* are large and complex compositions that were cast in a single pour. Both busts were cast in Prague in 1603. Martin Hilliger cast the bust of Christian; the technical study shows no reason to doubt that the bust of Rudolf was also cast by Hilliger. Although the armature has been removed from the bust of Christian, the extent of armature remaining in the Rudolf bust suggests what may have been removed from the bust of Christian: both models were built on heavy vertical armatures with additional thin auxiliary armature wires.

It is in the surface details that the differences between the two busts are most evident. On both, de Vries exquisitely modeled fine passages that have been left essentially untouched after casting, retaining the waxlike feel of their models. On the emperor's bust, the modeling is accompanied by extensive texturing applied both in the wax and in the metal, representing an extremely labor-intensive effort. On the elector's bust, in contrast, punches were used modestly and only in select areas. It is clear which of the two commissions the artist considered more important, perhaps as specified in the commission by the emperor or perhaps envisioned by the artist himself, who created the bust soon after being lured to the court with the title *Kammerbildhauer* and the privileges that it offered (Scholten 1998b: 22). It is telling that one of the most carefully crafted elements of the Christian bust is the portrait medallion of Emperor Rudolf.

CHAPTER 13

Hercules, Nessus, and Deianeira

Musée du Louvre, Paris, Département des Objets d'Art. Inv. no. OA 5424

Cast in Prague between 1603 and 1608

Dimensions: H: 82.1 cm × W: 45.8 cm × D: 35.8 cm (for internal dimensions, see p. 248)

Marks and inscriptions:

- **Stamped in metal on Nessus's left rear hoof: 187**
- **Stamped in metal below Nessus's left rear hoof: T.228.C**
- **Stamped in metal on Nessus's left haunch: CT111**
- **Painted on Nessus's right side: 1891**
- **Engraved on Hercules' left calf: N°301**
- **Engraved on Hercules' left calf: CT1891**
- **Painted under base: T.1397**
- **Painted in ink on paper label under base: 5424**

OVERVIEW

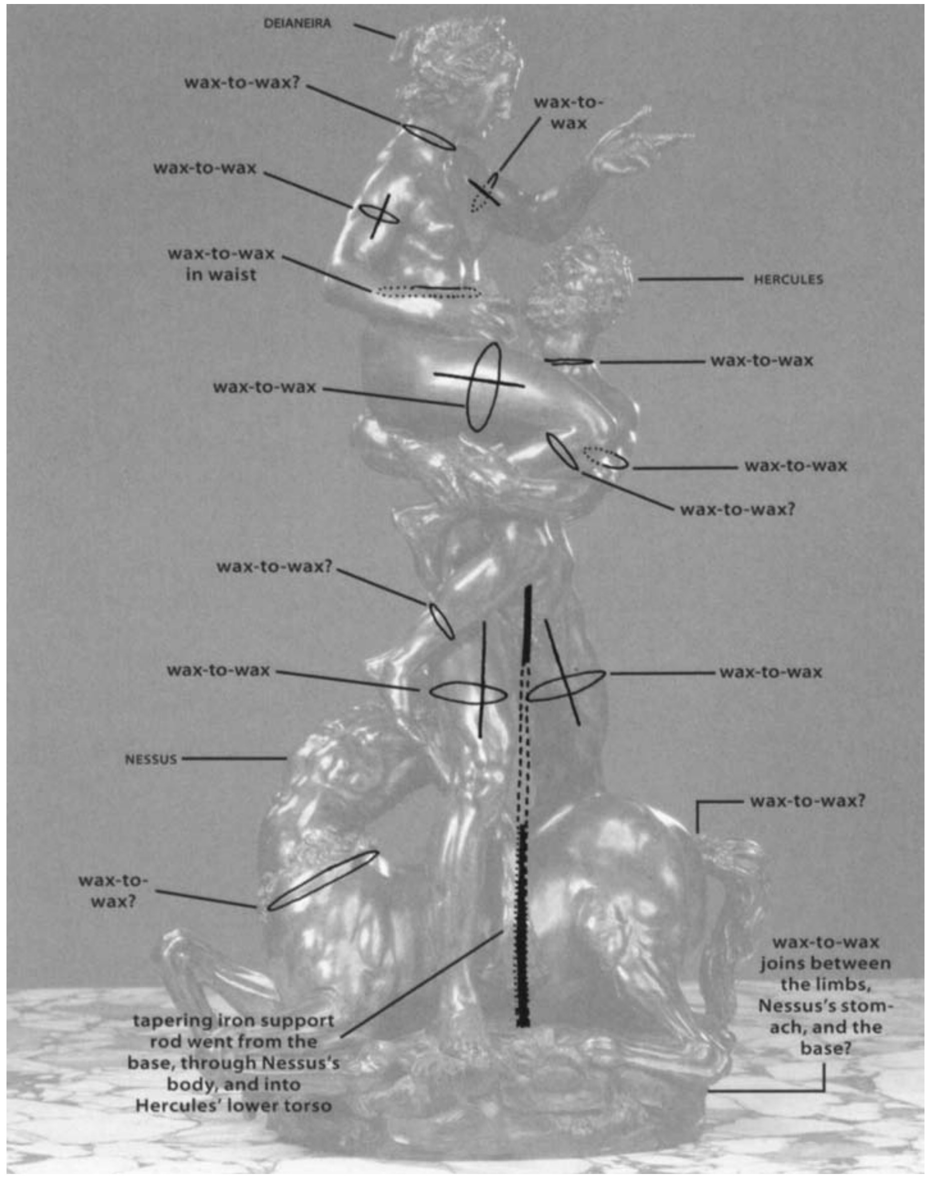
This composition, as recounted in Ovid's *Metamorphosis*, represents Hercules lifting his wife, Deianeira, to safety from the fallen centaur Nessus (figs. 13.1, 13.2). The group was likely in Emperor Rudolf's *Kunstkammer*. It first appears in the Grand Dauphin's collection in the inventory of 1689. The bronze is recorded in the Château de Meudon, the Garde-Meuble de la Couronne in Paris, Les Tuileries, and the Château de Trianon, finally entering the Louvre in 1901.

In the 1999 exhibition catalogue *Les Bronzes de la Couronne*, the sculpture is listed as "attribué à Adriaen de Vries," a step short of giving unquestioned authorship to de Vries (Baratte et al. 1999: 172). The technical study was undertaken to evaluate this attribution by comparing the work to other works attributed to or signed by de Vries.

FIGURE 13.1 *Hercules, Nessus, and Deianeira*
Musée du Louvre, Paris, Département des Objets d'Art. Inv. no. OA 5424

FIGURE 13.2 *Hercules, Nessus, and Deianeira*
Musée du Louvre, Paris, Département des Objets d'Art, Inv. number OA 5424

FIGURE 13.3 Summary of wax-to-wax joins and the remaining core supports. The dashed lines indicate the pathway of the primary support rod that has been removed. Where unshaded, the rod passed outside of the figures.



EXAMINATION

1. Alloy

Six locations were analyzed to determine the bulk alloy of the group. Results showed that the sculpture was cast in a bronze alloy containing approximately 12 to 13 percent tin in a copper matrix, with lead and zinc contents below 0.5 percent. Full alloy results can be found in table 4.1.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

The *Hercules, Nessus, and Deianeira* bronze differs from many of de Vries's medium-sized casts in the lack of armature in the interior. Rather than the complex, branching structure of iron armature rods observed in the artist's direct casts, the *Hercules, Nessus, and Deianeira* contains one short central rod and five thin, straight rods that do not connect to one another (fig. 13.3). These rods are reminiscent of core supports in indirect casts.

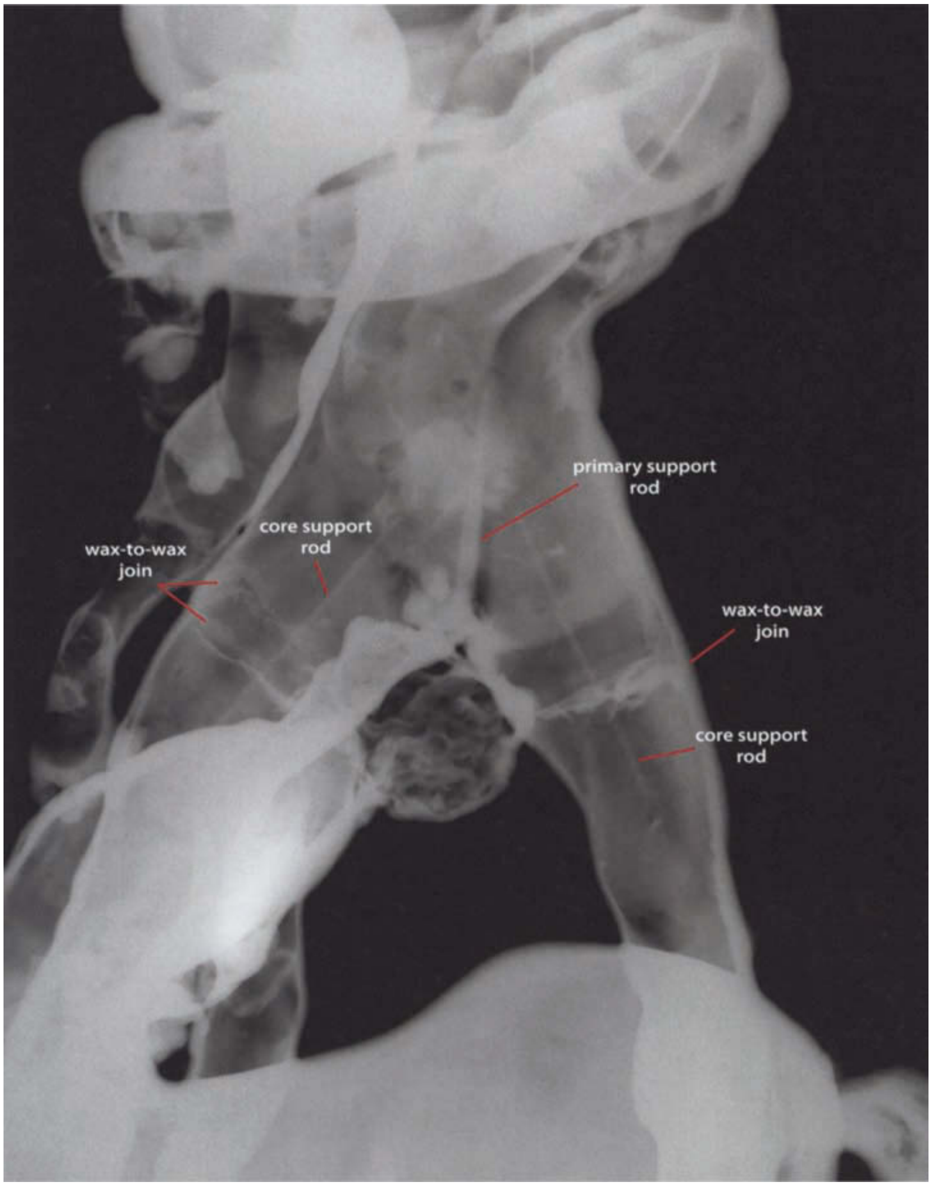


FIGURE 13.4 Radiograph of the center of the sculpture. Note the remains of the primary vertical support rod in Hercules' buttocks.

The remains of a tapering, large-diameter iron support rod can be seen in the radiograph of Hercules' lower torso (fig. 13.4). It is likely that this rod began in the base and extended up through Nessus's body, then up into Hercules' groin and into his torso, supporting the considerable weight of the two upright figures during casting. A slight increase in density in the radiograph of the back of Nessus (fig. 13.5) appears to be a plug filling the hole that was left when the rod was removed. The end of this rectangular rod is visible from the open bottom of the base (fig. 13.6).

b. Core pins

A tapering rectangular-sectioned iron core pin remains on the interior of the bronze and can be seen in the radiograph of Deianeira's chest. Various 0.3 cm diameter plugged core pin holes are also visible in this radiograph (fig. 13.7).

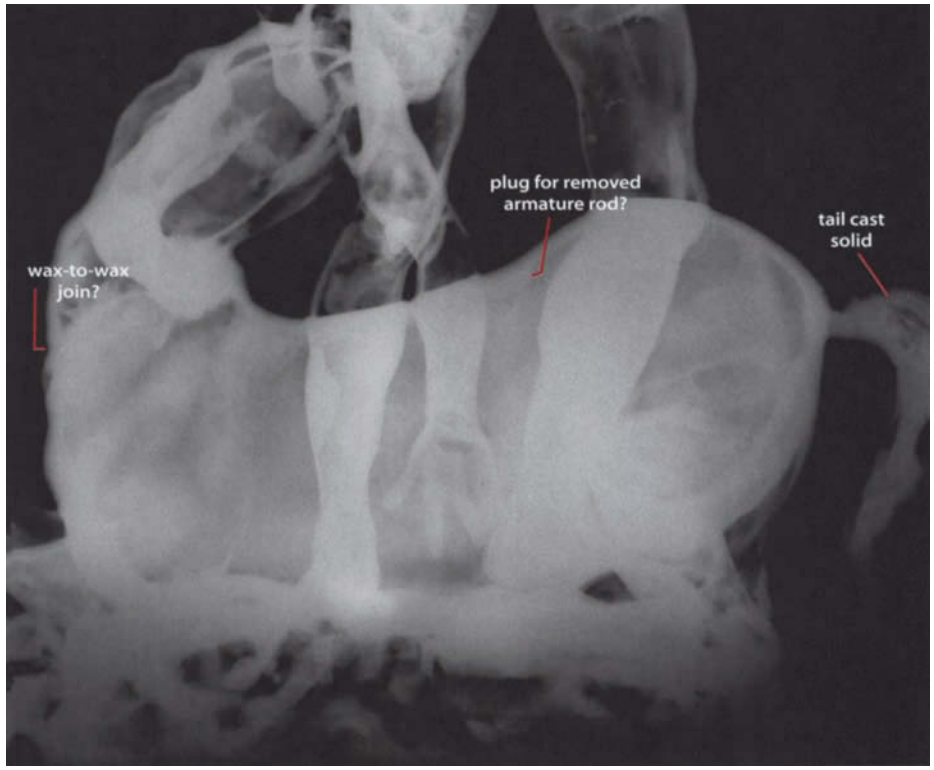


FIGURE 13.5 Radiograph of Nessus.

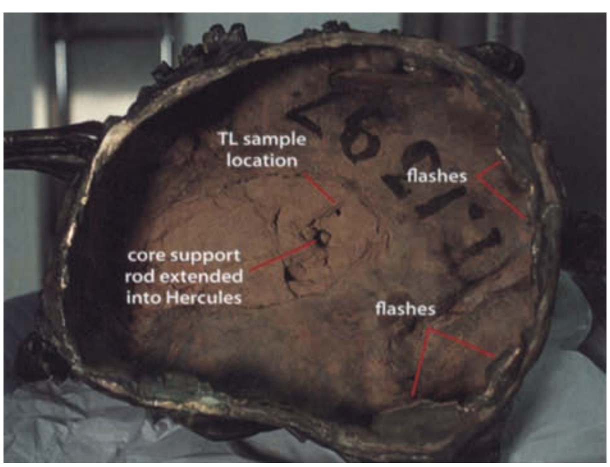


FIGURE 13.6 Open bottom of the base.

c. Core material

The core is reddish tan in color and crumbles easily. It runs continuously from the base into Nessus's body cavity and legs and into Hercules' feet. Much of the core has been removed from the base but remains in the figures. A core sample from inside Nessus's body was taken for compositional analysis. Quantitative analysis yielded the following:

- 80.5 percent reddish clay
- 9 percent quartz
- 8 percent calcite
- 1.5 percent hematite
- 0.5 percent feldspar
- 0.5 percent opaque grains
- traces of oxy-hornblende (lamprobolite), calcite rhombohedra, and polycrystalline quartz

Thermoluminescence analysis yielded a date of 1830 ± 15 years. According to the TL lab, the growth curve data

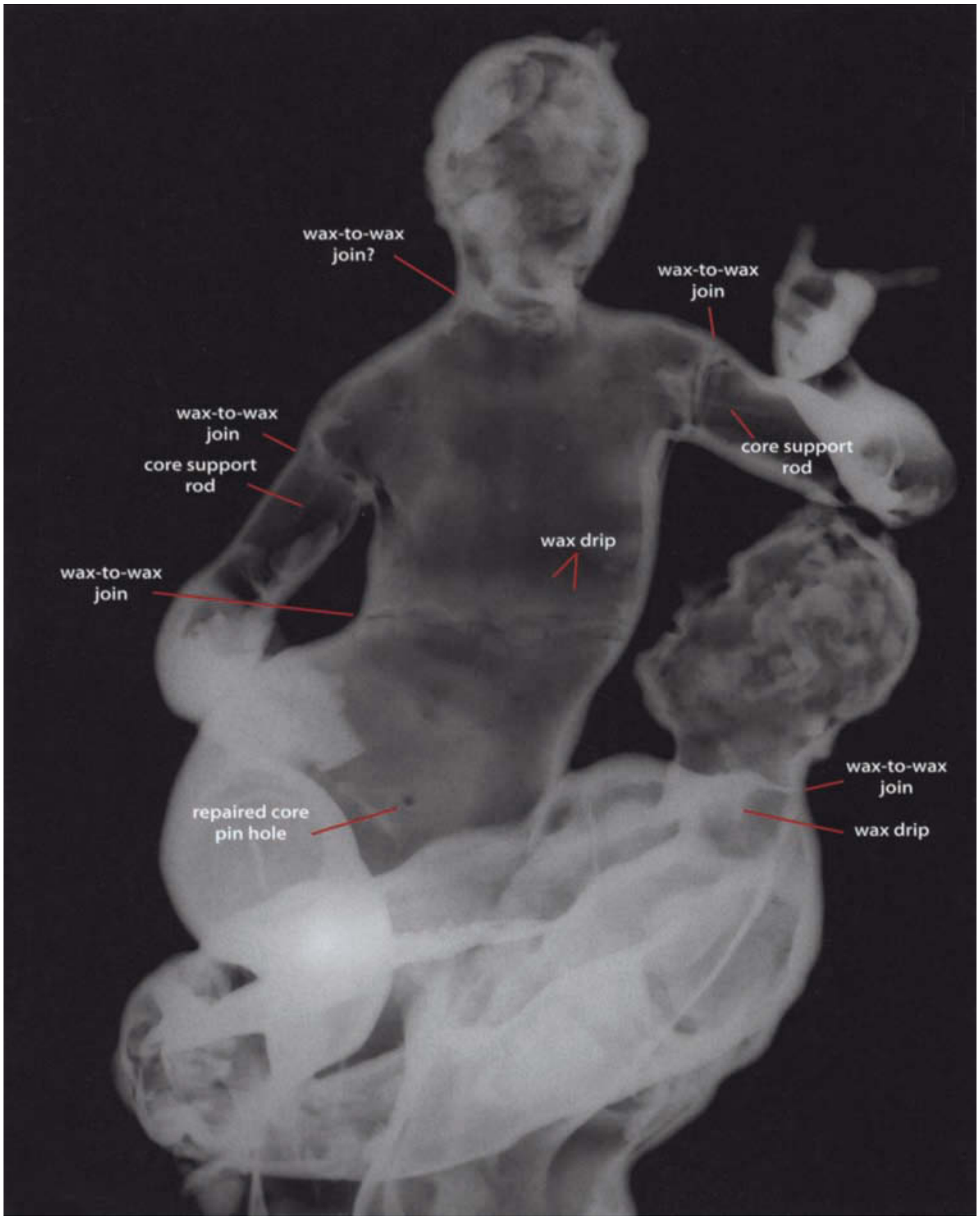


FIGURE 13.7 Radiograph of Deianeira and Hercules' upper body.

for this core is scattered, and the results are not reproducible, suggesting that the data are not reliable (C. Goedicke pers. com.).

d. Internal surface of the bronze

Drips retained in the metal from the formation of the wax-to-wax joins are further indication that the sculpture was cast using the indirect lost wax technique (fig. 13.7). As is often observed on indirect casts, the bronze walls are relatively even and thin. Nessus's tail and much of Deianeira's hands were cast solid, as were much of Hercules' nose and Deianeira's left toes. It may be that the small dimensions of these appendages did not permit insertion of a core strong enough to withstand the casting process intact.

e. Method of assembly and joining of individual wax or cast bronze components

The radiographs indicate that there are no metal-to-metal joins, yet there are numerous wax-to-wax joins. The wax-to-wax joins appear in the radiographs as ring-shaped features of varying densities (figs. 13.3, 13.4, 13.7). Wax-to-wax joins are characteristic of the indirect lost wax method, in which the casting model is assembled from separate, mold-made wax parts. Although sections of the composition are difficult to see clearly in the radiographs and others are difficult to interpret (Nessus's waist and neck and Deianeira's neck in particular), it can be conjectured that the casting model was constructed of the following parts, each of which was formed separately in piece molds (sections likely to be secured with wax-to-wax joins but whose joins are not clearly visible in the radiographs are marked with an asterisk [*]).

Hercules:

- head*
- legs
- torso (with Deianeira's left leg)
- arms (with Deianeira's right leg)

Deianeira:

- head*
- upper half of torso
- arms
- lower half of torso
- right thigh and knee
- left ankle and foot*

Nessus:

- upper (human) torso*
- horse body
- head
- arms*
- tail*

*Base**

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The figures were modeled with a considerable amount of detail (fig. 13.8). The hair on all three of the figures, as well as Hercules' beard and Nessus's tail, was carefully modeled in a similar manner. Each tuft or curl is composed of thick strands of hair set at varying angles. The strands are often slightly convex in section and are delineated not with recessed lines between them but rather by the differing angles of the intersecting strands, each of which is slightly skewed compared to its neighbor (figs. 13.9, 13.10). Although it is clear that this approach was quite time-consuming—each strand is depicted individually at a slightly different angle and location—the overall effect is lively and slightly chaotic, lending considerable life to the hair, beard, and tail.

The individual raised strands of hair on Nessus's chest (fig. 13.11) and the slight indication of Nessus's pupils and teeth (fig. 13.12) are uncommon on de Vries bronzes, which generally do not include this type of linear detail. Visual evidence seems to suggest that the marks were applied in the wax, although it is difficult to tell for certain.

FIGURE **13.8** The prominent veins in Nessus's left hand and distinct leaves on the base were carefully delineated in the wax model.

FIGURE 13.9 Detail of Nessus's hair. The curving planes of each modeled strand lend lively variation to the hair.

FIGURE 13.10 Nessus's tail was modeled in a manner similar to that of the figures' hair and beards.

FIGURE 13.11 The slightly raised curls on Nessus's chest were more likely added in the wax.

FIGURE 13.12 Pupils and teeth are suggested on the figure of Nessus.

The flesh is polished, with directional lines generally running parallel to the limbs and torso. Deep, haphazard scratch lines in the cloth appear to have been made in the wax (fig. 13.13), a method for depicting cloth seen on other de Vries bronzes (see fig. 11.10). A single oval convex punch was applied in lines with even spacing to create texture in the base (fig. 13.13).

A round-sectioned sprue has been left in place between Nessus's left shoulder and the back of Hercules' right thigh (fig. 13.14). This remnant of the casting process could easily have been cut off and all traces removed during fettling. Its presence, as with sprues remaining on other de Vries bronzes, may be a subtle clue left by the artist, suggesting that the complex composition was cast in a single pour (Bewer 2001: 180–81).

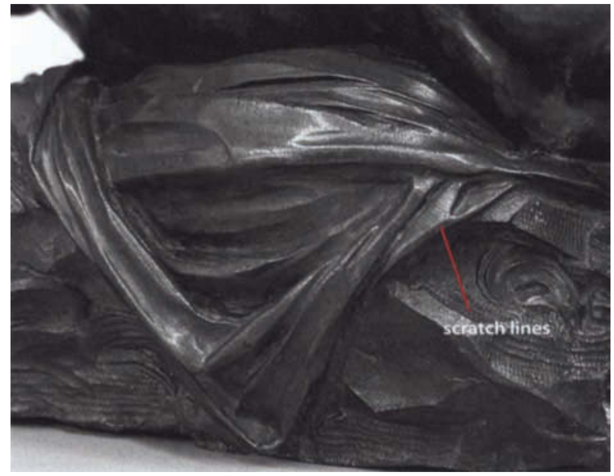


FIGURE 13.13 The drapery on the base was textured in the wax, with rough lines running perpendicular to the folds.

g. Patina

Much of the surface is coated with an uneven reddish brown lacquerlike patina. This organic coating varies from opaque to translucent, depending on its thickness. The warm golden color of the polished metal surface remains under this coating in many areas, particularly on the figures. Where the coating has rubbed off, the metal has oxidized to brown to gray-brown.

A newer clear organic coating has been applied overall; it is most visible in the base.

FIGURE 13.14 A sprue was left between Nessus's shoulder and Hercules' thigh.

3. Casting Defects and Foundry Repairs

Casting flaws in the recesses have been left unrepaired in some areas, for example, in Nessus's eye sockets (fig. 13.12). Small rectangular holes that have been filled with set-in patches are likely core pin holes. These repairs differ considerably from the irregular appearance of the cast-in repairs used on a number of the casting flaws, particularly in the extremities. Some of these repairs are not visible on the surface of the bronze due to the reddish brown coating.

The radiographs show only limited porosity in the figures. A very minor amount of flashing is visible in the radiographs. Flashes along the sides of the base (fig. 13.6) may indicate that extra height was added to the composition by building up the core below the base. Gaps between the two layers of core may have allowed molten bronze to flow between the original layer of clay core and the added level.

4. Later Modifications/Restorations

There are *surmoulage* marks through the patina, made when a mold was taken from the bronze. These scratches can be seen on the right side of Hercules' back and behind his right upper arm.

SUMMARY

The figures and the base of the *Hercules, Nessus, and Deianeira* were cast together in a single pour. The presence of wax-to-wax joins suggests the use of the indirect lost wax technique. The casting wax was constructed of as many as twenty sections that were separately made in molds that were likely taken from the artist's original model, a remarkably large number of parts. Thin, straight core support rods run through some of the wax-to-wax joins. A tapering iron rod extended from the base up into the back side of Hercules, functioning as the main support rod. Carefully modeled fine details appear throughout the composition, with little cold work in the metal after casting. Cast-in repairs appear in many areas, yet some casting flaws in the recesses were left unrepaired. The golden color of the polished metal can be seen below an uneven, reddish brown organic patina that covers most of the surface.

The results of the investigation into the methods and materials used to cast the Louvre *Hercules, Nessus, and Deianeira* suggest a strong correlation with the work of Adriaen de Vries. This study has shown other examples where the artist used the indirect lost wax casting technique for medium-sized bronzes such as this. The core material and alloy are of the same specific type as those used by de Vries. The characteristic modeling in the hair and tail and the perpendicular striations in the folds of the cloth are also typical of the artist. The relative lack of cold work and the number of flaws left unrepaired are also typical. The presence of a sprue in a location where it could easily have been removed is highly idiosyncratic and is seen on many other de Vries bronzes. The tapering core support remaining inside the figure of Hercules that once extended into the base is a type of external support seen in other de Vries bronzes, including the smaller, indirectly cast figure of *Mercury*.[1] The distinctive and slightly crude details of the chest curls, delineated teeth, and pupils on the figure of Nessus, while uncharacteristic for de Vries, are entirely appropriate for the subject.

Although the core received a thermoluminescence date of 1830 ± 15 years, the TL laboratory found the data were not reliable, which is borne out by the well-documented seventeenth-century provenance.

A comparison of this bronze with the two aftercasts of the composition that were included in the exhibition are discussed in the *Summary* section of chapter 30.

NOTES

1 A radiograph showing the end of a tapering rod remaining in the same location in the figure of *Mercury* is illustrated in Bewer 2001: 171, fig. 17.

CHAPTER 14

Allegory of the War against the Turks in Hungary

Kunsthistorisches Museum, Vienna. Inv. no. KK5474

Cast in Prague in 1604–1605

Dimensions: H: 74.0 cm × W: 91.4 cm × D: 9.8 cm

Marks and inscriptions:

Front of the relief:

Cast in relief near the top edge, to the proper left of center: •R•I•I•

Inscribed on the base of the tower on the proper left side of the relief:

ADRIANVS.FRIES.HAGENSIS.FECIT.

Reverse of the relief:

Printed on a paper label: 46

Written twice in red paint: 5474

Handwritten in wax pencil: Snppl ∂.99

OVERVIEW

The relief depicts the defeat of the Ottoman Turkish army in Hungary by Rudolf's imperial forces (fig. 14.1). The composition combines allegorical scenes of the Turkish war, broadly based on paintings made for the emperor by Hans von Aachen. The foreground figures are depicted in high relief, so that heads and arms project out toward the viewer. As the scenes recede into the background, the figures are depicted in medium and low relief. The work was commissioned by Rudolf for his *Kunstkammer*, where it is described in the inventories of 1607–11, 1619, 1621, and 1648. In 1648 it was taken by Queen Christina's forces and brought to Sweden. The relief then passed through the collections of Jan Stenbock, Stina Lillie, Erik Sparre, and Per Suther. It was purchased at auction in 1804 for the Kaiserliche Sammlungen in Vienna.

The technical study was undertaken as an example of the artist's early works commissioned by Emperor Rudolf II.

FIGURE 14.1 *Allegory of the War against the Turks in Hungary*
Kunsthistorisches Museum, Vienna. Inv. no. KK5474

EXAMINATION

1. Alloy

Three locations on the surface were analyzed to determine the bulk alloy. The metal is composed of approximately 9 to 10 percent tin in a copper matrix with zinc and lead contents below 0.5 percent. The bottom, proper left corner was cast separately and pinned in place. This repair was cast in the same alloy as the rest of the relief. The rivets used to secure the repair are made of a brass (copper-zinc) alloy. Full alloy results can be found in table 4.1.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

The sculpture was not radiographed for this examination. It is possible that internal core supports remain in the high-relief upper torsos and heads that still contain core material.

b. Core pins

A 2.5 cm long, square-sectioned, and tapering iron core pin remains in place on the back of the relief, bent over

FIGURE 14.2 Back of the relief. The cut-off sprues are indicated with white arrows and circles. The green arrows indicate the core pin holes, some now coated with bitumen. The red arrows indicate the cast-in hanging loops.

in a chunk of core. Although all the core pin holes have been repaired from the front, the patches do not extend all the way through the thickness of the relief. A number of square and rectangular core pin holes remain visible on the back of the relief, fairly evenly spaced approximately 15 to 20 cm apart. These square and rectangular holes vary from 0.3 cm to 0.4 cm across. A black bitumen-like material covers seven of the core pin holes at the back, perhaps applied to help hold the repairs in place (fig. 14.2).

c. Core material

The core crumbles easily. It is gray colored, varying toward pink in a couple of areas. Most of the core has been removed from the back of the relief, although it remains in the highly recessed areas (fig. 14.2).

A core sample was taken from the back of the relief for compositional analysis. Quantitative analysis yielded the following:

- 83 percent grayish clay
- 9.5 percent quartz
- 2.5 percent feldspar (albite)
- 3 percent opaque grains (hematite)
- 1 percent calcite grains
- 0.5 percent oxy-hornblende (lamprobolite)
- 0.5 percent muscovite

An additional small chunk of core was dated to 1695 ± 20 years using the thermoluminescence technique. As the bronze was first recorded in Rudolf's *Kunstkammer* in 1607–11, the TL date appears not to correlate with the date of facture of the bronze, even when the results are recorded with two standard deviations (1695 ± 40 years). The reason for this discrepancy remains unexplained.

d. Internal surface of the bronze

The back of the relief retains numerous clues as to how it was likely cast. Twenty-seven roughly circular, raised bits

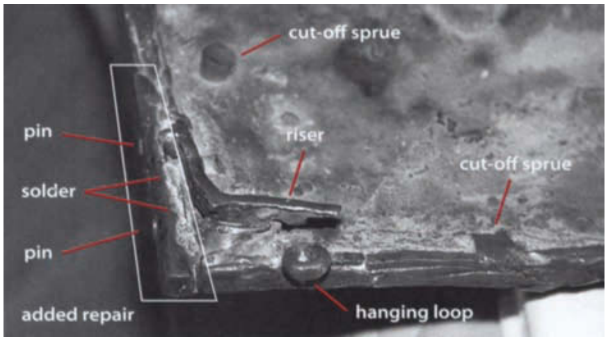


FIGURE 14.3 Bottom, proper left corner of the reverse of the relief.

FIGURE 14.4 Photomicrograph. The tiny scene, formed entirely in the wax, measures 3.5 cm across by 2.0 cm high.

of metal with chisel marks across them are remains of the sprues that were removed after casting (figs. 14.2, 14.3). The presence of these so-called internal sprues, as well as waxy drips across the back of the relief, suggests that the wax casting model was constructed inside a mold using the indirect lost wax technique. With the casting wax formed in this manner, the back would have remained accessible for the application of sprues before the refractory mold (core) was applied. The large number of sprues on the reverse may give a hint as to why de Vries chose to cast this bronze indirectly. By using a technique that allowed him to apply the sprues on the reverse, he was able to limit or possibly even avoid the application of sprues on the front of the relief—a front that is almost completely covered in finely modeled details. Removal of such a large number of sprues from the front of the relief would have necessitated a degree of cold work incompatible with his preferred as-cast surfaces.

In a recent publication on Lorenzo Ghiberti's *Gates of Paradise,* a technique for directly modeling relief sculptures over a temporary core is proposed (Bewer, Stone, and Sturman 2007). As described, the completed wax model is flipped over and the temporary core is removed, allowing access to the back, where additional wax as well as sprues can be added. Although it is possible that this variation of the direct casting technique was used for the *Allegory* relief, the comparatively flat composition of the de Vries work lends itself to relatively straightforward mold making. More important, the very close conformity of the back of the relief with even moderate relief on the front (such as the tower on the far proper left side) suggests that the wax was formed inside a mold using the indirect lost wax technique.

Two additions were made in the wax stage to address the mounting needs of the relief: a V-shaped riser was added on the proper left bottom corner to raise the corner out toward the viewer (fig. 14.3), and ten loops of wax were added at the edges and cast with the relief for hanging (figs. 14.2, 14.3).

e. Method of assembly and joining of individual wax or cast bronze components

Except for repairs, there are no metal-to-metal joins; the entire sculpture was cast in one piece. It is possible that portions of the figures that are in high relief were made in separate molds with wax-to-wax joins connecting them to the rest of the composition. These joins, if present, are now hidden under core material.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The surface is highly finished overall, except for a small number of recesses where casting flaws were not fully repaired.

Many of the very fine details were exquisitely modeled in the wax with little or no cold working. Examples are the figures on the river gods' vessels at the bottom of the relief (fig. 14.4) and the low relief figural groups in the far background (fig. 14.5). The uneven matte texture on the horses and riders in the background scenes is apparently the as-cast surface; these figures have been neither polished nor punched. Smooth surfaces such as the sky, lighthouse, and

FIGURE 14.5 The low-relief battle scene was masterfully depicted with minimal strokes in the wax and was left essentially as-cast.

FIGURE 14.6 Photomicrograph of the dragon's hide. The texture appears to have been applied in the wax.

flesh are polished, with directional polish lines remaining. Fine, short lines depict the lion's fur.

The remainder—the vast majority—of the relief is covered in a wide variety of textures applied with punches. It is difficult to tell which of these textures were applied in the wax and which in the metal. Some of the texture is quite three-dimensional and was likely applied in the softer wax before casting, such as the scales on the dragon, which were formed with a single, smooth, oval convex punch, applied randomly to give an overall pocked surface (fig. 14.6). Linear details in the narrative scene were cut into the wax (fig. 14.7). The signature too was cut into the wax. Many of the marks in the signature were made with two or more strokes, leaving raised lines between the strokes (fig. 14.8).

The repair in the bottom left corner was added after casting. Once the repair was pinned in place, the join was hidden with chasing and application of texture. The tool marks across the join resemble those on adjacent surfaces, yet the join line remains visible, giving the impression that the cold work was applied along the join to resemble the surrounding cast-in texture (fig. 14.9).

A rectangular, flat-headed matting tool was used to apply an overall texture on the background of the vessel in figure 14.4. A similar tool with even finer texture was used in the flag banners (fig. 14.7). The sharp texture in both of these areas suggests that it was applied in the metal after casting. This cold work is reminiscent of punched texture on the armor on the bust of Rudolf (fig. 11.11).

FIGURE 14.7 Fine detail in the banners in the background of the relief.

FIGURE 14.8 The signature was cut into the wax between fine horizontal guidelines above and below the letters.

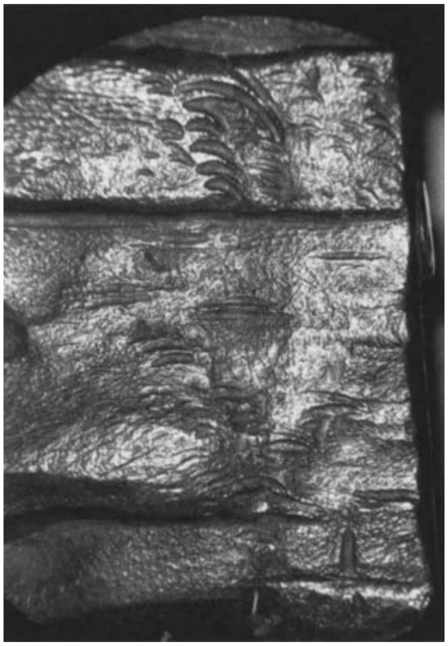


FIGURE 14.9 Photomicrograph of cold work across the join suggests that at least some of the texture throughout the relief may have been applied in the metal. The separately cast section is on the proper left side of the photo (viewer's right).

g. Patina

The surface varies from golden brown in the sky and middle ground to a richer and darker brown in the foreground, apparently the color of the oxidized metal. There is no visual evidence of a clear or colored organic patina on the surface.

3. Casting Defects and Foundry Repairs

There are remarkably few repairs on the relief. In the bottom proper left corner of the relief, a 10.5 cm × 1.0 cm × 1.3 cm repair using an alloy similar to that of the rest of the relief was soldered and pinned into place. The similar alloy, surface details, and oxidized surface color of the repair suggest that it was applied in the foundry. A rectangular repair (0.75 cm × 0.8 cm) that is darker than the surrounding metal is visible on the surface in the hillside on the proper left side of the relief. A cast-in repair (approx. 5.5 cm × 3 cm) can be seen at the back near the figure of Sava, yet it is not readily visible on the front.

Small-vacuole surface flaws due to gaseous porosity are scattered over the surface. Flashes are shallow and relatively minor and are scattered randomly across the back.

SUMMARY

The sculpture was cast in bronze in a single pour. Virtually the entire surface is richly embellished with scenes, many of diminutive size, in which the figures were exquisitely modeled in the wax and left unchiseled after casting. Many different textures were used to enhance the surface, some applied in the wax and some in the metal. Numerous cut-off sprues as well as waxy drips on the reverse of the relief suggest that it was cast using the indirect lost wax technique. Close conformity of the relief on the front with the back surface of the metal also suggests that the casting wax was formed in a mold using the indirect technique. Once removed from the molds, a wax riser was added in one corner, as well as wax hanging loops at the edges. The indirect technique allowed the artist to apply the bulk of the sprues to the back, avoiding the cold work that would have been necessary had the sprues been applied to the front after modeling. The metal has oxidized to a golden brown to darker brown color with no applied organic patina.

There is considerable similarity in the surface treatment of the *Allegory* relief and that of the *Bust of Emperor Rudolf II,* also in the Kunsthistorisches Museum in Vienna. Both combine lively and expertly modeled wax details, with some textures laboriously applied in the metal. However, these surface treatments are taken to a far greater extreme on the relief, as the details assume different roles in the two compositions. The bust is foremost a statement of power, expressed physically in the size and pose of the emperor and symbolically through the supporting figures, as well as the details in the cuirass. While also a statement of power, the relief works in a very different manner. The finely rendered scenes and details tell the story of the triumphs of the emperor in narrative manner, drawing the viewer in closely and challenging recognition and deciphering of the scenes. Brought to an almost obsessive level not equaled in de Vries's oeuvre, the entire message of the *Allegory of the War against the Turks in Hungary* is delivered in the fine details.

CHAPTER 15

Rearing Horse

J. Paul Getty Museum, Los Angeles. Inv. no. 86.SB.488

Cast in Prague in 1605–1610

Dimensions: H: 49.5 cm × W: ca. 54.6 cm × D: 17.8 cm

Marks and inscriptions:

Inscribed on the back of the base: **ADRIANVS FRIES HAGENSIS FECIT**

Painted in white on the back of the base: **86.SB.488**

OVERVIEW

The bronze depicts a rearing horse, unshod, with a band around the top of the tail (fig. 15.1). It was first recorded in the 1607–11 inventory of Rudolf II's *Kunstkammer*. It was taken from Prague by Swedish troops in 1648 and entered the collection of Queen Christina of Sweden. It then passed through private hands until its sale to the J. Paul Getty Museum in 1986.

The bronze was first examined by Francesca Bewer in 1995 in conjunction with the Renaissance Bronze Project at the J. Paul Getty Museum. Following the de Vries exhibition, the bronze was examined again in light of new information on the artist. This more recent examination offered an opportunity to reevaluate the radiographs and data and to then compare the cast to the slightly larger *Horse* from Prague (chapter 16).

EXAMINATION

1. Alloy

Horse: The horse was cast in a bronze alloy containing approximately 9 percent tin in a copper matrix with zinc and lead below 0.5 percent. One spectrum was acquired.

Base: Three spectra were acquired to determine the bulk alloy of the base. The composition of the base differs from that of the horse in that it contains considerably more lead. The alloy is composed of approximately 6 to 7 percent tin in a copper matrix with less than 0.5 percent zinc and 1 to 5 percent lead. Although the alloys differ, there is no evidence to suggest that the base is not original. Full alloy results can be found in table 4.1.

FIGURE 15.1 *Rearing Horse*
J. Paul Getty Museum, Los Angeles. Inv. no. 86.SB.488

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Horse: A plugged, oval-shaped hole (2.8 × 1.8 cm in diameter) is all that remains of the rod that would have run vertically out of the belly, supporting the structure during construction of the casting model and during the bronze pour. The projected location of the rod is illustrated in figure 15.2. Bewer (2001: 175) notes the use of such a support rod in both of the horses in Stockholm. In the Stockholm horses, the rectangular-sectioned rods ran from the bellies into the bases. Rectangular patches now fill the holes left when the rods were removed. In the Stockholm horses, as in the *Rearing Horse,* the holes in the bellies were enlarged to allow removal of the core and support rods. Radiographs of two horses by Giambologna, one rearing and one standing, show the upper ends of such vertical support rods still remaining inside the figures. In both examples, the rods are shaped like an upside-down *L*. The horizontal part of the rod would have kept the weight from slipping downward on the rod; a similar configuration may have been used for the de Vries armature, but since the rod has been

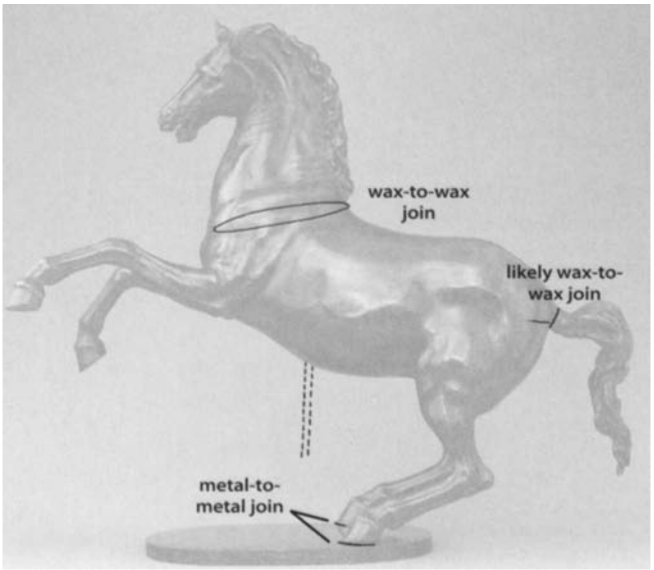


FIGURE 15.2 Summary of the wax-to-wax and metal-to-metal joins. Only one small segment of a core support remains; the rest have been removed. The dashed lines indicate the primary core support rod that has been removed.

removed, this is conjecture. The hole in the belly could have been used to remove the core and core supports before the repair plug was placed (fig. 15.3). A thin rod protruding into the body from the tail may be a support added to strengthen what was likely a wax-to-wax join at the base of the tail. No other core supports remain.

Base: Not applicable.

b. Core pins

Horse: Two tapering, blunt-end, rectangular-sectioned pins in the back half of the horse appear to be core pins that were cut off at the surface and pushed partly into the inner cavity. A 0.25 × 0.25 cm patch visible in the radiographs above the rear legs is likely a core pin hole repair, suggesting the possible diameter of the core pins.

Base: None observed.

c. Core material

Horse: Nearly all of the core material appears to have been removed, probably at the same time that the armature was taken out. A small core sample that remained loose in the interior was removed from a casting flaw hole between the buttocks. Unfortunately, the sample was too small for reliable analysis.

Base: All but the finest traces of core material have been removed from the open bottom of the base. Attempts to analyze a small sample of reddish corelike material were unsuccessful because of contamination from modern wax.

d. Internal surface of the bronze

Horse: There is no direct access to the interior surfaces of the bronze. The radiographs show that the walls of the cast are relatively thin. The bronze was cast hollow except for the muzzle, tail, ears, and bottom two-thirds of each leg, all of which were cast solid. In the head and the center of the body there are subtle changes of density that are likely wax drips formed during slush molding of the casting wax (fig. 15.4), suggesting that the bronze was cast using the indirect lost wax process.

Base: The underside of the base displays brushstrokes captured in the bronze from the wax casting model. It is likely that the brushstrokes were formed as the molten wax was painted into a mold, evidence that the base was also cast using the indirect lost wax process (figs. 15.5, 15.6).

e. Method of assembly and joining of individual wax or cast bronze components

Horse: The radiographs show evidence of a wax-to-wax join at the base of the horse's neck, again suggesting that the sculpture was cast indirectly (fig. 15.4). Lower radiographic density

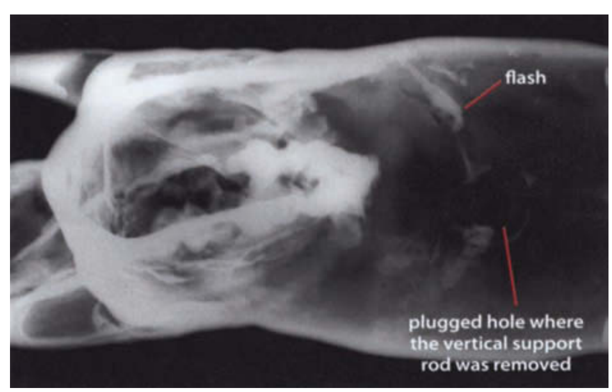


FIGURE 15.3 Radiograph of the front of the horse taken from above.

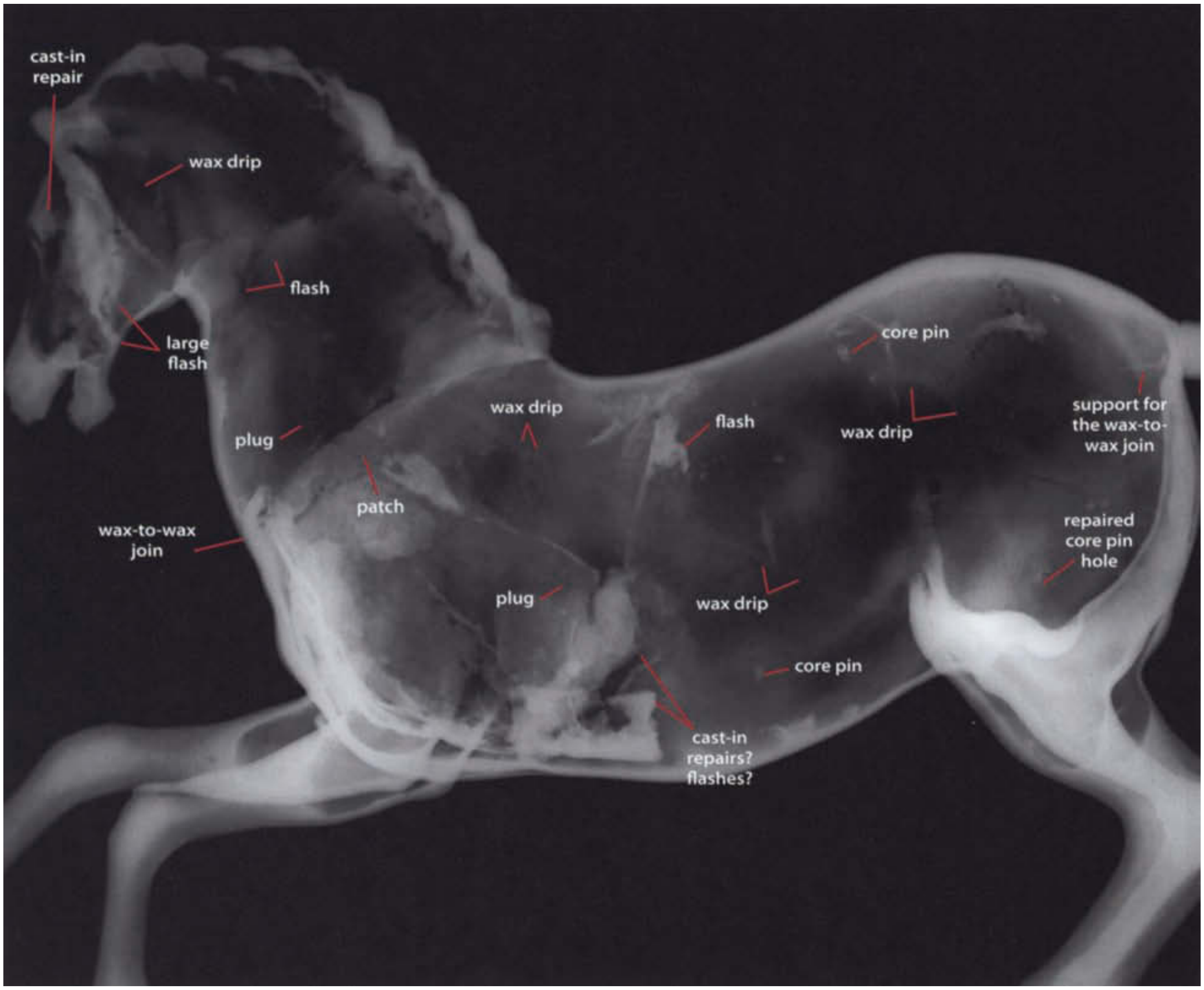


FIGURE 15.4 Radiograph of the horse.

of the head compared to the body indicates that the metal on the upper side of the join is thinner than that in the body, a variation due to the two sections having been slush molded separately from one another; these variations in the thickness of the wax were then transferred to the cast metal. Just above this wax-to-wax join, a second line that runs partway around the upper section of the neck could be interpreted as a wax-to-wax join. It is unlikely that a second join would have been necessary in this location, and, unlike with the join line lower in the neck, the thickness of the bronze walls does not vary from one side of this line to the other. This discontinuity in the thickness of the bronze wall is more likely due to flashing (fig. 15.4). It is likely that there is a second wax-to-wax join at the base of the tail. Because the tail was cast solid, this join is not visible in the radiographs.

Base: Metal-to-metal joins secure the horse to the separately cast base. Large (1.5 cm diameter) casting sprues that extend down from the two support hooves slip into circular sleeves that were integrally cast into the base. The sprue ends were splayed from the bottom with a large chisel in a cross-shaped configuration, helping to lock the horse to the base (fig. 15.5).

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

Horse: Details such as the teeth, gums, unshod hooves, double band around the base of the tail, veins, and folds in the horse's hide were fully modeled in the wax, apparently without chiseling of the features after casting (fig. 15.7). The mane and tail were modeled in loose and voluminous tufts, with individual strands set at different angles, a technique the artist also used for human hair, as seen on bronzes such as *Hercules, Nessus, and Deianeira* in the Louvre (fig. 13.9). The body of the horse is highly polished overall. Extremely fine parallel lines, likely from a wire brush, run primarily parallel to the limbs, depicting the horse's hide. A second set of abrasion lines appear in higher-relief areas such as the sides of the belly, perhaps due to later cleanings. Faint texturing along a few of the strands of the mane and tail appears to have been applied in the wax.

Base: The top and sides of the base are highly polished, with parallel wire brush marks running front to back on the top and horizontally on the sides of the base.

The side of the base is signed at the back (fig. 15.8). The letters were outlined, and then the material within the outlines was removed, often in parallel strokes, leaving raised lines between strokes in a method highly characteristic of de Vries. Although the thick organic patina in the recessed letters makes it difficult to interpret whether they were cut into the wax or the metal, the soft and wavy character of the raised lines suggests they were formed in the wax. In two letters, the basic outlines were made, but the inside was never removed (fig. 15.9).

g. Patina

It appears as though a very thick organic lacquerlike patina once covered the entire surface. This patina now remains over more than half of the horse. The patina is nearly black where thick, a translucent reddish brown where thin. In some areas, the golden polish of the metal remains below the lacquer, revealing a reddish glow under bright light. It is not known whether the patina is original, but it was

FIGURE 15.5 Open bottom of the base.

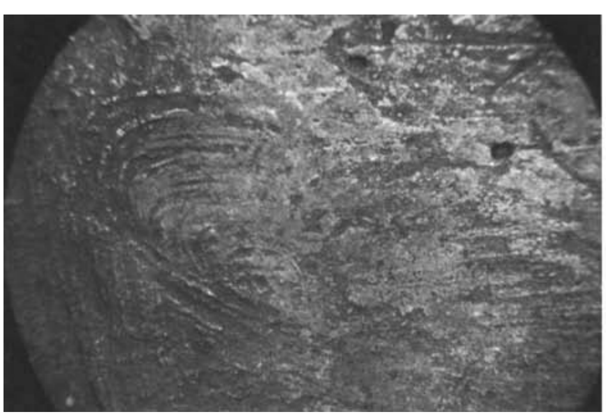


FIGURE 15.6 Photomicrograph detail of brushstrokes from the application of wax into the mold.

FIGURE 15.7 The features were fully modeled in the wax and left as-cast without enhancement with punches or a chisel.

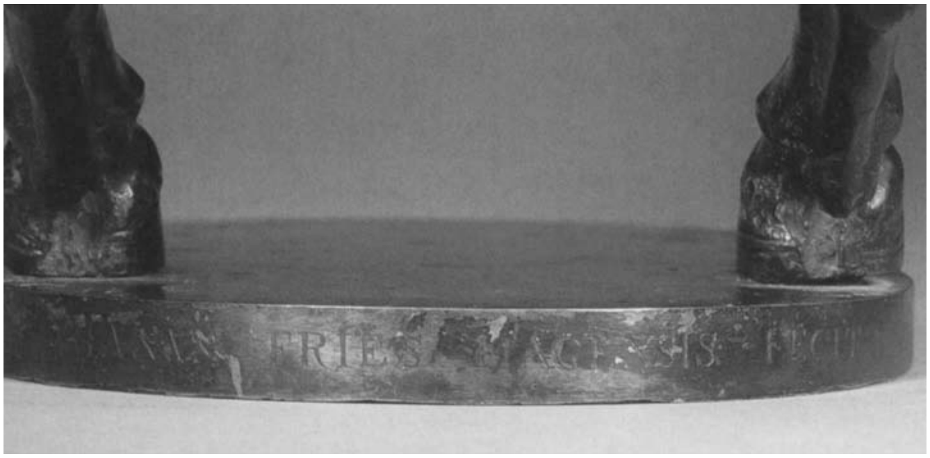


FIGURE 15.8 Signature on the base.

probably applied fairly soon after the surface was polished. A thin, translucent brown-colored organic patina was applied to the surface after considerable damage had already occurred to the thick patina below. This newer patina likely helped to saturate and unify the uneven earlier patina. It is most visible on the right side and top of the horse's body and the top of the base. Continued flaking of the lowermost thick patina may have been accelerated by the presence of this later patina. Flaking is heaviest in the recesses where the patina is thickest, revealing the light brown oxidized metal surface.

3. Casting Defects and Foundry Repairs

Horse: A small (0.2 cm × 0.1 cm) hole through the bronze in the recess between the buttocks probably corresponds to an area that was thin in the wax, where the metal may have cooled prematurely, inhibiting the flow of the bronze. Casting flaws in the upper part of the face have been treated in different ways. A casting flaw in the forelock where the bronze did not flow has been left as-cast. A crack and adjacent loss below the forelock are filled with a reddish wax-like material. Single flaws in each brow have been filled with cast-in repairs. Much of the forehead has been covered with

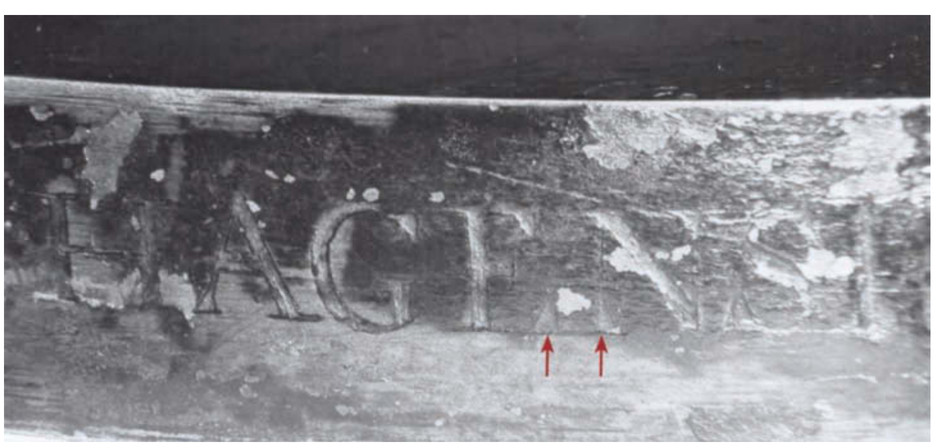


FIGURE 15.9 Photomicrograph of the signature. The arrows indicate areas where the outlines were applied but the inside was not carved out.

a thick, off-white, pastelike fill that is now hidden below the later translucent brown patina. It is not clear in the radiographs what the surface looks like below this fill.

The radiographs reveal repairs that are not visible on the surface due to very careful chasing, as well as the obscuring patina. These repairs include scattered rectangular patches and three circular plugs (one below the belly and two on the front half of the body). The large patch where the support rod exited the belly is slightly larger than the oval hole it repairs. This plug is invisible on the surface, even where the patina is lost. There is an irregularly shaped cast-in repair near the wax-to-wax join in the neck. A considerable amount of extra metal visible in the radiographs at the bottom of the belly suggests that there may be additional cast-in repairs in the area, as well as flashes.

The radiographs reveal considerable expanses of dense, fine-vacuole porosity throughout the figure as well as some areas of slightly larger porosity, such as on the rump and in the middle of the back. The latter is repaired with a large rectangular patch that is not visible from the surface.

Base: No repairs are visible on the base.

4. Later Modifications/Restorations

There have been at least two inpainting campaigns to hide patina losses. A variety of scratches cut through the patina to the metal surface. Some may be *surmoulage* lines made as a mold was being taken from the surface.

SUMMARY

The results of the examination confirm the findings from the earlier study carried out in 1995, with a slight but important change in interpretation. The horse and base were separately cast. Cut-off sprues below the support legs secure into circular sleeves integrally cast into the bottom of the base. Chisel blows across the bottom of the sprues lock them in place. The correct alignment of the sprues with the mounting sleeves, together with the characteristic cast-in signature on the side of the base, suggests that the base is original to the horse. Waxy driplike marks and a wax-to-wax join in the horse, as well as waxy brush marks below the base, indicate that both the horse and the base were cast using the indirect lost wax technique. The details in the face, mane, and tail were fully modeled in the wax, without chiseling of the features after casting. There are numerous flashes on the interior. Casting flaws are filled with round and rectangular set-in and cast-in repairs. The large oval patch in the belly fills the hole left when the primary support rod and the core were removed after casting. The hide is polished with very fine parallel scratch brush lines running primarily along the forms. The polished golden metal surface can be seen below the translucent reddish brown organic patina in areas.

According to Bewer (2001: 174), while the discontinuity in the neck seen in the radiograph of the horse has the appearance of a wax-to-wax join (therefore suggesting the use of the indirect technique), the bronze may actually have been cast directly. She speculates that the direct lost wax casting technique was more likely used for this medium-sized bronze, as the indirect casts examined up to that date are all relatively small. This statement can be reevaluated in light of the additional bronzes included in the present study, which has shown that a number of medium-sized compositions were cast indirectly, including *Hercules, Nessus, and Deianeira* and both *Cain and Abel* groups (see fig. 32.3). Further argument can be made for the indirect technique, as the present study has shown that the larger *Horse* in Prague was also indirectly cast.

For a comparison of the *Rearing Horse* and the Prague *Horse,* as well as a discussion of how the bronzes relate to Giambologna's horses, see the *Summary* section in chapter 16.

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CHAPTER 16

Horse

Národní Galerie v Praze, Prague. Inv. no. P 4605

Cast in Prague in 1610

Overall dimensions: H: 56.5 cm × W: 62.6 cm × D: 20.8 cm

***Circumference:* Horse's belly (largest circumference): 56.9 cm**

Above the knee on right hind leg (narrowest circumference): 9.0 cm

Just below the knee on left foreleg (narrowest circumference): 7.3 cm

***Width:* Tip of ear to tip of ear: 6.2 cm**

Marks and Inscriptions:

Inscribed in the metal on the proper right side of the base:

ADRIANVS FRIES HAGIENSIS FECIT 1610

Written in ink on a paper label adhered to the bottom: 271

Written in red ink on the bottom, directly on the bronze: DP408

Written in red pencil on the bottom, directly on the bronze: 2399

Printed on a modern label and adhered to the bottom of the base:

Prahal (480.) Majitel: Praha Národní galerie, sbirka starého umeni, Inv.c: P4605, Exponát: Vries, Krácející kun, Expozice: Dvür Obrazárna

OVERVIEW

The bronze represents a pacing horse on a polished oval base (fig. 16.1). The sculpture was likely commissioned by Rudolf II for his *Kunstkammer,* then taken from Prague by the Swedes in 1648. It was purchased on the English art market by the applied arts museum in Prague in 1887 and currently resides in St. George's Convent of the National Gallery, Prague.

The technical study was undertaken to add to our understanding of de Vries's methods and materials. The results were compared with those from the *Rearing Horse* (chapter 15).

FIGURE 16.1 Horse
Národní Galerie v Praze, Prague. Inv. no. P 4605

EXAMINATION

1. Alloy

Horse: The alloy of the figure was analyzed in four locations. The metal used to cast the horse is a tin bronze composed of approximately 10 percent tin in a copper matrix with less than 0.5 percent zinc and 1 percent lead. Full alloy results can be found in table 4.1.

Base: The alloy of the separately cast base differs from that of the horse. The base was cast in a quaternary bronze alloy composed of a copper matrix with added tin, zinc, and lead.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Horse: A 3.0 cm diameter circular hole in the belly is the only remaining evidence of what was likely a central rod used to support the structure during construction of the casting model and during the pour. The path of this rod is sketched in figure 16.2. Once the rod was removed, the hole may have been enlarged to allow the removal of

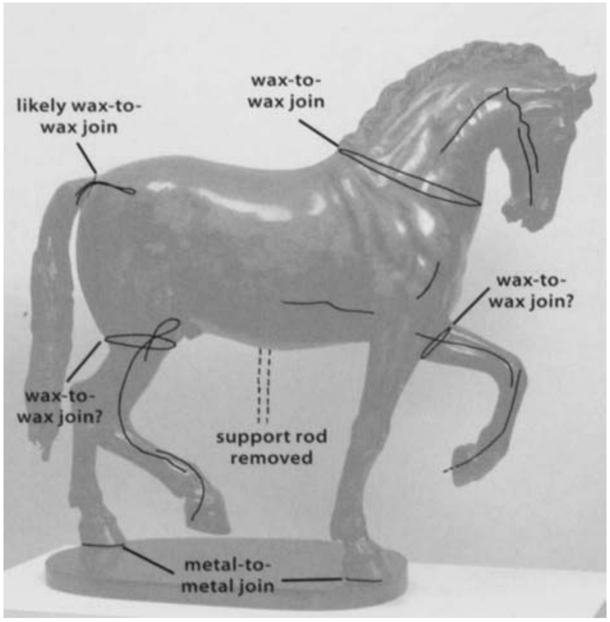


FIGURE 16.2 Summary of the remaining core support rods and wires. The dashed lines indicate the primary support rod that has been removed.

armature rods and core. The repair plug was carefully chased and is not visible on the surface of the sculpture. At 4.0 cm across, the plug is quite a bit larger than the hole it fills (fig. 16.3).

Of the remaining core support rods, there are two in the head, two in the body, two in the left rear leg, and three in the right foreleg. The wire in the front right hoof extended out of the wax and into the investment, doubling as a core pin. The cut-off end of the wire is visible below the hoof, as this hole was not plugged. A looping wire passes from the body into the tail. It is likely that originally there were many more core support wires that were removed after casting.

Base: Not applicable.

b. Core pins

Horse: A number of straight-edged square holes measuring either 0.25 or 0.3 cm across appear to be core pin holes, visible in the radiographs throughout the body and legs. It is likely that cut-off sprues, or other metal of an alloy similar to the rest of the sculpture, were used to plug the core pin holes; none of them are visible on the surface of the bronze. This is due in part to the patina but also to their color, which matches that of the surrounding bronze, and to the careful manner in which they were chased. In three locations, cut-off, tapering core pins remain on the inside of the bronze next to their plugged holes. The length of one of the pins was measured at approximately 1.5 cm.

Base: None observed.

c. Core material

Horse: There is no direct access to the interior of the bronze. Much of the core material was probably removed with the armature through the hole in the belly. Rough-edged areas of varying density in the radiograph of the center of the head are due to the uneven removal of core in this area (fig. 16.4).

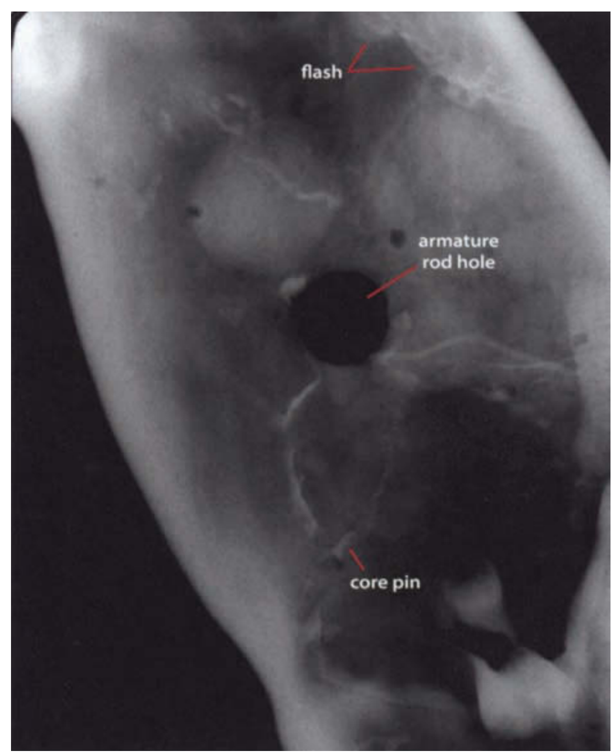


FIGURE 16.3 Radiograph of the center of the horse taken from above.

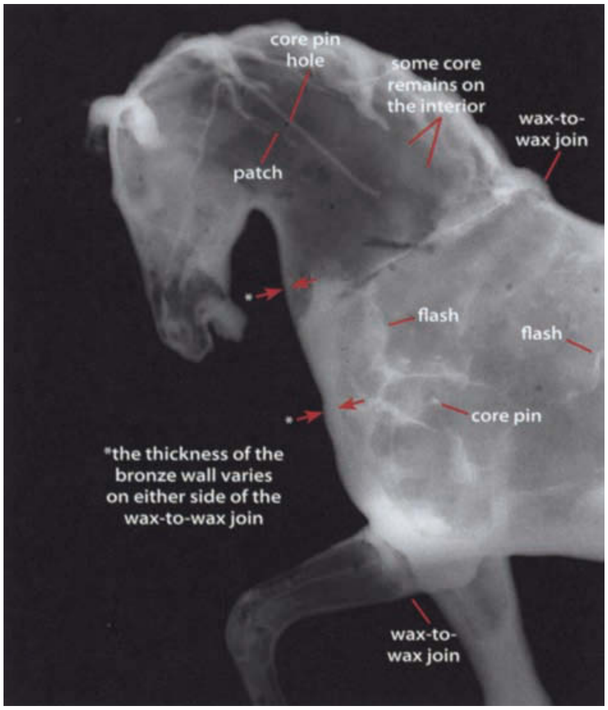


FIGURE 16.4 Radiograph of the front of the horse.

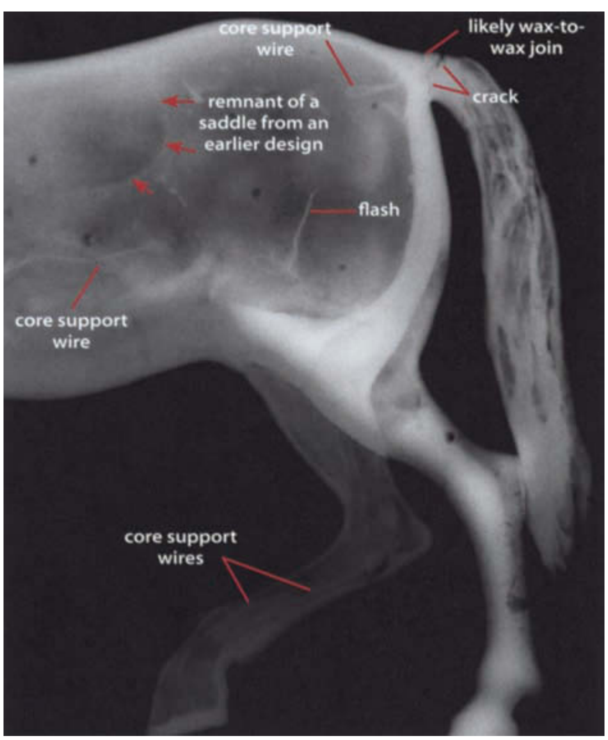


FIGURE 16.5 Radiograph of the back of the horse.

Base: All traces of core material have been removed from the open bottom of the base.

d. Internal surface of the bronze

Horse: The radiographs show that the bronze was cast hollow, except for the solid lower jaw, the ears, and the supporting legs, which are solid from the thighs down. There is the ghost of what appears to be part of a saddle on the back of the horse, which would have been included in the molds, yet must have been removed from the composition by the time the wax was finished (fig. 16.5).

Base: The underside of the base is smooth.

e. Method of assembly and joining of individual wax or cast bronze components

Horse: The radiographs show evidence of wax-to-wax joins used in constructing the wax casting model (fig. 16.2). They appear as lines of varying densities across the radiographs where separately mold-made sections of the wax model were joined.

- In the neck. The walls of the neck are thinner than those of the body (fig. 16.4).
- In the top of the right foreleg. There is a core support wire across the join (fig. 16.4).
- Possibly in the top of the left rear leg; the join is only partially visible in the radiograph. A core support wire crosses the join (fig. 16.6).
- Thickening of the metal at the base of the tail suggests a wax-to-wax join. A core support wire crosses the join (fig. 16.5).

The presence of wax-to-wax joins suggests that the bronze was cast using the indirect lost wax process.

Base: The horse is joined to the separately cast base using the casting sprues that extend down from the hooves. The sprues were left long enough that they set into circular sleeves cast with the base. The sprues were then soldered to the sleeves (fig. 16.7). Old mounting epoxy covers the bottom of the sprues, hiding any indication of whether the cut-off ends were splayed with X-shaped chisel marks, as observed on the *Rearing Horse* at the J. Paul Getty Museum (see fig. 15.5). Exact alignment of the back hooves with the

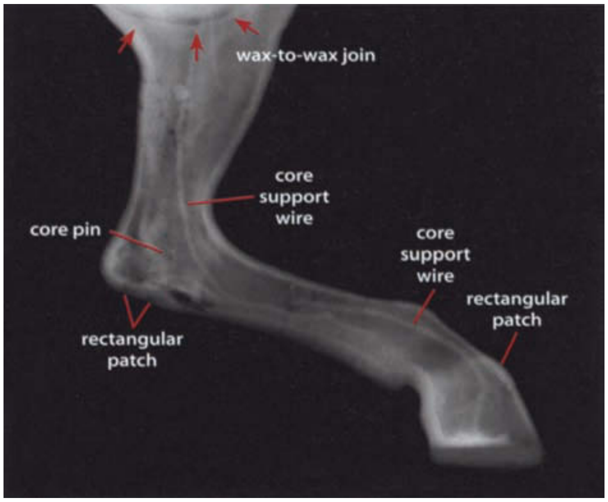


FIGURE 16.6 Radiograph of the left rear leg.

circular sleeves in the base indicates that the base was cast specifically for the horse. Similarity in the surface finish and wear of the horse and base suggest that the base is original, but this cannot be proven with the existing data.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

Horse: Details such as the veins, mouth, and folds in the horse's hide were fully modeled in the wax, apparently without chiseling of the features after casting (fig. 16.8). The top of the tail is bound in strands of fabric, and the hooves are unshod. The long, flowing strands of the tail were textured with an oval, convex punch. These lines of texture are quite faint in both the tail and the mane, suggesting they were made in the wax. The body of the horse is highly polished. The texture of the hide was then depicted, likely after casting, with fine scratch brush marks that run parallel to the body and limbs. The letters in the very detailed signature were embellished with fine vertical and horizontal lines. The signature appears to have been cut into the wax, perhaps with touch-ups in the metal after casting (figs. 16.9, 16.10).

Base: The top and sides of the base are polished, with very fine parallel wire brush marks running front to back on the top and horizontally on the sides of the base.

g. Patina

A translucent, dark reddish brown lacquerlike coating remains over much of the sculpture but has abraded off of the raised surfaces, including the horse's back. Where thin, as on the left side of the horse's neck, the coating is a stronger burgundy red and quite translucent. The preserved, bright golden color of the polished and scratch-brushed bronze is visible in these areas through the protective coating—sometimes even in the tiny recesses of a single scratch brush mark. Although it is unknown whether the patina is original, the presence of these bright areas below the lacquer suggests that the coating was applied soon after the surface was polished. Where the coating has

FIGURE 16.7 Open bottom of the base. The sprues below the hooves have been soldered into the circular sleeves that were cast integrally with the base.

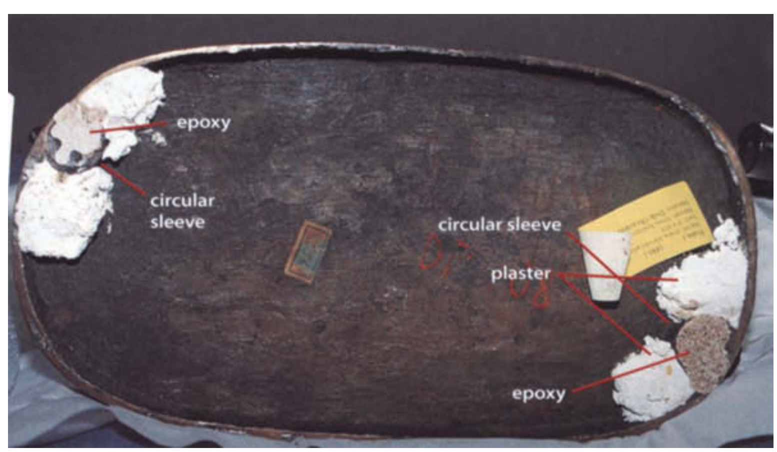


FIGURE 16.8 The features were fully modeled in the wax and left as-cast without chiseling into metal.

FIGURE 16.9 The signature on the base was cut into the wax.

FIGURE 16.10 Photomicrograph detail of the signature.

FIGURE 16.11 Where more heavily worn, a rich red (copper oxide?) surface is revealed.

abraded completely away, the surface varies in color from light brown to a rich red (with the appearance of copper oxide). This copper oxide surface occurs on the more heavily handled areas such as the horse's face and the top of the front right leg (fig. 16.11).

3. Casting Defects and Foundry Repairs

Horse: The horse was expertly cast, with very few flaws. The radiographs show that porosity is limited. There is a small amount of shrinkage porosity in the back half of the horse's body. Clusters of small- to medium-vacuole porosity appear throughout (fig. 16.5). There are a small number of unrepaired porosity holes on the surface. There are large flashes in the head and in the chest where molten metal flowed into cracks in the core.

A small number of rectangular repair patches are visible in the radiographs. These repairs appear to fill both core pin holes and casting flaws. Most of the holes have been patched with rectangular bronze plugs that are quite a bit larger than the pins or flaws themselves. These repairs were made by chiseling away part of the thickness of the metal around the holes and hammering in the rectangular fills. In the radiographs, the flaw or hole in the bronze is clearly visible due to the lower opacity of the thin repairs. An example can be seen in the core pin hole in the center of the neck in figure 16.4. The hole left when the core pin was removed measures 0.3 cm × 0.3 cm, yet its rectangular patch measures 0.7 cm × 0.7 cm. Appendix A, figure A.23 (set-in repair), illustrates how these repairs were made.

Base: The radiograph shows no repairs on the top surface of the base and scattered porosity that concentrates at the rear half of the cast. A very small number of porosity holes break through the top of the base.

4. Later Modifications/Restorations

Horse: There is a crack at the top of the tail, and the adjacent repair plug has fallen out. Long thin scratches through the surface coatings appear to be *surmoulage* marks, indicating that a mold was taken of the bronze at some time in the past. The scratches appear in the following locations: down the inside of all four of the legs; across the groin; across the left side of the forehead; down the right side of the neck and chest; on the left side of the belly; and below the chest between the forelegs. Some of these scratches are shown in Appendix A, figure A.32 (*surmoulage* marks). A rather thick layer of soil, likely including wax, has accumulated in the recesses.

Base: Spots of plaster and epoxy below the base remain from a previous installation (fig. 16.7).

SUMMARY

The horse and base were cast separately. Wax-to-wax joins and variations in the thickness of the bronze walls on either side of the joins suggest that the indirect lost wax casting technique was used. The radiographs show remnants of a saddle on the horse, apparently present in the molds but removed when the wax was finished. Perhaps archival documents may one day indicate the original intention for the model. Whereas the horse is cast in a bronze alloy typical of de Vries, the signed base was cast in a quaternary alloy containing copper with added tin, zinc, and lead. The horse secures to the signed base with cut-off casting sprues that project down from the two support legs and are soldered into sleeves integrally cast into the bottom of the base. The horse's hide is polished and textured with scratch brush lines that run parallel to the body and limbs. The bright, golden-colored metal remains visible in some of the scratch brush lines where an early translucent reddish brown patina remains.

The Prague *Horse* was compared with Adriaen de Vries's *Rearing Horse* in Los Angeles (1605–10) (chapter 15). There are obvious differences in the two, for example, the dissimilar poses and the larger size of the Prague composition. Regardless, there are notable similarities in the modeling and the casting technique. The modeling on both horses is quite detailed, including raised veins, sharply delineated folds, and carefully depicted facial features, with no apparent chiseling or refining of details in the metal after casting. Both horses were cast in one pour, separately from their bases, and secured with sprues extending down from the support legs into circular sleeves integrally cast with the bases, an unusual technique observed on two of Giambologna's autograph casts of Nessus and Dejanira (Bewer 2001: 175). Waxy drips as well as one or more wax-to-wax joins in the Los Angeles *Rearing Horse* indicate that it too was cast indirectly, although with fewer joins than seen on the larger Prague horse. Both horses retain evidence of a primary support rod having been removed from the center of the belly; similar rods have been removed from the two horses in Stockholm (Bewer 2001: 175). While the two support legs on the Prague *Horse* are solid-cast, all four of the legs and the tail on the *Rearing Horse* are solid, a difference that can perhaps be explained by the smaller dimensions of the latter animal, dimensions that would have yielded a very thin—and therefore weak—core. The core pin and vertical support rod holes on both have set-in repairs, but the oversized patches used on the Prague *Horse* are less common for de Vries (although they also appear on the *Bust of the Elector Christian II of Saxony*).

The metal compositions of both bases differ from those of the figures themselves, falling just outside of the usual range of de Vries alloys (see figs. 4.2, 4.3). Although the artist seems to have specified the alloy to be used for all his other casts, it is interesting to note that he did not find it necessary to control the metal used for the bases.

CHAPTER 17

Vulcan's Forge

Bayerisches Nationalmuseum, Munich. Inv. no. 69/57
Cast in Prague in 1611
Dimensions: H: 47 cm × W: 56.5 cm × D: approx. 9.6 cm
Thickness of the metal as measured with calipers: varies from 0.6 cm (background) to 0.9 cm (medium-relief areas).
Marks and inscriptions:
Inscribed below the anvil: ADRIANVS FRIES HAGIENSIS BATAVVS. F. 1611
Written on the reverse in the top proper right corner in white paint: 69/59

OVERVIEW

The relief represents Vulcan and four attendants, circled around an anvil, forging an armor commissioned by Venus for her son, Aeneus (fig. 17.1). The composition varies from low relief in parts of the background to freestanding high-relief foreground elements. It is mounted in a wooden frame with metal support bars and an open back (fig. 17.2). The bronze was purchased by the Bayerisches Nationalmuseum from a private collection in 1969.

The technical study was undertaken to add to our understanding of de Vries's methods and materials.

EXAMINATION

For the purpose of this report, the foundry men have been designated "A" (viewer's far left) through "E" (viewer's far right).

1. Alloy

The metal composition was determined by examining four locations on the relief. The sculpture was cast in a bronze alloy containing approximately 7 to 9 percent tin in a copper matrix with zinc content below 1 percent and lead below 0.5 percent. Full alloy results can be found in table 4.1.

FIGURE 17.1 *Vulcan's Forge*
Bayerisches Nationalmuseum, Munich. Inv. no. 69/57

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Core supports remain in two of the high-relief limbs: the right arm of foundry man "A" and the left leg of foundry man "E" (fig. 17.3).

b. Core pins

Two square core pins (measuring 0.3 × 0.3 cm in section) remain on the proper left side of the relief. The pins were

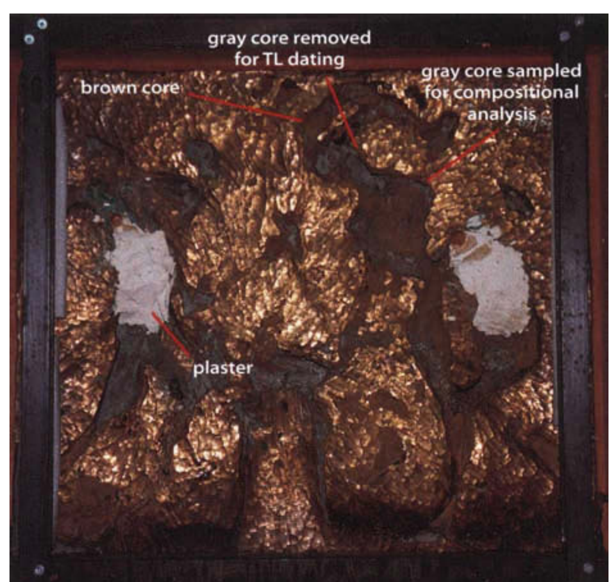


FIGURE 17.2 Back of the framed relief. Chisel marks cover much of the flat back. Core remains in the high-relief areas.

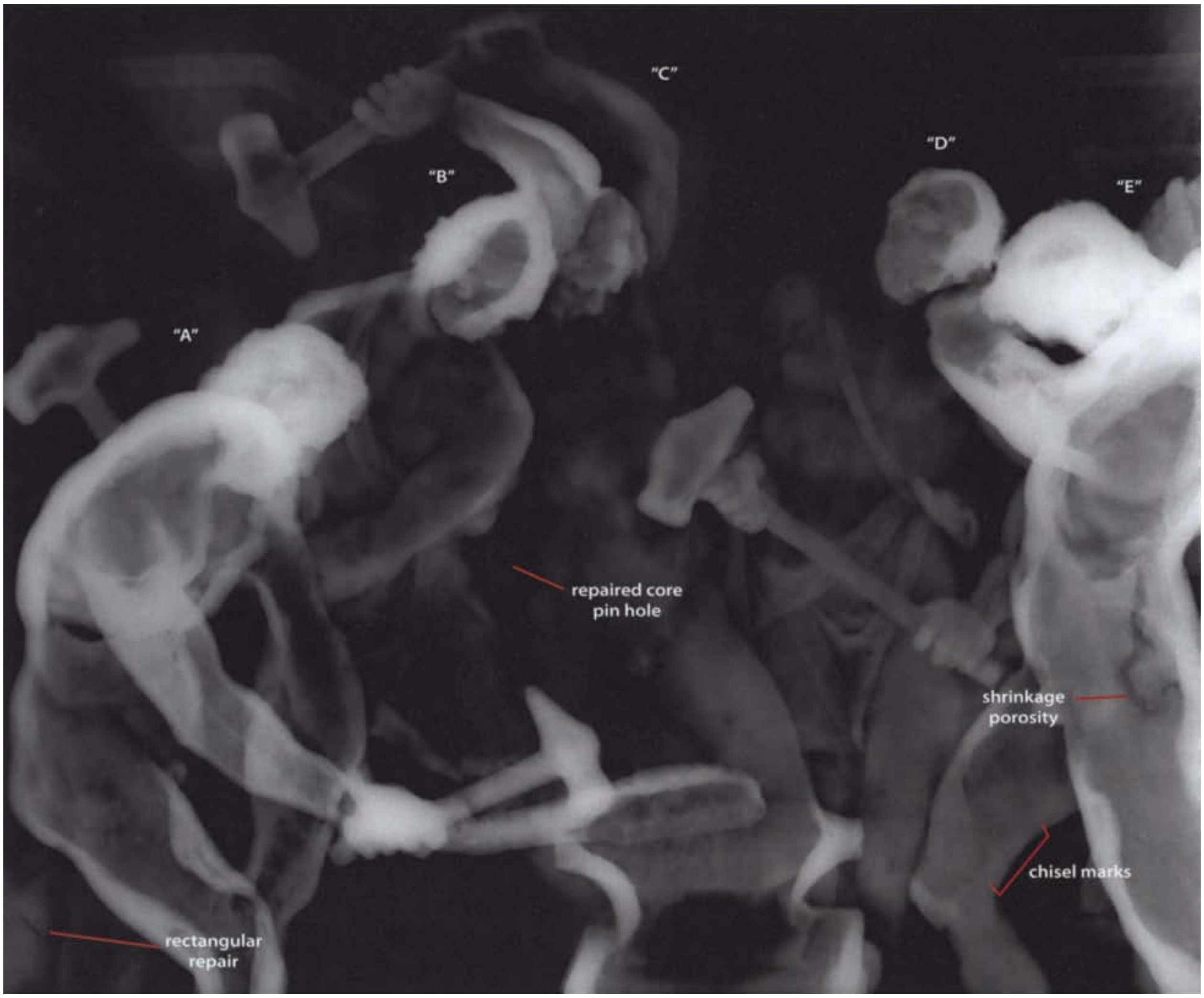


FIGURE 17.3 Radiograph of a portion of the relief.

cleanly cut through when the back of the relief was chiseled down (refer to section 2d below). Two square core pin holes are visible as dark spots in the radiographs where the surface was repaired with a bronze patch the same size as the hole, yet thinner than the surrounding cast surface (fig. 17.3). These core pin holes measure 0.2 × 0.2 cm and 0.25 × 0.25 cm.

c. Core material

There are three different materials on the back of the relief: gray core material that is directly against the metal surface, brown material that partially covers the gray core, and plaster applied over the core behind the high-relief figures "A" and "E." The plaster and the brown material have been applied over the chisel marks that cut across the reverse of the relief, indicating that both were applied after the relief was cast and the back partially chiseled down (fig. 17.2). They are not associated with repairs.

Much of the gray-colored core has been removed from the back, but it remains in the raised relief areas. Quantitative analysis yielded the following:

- 78 percent gray clay
- 14.5 percent quartz
- 3 percent feldspar (albite)
- 3 percent opaque grains
- 1 percent muscovite
- 0.5 percent orthopyroxene
- trace of oxy-hornblende (lamprobolite)

A small chunk of the gray core was dated to 1630 ± 20 years using the thermoluminescence technique.

d. Internal surface of the bronze

The bronze varies from very low relief to high-relief areas where elements stand free from the background. The radiographs show that two of these high-relief areas were cast solid without any core—the right hand of foundry man "A" with the hammer he holds and the handle of the metal slab on the anvil. All other high-relief segments were cast hollow, including most of foundry men "A" and "E," the heads of figures "B" and "D," the right elbow of "C," and the hammer heads held by figures "B" and "D."

With the exception of the high-relief areas, the entire back of the relief has been chiseled down (fig. 17.2). The marks cut through porosity vacuoles and core pins, indicating that the relief was chiseled in the metal rather than in the wax. This chiseling on the back has removed clues to how the relief was cast, such as evidence as to the conformity of the front and back surfaces, wax drips, sprue remains, and surface texture.

e. Method of assembly and joining of individual wax or cast bronze components

The appearance of the bronze surface and the radiographs suggest that the background and all of the figures were cast together in a single pour. There is no indication of metal-to-metal or wax-to-wax joins.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The entire sculpture was modeled and finished to great detail. The relief details, some of them quite small in scale, retain the feel of the wax model, without cold work (fig. 17.4). Although the subject of Vulcan's forge is unique for de Vries, some of the relief elements are reminiscent of those found on the artist's other compositions. Rough parallel scratches depicting the fabric in the hat and drape of foundry man "B" were applied in the wax, a textural detail found on *Hercules, Nessus, and Deianeira* in the Louvre and the *Bust of Emperor Rudolf II* (see fig. 11.10). The scales on the cuirass in the proper right bottom corner are a miniature version of those found on the *Laocoön* in Stockholm and the *Hercules* fountains in Stockholm and Augsburg. Although the size of the scales varies, they are all repeats of the same six-sided pattern in which each scale is tilted higher toward the bottom, with a raised vertical line down the center (see figs. 25.8, 25.11).

A variety of punches were used in different ways to apply designs or textures to the surface. It is unknown if these marks were applied in the wax or the metal. A single fine convex punch was used to "draw" the figure of Fortune in the center top background (fig. 17.5). In many locations, punches were repeatedly applied to depict texture variations. Figure 17.6 illustrates four different punches used to vary the surface. Three of the punches are carefully applied

FIGURE 17.4 Cupid holding a finished helmet. The exquisite modeling was left untouched after casting.

FIGURE 17.5 The figure of Fortune has been outlined using a round or oval punch.

FIGURE 17.6 The bottom, proper right corner of the relief. At least four punches were used to differentiate the textures, each kept within a specific area.

in lines; the matting punch is more randomly applied. As is seen throughout the artist's oeuvre, a single punch is used exclusively within each area, without mixing the textures.

The foundry men's flesh, the anvil, and some of the background areas were smoothed in the wax and polished in the metal. Polish lines run parallel to the limbs and are more haphazard in other areas. The signature was cut into the wax model, with fine parallel lines filling each letter (figs. 17.7, 17.8).

g. Patina

No traces of organic coatings remain on the surface. Much of the relief retains the golden color of the slightly oxidized polished bronze. Some areas have oxidized to a darker grayish brown, giving an overall mottled appearance. The XRF spectra were examined for the presence of gold, but no traces were found.

3. Casting Defects and Foundry Repairs

Overall, the relief was remarkably well cast. Two adjacent set-in rectangular repairs are visible in the radiographs. Both measure approximately 2.5 × 1.5 cm (fig. 17.3). No other repairs can be seen in the radiographs; however, some of the background where the thinner parts of the relief have been overexposed is difficult to read.

A small number of unrepaired porosity lacunae are scattered over the surface, for example, the second "N" in the signature (fig. 17.8). Shrinkage porosity appears throughout much of the cast. In most areas, minor shrinkage porosity appears as mottling in the radiographs, most clearly seen in the metal slab and the anvil on which it rests. A meandering gap in the radiograph of the hip of foundry man "E" also appears to be due to shrinkage porosity (fig. 17.3).

4. Later Modifications/Restorations

None apparent.

SUMMARY

Technical examination of the *Vulcan's Forge* shows that the alloy, core, and surface chasing are all consistent with the work of Adriaen de Vries, as seen throughout his career. The relief was cast in a single pour with few flaws. It is unclear whether the relief was cast directly or indirectly. Clay-based core material and core support wires remain

FIGURE 17.7 The artist's signature is prominently displayed on the anvil.

FIGURE 17.8 Photomicrograph detail of the signature. The relatively rounded points and edges suggest that it was cut into the wax.

in some of the figures. The surface details were carefully worked, both through the modeling and texturing in the wax and through the application of polish and possibly punched texture in the metal. Many of the surface details are found elsewhere in the artist's oeuvre, including the method for depicting fabric, the motif of the six-sided scale, and the use of a single punch in each textured area of the base. The surface of the relief is a mottled gold to grayish brown color, with no traces of organic coatings. Sometime after casting, the metal surface on the back of the relief was chiseled down, removing evidence of the casting technique that may have remained on the reverse. It is unknown why this was done, although it may have allowed the relief to fit into a closed-back frame.


157

CHAPTER 18

Cain and Abel

University of Edinburgh, Torrie Collection. Inv. no. 49

Cast in Prague in 1612

Dimensions: H: 74.5 cm × W: 28.0 cm × D: 38.0 cm

Marks and inscriptions:

Inscribed on the front of the sculpture on the recessed flange of the base:

ADRIANVS FRIES HAGIENSIS BA[T]VVS F. 1612.

Stamped on an iron bar that is glued to the base: England

Painted on the front of the base, above the signature: 137

OVERVIEW

Taken from the book of Genesis, the sculpture represents Cain, jawbone raised in his right hand, poised to strike his brother, Abel (fig. 18.1). Crouching on one knee, the grimacing and twisting Abel grabs Cain's left arm in a vain attempt to free himself. The figures spill over the small rectangular base. The bottom of the base is recessed, as though to allow it to slip into another base, although this would hide the signature, which is located on the recessed front edge. The sculpture is dated 1612, the year of Rudolf's death. It is likely the bronze was commissioned by the emperor, as it is listed in his 1619 *Kunstkammer* inventory. The bronze may have been looted by the Swedes, but there is no record of it in Queen Christina's inventory of 1652. The sculpture was given to the University College of Edinburgh by Sir James Erskin Torrie in 1835.

The technical examination was of particular interest as *Cain and Abel* is the only known signed composition by de Vries to exist in multiples. The other signed cast, that from the Statens Museum for Kunst in Copenhagen (chapter 24), is dated 1622, ten years after the Edinburgh cast. It was hoped that the technical study would help to determine whether they were both cast by de Vries, while clarifying the relationship between the two bronzes: were they both cast using the same set of molds, or is the latter bronze an aftercast made off the earlier one?

FIGURE **18.1** *Cain and Abel*
University of Edinburgh, Torrie Collection. Inv. no. 49

EXAMINATION

1. Alloy

The results of XRF analysis showed that the sculpture was cast in a bronze alloy containing approximately 17 to 18 percent tin in a copper matrix with lead and zinc contents below 1.0 percent. A square patch on the back of Cain's right shoulder (likely a core pin plug) was determined to be of an alloy similar enough to the bulk alloy to suggest that it could have been cut from a sprue or excess casting material from the same pour. Full alloy results can be found in table 4.1.

Seventeen percent is a larger-than-expected amount of tin in a bronze alloy because it yields a mixture generally considered too brittle for cold work. A drilled sample of the bronze was found to contain 13.7 percent tin, still a relatively high amount but one yielding a much more workable alloy.[1] The higher tin content found under XRF may be due to inverse segregation upon cooling, in which the tin-rich phase of the molten alloy rose to the surface of the bronze. In this instance, the lower tin content found in the drilled sample should be considered more representative of the overall alloy and is a good example of one of the problems that can be encountered with nondestructive surface alloy analysis.

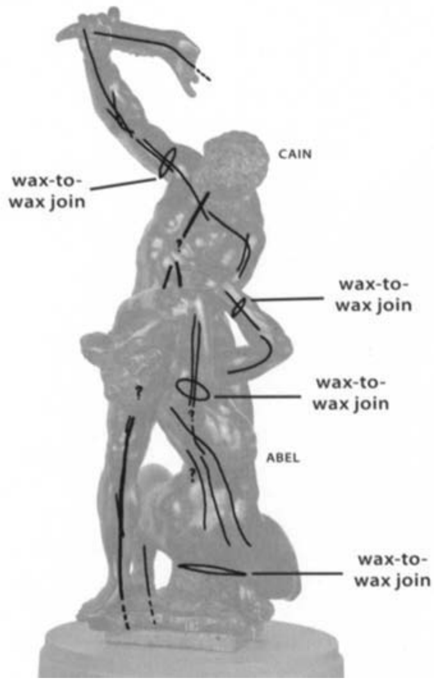


FIGURE 18.2 Summary of wax-to-wax joins and the remaining core support rods and wires. Question marks refer to areas that are not clearly legible in the radiographs. The dashed lines indicate the ends of core supports now cut off.

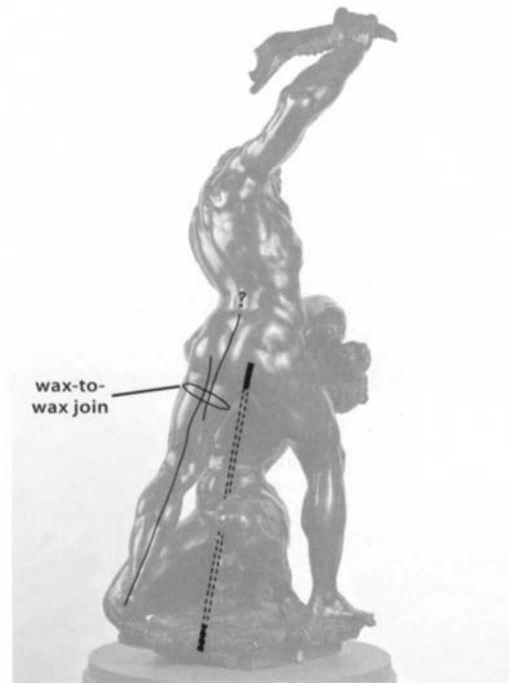


FIGURE 18.3 Summary of the wax-to-wax join in Cain's left leg and the likely path of the removed armature rod. The dashed lines indicate an arm rod that has been removed.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

A number of iron rods and wires are visible in the radiographs (figs. 18.2, 18.3). The supports are difficult to decipher in areas due to extensive flashing on the interior of the bronze, overlap of forms, and rusting of the iron that has left the rods and wires more X-ray transparent (figs. 18.4–18.6). Many of the rods and wires are relatively short, and they do not interconnect, suggesting they may function as core supports inserted into the wax casting model once it was formed—a process indicative of the indirect lost wax technique.

Cain: Increased density in the radiograph of Cain's right buttock appears to be the remaining end of a rod that exited the wax and extended down into the base, helping to support the weight of the torso (fig. 18.5). The rod was cut off at Cain's buttock and at the top of the base. The bottom end of the rod can be seen below the base (fig. 18.7). Magnetic attraction on the top of the base indicates where the rod once passed through the bronze. The hole left when the cut-off rod was pushed into the interior has been filled with a bronze plug (fig. 18.8).

A number of core support rods run vertically up the legs and into the torso. The rods overlap in areas but are not interconnected. The end of the rod in the right leg can be seen through the open base (fig. 18.7). Thinner core support wires run through the figure's arms (three in the right arm, two twisted wires in the left). These wires feed into the torso, although they do not appear to run continuously from one arm to the other. The core support wire that runs through the jawbone does not connect to the wire in the right hand.

Abel: It appears as though one or more core support rods run up the torso from the abdomen. It is possible that additional rods were removed from the torso and legs when the core was taken out. Short segments of wire and rod run through the legs and arms.

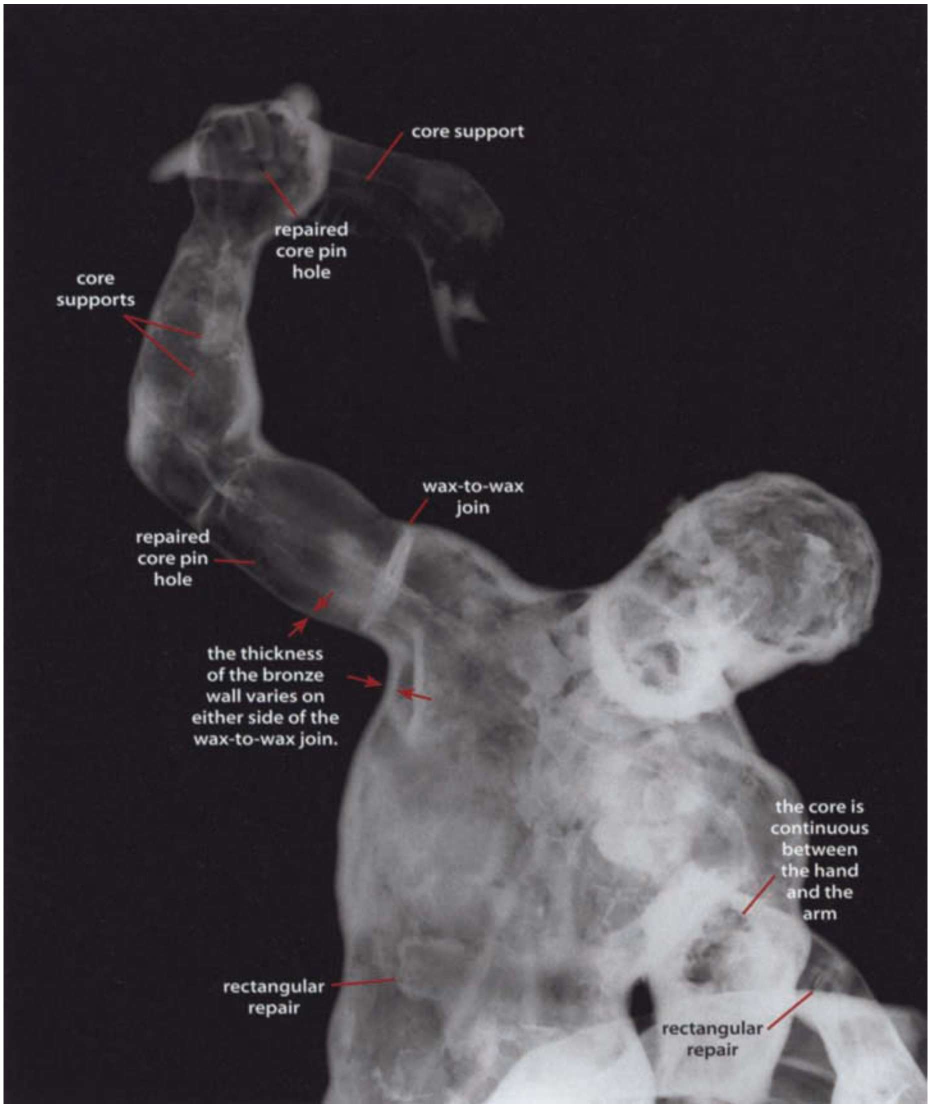


FIGURE 18.4 Radiograph of Cain's upper body.

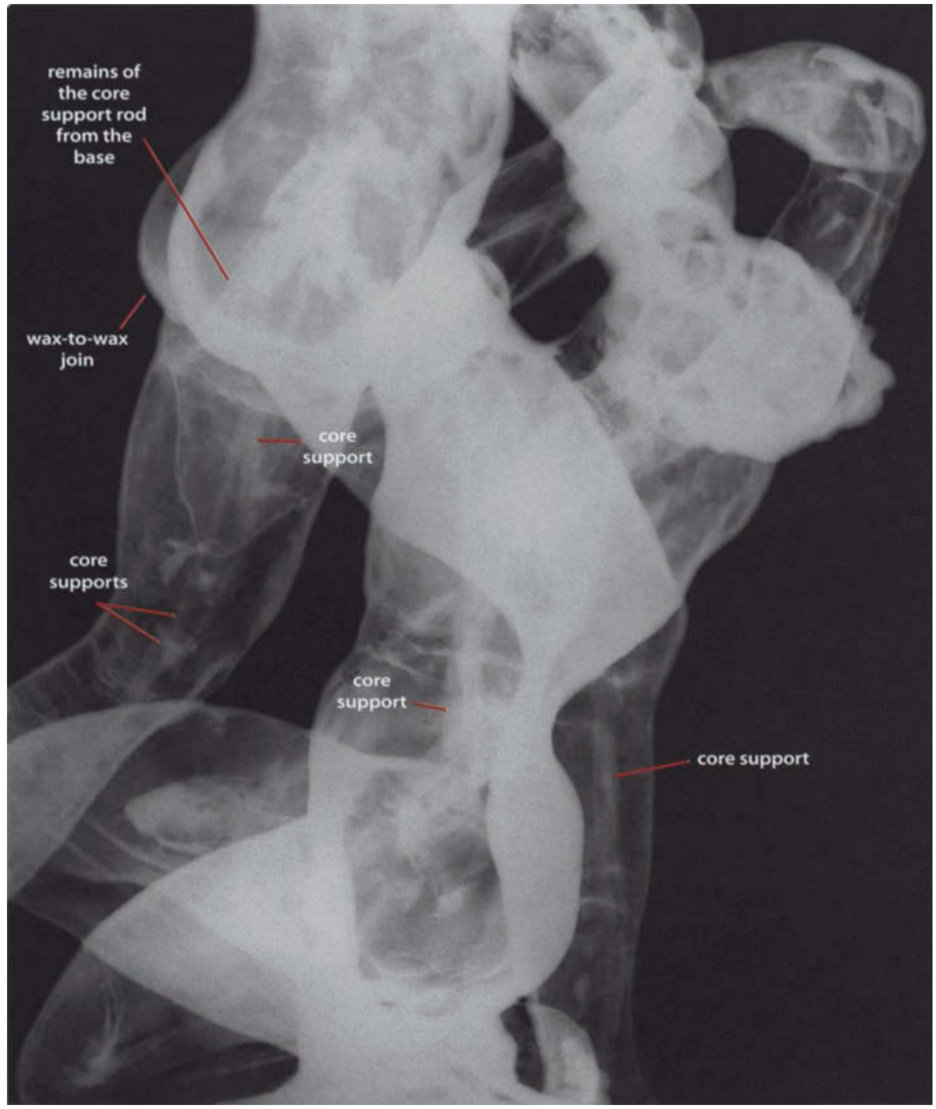
b. Core pins

The core pin holes and their bronze repairs are difficult to see in the radiographs due to extensive interior flashing and overlap of the forms. One hole is quite clear: an approximately 0.35 × 0.4 cm rectangular hole on Cain's upper right arm where the tapering 0.8 cm long pin still remains. A sharp-edged square hole approximately 0.2 × 0.2 cm in Cain's right hand may also be a core pin hole (fig. 18.4). One 0.4 × 0.4 cm rectangular patch on Cain's right shoulder blade is visible from the surface of the bronze. This is the core pin plug that was analyzed under XRF; it is difficult to pinpoint in the radiographs.

c. Core material

The core is gray colored. Examination of the open bottom of the sculpture shows that most of the core has been removed from the base and from Abel's torso (fig. 18.7). A core sample from inside the base below Abel's right calf was taken for compositional analysis. Quantitative analysis yielded the following:

FIGURE 18.5 Radiograph of the lower section of the sculpture.



- 76.5 percent gray clay
- 14.5 percent quartz
- 5 percent feldspar
- 4 percent calcite
- traces of oxy-hornblende (lamprobolite)
- traces of biotite

An additional small chunk of core was dated to 1630 ± 20 years using the thermoluminescence technique.

d. Internal surface of the bronze

The radiographs suggest that the inner walls of the bronze are relatively conformal to the outer contours, suggestive of indirect lost wax casting. The entire composition was cast hollow, except for the solid ends of the jawbone in Cain's raised hand and Cain's left thumb and first finger. The radiographs do show some variation in the thickness of the bronze walls on either side of the wax-to-wax joins,

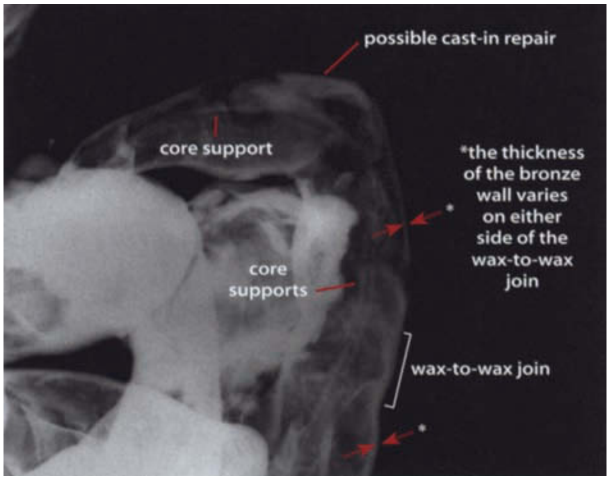


FIGURE 18.6 Radiograph of Abel's right shoulder.

due to the individual sections of the casting model (intermodel) having been formed in separate sections.

There is considerable corrosion visible on the interior, including rust corpuscles on the iron core supports and green corrosion throughout the interior of the base.

e. Method of assembly and joining of individual wax or cast bronze components

Thickening of the bronze where Abel's buttocks join the base is due to a wax-to-wax join where the separately molded sections of the casting wax were attached to one another (fig. 18.7). Four additional wax-to-wax joins appear in the radiographs as rings of varying density. One extends across Cain's right arm at the shoulder (fig. 18.4), the second goes across the top of Cain's left leg (fig. 18.5),

FIGURE 18.7 Open bottom of the base.

the third crosses the top of Abel's right arm at the shoulder (fig. 18.6), and the fourth crosses Abel's left wrist. It is likely that there are more wax-to-wax joins that are not visible in the radiographs. The presence of wax-to-wax joins suggests that the bronze was cast using the indirect lost wax technique.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The majority of surface elements were modeled in detail in the wax with little if any recutting or chiseling of forms after casting. The base is covered with grass and plants, the individual forms distinctly yet freely modeled in the wax (fig. 18.8). Abel's beard below his chin shows just a hint of curls, and the lips and teeth are loosely modeled, again left as-cast without cold work (fig. 18.9). The signature was inscribed in the wax (figs. 18.10, 18.11).

A small amount of texture has been applied to the base and hair. In the base, a single, convex, oval punch has been applied in lines. It is not entirely clear whether these marks were made in the wax or the metal, although they are more distinct than the very soft punch marks in the hair and Cain's beard, which appear to have been made in the wax. Fine file or scratch brush lines run along the length of the limbs.

g. Patina

The sculpture has an overall dark brown appearance. The surface is coated with a translucent brown organic patina that covers remnants of an older, uneven reddish brown organic coating. The patina is thick enough in many areas to obscure surface details. Where the patina has worn off, the metal surface has oxidized to a light brown color. Around the recessed base where the signature has been applied, there is no patina over the bright golden polished bronze (figs. 18.1, 18.10).

3. Casting Defects and Foundry Repairs

The radiographic images are mottled and broken up by numerous flashes and extensive shrinkage porosity. Some of this porosity extends onto the surface and lends a gen-

FIGURE 18.8 The arrow indicates where the iron armature rod passed through the base. The hole was plugged with bronze and carefully chased.

FIGURE 18.9 Abel's face was fully worked in the model and left as-cast.

FIGURE 18.10 The signature was inscribed in the wax along the recessed portion of the lower base.

FIGURE 18.11 Photomicrograph of the signature. The letters were formed with multiple strokes. A raised line often remains between the strokes.

eral unevenness to the metal. Regardless of the flaws, very few repairs were made. There are large unrepaired holes in the recessed rectangular base where metal failed to flow during the casting. Increased density in Abel's right elbow may be a cast-in repair (fig. 18.6). There is a set-in rectangular repair on Abel's left wrist (fig. 18.4). A rectangular plug can be seen on the surface of the bronze in Cain's abdomen (also visible in fig. 18.4). This plug was likely set-in. There may be additional repairs, but the flashing and porosity in the radiographs, as well as the heavy surface patina, make it difficult to clearly identify them.

4. Later Modifications/Restorations

Four 0.6 cm diameter round holes have been cut into the sides of the base, apparently for mounting purposes. The holes were cut into the metal sometime after the bronze was cast. The hole in the front of the sculpture cuts through the letter *T* in *BA[T]VVS*.

SUMMARY

The base and figures were cast together in one pour in a bronze alloy using a clay-based core material. Wax-to-wax joins, the relatively even and thin walls, and the fact that the internal iron supports are not continuous suggest that the bronze was cast indirectly. The surface details such as the faces, hair, and foliate base, as well as the signature, were modeled in the wax in detail, apparently with little cold work after casting. Surface porosity and small casting flaws mar the surface throughout; only a small number of repairs were made. The results of the technical study show that the materials, the handling of the surface details and signature in the wax model, the relative lack of cold work, and the approach to repairing the casting flaws are all typical of Adriaen de Vries. These results from the 1612 Edinburgh cast were compared with those from the technical study of the Copenhagen *Cain and Abel*, dated 1622. If the earlier cast is autograph de Vries, how does the later Copenhagen version relate to it? Was it cast by de Vries? Is it an aftercast made by taking molds off the original cast? Was the second version a free-hand copy of the first, or was the same mold used to cast both versions?

Although the lack of multiples in de Vries's known oeuvre might suggest that one of the bronzes is a copy by another artist, the core and alloy analysis results suggest that both of the models and both of the casts were produced by de Vries. As found throughout the artist's oeuvre, both of the complex compositions were successfully cast in a single pour. The alloys in both fall into the tight range used by de Vries, and the composition of the cores too falls squarely into the norm. In addition, the radiographs show that the casting waxes and core supports were constructed in similar ways—similarities that are particularly notable as these details differ in many ways from de Vries's other indirect casts, which tend to contain more wax-to wax joins and fewer core supports.

The Edinburgh and Copenhagen versions of *Cain and Abel* were exhibited side by side, allowing close visual comparison of the two. The compositions and alignments of the limbs are nearly identical. There are only slight variations in the postures of the figures: in the Edinburgh cast, Cain's right arm is slightly lower, and his head is tilted farther to the left. In the Copenhagen piece, Abel's right arm is tucked in more closely, slightly increasing the contortion of the torso. The similarities in the two suggest that one is not a free-hand modeled copy of the other—an approach that, regardless, would seem unlikely for a sculptor as inventive as de Vries.

Although interpretation of the radiographs is not entirely straightforward, they strongly suggest that both bronzes are indirect lost wax casts, a technique that allows the production of replicas: multiple, nearly identical casts. There are many similarities in the construction of the core supports, with individual segments of rod or wire extending into all parts of the composition, spanning and strengthening the wax-to-wax joins. Both bronzes also show evidence of external support rods running from the bases into Cain's buttocks.[2] More important, there are visible wax-to-wax joins in exactly the same location on both the Edinburgh and Copenhagen groups, suggesting that the same set of molds was used to make the casting waxes for both bronzes.

Taken to this point, the technical study of the two bronzes suggests that de Vries cast the first *Cain and Abel* in 1612, using the indirect lost wax technique. Ten years later, he then cast a second version indirectly, likely using the same set of molds from the earlier cast. A problem arises, though, when the measurements of the two versions are compared. If both were cast using the same set of molds, their measurements should be nearly identical. As shown in table 18.1 below, the Edinburgh version, dated 1612, is larger than the Copenhagen cast, dated 1622. The fact that the latter bronze is smaller suggests it is an aftercast, in which a second set of molds was made off of the Edinburgh bronze. However, a strong argument can be made against this proposal; the cast-in signature on the base of the Edinburgh version was not transferred to the Copenhagen cast. At this time the differences in size cannot be satisfactorily explained. Comparing measurements is notoriously difficult, especially in indirect casts because there will always be slight variations in how the wax-to-wax joins come together; a more sophisticated method of comparison such as 3-D scanning, relying on small features unaffected by wax joins, would provide a more telling comparison.

Even a brief look at the Edinburgh and Copenhagen bronzes tells us that the surfaces were chased and finished

Table 18.1. Size comparison for the *Cain and Abel* groups.

Location	Measurement on Edinburgh *Cain and Abel*	Measurement on Copenhagen *Cain and Abel*	% Change
Overall height	74.5 cm	73.4 cm	−1.5%
Overall width	28.0 cm	27.0 cm	−3.6%
Overall depth	38.0 cm	38.3 cm	+0.1%
Circumference:			
Cain's waist (narrowest point)	31.6 cm	29.6 cm	−6.3%
Cain's left calf (largest point)	16.3 cm	15.8 cm	−3.1%
Abel's waist (narrowest point)	26.3 cm	25.6 cm	−2.7%
Abel's right bicep (largest point)	13.3 cm	13.3 cm	0%
Length:			
End of Cain's big right toe to Abel's right elbow	39.5 cm	38.7 cm	−2.0%
Cain's right armpit to base of right heel	50.7 cm	50.1 cm	−1.2%

All measurements were taken with a cloth measuring tape.

in very different ways. See chapter 24 for more details on the comparison of the surfaces and a theory on their different histories.

NOTES

1 The sample was analyzed using electron probe microanalysis (Bewer 2001: 166–67).

2 A method for supporting figures used in other casts, such as the figure of Hercules in the Louvre *Hercules, Nessus, and Deianeira* and the figures of Amphion and Zethus in *Farnese Bull.*

CHAPTER 19

Juggling Man

J. Paul Getty Museum, Los Angeles. Inv. no. 90.SB.44

Cast in Prague in 1610–1615

Dimensions: H: 77.2 cm × W: 51.8 cm × D: 21.9 cm

Marks and inscriptions: None

OVERVIEW

De Vries based this allegorical figure juggling plates on his fingertips while working a set of bellows with his right foot on a Hellenistic marble of a dancing faun (fig. 19.1). The sculpture was sold at Sotheby's of London in 1952 from an English collection. It was again sold at Sotheby's of London in 1989 and purchased by the J. Paul Getty Museum in 1990.

The bronze was first examined by Bewer in 1995 in conjunction with the Renaissance Bronze Project at the J. Paul Getty Museum. Following the de Vries exhibition, the bronze was reexamined in light of new information on the artist.

EXAMINATION

1. Alloy

The sculpture was cast in a bronze alloy containing approximately 11 percent tin in a copper matrix with lead content below 0.5 percent and no measurable zinc. Full alloy results can be found in table 4.1.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

As illustrated in figure 19.2, an extensive armature structure remains inside the bronze. The primary remaining support is an iron rod that runs up the left leg, takes a U-turn in the upper torso, and then runs straight back down the right leg. The rod exited the bottom of the right foot, then reentered the model, passing through the bellows. The cut-off rod is still visible below the right foot; if

FIGURE 19.1 *Juggling Man*
J. Paul Getty Museum, Los Angeles. Inv. no. 90.SB.44

FIGURE 19.2 Summary of armature rods and wires. The dashed lines indicate parts of the rod that have been removed.

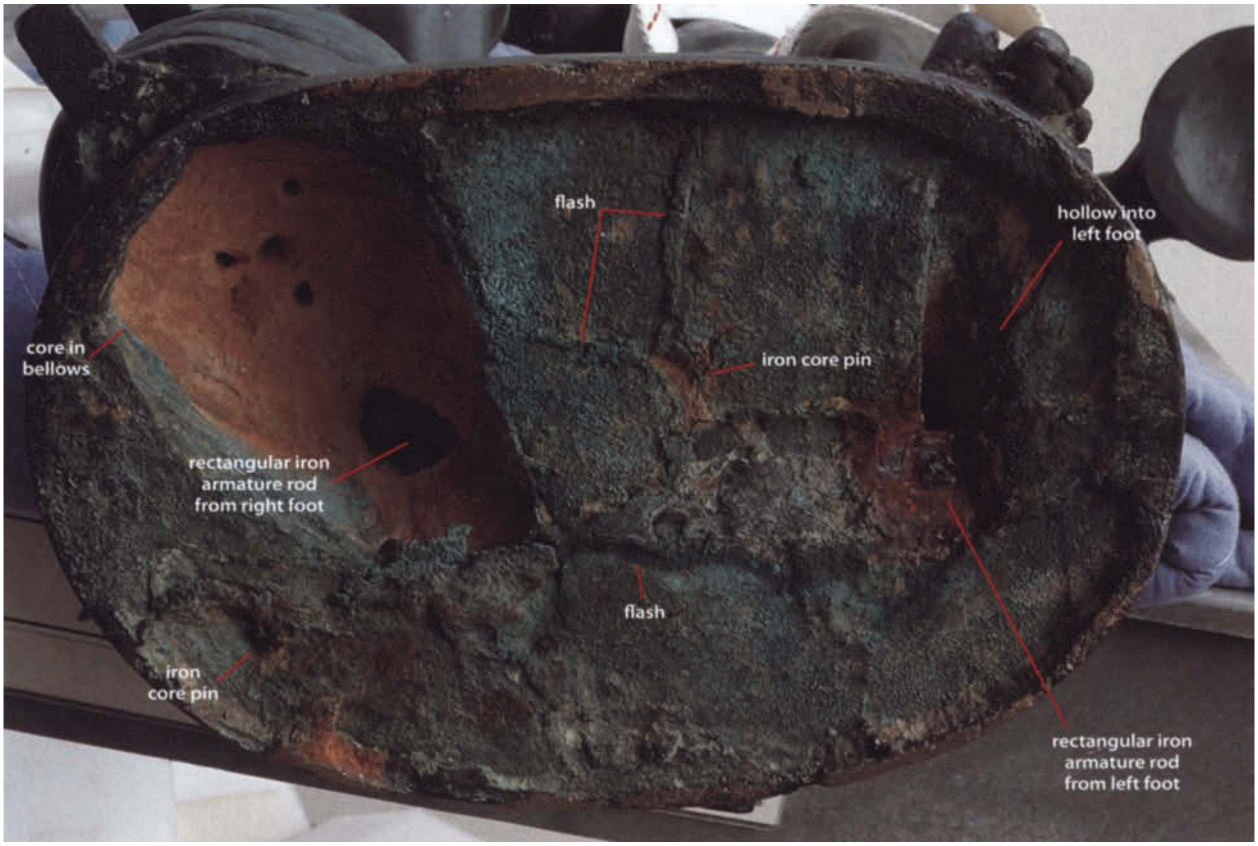


FIGURE 19.3 Open bottom of the base.

a plug had been applied, it has since been lost. The end of the rod can be seen both on top of the base and below it. In the base, the rod is square in section and is heavily rusted (fig. 19.3). The rest of the iron armature includes a second rod in the left leg, two rods that run from the left wrist straight through the torso to the right wrist, and a rod that curves through the torso and then enters the head, all of which are tied with wires to the larger-diameter primary support rod.

Although most of the armature rods are well centered in the limbs, it is interesting to note that this is not the case in the right leg, where the rod lies almost directly in contact with the bronze, both in the upper leg and in the shin (fig. 19.4). This feature appears to be an example of *pentimento;* the artist changed his mind about the placement of the leg after the rigid armature was constructed. In the original configuration, the leg would have been less flexed at the knee and therefore positioned as much as 2 cm lower than in its final position.

b. Core pins

Two rusting iron core pins remain in the base and are visible from the open bottom of the sculpture (fig. 19.3). The pins cannot be seen in the radiographs due to extensive rusting. The plugged holes adjacent to the pins can be clearly seen due to the relatively low density of the thin repairs compared to the surrounding metal (one measures 0.3 × 0.3 cm; the other, 0.5 × 0.5 cm) (fig. 19.5). Numerous 0.3 × 0.3 cm features appearing at regular intervals throughout the radiographs of the figure are also plugged core pin holes.

c. Core material

Most of the core material has been removed from the open bottom of the base, but it remains within the bellows (fig. 19.3).

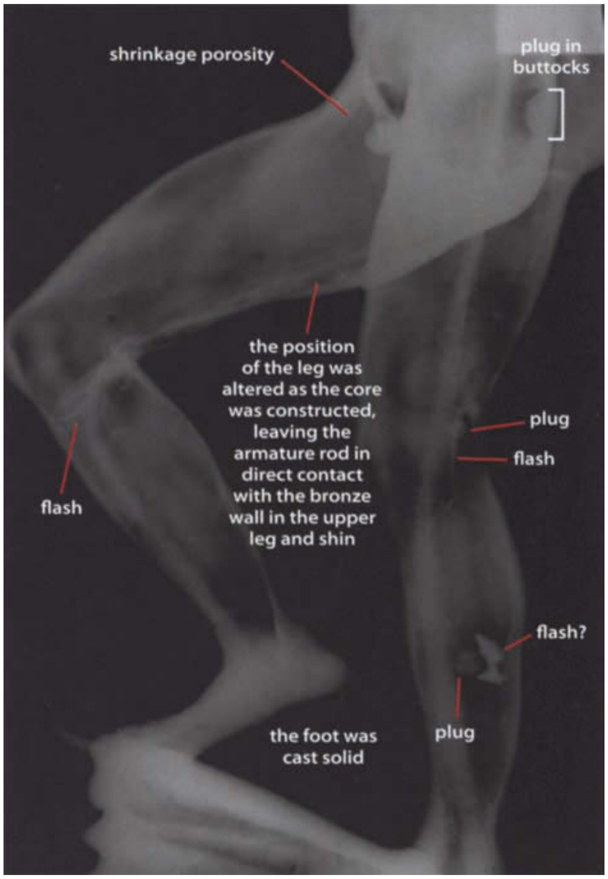


FIGURE 19.4 Radiograph of the sides of the legs.

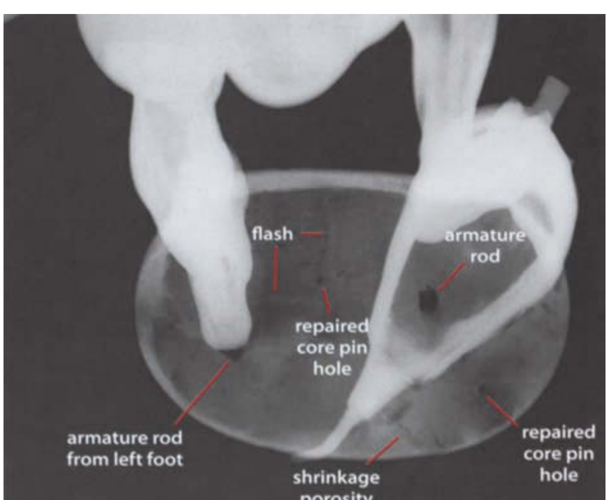


FIGURE 19.5 Radiograph of the base and bellows from above.

The radiographs suggest that core material likely remains in most of the figure. Two core samples were taken from the bellows for compositional analysis. Quantitative analysis yielded the following:

Sample 1

- 49 percent reddish clay
- 39 percent calcite (33% micrite matrix and 6% rimmed dolomite and calcite)
- 8 percent quartz
- 1 percent feldspar
- 1 percent metamorphic rock
- 1 percent hematite
- traces of muscovite and oxy-hornblende (lamprobolite)

Sample 2

- 77.5 percent reddish clay
- 21 percent quartz
- 0.5 percent feldspar (albite)
- 0.5 percent hematite
- 0.5 percent metamorphic rock
- traces of muscovite and oxy-hornblende (lamprobolite)

The samples differ considerably in the amount of calcite they contain: 39 percent in sample 1 and none in sample 2. These results illustrate the range of calcite that can be contained in the strata of marine-derived clay sediments.

In 1989, before the sculpture was purchased by the J. Paul Getty Museum, a sample of the core was taken from the bellows for thermoluminescence dating by the Oxford Research Laboratory for Archaeology, with a resulting date of 1539 ± 90 years.

d. Internal surface of the bronze

The radiographs and visual examination of the open bottom of the sculpture show that the core material ran continuously from the base, into the left foot, and up into the left leg. The core also extended from the base into the bellows, but it did not continue into the right foot, which is poised on top of the bellows, with the result that, except for the iron armature rod that extends through the ankle, the right foot was cast solid. Although the bulk of the sculpture was cast hollow with relatively thin walls, the nose, right foot, hands, and plates were cast solid as these parts of the composition were modeled in solid wax.

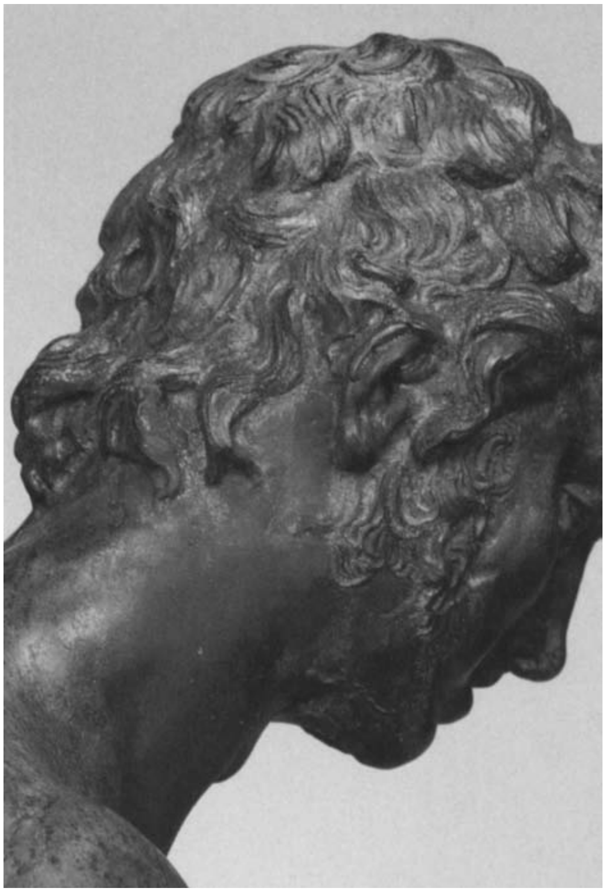


FIGURE 19.6 The details retain the waxy feel of the model.

e. Method of assembly and joining of individual wax or cast bronze components

Study of the radiographs, the bronze surface, and the underside of the sculpture leads to the conclusion that the base, the bellows, the figure, and the plates were cast integrally; there is no indication of metal-to-metal or wax-to-wax joins.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The modeled details such as the face, hair, fingers, and toes retain their waxy feel, without any chiseling in the metal (fig. 19.6). The hair is composed of small, undulating tufts into which the individual strands are modeled at different angles. Some of the more hidden recesses, such as below the chin (fig. 19.7) and below the right foot, are quite rough on the surface. It appears as though these areas were not fully finished in the model, and they also bear unrepaired casting flaws.

The flesh was polished smooth, without any remaining polish or scratch brush lines. There is no evidence of punched texture in the hair. It is possible that any faint texture that may have been applied has been removed by weathering and corrosion.

g. Patina

Any coating that might have been originally applied is now lost due to outdoor exposure and corrosion. There is currently a modern coating on parts of the surface; see section 4 below for further details.

3. Casting Defects and Foundry Repairs

Unrepaired casting flaws can be found in many areas, mostly in locations tucked out of view, such as the right

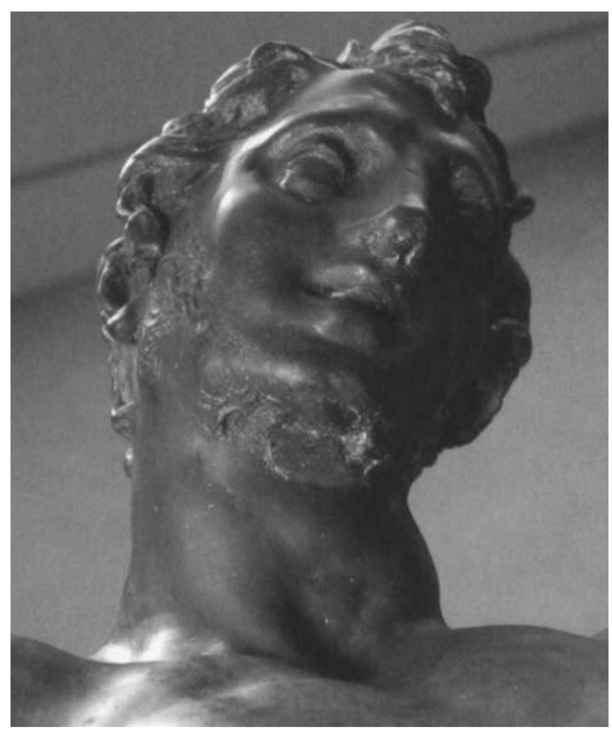


FIGURE 19.7 The surface below the chin was left rough in the wax; unrepaired casting flaws accentuate the unevenness.

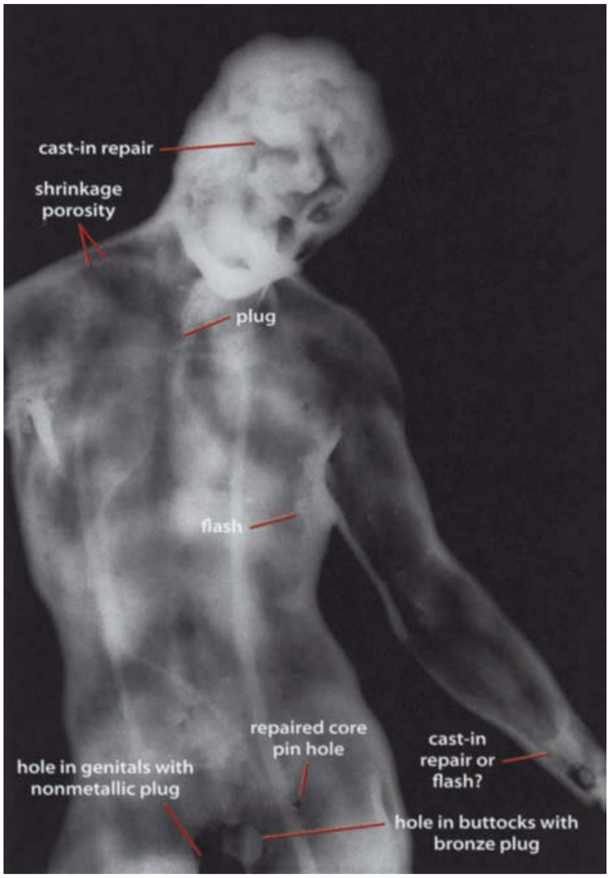


FIGURE **19.8** Radiograph of the top of the figure.

wrist, under the right foot, between the buttocks, and under the chin (fig. 19.7).

A large repair on top of the head was either cast-in or cast separately and then set-in; either way, the complex surface would have necessitated the re-modeling of the area in wax to replicate the details (fig. 19.8). This repair is not visible on the surface of the object, strongly suggesting that it was made in the foundry with the same alloy as that of the rest of the sculpture. Had the armature rods and core been removed from this bronze, one might conjecture that the top of the head was intentionally left open to allow the internal structure to be removed after casting. As they both remain intact, though, it suggests that the top of the head is a repair.

Five round plugs were used on the sculpture, measuring from 0.7 to 1.0 cm in diameter. Although the round plugs match the color and texture of the surrounding surfaces in their corroded condition, all but one of the plugs can be clearly seen on the surface due to slight gaps around the edges. Qualitative XRF analysis of two of these plugs indicates that they are made of a bronze alloy similar to that of the bulk metal.

The figure's penis is missing, although the testicles remain. The round hole in the area of loss, very distinct in the radiographs, is currently filled with a nonmetallic plug (2.0 cm in diameter). There is a corresponding, slightly larger hole in the buttocks on the back of the figure (fig. 19.8). This hole on the back side has been filled with a metal plug that has corroded to a different color from the surrounding bronze. XRF analysis indicates that this plug is made of brass, suggesting that it may be a later repair. The similar size and nearly front-back alignment of the holes suggests that they were made at the same time. The radiographs indicate that the core has been removed between the two holes. The reason for the holes is not known. Although it has been suggested that they were left when a large front-to-back armature rod/core pin was removed, there is no precedence for large round supports in the artist's oeuvre. In addition, it is unlikely that a core support would be placed in an area that would necessitate such extensively detailed modeling in the repair; placing the rod just centimeters higher in the torso would have allowed far simpler plugs to be used. It could be argued that the penis was cut away at a later date to apply a *cache-sexe,* yet this does not explain the presence of the corresponding hole in the buttocks. Without further evidence, the most likely scenario may be that the holes are simply remnants of a crude attempt to plumb the sculpture as a fountain.

The radiographs show little gaseous porosity, although it breaks through the metal surface in scattered areas on both the base and the figure. Shrinkage porosity can be seen in the right shoulder and neck (fig. 19.8) and the right side of the groin (fig. 19.4). Extensive porosity in the solid-cast left palm and wrist appears to have been repaired with cast-in metal (fig. 19.8).

Rough-edged flashes can be seen inside the figure in certain areas (fig. 19.4). Close comparison of the surface of the bronze with the radiograph of the base is a helpful reminder of the weaknesses and strengths of radiography as a diagnostic tool (fig. 19.5). When one looks at the open bottom of the base, some of the more prominent features are the metal flashes where molten metal entered cracks in the core (fig. 19.3). In the radiograph, though, many of these flashes are just barely visible and could easily be overlooked; for example, the vertical element in the backward L-shaped flash that is clearly visible on the base can only just be discerned in the radiograph. On the other hand, the radiographs of the base clearly indicate the extent of the porosity that occurs throughout the front half of the base, even though surface examination suggests that it is restricted to an isolated area adjacent to the left foot where the surface of the bronze is distinctly rough and porous.

The bellows nozzle is bent inward at an almost 45-degree angle. This bend was present in the wax; there are no indications (such as distortions or stress cracks) that the damage occurred in the metal.

4. Later Modifications/Restorations

The surface is covered with corrosion caused by outdoor exposure. The surface is primarily green and black, with some brown corrosion in areas. Analysis of a metallographic section shows that the corrosion layers have penetrated into the microstructure and are primarily composed of copper oxide and sulfate-rich corrosion products, suggesting that the bronze had been exhibited outside for over fifty years (Scott, pers. com.; 2002: 221). Recent treatment has included the application of a tinted resin wash in select areas to reduce the contrast between the alternating stripes of black and bright green corrosion.

Exposure to moisture has caused rusting of the iron armature rods with associated expansion of the iron. The rods that are closest to the surface of the sculpture have caused damage to the bronze. This damage is most severe behind the upper right leg, where the rusting iron forced the bronze to split open along a jagged line approximately 5 cm long, with associated staining (fig. 19.9). Unrepaired porosity in the area may have weakened the surface and accelerated the corrosion by allowing moisture to enter the bronze. In the right foot, rusting of the cut-off armature rod has caused extensive staining and may have opened up existing casting flaws in the area. Similarly, the iron rods in the right wrist may have forced the casting flaw crack in this area to open up.

FIGURE 19.9 Compositional changes in the right leg left the iron armature rod very close to the surface. Surface damage from the expanding iron has resulted.

Small, straight dents on the surface appear to be chisel marks from a heavy-handed cleaning campaign. These marks are sometimes seen on fountains where water scale has been removed,[1] further evidence that the figure may have been fitted as a fountain.

SUMMARY

The sculpture and oval base were cast together in one pour using the direct lost wax technique. The surface details retain the waxy feel of the model. The more hidden surfaces were left rough, both in the model and after casting.

Much of the core and most of the continuous armature remain on the interior of the bronze. In two places on the right leg, the bronze rests directly against the iron armature, suggesting an artist's change in composition as the core was being constructed over the rigid rods. This type of change in the composition is rare for de Vries, having been observed in just one other instance: in the *Empire Triumphant over Avarice,* the position of one of the arms was changed by cutting the original armature wire and inserting a new wire in an altered position.[2]

Outdoor exposure has caused a loss of any original patina that may have been applied, as well as corrosion of the surface and expansive rusting of the iron armature. There are a small number of set-in and cast-in repairs, including two large plugs roughly aligned in the groin and buttocks. These plugs, as well as rough chisel marks on the surface, may be associated with the use of the sculpture as a fountain.

The method for depicting the figure's hair in small, undulating tufts into which the individual strands are modeled at different angles is more typical of the artist's work before about 1613, by which time the artist had begun using the later style (see, for example, the *Lazarus* dated 1615 [fig. 22.6]).

NOTES

1 Similar marks can be found on the fountain figure *Triton with Shell* in Augsburg (Bewer 2001: 165, 188 n. 31).

2 National Gallery of Art, Widener Collection, inv. number 1942.9.148, as described in Bewer 2001: 176.

CHAPTER 20

Farnese Bull

Schlossmuseum, Gotha. Inv. no. P 50

Cast in Prague in 1614

Dimensions: H: 104.1 cm × W: 69.3 cm × D: 71.4 cm

Marks and inscriptions:

Inscription on the back of the base: **ADRIANVS FRIES HAGIENSIS BATAVVS.FE.1614**

OVERVIEW

The composition, based on the ca. A.D. 200 Roman marble excavated in Rome in 1545, comprises a rearing bull; the nude, bearded figure of Amphion wrestling with the head of the bull; his younger brother, Zethus, also nude, struggling to hold the bull from the other side; the partially draped figure of Dirce seated below the bull; the standing and fully clothed figure of the mother, Antiope; and a youth and dog observing the chaotic scene (fig. 20.1). The figures are clustered on a base of varying heights. It is unknown who, if anyone, commissioned the work from de Vries. It remained in the artist's studio until 1620, at which time he offered it to Ernst von Holstein-Schaumburg at the Schloss Bückeburg. It is unknown whether the bronze was purchased before the count's death in 1622. The whereabouts of the bronze are not known until it is recorded in the *Kunstkammer* in Gotha in 1721.

The technical study was undertaken to add to our understanding of de Vries's methods and materials. Visual examination of the bronze in preparation for the exhibition catalogue strongly suggested that it was cast in one pour (Scholten 1998a: 206). It was hoped that radiography would confirm this hypothesis and clarify exactly how the artist constructed the casting model of this very complex composition.

FIGURE 20.1 *Farnese Bull*
Schlossmuseum, Gotha. Inv. no. P 50

EXAMINATION

1. Alloy

Three locations on the surface were examined for alloy content. The spectra acquired from Antiope's drape showed an unusually high tin content, 58 percent. This high reading may be due to inverse segregation, whereby the tin-rich phase of the metal migrated to the surface of the sculpture during cooling. This phenomenon was also found on the *Putto with a Goose* (chapter 23) and on the *Laocoön* (chapter 25), both in the Nationalmuseum, Stockholm. In the latter two works, however, the areas of surface enrichment are visually apparent due to the silvery colored tin oxide surface corrosion. There is no visual evidence of surface enrichment on the *Farnese Bull.* Though the surface is not corroded, at 58 percent tin the metal should be nearly white in color in this area, suggesting that severe segregation may have taken place just below the surface of the sculpture (shallow enough to be picked up in the XRF surface examination but just deep enough not to affect the color of the surface metal).

The remaining two spectra from the surface of the *Farnese Bull* show a tin content of 16 to 17 percent in a copper matrix with zinc and lead contents below 0.5 percent. Seventeen percent is still a high tin content for a bronze.[1] As suggested by the spectra from Antiope's drape, it is possible that varying amounts of inverse segregation have occurred throughout the sculpture. In such a case, should the exact alloy content of the sculpture be needed in the

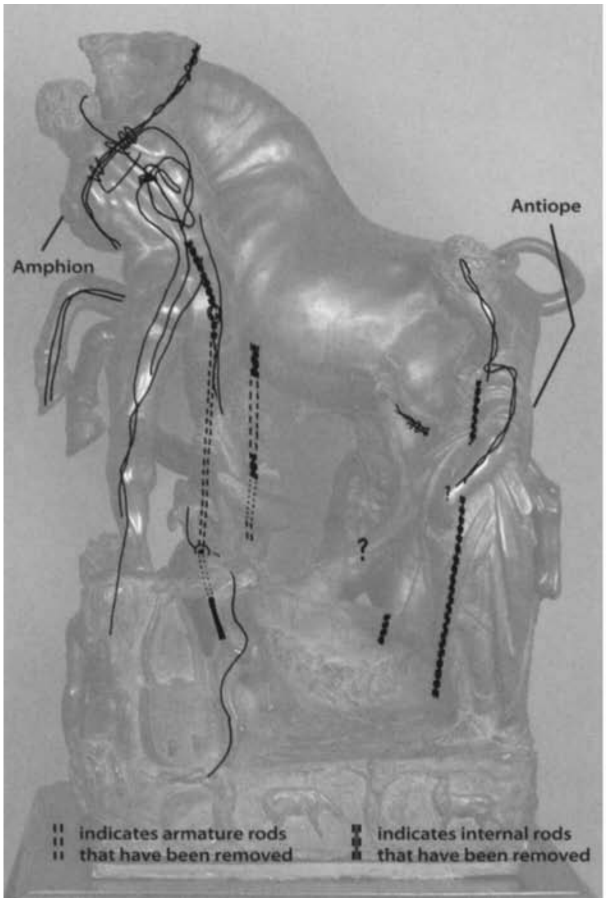


FIGURE 20.2 Summary of the remaining armature rods and wires. Dashed lines indicate possible pathway of rods that have been removed. The question mark refers to an area that is not clearly legible in the radiographs.

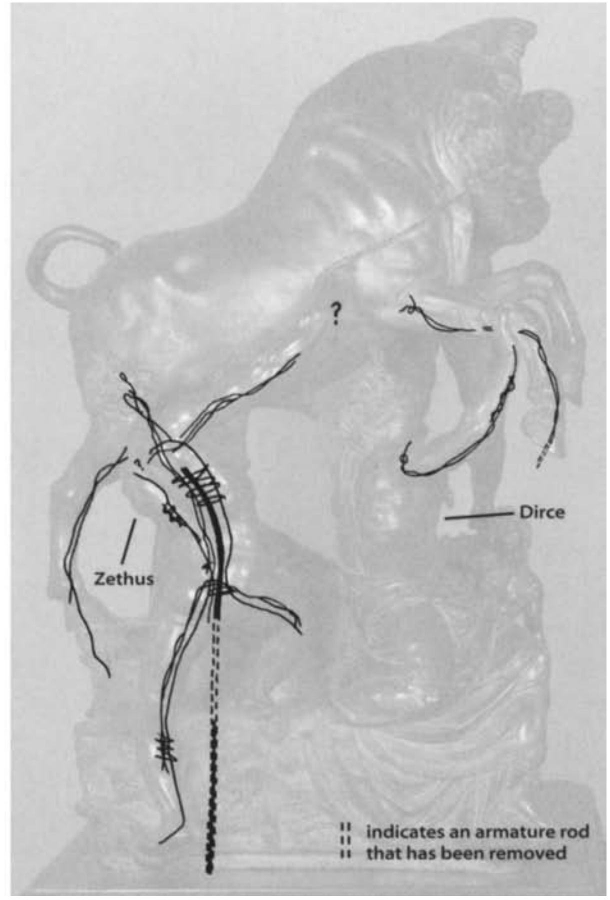


FIGURE 20.3 Structural summary of the remaining armature rods and wires. The question marks refer to areas that are not clearly legible in the radiographs.

future, it would be best to take a drilling of the metal for ICP-MS or similar analysis, which will yield more accurate results than surface analysis can offer.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

In many places within this composition, the armature rods protruded outside the wax skin, strengthening the core by tying the figures to one another and to the base. Examination of the radiographs, the underside of the sculpture, and the finished surface of the bronze can reveal the general structure of the armature, even though it has been removed in many places. Figures 20.2 and 20.3 illustrate the armature sections that are visible in the radiographs as well as the major rods that have been removed, based on evidence remaining inside the sculpture.

Zethus (standing younger brother): Most, if not all, of the armature remains inside the figure of Zethus, giving an idea of what the armature may have looked like in the other figures before parts of it were removed. A large rectangular-sectioned armature rod acted as the primary support for the body during the pour (fig. 20.4). Magnetic attraction in the buttocks confirms that the rod is iron. The rod ran from the torso, out of the buttocks, then into the base,

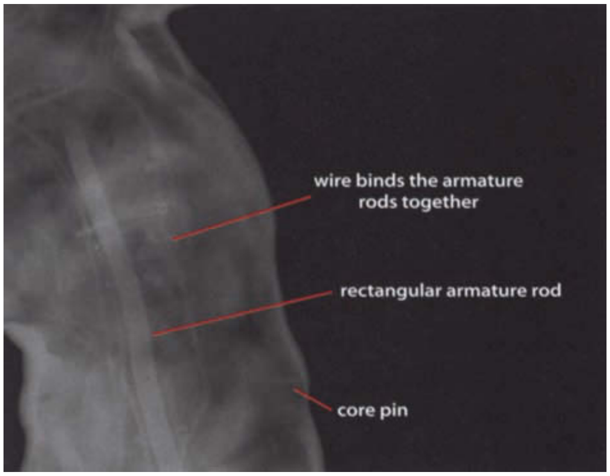


FIGURE 20.4 Radiograph of Zethus's torso. The rectangular armature rod extended out of the figure and into the base, supporting the figure during modeling and casting.

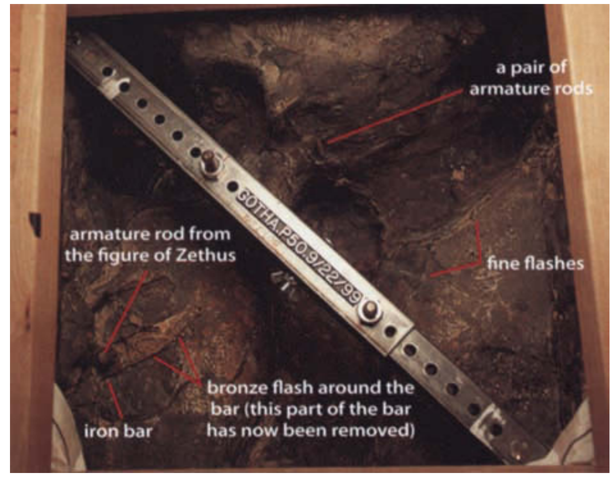


FIGURE 20.5 Open bottom of the base. A steel mount runs diagonally across the bottom in preparation for installation at the J. Paul Getty Museum.

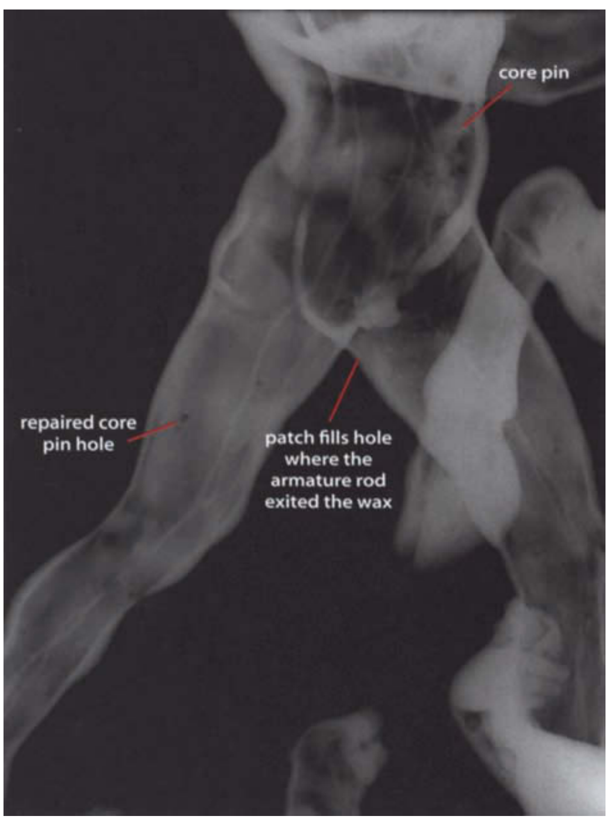


FIGURE 20.6 Radiograph of Amphion's lower body. The central iron armature rod has been removed. The loose rods in the buttocks would originally have been tied to this rod.

where the far end remains in place below the sculpture. The 1.3 cm × 1.1 cm rod passes through a flat iron bar that extended for at least 12 cm along the bottom side of the base. A flash of bronze holds part of the bar in place, but the rest of the bar has been removed (fig. 20.5).

Rods and wires extend throughout the limbs in groups of two or three. A single rod loops up into the head.

Amphion (standing bearded brother): A large iron armature rod, similar to the one remaining inside the figure of Zethus, has been removed from the inside of Amphion. The rod passed through the top of the back of the figure's right leg, into the dog, and then into the base (fig. 20.6).

Two rods twist up each leg. The larger one makes a U-turn in the chest, then runs down the other leg (fig. 20.6). The rod in the left leg then extends down into the raised outcropping of rock on which Amphion stands. Two armature rods twist from one arm, across the chest, and through the other arm. In the chest, the rods from the arms are bound with wire to other rods that extend down into the lower torso and up into the head.

Bull: An oval repair patch in the belly of the bull to the proper left of Dirce's head (located closer to the front legs than to the back) measures 3.5 × 3.2 cm. The patch fills an enlarged hole that remained when the armature rod was removed. This rod appears to have supported the massive

FIGURE 20.7 Dirce's left shoulder.

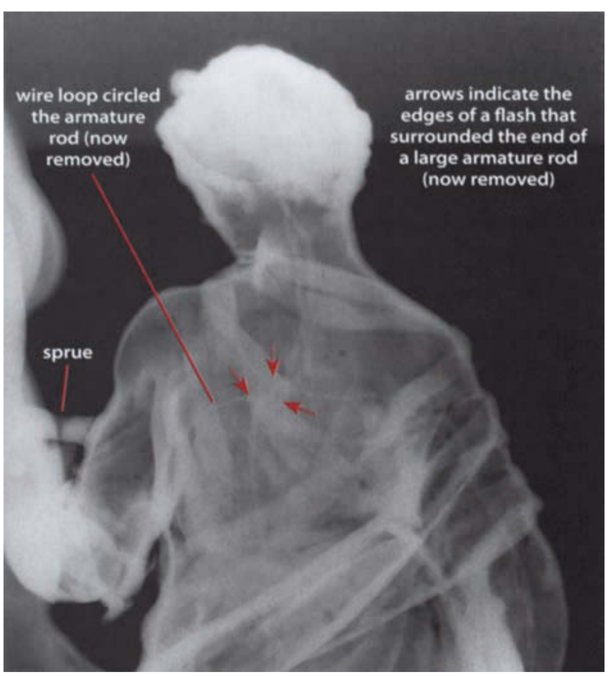


FIGURE 20.8 Radiograph of Antiope's upper body.

weight of the bull by passing through its belly, through the left side of the seated figure of Dirce, and down into the base. It is likely that the hole was enlarged to allow removal of the armature and core in order to reduce the weight of the bull. It is also likely that the top of the central support rod in the bull was configured in an upside-down L or T, which would have kept the mass of the animal from sliding down the vertical rod.

Pairs of armature rods and wires remain in all four of the bull's legs. Those in the back legs extend through the base. The wires twist loosely around one another, and those in the back legs are bound together with wire. The wires in the front right leg appear to have extended through the bronze in the hoof and possibly passed through Dirce's left leg for additional support.

Dirce (seated woman): Much of the armature has been removed from inside the figure of Dirce. A 1 cm wide hole in the left shoulder remains where an armature rod was removed. The rod passed from the belly of the bull, through Dirce's upper body, then into the base. Either the patch used to fill the armature hole in the shoulder has fallen out, or the hole was never plugged (fig. 20.7). The armature rod then exited through the large rectangular hole remaining in Dirce's left armpit and entered the base to the right of Amphion's right foot.

A rod and wire run through each arm. The rod in the left arm extends down a short way into the torso; the rod in the right arm turns up into the neck.

Antiope (standing woman): Much of the armature has been removed from inside the figure of Antiope, including a large-diameter rod that extended through the center of the body. Evidence for the presence of the rod includes a wire in the upper torso that once encircled the removed rod and a flash above this loop that retains the outline of the top of the rod (fig. 20.8). In addition, a square hole cast into the edge of the bronze directly below the figure remains where the rod has been removed (fig. 20.9). The hole measures 1.3 cm across, suggesting that this rod was the same diameter as the large rod remaining in Zethus.

A second large-diameter armature rod appears to have extended out of Antiope's bent right knee and into the base. Both of these patches measure approximately 1 cm

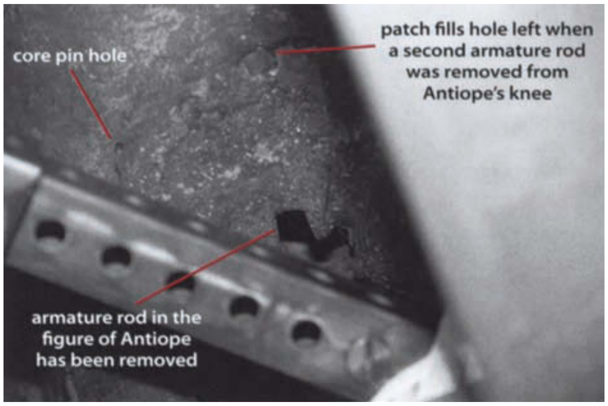


FIGURE 20.9 Detail of the open bottom of the base showing evidence of the original armature.

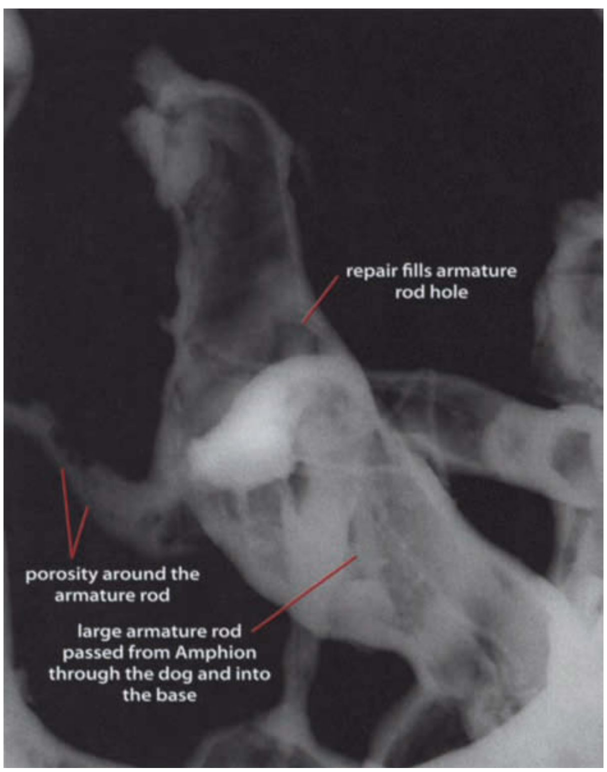


FIGURE 20.10 Radiograph of the dog.

across. The square edges of the hole and the plug can be clearly seen in the detail photograph of the open bottom of the base (fig. 20.9).

FIGURE 20.11 The patch in the left shoulder was carefully hidden.

A rod runs from the left arm, across Antiope's chest, and into the right arm. Additional wires join the rods in the arms. Two separate rods extend from the torso into the head (fig. 20.8).

Seated youth: The radiographs of the youth are difficult to read due to overlap with other elements of the composition. Much of the armature inside the youth has been removed from the open bottom of the base.

Dog: A segment of a large-diameter square or rectangular armature rod remains inside the body of the dog (0.7 cm in diameter). The segment is part of the rod that passed from Amphion, through the dog's left shoulder, through the belly of the dog, and then into the base. The repair in the dog's shoulder is clearly visible in figure 20.10 yet is difficult to discern on the surface of the bronze (fig. 20.11). The cut-off end of the rod remains visible below the dog's belly (fig. 20.12). The belly is in an area that is very difficult to reach, which would have made it very difficult to fully repair.

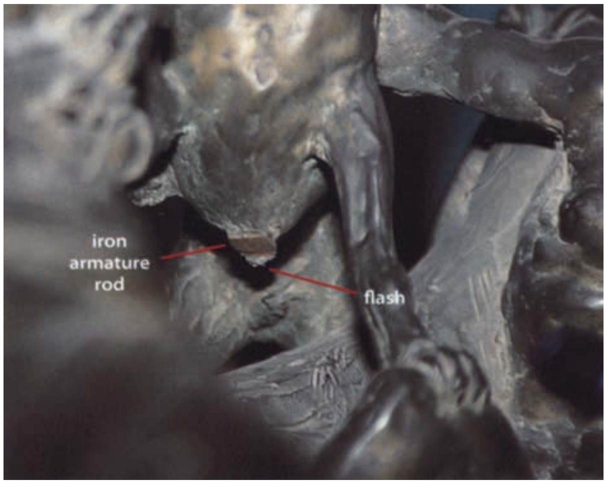


FIGURE 20.12 The cut-off end of the armature rod below the dog's belly was left rough.

Single armature rod wires can be seen in the dog's back left and front right legs, in the latter case with extensive porosity around the leg, which was solid-cast around the wire (fig. 20.10).

b. Core pins

A number of tapering iron core pins remain in the sculpture. The pins were cut off flush with the surface, then pushed inward just enough to allow a repair to be put in place (fig. 20.13). Many of these remaining pins can be seen in the radiographs, including one in Zethus's side that is 1.7 cm long (fig. 20.4). Some of the remaining core pins can be detected from the surface with a magnet. A relatively large number of square core pin holes can be clearly distinguished in the radiographs as the plugs that repair the holes are much thinner than the full thickness of the surrounding cast bronze. The holes measure approximately 0.25 cm × 0.25 cm (fig. 20.9).

c. Core material

The core is powdery and crumbles easily. The color varies from tan to light gray to dark gray. Examination of the bottom of the base suggests that much of the core has been removed from the base and from those figures that open onto it (fig. 20.5). The core was almost entirely removed from the bull through the hole in the belly and has presumably been removed from the figures where the armature rods and wires have been partially removed. A core sample was taken from under the base inside the figure of Dirce for compositional analysis. Quantitative analysis yielded the following:

- 72 percent brownish clay
- 18.5 percent quartz
- 1 percent feldspar
- 3 percent opaques
- 1.5 percent calcite grains
- 1 percent muscovite
- 1 percent biotite
- 0.5 percent fossil foraminifera
- 0.5 percent clinopyroxene
- 0.5 percent orthopyroxene
- 0.5 percent oxy-hornblende (lamprobolite)
- trace of monazite

A second sample was removed from the outer surface of the base as a possible example of investment material. Quantitative analysis yielded the following:

- 60 percent yellow-orange oily claylike matrix containing some uncharred organic material
- 39 percent quartz
- 1 percent feldspar
- trace of microcline

FIGURE 20.13 An iron core pin in the hollow base.

On visual examination, the sample was notable for its lack of cohesion compared to the fired cores. This material on the outside of the bronze appears to be merely a surface accretion.

An additional small chunk was removed from under the base below the right foot of Amphion and was dated to 1595 ± 20 years using the thermoluminescence technique.

d. Internal surface of the bronze

The radiographs indicate that only a few elements of the composition were solid-cast without core material: Dirce's hands; the bull's tail, ears, and horns; and the dog's front legs, face, and ears (fig. 20.10). The remainder of the composition was cast hollow. As is typical of the direct lost wax casting technique, though, the thickness of the bronze varies considerably. Because the artist constructed the core first and then built the casting wax over it, details such as the dog's head (fig. 20.10) and the drapery folds were added in the wax over the rather generalized core. Even inside a single limb, the thickness of the wax varies considerably as the artist finalized the modeling (fig. 20.6).

e. Method of assembly and joining of individual wax or cast bronze components

From a study of the radiographs, the bronze surface, and the inside of the sculpture, it appears that the base and all the figures were modeled and cast together; there is no indication of metal-to-metal or wax-to-wax joins.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The malleable and smooth qualities of the wax modeling medium remain visible throughout the sculpture. The recessed transition areas between figures were often left rather rough in the model. The assured and loose handling of the wax is retained in the bronze, which was not heavily chiseled or worked after casting (figs. 20.11, 20.14). Finish work after casting included careful repair of the more prominent areas, light texturing of the bull's hide, and polishing of the flesh. In contrast, the recesses and backs of many features were left unfinished. For example, casting flaws on the left side of Dirce's head were left rough (fig. 20.7), and the stomach of the dog was left unfinished where the rectangular remains of the cut-off armature rod and the adjacent flash project below the belly (fig. 20.12).

FIGURE 20.14 Detail of one of the exquisitely modeled scenes on the back of the base.

The base is covered in animal scenes and flora. The expert modeling is finely detailed in some areas and rougher and more generalized in others. The enormous effort put into this rich modeling is matched by the varied surface texturing covering much of the base. Some of the surface texture on the animals on the base, such as the scales on the snake, was clearly drawn into the wax (fig. 20.15). Overlapping marks from an oval punch were applied in lines to texture the hair and trees; the comparatively soft outlines of this punch suggest that it too was applied in the wax. Some surface textures found on the base, such as fine parallel lines carefully scratched into the wax with a brush, as well as the use of a donut-shaped punch appear only sparingly on de Vries bronzes. A textured flat-headed punch was used over much of the base. In keeping with de Vries's approach to texture throughout his career, a single punch was used in each discrete location; different punches are not mixed together in one area.

The signature was crisply formed in the base at the back of the sculpture (fig. 20.16). The letters are filled with accretions, making it difficult to determine if they were cut into the wax or the metal. In a couple of areas where the inside contour of the letters can be seen, the smooth, rounded

FIGURE **20.15** This photomicrograph detail of a snake on the side of the base shows the careful application of scales in the wax.

shape of the cut strokes is visible, suggesting that they were formed in the wax (fig. 20.17).

A number of round-sectioned sprues were left in place, connecting different segments of the composition:

- two connect the ropes in Zethus's hands to the belly of the bull
- one connects the top of Dirce's head to the belly of the bull (fig. 20.7)
- one connects Antiope's right upper arm to the side of the bull
- one connects the back of Zethus's left hand to the belly of the bull
- one connects Dirce's hair tie to her back (fig. 20.7)

g. Patina

Much of the surface is now the grayish color of the oxidized metal, although the untarnished golden bronze surface remains visible in places. There is no evidence of a colored patina. At present there is a thin clear coating overall.

3. Casting Defects and Foundry Repairs

The radiographs show that there is extensive small-vacuole porosity throughout the bronze. Much of the porosity that breaks onto the surface is unrepaired. There is also minor shrinkage porosity in the belly of the bull, above the bull's back left hoof, and on the left side of Dirce's body.

When the piece is examined from below, numerous thin flashes can be seen in the base where molten bronze poured into cracks in the core (fig. 20.5). However, the radiographs show very few flashes, and these are quite fine. The rope on the right side of the bull's neck was partially miscast, leaving a gap.

For a bronze of this complexity, there are remarkably few repairs. Many of the surface patches fill armature and core pin holes. All of the repairs appear to be set-in; there are no cast-in repairs visible in the radiographs. The set-in repairs are primarily rectangular, but the one under the bull's belly is oval, and one additional oval set-in repair and one irregularly shaped set-in repair are visible in the radiographs. Many of the core pin repairs were carefully applied and can only be seen on the surface because their color is slightly lighter than that of the surrounding

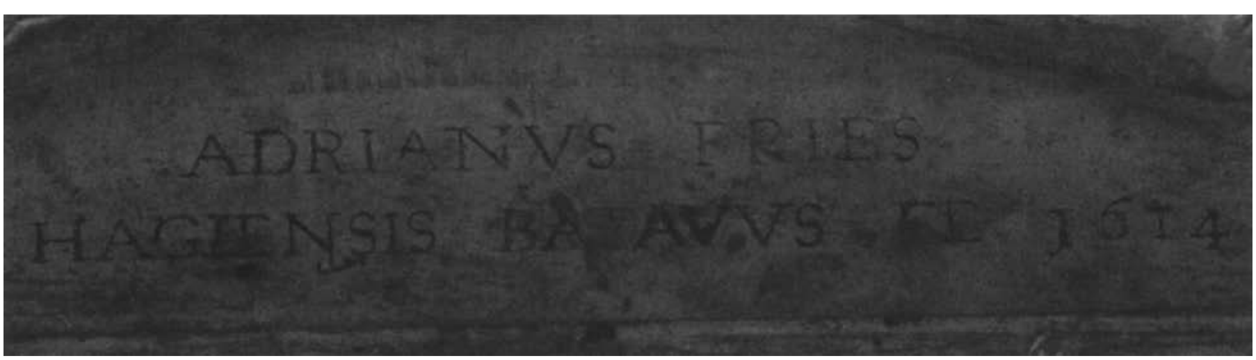


FIGURE **20.16** The signature was likely applied in the wax to the back of the base.

FIGURE 20.17 Photomicrograph detail showing the smooth and rounded inner contour of the letters.

bronze. Other repairs, though, are quite rough and easily discerned on the surface of the bronze, particularly those that are in hard-to-reach areas.

4. Later Modifications/Restorations

None apparent.

SUMMARY

Visual examination of the bronze in preparation for the exhibition catalogue revealed the presence of sprues remaining between many of the figures, strongly suggesting that it was cast in one pour. Radiography confirmed that the entire complex composition was cast in one pour, using the direct lost wax technique. Some of the clay-based core as well as the intricate iron armature remain on the interior of the sculpture. The armature in the individual figures was constructed in a manner similar to that used for de Vries's freestanding figures, with extensive double or triple wires extending throughout the limbs and torso, tied together with thinner wire. The distinctive external vertical support rod used in Amphion and Zethus (figs. 20.2, 20.3) was used on other de Vries bronzes, including Hercules in the Louvre *Hercules, Nessus, and Deianeira* and both figures of Cain in the two *Cain and Abel* casts. The strap of metal below the base that held the end of Zethus's vertical support rod is unique in the bronzes included in this study (fig. 20.5). In the *Farnese Bull,* two of the vertical support rods passed through other figures on their way to the base, one straight through the dog, the other through Dirce's shoulder. It can be surmised that the top of the central support rod inside the bull was shaped in an upside-down L or T, which helped to support the weight of the entire animal, as was likely used in the two de Vries horses included in this study (see chapters 15, 16).

Whereas the more visible surfaces were carefully modeled in detail and many were polished after casting, the recessed transition areas between figures were often left rough. The freshness of the modeled surface remains evident throughout the sculpture, as only a limited amount of chiseling or texturing appears to have been done after casting. The radiographs show that the artist constructed the casting model with a very clear vision of the final composition. There are no indications of compositional changes once the artist began building the armature, an indication of the extensive preparation that must have led to his innovative reworking of the classical model. The entire sculpture was originally the golden color of the polished bronze. This golden color, dulled slightly, remains only in the recesses; much of the surface has oxidized to a gray to brownish color.

Six circular-sectioned sprues were intentionally left in place. As stated in the catalogue, their presence, after the tremendous amount of work needed to finish the cast (including the patching of holes, the removal of the majority of the sprues, and the polishing of the figures), clearly indicates that they were left as a statement that the cast was successfully made in one pour, not out of carelessness (Scholten 1998b: 206). It is unlikely that the casual viewer would have known the significance of the remaining sprues; they appear to have been left for the educated connoisseur, and as a challenge to other sculptors working in bronze (Bewer 2001: 181).

NOTES

1 See chapter 4, "X-Ray Fluorescence Alloy Analysis," in this volume.

CHAPTER 21

Christ at the Column

Kunsthistorisches Museum, Vienna. Inv. no. KK8908

Cast in Prague ca. 1613

Dimensions: H: 86.5 cm

Marks and inscriptions:

Painted in red on the back of the column: 8908

Written in green pencil on a flower-shaped paper label under the base: n 661

(or perhaps: 199 u)

OVERVIEW

The bronze statue represents a scene in the Passion in which Pontius Pilate orders Christ tied to a pillar and beaten. Christ, naked except for a loincloth and crown of thorns, is bound by the wrists to a tall column with a Corinthian capital (fig. 21.1). The bronze is reported to have been found buried close to Lobositz in Bohemia. Therefore, it may have been war booty intentionally or accidentally left by the Swedes as they retreated from Prague. The bronze entered the collection of Mrs. Leokadia Hirschmann in Budweis, passed to Albert Figdor in Vienna, and then was acquired by the Kunsthistorisches Museum in 1935.

The technical study was undertaken to add to our understanding of de Vries's methods and materials.

EXAMINATION

1. Alloy

The sculpture was cast in a bronze alloy containing approximately 16 percent tin in a copper matrix with zinc content below 0.5 percent and lead below 1 percent. Due to difficulties with the XRF unit, the alloy was determined in only one location and therefore should be considered approximate.[1]

FIGURE **21.1** *Christ at the Column*
Kunsthistorisches Museum, Vienna. Inv. no. KK8908

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

The armature appears to remain intact within the figure but has been removed from the column. As summarized in figure 21.2, the armature is constructed of iron wires and thin rods, often slightly twisted together in pairs and bound together in a few locations with wire. The wires and rods extend from the base, through the left foot and up the left leg. They then continue up the torso, take a U-turn in the upper chest, and appear to continue down through the right side of the torso and right leg and into the base through the front of the right foot. It is not clear in the radiographs whether a single rod passes the entire distance from one foot through the body and down into the other foot. It is clear, though, that at least some and possibly all of the rods are in shorter sections, most of which are bound together with thinner wire to form the continuous central armature. The rod extending into the base from the left leg measures 0.4 × 0.4 cm; that from the right leg, 0.4 × 0.5 cm, quite a bit larger than as measured from the radiographs in the legs. This may be due to a combination of rust, which broadens the rods but does not appear in the radiographs, and tapering of the iron rods as they rise from the feet. A single wire loops through the head.

As discussed more fully in the *Summary* section, the wires in the arms do not tie into the rest of the armature and just barely extend into the torso (figs. 21.3, 21.4), suggesting that the position of the arms was determined

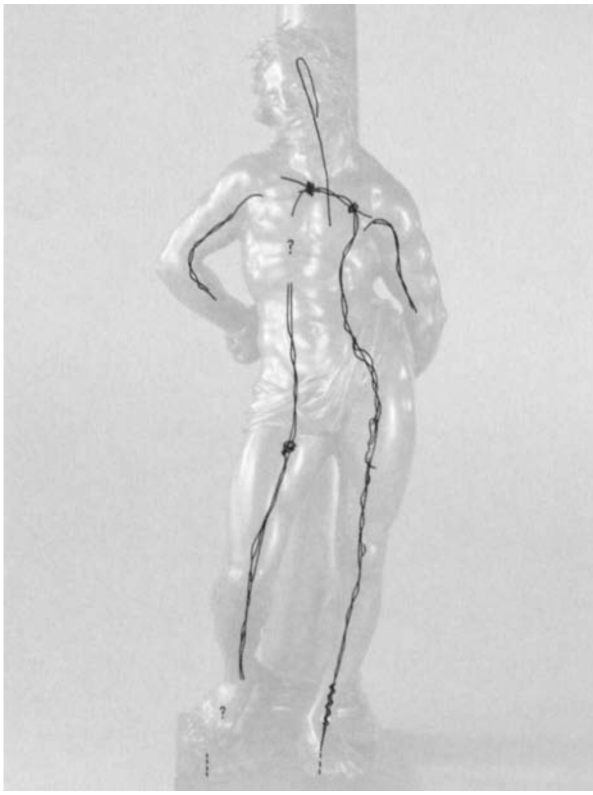


FIGURE 21.2 Summary of the remaining armature rods and wires. Question marks refer to areas that are not clearly legible in the radiographs. The dashed lines indicate parts of the armature wires that have been cut off.

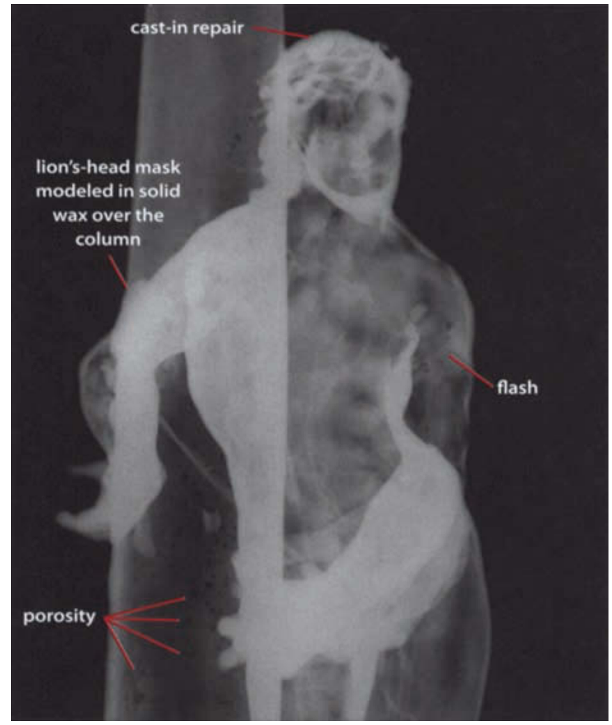


FIGURE 21.3 Radiograph taken from the proper right of center.

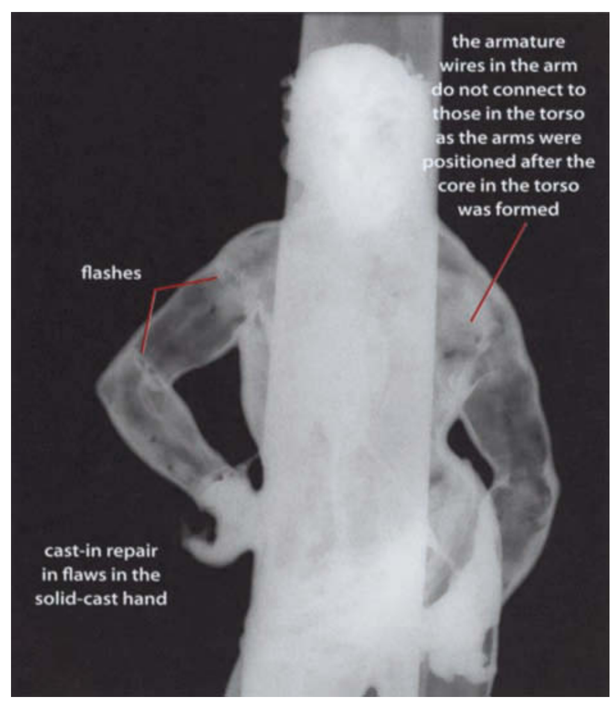


FIGURE 21.4 Radiograph of the upper body.

after the cores for the column and torso were already constructed. Much of the core has been removed from inside the column; it is likely that the armature rods were removed at the same time. One section of the armature extends from Christ's back into the column (approx. 5 cm long), evidence that the column was cast at the same time as the figure. Although difficult to see in the radiographs, this section of the armature is visible up the open base of the sculpture.

b. Core pins

Core pin holes cannot be discerned in the radiographs. Visual examination of the bottom of the base shows one square (0.1 × 0.1 cm) hole that may be from a core pin, but it is rather small in dimension for de Vries.

c. Core material

The core is reddish tan in color and crumbles easily under a hard crust. Much of the core has been removed from the interior of the column and base, although some remains in the corners and in the recess of the left foot. Varying densities in the radiographs indicate that some core remains at the top of the column, although the center has been hollowed out. It appears as though the core remains throughout the body of Christ. The core was constructed such that it extended from the base into part of the left foot but did not extend from the base into the right foot or from the column into the back or hands of Christ.

A core sample was taken from inside the column for compositional analysis. Quantitative analysis yielded the following:

- 80.5 percent reddish clay matrix
- 10.5 percent quartz
- 3 percent hematite
- 2 percent feldspar (albite)
- 1 percent calcite (fossil foraminifera)
- 1 percent biotite
- 1 percent oxy-hornblende (lamprobolite)
- 0.5 percent orthopyroxene
- 0.5 percent quartz/feldspar rock fragments
- trace of zircon and microcline

An additional small chunk of core was dated to 1591 ± 22 years using the thermoluminescence technique.

d. Internal surface of the bronze

The bronze was cast hollow, except for the following parts, which were cast solid without core: the hands, much of the left foot, the lion's head on the back of the column, the ropes, the crown of thorns, and Christ's beard.

The thickness of the walls varies considerably in the figure of Christ, evidence that the wax was added directly to a roughly modeled core. For example, the core of the left arm was quickly built up with lumps of clay, resulting in uneven thickness of the bronze (figs. 21.3, 21.4). In contrast, the simple form of the turned core in the column has relatively even and smooth sides. The interior of the column behind the hands is completely uninterrupted, confirming that the core does not extend from the column into the hands; once the position of the arms was determined, the hands were modeled in solid wax over the completed column. Waiting to place the hands would have given the artist the freedom to decide their final posture once the rest of the body was situated.

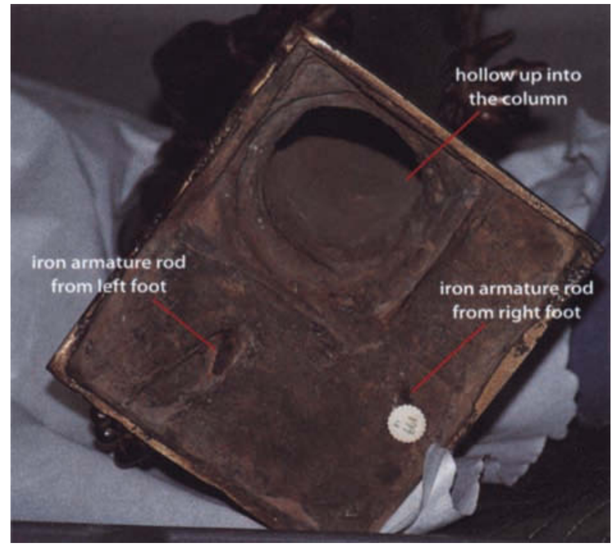


FIGURE 21.5 Open bottom of the base.

e. Method of assembly and joining of individual wax or cast bronze components

Examination of the interior of the base of the sculpture shows smooth transitions between the base, the column, and the left foot, suggesting a lack of wax-to-wax or metal-to-metal joins. This lack of joins indicates that the wax was modeled continuously over a preformed core, and the bronze was cast in one pour—all suggestive of the direct lost wax casting method (fig. 21.5).

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The casting preserves the sketchy feel of the wax model, including the undulating muscles and impressionistic facial features (fig. 21.6). The pliant nature of the wax modeling medium is evident in the crown of thorns, ropes, and volutes of the capitals, which were fashioned as thin rolls of wax (figs. 21.6, 21.7).

The hair and beard were modeled in the wax in a manner typical of the artist's later compositions, such as *Laocoön, Lazarus,* and *Putto with a Goose.* Each raised tuft was likely added as a separate clump of wax. The parallel strands were then sketched into each tuft with a toothed tool, similar to a comb. In the most time-consuming part of the process, these lines were then textured by the careful application of a single, rounded, finely textured punch. By varying the amount of pressure applied to the punch, the texture brought considerable variety to the surface, which would have been lacking if only a comb were used. On this figure and others, the hair was accented with smooth outlines drawn into the wax between tufts with a round-tipped modeling tool. Individual curving gouge marks were then added as accents (fig. 21.6). The depth of the punch marks and rounded sides of their impressions strongly suggest that they were made in the wax. The waxy edges of the gouge marks suggest that they too were applied in the wax, evidence that the entire process was applied in the wax model and cast-in to the bronze.

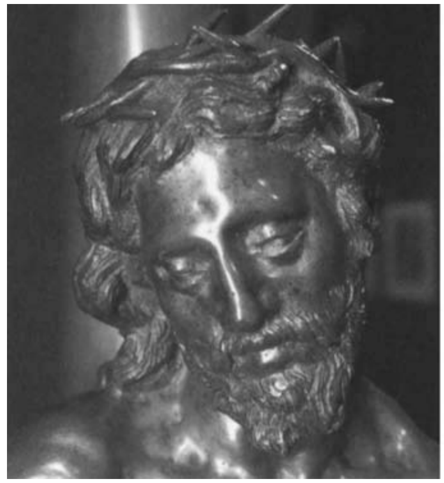


FIGURE 21.6 Loose handling of the wax model is apparent throughout the cast.

FIGURE 21.7 Lion's mask on the back of the column.

After casting, the flesh was highly polished, preserving fine traces of polish marks (see Appendix A, fig. A.18 [polish]). The end of a cut-off sprue remains at the tip of the right pinky finger. Details such as Christ's toenails and the lion's teeth and eyes may have been sharpened in the metal. Neither Christ's nor the lion's pupils are delineated, but the lion's teeth clearly are (figs. 21.6, 21.7).

g. Patina

The surface has lightly oxidized to a warm golden brown color. Traces of a reddish brown organic patina remain in localized areas on the back of the figure and in areas of the column closest to the figure's back. At present there is a translucent wax layer and/or varnish on the surface.

3. Casting Defects and Foundry Repairs

As seen in the radiographs, porosity appears scattered throughout the piece but is most concentrated in the center of the column and in the left foot. Porosity breaks through to the outer surface in many areas; the underside of the hands and the area where the figure joins the column are porous and flawed. The surface under the toes of the left foot is discontinuous, as is the join of the left wrist above the rope; it is uncertain if these flaws were in the wax or are casting defects. There are internal flashes where the metal flowed into cracks in the core in the shoulders, the right elbow, and the right knee (figs. 21.4, 21.8).

The radiographs show rectangular patches set into the top of the column, the neck, the left ankle, and the right knee and shin, as well as cast-in repairs in the top of the head and in both hands. A number of the smaller surface repairs are visible on the surface; they are slightly more reddish in color than the surrounding metal.

The feet and tail feathers are all that remain of a cockerel perched on top of the column. The bottom of a number of concave porosity bubbles can be seen in the center of what remains of the body. The porosity suggests that the area was weak due to casting flaws. The appearance of the metal surface suggests that the top of the bird broke off across the porosity bubbles sometime after casting, leaving the open lower halves of the bubbles exposed (fig. 21.9).

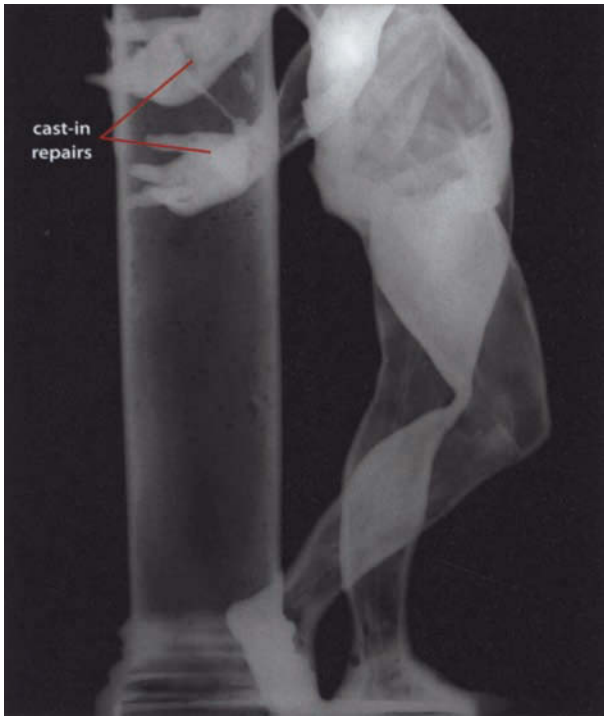


FIGURE **21.8** Radiograph of the side of the legs.

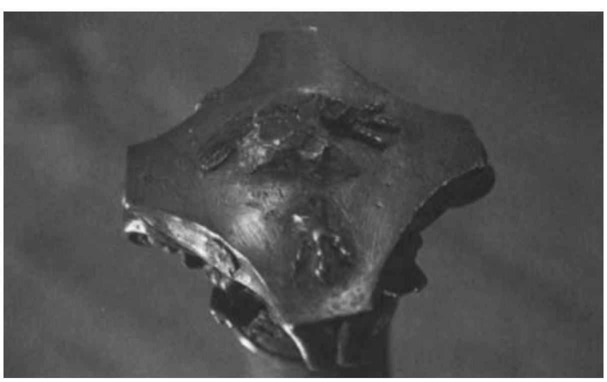


FIGURE **21.9** The lost cockerel on top of the column may have been weakened by porosity.

The ropes tying Christ's hands were imperfectly cast and have been repaired with solder. There is no indication as to when this repair was done.

SUMMARY

Technical examination of *Christ at the Column* shows that the alloy, the core composition, the method in which the model was constructed, and the surface chasing are all consistent with the work of de Vries. The figure, column, and base were cast in one pour using the direct lost wax method. The armature consists of loosely twisting wires that are themselves tied together with wire. It is interesting to note that unlike with the *Juggling Man* or *Lazarus* armatures (figs. 19.2, 22.2), there is no dominant heavy weight rod in the figure of Christ, perhaps because of the support offered by the column.

Remains of a cockerel that once perched on top of the column are riddled with gaseous porosity bubbles cut through their centers where the bird has broken off. There is a cast-in repair on top of Christ's head; set-in rectangular patches fill core pin holes and some of the surface porosity. The bronze has oxidized to a light golden brown; small traces of what may be an original reddish brown varnish remain.

The radiographs suggest that the composition was nearly complete before the arms were positioned. In the first stage, the armature and core in the column and body were modeled. The armature wires for the arms were then pushed into the soft clay in the shoulders and the arm core modeled over the wires. Flashes across both shoulders are likely due to slight gaps where the core in the arms and torso join (figs. 21.3, 21.4). This approach of determining the final composition in stages has been observed on one other de Vries bronze, the *Theseus and Antiope* in the Royal Collection, in which the armature for the figure of Antiope, held in Theseus's arms, was not completed until the core for the latter figure was partially complete (Bewer 2001: 168–69).

Certain elements of the wax model and the subsequent finishing of the cast metal are characteristic of de Vries's later work. Perhaps most idiosyncratic is the very loose modeling of the facial features. The eyes are asymmetrical and roughly rendered; the lower lip, a mere suggestion of form. A similar approach can be seen in the figures of Lazarus signed and dated 1615 (fig. 22.6) and Laocoön signed and dated 1623 (fig. 25.3). The distinctive treatment of Christ's hair is also reflected in these and other later bronzes.

NOTES

1 Previous XRF analysis undertaken in 1986 at the National Gallery in Washington, D.C., yielded an alloy of 14.4% tin, 0.6% zinc, and 1.1% lead (Bewer 2001: 166–67).

CHAPTER 22

Lazarus

Statens Museum for Kunst, Copenhagen. Inv. no. 5493
Cast in Prague in 1615
Dimensions: H: 61.9 cm × W: 42.4 cm × D: 37.9 cm
Marks and inscriptions:
Inscribed in the metal between two fine parallel lines on the front edge of the base:
ADRIANVS FRIES HAGIENSIS BATAVVS FECIT. 1615
Inscribed into a brass plate that is secured to the base with iron screws: CA.6.3
Stamped into the metal along the edge of the base: INV 5493
Written on a paper label and adhered to the interior: SR.INV.NA.493 Adrian de Fries: Lasarus

OVERVIEW

In this work, which derives from a parable in Luke (16:19–31), the nude figure of the beggar Lazarus reaches out imploringly with his right hand, as two dogs lick his wounds (fig. 22.1). The work is first recorded in the Danish royal *Kunstkammer* from 1749 but may well have been commissioned from the artist by King Christian IV (1577–1648).

The technical study was undertaken to add to our understanding of de Vries's methods and materials.

EXAMINATION

1. Alloy

The alloy of the figure was analyzed in three locations. The metal is a bronze composed of approximately 16 percent tin in a copper matrix with zinc content below 1 percent and lead below 2 percent. The replaced right ring finger was cast in a brass (copper-zinc) alloy. Full alloy results can be found in table 4.1.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

An extensive armature remains inside the hollow bronze, as illustrated in figure 22.2. All segments are lashed together

FIGURE 22.1 *Lazarus*
Statens Museum for Kunst, Copenhagen. Inv. no. 5493

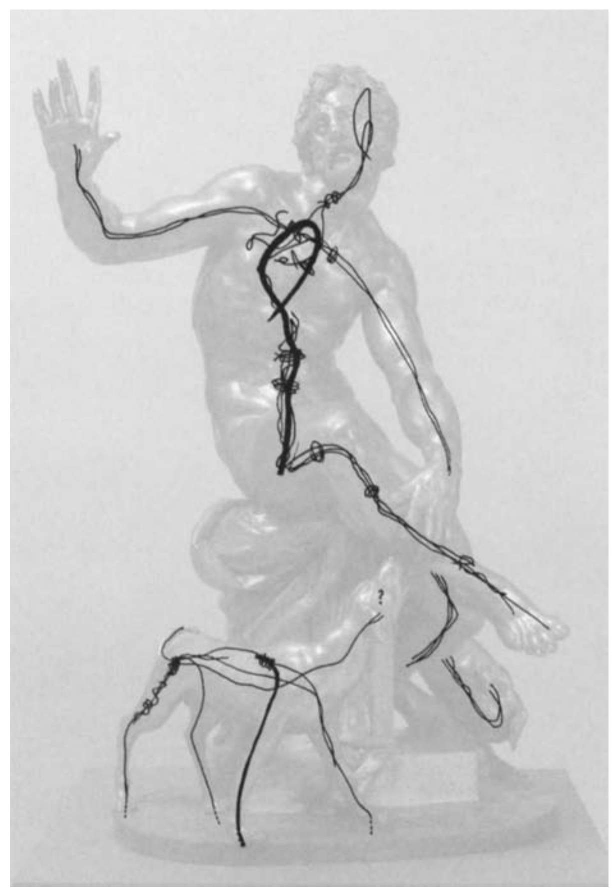


FIGURE 22.2 Summary of the remaining armature rods and wires. The question mark indicates an area not clearly legible in the radiographs.

with wire, creating a continuous structure of iron rods and wires. The ends of many of the remaining rods and wires can be seen up the open bottom of the sculpture (fig. 22.3).

Lazarus: A heavy-gauge rod loops through the torso. The rod ends in the buttocks, far short of the bottom of the base. It would be expected that this rod would extend down through the plinth to the base, helping to support the figure from below. This lower support must have been removed from the plinth and center of the torso when the core was partially excavated, suggesting that the rod was originally in two parts.

Two wires loop from the upper torso into the head. The rusting end of one of these wires extends through the bronze at the back of the head. This wire functioned as both an armature support and a core pin during the pour; it has not been plugged. Two parallel wires run continuously through the arms from wrist to wrist. Three wires run through each leg. One of the wires in the heel of the right foot extended through the wax model, also functioning as a core pin.

FIGURE 22.3 Open bottom of the base.

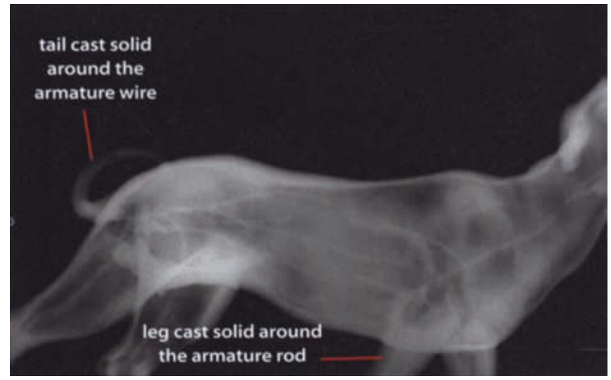


FIGURE 22.4 Radiograph of the standing dog.

Dogs: Extensive armature remains inside both of the dogs, mostly consisting of wires that run the length of the body between one limb and another, tied together with smaller wire. One of the wires runs from the standing dog's left forepaw, through the body, and along most of the tail (fig. 22.4). Whereas the armature rods and wires in the standing dog's legs extend down through the bottom of the base, none of the crouching dog's armature does. This difference suggests that the crouching dog was modeled onto the base after the construction of the casting model was well advanced (fig. 22.3).

b. Core pins

As mentioned above, at least two of the wires extended through the wax and into the outer investment, functioning as core pins as well as armature supports. Two core pins can be seen in the radiographs where they remain adjacent to their plugged holes: one of the larger pins remains in the torso; a smaller one, in the left upper arm (fig. 22.5). A third iron core pin can be seen from the open bottom of the bronze. It is tapered at the end and measures approximately 2.5 cm long. A small number of rectangular core pin holes can be seen in the radiographs. When measured on the images, these holes are of two sizes: 0.2 × 0.15 cm and 0.3 × 0.3 cm.

c. Core material

The core is powdery beneath a crusty surface and is reddish brown in color. Most of the core has been removed from the

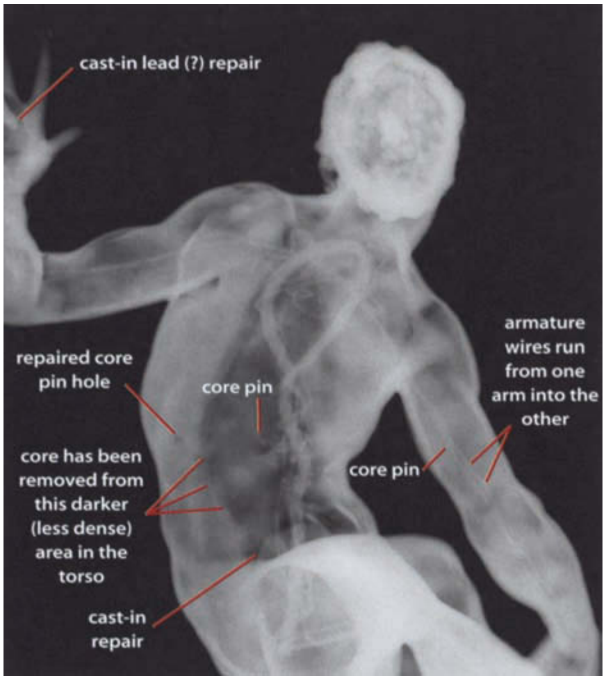


FIGURE **22.5** Radiograph.

base, up the plinth (fig. 22.3), and in a channel up the center of the torso (fig. 22.5). Core material likely remains in the body of the two dogs. A core sample was taken from below the sculpture, a third of the way up the proper right side of the plinth. Quantitative analysis yielded the following:

- 61 percent reddish clay
- 14.5 percent brown clay
- 3.5 percent dark reddish clay
- 14.5 percent quartz
- 3 percent feldspar (albite)
- 0.5 percent calcite
- 1.5 percent hematite
- 0.5 percent oxy-hornblende (lamprobolite)
- 0.5 percent biotite
- traces of zircon and plant debris

An additional small chunk of core was dated to 1645 ± 22 years using the thermoluminescence technique. Although this date is a bit more recent than the date on the base, as explained in chapter 6, the results should be read with two standard deviations (1601–89).

d. Internal surface of the bronze

The bronze appears to be of a rather even thickness overall, except for areas where the details were applied in the wax over a more generalized core. For example, Lazarus's nose and mustache, as well as much of his right hand, were cast solid (fig. 22.5). The dogs' ears, snouts, tails, and part or all of some of the legs were also cast solid. In the standing dog's tail, the wax was modeled directly onto the armature wire (fig. 22.4).

e. Method of assembly and joining of individual wax or cast bronze components

The open bottom of the base was examined. The smooth transitions between the body, the plinth, and the base indicate that they were modeled directly onto the core, without metal-to-metal or wax-to-wax joins (fig. 22.3). Indeed, the radiographs confirm that the entire bronze was modeled together and cast in one pour.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

Much of the surface was carefully finished both in the model and in the metal after casting, although unrepaired surface porosity and other small flaws remain in the hard-to-reach areas such as the left hand and behind the right knee. Lazarus's skin and the coats of the dogs are polished, with haphazard abrasive marks remaining. Some of these polish marks may be due to later cleaning and may not be original to the surface.

The waxy quality of the loosely modeled surface remains in Lazarus's face and throughout the dogs (fig. 22.6). The drape was textured with rough scratch marks applied in the wax perpendicular to the folds. These marks appear to have been polished away in the raised areas. The round outlines of the irises were rather loosely delineated in the wax. The signature was engraved in the wax between two fine parallel guidelines (fig. 22.7). As illustrated in figure 22.6, the hair and beard were modeled and carefully textured completely in the wax in a manner described in detail in chapter 21, section 2f (*Christ at the Column*).

The rendering of the foliage in the base is reminiscent of passages in many of the artist's bronzes (fig. 22.8):

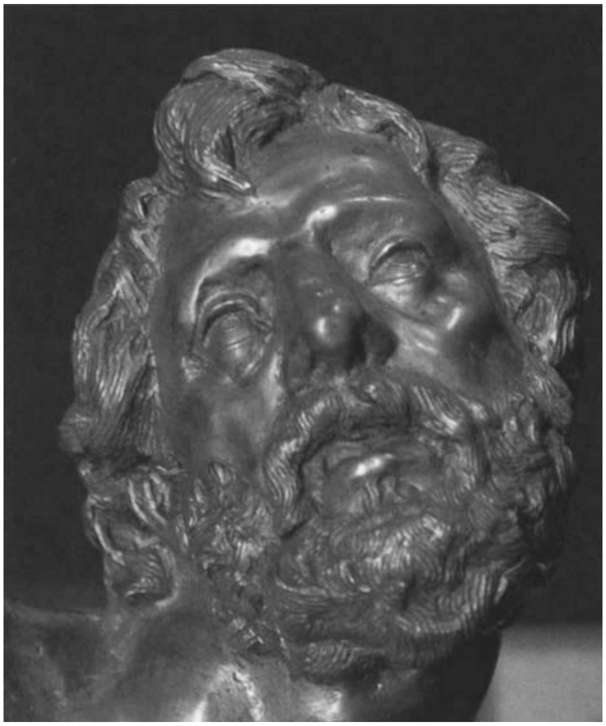


FIGURE 22.6 Lazarus's face and hair retain the waxy feel of the modeling and surface texturing.

1. Large, flat, elongated leaves are generally smooth, with occasional texture added with a flat, matte punch. The centerline down these leaves was applied with a very loose hand, likely in the wax.
2. Lines loosely applied in the wax were used to depict strands of grass and to separate different textural areas.
3. Patches of the ground were textured with convex round and oval punches of varying size (all larger than that used in the hair and beard), applied in lines side-to-side and end-to-end. Individual areas were textured with a single tool used in a consistent manner; there is no mixing of tools within an area.

g. Patina

The sculpture is a bright golden color. Although there are reports of its having been gilded, XRF analysis of the surface shows no gold; the present surface is simply the

FIGURE 22.7 Photomicrograph of the signature slightly obscured by the thick, translucent varnish.

polished bronze, protected with a transparent, glossy varnish with a slight reddish tint. The varnish was unevenly applied. In areas where the coating was thinly applied or has abraded off, the surface is dull and has darkened to varying degrees. Where it remains, it has saturated the surface, enhancing the golden color of the polished bronze and retarding oxidation of the metal (fig. 22.9). The varnish is heaviest on the sides of the base, where two coats were applied; it has pooled in and around the signature (fig. 22.7). The patina has also pooled inside the stamped inventory number located on the side of the base: "INV 493." Interestingly, the number 5 was added after the coating was applied, altering it to "INV 5493," causing the varnish to pop off of the surface under the 5. Evidently, the

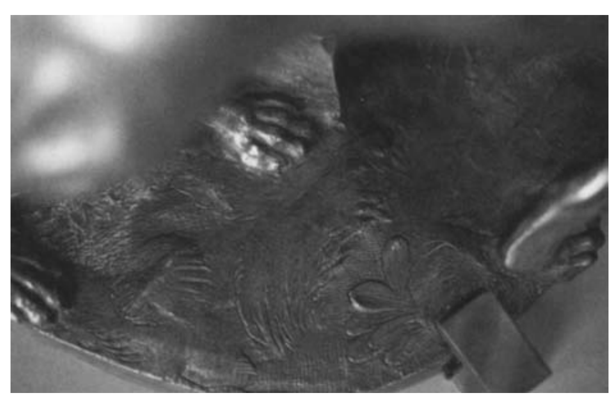


FIGURE 22.8 Top of the base. The foliage and manner of texturing are found on many of de Vries's other bronzes.

FIGURE 22.9 Where the varnish was more heavily applied, the surface has not oxidized.

coating was applied sometime after the bronze entered the collection, yet before the inventory number was changed.

Remains of an older, opaque bright golden-yellow coating can be seen in the deep recesses. XRF analysis of a thick remnant of the coating in a recess detected slightly higher zinc than in the surrounding metal, and possibly a trace of mercury, yet no gold. The possible presence of mercury in this location, yet not in others, is puzzling and should not be taken as an indication that the bronze was once mercury gilded. The XRF results cannot be used to characterize the coating, as the X-rays penetrate straight through to the bulk metal below, overwhelming the spectra with the bronze alloy. Should it be necessary in the future, analysis using a microsample of the bright gold–colored coating may yield a better result.

3. Casting Defects and Foundry Repairs

The bronze was cast in a single pour with a notable lack of flaws. The radiographs indicate that although there is porosity throughout the cast, it is relatively minor; some of it breaks through the surface in areas, with associated pits and loss of detail. There is no indication of porosity holes having been filled.

With the exception of rectangular core pin repairs, the only repairs present on the sculpture are the later replaced right finger and cast-in repairs. These cast-in repairs appear on the top of the right thigh and knee and between the second and third fingers on the right hand (this repair is particularly dense in the radiograph and may be a lead repair; fig. 22.5). In addition, a large, irregular cast-in repair on the back of the left hip is visible in the radiographs and on the surface of the bronze. There is a crack across the palm of the right hand.

4. Later Modifications/Restorations

The right ring finger has been replaced from the second knuckle. The replacement was cast in a brass alloy and has been secured with a pin. It is not known when the repair was made, but it would appear not to be original as pinned repairs are not seen on other bronzes cast by de Vries.

Abrasion has led to loss of surface details. Deep, rather haphazard surface scratches as well as light green corrosion in some of the recesses may be due to previous cleanings.

SUMMARY

The figure, dogs, and base were cast in a single pour using the direct lost wax technique. The bronze was cleanly cast with few flaws. The core as well as a substantial and continuous armature remain within Lazarus's torso and the dogs. The metal is a copper-tin bronze alloy; the core is clay based.

The golden surface of the sculpture is from the polished bronze metal. Isolated remnants of a rather thick, bright gold coating can be found in some of the recesses. This coating may be a relatively recent bronze or brass powder paint. Abrasion, possibly from removal of coatings, has altered the original surface somewhat.

As found on many of de Vries's bronzes, the surface was prepared in detail in the wax model, including the loose modeling of passages such as the heads of the dogs and the careful texturing of the hair and beard.

CHAPTER 23

Putto with a Goose

Nationalmuseum, Stockholm. Inv. no. Drh Sk 61
Cast in Prague in 1615–1618
Dimensions: H: 46 cm
Marks and inscriptions: None on the outer surface.
Written on a paper label adhered to the underside of the base: M502

OVERVIEW

The sculpture depicts a putto, semirecumbent on a flat base, with the neck of a goose grasped in his left hand and his right leg thrown over the goose's back (fig. 23.1). The putto is one of sixteen bronzes by de Vries from the *Neptune Fountain* commissioned by King Christian IV of Denmark for Frederiksborg Castle in Hillerød. The fountain figures were taken from the castle grounds by Swedish troops in 1659 and were eventually installed in the gardens of Drottningholm Palace, where they remained until their recent relocation to an indoor setting in the Nationalmuseum, Stockholm.

The technical study was undertaken to add to our understanding of de Vries's methods and materials.

EXAMINATION

1. Alloy

Five locations on the sculpture were examined to determine the composition of the bulk alloy. The sculpture was cast in bronze with wide variations in the tin, lead, and iron measurements. The tin content was measured at 13 to 66 percent. The highest tin reading is likely the result of severe inverse segregation, in which the tin-rich phase of the metal migrated to the surface of the sculpture during cooling. On parts of the back of the putto, where the crystalline structure of the metal can be clearly seen, some of the corrosion products are silvery in color due to the elevated tin content (fig. 23.2).[1] Inverse segregation has also likely occurred in the three areas where the tin content was measured as 17, 17, and 21 percent, even though the corrosion in these areas is green in color. As discussed by David Scott in chapter 4,

FIGURE 23.2 The varying colors of the corrosion products highlight the metallographic structure of the cast metal on the back of the putto.

FIGURE 23.1 *Putto with a Goose*
Nationalmuseum, Stockholm. Inv. no. Drh Sk 61

tin content of more than 14 percent produces an alloy with a very hard surface that is more likely to contain planes or areas of weakness, offering no advantage over alloys with tin content equal to or below 14 percent. Indeed, the 13 percent tin reading taken from a polished corner of the base where the surface has been abraded may well be more accurate for the bulk alloy of the piece.

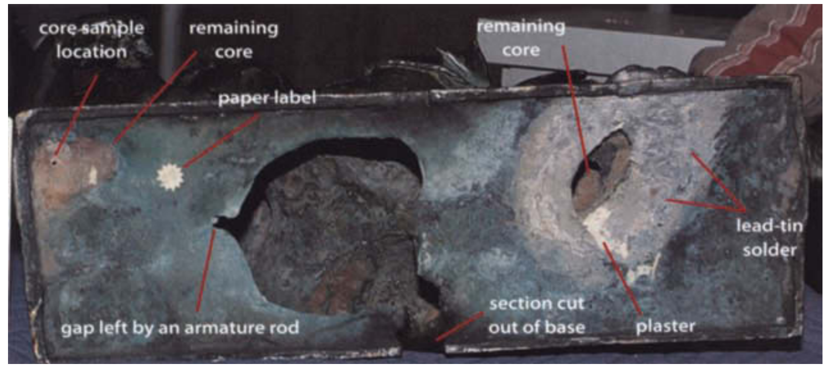


FIGURE 23.3 Open bottom of the base.

Elevated lead in the readings taken from below the base and from the goose's beak (5% and 7%) may be due to surface contamination from the adjacent solder repairs.[2] Elevated zinc found on the spectra of the abraded corner under the base (2%) cannot be as easily explained. Four of the spectra show rather elevated levels of iron, possibly due to contact with corrosion products from the iron components in the fountain. Should more exact alloy content results be needed in the future, a drilled sample should be taken, thereby avoiding surface contamination.

Spectra were also acquired for two repairs. The set-in repair on the base is a heavily leaded bronze with some added zinc. The large white metal repair on the base below the goose's tail is a 3:1 lead-tin solder alloy.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Much of the armature was removed with the core. A rectangular gap in the edge of the join where the putto's bottom joins the base appears to be the impression left by an armature rod, now removed (fig. 23.3).

The rods that remain in the figure are relatively difficult to read due to corrosion of the iron. Two rods remain within the head and apparently end at the neck. There are two rods in each of the putto's arms and legs, often twisting together loosely. No armature is visible in the goose, although much of the animal was not radiographed because of the difficult geometry of its orientation within the sculpture.

b. Core pins

The iron core pins are square in section (approx. 0.3 × 0.3 cm) and taper to a blunt point. Some of the pins were cut off at the surface and pushed partway into the inner cavity. These remaining pins are visible from the open bottom of the sculpture. Many are situated quite close together (7 to 10 cm apart).

c. Core material

The remaining core crumbles easily when probed. The core has been removed from the base, from most of the goose's body, and from the putto's torso and partway into his thighs. The increased radiographic density of the arms and head compared to the torso suggests that core remains in these extremities (fig. 23.4). A core sample was taken from below the sculpture, inside the putto's left thigh. Quantitative analysis yielded the following:

- 77.5 percent reddish clay
- 17 percent quartz
- 0.5 percent feldspar
- 1 percent calcite (0.5% of calcite is foraminifera)
- 2 percent opaque rock fragments (andesite)
- 1.5 percent oxy-hornblende (lamprobolite)
- 0.5 percent biotite

An additional sample of core was drilled under safelight from below the area where the right elbow meets the base and was dated to 1615 ± 20 years using the thermoluminescence technique.

d. Internal surface of the bronze

The thickness of the metal varies from area to area, suggesting that the core was roughly formed. The toes, fin-

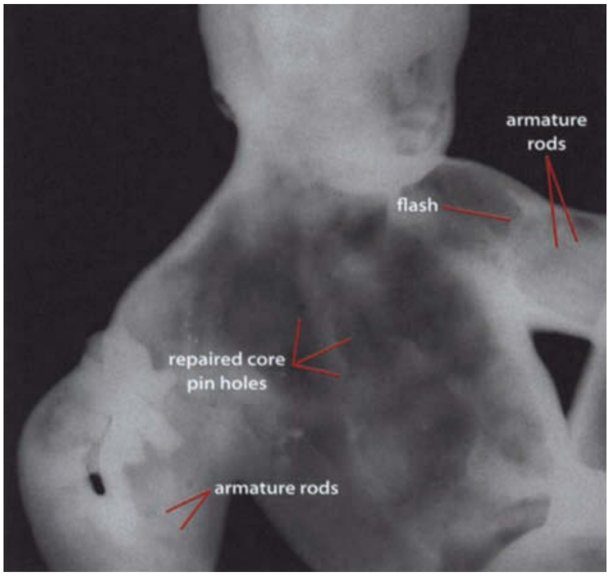


FIGURE 23.4 Radiograph of the putto's chest. The density decreases in the torso where the core has been removed.

gers, much of the nose, the beak, and the wings were cast solid.

e. Method of assembly and joining of individual wax or cast bronze components

Examination of both the open bottom and the radiographs shows that the entire sculpture was modeled and cast in one piece without wax-to-wax or metal-to-metal joins. Lead in three areas was used for repairs rather than intentional joins.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The forms were modeled and textured in detail in the wax. Many of the linear details appear to have been quickly applied, yet overall considerable time was spent applying various surfaces and textures in the wax. Some of the hard-to-reach areas, such as the leaves under the goose's tail and behind the putto's back, were only cursorily modeled. The outlines of single hair strands were cut into the figure's forehead, likely in the wax. The skin surfaces are smooth and polished but preserve some file marks.

The hair was fully modeled in the wax in a distinctive and very deliberate manner that is repeated on de Vries's bronzes after about 1613 (fig. 23.5). He moves from his earlier style emphasizing the differing planes of individual strands toward a quicker, although undoubtedly still quite laborious, approach, in which entire tufts of hair are formed with a toothed tool, followed by texturing in lines with a punch, as described in chapter 21, section 2f (*Christ at the Column*).

The three different types of goose feathers were depicted in different ways, another example of the artist's continuing attention to detail.

1. *Flight feathers:* The center quills of the larger flight feathers were deeply engraved in the wax. The curving lines of the barbs were then engraved in the wax, and the remaining raised line between the engraved lines was textured with lines of single punches to depict the barbules (fig. 23.6).
2. *Tail feathers:* The center quills of the tail feathers were also deeply inscribed in the wax, but the barbs and recessed barbules were created at the same time by the application of lines of a single punch, a technique similar to that used in the hair (fig. 23.7).
3. *Secondary feathers:* The outline of each oval secondary feather was drawn into the wax. Each feather was then lightly textured with a slightly convex matting tool applied either in the wax or in the metal (fig. 23.8).

A considerable amount of detailed texturing was applied in the wax stage to decorate the base. A round single punch,

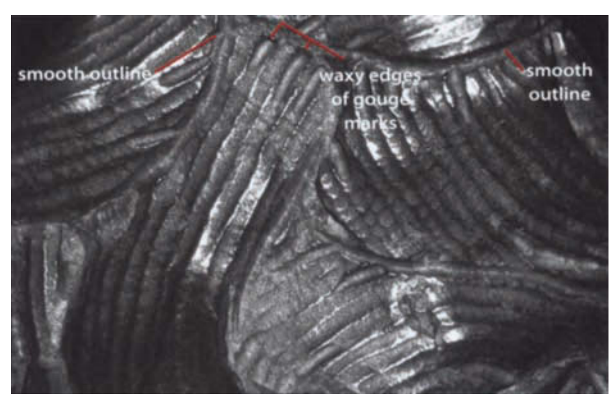


FIGURE 23.5 Photomicrograph detail of the putto's hair showing the textured parallel strands, the smooth outlines between the tufts, and the small accent gouges.

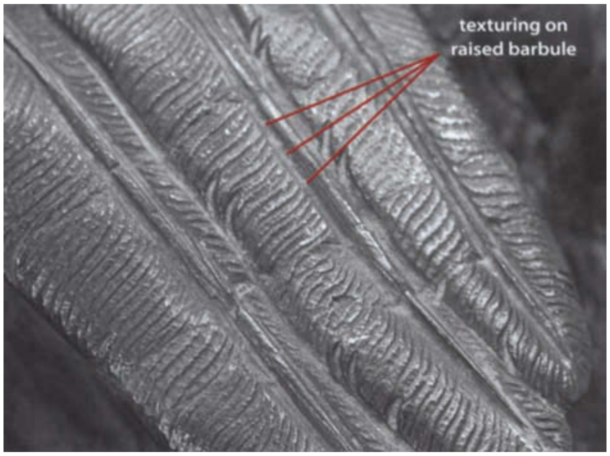


FIGURE 23.6 Photomicrograph detail of the left wing flight feathers. The central quills and side barbs were engraved, then the raised lines punched to depict barbules.

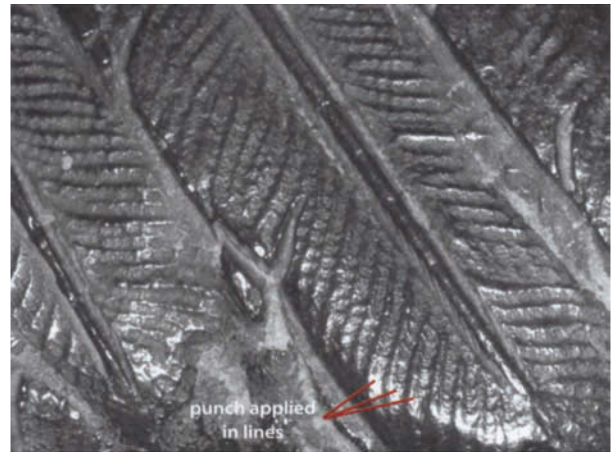


FIGURE 23.7 Photomicrograph detail of the tail feathers. The central quills were engraved and the barbs and recessed barbules formed at the same time with a punch applied in lines.

as well as a donut-shaped punch, was applied in lines over much of the base. Smooth lines cut deeply in the wax outline the large, flat leaves and were used as accents around some of the rocklike forms. Many of the smooth outlines depicting leaves are partially "shadowed" by lines of single punches (fig. 23.9). These lines cut through the round punch marks in areas, with excess wax curled over the punches, indicating that the texture as well as the smooth outlines were formed in the wax. Indeed, in light of the high tin content found on the surface of this bronze, it seems likely that all of these deep marks were applied in the wax. As is typical throughout de Vries's oeuvre, each specific area is textured with a single type of punch; the textures are not mixed within an area.

g. Patina

Most of the surface is covered with corrosion products from outside exposure, although the corrosion is remarkably thin and even, with relatively little disruption of the polish on the original surface. There is no sign of original lacquer- or paintlike organic coatings. A recent clear glossy organic coating now covers the surface.

3. Casting Defects and Foundry Repairs

A large casting flaw under the base has been repaired with a lead-based solder (fig. 23.3). This damage only penetrates partway through the thickness of the base, with no corresponding damage on the top side, suggesting that the solder fills and strengthens what may have been an overly porous or thinly cast area. Lead-based solder also fills a large gap in the top of the left wing. The lack of corrosion on these lead repairs suggests that they are not original.

The radiographs show that the sculpture was cast with a moderate number of flashes and limited porosity.

There are no cast-in bronze repairs visible in the radiographs. The only set-in patches appear to be repairs to core pin holes. These repairs are difficult to see on the surface

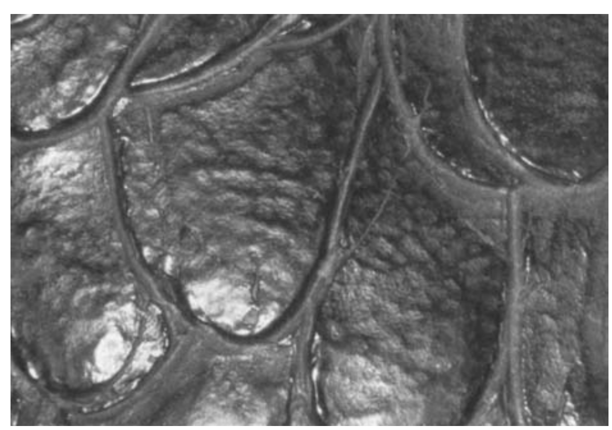


FIGURE 23.8 Photomicrograph detail of the secondary feathers. The outlines of the oval secondary feathers were drawn into the wax. Each feather was then lightly textured with a slightly convex matting tool.

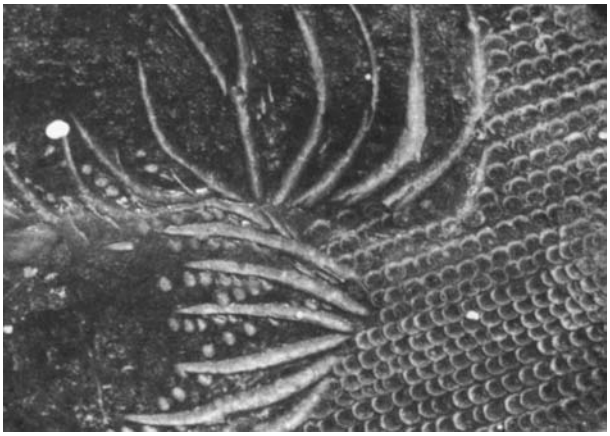


FIGURE 23.9 Photomicrograph detail of the punch work in the base, including a donut-shaped punch that is relatively unusual on de Vries bronzes.

of the bronze as they have oxidized to the same color as the surrounding metal, suggesting that they were made of sprues removed from the original casting. A leaded bronze repair has been set into the front of the base.

A crack across the top beak has been filled with an X-ray-transparent material (the X-rays passed right through the fill, yielding a dark band in the radiograph) (fig. 23.10).

4. Later Modifications/Restorations

A section of the base and the left upper thigh have been cut out and may be damage that occurred when the piece was removed from its original setting in Denmark. The mouth of the goose, which would originally have served as a fountain spout, has been closed off with what appears to be a lead alloy. The lead has dripped onto the left side of the lower beak (fig. 23.10).

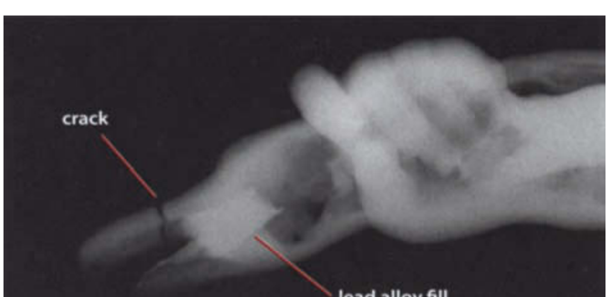


FIGURE 23.10 Radiograph of the putto's left hand grasping the goose.

The section of rope between the putto's right hand and his right thigh is missing.

The surface is oxidized due to outdoor exposure. The corrosion layer is remarkably thin and even in texture, with a slight gloss. Under strong lighting, color variations of the corrosion include golden brown, brick red, olive green, and grayish blue-green.

Spots of a plasterlike material on the bottom of the base are likely from an earlier installation (fig. 23.3).

SUMMARY

The sculpture was cast using the direct lost wax technique. The putto, goose, and base were cast together in one pour. The forms were fully and freely modeled in the wax. The details were drawn and punched into the wax with a quick, confident hand. Considerable attention was paid to the textures in different areas, such as the putto's hair, the decorated base, and the three different types of goose feathers. As seen on the putto, de Vries repeatedly (and laboriously) suggests individual strands of hair by applying lines of single punch marks. The technique of highlighting the hair with short, curving gouges is seen on the *Christ at the Column* in Vienna and on the *Laocoön* in the Nationalmuseum, Stockholm. This highly labor-intensive approach to depicting the hair yielded an expressive, lively surface, reflecting a contrast seen throughout de Vries's oeuvre, in which spontaneous, loose, and waxy passages in the flesh contrast with areas of considerable textural and linear detail.

The surface is currently an overall mottled greenish brown color due to outdoor exposure. Lead alloy repairs on top of the left wing and below the base fill large casting flaws. The alloy results vary considerably, with spectra showing higher levels of tin, lead, iron, and/or zinc than observed in other de Vries alloys. Some of these variations are likely due to surface enrichment and/or contamination.

NOTES

1 The silvery appearance may be due to tin oxide corrosion products. No analysis of the corrosion has been done.

2 The spectra acquired from a polished spot under the base may show elevated lead content due to contamination of the location by placement of the sculpture on a lead sheet during an earlier exhibition installation.

CHAPTER 24

Cain and Abel

Statens Museum for Kunst, Copenhagen. Inv. no. 5492

Cast in Prague in 1622

Dimensions: H: 73.4 cm × W: 27.0 cm × D: 38.3 cm

Marks and inscriptions:

Engraved in the metal around the recessed area of the base: ADRIANVS FRIES HAGIENSIS BATAVS•FECIT 1622.

Stamped in the bronze on the recessed base: INV 492

Stamped in the bronze on the recessed base: 5492

Stamped on a metal plate that has been applied to the recessed base: Cab 4

Written on a paper label placed on the inside of the sculpture: SR.In.No.492 Adrian de Fries:kain dra ber Abel i

OVERVIEW

The cast represents Cain, jawbone raised in his right hand, poised to strike his brother, Abel (fig. 24.1). The bronze is nearly identical in composition to the signed *Cain and Abel* group at the University of Edinburgh (see chapter 18). In a letter dated 11 March 1621 from de Vries to his patron, Count Ernst von Holstein-Schaumburg, the artist mentioned five sculptures that he was working on, including *Un groppo di Cain et Abel di 2 piedi di bronzo* (cited in Scholten 1998a: 230). It is assumed that this is the cast referred to in the letter. The sculpture is first recorded in the Danish royal *Kunstkammer* in 1749 but may have been in the collection of King Christian IV (1577–1648) at a much earlier date. It came to the Statens Museum in 1905 from the Kunstakademie in Copenhagen.

The *Cain and Abel* was examined alongside the second cast of the composition, now in the University of Edinburgh, that is dated ten years earlier. A technical examination of the two groups was of particular interest as this is the only known signed composition by de Vries to exist in multiples. It was hoped that the technical study would help to determine whether they were both cast by de Vries and also clarify their relationship: were both bronzes cast using the same set of molds, or is the latter bronze a copy made off of the earlier one?

FIGURE 24.1 *Cain and Abel*
Statens Museum for Kunst, Copenhagen. Inv. no. 5492

EXAMINATION

1. Alloy

The alloy was analyzed in five locations. The metal is composed of approximately 12 percent tin in a copper matrix with zinc content below 1 percent and lead content of approximately 1 percent. Although the sculpture is thought to have been gilded, no gold was found on the surface; the golden color is that of the polished bronze. Full alloy results can be found in table 4.1.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

A number of iron core support rods and wires are visible in the radiographs (figs. 24.2, 24.3). As the core remains intact within the figures, it seems likely that all the core supports remain in place. Many of the rods are relatively short. Those in Abel's body are bound together with a wire; otherwise, the rods and wires are not interconnected.

Cain: A large-diameter rod appears to have supported Cain's weight during the casting. The rod began below the base, extended vertically out of the wax model, and passed

FIGURE 24.2 Summary of the wax-to-wax joins and the remaining core support wires. The dashed lines indicate the end of core supports now cut off.

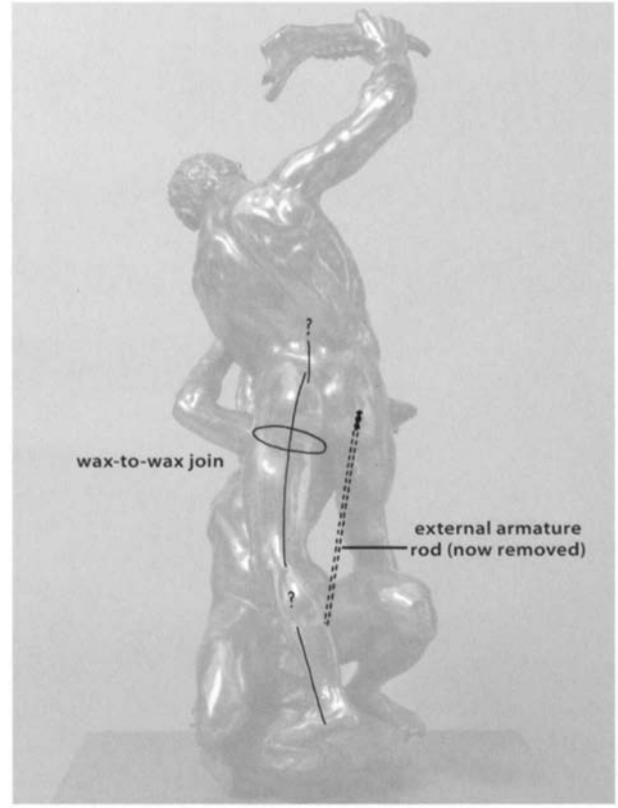


FIGURE 24.3 Summary of the wax-to-wax joins and remaining core support wires.

back into the wax up into Cain's right buttock. As seen in figure 24.4, there is a 1 cm wide × 1 cm long gap in the core that was left when the rod was removed. A repair patch is just visible in the radiograph and on the surface of the bronze (figs. 24.4, 24.5).

Single support rods run up the legs; the one in the left leg passes through a wax-to-wax join. Two separate rods run up the torso and into the head. There are four separate wires in the right arm and hand; two of them run through the wax-to-wax join in the right shoulder. A fifth wire runs from the right hand through the jawbone (fig. 24.6). The radiograph of the left arm is not clear due to overlap of the figures.

Abel: Two rectangular-sectioned iron rods twist up the torso and are bound together with wire (fig. 24.4). The ends of the rods extend into the open bottom of the base. The ends measure 0.7 × 0.4 cm and 0.5 × 0.4 cm (fig. 24.7). Three core support wires in the left leg do not connect to the rods in the torso (fig. 24.4). Two wires in the right arm are not attached to one another but cross in the elbow; the wire in the upper arm spans the wax-to-wax join. A single wire runs through the left arm.

b. Core pins

One rusted iron core pin remains in the base where it was left after being pushed down from the surface and plugged. The square-sectioned pin measures 0.3 cm × 0.3 cm (fig. 24.7). Three square core pin holes can be identified on the radiographs: one in Abel's left forearm measuring 0.2 × 0.2 cm and two in Cain's torso measuring 0.3 × 0.3 cm (fig. 24.6). There are likely more core pin holes that are not visible in the radiographs.

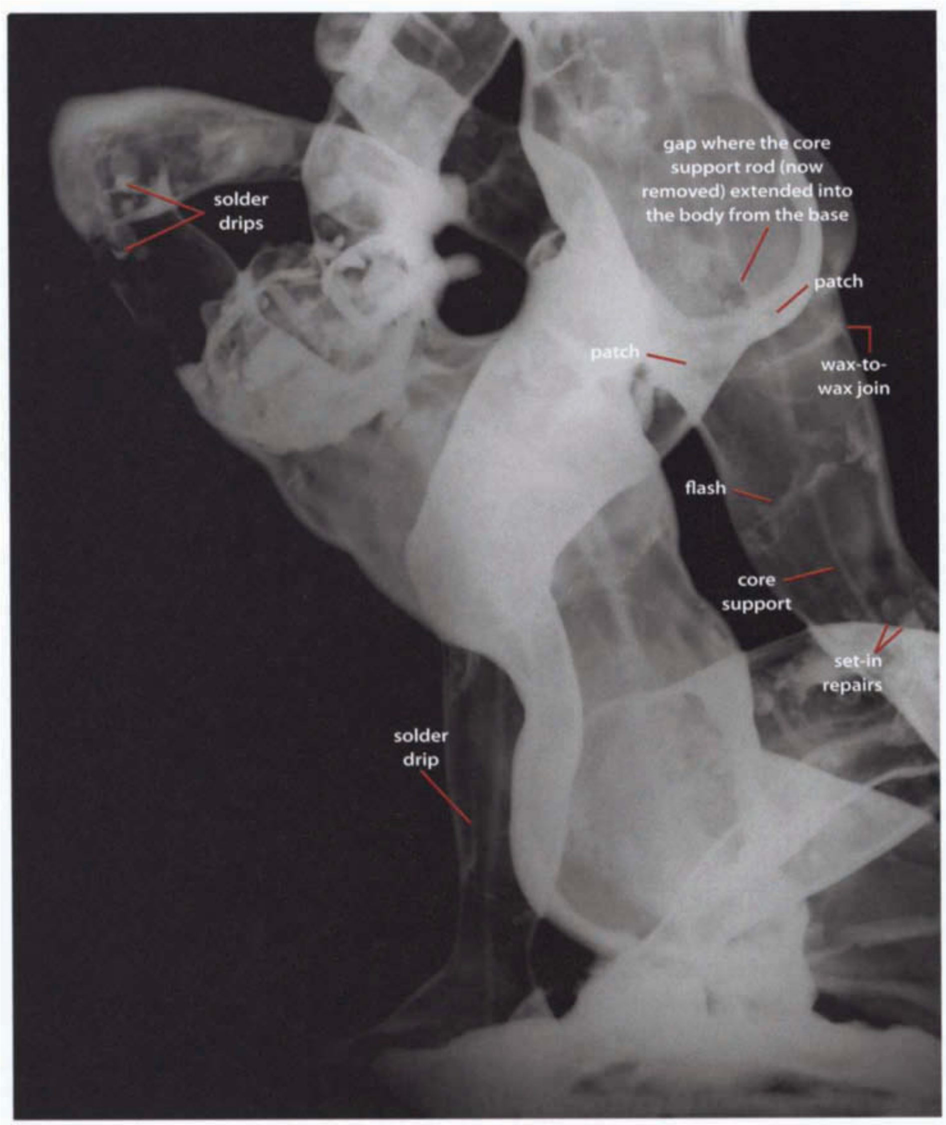


FIGURE 24.4 Radiograph of the lower section of the sculpture.

c. Core material

The black-colored core crumbles when probed. Much of the core has been removed from the base, but it remains within the figures (fig. 24.7). Quantitative analysis yielded the following:

- 71.5 percent brown clay
- 15 percent quartz
- 5 percent opaque clay
- 3 percent feldspar
- 1.5 percent calcite
- 1.5 percent muscovite
- 1 percent opaque rock fragments (andesite)
- 0.5 percent pyroxene
- 0.5 percent biotite
- 0.5 percent quartz/feldspar rock fragments
- traces of plant fibers
- traces of calcite rhombohedra

FIGURE 24.5 The sprue was cut off and subsequently covered with punch marks haphazardly applied.

Oxy-hornblende (lamprobolite), a mineral typically seen in trace amounts in de Vries cores, was not found in the prepared sample. It was found, however, in another core sample from this bronze that was analyzed at an earlier date.[1]

An additional small chunk of core was dated to 1720 ± 15 years using the thermoluminescence technique. This late date does not correspond with the other technical data acquired for the bronze and is further discussed in the *Summary* section below.

d. Internal surface of the bronze

The entire composition was cast hollow, except for either end of the jawbone, Cain's left thumb and first finger, and the hank of Abel's hair held in Cain's left hand, which were cast solid. The radiographs confirm that the base and figures were cast together in one pour. The walls of the hollow-cast bronze are rather thin; the inner wall conforms well to the outer surface of the bronze. Features on the interior of Cain's torso could be interpreted as wax drips, suggesting that the indirect lost wax technique was used (fig. 24.6).

e. Method of assembly and joining of individual wax or cast bronze components

There are no metal-to-metal joins. Four wax-to-wax joins are visible in the radiographs. They appear as rings of slightly increased density where the separately molded sections of the casting wax were joined. The variation in thickness of the walls of the bronze above and below the join in both Cain's and Abel's right shoulders further distinguishes them as wax-to-wax joins (figs. 24.6, 24.8). The joins appear in Abel's upper right arm (fig. 24.8), in Cain's upper right arm (fig. 24.6), in Cain's upper left leg (fig. 24.4), and in Abel's left wrist. The wax-to-wax joins are a further indication that the sculpture was indirectly cast. There are likely other wax-to-wax joins not visible in the radiographs, including one where Abel's body meets the base (currently hidden from view when one looks up the open base as the area is covered with core material).

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The plants and rocks on the base were only roughly modeled in the wax, with minimum differentiation of forms. Details such as the toenails, hair, and facial features were fully modeled in the wax, yet the latter were extensively highlighted with chiseling and punching in the metal. Worry lines were engraved on the foreheads; a graver or a round circular punch was used to delineate the edge of the pupils, the irises were bossed with a round, convex punch, and Abel's teeth were delineated with a straight chisel (fig. 24.9). A crescent-shaped punch was used under Abel's chin to depict facial hair, and crossing chisel marks were applied across the tip of the penis (fig. 24.5). A chisel was used to further delineate the locks of hair. The surface was finished all around after casting, including high polish of the flesh. The exceptions are the fingers and nails of Abel's

FIGURE 24.6 Radiograph of Cain's upper body.

right hand, which would have been difficult to reach with chasing tools and were left as-cast. Scratch brush or file marks run parallel to the limbs in areas.

The ends of two round cut-off sprues remain visible on the top of the base: one to the right of Cain's left foot (approx. 1.4 cm diameter; fig. 24.5) and one on the rock under Abel's left buttock (approx. 1.5 cm diameter; fig. 24.10). A single small circular punch was used in a haphazard manner to texture the base, including the remaining cut-off sprues (figs. 24.5, 24.10). A flat, textured punch was used on some of the strands of hair on both figures.

The signature was cut into the metal and is quite rough and haphazard compared to other signatures by the artist. The letters were stiffly engraved, with lines cut twice where necessary. The sizes of the letters vary considerably on each of the four sides (figs. 24.11–24.14).

g. Patina

The bronze has been coated with a clear lacquer that is not original. Streaks of light-colored tarnish are due to uneven application of the coating. Patches of bluish green on the surface (such as Abel's lower back) appear to be due to

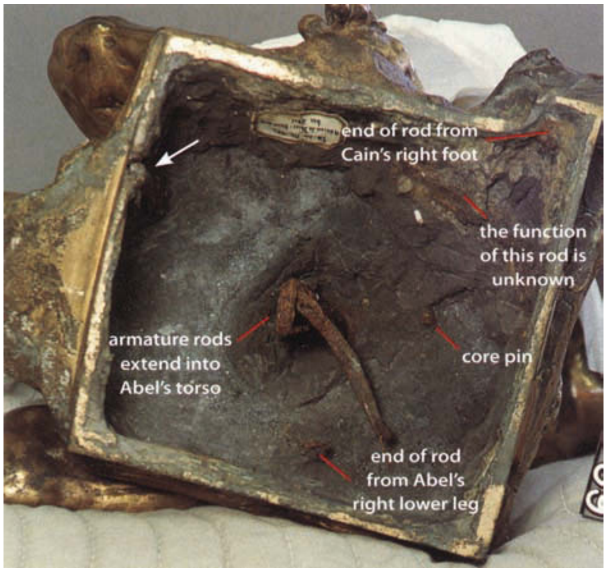


FIGURE 24.7 Open bottom of the base. Arrow indicates the end of the rod that likely continued through the top of the base, then outside of the wax to support Cain's torso.

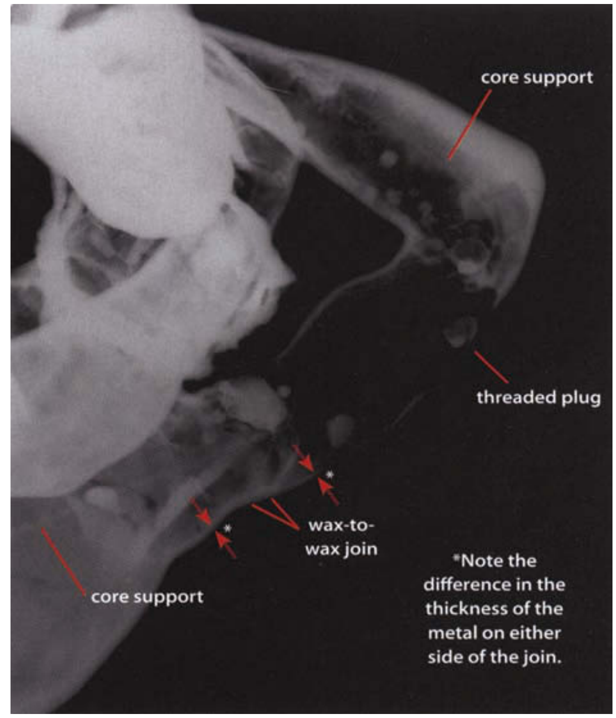


FIGURE 24.8 Radiograph of Abel's right shoulder.

FIGURE 24.9 Abel's face. Whereas the beard and mustache were present in the wax model, the worry lines, pupils, irises, and teeth were applied in the metal.

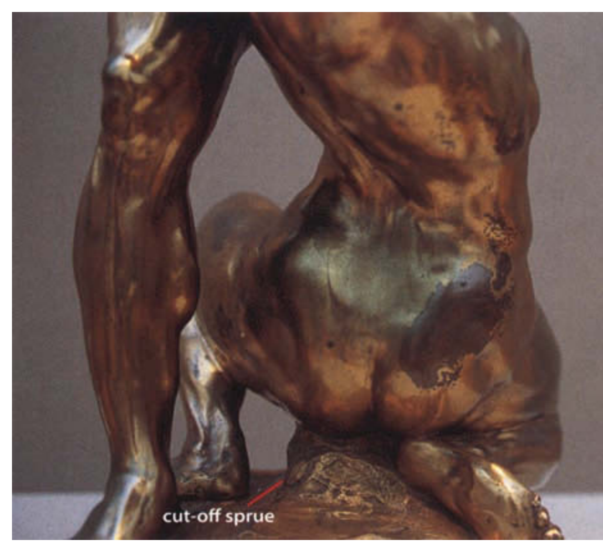


FIGURE 24.10 Abel's back. The polished bronze surface is corroding to varying degrees.

FIGURE 24.11 Signature (proper left side of base). The letters were engraved into the metal.

FIGURE 24.12 Signature (back of the base). The size of the letters is not consistent.

FIGURE 24.13 Signature (proper right side of the base).

FIGURE 24.14 The date (front of the base) is partly covered by a later inventory tag.

corrosion of the bronze from unstable components in the lacquer, or from an unstable material left on the surface below the coating. The larger brownish black spots, as on Abel's right buttock, are where more advanced corrosion has taken place (fig. 24.10).

3. Casting Defects and Foundry Repairs

Moderate flashing appears in the interior. Shrinkage porosity clusters in the extremities such as Cain's right arm (fig. 24.6). The shrinkage porosity has broken through the surface in many areas, much of which has been plugged. A large number of round plugs of varying diameters can be seen on the radiographs (0.25 cm to 1.5 cm diameter). Some of the plugs are threaded, and some are not. Two round plugs in Abel's right elbow appear to have been soldered in place with drips of solder running down from them (fig. 24.4). Many of the plugs are easily seen on the polished surface of the sculpture, either because of the gap between the plug and the surrounding bronze or because the polished repairs are a different color from the surrounding metal (often more yellow). The high density of the small, irregularly shaped repairs in the jawbone and in Cain's right hand and forearm suggests that they are cast-in lead repairs (fig. 24.6). There is a crack across Cain's fingers and the top of the jawbone.

4. Later Modifications/Restorations

The tip of one of the teeth on the jawbone has been repaired; it is not clear when this repair was done. There are four holes in the sides of the base. Metal flanges in the interior indicate that the holes were drilled after casting, perhaps for mounting of the piece.

SUMMARY

The technical examination of the Copenhagen *Cain and Abel* has shown that the base and figures were cast together in one piece using a bronze alloy with a clay-based core typical of those used by de Vries. The sculpture was cast using the indirect lost wax technique, as indicated by the wax-to-wax joins and remnants of wax drips from the slush molding of the casting model. Extensive cold work was done to rework the features after casting. There are extensive repairs, including threaded plugs and soft solder.

The *Cain and Abel* was examined alongside the version now in the University of Edinburgh. In the *Summary* section of chapter 18, the materials and methods used to cast the two compositions are examined and the argument is presented that both models were made and cast by de Vries using the indirect lost wax technique, likely using the same set of molds. In the discussion below, the work done after casting is shown to differ significantly between the two versions and a hypothesis is presented for the early history of the Copenhagen version.

Unlike with the Edinburgh version, the surface repairs and cold working of the Copenhagen bronze are not at all reminiscent of the work of de Vries. First, the artist generally used only minimal repairs, often leaving surface porosity as-cast. In contrast, there are a large number of small repairs on the Copenhagen version. Techniques used to repair the flaws in the Copenhagen bronze include cast-in lead repairs, threaded plugs, and soldered plugs, techniques rarely seen in de Vries's other work. The surface chasing on the Copenhagen cast differs from de Vries in that the artist often concentrated on finishing the fine details in the wax, without further touch-up in the metal. In contrast, a considerable amount of cold work has been added to the Copenhagen version, some of which is quite haphazard. For example, Abel's pupils, teeth, and forehead lines were left as-cast on the Edinburgh version, yet are delineated in the metal on the Copenhagen version, lending the later version a cartoonlike nature (compare figs. 18.9 and 24.9). In addition, the random application of a circular punch in the base is atypical. Throughout his career, de Vries textured the bases by applying just one type of punch in a given area; the texture often complements the modeling—differentiating rock from fern, for example. In this instance, though, the punch was randomly applied without reference to the different surfaces. Finally, the signature on the Copenhagen cast shows none of the characteristic exactitude found on all of de Vries's other signed pieces (compare fig. 18.10 and figs. 24.11–24.14).

What evidence do we have for the history of the pieces that may clarify the artist's original intentions for the composition, and why does the surface chasing differ so much between the two casts? Evidence points to the 1612 Edinburgh version having been cast and finished by de Vries, then sometime after Rudolf's death in January 1612 placed into Rudolf's *Kunstkammer,* where it was recorded in the 1619 inventory (Scholten 1998a: 192). The history of the Copenhagen bronze is less clear. First mention of it was made in a 1621 letter from the artist to his patron Count Ernst von Holstein-Schaumburg, where he includes it in a list of five as-yet-unfinished statues that he was working on for the count. The count died in January 1622, and the bronze was never delivered to his estate. The history of the group is unclear until it appears in Danish royal inventories in 1749 (Scholten 1998a: 230).

The following scenario is proposed. Sometime before 1612, de Vries made a model of the *Cain and Abel* group, most likely as a commission from Rudolf II. For some reason, he chose to cast the sculpture indirectly, so molds were taken from the original model.[2] The casting wax was formed in the molds, and final details such as the signature were added to the wax. The sculpture was cast and chased, and the bronze entered the royal *Kunstkammer* in Prague. Ten years later de Vries was still working in Prague, but after the death of Rudolf, he concentrated on major commissions for other patrons, including the simultaneous creation of five sculptures for Count Ernst von Holstein-Schaumburg. From the letter of 1621, we know that one of these sculptures was a *Cain and Abel* group. The fact that the earlier version was cast indirectly would suggest that de Vries simply used the same molds for the second version. The smaller dimensions of the Copenhagen cast might suggest that de Vries took a second set of molds from the bronze in the *Kunstkammer,* yet the lack of an original signature on the Copenhagen version would argue that the original molds were reused. The smaller size of the Copenhagen version may be due to the inexact nature of the measuring technique and to the many variables in the indirect lost wax casting technique.

From the molds, a casting wax was made. Perhaps because it is a multiple, de Vries did not sign the wax, and—in keeping with the artist's style at the time—the base was left more impressionistically modeled than on the earlier version (compare figs. 18.8 and 24.5). A letter of assurance was written to the count letting him know that the project was under way, and the bronze was then cast. Soon after, though, the count died and the bronze was never delivered. It seems likely that the bronze sat in de Vries's workshop, untouched until de Vries himself died four years later. In his will de Vries arranged for his assistants to remain in his house for one year after his death to complete all the unfinished sculptures (Scholten 1998b: 34). It may be that during this period after de Vries's death the *Cain and Abel* group was completed: repairs were made and the final surface chasing done. It may well have been de Vries's workshop that finished the bronze, not some other studio to which the remaining effects were sold, because of the date engraved with the signature. In considering de Vries's letter of 1621, this may well be the correct date for the casting of the piece, a fact his workshop assistants would know. It is troubling that the quality of the chasing is far inferior to that of the master, but it is reasonable to assume that the most talented assistants left in the months after de Vries's death; it may also reflect the degree to which the artist was directly involved with each piece.[3] The version that had been in Rudolf's *Kunstkammer* then somehow made its way to Edinburgh; the second, later version then ended up in Denmark, perhaps having entered through the Copenhagen *Kunstkammer* of King Christian IV (Scholten 1998a: 230). It may have been while in the royal collection that the patina was removed, revealing the polished bronze surface. An aged organic patina left on a bronze surface undergoes extensive cross-linking, rendering it extremely difficult to remove. One method for removing the patina would be to burn it off. As temperatures as low as 300 degrees C will begin to erase an accumulated TL signal, heating of the bronze in order to remove the organic patina may be the reason the thermoluminescence results showed an early-eighteenth-century date for the bronze.

In conclusion, the analytical data indicate that the Edinburgh *Cain and Abel* was indirectly cast by Adriaen de Vries. De Vries also cast a second version, now in Copenhagen, most likely using the same molds as those used for the Edinburgh bronze. Although a fairly large percentage of the bronzes examined in this study were cast indirectly—far more than anticipated at the outset of the project—the fact that so few of them were cast in multiple suggests that there is much about de Vries's workshop, his output, and his commissions that is yet to be discovered.

NOTES

1 The sample was removed by Bewer during preparation for the exhibition catalogue (R. Schmidtling, unpublished report).

2 A reason for casting indirectly may have been that the artist created the original model in solid wax or in clay—both of which would have necessitated the use of molds to make a hollow wax casting model. As the Edinburgh cast is dated the same year as Rudolf's death, it is also possible that the artist anticipated a move away from one-off casts with the loss of his primary patron.

3 An intriguing note in an article by Eliška Fučíková (2005) mentions a *Mercury* recently discovered in the Karlskrone (Karlova Koruna) Manor in Chlumec nad Cidlinou. The bronze evidently bears extensive casting flaws and repairs. Fučíková surmises that the bronze may date from the very end of the artist's life. A close examination of the surface might show evidence of it too having been completed in the workshop after de Vries's death; a comparison of the cold work with that of the Copenhagen *Cain and Abel* would be of interest.

CHAPTER 25

Laocoön and His Sons

Nationalmuseum, Stockholm. Inv. no. Drh Sk 68
Cast in Prague in 1623
Dimensions: H: approx. 169 cm × W: 91.1 cm × D: 105.7 cm
Marks and inscriptions: Inscribed in the wax on the back of the base:
ADRIANVS FRIES HAGIENSIS BATTAVVS FE. 1623

OVERVIEW

The group is a variation of the celebrated Roman marble now in the Vatican Museum, representing the Trojan priest Laocoön with his sons, fighting sea serpents (figs. 25.1, 25.2). The work was commissioned by Albrecht von Waldstein for his palace in Prague. It stood in the gardens at Waldstein Palace from 1626 to 1648. Taken to Sweden in 1648, it was installed in the Drottningholm Palace garden in 1684 and moved indoors to the Nationalmuseum, Stockholm, in 1973.

The technical study was undertaken to add to our understanding of de Vries's methods and materials. It was of particular interest to determine how the artist constructed the casting model and whether the bronze was cast in one pour.

EXAMINATION

1. Alloy

Five areas from the bulk alloy of the sculpture were analyzed. The results yielded an alloy containing approximately 19 to 30 percent tin in a copper matrix with less than 0.5 percent zinc and lead content of 1 to 3 percent. The measured amount of tin likely differs from that of the bulk alloy due to tin enrichment of the surface caused by inverse segregation. Indeed, the highest level of tin found

FIGURE 25.1 *Laocoön and His Sons*
Nationalmuseum, Stockholm. Inv. no. Drh Sk 68

FIGURE 25.2 *Laocoön and His Sons*
Nationalmuseum, Stockholm, Inv. number Drh Sk 68

FIGURE 25.3 The silvery color on the side of the supine son's face is due to surface enrichment with tin caused by inverse segregation of the metal as it cooled.

during the alloy analysis (30%) was measured in an area of silvery patina on the cheek of the supine son (fig. 25.3). Although the corrosion product was not identified, it strongly resembles tin oxide. The surface enrichment is not isolated to just the silvery areas, as the tin in all of the spectra measured 20 percent and above. Should a more accurate assessment of the overall alloy be needed in the future, it will be necessary to take a drilled sample that will not be influenced by surface phenomena.

A small, set-in repair on Laocoön's left thigh is composed of an alloy that closely resembles that of the sculpture itself, suggesting it may have been applied in the foundry. Three larger repairs on the left thigh are brasses with 10 to 13 percent zinc, 3 percent lead, and low amounts of tin. Large, set-in geometric repairs such as these are unusual for de Vries. It is unclear if they repair casting flaws or subsequent damage to the bronze resulting from expansion of the iron armature that remains in the interior.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Iron armature rods remain in all three figures, although many of the rods have been removed. There are no rods or wires in the serpent; the radiographs suggest that none were used. The complexity of the composition and the high density of the radiographs in thicker areas, such as Laocoön's torso, make it difficult to see the remaining armature in some areas.

Laocoön: A rectangular hole remains in the interior of the bronze where a large-diameter armature rod has been removed. The hole measures 2.5 cm × 2.5 cm and is located in the metal that joins Laocoön's right buttock and the left side of the kneeling son's back. The location of this hole is illustrated in the structural summary (fig. 25.4). It is unclear exactly where the armature would have extended, but its size indicates that it would have been one of the major supports inside the figure of Laocoön, perhaps in a manner similar to the support rods in Amphion and Dirce in the *Farnese Bull* composition that run through adjacent figures.

Pairs of rods run through each of the arms. Two rods run through the left leg; a twisting wire near the knee binds the pieces together. Three rods run through the right leg; the largest rod in the right leg measures 1.3 cm in the foot, tapering to 0.8 cm in the upper leg. Examination of the open bottom of the sculpture shows that armature rods extend through to the underside of the base from both of Laocoön's feet (fig. 25.5). It is likely that there are numerous additional rods in the figure of Laocoön that cannot be seen due to the density of the radiographs.

Kneeling son: A large hole in the front of the torso allowed removal of much of the armature in the body. A rod circles through the head, although the radiographs do not show where this rod begins and ends. A rod and wire run together through each arm. Thin wire binds the armature together in the left wrist.

Two vertical rods bound to one another with a thin wire extend down the left thigh. The ends of the rods are not visible in the radiographs. Two rods rise from the right foot through the bent leg and into the torso (fig. 25.6).

Supine son: The relative lack of density in the torso of the supine son indicates that the core has been removed in this

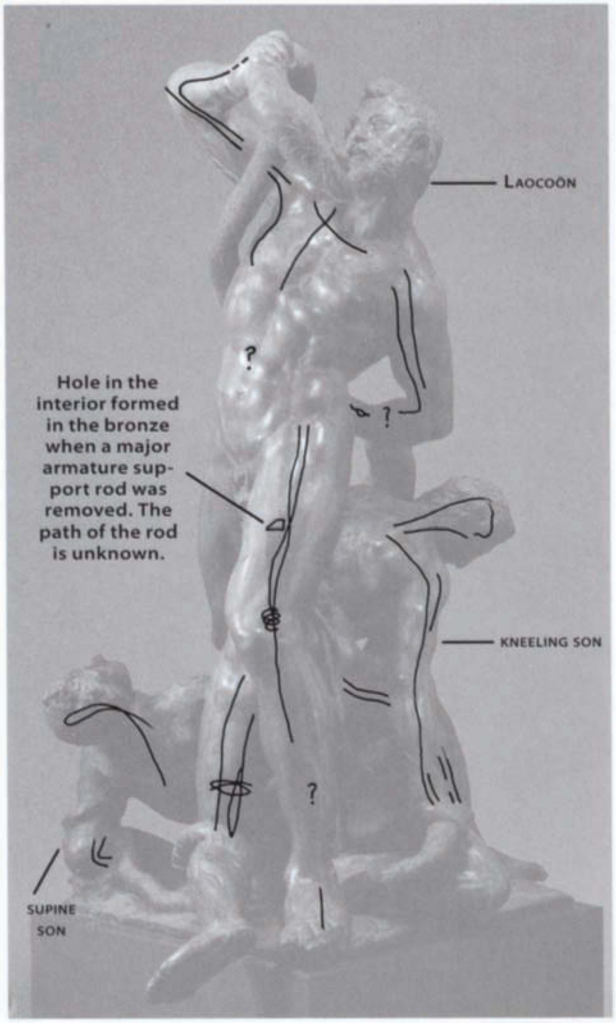


FIGURE 25.4 Summary of the remaining armature rods and wires. Question marks refer to areas that are not clearly legible in the radiographs.

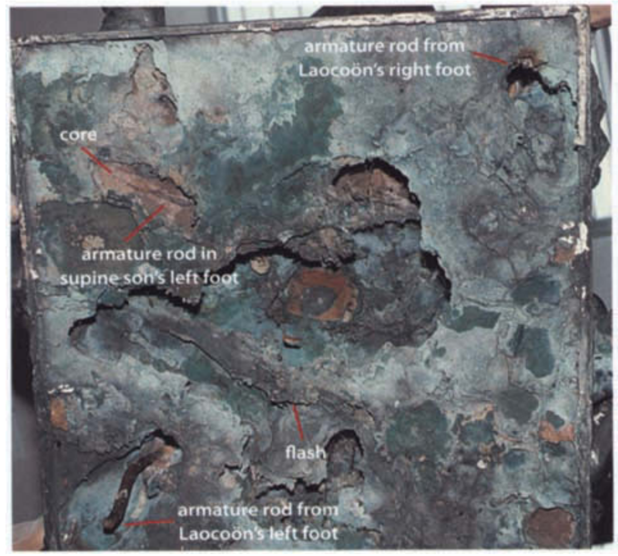


FIGURE 25.5 Open bottom of the base.

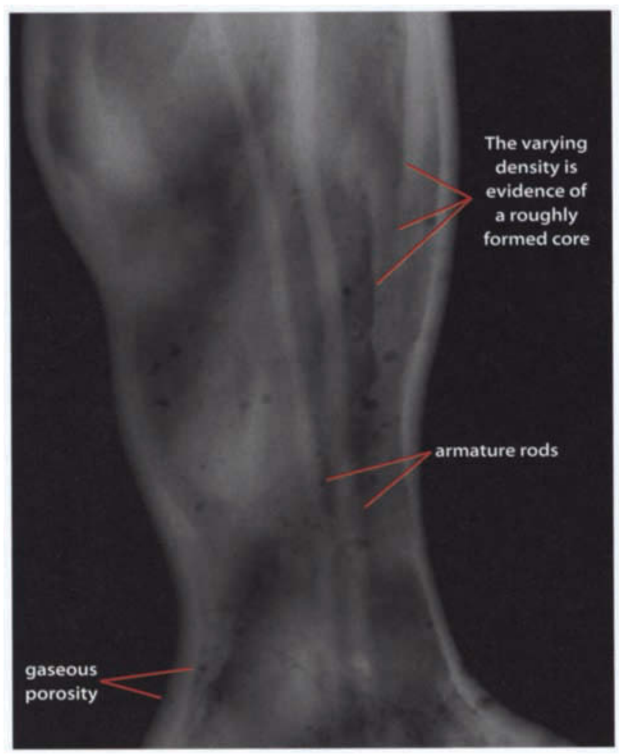


FIGURE 25.6 Radiograph of the kneeling son's right lower leg.

area. Much of the armature was surely removed at the same time (fig. 25.7). A single wire loops from the center of the chest into the head, ending back in the upper torso. A single rod runs diagonally from the right shoulder through the torso. In the left arm, a rod and wire curve through the elbow. There are no rods or wires remaining in the right upper arm; the core appears to have been removed in this area also. Two rods curve through the left leg as it bends sharply at the knee; one of the rods exits the foot below the base (fig. 25.5).

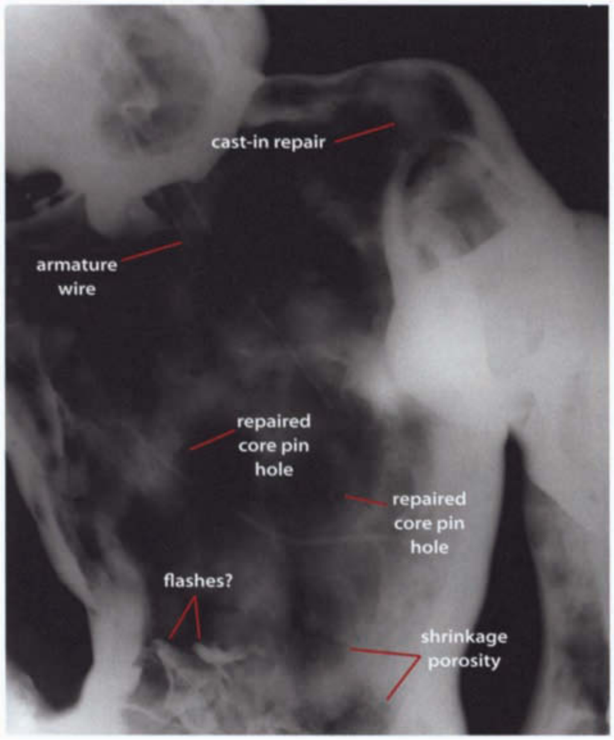


FIGURE 25.7 Radiograph of the supine son's torso. Much of the core has been removed.

b. Core pins

A number of rusty red spots on the surface of the bronze appear to be from iron core pins that were cut off but not removed or plugged. None of these pins are visible in the radiographs (fig. 25.8). The core pins are square in section. Two repaired core pin holes on the chest of the supine son measure 0.3 × 0.3 cm (fig. 25.7).

c. Core material

The core is soft and crumbles easily. It varies in color from reddish brown to gray. The core remains in the serpent and in most of the figures but has been removed from the base, from Laocoön's right foot, and from much of the kneeling son's and supine son's torsos. The color of the samples is related to the temperature or state of oxidation in the core during firing and not to variations in the composition. The variations in composition are likely due to the uneven distribution of sand and minerals that occurs naturally in the clay. Quantitative analysis yielded the following:

Reddish portion of sample

- 68 percent reddish clay
- 23.5 percent quartz
- 5 percent feldspar
- 1.5 percent opaque rock fragments (andesite)
- 1 percent biotite
- 0.5 percent muscovite
- 0.5 percent hematite
- trace of oxy-hornblende (lamprobolite)

Gray portion of sample

- 77.5 percent gray clay
- 18 percent quartz
- 3.5 percent feldspar
- 1 percent hematite
- trace of oxy-hornblende (lamprobolite) and muscovite

An additional small chunk of core was dated to 1610 ± 20 using the thermoluminescence technique.

d. Internal surface of the bronze

The entire sculpture was cast hollow, with the exception of the figures' toes and fingers and the serpent's tongue, which were cast solid. The core runs continuously from the base into the figures and from the hands into the serpents. This evidence of the continuous modeling of the core from the hands to the serpent is illustrated in figure 25.9, an X-ray scan of the kneeling son's left hand on the serpent,

FIGURE 25.8 The serpent scales were laboriously formed by hand entirely in the wax.

FIGURE 25.9 Radiograph of the kneeling son's left hand. The lack of a distinct line of higher density between the hand and the serpent indicates that the core runs continuously from the hand into the serpent, evidence that they were modeled and cast together.

where only the relatively low opacity of the core is found between the serpent and the hand.

The relative lack of solidly cast elements suggests that the core was formed with great accuracy, but the rough contours and varying thickness of the bronze in many of the limbs indicate that it was also formed quickly (fig. 25.6).

There are two places where fills have fallen out, allowing measurement of the thickness of the metal:

1. The metal around the hole in the kneeling son's chest measures 0.5 to 1.0 cm thick.
2. The metal around the hole in the kneeling son's left foot is much thinner, at 0.1 cm thick.

e. Method of assembly and joining of individual wax or cast bronze components

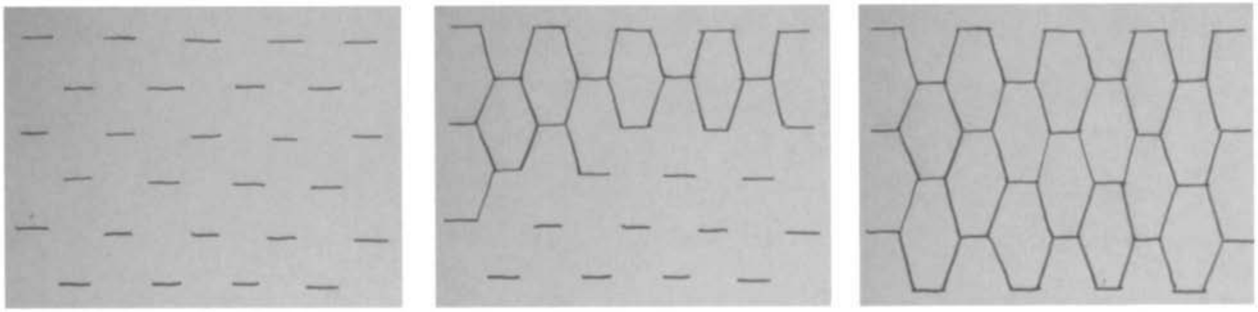
Examination of the radiographs as well as the inside of the sculpture through the open bottom and through the hole in the kneeling son's chest show that the entire sculpture was modeled and cast in one piece without wax-to-wax or metal-to-metal joins.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The wax model was brought to a careful finish in some areas, yet quickly worked in others, in particular, in the transition areas, which were often left rough (fig. 25.10). The faces were loosely formed in an impressionistic style typical of de Vries's later years (fig. 25.3). The flesh is highly polished, with coarse to fine polish lines in many areas, although some of these may be the result of later cleanings. A considerable amount of texturing covers the hair, scales, foliage, and base.

In contrast to the loose modeling in many areas, the scales of the serpent were meticulously formed (figs. 25.8, 25.10). The scales were individually drawn and textured in the wax in what would have been an extremely time-consuming process, allowing adjustments for the varying dimensions as well as twists and turns of the serpent. It would not have been possible to apply the pattern with a stamp, which would lack the flexibility needed to vary the scales from area to area. Figure 25.11 describes how the scales may have been formed and textured in the wax.

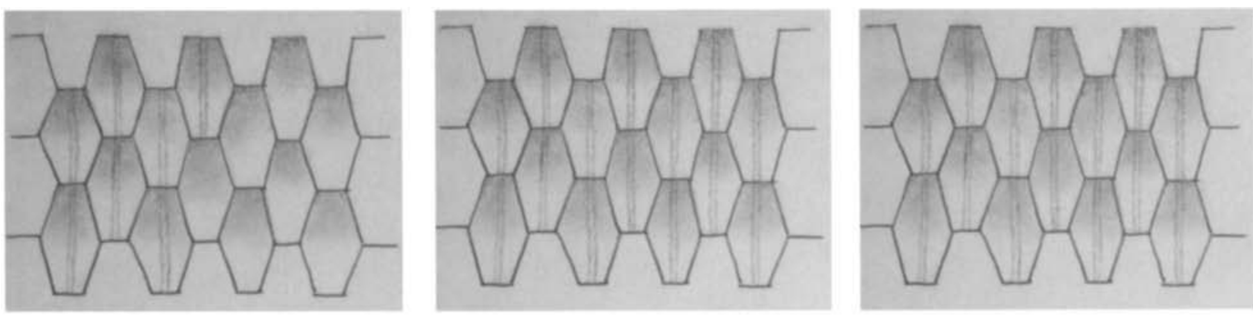
FIGURE 25.10 The modeling was left rough where the supine son's back meets the base (at the top of the photo).



a. Parallel lines of short dashes were scored into the wax to define the top and bottom of each scale.

b. Downward strokes were made, connecting the dashes.

c. Each scale was outlined once the dashes were connected.



d. The top half (or more) of each scale was carved down at a slope, making it so that the bottom half stands higher than the top half.

e. Two parallel lines were then punched down the center of each scale, causing the wax down the center of the line to bulge up.

f. Finally, each scale was textured overall with a small oval or rectangular flat punch; the amount of texturing varies from area to area.

FIGURE 25.11 Steps in forming serpent scales.

The carefully modeled and textured hair was also formed in the wax, in steps (fig. 25.12) (for a detailed description, see chapter 21, section 2f). This same technique, without the addition of the accenting gouges, was used for many of the leaves that cover the base (fig. 25.10). Much of the base and all of the vines were textured with a rectangular punch with raised squares similar to that used on the tree trunk, vine, and club of the *Hercules Pomarius* (fig. 26.8).

A set-in repair on the base of the sculpture has been textured in a manner that matches that of the surrounding metal. The punch marks were likely applied to the plug after it was fit into the gap (fig. 25.13). For various reasons, including the relative lack of repairs, there are very few similar instances in de Vries's oeuvre where we can be certain that punched texture was applied in the metal. Certainly the very hard alloy in which the artist worked

FIGURE 25.12 Laocoön's hair and beard were formed in a manner typical of the artist after about 1613.

FIGURE 25.13 Photomicrograph detail of a repair plug in the base under raking light, illustrating an area where the punched texture was applied in the metal.

and the extensive texturing on many of his pieces suggest that it would have been far easier to have added the texture in the wax. At present, though, this is one small example of texturing that can be attributed to cold work.

The signature was written between guiding lines on the back of the base. The signature and date were likely engraved into the wax rather than the metal. The letters and numbers have not been as perfectly applied as the artist's earlier signatures (fig. 25.14).

As seen on many of de Vries's larger bronzes, in this one he adapted the sprues—normally a purely functional element of the casts—into the final design. A series of thin vines (with leaves attached sporadically) twist between the figures. The vines and leaves are roughly modeled and, as on many other de Vries compositions, appear conspicuously inelegant. The branching vines act as a *cache-sexe* for the three figures, partially covering the quickly formed genitals (fig. 25.15). The vines likely served the function of sprues, helping either to feed metal into or push gases out of the mold. The vines remain in the following areas:

1. A double twisting vine begins in the fold between the supine son's legs and disappears behind Laocoön's left upper thigh, ending at his genitals. Two vines branch off of this vine.

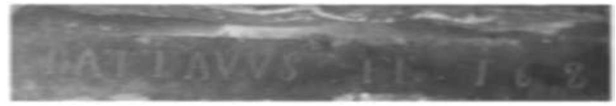


FIGURE 25.14 The signature was inscribed in the wax on the back of the integral base.

FIGURE 25.15 The large repairs on the left thigh may not be original and have been recently altered. Sprues such as this one with added leaves act as a *cache-sexe*, partially covering the roughly formed genitals.

2. One side branch reappears below Laocoön's left buttock.
3. The second double twisting vine branches off near the bottom and ends as a cover to the kneeling son's genitals.
4. A separate short vine extends from the base to cover the supine son's genitals.

g. Patina

Any original coating that might have been applied is now lost due to outdoor exposure and corrosion.

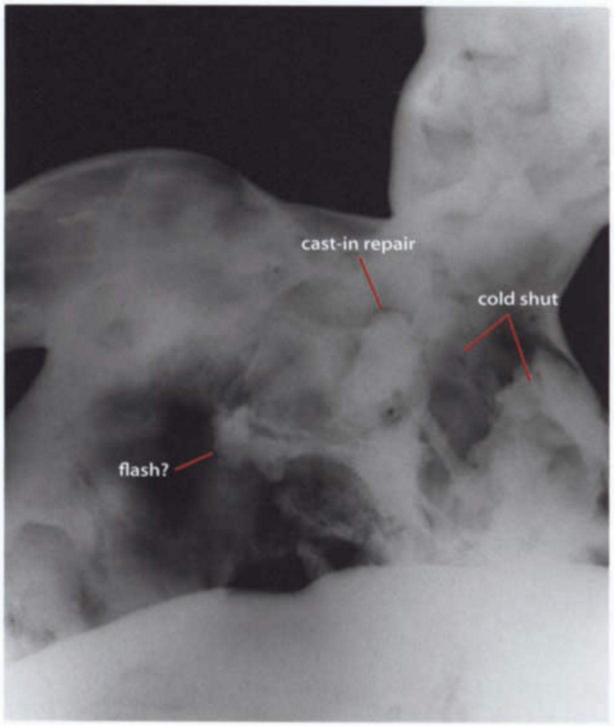


FIGURE 25.16 Radiograph of the kneeling son's torso.

3. Casting Defects and Foundry Repairs

As might be expected of a complex cast of this size, de Vries ran into difficulties with the cast. Discontinuities in Laocoön's neck and right shoulder, as well as the adjacent serpent and the top left side of the kneeling son's chest, were caused by a "cold shut," in which the metal began to cool before filling the mold, keeping it from fully fusing to itself.[1] In the radiographs, these cold shuts appear as thin lines of lower density between the areas that did not fuse (fig. 25.16). When first cast, the cold shut flaws were likely less disfiguring on the surface, appearing simply as meandering, recessed lines. Over time, though, corrosion has accentuated the differences in the metallographic structure from one side of the cold shut to the other, highlighting the flaws (fig. 25.17). Although a variety of minor casting flaws can be observed on de Vries bronzes, this is the only bronze examined that exhibits this type of damage.

Small- to medium-vacuole porosity, formed by the trapping of gases in the metal, is clustered in the extremities. Large-vacuole porosity appears more rarely. Some of this porosity extends into the surface of the bronze, and in many places it has not been repaired (fig. 25.12). Numerous porosity holes in the base go straight through the metal, which is quite thin around the holes. Minor shrinkage porosity due to uneven cooling of the metal appears in all three figures.

There is a large hole in the kneeling son's chest. The bronze repair that once filled the hole is now lost. It is not clear what system had been used to secure the repair. The hole may be a large casting flaw whose edges were chiseled straight, as the edges of the hole are riddled with porosity. It has also been suggested that the hole has been left intentionally in this rather hidden area to allow removal of the core, although this step was not carried out, as a considerable amount of core remains in the torso.

Figure 25.5, showing the open bottom of the sculpture, reveals a large number of jagged-edged flashes where molten metal entered cracks in the core. It is likely that many of the large sharp-edged areas of increased density in the radiographs, such as those in the kneeling son's torso (fig. 25.16), are flashes also. Fine flash lines appear in almost every radiograph.

For a sculpture of this size, cast in one piece, there are relatively few repairs. Three types of repairs were used: set-in bronze patches, cast-in repairs, and bronze repairs soldered in place. Many of the set-in repairs can be seen in the radiographs but are more difficult to see on the surface of the bronze. The cast-in repairs appear as smooth-edged areas of increased density on the radiographs and as irregularly

FIGURE 25.17 Discontinuities in Laocoön's right shoulder are likely due to "cold shut" caused by premature cooling of the metal during the pour, now accentuated by uneven corrosion.

shaped fills on the surface of the bronze, such as the oval cast-in repair on the right shoulder of the supine son (fig. 25.7).

The soldered-in plugs are distinctive for the corroded, light-colored metal that surrounds them, likely a lead-tin soft solder. A copper alloy plug soldered into the left side of the kneeling son's left calf is likely a later addition. The plug was crudely formed and appears to be of a different alloy than the surrounding metal. Plugs soldered into the kneeling son's left ankle and foot better match the surrounding surface and are more likely to be earlier in date. The solder has corroded overall; a rectangular repair soldered in place below the kneeling son's left foot has fallen out, leaving a rim of white solder metal exposed at the edges of the loss.

4. Later Modifications/Restorations

The surface is covered with corrosion caused by outdoor exposure. It is a dark bluish to olive green color that is streaked in areas. The silvery appearance on some surfaces is due to elevated tin on the surface caused by inverse segregation, now accentuated by corrosion (see sec. 1 above; fig. 25.3).

Four large angular brass patches on the left thigh of Laocoön lack the elegance of many de Vries repairs and may not have been applied in the foundry (fig. 25.15). The repairs have corroded to quite a different color than the surrounding bronze. One of the large fills is lifting. Pins around the lifting fill may be an earlier attempt to hold it in place. File marks go through the corrosion and over the edges of these repairs. The entire front of the left thigh has been wiped with a liquid that etched the corrosion patina, lightening the color of the surface and accentuating the repairs.

The fill in what appears to be a shrinkage crack on the right side of Laocoön's belly bears similar rough file marks and has also been wiped with a liquid that has lightened the surface, suggesting it too may be a recent repair or an old repair that has been more recently tampered with.

SUMMARY

The technical study shows that the bronze was cast in a single pout, an impressive feat for a sculpture of this size and complexity. Two details revealed in the radiographs offer clues as to the artist's method of creating the composition. When one is working in the direct lost wax method, few changes can be made to the casting model once the rigid armature and clay core have been put in place. Throughout *Laocoön and His Sons,* there are remarkably few solid-cast or very thick areas, indicating that the artist had a clear picture of the exact composition as the armature and core were being formed, allowing the wax layer to remain even throughout. The complexity of the composition would strongly argue, therefore, that the artist created at least one three-dimensional model from which to build this piece. The second interesting construction detail revealed in the radiographs is the lack of armature rods and wires in the serpent. By leaving the rods out, the artist would have been free to complete the core in the rest of the composition before deciding the exact undulations and bends in the body of the serpent between the grasping hands, allowing flexibility in the design of this important feature.

Roughly modeled leaves attached to a number of sprues that were left in place act as a *cache-sexe* for the three figures, partially covering the quickly formed genitals. As recognized by Bewer (2001: 182), the entire composition was designed to allow the metal to flow from one form to another, with few "dead ends" where the metal did not lead directly to another form. This interconnection includes the limbs of the figures themselves as well as the serpent and would have allowed for a reduction in the number of sprues needed to feed metal into the mold.

The remarkably few casting flaws are cold shut surface discontinuities resulting from premature cooling of the metal and minor surface porosity. A relatively small number of set-in, cast-in, and soldered-in repairs are visible on the surface and in the X-ray radiographs. Two repairs, one of which is quite sizable, are now lost. Corrosion from outdoor exposure accentuates the casting flaws and repairs.

The sculpture is an exemplar of de Vries's expertise in creating a complex model that could be cast in a single pour with a minimum of flaws, one in which he beautifully combines the loose modeling of his later years with passages of meticulous detailing.

NOTES

1 I am grateful to Sandy Decker of the Decker Studios foundry, North Hollywood, California, for discussions about this flaw.

CHAPTER 26

Hercules Pomarius

Muzeum hlavního města Prahy, Prague. Inv. no. VP 400

Cast in Prague in 1626

Dimensions: H: 167 cm × W: 81.2 cm × D: 75.8 cm

Smallest waist circumference: 75.2 cm

Marks and inscriptions: None.

OVERVIEW

The sculpture represents Hercules, standing with a club thrown over his left shoulder and a large cornucopia between his striding legs (fig. 26.1). It is unknown for whom the sculpture was made. Although the figure is in keeping with the style and subject matter of bronzes cast for Albrecht von Waldstein, it is not included in the list of works commissioned from de Vries for Waldstein Palace. The bronze was found in a private collection in Prague at the end of the 1800s and is currently being exhibited in the Museum of the Capital Prague.

The technical study of this very late bronze was undertaken to add to our understanding of de Vries's methods and materials.

EXAMINATION

1. Alloy

Two areas of the bulk alloy of the cast were analyzed, showing a metal composition of approximately 14 to 15 percent tin in a copper matrix with zinc and lead contents below 0.5 percent. The *cache-sexe* was cast of a brass containing approximately 17 percent zinc, 2 percent tin, and 2 percent lead.

FIGURE **26.1** *Hercules Pomarius*
Muzeum hlavního města Prahy, Prague. Inv. no. VP 400

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

A summary sketch of the primary armature rods and wires can be found in figure 26.2.

The radiographs show that a relatively small number of armature rods run through the figure. They include a pair of rods that run up each leg and straight into the torso. A single rod runs up from the pelvis, through the middle of the torso, and into the head. Lines of lower density running along the length of two of the rods are likely due to a fold or structural defect caused while the wrought iron was being shaped, an unusual feature in this study of de Vries's sculptures.

The vertical rods in the torso are tied together with one horizontal rod in the stomach and numerous wires. A 2.5 cm wide "strap" of thin metal makes a large loop around the thin rod that extends up into the head. Just below this loop, a horizontal rod makes a similar loop. It is possible that a large-diameter armature rod that was once encircled by these ties was removed from the center of the torso, although there is no obvious evidence of this on the surface of the bronze. The rod would likely have extended up the tree trunk, into the buttocks, and straight up into the torso (figs. 26.2, 26.3). Evidence for this type of central support rod has been observed on a number of de Vries bronzes, cast using both the direct and the indirect lost wax techniques, including *Farnese Bull, Laocoön and His Sons,* and *Hercules, Nessus, and Deianeira*. The rather small

Hi-res Fig. 26.2 TK

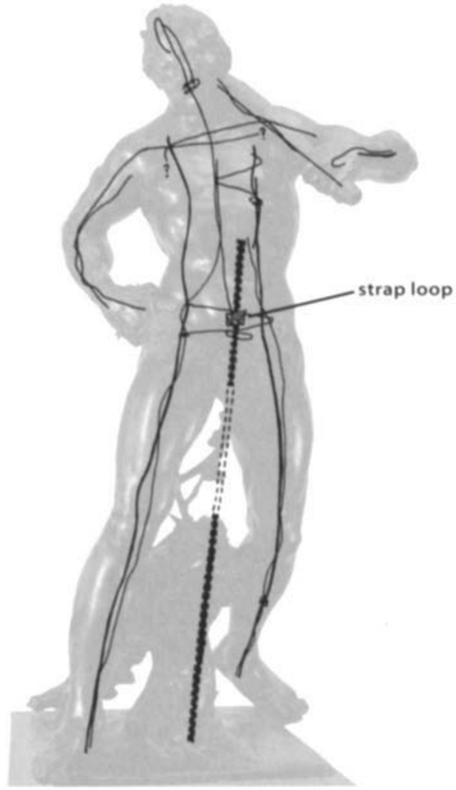


FIGURE 26.2 Summary of the remaining armature rods and wires. The dashed lines indicate the likely path of the primary support rod, now removed. The unshaded section indicates where the rod ran outside of the wax model.

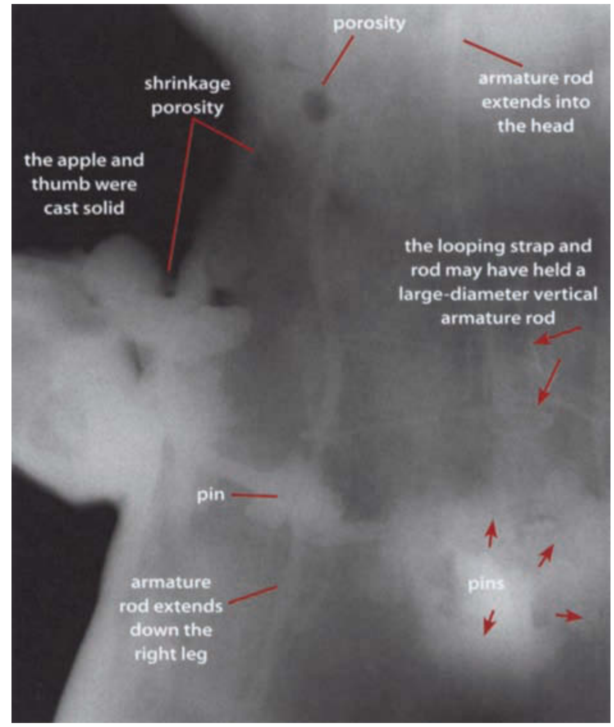


FIGURE 26.3 Radiograph of the right side of the torso.

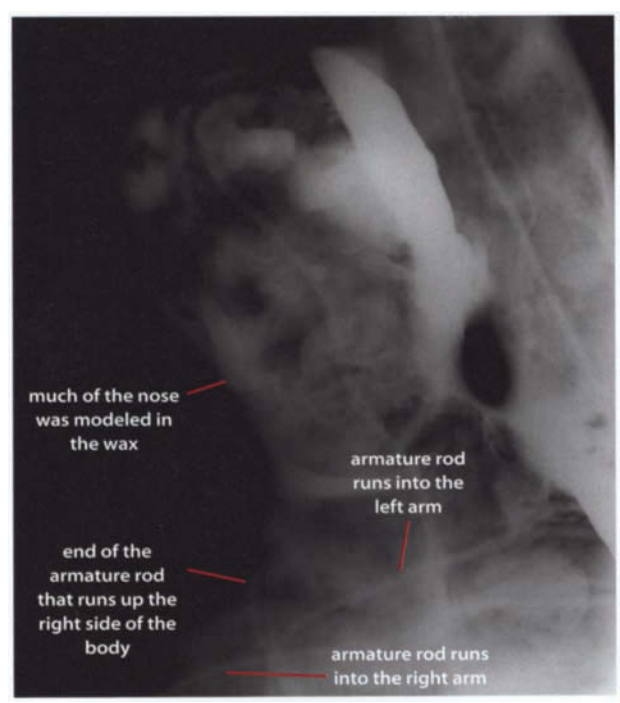


FIGURE 26.4 Radiograph of the head, shoulders, and club.

gauge of the armature rods that remain in the figure seems to support the argument that a larger central rod has been removed.

Like the legs, each of the arms contains a thicker rod and thinner wire. These armature supports run from the lower arms, up through the shoulders, and into the torso (fig. 26.4). A rod that runs straight through the length of the club does not connect to the armature rod in the left hand, allowing final placement and proportion of the club to be determined once the core in the figure was nearly completed (fig. 26.5). Two to four wires run inside the cornucopia; it is not clear in the radiographs exactly how many wires there are and where they start or finish. The armature rods in the tree trunk appear to have been removed when the core was taken out.

FIGURE **26.5** Radiograph of the left hand on the club.

b. Core pins

A small number of square holes (0.2 cm × 0.2 cm) visible in the radiographs appear to be core pin holes (e.g., in the left hand in fig. 26.5). Surely many more pins were used than are visible in the radiographs; fine features such as core pin holes are less clear in the radiographs of the denser sections of the sculpture.

c. Core material

The core is soft and crumbles easily. Most of the core has been removed from the base and up the tree trunk (fig. 26.6) but remains in the body. A core sample was taken for compositional analysis from inside the tree trunk. Quantitative analysis yielded the following:

- 82.5 percent reddish clay
- 10.5 percent quartz
- 3 percent gray clay
- 2 percent feldspar
- 1 percent calcite grains
- 0.5 percent sericite
- traces of oxy-hornblende (lamprobolite) and biotite

An additional small chunk of core was removed from inside the tree trunk and dated to 1595 ± 25 years using the thermoluminescence technique (1545–1645 when reported with two standard deviations).

d. Internal surface of the bronze

Only small, select parts of the composition were cast solid, indicating that the artist had a very clear vision of the final composition as the core was constructed. The radiographs indicate that the toes, fingers, apples, ears, and nose were cast solid (figs. 26.3–26.5).

e. Method of assembly and joining of individual wax or cast bronze components

Study of the radiographs, the bronze surface, and the open bottom of the sculpture reveals that the base and all of the figures were cast integrally; there is no indication of metal-to-metal or wax-to-wax joins.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The figure was loosely modeled, particularly in the face and genitals, which are depicted as generalized forms without linear details. Although the genitals are covered by a *cache-sexe,* only the slightest suggestion of a penis is hidden under the leaves. Although the modeling style is quite loose, de Vries paid considerable attention to careful texturing of many of the surfaces. In addition, the transition areas between the forms are fully modeled, a step that de Vries often did not take in his larger compositions (see, e.g., fig. 25.10).

A few of the long flat leaves on the cornucopia and base of the *Hercules Pomarius* have a polished finish, with the stems and veins applied as simple lines incised in the wax or as fine lines of single dots. Additional tufts of foliage were engraved loosely in the wax model. The hair, parts of the base, and some of the leaves were textured in a similar manner with a single, oval, convex, finely textured punch, applied in lines (fig. 26.7). Displacement of the material at the sides of the punch marks in these areas suggests

FIGURE 26.6 Open bottom of the base.

that they were applied in the wax. The tree trunk, vine, parts of the base, and the club were textured with a punch that appears to be a single or double line of small, raised squares, a relatively unusual punch for this study of de Vries bronzes but used extensively on the *Laocoön*. The texture from this punch is sharp in some areas, suggesting it may have been applied in the metal. Overall, the crispness of the texturing varies; some of it on the raised surfaces appears to have softened due to wear.

Scratch brush marks run horizontally across the chest and roughly parallel to the limbs and the rest of the torso. There are cross-hatching and random scratch brush marks

FIGURE 26.7 The strands of hair were loosely modeled, yet carefully textured with a punch.

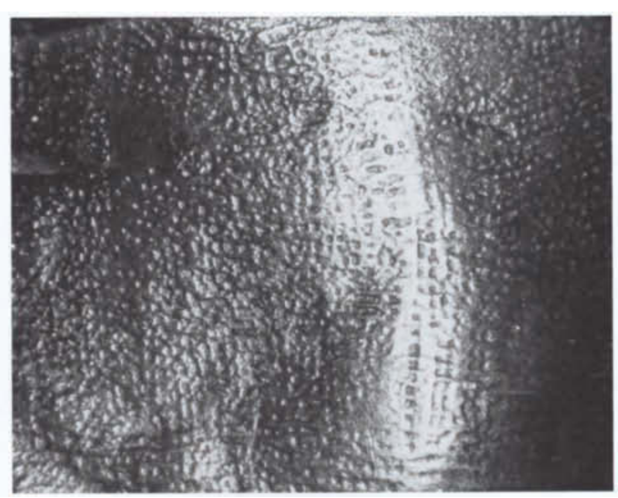


FIGURE 26.8 Photomicrograph of the texture in the tree trunk.

g. Patina

A translucent dark brown organic patina remains on the metal surface in the recesses, on the back of the figure, and on the base. The patina is nearly opaque where thickly applied. There are remains of a second coating over the translucent dark brown patina. This second coating is opaque, thick, and gray in color and is concentrated in the recesses of the cornucopia, on the back of the sculpture in the hair, under the club, and around the fruit in Hercules' right hand. On close examination, raised spots of green corrosion can be seen below this opaque gray coating; corrosion only occurs where the gray coating remains. Although no analysis was carried out, the material may be remnants of a nondrying oil that has accumulated a considerable amount of dust and soil over time. In areas where the organic patina layers are gone and the metal is exposed,

FIGURE 26.9 Originally, a sprue with added leaves loosely covered the genitals. At a later date, the penis was cut down and the area covered with a tightly modeled cluster of leaves that were pinned in place.

on the cornucopia horn and fruit. Some of the coarser marks may be later abrasions.

Sprues remain visible in four places. A few roughly modeled leaves attached to two of the sprues disguise them as vines. One connects the upper left calf to the tree trunk; another connects the top of the cornucopia to the side of the right upper leg, then branches up to the genitals (fig. 26.9; see also Appendix A, fig. A.31). The remains of two cut-off sprues attached to the bottom of the feet extend horizontally out from the base; they can be seen from the view of the bottom of the base (fig. 26.6).

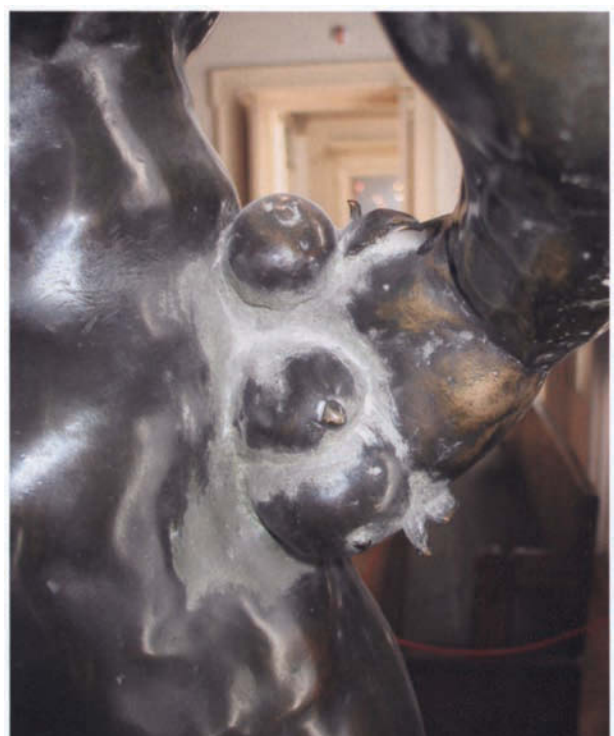


FIGURE 26.10 The apples of Hesperides in Hercules' right hand. This relatively protected area retains a considerable amount of the translucent dark brown patina as well as the later opaque gray material.

the surface has oxidized to a yellowish brown to greenish yellow brown (fig. 26.10). There is currently a clear glossy organic coating overall.

3. Casting Defects and Foundry Repairs

As with so many of de Vries's bronzes, the composition was cast with remarkably minor flaws. The radiographs show scattered small- to large-vacuole porosity throughout the sculpture. There is shrinkage porosity in the vine on top of the cornucopia, in the apples, and on the right side of the torso (fig. 26.3). Unrepaired porosity that breaks through the surface is concentrated below the right forearm and appears randomly in the base. Flashes can be seen in the radiographs in relatively few locations. Some occur as large, sharp-edged areas of additional metal and others as thin, distinct lines.

Only a small number of repairs can be seen in the radiographs or on the surface of the sculpture. There appears to be a cast-in repair between the shoulder blades and one on the right forearm. There are at least two repairs on the club: a set-in rectangular one near the left thumb and a large white paste fill higher up on the club (fig. 26.5). There are set-in repairs in the left thumb and left forearm.

4. Later Modifications/Restorations

A three-piece vine has been added to the front of the sculpture. The vine was cast in a leaded brass alloy quite unlike that used for the rest of the sculpture. The vine crosses from the right hand to the genitals, covering them with grape leaves (fig. 26.9). It appears as though the penis and perhaps the original leaf that partially covered it were cut off a bit to allow the leaves closer contact with the torso. The separately cast sections of the vine are pinned to the body (fig. 26.3). The leaves were carefully modeled in a stylized, curvilinear fashion and covered with very precise texturing in a manner not at all reminiscent of de Vries. It may be that the grapevine was added by a later owner who objected to the rough modeling or felt that the original leaves offered insufficient modesty.

SUMMARY

A comparison of the techniques and materials used for *Hercules Pomarius*, the latest cast by de Vries included in this study, with *Psyche Borne Aloft by Putti*, the earliest bronze in the study, offers some interesting points. Cast over thirty-five years apart, the two sculptures have different themes and characters, yet notable technical similarities. Both sculptures were cast in bronze with clay-based cores. Both were cast in one pour using the direct lost wax technique. Both show evidence of armature rods that passed outside of the model and back inside, supporting the models as they were constructed and the bronze poured. Both casts were remarkably successful and, with the exception of the repair in the left hand of Psyche, the repairs are relatively minor.

Hercules' facial features and anatomy were created in a free, painterly modeling style that differs from the precision of Psyche's smooth forms and facial features. The different subject matter of the two sculptures can account for only some of these differences. The influence of Giambologna so clearly evident in *Psyche* has been replaced thirty-five years later by an equal self-confidence but an entirely different approach to the form in which the undulating surface defies a precise outline. On both of the figures, though, details such as the formation and texturing of the tufts of hair were carried out with a careful and thorough finish. The cornucopia and base of the *Hercules Pomarius* are covered with fine texture carefully applied and the transition areas fully and carefully modeled throughout. On this, one of the last bronzes of de Vries's career, no surface was left unfinished, further evidence of the lasting patience and energy seen in *Psyche* and other early works such as the *Allegory of the War against the Turks*. *Hercules Pomarius* offers little evidence of the artist slowing down as he neared the end of his life.

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CHAPTER 27

Mercury

Willem van Tetrode

Los Angeles County Museum of Art. Inv. no. TR.10706.1.1

Cast in 1560–1565 (model)

Dimensions: H: 55.2 cm × W: 21.9 cm × D: 19.4 cm

Marks and inscriptions: None.

OVERVIEW

This statuette represents Mercury, nude except for his winged helmet and sandals, alighting on his right leg with his left arm raised (fig. 27.1). The work is attributed to Willem van Tetrode (ca. 1525–80), a Netherlandish sculptor who spent part of his career in Florence and Rome but later returned to the North, working in both Delft and Cologne (Nijstad 1986: 259–79).[1] The bronze descended to the heirs of Victor Korda, from whom it was purchased by the Los Angeles County Museum of Art (LACMA) in 1996.

Numerous variations of the *Mercury* exist, some of which are standing on the right leg, some on the left. A version of the statuette in the Louvre, in which the figure stands on his left leg, has recently been attributed to Adriaen de Vries (Jestaz 2005: 12). The LACMA version is similar in pose to that in the Bargello, which is considered the original model by Tetrode, prompting a comparison of the casting materials and techniques of the Los Angeles version under consideration here with those of both de Vries and Tetrode.

EXAMINATION

1. Alloy

As illustrated in figure 27.2, the sculpture is constructed of six separately cast elements. The alloy was determined

FIGURE 27.1 *Mercury*
Willem van Tetrode
Los Angeles County Museum of Art. Inv. no. TR.10706.1.1

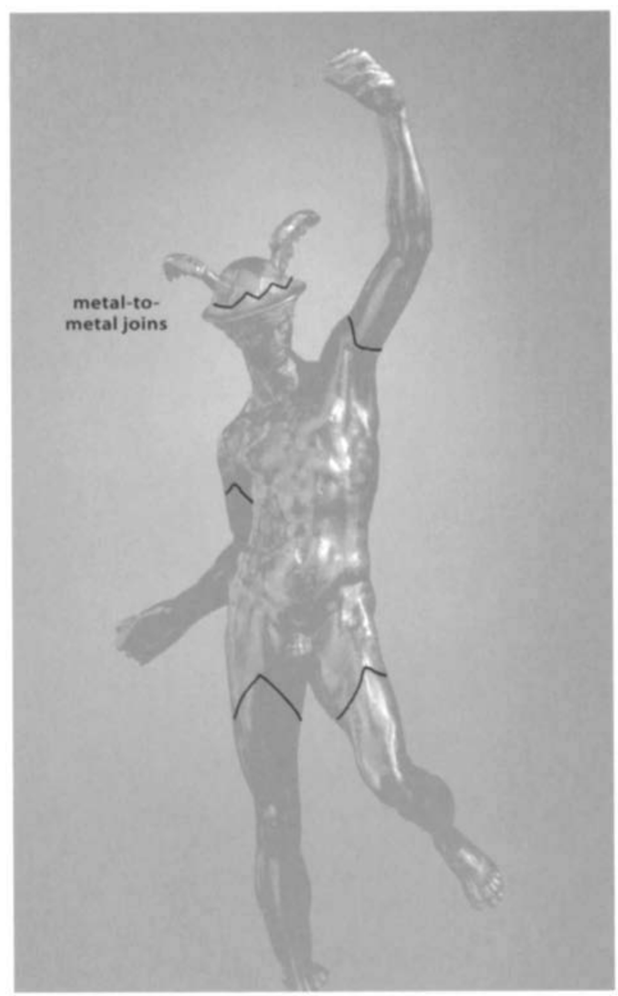


FIGURE 27.2 Summary of the zigzag metal-to-metal joins.

FIGURE 27.3 The hole in the foot was caused when a bit of broken core fell against the outer mold during casting.

for the torso, for the separately cast left arm, and for the large soldered-on repair on the right calf. The results for these components are similar enough to suggest that the separately cast elements and the repairs are likely original to the bronze. There are minor variations in the metal content, yet overall the alloy is a leaded brass consisting of 8 to 13 percent zinc in a copper matrix with added tin and lead in amounts measured between 1 and 5 percent (see table 4.1).

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

There are no armature or core support wires in the interior. Any supports that may have been used for modeling or casting were likely removed before the separately cast parts were assembled.

b. Core pins

No core pins, core pin holes, or core pin plugs are visible in the radiographs. Because the statuette was cast in sections, it would have been possible to cast the bronze with fewer pins, but surely some sort of spacers or core pins would have been necessary to hold the core in place during the casting. It may be that fine core pin holes are now hidden among the porosity flaws.

c. Core material

A small sample of chunky gray material was removed for compositional analysis from a hole in the bottom of the left foot (fig. 27.3). Although a solid flash across the left ankle blocks the view up the leg (fig. 27.4), it is likely that the majority of the core was removed with the core supports. Quantitative analysis of the sample yielded the following:

- 73.5 percent gypsum
- 14 percent iron shavings with red hematite (rust)
- 0.5 percent quartz
- 8.5 percent charred plant matter
- 0.5 percent glauconite

The plaster matrix allowed the core to be poured into a preformed casting wax and suggests that the indirect lost wax process was used. The core contains a sizable amount

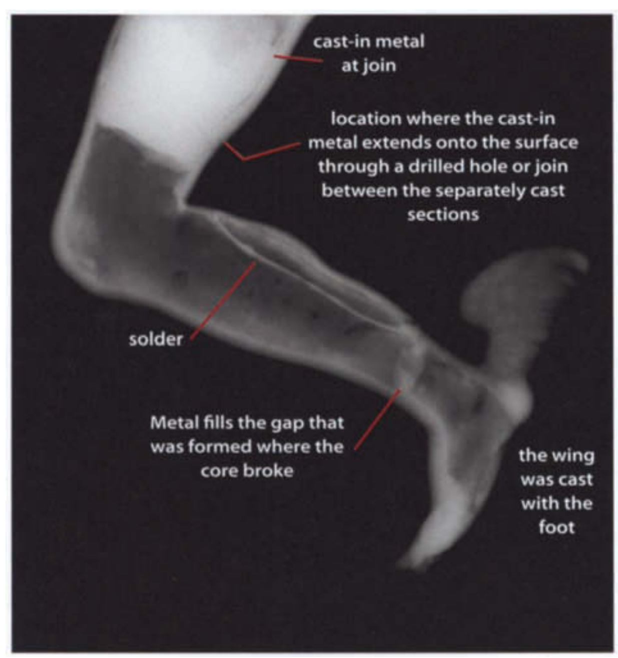


FIGURE 27.4 Radiograph of the left leg.

of partially rusted iron shavings. Although rust particles are commonly found in cores from the deterioration of iron components such as armature rods, the rods do not seem to be the source in this instance because the core supports were removed after casting. Furthermore, the source of the iron particles does not appear to be accidental; seen under magnification, the particles are relatively even in size and are evenly distributed within the gypsum matrix. Considering the relatively small amount of quartz in the core, the iron was likely added as temper. The core also contains sufficient charred plant material to suggest that it was present during the casting and that it too was added intentionally.[2] Also removed with the sample were a small number of uncharred fibers and bug parts, evidence of some degree of sample contamination.

Although a small sample could be coaxed out of the foot for petrographic analysis, not enough sample was available to attempt thermoluminescence dating.

d. Internal surface of the bronze

The wings as well as about half of the each hand and foot were cast solid. The rest of the figure was cast hollow with relatively uneven wall thickness. The walls are surprisingly thick in certain areas, such as the right hip, yet quite thin in the lower left arm (fig. 27.5). The thickness of the metal was measured on the left foot where a large flaw extends through the bronze. The metal edges vary from 0.05 to 0.15 cm thick in this area (fig. 27.3). These variations in thickness appear to be due to uneven formation of the casting wax inside the molds. Although variations in wall thickness can suggest the direct lost wax casting technique, the fact that the statuette was intentionally cast in a number of sections strongly indicates that they were cast indirectly.

e. Method of assembly and joining of individual wax or cast bronze components

Although the radiographs are not entirely clear and the surface of the bronze difficult to read in spots because of the opaque patina, it is likely that the top of the helmet and all four of the limbs were cast separately as follows:

1. Torso with head
2. Top of helmet with wings
3. Left leg
4. Right leg
5. Left arm
6. Right arm

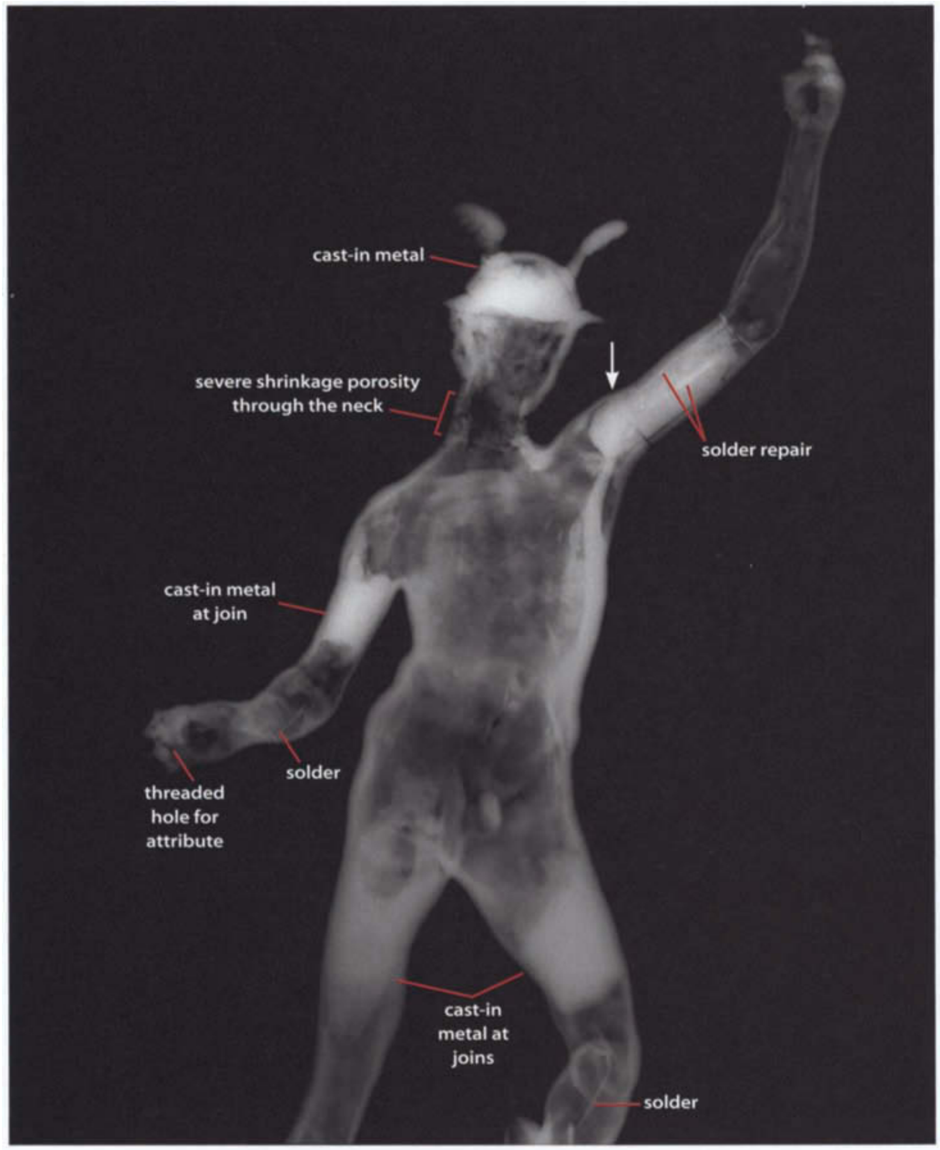
The parts were cast with zigzag join edges that allow the sections to key into one another. The symmetry of the placement of the joins suggests that they were an intentional part of the design for the bronze. Had the artist set out to cast the figure in one pour but encountered problems that necessitated recasting of repairs, it seems unlikely that all four limbs would have required complete replacement. The join in the helmet is quite obvious; the joins in the limbs are well hidden in many areas by chasing and an opaque organic patina (figs. 27.6, 27.7). It appears as though the separately cast limbs and the top of the helmet were secured to the torso with cast-in metal in a method illustrated in Appendix A, figure A.11: the core was partially excavated around the join; holes were drilled in the metal on either side of the join; wax was applied to fill the gaps at the join and the drilled holes; the area was invested with a refractory material and the wax melted out; and molten metal was then poured into the join. As it cooled, the metal in the drilled holes helped to lock the limbs in place. This example of a cast-in metal join is most clearly seen on the right leg, where the added metal is a more reddish color (fig. 27.7). The fine line between the separately cast sections is just visible in the radiograph of the right leg (see Appendix A, fig. A.12).

As no holes have been drilled in the helmet, it appears as though the metal added to join the sections may have simply been poured into the gap between the two in an adaptation of the process described above.

It is interesting to note that with a couple of exceptions, the joins are not visible in the radiographs, as the gaps between the sections are filled with the cast-in metal. If it were not for the visual clues of the different color of the cast-in metal and the slight misalignment of the parts, it would be difficult to surmise that all of the limbs were cast separately.

The figure is mounted on a green stone socle with three pins through the proper right foot. There is no evidence in the radiographs of wax-to-wax joins or sleeve joins.

FIGURE 27.5 Radiograph. The arrow indicates the location where the cast-in metal extends onto the surface through the join between the separately cast sections.



f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The surface of the bronze is quite rough due to a lack of refinement in the modeling of some of the features, extensive surface porosity, and minimal surface repairs (fig. 27.8). Although the surface is a bit difficult to read due to patina or accretions in the recesses, sections such as the wings, hair, ears, facial features, and toe- and fingernails were modeled in the wax and, with the exception of repairs, were left as-cast. The wing on the proper right side of the helmet is completely different in form and detail from the other wings, yet appears to have been cast with the helmet and left wing, suggesting it was replaced in the wax model (fig. 27.6). Both pupils are recessed. The mouth is partly open, but there are no teeth. Some of the distortion in the face, such as the slightly flattened left side of the cheek near the mouth, may be due to hammering of the surface after casting to hide surface flaws (fig. 27.8).

FIGURE 27.6 The top of the helmet keys into the bottom section. The right wing is a repair added in the wax.

Clusters of thin, parallel lines are rather haphazardly oriented and appear to have been made in the bronze with a scratch brush or file or both (fig. 27.7). There is no other evidence of applied surface texture.

g. Patina

The surface generally varies from the dark brown organic patina to the warm brown oxidized metal surface where the patina has worn away. The patina appears to have at least two layers: a black paintlike coating that remains over approximately half of the surface and is very thick and obscuring in areas and below it a more translucent, thinner dark brown organic patina on the metal surface. In large areas such as the chest, the center of the back, and the right hip and buttock, the surface is red in color—in contrast to the warm brown oxidized metal observed elsewhere. The red resembles cuprite (copper oxide), suggesting that the surface was heated at some point, possibly during the application of the solder repairs.

3. Casting Defects and Foundry Repairs

There is minor small-vacuole gaseous porosity in the cast. The radiographs show shrinkage porosity in the right elbow, left forearm, right ankle, torso, head, and neck due to uneven shrinkage during cooling of the cast (fig. 27.5). Porosity breaks through the surface throughout the sculpture; it is especially severe on the left side of the neck and the back of the torso.

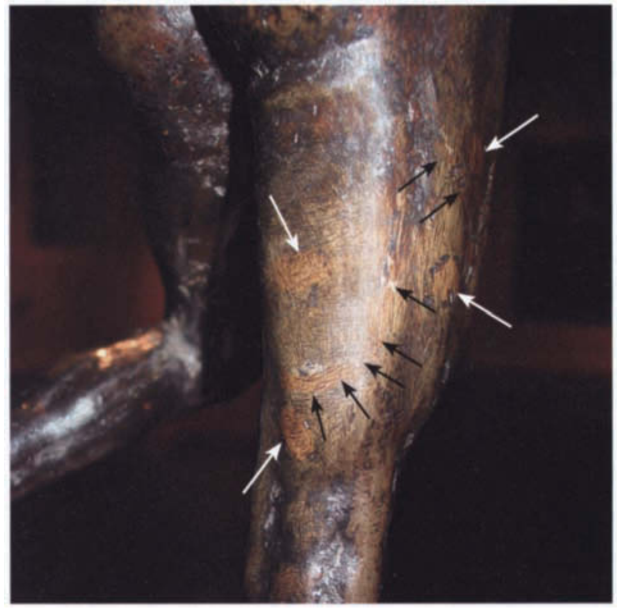


FIGURE 27.7 Back of the right leg where the separately cast sections key into one another. The black arrows indicate the zigzag join line; the white arrows point to the holes on either side of the join, now filled with cast-in metal.

FIGURE 27.8 The face is distorted by casting flaws.

The radiographs confirm that no set-in repair plugs or patches were used on the bronze. Large soldered-in repairs on the top of the left calf, the left upper arm, and the right lower arm likely fill large casting flaws (figs. 27.4, 27.5). The repair on the left upper arm is quite sizable; the applied organic coating masks its full extent. The soldered-in repairs on the arms do not follow the contours of the modeling. The repair on the top of the left calf, on the other hand, contains considerable undulation in keeping with the modeling of the leg and appears to have been cast separately using a section of wax taken from the molds.

The core in the left leg broke at the ankle during casting. The broken end settled down onto the bottom of the foot, causing a flaw in the bottom sole. This flaw is the hole through which the core sample was removed. The hole may have been plugged at one time, although there is no obvious indication of this (figs. 27.3, 27.4). Lack of porosity in the bronze wedge under the right foot and partial join lines around the heel of the foot suggest that the wedge may have been added after casting, likely in the foundry.

The radiographs indicate that flashes, where the molten metal poured into cracks or other flaws in the core, appear throughout the interior of the bronze.

Large organic fills on the back of the left knee and in the lower abdomen may repair surface flaws, although these flaws are not apparent in the radiographs.

4. Later Modifications/Restorations

Threads in the handle held in the right hand are all that remain of the missing attribute (fig. 27.5). Whether the threads are original or late modifications could not be definitively determined.

SUMMARY

Different attributions for the numerous variations of the *Mercury* exist, including both Tetrode and de Vries, prompting the following comparison of the casting materials and techniques of the LACMA *Mercury* with those of both sculptors. Thanks to research carried out as part of the recent Tetrode exhibition (Bewer et al. 2003), it is possible to compare the results of the technical study of the *Mercury* in Los Angeles to characteristics of a number of other bronzes attributed to Tetrode, including the cast of *Mercury* in the Rijksmuseum,[3] which is a version of the Louvre bronze (standing on the left leg) recently attributed by Jestaz to de Vries.[4]

The LACMA *Mercury* was hollow-cast of leaded brass. The presence of a gypsum-based core suggests that it was cast using the indirect lost wax technique. The limbs and top of the helmet were cast separately from the torso. The zigzag joins between the separately cast elements key into one another and were locked in place with metal cast into the joins. The proper right wing on the helmet differs from that on the left and appears to have been replaced in the wax. The surface remains essentially as-cast, with minimal cold work beyond the repairs. The surface is heavily flawed in areas due to shrinkage porosity. Three large copper alloy repairs have been soldered into place.

Alloy

The leaded brass alloy of the Los Angeles statuette bears no relation to de Vries's typical bronze alloy. It does seems to fall within the general range of compositions observed on the attributed Tetrode bronzes, however, although only very limited comparative data were included in the catalogue.

Wax Casting Model

The flat and generalized modeling in the face of the LACMA figure is not reminiscent of de Vries. When the LACMA and Rijksmuseum *Mercury* casts are compared, there are clear differences in how the surfaces of the casting waxes were finished. The Rijksmuseum forms such as the thighs and buttocks are softer in the musculature. The details in the Rijksmuseum wing feathers and curls were drawn with a pointed tool, yielding a flatter and far more linear surface than on the LACMA piece, in which the forms are more fully modeled. The LACMA penis is circumcised, a detail added in the wax; the Rijksmuseum penis is not.

Casting Technique

The casting of the LACMA *Mercury* in numerous small pieces is uncharacteristic of de Vries.

Characterization of Tetrode's casting techniques is not as straightforward as that of de Vries. Radiographs of thirteen bronzes were published in the Tetrode exhibition catalogue. Of these thirteen, it is likely that all were cast indirectly, yet the method of forming the casting waxes varies considerably, and there is wide discrepancy in the number of wax-to-wax joins, the location of these wax-to-wax joins, and the number of pieces from which the sculptures were cast. In addition, a variety of methods were used to join the separately cast sections. Five of the sculptures were cast in pieces that were then assembled, including the *Écorché* and *Christ at the Column,*[5] as well as all three of the *Striding Warriors.*[6] The joins in the LACMA *Mercury* are most like those found in the *Écorché,* as they too were made by casting excess metal into space created by excavating the core adjacent to the join edges.

Although the Rijksmuseum *Mercury* and the LACMA *Mercury* compositions are superficially related (they differ primarily in the choice of bearing leg), the method for constructing the casting models is quite different. Whereas the Rijksmuseum bronze was cast in one piece with one or two wax-to-wax joins, the LACMA version was cast in six separate pieces without any wax-to-wax joins. The walls of the Rijksmuseum *Mercury* are thin and even, differing from the uneven and often thick walls of the LACMA piece.

Casting Flaws and Repairs

There are no cast-in or set-in repairs on the LACMA version, a type of repair used most commonly by de Vries and seen on many of the attributed Tetrode bronzes. Instead, the casting flaws on the LACMA version are soldered into place, a type of repair not seen on any of the other Tetrode bronzes.[7] There are unrepaired flaws on both the Rijksmuseum and the LACMA bronze, although there is far more damage in the latter.

Conclusion

The study of Adriaen de Vries's bronzes has shown a clear uniformity in his methods for casting and finishing a bronze, greatly simplifying any attempts at attribution based on these methods and allowing a quick separation of the LACMA *Mercury* from his work. In contrast, the results of the technical study of Tetrode's bronzes are distinctive for their *lack* of consistency. With this in mind, the variations in the LACMA bronze compared to the other Tetrode bronzes in the general study, and the Rijksmuseum version in particular, come as no surprise and bring us no closer to understanding how the bronze falls into the artist's oeuvre. There is no evidence, however, to doubt that the LACMA *Mercury* was cast in the sixteenth century. In addition, its having been cast in numerous pieces, coupled with the brassy composition of the metal, points to its having been cast in a workshop with Northern rather than Florentine influences, a possibility that does not rule out a workshop in Florence headed by a Netherlandish artist.

NOTES

1 My thanks to Mary Levkoff for sharing her knowledge of this piece and related works.

2 See note 3 in chapter 10, Braunschweig *Venus.*

3 *Mercurio volante,* inv. no. BK 1953-19, H: 44.5 cm. The technical examination, including unpublished radiographs, was carried out by Robert van Langh of the Rijksmuseum.

4 No radiographs of this bronze have been published.

5 Both bronzes are in the Hearn Family Trust, New York.

6 Hearn Family Trust, New York; Rijksmuseum, Amsterdam, inv. no. BK 1959-3; private collection (Mr. and Mrs. J. Tomilson Hill, New York).

7 Lack of patina around the solder repairs on their *Mercury* suggests that they were done well after manufacture (R. van Langh, pers. com.). It should be noted here that the date of the Rijskmuseum version is still debated.

CHAPTER 28

Mercury and Psyche

Authorship and date uncertain
Huntington Art Collections, San Marino. Inv. no. 17.28
Dimensions: H: 59.3 cm × W: 25.5 cm × D: 16.9 cm
Marks and inscriptions: None.

OVERVIEW

The statuette depicts Mercury lifting Psyche up toward Mount Olympus (figs. 28.1, 28.2). Purchased from Duveen Brothers by Henry Huntington in 1917, the statuette is said to have come from the Chabrières-Arles family of Paris.

Attributions for the composition have included Adriaen de Vries (workshop), Hubert Gerhard (ca. 1540/50–before 1621), and, more recently, Casper Gras (1585–1674) (Diemer and Pettit 2001: 205). The technical study has offered an opportunity to reexamine these attributions.

EXAMINATION

1. Alloy

As illustrated in the Structual Summary (fig. 28.3), the bronze was cast in thirteen or fourteen sections. Four of the sections were examined for alloy content. The cast is a brass with zinc content from approximately 19 to 26 percent and lead levels from below 0.5 to 2 percent. Analysis of a large white metal repair on Mercury's left forearm shows 44 percent lead, 22 percent tin, and 16 percent copper. It is likely that the repair is a lead-tin soft solder with XRF spectra interference from the adjacent copper alloy metal. Full alloy results can be found in table 4.1.

FIGURE **28.1** *Mercury and Psyche*
Artist unknown
Huntington Art Collections, San Marino. Inv. no. 17.28

FIGURE **28.2** *Mercury and Psyche*
Artist unknown
Huntington Art Collections, San Marino. Inv. no. 17.28

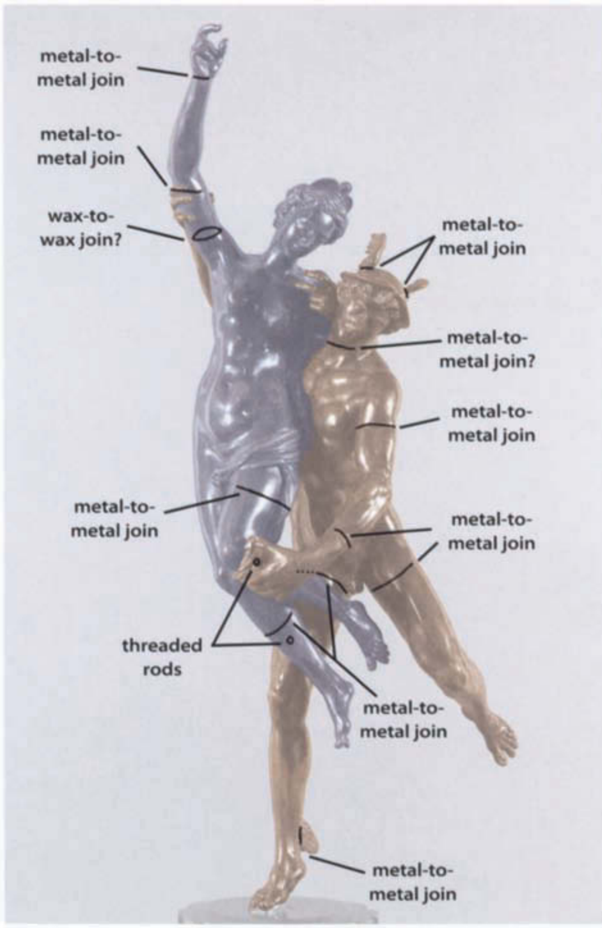


FIGURE 28.3 Summary of the metal-to-metal joins, a possible wax-to-wax join, and the pins that join the two figures.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

The casting core and core supports appear to have been removed before the separately cast sections were joined. The one remaining section of rod is located in Psyche's left foot. A round copper alloy plug fills the hole where the rod passed through the bronze.

b. Core pins

All of the core pins have been taken out of the sculpture. A number of the smaller threaded surface plugs (0.3–0.4 cm diameter) likely fill the holes left when the core pins were removed.

c. Core material

A gap remains where the two figures attach to one another. By shining a light into the gap, one can see that the core has been removed from the interior. The core was likely removed from inside the figures before they were joined.

d. Internal surface of the bronze

This sculpture serves as a good example of the difficulty of interpreting radiographs without consulting the object itself. At first glance, the many ring-shaped variations in the radiographic density of the walls of the bronze, such as that on the top of Mercury's thighs (fig. 28.4), are suggestive of wax-to-wax joins. As explained below in more detail, though, surface examination shows slight recesses, color variations, and raised corrosion in these areas due to the presence of soldered metal-to-metal joins.

The bronze was hollow-cast except for the wings, Psyche's hands and feet, Mercury's fingers, and the front half of Mercury's right foot, all of which were cast solid. The thickness of the bronze varies from area to area. Whereas the metal wall in Mercury's left leg is quite thin, the metal along Psyche's right side and thigh is comparatively thick (fig. 28.4). Variation in the thickness of the bronze walls in Psyche's right arm near the wrist is due to a break in the core during casting, allowing the loose piece of core to float out of alignment and causing considerable variation in the thickness of the bronze walls in the area (fig. 28.5).

Numerous drip marks are visible on the inside of both torsos. The marks look very much like drips formed during slush molding of the casting wax, which would indicate that the bronze was cast using the indirect lost wax method. There is the possibility, though, that they are in fact drips of solder metal. Although it seems unlikely that solder would have dripped into these areas in the torsos from the metal-to-metal joins in the limbs, there are two other fittings above the drips that help to hold the figures together that may have been soldered in place after the bronze was cast (fig. 28.5).

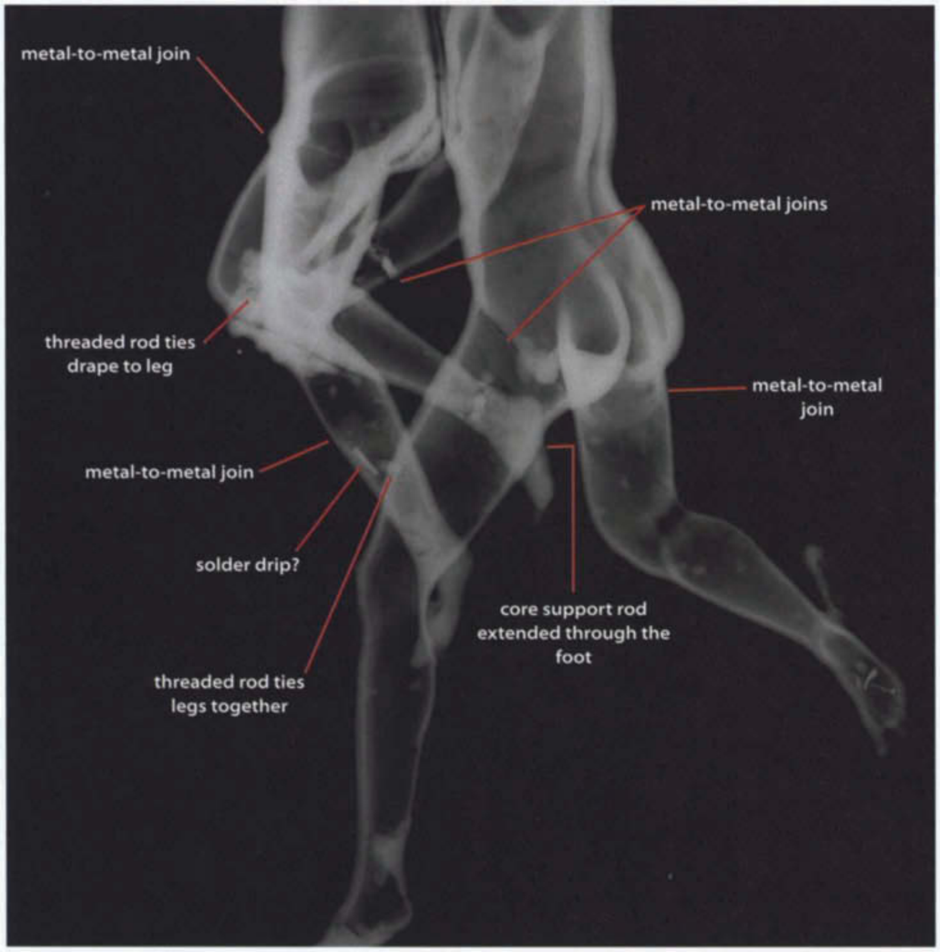


FIGURE 28.4 Radiograph of the lower portion of the sculpture.

e. Method of assembly and joining of individual wax or cast bronze components

Close examination of the radiographs and the surface of the bronze suggest that the bronze was cast in many sections.

Separately cast sections:

- Psyche's head, torso, right arm to the elbow, left arm, and upper right leg and Mercury's right arm
- Psyche's right arm from the just above the elbow to the wrist
- Psyche's right hand
- Psyche's right lower leg from the calf
- Psyche's left leg from the upper thigh
- Mercury's torso
- Mercury's left leg from the upper thigh
- Mercury's right leg from the upper thigh
- Mercury's left arm to the upper wrist
- Mercury's left wrist and hand, including the partial drape in the left hand
- Mercury's head (?)
- The wing on Mercury's right ankle and foot
- The left wing on Mercury's helmet
- The right wing on Mercury's helmet

Solder joins: Except for the wings on the helmet, which were joined mechanically, the separately cast parts in each figure were joined with solder. In the radiographs, excess solder appears on some, but not all, of the joins as spots or

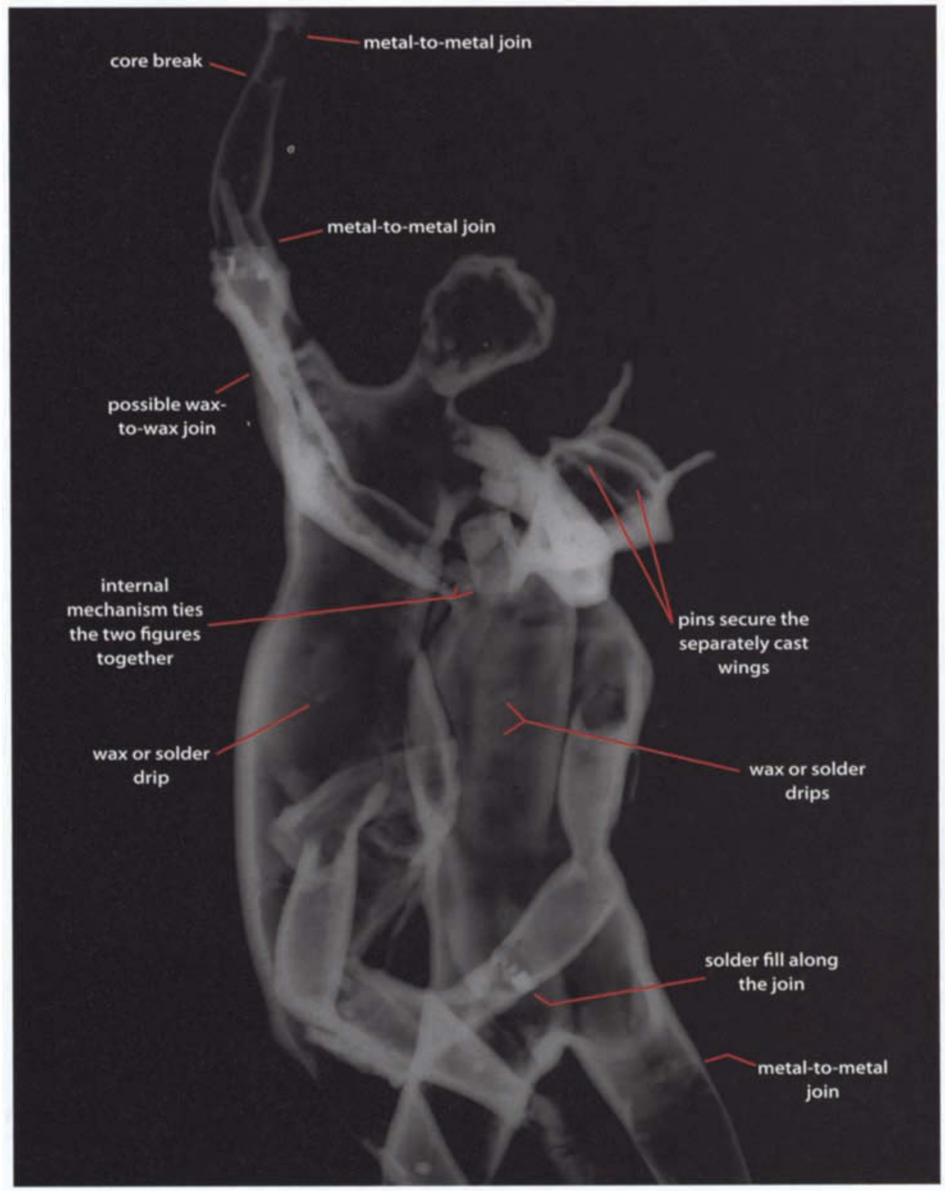


FIGURE 28.5 Radiograph of the upper portion of the sculpture.

lines of higher density. In most cases, a minimum of solder appears to have been used. On the surface of the bronze, the appearance of the joins varies: in some areas the lighter-colored solder metal is clearly visible on the surface; in others there is a thin recessed line between the sections; in yet others the flux used during soldering has caused a rough-textured, raised line of corrosion along the join.

The radiographs suggest a join in Mercury's neck, although it is difficult to see on the surface of the bronze.

Mechanical joins: Once the separately cast sections of each figure were soldered together, the figures of Mercury and Psyche were joined mechanically. Unlike the solder joins, which are fairly well hidden, there is an open gap between the figures (fig. 28.6). The primary attachment between the figures is composed of two rectangular pieces of metal on the interior of the sculpture located near Mercury's right shoulder; it is unclear exactly how they function, and they are not visible on the surface of the bronze (fig. 28.5). Solder may have been used at these attachment points. Two threaded rods help to tie the lower parts of the figures together (figs. 28.3, 28.4). The hole in the drape below Mercury's left hand does not align exactly with the corresponding hole in Psyche's shin. These holes have been left empty without a pin.

The wings were pinned to the helmet (fig. 28.5). The pins are well hidden on the surface.

Wax-to-wax join: Discontinuities in the radiographs of Psyche's right shoulder are suggestive of a wax-to-wax join. Locating a join so close to the end of the casting seems unnecessary, though, as this section of the arm ends just above the elbow. If indeed this is a wax-to-wax join, it suggests that the metal-to-metal join above the elbow is a repair rather than part of the original design.

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

The surface is highly finished overall. Features such as the feathers, faces, hair, and tiara were all crisply modeled in the wax with little if any chiseling or reworking of the features in the metal. The facial features are clearly defined (fig. 28.7). The feathers were carefully modeled and drawn into the wax with lively variation. There is no indication of punched texture having been applied to the wax or the metal.

g. Patina

The thin, opaque black organic patina is worn in many areas, revealing the oxidized metal surface below. This metal surface varies from greenish brown to a warmer brown color.

FIGURE **28.6** The figures were cast in multiple parts, which were then soldered together. As show here at the back, the two figures were then joined mechanically with no attempt to hide the join.

FIGURE **28.7** The features, including the rounded punch mark in the pupils and the outlines around the irises, were crisply formed in the wax model.

3. Casting Defects and Foundry Repairs

Was the statuette cast in multiple pieces by design, or are some of the separately cast elements repairs that were necessary due to flaws in the original casting? When complex mechanical joins are used on bronzes, it is often clear that they were part of the original design. In this case, in which the sections are mostly attached to one another with soldered butt joins, the intention is not as clear. Small indications, such as the possible wax-to-wax join in Psyche's right upper arm that is located nearly on top of the adjacent mechanical join and the fact that the wing on Mercury's right ankle was cast separately but not the the wing on the left, hint that at least some may be repairs.

Even though the bronze was cast in relatively small sections, many areas are flawed due to uneven shrinkage of the metal as it cooled. This shrinkage porosity is visible in the radiographs as fine-textured splotches of lower density. Shrinkage porosity appears on the surface of the figure of Psyche on the right side and front of her neck, across her left upper back, across her left ankle, and on the back of her left upper arm. Cracks also appear on the top outside surface of Mercury's right thigh and right inner knee. There is only minimal gaseous porosity in the cast.

A small, roughly rectangular metal patch has been inserted into the gap under Psyche's left armpit. The edges of the repair have not been chased; as with the rest of the gap between the figures, no attempts have been made to hide it. Some of the threaded plugs probably repair casting flaws as well as core pin holes. Many of the plugs are visible on the surface as their perimeters are recessed. There is a large and messy cast-in lead solder fill along the metal-to-metal join on Mercury's left forearm.

4. Later Modifications/Restorations

White accretions in many of the recesses may be remains of plaster from a mold having been made of the statuette. A few scattered spots of a deep black, shiny, inklike coating appear to be attempts to retouch patina losses. The presence of an opaque purplish brown paint applied over the two large threaded rods that secure the figures to one another suggests that the rods may have been tightened relatively recently.

SUMMARY

The statuette was cast in brass in thirteen or fourteen separate parts with numerous flaws. The separately cast sections within each figure were soldered together, and then the two figures were joined mechanically. There is some indication that the sections were cast using the indirect lost wax method.

Alloy

The *Mercury and Psyche* is brass; all the de Vries casts studied to date are bronzes, an early indication that the statuette in question was not cast by Adriaen de Vries.

Published alloy data are available for eight Hubert Gerhard compositions. The alloys vary considerably and include leaded brass, leaded bronze, bronze with no added zinc or lead, and sculptures whose sections were cast in a variety of alloys.[1] Alloy data are also available for four Gras compositions; all four are leaded brasses.[2] Although a comparison based on so few examples is not ideal, it does suggest that further comparison with Gerhard and Gras is warranted.

The Artist's Model

The handling of the facial details on the *Mercury and Psyche* differs considerably from de Vries's approach to the wax model. The Huntington features are crisply and clearly depicted, with careful delineation of the eyelids, lips, and nose. Even in his early bronzes, before his style loosened up considerably, de Vries's facial features tended to flow smoothly from form to form, without the linear demarcation of features seen on this bronze. Although the eyes of the *Mercury and Psyche* group have been compared to those of *Hebe* by Hubert Gerhard in the Detroit Institute of the Arts (inv. number 59.123), Diemer and Pettit (2001: 205) believe that this attribution is incorrect due to the pieced construction of the *Mercury and Psyche*—a type of construction that is not typical of Gerhard.

Casting Technique

Specifics of the casting technique are also not reminiscent of de Vries. Although he did cast a number of his bronzes using the indirect lost wax casting technique, de Vries cast them in one or two sections, not in multiple parts as observed on the *Mercury and Psyche*.

Diemer and Pettit propose Gerhard's pupil Caspar Gras as a possible author of the bronze, based in part on its having been cast in pieces. According to them, "Scholars have recently begun to consider the casting of bronze groups in several pieces as a primary defining feature of works by Gras" (2001: 205). The Getty *Kicking Horse* by Gras was cast in three pieces, and, as with the Huntington bronze, the parts are soldered together. There is a difference, though, in that solder is used along with pinned sleeve joins in the Getty example, a type of join not seen on the *Mercury and Psyche*.

Conclusion

The brass alloy, the casting of the bronze in multiple parts, and the finish of the surface of the bronze clearly indicate that the Huntington's *Mercury and Psyche* was not cast by de Vries. The alloy of the Huntington piece does fall within the range of alloys observed on both Gerhard and Gras casts, although the small amount of available data limits the usefulness of the comparison. The crisp delineation of the facial features bears comparison with Gerhard and Gras, although the casting of the bronze in multiple pieces is more in keeping with the work of Gras.

There are three other *Mercury and Psyche* bronzes: one in Berlin, one in the Bayerisches Nationalmuseum, Munich, and one in London. According to Diemer (2001: 205), in all four versions the two figures were cast separately, then joined. Presumably all were joined along the bodies, as we have observed on the Huntington cast (fig. 28.6). This method of joining two figures vertically is unusual. It likely reflects a close relationship between the four casts and may one day help to securely identify the artist or foundry.

NOTES

1 Riederer 1988: 92–93; and 2000: 188–89, 190, 194; Baxandall 1966: 144. Published data are available for *Mars, Venus, and Cupid* in the Kunsthistorisches Museum, Vienna, inv. number 5848 (a leaded brass containing approximately 14% zinc and 3% lead in a copper matrix); *Mars, Venus, and Cupid* in the Nationalmuseum, Munich (the sections that were analyzed range from leaded brass to leaded bronze); the Augustus fountain in Augsburg (alloys vary from leaded brass [15% zinc with 2% lead] to leaded bronze [5% tin with 4% lead and 1% zinc]; the *Resurrection* relief in the Victoria and Albert Museum, London, inv. number A. 20-1964 (a leaded brass containing approximately 18% zinc and 3% lead); *St. Michael* in the St. Michaelskirche, Munich (bronze containing 8% tin with no added zinc or lead); and three casts in the Residenz, Munich: *Diana* (a leaded bronze with 5% tin and 1% lead), *Löwen* (a leaded bronze), and the *Wittelsbacher* fountain (bronze with no added lead or tin).

2 Fogelman et al. 2002: 360–63; Riederer 2000: 188, 189. *Kicking Horse* in the J. Paul Getty Museum, attributed to Gras, inv. number 85.SB.72 (16% zinc and 3% lead); and *Emperor Ferdinand III*, inv. number 5989 (14% zinc with 4% lead), and an equestrian group of *Leopold V*, inv. number 6025 (10% zinc with 3% lead), both in the Kunsthistorisches Museum. The leaded brass Gras statuette *Seated Woman* in the Herzog Anton Ulrich–Museum, Braunschweig, contains approximately 20% zinc and 2% lead.

CHAPTER 29

Christ Mocked

Artist unknown
Los Angeles County Museum of Art. Inv. no. M.84.65.2
TL date: 1695 ± 40 years
Dimensions: H: 38.3 cm
Marks and inscriptions: None.

OVERVIEW

The sculpture depicts the nude figure of Christ seated on a base with two steps (fig. 29.1). As adopted from the Passion, the subject is Christ awaiting the crucifixion. The sculpture was previously in the David Daniels Collection[1] and was donated in 1984 to the Los Angeles County Museum of Art.

The massive musculature and the seated composition of this bronze are reminiscent of the much larger *Christ in Distress* by Adriaen de Vries in the Liechtenstein Museum, Vienna. Although the sculpture has long been considered "Italo-Flemish,"[2] the technical study was undertaken for the sake of comparison and in an attempt to determine if there is any possibility that the bronze was cast by de Vries.

EXAMINATION

1. Alloy

As delineated in figure 29.2, the figure was cast in five parts; the base was cast separately. The metal content was determined for the figure's torso and the base. Both are quaternary alloys containing approximately 2 percent zinc, lead, and tin in a copper matrix. The alloys are similar enough to suggest that they may have been cast at the same time.

FIGURE 29.1 *Christ Mocked*
Artist unknown
Los Angeles County Museum of Art. Inv. no. M.84.65.2

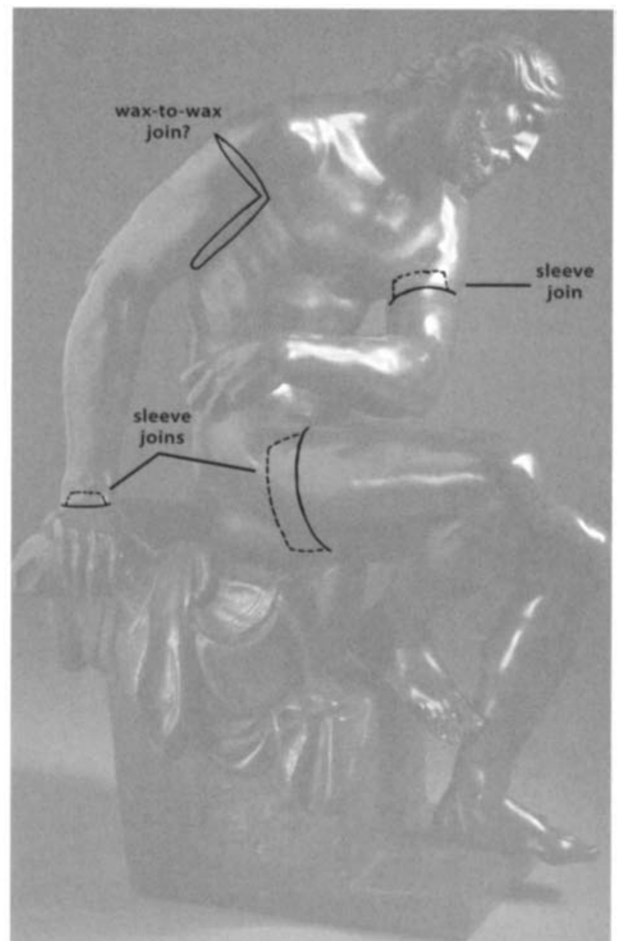


FIGURE 29.2 Summary of the sleeve joins and a possible wax-to-wax join. There is also a sleeve join in the left thigh.

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Figure: All core supports have been removed from the interior. They were likely removed before the separately cast sections were attached to one another.

Base: All core supports have been removed from the interior of the base.

b. Core pins

Figure: There are no core pins remaining in the interior of the bronze. It is likely that some of the round threaded plugs seen in the radiographs fill holes left when the core pins were removed. These plugs vary in diameter from approximately 0.3 to 0.8 cm, with the majority 0.4 or 0.5 cm.

Base: No core pins remain in the interior of the base. Thirteen round threaded plugs in the base (0.5 to 0.6 cm as measured off the radiographs and in the interior of the base) are quite evenly spaced. Some of the plugs may fill holes left when the core pins were removed.

c. Core material

Figure: Large holes in the palm of the right hand, in the area of the missing little finger of the left hand, and in the bottom of the left foot were examined to see if any core remains in the interior of the body. No core was seen through the holes, although some may remain hidden in the recesses.

Base: The remaining core varies from tan to gray in color. Examination of the open bottom of the sculpture shows that most of the core has been removed from the base (fig. 29.3), although some of the core can still be found tucked into surface contours. A sample was removed for compositional analysis from the top of the inside of the base near the back proper right corner. Quantitative analysis yielded the following:

- 83.5 percent gypsum
- 7 percent quartz
- 4 percent metal fragments
- 3.5 percent red clay
- 1.5 percent feldspar
- 1.5 percent calcite

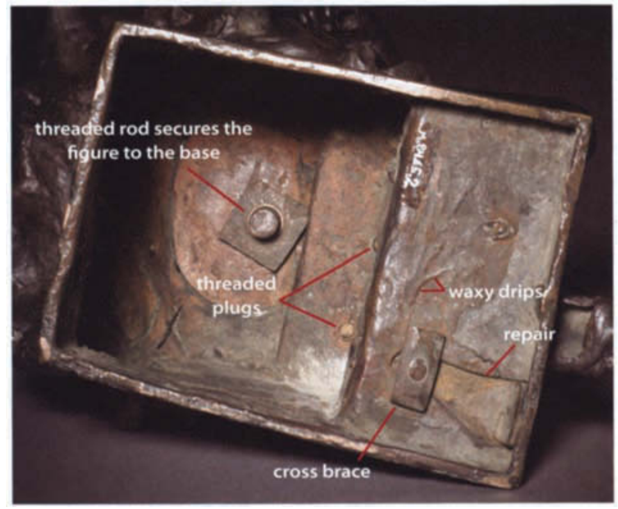


FIGURE 29.3 Open bottom of the base.

The plaster matrix for the core suggests that the bronze was cast using the indirect lost wax technique. The metal fragments were identified as a copper alloy containing some iron, zinc, and lead. The fragments were examined under the microscope in an attempt to determine whether they were intentionally added to the core or are an accidental contamination. Seen under magnification, each fragment is integrally bound in the plaster, strongly suggesting that they were added as the core was being prepared, allowing the plaster matrix to harden around them.[3]

An additional small chunk of core was dated to 1695 ± 20 years using the thermoluminescence technique. Given the results of the TL study discussed in chapter 6, the date should be considered 1695 ± 40 years (1655–1735).

d. Internal surface of the bronze

Figure: With the exception of the solid-cast righthand fingers and a few of the toes, the entire figure was hollow-cast. The walls of the figure are generally uniform and rather thin, with good conformity between the inside and outside surfaces of the bronze (fig. 29.4). The thickness of the bronze was measured in two locations where there are holes through the metal to the hollow interior. The metal is approximately 0.2 cm thick around the missing left little

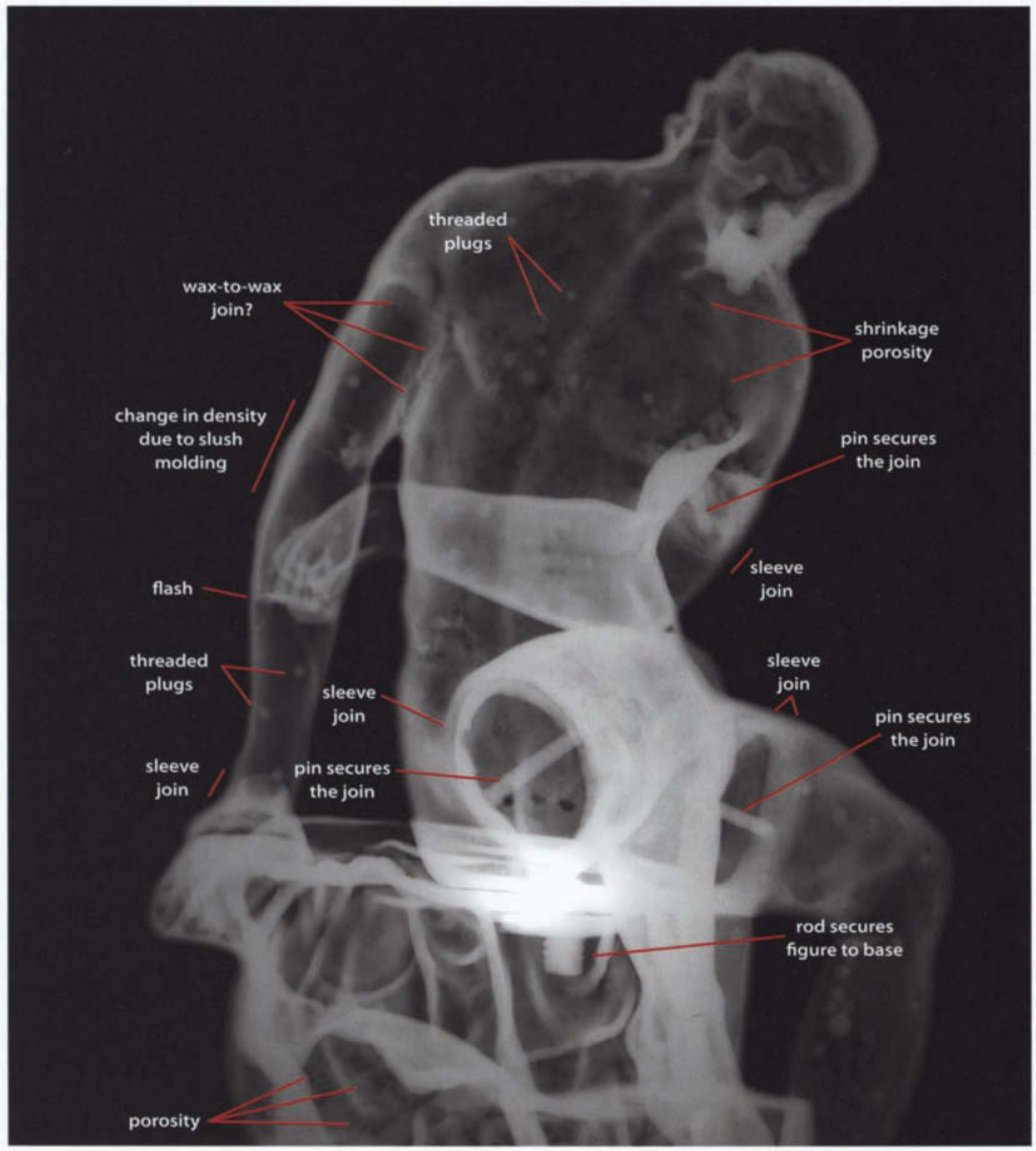


FIGURE 29.4 Radiograph.

finger and 0.1 cm thick around the hole in the bottom of the left foot. A smooth-contoured area of increased density inside the right arm appears to be due to a "drip" from the slush molding of the casting wax that has been transferred into the bronze (fig. 29.4).

In addition to the plaster-based core, the thin walls, the close conformity of the inside and outside walls of the cast, and the evidence of slush molding suggest that the bronze was cast using the indirect lost wax technique.

Base: The bottom of the hollow base is open, allowing visual examination of the interior (fig. 29.3). The metal on the inside of the base is very waxy in appearance, with smooth contours and a drip along the proper right side and top of the lower step. The metal at the bottom edge of

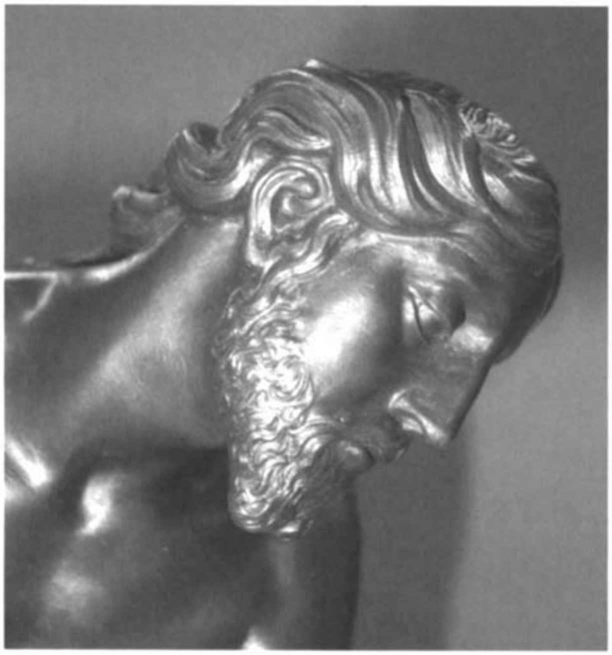


FIGURE 29.5 The surface was carefully finished in the model and in the metal after casting.

the base measures approximately 0.4 cm thick. Spheres of metal cast onto the inner surface of the bronze wall measure from 0.1 to 0.15 cm in diameter. The metal spheres were likely caused by air bubbles trapped against the wax as the plaster core was poured into the interior cavity of the casting model. The air bubbles were then filled with molten metal during the pour.

The wax drip and cast-in bubbles suggest that the base was also cast using the indirect lost wax process.

e. Method of assembly and joining of individual wax or cast bronze components

Figure: The figure of Christ was cast separately from the base. As illustrated in figure 29.2, the figure was cast in five sections:

- Torso with the head and right arm to the wrist
- Right hand
- Right leg
- Left leg
- Left arm

The radiographs indicate that the separately cast sections attach to the body with pinned sleeve joins (also known as Roman joins). In all of the joins, the sleeve was cast with the limb and inserted into the torso (and in the case of the right hand, into the arm). The sleeves slip into the hollows on the other side of each join and are pinned in place. In the left arm and the legs, single straight pins measuring 0.5 to 0.6 cm in diameter were used (fig. 29.4). There is no pin in the join in the right hand. The join in the left upper arm is not visible on the surface of the bronze; the remaining three joins can be seen on the surface, as there are slight gaps between the sections.

Increased density in the radiograph of the proper right shoulder has the appearance of a wax-to-wax join, suggesting that the right arm was formed separately from the torso, and the two were joined in the wax. The increased density appears as a ring-shaped line around the upper arm that continues down the right side of the body where the arm is attached. If indeed this is a wax join, it is unusual for its location high in the arm—necessitating a vertical join along the torso, as well as the horizontal join along the top of the arm (figs. 29.2, 29.4).

Base: The figure attaches to the base with a 1.1 cm diameter copper alloy rod with hand-cut threads that extends through the buttocks and secures below the base with a nut (figs. 29.3, 29.4).

f. External surface of the bronze: Evidence of the wax model and of final surface chasing

Figure: The figure has been carefully finished overall, both in the wax and in the metal after casting. The flesh has been textured with short, fine, parallel scratchlike marks that run perpendicular to the torso and limbs (fig. 29.5). The marks are fairly evenly applied overall, even in the hard-to-reach areas, suggesting they were applied either in the wax or in the metal before the separately cast sections were attached to one another.

The fine details on the head, toes, and fingers were modeled in the wax with considerable care. Neither the irises nor the pupils are delineated. The long individual strands of hair were formed in the wax model with a very small flat-headed tool followed by a textured punch.

FIGURE 29.6 Drapery on the left side of the base. The modeling in the base is less refined than that on the figure.

These punch marks are quite soft and may have been applied in the wax (fig. 29.5). No additional punched texture has been applied to the surface. The curls in the beard retain the pliant character of the model (fig. 29.5). The genitals were modeled with less attention than the facial features and hair.

Base: Overall, the base is rougher than the figure. This is due to less refined modeling and finishing of the wax and to less refined texturing and repair of the bronze after casting. A double line was smoothly incised into the edge of the drapery with a rounded tool. The smooth, unbroken character of the line suggests that it was formed in the wax rather than in the metal. Most of the fabric has been textured with an oval matting punch (fig. 29.6). The texture remains quite sharp and extends over the repairs, indicating that it was applied in the metal. The punch goes over the repairs on top of the base, hiding them well. In some areas, the fabric is roughly textured with scratch brush lines that run basically parallel to the folds. The back and left sides of the base are rough on the surface, apparently retaining the as-cast texture of the model. The front and proper right sides of the base have been roughly textured with deep scratch brush lines. These lines were applied in the metal, as shown by the fact that they run over the repair plugs.

g. Patina

Figure: The figure of Christ is gray-green in color due to a thin bluish green paintlike coating. Enhancing the color of the surface are two colored wax coatings: a blue-green wax over most of the figure and a maroon wax applied primarily on the back. Brush strokes in the wax remain clearly visible in areas. Under the wax and the bluish green paint is a thin dark brown patina that resembles a similar layer found over much of the base. This dark brown patina is visible in a few areas, such as the fingers of the right hand, where the bluish green paint and the wax have not been applied. The bluish green paint layer is flaking off on the right arm. In a few areas where all of the coatings have been rubbed away the warm golden brown color of the oxidized metal surface is revealed.

Base: The base is brown in color due primarily to a thin dark brown organic patina that also appears on the figure. A thick, black, paintlike layer on the back of the stairs has flaked in areas. This black coating does not appear elsewhere.

3. Casting Defects and Foundry Repairs

Figure: The radiographs reveal sharp, angular spots of shrinkage porosity throughout the torso, right ankle, left calf, and right lower arm. Numerous round plugs repair some of the porosity that extended through to the surface. All of these round plugs are threaded. The plugs vary from 0.3 to 0.8 cm in diameter; most of the plugs are more dense in the radiographs than the surrounding metal, suggesting that they are quite long, extending into the inner cavity. The plugs are not visible on the surface of the bronze as they were carefully chased and are now hidden under the thin surface coating. There is one set-in oval plug on the right lower arm. A small number of unrepaired porosity flaws on the surface of the sculpture are located primarily in more hidden areas, such as under the right leg and behind the left arm. The radiographs show that a small number of flashes run horizontally through the interior of the figure, including a rather large one in the right ankle.

Base: Four large repairs have been soldered into the top of the base:

- Under the right hand
- In an oval directly under the figure's bottom
- In the back proper left corner of the base
- In a diagonal connecting the repairs under the hand to the repair under the figure

The repairs are partially hidden by the applied matting texture. There is no clear indication as to why the repairs were needed. Considering the success of the rest of the cast, they are rather large for casting flaws in these locations, and two of them occur coincidentally where the figure touches the base.

Sharp, angular spots of shrinkage porosity similar to that seen on the radiographs of the figure are also visible on the base. Porosity flaws extend through both the inside and the outside metal surfaces of the base. Thirteen threaded 0.5 to 0.6 cm diameter plugs were used in the base. Some of these likely fill casting flaws as well as core pin holes. There are more unrepaired porosity flaws on the surface of the base than on the figure. A moderate number of flashes are visible from the open bottom of the base; the thicker flashes have been chiseled or sawn off.

In general terms, the base fits the figure rather well. The right hand curls over the side of the base, and there is a step for each foot. On close inspection, though, the fit is less than perfect. Neither the right hand nor the feet rest directly on the base. Even though the left foot hovers above the step, the bronze below has been chiseled partway through the metal, as though to compensate for an overly tight fit.

A hole in the shape of the left foot has been sawn completely out of the bottom step (saw marks are visible along the cut edge). This hole is located less than a centimeter to the outside of the left foot. The hole was evidently cut in the wrong location and filled with a metal repair. The repair is held in place with one pin that goes straight through the repair and one that secures a cross-brace (fig. 29.3). That this hole is exactly the shape of the foot indicates it was cut for this particular figure but in the wrong location. This repair suggests sloppy workmanship rather than reuse of the base from another composition.

4. Later Modifications/Restorations

An attribute in the left hand is missing and seems to have taken the little finger in the left hand with it.

SUMMARY

The figure and base were cast separately using the indirect lost wax technique. The figure was cast in five sections that secure to one another with sleeve joins. Numerous shrinkage porosity flaws in both the figure and the base were repaired with threaded plugs. Matting texture helps to hide numerous large soldered-in repairs on the top of the base. Both the base and the figure were coated with a thin dark brown organic patina, but the figure is presently bluish green in color due to thin paint and tinted wax coatings applied over the dark brown patina. The modeling of the base is less refined than that of the figure, and the two pieces do not fit together well, suggesting the models for the figure and the base originated from different compositions, if not different artists. Adjustments in the base appear to have been made in the foundry in an attempt to fit the figure to the base. Although their origins may have been different, it is possible that they were both *cast* in the same foundry. This is suggested by similarities in the alloys, the similar type and frequency of the casting flaws, and the type and number of threaded plugs.

The technical study clearly indicates that the *Christ Mocked* was neither conceived nor cast by Adriaen de Vries.

Alloy

The quaternary alloy containing low and nearly equal amounts of tin, zinc, and lead in a copper matrix that was used for the *Christ Mocked* varies markedly from de Vries's metal of choice.

Core

The plaster-based core used to cast the base of the *Christ Mocked* bears no relation to the de Vries cores that have been analyzed. Copper alloy fragments as found in this core are unusual and may one day help to tie the bronze to a specific artist or foundry.

Casting Technique

Although de Vries seems to have cast a certain percentage of his bronzes using the indirect lost wax technique, he constructed his casting cores in a very different manner from that observed on the *Christ Mocked.* Whereas the figure of Christ was cast in five sections that were mechanically joined in the metal, de Vries relied on wax-to-wax joins to build his figures, which were then cast in one pour.

Repairs

The number and type of repairs on both the figure and the base of the *Christ Mocked* also differ considerably from those on de Vries casts. With the number of repairs in the base, it is difficult to imagine de Vries not simply throwing the flawed cast back in the crucible and trying again. Rarely is a single threaded plug found on a de Vries cast. The meticulous work associated with the numerous threaded plugs on the Christ composition is completely antithetical to de Vries's oeuvre.

Conclusion

The technical study of the statuette has shown that it is merely a variant of *Christ in Distress* in the Liechtenstein Palace, Vienna, as there is no relationship in the materials and techniques to the work of de Vries.

The large number of threaded plugs of varying diameters suggests a comparatively sophisticated screw-cutting capability that would have been possible only after the third quarter of the sixteenth century (Bewer et al. 2003: 105). This observation is in keeping with the TL date of 1655 to 1735 that was recorded for this bronze.

NOTES

1 *Sculpture from the David Daniels Collection*, exhibition catalogue, Minneapolis Institute of Arts, October 26, 1979–January 13, 1980, 58–59.

2 Avery attribution, in *Sculpture from the David Daniels Collection,* 58. LACMA accessioned the work with this same attribution in 1984.

3 The use of bits of copper in a casting core is a variation on Biringucci's recommendation for adding iron rust or scale as a temper (Biringucci, Smith, and Gnudi 1990: 219–20). There is some possibility, although unlikely, that the metal bits and copper relate not to the casting core but to later repairs.

CHAPTER 30

Hercules, Nessus, and Deianeira

Attributed to Charles Crozatier (1795–1855), after Adriaen de Vries
Nelson-Atkins Museum of Art, Kansas City. Inv. no. 44-53
Cast in Paris, c. 1845–1850
Dimensions: H: 79 cm × W: 44.5 cm × D: 31.3 cm (see comparisons chart, p. 248)
Marks and inscriptions: None.

OVERVIEW

This group depicting Hercules lifting his wife, Deianeira, to safety from the centaur Nessus (fig. 30.1), is an aftercast of the original Adriaen de Vries composition in the Louvre (see chapter 13). This aftercast and another from the Rijksmuseum (see chapter 31) have been attributed to the Parisian bronze founder Charles Crozatier.[1] The bronze is recorded in a private collection in New York ca. 1913. It remained in private hands until its purchase by the Nelson-Atkins Museum of Art in 1944.

The technical study was undertaken together with the study of the Rijksmuseum aftercast in order to gain a fuller understanding of the production of copies of de Vries's compositions and to determine, if possible, their relationship to each other and to the Louvre's attributed original cast.

EXAMINATION

1. Alloy

The alloy was determined for five of the eight separately cast sections. The metal is a brass composed of approximately 10 to 13 percent zinc in a copper matrix with 2 percent tin and less than 1 percent lead. One repair plug that was examined was found to be a brass containing a higher amount of zinc (29%). Full alloy results can be found in table 4.1.

FIGURE **30.1** *Hercules, Nessus, and Deianeira*
Attributed to Charles Crozatier (1795–1855), after Adriaen de Vries
Nelson-Atkins Museum of Art, Kansas City. Inv. no. 44-53

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Most of the core and support rods appear to have been removed before the separately cast sections were joined. Five core support rods remain in the interior of the limbs (fig. 30.2). The rods are of varying dimensions; wire twists around the two in Hercules' lower legs.

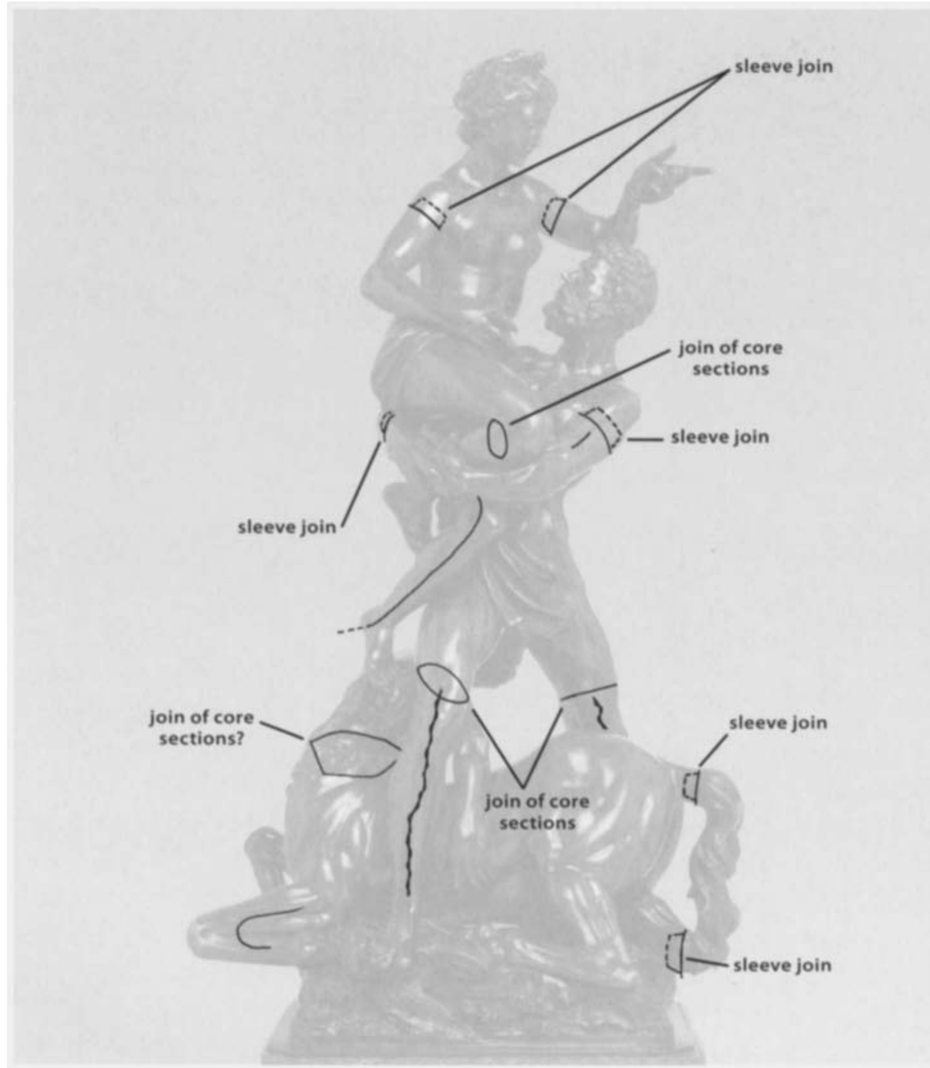
b. Core pins

No core pins remain in the bronze, although some of the round plugs may fill holes left when core pins were removed. The core support in Deianeira's left leg exited the core and wax in the foot and extended into the outer mold, functioning as both a core support and a core pin (fig. 30.3). It is likely that rods entered the outer mold in other locations, including the top of Hercules' and Deianeira's heads where threaded plugs fill what are probably core support or core pin holes (fig. 30.4).

c. Core material

Most of the core material has been removed from inside the bronze. Examination of the open bottom of the sculpture shows that almost no core remains in the base or in Nessus's body and torso (fig. 30.5). A small amount of black core remains against the flashes in the interior, from which

FIGURE 30.2 Summary of the remaining sleeve joins, core joins, and core support rods and wires.



a sample was removed for analysis. Quantitative analysis yielded the following:

- 52 percent black clay
- 41 percent quartz
- 6.5 percent feldspar
- 0.5 percent muscovite
- traces of oxy-hornblende (lamprobolite), uncharred plant fibers, and bronze metal fragments

As the technical study progressed, it became increasingly apparent that the sculpture was cast using the sand casting process. With this in mind, a sand component of only 47.5 percent for the core (the sand is primarily composed of quartz and feldspar), yielding a nearly 1:1 sand-clay ratio, seemed to be rather low. Indeed, the percentage of sand in the core is not too far from some of the sand content found in what are thought of as clay cores. To further investigate, a sample of French sand-casting investment sand was acquired for comparison with the core from the Nelson-Atkins *Hercules, Nessus, and Deianeira*.[2] Thin section analysis of the French sand shows that it contains 47 percent sand, 47 percent red clay, and minor amounts of hematite, metamorphic rock fragments, and assorted minerals. Indeed, the high percentage of clay observed both in

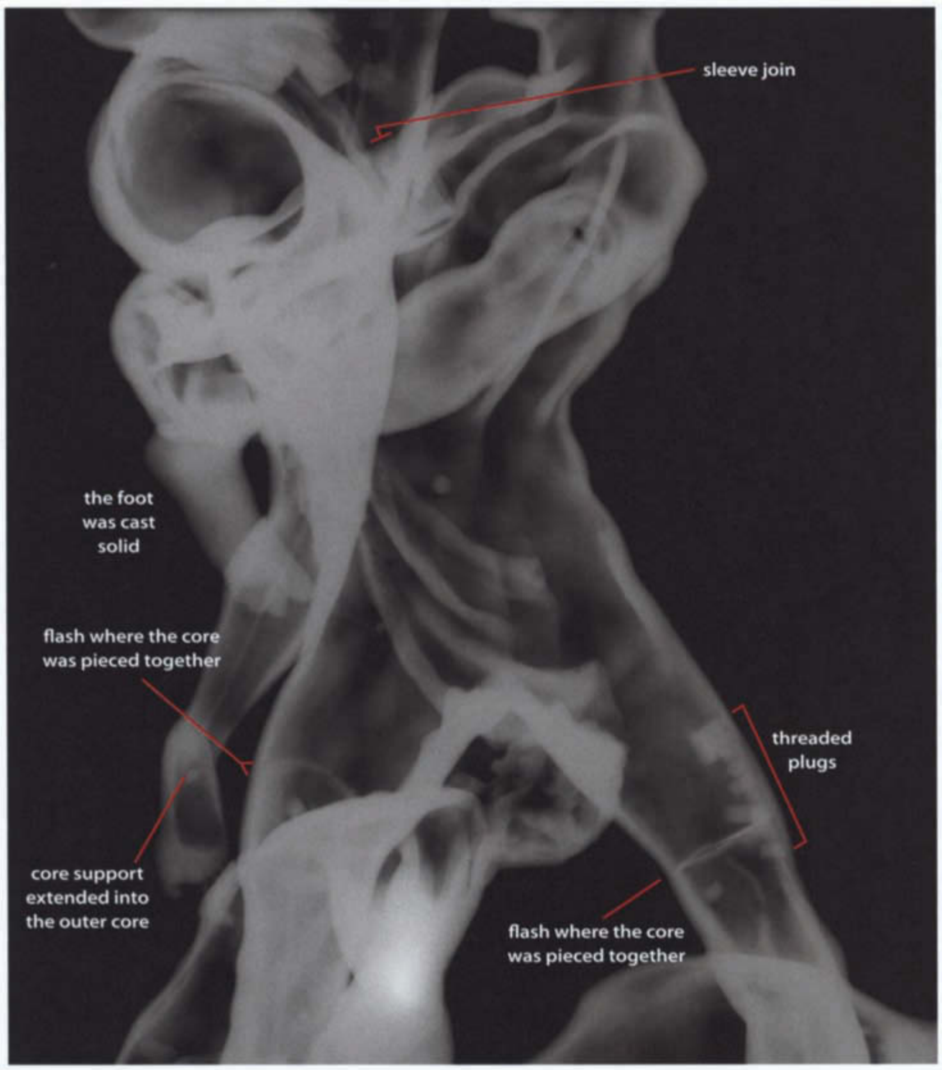
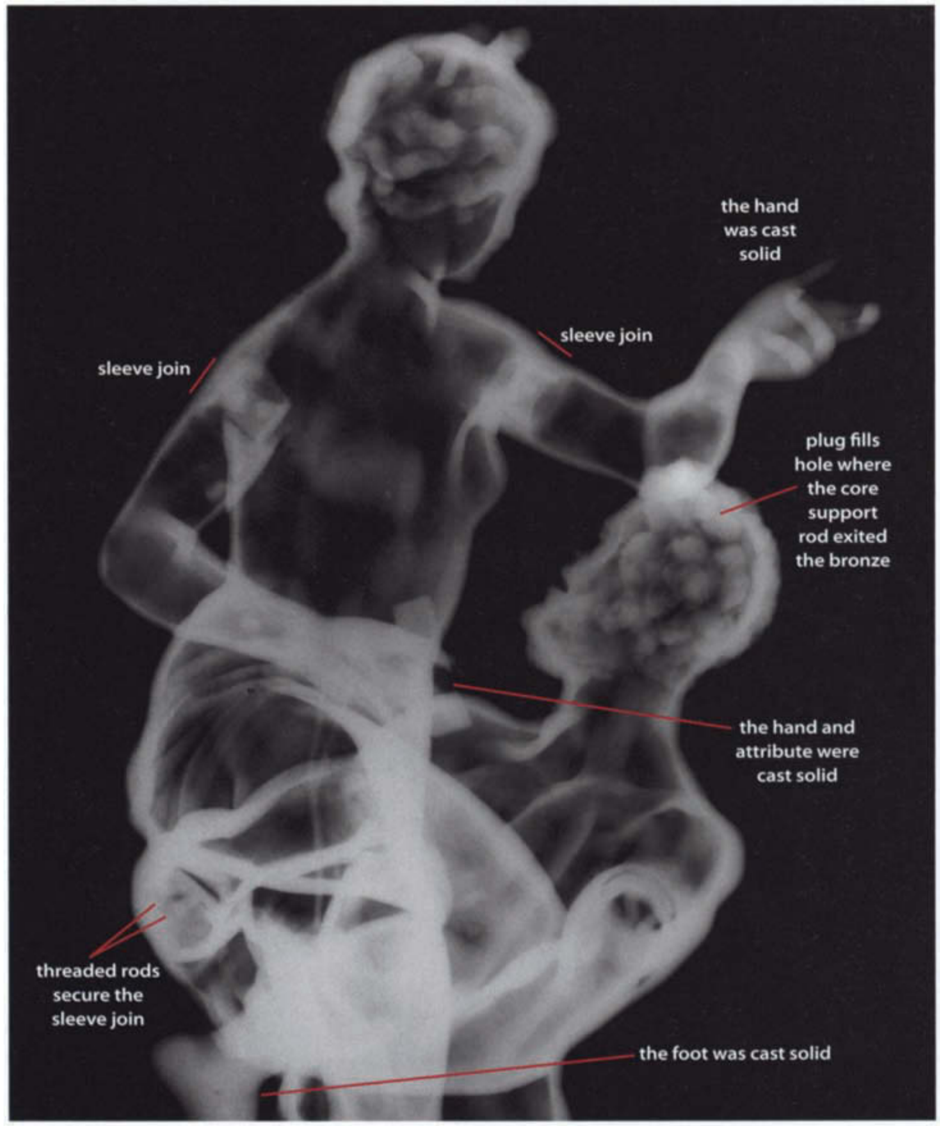


FIGURE 30.3 Radiograph of the center of the sculpture.

the core and in the sample of French sand is reflected by founder man William Donald Mitchell: "Though called 'sand' by the foundryman, as a matter of fact it closely resembles a mixture of sand and clay" (Mitchell 1916: 18). Further similarities are found in the appearance of the bronze core and the sand sample under magnification. A distinctive visual feature common to both the sand-casting investment material and the *Hercules, Nessus, and Deianeira* core is the orientation of the clay with the sand. In both cases, each discrete sand particle is evenly coated with a layer of clay (figs. 5.3, 5.7). This even distribution contrasts with the typical clay-based de Vries cores, in which the sand is interspersed randomly within the clumps of clay. The two samples also stand apart for their large grain size: very fine sand is observed in the de Vries cores. It should be noted, however, that this grain size is only apparent under magnification. To the touch, the French investment sand is extremely fine textured and is able to take a fine impression.

The plant fibers contained in the core are uncharred and clean, without any sand or soil embedded in them, suggesting that they were not part of the original casting core. Similarly, the few bronze fragments were not well incorporated into the core material and were evidently not part of the original casting core.

FIGURE 30.4 Radiograph of Deianeira and Hercules' upper body.



d. Internal surface of the bronze

Visual examination of the open bottom of the base and of the radiographs suggests that the bronze was made using the sand casting process. The inner contour of the base is geometric and stepped (fig. 30.5), differing from the more fluid interior contours expected in lost wax casts. The radiographs show that, with the exception of the appendages, the metal is fairly even in thickness overall. In the appendages, though, the thickness of the metal varies from area to area, again characteristic of the sand casting technique, in which the core is cut down to approximately—but not perfectly—reflect the outer contours. This method of forming the core leads to areas where the exterior contains raised details not reflected on the interior. Because a sand core can be delicate and does not lend itself to long, thin shapes, sand casting cores are often cut off in areas where a limb or other part narrows. This abrupt abbreviation of the core produces solid cast elements, as seen in Nessus's arms (fig. 30.6), as well as in Deianeira's hands and right foot (fig. 30.4). Nessus's right foreleg and rear legs are also

FIGURE 30.5 Open bottom of the base revealing the geometric contours expected in a sand cast. The arrows indicate fine flashes that formed between the separate sections of the sand piece mold.

FIGURE 30.6 The core in Nessus's right shoulder was cut into an abbreviated, geometric shape, yielding a nearly solid-cast arm.

predominantly solid, with only a simplified lump of core (fig. 30.7). His tail also appears to be solid throughout (not fully covered in fig. 30.7).

Visual examination of the inside of the base suggests that the inner core was constructed in at least four sections. Fine, straight flashes run across the bottom of the base where metal leaked into thin gaps between these sections (fig. 30.5).

Hammer marks on the inside of the base are evidence of adjustments made to the base to allow a better fit with the separately cast figure of Nessus. The largest number of marks appear around the hole leading to Nessus's belly and where the base meets his back right leg (fig. 30.5).

e. Method of assembly and joining of individual cast bronze components

The sculpture was cast in eight separate pieces, as listed below:

1. Deianeira's head, torso, and legs and Hercules' right arm[3]
2. Deianeira's right arm
3. Deianeira's left arm
4. Hercules' head, torso, and legs
5. Hercules' left arm and right hand and wrist
6. Nessus's head, upper and lower bodies, arms, and forelegs and most of the back right leg (back left leg is not clear in the radiographs)
7. Nessus's tail and a bit of the right rear leg
8. Rectangular base

Most of the sections secure to one another with sleeve, or Roman, joins. The joins are held together with threaded rods, the ends of which are clearly visible on the surface of the sculpture. The join at the base of the tail is a modified sleeve join. In this example, the sleeve is solid, not hollow, and only one threaded rod passes through the join, securing the tail. Along with the threaded rod, a curved rod, perhaps integrally cast, appears to wedge against the edge of the sleeve, helping to hold the tail in place (fig. 30.7).

In four locations, there are ring-shaped discontinuities in the inner walls of the bronze. At first glance, these marks are reminiscent of meticulously made wax-to-wax joins, yet further investigation suggests otherwise. The marks appear in the following locations: below Deianeira's right knee, above both of Hercules' knees (fig. 30.3), and between Nessus's human and animal torsos (fig. 30.7). The marks are due to fine flashes that have occurred where the metal entered gaps between the pieced-together cores. In other words, the cores for Deianeira's left lower leg, Hercules' lower legs, and Nessus's upper body were made separately from the torsos. The cores were then placed together in the mold, with thin gaps between the sections. This would also explain why the core support rods in Hercules' lower legs do not extend from one section of the core into the adjacent section: the parts of the core were completed before they were inserted into the mold.

The sleeve joins and core joins are illustrated in figure 30.2.

The separately cast figures secure to the base with iron and copper alloy screws. Four holes that would have held screws to help secure Hercules and Nessus remain empty, even though the holes between the base and the figures line up fairly well. The figures appear to be well secured anyway; perhaps the bronze was disassembled sometime in the past and the screw lost, or the foundry thought these screws were redundant (fig. 30.5).

f. External surface of the bronze: Evidence of the model and of final surface chasing

The modeling was carefully rendered throughout. The flesh and drapes are highly polished (figs. 30.8a–30.10a). The joins between the individually cast sections, all of which are in polished areas of the flesh, were carefully chased (fig. 30.11). A round punch was used to texture the tail, foliage, and hair; the surface texture is rather soft in most areas, suggesting that the texture originated in the model and was not applied in the metal (fig. 30.12). Indeed, there is little evidence of texturing or chiseling in the metal.

g. Patina

The thin, even, chocolate brown patina on the metal surface has the appearance of a chemical patina. No distinctive elements from the patina were identified through X-ray fluorescence surface analysis. Remnants of a thin, opaque, dark brown organic patina remain over the chemical patina in recessed and more protected areas such as the top of Hercules' right foot and below Deianeira's lower legs. Where the surface is worn, the greenish yellow oxidized metal surface is exposed.

3. Casting Defects and Foundry Repairs

The radiographs reveal a relatively flawless cast with limited fine- to medium-vacuole porosity due to gases having been trapped in the metal during the pour. As discussed in sections 3d and 3e above, fine flashes on the base and inside the figures appear to have formed between separate sections of core that were brought together in the mold. The rest of the sculpture is free of flashes.

Repairs are made with round plugs, many of which are easy to see on the surface, as they are a different color than the surrounding metal. Plugs applied in difficult-to-reach areas, such as below Deianeira's upper right arm, were applied before the separately cast parts were assembled. Most, but not all, of the larger plugs are threaded. Nine threaded plugs are clustered on Hercules' left outer thigh; small plugs such as those on Hercules' right calf are not threaded.

SUMMARY

The technical study has shown that the sculpture was sand cast in eight separate sections that were joined mechanically using sleeve joins secured with threaded rods. The pieces were cleanly cast, with moderate gaseous porosity. Elements that suggest the sand casting process include the physical characteristics of the core; the angular, geometric contours of the interior of the cast, as can be seen inside the open base and in the radiograph of Nessus's right shoulder; nonconformity of the inner and outer walls of the sculpture; the fact that the composition was cast in a number of sections; and the lack of internal flashes, with the exception of those that are associated with joins between the mold sections. Most of the core material and core supports have been removed. Some of the core supports extended through the bronze, functioning also as core pins. Clusters of round plugs were used for surface repairs; most of these are threaded. The surface is covered overall with a thin, even, chocolate brown chemical patina that, together with the overall polish and lack of sharp texturing, lends a distinctive soft and smooth feel to the sculpture.

Comparison of the Aftercasts with the Louvre Original

Examination of the original cast in the Louvre (chapter 13) with both the Nelson-Atkins and Rijksmuseum aftercasts

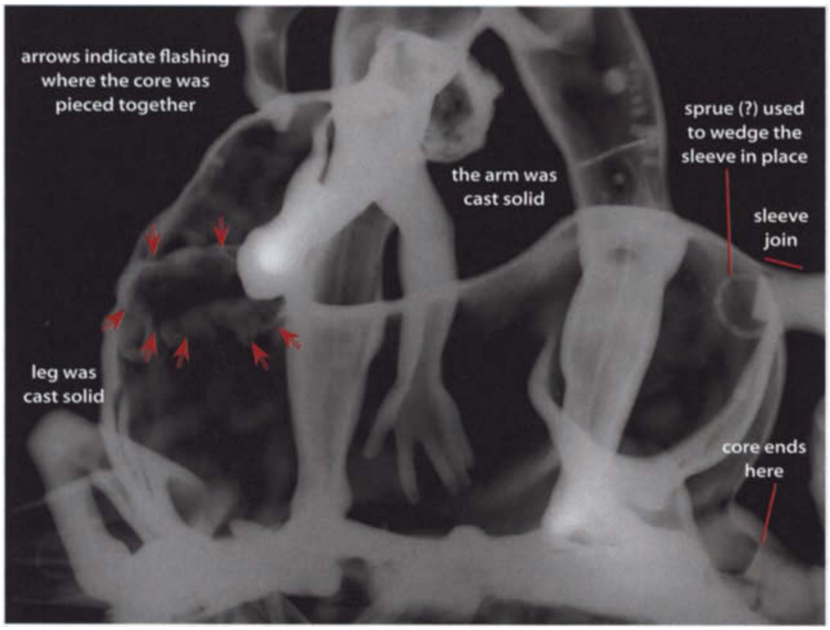


FIGURE 30.7 Radiograph of Nessus.

FIGURE 30.8A Nessus's hand on the Nelson-Atkins cast. The details were carefully modeled and the surface highly polished after casting.

FIGURE 30.8B Nessus's hand. The modeling is less precise, and cross-hatched texture was applied on the hide. *Hercules, Nessus, and Deianeira,* Charles Crozatier, Rijksmuseum, Amsterdam, inv. number BK-1957-2.

FIGURE 30.9A The Nelson-Atkins Deianeira.

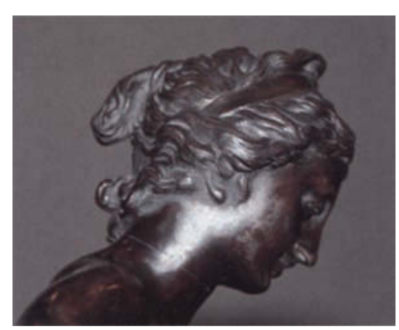


FIGURE 30.9B Deianeira from *Hercules, Nessus, and Deianeira,* Charles Crozatier, Rijksmuseum, Amsterdam, inv. number BK-1957-2.

FIGURE 30.10A Drapery on the base. The surface is polished. The Nelson-Atkins cast.

FIGURE 30.10B Drapery on the base. Note the cross-hatched texture. *Hercules, Nessus, and Deianeira,* Charles Crozatier, Rijksmuseum, Amsterdam, inv. number BK-1957-2.

offers an example of the types of changes that can occur when a bronze is copied. The casting techniques have left their distinctive marks on each. The original in the Louvre is an indirect lost wax cast; the two aftercasts are sand casts. By using the lost wax technique, de Vries was able to cast the original bronze in one piece without regard to the difficulties presented by the complex composition. In contrast, it was necessary to make the two later sand casts in sections that were then joined in the metal. In at least one place, casting in sections and the chasing that followed caused an alteration in the modeling. The ribbon on the tail of the Louvre original has been removed on the two later casts (figs. 13.10, 30.11). The ribbons, located where the separately cast tails join the bodies, were removed in the sand casts, perhaps to avoid undercuts and also to allow free access to the area to allow chasing of the join.

With use of the indirect method of lost wax casting, the inner and outer walls of the bronze conform quite closely to one another in the de Vries original. In both sand casts, there is poor conformity between the walls of the bronze in areas such as the base and Nessus's left arm, yielding distinctly geometric contours, as observed in photos taken under the bases (figs. 13.6, 30.5, 31.5) and in the radiograph of Nessus's arm (fig. 30.6). The sand casts also lack the rough flashes typical of lost wax casts (figs. 13.6, 30.5, 31.5).

A comparison of the three casts also reveals changes in the modeling and surface texture that occurred between original and aftercasts. Although the original composition is essentially unchanged in the aftercasts, minor variations in the modeling of both include alteration of the details in the bases, the addition of drapery as a *cache-sexe,* and changes in how the hair is depicted. The very lively and slightly chaotic mass of the figures' hair, Hercules' beard, and Nessus's tail on the Louvre version is translated to a more uniform, repetitive modeling of the hair on the aftercasts (figs. 13.1, 30.1, 31.1). Modifications in the surface texture can be found in the base where the deep punch marks on the Louvre version have been removed in the aftercasts. The characteristic deep, rough, and unevenly applied brushed texture in the drape of the Louvre cast has been completely removed on the Nelson-Atkins version and altered to an even cross-hatching on the Rijksmuseum bronze (figs. 13.13, 30.10a, 30.10b).

At the very least, the steps for sand casting the later copies would have included taking a mold from the original bronze, casting a foundry model in the mold, forming a sand mold around the foundry model, and then casting the bronze copy

FIGURE 30.11 The sleeve joins such as this one on the base of Nessus's tail are well hidden.

FIGURE 30.12 Photomicrograph of Nessus's hair. The indistinct punch marks were likely made in the wax.

in the mold. Each one of these steps holds the possibility for unintentional changes, such as the softening or loss of details, as well as intentional surface alterations, both of which may have been at play in producing the observed changes.

Comparison of the Nelson-Atkins and Rijksmuseum Casts

The two aftercasts were compared in an attempt to determine how they relate to each other, including whether they were cast in the same foundry. Installation of the two copies on the same pedestal allowed a close visual comparison. The composition of the figures is extremely similar, the only difference being in Deianeira's left arm, which is slightly lowered in the Rijksmuseum bronze. Both versions contain drapery that acts as a *cache-sexe,* an element not found on the original version in the Louvre.[4] As with the Louvre cast, the Rijksmuseum base is roughly oval; the Nelson-Atkins base is rectangular, with a cast-in mounting flange. Nessus's tail on the Rijksmuseum copy is quite similar to that of the Louvre original; the Nelson-Atkins tail is considerably larger.

Although the modeled details on the Rijksmuseum cast more closely resemble those on the original bronze, they are simplified and flattened in comparison to the more detailed and lively modeling on the Nelson-Atkins version. For example, the Nelson-Atkins bronze includes protruding veins on Nessus's arms and hands, the hair is more three-dimensional, and the drapery has a more natural line than that on the Rijksmuseum cast (figs. 30.8a–30.10b). Although there is raised foliage on both of the bases, there is more on the Nelson-Atkins base, and it is more lifelike. There is far more surface texture on the Rijksmuseum version, where, for example, a textured punch was used to apply lines to depict Nessus's sideburns (rather than modeled clumps of hair), and a distinctive cross-hatch texture was applied to the drapery and Nessus's hide (cf. figs. 30.8a and 30.8b; 30.10a and 30.10b). Although opinions will vary as to the end effect of such texturing, it is this researcher's opinion that the even lines, repetitively applied, serve to visually flatten the surface.

The Nelson-Atkins bronze was cast in eight parts, the Rijksmuseum bronze in nearly double that at fourteen. This variation in the number of separately cast sections indicates that different sets of foundry models were used for the two versions.

Both the Nelson-Atkins and Rijksmuseum versions were cast using a brass alloy with a small amount of tin and lead.

The Nelson-Atkins alloy contains approximately 13 percent zinc, whereas the Rijksmuseum alloy contains almost double that, at approximately 23 to 26 percent zinc.[5]

Although more than two hundred bronze casting core samples have been analyzed at the J. Paul Getty Museum, the only cores originating from sand casts as of 2000 are the two from the *Hercules, Nessus, and Deianeira* aftercasts, both of which contained more clay than sand. As it was expected that the opposite would be true—that is, that the "sand" would contain more sand than clay—a sample of fine French sand casting mold material was analyzed for comparison. The sample was found to be remarkably similar to the core material from the aftercasts. Quantitatively, the French sand was found to contain equal amounts of clay and sand. More important, petrographic sections of the three show striking similarities in the large size of the grains and in the structure, in which each sand particle is coated with an even layer of clay, quite a different arrangement from that typically observed in clay cores. Although only a very small sampling, this preliminary comparison confirms the results based on structural analysis that the bronzes were indeed made using the sand casting technique.

The surface coatings of the two bronzes are quite different. The Nelson-Atkins bronze is most distinctive for its rather even, chocolate brown surface. The Rijksmuseum bronze is darker overall and far less uniform in color due to the damaged organic patina remaining on its surface. Because a bronze can be repatinated without any outward sign of the process having occurred, reaching conclusions about the origin of the two aftercasts based on the patina is fraught with problems. It is also likely that a foundry producing casts of this quality, at this date, would have had a range of finishing options available (cf. figs. 30.9a and 30.9b).

Comparing the dimensions of different versions of a bronze sculpture can be helpful in determining their relationship. When a mold is taken off of an original bronze and a copy is cast, the aftercast will be smaller due to shrinkage of the materials used in the process. If a mold is then taken off of the aftercast, further copies will be smaller yet. Table 30.1 compares the dimensions of the original de Vries bronze in the Louvre to those of the two aftercasts discussed here.

Comparison of A and B shows that the Nelson-Atkins Museum of Art bronze averages approximately 2.1 percent

TABLE 30.1 Size comparison for the Hercules, Nessus, and Deianeira groups.

Location	A: *Louvre*	B: *Nelson-Atkins*	C: *Rijksmuseum*	Change A:B	Change A:C	Change B:C
Overall height	82.1 cm	79 cm	78.4 cm	−3.8%	−4.5%	−0.8%
Overall width	45.8 cm	44.5 cm	44.2 cm	−2.8%	−3.5%	−0.7%
[Overall depth]*	[35.8 cm]	[31.3 cm]	[32.5 cm]	[−12.6%]	[−9.2%]	[+3.8%]
Hercules' left calf (largest circumference)	14.4 cm	14.1 cm	13.8 cm	−2.1%	−4.2%	−2.1%
Hercules' neck (smallest circumference)	15.3 cm	15.1 cm	14.6 cm	−1.3%	−4.6%	−3.3%
Deianeira's left upper arm (largest circumference)	12.2 cm	12 cm	11.6 cm	−1.6%	−4.9%	−3.3%
Deianeira's waist (smallest circumference)	24 cm	23.5 cm	23.2 cm	−2.1%	−3.3%	−1.3%
Deianeira's left armpit to Hercules' left heel	59 cm	58.5 cm	58.5 cm	−0.8%	−0.8%	0%

* The bases determine the depth measurements. Because the bases are of different designs, those measurements are not useful for comparing minor differences in size.

smaller than the de Vries original in the Louvre. A lost wax aftercast taken from an original bronze is expected to shrink approximately 1.5 to 5 percent, depending on the composition of the wax and the specific bronze alloy used (Bewer 1996: 88–89). In this case, as the copy is a sand cast, it is likely that plaster, instead of wax, was used as the foundry model, decreasing somewhat the expected shrinkage rate. Based on this small comparison of the dimensions, it is possible that the Nelson-Atkins bronze could have been cast using molds taken from the Louvre original.[6] Comparison A:C shows us that the Rijksmuseum bronze measured, on average, approximately 3.7 percent smaller than the Louvre original. Based on these preliminary measurements, it is also possible that the Rijksmuseum bronze was cast directly from molds taken from the Louvre bronze. It can also be said that when comparing the measurements of the two aftercasts (B:C in table 30.1), we see that in all the measurements except for two, the Rijksmuseum bronze is on average 1.6 percent smaller than the Nelson-Atkins Museum of Art bronze. It is possible, therefore, that the Rijksmuseum bronze is a second-generation aftercast. Because the modeled details on the Nelson-Atkins cast (the shape of the base and tail, as well as some of the details of the foliage in the base) differ markedly from those on the Louvre original, though, it is unlikely that the Rijksmuseum bronze, which remains similar to the original in these details, is an aftercast of the Nelson-Atkins version.

A comparison of the Nelson-Atkins and Rijksmuseum aftercasts of de Vries's *Hercules, Nessus, and Deianeira* has shown a remarkable similarity in their overall compositions, yet the varying number of parts they were cast in and the variations in size and surface details suggest that they were made with two different sets of foundry models. The attribution of both to the Crozatier workshop should be reconsidered. To date, no studies of the processes and techniques used at the Crozatier foundry have been published. In fact, the study of nineteenth-century French foundry practices is a field open for research.[7]

NOTES

1 This attribution is based on a signature and date on another copy of the composition sold in London in 1990 (Scholten 1998a: 148).

2 This sample was kindly supplied by Johan Pettersson. The Pettersson Art Foundry, located outside of Stockholm, Sweden, has been sand casting bronze statuary for three generations. The sample provided was purchased in France in the 1950s.

3 The radiographs suggest that Hercules' right arm was cast with Deianeira's body, although they are not easy to read in this area. It is possible that the arm was cast separately, bringing the number of separately cast elements to nine.

4 Inv. number OA 5424; chapter 13 this volume.

5 To date there is no comprehensive database of nineteenth- and twentieth-century copper alloys used for sculpture, although one day the variations in zinc and other components of cast brass may well be an important key to dating them.

6 *Surmoulage* scratches on the surface of the Louvre bronze confirm that at some date molds were taken from its surface.

7 Ann Boulton's essay on Antoine-Louis Bayre provides an excellent introduction to many of the questions surrounding foundry practices in the nineteenth century (Boulton 2006).

CHAPTER 31

Hercules, Nessus, and Deianeira

Attributed to Charles Crozatier (1795–1855), after Adriaen de Vries
Rijksmuseum, Amsterdam. Inv. no. BK-1957-2
Cast in Paris, c. 1845–1850
Overall dimensions: H: 78.4 cm × W: 44.2 cm × D: 32.5 cm (see comparisons chart, p. 248)
Marks: Painted on the interior: R.B.K. 1957.-2.

OVERVIEW

This group depicting Hercules lifting his wife, Deianeira, to safety from the centaur Nessus (fig. 31.1) is an aftercast of the original Adriaen de Vries composition in the Louvre (chapter 13). This and other aftercasts of the group have been attributed to the Parisian bronze founder Charles Crozatier, based on a signature and date on another copy sold in London in 1990 (Scholten 1998a: 148). The bronze was purchased in London by the Rijksmuseum in 1957.

The technical study was undertaken together with the study of the Nelson-Atkins aftercast in order to understand more about the production of copies of de Vries's compositions and to determine, if possible, their relationship to each other and to the Louvre's attributed original cast.

EXAMINATION

1. Alloy

The alloy was determined for five of the fourteen separately cast sections. The metal is a brass composed of approximately 26 percent zinc in a copper matrix with 1 percent tin and 1 to 2 percent lead. Full alloy results can be found in table 4.1.

FIGURE 31.1 *Hercules, Nessus, and Deianeira*
Charles Crozatier (1795–1855)
Rijksmuseum, Amsterdam. Inv. no. BK-1957-2

2. Evidence of the Technique of Fabrication

a. Internal metal armature and core supports

Many of the core supports seem to have been removed from inside the bodies of Nessus and Hercules, although many remain in other parts of the sculpture, as illustrated in figure 31.2. Although most of the supports are solid rods, some in the figure of Deianeira are hollow tubes made of wrapped sheet metal. The edges of the sheet join loosely along the length of the tubes (fig. 31.3). Gaps along the tubes would have allowed gases to enter, helping to funnel released gas out of the core. Although this type of armature generally extended outside the sand casting molds,[1] in this instance the rods end well clear of the walls of the bronze, suggesting either that they have been cut off at the surface and pushed back into the bronze or that they never extended out of the bronze, simply offering a void in which gases could collect.

Most of the rods and tubes are wrapped in wire, a practice that gave "tooth" to the support, allowing a stronger mechanical bond with the core. Although there are at times multiple supports within a section, the supports are not bound to one another. The supports that remain within the sculpture are summarized below and in figure 31.2.

Deianeira: There are two vertical core supports in the head: one hollow and one solid. There are four supports in the torso, three of which are hollow. Two of the supports in the torso extend into the legs. One of the three rods in the right arm extended out of the core in the elbow and into the outer mold, doubling as a core pin. A hollow support and a wire run through the left arm; both end below the shoulder.

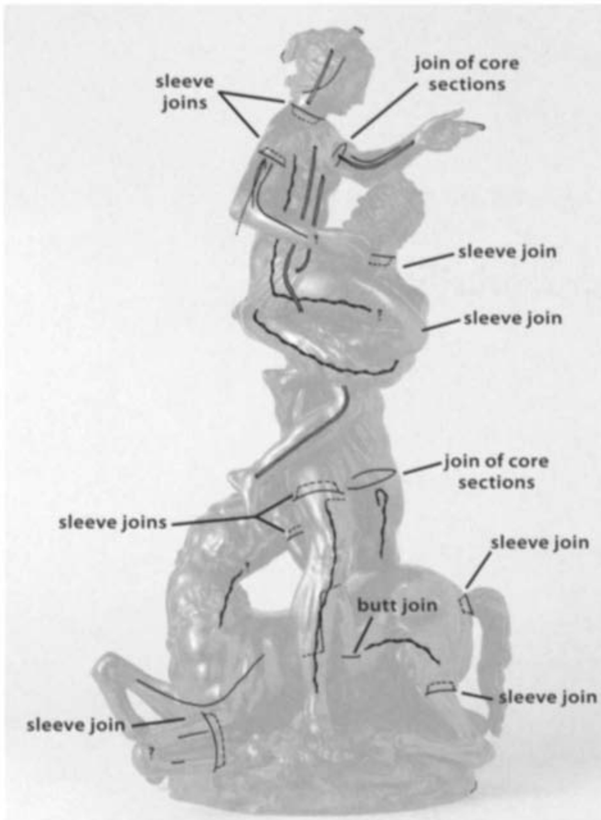


FIGURE 31.2 Summary of sleeve joins, core joins, one butt join, and the remaining core support rods and wires. The dashed lines indicate core support wires that were cut off at the surface of the bronze. Question marks refer to areas that are not clearly visible in the radiographs.

Hercules: There are no core supports in the head, the torso, or the right upper arm. Two supports in the left arm start at the shoulder, below the point at which the two separate sections of core join.

A support extends through the full length of the right leg. A second, shorter vertical rod is located in the lower leg. Both ends of the shorter rod, as well as the top end of the longer rod, appear to have extended out of the core and into the outer mold, doubling as core pins. A single vertical rod in the left leg begins below the point at which the two sections of the core join.

Nessus: All but a small number of partial supports have been removed from inside the figure of Nessus. The radiographs of the left foreleg are difficult to decipher.

b. Core pins

Some of the round plugs visible on the surface may fill core pin holes.

As mentioned above, three of the core supports exited the core and extended into the outer mold, helping to hold the core in place while the bronze was being poured. The two examples in Hercules' leg are solid rods that take a 90-degree turn at their ends (fig. 31.4). One rod in Deianeira's right arm exits straight out the elbow (fig. 31.3).

c. Core material

Examination of the bronze from below shows that the core has been removed from the base and part of Nessus's body. The core material that remains on the interior is gray colored (fig. 31.5). A core sample was taken for compositional analysis from under the open base through the opening that extends into Nessus's body. The sample was removed from the right side of Nessus's torso where human meets animal. Quantitative analysis yielded the following:

- 60 percent dark gray clay
- 31 percent quartz
- 8 percent feldspar
- 0.5 percent quartz/feldspar rock fragments
- 0.5 percent opaque minerals
- traces of pyroxene, serpentine, and muscovite

A sample of French sand-casting investment sand was analyzed for comparison of the two *Hercules, Nessus, and Deianeira* cores attributed to Crozatier. The French sand closely resembles the cores of the two aftercast bronzes both in the distribution of the clay around each sand particle and in the size of the grains.

An additional small chunk of core was given a "recent" date through thermoluminescence dating, suggesting a casting date after 1900, which falls outside of Crozatier's lifetime.

d. Internal surface of the bronze

The interior surface of the bronze offers clues that the sand casting technique was used. The inner contour of the base is geometric and stepped (fig. 31.5) and quite different from the more fluid interior contours expected with lost wax casts.

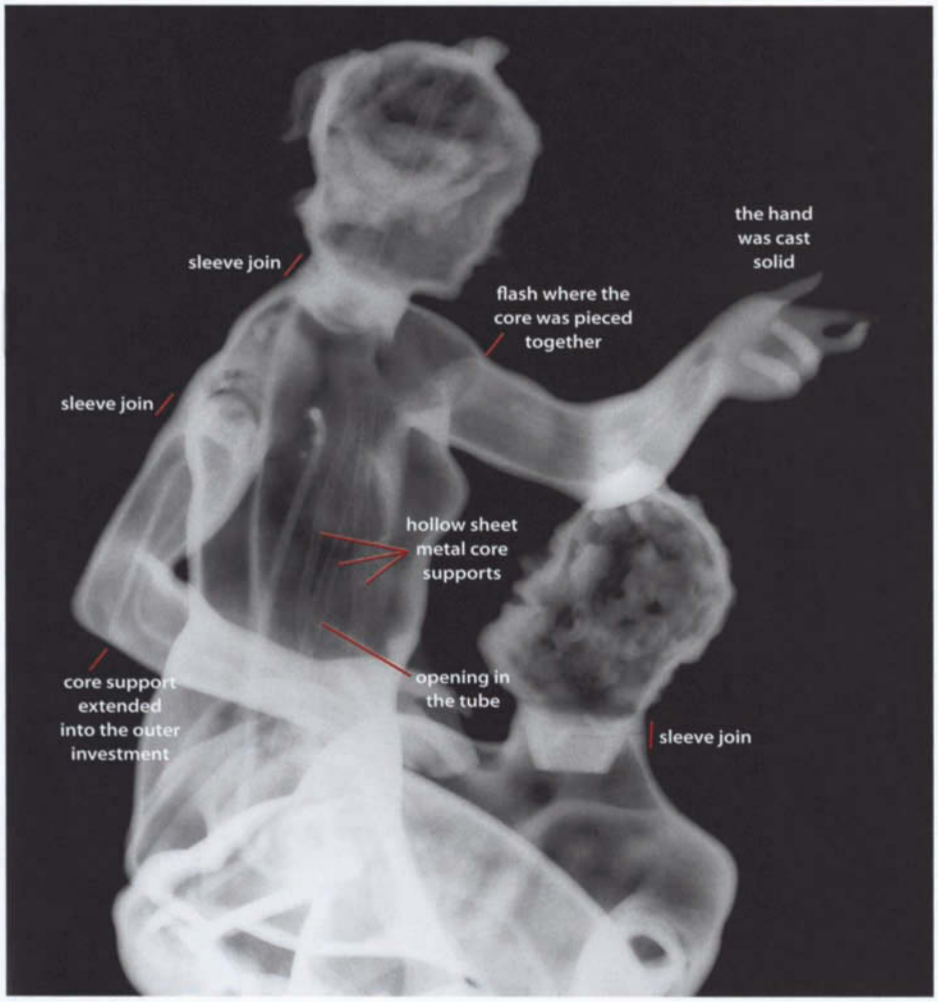
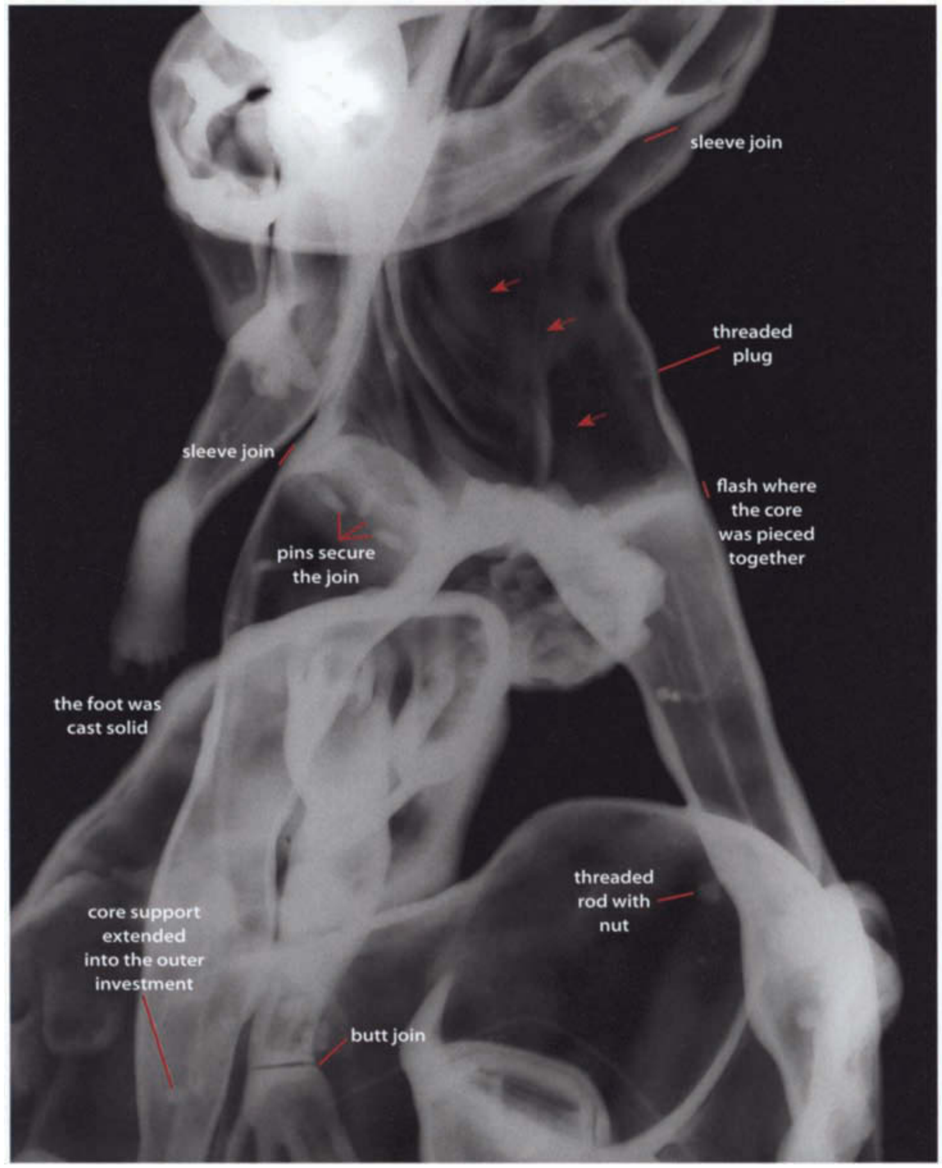


FIGURE 31.3 Radiograph of Deianeira and Hercules' head.

In some places, for example, Nessus's horse body and human torso, the metal is quite even in thickness where the inner core conforms closely to the outer contour of the bronze (fig. 31.6). In most places, however, the radiographs show varying metal thickness, again characteristic of the sand casting technique, in which the core is cut down to approximately reflect the outer contours. In some areas, the exterior contains raised details not reflected on the interior. In other areas, abrupt abbreviation of the core has produced solid-cast elements, such as in Deianeira's left arm, where the core ends in the wrist and the hand is cast solid (fig. 31.3). Similarly, Deianeira's right hand (fig. 31.3), her left foot, and much of her right foot are cast solid (fig. 31.4). Both of Nessus's hands are cast solid, as is his tail, his right lower foreleg, and the left-side hooves (the right rear leg is difficult to discern in the radiographs) (fig. 31.6). Although Nessus's left arm is hollow, the inner contour of the core is not at all conformal with the outer contour of the bronze, yielding an arm of varying thicknesses, again characteristic of a cut-down sand core (fig. 31.7). X-rays reveal unusual vertical striations that follow the length of Hercules' body (fig. 31.4). The lines appear to be from coarse paring down of the core.

Visual examination of the inside of the base suggests that the inner core was constructed in at least five sections. Fine, straight flashes run across the bottom of the

FIGURE 31.4 Radiograph of the center of the sculpture. Arrows indicate striations where the core was roughly cut down.



base where metal leaked into the thin gaps between the sections (fig. 31.5). Undercuts on the top surface of the base would also have necessitated forming the mold in pieces. The inside surface of Nessus's animal body is very smooth, without flashes.

There are hammer marks on the inside of the base and inside Nessus's belly where the edges of the two separately cast elements were adjusted slightly to allow them to fit together better (fig. 31.5).

e. Method of assembly and joining of individual cast bronze components

The sculpture was cast in fourteeen separate pieces, as listed below. Many of the joins between the sections are visible on the surface of the sculpture.

1. Deianeira's head
2. Deianeira's body with her left leg and right leg to below the knee (? not clear in the radiographs) and Hercules' right elbow

3. Deianeira's right arm
4. Hercules' head
5. Hercules' torso and left leg
6. Hercules' right upper arm
7. Hercules' left arm and right forearm and Deianeira's right lower leg
8. Hercules' right leg
9. Nessus's head, upper and lower bodies, front right leg, left hand, and possibly right rear leg
10. Nessus's front left leg
11. Nessus's back left leg
12. Nessus's left upper arm to wrist
13. Nessus's tail
14. Oval base

Ten of the sections are attached with sleeve, or Roman, joins. A clear radiographic image of a sleeve join can be seen in figure 31.4 in Hercules' right thigh, in which three straight bronze pins hold the join together. As illustrated in figure 31.2, there are a total of ten sleeve joins (the sleeve join in Hercules' right upper arm is not visible in the illustration).

A simple butt join was used in Nessus's left wrist (fig. 31.6).

The separately cast figures tie to the base with screws (fig. 31.5). In two places, the separately cast parts of the figures attach with screws and nuts: Nessus's lower left arm attaches to his back (fig. 31.6); Hercules' left knee attaches to Nessus's left back haunch (fig. 31.4).

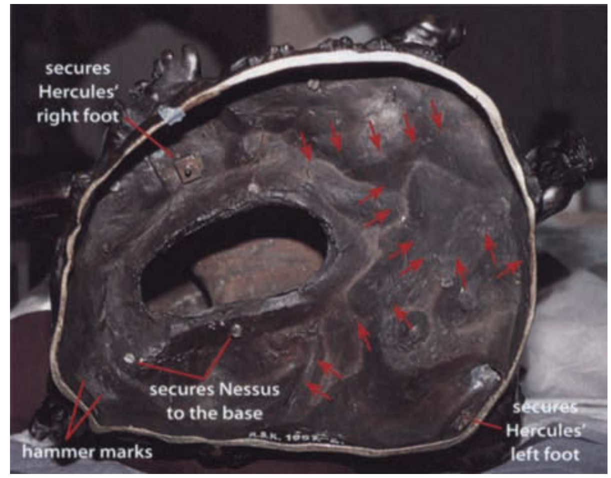


FIGURE 31.5 Open bottom of the base revealing the geometric contours expected in a sand cast. The arrows indicate what may be fine flashes between the separate sections of the sand piece mold.

Deianeira's left upper arm (fig. 31.3) and Hercules' left thigh (fig. 31.4) show fine ringlike discontinuities in the inner surface. The marks are reminiscent of wax-to-wax joins, yet overall the sculpture seems to be sand cast, in which process such joins would not be found. Instead of joins in the wax, these marks appear to be fine flashes where the metal entered gaps between the pieced-together core. In other words, the cores for Deianeira's left arm and Hercules' left leg were made separately from those for the

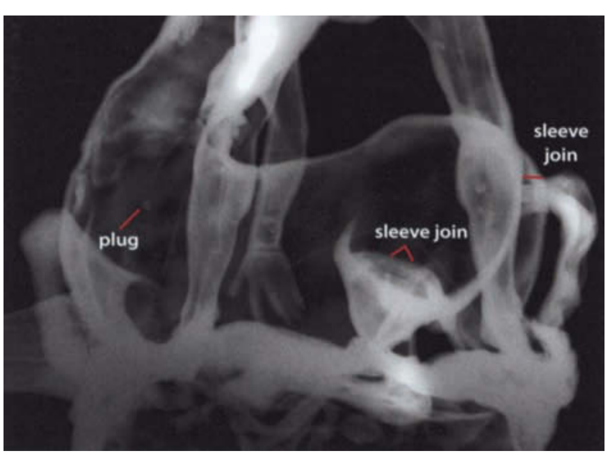


FIGURE 31.6 Radiograph of Nessus.

FIGURE 31.7 Radiograph of Nessus's torso.

FIGURE 31.8 Photomicrograph of the texture in Nessus's hair. Made using a punch into which small holes (approx. 0.5 mm) were drilled in a line.

torsos. The cores were then placed next to one another in the mold, with a slight gap between the sections. The formation of the inner core in pieces would also explain why the core support rods do not extend from one section of the core into the adjacent section.

f. External surface of the bronze: Evidence of the model and of final surface chasing

The figures were carefully finished throughout, with polishing of the flesh in most areas and texturing in others. Rather uniformly applied cross-hatching covers the drapes as well as Nessus's lower body and hooves and could have been applied either in the model or in the metal before the separate sections were assembled (see chapter 30, figs. 30.8b and 30.10b). The figures' hair and Nessus's tail were textured with a punch (fig. 31.8). The matting tool used on some of the foliage on the base was rectangular in shape. Otherwise, the base was left comparatively rough, with some file or brush marks, some random punches, and what appears to be intentional roughening up of the surface of the model.

g. Patina

The surface is coated with a dark reddish brown organic patina that is quite thick and opaque in the modeled and textured recesses, yet very thin and translucent on the raised surfaces. In a few spots, the golden reflection of the polished metal surface can be seen below the patina. Where the coating has worn away, the metal is generally a warm brown color. Where further worn, the metal has oxidized to a light gray.

3. Casting Defects and Foundry Repairs

There does not appear to be any porosity in the metal, due in part to the hollow core support rods and the sand mold, which itself absorbs gases during the pour. A small number of round plugs fill what were likely casting flaws as well as possibly some core support holes. Some of the larger plugs, such as the one on Hercules' left hip, are threaded (fig. 31.4). The relative lack of flashes under the base is suggestive of the sand casting technique.

4. Later Modifications/Restorations

None observed.

SUMMARY

The *Summary* section of chapter 30 presents a discussion of the Rijksmuseum and Nelson-Atkins aftercasts of the *Hercules, Nessus, and Deianeira* composition and their relationship to the original cast in the Louvre.

The Rijksmuseum *Hercules, Nessus, and Deianeira* sculpture was sand cast in a brass alloy (26% zinc) in fourteen pieces. The separately cast sections are joined with a variety of screws and pins, often using sleeve joins. Core supports include wires and rods, as well as hollow rods made from sheet metal. Elements that indicate the sand casting process are the angular, geometric contours inside the base; nonconformity of the inner and outer walls of the bronze, as seen in Deianeira's and Nessus's limbs; parallel striations captured in the bronze from the shaping of the core; the large number of separately cast sections; flashes between the separately formed sections of the core; the lack of other flashes on the interior; and the visual characteristics of the core under high magnification.

The sculpture was cleanly cast, with very few repairs. The repairs are primarily round plugs, many of which are threaded. The surface is distinctive for the deep cross-hatching texture on the drapery and the horse's hide. The bronze is coated with a dark reddish brown organic patina.

NOTES

1 This type of rod, open along the length and with intermittent holes, is illustrated in Rama and Berthelot 1988: 162.

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ADRIANVS
FRIES
HAGIENSIS
BATAVVS F
1611

CHAPTER 32

Conclusion: Adriaen de Vries, Sculptor

As there are relatively few written records about de Vries that date to his lifetime, his sculptures remain the most important documents from which we can learn about his artistic personality and his workshop practices. Bewer's study clearly delineated the artist's preferred working materials and methods. The present study confirms many of the conclusions of Bewer's earlier one and broadens our understanding of the variations of these patterns, offering new information on de Vries's early years, design process, and workshop. It also confirms the consistency of alloy and core materials preferred by the artist, allows a fuller characterization of the common elements in de Vries cores, and identifies the presence of inverse segregation of the metal—a cause of potential problems in the nondestructive surface analysis of de Vries alloys. In its investigation of the use of thermoluminescence dating for bronze casting cores, the present study sheds light on the dating of some of the casts. Further, it confirms Bewer's earlier characterization of the artist's approach to direct lost wax casting and has greatly broadened our understanding of the artist's use of the indirect lost wax process. The examinations have provided a wealth of new information on all of the bronzes. Large compositions such as *Psyche Borne Aloft by Putti, Farnese Bull,* and *Laocoön and His Sons* were cast in one pour. The two *Cain and Abel* groups were cast by de Vries using the indirect lost wax technique, although the later of the two casts was chased after his death. We have been able to trace the development in the artist's modeling style as his career advances. An evaluation has been made of how specific surfaces, such as human hair and six-sided scales, were modeled. The study suggests that nearly all of the surface features, including applied texture, were formed in the wax (fig. 32.1).

Authorship for a small group of bronzes was reevaluated based on the parameters of de Vries's materials and methods. Three bronzes attributed to de Vries in the catalogue but whose attribution has varied over the years were found to deviate in major ways from signed de Vries bronzes, casting doubt on their attribution to him. The study also presented the opportunity to reevaluate three works included in the exhibition as works related to de Vries, all with either past attributions or stylistic ties to the artist. Finally, two aftercasts of a de Vries composition were included as examples of the types of alterations a sculpture can undergo through the process of reproduction. The variations in materials and techniques observed in these eight bronzes set them apart from the work of de Vries and underscore the distinct patterns that characterize his casts.

FIGURE 32.1 *Vulcan's Forge* (detail)
Bayerisches Nationalmuseum, Munich. Inv. no. 69/57.

FIGURE 32.2 Giambologna (Italian, 1529–1608) (and Adriaen de Vries?), *Caritas* (from the Grimaldi Chapel, Genoa), 1581–85. Bronze, H: approx. 175 cm. Genoa, University Museum.

TECHNICAL INFLUENCES

The technical study offered the chance to reevaluate what we know about de Vries's early years as a sculptor. Although the stylistic influence of master on student is often discussed in the literature, the growing body of technical studies allows a comparison of technique as well. It is not known where de Vries first trained. It has been proposed that he worked with the Netherlandish sculptor Willem van Tetrode (ca. 1525–after 1588). Tetrode spent his formative years in Florence with Benvenuto Cellini and in Rome in the workshop of Guglielmo della Porta. He returned to Delft in 1568, and it is possible that de Vries worked with him at this time (Scholten 1998b: 13). It was hoped that a comparison of Tetrode's working methods with those of de Vries might suggest some areas in which Tetrode may have had lasting influence on his younger countryman. A study of many of Tetrode's bronzes was undertaken in conjunction with the 2003 monograph exhibition held at the Rijksmuseum and the Frick Collection. Generally, however, this group of bronzes showed little consistency in technique (Bewer et al. 2003).[1] Some of the statuettes were cast in pieces, some in one pour. Although most were likely cast using the indirect lost wax technique, there are great variations in how the casting models were constructed. Moreover, the types of repairs varied considerably, and some of the bronzes were left as-cast while others were reworked in the metal. In fact, this variation in approach contrasts markedly with the consistency of materials and methods that de Vries maintained throughout his career. If de Vries did first learn the art of bronze casting as a young apprentice in Tetrode's workshop, he may have quickly surpassed his teacher in the mastery of technique. There is little question, however, that the next stage of de Vries's career provided lasting stylistic and technical inspiration.

By 1581, at the age of twenty-five, de Vries was employed in the Florentine workshop of Giambologna (1529–1608), and he remained there until 1586. The workshop was highly successful, producing exquisite bronzes of both tabletop and monumental size and giving de Vries the opportunity to observe the advanced production methods that allowed a large and varied output. Giambologna relied on the indirect lost wax technique to produce multiple editions of his smaller compositions (Bewer 1995a exh. cat.; Sturman 2001), which de Vries would have observed firsthand. Indeed, many aspects of two early de Vries indirect casts—the *Apollo* and the *Hercules, Nessus, and Deianeira*[2]—are highly reminiscent of Giambologna, including the relatively thin walls, distinct wax-to-wax joins, and short core supports.

It is likely that de Vries also learned to use the direct lost wax technique at this time, as he was present in the workshop when the life-sized bronze figures for the Grimaldi Chapel in Genoa were cast.[3] Giambologna's large figures in the *Neptune* fountain in Bologna, as well as the *Turkey* in Florence were cast directly (Bewer 1995a: 89 n. 29). Although no technical studies have been published on the Grimaldi Chapel figures (now in the University Museum, Genoa), it seems likely that they too were cast in this method due to their deep and complex drapery folds, which would have presented considerable challenges in making a piece mold (fig. 32.2). With the direct process, the complex model could have been translated into bronze without the added mold-making step. The nature of the commission—Giambologna created single casts of each figure—also lends itself to the direct process.

This experience of observing the casting of large-scale bronzes may be one reason why, at the age of thirty, de Vries was hired as chief assistant to Pompeo Leoni (ca. 1533–1608). At the Leoni workshop in Milan, de Vries was entrusted with the production of three monumental bronze figures for the high altar of Phillip II's palace-monastery, San Lorenzo de El Escorial, outside of Madrid.[4] When de Vries arrived in Milan, models for all of the Evangelists had already been completed by Leoni. The contract specifies that de Vries was to form the full-scale clay cores over which the wax was to be applied, "equal all over so that the bronze will be of equal thickness" (Bewer 2001: 165), clearly a reference to the direct lost wax casting technique. As with the Grimaldi bronzes, it would have been advantageous to cast these one-off figures, with their complex, deep drapery folds, using the direct technique (fig. 32.3).[5]

After having worked in two of the most productive and important bronze workshops in Europe at that time, de Vries set out as an itinerant sculptor, working independently for the next dozen years in Turin, Prague, Rome, and Augsburg and finally returning to the Prague court of Rudolf II, where he was to spend the rest of his life. It was in Prague that all of the autograph de Vries bronzes examined at the J. Paul Getty Museum were cast.

FIGURE **32.3** Pompeo Leoni and Adriaen de Vries, *St. John*, gilded bronze, 230 cm high. (Photo: Patrimonio Nacional.)

THE WORKING TECHNIQUES OF DE VRIES

In many ways, de Vries is the perfect subject for a study of this type. Although his compositions are highly innovative, certain aspects of his technique are remarkably consistent. The studies show a clear preference for a specific core composition and casting alloy, as well as recurring methods for constructing the models, repetition of decorative motifs, and consistency in the approach to the repair and chasing of the casts.[6] As also shown in the concurrent examinations of eight additional sculptures published here, the consistency of the artist's output is highlighted when bronzes of unknown or disputed authorship are thrown into the mix, as they quickly fall into or out of the pattern.

Regardless of the size and complexity of his compositions, de Vries bronzes included in the project were all cast in one pour with a relative lack of flaws, an impressive feat. It is likely that the artist did not run his own foundry but instead used professional foundries to cast his bronzes. When working in Augsburg, de Vries cast his bronzes with the city founder, Wolfgang Neidhart; it is likely that in Prague de Vries cast much of his work with Martin Hilliger, arsenal master and cannon founder at Prague Castle (Scholten 1998b: 20, 23). Can the founders be given full credit for the successful casts? The technical study suggests otherwise: de Vries was intimately involved with every step of the process, from design to the final preparation of the casting models to the chasing of the metal surface.

The Design Process

Drawings, as well as wax and clay models, can be used in the progressive stages of designing for sculpture, some artists showing a clear preference for one or the other. According to Avery (1984: 175), whereas Gianlorenzo Bernini began with drawings and then moved to clay as the design progressed, Giambologna preferred to design in three dimensions, choosing clay and wax over drawing. Of the ten existing drawings firmly attributed to the hand of de Vries, almost all are probably preliminary drawings for sculpture rather than images of completed works (Kaufmann 1998: 87). In contrast, none of his three-dimensional working models remain. It is Kaufmann's opinion that the lack of de Vries models and the fact that the remaining drawings are preliminary studies rather than depictions of completed projects reflect de Vries's tendency to rely on drawings, rather than clay and wax, as a designing medium (Kaufmann 1998: 87).

The technical studies of de Vries's direct casts seem to suggest otherwise. The direct lost wax casting technique does not easily allow unplanned design changes once the model is under way. It is clear that the sculptor carefully determined his compositions before he began constructing each casting model. Because large solid-cast sections of a sculpture are prone to flaws due to uneven cooling of the metal, care is given to ensuring that the wax layer is relatively even throughout the casting model. For this reason, it was not possible to work out large areas of the design in solid wax as the modeling progressed. Although sections such as the feet and hands in smaller compositions and facial features and decorative details in larger compositions were often composed in solid wax, the vast majority of de Vries's compositions had to be determined well before the wax was applied to the model. By carefully planning the design before the model was constructed, de Vries was able to build the armature and the clay core to closely resemble the final composition, over which a relatively thin layer of wax was applied.

One group of bronzes shows a variation from this rule. Select portions of four of the sculptures were designed so that their final compositions could be determined after the casting models were partially constructed. On all four compositions, the armature rods for the bulk of the structures were constructed as a continuous unit—except for the extremities, which were then added into the clay once the primary structure of the core was modeled. These include both figures' arms in *Theseus and Antiope*,[7] the club in *Hercules Pomarius*, the serpent in *Laocoön*, and the arms in *Christ at the Column*. In the latter bronze, for example, the cores in the torso and the column were completed over the primary armature rods, and then the rods supporting the arms were inserted into the clay shoulders and positioned behind the column. In all of these examples, the artist intentionally planned this step-by-step progression for designing the casting models.

The radiographs suggest that, regardless of the artist's careful planning, unanticipated changes were made on two of his bronzes after the models were well under way. As reported by Bewer (2001: 176), in order to alter the position of Empire's left arm in *Empire Triumphant over Avarice*, it was necessary for de Vries to cut the armature wires in the shoulder and insert new wires into the clay core as he worked. In the second instance, de Vries chose to alter the position of the right leg in the *Juggling Man* after the rigid armature had been constructed, with the result that the rod is off center in the leg, resting directly against the bronze. With the exception of these two bronzes, it appears that de Vries's designs were far enough advanced at the outset for him either to construct the entire armature and core without changes or to intentionally construct it such that minor adjustments could be made as the work progressed.

This assuredness in working technique suggests to me that de Vries may well have relied heavily on three-dimensional models in final preparation for the construction of the casting model. Indeed, he was well known as a *bossierer,* a modeler, and was described as such in several sixteenth- and seventeenth-century documents (Scholten 1998b: 35). Until further documentary evidence provides more information, exactly how de Vries developed his compositions must remain speculation. The assuredness with which he constructed even his largest and most complex sculptures would suggest, however, that in addition to preparatory drawings, three-dimensional models were an essential part of the process.

The direct or indirect method

De Vries used two methods to create his casting models: the direct method, in which he modeled the clay core and wax directly over an armature; and the indirect method, in which the wax casting model was formed inside molds taken off of an original full-sized model. As discussed above, the rigidity of the armature and clay core demanded that, when using the direct technique, de Vries determine the composition with three-dimensional models well before building the full-sized casting model. When using the indirect technique, though, the artist had the option of constructing the full-sized model in solid clay or in wax, allowing him to determine the composition as he worked.

What evidence survives to suggest why de Vries chose one technique over the other? *Psyche Borne Aloft by Putti,* his earliest known large work cast as an independent sculptor, was cast using the direct technique, which he continued to use throughout his lifetime. But de Vries also used the indirect lost wax technique with some regularity. Of the seventeen bronzes included in this study and clearly attributed to de Vries, ten were cast directly and six were cast indirectly (the technique used for the *Vulcan's Forge* relief remains unknown). It should not be assumed that this ratio of direct to indirect casting is indicative of the artist's career as a whole, as the bronzes included in the examination were biased toward the compositions that were able to travel with the exhibition. What can be surmised is that de Vries used the indirect technique for small- to medium-scale, rather than large-scale, compositions (fig. 32.4).

Two factors can influence a sculptor's choice of technique: the nature of the commission and technical considerations. Bewer (2001) has pointed out the possible influence of the commission in determining the casting method used. De Vries's use of the direct technique may be due in part to the fact that he worked directly for wealthy clients much of his life. It may have been that some clients insisted that he use the direct lost wax technique, as it ensured that this would produce unique casts, which would be more valuable. Indeed, many of de Vries's direct casts were commissioned by Emperor Rudolf II, the Danish king Christian IV, and Albrecht von Waldstein of Prague. Bewer (2001: 172) has also pointed out that for Giambologna, the indirect technique allowed the production of replicas, which suited both his entrepreneurial desires and the demand for multiple diplomatic gifts placed on him by the Medicis. With the exception of the very early commission by Rudolf for the one-off cast of the *Bust of the Elector Christian II of Saxony,* de Vries was not under pressure to create diplomatic gifts, nor apparently was he interested in exploiting the commercial potential made possible by the production of replica casts using the indirect technique. Although a fairly large number of his casts were made using the indirect technique, only one signed composition, *Cain and Abel,* exists in multiple.

Bewer (1996: 36) and Stone (2001: 59) have observed that during the Renaissance generally (as with de Vries) large compositions were often cast directly. Yet if a direct casting fails, the original model is lost and the artist must start over again, building the casting model from scratch. Why would an artist expose himself to such a risk, particularly for the large compositions? Clearly there are technical advantages to using the direct technique for large bronzes. The argument that the direct technique might be used in cases in which a complex surface with deep undercuts makes it tremendously difficult to make a piece mold (Stone 2001) is admittedly less relevant for de Vries's large compositions—most of which are of nude figures with relatively simple contours. It may be that the extra steps necessary in the indirect technique made it impractical and prohibitive for large casts. To make an indirect cast, the artist must sculpt a full-sized model from which molds are taken and then make the casting wax in the molds. Creating a full-sized model and molds from it would

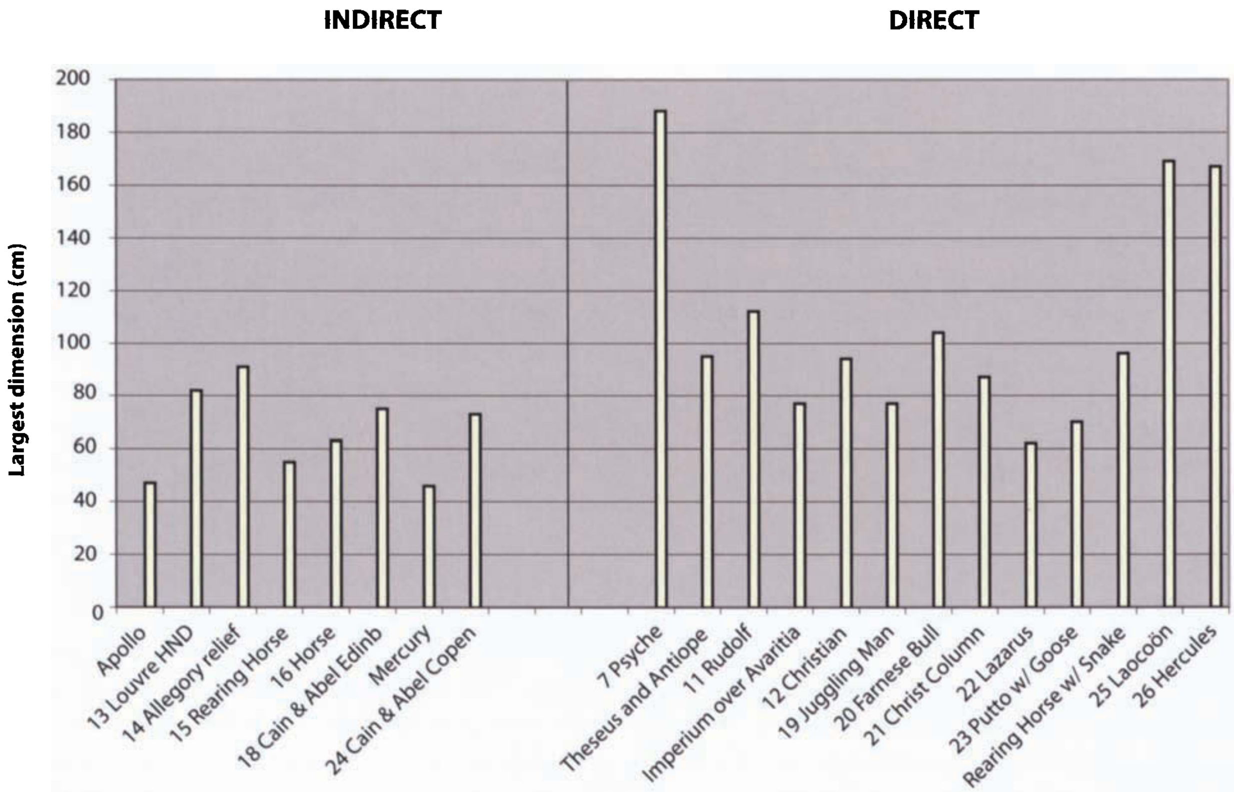

FIGURE 32.4 A comparison of casting technique with size, including de Vries bronzes for which the casting technique has been determined. Chapter number is included for those examined at the J. Paul Getty Museum; others are referred to in Bewer 1998, 2001.

necessitate considerable extra material and labor costs. The sculptor may have been faced with a gamble between the certain extra costs of working in the indirect technique and the uncertain possibility of a casting failure. It may also be that a sculptor chose to cast directly in order to avoid the difficulty of manipulating large hollow wax sections without distortion. Finally, from the lack of cold work and the expertise of the modeled surfaces, it is clear that de Vries prided himself on his modeling. He may have tended toward the direct technique because it better conveys the immediacy of the pliant modeling material and avoids the intermediate mold-making step used in the indirect process, a step that can diminish the quality of the surface.

The indirect technique offers at least two technical advantages. Original models made in clay or in solid wax must be cast using the indirect process. Being able to model freely without worrying about the even thickness of the wax layer is one clear advantage of the indirect technique. The *Allegory of the War against the Turks in Hungary* relief suggests another technical reason for casting indirectly. The front of the relief is covered in finely modeled figures and detailed texture. Because the casting wax was formed in a mold, the sculptor had access to the back of the relief, thereby avoiding the cold work that would have been necessary if the sprues had been applied to the front.

All in all, until more primary documents are found, the arguments for why de Vries used one technique over the other must remain speculation.

Armature (direct casts)

The armature functions within the direct casts as the support on which the clay core is constructed. The armature then continues to support the dried clay core during the pour, as the molten metal rushes through the mold. Hand forged of wrought iron, a square- or rectangular-sectioned rod of heavier weight generally forms the main support within the primary figure of each de Vries cast. A network of thinner rods and wires then extends into the extremities. These rods and wires are bound together with wire to form a continuous unit. The wires that extend into the limbs run in pairs that lightly twist together. These wires are often quite long, extending from one limb, across the torso, and into the opposite limb. The ends of the wires usually end within the limb but occasionally extend outside the wax model and into the investment, acting as core pins to help hold the core in place during casting. This basic armature construction has been observed in the radiographs of the medium-sized direct casts such as *Lazarus* (see fig. 22.2) and the nearly life-sized *Hercules Pomarius* (see fig. 26.2). The diameter of the armature components found within each sculpture is presented in Appendix B2. De Vries used wires and rods of varying size. The most common element is a 0.2 cm diameter wire, although both smaller and larger wires are used. In the late sixteenth and early seventeenth century wires would have been made by pulling the iron through plates with holes of varying diameter in a process called drawing. Not enough evidence remains to suggest whether de Vries made his own wire. The larger wrought iron rods vary considerably in dimension and would have been formed to the precise specifications of each bronze, forged for each project either by the artist or under his supervision.

In a majority of the direct casts, de Vries did not attempt to keep all of the armature inside the model. At times, in order to offer maximum support, segments of the armature rods extend out of the wax. These rods would be visible on the outside of the bronze and were cut off at the surface during chasing. This type of support was observed in figures such as the uppermost putto in *Psyche Borne Aloft by Putti* where it ties to Psyche, below the right heel of the *Juggling Man,* in the figures of Amphion and Zethus in the *Farnese Bull,* and in the central figure in *Laocoön and His Sons.* Although many of these central support rods have been removed, in some of the casts their paths through the wax casting model remain visible as distinctive straight-edged square or rectangular holes left in the bronze, such as those seen in the radiographs of the base of the *Juggling Man* and in multiple locations on the *Farnese Bull.* These distinct holes remain intact because the temperature of the molten bronze as it entered the mold and surrounded the iron rods was not high enough to melt the iron. In addition, copper and iron do not alloy together well. For this reason, the molten bronze flows around the iron but does not stick to it, allowing the rods and wires to be pulled out or cut off at the surface and hammered back into the interior (D. Scott pers. com.).

Although de Vries could have removed the armature and core from his bronzes in order to decrease their weight or to allow reuse of the iron, this does not seem to have been a priority for him.[8] As illustrated in the Structural Summaries, many compositions retain much of their internal armature, although at least some of the rods and wires appear to have been removed from all of the sculptures examined here. It is likely that pieces of rod and wire were removed, along with core, from the easily accessible open bottoms of the bases. The torso of Psyche in *Psyche Borne Aloft by Putti* is unusual in this regard. Although the form is closed, offering no easy access to the interior, her internal armature has been removed, probably through flaws before they were repaired. This must have a been a laborious task as the holes in the body are small and the one substantial flaw in the raised arm is quite a distance from the majority of the torso.

Iron armature rods inside bronze casts can cause extensive damage due to expansion of the corroding iron when the sculptures are left outside. Such damage occurred on the right leg of the *Juggling Man,* where the rod, situated directly against the bronze wall, distorted and split open the wall as it corroded (see fig. 19.9). This is the only bronze included in this study that shows clear evidence of surface damage due to rusting of the armature, although it has occurred on other de Vries bronzes.[9]

Core supports (indirect casts)

Due to the difference in their function, iron rods and wires in indirect casts are often referred to as core supports rather than armature. Core supports help to hold together the separately formed sections of the casting model (the so-called wax-to-wax joins) and strengthen the core during the pour. As a whole, the de Vries indirect casts show more variation in construction than is observed in his direct casts, although many patterns emerge. The most notable pattern is the presence of a central armature rod in the torsos of all but one of the nude, indirectly cast standing figures, similar to those observed in many of the direct casts. These rods extended out of the buttocks, functioning as primary supports during the cast, and would seem to be strong indicators of models of this subject constructed by de Vries: Hercules in the Louvre *Hercules, Nessus, and Deianeira* (see fig. 13.3), Cain in both of the *Cain and Abel* casts (see figs. 18.3, 24.3), and the independent figure of *Mercury*.[10]

The core supports in the New York *Apollo* and the Louvre *Hercules, Nessus, and Deianeira* include short wires across the wax-to-wax joins, similar to those observed in Giambologna statuettes (Bewer 2001: 170–71; 1995a: 88). The long core supports used in the Lambach *Mercury*[11] and the two *Cain and Abel* groups extend farther into the limbs (see figs. 18.2, 24.2). The core supports in both *Cain and Abel* groups are in pairs in some areas; in the torso of the Copenhagen Abel, a wire twists around the two main rods, holding them together. Both of these observations are reminiscent of the armatures in de Vries's direct casts. However, they differ from the armatures: the rods are not continuous, indicating that they could have been inserted in pieces into the premade casting wax.

Core pins

De Vries used square- or rectangular-sectioned iron core pins that taper to a blunt or pointed end. No evidence of round-sectioned core pins was found. Although most of the pins were removed after casting, many of the sculptures retain one or more pins that were cut off at the surface and hammered into the hollow interior. Red rust that sometimes appears on the surface of the bronze indicates the presence of these extant core pins. Pins remaining on the interior measure up to 2.5 cm in length (as summarized in Appendix B2). The set-in rectangular repairs that fill the core pin holes are often invisible on the surface of the bronze, in part because they were made using cut-off sprues or other metal from the original casting and are thus of the same or quite similar alloys. On the bronzes that have corroded as a result of outside exposure, the core pin patches are more likely to be visible on the surface—even when the alloy is similar to the bulk alloy—due to changes in the crystalline structure of the repairs when cold work was undertaken to fit them in place.

The plugs used to fill the core pin holes are generally thinner than the surrounding metal and are therefore more easily seen in the radiographs (see Appendix A, fig. A.23). In two instances (the *Bust of the Elector Christian II of Saxony* and the Prague *Horse*), core pin repairs that are quite a bit larger than the original holes were used. As many of the core pin plugs are not visible in the radiographs, it is possible that this type of repair also appears on other de Vries bronzes.

A relatively large number of core pin holes remain visible on the *Psyche Borne Aloft by Putti*, in which the pins appear to have been applied in pairs on either side of some of the limbs and the torso. None of the other bronzes showed evidence of what may have been side-to-side core pins. On the back of the *Allegory* relief, the back side of most of the core pin holes is visible on the reverse. The holes are regularly spaced between 15 and 20 cm apart (see fig. 14.2). Aside from the exceptions of the *Psyche* and the *Allegory* relief, visible evidence of the core pins is relatively scant, and there is therefore no clear pattern of how de Vries arranged them on his casting models.

Internal surface of the bronze

The descriptive category "internal surface of the bronze" refers to the contour and surface characteristics of the inner bronze wall and its overall thickness, therefore suggesting where the bronze is hollow-cast or solid-cast. The surface of the inner walls of the base can at times be directly viewed when the sculpture is placed on its back or lifted for viewing from below as the core has often been removed from the lower portion of the sculpture. Where the core remains, though, radiography must be relied on. In the earliest bronze included in the study, *Psyche Borne Aloft by Putti*, the relatively even interior walls suggest that the core was quite smoothly formed. Faint parallel marks from a toothed tool used in forming the core remain on Psyche's left leg, the only such tool marks observed on the de Vries cores in this study (see fig. 7.11). Over time, de Vries's cores become much more roughly modeled, yielding bronze walls that vary considerably in thickness from area to area. Compare, for example, the uniform walls and consistent density within Psyche's leg in *Psyche Borne Aloft by Putti* to the highly uneven walls and varying density within the figure of Christ in *Christ at the Column* (see figs. 7.11, 21.3). In the *Laocoön,* an even later cast, sharp lines of density variation running vertically through the kneeling son's right lower leg are evidence of the very rough modeling of the core (see fig. 25.6).

Throughout de Vries's oeuvre, sculptures both large and small were cast almost entirely hollow, with only small parts solidly cast. These solid elements are usually found in the direct casts at the ends of the extremities, such as fingers and toes, and in added relief details, such as the lion mask in *Christ at the Column* (see fig. 21.3).[12] In the *Bust of the Elector Christian II,* for example, the bronze is nearly solid through the elector's nose and mouth, indicating that these details were modeled in solid wax over a generalized core (see fig. 12.2), as is indicative of the direct lost wax technique. The walls of the indirect casts, in contrast, are of comparatively uniform thickness. Other elements on the interior of de Vries's indirect casts suggest the method used to form the casting waxes, including the presence of waxy drips (from slush molding), wax-to-wax joins (as described below), and slight variations in the thickness of elements (due to their having been formed separately in different sections of the mold). No matter the casting technique used, very thin elements such as the plates balanced by the *Juggling Man* or the wings on the *Putto with a Goose* were cast solid as any core in these areas would have been too thin and weak to withstand the pressure from the molten metal entering the mold.

The bases of the two later *Hercules, Nessus, and Deianeira* casts, when viewed from below, have an entirely different character from those observed on the original de Vries cast in the Louvre, or any of the other lost wax casts. As shown in figures 30.5 and 31.5, the inner walls of the two later sand casts are more geometric and angular than those of the lost wax casts. In addition, sand casts are often relatively free of the sometimes sizable flashes often found on the interior of lost wax casts such as those on the base of the Louvre *Hercules, Nessus, and Deianeira* (fig. 13.6). The very thin, slightly raised flashes that dissect the bottoms of the two aftercasts are fins that formed between the separate parts of the sand piece mold. These fins are much finer than the often quite large flashes observed on the interior of many of the de Vries casts.

Method of assembly and joining of individual wax or cast bronze components

Although wax joins are rarely seen in the radiographs of direct lost wax casts,[13] they are almost always present in indirect casts. Wax-to-wax joins appear on all of the de Vries indirect casts except for the *Allegory of the War against the Turks* relief, whose casting wax was formed in one piece in an open mold.

The number of wax-to-wax joins in de Vries's indirect casts varies. The New York *Apollo* and the Lambach *Mercury* are quite similar in construction, with wax-to-wax joins in the upper arms and thighs (Bewer 2001: 171, figs. 16, 17). The Los Angeles *Rearing Horse* and the Prague *Horse* both have wax-to-wax joins in the neck, but the Prague example, which is larger, has two additional joins at the top of both raised legs. The four visible joins in the two *Cain and Abel* groups are in identical locations, suggesting that the models could have been made using the same set of molds. The figures of Cain and Abel are a bit larger than those in the *Hercules, Nessus, and Deianeira* group in Paris, in which, surprisingly, there are nineteen wax-to-wax joins. Although admittedly the latter is a more complex composition, it is interesting to compare the different approaches the artist took to forming the casting waxes for the two. In the *Cain and Abel* groups, each separately formed section of the wax model is relatively large and complex. In contrast, the *Hercules, Nessus, and Deianeira* group was broken up into comparatively small sections that were then joined before casting. These different approaches seem to suggest either that de Vries was experimenting with his approach or, more likely, that he was using different mold makers. If the latter is true, this is one rare example pointing to the presence of assistants in de Vries's workshop.

One of the most distinctive aspects of de Vries's output was his ability to cast even the largest compositions in one pour, a goal of many sculptors working in bronze in the sixteenth century (see introduction, this volume). Of the de Vries bronzes examined, only the horses, which were cast separately from their bases, were intentionally cast in two parts.[14] The engineering and design feat that casting in one piece represents is highlighted by the bronzes studied here that are not by de Vries; they are all of small to medium size, but only one of them was cast in one piece (see Appendix B1 for a list of the number of sections in each bronze).

External surface of the bronze: Evidence of the wax model and of final surface chasing

De Vries's work is distinguished by passages of exquisite modeling. Whether in the smallest background details (fig. 20.14), the depiction of human emotion (fig. 18.9), or the portrayal of the nude form in action (figs. 25.1, 25.2), he is remarkable for his consistent and seemingly effortless modeling abilities. As his career progressed, his modeling style loosened up considerably. In the figures, planes blur such that there are no clear outlines, and facial details become abstractions. In most of de Vries's later compositions, his consciously loose style of modeling, related to the Italian concept of *sprezzatura,* or virtuoso nonchalance (Scholten 1998b: 40), is contrasted with highly detailed passages. In the *Putto with a Goose,* for example, the loose, broken planes of the putto contrast with the carefully applied details in the child's hair and the wings of the goose. In a similar manner, the meticulous application of the repetitive patterning of the scales of the serpent in the *Laocoön* weaves together the two very different surfaces of flesh and serpent, creating a self-conscious contrast between the two.

Although it is difficult to tell how much of the surface texture was applied in the wax and then cast-in, and how much was applied directly to the metal surface after casting, it would appear that de Vries did not apply texture in the wax and then again in the bronze, as there is no evidence of overlapping or misaligned strikes, which would have occasionally occurred if the texture had been applied twice. After careful examination of the surfaces under magnification, it appears as though de Vries preferred an as-cast surface with minimal cold work. Although passages of the very crisp detailing on the early works *Bust of Emperor Rudolf II* and *Allegory of the War against the Turks* may have been applied in the metal, these two bronzes may well be the exception. Texturing the surface in the wax rather than the metal would have greatly reduced de Vries's reliance on workshop assistants, as it would have been extremely time-consuming to have punched the texture into the very hard alloy he preferred. In turn, this very hard alloy would have allowed retention of the as-cast surface with minimal rounding of the details through finishing of the surface or due to wear, corrosion, and cleaning over time. In many areas, for example, Lazarus's hair (fig. 22.6), it is clear that the texture was added in the wax as the depth of the punch marks applied adjacent to one another creates recessed lines in the soft modeling material while simultaneously texturing the surface.

The signatures too were fashioned in the wax. Of the seventeen de Vries casts examined at the Getty, eleven are signed (see Appendix C). Examination of these signed casts under magnification reveals the rounded channels, blunt and rounded stroke ends, and small casting flaws across the letters that indicate that all but one of the signatures were drawn into the wax model. The exception is the *Cain and Abel* group in Copenhagen, whose signature was not applied under the artist's supervision. The fine, V-shaped taper at the end of each stroke suggests that the signature was engraved in the metal without his supervision.

It seems that the majority of punchwork was applied in the wax, but there is one place where it was clearly applied in the metal. A set-in rectangular patch in the base of the *Laocoön* has been textured with a punch that continues over the plug and onto the adjacent metal (fig. 25.13). This texturing over a repair is unusual for de Vries, due in part to the relative lack of flaws on his casts, to the careful placement of core pins in areas without extensive surface detail, and to a preference for leaving many flaws unrepaired (for more on repairs, see *Casting defects* and *Foundry repairs* below). Although it is clear that the surface of the repair was textured in the metal, a craftsman skilled at chasing may well have been able to blend the cold work with the adjacent cast-in texture;[15] therefore, we do not know how much of the overall texturing on the base was cast-in and how much was applied after the repair was set in place.

Unwanted metal on the surface of the bronze such as sprues and flashes would have necessitated chiseling and retexturing, but no evidence of such work was found. As with the core pins, sprues were probably carefully placed in flat or polished areas, which would have minimized the punched texture needed to blend with the surrounding surfaces when the sprues were removed.

De Vries used certain decorative motifs repeatedly throughout his career. Specific flowers and leaves are used frequently whose form varies only slightly from one sculpture to another. To depict fabric, de Vries repeatedly used the technique of applying rough striations in the wax perpendicular to the folds (see fig. 11.10). In depicting human hair, as well as horses' manes and tails, de Vries began his career with one method, then changed it sometime between 1610 and 1615. In his early style, each tuft or curl is composed of thick strands of hair set at varying angles. The strands are often slightly convex in section and are delineated not with recessed lines between them but rather by the differing angles of the intersecting strands, each of which is slightly skewed compared to its neighbor (figs. 13.9, 13.10).[16] In the later style, parallel hair strands were sketched into the raised tufts using a toothed tool, similar to a comb. These lines were then textured by the careful application of a single, rounded, finely textured punch applied side to side along the lines established with the toothed tool. By varying the amount of pressure applied, the punch brought considerable variety to the surface that would have been lacking if only a comb had been used. Once textured, some of the bronzes in this later style show the addition of smooth outlines drawn into the wax between many of the tufts with a round-tipped modeling tool. Finally, individual curving gouge marks were added rather randomly as accents (fig. 25.12).

Perhaps de Vries's most complicated motif is the distinctive six-sided serpent scales found on the *Laocoön,* the *Hercules* fountains now in Drottningholm and Augsburg,[17] and the much smaller *Vulcan's Forge.* Although at first glance one would assume that the pattern was applied with a hexagonal punch, step-by-step free-hand application of the motif in the wax allowed adaptation to the scale and contour of each segment of each sculpture (the procedure used to form the scales is shown in fig. 25.11).

In addition to this repetition of motifs, de Vries seems to have consistently applied certain rules to govern his surface texturing and embellishments. Whenever texture is applied, it is done methodically. In particular, de Vries consistently uses just one punch in an area, never mixing two different textures. Oval punches were often applied in lines to texture the surface as well as to give a secondary linear pattern.

The consistency of motifs and methods for depicting hair, texture, and patterns throughout the artist's career strongly suggests that he was intimately involved in the modeling of each sculpture. As for the chasing, because of the lack of documentation on de Vries's workshop, there has been disagreement about how involved he was in the final finishing of his sculptures. The steps to finish a bronze once it is cast are extremely time-consuming. Although it is commonly held that de Vries finished his sculptures himself (Scholten 1998b: 23), Diemer quotes a receipt for payment of 100 guilders to de Vries and 36 guilders to his assistants for their work on the *Hercules* fountain (Diemer 1999: 252). Although this document does not state directly that de Vries hired others to fettle and chase his casts, the very hard bronze alloy that he was casting in, as well as the size of his casts, would suggest that it would have been impractical for him to do all the finishing work—removing oxides, chiseling away sprues and flashes, repairing and polishing—himself. However, there is great consistency in the chasing, suggesting that if assistants were involved, they were carefully supervised. This consistency includes a tendency to leave modeled details as-cast without reworking in the metal, minimal if any texturing in the metal, retention of select sprues, and uniformity in approach to the repairs (see below).

Sprues

One of the many crucial steps in preparing the wax model for casting is the proper design and attachment of the sprues. A variety of different approaches can be used to circulate the metal into the mold and the air and gases out.[18] There are no remaining de Vries sketches or unfettled bronzes to tell us which systems he preferred. Although porosity can rise within a cast, suggesting whether a bronze was cast right side up or down, the radiographs provide no overwhelming evidence of the sculptures' orientation during the casting. The presence of lead globules that have settled to the bottom of a cast can be visible in radiographs, but that was not the case here, where the alloys are essentially unleaded. None of the bases shows evidence of cut-off sprues attached vertically along the bottom edge, as might occur if the bronze were indirectly sprued in an upright position. On the *Hercules Pomarius,* though, two cut-off sprues run horizontally under the feet that project over the edge of the base (see fig. 26.6), perhaps suggesting that it was cast upright with modified indirect spruing, as illustrated in figure 2.9.

De Vries left sprues visible on the surface of a number of the bronzes examined in this study (see Appendix B1). On the Louvre *Hercules, Nessus, and Deianeira,* a single, short sprue remains between the figures of Nessus and Hercules. On the *Farnese Bull,* six short sprues remain between various elements of the cast. In both instances, they may well have been left as a subtle boast that the complex compositions were cast in one pour (Bewer 2001: 181). On the larger compositions such as the *Laocoön* and the *Hercules Pomarius,* the remaining sprues play a more dominant role in the composition: the sprues are adapted into the final design as a series of thin, twisting vines with rough and inelegant leaves sporadically attached, acting as a *cache-sexe* and only loosely covering the quickly formed genitals. The full significance of why the sprues were left remains open to speculation. As elegantly described by Bewer (2001: 180–82), de Vries may have left these prominently situated sprues as a reference to his skill as an artist working in bronze, as well as to his role as creator. That in many instances the sprues were included as decorative elements strongly suggests that they were attached to the surface by de Vries himself, providing evidence of his direct involvement in preparing the models for casting. Although the step-by-step process of bronze casting may allow an artist to create a model that is then cast by others, the technical studies point to de Vries's involvement throughout the process, as reflected in his contract for the *Hercules* fountain cast in Augsburg in 1602, which stipulated that he prepare his models "so that nothing more need[ed] to be done but to take them to the pit for casting" (Bewer 2001: 164).

Patina

The original surface treatment of a bronze may be difficult to determine due to alterations over time such as repatination and corrosion. Four different types of surface were observed, alone and in combination: (1) covered wholly or partially with one or more layers of old colored lacquerlike organic patina, (2) bare metal with no evidence of old tinted organic patina coatings, (3) covered in corrosion due to exhibition outdoors for an extensive period, or (4) covered with a more recent clear and glossy wax or resin layer. It can be assumed that when completed all of de Vries's sculptures were brought to the golden color of the polished metal. Documentary evidence would suggest that at least some of the bronzes were left this color, and others may have been toned with colored lacquerlike organic patinas that lent a brown or reddish brown color to the surface (Heithorn 1998). Chemical patination, a technique combining the application of chemicals to the surface of a bronze with heat, was used only in rudimentary form in the seventeenth century for imparting an "antique" green surface—a finish likely never desired by de Vries (Heithorn 1998: 79). There is no clear indication of chemical patinas having been used on any of the de Vries bronzes included in this study, although the very thin and even brown surface on the Nelson-Atkins *Hercules, Nessus, and Deianeira* appears to have been applied with chemicals (see fig. 30.1).

Tinted organic patinas were found on nine of the de Vries bronzes. The patinas are much darker and more opaque in the recesses and translucent where thin. In all cases, the organic patinas are worn, with considerable loss due to flaking or abrasion. Four of the nine—*Bust of the Elector Christian II, Hercules, Nessus, and Deianeira* (Louvre), *Rearing Horse*, and *Horse*—contain areas where the patina covers unoxidized polished metal, yielding a warm golden color when viewed under strong light. It is likely that these organic coatings were applied soon after the surfaces were polished; it is tempting to assume that they are original, although they may well be later repatinations.

Five bronzes—*Allegory of the War against the Turks, Vulcan's Forge, Farnese Bull, Lazarus,* and *Cain and Abel* (Copenhagen)—show no evidence of either corrosion or old tinted organic patina coatings. Although once polished to a golden color, the first three bronzes have oxidized to varying shades of grayish brown.[19] *Lazarus* and *Cain and Abel* are now the golden color of the polished bronze metal. Because polished bronze will eventually discolor, even when varnished, it can be assumed that the polish is not original. The technical study suggests that an older lacquer patina may have been removed from the *Cain and Abel* group in the nineteenth century. The clear varnish now covering the polished surface of *Lazarus* was applied after the bronze entered the collection of the Statens Museum for Kunst.

Many of de Vries's most important commissions were for outdoor installation, with the result that many are now covered in corrosion. With the exception of *Psyche Borne Aloft by Putti,* which has spent a comparatively limited time outdoors, the outdoor bronzes no longer have any traces of old organic patinas. *Putto with a Goose* and *Laocoön* are among the bronzes taken from Prague and Denmark by Swedish troops in 1648 and 1659 and installed in the gardens of Drottningholm Palace, where they remained for more than three hundred years.[20] Although there is no record of the surfaces having been waxed or maintained during that period (Gullman and Törnblom 1994: 60–61), the bronzes are in remarkably good condition, with corrosion layers that are thin, compact, and glossy, and with little sign of dissolution of the surface. The excellent condition of these bronzes appears to be due to a fortuitous combination of the low pollution levels in the parks in Drottningholm and the relatively pure copper and tin alloy that the artist used.

Casting defects

Given the complexity and size of many of the de Vries sculptures that were examined, there are remarkably few casting flaws, and most of these are relatively minor. The most common problem found in the casts is porosity from trapped gases and uneven shrinkage of the metal as it cooled after the pour. Porosity extends to the surface of the bronzes in varying amounts but causes only minor disfigurement. A different type of casting flaw occurred on the *Laocoön:* a cold shut, in which a portion of the molten metal cooled as it ran through one section of the mold, causing a discontinuity where the metal filled the mold but did not bond to itself properly. It is likely that this flaw was visible only as a slight discontinuity in the surface when first cast. With corrosion of the surface over time, the differing crystalline structure of the metal on either side of the line where the bronze did not fully bond has led to an accentuation of the flaw (see fig. 25.17).

It is quite common to find areas on bronzes where, for one reason or another, the molten metal failed to flow into part of the mold, necessitating repairs. The relative lack of miscast elements in de Vries's bronzes of all sizes is quite remarkable and speaks to the skill with which the casting models were prepared. The small *Crucifix,* in which both lower legs are replacements, is an example in which the relatively large repairs stand as one argument for an authorship other than de Vries.

Foundry repairs

There are relatively few repairs on de Vries bronzes. This is due to the small number of flaws, and also to the sculptor's preference for allowing minor flaws, including much of the surface porosity, to remain unrepaired. The only exceptions are the raised arm and vase on the *Psyche* group, which necessitated cast-in repairs; the bottom proper left corner of the *Allegory* relief, for which a new corner was cast; and the repair of the very top of the *Juggling Man*'s head. It is unclear whether the latter repair was cast in place or recast separately and then set in place.

The primary methods for repair found on de Vries's bronzes were cast-in copper alloy repairs and set-in copper alloy patches or plugs. The majority of the set-in repairs are square or rectangular, although some round plugs occasionally appear. Many of the patches fill core pin holes. As with the sprues, it appears that de Vries intentionally placed the core pins in smooth areas where there is little surface texture or relief so that minimal chasing was necessary to hide the repairs. Two set-in core pin plugs were analyzed in the course of this study; both were made of alloys similar to that of the bulk alloy, suggesting that they were made from cut-off sprues or other metal from the original pour. Some of the set-in repairs are very carefully chased and visible only in the radiographs. Most of the set-in repairs are thinner than the surrounding metal and are approximately the size of the flaw or core pin hole that they fill. In a few cases, though, oversize repairs were used (such as the square core pin patch in the chest of the *Bust of the Elector Christian II* and the oval plug in the belly of the *Rearing Horse*).

It is of note that although threaded repair plugs were used regularly by Antonio Susini (fl. 1572–1624) in Giambologna's workshop in Florence (Bewer et al. 2003: 105), none were found on the de Vries casts. Of the eight bronzes discussed in this volume that were not cast by de Vries, six contain threaded plugs (see Appendix B3). The Copenhagen *Cain and Abel,* which was chased and repaired after de Vries's death, also contains a number of threaded plugs.

Occasionally, lead-tin solder was used in the repairs either cast-in as a fill material or as solder to secure repairs. Some of these lead repairs may have been added later, but on the *Allegory* relief lead was used to secure the original corner repair. Some repairs are made of brass, including the repaired finger on Lazarus's right hand and the large set-in plugs on Laocoön's left thigh. It is likely that these brass repairs were not done in the foundry. Nonmetallic fills appear in some of the bronzes examined. A number of those in the *Psyche Borne Aloft by Putti* cast were analyzed, each with a different result: whiting (calcium carbonate), plaster (calcium sulfate), lead white (lead carbonate), and an unidentified wax/resin mixture. This suggests that the bronze has undergone numerous restoration campaigns. Appendix B3 lists the occurrence of the different types of repairs.

* * *

The work of Adriaen de Vries is distinguished not only by its highly inventive and daring compositions and modeling style but also by the mastery of the technical challenges of casting. De Vries was a masterful artist and craftsman. His hand can be discerned in all aspects of his oeuvre, for he was actively involved throughout the creative process. Although he experimented broadly with his compositions, he was relatively consistent in his working processes. This consistency has allowed a characterization of his materials and methods and illustrates the important role of technical studies in the authentication of Renaissance and later bronzes.

NOTES

1 With the exception of a small group of bronzes now in Florence, only one of which has been examined in detail, the authorship of many bronzes attributed to Tetrode is unclear.

2 For the *Apollo*, see Bewer 1998: 73.

3 As cited in Scholten 1998b: 42 n. 36: "Holderbaum 1983, p. 211, mentions a document recording de Vries's presence in Giambologna's shop in 1585, around the time that the *Caritas* was cast for the Grimaldi Chapel."

4 De Vries was involved in the production of three sculptures: *St. James*, 260 cm high; *St. Andrew*, 260 cm high, and *St. John*, 230 cm high (Mulcahy 1994: 176).

5 In a letter to Juan de Ybarra, secretary of the king's works, Pompeo Leoni states, "Believe me I am using the greatest art in the world to make the folds deep so that from below one can see the contours of the figures" (cited in Mulcahy 1994: 172).

6 The data considered in this summary include those from the seventeen de Vries bronzes examined at the J. Paul Getty Museum, as well as the technical examination results for the Royal Collection *Theseus and Antiope;* the National Gallery of Art, Washington, D.C., *Empire Triumphant over Avarice;* the Metropolitan Museum of Art *Apollo;* and the Lambach *Mercury*, in Bewer 2001.

7 As reported in Bewer 2001: 168–69.

8 Cellini describes cutting openings in the wax layer of his casting model for *Perseus*, both to hold the core in position during the pour and to allow removal of the core after casting, a step not observed on any of the bronzes included in this study (Cellini 1967: 114).

9 *Mercury and Cupid* from the *Mercury* fountain in Augsburg has sustained considerable damage from the expansion of the iron armature, necessitating repeated repairs (Höhne 1998: 170).

10 The remains of such a rod also exist in the indirectly cast figure of *Mercury* in Lambach (Bewer 2001: 171, fig. 17).

11 For the Lambach *Mercury*, see Bewer 2001: 170; and additional unpublished radiographs, courtesy of F. Bewer.

12 A stark comparison can be found in the radiographs of the *Venus* or *Nymph* (authorship uncertain), in which the arms and lower legs are all solid-cast (fig. 10.3).

13 An exception was found on the left arm of Empire (*Empire Triumphant over Avarice*, National Gallery of Art), in which a change in the arm necessitated a wax-to-wax join near the shoulder (Bewer 2001: 175–76).

14 Both horses are mounted to their bases using the integrally cast sprues that extend down from the hooves (figs. 15.2, 16.2), a method also used by Giambologna (Bewer 2001: 175).

15 S. Decker, proprietor, Decker Studios fine art foundry, pers. com.

16 This manner of depicting hair can also be found on de Vries's large sculptures, for example, the *Hercules* fountain in Augsburg (Emmendörffer and Kommer 2000: 165).

17 Illustrated in Larsson 1992: 73; and Emmendörffer 2000: 179.

18 Schematic drawings of four types of sprue systems for a single figure are illustrated in Avery and Dillon 2002: 227, 235.

19 It is known from archival documents that the *Farnese Bull* was originally left a golden color, some of which remains visible in the recesses (Scholten 1998a: 208). The golden surface remains visible in areas on both reliefs. The richer brown surface of the *Allegory* relief may be attributed to the application of oils or wax over the years.

20 For more on the Swedish looting of de Vries's bronzes, see Cavalli-Björkman 1998.

APPENDIX A

Glossary[1]

AFTERCAST (or *surmoulage*): A sculpture cast in metal using molds taken from a preexisting metal cast rather than from the original model. An aftercast is smaller than the original sculpture due to shrinkage of the metal and molten wax (if used) on cooling. Aftercasts can vary considerably in their quality and degree of conformity with the original bronze. The process of taking molds from an existing bronze will replicate surface flaws and may result in the softening or loss of surface detail. Although this deficiency can be somewhat compensated for by reworking of the model before casting or by careful CHASING of the bronze surface, it nevertheless explains why aftercasts are usually considered of diminished quality. An aftercast can be created using the INDIRECT LOST WAX technique or, as in the example of the two aftercasts of de Vries's *Hercules, Nessus, and Deianeira* in this study, can be sand cast (see chapters 30, 31).

ALLOY: A mixture of two or more metals that have been melted together. Metals are alloyed in order to alter characteristics such as color, hardness, corrosion resistance, melting point, malleability, and strength. Often, alloying one metal with another sacrifices a property of the original, pure metal, such as malleability, in favor of other desired properties, such as lowered melting point, which is useful in casting. Trace elements found in copper alloys generally enter the melt as impurities from the original ores or during the refining process. Even at every low concentrations, they may affect the alloys' characteristics. The alloys of the sculptures contained in this volume were determined using X-RAY FLUORESCENCE analysis.

ARMATURE: In DIRECT LOST WAX CASTING, the armature is the internal skeleton that supports the model as it is being constructed. The armature is composed of interconnected iron rods and wires that extend up from the base into part or all of the sculpted composition. Smaller wires wrapped around the major supports add "tooth" to the rods, helping to hold the heavy damp clay in place as it is modeled. The iron rods used to support the core in the SAND CASTING process are also referred to as armature. A foundry may remove the armature after casting in order to allow reuse of the rods and wires and reduce the weight of the sculpture. When exposed to moisture, iron left inside bronzes can be the cause of damage due to rusting and expansion of the metal. When present, armature remnants can be detected through the use of X-RAY RADIOGRAPHY. The identification of the metal as iron can often be confirmed with a magnet. (Fig. A.1.)

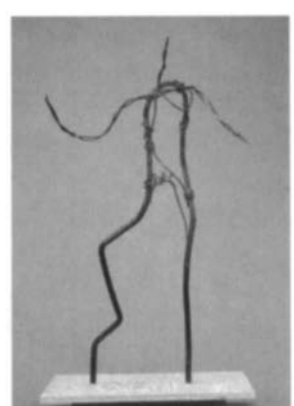

FIGURE A.1 This modern reproduction of the armature in de Vries's *Juggling Man* is based on radiographs of the original sculpture that indicate the presence of iron rods and wires.

1 The terms and definitions provided here describe the more commonplace approaches to the casting techniques observed on the sculptures in this study. Today, as in the past, there is lack of uniformity in the terminology applied to the techniques of bronze casting. An attempt has been made to be consistent with recent works that describe historic methods and materials, including Stone 1981; Bewer 1995b; Bassett and Fogelman 1997; and Dillon 2002.

BRASS: An ALLOY containing primarily copper with added zinc. Brass may also contain varying amounts of other components, such as lead and tin, as well as trace amounts of iron, antimony, silver, nickel, and arsenic. In this volume, a brass containing more than 1 percent lead is referred to as leaded brass. Brass is less malleable but stronger, harder, and easier to cast than pure copper. Sculptures that are technically brass alloys are often classified as BRONZE. This is because of the difficulty of distinguishing between the two visually and, perhaps, because of the association of brass with the production of utilitarian objects rather than fine art.

BRONZE: An ALLOY containing primarily copper, with added tin. Bronze may also contain varying amounts of other components, such as lead and zinc, as well as trace amounts of iron, antimony, silver, nickel, and arsenic. The addition of more than 1 percent lead is referred to as leaded bronze. Adding tin to copper lowers the melting point and increases the hardness. When added, lead increases the fluidity of the melted metal, lowers the melting point, and makes the bronze easier to chisel and work after casting. Zinc and lead added to a bronze alloy reduce the shrinkage of the cast bronze. Generally, the term *bronze* has been used for all fine art sculpture and predominates in art historical literature. An alloy suspected of being either bronze or brass is often referred to as "copper alloy" until confirmed through analysis.

CASTING MODEL: The wax model that will be melted out, or "lost," in the lost wax casting technique. In DIRECT LOST WAX CASTING, the artist's original wax model becomes the casting model. In the INDIRECT LOST WAX process, the casting model (also known as the INTERMODEL) is formed in molds, usually made from the artist's original model.

CHASING: The refinement of the surface of a cast sculpture after FETTLING has been completed. The quality and amount of chasing may vary considerably from one artist to another. The term most correctly refers to the refinement of forms with sharpened chisels or gravers and the application of texture with PUNCHES. The term is sometimes used to refer to all steps taken after a bronze is fettled, including polishing using a variety of abrasives, scrapers, or burnishers; hammering to hide fine blemishes, plugs, joins, and repairs; and the use of files or scratch brushes to apply linear texture, including fine light-catching striations. (Fig. A.2.)

FIGURE **A.2** In this modern reproduction of de Vries's *Juggling Man*, a graver is used during chasing to strengthen the lines around the fingernails.

COLD SHUT: A casting flaw in which the metal entering a section of the mold cools to the point at which it fails to fully fuse with metal entering from another direction. On de Vries's *Laocoön*, a cold shut across the right shoulder has the appearance of a long, thin, linear discontinuity with fluid edges, now further accentuated by differently colored corrosion along either side of the line (see fig. 25.17).

COLD WORK: Refers to steps taken to enhance the bronze surface that are done in the metal after casting, as distinct from those made in the model. Cold work includes FETTLING and CHASING. De Vries preferred the appearance of the as-cast surface over one with extensive cold work. (Fig. A.3.)

FIGURE **A.3** Cold work on the Faun, cast after de Vries, includes application of the brows and lashes in the metal with single chisel blows.

CORE: The interior section of the mold in a hollow cast. The core's size in relation to the outer mold determines the final thickness of the cast metal. One of the primary functions of the core is to reduce the amount of metal to be purchased and melted, thus reducing costs. The other is to keep the walls of the cast uniform in thickness to help avoid extreme or uneven shrinkage and associated porosity and distortion. The core must be made of REFRACTORY MATERIAL that will not burn, melt, or distort during the pour. Thoroughly dried and heated to harden, the core must be strong enough to withstand the force of the molten metal as it enters the mold, yet it must have enough give to allow the metal to shrink as it cools and sufficient pososity to absorb released gases. In LOST WAX CASTING, either clay or plaster was used as the main core component. Sand, grog (ground ceramic material), metal filings, ash, and organic material such as chopped animal hair or plant fibers could be added to strengthen the core, avoid shrinkage, and increase its porosity. Regardless of the size of the sculpture or the casting technique used, de Vries appears to have exclusively used a sandy clay for his cores. In SAND CASTING, a relatively high clay content gives coherence to the sandy core material that allows it to retain its shape as the mold is being formed and when heated. (Fig. A.4.)

FIGURE **A.4** In this modern reconstruction of the direct lost wax technique, a clay core has been modeled over an armature, in preparation for the addition of the wax layer.

CORE PIN (or chaplet): An iron pin or rod used to secure the core and to hold the core in correct alignment with the outer mold when the wax is removed, preserving the space between the two that determines the thickness of the metal. Usually made of iron, core pins extend from the outer mold or investment into the core and resist melting during the pour. In CHASING, the core pins were often pulled out, or they were cut off at the surface and driven into the hollow interior of the bronze. Iron core pins remaining in the bronze are often visible in radiographs and can sometimes be detected on the sculpture's surface with a magnet. Although core pins can be round in section, those observed in the de Vries bronzes are tapering and square- or rectangular-sectioned. (Figs. A.5, A.6.)

FIGURE **A.5** In this modern reproduction of the *Juggling Man*, a core pin is being inserted through the wax and into the core of the casting model.

FIGURE **A.6** The arrows in the radiograph indicate tapering core pins remaining in the interior.

CORE PIN (side-to-side): A type of core pin that runs from one side of a casting model straight through to the other side. Although the iron pins themselves are often removed after casting, when the core material remains on the interior their use may be indicated by a gap in the remaining core or by the presence of two core pin holes or plugs directly opposite each another.

CORE PIN HOLE: Holes left in the bronze when the CORE PINS are removed or cut off and pushed into the interior. The holes are generally repaired with SET-IN REPAIRS or THREADED PLUGS. In a radiograph, core pin holes can often be distinguished from porosity holes as they extend through the entire thickness of the bronze wall. (Fig. A.7.)

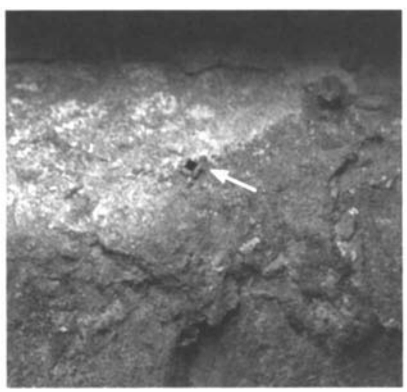

FIGURE **A.7** This (0.25 × 0.25 cm) feature on the interior of the sculpture can be identified as a core pin hole because it extends straight through the bronze wall and is of the same dimensions as the extant core pins.

CORE SUPPORTS: Metal rods or wires that help to strengthen the core during casting. Core supports are found in INDIRECT LOST WAX casts. They differ from armature rods in that they are generally inserted into the hollow INTERMODEL after it is formed and are composed of relatively short, separate sections of rod or wire. (Fig. A.8.)

FETTLING: The process of cleaning up a wax or bronze when it is removed from a mold. The wax INTERMODEL in INDIRECT LOST WAX CASTING is fettled to remove FINS formed between the mold sections and to smooth the outer surface of WAX-TO-WAX JOINS. In a cast BRONZE, fettling includes removal of the black oxides from the surface, as well as chiseling, scraping, and filing to remove unwanted surface features such as sprues and flashes.

FIN (or mold seam): Raised lines formed in the fine gap between mold sections when a material such as plaster, wax, or bronze is cast into a PIECE MOLD.

FLASH: Metal unintentionally deposited on the inside or outside of a BRONZE during the pour. Flashes form when molten metal enters shrinkage cracks in the mold. They may also form in areas of weakness within the core, such as the point where core pins are inserted, across WAX-TO-WAX JOINS, or between layers of core material. Flashes on the outside of a bronze are generally removed in FETTLING; those remaining on the interior are often visible in radiographs or inside an open base if the core has been removed. A relatively small number of flashes may be found in sand casts compared to lost wax casts due to the greater amount of porosity of the mold material. (Fig. A.9.)

FIGURE **A.8** The short iron core supports that span the wax-to-wax joins in Deianeira's upper arms strengthen the joins, helping to hold them together during the casting. A horizontal wax-to-wax join can be found in the mid-torso, this one without a core support rod.

FIGURE A.9 Flashes within the figure of Abel complicate the reading of the interior. The flashes appear as dense jagged-edged shapes of varying size, including thin branching lines and compact forms.

FLASK: Iron frames with removable bottoms that are used to contain the molds in the SAND CASTING process. The flask is composed of two sections: the cope (top half) and the drag (bottom half).

FOUNDRY MODEL: A model made specifically for the purpose of forming the mold in the SAND CASTING process. The foundry model for a large or complex composition is made in parts in order to simplify the molds. The foundry model is placed in a bed of sand within a FLASK. The mold sections are made by compacting sand tightly against the model. To withstand this pressure, foundry models are made of hard materials such as plaster or metal (for large editions). (Fig. A.10.)

INTERMODEL: A term used in conjunction with the INDIRECT LOST WAX technique. The intermodel is the wax CASTING MODEL made in the PIECE MOLD taken off of the original model. The intermodel can be made by brushing or pouring liquid wax into the piece mold (as in SLUSH MOLDING) or by pressing sheets of wax into the mold. Numerous intermodels can be made using the same set of molds, thus allowing the casting of REPLICAS.

INVERSE SEGREGATION: An unintentional occurrence during casting in which the lower-melting-point constituents of an alloy concentrate on the surface. In cast bronzes, inverse segregation occurs when the tin-rich phase of the alloy is forced toward the surface of the mold during cooling (also known as tin segregation). When this occurs, surface analytical techniques such as X-RAY FLUORESCENCE will indicate that the alloy contains far more tin than is true for the alloy as a whole. On the *Laocoön,* for instance, the silvery area of the supine son's cheek was found to contain up to 30 percent tin, a content elevated as a result of inverse segregation (see fig. 25.3).

INVESTMENT: The outer mold in LOST WAX CASTING, composed of REFRACTORY MATERIAL similar or identical to that used for the CORE. The first coats of investment were often very fine in texture, allowing a detailed transfer of the surface of the wax model, with coarser layers then added. It is unusual to find investment remaining on the surface of a bronze as it is generally completely removed during FETTLING.

LOST WAX CASTING (or *cire-perdu*): A technique used since antiquity for casting bronze sculpture. In basic terms, lost wax casting involves replacement of a wax model with molten bronze within a mold. The wax model (referred to

FIGURE A.10 This section of a plaster foundry model is being used to make a sand cast replica of a de Vries bronze.

as the CASTING MODEL) is usually formed in two ways: the direct lost wax and the indirect lost wax methods.

DIRECT LOST WAX CASTING: A method of lost wax casting in which the bronze is cast *directly* off of the artist's original model. In the direct technique, the casting model is constructed over a preformed core. (For a full description, see chapter 2.)

INDIRECT LOST WAX CASTING: A method of lost wax casting in which the original model is preserved by making a mold of it. One or many INTERMODELS can then be made *indirectly* in the molds. (For a full description, see chapter 2.)

MAGNETIC ATTRACTION: An attraction for iron, as exhibited by magnets. The attraction of a magnet to a spot on a BRONZE indicates the presence of iron below the surface. Useful for identifying an unknown white metal alloy as iron and for determining the presence of iron CORE PINS or rods under the bronze surface.

METAL-TO-METAL JOINS: Joins made between separately cast sections of a metal sculpture. Sculptures were often cast in parts due to the difficulty and risks of casting complex compositions in one pour. Joins can include simple mechanical ties such as threaded rods secured with nuts or more permanent methods using cast-in copper alloy or solder metal. Metal-to-metal joins may be carefully chased, but on close inspection they are generally visible on the surface. Radiography can often be used to identify the type of join used on a sculpture.

CAST-IN METAL JOIN: A method for joining two separately cast parts of a sculpture in which metal is poured between the two to hold them in place. Due to slight shrinkage of the cast-in metal, a fine line between it and the original metal wall can often be seen in a radiograph of the join. (Figs. A.11, A.12.)

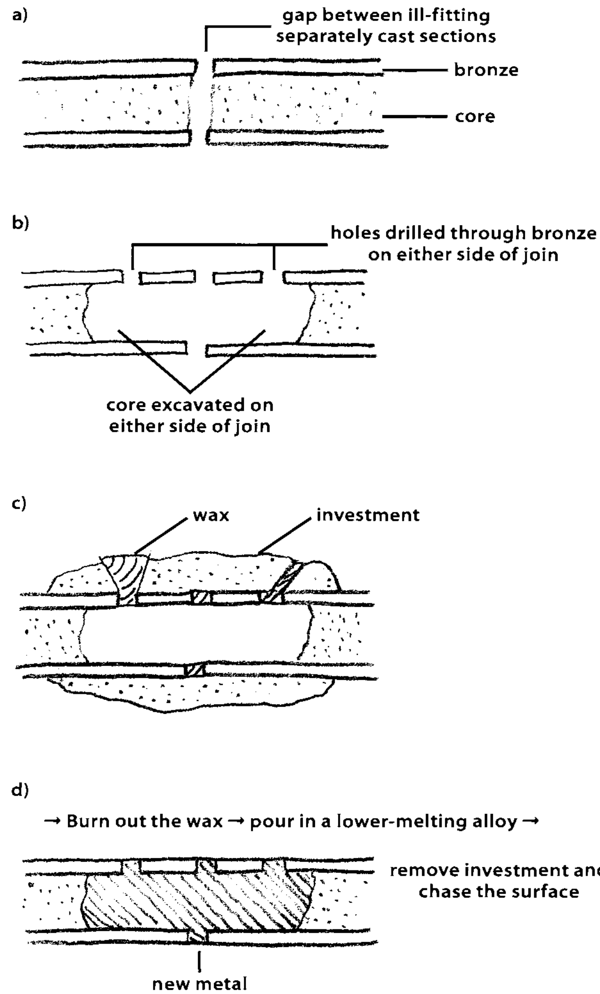

FIGURE **A.11** Illustration of the cast-in metal join on the Tetrode *Mercury*. a. The separately cast sections with their core intact. b. The core was partially excavated and two holes drilled on either side of the join. c. Wax was used to fill the gap between the separate sections and the drilled holes, with a wax extension attached to one of the holes to act as a pouring channel and another channel to allow air and gases out of the mold; the entire area was invested with refractory material. d. The join was heated to melt out the wax; bronze was poured into the makeshift mold, filling the internal cavity and locking the join in place; and the channels were chiseled off and the surface smoothed.

FIGURE A.12 The cast-in metal that secures the separately cast legs to the torso appears as solid fills in the radiograph.

MECHANICAL JOIN: A method for joining two separately cast parts of a sculpture that involves securing them without the use of heat or molten metal. Mechanical joins can include the use of a SPRUE end to secure a figure to its base or threaded rods secured with nuts. More complicated mechanical joins include sleeve joins and dovetail joins (rare). (Fig. A.13.)

SLEEVE JOIN (or Roman join): A method for joining two separately cast parts of a sculpture using an internal sleeve. The sleeve is cast with one of the two parts. It slips inside the adjacent section, and the two are secured with pins. (Fig. A.14.)

SOLDER JOIN: A method for joining two separately cast parts of a sculpture by applying soft SOLDER. The presence of solder in a join can be identified on the surface by the white color of the metal and by radiography due to the high density of the lead. If not properly removed, flux used to aid the flow of the solder can cause raised corrosion over time. (Fig. A.15.)

FIGURE A.13 The threaded rods used to secure the separately cast wings form a mechanical join with Mercury's helmet.

FIGURE A.14 In this sand casting, the separately cast arms are secured with pinned sleeve joins just below the shoulders. The sleeves, cast with Nessus's arms, slip into the shoulders and are held in place with pins.

FIGURE A.15 The high density of the thin line of lead-based solder in this solder join in Mercury's left thigh is just visible in the radiograph.

MODEL: A preliminary version of a projected sculpture, made to facilitate the design and/or execution of the final sculpture. In bronze casting, reference is made to the artist's original model (generally created by building up and manipulating a malleable material such as clay or wax), the CASTING MODEL (lost wax casting), the INTERMODEL (indirect lost wax casting), and the FOUNDRY MODEL (sand casting).

MOLD: The negative impression of a form into which a sculpting material such as plaster, wax, or molten metal is poured or pressed. Molds made of REFRACTORY MATERIAL were used for lost wax casting and sand casting of bronze sculptures. Types of mold discussed in this volume include plaster PIECE MOLDS for the formation of the wax INTERMODEL in indirect lost wax casting; INVESTMENT molds, used in lost wax casting; and piece molds, used in sand casting.

PATCH: A metal insert used to hide a flaw on a bronze surface. The term is often used to refer to square, rectangular, or other angularly shaped repairs. Patches may be set-in or soldered-in (refer to REPAIRS below).

PATINA: A term most commonly used to describe a naturally or artificially induced surface alteration on metal but that also includes applied organic coatings. In the Renaissance through the eighteenth century, bronzes were typically coated with organic patinas such as translucent lacquerlike varnishes or paint. To retain the bright, lustrous appearance of a polished or brushed bronze surface, a protective coating of drying oils could be applied, sometimes with resins or pigments added. More opaque paintlike layers were at times applied to hide casting blemishes. Thin and even coatings in a wide range of colors became common in the nineteenth century using chemical patinas, mixtures—often applied with heat—that cause chemical changes to the metal surface. Protective wax coatings found on many bronzes alter the appearance of the surface and may also be considered part of the patina. The original appearance of the surface of many early bronzes has been lost because of repatination. (Figs. A.16, A.17.)

PIECE MOLD: A mold made in sections that can be repeatedly assembled and reassembled. Piece molds accommodate undercuts in the surface from which the mold is being taken and allow for the removal of the original from a rigid plaster mold without damage. Although flexible moldmaking materials such as gelatin and wax were known in Renaissance and Baroque Europe, they were not widely used for sculpture. In the INDIRECT LOST WAX technique, plaster piece molds taken off of the artist's original model

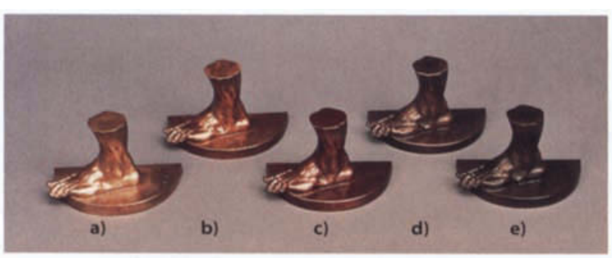

FIGURE **A.16** Examples of tinted organic patinas composed of linseed oil and mastic resin with added colorants. From the left: a) the unpatinated bronze; b) a transparent golden brown containing bitumen (a petroleum product); c) transparent red containing madder lake (from the root of the madder plant) and carbon black; d) transparent chestnut brown containing pine pitch, carbon black, and burnt umber; e) opaque black containing carbon black applied to a heat-oxidized surface. (Tests of tinted organic patinas prepared by Richard Stone.)

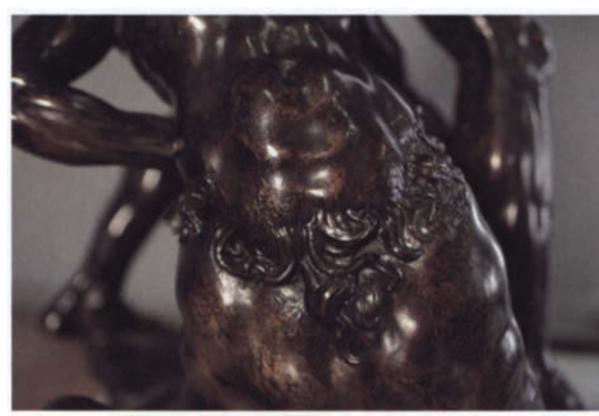

FIGURE **A.17** The bronze below the translucent brown patina on Nessus's abdomen retains its golden polish.

are used to form multiple wax INTERMODELS to be used in casting. In SAND CASTING, piece molds are used to facilitate the removal of the FOUNDRY MODEL from the FLASK.

PLUG: A type of metal insert used to hide flaws in a bronze surface. The term is often used to refer specifically to round repairs. Plugs are often secured in place using threads (THREADED PLUG) but can be soldered into place (SOLDERED-IN REPAIR).

POLISH: Smoothing of the metal surface. A bronze can be polished using abrasives of increasingly fine grade. Deeper lines from coarse polishing are sometimes not fully removed, leaving the so-called polish lines that may be difficult to distinguish from SCRATCH BRUSH lines added intentionally to texture the surface. Smoothing of the surface can also be achieved using scrapers, which remove raised material until the surface is leveled, or burnishers, which flatten irregularities without removing material. (Fig. A.18.)

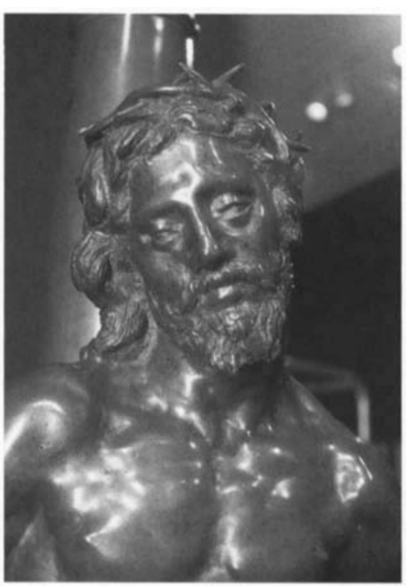

FIGURE A.18 The column and the flesh have been finished with a high polish. Fine abrasive lines from the process remain visible in the right shoulder and right side of the neck.

POROSITY: Casting flaws due to trapping of gases or to uneven shrinkage of the cast as it cools, resulting in voids in the metal. Porosity may be hidden within the walls of the bronze or may extend through to the surface. Surface porosity can be repaired with plugs, patches, or cast-in metal, or left unrepaired, as found on many of de Vries's casts.

GASEOUS POROSITY: A type of casting flaw caused when gases are trapped in the metal as it cools. The composition of the core and the layout of the SPRUES are designed to allow the gases to escape the mold. If the core is not sufficiently porous or the mold is inadequately vented, the gases will remain in the metal, forming voids that appear in the radiographs as distinct, globular areas of lower density of varying size and concentration. (Fig. A.19.)

SHRINKAGE (retraction) POROSITY: A type of casting flaw resulting from localized, uncontrolled contraction of the cast metal as it solidifies, caused by uneven cooling within the mold. As the metal in one area cools, it shrinks, creating space into which the adjacent molten metal is pulled by vacuum. Its appearance in radiographs

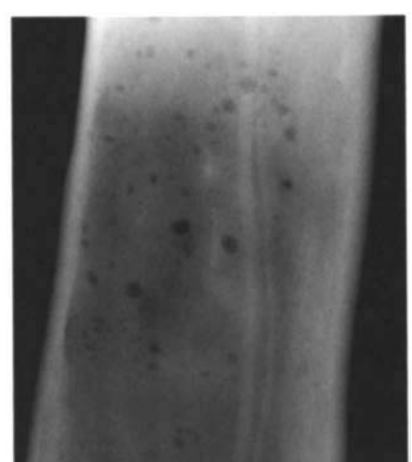

FIGURE A.19 The darker round voids of lesser density on the radiograph of Hercules' club are spots of gaseous porosity.

varies from mottled areas of lower density to more distinct, branching lines of jagged-edged gaps in the metal. (Fig. A.20.)

FIGURE A.20 The dark, sharp-edged shrinkage porosity throughout the torso, buttocks, and right thigh was caused by uneven cooling of the cast metal. The horizonal line of increased density across the chest is a drip formed during slush molding of the intermodel.

PUNCH: A thin iron tool used to apply texture to a metal surface. One end of the tool is hammered while the textured head of the tool rests against the surface of the sculpture. The texture needed for a particular application can be filed or hammered into the head of the punch. A punch can also be used to texture the wax model. It can be difficult to determine whether the punch was used in the wax or metal stage; the sharpness of the punched texture in figure 14.7, for example, strongly suggests it was applied in the metal.

RADIOGRAPH: See X-RAY RADIOGRAPHY.

REFRACTORY MATERIAL: A material that is able to withstand the high temperatures associated with casting without burning or melting. Clay, sand, plaster, and grog (ground ceramic material) are refractory materials often used to make molds for casting metals.

REPAIRS: Repairs are used to fix casting flaws and to fill holes remaining when the armature rods, core supports, or core pins are removed.

CAST-IN REPAIR: A repair made by pouring molten metal into a miscast area of a bronze. Cast-in repairs can vary from a small quantity of molten metal poured into a surface porosity to in situ recasting of entire sections of a sculpture. Lead alloys are sometimes used for simpler cast-in repairs. A copper alloy similar to the rest of the cast is most often used, making it difficult to see repairs on the surface of the bronze when chased. In radiographs, cast-in repairs look like irregularly shaped areas of higher density than the surrounding metal, as they partially fill the interior hollow where the core was removed. Shrinkage upon cooling will form a small gap between the two thicknesses of metal. This gap, together with the excess density and a generally free-form (not geometric) perimeter, is diagnostic for cast-in repairs. (Figs. A.21, A.22).

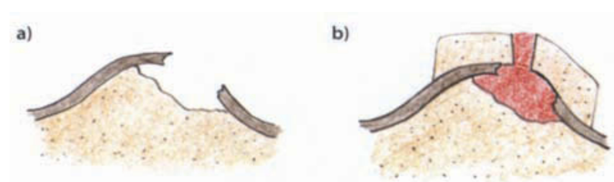

FIGURE A.21 A cast-in repair. a) The core is partially cleared below the flaw; losses in flat, polished areas can be poured into the hole at this stage and filed flat. b) For more complex surfaces, the damaged portion is first modeled in wax directly on the bronze, then the wax is invested with refractory material, which is heated to harden the investment and melt out the wax. Molten metal is then poured into the gap left where the wax was. Finally, the surface of the repair is filed, hammered, and textured as necessary to blend with the surrounding metal.

FIGURE A.22 The irregularly shaped dense spot on the top of the head is a cast-in repair, possibly filling a hole left when a section of the armature was removed. Note the fine gap at the edge of the repair due to shrinkage on cooling.

FIGURE A.23 To fill holes that extend all the way through the bronze, such as those left when core pins are removed, a repair much thinner than the surrounding metal is often used. To lock the plug in place, a bevel is chiseled into the sides of the hole and the set-in repair hammered into place. The repair plug may not completely fill the chiseled bevel, in which case a radiograph of the repair will show a thin line of lower density around the perimeter of the plug.

FIGURE A.24 The patch used for this set-in repair is considerably thinner than the surrounding cast metal, appearing as a dark square of lesser density. The dark outline around the square is the fine gap between the chiseled bevel and the edge of the patch, a detail not always seen in radiographs.

FIGURE A.25 A porosity flaw that extends only partway through the metal has been filled with a set-in repair.

SET-IN REPAIR: A mechanical repair made by fitting a PLUG or PATCH tightly into a flaw in a bronze. If the flaw is asymmetrical, the bronze is often chiseled or drilled into a roughly geometric shape such as a circle or rectangle. In radiographs, set-in repairs appear quite different from cast-in repairs because of their geometric shape and because they are of equal or less density than the surrounding metal. (Figs. A.23, A.24.)

Set-in repairs can also be used to repair flaws that extend only partway through the thickness of the bronze. In this example, the flawed surface is chiseled away to create a flat surface into which the repair can be hammered. The edges of the hole are slightly beveled to lock the plug in place. In a radiograph, the repaired area is the same thickness as the surrounding surface and therefore of equal density, often making this type of set-in repair difficult to see. (Fig. A.25.)

SOLDERED-IN REPAIR: A method for repairing flaws that involves securing copper alloy PLUGS or PATCHES using a lead alloy SOLDER (soft solder) that melts at a lower temperature than that of the metals being joined. As with set-in repairs, the edges of the flaw are often chiseled to a geometric shape. Soldered-in repairs are frequently easy to identify due to one or more factors: the white color of the solder, the presence of corrosion along the solder line caused by remaining flux, and the high radiographic density of the lead. (Figs. A.26, A.27.)

THREADED PLUG: A round plug secured with spiral threads. Until the advent of lathes to cut threads with precision, they were cut by hand. Threaded plugs can be of varying lengths. Unless shot at an angle to the rod, the threads can be difficult to see in a radiograph, particularly if there are only a minimal number of spirals. Although de Vries did not use threaded plugs, they appear on most of the comparison bronzes included in this study. (Fig. A.28.)

REPLICA (or edition): Multiple casts made from the same set of molds. Using the INDIRECT LOST WAX technique, it is possible to make numerous virtually identical replica casts. In practice, variations due to deterioration of the mold, casting flaws, and differences in how the wax INTERMODELS and cast bronzes are finished may result in substantial variations between replicas. In this study, it is likely that the two *Cain and Abel* casts (see chapters 18, 24) are replicas.

SAND CASTING: A technique for casting metals in which the mold is formed in FLASKS around a reusable FOUNDRY MODEL. Before the eighteenth century, sand casting was used primarily for simple forms such as medals and furniture hardware. Methods for sand casting complex sculptural compositions were likely developed in the late eighteenth or early nineteenth century in France, where for a time the process replaced lost wax casting for sculpture. Sand cast bronzes are often cast in sections that are then joined in the metal, necessitating extensive CHASING to hide the joins. Other characteristics of sand cast bronzes

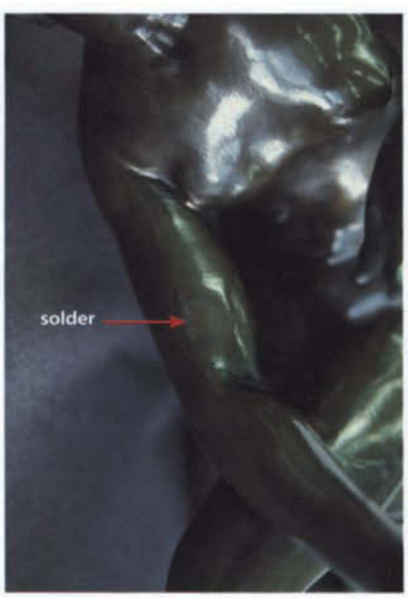

FIGURE **A.26** The white color of the solder metal surrounding the plug in the top of the Nymph's arm identifies it as a soldered-in repair.

FIGURE **A.27** The higher density of the lead at the edges of the two soldered-in repairs on the Faun's arm appear white on the radiograph.

FIGURE **A.28** The spiral threads in the threaded plug on top of the knee are visible in the radiograph.

include lack of conformity between the inner and outer walls of the bronze, distinctively simplified and angular interior contours, and a comparatively small amount of porosity and interior flashing when compared to many lost wax casts. (For more detail, see chapter 2.)

SCRATCH BRUSH: A type of wire brush used in CHASING to make fine lines in the surface of a bronze. It can be difficult to distinguish between wire brush and file marks on a bronze; however, wire brush marks more closely follow the undulating contours of forms, as the bristles are more flexible than the cutting edges on a file. Scratch brush lines often run parallel to the torso and limbs of de Vries's nude figures; they were also used to texture horse hides. (Fig. A.29.)

SLUSH MOLDING: Refers to a process in which a fluid material is swirled inside a mold. Once the desired thickness of material has hardened against the mold, the excess liquid material is poured out. In INDIRECT LOST WAX CASTING, slush molding is one way to form a thin wax INTERMODEL of uniform thickness. Wax drips captured in bronze from slush molding of the casting wax may be visible in radiographs of indirect lost wax casts. (Fig. A.20.)

SOLDER: A metal of a lower melting point used to join or repair metallic parts that have a higher melting point. For bronze sculpture, "soft solder" (an alloy of lead and tin) was sometimes used to join separately cast elements, to attach repairs, and to fill casting flaws. When soft solder is used on a bronze, its grayish white color is often visible on the surface, in contrast to the golden color of the bronze metal. Due to the density of lead, soft solder can be clearly seen in radiographs. Although solder repairs are sometimes applied in the foundry, those applied at a later date can sometimes be distinguished, as the heat used to make the repair will damage the surrounding patina. To aid the flow of the solder, flux is applied to the join. A wide variety of fluxes can be used for soft soldering of copper alloys, most of which will cause corrosion of the surface over time if not fully removed after soldering.

FIGURE **A.29** Lines running parallel to the limbs on the *Hercules Pomarius* were likely made with a scratch brush.

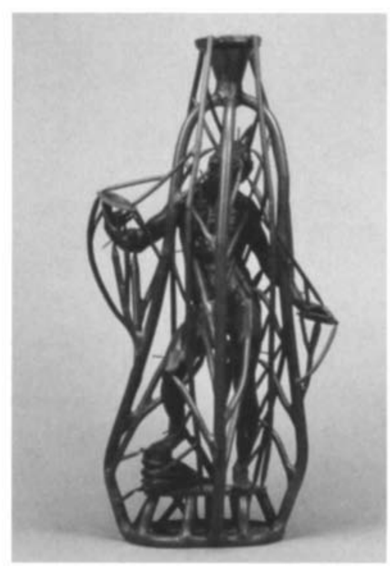

FIGURE **A.30** The pouring cup and sprues are attached to a modern reproduction wax model of the *Juggling Man*.

SPRUE: A general term for the parts of the circulatory system in a LOST WAX CASTING that include the gates or runners that allow the molten metal to enter the mold, as well as risers or vents that allow air and gases to escape. It can be difficult to tell the specific function of parts of the sprue system that remain on the surface of a finished bronze. For this reason, the general term *sprue* is often used in technical studies. Proper placement of the sprues includes consideration of the amount of CHASING necessary to repair the surface once the sprue is chiseled off. De Vries left sprues of varying lengths on the surface of many of his sculptures. (Fig. A.30, A.31.)

FIGURE **A.31** The sprue system for the *Hercules Pomarius*, disguised as twisting vines that connect the cornucopia to the figure's legs and genitals, was apparently designed by de Vries to remain in place once the bronze was cast.

***SURMOULAGE* MARKS:** Scratches formed on the surface of a sculpture as a mold is being taken off of it. The presence of *surmoulage* marks on a bronze suggests that aftercasts may have been made. (Fig. A.32.)

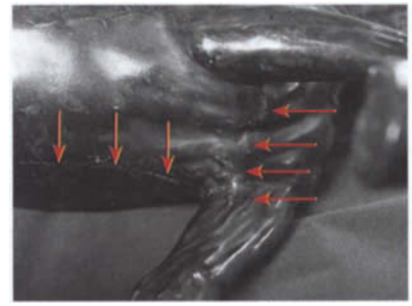

FIGURE **A.32** Thin, straight surface scratches are *surmoulage* marks found in many locations on the *Horse*. They were made while a mold was being taken of the figure.

THERMOLUMINESCENCE (TL) DATING: An analytical technique used to date certain types of artifacts that have been exposed to high temperatures during facture. The technique is usually applied for ceramics, although it can also be used for dating bronze casting cores. The technique is based on the observation that certain materials found in clay absorb minute amounts of energy over time. When a core sample is exposed to heat, the stored energy is released as light. The amount of light released is proportional to the amount of time that has passed since the sculpture was last heated, allowing a calculation of the age of the bronze.

VARIANT: A bronze that is similar to another but has been cast from a model that has been made independently. An artist may make variants of his own work, or variants can be made by later sculptors or imitators. In this study, the *Venus* (see chapter 10) is likely a variant of the seated bronze naiads on de Vries's *Hercules* fountain, modeled and cast by a later artist.

WAX-TO-WAX JOINS: Refers to joins between sections of a wax INTERMODEL, often appearing in radiographs as circles of varying density around necks, upper limbs, and sometimes torsos. For ease of manipulation, the intermodel in the INDIRECT LOST WAX process is often made in parts that are then joined together. The joins are made by quickly heating the wax with a spatula, then pressing the melted edges together. This action leads to an excess of wax at the join that is cleaned off of the surface of the wax intermodel but remains on the inside of the sculpture, where it is subsequently cast in bronze and therefore can be seen in a radiograph. When the wax edges have failed to weld, a wax-to-wax join may partially appear as an area of lower density. This type of join will be invisible in a radiograph if a solid section of wax is joined to a hollow section or to another solid section. Iron CORE SUPPORT wires or rods often span wax-to-wax joins, helping to hold them together. Because the sections of wax to be joined are made separately, there may be variations in the thickness of the walls on either side of the wax-to-wax join, which can sometimes be seen in the radiographs. (See fig. A.8 above.)

X-RAY FLUORESCENCE SPECTROMETRY (XRF): An analytical technique for determining elemental composition. This is a nondestructive technique for the analysis of metals, as it can be undertaken without removing a sample. A beam of X-rays generated by the instrument is directed onto the surface of the object. The X-rays knock electrons out of the surface atoms. As the atoms return to stable states, they emit radiation. The wavelengths, or energy, of the emitted radiation are characteristic of the elements present on the object's surface, thus indicating the specific alloy in the area that is tested. Because it is a nondestructive method, XRF allows analysis of numerous locations on the bronze, including separately cast elements and repairs. The disadvantage of the technique is that the results are less precise than for methods in which a sample is removed from the object.

X-RAY RADIOGRAPHY: A technique used in the examination of bronzes to reveal features that are difficult to see on the outside surface or are hidden on the inside of a sculpture. The process is similar to that used in the medical field, except that considerably higher energy is necessary to penetrate the metal walls. A sheet of film placed behind the bronze as the X-rays are shot through it from the front records very fine and subtle variations in the density of the sculpture. Materials such as lead, iron, and copper absorb X-rays, partially blocking them from exposing the film. When the film is developed, denser areas, such as armature rods and solid-cast elements, appear light gray or white on the film. Less dense areas, such as porosity voids and hollow-cast elements, appear darker on the film. The image produced is called a radiograph.

APPENDIX B1

Summary Tables

General observations from the 1999–2000 J. Paul Getty Museum Technical Study

Chapter	Title/Collection	Artist	Date	Casting Method	Number of Parts Cast-In	Bulk Alloy	Core Matrix	Interior Features of Note	Remaining Sprues
7	*Psyche Borne Aloft by Putti* Nationalmuseum, Stockholm	Adriaen de Vries	1590–92	Direct	1	Bronze	Clay	Tool marks in core	None observed
8	*Faun and Nymph* Staatliche Kunstsammlungen, Grünes Gewölbe, Dresden	After de Vries	Before 1621	Indirect (only Faun examined)	1	Leaded bronze	Gypsum plaster	Wax-to-wax joins and wax drip	None observed
9	*Crucifix* Kirchenstif-tung Mariä Verkündigung, Wullenstetten	Authorship uncertain	Uncertain	Indirect	3 (two are likely repairs)	Bronze	Not deter-mined	Wax-to-wax joins and wax drips	None observed
10	*Venus* or *Nymph* Herzog Anton Ulrich-Museum, Braunschweig	Authorship uncertain	Uncertain	Indirect (unusual variation)	2 (figure + base)	Leaded brass	Gypsum plaster	Drip? Extreme variation in wall thickness	None observed
11	*Bust of Emperor Rudolf II* Kunsthistorisches Museum, Vienna	Adriaen de Vries	1590–92	Direct	1	Bronze	Clay		None observed
12	*Bust of the Elec-tor Christian II of Saxony* Skulpturen-sammlung, Staatliche Kunstsammlungen, Dresden	Adriaen de Vries	1603	Direct	1	Bronze	Clay		None observed
13	*Hercules, Nessus, and Deianeira* Musée du Louvre, Paris	Adriaen de Vries	1603–8	Indirect	1	Bronze	Clay	Wax-to-wax joins	Yes (one between Nessus's left shoul-der and back of Hercules' right thigh)
14	*Allegory of the War against the Turks in Hungary* Kunsthistorisches Museum, Vienna	Adriaen de Vries	1604–5	Indirect	1	Bronze	Clay	Sprues attached to the back and wax drips	Yes (remnants of 27 cut off the back)

Chapter	Title/Collection	Artist	Date	Casting Method	Number of Parts Cast-In	Bulk Alloy	Core Matrix	Interior Features of Note	Remaining Sprues
15	*Rearing Horse* J. Paul Getty Museum, Los Angeles	Adriaen de Vries	1605–10	Indirect	2 (figure + base)	Horse: bronze Base: leaded bronze	Not determined	Horse: wax-to-wax joins and wax drips; Base: waxy brush marks	Yes (for mounting to base)
16	*Horse* Národní Galerie v Praze, Prague	Adriaen de Vries	1610	Indirect	2 (figure + base)	Horse: bronze Base: quaternary bronze	Not determined	Horse: wax-to-wax joins; evidence of a saddle shape in the core	Yes (for mounting to base)
17	*Vulcan's Forge* Bayerisches Nationalmuseum, Munich	Adriaen de Vries	1611	Uncertain	1	Bronze	Clay	Entire back chiseled down	None observed
18	*Cain and Abel* University of Edinburgh, Torrie Collection	Adriaen de Vries	1612	Indirect	1	Bronze	Clay	Wax-to-wax joins	None observed
19	*Juggling Man* J. Paul Getty Museum, Los Angeles	Adriaen de Vries	1610–15	Direct	1	Bronze	Clay		None observed
20	*Farnese Bull* Schlossmuseum, Gotha	Adriaen de Vries	1614	Direct	1	Bronze	Clay		Yes (six of them)
21	*Christ at the Column* Kunsthistorisches Museum, Vienna	Adriaen de Vries	ca. 1613	Direct	1	Bronze	Clay		Yes (remains of one on finger)
22	*Lazarus* Statens Museum for Kunst, Copenhagen	Adriaen de Vries	1615	Direct	1	Bronze	Clay		None observed
23	*Putto with a Goose* Nationalmuseum, Stockholm	Adriaen de Vries	1615–18	Direct	1	Bronze	Clay		None observed
24	*Cain and Abel* Statens Museum for Kunst, Copenhagen	Cast by Adriaen de Vries Surface chasing: unknown	1622	Indirect	1	Bronze	Clay	Wax-to-wax joins and wax drips	Yes (remains of two on top of the base)
25	*Laocoön and His Sons* Nationalmuseum, Stockholm	Adriaen de Vries	1623	Direct	1	Bronze	Clay		Yes (as vines/ *cache-sexe*)

Chapter	Title/Collection	Artist	Date	Casting Method	Number of Parts Cast-In	Bulk Alloy	Core Matrix	Interior Features of Note	Remaining Sprues
26	*Hercules Pomarius* Muzeum hlavního města Prahy, Prague	Adriaen de Vries	1626	Direct	1	Bronze	Clay		Yes (as vines/ *cache sexe*)
27	*Mercury* Los Angeles County Museum of Art, Los Angeles	Willem van Tetrode	1560–65 (model)	Indirect	6	Leaded brass	Gypsum plaster	Zigzag metal joins	None observed
28	*Mercury and Psyche* Huntington Art Collections, San Marino	Authorship uncertain	Uncertain	Likely indirect	13 or 14	Brass	Not deter-mined	Separately cast elements soldered together	None observed
29	*Christ Mocked* Los Angeles County Museum of Art, Los Angeles	Authorship uncertain	1655–1735 (TL date)	Indirect	6 (figure in 5 + base)	Qua-ternary bronze	Gypsum plaster (base)	Figure and base: wax drips	None observed
30	*Hercules, Nessus, and Deianeira* Nelson-Atkins Museum of Art, Kansas City	Attributed to Charles Crozatier, after de Vries	ca. 1845–50	Sand cast	8	Brass	Sand with clay	Geometric contours	None observed
31	*Hercules, Nessus, and Deianeira* Rijksmuseum, Amsterdam	Attributed to Charles Crozatier, after de Vries	ca. 1845–50	Sand cast	14	Brass	Sand with clay	Geometric contours	None observed

Note: Shading indicates a sculpture not by de Vries.

APPENDIX B2

Armature Rods/Core Supports/Core Pins*
Observations from the 1999–2000 J. Paul Getty Museum Technical Study

Ch.	Title/Collection	Artist	Cross Section of Primary Arma-ture/Core Supports	Rod and Wire Diam-eter* (cm)	Dou-bling as Core Pins? (exiting bronze)	Exiting, Then Reenter-ing Wax Model?	Cross Section of Core Pins	Core Pin Diam-eter*	Pins Remain in Interior? (length)**	Side-to-Side Core Pins?
7	*Psyche Borne Aloft by Putti* Nationalmuseum, Stockholm	Adriaen de Vries	Rectan-gular	• 0.8 × 0.2 (arm. fragment) • 0.3 to 0.5	Yes	Yes	Square/ rectan-gular	Varies between 0.3 and 0.5	Yes	Possible
8	*Faun and Nymph* Staatliche Kunst-sammlungen, Grünes Gewölbe, Dresden	After de Vries	Round	• 0.1 to 0.3	Yes	No indi-cation	None clearly distin-guishable	N/A	No	No indi-cation
9	*Crucifix* Kirchenstiftung Mariä Verkündigung, Wullenstetten	Author-ship uncertain	Unknown shape	• 0.2 to 0.3	No indi-cation	No indi-cation	Round	0.3	No	Likely
10	*Venus* or *Nymph* Herzog Anton Ulrich-Museum, Braunschweig	Author-ship uncertain	Tightly twisted wires + round	• 0.15 to 0.35	Yes	No indi-cation	None clearly distin-guishable	N/A	No	Yes (core sup-ports)
11	*Bust of Emperor Rudolf II* Kunsthistorisches Museum, Vienna	Adriaen de Vries	Flat bar + rod of unknown shape	• Flat bar: 2.5 wide • Tapering 1.8 to 0.7 • 0.2 to 0.5	Yes (through top of head?)	No indi-cation	Rectan-gular	0.4 × 0.45	Yes (ca. 1.5 cm)	No indi-cation
12	*Bust of the Elector Christian II of Saxony* Skulpturen-sammlung, Staatliche Kunstsammlungen, Dresden	Adriaen de Vries	Unknown	• Big ones removed • 0.2	No indi-cation	No indi-cation	Square	0.5 × 0.5	No	No indi-cation
13	*Hercules, Nessus, and Deianeira* Musée du Louvre, Paris	Adriaen de Vries	Rect-angular (tapering)	• Tapering: 0.8 to 0.3 • 0.2 to 0.3	Yes (primary rod only)	Yes	Square	0.3 × 0.3	Yes	No indi-cation
14	*Allegory of the War against the Turks in Hungary* Kunsthistorisches Museum, Vienna	Adriaen de Vries	Not applicable	• No radiographs	No radio-graphs	No radio-graphs	Square and rect-angular	Varies between 0.3 and 0.4	Yes (2.5)	Not appli-cable
15	*Rearing Horse* J. Paul Getty Museum, Los Angeles	Adriaen de Vries	Removed	• 0.2	Yes (through belly)	No indi-cation	Square	0.25 × 0.25	Yes (0.4 and 0.7)	No indi-cation

Ch.	Title/Collection	Artist	Cross Section of Primary Arma-ture/Core Supports	Rod and Wire Diam-eter* (cm)	Dou-bling as Core Pins? (exiting bronze)	Exiting, Then Reenter-ing Wax Model?	Cross Section of Core Pins	Core Pin Diam-eter*	Pins Remain in Interior? (length in cm)**	Side-to-Side Core Pins?
16	*Horse* Národní Galerie v Praze, Prague	Adriaen de Vries	Removed	• 0.2 to 0.45	Yes (through belly)	No indi-cation	Square	• 0.25 × 0.25 • 0.3 × 0.3	Yes (1.5)	No indi-cation
17	*Vulcan's Forge* Bayerisches Nationalmuseum, Munich	Adriaen de Vries	Not applicable	• 0.2	No indi-cation	No indi-cation	Square	• 0.2 × 0.2 • 0.25 × 0.25 • 0.3 × 0.3	Yes (chis-eled off at back)	No indi-cation
18	*Cain and Abel* University of Edinburgh, Torrie Collection	Adriaen de Vries	Can't tell	• 1.5 (removed rod) • 0.2 to 0.8	Yes	Yes	Square and rect-angular	• 0.2 × 0.2 • 0.4 × 0.4 • 0.35 × 0.4	Yes (0.8)	No indi-cation
19	*Juggling Man* J. Paul Getty Museum, Los Angeles	Adriaen de Vries	Square to rectangular	• Tapering 0.8 to 0.4 • 0.2 to 0.4	Possibly through top of head	Yes	Square	• 0.3 × 0.3 • 0.5 × 0.5	No	No indi-cation
20	*Farnese Bull* Schlossmuseum, Gotha	Adriaen de Vries	Square + rectangu-lar + a flat bar	Zethus: • 1.3 × 1.1 • 0.1 to 0.25 Amphion: • 0.2 to 0.3 Bull: • 0.1 to 0.3 Dirce: • ca. 1.0 • 0.1 to 0.3 Antiope: • 1.3 • ca. 1.0 Dog: • 0.2 to 0.7	Yes	Yes	Square	0.25 × 0.25	Yes (many 1.7)	No indi-cation
21	*Christ at the Column* Kunsthistorisches Museum, Vienna	Adriaen de Vries	Square or rectangular	• 0.2 to 0.4	No indi-cation	No	Cannot see any	Not appli-cable	No	No indi-cation
22	*Lazarus* Statens Museum for Kunst, Copenhagen	Adriaen de Vries	Cannot determine	• 0.1 to 0.8	Yes	No indi-cation	Square and rect-angular	• 0.2 × 0.15 • 0.3 × 0.3	Yes (2.5)	No indi-cation
23	*Putto with a Goose* Nationalmuseum, Stockholm	Adriaen de Vries	Cannot determine; most removed	• 0.3	No indi-cation	No indi-cation	Square	0.3 × 0.3	Yes	No indi-cation

Ch.	Title/Collection	Artist	Cross Section of Primary Armature/Core Supports	Rod and Wire Diameter* (cm)	Doubling as Core Pins? (exiting bronze)	Exiting, Then Reentering Wax Model?	Cross Section of Core Pins	Core Pin Diameter*	Pins Remain in Interior? (length)**	Side-to-Side Core Pins?
24	*Cain and Abel* Statens Museum for Kunst, Copenhagen	Cast by: Adriaen de Vries Surface chasing: unknown	Rectangular (large ones visible under base)	• 1.0 × 1.0 (removed rod) • 0.7 × 0.4 • 0.5 × 0.4 • 0.2 to 0.35	Yes	Yes	Square	• 0.3 × 0.3 • 0.2 × 0.2	Yes	No indication
25	*Laocoön and His Sons* Nationalmuseum, Stockholm	Adriaen de Vries	Square (one under base + hole in center)	• 2.5 × 2.5 (removed rod) • 0.2 to 0.8	No indication	Possibly	Square	0.3 × 0.3	Yes	No indication
26	*Hercules Pomarius* Muzeum hlavního města Prahy, Prague	Adriaen de Vries	Cannot determine; large support removed	• 0.2 to 0.9	No indication	Likely	Rectangular or square	Approx. 0.2 × 0.2	No	No indication
27	*Mercury* Los Angeles County Museum of Art, Los Angeles	Willem van Tetrode	All gone; cannot determine	• All removed	No indication	No indication	Cannot see any	Not applicable	No	No indication
28	*Mercury and Psyche* Huntington Art Collections, San Marino	Authorship uncertain	Round	• 0.4	No indication	No indication	Round (guessing by remaining plugs)	0.3 to 0.4	No	No indication
29	*Christ Mocked* Los Angeles County Museum of Art, Los Angeles	Authorship uncertain	All gone; cannot determine	• All removed	No indication	No indication	Round (guessing by remaining plugs)	0.3 to 0.8 (most 0.4 and 0.5)	No	No indication
30	*Hercules, Nessus, and Deianeira* Nelson-Atkins Museum of Art, Kansas City	Attributed to Charles Crozatier, after de Vries	Cannot determine (though head plugs are round)	• 0.7 (plug diameter of removed rods) • 0.2 to 0.5	Yes	No indication	Round (guessing by remaining plugs)		No	No indication
31	*Hercules, Nessus, and Deianeira* Rijksmuseum, Amsterdam	Attributed to Charles Crozatier, after de Vries	Hollow tubes: round	• 0.1 to 0.2 • Hollow tubes: 0.3 to 0.5	Yes	No indication	Round (guessing by remaining plugs)		No	No indication

Note: Shading indicates a sculpture not by de Vries.

* All measurements are in centimeters. Measurements were taken off the radiographs and therefore are approximate.

** Core pin lengths are listed only when the remaining pins appear to lie nearly parallel to the radiograph.

Repairs
General Observations from the 1999–2000 J. Paul Getty Museum Technical Study

Ch.	Title/Collection	Artist	Cast-In Bronze	Cast-In Lead	Set-In Repairs	Shape of Set-In	Threaded Round Plugs	Soldered-In Repairs	Other
7	*Psyche Borne Aloft by Putti* Nationalmuseum, Stockholm	Adriaen de Vries	Yes	Yes	Yes	Rectangular	None observed	No	Whiting, plaster, lead white, wax/resin
8	*Faun and Nymph* Staatliche Kunstsammlungen, Grünes Gewölbe, Dresden	After de Vries	None observed	None observed	Yes	All roughly geometric	None observed	Yes	
9	*Crucifix* Kirchenstiftung Mariä Verkündigung, Wullenstetten	Authorship uncertain	None observed	None observed	Yes	Round	Yes	None observed	Large repairs cast separately, then attached
10	*Venus or Nymph* Herzog Anton Ulrich-Museum, Braunschweig	Authorship uncertain	Yes	None observed	Yes	Rectangular and round	Yes	None observed	
11	*Bust of Emperor Rudolf II* Kunsthistorisches Museum, Vienna	Adriaen de Vries	Yes	None observed	Yes	Not noted	None observed	None observed	
12	*Bust of the Elector Christian II of Saxony* Skulpturensammlung, Staatliche Kunstsammlungen, Dresden	Adriaen de Vries	Yes	None observed	Yes	Oval; others likely	None observed	None observed	
13	*Hercules, Nessus, and Deianeira* Musée du Louvre, Paris	Adriaen de Vries	Yes	None observed	Yes (core pin holes only)	Rectangular	None observed	None observed	
14	*Allegory of the War against the Turks in Hungary* Kunsthistorisches Museum, Vienna	Adriaen de Vries	Yes	None observed	Unclear as no radiographs taken	Unclear as no radiographs taken	None observed	Yes (pinned + soldered)	Repair cast separately, pinned and soldered
15	*Rearing Horse* J. Paul Getty Museum, Los Angeles	Adriaen de Vries	Yes	None observed	Yes	Oval and rectangular	None observed	None observed	Wax or resin and white paste
16	*Horse* Národní Galerie v Praze, Prague	Adriaen de Vries	None observed	None observed	Yes	Rectangular	None observed	None observed	

Ch.	Title/Collection	Artist	Cast-In Bronze	Cast-In Lead	Set-In Repairs	Shape of Set-In Plugs	Threaded Round Plugs	Soldered-In Repairs	Other
17	*Vulcan's Forge* Bayerisches National-museum, Munich	Adriaen de Vries	None observed	None observed	Yes	Rectangular	None observed	None observed	
18	*Cain and Abel* University of Edin-burgh, Torrie Collection	Adriaen de Vries	Yes	None observed	Yes	Rectangular	None observed	None observed	
19	*Juggling Man* J. Paul Getty Museum, Los Angeles	Adriaen de Vries	Possibly	None observed	Yes	Round	None observed	None observed	Large Cu alloy repair top of head
20	*Farnese Bull* Schlossmuseum, Gotha	Adriaen de Vries	None visible	None observed	Yes	Round (Bull's belly), oval, irregu-lar, and rectangular	None observed	None observed	
21	*Christ at the Column* Kunsthistorisches Museum, Vienna	Adriaen de Vries	Yes	None observed	Yes	Square/ rectangular	None observed	Yes (holding together rope breaks)	
22	*Lazarus* Statens Museum for Kunst, Copenhagen	Adriaen de Vries	Yes	Yes	Yes	Square/ rectangular	None observed	None observed	
23	*Putto with a Goose* Nationalmuseum, Stockholm	Adriaen de Vries	None observed	Large flaws filled with lead	Yes	Square/ rectangular	None observed	None observed	
24	*Cain and Abel* Statens Museum for Kunst, Copenhagen	Cast by Adriaen de Vries Surface chasing: unknown	None observed	Yes	Yes	Round	Threaded plugs sol-dered in	Threaded plugs sol-dered in	
25	*Laocoön and His Sons* Nationalmuseum, Stockholm	Adriaen de Vries	Yes	None observed	Yes	Rectan-gular, assorted roughly geometric shapes (likely newer repairs)	None observed	Yes (possibly different genera-tions)	
26	*Hercules Pomarius* Muzeum hlavního města Prahy, Prague	Adriaen de Vries	Yes	None observed	Yes	Rectangular	None observed	None observed	White pastelike
27	*Mercury* Los Angeles County Museum of Art, Los Angeles	Willem van Tetrode	None observed	None observed	None observed	Not applicable	None observed	Yes	

Ch.	Title/Collection	Artist	Cast-In Bronze	Cast-In Lead	Set-In Repairs	Shape of Set-In Plugs	Threaded Round Plugs	Soldered-In Repairs	Other
28	*Mercury and Psyche* Huntington Art Collections, San Marino	Authorship uncertain	None observed	Yes	Yes	Rectangular	Yes	None observed	
29	*Christ Mocked* Los Angeles County Museum of Art, Los Angeles	Authorship uncertain	None observed	None observed	Yes	Oval + assorted	Yes	Yes (base only)	
30	*Hercules, Nessus, and Deianeira* Nelson-Atkins Museum of Art, Kansas City	Attributed to Charles Crozatier, after de Vries	None observed	None observed	Yes	Round	Yes	None observed	
31	*Hercules, Nessus, and Deianeira* Rijksmuseum, Amsterdam	Attributed to Charles Crozatier, after de Vries	None observed	None observed	Yes	Round	Yes	None observed	

Note: Shading indicates a sculpture not by de Vries.

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APPENDIX C

Signatures

Chapter	Title/Collection	Inscribed in Wax/Metal	Guiding Lines?	Inscription	Text illustration
11	*Bust of Emperor Rudolf II* Kunsthistorisches Museum, Vienna	Wax	No	ADRIANVS FRIES HAGIEN FECIT 1603	Figs. 11.14, 11.15
12	*Bust of the Elector Christian II of Saxony* Skulpturensammlung, Staatliche Kunstsammlungen, Dresden	Wax	Yes	ADRIANVS FRIES HAGENSIS FECIT 1603	Fig. 12.9
14	*Allegory of the War against the Turks in Hungary* Kunsthistorisches Museum, Vienna	Wax	Yes	ADRIANVS.FRIES.HAGENSIS.FECIT	Fig. 14.8
15	*Rearing Horse* J. Paul Getty Museum, Los Angeles	Wax	No	ADRIANVS FRIES HAGENSIS FECIT	Figs. 15.8, 15.9
16	*Horse* Národní Galerie v Praze, Prague	Wax	No	ADRIANVS FRIES HAGIENSIS FECIT 1610	Figs. 16.9, 16.10
17	*Vulcan's Forge* Bayerisches National-museum, Munich	Wax	No	ADRIANVS FRIES HAGIENSIS BATAVVS. F. 1611	Figs. 17.17, 17.18
18	*Cain and Abel* University of Edinburgh, Torrie Collection	Wax	Unclear	ADRIANVS FRIES HAGIENSIS BA[T]VVS F. 1612	Figs. 18.10, 18.11
20	*Farnese Bull* Schlossmuseum, Gotha	Wax	No	ADRIANVS FRIES HAGIENSIS BATAVVS.FE.1614	Figs. 20.16, 20.17
22	*Lazarus* Statens Museum for Kunst, Copenhagen	Wax	Yes	ADRIANVS FRIES HAGIENSIS BATAVVS FECIT. 1615	Fig. 22.7
24	*Cain and Abel* Statens Museum for Kunst, Copenhagen	Metal	No	ADRIANVS FRIES HAGIENSIS BATAVS•FECIT 1622	Figs. 24.11, 24.12, 24.13, 24.14
25	*Laocoön and His Sons* Nationalmuseum, Stockholm	Wax?	Yes	ADRIANVS FRIES HAGIENSIS BATTAVVS FE. 1623	Fig. 25.14

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ILLUSTRATION CREDITS

Chapter 2
Figs. 2.1–2.19: Drawings by Jane Bassett.

Chapter 3
Fig. 3.1: *Psyche Borne Aloft by Putti*, Nationalmuseum, Stockholm. Inv. no. NM Sk 352. Photograph by Jane Bassett.

Chapter 4
Fig. 4.1: *Farnese Bull*, Schlossmuseum, Gotha Inv. no. P 50. Photograph by Jane Bassett.

Chapter 5
Figs. 5.1–5.7: Ronald C. Schmidtling II.

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Figs. 9.1, 9.2: Katholische Pfarrkirchenstiftung Mariuä Verkündigung, Wullenstetten. Figs. 9.3–9.5: Photographs by Jane Bassett, published with the permission of the Katholische Pfarrkirchenstiftung Mariuä Verkündigung, Wullenstetten, Germany.

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Figs. 10.1, 10.2: Herzog Anton Ulrich-Museums Braunschweig, Kunstmuseum des Landes Niedersachsen. Figs. 10.3–10.5: Photographs by Jane Bassett, published with the permission of the Herzog Anton Ulrich-Museums Braunschweig, Kunstmuseum des Landes Niedersachsen.

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Chapter 20
Figs. 20.1, 20.2, 20.3: Courtesy Schlossmuseum Gotha. Figs. 20.4–20.17: Photographs by Jane Bassett, published with the permission of the Schlossmuseum Gotha.

Chapter 21
Figs. 21.1, 21.2: Kunsthistorisches Museum, Vienna. Figs. 21.3–21.9: Photographs by Jane Bassett, published with the permission of the Kunsthistorisches Museum, Vienna.

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Figs. 31.1, 31.2: Courtesy Rijksmuseum, Amsterdam. Figs. 31.3–31.8: Photographs by Jane Bassett, published with the permission of the Rijksmuseum, Amsterdam.

Chapter 32: Conclusion

Fig. 32.1: Bayerisches Nationalmuseum München. Fig. 32.2: © Paolo Polidori/Ikona 7331. Fig. 32.3: © Patrimonio Nacional.

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Figs. A.1, A.2, A.4, A.5, A.16, A.30: © J. Paul Getty Museum, Los Angeles. Photographs by Lou Meluso.The following photographs by Jane Bassett, published with permission: Figs. A.3, A.20, A.26, A.27: *Faun and Nymph,* Staatliche Kunstsammlungen, Grünes Gewölbe, Dresden, Inv. no. IX 36. Figs. A.6, A.7: *Farnese Bull,* Schlossmuseum, Gotha, Inv. no. P 50. Figs. A.8, A.17: *Hercules, Nessus, and Deianeira,* Musée du Louvre, Paris, Département des Objets d'Art. Inv. no. OA 5424. Fig. A.9: *Cain and Abel,* University of Edinburgh, Torrie Collection. Inv. no. 49. Fig. A.10: Johan Pettersson Foundry, Stockholm, Sweden. Fig. A.12: *Mercury,* Willem van Tetrode, Los Angeles County Museum of Art. Inv. no. TR.10706.1.1. Figs. A.13, A.15: *Mercury and Psyche,* Huntington Art Collections, San Marino, California. Inv. no. 17.28. Figs. A.18, A.22: *Christ at the Column,* Kunsthistorisches Museum, Vienna. Inv. no. Pl 8908. Figs. A.19, A.29, A.31: *Hercules Pomarius,* City of Prague Museum. Inv. no. VP 400. Figs. A.11, A.21, A.23: Drawings by Jane Bassett. Figs. A.24, A.32: *Horse,* National Gallery, Prague. Inv. no. P 4605. Fig. 25: *Laocoön and His Sons,* Nationalmuseum, Stockholm. Inv. no. Drh Sk 68. Fig. A.28: *Venus* or *Nymph,* Herzog Anton Ulrich-Museum, Braunschweig, Germany. Inv. no. Bro 93.

INDEX

Note: *Italic* page numbers indicate illustrations. **Bold** page numbers indicate main discussions.

Aachen, Hans von, 113
Abel. *See Cain and Abel*
Adriaen de Vries, 1556–1626 (2000 exhibition), 7
Adriaen de Vries: Imperial Sculptor (1999 exhibition), vii, xi, 4–5
aegerine, in cores, 40
Aeneus, 135
aftercasts
Cain and Abel (Copenhagen) as, 147
definition of, 273
Faun and Nymph as, 63, 70, 7–7
fins in, 267
of *Hercules, Nessus, and Deianeira* (Louvre), 239, 244–49
Venus or *Nymph* as, 81
air bubbles, in *Christ Mocked,* 234
Aitken, M. J., 49n8
albite, in cores
polarized light microscopy of, 40, 41, *41*
X-ray diffraction of, 42, *42*
allegory, *Juggling Man* as, xiii–xiv
Allegory of the War against the Turks in Hungary (de Vries), *112,* **113–17**
alloy composition of, *28–29,* 113
armature and core supports in, 113
casting method for, 115, 117, 264, 267
core analysis of, 38, 114
core pins in, 113–14, *114,* 266
defects and repairs in, 116, 117, 271
external surface of, 93, 95, *115,* 115–16, *116,* 268
internal surface of, 114–15
patina of, 117, 270
thermoluminescence dating of, 48, 114
X-ray radiography on, lack of, 5
alloy(s), definition of, 273
alloy analysis, 21–26
of *Allegory of the War against the Turks in Hungary, 28–29,* 113
in authentication, 21, 24
of *Bust of Emperor Rudolf II, 28,* 89
of *Bust of the Elector Christian II of Saxony, 28,* 97
of *Cain and Abel* (Copenhagen), *30,* 187
of *Cain and Abel* (Edinburgh), 25, *29–30,* 141
of *Christ at the Column, 30,* 169
of *Christ Mocked,* 26, *32,* 231, 236
of *Crucifix,* 26, *27,* 69, 73
in examination methodology, 4, 5
of *Farnese Bull,* 25, *30,* 159–60
of *Faun and Nymph,* 26, *27,* 63–64, 69
goal of, 21
of *Hercules, Nessus, and Deianeira* (Louvre), *28,* 104
of *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 26, *32–33,* 239
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), 26, *33,* 251
of *Hercules Pomarius, 31–32,* 207
of *Horse, 29,* 127, 132
of *Juggling Man, 30,* 151
of *Laocoön and His Sons,* 25, *30,* 159, 197–98
of *Lazarus,* 24–25, *25, 30,* 175
of *Mercury* (Tetrode), 26, *32,* 215–16, 220
of *Mercury and Psyche,* 24, 26, *32,* 223, 228
of *Psyche Borne Aloft by Putti,* 24, *25, 27,* 53–54
of *Putto with a Goose,* 25, *30–31,* 159, *181,* 181–82
of *Rearing Horse, 29,* 119, 132
of *Venus* or *Nymph,* 26, *27,* 81
of *Vulcan's Forge, 29,* 135
with X-ray fluorescence, 5, 21–26
alloy composition
analysis of (*See* alloy analysis)
of de Vries, xii, xiv*n*4, 21, 23, *24*
of Gerhard, 23, *24,* 228, 229n1
of Giambologna, 23, *24*
of Gras, 228, 229n2
histograms of, 24–25, *25*
impurities in, 21
alpha phase, 26n7
Amphion, in *Farnese Bull,* 159, 161, *161*
Amsterdam, Rijksmuseum in, xi, 4, 220–21, 251
ancient sculptures
core analysis of, 36
de Vries's reinterpretation of, xiv
technical examination of, 3
thermoluminescence dating of, 45
animals. *See specific types*
annual dose, 45
Antico, 3, 4
Antiope, in *Farnese Bull,* 159, *162,* 162–63
Aphrodite (Getty), 36
Apollo (de Vries)
casting method for, 69, 77, 267
core supports in, 266
external surface of, 70
Giambologna's influence on, 261
production of, xiii
armature, 265
in *Allegory of the War against the Turks in Hungary,* 113
in *Bust of Emperor Rudolf II, 89,* 90, *90, 91,* 101
in *Bust of the Elector Christian II of Saxony, 97,* 97–98, *98,* 101
in *Cain and Abel* (Copenhagen), 187–88, *188, 189*
in *Cain and Abel* (Edinburgh), 142, *142, 143, 144, 145, 146*
in *Christ at the Column,* 169–70, *170*
in *Christ Mocked,* 232
conclusions about use of, 262, 265
vs. core supports, 266, 276
in *Crucifix,* 74
definition of, 273
in design process, 262
in *Farnese Bull, 160,* 160–64, *161, 162, 163, 164,* 167, 265
in *Faun and Nymph,* 64–65
functions of, 265
in *Hercules, Nessus, and Deianeira* (Louvre), *104,* 104–5, *105*
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 239, *240*
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 251–52, *252, 253*
in *Hercules Pomarius,* 207–8, *208, 209*
in *Horse,* 127–28, *128*
in *Juggling Man, 151,* 151–52, *152, 153,* 265, *273*
in *Laocoön and His Sons,* 198–99, *199, 200,* 265
of *Lazarus, 175,* 175–76, *176*

in *Mercury* (Tetrode), 216
in *Mercury and Psyche,* 224
in *Psyche Borne Aloft by Putti,* *54,* 54–55, *55,* 265
in *Putto with a Goose,* 182, *182*
in *Rearing Horse,* 119–20, *120*
summary chart of, *291–93*
in *Venus* or *Nymph,* 81–83, *82, 83,* 85
armor
in *Bust of Emperor Rudolf II,* 92
in *Bust of the Elector Christian II of Saxony,* 99, *99,* 100
Arsenal foundry (Prague), xiii
Art and Technology: A Symposium on Classical Bronzes, 3
art history, materials and techniques in, xiv, 3
assembly methods. *See* casting methods; *specific types of joins*
assistants, workshop, 194–95, 267, 269
Atalanta fugiens (Maier), xiv*n*7
attribution(s). *See also* authentication
alloy analysis in, 26
of *Cain and Abel* (Copenhagen), 147
challenges of, 3
of *Christ Mocked,* 231, 236–37
of *Crucifix,* 5, 69, 73, 77–78
of *Faun and Nymph,* 5, 63, 69–70
of *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 249
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), 48, 249, 251
of *Mercury and Psyche,* 26, 223, 228–29
technical examination in, 3, 5
thermoluminescence dating in, 48
of *Venus* or *Nymph,* 5, 69, 86
auctions, xi, 151
Augsburg
de Vries in, xii–xiii, 262
Hercules fountain in, 81, 137, 269, 270
Städtischen Kunstsammlungen in, 7
authentication. *See also* attribution
alloy analysis in, 21, 24
core analysis in, 35
technical examination in, 3, 5
thermoluminescence dating in, 46, 49
Avery, C., 262

Baker, Malcolm, xiv
Bandinelli, Baccio, xiv
Bargello, 215
Barkan, Leonard, xiii
Bassett, Jane, xi
Bayerisches Nationalmuseum (Munich), 135
bellows, in *Juggling Man,* 151–53, 156
Berger, U., 81
Bernini, Gianlorenzo, 262
Bewer, Francesca, xi, xiv*n*4, 4, 9n6, 25, 35, 36, 77–78, 119, 124, 151, 205, 259, 262, 263, 270
bibliography, 299–303
biotite mica, in cores, 43
bird(s)
in *Christ at the Column,* 172, 173, *173*
in *Putto with a Goose,* 181–85
Biringuccio, Vannoccio, 3, 42, 86n3, 237n3
borescopes, 17
brass
definition of, 9n1, 21, 274
in *Mercury and Psyche,* 228
in repairs, 272
Braunschweig, 81
bronze
color of, 21
definition of, 9n1, 21, 274
vs. marble, xi, xii, xiii
properties of, 21
use of term, 9n1, 21
Les Bronzes de la Couronne (exhibition), 103
bubbles, in *Christ Mocked,* 234
bull, in *Farnese Bull,* 159, 161–62
Bust of Emperor Rudolf II (de Vries), *88,* **89–95**
alloy composition of, *28,* 89
armature and core supports in, *89,* 90, *90, 91,* 101
casting method for, 91, 101
core analysis of, 91
core pins in, 91
defects and repairs in, 93–94, *95*
external surface of, 91–93, *92, 93,* 117, 268
internal surface of, 91, 267
patina of, 93, 270
thermoluminescence dating of, 91
Vulcan's Forge compared to, 137
X-ray radiography of, 18
Bust of the Elector Christian II of Saxony (de Vries), *96,* **97–101**
alloy composition of, *28,* 97
armature and core supports in, *97,* 97–98, *98,* 101
casting method for, 99
core analysis of, *37,* 38, *38,* 42, 44, 98
core pins in, 98
defects and repairs in, 101, 271
external surface of, *99,* 99–100, *100, 101*
internal surface of, *98,* 98–99
patina of, 100
thermoluminescence dating of, 98
butt joins, in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 255

cache-sexe
in *Hercules, Nessus, and Deianeira* aftercasts, 247
in *Hercules Pomarius,* 207, 209
in *Juggling Man,* 155
in *Laocoön and His Sons,* 203, *203,* 205
Cain and Abel (de Vries, Copenhagen), *186,* **187–95**
alloy composition of, *30,* 187
armature and core supports in, 187–88, *188, 189,* 266
attribution of, 147
casting method for, 148, 190, 193, 194, 195
core analysis of, 37, 189–90
core pins in, 188
after death of de Vries, 194–95, 272
defects and repairs in, 70, 188, 193–95, 272
Edinburgh version compared to, 141, 147–49, *148,* 187, 193–95
external surface of, 190–91, *192, 193*
internal surface of, 190
modifications and restorations to, 193
patina of, 191–93, *192,* 195, 270–71
thermoluminescence dating of, 45–46, 48, 190
Cain and Abel (de Vries, Edinburgh), *140,* **141–49**
alloy composition of, 25, *29–30,* 141
armature and core supports in, 142, *142, 143, 144, 145, 146,* 266
casting method for, 142, 144–48, 194, 195
Copenhagen version compared to, 141, 147–49, *148,* 187, 193–95
core analysis of, 143–44
core pins in, 143
defects and repairs in, 146–47

external surface of, 146, *146, 147*
internal surface of, 144–45
modifications and restorations to, 147
patina of, 146
replication of, xiii, 141
thermoluminescence dating of, 45–46, 144
calcite, in cores
of *Juggling Man,* 153
polarized light microscopy of, 40, *41*
X-ray diffraction of, 42, *42*
calcium carbonate, in cores, 37–38
calcium sulfate, in cores, 37–38
calipers, 6
carbon, in cores, 36
carbonates, in cores, 37–38, 39
career path, of de Vries, xii–xiii, 260–61
Caritas (Giambologna), *260,* 272n3
case studies, in examination methodology, 4
Castaing, J., 45, 49n2
cast-in metal joins
definition of, 278, *278, 279*
in *Mercury* (Tetrode), 217, *218, 278*
cast-in repairs
to *Allegory of the War against the Turks in Hungary,* 117
to *Bust of Emperor Rudolf II,* 94
to *Bust of the Elector Christian II of Saxony,* 101
to *Cain and Abel* (Copenhagen), 193, 194
to *Cain and Abel* (Edinburgh), 147
to *Christ at the Column,* 173
conclusions about, 271
definition of, 282, *282, 283*
to *Hercules Pomarius,* 212
to *Juggling Man,* 155
to *Laocoön and His Sons,* 204–5
to *Lazarus,* 179
to *Psyche Borne Aloft by Putti,* 55, *56*
to *Venus* or *Nymph,* 85
casting cores. *See* core(s)
casting defects. *See* defects
casting methods, 11–15, 267–68. *See also* direct lost wax casting; indirect lost wax casting; sand casting
for *Allegory of the War against the Turks in Hungary,* 115, 117, 264, 267
in authentication, 3
for *Bust of Emperor Rudolf II,* 91, 101
for *Bust of the Elector Christian II of Saxony,* 99
for *Cain and Abel* (Copenhagen), 148, 190, 193, 194, 195
for *Cain and Abel* (Edinburgh), 142, 144–48, 194, 195
for *Christ at the Column,* 171, *171*
for *Christ Mocked,* 231, *231,* 232, 233, 234, 236, 237
conclusions about, 267–68
core analysis revealing, 35
for *Crucifix,* 75, 77, 86n5
de Vries's participation in, xiii, 270
de Vries's use of, xi–xii, 7–8, 267–68
for *Farnese Bull,* 165, 167
for *Faun and Nymph,* 65, 66–67, 69
Gras's use of, 229
for *Hercules, Nessus, and Deianeira* (Louvre), xii, 107–8, 111, 246
for *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 8, 15, 240–44, 246–48
for *Hercules, Nessus, and Deianeira* (Rijksmuseum), 8, 15, 246–48, 252–56
for *Hercules Pomarius,* 209
history of, 11
for *Horse,* 129–30, 132
for *Juggling Man,* 154
for *Laocoön and His Sons,* 201, 205
for *Lazarus,* 177, 179
for *Mercury* (Tetrode), 216, 217, 220–21
for *Mercury and Psyche,* 224–27, *227,* 228, 229
for *Psyche Borne Aloft by Putti,* 58, 263
for *Putto with a Goose,* 183, 185
for *Rearing Horse,* xiii, 120–21, 124, 132
reasons for preference in, xii–xiii, 263–65
size of sculpture and, xii, 263–64, *264*
for *Venus* or *Nymph,* 81, 82–83, 84, 85–86
for *Vulcan's Forge,* 137
X-ray radiography and, 19
casting models
definition of, 11, 274
in lost wax casting, 11–13, *12, 13, 14*
casting quality, X-ray radiography revealing, 19–20
Cellini, Benvenuto, xi, xiii, xiv, 3, 73, 260, 272n8
Cennini, Cennino, 3
ceramics
petrographic analysis of, 35
thermoluminescence dating of, 46
Chabrières-Arles family, 223
chaplets. *See* core pin(s)
chasing, 268–69
in *Allegory of the War against the Turks in Hungary,* 115–16
in *Bust of Emperor Rudolf II,* 91–93
in *Bust of the Elector Christian II of Saxony,* 99–100
in *Cain and Abel* (Copenhagen), 190–91, 194–95
in *Cain and Abel* (Edinburgh), 146
in *Christ at the Column,* 171–72
in *Christ Mocked,* 234–35
conclusions about, 268–69
in *Crucifix,* 75–76
de Vries's participation in, 269
definition of, 274, *274*
in *Farnese Bull,* 165–66
in *Faun and Nymph,* 67–68
in *Hercules, Nessus, and Deianeira* (Louvre), 108–10
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 256
in *Hercules Pomarius,* 209–11
in *Horse,* 130
in *Juggling Man,* 154
in *Laocoön and His Sons,* 201–3
in *Lazarus,* 177–78
in *Mercury* (Tetrode), 218–19
in *Mercury and Psyche,* 227
in *Psyche Borne Aloft by Putti,* 58
in *Putto with a Goose,* 183–84
in *Rearing Horse,* 122
in *Venus* or *Nymph,* 84–85
in *Vulcan's Forge,* 137–38
chemical patination, 270
Chlumec nad Cidlinou (Czech Republic), 195n3
Christ at the Column (de Vries), *168,* **169–73**
alloy composition of, *30,* 169
armature and core supports in, 169–70, *170*
casting method for, 171, *171*
core analysis of, 171
core pins in, 170
defects and repairs in, 172–73, *173*
design process for, 262

external surface of, 171–72, *172*, 185
internal surface of, 171, 267
patina of, 172
thermoluminescence dating of, 171
Christ at the Column (Tetrode), 221
Christ in Distress (de Vries), 231, 237
Christ Mocked (uncertain authorship), *230*, **231–37**
alloy composition of, 26, *32*, 231, 236
armature and core supports in, 232
attribution of, 231, 236–37
casting method for, 231, *231*, 232, 233, 234, 236, 237
core analysis of, 38, 39, 43, 44, 232, 237
core pins in, 232
defects and repairs in, 235–36, 237
external surface of, *234*, 234–35
internal surface of, 232–34, *233*
modifications and restorations to, 236
patina of, 235
thermoluminescence dating of, 232
Christian II (elector of Saxony). *See Bust of the Elector Christian II of Saxony*
Christian IV (king of Denmark and Norway), 175, 181, 187, 195, 263
Christina of Sweden (queen), 53, 113, 119, 141
cire perdue. See lost wax casting
clay, in cores, 35, 43–44
color of, 43
of *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 240–41, 248
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), 248, 252
microchemical analysis of, 37
polarized light microscopy of, 38–40
from Prague, 43, 44
thermoluminescence dating of, 45
visual analysis of, 36, *37*
clay models, in design process, 262
Cleveland Museum of Art, 3
cloth
in *Bust of Emperor Rudolf II*, 92, *93*
in *Bust of the Elector Christian II of Saxony*, 100
in *Christ Mocked*, 235, *235*
de Vries's approach to, 269
in *Hercules, Nessus, and Deianeira* (Louvre), 110, *110*
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), *246*
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), *246*
cockerel, in *Christ at the Column*, 172, 173, *173*
cold shut
definition of, 274
in *Laocoön and His Sons*, 204, *204*, 205, 271, 274
cold work. *See also* chasing
on *Allegory of the War against the Turks in Hungary*, 116, *117*
on *Cain and Abel* (Copenhagen), 193–94
definition of, 274, *274*
on *Laocoön and His Sons*, 203
on *Psyche Borne Aloft by Putti*, 58, *58*
with tin alloys, 25
on *Vulcan's Forge*, 137
Cole, Michael, xiii
color
in alloy analysis, 21
in core analysis, 36, *37*, 43
commissions
and casting methods, xii, 263
by Christian IV, 175, 181, 263
history of, xii–xiii
by Rudolf II, 53, 89, 97, 113, 127, 141, 194, 263
by Waldstein, 197, 263
compositions, in design process, xii, 262–63
Considine, Brian, 9n5
consistency, xi–xii, 261, 272
Copenhagen
Kunstakademie in, 187
Statens Museum for Kunst in, 141, 175, 187
copper alloys
composition of, 21
properties of, 21
use of term, 274
copper oxide, on *Horse*, 131, *131*
core(s)
composition of (*See* core analysis)
definition of, 275, *275*
functions of, 275
thermoluminescence dating of, 45–49
core analysis, 35–44
of *Allegory of the War against the Turks in Hungary*, 38, 114
in authentication, 35
of *Bust of Emperor Rudolf II*, 91
of *Bust of the Elector Christian II of Saxony*, *37*, 38, *38*, 42, 44, 98
of *Cain and Abel* (Copenhagen), 37, 189–90
of *Cain and Abel* (Edinburgh), 143–44
of *Christ at the Column*, 171
of *Christ Mocked*, 38, 39, 43, 44, 232, 237
color in, 36, *37*, 43
of *Crucifix*, 75
in examination methodology, 4, 5
of *Farnese Bull*, 36, 43, 164–65
of *Faun and Nymph*, 38, 39, 43, 44, 65
goal of, 35
of *Hercules, Nessus, and Deianeira* (Louvre), 38, 44, 106–7
of *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 37–39, 43, 44, 239–41, *243*, 248
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), 36–39, *37*, *38*, 42–44, 248, 252, *255*
of *Hercules Pomarius*, *37*, 38, 42, 44, 209
history of, 35–36
of *Horse*, 128–29, *129*
of *Juggling Man*, 39, 152–53
of *Laocoön and His Sons*, 37, 38, 42, 44, 200
of *Lazarus*, 176–77
of *Mercury* (Tetrode), 38, 39, 43, 44, *216*, 216–17
of *Mercury and Psyche*, 224
of *Psyche Borne Aloft by Putti*, 38, 42, 44, *56*, 56–57, *57*
of *Putto with a Goose*, 182, *183*
of *Rearing Horse*, 120
statistical analysis of results of, 42–43, *44*
techniques of, 18, 36–43, *37*
of *Venus* or *Nymph*, *37*, 37–39, *38*, 42–44, 82–84, *84*, 86
of *Vulcan's Forge*, 136–37
core pin(s), 266
in *Allegory of the War against the Turks in Hungary*, 113–14, *114*, 266
in *Bust of Emperor Rudolf II*, 91
in *Bust of the Elector Christian II of Saxony*, 98
in *Cain and Abel* (Copenhagen), 188
in *Cain and Abel* (Edinburgh), 143
in *Christ at the Column*, 170
in *Christ Mocked*, 232
conclusions about use of, 266, 271
in *Crucifix*, 74, *75*, 77

definition of, 275, *275*
in *Farnese Bull,* 164, *164,* 166–67
in *Faun and Nymph,* 65
in *Hercules, Nessus, and Deianeira* (Louvre), 105
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 239, *241, 242*
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 252, *254*
in *Hercules Pomarius,* 209
in *Horse,* 128
in *Juggling Man,* 152
in *Laocoön and His Sons,* 200, *200*
in *Lazarus,* 176, *177*
in *Mercury* (Tetrode), 216
in *Mercury and Psyche,* 224
in *Psyche Borne Aloft by Putti,* 55–56, 266
in *Putto with a Goose,* 182
in *Rearing Horse,* 120
side-to-side, 77, 276
summary chart of, *291–93*
in *Venus* or *Nymph,* 82
in *Vulcan's Forge,* 135–36, *136*
core pin holes, 266
in *Allegory of the War against the Turks in Hungary,* 114, *114,* 266
in *Bust of Emperor Rudolf II,* 91
in *Bust of the Elector Christian II of Saxony,* 98
in *Cain and Abel* (Copenhagen), 188
in *Cain and Abel* (Edinburgh), 143
in *Christ at the Column,* 170
in *Christ Mocked,* 232
definition of, 276, *276*
in *Farnese Bull,* 164
in *Faun and Nymph,* 65
in *Hercules Pomarius,* 209
in *Horse,* 128, 131–32
in *Juggling Man,* 152
in *Laocoön and His Sons,* 200
in *Lazarus,* 176, *177,* 179
in *Mercury and Psyche,* 224
in *Psyche Borne Aloft by Putti,* 55, *56,* 59, 266
in *Putto with a Goose,* 184–85
in *Vulcan's Forge,* 136
core supports, 266
in *Allegory of the War against the Turks in Hungary,* 113
vs. armature, 266, 276
in *Bust of Emperor Rudolf II, 89,* 90, *90*
in *Bust of the Elector Christian II of Saxony, 97,* 97–98, *98*
in *Cain and Abel* (Copenhagen), 187–88, *188, 189,* 266
in *Cain and Abel* (Edinburgh), 142, *142, 143, 144, 145, 146,* 266
in *Christ at the Column,* 169–70, *170*
in *Christ Mocked,* 232
conclusions about use of, 262, 266
in *Crucifix, 73,* 74
definition of, 276, *276*
in design process, 262
in *Farnese Bull, 160,* 160–64, *161, 162, 163, 164,* 167, 198
in *Faun and Nymph, 64,* 64–65
functions of, 266
in *Hercules, Nessus, and Deianeira* (Louvre), *104,* 104–5, *105,* 266
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 239, *240*
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 251–52, *252, 253*
in *Hercules Pomarius,* 207–8, *208, 209*
in *Horse,* 127–28, *128*
in *Juggling Man, 151,* 151–52, *152, 153*
in *Laocoön and His Sons,* 198–99, *199, 200*
of *Lazarus, 175,* 175–76, *176*
in *Mercury* (Tetrode), 216
in *Mercury and Psyche,* 224
in *Psyche Borne Aloft by Putti,* 54–55
in *Putto with a Goose,* 182, *182*
in *Rearing Horse,* 119–20, *120*
summary chart of, *291–93*
in *Venus* or *Nymph,* 81–82, *82, 83,* 85
in *Vulcan's Forge,* 135, *136*
corrosion, 271
on *Cain and Abel* (Copenhagen), 193
on *Cain and Abel* (Edinburgh), 145
on *Farnese Bull,* 159
on *Hercules Pomarius,* 211
on *Juggling Man,* 156, 265
on *Laocoön and His Sons,* 204, 205, 271
on *Putto with a Goose,* 181, *181,* 182, 184, 185, 185n1, 271
X-ray radiography and, 20
cross, in *Crucifix,* 77
Crozatier, Charles, 239, 251. *See also Hercules, Nessus, and Deianeira*
Crucifix (Cellini), 73
Crucifix (Giambologna), 73, 78
Crucifix (uncertain authorship), *72,* **73–78**
alloy composition of, 26, *27,* 69, 73
armature and core supports in, *73,* 74
attribution of, 5, 69, 73, 77–78
casting method for, 75, 77, 86n5
core analysis of, 75
core pins in, 74, *75*
defects and repairs in, 76, 271
external surface of, 75–76, *76*
internal surface of, *74,* 75
modifications and restorations to, 77
patina of, 76

Dancing Faun, xiv
dating, with optically stimulated luminescence, 49. *See also* thermoluminescence dating
David Daniels Collection, 231
de Bari, C., 36, 41–42
de Vries, Adriaen. *See also specific works*
artistic personality of, xi, 259
career path of, xii–xiii, 260–61
consistency of, xi–xii, 261, 272
death of, 194–95, 272
design process of, xii, 262–63
reputation of, xi, xiv
technical influences on, 260–61
working techniques of, 261–72
defects, 271
in *Allegory of the War against the Turks in Hungary,* 117
in *Bust of Emperor Rudolf II,* 93–94, *95*
in *Bust of the Elector Christian II of Saxony,* 101
in *Cain and Abel* (Copenhagen), 193
in *Cain and Abel* (Edinburgh), 146–47
in *Christ at the Column,* 172–73, *173*
in *Christ Mocked,* 235–36
conclusions about, 271
in *Crucifix,* 76, 78, 271
in *Farnese Bull,* 165, 166–67
in *Faun and Nymph,* 68–69
in *Hercules, Nessus, and Deianeira* (Louvre), 110
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244

in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 256
in *Hercules Pomarius,* 212
in *Horse,* 131–32
in *Juggling Man,* 154–56, *155*
in *Laocoön and His Sons, 204,* 204–5, 271
in *Lazarus,* 179
in *Mercury* (Tetrode), 219–20, 221
in *Mercury and Psyche,* 224, 228
in *Psyche Borne Aloft by Putti,* 59
in *Putto with a Goose,* 184–85
in *Rearing Horse,* 123–24
in *Venus* or *Nymph,* 85
in *Vulcan's Forge,* 138
X-ray radiography revealing, 19–20
Deianeira. *See Hercules, Nessus, and Deianeira*
delta phase, 26n8
design process, xii, 262–63
Detroit Institute of the Arts, 228
Diemer, D., 78, 228, 229, 269
dimensions, in examination methodology, 6, 9n16
Dirce, in *Farnese Bull,* 159, 162, *162*
direct lost wax casting, 263–65
armature in, 265
of *Bust of the Elector Christian II of Saxony,* 99
of *Christ at the Column,* 171
de Vries's use of, xii–xiii, 263–65
definition of, 278
design process for, 262
distinctive features of, 19
of *Farnese Bull,* 165, 167
Giambologna's use of, 261
as heroic, xiii
internal surface with, 267
of *Lazarus,* 177, 179
of *Psyche Borne Aloft by Putti,* 58, 263
of *Putto with a Goose,* 183, 185
of *Rearing Horse,* 124
reasons for using, xii–xiii, 263–65
of reliefs, 115
risks of, xii
technique of, 11, *12*
of *Theseus and Antiope,* xii
X-ray radiography and, 19
divine artistry, xiii
dog(s)
in *Farnese Bull,* 159, *163,* 163–64
in *Lazarus,* 176, *176,* 177
dragon, in *Allegory of the War against the Turks in Hungary,* 116, *116*
drawings, in design process, 262
Dresden
Grünes Gewölbe in, 63, 70
Skulpturensammlung in, 70, 97
drilling, in alloy analysis, 25
drips
in *Allegory of the War against the Turks in Hungary,* 115
in *Cain and Abel* (Copenhagen), 190
in *Christ Mocked,* 233
in *Crucifix,* 74, 75, 77
in *Faun and Nymph,* 65
in *Hercules, Nessus, and Deianeira* (Louvre), 107
in *Mercury and Psyche,* 224
in *Rearing Horse,* 120
Drottningholm Palace, 181, 197, 269, 271
Duveen Brothers, 223

eagle, in *Bust of Emperor Rudolf II,* 89, 92, 93
Écorché (Tetrode), 221
editions. *See* replicas
El Brujo, 36
elements, in alloys, 21
Empire Triumphant over Avarice (de Vries), 157, 262, 272n13
energy
in optically stimulated luminescence, 49
in thermoluminescence dating, 45
environmental dose, 45
examination. *See* technical examination
exhibitions
Adriaen de Vries, 1556–1626 (2000), 7
Adriaen de Vries: Imperial Sculptor (1999), vii, xi, 4–5
Les Bronzes de la Couronne, 103
technical examinations at, vii, xi, 4–5
external surface, 268–70
of *Allegory of the War against the Turks in Hungary,* 93, 95, *115,* 115–16, *116,* 268
of *Bust of Emperor Rudolf II,* 91–93, *92, 93,* 117, 268
of *Bust of the Elector Christian II of Saxony, 99,* 99–100, *100, 101*
of *Cain and Abel* (Copenhagen), 190–91, *192, 193*
of *Cain and Abel* (Edinburgh), 146, *146, 147*
of *Christ at the Column,* 171–72, *172,* 185
of *Christ Mocked, 234,* 234–35
conclusions about, 268–70
of *Crucifix,* 75–76, *76*
of *Farnese Bull, 165,* 165–66, *166, 167,* 270
of *Faun and Nymph, 67,* 67–68, *68,* 69–70
of *Hercules, Nessus, and Deianeira* (Louvre), *108,* 108–10, *109, 110,* 270
of *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244, *245*
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), *245, 246,* 256, *256*
of *Hercules Pomarius,* 202, 209–11, *210, 211,* 270
of *Horse,* 130, *131*
of *Juggling Man,* 154, *154*
of *Laocoön and His Sons,* 185, *201,* 201–3, *202, 203,* 268, 269, 270
of *Lazarus,* 177–78, *178,* 268
of *Mercury* (Tetrode), 218–19, *219*
of *Mercury and Psyche,* 227, *227*
of *Psyche Borne Aloft by Putti,* 58, 70
of *Putto with a Goose, 183,* 183–84, *184, 185,* 268
of *Rearing Horse,* 122, *122, 123*
of *Venus* or *Nymph,* 84–85
of *Vulcan's Forge, 137,* 137–38, *138, 139,* 269
eyes
in *Bust of Emperor Rudolf II,* 93, *94*
in *Bust of the Elector Christian II of Saxony,* 99
in *Cain and Abel* (Copenhagen), 190
in *Christ at the Column,* 172, 173
in *Christ Mocked,* 234
in *Faun and Nymph,* 67, *67,* 68
in *Hercules, Nessus, and Deianeira* (Louvre), 108, *109*
in *Lazarus,* 177
in *Mercury and Psyche, 227,* 228

fabric. *See* cloth
faces. *See also* eyes; hair
in *Bust of Emperor Rudolf II,* 93
in *Bust of the Elector Christian II of Saxony, 101*
in *Cain and Abel* (Copenhagen), 190, *192*
in *Cain and Abel* (Edinburgh), 146, *146*
in *Christ at the Column,* 171–72, *172,* 173

in *Christ Mocked, 234*
in *Crucifix,* 75–77, *76,* 77
in *Juggling Man,* 154, *154*
in *Laocoön and His Sons,* 201
in *Lazarus,* 177, *178*
in *Mercury* (Tetrode), 218, *219*
in *Mercury and Psyche,* 227, *227,* 228
factorial analysis, 42, *44*
Farnese Bull (de Vries), *158,* **159–67**
alloy composition of, 25, *30,* 159–60
armature and core supports in, *160,* 160–64, *161, 162, 163, 164,* 167, 198, 265
casting method for, 165, 167
core analysis of, 36, 43, 164–65
core pins in, 164, *164,* 166–67
defects and repairs in, 163, 165, 166–67
external surface of, *165,* 165–66, *166, 167,* 270
internal surface of, 165
patina of, 166, 270
as reinterpretation, xiv, 159
sprues in, xiv, 166, 167
thermoluminescence dating of, 165
X-ray fluorescence of, *22*
Faun and Nymph (after de Vries), *62,* **63–70**
alloy composition of, 26, *27,* 63–64, 69
armature and core supports in, *64,* 64–65
attribution of, 5, 63, 69–70
casting method for, 65, 66–67, 69
core analysis of, 38, 39, 43, 44, 65
core pins in, 65
defects and repairs in, 63–64, 68–69, 70
external surface of, *67,* 67–68, *68,* 69–70
internal surface of, 65–66, *66*
modifications and restorations to, 69
patina of, 68, *68*
thermoluminescence dating of, 65
versions of, 63, 70
X-ray radiography on, lack of, 5, 64
feathers
in *Mercury and Psyche,* 227
in *Putto with a Goose,* 183, *184*
feldspar, in cores
polarized lighr microscopy of, 39–40, 41, *41*
X-ray diffraction of, 42, *42*
fettling, definition of, 276
Figdor, Albert, 169
fills, in *Psyche Borne Aloft by Putti,* 59
film, radiographic, 17, 18
fins
in aftercasts, 267
definition of, 276
flaking of patina, on *Rearing Horse,* 123
flashes, 267
in *Allegory of the War against the Turks in Hungary,* 117
in *Cain and Abel* (Copenhagen), 193
in *Cain and Abel* (Edinburgh), 142, 146, 147
in *Christ at the Column,* 172
in *Christ Mocked,* 236
definition of, 276, *277*
in *Farnese Bull,* 166
in *Hercules, Nessus, and Deianeira* (Louvre), 110
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 243, 244
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 253–54, 255
in *Hercules Pomarius,* 212
in *Juggling Man,* 155–56
in *Laocoön and His Sons,* 204
in *Mercury* (Tetrode), 220
in *Psyche Borne Aloft by Putti,* 59
in *Putto with a Goose,* 184
in *Rearing Horse,* 121
flasks, definition of, *15,* 277
flaws. *See* defects
flesh. *See* faces
Flying Mercury (de Vries), 69, 77
foliage
de Vries's use of, 269
in *Hercules Pomarius,* 209
in *Laocoön and His Sons,* 202, 203
in *Lazarus,* 177–78, *178*
in *Putto with a Goose,* 183, 184
Fortune, in *Vulcan's Forge,* 137, *138*
foundry models, definition of, *15,* 277, *277*
foundry repairs. *See* repairs
fountain(s)
Hercules, 81, 137, 269, 270
Juggling Man as, 155, 156, 157
Neptune (de Vries), 181
Neptune (Giambologna), 261
Francavilla, 36
Frederiksborg Castle (Hillerød), 181
Fučíková, Eliška, 195n3
Fusco, Peter, 4, 9n5
gamma-radiography, 20n4
gaseous porosity
in *Allegory of the War against the Turks in Hungary,* 117
in *Bust of the Elector Christian II of Saxony,* 101
conclusions about, 271
definition of, 281, *281*
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244
in *Juggling Man,* 155
in *Mercury* (Tetrode), 219
in *Mercury and Psyche,* 228
in *Venus* or *Nymph,* 85
Gates of Paradise (Ghiberti), 115
GCI. *See* Getty Conservation Institute
Genesis, 141
genitals. *See also* penis
in *Christ Mocked,* 235
in *Hercules Pomarius,* 209, 211, *211,* 212
Genoa, 261
Gerhard, Hubert
alloy composition used by, 23, *24,* 228, 229n1
Hebe, 228
Mercury and Psyche attributed to, 26, 223, 228–29
Getty Conservation Institute (GCI), 4
Getty Museum. *See* J. Paul Getty Museum
Ghiberti, Lorenzo, 42, 115
Giambologna
alloy composition used by, 23, *24*
Caritas, 260, 272n3
core analysis of works, 36, 42
Crucifix attributed to, 73
Crucifix in Vienna by, 73, 78
de Vries in studio of, xi, xiv*n3,* 60, 260–61
design process of, 262
direct casting by, 261
horses by, 119
indirect casting by, 260–61, 263
influence on de Vries, 212, 260–61
multiples cast by, 63, 260–61
technical examination of works, 4
threaded plugs used by, 272
gilding
on *Cain and Abel* (Copenhagen), 187
on *Lazarus,* 178, 179
glossary, 273–87

goat, in *Bust of Emperor Rudolf II,* 89
goose, in *Putto with a Goose,* 181–85
Gotha, 159
Gras, Casper
alloy composition used by, 228, 229n2
casting method used by, 229
Kicking Horse, 229
Mercury and Psyche attributed to, 26, 223, 228–29
greywacke, 43
Grimaldi Chapel (Genoa), 261
Grünes Gewölbe (Dresden), 63, 70
gypsum, in cores, 43–44
microchemical analysis of, 37
polarized light microscopy of, 39
statistical analysis of, 43
thermoluminescence dating with, 46
X-ray diffraction of, 42

Hainhofer, Philipp, 70
hair
in *Bust of Emperor Rudolf II,* 92, *92*
in *Bust of the Elector Christian II of Saxony,* 99, *99*
in *Cain and Abel* (Copenhagen), 190, *192*
in *Cain and Abel* (Edinburgh), 146
in *Christ at the Column,* 172, *172,* 173, 185
in *Christ Mocked, 234,* 234–35
in *Crucifix,* 76, *76,* 77
de Vries's approach to, 269
in *Faun and Nymph,* 67, *67,* 68, 69–70
in *Hercules, Nessus, and Deianeira* (Louvre), 108, *109,* 246, *247*
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 256, *256*
in *Hercules Pomarius,* 209, *210*
in *Horse,* 130
in *Juggling Man,* 154, *154,* 157
in *Laocoön and His Sons,* 185, 202, *202*
in *Lazarus,* 177, *178,* 268
in *Psyche Borne Aloft by Putti,* 58, 70
in *Putto with a Goose,* 183, *183,* 185
in *Venus* or *Nymph,* 84–85, *85,* 86
hands, in *Cain and Abel* (Copenhagen), 190–91
Hebe (Gerhard), 228
hematite, in cores, 42–43
Hercules, Nessus, and Deianeira (Crozatier, Nelson-Atkins Museum), *238,* **239–49**
alloy composition of, 26, *32–33,* 239
armature and core supports in, 239, *240*
attribution of, 249
casting method for, 8, 15, 240–44, 246–48
core analysis of, 37–39, 43, 44, 239–41, *243,* 248
core pins in, 239, *241, 242*
defects and repairs in, 244
external surface of, 244, *245, 246*
internal surface of, 242–43, *243,* 267
Louvre version compared to, 244–47
patina of, 244, 248, 270
Rijksmuseum version compared to, 247–49, *248*
Hercules, Nessus, and Deianeira (Crozatier, Rijksmuseum), *250,* **251–56**
alloy composition of, 26, *33,* 251
armature and core supports in, 251–52, *252, 253*
attribution of, 48, 249, 251
casting method for, 8, 15, 246–48, 252–56
core analysis of, 36–39, *37, 38,* 42–44, 248, 252, *255*
core pins in, 252, *254*
defects and repairs in, 256
external surface of, *245, 246,* 256, *256*
internal surface of, 252–54, *255,* 267
Louvre version compared to, 244–47
Nelson-Atkins version compared to, 247–49, *248*
patina of, 248, 256
thermoluminescence dating of, 48, 252
Hercules, Nessus, and Deianeira (de Vries, Louvre), *102, 103,* **103–11**
aftercasts compared to, 239, 244–47
alloy composition of, *28,* 104
armature and core supports in, *104,* 104–5, *105,* 266
casting method for, xii, 107–8, 111, 246
core analysis of, 38, 44, 106–7
core pins in, 105
defects and repairs in, 110
external surface of, *108,* 108–10, *109, 110,* 270
Giambologna's influence on, 261
internal surface of, 107, *107*
modifications and restorations to, 110
patina of, 110, 270
thermoluminescence dating of, 48, 106–7, 111
Vulcan's Forge compared to, 137
Hercules fountains (de Vries), 81, 137, 269, 270
Hercules Pomarius (de Vries), *206,* **207–12**
alloy composition of, *31–32,* 207
armature and core supports in, 207–8, *208, 209*
casting method for, 209
core analysis of, *37,* 38, 42, 44, 209
core pins in, 209
defects and repairs in, 212
design process for, 262
external surface of, 202, 209–11, *210, 211,* 270
internal surface of, 209
modifications and restorations to, 212
patina of, *211,* 211–12
thermoluminescence dating of, 209
heroism, sculptural, xiii–xiv
Herzog Anton Ulrich-Museum (Braunschweig), 81
Herzogliche Kunst-und Naturalienkabinett, 81
high-tin bronzes, 26n7
Hillerød (Denmark), 181
Hilliger, Martin, 97, 101, 262
Himalayan bronzes, 4, 35–36
Hirschmann, Mrs. Leokadia, 169
histograms, 24–25, *25*
holes. *See also* core pin holes
in *Cain and Abel* (Copenhagen), 193
in *Cain and Abel* (Edinburgh), 147
in *Christ Mocked,* 232, 236
in *Crucifix,* 76, 77
in *Farnese Bull,* 161–62
in *Hercules, Nessus, and Deianeira* (Louvre), 110
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244
in *Horse,* 127–28, 131
in *Juggling Man,* 155
in *Laocoön and His Sons,* 198, 204
in *Mercury and Psyche,* 224
in *Psyche Borne Aloft by Putti,* 54–55, *55*
in *Rearing Horse,* 119–20, *120*
X-ray radiography of, 19–20
hollow casts, 11
Holstein-Schaumburg, Ernst von, 159, 187, 194
Holtermann-Wahrendorff, C., 53
hornblende, in cores, 42
Horse (de Vries), *126,* **127–32**
alloy composition of, *29,* 127, 132
armature and core supports in, 127–28, *128*

casting method for, 129–30, 132
core analysis of, 128–29, *129*
core pins in, 128
defects and repairs in, 131–32
external surface of, 130, *131*
internal surface of, 129, *129*
modifications and restorations to, 132
patina of, 130–31, *131*, 270
Rearing Horse compared to, 129, 132
Houdon, Jean-Antoine, 36
Huntington, Henry, 223
Huntington Art Collection (San Marino), 4, 36, 223
Hutchinson, C. S., 39

Indictor, N., 22
indirect lost wax casting, 263–65
of *Allegory of the War against the Turks in Hungary,* 115, 117
of *Cain and Abel* (Copenhagen), 190, 193, 195
of *Cain and Abel* (Edinburgh), 142, 144, 146, 147, 148, 194, 195
of *Christ Mocked,* 232, 233, 236, 237
core supports in, 266
of *Crucifix,* 75, 77
de Vries's use of, 263–65
definition of, 278
distinctive features of, 19
of *Faun and Nymph,* 65, 67, 69
Giambologna's use of, 260–61, 263
of *Hercules, Nessus, and Deianeira* (Louvre), xii, 107–8, 111, 246
of *Horse,* 129, 132
internal surface with, 267
of *Mercury* (Tetrode), 216, 217, 220–21
of *Mercury and Psyche,* 224, 228
of *Rearing Horse,* xiii, 120–21, 124, 132
vs. sand casting, 20n7
technique of, 12, *13*
of *Venus* or *Nymph,* 81, 85–86
X-ray radiography and, 19
inpainting, 124
inscriptions. *See* signature
intermodels, definition of, 12, 277
internal dose, 45
internal metal armature. *See* armature
internal surface, 266–67
of *Allegory of the War against the Turks in Hungary,* 114–15
of *Bust of Emperor Rudolf II,* 91, 267
of *Bust of the Elector Christian II of Saxony,* *98,* 98–99
of *Cain and Abel* (Copenhagen), 190
of *Cain and Abel* (Edinburgh), 144–45
of *Christ at the Column,* 171, 267
of *Christ Mocked,* 232–34, *233*
conclusions about, 266–67
of *Crucifix,* *74,* 75
definition of, 266
of *Farnese Bull,* 165
of *Faun and Nymph,* 65–66, *66*
of *Hercules, Nessus, and Deianeira* (Louvre), 107, *107*
of *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 242–43, *243,* 267
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), 252–54, *255,* 267
of *Hercules Pomarius,* 209
of *Horse,* 129, *129*
of *Juggling Man,* 153, 267
of *Laocoön and His Sons,* 200–201, *201,* 267
of *Lazarus,* 177
of *Mercury* (Tetrode), 217, *218*
of *Mercury and Psyche,* 224, *225, 226*
of *Psyche Borne Aloft by Putti,* 57, *57,* 266–67
of *Putto with a Goose,* 182–83, 267
of *Rearing Horse,* 120, *121*
of *Venus* or *Nymph,* 84
visual examination of, 17
of *Vulcan's Forge,* 137
X-ray radiography of, 18
inventory numbers, on *Lazarus,* 178–79
inverse segregation
in *Cain and Abel* (Edinburgh), 141
definition of, 25, 26n8, 277
in *Farnese Bull,* 159
in *Laocoön and His Sons,* 197–98, *198,* 205, 277
in *Putto with a Goose,* 181
investment
definition of, *14,* 277
in *Farnese Bull,* 164
in *Venus* or *Nymph,* 81
iron
in *Mercury* (Tetrode), 217
in *Putto with a Goose,* 182
in *Venus* or *Nymph,* 82, 86
J. Paul Getty Museum (Los Angeles)
Adriaen de Vries: Imperial Sculptor exhibition at, xi, 4–5
Aphrodite at, 36
core analysis at, 36
Juggling Man at, xi, 151
Rearing Horse at, 119
technical examination at, 3–4, *6–7*
Jestaz, B., 220
Johann Georg I (elector of Saxony), 63
joins. *See specific types*
Juggling Man (de Vries), *150,* **151–57**
allegorical meaning of, xiii–xiv
alloy composition of, *30,* 151
armature and core supports in, *151,* 151–52, *152, 153,* 265, *273*
casting method for, 154
core analysis of, 39, 152–53
core pins in, 152
defects and repairs in, 154–56, *155,* 271
design process for, 262
external surface of, 154, *154*
as fountain, 155, 156, 157
internal surface of, 153, 267
modifications and restorations to, 156, *156*
patina of, 24, 154
sale at auction, xi, 151
thermoluminescence dating of, 153
Jupiter, in *Bust of Emperor Rudolf II,* 89

Kaiserliche Sammlungen (Vienna), 89, 113
Kansas City, 239
Karlskrone Manor (Chlumec nad Cidlinou), 195n3
Kaufmann, T. D., 262
Kevex X-ray fluorescence instrument, 22, *22*
Kicking Horse (Gras), 229
Kirchenstiftung Mariä Verkündigung (Wullenstetten), 73
Korda, Victor, 215
Krahn, V., 63, 81
Kunstakademie (Copenhagen), 187
Kunsthisorisches Museum (Vienna), 3–4, 89, 113, 169
Kunstkammer, 53, 63, 103, 113, 127, 141, 175, 187, 194, 195

LACMA. *See* Los Angeles County Museum of Art
lamprobolite, in cores
of *Cain and Abel* (Copenhagen), 190
polarized light microscopy of, 40, 41, *41*
of *Venus* or *Nymph*, 86
Laocoön and His Sons (de Vries), *196, 197,* **197–205**
alloy composition of, 25, *30*, 159, 197–98
armature and core supports in, 198–99, *199, 200*, 265
casting method for, 201, 205
core analysis of, 37, 38, 42, 44, 200
core pins in, 200, *200*
defects and repairs in, 70, 198, 202, *203, 204*, 204–5, 271
design process for, 262
external surface of, 185, *201*, 201–3, *202, 203*, 268, 269, 270
internal surface of, 200–201, *201*, 267
modifications and restorations to, 205
patina of, 198, *198*, 203, 271
as reinterpretation, xiv, 197
thermoluminescence dating of, 200
Vulcan's Forge compared to, 137
Larsson, L. O., 63, 70
Lazarus (de Vries), *174*, **175–79**
alloy composition of, 24–25, *25, 30*, 175
armature and core supports in, *175*, 175–76, *176*
casting method for, 177, 179
core analysis of, 176–77
core pins in, 176, *177*
defects and repairs in, 179
external surface of, 177–78, *178*, 268
internal surface of, 177
modifications and restorations to, 179
patina of, 178–79, *179*, 270–71
thermoluminescence dating of, 46, 177
tin content of, 25
lead
in alloy analysis, 21, 23
de Vries's use of, 23
in patinas, 23–24
in *Psyche Borne Aloft by Putti*, 53–54
in *Putto with a Goose*, 182, 183, 184, 185, 185n2
in repairs, 272
in X-ray fluorescence, 23
lead white, in *Psyche Borne Aloft by Putti*, 59
Leonardo da Vinci, 3
Leoni, Pompeo, xii, 60, 261, *261*, 272n5
Liechtenstein Museum (Vienna), 231, 237
light, in optically stimulated luminescence, 49
Lillie, Stina, 53, 89, 113
lion(s)
in *Bust of Emperor Rudolf II*, *92*
in *Christ at the Column*, 172, *172*
loincloth, in *Crucifix*, 76, 77
London, Victoria and Albert Museum in, 3
Los Angeles. *See* J. Paul Getty Museum
Los Angeles County Museum of Art (LACMA)
Christ Mocked at, 231
Mercury (Tetrode) at, 215, 220–21
technical examination at, 3–4
lost wax casting, 11–14. *See also* direct lost wax casting; indirect lost wax casting
core analysis and, 35
definition of, 277–78
prevalence of, 8
technique of, 11–14
Louvre
Hercules, Nessus, and Deianeira in, 103
Mercury in, 215, 220–21
low-tin bronzes, 26n7
Luke, Gospel of, 175

magnetic attraction
in *Cain and Abel* (Edinburgh), 142
definition of, 278
in *Farnese Bull*, 160
in *Psyche Borne Aloft by Putti*, 54–55
Maier, Michael, xiv*n7*
marble sculpture, xi, xii, xiii
materials, in art history, xiv, 3
matting tool, 116, 183, *184*, 256
Mattusch, Carol, 3
MC. *See* microchemical
mechanical joins
definition of, 279, *279*
in *Mercury and Psyche*, 226–27, *227*, 228
media, in art history, xiv
Medusa, in *Bust of the Elector Christian II of Saxony*, *99*
Mercury, in *Bust of Emperor Rudolf II*, 89
mercury, on *Lazarus*, 179
Mercury (de Vries, Karlskrone Manor), 195n3
Mercury (de Vries, Lambach), 266, 267
Mercury (de Vries, Louvre), 215, 220–21
Mercury (Tetrode, LACMA), *214*, **215–21**
alloy composition of, 26, *32*, 215–16, 220
armature and core supports in, 216
casting method for, 216, 217, 220–21
core analysis of, 38, 39, 43, 44, *216*, 216–17
core pins in, 216
defects and repairs in, 219–20, 221
external surface of, 218–19, *219*
internal surface of, 217, *218*
modifications and restorations to, 220
patina of, 217, 219
thermoluminescence dating of, 217
Mercury (Tetrode, Rijksmuseum), 220–21
Mercury and Psyche (de Vries), xii
Mercury and Psyche (uncertain authorship), *222, 223*, **223–29**
alloy composition of, 24, 26, *32*, 223, 228
armature and core supports in, 224
attribution of, 26, 223, 228–29
casting method for, 224–27, *227*, 228, 229
core analysis of, 224
core pins in, 224
defects and repairs in, 223, 224, 228
external surface of, 227, *227*
internal surface of, 224, *225, 226*
modifications and restorations to, 228
patina of, 227
versions of, 229
metal, in core analysis, 35, 40, 42, 44
metal armature. *See* armature
metal-to-metal joins
in *Allegory of the War against the Turks in Hungary*, 115
in *Crucifix*, *73*, 75, 76, 78
definition of, 278
in *Mercury* (Tetrode), *215*, 216
in *Mercury and Psyche*, 224, *224*, 227
in *Psyche Borne Aloft by Putti*, 58, 60n3
in *Rearing Horse*, *120*, 121
types of, 278–79
Metamorphosis (Ovid), 103
Michelangelo, xi, xii, xiv
microchemical (MC) core analysis, 36, 37–38
microscopy. *See* polarized light microscopy; visual examination
Milam, Billy, 3–4
Milan, de Vries in, xii, 261
minerals, in core analysis, 35, 40

mirrors
in *Faun and Nymph,* 69, 70
in visual examination, 17
Mitchell, William Donald, 241
models. *See also* wax models
casting, 11–13, *12, 13, 14,* 274
definition of, 280
in design process, 262, 263
foundry, *15,* 277, *277*
intermodels, 12, 277
modifications
to *Cain and Abel* (Copenhagen), 193
to *Cain and Abel* (Edinburgh), 147
to *Christ Mocked,* 236
to *Crucifix,* 77
to *Faun and Nymph,* 69
to *Hercules, Nessus, and Deianeira* (Louvre), 110
to *Hercules Pomarius,* 212
to *Horse,* 132
to *Juggling Man,* 156, *156*
to *Laocoön and His Sons,* 205
to *Lazarus,* 179
to *Mercury* (Tetrode), 220
to *Mercury and Psyche,* 228
to *Psyche Borne Aloft by Putti,* 59–60
to *Putto with a Goose,* 185
to *Rearing Horse,* 124
to *Venus* or *Nymph,* 85
mold seams. *See* fins
molds
definition of, 280
inner (*See* core analysis)
piece, 81, 83, 280–81
motifs, de Vries's use of, 269
Munich, 135
Munsell Soil Color Charts, 36
muscovite mica, in cores, 43
Musei Vaticani, 197
Museum of the Capital Prague, 207

National Gallery (Prague), 127
National Gallery of Art (Washington, D.C.), 3
Nationalmuseum (Stockholm), xi, 4, 53, 181, 197
Neidhart, Wolfgang, 262
Nelson-Atkins Museum of Art (Kansas City), 239
Neptune Fountain (de Vries), 181
Neptune fountain (Giambologna), 261
Nessus. *See Hercules, Nessus, and Deianeira*
nickel, 21
Niedhart, Wolfgang, xiii
Nosseni, Giovanni Maria, 63, 70
Nymph or *Venus. See Venus* or *Nymph*

obscurity, of de Vries, xi, xiv
oligoclase, in cores, 42
optically stimulated luminescence (OSL), 49
organic material, in core analysis, 35
OSL. *See* optically stimulated luminescence
Ovid, 103
Oxford Research Laboratory for Archaeology, 153
oxy-hornblende. *See* lamprobolite

Paris. *See* Louvre
paste fills, in *Psyche Borne Aloft by Putti,* 59
patches
in *Cain and Abel* (Copenhagen), 188
in *Cain and Abel* (Edinburgh), 141, 143
in *Christ at the Column,* 172
conclusions about use of, 271
definition of, 280
in *Farnese Bull,* 161, 162–63, 166
in *Horse,* 131–32, 132
in *Laocoön and His Sons,* 205
in *Mercury and Psyche,* 228
in *Rearing Horse,* 124
in *Vulcan's Forge,* 136
patina(s), 270–71
of *Allegory of the War against the Turks in Hungary,* 117, 270
of *Bust of Emperor Rudolf II,* 93
of *Bust of the Elector Christian II of Saxony,* 100, 270
of *Cain and Abel* (Copenhagen), 191–93, *192,* 195, 270–71
of *Cain and Abel* (Edinburgh), 146
of *Christ at the Column,* 172
of *Christ Mocked,* 235
conclusions about, 270–71
of *Crucifix,* 76
definition of, 280, *280*
in examination methodology, 5–6, 9n15
of *Farnese Bull,* 166, 270
of *Faun and Nymph,* 68, *68*
of *Hercules, Nessus, and Deianeira* (Louvre), 110, 270
of *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244, 248, 270
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), 248, 256
of *Hercules Pomarius, 211,* 211–12
of *Horse,* 130–31, *131,* 270
of *Juggling Man,* 24, 154
of *Laocoön and His Sons,* 198, *198,* 203, 271
of *Lazarus,* 178–79, *179,* 270–71
of *Mercury* (Tetrode), 217, 219
of *Mercury and Psyche,* 227
of *Psyche Borne Aloft by Putti,* 6, 58, *59,* 271
of *Putto with a Goose,* 184, 271
of *Rearing Horse,* 122–23, 124, 270
repatination, 20, 270
of tin bronzes, 23–24
of *Venus* or *Nymph,* 85
of *Vulcan's Forge,* 138, 270
in X-ray fluorescence, 22
patronage, xii–xiii. *See also* commissions
penis
in *Cain and Abel* (Copenhagen), 190
in *Hercules Pomarius,* 209, *211,* 212
in *Juggling Man,* 155
pentimento, in *Juggling Man,* 152, 157
Perseus (Cellini), xiii, 272n8
personality, artistic, xi, 259
petrographic analysis, 5, 35
Pettit, R. W., 228, 229
Phillip II, 261
Phillips 450 kilovolt tube, 18
philosopher's stone, xiii
piece molds
definition of, 280–81
for *Venus* or *Nymph,* 81, 83
Pilate, Pontius, 169
pinned sleeve joins. *See* sleeve joins
plaster cores
analysis of, 35
in *Christ Mocked,* 232
in *Faun and Nymph,* 65, 69
thermoluminescence dating with, 46
in *Venus* or *Nymph,* 81, 82
in *Vulcan's Forge,* 136
Pliny, xiii
PLM. *See* polarized light microscopy

plugs
in *Bust of Emperor Rudolf II,* 91, 94
in *Bust of the Elector Christian II of Saxony,* 98
in *Cain and Abel* (Copenhagen), 193, 194
in *Cain and Abel* (Edinburgh), 142, 143, 147
in *Christ Mocked,* 232, 235–36, 237
conclusions about use of, 266, 271–72
in *Crucifix,* 74, *75,* 76, 77–78
definition of, 281
in *Farnese Bull,* 164
in *Faun and Nymph,* 65, 68
in *Hercules, Nessus, and Deianeira* (Louvre), 105
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 239, 244
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 252, 256
in *Horse,* 128, 131
in *Juggling Man,* 152, 155, 157
in *Laocoön and His Sons,* 205
in *Mercury and Psyche,* 224, 228
in *Psyche Borne Aloft by Putti,* 55–56
in *Rearing Horse,* 119–20, 124
in *Venus* or *Nymph,* 85
point-count analysis, 39
polarized light microscopy (PLM), of cores, 36, *38,* 38–40, *40,* 41, *41*
polish. *See also* chasing
definition of, 281, *281*
porosity
in *Bust of Emperor Rudolf II,* 93–94
in *Bust of the Elector Christian II of Saxony,* 101
in *Christ at the Column,* 172, 173
conclusions about, 271
definition of, 281
in *Farnese Bull,* 166
in *Faun and Nymph,* 68
in *Hercules Pomarius,* 212
in *Horse,* 131, 132
in *Laocoön and His Sons,* 204
in *Lazarus,* 177
in *Psyche Borne Aloft by Putti,* 59
in *Putto with a Goose,* 184
in *Rearing Horse,* 124
types of, 281–82
in *Venus* or *Nymph,* 84, 85
in *Vulcan's Forge,* 138
Porta, Guglielmo della, 260
Prague
clay from, 43, 44
de Vries in, xii–xiii, 262
Museum of the Capital in, 207
Venus or *Nymph* in, 86
Waldstein Palace in, 197, 207
preliminary drawings, 262
processes, in art history, xiv, 3
Psyche. *See Mercury and Psyche*
Psyche Borne Aloft by Putti (de Vries), *52, 53,* **53–60**
alloy composition of, 24, *25, 27,* 53–54
armature and core supports in, *54,* 54–55, *55,* 265
casting method for, 58, 263
core analysis of, 38, 42, 44, *56,* 56–57, *57*
core pins in, 55–56, 266
defects and repairs in, 55, *56,* 59, *59,* 271, 272
external surface of, 58, 70
Hercules Pomarius compared to, 212
internal surface of, 57, *57,* 266–67
modifications and restorations to, *59,* 59–60
patina of, 6, 58, *59,* 271
production of, xii
thermoluminescence dating of, 57
punches
in *Allegory of the War against the Turks in Hungary,* 116
in *Bust of Emperor Rudolf II,* 92, 93
in *Bust of the Elector Christian II of Saxony,* 99, 100
in *Cain and Abel* (Copenhagen), 190, 191, 194
in *Cain and Abel* (Edinburgh), 146
in *Christ at the Column,* 172
in *Christ Mocked,* 234–35
conclusions about use of, 268–69
definition of, 282
in *Farnese Bull,* 165
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244
in *Hercules Pomarius,* 209–10
in *Horse,* 130
in *Laocoön and His Sons,* 202–3
in *Lazarus,* 178
in *Mercury and Psyche,* 227
in *Putto with a Goose,* 183–84, *184, 185*
in *Vulcan's Forge,* 137–38, *138*
pupils. *See* eyes
Putto with a Goose (de Vries), *180,* **181–85**
alloy composition of, 25, *30–31,* 159, *181,* 181–82
armature and core supports in, 182, *182*
casting method for, 183, 185
core analysis of, 182, *183*
core pins in, 182
defects and repairs in, 182, 184–85, *185*
external surface of, *183,* 183–84, *184, 185,* 268
internal surface of, 182–83, 267
modifications and restorations to, 185
patina of, 184, 271
thermoluminescence dating of, 182

quartz, in cores
polarized light microscopy of, 39–40, *41*
X-ray diffraction of, 42

radiography, types of, 20n2. *See also* X-ray radiography
Rearing Horse (de Vries), *118,* **119–24**
alloy composition of, *29,* 119, 132
armature and core supports in, 119–20, *120*
casting method for, xiii, 120–21, 124, 132
core analysis of, 120
core pins in, 120
defects and repairs in, 123–24, 271
external surface of, 122, *122, 123*
Horse compared to, 129, 132
internal surface of, 120, *121*
modifications and restorations to, 124
patina of, 122–23, 124, 270
Reedy, Chandra, 3–4, 35–36, 39, 43
refractory material, definition of, 282
reliefs. *See also Allegory of the War against the Turks in Hungary; Vulcan's Forge*
casting methods for, 115
Renaissance Bronze Project, 4, 5, 119, 151
Renaissance bronzes
core analysis of, 35–36
technical examination of, 3–4
Renaissance Master Bronzes (exhibition), 4
repairs, 271–72. *See also specific types*
to *Allegory of the War against the Turks in Hungary,* 116, 117, 271
to *Bust of Emperor Rudolf II,* 93–94
to *Bust of the Elector Christian II of Saxony,* 101, 271

to *Cain and Abel* (Copenhagen), 70, 188, 193–95, 272
to *Cain and Abel* (Edinburgh), 146–47
to *Christ at the Column,* 172–73, *173*
to *Christ Mocked,* 235–36, 237
conclusions about, 271–72
to *Crucifix,* 76
definition of, 282–84
to *Farnese Bull,* 163, 165, 166–67
to *Faun and Nymph,* 63–64, 68–69, 70
to *Hercules, Nessus, and Deianeira* (Louvre), 110
to *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244
to *Hercules, Nessus, and Deianeira* (Rijksmuseum), 256
to *Hercules Pomarius,* 212
to *Horse,* 131–32
to *Juggling Man,* 154–56, *155,* 271
to *Laocoön and His Sons,* 70, 198, 202, *203,* 204–5
to *Lazarus,* 179
to *Mercury* (Tetrode), 219–20, 221
to *Mercury and Psyche,* 223, 228
to *Psyche Borne Aloft by Putti,* 55, *56,* 59, *59,* 271, 272
to *Putto with a Goose,* 182, 184–85, *185*
to *Rearing Horse,* 123–24, 271
summary chart of, *294–96*
types of, 282–84
to *Venus* or *Nymph,* 85
to *Vulcan's Forge,* 138
X-ray radiography revealing, 19–20
repatination, 20, 270
replicas
of *Cain and Abel,* xiii, 141
and casting methods, 263
definition of, 284
of imperial bronzes, xiii
reputation, of de Vries, xi, xiv
restorations
to *Cain and Abel* (Copenhagen), 193
to *Cain and Abel* (Edinburgh), 147
to *Christ Mocked,* 236
to *Crucifix,* 77
to *Faun and Nymph,* 69
to *Hercules, Nessus, and Deianeira* (Louvre), 110
to *Hercules Pomarius,* 212
to *Horse,* 132
to *Juggling Man,* 156, *156*
to *Laocoön and His Sons,* 205
to *Lazarus,* 179
to *Mercury* (Tetrode), 220
to *Mercury and Psyche,* 228
to *Psyche Borne Aloft by Putti, 59,* 59–60
to *Putto with a Goose,* 185
to *Rearing Horse,* 124
to *Venus* or *Nymph,* 85
retraction. *See* shrinkage porosity
Riccio, 3, 4
Rijksmuseum (Amsterdam), xi, 4, 220–21, 251
rods. *See* armature
Roman joins. *See* sleeve joins
Rome, de Vries in, xii
Rudolf II (Holy Roman Emperor)
bust of (*See Bust of Emperor Rudolf II*)
de Vries as official sculptor of, xii, xiii
de Vries at court of, xii
death of, 141, 194
works commissioned by, 53, 89, 97, 113, 127, 141, 194, 263
rulers, 6
rust
on *Cain and Abel* (Edinburgh), 142, 145
on *Christ at the Column,* 169
on *Juggling Man,* 152, 156, 265
on *Laocoön and His Sons,* 200, *200*
on *Lazarus,* 176
on *Mercury* (Tetrode), 217

saddle, in *Horse,* 129, 132
samples
in alloy analysis, 25
in core analysis, 36
for thermoluminescence dating, 46
Samson Slaying the Philistines (Michelangelo), xiv
San Marino, Huntington Art Collection in, 4, 36, 223
sand, in cores, 35, 43–44, 275
of *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 240–41, 248
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), 248, 252
polarized light microscopy of, 38–40, *40*
sand casting, 11
core analysis and, 35
definition of, 284–85
distinctive features of, 19
of *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 8, 15, 240–42, 244, 246, 248
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), 8, 15, 246, 248, 252–53, 256
vs. indirect casting, 20n7
internal surface with, 267
rise of, 8
technique of, 11, 15, *15–16*
of *Venus* or *Nymph,* 84
X-ray radiography and, 19
Savoy, duke of, xii
scales, in *Laocoön and His Sons, 200,* 201, *202,* 268, 269
Schlossmuseum (Gotha), 159
Schmidtling, Ron, 36, 40
Scholten, Frits, xi
Scott, David, 9n5
scraping. *See also* chasing
of *Psyche Borne Aloft by Putti,* 59–60
scratch brushes. *See also* chasing
definition of, 285, *285*
screws
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 255
secondary-target X-ray fluorescence (STXRF), 22, 23
segregation. *See* inverse segregation
serpent. *See* snake
set-in repairs
to *Bust of the Elector Christian II of Saxony,* 101
to *Cain and Abel* (Edinburgh), 147
conclusions about, 271
definition of, 283, *283*
to *Farnese Bull,* 166
to *Hercules Pomarius,* 212
to *Laocoön and His Sons,* 198, 202, 204
to *Putto with a Goose,* 182, 184–85
to *Vulcan's Forge,* 138
shrinkage porosity
in *Bust of the Elector Christian II of Saxony,* 101
in *Cain and Abel* (Copenhagen), 193
in *Cain and Abel* (Edinburgh), 146–47

in *Christ Mocked,* 235, 236
conclusions about, 271
definition of, 281–82, *282*
in *Farnese Bull,* 166
in *Faun and Nymph,* 68
in *Hercules Pomarius,* 212
in *Horse,* 131
in *Juggling Man,* 155
in *Laocoön and His Sons,* 204
in *Mercury* (Tetrode), 219
in *Mercury and Psyche,* 228
in *Psyche Borne Aloft by Putti,* 59
in *Venus* or *Nymph,* 85
in *Vulcan's Forge,* 138
side-to-side core pins
in *Crucifix,* 77
definition of, 276
signature(s)
on *Allegory of the War against the Turks in Hungary,* 116, *116*
on *Bust of Emperor Rudolf II,* 93, *94, 95*
on *Bust of the Elector Christian II of Saxony,* 100, *100*
on *Cain and Abel* (Copenhagen), 191, *193,* 194, 268
on *Cain and Abel* (Edinburgh), 141, 146, *147*
conclusions about, 268
on *Farnese Bull,* 165–66, *166, 167*
on *Horse,* 130, *131*
on *Laocoön and His Sons,* 203, *203*
on *Lazarus,* 177, *178*
on *Rearing Horse,* 122, *123*
summary chart of, *297*
on *Vulcan's Forge,* xiii, 138, *139*
silver, 21
size of sculptures, and casting methods, xii, 263–64, *264*
Skulpturensammlung (Dresden), 70, 97
sleeve joins
in *Christ Mocked,* *231,* 234
definition of, 279, *279*
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 243, 244
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), *252,* 255
in *Kicking Horse* (Gras), 229
slush molding, *13*
in *Christ Mocked,* 233
definition of, 285
in *Faun and Nymph,* 65
in *Mercury and Psyche,* 224
in *Rearing Horse,* 120, 121
in *Venus* or *Nymph,* 84
snake(s)
in *Farnese Bull,* 165, *166*
in *Laocoön and His Sons,* *200,* 200–201, *202,* 268, 269
solder
in *Cain and Abel* (Copenhagen), 193
conclusions about use of, 272
definition of, 285
in *Mercury and Psyche,* 224, 225–26, 229
in *Putto with a Goose,* 184
soft, 285
solder joins
definition of, 279, *279*
in *Mercury and Psyche,* 225–26, 228
soldered-in repairs
to *Christ Mocked,* 236
definition of, 284, *284*
to *Faun and Nymph,* 68–69, 70
to *Laocoön and His Sons,* 204–5
to *Mercury* (Tetrode), 220, 221
Sotheby's of London, 151
Sparre, Eric, 53, 89, 113
sprezzatura, 268
sprues, 269–70
in *Allegory of the War against the Turks in Hungary,* *114,* 115, *115,* 117
in *Cain and Abel* (Copenhagen), *190,* 191
conclusions about, 269–70
de Vries's use of, xi, xiii, 269–70
definition of, *285,* 286
in *Farnese Bull,* xiv, 166, 167, 270
in *Faun and Nymph,* 64, *64,* 67
in *Hercules, Nessus, and Deianeira* (Louvre), 110, *110,* 270
in *Hercules Pomarius,* 211, *211,* 270
in *Horse,* 128, 129, *130,* 132
in *Laocoön and His Sons,* 203, 270
in *Putto with a Goose,* 185
in *Rearing Horse,* 121, 124
St. John (Leoni and de Vries), *261*
Städtischen Kunstsammlungen Augsburg, 7
Statens Museum for Kunst (Copenhagen), 141, 175, 187
statistical analysis, 42–43, *44*
Stenbock, Jan, 89, 113
Stenbock, Johan Gabriel, 53
Stockholm. *See* Nationalmuseum
Stone, R. E., 22, 263
Stone, Richard, 3, 4
Striding Warriors (Tetrode), 221
structural summaries, 8
"A Study of the Technology of Renaissance Bronze Statuettes" (Bewer), 4
STXRF. *See* secondary-target X-ray fluorescence
sulfate ions, 37–38
sulfur, 21
surfaces. *See also* external surface; internal surface
chasing of (*See* chasing)
visual examination of, 17
X-ray fluorescence of, 22–23
X-ray radiography of, 18, 19
surmoulage. See aftercasts
surmoulage marks
definition of, 286, *286*
on *Hercules, Nessus, and Deianeira* (Louvre), 110, 249n6
on *Horse,* 132
on *Rearing Horse,* 124
on *Venus* or *Nymph,* 85
Susini, Antonio, xiv, 36, 78, 272
Suther, Per, 53, 89, 113

technical examination, 3–9. *See also specific techniques*
authentication through, 3, 5
at exhibitions, vii, xi, 4–5
form used for, 5
history of, 3–4
interpretation of results of, 6–7
methodology for, 4, 5–7, 8
summary of results of, *288–97*
techniques
in art history, xiv, 3
of de Vries, 261–72
influences on de Vries's, 260–61
teeth
in *Cain and Abel* (Copenhagen), 190, 193
in *Christ at the Column,* 172
in *Hercules, Nessus, and Deianeira* (Louvre), 108, *109*
temper
in *Faun and Nymph,* 69

in *Mercury* (Tetrode), 217
Tessin, Carl Gustaf, 53
Tetrode, Willem van, 215, 220–21, 260. *See also Mercury*
thermoluminescence (TL) dating, 45–49
of *Allegory of the War against the Turks in Hungary,* 48, 114
in authentication, 46, 49
of *Bust of Emperor Rudolf II,* 91
of *Bust of the Elector Christian II of Saxony,* 98
of *Cain and Abel* (Copenhagen), 45–46, 48, 190
of *Cain and Abel* (Edinburgh), 45–46, 144
challenges of, 46
of *Christ at the Column,* 171
of *Christ Mocked,* 232
definition of, 286
in examination methodology, 5
of *Farnese Bull,* 165
of *Faun and Nymph,* 65
goal of, 45–46
of *Hercules, Nessus, and Deianeira* (Louvre), 48, 106–7, 111
of *Hercules, Nessus, and Deianeira* (Rijksmuseum), 48, 252
of *Hercules Pomarius,* 209
of *Juggling Man,* 153
of *Laocoön and His Sons,* 200
of *Lazarus,* 46, 177
of *Mercury* (Tetrode), 217
of *Psyche Borne Aloft by Putti,* 57
of *Putto with a Goose,* 182
reliability of, 46
results of, 46–48, *47*
of *Venus* or *Nymph,* 83–84
of *Vulcan's Forge,* 137
Theseus and Antiope (de Vries), xii, 173, 262
thin section analysis, 35, 36
threaded plugs
in *Christ Mocked,* 235, 237
in *Crucifix,* 77–78
definition of, 284, *284*
in *Hercules, Nessus, and Deianeira* (Nelson-Atkins), 244
Susini's use of, 78, 272
tin
in alloy analysis, 21, 23–25
in *Cain and Abel* (Edinburgh), 25, 141
color of, 21
de Vries's use of, 23–24, 25
in *Farnese Bull,* 25, 159
in *Laocoön and His Sons,* 25, 197–98, 205
in patinas, 23–24
in *Putto with a Goose,* 25, 181–82
reasons for using, 23–24
tin oxides
on *Juggling Man,* 24
on *Laocoön and His Sons,* 198
TL. *See* thermoluminescence
tomography, 20n6
Torrie, Sir James Erskin, 141
tree trunk, in *Hercules Pomarius,* 207–10, *210*
Turin, de Vries in, xii
Turkey (Giambologna), 261

ultraviolet light, 17
University of Edinburgh, 141

variants, definition of, 286
varnish. *See* patina
Vasari, Giorgio, 3
Venus, in *Vulcan's Forge,* 135
Venus or *Nymph* (uncertain authorship), *80,* **81–86**
alloy composition of, 26, *27,* 81
armature and core supports in, 81–83, *82, 83,* 85
attribution of, 5, 69, 86
casting method for, 81, 82–83, 84, 85–86
core analysis of, *37,* 37–39, *38,* 42–44, 82–84, *84,* 86
core pins in, 82
defects and repairs in, 85
external surface of, 84–85
internal surface of, 84
modifications and restorations to, 85
patina of, 85
thermoluminescence dating of, 83–84
Verrochio, Andrea del, 42
Victoria and Albert Museum (London), 3
Vienna
Kaiserliche Sammlungen in, 89, 113
Kunsthisorisches Museum in, 3–4
Liechtenstein Museum in, 231, 237
vines
in *Hercules Pomarius,* 212
in *Laocoön and His Sons,* 203
virtuosity, artistic, xiii–xiv
visual examination
in core analysis, 36–37, *37*
in technical examinations, 4, 5, 17–20
Vries, Adriaen de. *See* de Vries, Adriaen
Vulcan's Forge (de Vries), *134,* **135–39,** *258*
alloy composition of, *29,* 135
armature and core supports in, 135, *136*
casting method for, 137
core analysis of, 136–37
core pins in, 135–36, *136*
defects and repairs in, 138
external surface of, *137,* 137–38, *138, 139,* 269
internal surface of, 137
patina of, 138, 270
signature on, xiii, 138, *139*
thermoluminescence dating of, 137

Wahrendorff, Anders, 53
Waldstein, Albrecht von, 197, 207, 263
Waldstein Palace (Prague), 197, 207
Washington, D.C., 3
water content, of core, 46
wax casting. *See* lost wax casting
wax models, xi–xii, 268–69
in *Allegory of the War against the Turks in Hungary,* 115–16
in *Bust of Emperor Rudolf II,* 91–93
in *Bust of the Elector Christian II of Saxony,* 99–100
in *Cain and Abel* (Copenhagen), 190–91, 267
in *Cain and Abel* (Edinburgh), 146, 267
in *Christ at the Column,* 171–72
in *Christ Mocked,* 234–35
conclusions about use of, 268–69
in *Crucifix,* 75–76, *76,* 77
in *Farnese Bull,* 165–66
in *Faun and Nymph,* 67–68
in *Hercules, Nessus, and Deianeira* (Louvre), 108–10
in *Hercules Pomarius,* 209–11
in *Horse,* 130, 267
in *Juggling Man,* 154
in *Laocoön and His Sons,* 201–3
in *Lazarus,* 177–78
in lost wax casting, 11–13, *12, 13, 14*
in *Mercury* (Tetrode), 218–19, 220
in *Mercury and Psyche,* 227, 228
in *Psyche Borne Aloft by Putti,* 58
in *Putto with a Goose,* 183–84

in *Rearing Horse,* 122, 267
in *Venus* or *Nymph,* 84–85
in *Vulcan's Forge,* 137–38
wax-to-wax joins, 267
in *Allegory of the War against the Turks in Hungary,* 115
in *Cain and Abel* (Copenhagen), 188, *188,* 190, *192*
in *Cain and Abel* (Edinburgh), *142,* 144–46
in *Christ Mocked, 231,* 234
conclusions about, 267
in *Crucifix, 73,* 75, 77
definition of, 286–87
in *Faun and Nymph,* 64, *64,* 66–67, 7–7
in *Hercules, Nessus, and Deianeira* (Louvre), 107, 108, 111, 267
in *Hercules, Nessus, and Deianeira* (Rijksmuseum), 255
in *Horse,* 129
in *Mercury* (Tetrode), 221
in *Mercury and Psyche,* 224, *224,* 227, 228
in *Psyche Borne Aloft by Putti,* 58, 60n3
in *Rearing Horse, 120,* 120–21, 124
in *Venus* or *Nymph,* 83, 84
White, R., 22
wires. *See* core supports
wood blocks, in *Faun and Nymph,* 64, 65, *65*
workshop, de Vries's
assistants in, 194–95, 267, 269
Cain and Abel (Copenhagen) in, 194–95
practices in, 259
Wullenstetten, 73

X-ray diffraction (XRD), of cores, 36, 40–42
X-ray fluorescence (XRF), 21–26
alloy analysis with, 5, 21–26
definition of, 287
in examination methodology, 5
instruments in, 21–22, *22*
summary of results of, *27–33*
technique of, 22–23
X-ray radiography, 17–20
definition of, 287
interpretation of results of, 18
questions answered by, 18–20
in technical examinations, 4, 5, 8, 17–20, *18*
technique of, 17–18

youth, in *Farnese Bull,* 159, 163

Zethus, in *Farnese Bull,* 159, 160–61, *161*
zinc
in alloy analysis, 21
de Vries's use of, 23
in *Faun and Nymph,* 69
in patinas, 23–24
in *Putto with a Goose,* 182