LINDA OWEN

Fire and Paper: An Examination of the Materials and Techniques of Lee Bontecou's Soot Drawings

ABSTRACT

Using soot from an acetylene torch, American artist Lee Bontecou created a series of drawings on paper, beginning in the late 1950s. Soot has been used for centuries as a pigment, and carbon blacks in general have been used as pigments for both artists and industry. However, Bontecou's method of directly applying the soot to the paper support with an acetylene torch was a new approach. The treatment of an early soot drawing, *Untitled*, from 1958, was the impetus for this research, and an understanding of the medium was necessary before treatment. Bontecou's working method and manipulation of the medium were investigated with visual examination and mock-ups. Discussion with the artist provided further insight into her technique, materials, and use of fixative. While very similar in many respects to other friable media, soot has some distinctively different characteristics and properties. Although the main component of soot is carbon, organic species are present due to incomplete combustion and contaminants. Paper samples covered with acetylene torch soot were analyzed. This innovative use and application of a traditional medium by a contemporary artist has presented interesting questions for treatment, display, and storage.

INTRODUCTION

In the late 1950s, the American artist Lee Bontecou, born 1931, began experimenting with the use of an oxy-acetylene torch for drawings on paper. While soot has been used for centuries as a pigment, Bontecou's use of the welding torch to directly apply the soot to the paper, with no intermediary steps, was an innovative and unusual approach. Her ability to manipulate and control the soot created works of art of an ethereal, striking beauty. Bontecou's discovery of the technique was a breakthrough in her work. She said that "[g]etting the black…opened everything up" (Hadler 1994, 56). As the art historian Mona Hadler proposes, the series of soot drawings mark a pivotal point in Bontecou's career and lead directly into her best known works, wall-mounted sculptures generally consisting of a welded steel frame with found materials such as canvas around a central void (1992) (fig. 1).

Fig. 1. Lee Bontecou, *Untitled*, 1960, metal and canvas relief, 17.1 x 19.1 x 10.2 cm. Gift (partial and promised) of Mr. and Mrs. Carl J. Gerwitz, Department of Visual Services, National Gallery of Art, Washington DC, 1992.52.1

One of these early soot drawings, *Untitled*, from 1958 (fig. 2), came into the paper conservation lab at the National Gallery of Art (NGA) for assessment. A long, vertical mark in the right portion of the drawing raised some questions. It appeared to be a scratch, approximately ten inches long and half an inch wide. Once it was confirmed with the artist, through the intermediary of Knoedler Gallery which represents the artist, that the mark was damage and not part of the drawing, the curator requested that the drawing be treated. An understanding of the medium was necessary to determine an appropriate approach to treatment and long-term preservation. Bontecou's working method and manipulation of the medium were investigated with visual examination and mock-ups. Visits to other institutions and private collections

Presented at the Book and Paper Group session, AIC 36th Annual Meeting, April 21–24, 2008, Denver, Colorado.

Fig. 2. Before treatment, Lee Bontecou, *Untitled*, 1958, acetylene soot on paper, 70.0 x 99.8 cm. Promised gift, Department of Visual Services, National Gallery of Art, Washington DC, 130745

provided additional examples of the artist's work, and discussion with the artist allowed further insight into her technique. While very similar in many respects to friable media such as pastel and charcoal, soot has some distinctively different characteristics and properties.

Instrumental analysis helped to resolve some questions about the stability and structure of the soot drawings. While the main component of soot is carbon, organic species are present due to incomplete combustion and reactions with carbon radicals. Paper samples covered with acetylene torch soot were tested for lightfastness. Paper fibers coated with soot were examined with scanning electron microscopy (SEM) to gain an understanding of the soot agglomerate morphology and the interaction between soot and paper.

THE ARTIST

Lee Bontecou was born in Rhode Island in 1931 but raised in New York. From 1952 to 1955, the artist attended the Art Students League in New York, and learned to weld at a summer program at the Skowhegan School in Maine. A Fulbright Scholarship brought Bontecou to Rome in 1956, and she remained there until 1958. During her time in Rome, Bontecou created a series of terracotta animals with a welded steel structure (Smith 2003). For her welding she used an oxy-acetylene torch. The oxygen and acetylene gases are mixed to create a hot, controllable flame suited to welding steel. Bontecou realized that when she turned off the oxygen and ran the torch solely from the acetylene she could draw with the heavily sooting flame. The acetylene burns at a much lower temperature and the combustion is incomplete, resulting in copious amounts of soot or settling that flows off of the flame in a plume. The low temperature of the flame is also helpful in preventing the paper from burning.

Bontecou called the series of drawings "worldscapes" (Hadler 2003); she found the deep blacks to be reminiscent of outer space. The velvety black of the drawings was a natural precursor to the dark voids so characteristic of her sculptures. She would often fill the central voids with soot or black velvet to further enhance the feeling of depth and space.

Bontecou became well-known for her sculpture and had a solo exhibition at Leo Castelli Gallery in New York in 1960, which also represented Jasper Johns and Robert Rauschenberg. One of only a few women on the art scene at the time, Bontecou's career took off in the 1960s (Duncan 2004). Her thought-provoking sculpture and waifish look attracted widespread attention, leading to articles in *Art in America* as well as *Vogue* and *Cosmopolitan*. However, as her work evolved in a new direction and her life changed, Bontecou completely withdrew from the art world in the early 1970s (Smith 2003). She never stopped making art and in 2003 a major retrospective organized by Elizabeth A. T. Smith of the Museum of Contemporary Art in Chicago and the Hammer Museum rekindled interest in her work. Her early soot drawings in particular generated excitement, which Bontecou finds ironic since their reception was decidedly unenthusiastic when she brought them back from Rome (Bontecou 2007). Her early soot drawings are now in the collection of the Museum of Modern Art (MoMA), the Los Angeles County Museum of Art (LACMA), and private collections. There are only around ten of the drawings still in existence. Bontecou lives in rural Pennsylvania and works in a large barn that is converted to a studio, much as she has for the last forty years. Bontecou still uses welding in her sculptural work occasionally, but for the most part no longer uses soot in her drawings (Bontecou 2007).

SOOT AND CARBON BLACK

Soot, as described in technical literature, "is a randomly formed particulate carbon which in addition to carbon contains a large variety of inorganic and organic impurities" (Bansal and Donnet 1993, 67). The exact mechanism of soot formation is still not completely understood, but is likely a combination of the dehydrogenation of the fuelstock to atomic carbon or carbon radicals and/or the formation of a large hydrocarbon which is then dehydrogenated to soot (Bansal and Donnet 1993). The size of an individual soot particle is extremely small, in the order of one nanometer or less. However, during soot formation the particles quickly form aggregates, 10–50nm, and then agglomerates of much larger size, up to 1mm in length (Bansal and Donnet 1993). The fuelstock will effect the composition of the soot. Wax or oil will produce a greasy soot with a high level of organic impurities and small particles of the original fuel (Spafford-Ricci and Graham 2000).

Soot has been characterized in the conservation literature primarily in the context of damage from fire or smoke.

Methods of surface cleaning soot are discussed, and its composition has been analyzed for that purpose (Roberts et al. 1988, Spafford-Ricci and Graham 2000). Organic greasy materials and carbon can penetrate and become embedded in surfaces; the adhesion to the substrate is increased by electrostatic attraction (Spafford-Ricci and Graham 2000). Even though the soot produced by the acetylene torch is not as tarry as soot from more heterogeneous sources, acetylene soot still contains numerous organic species that are formed by the carbon radicals.

Purified soot or combustion products are used extensively as black pigments, but that use accounts for only 10% of the production of carbon black (Kuhner and Voll 1993). Carbon blacks are used extensively in plastics and rubber manufacturing as a conductor, a UV inhibitor, filler, and strengthening agent. The tire industry accounts for the majority of carbon black production (Bansal and Donnet 1993). As a pigment, carbon black is indispensable in xerographic toners for its ability to hold an electrostatic charge (Donnet et al. 1993). This ability plays a very important role in the characteristics of soot as a media. The highly charged particles are attracted to the paper substrate, and the charge helps to hold them in place.

Historically, carbon blacks are some of the oldest pigments known to mankind. Charcoal was used in cave paintings and graphite has been identified at ancient Egyptian sites (Winter and West FitzHugh 2007). Lamp black has long been used to produce Chinese or India ink (Mitchell 1937). Bistre is ink produced from oily soot that is completely unpurified; in fact, the organic impurities produce the desired yellow-brown hue that is characteristic of the ink. Bistre is known to be sensitive to light, as a result of the organic components (Winter 1983). This tendency of bistre to fade raised the concern that some portions of Bontecou's soot drawings might be fugitive as well. The lighter portions of the artist's drawings, where the soot has a brown hue, were considered to be the most likely to fade. In order to have a better understanding of the characteristics of soot as a pigment, further study using mock-ups was necessary.

TECHNIQUE

Samples were created to better comprehend the soot's properties and Bontecou's technique (fig. 3). The samples were made with soot from an oxy-acetylene torch and papers that were similar to Bontecou's—white, heavyweight, smooth, and wove. Some points became obvious during the construction of the samples. The movements needed to be quick because lingering in one area too long led to a heavy deposition of soot, and the paper support would start to smolder. A few passes of the torch could also cover any lighter areas. Lighter passages, therefore, must be deliberately reserved. The soot was also extremely sensitive to abrasion, and extensive loss could occur with a light touch. With the knowledge gained from making the samples, a better understanding of Bontecou's technique was possible.

Bontecou created some of the soot drawings in a careful build-up of layers, reserving the highlights in some areas and allowing a heavy layer of the fluffy soot to form in others. She maintained very good control of the torch and could achieve the effects she desired easily. Bontecou used masks to help protect lighter sections from accidental deposition of soot, which were taped down to the surface of the drawing (Bontecou 2007). Two soot drawings, one from LACMA and one in a private collection, have pressure-sensitive tape residues along the edge; it is possible that these are the remnants of a mask. Bontecou also used fixative between the layers of soot to help protect the lighter areas and stabilize the darker areas. The final layer of soot would remain unfixed in order to preserve the velvety, matte texture of the soot.

Tack holes along the margin are evidence that the artist secured her paper while drawing with the torch. The tack head protected the paper beneath it, resulting in less soot being deposited and a lighter spot. An early photograph from the artist's Rome studio shows soot drawings tacked to the wall, although she could have put them up for display. When discussing the matter with Bontecou, she could not say specifically if she worked horizontally or vertically. Bontecou also spoke about the effects that she could obtain by holding

Fig. 3. Making soot samples with oxy-acetylene welding torch

the torch beneath the drawing and allowing the soot to blow upwards (Bontecou 2007). The language that she used also indicates that the drawing may have been vertical at the time.

The majority of Bontecou's early soot drawings from 1958 are composed only of soot. The range of color obtained is very impressive as are the different surface textures that she produced. For example, there is a light brown that is the result of very little soot deposition and smaller agglomerates. A cool blue gray with a slightly graphitic sheen occurs when she has rubbed or burnished the surface. In some areas a speckling of the soot is apparent that occurred during the application. The deep black is a much more three-dimensional layer; it is extremely matte and reminiscent of velvet. The underlayer of blacks that was fixed appears significantly less saturated than the unfixed top layer and reads as lighter in value.

The careful layering is an additive technique, but Bontecou also used a subtractive method. She would lay down a heavy layer of soot and then work back into it. The soot layer would not cover the entire surface of the paper support. The major components of the composition would be blocked out with the torch and then intricate details scraped in. With a variety of tools, the artist would remove soot, sometimes only the top layer, and at others scraping all the way down to the paper surface and disrupting fibers. Bontecou recalls using a brush to remove the soot (Bontecou 2007), and it is evident that she also used razors and her hands to further manipulate the medium. The MoMA drawing (fig. 4) is an example of the subtractive technique; here, Bontecou has removed the majority of the soot with razors, patterning the surface with staccato scraping. Only in one drawing from this series, at the Knoedler Gallery in New York, has she added other media. The drawing is in the subtractive technique with extensive working of the soot layer. Charcoal and black ink lines have been drawn in to continue the scratched lines in the soot (fig. 5).

Fig. 4. Lee Bontecou, *Untitled*, c.1958, soot on paper, 76.2 x 101.6 cm. Judith Rothschild Foundation Contemporary Drawings Collection, Museum of Modern Art, TR12112.253

Fig. 5. Detail of Lee Bontecou, *Untitled,* c. 1958, soot on paper, 68.6 x 99.1 cm. Collection of the artist, Knoedler Gallery

All of the soot drawings examined were dated 1958 or "c. 1958," so establishing a chronology is somewhat difficult. It is possible that Bontecou started with the subtractive technique, and then, as she became more adept at controlling and manipulating the torch, moved on to the additive technique. She may have stopped relying on tools to rework the surface and been able to use the torch to achieve the effects she desired.

ANALYSIS

Some instrumental analysis was done in order to better understand how the soot interacted with the paper support and to answer questions about display, handling, and storage.

The soot samples were initially examined with a stereobinocular microscope. Under magnification, the soot appeared as a continuous coating. In the lighter areas of application shown in figure 6, the soot barely covers the paper fibers. In the midtones (fig. 7) the soot completely coats the fibers, but the structure of the fiber network is still evident. The deep blacks are three-dimensional; the soot has built up to such a degree that the paper fibers are no longer visible as in figure 8.

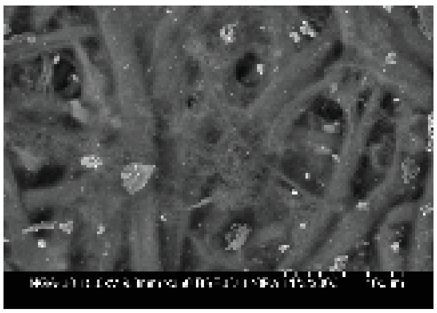
Scanning electron microscopy (SEM) was performed on the prepared samples to try to further resolve the interaction between the soot and fibers. Individual soot particles are too small to be captured with SEM, but images are possible with transmission electron microscopy (TEM). Images of individual carbon black particles can be found in the technical literature (Hess and Herd 1993) so it was not thought necessary to try and discern the individual particles. As seen in figure 9, the paper fibers are coated with soot, which appears as a diaphanous layer on the fibers. When compared with the control paper sample in figure 10, it is apparent how completely the soot covers the paper fibers, penetrating into the interstices of

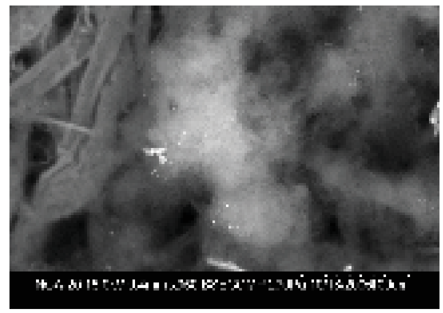


LEFT TO RIGHT

Figs. 6–7. Photomicrograph of soot sample, 100x, polarizing light microscope

Fig. 8. Photomicrograph of soot sample, 25x, stereo-binocular microscope





Figs. 9–11. Photomicrograph of soot sample, 350x, scanning electron microscope

the fiber network. Figure 11 shows the soot agglomerates in an area of very heavy application. The large soot agglomerate rests lightly on the surface of the paper fibers; it becomes clear how very little mechanical action would easily remove the larger agglomerates.

One of the most interesting things about soot was that while it was incredibly sensitive to touch, it was remarkably stable to shock. When the samples were held over a white sheet of paper facedown and tapped forcefully on the verso, no loss occurred. The most heavily coated samples were selected, with very large soot agglomerates, and after tapping, some eventually fell off. The majority of the soot was stable to shock; only the largest agglomerates proved vulnerable. This is where the ability of carbon to hold a charge becomes evident. The attraction between the soot particles and the paper fibers is so great that it can overcome the effect of some shock. While soot certainly appears to be more stable than pastel to shock, it is still a particulate material and should be treated with care. One of the drawings in a private collection did have a few deposits of what appeared to be soot on the window mat bevel, indicating that losses may be possible.

There was some concern that the organic components of the soot might be susceptible to fading. The microfading tester was selected to gauge the light sensitivity of the soot. Rather than unframing the sensitive drawing for testing, the prepared samples were used in its place. Different colors and applications of the soot were tested, from light brown to black. All of the samples exhibited no change; generally, if a substance is light sensitive, some fading will occur. The soot, therefore, was very stable and not fugitive. The Bontecou drawings are fixed, so it is possible that the fixative may yellow slightly with light exposure.

A small sample from the darkest black area was tested with Fourier transform infrared reflectometry (FTIR) with attenuated total reflectance (ATR) in an attempt to determine the fixative used. In 1958, acrylic fixatives had been introduced to the market, but earlier fixatives, like nitrocellulose and shellac, were still in use (Ellis 1996). Bontecou remembers using a mouth-blown atomizer to apply the fixative and that it had a terrible taste, but she does not recall the brand that she used. Currently she uses matte spray fixative, which has an acrylic base (Bontecou 2007). The results from the ATR FTIR were inconclusive; the weak peaks observed could not be definitively attributed to a specific fixative. Bontecou has experimented with new materials and techniques throughout her career, and so it seems possible that she might have adopted the new acrylic fixatives early on.

TREATMENT

With the information gained from the mockups, analysis, and examination of other Bontecou drawings, it was possible to proceed with the treatment phase of the project. Overall the drawing was in very good condition, considering the fragility of the medium. The drawing was received matted and framed. Japanese paper hinges were located along the top and sides. The hinges were not released because the current matting was of good quality, and the treatment did not require access to the verso. Examination of the verso, therefore, was not possible. Numerous scratches, fingerprints, and small abrasions were present along the perimeter, especially along the right and left edges. An area of burnishing or erasure was in the middle of the left edge. The long vertical scratch passed through several different applications of the soot near the center of the right side. After consulting with the curator, it was decided to inpaint the areas of loss within the vertical scratch to minimize its appearance.

When discussing the drawings with Bontecou, she explained how she had retouched them herself occasionally. Again using masks to protect lighter or undamaged areas, she would go over the damage with the welding torch (Bontecou 2007). Given the nature of the soot, this method would only have worked well on the unfixed, heavily applied layers, and would not have been effective on the scratch in question. The vertical nature of the scratch, and its location in the lighter areas of application would have made retouching with the torch nearly impossible. Retouching with the torch would also cover undamaged parts of the drawing, which would be unacceptable for ethical reasons.

To test inpainting materials, the soot samples were scratched to replicate the damage. Watercolor, dyes, acetylene soot, and powdered pigments were all tested on the samples. Watercolor and dyes proved to have too much surface gloss, and the acetylene soot collected from the samples held such a static charge that it would not release from the brush. Powdered pigment applied with a brush was the most effective, especially in the lighter areas of soot. To achieve the look of the darker areas, wetting of the powdered pigment with a small amount of ethanol was necessary to obtain the right depth of color. Trying to apply the pigment, however, was problematic. Any attempt to touch the soot on the mock-ups resulted in further loss. In fact, the charged soot particles could be chased away with the dry brush, without even touching the particles directly. In order to disperse the charge, a very fine line of water was painted just shy of the edge of the loss. The inpainting material could then be applied and would flow up to the edge of the water line.

For the treatment of the drawing, dry powdered pigments applied with a brush were sufficient and the wetting of the pigments was not necessary. The majority of the damage occurred in the lighter areas. By breaking up the line of loss, its appearance was greatly diminished and no longer visually distracting (fig. 12). Ivory black and raw umber were the best color matches. Once the large scratch was diminished, the smaller scratches at the sides gained prominence and the curator found them to be distracting. A few of the scratches on the right and left side were then inpainted. Although the lower layers of the drawing were fixed, the top layer of deep black was not, so extreme care was taken not to disturb it.

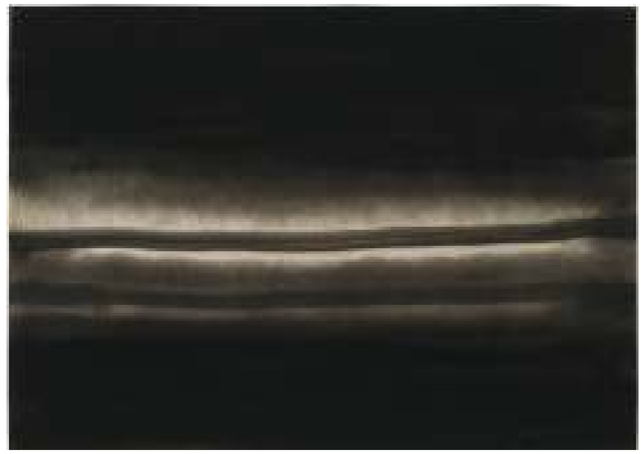


Fig. 12. After treatment, Lee Bontecou, *Untitled*, 1958, acetylene soot on paper, 70.0 x 99.8 cm. Promised gift, Department of Visual Services, National Gallery of Art, Washington DC, 130745

During treatment, the accumulation of dust and fibers on the surface of the drawing became problematic. Due to the sensitivity of the medium, it was desirable to have the treatment proceed as quickly as possible, and not leave the drawing unframed and vulnerable for a prolonged period of time. The drawing was covered at all times, except when it was being actively worked on. Even during the relatively short period of time that the drawing was uncovered, dust and fibers collected on the surface. The large dust particles and light colored fibers that landed on the drawing stood out quite clearly. The largest particles and fibers were removed with a small, pointed rubber artist's tool. The charged dust particles would leap off of the surface of the drawing and onto the rubber tool. Lightly rubbing the tool on cloth built up enough of a charge to overcome the attraction between the dust and the soot and attract the dust to the tool instead. The dust was removed without having to touch the delicate surface of the drawing, by overcoming the static charge that held the dust to the soot.

The fact that Bontecou used fixative on her drawings greatly adds to their stability, but it should always be kept in mind that the top layer is unfixed and vulnerable. The drawing is unframed only when absolutely necessary, and it is stored framed and shipped in a double crate when it travels. When asked how she had shipped the drawings back to the U.S., Bontecou replied that she had interleaved them with paper and rolled them up. Retouching with the torch and masks had been necessary upon her return to the New York (Bontecou 2007). Although the drawings are in good condition overall, it is due in part to their maintenance by Bontecou.

CONCLUSION

Bontecou's willingness to experiment and innovate was evident early in her career when she began using the welding torch to create drawings. These drawings are unique works of art with specific characteristics that are unlike traditional drawing media. Despite soot's sensitivity to abrasion, a property that it shares with pastel and charcoal, soot is much more stable to shock than other friable media. As artists continue to innovate and experiment, the resulting art works will continue to pose new questions and challenges to conservators.

ACKNOWLEDGMENTS

Special thanks to the paper lab at the National Gallery of Art for all of their support and advice, especially Kimberly Schenck and Marian Dirda, and thanks to Christopher Maines and Michael Palmer of the scientific research department for their expertise in running and interpreting the instrumental analysis. I would also like to thank the helpful staff at MoMA, LACMA, and Knoedler Gallery, and the private collectors who opened their homes to me. Sincere thanks to Mr. Tony Ganz for his assistance. I appreciate the support of the Andrew W. Mellon Foundation, which funded my fellowship and this research project.

ANALYTICAL TECHNIQUES

Microscopy

The samples were examined with a Leica DMRX polarizing light microscope equipped with a Canon EOS-1 Ds Mark II digital camera.

SEM

The samples were examined with a Hitachi S3400-N scanning electron microscope fitted with an Oxford ATW2 Si(Li) detector and the INCA 300 energy dispersive spectroscopy analysis system. Analysis was carried out at a working distance of 10 mm and with an accelerating voltage of 20 eV.

ATR FTIR

The sample was analyzed using a Fourier-transform infrared Thermo Nicolet Nexus 670 FT-IR Bench equipped with a Spectra-Tech Continuum IR Microscope both by transmission through a single diamond cell window and by reflectance using an attenuated total reflectance accessory (ATR-FTIR). The microscope has a liquid nitrogen-cooled MCT-A detector (11,700–600 cm^{-1}) and a 15X infinity-corrected Reflachromat objective fitted with an adapter for a slide-on ATR Si crystal. 512 scans at 8 cm^{-1} resolution were collected using Nicolet OMNIC version 7.4. Spectral searching was done using OMNIC and the Infrared Users' Group (IRUG) libraries.

REFERENCES

Bontecou, L. 2007. Personal communication. Knoedler Gallery, New York, New York.

Donnet, J.B., and R. C. Bansal. 1993. *Carbon black: Science and technology.* New York: Marcel Dekker, Inc.

Duncan, M. 2004. Catching up with Bontecou. *Art in America* 92(6): 150–9.

Ellis, M. H. 1996. The shifting function of artists' fixatives. *Journal of the American Institute for Conservation* 35 (3): 239–54.

Hadler, M. 1992. Lee Bontecou: Heart of a conquering darkness. *Source: Notes in the History of Art* 12 (Fall): 38–44.

——. 1994. Lee Bontecou's "Warnings". *Art Journal* 53 (4): 56–61.

——. 2003. Lee Bontecou's Worldscapes. In *Lee Bontecou: A Retrospective*, ed. E.A.T. Smith, 200–11. Chicago: Museum of Contemporary Art.

Hess, W. M., and C. R. Herd. 1993. Microstructure, morphology and general physical properties. In *Carbon black: Science and technology,* 89–173. New York: Marcel Dekker, Inc.

Kuhner, G., and M. Voll. 1993. Manufacture of carbon black. In *Carbon black: Science and technology,* 1–66. New York: Marcel Dekker, Inc.

Mitchell, C.A. 1937. *Inks: Their composition and manufacture.* London: Charles Griffin & Company, Ltd.

Roberts, B., et al. 1988. An account of the conservation and preservation procedures following a fire at the Huntington Library and Art Gallery. *Journal of the American Institute for Conservation* 27 (1): 1–31.

Smith, E.A.T. 2003. All freedom in every sense. In *Lee Bontecou: A retrospective*, ed. E.A.T. Smith, 168–181. Chicago: Museum of Contemporary Art.

Spafford-Ricci, S., and F. Graham. 2000. The fire at the Royal Saskatchewan Museum: Part 2: removal of soot from artifacts and rediscovery of the building. *Journal of the American Institute for Conservation* 39 (1): 37–56.

Winter, J. 1983. The characterization of pigments based on carbon. *Studies in Conservation* 28 (2): 49–66.

Winter, J., and E. West FitzHugh. 2007. Pigments based on carbon. In *Artists' Pigments: A handbook of their history and characteristics,* vol. 4, ed. B. Berrie, 1–37. Washington: National Gallery of Art.

LINDA OWEN
Andrew W. Mellon Fellow in Paper Conservation
The National Gallery of Art
Washington DC
limowen@yahoo.com