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by John Powers

Abstract: This article provides a history of low-budget optical printing in avant-garde cinema. Drawing on archival research to trace its path from its innovation in do-it-yourself amateur filmmaking circles to its diffusion in filmmaking cooperatives and universities, the article argues that optical printing represents an instance of a semiprofessional network of advanced amateurs, hobbyists, and artists repurposing a commercial technology for their own ends. In addition to shifting the avant-garde's investment in perceptual transformation from in-camera effects to post hoc manipulation of footage, optical printing became a cultural resource that avant-garde filmmakers could use to reimagine their relationship with their materials and mobilize in relation to their practice.

During the 1970s and 1980s, avant-garde filmmakers mastered a device traditionally used for Hollywood special effects work: the optical printer. A complex apparatus that allows for duplication of film through rephotography, the optical printer contributed to a shift in emphasis from the camera-bound spontaneity of shooting to the analytical revisionism of postproduction, as filmmakers transformed their images with unprecedented levels of control. Some used the printer functionally to achieve very specific effects, while others became virtuosos whose films depended on a thorough understanding of the device's possibilities. Soon, the optical printer became a mainstay of MFA programs and filmmakers' cooperatives, as fundamental to avant-garde practice as Bolex cameras and reversal film stocks. Surveying the previous decade, P. Adams Sitney concluded: "Just as rapid editing with invisible splice marks had, for many filmmakers, become a mark of aesthetic authority in the early sixties, optical printing represented technical mastery in the seventies."[1]

Despite the optical printer's importance for multiple generations of filmmakers, we lack a historiographical account of its role within avant-garde cinema.[2] In recent years, the work of scholars such as Scott MacDonald, Michael Zryd, and

1 P. Adams Sitney, "*Saugus Series*," *Millennium Film Journal* 16–18 (Fall 1986–Winter 1987): 158.

2 Kathryn Ramey offers a brief, production-oriented account in *Experimental Filmmaking: Break the Machine* (Burlington, MA: Focal Press, 2015), 71–73.

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Erika Balsom has signaled an "institutional turn" in avant-garde film scholarship, illuminating neglected topics like distribution, exhibition, and the relationship between the avant-garde and academia.[3] This article contributes to such development by arguing that filmmaking technologies were an essential locus for the material, cultural, and discursive self-definition of the avant-garde. Additionally, Gregory Zinman and Julie A. Turnock have examined the avant-garde's influence on commercial special effects, charting the ways in which experimental filmmakers have shaped blockbuster aesthetics through handmade processes and composite mise-en-scène.[4]

Turnock offers the most extensive treatment of optical printing in the avant-garde, so the differences between our approaches deserve comment. Turnock's interest is in a particular subset of West Coast experimental filmmakers and their contributions to the blockbuster aesthetics of the 1970s. She notes that CalArts served as a training ground for cutting-edge optical printing techniques, arguing persuasively that artists like Pat O'Neill, John and James Whitney, and Betzy Bromberg taught filmmakers like George Lucas and Steven Spielberg "strategies for organizing and mobilizing the elaborately designed composite mise-en-scène."[5] Although Turnock's account is definitive, it focuses on a geographically specific minority of avant-garde filmmakers who, though influential, were not especially representative of avant-garde optical printing overall. Furthermore, Turnock's goal is to explain the influence of the avant-garde on blockbuster filmmaking, not to examine the role of optical printing within the avant-garde itself, which was more varied than the composite mise-en-scène that dominated the West Coast milieu. In this article, I take the opposite approach, locating avant-garde optical printing within advanced amateur, semiprofessional, and experimental film discourses, where it was framed as a more low-budget, do-it-yourself endeavor.[6] Ultimately, I argue that optical printing provides a remarkable example of artists, machinists, and hobbyists assimilating a commercial technology and repurposing it as a cultural resource for their own aesthetic and political ends.

3 See Scott MacDonald, ed., *Cinema 16: Documents toward a History of the Film Society* (Philadelphia: Temple University Press, 2002); Scott MacDonald, ed., *Art in Cinema: Documents toward a History of the Film Society* (Philadelphia: Temple University Press, 2006); Michael Zryd, "The Academy and the Avant-Garde: A Relationship of Dependence and Resistance," *Cinema Journal* 45, no. 2 (2006): 17–42; Scott MacDonald, ed., *Canyon Cinema: The Life and Times of an Independent Film Distributor* (Berkeley: University of California Press, 2008); Michael Zryd, "Experimental Film and the Development of Film Study in America," in *Inventing Film Studies*, ed. Lee Grieveson and Haidee Wasson (Durham, NC: Duke University Press, 2008), 182–216; Steve Anker, Kathy Geritz, and Steve Seid, eds., *Radical Light: Alternative Film and Video in the San Francisco Bay Area, 1945–2000* (Berkeley: University of California Press, 2010); Erika Balsom, *Exhibiting Cinema in Contemporary Art* (Amsterdam: Amsterdam University Press, 2013); Scott MacDonald, ed., *Binghamton Babylon: Voices from the Cinema Department, 1967–1977* (Albany: SUNY Press, 2015); and Erika Balsom, *After Uniqueness: A History of Film and Video Art in Circulation* (New York: Columbia University Press, 2017).

4 See Gregory Zinman, "The Right Stuff? Handmade Special Effects in Commercial and Industrial Film," in *Special Effects: New Histories, Theories, Contexts*, ed. Dan North, Bob Rehak, and Michael Duffy (London: British Film Institute, 2015), 224–240; and Julie A. Turnock, *Plastic Reality: Special Effects, Technology, and the Emergence of 1970s Blockbuster Aesthetics* (New York: Columbia University Press, 2015).

5 Turnock, *Plastic Reality*, 152.

6 I borrow the term "advanced amateur" from Charles Tepperman, *Amateur Cinema: The Rise of North American Moviemaking, 1923–1960* (Oakland: University of California Press, 2015), 1–2, to refer to the technologically and aesthetically sophisticated branch of filmmakers who participated in the Amateur Cinema League and were active in or targeted by amateur cinema-related discourses.

The technological history of the avant-garde is difficult to document. Because technology is a more diffuse phenomenon than a distribution cooperative or exhibition venue, sources are dispersed, and crucial information is often recollected in passing by filmmakers in interviews or oral histories. Furthermore, most low-budget film technologies were not specific to the avant-garde but were developed for the commercial, industrial, and amateur markets. These markets were less coordinated than the Hollywood studio system, where technological innovation tended to be systematized for efficiency. Therefore, the regulatory mechanisms that provide coherence to histories of studio technology (as well as key concepts such as product differentiation and standards of quality) are either nonexistent or more nebulous when applied to the avant-garde.[7] As Charles Tepperman observes, amateur film technology is "a story of nonstandardization," which makes it incumbent upon the historian to be especially sensitive to its nonlinearity and the variety of cultural, ideological, and aesthetic determinants that inform its development.[8] Moreover, avant-garde filmmakers were inventing new technologies, repurposing or reconfiguring existing technologies, and using commercial technologies against their intended uses, sometimes all at once. Keeping this complex set of negotiations in mind, my account is based on a survey of periodicals, newsletters, and technical advice columns that circulated among the avant-garde filmmaking community, most notably *Filmmakers Newsletter* and *Canyon Cinemanews*. This research is supplemented with documents from various archives, including the James Stanley Brakhage Collection, as well as personal interviews with filmmakers and technicians.[9]

Institutional histories of the avant-garde emphasize its autonomy from, and opposition to, the studio system. P. Adams Sitney's claim that the avant-garde and commercial cinema "operate in different realms with next to no significant influence on each other" alludes to the fact that the avant-garde was often forced to build its own infrastructure for distribution, exhibition, and criticism.[10] In what follows, I argue that avant-garde filmmaking technology was imbricated in a semiprofessional network of advanced amateurs, tinkerers, hobbyists, and technology enthusiasts who capitalized on the influx of 16mm film equipment that flourished after World War II.[11] As a product of this networked affiliation, low-budget optical printers represent instances

7 Production efficiency, product differentiation, and standards of quality are concepts applied to technological innovation in Hollywood in David Bordwell, Janet Staiger, and Kristin Thompson, *The Classical Hollywood Cinema: Film Style & Mode of Production to 1960* (New York: Columbia University Press, 1985), 243–247.

8 Tepperman, *Amateur Cinema*, 98.

9 The scope of this article is limited to the American context. Of course, there is a rich international history of optical printing, especially in Europe. Famously, the pioneering films of Malcolm Le Grice, Guy Sherwin, and others at the London Film-Maker's Co-op, as well as the acclaimed work of Austrian filmmakers such as Martin Arnold and Peter Tscherkassky, are only the best-known exemplars of European optical printing.

10 P. Adams Sitney, *Visionary Film: The American Avant-Garde* (New York: Oxford University Press, 1974), viii. For the counterargument that avant-garde cinema exists in dialectical relationship to Hollywood, see David E. James, *The Most Typical Avant-Garde: History and Geography of Minor Cinemas in Los Angeles* (Berkeley: University of California Press, 2005), 11–19.

11 Although none of the essays discusses optical printing, some of this history shares an affinity with the institutional, educational, and technological contexts elaborated in the essays in Charles R. Acland and Haidee Wasson, eds., *Useful Cinema* (Durham, NC: Duke University Press, 2011).

of filmmakers and technicians reimagining the advertised capacities of commercial filmmaking technologies as technical and cultural resources that could be alternately embraced, elaborated on, challenged, or rejected. Consequently, I trace the path of the optical printer from its innovation in do-it-yourself (DIY) amateur filmmaking circles to its diffusion in filmmaking cooperatives and universities, where it became a standard component of the avant-garde filmmaking curriculum in the 1970s and 1980s.

Additionally, I claim that the widespread adoption of the optical printer influenced filmmaking aesthetics, as the avant-garde's long-standing investment in perceptual transformation shifted from in-camera effects to post hoc manipulation of footage. Emboldened by the Bolex H16 camera, the first-generation postwar avant-garde relied heavily on in-camera techniques such as superimposition, slow and fast motion, and pixilation, as exemplified by films such as *The Cage* (Sidney Peterson, 1947) and *Go! Go! Go!* (Marie Menken, 1962–1964). For later generations, the optical printer refigured the process of shooting as gathering raw material to be revised later. Images became susceptible to rhythmic alteration, repetition and multiplication, and being slotted into grids, composited with other images, or used in conjunction with techniques like hand processing and backlighting (see Figure 1). Furthermore, avant-garde optical printing is more diverse than usually assumed, as the device proved equally useful for poetic transformation, Structural film strategies, found-footage deconstruction, and other formal operations. These tendencies persisted in the digital era, when the visual vocabulary of optical effects became incorporated into nonlinear editing systems and visual effects software.

Figure 1. An optically printed shot of filmmaker Barbara Hammer at work on her JK optical printer (*Endangered*, 1988). Image courtesy of Barbara Hammer.

The relationship between technology, aesthetics, and discursive self-definition in the avant-garde raises substantial questions about degree of influence in positing causal determinants for filmmaking practice. The most common explanatory forces for experimental filmmaking aesthetics are typically conceptual paradigms borrowed from adjacent arts, such as abstract expressionism, pop art, serial music, or collage. In this article, I argue that technology is as proximate an influence, and that understanding the history of optical printing contributes to a more nuanced sense of visual style in a wide variety of avant-garde films as well as the cultural contexts that informed the development of the postwar experimental film as an established mode of film practice. That said, it is imperative for scholars to avoid technologically deterministic accounts and maintain sensitivity to alternate inputs, especially when confronted with the heterogeneity of avant-garde filmmaking practice, where it is impossible to separate aesthetics and technology from intermedial, discursive, and cultural topographies. Within the avant-garde, technology often sets limitations and possibilities for formal

operations, but these are in turn shaped by other artistic and cultural imperatives. This article isolates one parameter, arguing for the importance of technology while remaining sensitive to the complex interplay of factors that shape film aesthetics.

Perhaps the most acute conceptual dynamic in the relationship between technology and avant-garde filmmaking practice is that of constraint and potentiality. As any survey of interviews or artist statements will attest, avant-garde filmmakers often claim to use technological constraints as productive generators for films or ideas for films. This is especially pertinent with optical printing, where the transaction between concept and realization and the filmmaker's physical and mental engagement with the material constraints of the technological apparatus become productive elements. "Constraint," however, carries a negative valence, suggesting that the technology furnishes a set of impositions that the artist struggles heroically to overcome, reinscribing Romantic paradigms that posit the avant-garde filmmaker in unqualified opposition to commercial culture. Undoubtedly, some of the pleasure of avant-garde cinema is the ingenious use and misuse of technology, as the films display an imaginative set of formal strategies for exploiting the technology's built-in limitations. As this article aims to demonstrate, however, optical printing was more accurately a productive means of opening up the filmmaking process, exploring the possibilities of delving into an image, and theorizing a conceptual relationship to technology that could reimagine cinema's potential.

Early Experiments. An optical printer is a device on which film is rephotographed one frame at a time. As opposed to contact printing, whereby film is copied by holding two strips of film together, the defining characteristic of optical printing is separation. At its most basic, an optical printer consists of four principal components: a camera with an attached lens system, a projector, and a light source. The projector and camera face each other. Previously exposed film advances through the projector gate, where it is illuminated by the light source and rephotographed by the camera. Although commonly referred to as a "projector," the original film isn't projected in the ordinary sense; it is more accurate to think of the projector as a light box over which film advances at regular intervals. The chief advantage of the system is that it permits a wide variety of manipulation of the original image during the rephotography process. Images can be sped up, slowed down, reframed, alternately lit and colored, or composited with other images in complex ways. In conjunction with techniques like painting, dyeing, or bleaching the film, the printer becomes capable of qualitatively transforming the image.[12]

Although its fortunes waxed and waned, optical printing was available to the Hollywood studios as early as the 1920s, when new fine-grain, low-contrast film stocks were introduced, allowing for duplication without dramatic image degradation.[13]

12 For an excellent technical primer on DIY optical printing, see Ramey, *Experimental Filmmaking*, 69–112, 233–282.

13 See Herfrod Tynes Cowling, "For Trick Work, Mr. Fred A. Barber Announces the Perfection of a Wonderful New Optical Printer," *American Cinematographer* 8, no. 12 (March 1928): 7, 22, 24; and Carl Louis Gregory, "An Optical Printer for Trick Work," *Journal of the Society of Motion Picture Engineers* 12 (April 1928): 419–426. The link between new film stocks and optical printing is made in Barry Salt, *Film Style and Technology: History and*

Throughout the following decade, the studios built their own makeshift printers, often assembled from discarded photographic equipment and catering to the individual needs of specific projects. Optical printing received a degree of notoriety in the industry as a result of the pioneering work of Linwood Dunn, who was in charge of the optical effects department at RKO, where he worked on films such as *King Kong* (Merian C. Cooper and Ernest B. Schoedsack, 1933) and *Citizen Kane* (Orson Welles, 1941). Optical printers were primarily used for compositing material shot separately into a single frame, usually as traveling mattes—prototypical examples include Katharine Hepburn interacting with a leopard in *Bringing Up Baby* (Howard Hawks, 1938) and the dramatic deep-space composition of Charles Foster Kane discovering Susan's body after her attempted suicide.[14] In 1944, Dunn and his colleague Cecil Love developed a printer for Eastman Kodak to service the US Armed Forces Photographic Units. The result, the Acme-Dunn optical printer, quickly became the standard for Hollywood special effects.[15] In 1957, a competing model, the Oxberry optical printer, was introduced.[16]

In the realm of avant-garde filmmaking, however, optical printing remained a minority practice. Most prohibitive was the exorbitant expense of such a massive, mechanically complex piece of equipment. When the Acme-Dunn printer debuted in 1944, it sold for $25,000 (roughly $350,000 in 2018 dollars), far beyond the reach of any individual filmmaker; by 1975, the cost was closer to $100,000 (approximately $455,000 in 2018 dollars).[17] Furthermore, an infrastructure that would allow avant-garde filmmakers access to expensive equipment did not begin to emerge until the late 1960s. In the absence of artist cooperatives or film production departments in universities, where member donations or academic budgets could be allotted for shared equipment, avant-garde filmmakers were left to execute most of their effects in-camera or at the lab. Of course, a filmmaker could build his or her own optical printer, but this was easier in theory than in reality. At the very least, one would need a camera augmented by bellows attachments or extension tubes, a projector capable of advancing one frame at a time, and a light source bright enough for illumination but cool enough that it would not burn the film in the gate. Lining up the camera precisely with the projector's aperture, keeping the entire apparatus steady, and ensuring proper

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Analysis, 2nd ed. (London: Starword, 1992), 210; and George E. Turner, "The Evolution of Special Visual Effects," in *The ASC Treasury of Visual Effects*, ed. George E. Turner (Los Angeles: ASC Holding Co., 1983), 48–49.

14 In 1934, Dunn wrote the most detailed and widely circulated article on optical printing in the industry. See Linwood Dunn, "Optical Printing and Technique," *American Cinematographer* 14, no. 12 (March 1934): 444–446, 470–471. Another Dunn article from this period is "Tricks by Optical Printing," *American Cinematographer* 15, no. 1 (April 1934): 487, 496. Turnock discusses Dunn's influence on the 1970s generation in *Plastic Reality*, 95–98.

15 "The New Acme-Dunn Optical Printer," *American Cinematographer* 25, no. 1 (January 1944): 11, 29; "Historic Facts about the Acme-Dunn Optical Printer," *American Cinematographer* 62, no. 5 (May 1981): 479. Dunn won an honorary Academy Award for the printer in 1980.

16 Interestingly, Julie A. Turnock notes that studios turned away from optical printing in favor of process photography around the time that the Acme-Dunn debuted. See Turnock, *Plastic Reality*, 37. For information on the Oxberry printer, see Vern Palen, "A Newly Designed Optical Printer," *Journal of the Society of Motion Picture Engineers* 67 (February 1958): 98–102.

17 "Developers of Optical Printer Win Oscar for Special Effects," *New York Times*, April 3, 1981, D5.

registration were constant technical struggles. For this reason, most homemade printers were DIY affairs, lacking the finesse and polish of their professional counterparts. Even as late as 1975, the author of a how-to article for amateurs on building an optical printer damns his own creation with faint praise: "As an optical printer the device is primitive, but it works as long as you're careful."[18]

Despite these difficulties, a few of the more technologically inclined filmmakers succeeded in building their own printers. Using a lathe as a base, James Sibley Watson Jr. made his own optical printer for *Lot in Sodom* (codirected with Melville Webber, 1933), where it was used for a series of lengthy dissolves that effectively function as multiple superimpositions (see Figure 2). These lap dissolves were so impressive as to be focal points for praise from critics, who noted that the effects were advanced enough to surpass the "best achievements of the professional screen."[19] Interestingly, the technique was sufficiently novel in 1933 that even sophisticated critics could not determine how the film was made. Writing in *Film Art*, a British journal, the critic Leonard Hacker noted that the superimpositions were both the most interesting and the most mysterious aspect of the film: "Its chief distinction is the use of the 'Dissolve' harmonizing mobile forms one into the other, akin to the 'Lap-Dissolve' but employing a method still unexplained."[20]

Figure 2. "Lap dissolves" made on a homemade optical printer in James Sibley Watson Jr. and Melville Webber's *Lot in Sodom* (1933; Kino International, 2005).

Later in the decade, John Whitney designed an optical printer for 8mm on which he and his brother, James, made their first film, *Twenty-Four Variations on an Original Theme* (1939–1940). The brothers used a stencil-and-airbrush technique to create hundreds of patterned file cards, which were photographed in succession. This black-and-white film was later "colorized" by rephotographing the cards onto color film stock on the optical printer. Shortly thereafter, Whitney secured a loan for a Kodak Cine Special 16mm camera, which he combined with an Eastman projector to make an upgraded optical printer. It was on this printer that the brothers made *Five Film*

18 L. Bruce Holman, "Build an Optical Printer," *Filmmakers Newsletter* 8, no. 8 (June 1975): 44.

19 Leonard Hacker, "*Lot in Sodom*," *Film Art* 1, no. 3 (1934): 23.

20 Hacker, "*Lot in Sodom*," 23. See also Lisa Cartwright, "U.S. Modernism and the Emergence of 'The Right Wing of Film Art': The Films of James Sibley Watson, Jr. and Melville Webber," in *Lovers of Cinema: The First American Film Avant-Garde, 1919–1945*, ed. Jan-Christopher Horak (Madison: University of Wisconsin Press, 1995), 156–179. Filmmaker Barbara Hammer also documented Watson's optical printer in her video *Watson's X-Rays* (1991). The device itself is on display at George Eastman House in Rochester, New York.

Exercises (1943–1944). For these short animated experiments, the brothers took single-frame exposures of paper cutouts changing shape in conjunction with a pantograph machine. Using this footage as raw material, the shapes were rephotographed on the printer, where, according to John Whitney, "[w]e could exert another level of editorial or creative control and generate permutations of [a given shape], variations on [the shape], and juxtapositions of it over itself. We also took advantage of the fact that we could invert the film so we'd have the same image upside-down, and we could flop the film so we'd have the same image mirrored, and we could run the film forwards or backwards throughout optical printing."[21]

Inspired by the Whitneys, the visual music artist Hy Hirsh built an optical printer by hand, on which he helped Harry Smith step print (i.e., decelerate motion by rephotographing each frame multiple times) the first few of his handmade *Early Abstractions* (1946–1949), which obviated the necessity of commissioning the lab, where Smith feared that the laboriously worked 16mm filmstrips would be damaged. Hirsh, who had been a cinematographer for Columbia Pictures in the 1930s, had established a reputation in the Bay Area as a technical expert. In addition to his printer, he developed an "oil wipe" process similar to that of the Whitneys and experimented with oscilloscope technology, earning him, according to William Moritz, the title of "*bricoleur*: someone who can make everything himself."[22] He was also generous with his knowledge, providing technical assistance for nearly all the West Coast avant-garde filmmakers, including Jordan Belson, Frank Stauffacher, Patricia Marx, Larry Jordan, and James Broughton.[23]

The Whitneys and Hirsh shared affinities with a branch of advanced amateur filmmakers who could be appropriately described as semiprofessional technology enthusiasts. As Tepperman has argued, the gap between amateur and professional filmmaking narrowed in the postwar years, as amateurs strived for greater degrees of sophistication and associated more freely with the burgeoning spheres of experimental, nontheatrical, and independent film production.[24] This loose affiliation of amateur filmmakers was also characterized by a willingness to experiment with different technologies. Tepperman notes that "amateur cinema provided opportunities for individuals to engage productively with machines and to adapt the use of these machines to individual—expressive, artistic, familial—objectives."[25] The results of this experimentation varied, but the desire to adapt professional technologies for the amateur market, from sound to color to widescreen and 3D moviemaking, was pursued with increased vigor.

21 Richard Brick, "John Whitney Interview," *Film Culture* 53–55 (Spring 1972): 39–40. All the information about the Whitneys' optical printers is culled from this interview.

22 William Moritz, "Harry Smith, Mythologist," in *Harry Smith: The Avant-Garde in the American Vernacular*, ed. Andrew Perchuk and Rani Singh (Los Angeles: Getty Research Institute, 2010), 65.

23 The most detailed description of Hirsh's work in film is Dennis Reed, "Hy Hirsh: Experiments in Filmmaking and Photography," in *Hy Hirsh / Color Photography*, ed. Paul Hertzmann (San Francisco: Paul Hertzmann, 2008), http://www.hertzmann.net/pages/catalogs/79.pdf.

24 Tepperman, *Amateur Cinema*, 142–148. See also Patricia Zimmermann, *Reel Families: A Social History of Amateur Film* (Bloomington: Indiana University Press, 1995), 112–121.

25 Tepperman, *Amateur Cinema*, 99.

While undoubtedly a minority, advanced amateurs—many of whom operated outside of avant-garde film circles—began to show some interest in building their own optical printers throughout the 1950s. In 1959, *American Cinematographer* published an article detailing the creation of a homemade optical printer by Tullio Pellegrini, an Italian American amateur filmmaker with an interest in technology. Pellegrini had previously experimented with widescreen in his acclaimed travelogue *San Francisco* (1955), which used its wider format to present panoramic views of the city.[26] Pellegrini also took out ads in *Movie Makers*, the publication of the Amateur Cinema League, selling his specially designed variable-speed shutter unit for Bolex cameras.[27] To make a low-budget printer that would be capable of producing superimpositions, Pellegrini combined a Bell & Howell 16mm projector with a Bolex camera and used a turntable as the base. The device was powered by pulleys that were fastened to the turntable. An electrical connector and a solenoid were used to synchronize the shutters of the projector and camera, and a piece of cardboard was used as a screen to channel light from the projector to the camera. Several other slight modifications are outlined in the article, which provides step-by-step instructions for readers anxious to follow in Pellegrini's footsteps.[28]

American Cinematographer's proclamation that "reader interest" compelled them to publish the details of Pellegrini's invention implies that other amateurs may have wished to replicate the experiment at home.[29] Pellegrini was noteworthy not only for his inventiveness but also for the fact that he was interested in marketing his DIY designs to the wider semiprofessional community, even selling his variable-speed shutter for $109.80 (approximately $1,000 in 2018), complete with insurance and a one-year guarantee.[30] Pellegrini's example testifies to the fact that the boom in postwar semiprofessional filmmaking brought with it an excitement over technological innovation and networked circuits for dissemination. This simultaneous emphasis on infrastructure, ingenuity, and aesthetics would characterize the next phase of the development of a low-cost optical printer.

Emerging Infrastructure, Changing Aesthetics. The path to an affordable and feasible optical printer for avant-garde and semiprofessional filmmakers was cleared in the 1960s, a decade marked by three major developments. First, the avant-garde's association with the semiprofessional market only increased, freely mixing technological fetishism with a DIY ethos that stressed handmade solutions to artistic and technical problems. Second, an infrastructure for the avant-garde began to emerge, with distribution cooperatives, media centers, exhibition spaces, and faculty appointments at colleges and universities providing support for experimental filmmakers and their

26 Tepperman, *Amateur Cinema*, 125.

27 Tullio Pellegrini, advertisement for variable shutter unit, *Movie Makers* 28, no. 1 (January 1953): 4.

28 Clifford V. Harrington, "Low Budget Optical Printer," *American Cinematographer* 40, no. 5 (May 1959): 300, 302, 304. Pellegrini had pursued rephotography as early as 1953, when he pioneered a method of rephotographing projected images off a screen. See Sal Pizzo, "3,000 Clicks!," *Movie Makers* 29, no. 5 (May 1954): 122, 132–133.

29 Harrington, "Low Budget Optical Printer," 300.

30 Pelligrini, advertisement, 4.

students. Third (and most important), avant-garde filmmakers embraced a set of formal paradigms and discursive contexts for their work that encouraged the use of optical effects and rephotography. Consequently, the 1960s was a period of institutional fits and starts that would set the stage for the technological standardization that would occur in subsequent decades.

Even if their aesthetic and cultural goals differed, the desires of advanced amateurs to gain access to professional equipment continued to dovetail with those of many avant-garde filmmakers. The technological imbrication of the avant-garde with the semiprofessional market can be illustrated in microcosm by the vicissitudes of *Filmmakers Newsletter*, a publication founded in 1967 as an outgrowth of the Film-Maker's Cooperative. Like its West Coast "sister publication," *Canyon Cinemanews*, *Filmmakers Newsletter* disseminated information about screenings, festivals, Happenings, and technological developments to the Coop's members. In its first few years, *Filmmakers Newsletter* fulfilled this commitment to the avant-garde, reporting on the Coop's activities, the formation of Millennium Film Workshop in New York, the Ann Arbor Film Festival, and filmmakers such as Will Hindle and Robert Nelson, even publishing significant personal essays, such as Stan Brakhage's "In Defense of the 'Amateur' Filmmaker."[31]

Remnants of these avant-garde beginnings carried over into the 1970s through the participation of technical experts of the experimental film scene such as Lenny Lipton and Bob Parent, occasional profiles of filmmakers like Jordan Belson, and wrap-ups of avant-garde festivals, including Ann Arbor and Bellevue.[32] For the most part, however, the magazine evolved into a kind of *American Cinematographer* for semiprofessionals, assigning most of its pages to features on artier studio films, television production (especially newsworthy affairs such as the 1976 presidential election), and "event shooting," often in the form of firsthand accounts of technically complicated film shoots, like skydiving or a man freeing himself from a straitjacket while suspended over Niagara Falls.[33] These features were combined with promotional material, advertisements, and reviews for new products, including cameras, tripods, microphones, accessories, labs, optical houses, and film equipment rental services.

In the pages of *Filmmakers Newsletter*, a fetishization of technical ability (especially to execute tricky film shoots or achieve results comparable to studio productions) and

31 Most articles from early issues of *Filmmakers Newsletter* could be cited for their relevance to avant-garde film practice. A representative sample would include Ubu Films, "Handmade Film Manifesto," *Filmmakers Newsletter* 1, no. 8 (June 1968): 12; Jonas Mekas, "Filmmakers' Cooperative Directors' Meeting, June 24th 1968," *Filmmakers Newsletter* 1, nos. 9–10 (Summer 1968): 6; Will Hindle, "Hindle Films," *Filmmakers Newsletter* 1, nos. 9–10 (Summer 1968): 1–3; Gary Smith, "Millennium Film Workshop Inc.," *Filmmakers Newsletter* 2, no. 4 (February 1969): 20; and Stan Brakhage, "In Defense of the 'Amateur' Filmmaker," *Filmmakers Newsletter* 4, nos. 9–10 (Summer 1971): 20–25.

32 See, for instance, Larry Sturhahn, "Experimental Filmmaking: The FilmArt of Jordan Belson," *Filmmakers Newsletter* 8, no. 7 (May 1975): 22–26; Gloria Allen, "Avantgarde Super-8 in Venezuela," *Filmmakers Newsletter* 9, no. 7 (May 1976): 50–51; Ron Epple, "Festivals: Ann Arbor 77," *Filmmakers Newsletter* 10, no. 8 (May 1977): 57–64; and P. Gregory Springer, "Festivals: Bellevue," *Filmmakers Newsletter* 10, no. 12 (October 1977): 60–65.

33 See, for example, Betty Jeffries Demby and Larry Sturhahn, "Michelangelo Antonioni Discusses *The Passenger*," *Filmmakers Newsletter* 8, no. 9 (July 1975): 22–26; Steven T. Smith, "CBS Covers the Conventions," *Filmmakers Newsletter* 9, no. 9 (July 1976): 26–29; and Walter S. Clayton III, "Filming Skydiving: '*Jump*'!" *Filmmakers Newsletter* 10, no. 7 (May 1977): 20–23.

commitment to professionalization sat alongside a DIY ethos that never completely abandoned the idea of an experimental cinema rooted in smaller gauges, amateur ingenuity, and alternative platforms. This latter impulse can be seen most clearly in the equipment reviews and technical advice columns, which offered explanations of basic film technology and suggestions for how to build filmmaking accessories of nearly every variety at home. One of the magazine's longest-running columns was animator L. Bruce Holman's "Building Cine Stuff," which ran in almost every issue from 1970 to 1977. In the column, Holman offered tutorials on designing and building filmmaking devices with readily accessible materials on a budget. Some of Holman's most ingenious designs included trim bins, editing benches, camera cases, animation stands, microphone booms, rear projection screens, and optical printers.[34] A model of resourcefulness, Holman's DIY optical printer was cobbled together from discarded camera equipment. It involved turning a "blitzed" movie projector (with the lamphouse, case, and shutter yanked out) upside down and bolting it to a wooden board by means of mounting screws gleaned from the handle. A Mitchell matte box (a device typically used on the end of a lens to block glare or lens flare) was taken apart and refashioned as a sliding mount for the camera to move in and out in relation to the projector. Although the optical printer would work, it was extraordinarily precarious. In characteristically droll prose, Holman encapsulates the handcrafted ethos when he writes: "Bear in mind that home-made optical printers are not quite the equal of ones which cost a hundred G's, but you can build one which will work, and building it yourself will save you about nine hundred ninety-nine thousand dollars and some change."[35]

In many respects, this strand of the avant-garde, in which the filmmaker is also inventor, educator, and adviser, is epitomized by Lenny Lipton, whose own films never became as well known as his encyclopedic technical knowledge and willingness to share information with the avant-garde filmmaking community. In the 1960s, Lipton was active in both professional and countercultural spheres, writing for *Popular Photography*, serving on the board of Canyon Cinema, contributing to the *Realist* and the *Berkeley Barb*, and associating with figures like Timothy Leary and Ken Kesey. While making short avant-garde films between 1965 and 1975, Lipton wrote two hugely influential books, *Independent Filmmaking* and *The Super 8 Book*, which meticulously explained the basics of film technology to the experimental filmmaker in highly readable, conversational prose.[36] Because of his varied interests and technical facility, Lipton operated within the avant-garde, the industry, and the amateur filmmaking scene, serving as a guide for filmmakers who needed technological proficiency to realize their unorthodox formal objectives.

34 See L. Bruce Holman, "Trim Bins and Other Things," *Filmmakers Newsletter* 3, no. 4 (February 1970): 16; L. Bruce Holman, "A Bit about Benches," *Filmmakers Newsletter* 3, no. 6 (April 1970): 24–25; L. Bruce Holman, "Design & Build Your Own Camera Case," *Filmmakers Newsletter* 3, nos. 9–10 (Summer 1970): 20; L. Bruce Holman, "Build an Animation Stand—Part 1," *Filmmakers Newsletter* 5, no. 2 (December 1971): 39; L. Bruce Holman, "Build a Microphone Boom," *Filmmakers Newsletter* 5.9–10 (Summer 1972): 42–43; and L. Bruce Holman, "Rear Projection Screen," *Filmmakers Newsletter* 6, no. 1 (November 1972): 34. Many of Holman's columns were collected in L. Bruce Holman, *Cinema Equipment You Can Build* (Tully, NY: Walnut Press, 1975).

35 L. Bruce Holman, "Build an Optical Printer," 44.

36 See Lenny Lipton, *Independent Filmmaking* (San Francisco: Straight Arrow Books, 1972); and Lenny Lipton, *The Super 8 Book* (San Francisco: Straight Arrow Books, 1975).

Outside of the semiprofessional market, the avant-garde was developing its own infrastructure that would facilitate access to equipment for filmmakers. Ruminating in *Filmmakers Newsletter*, avant-garde filmmaker Charles Levine proposed a theoretical entity called the Institute of Advanced Cinema. Noting that tools like computers, videotape recorders, and optical printers were prohibitively expensive, primarily owned by corporations or government agencies, and scattered in remote locations, Levine suggested that the institute could make "both the technicians and hardware available to artists under one roof and at the same location."[37] Two issues later, Gary Smith offered a rejoinder titled "Millennium Exists," calling attention to the fact that Millennium Film Workshop, an independent film school, workshop, and equipment library, was "open to anyone wishing to make films; to anyone who already makes films and needs equipment; to anyone who just wants to learn about sound recording, editing on professional equipment, and cameras."[38] In addition to snarkily pointing out the chief advantage of Millennium over the Institute of Advanced Cinema—namely the fact that Millennium actually existed in reality—Smith took pains to assert that buying sophisticated machines like computers was premature, both financially and practically:

> Millennium has to have basic equipment first before we get our computers installed. We want things for immediate use such as optical benches, animation stands, cameras, projectors, editing equipment of all kinds, developers, sound rooms, and equipment for recording, mixing, and transferring. All this equipment is expensive, but not beyond thinking about. We want all of it, but we want it in proper order. What would we do with a computer when we hardly know how to take care of a developer? If we owned a computer, it would inevitably be hung with a "Do Not Kick" sign. All that machinery will be ours someday, but when I called I.B.M. to price some things, the man said, "If you have to ask, you can't afford it." And Charles baby, we have to ask.[39]

In addition to Millennium Film Workshop, cooperatives were beginning to spring up in other cities, offering consultation, workshops, and most crucially, cheap access to expensive equipment for avant-garde filmmakers. For $20 a year, the Pittsburgh Independent Film-Makers Coop provided editing and screening facilities and training in a variety of equipment and accessories. The Chicago co-op, which boasted filmmakers Tom Palazzolo and Ronald Nameth on its board of directors, offered similar services, as well as distribution of members' films.[40] In addition to artist-run cooperatives, the late 1960s marked the first wave of avant-garde filmmakers teaching in college production programs, where students were exposed to film technology and its more radical aesthetic applications by Gregory Markopoulos at the School of the Art Institute of Chicago, Robert Nelson at the San Francisco Art Institute, Carl Linder

37 Charles I. Levine, "Toward an Institute of Advanced Cinema," *Filmmakers Newsletter* 1, no. 3 (January 1968): 1.

38 Gary Smith, "Millennium Exists," *Filmmakers Newsletter* 1, no. 5 (March 1968): 11.

39 Smith, "Millennium Exists," 11–12.

40 The Pittsburgh and Chicago Co-ops are discussed in "Film-Makers' Cooperatives," *Filmmakers Newsletter* 2, no. 4 (February 1969): 7–9.

at the School of Visual Arts in New York, and Paul Sharits at the Maryland Institute College of Art.[41]

Within avant-garde film circles, the need for low-cost, effective filmmaking equipment that was easy to access became a paramount concern. In a letter to Stan Brakhage, Larry Jordan decried the dearth of reliable tools for independent filmmakers, explaining that he had been designing sound mixers and optical printers to rectify this deficiency: "[I] am bringing to a close a two-year period of designing and either building myself, or having built, sane pieces of filmmaking equipment, as I found there were relatively few on the market to buy. . . . But I have satisfied that drive and feel these things had to be done and now they are done and I can settle down in a saner area of 16mm film tools and get into the films the way it should have been possible to do in this technologically mad society years ago."[42] Jordan's choice of the phrases "sane" and "technologically mad" seems especially provocative. In a single passage, he manages to condemn a capitalist economy driven by technology for both failing to produce affordable and reliable filmmaking tools for independent filmmakers *and* fetishizing technology over creativity. Consequently, Jordan frames the problem as both a necessity and a distraction, a situation that filmmakers are obliged to confront but one that ultimately takes them away from the more important business of artmaking. This sentiment was echoed by *Filmmakers Newsletter*: "It's easy to get caught up in the heady thrill of manufacturing your own super cine-gizmos, however . . . the object of the game is to make films to change the world, not to piddle away your time re-inventing cute little machines that have been around since D. W. Griffith's time. If you can afford the going market price of a piece of equipment, and there's no good reason to boycott the manufacturer, buy it and get back to filmmaking."[43]

As in the 1930s and 1940s, avant-garde filmmakers were compelled to make their own optical printers, but with the newly established institutional infrastructure, the information was easier to disseminate. In 1967, filmmaker Loren Sears published a set of instructions for re-creating his own homemade optical printer in *Canyon Cinemanews*.[44] Sears, who had a background in electronics, physics, and computer programming, had spent a year scavenging for parts with the intention of making a freeze frame for one of his films. After collecting a dismantled, hand-cranked Kodascope projector from Michael Mideke, a 35mm extension bellows from a photographer friend, and a C-mount adapter (for use with 16mm lenses), Sears began experimenting with the printer "under the influence of the 1966 San Francisco cultural milieu."[45] This resulted in two films, *Be-In: A Free Space Film* and *Tribal Home Movie #2* (both 1967), and

41 An exchange between Paul Sharits and Carl Lindner about the difficulties and rewards of teaching avant-garde filmmaking to students can be found in Sharits and Lindner, "Letters," *Filmmakers Newsletter* 1, no. 6 (April 1968): 17–19.

42 Larry Jordan to Stan Brakhage, 4/19/72, James Stanley Brakhage Collection, box 20, folder 10, Special Collections and Archives, University of Colorado Boulder Archives.

43 L. Bruce Holman, "How to . . . Convert Regular Rewinds to Long-Shaft," *Filmmakers Newsletter* 3, no. 2 (December 1969): 12.

44 For a detailed history of *Cinemanews*, see MacDonald, introduction to *Canyon Cinema*, 1–36.

45 Loren Sears, email conversation with the author, October 27, 2017.

also served as the printer for Robert Nelson's *Grateful Dead* (1967) and Gunvor Nelson's *My Name Is Oona* (1969).

In the article, Sears extolled the virtues of the printer, highlighting the device's liberatory potential for intrepid filmmakers: "What can be done by this printer is limited only by the imagination. Dissolves of all lengths and multiple exposures, freeze frames intermixed with action, repeat scenes, masking, bi-packing originals in the film gate, color alteration that has no end . . . and more! For those who like, A&B&C& roll printing could be done, at least over 100ft lengths. We've had fun printing color separations of a single scene slightly out of phase with one another."[46]

For Sears, the idea of the optical printer evolved from a technical or material resource designed to produce a specific formal effect to a cultural resource with utopic dimensions. After leading a Canyon-wide effort to memorialize the Human Be-In at Golden Gate Park on January 14, 1967, Sears gathered footage shot at the event and "began to play on the optical printer like a composer might noodle at the piano."[47] Under the influence of the San Francisco Diggers, an activist group of "community anarchists" who advocated for a selfless approach to consumer culture, Sears rented the film through Canyon for free, advertising it explicitly as a kind of demonstration of the printer's radical potential.[48] In his article, however, Sears also adopts a functional attitude toward the printer, stressing that potential builders must remain steadfast in the face of so much testing, checking, securing, and controlling, documenting a process rife with technical problems that took patience and time to solve.

A slightly different material orientation was evidenced in the extraordinarily sophisticated optical printer built by filmmaker Standish Lawder in 1972–1973. Lawder already had experience forging homemade filmmaking devices out of unlikely materials, having made a contact printer out of an old camera, an incandescent light bulb attached to a dimmer, and a Chock Full o'Nuts coffee can.[49] On an episode of Robert Gardner's television series *Screening Room* (WCBV, 1973), Lawder displayed his newly constructed optical printer for Gardner and Stanley Cavell (see Figure 3). In contrast to the DIY printers made by Pellegrini or Sears, Lawder's projector head threw the image onto a mirror, where it was bounced onto a "piece of rear-screen material" that essentially functioned as a screen. The camera was attached to a motor that pulled it closer or farther away from the screen, circumventing the need for a bellows attachment. In addition, Lawder's printer was equipped with a sequencer that programmed the machine to perform a predetermined exercise, "a little like a slow motion computer," according to Lawder, leading him to joke that he could program the device, go to bed, and wake up in the morning to find his film completed.[50] Unlike Sears, Lawder was fascinated by the printer's ability to carry out computer-like applications,

46 "Canyon Cinema Research and Development: Optical Printing Stand," *Canyon Cinemanews* (July 1967), n.p.

47 Loren Sears, email conversation with the author, October 27, 2017.

48 "Catalog Supplement: Canyon Cinema Freebie," *Canyon Cinemanews* (May 1967), n.p.

49 The film preservationist Mark Toscano has photographed and described this contact printer online at Mark Toscano, "*Runaway,*" http://preservationinsanity.wordpress.com/2014/08/runaway.html.

50 *Screening Room with Robert Gardner: Standish Lawder*, DVD, produced by WCVB-TV and Studio 7 Arts (1973; Watertown, MA: Documentary Educational Resources, 2008).

explaining, "I'm going to develop the machine as an instrument so as to understand what it is best, itself, capable of expressing."[51]

Figure 3. Standish Lawder shows off his custom optical printer on Robert Gardner's *Screening Room* (1973; Documentary Educational Resources, 2008).

For instance, Lawder's *Intolerance (Abridged)* (1973) explores a schematic application of skip printing, in which original frames are skipped during rephotography, which leads to fast and/or fragmented motion. As its title suggests, the film is an abridged version of D. W. Griffith's *Intolerance* (1916), described by Lawder as "the most sacred monument in the history of film."[52] Lawder made the film automatically by setting the sequencer on his homemade printer to photograph every fortieth frame twice, condensing 176 minutes into 5.[53] The images zip by at breakneck speed, prefiguring the fast-forward button and the scroll bar. Griffith is often cited as the filmmaker most instrumental in advancing the notion of film as a storytelling device, but Lawder's ironic encapsulation wrenches the film from narrative's grasp, rearticulating it as purely visual sensation. The skip printing functions as an experiment in how much visual information the eye can grasp in a two-frame segment of film.

Lawder's language in the *Screening Room* segment, which invokes computers, predetermined filmic algorithms, and medium specificity, suggests that his appreciation for optical printing was linked to ideas associated with Structural film, the reigning formal paradigm of the era.[54] Of course, the optical printer did not determine the films that were made, but it did facilitate visual effects that avant-garde filmmakers were already struggling to achieve by different means. For instance, without recourse to an optical printer, Bruce Baillie experimented with other methods of compositing images in films such as *Quixote* (1965), *Tung* (1966), and *Castro Street* (1966). Anticipating an optical printing aesthetic, Baillie made homemade mattes with black tape, prisms, and glasses, which he then combined with multiple-roll printing at the lab for densely packed superimpositions.[55] In a famous example from *Castro Street*, railroad cars moving

51 *Screening Room*.

52 Lawder, quoted in *Screening Room*.

53 *Intolerance* has existed in different cuts over the years, ranging from 163 to 210 minutes, depending on the projection speed and the amount of material included. I cannot be certain which version Lawder used, but the most likely candidate is the 16mm Killiam Shows cut, which runs 176 minutes.

54 Note that one need not subscribe to P. Adams Sitney's controversial definition of Structural film to recognize the ubiquity of the techniques that came to be associated with it. See Sitney, "Structural Film," *Film Culture* 47 (Summer 1969): 1–10.

55 Baillie discusses some of these techniques in Scott MacDonald, "Interview with Bruce Baillie," *A Critical Cinema 2: Interviews with Independent Filmmakers* (Berkeley: University of California Press, 1992), 127–131.

in opposite directions are split in the center of the frame while another image of a car is superimposed at an oblique angle, creating a mesmerizing and lyrical parallax effect. Despite his success, Baillie expressed his frustration with the "virtual optical printing" that he was forced to do in lieu of the real thing. Explaining a complicated two-projector system for matte control that he had devised for an unrealized project, *Morning Star*, Baillie complained: "There really ought to be control and availability with optical printing to do this type of thing. . . . The ideal thing would be an optical printer with at least three projectors operating just like tape recorders. Three projectors playing back into the recording camera, each of which can be controlled in terms of light intensity, total malleable matting on each. . . . And so then a guy can just sit down and play [the optical printer] like an organ and mix as he will, and not at all be stuck with random superimpositions."[56]

In a different vein, other avant-garde filmmakers were pursuing rephotography to mine images for alchemical revelations. In the influential *Tom, Tom, the Piper's Son* (1969–1971), Ken Jacobs performed an act of cinematic resurrection, subjecting a 1905 American Mutoscope & Biograph short of the same name to a two-hour workout on a Kalart-Victor analytic projector, the results of which were photographed on an adjacent Bolex. The original was slowed down and sped up again, details were isolated, and gestures were repeated in cycles of infinite return, as Jacobs made visible what was easily overlooked on first, second, or third viewing. As many critics have noted, Jacobs's intention is ultimately pedagogical, using technology to delve into the image to see what it can reveal. In his own words: "I enjoy mining existing film. Seeing what film remembers, what's missed when it clacks by at normal speed. . . . I usually take short lengths of film and pore over them, or pour into them. Dig into them. So it's mining. And I'm looking for things that literally you just don't see when it zips by at 24 frames per second, normal sound speed."[57]

Even if Jacobs had gained access to an optical printer, he likely would not have used it. A major component of *Tom, Tom* is the fact that it is performed. This aspect of the work is both a reminder that visual analysis always reflects on the apparatus that makes it possible and a pedagogical imperative that deeper understanding stems from an active and scrupulous engagement with an image.[58] Nonetheless, Jacobs's film demonstrated the possibilities of rephotography to dramatically alter found or original footage through frame-by-frame manipulation. In terms of both methodology and specific visual effects, *Tom, Tom*—along with films by Baillie, Kenneth Anger, Chick Strand, Pat O'Neill, and others—signaled that a standardized, low-cost optical printer would be hugely beneficial to avant-garde filmmakers in realizing some of their most ambitious aesthetic and conceptual goals.

56 Richard Whitehall, "An Interview with Bruce Baillie," *Film Culture* 47 (Summer 1969): 17.

57 Harry Kreisler, "Film and the Creation of Mind: Conversation with Ken Jacobs, Film Artist," *Conversations with History*, Institute of International Studies, University of California, Berkeley, October 14, 1999, http://globetrotter.berkeley.edu/people/Jacobs/jacobs-con0.html.

58 *Tom, Tom, the Piper's Son* as an example of Jacobs's pedagogy is discussed in Michael Zryd, "Professor Ken," in *Optic Antics: The Cinema of Ken Jacobs*, ed. Michele Pierson, David E. James, and Paul Arthur (New York: Oxford University Press, 2011), 255–258; and MacDonald, *Binghamton Babylon*, 198–202.

The San Francisco Art Institute and the JK Optical Printer. Standish Lawder's printer, which was constructed over the course of a year in piecemeal fashion, was a technical marvel, but it was a one-of-a-kind machine, too gigantic, complex, and unwieldy to be mass produced, even on a small scale. The most pressing need was for an optical printer similar in ambition and functionality to the DIY printers fashioned by Pellegrini and Sears but standardized with reliable solutions to basic technical problems and capable of being mass produced. The JK optical printer, invented by Jaakko Kurhi of JK Camera in 1971–1972, addressed this need.[59] Although its design was fairly simple, and the operations that it could perform were limited in comparison to a professional printer like an Oxberry, the JK printer leveled many of the technical hurdles that plagued earlier inventors. In addition, Kurhi was a machinist who had the capacity to reproduce his design repeatedly with standardized parts; in contrast to the one-of-a-kind quality that characterized printers from Watson to Hirsh to Lawder, the JK printer could be made to order and purchased by colleges or arts institutions across the country. By the early 1980s, the JK had become the most frequently used optical printer for avant-garde filmmakers.

Kurhi's printer emerged from the 16mm filmmaking scene in San Francisco in the late 1960s. Much of the technological innovation in this period orbited around the film department at the San Francisco Art Institute (SFAI). In 1965, filmmaker Robert Nelson became the first chair of the department, and by the time he accepted a teaching appointment at CalArts in 1969, SFAI had become one of the leading schools for independent and experimental filmmaking. When Nelson left, he sold the department a 16mm Arriflex camera and a Nagra portable audio recorder, but the facilities remained rudimentary. At the end of his tenure, Nelson had tried to commission Loren Sears to modify his optical printer design for commercial use, but the idea was scuttled when the financing collapsed.[60]

When Larry Jordan was hired to replace Nelson, he took it as his mission to "collect all the top filmmakers," quickly hiring Gunvor Nelson, James Broughton, and later, George Kuchar.[61] One of Jordan's first priorities as chair was to "hustle to get equipment for the place." He recalled: "One day, I walked past the Dean's Office into the President's Office and told him we needed $20,000 to buy equipment. I thought he was going to kick me out, but he said, 'Well, I think you know what you're talking about.' And in those days, private institutions like the Art Institute were funded pretty much by the wealthy people in the community, and he was one of them. He got on the phone with his friends, and right away there was $20,000 and we got more equipment. In those days, $20,000 could buy a lot of stuff."[62] In addition to Jordan's general investment in building an avant-garde infrastructure, his efforts were on behalf of an adventurous group of MFA students that included Peter Hutton, Babette Van Loo, Vincent Grenier, Henry Hills, Sandra Davis, and Diane Kitchen, among many others.

59 When it was first invented, the company and printer were stylized as "J-K," although it is now more common to use "JK."

60 Loren Sears, email conversation with the author, October 27, 2017.

61 Larry Jordan, telephone conversation with the author, January 9, 2014.

62 Jordan, telephone conversation.

According to Jordan, his students "wanted to do things that nobody had thought of. They were inventing things that were way beyond [the capacities of the faculty]. Everybody was learning from everybody else."[63]

The general eagerness on behalf of the SFAI faculty and their students to push filmmaking to its limits fostered an environment within which DIY technological innovation was considered valuable and exciting, with each new device representing an opportunity to try something new. Whenever Jordan and his students conceived of an effect or technique to explore, they would take their ideas to Jaakko Kurhi. Kurhi, a Finnish immigrant who worked in the Bay Area, was a master machinist and licensed Bolex repair technician. Kurhi had been employed at the Bolex Factory in Switzerland, where he had been trained in adapting the company's cameras to accommodate 8mm, Super-8, Double-8, and 16mm formats. He owned a machine shop in Oakland (he later relocated to San Leandro and operated Meritex Inc., a company that produced surfboards), doing small manufacturing of various kinds, producing limited runs on a contractual basis.[64] Although he was something of a jack-of-all-trades, his education at Bolex made him predisposed to work with film technology. Jordan explains:

> I and other graduate students would keep going to Jaakko to try to make gadgets.
>
> He would build this and build that, and he would build things for my [personal] animation stand. He was very accommodating, and he could always do it. Just describe what you needed, and he'd build it! He was making these gadgets for us, so he knew that we were trying to rephotograph. And, finally, it got to the point where everybody just knew that he had to build an optical printer.[65]

Although Jordan did not use optical printing for his own films, preferring the crisp look of a first-generation image, it seemed like the next logical piece of equipment for Kurhi to build. Jordan drafted a list of requirements, a "wish list" of features that were most important to him and his students in an optical printer. Jordan gave the list to Gary Richardson, a student from an earlier teaching stint at California College of the Arts, who lived in Oakland and had worked with Kurhi on an animation stand. From Jordan's sketch, Kurhi set to work on the prototype for the JK.

In the patent that he filed, Kurhi stated his goals: "To provide an optical printer which is reliable, easy to operate, has extremely accurate picture centering means and is relatively inexpensive so that it can be purchased by individual filmmakers and film teaching schools."[66] The resultant model, the K103, was rudimentary in comparison to a professional printer like an Acme-Dunn or an Oxberry, but it was more reliable than most of the homemade printers that filmmakers were fashioning at the time (see Figure 4). Kurhi kept costs low by eliminating the Geneva drive, or Maltese cross, a gear mechanism used

63 Jordan, telephone conversation.

64 The website for Meritex and JK Camera can be found at http://www.jkcamera.com. Information about Kurhi's background stems from the conversation with Larry Jordan cited earlier.

65 Larry Jordan, telephone conversation.

66 Jaakko Kurhi, Optical Printer, US Patent 3,846,022, filed March 5, 1973, and issued November 5, 1974.

in motion-picture projectors to convert continuous movement into intermittent movement. This allowed for film to be held in the gate without slipping or strobing during rephotography. Kurhi's printer used a step motor to advance the film through completely intermittent movement. Although this was a more laborious, time-consuming process, it eliminated expensive parts, which allowed the printer to be manufactured at low cost. The K103 came equipped with other features, including a 300-watt ELH lamp, a bellows for magnification and reduction, and a control keyboard for the step motor. Filmmakers could replace many of the pieces at their discretion.

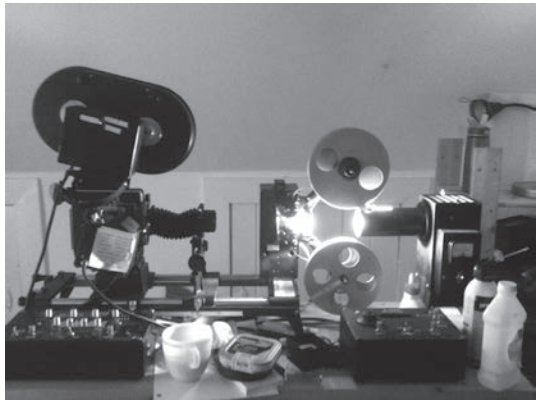

Figure 4. A JK optical printer, model K103. Image courtesy of Kathryn Ramey.

Kurhi initially made ten printers, which he sold to local institutions and individual filmmakers, including SFAI and California College of the Arts. Through word of mouth, he began to receive orders for more printers, both within the Bay Area and around the country.[67] In April 1972, Kurhi took out advertisements in *American Cinematographer* and *Filmmakers Newsletter* trumpeting the phenomenally low price of the K103, which was initially sold for only $550 (approximately $3,200 in 2018 dollars) (see Figure 5).[68] As Kurhi continued to improve his design, the cost of the printers gradually increased, although the price remained under $1,000 throughout the decade; by contrast, an Acme-Dunn printer cost $75,000 in 1981 (approximately $200,000 in 2018 dollars).[69] Fortuitously, Kurhi's invention coincided with the institutionalization of the avant-garde in the 1970s. As avant-garde filmmakers took up residency in film production departments around the country, departmental budgets could be allocated to film equipment. Soon the K103 and its descendant, the K104, were recognized by colleges and universities as basic instructional tools. Moreover, students were allowed access and given instruction on the device's capabilities. In addition to SFAI and CalArts, the optical printer became a staple of the BFA and MFA curriculum in places like the School of the Art Institute, University of Wisconsin–Milwaukee, MassArt, University of Colorado–Boulder, and SUNY Binghamton.

67 Jaakko Kurhi, telephone conversation with the author, August 18, 2009.

68 Advertisement for J-K Camera Service, *American Cinematographer* 53, no. 4 (April 1972): 454. The same advertisements appear in *Filmmakers Newsletter* throughout this period. The advertisements provide a means of tracking price increases in the JK's early years. For instance, the cost of the printer increased to $680 in February 1973 and then to $753 in January 1974.

69 "Developers of Optical Printer Win Oscar," D5. For a laudatory appraisal of Kurhi's modification of the JK optical printer for Super-8, see Dennis Duggan, "Double Your Pleasure: The Joys of Optical Printing," *Super8Filmaker* 8, no. 1 (January–February 1980): 19–23.

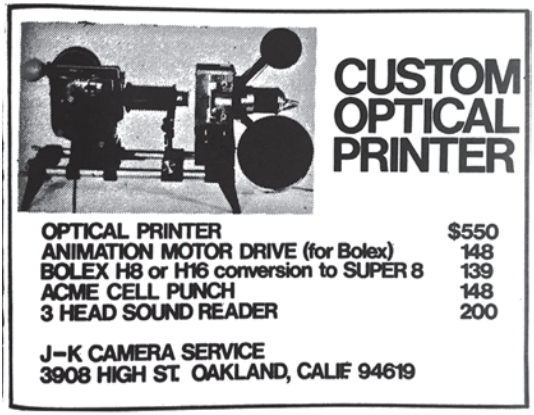

Figure 5. The first advertisement for the JK optical printer, which Jaakko Kurhi advertised in *American Cinematographer* and *Filmmakers Newsletter* in spring 1972.

To some degree, the JK standardized low-budget optical printing in avant-garde circles. The case of Bill Brand is representative. Since the early 1970s, Brand had been incorporating rephotography into his films, mostly inventing one-off machines for the specific purposes of a single film. In 1975, he was lured to the School of the Art Institute, where he was told they possessed an optical printer; upon arrival, however, he realized that he had in effect been recruited to build one. Later in the year, he was invited to screen his films at Pittsburgh Filmmakers, where he encountered their newly purchased K103. "That was it," Brand later recalled. "I messed around with that JK printer for awhile, and decided, 'I have got to get one of these!'"[70] Shortly thereafter, Brand purchased his own printer from Kurhi directly. In addition to making some of his best-known films on the printer, including *Works in the Field* (1978) and *Split Decision* (1979), Brand began doing favors for other avant-garde filmmakers, optically blowing up their 8mm films to 16mm. Under the aegis of BB Optics, Brand has worked with hundreds of avant-garde, independent, and documentary filmmakers on optical effects, blow-ups, and restorations.[71]

Film cooperatives also benefited from the JK optical printer. Early in 1977, Howard Guttenplan, the director of Millennium Film Workshop, partially fulfilled Gary Smith's promise from ten years earlier that "all that machinery will be ours someday" when he purchased a K103, a module for use with Super-8, a quartz lamp system, and a collection of color correction and neutral density filters for a combined total of $1,900 (approximately $7,600 in 2018 dollars).[72] He also enlisted Boris Bode to teach a weekly class at Millennium on how to use the printer. (This class was later taught by filmmakers Michael Gitlin and Su Friedrich.) "It can be quite precise, once you get used to it," Guttenplan observed, in a statement echoed by most filmmakers who had experience with the JK.[73] When Stan Brakhage visited Millennium in 1977, Guttenplan expressed excitement over the JK and provided him with a copy of the

70 Bill Brand, interview with the author, September 30, 2015.

71 For information on BB Optics, see Andrew Lampert, ed., *Results You Can't Refuse: Celebrating 30 Years of BB Optics* (New York: Anthology Film Archives, 2006).

72 Gary Smith, "Millennium Exists," 12.

73 Howard Guttenplan to Stan Brakhage, 5/30/77, James Stanley Brakhage Collection, box 49, folder 11, Special Collections and Archives, University of Colorado Boulder Archives. The details about Millennium's purchase of the JK are outlined in this letter.

instructions.[74] Although Brakhage would not work with the printer until the 1990s, Guttenplan's gesture is indicative of the word-of-mouth proliferation of interest in the optical printer at the time.

Once the JK optical printer became widely available, a new generation of avant-garde filmmakers could incorporate it into their practice. In the same way that one could define oneself as a handmade filmmaker or film essayist, one could brand oneself an optical printer filmmaker, someone whose practice was characterized by a particular set of aesthetic and conceptual concerns. Because of its versatility, the optical printer appealed to a broad range of filmmakers, uniting disparate strands of avant-garde practice. For poetic filmmakers such as Gunvor Nelson and Phil Solomon, images could be slowed down and invested with tactility and lyricism, with rhythm imposed on the film after the fact. Structural filmmakers such as Bill Brand and Peter Rose, who were already exploring loop printing and permutational schemas, found that their images could be repeated, multiplied, slotted into grids, and systematically manipulated with precision. Filmmakers such as Craig Baldwin could combine home movies and found footage with abandon, and for experimental animators, the optical printer was much like an animation stand or multiplanar camera, which demanded a solitary, craft-based practice. Other filmmakers, such as Su Friedrich, used the optical printer to mix modes, merging lyrical and Structural paradigms by submitting poetic footage to rigorous organizational schemas. In *Gently Down the Stream* (1981), text, frames-within-frames, streaking, and freeze-frames become methods for Friedrich to examine her dreams, the printer refigured as a means for excavating her personal history.

In this way, the optical printer became a cultural resource and discursive trope that avant-garde filmmakers could mobilize in relation to their practice. For instance, in describing their relationship to the printer, many filmmakers invoke other detail-oriented, process-based arts. For Barbara Hammer, the printer is a painting tool that allows her to touch film, while Ken Kobland views the printer as a kind of sewing machine and the process of making a film a dance. Pat O'Neill's interest in the combinatory possibilities of working with the printer stemmed from his enthusiasm for building cars in his youth.[75] The portability of the JK printer, originally a technical necessity, signified a sensual appeal for Hammer, whose films were already deeply invested in tactility:

> The JK printer was my machine of choice from the mid-80s to 90s. There were only two hundred printers in existence when I bought mine in 1983. It went everywhere with me: San Francisco, Chicago, apartment to apartment in New York City; I even took it to France. It encouraged creative intimacy with its DIY come-on. I could scratch, paint, burn, filter and superimpose frames. I worked intuitively and kept journals of detailed technical notes. I would have an idea, make it happen, and follow whatever idea came next.

74 Guttenplan to Brakhage.

75 Barbara Hammer, telephone conversation with the author, May 31, 2014; and Ken Kobland, email conversation with the author, August 20, 2014. O'Neill discusses combinatory artistic practice, including car building and optical printing, in David E. James, "An Interview with Pat O'Neill," *Millennium Film Journal* 30–31 (Fall 1997): 121.

> This process was extremely satisfying and exemplified my creative process. I loved this printer.[76]

To cite another example, because the printer was far removed from real-world shooting and demanded close attention to each frame—making "decisions on the slightest bits of information," as Carolee Schneemann put it—filmmakers' working processes shifted toward immersive, almost monastic devotion to their images.[77] Some filmmakers embraced an artistic practice rooted in recombination, revision, and reworking, and incorporated this into the rationale for their artmaking. As Phil Solomon recalled: "I remember Saul Levine saying, *half* in jest, 'Optical printing is for people who couldn't get it together the first time.' In some ways that's absolutely true for me. I have a primary phase where I shoot in the world, and a secondary phase where I resee and transform what I've shot."[78]

For instance, Solomon's practice is largely rooted in combining optical printing with chemical treatments of the filmic emulsion to transform original and found footage into elegies with heavy autobiographical and allegorical resonance. In films such as *Remains to Be Seen* (1989/1994) and *Clepsydra* (1992), Solomon step prints his chemically reconstituted images through colored filters and with altered lighting schemes to bring the primal, talismanic import of found footage to the fore (see Figure 6). The imposition of aesthetic distance on the material is mirrored at the level of Solomon's working process, which tends toward the solitary. Through his printer, Solomon can meditate on each frame, considering the personal and allegorical weight of his images. Solomon explains:

> Original photographed moments, often teeming with life, are frequently rendered [by optical manipulation] into *analysis*, so that we are no longer in an aesthetic present tense, but are made passive by *watching the watcher watch*. . . . We see what *the filmmaker has already seen and noted*, we now know what they have already known. . . . We begin having a *secondary experience* rather than a primary revelation.[79]

In this passage, Solomon imagines himself as a voyeur in search of the transcendent moment, poring over images one frame at a time to bring out their revelatory potential. In contrast to a filmmaker like Stan Brakhage, who often seems to be bringing the world inside himself, sifting it through his own consciousness, and projecting it back outward in a flurry of activity, Solomon's process involves introverted contemplation of the image, held at a layer of remove through a physical engagement with the technology.

76 Barbara Hammer, *Hammer! Making Movies out of Sex and Life* (New York: Feminist Press, City University of New York, 2010), 207.

77 Schneemann quoted in Scott MacDonald, "Interview with Carolee Schneemann," *A Critical Cinema: Interviews with Independent Filmmakers* (Berkeley: University of California Press, 1988), 145.

78 Solomon, quoted in Scott MacDonald, "Interview with Phil Solomon," *A Critical Cinema 5: Interviews with Independent Filmmakers* (Berkeley: University of California Press, 2006), 206.

79 Phil Solomon, "The Frame," *Millennium Film Journal* 35–36 (Fall 2000): 123.

Figure 6. A found image is allegorized by chemical treatments and optical printing in Phil Solomon's *Remains to Be Seen* (1989). Image courtesy of Phil Solomon.

Conclusion. The ability of experimental and advanced amateur filmmakers to realize complex visual effects has only increased with the advent of digital technology. Just as computer-generated imagery has reified the Industrial Light & Magic aesthetic pioneered by optical effects artists in Hollywood, the basic vocabulary of avant-garde optical printing has become a standard feature of nonlinear editing systems, which allow for highly sophisticated effects with just a few mouse clicks.[80] Lev Manovich has argued that "avant-garde aesthetic strategies came to be embedded in the commands and interface metaphors of computer software," noting that collage (i.e., cut and paste), painting on film, composite imagery, and frames-within-frames are basic components of most off-the-shelf software.[81] Practically any image can be downloaded from the internet or ripped from a DVD and dropped into a timeline in Final Cut Pro or Adobe Premiere. A virtually unlimited number of clips can be stacked on top of each other, their opacities carefully adjusted for precise post hoc superimposition. The "strobing" effect introduces a persistent flicker. Shots can be slowed down or sped up simply by typing in a number or copying, pasting, and deleting frames. In Adobe After Effects, video makers and animators can composite their own images with features such as rotoscoping, motion tracking, and foreground-background integration.[82] Perhaps most striking, the hours of laborious trial-and-error on an optical printer have been replaced with "⌘ + Z," which quickly undoes any failed attempt.

This evidence is not marshaled to suggest that digital video artists lack the fortitude of their analog forebears, but to point out the ways in which the visual vocabulary of the optical printer has been incorporated into digital technology. Unsurprisingly, avant-garde filmmakers have capitalized on these innovations. For instance, Michael Robinson's acclaimed *Light Is Waiting* (2007), a deconstruction of a vacation-themed episode of the sitcom *Full House* (ABC, 1987–1995), extends an optical printing aesthetic into the digital realm through slow motion, image layering, flicker, and rephotography off a television monitor. Robinson essentially made digital superimpositions, placing two layers of the same image track directly on top of one another in Final Cut Pro, flopping the top layer to create a mirroring effect, and then adjusting the "composite mode" of the layers, which affects the opacity of each image (see Figure 7). The

80 Turnock argues that "digital tools typically bend to the ILM aesthetic rather than the other way around," in *Plastic Reality*, 100–101.

81 Lev Manovich, *The Language of New Media* (Cambridge, MA: MIT Press, 2001), 306–307.

82 See Lev Manovich, "After Effects or the Velvet Revolution," *Millennium Film Journal* 45–46 (Fall 2006): 5–19.

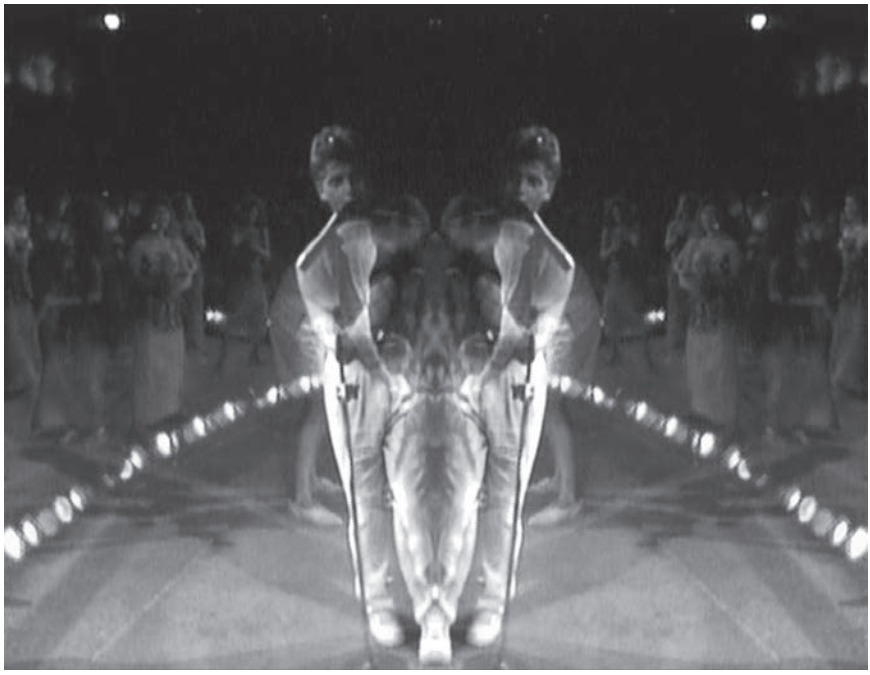

Figure 7. An optical printing aesthetic refigured for Final Cut Pro in *Light Is Waiting* (Michael Robinson, 2007). Image courtesy of Michael Robinson.

shots were then rendered in slow motion, and Robinson created an "artificial" flicker by copying and pasting frames of solid color (red, white, and blue) and layering them over the image tracks. Despite the fact that *Light Is Waiting* prominently displays video artifacts as the image breaks itself down, Robinson claims that his effects were "definitely informed by my experiences with analog film 'special effects.'"[83] Additionally, this hands-on process of making small adjustments in Final Cut Pro is analogous to the frame-by-frame logic of the optical printer, but the technology enables Robinson to be far more precise in his compositing.

As digital technologies transform the working processes of avant-garde filmmakers, it becomes imperative to understand the cultural contexts within which these filmmaking techniques were first developed. This history of optical printing has attempted to clarify the tangled relationships between technology and aesthetics, as well as the avant-garde and the semiprofessional market. This article has shown that avant-garde optical printing was born of the ingenuity of DIY amateurs, technologically minded artists, and machinists for hire who were jointly invested in the problem of reliable, low-budget rephotography. These early inventions were standardized with the JK optical printer, which became an essential component of the avant-garde curriculum, adopted by a new generation of artists eager to differentiate themselves from their predecessors while extending an important filmmaking tradition. But it also represents

83 Michael Robinson, email conversation with the author, October 26, 2015.

an instance of avant-garde filmmakers appropriating a commercial technology and repurposing it.

As scholars continue to examine the institutionalization of avant-garde cinema, technology will prove especially relevant for understanding the ways in which the avant-garde has operated both apart from and within broader cultural contexts. This article has focused largely on the factors that led to the widespread adoption of optical printing as a material practice. In gesturing toward the relationship between concept and realization, filmmakers' physical and intellectual engagement with technology, and the interplay between limitation and potentiality, however, I would also suggest that optical printing was as much a cultural resource as a technical one, a process, rationale, and conceptual set that reimagines filmmakers' relationship to their materials. Through the reconstruction of the historical and discursive contexts, and close analysis of the filmmakers' statements, working processes, and films, we can begin to understand the avant-garde's productive reimagining of cinematic technology. ✻