

Serendipity, Punctuated

J.F. Asmus

Summary. Laser divestment entered the field of art conservation through a non-linear sequence of positive accidental events (serendipity) that involved the cinema industry, the invention of spread-spectrum and frequency-hopping communications, nuclear space propulsion, and oceanography. The unlikely chain of events began with the invention of a secure military communications system by a Viennese motion picture actress (1942). A first evaluation of the novel communications concept took place during a high-altitude nuclear test (TEAK) over the Pacific Ocean in 1958. The secure radio link proved to be a failure; however, analyses of the backscattered electromagnetic radiation contributed to the realization that nuclear-explosion plasmas need not be spherically symmetrical. Nobel Laureate Freeman Dyson exploited this nuclear option to guide in the design and prototype development of the ORION spaceship that was to rendezvous with the planet Saturn in 1970. For this space vehicle the high-specific-impulse nuclear propulsion was generated by means of superradiant X-ray-beam ablation of the spaceship's rear surface by the remote detonation of a sequence of asymmetrical bombs projected rearward from the ORION. In the wake of the Nuclear Test Ban Treaty (1962) ORION was canceled. Through a Scripps Institution of Oceanography project in Venice (involving ORION scientists and holographic technology) the nondestructive radiation-ablation process found a resurrection in the field of stone conservation (1972). Ironically, the first major art-conservation project to employ laser ablation (Porta della Carta of the Palazzo Ducale) was paid for in part by Warner Brothers Motion Picture Studios (1980). Finally, the "Venice Laser Statue Cleaner" followed the Viennese actress (Hedy Lamarr/Hedwig Eva Maria Kiesler) to Hollywood where it was employed to treat the granite veneer of the Warner Center (1981).

1.1 Introduction

The fields of art conservation and laser science merged, formally and fittingly, in the land of Polyclitus and Democritus with a 1995 event now called LACONA I (held at FORTH). However, appropriate that symbolic recognition of the sources of Western cultural heritage may seem, LACONA VI has, in Vienna, returned to the direct technological genesis of lasers in the service

of art. The implausible trajectory of “unintended consequences” that led to the introduction of laser technology into art conservation was triggered in 1941–1942 when Viennese cinema actress Hedy Lamarr invented a novel (jamming proof) concept for the radio transmission of guidance information to naval torpedoes.

Subsequent decades witnessed initial evaluations of the Lamarr modulation schemes that helped uncover new avenues in nuclear weapons design as well as in the invention of the nuclear-propelled spaceship (ORION). Subsequently, the holographic plasma diagnostics developed for the engineering design of the spaceship were applied to the in situ archival recording of deteriorating Venetian statuary. This, in turn, led to the improbable realization that the radiation-propulsion mechanism of ORION could provide a means of self-limiting divestment (and conservation) of crumbling marble statues.

The series of “connections” and happy accidents that helped in bringing about LACONA VI are summarized in the paragraphs that follow.

1.2 Hedy Lamarr and Her Communications Patent

In 1942 Viennese motion picture actress Hedy Lamarr (Figs. 1.1 and 1.2) (Hedwig Eva Maria Kiesler) of MGM was granted US Patent #2,292,387 for a “Secret Communication System” based on her invention of spread-spectrum (Figs. 1.3 and 1.4) and frequency-hopping concepts. Evidently, the idea was a merging of art and science in that it sprang from her knowledge of the military business of her husband, Fritz Mandl, and her understanding of the player piano (gained from her friendship with artist George Antheil). As her discovery formed the basis of cell phone technology, Wi-Fi protocols, and the wireless Internet, she won a US\$1/4M infringement claim against Corel Corporation and received the 1997 Electronic Frontier Award. (Upon receiving the award, 55 years after the fact, her response, “It’s about time,” received almost as much notice as her “au naturel” appearance in the 1933 Czech film, “Ecstasy.”)



Fig. 1.1. MGM motion picture star Hedy Lamarr

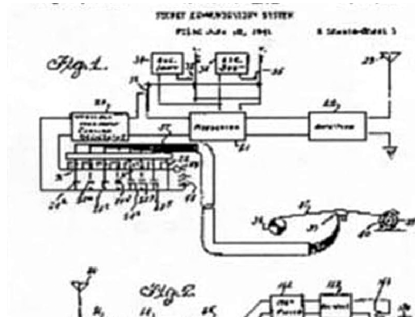


Fig. 1.2. The first page of Hedy Lamarr's 1942 patent, "A Secret Communication System," that introduced the frequency-hopping and spread-spectrum concepts to the communications field

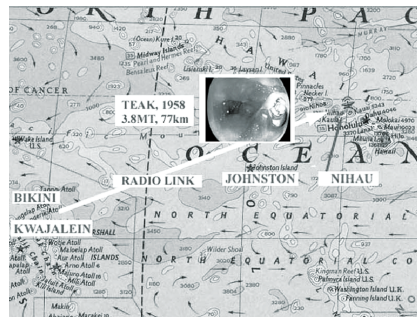


Fig. 1.3. Spread-spectrum communication link of Project ARGUS during the high-altitude nuclear detonation, TEAK (*inset*)



Fig. 1.4. The receiver site on the island of Niihau, Hawaii

The first evaluation of Hedy Lamar's approach to secure communications was carried out between Hawaiian Pacific Islands in 1958 during the Johnston Island high-altitude nuclear explosion TEAK (3.8 MT at 77 km altitude). Disappointingly, the experimental radio-wave transmission link was completely blacked out by the bomb's gamma-ray-induced aurora. However, spectral

analyses of the backscattered electromagnetic signal revealed that the H-bomb had, through a performance asymmetry, ejected a plasma jet.

1.3 Orion: Nuclear Spaceship

The ARGUS backscatter data together with other theoretical and experimental results predicted that nuclear explosive devices possessed the potential for being redesigned into directed-energy radiation sources. Upon this realization, members of the TEAK team joined with theoretical physicist Freeman Dyson and virtuoso minibomb designer Theodore Taylor to exploit and optimize this phenomenon in order to develop a nuclear-propelled spaceship, ORION, for a mission to the planet Saturn (scheduled for 1970). Following a first ORION test flight (1962), the adoption of the Nuclear Test Ban Treaty led to the demise of the program. Figures 1.5–1.7 display a few of the test results of laboratory proof-of-principle ORION technology demonstrations that reveal the impulse delivered by laser ablation.



Fig. 1.5. Deformation of a restrained metallic coin through the impulse delivered by laser ablation pressure at a multigigawatt and kilojoule level

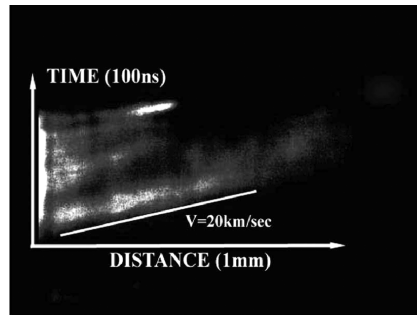


Fig. 1.6. A streak camera record of the laser propulsion of an unrestrained metallic disk to $V = 20 \text{ km s}^{-1}$

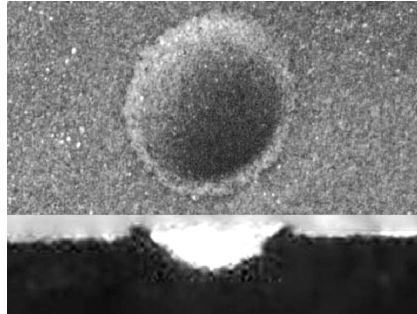


Fig. 1.7. Hypervelocity impact crater (and its cross section) produced by the energy released by a laser-propelled projectile

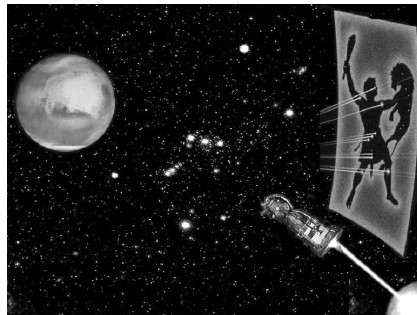


Fig. 1.8. A conceptual portrayal of a nuclear-driven ORION spaceship

Figure 1.8 presents a conceptual rendering of the ORION space vehicle near Mars.

1.4 Laser Divestment in Venice

The real-time holographic diagnostics developed for ORION were resurrected for art-conservation purposes in Venice in January 1972. This was a consequence of a collaboration of Scripps Institution of Oceanography geophysicists and ORION project alumni in research directed toward the alleviation of the “acqua alta” problem being experienced by the lagoon. By March 1972 the ruby holographic laser was being employed to clean marble sculpture by means of radiation-induced ablation in accordance with results from the radiation-hydrodynamic modeling of the earlier X-ray-beam nuclear-propulsion system (Fig. 1.9). This came about at the suggestion of Lorenzo Lazzarini and Giulia Musumeci of the Venetian Soprintendenza in response to the unacceptable cleaning results on friable stone with conventional air-abrasive and chemical approaches (Fig. 1.10).



Fig. 1.9. Arch. Calcagno’s first in situ ruby-laser cleaning demonstration on one of the “Ruskin Capitals” of the Palazzo Ducale in Venice)



Fig. 1.10. Unsuccessful conventional cleaning test areas on a Piazza San Marco facade

This preamble to the formation of LACONA (more than a decade later by scientists at FORTH) came full circle with the entrance of an MGM competitor, Warner Brothers Films. At a 1977 Venice Film Festival event (a showing of “Clockwork Orange” in Asolo), Jack Warner, Jr. offered to divert a portion of his profits from “Clockwork Orange” to pay for a laser restoration feasibility project. He, together with his friends and associates, raised US\$ 5,000 toward this end.

Arch. Giancarlo Calcagno of the Soprintendenza selected the artwork to be the subject of the first laser cleaning demonstration. The piece he selected in the Porta della Carta was a marble relief depicting “The Last Supper.” It was approximately 60 cm high and 180 cm wide. After a protracted sequence of laser validation tests in the laboratory, the actual laser demonstration took place in 1980 when an Nd:YAG laser was used to clean the marble relief in support of the overall Porta della Carta conservation effort.

As the relief had been laid horizontally on its back for treatment, the laser was mounted on a beam above the artwork. The laser beam was directed vertically downward to impinge on the marble surface. The laser head was attached to the supporting beam with a swivel joint so that the laser beam



Fig. 1.11. Porta della Carta of the Palazzo Ducale in Venice and a vertically mounted laser cleaning the marble relief of “The Last Supper”



Fig. 1.12. The central, cleaned area of the marble piece

could be manually scanned across the surface. The laser functioned in the normal mode ($400\mu\text{s}$) at 1 J per pulse. In most areas a spot size of 3 mm was employed. Figure 1.11 shows the Porta della Carta and the laser pointing downward onto the relief. The initial, centrally cleaned area is shown in Fig. 1.12.

1.5 Return to Hollywood and the Cinema

A new Warner Brothers corporate office complex was constructed in the Los Angeles area while the laser work proceeded in Venice. The following year (1981), with the completion of the central corporate tower of the Warner Center, the general contractor found that rubber cushioning used during shipping had discolored the tower’s South African granite veneer slabs. Chemical treatments that removed the stains also etched the stone and left it with a frosted appearance. Figure 1.13 shows the central tower of the Warner Center complex. The dark vertical stripes, as well as the horizontal bands at the top and bottom, are the South African granite veneers.



Fig. 1.13. Warner center tower with the prominent granite veneer bands and vertical stripes



Fig. 1.14. A detail of laser treatment (bleaching) of the stained granite

As a last resort, the “Venetian” laser was sent to the Warner Tower for a cleaning trial. At low fluxes and high fluences, the laser-induced optical damage in the mineral grains of the stone. The resulting cleavages within the mineral grains resembled the normal heterogeneity of granite, yet masked the in-depth chemical blemish. This approach was selected as the most suitable treatment. Consequently, good fortune made one further appearance when the “Venetian” laser repaid a debt to the cinema industry by removing the blemishes from the exterior granite of the corporate center after the failure of chemical cleaning techniques. Figure 1.14 shows the results of the laser irradiation of the blemished granite veneer.

1.6 Conclusions

Histories of developments in science and technology are replete with instances of unintended and/or unanticipated consequences. Sometimes such surprises are favorable. Often they bode disaster. All of the earliest pioneers of the laser have expressed bemusement at the laser’s entry into the field of art conservation practice (as well as its ubiquitous role in the worlds of the audio

CD and the video DVD). Most certainly, that occurrence is an “untended consequence” of investigations into the very diverse fields of spread-spectrum communications, deep-space nuclear propulsion, holographic plasma diagnostics, and archival holographic recording. In retrospect it is clear that laser surface divestment would have found its way into the field of art conservation at some point. However, the route that did lead initially to the laser in the arts is a testimonial to the tenacious punctuality with which serendipity invades the circuitry of technological progress. This individual route to innovation, beginning, and then returning to Vienna, is one more example (in a myriad of examples) demonstrating that discovery seldom proceeds in a linear and predictable fashion.

Acknowledgments

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