CASE REPORT

Richard E. Russo,[1,3] *Ph.D.; G. Ernestine Pelkey,*[2] *B.S.; Patrick Grant,*[3] *Ph.D.; Richard E. Whipple,*[3] *B.A.; and Brian D. Andresen,*[3] *Ph.D.*

Laser Interrogation of Latent Vehicle Registration Number

REFERENCE: Russo, R. E., Pelkey, G. E., Grant, P., Whipple, R. E., and Andresen, B. D., **"Laser Interrogation of Latent Vehicle Registration Number,"** *Journal of Forensic Sciences*, JFSCA, Vol. 39, No. 5, September 1994, pp. 1331–1334

ABSTRACT: Optimally tuned laser light illumination through the back of multilayered license-plate decals provided nondestructive absolute identification of a latent registration number.

KEYWORDS: forensic science, laser illumination, vehicle registration decals

A recent investigation involved automobile registration numbers as important evidentiary specimens. In California, as in most states, small, thin metallic decals are issued to owners of vehicles each year as the registration is renewed. The decals are applied directly to the license plate of the vehicle and typically on top of the previous year's expired decal. To afford some degree of security, the individual registration decals have been designed to tear easily; they cannot be separated from each other, but can be carefully removed intact from the metal license plate by using a razor blade.

In September 1993, the City of Livermore Police Department obtained a blue 1993 California decal that had been placed over an orange 1992 decal. The two decals were being investigated as possible evidence in a case involving vehicle registration fraud (violation 4462.5 of the California Vehicle Code). To confirm the suspicion and implicate a suspect, the department needed to know the registration number on the bottom (completely covered) 1992 decal. Because of the delicacy of the decal assembly, it presented a formidable challenge to ascertain the latent registration number. Several manipulations and chemical techniques were unsuccessful in separating the two decals. These experiments included applications of several solvents, as well as heat and liquid-nitrogen temperature treatments. All of these attempts were destructive and were not successful in separating the decals in

Received for publication 10 Feb. 1994; accepted for publication 7 March 1994.

[1] Staff Scientist, Energy & Environment Division, Lawrence, Berkeley Laboratory, Berkeley, CA.
[2] Forensic Specialist, City of Livermore Police Department, Livermore, CA.
[3] Deputy Director, Chemist, and Director, respectively, Forensic Science Center, Livermore National Laboratory, Livermore, CA.

a coherent state. As designed, these vehicle registration decals are quite impressive in their resistance to postapplication manipulations.

Based on our background in lasers and optics [*1–5*], we attempted to use intense and directed light to interrogate the colored stickers. Optical illumination using a filtered white-light source partially identified the latent number. However, the most successful technique used a tunable dye laser pumped by a pulsed Nd:YAG laser. By selectively tuning the wavelength and intensity of the dye laser, backlit illumination of the decals permitted visualization of the underlying registration number through the surface of the top sticker. With optimally-tuned wavelength and intensity, 100% accuracy was obtained in identifying the sequence of latent characters. Light and lasers have found recent use for forensic fingerprinting purposes [*6–8*], but to the best of our knowledge, lasers have not been used for this type of imaging application before. The advantage of optical techniques is their completely nondestructive nature, thus preserving the evidence for further interrogation or courtroom presentation.

Experimental System and Method

The decals were removed from a license plate and were free-standing, measuring approximately 2 × 3 cm. The top 1993 decal was blue with an alphanumeric registration sequence: T6929617. The underlying 1992 decal was orange, as evidenced by the edges of the assembly and knowledge of the 1992 California DMV color-code protocol. The two decals were closely aligned in their overlap (see Fig. 1). Because of the opacity of the upper decal, it was impossible to discern the underlying orange decal or its number sequence with the unaided eye.

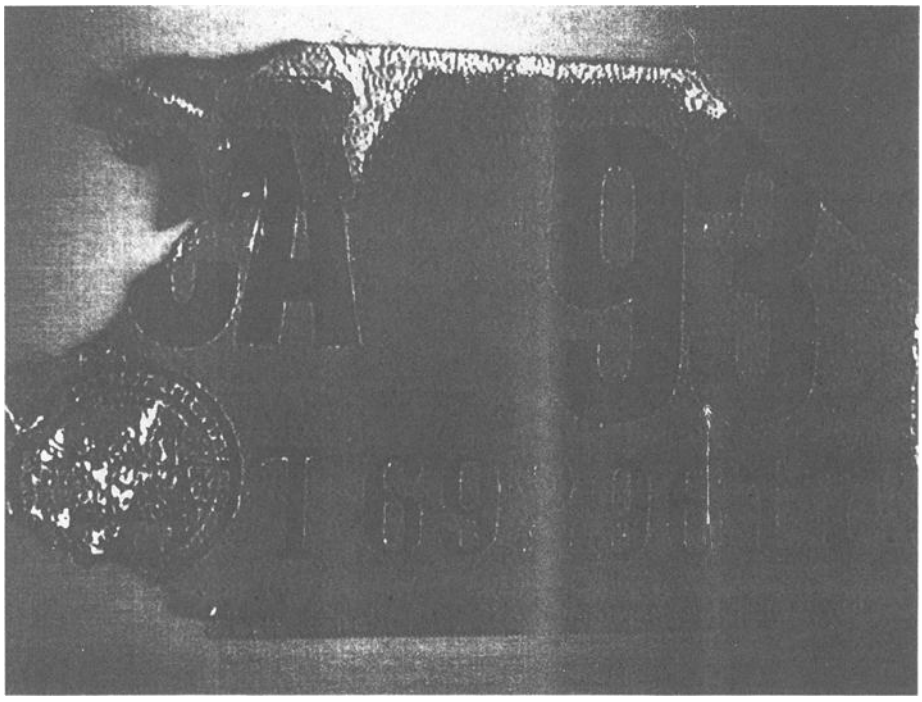

FIG. 1—*Photograph showing 1993 registration decal with edges peeled back to expose underlying 1992 decal.*

Two experimental systems were utilized: an Omnichrome 9000 alternate light source and a Spectra Physics Nd:YAG pulsed dye-laser system. The Omnichrome provided distinct broadband wavelengths by rotating one of five filters into a white-light beam, or gave tunable spectral irradiance from about 350 nm to 700 nm, with 10 nm bandpass, via a diffraction grating. Either beam could be directed into an optical fiber cable for delivery to the specimen. The laser system consisted of a nanosecond-pulsed Nd:YAG laser (DCR-2A) pumping a dye laser (PDL-2). The second harmonic frequency of the Nd:YAG laser (532 nm) was used to pump Rhodamine 640 dye (Exciton). The tunable spectral range available with this dye was approximately 580 nm to 620 nm, with a spectral purity of 0.1 nm. Only the oscillator cell in the dye laser cavity was used; for higher intensity requirements, an amplifier cell was also available. The dye laser output was attenuated by means of a variable neutral-density filter (Newport 935-5). Using either system, focused light was directed at one side of the decal assembly while the alphanumeric characters were viewed from the other side.

Results and Discussion

To determine the underlying registration number, our approach was to ascertain the appropriate light of optimum wavelength to illuminate one side of the decal assembly and observe the black numbers underneath. The Omnichrome was used initially with variable spectral output. However, the intensity of this source was insufficient to penetrate both layers, using either back-illumination with orange light or front-illumination with blue light. The discrete-output port of the Omnichrome provided higher intensity at each of its five filter settings. Front illumination with blue light (450 nm) from the Omnichrome was not successful in penetrating to the underlying layer.

Next, the 570-nm filter was chosen as the closest color match to the orange decal. Using back-illumination, the underlying black characters were faintly visible when viewed through the front blue layer. The majority of the digits could be deciphered, but two of them were still uncertain. Several of the characters were easily determined, particularly the leading letter, "R." The interpretation difficulty arose because of the low light intensity provided by the Omnichrome, the non-optimal wavelength, and the overlap of top and bottom black numbers of the decals. After tedious visual inspection, the latent sequence was interpreted and proposed to be either R4082949 or R4082999. The illuminated decal was photographed; however, the photographs were poor because of the high film exposure associated with a high-intensity light source. As a consequence of this initial analysis, the two candidate registration numbers were submitted to the California DMV for database identification. Both numbers were identified, but were judged unlikely to have an association with the investigation.

The laser system was then used with the output wavelength tuned to 595 nm (orange) at an average power of 20 mW. Care was taken to avoid burning the backing with excessive beam intensity. Using the dye laser, the character sequence was identified as R8082999. This registration number was submitted to the California DMV for database identification and was returned as correct and pertinent to the investigation. The use of laser-generated blue light with front-surface illumination was not attempted. For this particular laser, tuning to the blue spectral region required changing the dye and optical configuration.

After spectral analysis, a destructive technique was then discovered that allowed us to directly validate the imaging results. By using fine-grit (320), wet/dry sandpaper, it was possible to carefully remove the upper blue decal without damaging the underlying orange one. The metallic layer of the decal sanded easily until the glue layer was reached, at which point the sandpaper was not as effective. Once the metallic blue component was removed, the glue layer could be easily lifted off the underlying sticker. The latent registration number was confirmed to be R8082999, indicating that laser illumination with optimum wavelength

could provide absolute identification. In certain other situations, the Omnichrome analysis would likely be more successful; in this instance, however, it resulted in an effective 1.5-digit mismatch.

We are currently developing an imaging system that will use either the Omnichrome source or the dye laser in conjunction with a Photonics CCD digitizing camera. Using image-manipulation software, it will then be possible to digitally subtract obscuring attributes of the overlaying image to enhance the identification of latent features.

Acknowledgment

This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

References

[1] Russo, R. E., Rojas, D., Robouch, P., and Silva, R. J., "Remote Photoacoustic Measurements In Aqueous Solutions Using An Optical Fiber," *Review of Scientific Instruments,* Vol. 61, 1990, pp. 3729–3732.

[2] Spear, J. D., Russo, R. E., Andrews, J., and Grant, P., "Lens Correction for the Implementation of Cylindrical Vessels in a Spectrophotometer," *Review of Scientific Instruments,* Vol. 63, 1992, pp. 4457–4458.

[3] Schurig, D. A., Klunder, G. L., Silva, R. J., and Russo, R. E., "Signal Analysis of Transients in Pulsed Photoacoustic Spectroscopy," *Review of Scientific Instruments,* Vol. 64, 1993, pp. 363–373.

[4] Faulques, E. and Russo, R. E., "Raman Spectra of Iodide Species in Intercolated IBiSrCaCuO," *Solid State Communications,* Vol. 82, 1992, pp. 531–535.

[5] Rojas, D., Silva, R. J., and Russo, R. E., "Thermal Lens Spectroscopy Using a Diode Laser and Optical Fibers," *Review of Scientific Instruments,* Vol. 63, 1992, pp. 2989–2993.

[6] Kaymaz, E. and Mitra, S., "A Novel Approach to Fourier Spectral Enhancement of Laser-Luminescent Fingerprint Images," *Journal of Forensic Sciences,* Vol. 38, No. 3, May 1993, pp. 530–541.

[7] Menzel, E. R., "Detection of Latent Fingerprints by Laser-Excited Luminescence," *Analytical Chemistry,* Vol. 61, No. 8, 1989, pp.557A–561A.

[8] Menzel, E. R., *Fingerprint Detection with Lasers,* Marcel Dekker, New York, 1980.

Address requests for reprints or additional information to
Rick Russo or Pat Grant
Forensic Science Center, L-371
Livermore National Laboratory
Livermore, CA 94550