Michael J. Auvdel,[1] *M.Sc.*

Comparison of Laser and High-Intensity Quartz Arc Tubes in the Detection of Body Secretions

REFERENCE: Auvdel, M. J., **"Comparison of Laser and High-Intensity Quartz Arc Tubes in the Detection of Body Secretions,"** *Journal of Forensic Sciences,* JFSCA, Vol. 33, No. 4, July 1988, pp. 929-945.

ABSTRACT: The detection capabilities of both laser and high-intensity quartz arc tubes were evaluated. The Spectra-Physics Model 171-19, 18-W argon ion laser and Laser Sonics Model CS-2, 200-mW air-cooled argon ion laser were compared with Payton Scientific's Luma-Print, high-intensity quartz arc tube. The light sources were evaluated as to their detection limits for various biological stains. The stains that were evaluated had been made during prior research. These stains had been stored at room temperature for approximately two years. The stains were a serial dilution made from semen, saliva, and sweat specimens and were examined using both laser light sources and the high-intensity quartz arc tube. The advantages and disadvantages of each light source in relationship to its initial costs and potential use in forensic serology are discussed.

KEYWORDS: forensic science, body fluids, quartz arc tubes, lasers, Luma-Print light, saliva, semen, sweat

The detection and localization of various body fluid stains encountered in forensic science casework is of major importance to the forensic serologist. White light, ultraviolet light, and laser light sources can be used in the visualization of stains made by various body secretions [*1*]. The ability of a number of body fluid stains to fluoresce under ultraviolet and laser light sources makes these light sources valuable tools in the screening of various articles for body secretion stains [*2–5*]. There is an alternative light source now available which can be used for the detection of body fluid stains. This light source is the Luma-Print (by Payton Scientific), which is a high-intensity quartz arc tube.

This project dealt with the detection capabilities of two different lasers and the high-intensity quartz arc tube. The light sources were evaluated as to their detection limits on stains made from serial dilutions of semen, saliva and sweat. The advantages and disadvantages of each light source in relationship to its initial costs and potential use in forensic serology are discussed.

The equipment used in this project comprised the following:

1. Spectra-Physics Model 171-19 argon ion laser;
2. Laser Sonics Model CS-2, 200-mW air-cooled argon ion laser; and
3. Payton Scientific's Luma-Print, high-intensity quartz arc tube.

The opinions expressed herein are those of the author and do not necessarily reflect the views of the Department of the Army or the Department of Defense. Received for publication 5 Sept. 1987; revised manuscript received 29 Oct. 1987; accepted for publication 30 Oct. 1987.

[1]Forensic chemist, U.S. Army Criminal Investigation Laboratory-CONUS, Fort Gillem, Forest Park, GA 30050-5000.

Method

The semen, saliva, and sweat specimens used in this study had been stored at room temperature for two years. Serial dilutions of neat, 1/2, 1/4, 1/8, and 1/16 had been made using fluid semen, saliva, and sweat from one laboratory donor. Stains were made using 50 μL of each specimen and its dilutions on sections cut from 23 different articles including clothes, control cloth, and a bedsheet. The stained fabrics were examined with the two different lasers and the Luma-Print light.

Table 1 lists the different articles used for staining purposes, their color, and whether or not the items were washed before application of the specimens. Table 2 lists both the weave/knit and fiber composition of the different articles tested.

The results on Table 3 were obtained by screening Items 1 through 23 that had a serial dilution series of semen. Twenty-one of Items 1 through 23 had seminal stains visible using the Luma-Print light. Seventeen of these twenty-one stains were visible using both the 18-W and the 200-mW lasers. Two of the items, 15 and 22, had strong fluorescence which masked the presence of the stains. These items that had strong fluorescence with both the Luma-Print light and both lasers made it impossible to visualize the seminal, saliva, and sweat stains on them.

The results on Table 4 were obtained from screening Items 1 through 23 that had a serial dilution of saliva. Eleven of the twenty-three items had saliva stains visible with the Luma-Print light. Seven of these eleven stains were visible with both the 18-W laser and the 200-mW laser. Table 5 gives the results of the screening of Item 1 through 23 that had a serial dilution of sweat. Seven of the twenty-three items had sweat stains detected with the Luma-Print light. Five of the seven stains were detected using both lasers.

Discussion

Laser light sources can be used as simple and nondestructive screening techniques for the presence of various body fluid stains. Inherent luminescence of various body fluids results in

TABLE 1—*Items used in testing.*

Item No.	Article	Color	Times Washed
1	standard cloth	white	one
2	pants	blue	many
3	bed sheet	white	many
4	panties	white	many
5	shirt	blue/brown	many
6	shirt	white/blue	many
7	shirt	cream/red	many
8	shirt	white	many
9	shirt	yellow/orange	many
10	shirt	white/blue	many
11	shirt	yellow/brown	many
12	shirt	brown	many
13	sweater	gray/brown	many
14	sweater	navy/blue	many
15	sock	burgundy	many
16	sweater	charcoal/gray	many
17	shirt	tan	many
18	sock	charcoal/gray	many
19	sock	brown	many
20	sock	gray	many
21	sock	white	many
22	sock	burgundy	many
23	sock	brown	many

TABLE 2—*Fiber composition of items tested.*

Item No.	Weave/Knit	Fiber Composition
1	weave	cotton
2	weave	cotton/polyester
3	weave	cotton
4	knit	nylon continuous filament
5	weave	cotton/polyester
6	weave	polyester and polyester/cotton
7	knit	acetate-continuous filament
8	knit	cotton
9	weave	cotton/polyester
10	weave	cotton/polyester
11	knit	polyester continuous filament and cotton
12	knit	polyester continuous filament and cotton
13	knit	polyester continuous filament and cotton/rayon
14	knit	nylon continuous filament and acrylic
15	knit	nylon continuous filament and acrylic
16	knit	nylon continuous filament and acrylic
17	knit	polyester continuous filament and cotton
18	knit	nylon continuous filament and acrylic
19	knit	nylon continuous filament and acrylic
20	knit	polyester continuous filament and cotton/rayon
21	knit	acrylic
22	knit	nylon continuous filament and acrylic
23	knit	nylon continuous filament and acrylic

TABLE 3—*Screening results for seminal stains.*

Item No.	18-W Laser	200-mW Laser	Luma-Print
1	1/16w[a]	1/16w	1/16w
2	NV[b]	NV	1/4w
3	1/16s	1/16s	1/16s
4	1/4w	1/2w	1/4w
5	1/2w	1/2w	1/2w
6	1/4w	1/4w	1/4w
7	1/16s	1/16s	1/16s
8	1/16w	1/16w	1/16w
9	1/2w	1/2w	1/2w
10	1/4w	1/2w	1/16s
11	1/2s	1/2s	1/2s
12	1/4w	1/4w	1/4w
13	1/4w	1/4w	1/4w
14	1/2w	neat	1/2w
15	NV	NV	NV
16	NV	NV	neat
17	1/4w	1/4w	1/4w
18	NV	NV	neat
19	1/4w	1/2w	1/4w
20	1/16w	1/16w	1/16w
21	1/8w	1/4w	1/8w
22	NV	NV	NV
23	NV	NV	1/2w

[a]Dilution series was neat, 1/2, 1/4, 1/8, and 1/16. (s = strong, w = weak).
[b]NV = not visible.

TABLE 4—*Screening results for saliva stains.*

Item No.	18-W Laser	200-mW Laser	Luma-Print
1	1/8w[a]	1/4w	1/4w
2	NV[b]	NV	NV
3	1/16s	1/16w	1/16s
4	neat w	neat w	neat w
5	NV	NV	NV
6	NV	NV	NV
7	1/4w	1/2w	1/4w
8	neat w	neat w	1/8w
9	NV	NV	1/2w
10	1/4w	1/2w	1/4w
11	NV	NV	NV
12	NV	NV	NV
13	NV	NV	NV
14	neat w	neat w	neat w
15	NV	NV	NV
16	NV	NV	NV
17	NV	NV	neat
18	NV	NV	NV
19	NV	NV	neat
20	NV	NV	NV
21	NV	NV	NV
22	NV	NV	NV
23	NV	NV	neat

[a]Dilution series was neat, 1/2, 1/4, 1/8, and 1/16. (s = strong, w = weak).
[b]NV = not visible.

TABLE 5—*Screening results for sweat stains.*

Item No.	18-W Laser	200-mW Laser	Luma-Print
1	1/16s[a]	1/16w	1/16s
2	NV[b]	NV	NV
3	1/16w	1/16w	1/16w
4	1/16s	1/16w	1/16s
5	NV	NV	NV
6	NV	NV	NV
7	1/8w	1/4w	1/8w
8	neat w	neat w	1/2w
9	NV	NV	NV
10	NV	NV	1/4w
11	NV	NV	NV
12	NV	NV	NV
13	NV	NV	NV
14	NV	NV	NV
15	NV	NV	NV
16	NV	NV	NV
17	NV	NV	neat
18	NV	NV	NV
19	NV	NV	NV
20	NV	NV	NV
21	NV	NV	NV
22	NV	NV	NV
23	NV	NV	NV

[a]Dilution series was neat, 1/2, 1/4, 1/8, and 1/16. (s = strong, w = weak).
[b]NV = not visible.

their ability to fluoresce under laser light. This ability also enables these fluids to be detected with the high-intensity quartz arc tube of the Luma-Print light.

Figures 1 through 3 show the result of screening a piece of commercially purchased standard white cloth, Item 1, that had been washed once after purchase and the semen then applied. Figures 4 through 6 show the result of screening a piece of white cotton bedsheet, Item 3. The bedsheet had been washed numerous times before the semen was applied. The stains were visible through a 1/16 dilution on Items 1 and 3 using the Luma-Print light and both lasers. The Luma-Print light detected four stains that were not detected by either laser. The Luma-Print light and the 18-W laser were shown to be comparable as far as detection limits with the stains that were detected by both units. A majority of the stains detected with the 18-W laser were also detected with the 200-mW laser. However, because of the lower output power of the 200-mW laser, the overall intensity was less and several of the greater dilutions were not detected.

Figures 7 through 9 show the result of screening a white T-shirt from laboratory casework for the presence of semen. The T-shirt was composed of cotton and polyester fibers. The seminal stain was easily observed using the Luma-Print light and both lasers.

Seminal stains were detected on 91% of the test items screened with the Luma-Print light. The detection rate for the seminal stains using the two lasers was 73%.

Figures 10 through 12 show the result of screening sections of a standard white cloth, Item 1, for the presence of saliva. The dilution of 1/8 was detected using the 18-W laser. The Luma-Print light and the 200-mW laser detected dilutions through 1/4.

Figures 13 through 15 show the result of screening sections of the bedsheet, Item 3, for the presence of saliva. Stains diluted 1/16 were easily visible using both the 18-W laser and the Luma-Print light. The stains showed a greater degree of fluorescence with the 18-W laser. The stains were also detected but only weakly through a 1/16 dilution with the 200-mW unit. Four stains were detected with the Luma-Print light that were not detected with either laser. The Luma-Print light and the 18-W laser were comparable to each other on the saliva stains that were detected by both units. The detection limits and intensity were less with the 200-mW laser.

Saliva stains were detected on 48% of the test items screened with the Luma-Print light. Saliva stains were detected on 30% of the items screened with both the 18-W and 200-mW lasers.

Figures 16 through 18 show the result of screening sections of a standard white cloth, Item 1, for the presence of sweat. The stains were easily detected through a 1/16 dilution using both the Luma-Print light and the 18-W laser. The same stains were weak but still detected through a 1/16 dilution with the 200-mW laser.

Figures 19 through 21 show the result of screening sections of the bedsheet, Item 3, for the presence of sweat. The stains were detected through a 1/16 dilution using the Luma-Print light and both the 18-W laser and the 200-mW unit.

Two stains were detected with the Luma-Print light that were not detected with either laser. The Luma-Print light and the 18-W laser were comparable to each other on the sweat stains that were detected by both units. The detection limits and the intensity were less with the 200-mW unit.

Sweat stains were detected on 30% of the items screened with the Luma-Print light. The detection rate for both of the lasers was 21%.

Conclusion

The Luma-Print light and both the 18-W and 200-mW lasers are excellent instruments for the detection of body fluid secretions. Table 6 gives a comparison of equipment specifications and costs for each unit.

Comparison of the three instruments showed the Luma-Print light to have a better detec-

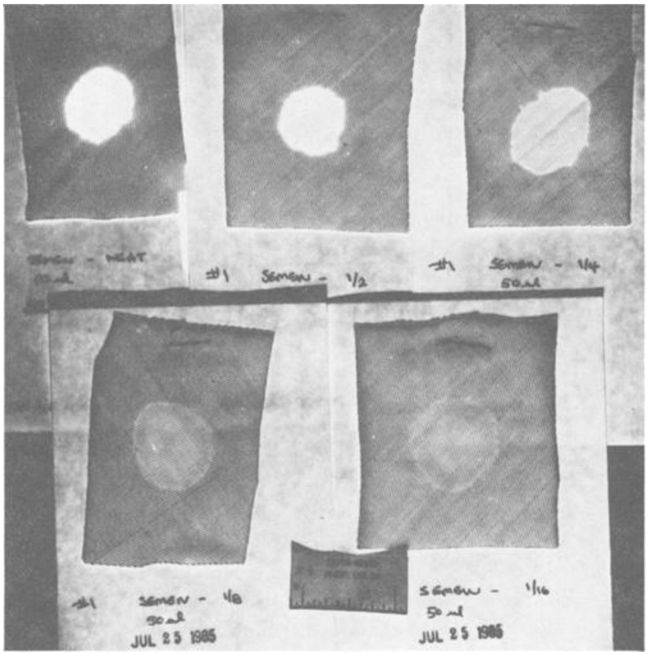

FIG. 1—*Screening of a piece of commercially purchased standard white cloth, Item 1, with Luma-Print light that was washed once after purchase and then stained with semen.*

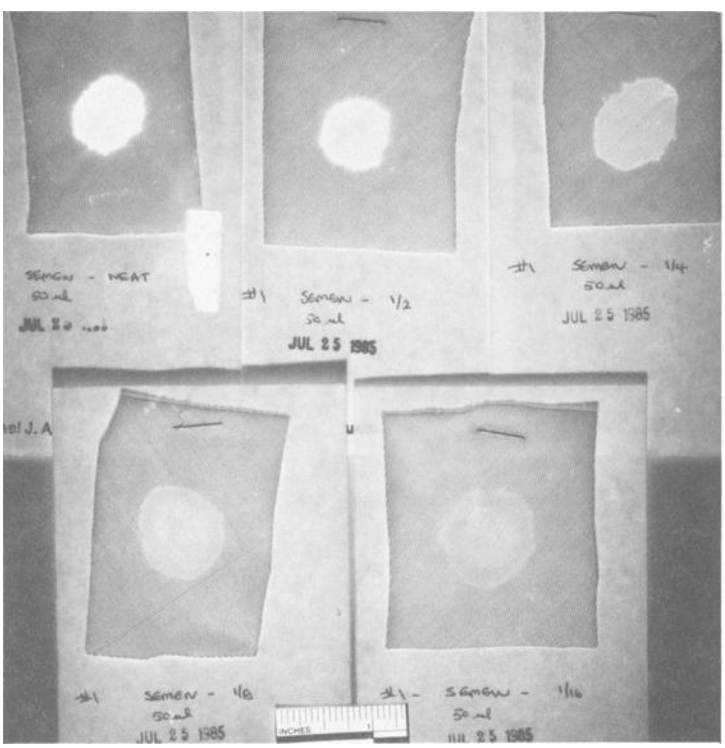

FIG. 2—*Same conditions and cloth as Fig. 1, except screened with 200-mW laser.*

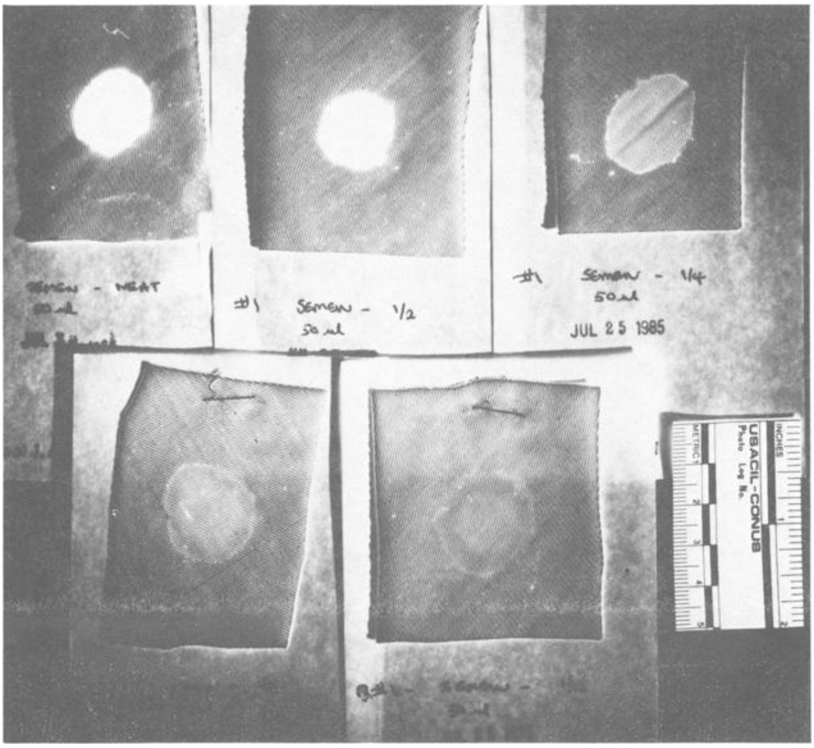

FIG. 3—*Same conditions and cloth as Fig. 1, except screened with 18-W laser.*

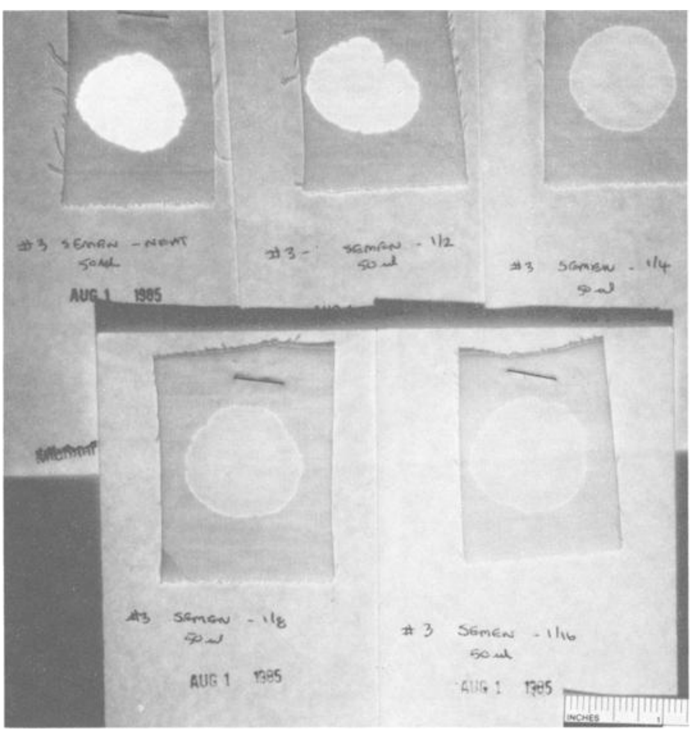

FIG. 4—*Screening with Luma-Print light of a white cotton bedsheet, Item 3, that had been washed numerous times before semen was applied.*

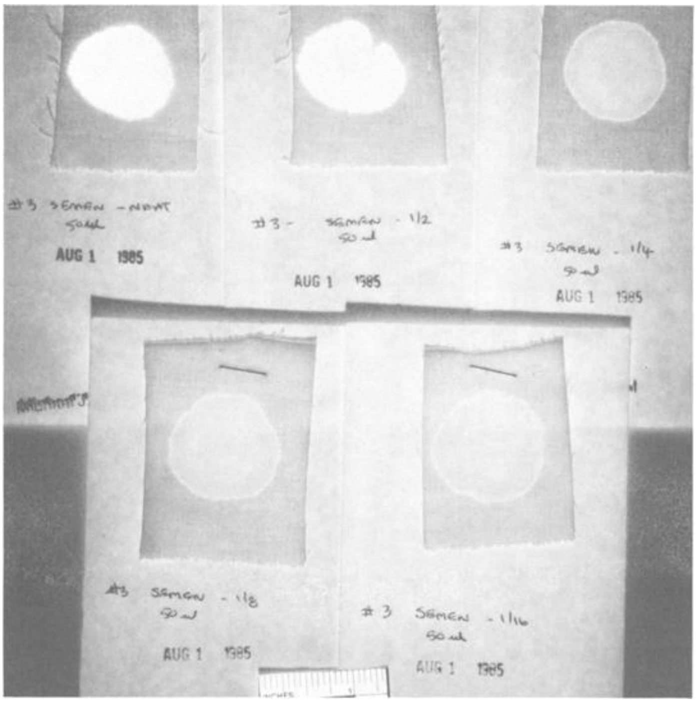

FIG. 5—*Same conditions and bedsheet as Fig. 4, except screened with 200-mW laser.*

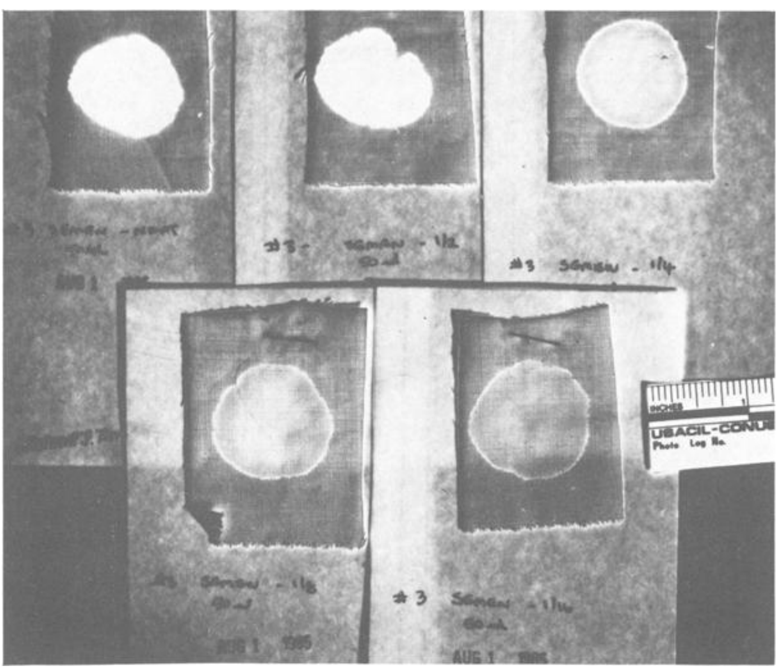

FIG. 6—*Same conditions and bedsheet as Fig. 4, except screened with 18-W laser.*

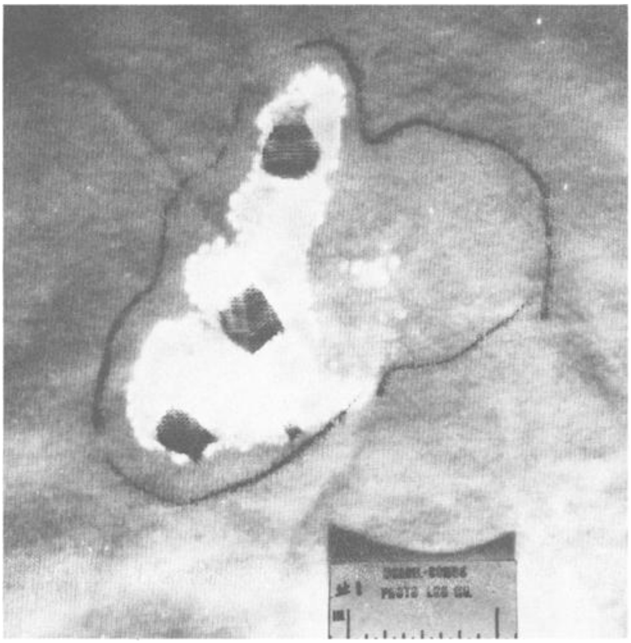

FIG. 7—*Screening of a white T-shirt for semen with Luma-Print light.*

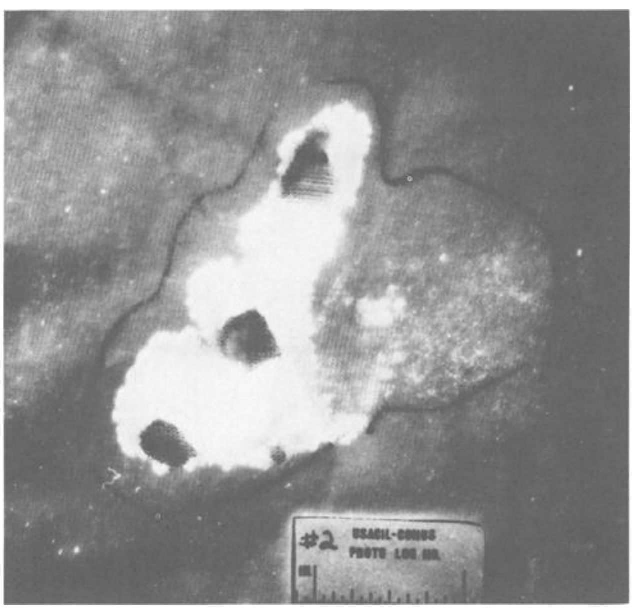

FIG. 8—*Screening of a white T-shirt for semen with 200-mW laser.*

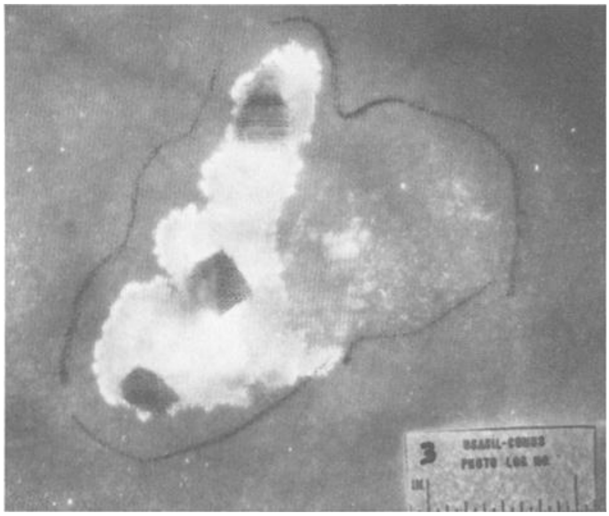

FIG. 9—*Screening of a white T-shirt for semen with 18-W laser.*

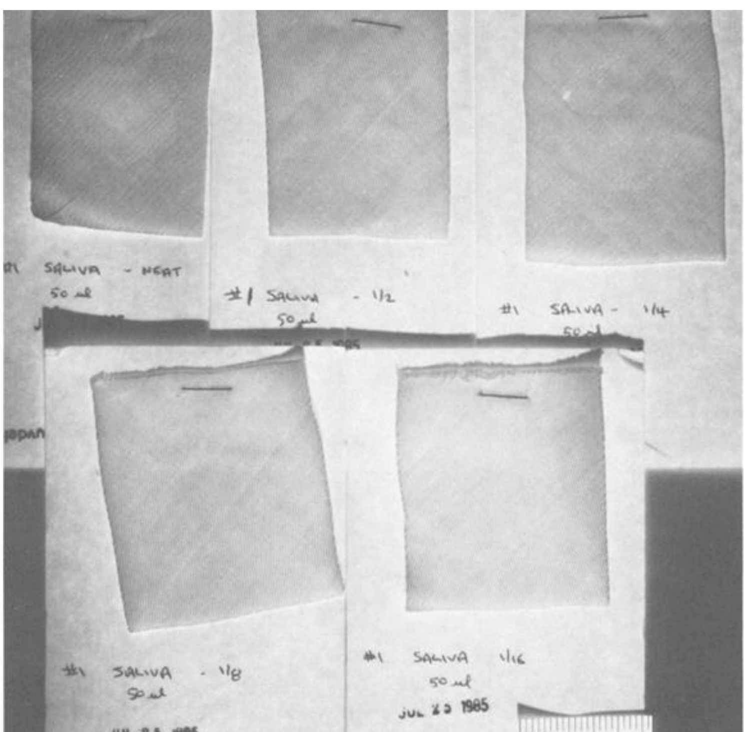

FIG. 10—*Screening of a piece of commercially purchased standard white cloth, Item 1, with the Luma-Print light that was washed once after purchase and then stained with saliva.*

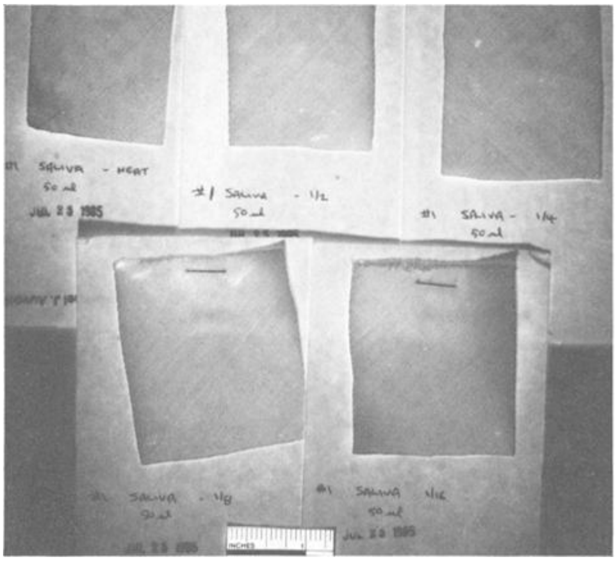

FIG. 11—*Same conditions and cloth as Fig. 10, except screened with 200-mW laser.*

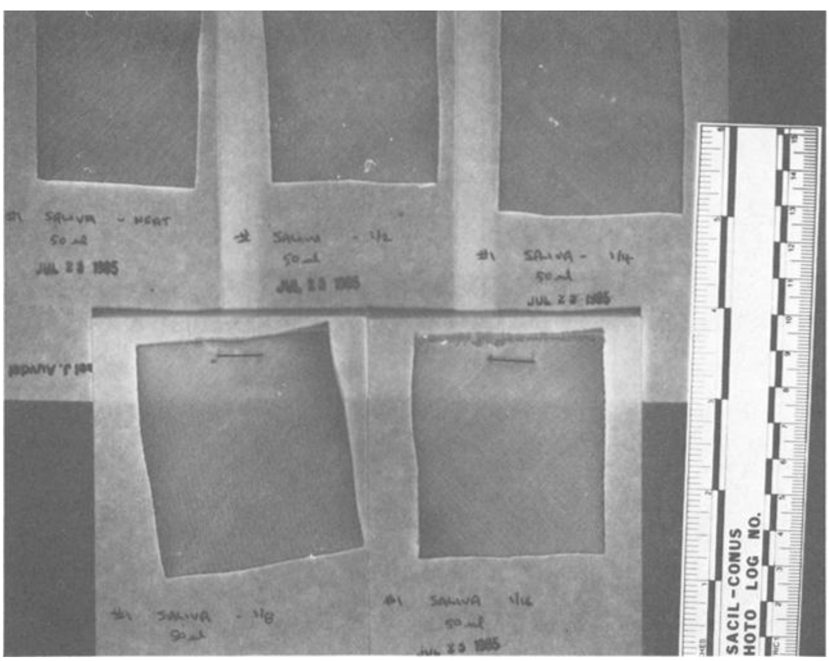

FIG. 12—*Same conditions and cloth as Fig. 10, except screened with 18-W laser.*

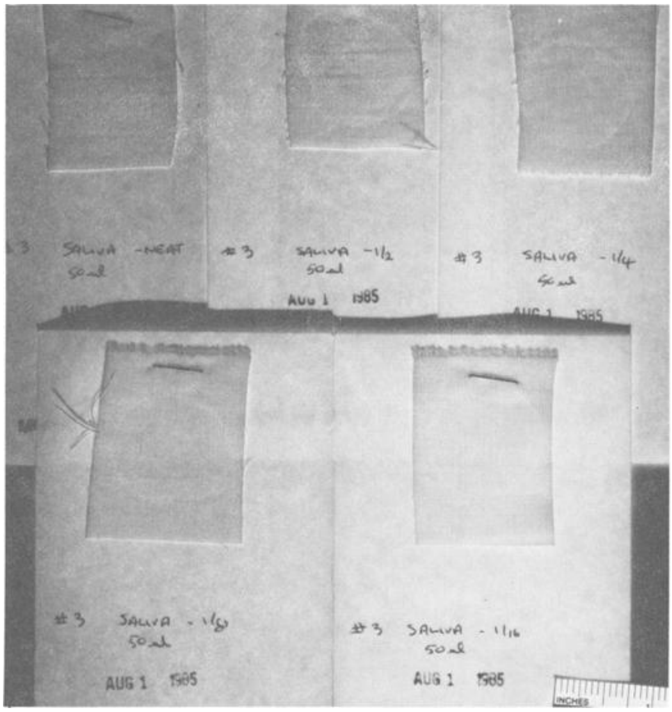

FIG. 13—*Screening with Luma-Print light of a white cotton bedsheet, Item 3, that had been washed numerous times before saliva was applied.*

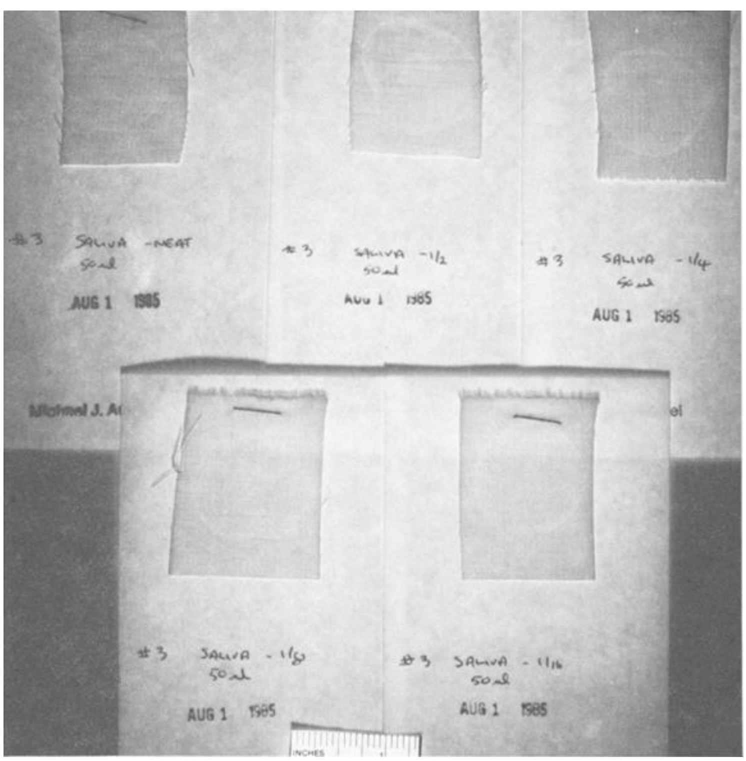

FIG. 14—*Same conditions and bedsheet as Fig. 14, except screened with the 200-mW laser.*

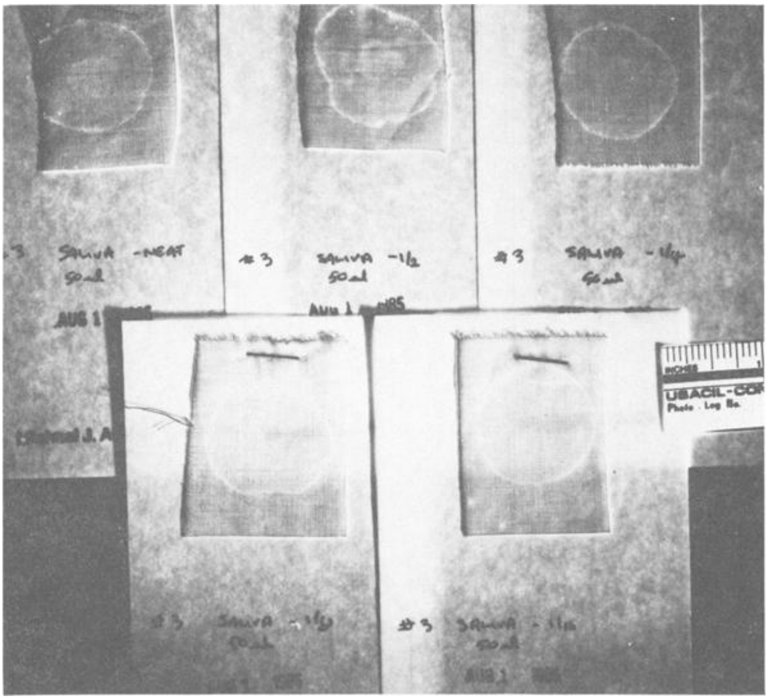

FIG. 15—*Same conditions and bedsheet as Fig. 14, except screened with 18-W laser.*

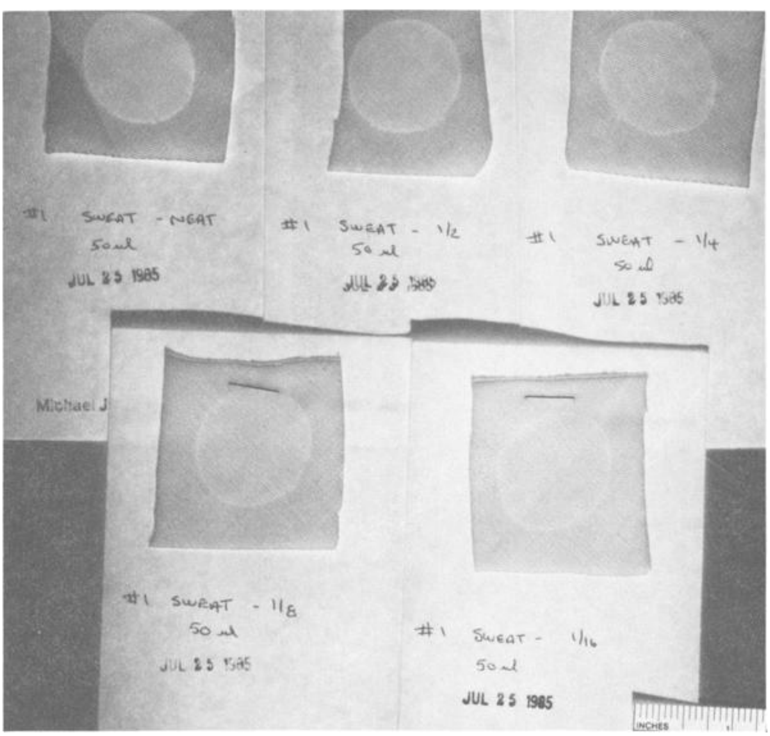

FIG. 16—*Screening of a piece of commercially purchased standard white cloth, Item 1, with Luma-Print light that was washed once after purchase and then stained with sweat.*

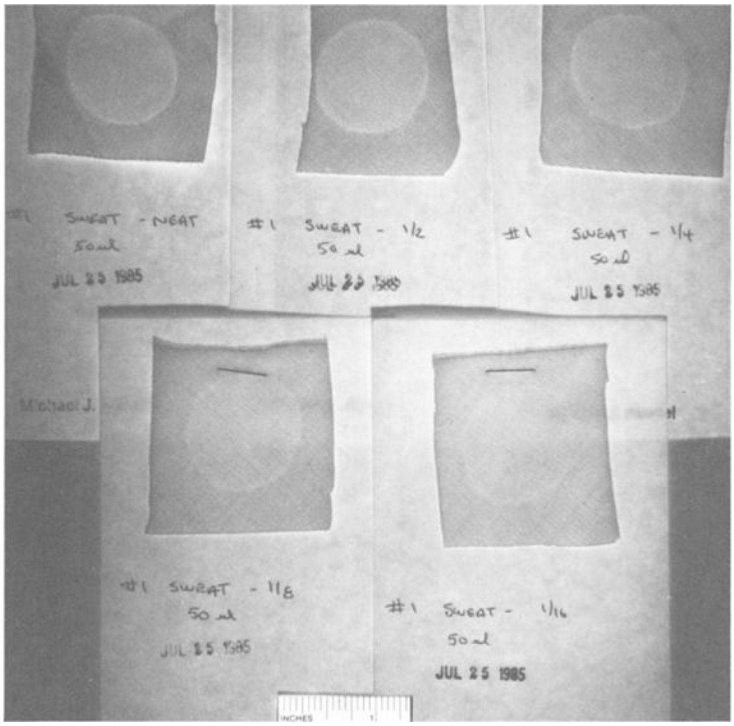

FIG. 17—*Same conditions and cloth as Fig. 16, except screened with 200-mW laser.*

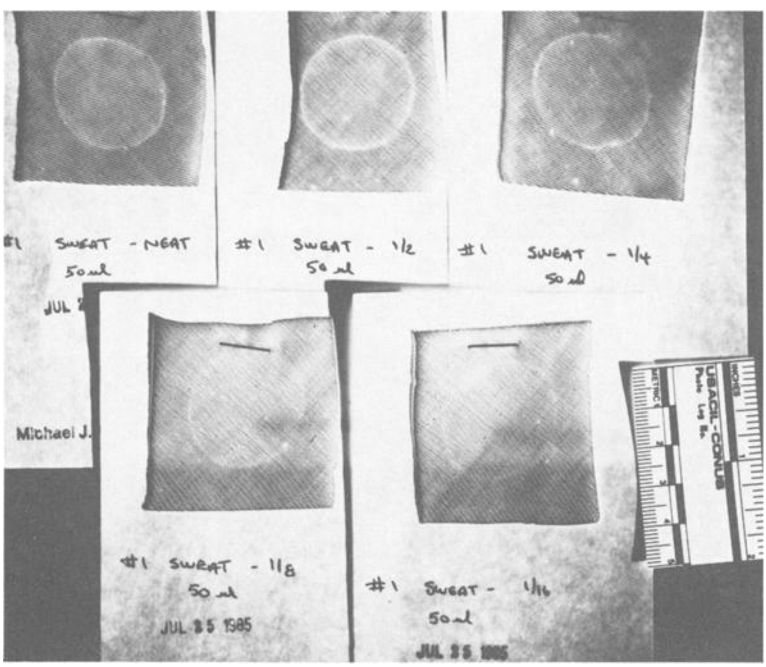

FIG. 18—*Same conditions and cloth as Fig. 16, except screened with 18-W laser.*

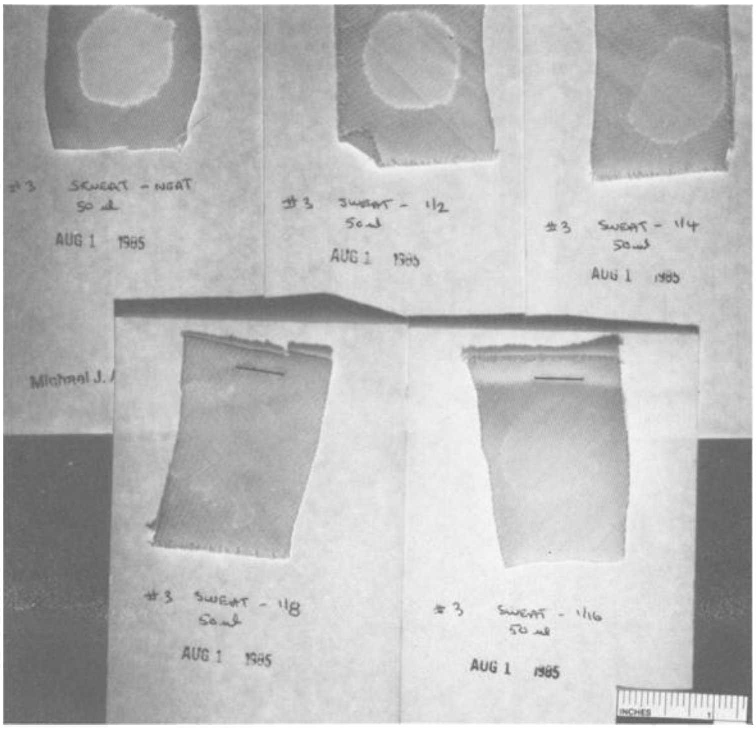

FIG. 19—*Screening with Luma-Print light of a white cotton bedsheet, Item 3, that had been washed numerous times before sweat was applied.*

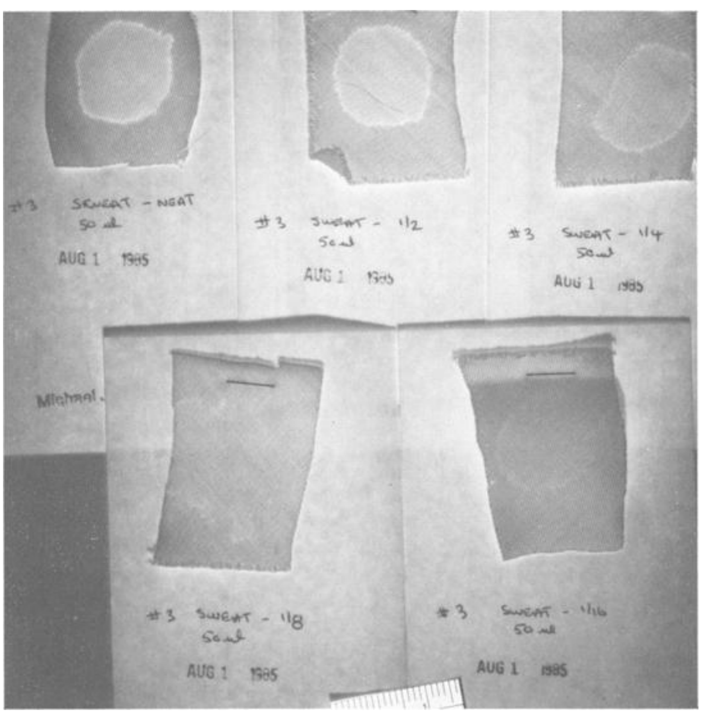

FIG. 20—*Same conditions and bedsheet as Fig. 19, except screened with 200-mW laser.*

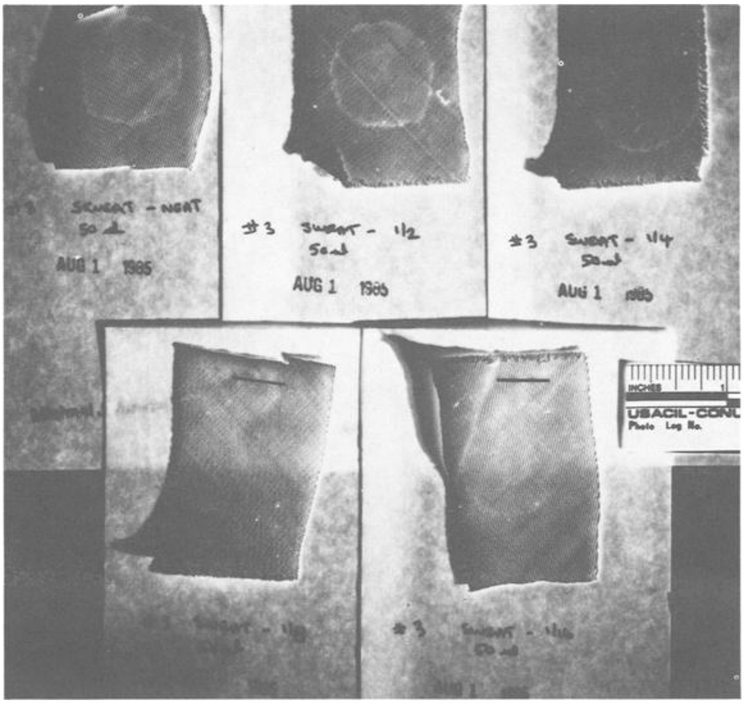

FIG. 21—*Same conditions and bedsheet as Fig. 19, except screened with 18-W laser.*

tion rate for the semen, saliva, and sweat stains examined. The Luma-Print light and the 18-W laser were shown to be comparable to each other when the same stains were detected by both units. The detection rates were the same for both the 18-W and 200-mW lasers. The greater output power of the 18-W laser resulted in both increased fluorescence being observed and the ability to detect body fluid secretions at greater dilutions than the 200-mW laser.

The major disadvantage or prohibited factor of the 18-W laser when compared with the

TABLE 6—*Comparison of equipment specifications.*

Specifications	18-W Laser	200-mW Laser	Luma-Print
Cost	$48 000	$10 000	$10 000
Output power	18 W	200 mW	15 W
Wavelengths	454.5-514.5 nm	454.5-514.5 nm	400-520 nm
Power requirements	460V ± 8%	115 VAC	115 VAC
	3 Phase	15 A	3 A
	60 A	60 Hz	60 Hz
Cooling	H_2O	air	air
Average tube life	2000 h	1000 h	60-100 h
Replacement tube cost	$18 000	$1 100	$300
Portable	no	yes	yes
Power supply weight	N/A	10.5 lbs[a]	2.7 lbs
Tube/lamp weight	N/A	10.5 lbs	1.9 lbs

[a] 1 lb = 0.4536 kg.

Luma-Print light and the 200-mW laser is its cost. Other disadvantages of the 18-W laser are its higher power consumption, lack of mobility, and replacement cost for the plasma tube.

The portability of both the Luma-Print light and the 200-mW laser enables a crime laboratory to screen for body fluid stains in both the laboratory and crime scene environments. The initial costs are similar for the Luma-Print light and the 200-mW laser. However, the 15-W output power of the Luma-Print light makes it superior to the 200-mW laser in the ability to detect body fluid secretions. A disadvantage of the Luma-Print light when compared with the 200-mW laser would be its average tube life. The Luma-Print light has approximately one tenth the tube life of the 200-mW unit. The advantages of the Luma-Print light are its superior detection ability, lower replacement-tube costs, and tube replacement by laboratory personnel.

Continuing research in the fields of both lasers and alternative light sources will result in newer, more portable, and more cost-effective units which will have varying forensic science applications. This project, which dealt with the evaluation of several instruments now available, provides information that, it is hoped, can be useful to crime laboratory personnel in the selection of equipment to meet their forensic science needs.

Acknowledgments

The author would like to thank Mr. Bob Baker, president of Payton Scientific, Inc., for the use of the Luma-Print light. I would also like to thank Mr. Edward R. German of our Latent Print Division for sharing his technical knowledge on both the laser and the high-intensity quartz arc tube; Mr. R. Wayne Staley and Mr. David Deitze in our Photo Division for their photographic support during the project; and Mr. David Flohr of our Trace Section for his fiber identification on the articles used in the project.

References

[1] Auvdel, M. J., "Comparison of Laser and Ultraviolet Techniques Used in the Detection of Body Secretions," *Journal of Forensic Sciences*, Vol. 32, No. 2, March 1987, pp. 326–345.

[2] Kirk, P. L., *Crime Investigations*, Interscience, New York, 1953.

[3] Pollack, O. J., "Semen and Seminal Stains," *Archives of Pathology*, Vol. 35, No. 2, March 1943, pp. 140–196.

[4] Nickolls, L. C., *The Scientific Investigation of Crime*, Butterworth, London, 1956.

[5] Sensabaugh, G. F., "Identification and Individualization of Semen in the Investigation of Rape," Final Report, Grant 74-NI-99-0041, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, DC, 1977.

Address requests for reprints or additional information to
CDR Michael J. Auvdel
U.S. Army Criminal Investigation Laboratory-CONUS
Fort Gillem
Forest Park, GA 30050-5000