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(56) Documents Cited:
WO 2005/067608 A2 **US 5601867 A**
US 20110076383 A1 **US 20070026130 A1**
Consolite, "Hot print system"

(58) Field of Search:
INT CL **A61B, B41M, G06K**
Other: **WPI, EPODOC**

(54) Title of the Invention: **Heating**
Abstract Title: **Visualising latent fingerprints on thermal paper using a heater**

(57) Apparatus for applying a spatially and temporally uniform heat source to thermal paper (D) is disclosed. The source may be provided beneath a hot plate (A). The apparatus enables latent fingerprints deposited on the paper to be generated. Visualization can be enhanced by the use of a blue LED light source (F) of 395 nm peak wavelength. The light sources may be provided in the housing (E) of the apparatus.

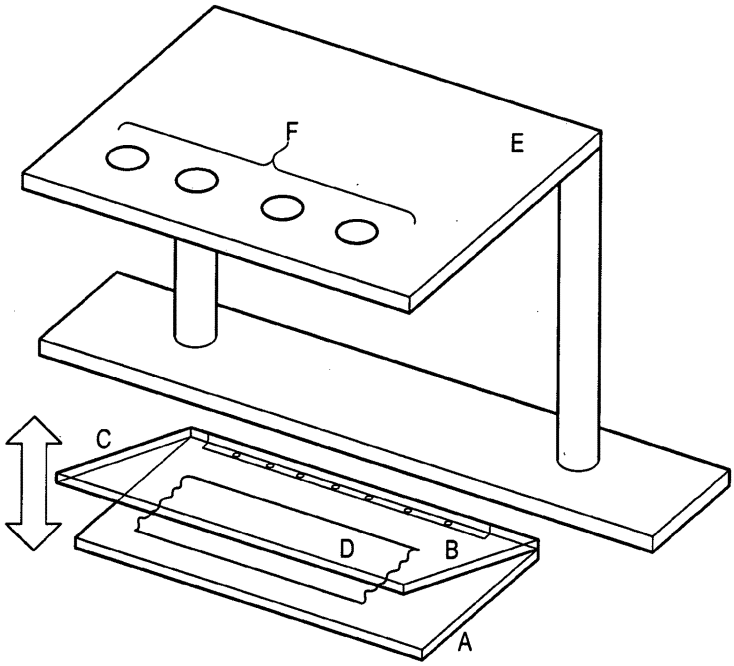

FIG. 1(a)

Schematic representation of apparatus used to develop latent fingerprints deposited onto thermal paper.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

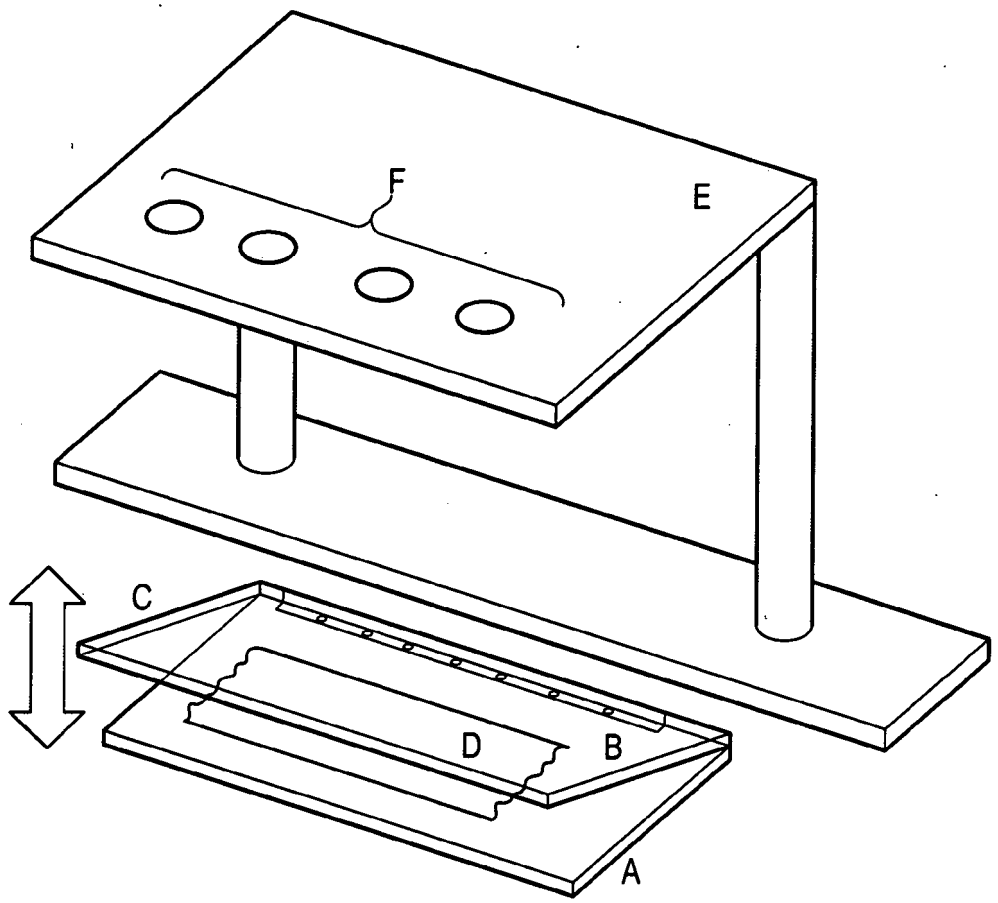

FIG. 1(a)

Schematic representation of apparatus used to develop latent fingerprints deposited onto thermal paper.

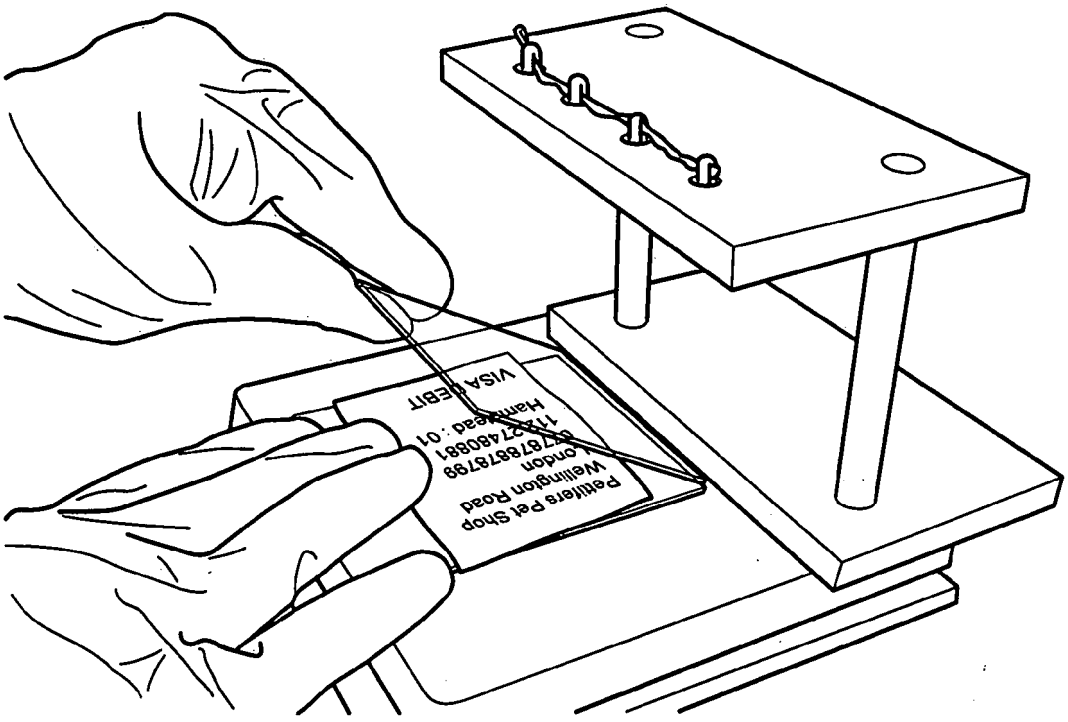

FIG. 1(b)

the apparatus in use.

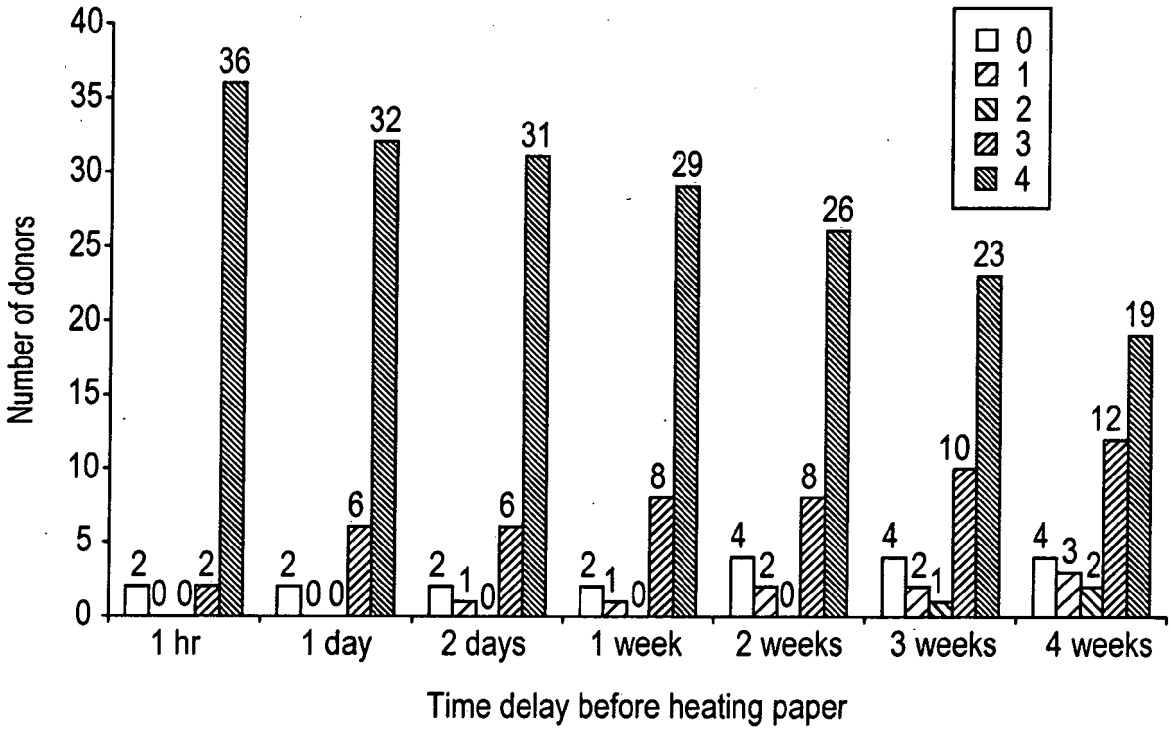

FIG. 2

Grading of fingerprints developed on thermal paper using the grading scale shown in Table 1.

Examples of grade 4 developed fingerprints for elapsed times of (a) 1 hr, (b) 1 day, (c) 2 days, (d) 1 week, (e) 2 weeks, (f) 3 weeks and (g) 4 weeks.

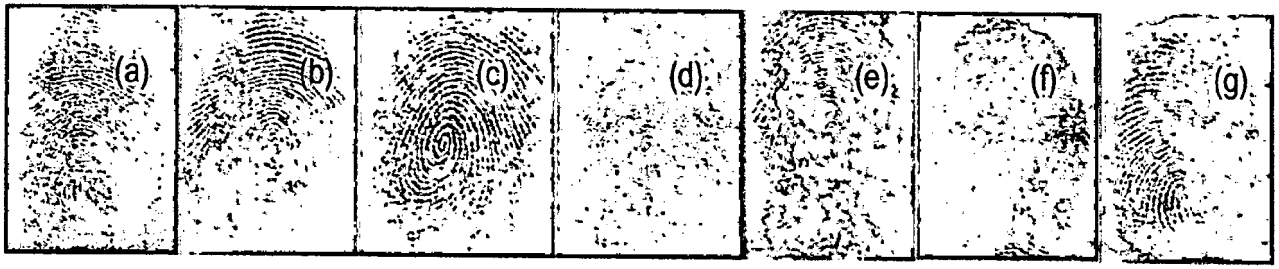

FIG. 3

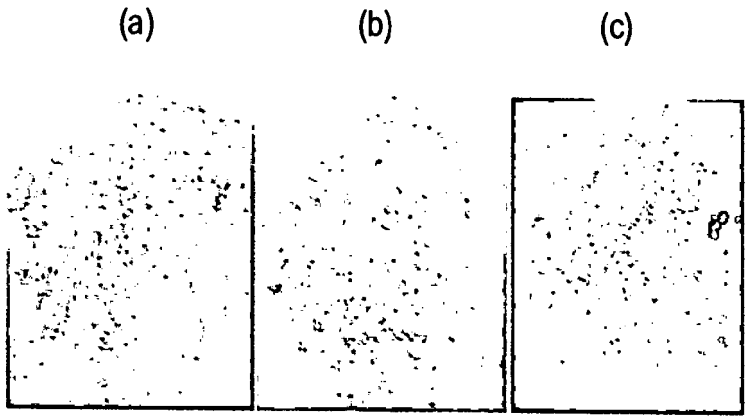

FIG. 4

A faint fingerprint developed after 4 weeks elapsed time and photographed with (a) a Daylight™ lamp, (b) a white Crime-Lite and (c) a blue LED.

(a) (b)

FIG. 5

A developed mark of (a) lysine solution and (b) distilled water on heated thermal paper.

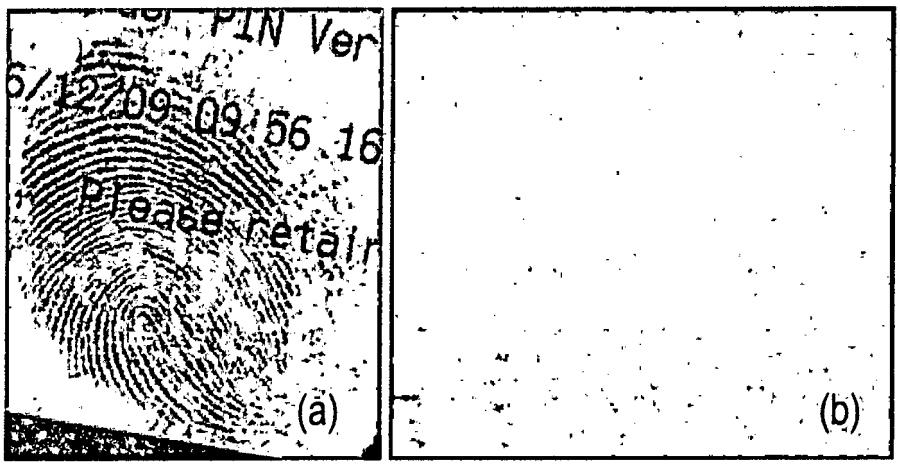

FIG. 6

Developed fingerprints on (a) a receipt dated 2009 and (b) a receipt dated 2006. Both (a) and (b) were photographed with the blue LED light source.

The following terms are registered trademarks and should be read as such wherever they occur in this document:

Daylight, Crime-Lite

Development of latent fingerprints by the application of heat

Runner: Experiments with thermal paper

KEYWORDS: forensic science, latent fingerprint, thermal paper, detection, light source, heating

In recent years, the use of thermal paper for rapid and low noise printing of receipts has become more widespread (1). This extended use has prompted the investigation of suitable ways of enhancing latent fingerprint deposits on thermal paper as polar organic solvents such as those used in conventional treatments for latent fingerprint enhancement on paper (2) initiate colouring of the leuco dye in thermal paper, thus making fingerprint visualization problematic (3). A number of chemical treatment methods have been reported to overcome this problem (4-8) with, most recently, integrating polyvinylpyrrolidones into a ninhydrin solution to prevent the colour change of the leuco dye (9,10). In addition to these chemical treatments, the application of heat has been reported to develop latent fingerprints on thermal paper (11). Wakefield and Armitage (12) assessed the effectiveness of a low temperature application of heat using a commercially available hair dryer held 5cm above the paper surface and found that latent fingerprints developed at a temperature approximately 30°C less than the normal colour change temperature of the paper. A slight variation in development temperature was attributed to the dye/acid combination in different brands of thermal paper. Wakefield and Armitage found that latent fingerprint ridge detail could be developed on thermal paper by the application of heat up to two weeks after fingerprint deposition, depending on the brand of thermal paper. Subsequently, Scott (13) increased the humidity by placing a beaker of water on a hot plate underneath the paper being treated by the application of heat and found that latent fingerprints developed as black on white images.

In this technical note, we describe firstly apparatus constructed to provide a more controlled method of heating thermal papers to the temperature required to develop latent fingerprints and then show how the use of a light source (built into the apparatus) can enhance visualization of aged and faintly developed fingerprint deposits. Results are compared to the findings of Wakefield and Armitage and an assessment is made of the effectiveness of the

apparatus on both fresh and aged (up to four weeks) fingerprint deposits on thermal paper. Reasons why fingerprint sweat affects thermal paper in this way are investigated. The effectiveness of the apparatus to develop latent fingerprints on aged thermal paper receipts from a variety of sources (automatic teller machines, supermarket checkouts, credit/debit card transactions and supermarket product labels) is demonstrated.

Experimental Details

Apparatus

The apparatus used to heat latent fingerprint deposits on thermal paper is shown schematically in Fig. 1(a) with Fig. 1(b) showing a photograph of the apparatus in use. In Fig. 1(a), A represents a 1 mm thick brass rectangular plate, placed onto the flat surface of a hotplate (Barlowworld Scientific, Stone, UK). To this, via a brass piano hinge (B), is fixed a 1 mm thick glass rectangular plate (C) of similar dimensions to the brass plate such that the glass plate can be raised or lowered. A sample of thermal paper to be treated (D) is placed onto the brass plate and the glass plate lowered to ensure good thermal contact between the paper and brass. E represents a housing for a series of 395 nm peak wavelength LED lamps (F) (Yoldal, Zhonghe City, Taiwan), used to illuminate the thermal paper. Reasons for selection of this illumination wavelength are discussed later.

Materials and method

Latent fingerprint deposits were taken from 20 male and 20 female donors onto thermal paper (Till Rolls Direct, Bletchingly, UK) such that each person donated impressions from seven

different fingers. Fingerprints were deposited by pressing a finger onto the paper surface for 1 –2 seconds with a light pressure sufficient to ensure contact between the finger and paper. Whilst no attempt was made to regulate the amount of pressure applied by individuals, this procedure was intended to produce reasonably uniform deposition. No artificial stimulation of sweat was employed such as placing the hand in a plastic bag (14) or wearing a latex glove prior to deposition (15). One of the impressions from each donor was developed using the above apparatus after either 1 hr, 1 day, 2 days or 1, 2, 3 or 4 weeks, this time period being in keeping with that considered by Wakefield and Armitage (12). Between deposition and development, the thermal paper was left in an office environment, exposed to both artificial and natural light, but not direct sunlight. Donors had not washed their hands 20 minutes before deposition and, prior to deposition, each donor rubbed their hands together to ensure a uniform distribution of sweat as previous research has indicated that sweat composition can differ between fingers for the same individual (16).

Results and discussion

Development of latent fingerprint deposits on thermal paper

Fingerprint ridge development on thermal paper after the application of heat as described above was graded based on the quality of ridge detail visible (as a black impression on the white paper). For this, the grading system devised by Bandey (17) was used and this is reproduced in Table 1. Initial experimentation determined that, for fingerprint development, the optimum temperature for the top surface of the brass rectangle was 44°C. This was measured across the top surface of the brass rectangle by means of a k-type thermocouple and found to vary both spatially and temporally by $< \pm 0.5$°C. This development temperature is

in keeping with that reported by Wakefield and Armitage (12) of between 45°C and 47°C depending on the brand of thermal paper.

Samples from only two of the 40 donors failed to produce any fingerprint ridge development for any of the time periods listed above. Of the remaining 38 donors, Fig. 2 shows that the majority in all time periods gave a grade 4 on the Bandey scale (full ridge development). Over time, the number of donors that gave a grade 4 diminished from 36 (after an elapsed time before heating of 1 hr) to 19 (after an elapsed time of four weeks). However, the number of donors that gave a grading of 0 – 2 only increased slightly in this time period from two (after 1 hr) to nine (after four weeks). Therefore, the majority of donors (78%) still produced a grading of 3 or 4 after an elapsed time of four weeks. Development time (t) (i.e. the time that the thermal paper was required to be in contact with the brass rectangle for fingerprint development to occur) varied between individual donors in the range 2 s $\leq t \leq 20$ s. This development time is less than that reported by Wakefield and Armitage (12) and this may be as a result of the improved thermal contact between the heat source used here (the hotplate and brass rectangle) and the thermal paper. There was no evidence to suggest that t increased with elapsed time before development. Fig 3 shows typical examples of grade 4 development for each of the elapsed times. All images in Fig. 3 were taken whilst the paper was illuminated with a Daylight^{TM} lamp (Daylight Company, London U.K.) although office lighting as illumination gave similar results.

The number of developed fingerprints giving grade 3 or 4 after an elapsed time > 2 weeks is in contrast to the results of Wakefield and Armitage (12) where no fingerprint development was observed for an elapsed time > 2 weeks. As discussed by Wakefield and Armitage, these differences may be due to the variation in chemicals used in the manufacturing process for

different brands of thermal paper. Further, Wakefield and Armitage noted that developed fingerprints had faded one week after development. Here, developed fingerprints did not exhibit any fading for at least 26 weeks after development (the time limit of the experiment). Again, this difference may be due to a variation in the chemicals used in the manufacturing process.

It was noticed that, for elapsed times of greater than two weeks, some of the developed images were faint and difficult to see when the paper was under the glass plate and being heated. As this would affect the heating time required (t), a light source to illuminate the paper whilst being heated was investigated. It was found that blue light produced the most visible contrast between the paper and a faint developing fingerprint and so the housing shown as E in Fig.1 was constructed to enable the paper to be illuminated and observed whilst being heated. Fig. 4 shows a faint fingerprint developed after four weeks elapsed time, and photographed with (a) a Daylight^{TM} lamp, (b) a white Crime-Lite (Foster & Freeman, Evesham U.K.) and (c) a blue LED with 395 nm peak wavelength. Whilst having a somewhat 'dotty' appearance, the dots are most distinct when illuminated with the blue LED. It was observed that there was greater transmission of the blue light through the thermal paper compared with both the Daylight^{TM} lamp and the white Crime-Lite and this is thought to be contributing to the improved visualization of faint fingerprints.

Investigating why latent fingerprint deposits affect thermal paper

It was noted above that polar organic solvents initiate colouring of the leuco dye in thermal paper (3). This reaction was investigated further in order to determine the fingerprint sweat components that act as a solvent for the dye and hence are able to reduce the temperature at

which it changes colour. Using the same brand of thermal paper as above, various common polar and non-polar solvents were applied to the paper by means of a small brush. The results are shown in Table 2 where it can be seen that, at room temperature and with no additional heating, polar protic solvents (with the exception of water) all increased the solubility of the dye. Thus, for the dye used in this brand of thermal paper, it was assumed that the most favourable solvent would be polar protic, that is, one that can donate a proton attached to (for example) oxygen in a hydroxyl group (OH^-) or nitrogen in an amino group (NH_2) (18).

It is well known that certain amino acids have a polar side chain, including some that are found commonly in eccrine sweat (18). One such amino acid, lysine (16) has an amino group side-chain that is fully protonated in a weak base solution (18).

To test whether a solution of lysine would increase the solubility of the dye, a concentration of $10mgL^{-1}$ of lysine was prepared by dissolving the monohydrate (Thermo Fisher Scientific, New Jersey US) in distilled water. This concentration was chosen as it is typical of that found in fingerprint sweat (16). The solution was applied to the thermal paper by means of a small brush. As a control, a similar amount of the distilled water was also applied to the paper. Neither the lysine nor the water gave any colour change to the dye at room temperature. However, on heating using the apparatus described above, a colour change to the dye was noted, which was much more pronounced for lysine than for the water control. The results are shown in Fig. 5 for (a) lysine and (b) water. Thus the amino acid present in eccrine sweat may well be affecting the solubility of the dye observed when heating fingerprint sweat deposits. Fingerprint deposits of eccrine sweat were obtained by asking the same 40 donors to wash their hands in warm soapy water and then to wear a latex glove for

20 mins before donating fingerprints (14). Results obtained were found to be consistent with those described above.

Development of aged latent fingerprint deposits on thermal paper from a variety of sources

Samples of used thermal paper, that is, paper that had been used to print receipts etc. were obtained from a variety of sources including automatic teller machines, supermarket checkouts, credit/debit card transactions and supermarket product labels. These samples had been stored since they had been printed and ranged in age from a few days to several years. In total, 50 different receipts were subject to the heat treatment described above. Prints graded 3 or 4 were found on four (8%) of the samples, Fig. 6 showing typical examples from receipts dated 2009 and 2006. In Fig. 6, both developed fingerprints were photographed using the blue LED light source.

Conclusion

By introducing a spatially and temporally uniform heat source, development of fingerprint ridge characteristics deposited as sweat onto thermal paper has been achieved. Results have shown an improvement over previous research, particularly with regard to the visualization of aged or faintly developed fingerprints, by employing a blue LED light source with 395 nm peak wavelength. An investigation of the components in fingerprint sweat that affect the solubility and hence colour change of the dye has shown that polar solvents able to donate a proton are favoured and an amino acid found in eccrine fingerprint sweat (lysine) has been shown to produce the desired colour change. Aged fingerprint deposits on thermal paper from a variety of sources have been visualized with this technique.

Future studies would benefit from an investigation of different brands of thermal paper to assess their suitability for fingerprint ridge development by the application of heat.

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CLAIMS

1. Apparatus for visualising latent fingerprints deposited onto thermal paper, the apparatus comprising a spatially and temporally uniform heat source.

2. Apparatus as claimed in claim 1, further comprising a light source to improve visualisation of developing fingerprints.

3. Apparatus as claimed in claim 2, in which the light source emits blue light.

4. Apparatus as claimed in claim 3, in which the light source emits light of 395nm peak wavelength.

5. Apparatus as claimed in any of claims 2 to 4, in which the light source comprises an LED.

6. Apparatus as claimed in any preceding claim, in which the heat source comprises a hot plate.

7. Apparatus as claimed in any preceding claim, comprising a flat surface for receiving thermal paper.

8. Apparatus as claimed in any preceding claim, comprising a housing which allows illumination and observation during heating.

9. Apparatus as claimed in any of claims 2 to 8, in which the light source is built in to the apparatus.

10. Apparatus as claimed in any preceding claim, in which the heat source applies heat from under the paper.

11. A method for visualising latent fingerprints deposited onto thermal paper comprising the steps of:

- providing a heat source; and
- using the heat source to uniformly heat the thermal paper to develop latent fingerprints.

12. A controlled method of heating thermal paper to a temperature required to develop latent fingerprints, comprising the steps of:
    - providing a heat source;
    - placing a thermal paper sample onto the heat source; and
    - heating the sample to develop latent fingerprints.

13. A method as claimed in claim 11 or claim 12, further comprising the step of illuminating the paper during heating.

14. A method as claimed in any of claim 11 to 13, in which the heat source heats to a development temperature in the range 45°C to 47°C.

15. Apparatus substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

16. A method substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

Application No:	GB1210206.7	**Examiner:**	Mr Alan Phipps
Claims searched:	1-14	**Date of search:**	17 June 2013

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X,Y	X: 1-4,6,7,10-14; Y: 5,9	US 2011/076383 A1 UNIV SYDNEY TECH, see paragraphs 8-12,57
X	1,6-8,10-12,14	US 2007/026130 A1 ARMOR HOLDINGS FORENSICS, see whole document
X	1,6-8,10-12,14	US 5601867 A US ARMY, see whole document
Y	5,9	WO 2005/067608 A2 IDENTIFICATION INTERNATIONAL, see Figure 2
A	1,11,12 at least	Consolite, "Hot print system" http://www.consolite.co.uk/Forensics/downloads/HPS%20Datasheet.pdf . See whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A61B; B41M; G06K

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
G06K	0009/00	01/01/2006
A61B	0005/117	01/01/2006
B41M	0003/00	01/01/2006