

Examination of 35 mm Color Transparencies

Paul Westwood and Michelle Novotny

Forensic Document Services Pty Ltd., P.O. Box 167, Manly N.S.W. 1655, Australia

Forensic Document Services (FDS) was engaged by the New South Wales Police to examine 157 35 mm color transparencies (positives) and a 35 mm camera to assist in the investigation of the disappearance of a young girl. The purpose of the examinations was twofold: first, to determine whether 2 or more of the transparencies originally formed part of the same roll of 35 mm film and, second, whether any of these films had been exposed using the suspect camera. The combination of the findings revealed that the transparencies originated from 26 rolls of film and were exposed using at least 2 different cameras, one of which was the camera submitted for examination. The methodology applied in this examination is equally applicable to the examination of negatives.

Introduction

Forensic Document Services was engaged by the New South Wales Police to examine one hundred fifty-seven 35 mm color transparencies and a camera to assist in their investigation into the disappearance of a young girl. The purpose of the examination was twofold: first, to determine whether 2 or more of the transparencies had been originally part of the same roll of 35 mm film and, second, whether any of these films had been exposed using the suspect camera. Of particular interest was whether 2 color transparencies, which the police believed depicted partial images of the missing girl, could be linked to a series of other color transparencies linked to other girls of known identity.

A literature review revealed that Fowkes (1978) described 2 cases where cameras were identified by comparative examination of the edge detail on photographs of questionable origin and those produced as specimens. Davies (1999) discussed the identification of both negatives and photographs as having been produced from a particular camera by reference to the peculiar and class characteristic edge mark details and their clarity as a function of the f-stop of the lens. Gupta, et al. (1981) reported a case where multiple negatives were physically matched with the assistance of printed film specification details and overlapping frame edges.

In addition, Ponnuswamy and Kuppaswamy (date unknown) suggested a general procedure for establishing individual relationships between

cameras and negatives following the examination of 204 cameras and numerous film negatives exposed in each camera by reference to dimensions, corners, edges, friction marks, and marks caused by the bellows. Friction marks and marks caused by the bellows were not considered in this examination due to the repeated handling of the transparencies and their casing prior to being submitted to the laboratory. Finally, Goldberg (1980) described the relationship between image frames and sprocket holes on films exposed in the same camera and in different cameras.

The identification of specific 35 mm cameras by means of deliberately introducing frame imperfections was used by the primary author of this paper in the 1970s and 1980s while employed by the Australian Federal Police (AFP). This technique was useful in linking negatives exposed in cameras used by members of surveillance squads, laboratory workers, and crime scene photographers. In relation to the 1982 Mickelberg gold bullion case in Western Australia, Dr. Chris Lennard of the AFP established the connection between negatives and a specific camera used to photograph fingerprints.

Methods and Materials

This paper discusses the application of methodologies to address whether transparencies were exposed in the same camera and, in particular, the subject camera. It also addresses whether transparencies can be shown to be consecutive images on the same roll of film and, where there

are transparencies missing in a sequence, whether nonconsecutive transparencies originally formed part of the same roll of film. The instruments used were: Intralux 5000 optical light sources, MGI VideoWave III software, Panasonic wv-GL702 closed-circuit camera, Vicam SCM-1400 color monitor, Wild M3Z stereo-microscope, and a Color 5000 transmitted light box.

It was assumed that the color transparencies submitted were the original camera-exposed transparencies and not duplicates thereof. The transparencies were examined macroscopically and microscopically using incident and transmitted light to determine: (a) whether there was any evidence to support a proposition that 2 or more transparencies were exposed in the same camera; and, if so, (b) whether there was any evidence to support a proposition that 2 or more transparencies originated from the same roll of film.

Various factors were considered:

- (1) Position of the image frame relative to the sprocket holes,
- (2) Imperfections around the edges of the exposed image,
- (3) Cut edge details,
- (4) Partial image frames,
- (5) Spacing between and shape of sprocket holes,
- (6) Pre-exposed film specification details and frame numbers, and
- (7) Spacing between pre-exposed frame numbers and repetitions of pre-exposed film specification details relative to image frames.

Factors (1) and (2) above related to determining whether transparencies were exposed in the same camera and, in particular, the subject camera. Factors (3) to (7) related to determining whether any of the transparencies once formed part of the same roll of film, consecutively or otherwise. The subject camera was used to produce test films. These test films were examined to detect the presence of frame imperfections or other identifying characteristics of this camera that may correspond with features on the subject transparencies.

Results and Discussion

(1) Position of the image frame relative to the sprocket holes

Films exposed in the same 35 mm camera that is in good working order will exhibit a reasonably consistent spatial relationship between the corners of the image frames, including the shapes of

the corners (Ponnuswamy and Kuppuswamy) and adjacent sprocket holes (Goldberg, 1980) (Figure 1). This is not to say that every camera is unique in this regard. It does, however, provide a basis upon which one can associate transparencies as having possibly been exposed in the same camera. Possible explanations for any marked difference in this spatial relationship between 2 transparencies could be the use of different cameras or the use of a camera with a faulty film transportation mechanism. On the basis of this feature the transparencies were divided into 2 categories.



Figure 1. Examples showing differences in the position of the image frame relative to the sprocket holes.

Category 1 transparencies have the left-hand corners of each image offset to the left of the left-hand edges of the adjacent upper and lower sprocket holes (Figure 1, left image). The right-hand corners of each image are in approximate alignment with the right-hand edges of the adjacent upper and lower sprocket holes. The spatial relationship of the exposed area of the film and the sprocket holes in this category varies by approximately 0.4 mm.

Category 2 transparencies all exhibit upper and lower left-hand corners which curve towards the adjacent sprocket holes (Figure 1, right image). A number of these transparencies bear the right-hand edge of the preceding frame. The corners of these right-hand edges also curve slightly towards the adjacent sprocket holes. The spatial relationship of the corners of the image frames to adjacent sprocket holes varies by 2.8 mm. The extent of this variability is further discussed below in the section relating to the subject camera. This

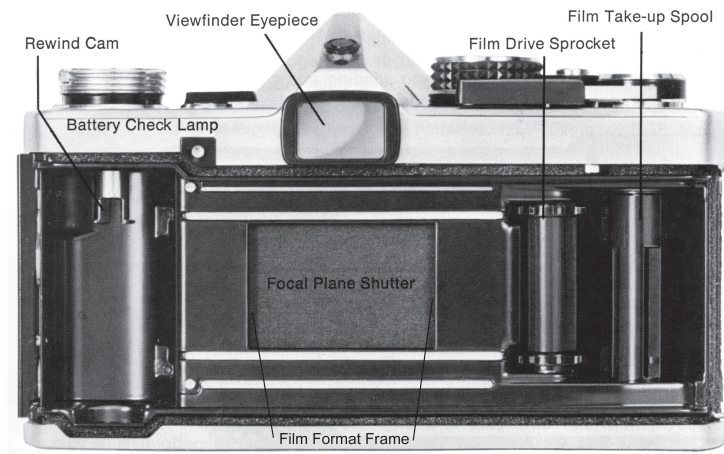


Figure 2. Image showing the inside of a camera and the location of the film format frame.

range of variation of the Category 2 images could incorporate some of the transparencies in Category 1; however, the turning of the left-hand corners of the images distinguishes between these 2 categories.

(2) Imperfections around the edges of the exposed image

The film format frame of a 35 mm camera determines the format of the exposed image (Figures 2 and 3).

A microscopic comparative examination of the imperfections in the edges of the film format

frame of a camera and corresponding edges of an exposed transparency or negative may allow one to determine if the transparency or negative was exposed in a given camera. Similarly, a microscopic comparative examination of the edges of exposed images on 2 or more transparencies or negatives may allow one to determine if they were exposed in the same camera (Figure 4).

Such imperfections are caused by defects in the edges of the film format frame within the camera. These defects may be attributed to camera manufacturing defects, which may be individual or common to a number of cameras of the same

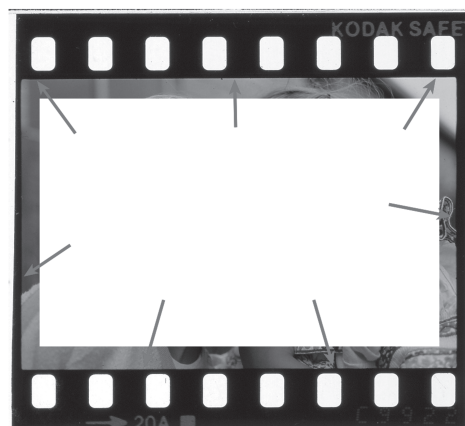


Figure 3. The edge of the exposed image is indicated by the arrows.

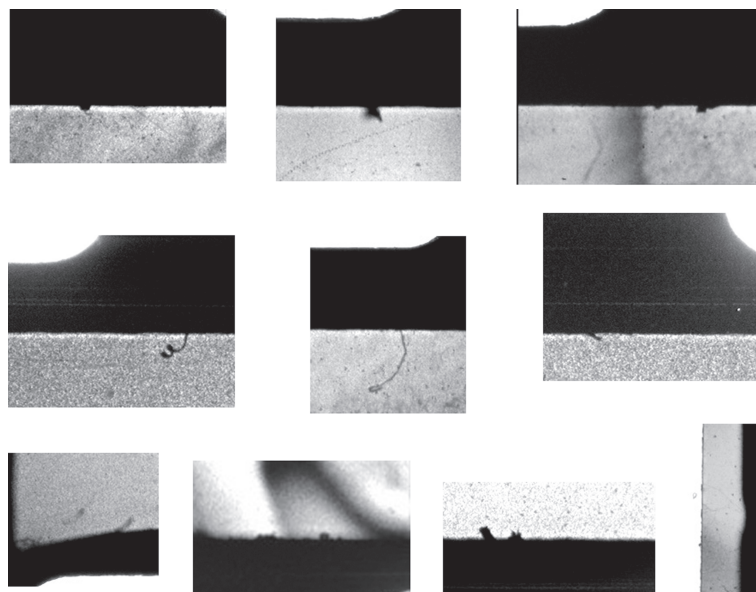


Figure 4. Magnified images of some of the imperfections identified around the edges of the exposed images.

make and model (i.e., *class defects*); damage due to use (i.e., *individual defect*); and transient foreign material such as a fiber or dust adhering to the edges of the film format frame (i.e., *transient individual defect*).

The *class* and *individual* defects may either intrude into the light path of the lens and mask parts of the edges of the exposed film or result in more of the film being exposed than would normally be the case. If the defect is of the *transient individual* type, it too may intrude into the light path of the lens and mask the film. The masked areas caused by imperfections on the frame will record, with varying degrees of clarity, as silhouettes on a transparency. These silhouettes may not be discernable if they coincide with dark areas in the original scene on a transparency.

If the imperfection is the result of *transient foreign material* adhering to the camera frame, the imperfection may only be recorded on a limited number of frames within 1 film. It may also be possible for such transient foreign material to persist throughout the exposure of a number of films exposed consecutively in the same camera. Foreign material within the camera “bellows” may also intrude into the light path and be recorded as a less defined silhouette on the film. The clarity of this silhouette may depend

on the brightness/darkness of the image being exposed and the lens aperture.

The combinations of frame imperfections in a given camera frequently vary over time. While it may not be possible to determine the precise cause of an imperfection, given a sufficient number of transparencies and frame imperfections, it may be possible to record their evolution and thereby possibly determine whether they are likely to be class or individual characteristics.

The examination of the subject transparencies revealed numerous imperfections in the edges of the images. The shape and location (with respect to the sprocket holes) of 59 of these imperfections were catalogued for the purposes of the report. The identification and comparison of the 59 frame imperfections across the 157 subject transparencies resulted in them being divided into 5 discrete groups according to common frame imperfections. The transparencies within each of these 5 groups could be divided further into 26 subgroups according to common combinations of frame imperfections. It was noted that the transparencies in groups 1 to 4 conform to Category 1 and group 5 conforms to Category 2 discussed above with respect to the position of the image frame and the sprocket holes.

(3) *Cut edge detail*

Cut edge detail caused by the nonuniform cutting of the film into individual transparencies can provide evidence as to whether the roll was cut using scissors or some other nonfixed cutting instrument. The presence of cutting characteristics that are similar in appearance and location along the cut edges of transparencies could be the result of the use of a fixed cutting device, such as a guillotine. These cutting characteristics can also provide evidence as to whether the same cutting instrument or device was used (Figure 5). This assumes that 1 or both transparencies have not been recut.

Comparative examinations of the edge details of the transparencies revealed combinations of different cut characteristics that were common to many transparencies. The transparencies were collated on the basis of these cut characteristics as well as the position of and angle at which they were cut relative to the edge of the image. It was found that the groups of transparencies collated on the basis of these features conformed to the groups and subgroups of transparencies discussed above with respect to the frame imperfections.

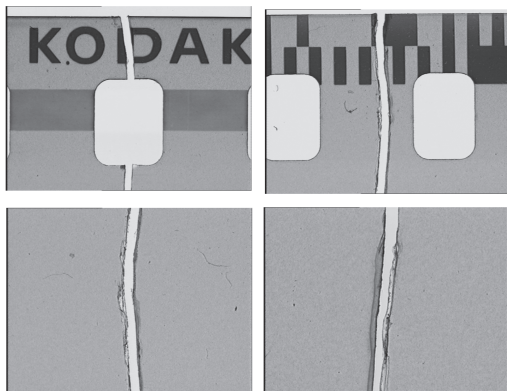


Figure 5. Magnified images of examples of cut edge details.

The relative consistency in the location of the cut characteristics from 1 transparency to another within any 1 group suggests the likely use of a fixed cutting device such as a guillotine rather than scissors. It was not possible, on the basis of the available material, to determine whether the common cut characteristics within each group were produced by the same cutting device or different devices exhibiting the same or similar cutting characteristics.

(4) *Partial image frames*

Many of the transparencies were cut through the image rather than through the unexposed area between frames. Consecutive images could therefore be associated by comparison of the image details (Gupta, et al., 1981) (Figure 6). This also, to some extent, assumes that 1 or both transparencies have not been recut.

Matching partial image frames were noted with respect to pairs (or triplets) of 53 of the 157 subject transparencies. The association of these sets of consecutive transparencies conformed to the previous grouping of transparencies according to the frame imperfections.



Figure 6. Consecutive transparencies associated by partial image frames.

(5) *Spacing between and shape of sprocket holes*

When a film is cut into individual transparencies, the cut will either be between sprocket holes or through sprocket holes. The spacing between and the shape of the sprocket holes on 2 transparencies should conform to the size, shape, and spacing of standard sprocket holes if they are consecutive transparencies (Figure 7). This also assumes that one or both transparencies have not been recut. While such conformity does not on its own establish that 2 transparencies were consecutive frames, it is consistent with this possibility and needs to be considered in conjunction with other evidence.

The comparative examination of the size and shape of cut sprocket holes, along with the spacing between uncut sprocket holes on the edges of

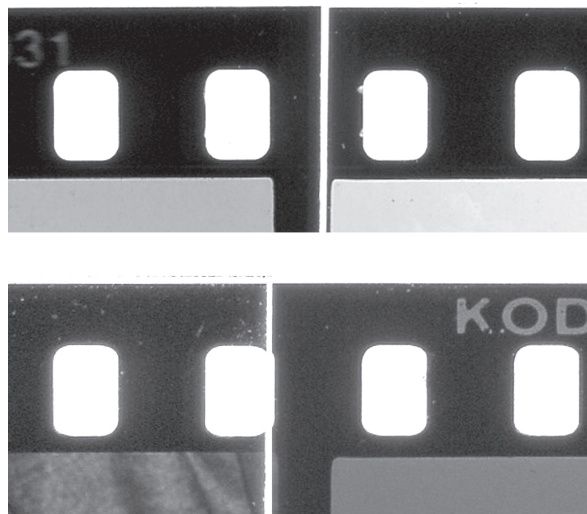


Figure 7. Matching the spacing between sprocket holes (upper images) and matching the shape of sprocket holes (lower images).

the transparencies, was found to be consistent with standard measurements on pairs of 120 of the 157 subject transparencies. The association of these transparencies conforms to the previous grouping of transparencies according to frame imperfections.

(6) Film specification details and frame numbering

Transparencies which have been cut through the pre-exposed film specification details along the top and/or the frame numbers along the bottom of the film can be associated by matching details across the cuts (Gupta, et al., 1981) (Figure 8). This examination revealed matches between pairs of 84 of the 157 subject transparencies. The association of these transparencies conforms to the previous groupings of transparencies according to the frame imperfections.

(7) Spacing between frame numbers and repetitions of film specification details relative to image frames

Allowing for some variation arising from the shape of numerals and the use of single- and double-digit numbers, the relative spacing of frame numbers on a roll of film is reasonably consistent. The relative spacing between repetitions

of film specification details on a single roll of film and on multiple films of the same manufacturing batch is also reasonably consistent. This is not to say, however, that the distance between the specification details on films from different manufacturing batches might not be the same.

Assuming that the film transportation mechanism of the camera used to expose a roll of film is not malfunctioning, the positioning of the images relative to the frame numbers will also be reasonably consistent. The positioning of the images relative to the frame numbers on a given film is determined by the variable degree to which the film leader is fed into the film take-up spool of the camera. There was no evidence to suggest that the film transportation mechanism of the camera or cameras used to expose the transparencies in Category 1 was malfunctioning. There was evidence indicating that the transportation mechanism of the camera (or cameras) used to expose the transparencies in Category 2 was malfunctioning. This malfunction is discussed below in the section dealing with the subject camera.

The subject transparencies consisted of 2 film types: Kodak Safety Film 5031 and Kodak EN 100 5039. The transparencies were initially divided according to these film types and then further divided according to the relative positioning of

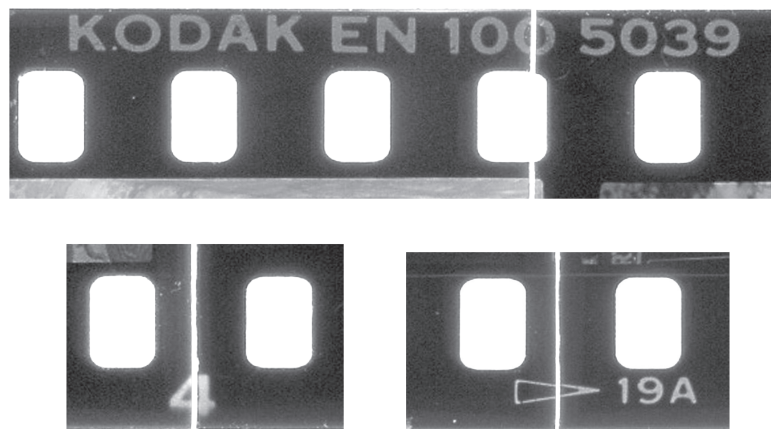


Figure 8. Matching film specification details and frame numbering across cuts.

the frame numbers to the image. This process divided the subject transparencies into 26 subgroups that corresponded with the 26 subgroups identified on the basis of combinations of frame imperfections. Wherever possible, the transparencies within these groups were arranged in frame number order, taking into account the discussions and observations noted with respect to the factors discussed above.

The distances between repetitions of the film specification on each type of film were measured on the consecutive transparencies. These measurements were then used to create templates for gauging how many transparencies could fit into the gaps between nonconsecutive transparencies of the same film type. The longest series of consecutive type 5031 transparencies consisted of 10 transparencies bearing 7 repetitions of film specification details. The position of the commencement of the 1st letter "K" in each repetition of "KODAK" on these transparencies was used to create a film type 5031 template. The distances between these points varied from 50 mm to 51 mm. A median distance of 50.5 mm was used to extend the overall length of the template beyond these consecutive transparencies.

The longest series of consecutive type EN 100 5039 transparencies consisted of 8 transparencies bearing 5 repetitions of film specification details. The position of the commencement of the 1st letter "K" in each repetition of "KODAK" on these transparencies was used to create a film type EN 100 5039 template. The distances between

these points varied from 49.5 mm to 54.5 mm. A median distance of 52 mm was used to extend the overall length of the template beyond these consecutive transparencies.

On placing the subject transparencies on the appropriate template, no evidence was found to suggest that the transparencies within each of the 26 subgroups did not form part of the 1 roll of film.

Examination Results of the Subject Camera

The subject camera was used to produce test films to determine whether any frame imperfections (that may be caused by this camera) corresponded with any of the 59 frame imperfections identified on the subject transparencies. The test exposures made using the Kodak camera were characterized by image frames with corners that curl towards adjacent sprocket holes. The cause of this curling appears to be the result of a defective film pressure plate which serves to hold the film flat against the format frame. Such curling was found in the corners of the Category 2 transparencies but not in the corners of the Category 1 transparencies. As noted previously, there is no overlap in occurrence of frame imperfections on the transparencies in Categories 1 and 2.

It was also noted on the test films that a number of the frames overlap one another while other frames exhibited a larger than normal gap between them. As a result, the relative position of the frame numbers and image frames varied greatly. Similar observations were made with respect to

the transparencies in Category 2 and were very likely the result of a faulty film transportation mechanism.

Our preliminary findings were that the subject camera very probably was used to produce the transparencies in Category 2 and that there was no evidence to suggest that it was used to produce any of the transparencies in Category 1.

Conclusions

The combination of observations with respect to the frame imperfections (*cut edge details, partial image frames, spacing between and shape of sprocket holes, pre-exposed film specification details and frame numbers, and spacing between pre-exposed frame numbers and repetitions of pre-exposed film specification details relative to image frames*) provided evidence that the transparencies originated from 26 separate rolls of film. The observations with respect to the position of the image frame relative to the sprocket holes established the likely use of at least 2 cameras to expose the subject transparencies.

Observations regarding frame imperfections indicated the use of possibly as many as 6 cameras, 5 of which exhibited the same image frame/sprocket hole relationship. The existence of this common image frame/sprocket hole relationship means that there was very probably only 1 camera used to expose the Category 1 transparencies. The frame imperfections changed over time according to the 4 discrete groups identified for frame imperfection combinations.

Acknowledgements

The authors would like to acknowledge the invaluable assistance of Jerry Richards regarding the examination of 35 mm film.

References

- Author unknown (1972). Laboratory Examinations of Photo-Related Evidence. *FBI Law Enforcement Bulletin*, May, pp. 10-15.
- Davies, D. B. (1999). Examination of 35 mm Camera Frame Edge Mark Characteristics. Presented at the 51st Annual Meeting of the American Academy of Forensic Sciences, Orlando, FL, February 15-20.
- Fowkes, D. (1978). How a picture can catch a camera. *International Criminal Police Review*, No. 318, pp. 145-146.
- Goldberg, N. (1980). Which camera took the picture? In 35 mm, sprocket holes will tell. *Popular Photography*, May, pp. 37, 40.

Gupta, S. K., et al. (1981). Photographic Negatives as Evidence—A Case Report. *Journal of the Forensic Science Society*, Vol. 21, pp. 355-357.

Ponnuswamy, P. K. and Kuppaswamy, R. Establishing the Identity of the Camera from a Study of Film Negatives Exposed in It. Source and date unknown.

Schima, K. (1977). Criminalistic Examination of Film Negatives. *International Criminal Police Review*, No. 309, pp. 189-191.