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Studies on the Formation, Temporal Evolution, and Forensic Applications of Camera "Fingerprints"

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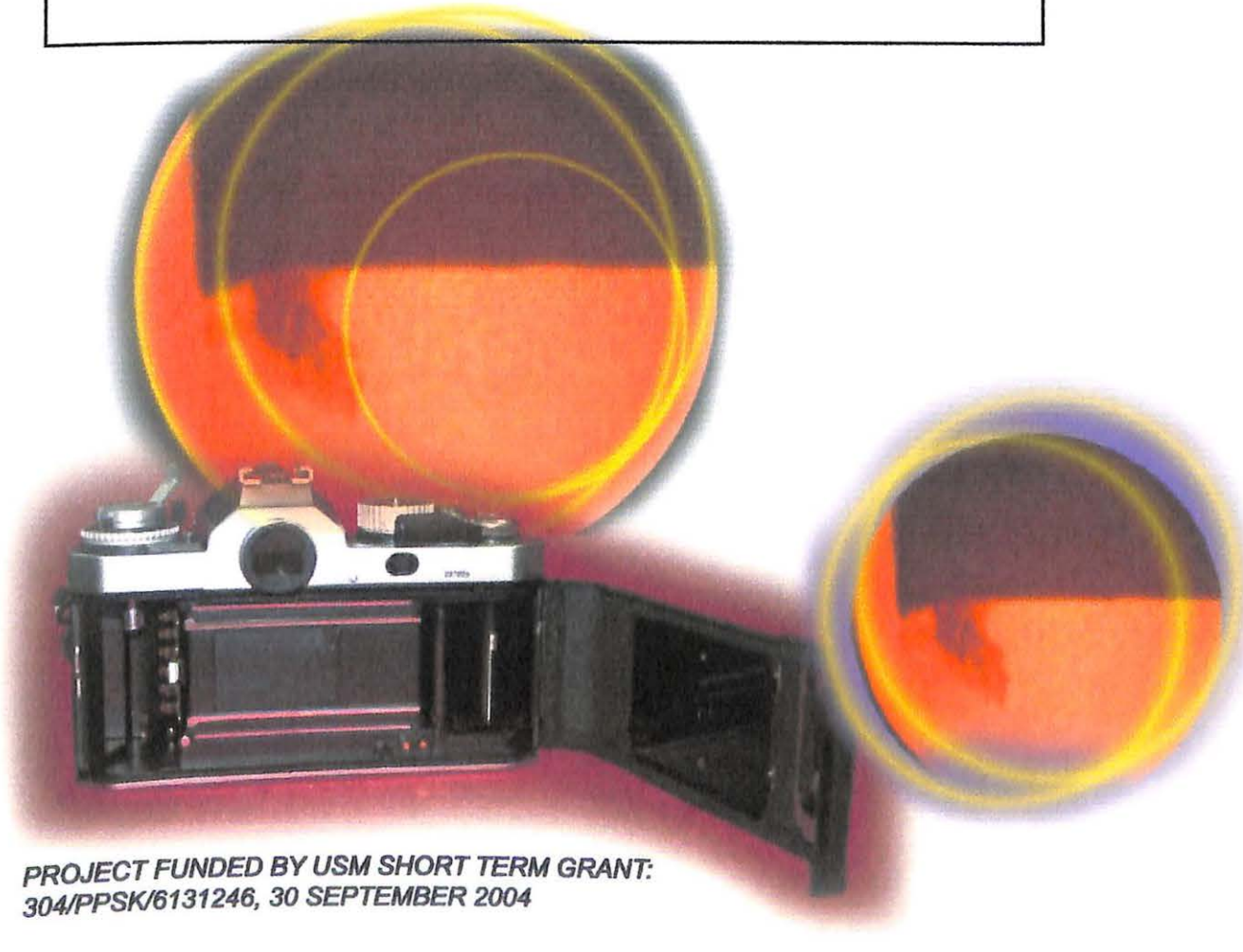

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CONTENTS

Abstract

A series of experiments was conducted by exposing negative film in brand new cameras of different make and model. The exposures were repeated at regular time intervals spread over a period of two years. The processed film negatives were studied under a stereomicroscope (x10-x40) in transmitted illumination for the presence of the characterizing features on their four frame-edges. These features were then related to those present on the masking frame of the cameras by examining the latter in reflected light stereomicroscopy (x10-x40). The purpose of the study was to determine the origin and permanence of the frame-edge-marks, and also the processes by which the marks may probably alter with time.

The investigations have arrived at the following conclusions: i) the edge-marks have originated principally from the imperfections received on the film mask from the manufacturing and also occasionally from the accumulated dirt, dust and fiber on the film mask over an extended time period. ii) The edge profiles of the cameras have remained fixed over a considerable period of time so as to be of a valuable identification medium. iii) The marks are found to be varying in nature even with those cameras manufactured at similar time. iv) The influence of f/number and object distance has great effect in the recording of the frame-edge marks during exposure of the film.

The above findings would serve as a useful addition to the technique of camera edge-mark comparisons.

Keywords: Criminalistics; Photography related evidence; Masking frame; Film-edge marks; Camera identity

Introduction

A problem of considerable interest in crime investigation is the determination of whether or not a specific camera was used to expose certain incriminating film negatives. This determination is necessary in order to establish the association of a camera with negatives seized during the investigation of the publication of obscene photographs or in spying or in other cases of criminal activity. It may also be useful to prove the ownership of a camera in a simple case of theft. These identifications are carried out on the premise that an exposed film negative carries the characteristics of the camera in a manner similar to that of a bullet which carries on its surface the marks of the barrel through which it has been fired.

The method of proof in camera identification is also similar to that of firearm identification. A test negative is made by exposure of a film in the camera and characteristics presented by the test negative are correlated with those found on the questioned film negatives. The five characteristics on the film negatives traditionally used for identifying the camera are: i) dimensions of the exposure area, ii) corners around the edges, iii) edge marks, iv) friction marks, and v) marks of bellows reproduced on the edges of the negatives, (applicable to bellows cameras).

The technique of camera features comparison has been used by forensic laboratories and presented in court cases in many countries for many years [1-7]. Among the above five characteristics listed, the edge marks on the exposed film negatives are believed to be the "fingerprint" of the camera. A study conducted by the author (with Ponnuswamy), utilizing film negatives exposed in 200 more cameras of different make, model and format, had shown that each camera produced unique edge marks on its negatives [3]. These edge marks are usually thought to originate from the deformities or imperfections present on the film mask of the camera (where the film rests during exposure) and/or from accumulation of dust or debris present on the film mask.

Recently, Chris Lennard and Milutin Stoilovic [6] had used the imperfections on the frame edges of the film negatives to establish the fact that a strip of questioned film negative alleged to be the second or third generation copies was but the original negatives from a specific Olympus camera. The original camera was not available to these investigators for comparison. However, they compared the frame-edge defects of the alleged strip of film negatives with those of the film negatives taken during the same period and thus arrived at the conclusion. More recently [7], this author reported a case in which a camera recovered from a site of bomb blast in a sensitive assassination case was linked to some incriminating film negatives by the characteristics existing along the small portion of the edge of the film negatives.

Thus, the study of edge mark is thus a topic of interest for many workers in solving issues [1- 7]. However, the origin of the marks, and the processes that can affect the occurrence, absence, or permanence of the marks, are not fully understood. This study is important for a proper interpretation and evaluation of the edge marks. The work reported by the present author with Ponnuswamy [3] was however mainly concerned with the appearance of the characterizing marks in a large number of cameras of different make and model. But, they did not address the above issues in detail.

A study conducted on 20 new cameras by Davies in the FBI laboratory [4] had shown that all the 20 cameras had clean edges with no edge mark characteristics. Hence, Davies concluded that all the characteristic edge marks usually noticed on the film negatives, and used for identification purpose should have arisen only from dust or dirt, which gets deposited on the film mask of the camera during use. His conclusions were supported by the fact that a used Canon camera, which he examined, showed multitude of small marks caused by random dirt and dust particles. He further noticed a reduction in the edge marks when the film chamber of the camera was cleaned with air; interestingly the marks were completely removed when he cleaned it with an alcohol swab [6]. However, in a study conducted by the author (Kuppuswamy, unpublished) it was found that some new expensive Leica cameras did possess characteristic edge marks that were not caused by dust or dirt but from the manufacturing, by which they could be identified.

Under the circumstances it was felt that there was a need to repeat experiments with new cameras in order to understand the origin as well the persistence of the edge marks over time intervals, as the results generated from such a study would provide a valid and more reliable identification technique in problems involving identification of cameras.

Methodology

Fifteen new 35 mm cameras of different make and model, one new Leica MPS 60 35 magazine and one old Yashica 635 120 camera were used in the study. The cameras examined are shown in Table 1. Negative film was exposed in these cameras. The exposed films were processed and the resultant negatives were examined in a Stereomicroscope in transmitted illumination under magnification x10---x40. The examination was mainly focused to the four edges of the negatives.

The characteristics of the edge marks were then critically examined for their origin by referring them back to the film mask from which they would have arisen. The film mask was examined in reflected light microscopy for this purpose. The chance that the edge marks being repeated between negatives of different cameras was considered during the study.

Table 1: Make and number of cameras examined for the characteristic features in the present study

Make and model of the camera	Serial number of the camera	Quantity
Nikon FM 3A	237026	1
Nikon FM 10	2428327	1
Canon Prima BF-9S	6257274	1
Canon BF 800	821300981	1
Canon Prima BF-90	6766725	1
Olympus Trip 505	7855176 7855177 5939724 5939721	4
Kodak KB 28	-	3
Kodak KB 10	-	3
Yashica 635, 120 format	-	1
Leica MPS 60 35 mm magazine	010403019	1
	Total	17

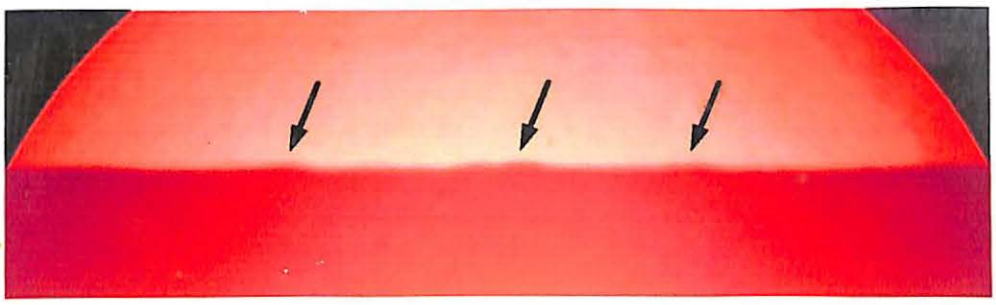
After the initial recording of the edge marks, some cameras were exposed at regular time intervals spread over a period of six months or more. The cameras chosen were under normal use with several rolls of film being exposed in them during the interval. In each such instance, the exposed negatives were examined under the microscope as described in the preceding paragraph, and the characteristics of the edge marks were compared with the original marks. Further the edge marks recorded in the negatives between different times intervals were studied. The purpose of the above comparisons was to see whether the edge marks were subject to changes, and if so what factors had produced these changes. The temporal evolution in the deformities or imperfections of the edges was thus investigated. The study was necessary to know whether camera identity at a later time would be possible in the event that the edge marks undergo changes from their original appearance.

Results and Discussion

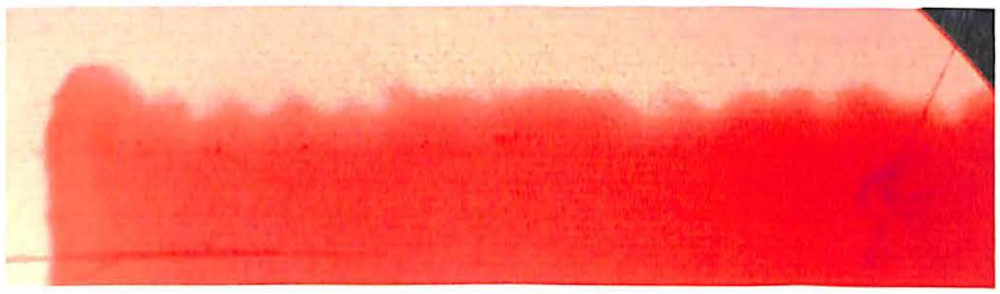
i) Occurrence and description of the marks

The characteristics of the edge marks present on the film negatives were critically examined for their origin by referring back to the film masks from which they had originated. The examination had revealed that they were produced principally from the following **three** processes.

1. The by-product of the original punching process that generated the film masks produced some characterizing features in most instances. The original punching imparted imperfections on the edges of the film mask resulting in their recording as irregular edge profiles in the film negatives. This imperfection presented in the form of minute bumps, irregular wavy edges, rounded or dimple corners, characteristic light and shadow formation around the corners and a variety of other features. Some of these are seen in Figure 1.



(a)



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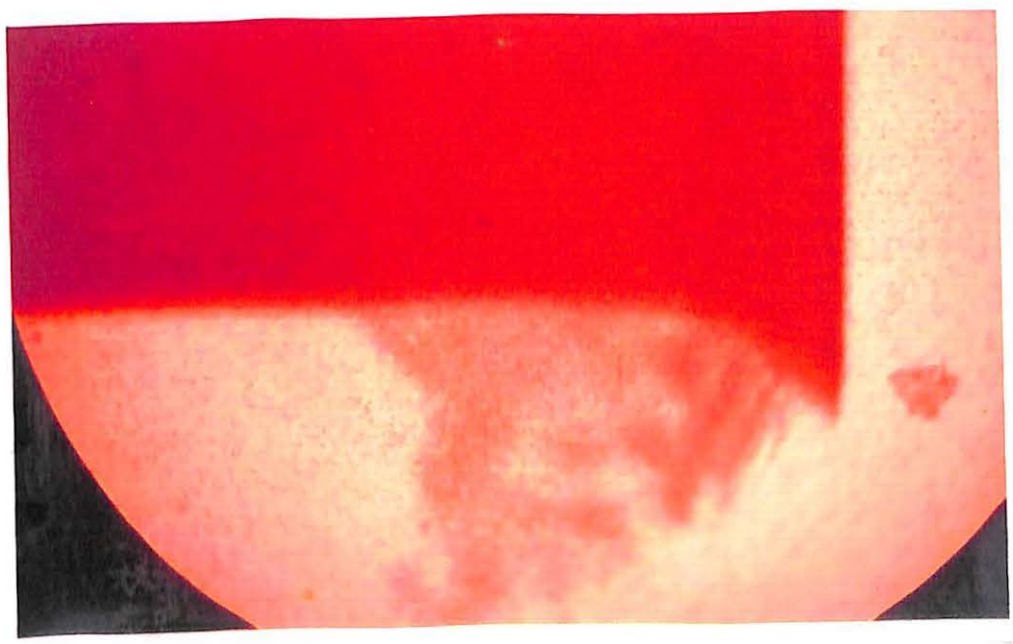
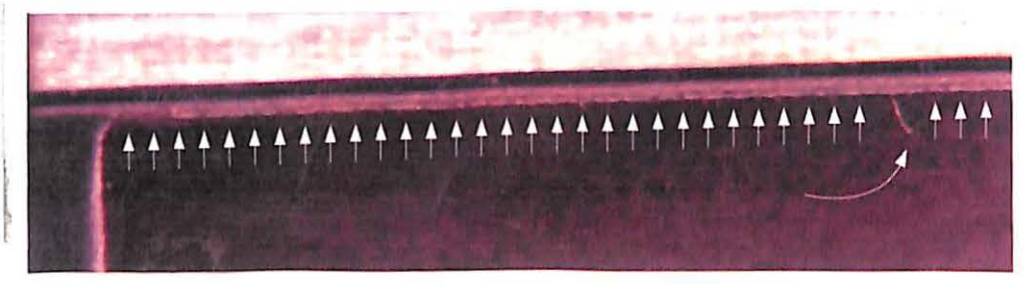


(c)

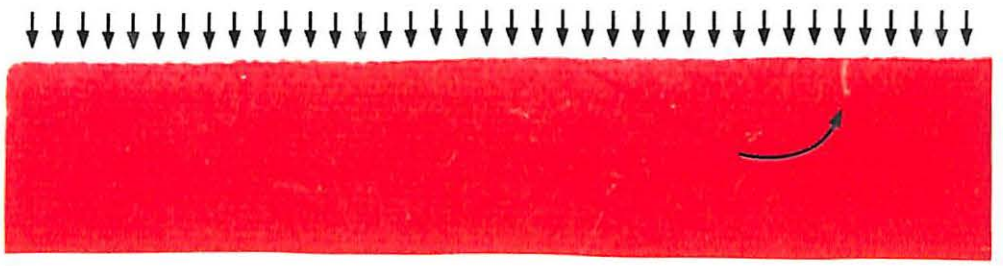
FIGURE 1 Edge profiles on the film negatives recorded by some brand new cameras presenting characteristic features. (a) Three minute bumps (see arrows), (b) Wavy outlines with typical corner, (c) "light patch" around a corner.
These features have arisen from the manufacturing frame masks.
Photomicrographs, X40.

2. The soft "padding material" that was pasted around the masking frame inside the camera bodies of many kinds was well within the masking frame of the camera. (FIG.2 a). However, their tiny projections into the exposure area have invariably contributed to the edge-marks in the film negatives. (FIG.2 b). These marks have appeared as sharp and sometimes as hazy wavy outlines **(FIG.1b).** When they occur as hazy outlines as was the case with some kinds of Canon cameras, their evaluation need very careful attention.

3. The secondary characteristics such as dirt, dust or fiber that are acquired accidentally with the use of the camera produce shadows/images in the film negatives to extend from the image boundary to the image area in the negative (see Figure 2 and also Figure 7).



(a)



(b)

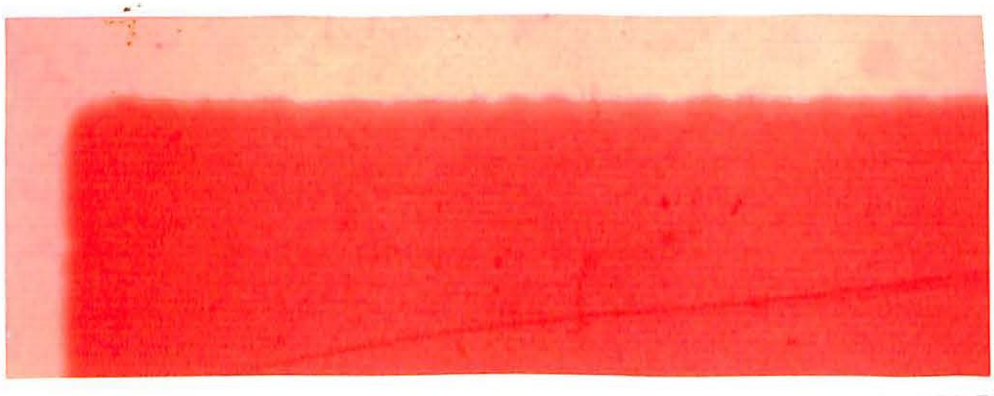
FIGURE 2 (a) One edge of the masking frame of a new Nikon FM 3A camera. Notice the projection of the padding material pasted inside the camera into the exposure area (shown by arrows). (b) innumerable minute ridges (shown by arrows) are reproduced on the film-edge from the above projection.
See also the embedment of a fibre inside the masking frame (a), which is imaged in the film (b). The fibre in both is indicated by curved arrow.
Photomicrographs, X12.5

ii) ***Influence of f/ number in recording the features of the masking frame***

It is known that the f/number of aperture setting determines depth of field in photography. If the features on the masking frame such as a fibre, padding material and other imperfections surrounding the masking frame are not in physical contact with the film but, are lying at different distances from the masking frame, then the sharp recording of the features would not be expected in the film negatives. Experiments originally conducted by Davies [4] and currently by the present author have shown that the fine details of the edge marks were sharpest at small apertures or large f/ numbers (FIG.3). At large apertures as Davies has pointed out the fine detail became very soft to the point where the fine details necessary to determine if the film was unique to a particular camera was no longer detectable.

Another useful finding with regard to recording of the features with f/number settings was that while it was important in ordinary photography involving large object distance to use a relatively small aperture or large f/number (f/11-f/32) for recording of fine details of the masking frame, at very close object distances (a minimum distance of 0.30 m or so) photography using micro lens the recording of details was not influenced by large aperture setting.

(a)



(b)

FIGURE 3 Edge features on the film negatives exposed at aperture stops (a) f/ 16 and (b) f/ 8. The object distance is infinity.
As the f/ number setting becomes smaller, or the aperture diameter becomes larger , the edge profiles become diffused as seen in fig (b); however, the features are discernible for a careful comparison. Photomicrographs, X40.

For example, at a close object distance of 0.314 m the edge features were extremely good either at large aperture f/4 or at small aperture f/132 **[**FIG. 4**].**

This information will be useful in disputes especially those involving evidence negatives in forensic science practice, like recording of fingerprint, tool marks etc. When such negatives have become the bone of contention, as was reported in an actual case by Lennard and Stoilovic [6] there would be reasonably faithful recording of the finer details at all f/number settings.

(a)

(b)

(c)

FIGURE 4 Edge profiles recorded on the film negatives at different aperture stops: (a) f/ 4; (b) f//16; and (c) f/32. The object distance is 0.314 m. Notice neat recording of the details at all apertures.

It appears that the recording of the masking frame is not much influenced by the f/number settings at short object distances. Contrast the features seen in this figure with those shown in Figure 3.

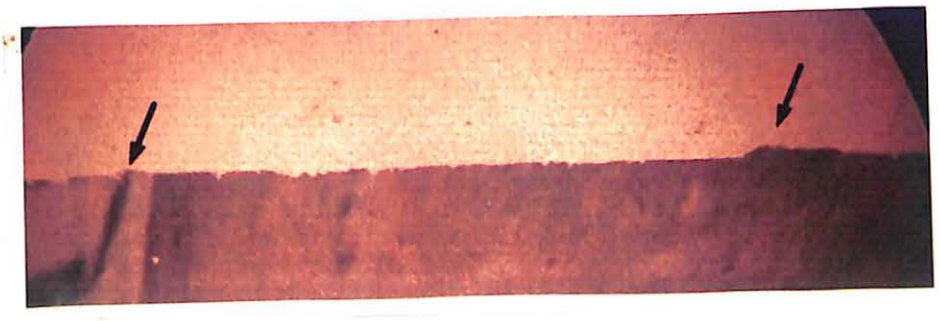
Photomicrographs, X40

(iii) Permanence or Persistence of the Marks

The characteristics observed on the film negatives were mostly recorded by the deformations or imperfections existing on and around the masking frame. These features have remained permanent and could be relied on for identification of the camera on a later date. Examination of the film negatives exposed over regular time intervals have shown that the original marks were retained without any changes. In a few instances some additional marks were added by dust and dirt accumulated over a period of time. These additional marks have also remained for a sufficiently long time giving the uniqueness to the camera. Under normal use the photographer has no occasion to touch or disturb this area to clear of the depositional edge-marks

In the experiments conducted by the author the original frame edge marks had not been masked or obliterated at least during the current period of study of two years. However, when the time interval was very large the original edge marks had undergone transformation with the addition of new marks. In one such instance when the original negatives of a Yashica camera were compared with those obtained from it after a 20-year period, the original marks were possible to be identified despite the degradation of the masking frame in the time interval (Figure 5). During this period dust randomly found their way to the edge of the mask area of the camera.

(a)



(b)

FIGURE 5 (a) Edge profile of a yashica camera, and (b) the edge profile from the same camera recorded after a period of 20 years. The original two bumps (indicated by arrows), separated by a distance, are still distinguishable in the figure (b);however, new marks caused by accumulated dust during this period are seen here.
Photomicrographs, X40.

The camera has now acquired a new uniqueness, which is likely to remain for a considerable period. The period of twenty years is too long a period to be of any practical interest for an actual case investigation and this observation could however be of some academic interest.

(iv) Individuality of the Marks

A careful examination of the edge markings (x10 –x40) produced on the film negatives from the brand new cameras of different make and model had shown that the markings were sufficiently varied allowing them to be distinguished from one another. The markings were all related to the imperfections and other depositional materials like fiber surrounding the masking frame of the cameras. Thus the edge markings of all the new cameras have originated from the features arising from the masking frame of the cameras. Even with the use of the cameras these marks have remained invariant, as discussed under the heading *'permanence of the marks*".

While discussing the individuality of the film-edge-marks the following features that presented wide variations among the many different kinds of cameras could be considered to be highly characteristic and accordingly more reliance can be placed on them when reporting.

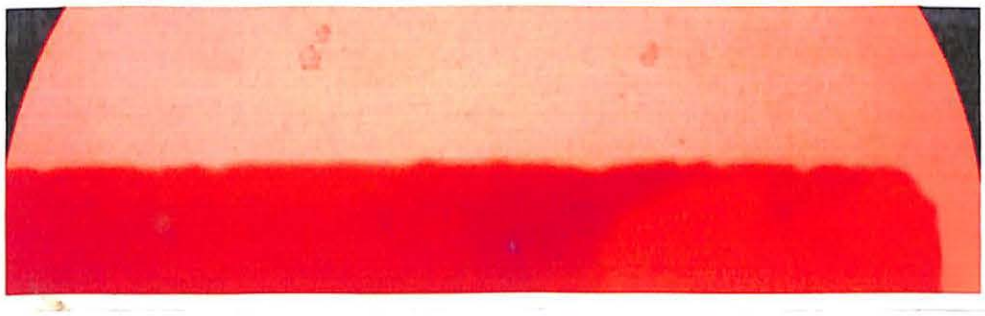
(1) *the projection into the exposure area of the "padding" and other materials surrounding the masking frame, (Figure 2);*

(2) Typical corners together with characteristic shadow formation (Figure 1, c); and

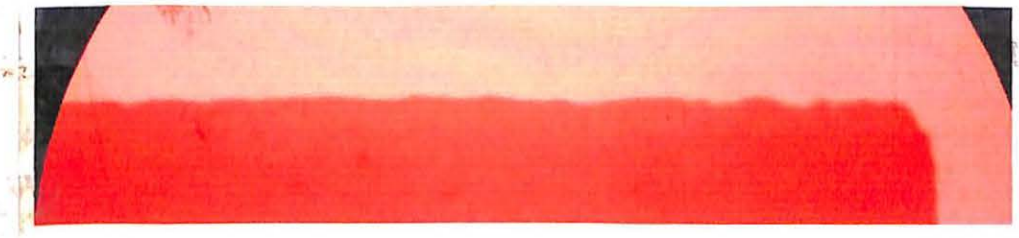
(3) Secondary characteristics arising from dust (Figure 5(b), and Figure 2).

The above characteristics if carefully evaluated could aid in individualizing cameras.

The experiments were also conducted with same brands of cameras having a close range of serial numbers to study the inter-comparison in a search for possible class characteristics. This study had shown that the features in a series of Olympus cameras, which had narrow range—that could be assumed that these cameras had been manufactured at approximately the same time—showed identifiable edge profiles. In one such series the edge markings provided striking class characteristics in all the four edges of the film negatives suggesting that the masking frames of these cameras had arisen from the same stamping die. A careful observation of the microscopic features of the edge profiles had although shown a subtle variation among themselves, the distinction between the two cameras was difficult to be established (FIG. 6). A misidentification is thus possible when one encounters cameras of this kind, especially if all the edges are not available in the film negatives for comparison.



(a)



(b)

FIGURE 6 Edge profiles of two Olympus Trip 505 cameras bearing the serial numbers 5939724 and 5939721 are seen in figures (a) and (b) respectively. Notice similarities and differences in the edge profiles of the cameras. The masking frames apparently coming from the same mold showed subtle deviations.
Photomicrographs, X40

The present author's finding regarding the class characteristic of cameras are in agreement with those of Davies [6] who found the same mark caused by the machining of the mask itself in all the 20 new Canon F1 35 cameras he examined.

The above discussions point out that it is mandatory on the part of the examiners to ascertain the nature of the edge marks the he has identified in a particular case by relating them to those present in the masking frame of the camera. For this purpose he has to examine the masking frame in reflected light microscopy.

Forensic Applications

Cameras of different make and model can readily be distinguished based on their edge profiles by a close microscopic magnification. This is also true of cameras manufactured of the same batches, provided all the four edges are available for comparison and also the details are well recorded on them.

It is of great concern whether the edge profiles retain their original features during their use over a period of time. Except for a long interval of time the edges are most likely to retain their character for identification on a later date.

The establishment of the relationship existing between the camera and the film negatives carried out in this research can be used effectively to tackle the problem of film camera identification in criminal cases. Though digital cameras are becoming popular, there is still wide spread use of film cameras by people at all levels. Thus the study should benefit the police and forensic investigators, as the identification of cameras would play critical role in many sensitive crime cases.

Conclusions

i. Examination of the frame edges of film negatives exposed with brand new cameras of different make and model had shown that the film-edges had possessed sufficient characteristics, a careful evaluation of which would provide information on identity of the camera in question.

ii. The features on the edges had not evolved at least over a reasonable time period

iii. When the questioned film negatives were taken under poor lighting conditions the edges could not be properly exposed in the film negatives; further, if they were exposed using too large an aperture (or small f/ number) then the delineation of the edge features poses problems.

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