FIRED CARTRIDGE EXAMINATION METHOD AND IMAGING APPARATUS

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1 FIRED CARTRIDGE EXAMINATION
 METHOD AND IMAGING APPARATUS

Matter enclosed in heavy brackets [ ] appears in the
original patent but forms no part of this reissue speci-
fication; matter printed in italics indicates the additions
made by reissue.

FIELD OF THE INVENTION

The present invention relates to a fired cartridge exam-
ination imaging apparatus for use during forensic analysis of
spent firearm cartridges. The invention relates further to a
method of comparing fired cartridges from firearms.

BACKGROUND OF THE INVENTION

Fired bullets and bullet cartridges are left with markings
from the firearm from which they come. These markings
result from forced contact with metal parts in the firearm and
are unique to the firearm since the metal parts have engraved
surfaces which are themselves unique due to the machining
process during manufacturing. Using microscopic examina-
tion of fired bullets and cartridges (casings or shells), firearms
experts have traditionally been able to compare markings to identify whether fired bullets or spent cartridges
originate from a given firearm.

The process of bullet examination has been successfully
automated using apparatus as set out in PCT/CA92/00216
(published as WO 92/20988). Bullet illumination is
described in U.S. Pat. No. 5,379,355.

In manual comparison of fired cartridges, the cartridge
under investigation is placed under a microscope along with
a test cartridge from a known firearm. The impression of the
breach face on the primer and the firing pin impression in the
primer surface have markings that are compared.
Conventionally, side illumination is used which provides an
image dependent on the direction of the illumination. To
compare the markings on cartridge bases, the angle of
illumination must be the same. For this purpose, illumina-
tion direction protocols are used. When two cartridges
originate from the same firearm, the markings will have the
same characteristics. Since the appearance of the primer
breach face impression and firing pin impression is different
using different angles of illumination, the firearms examiner
will usually confirm a match using illumination from more
than one angle.

The need to use an illumination direction protocol and
possibly additional images of each cartridge using different
illumination angles is a problem for automating the process
of imaging and analysis.

SUMMARY OF THE INVENTION

It is an object of the present invention to simplify and
therefore to improve the automated process of fired cartridge
imaging and analysis. In brief, the object of the present
invention is achieved by using axially symmetric illumina-
tion for obtaining images of the fired cartridges. These
images can be rotated with respect to one another and
compared to obtain a correlation factor.

It is a further object of the present invention to provide
such an apparatus which can switch between a magnification
suitable to view the firing pin impression and a magnifica-
tion suitable to view the breach face impression on the
primer surface.

According to the invention there is provided a fired
cartridge imaging apparatus comprising a fired cartridge
mounting device for holding the cartridge substantially
aligned with a longitudinal axis, a primer surface of the
cartridge being substantially perpendicular to the axis, a
cartridge microscope having an optical axis and mounted
with the optical axis substantially parallel to the longitudinal
axis, focusing means for focusing the microscope to image
a breech face impression on the primer surface and a firing
pin impression surface in the primer surface, and an axi-
symmetric light source mounted to project axially symmet-
ric light onto the breech face impression and the firing pin
impression surface about the longitudinal axis. In this way,
images of the breech face and the firing pin impressions can
be used for comparative analysis independently of an angu-
lar orientation of the cartridge held by the mounting device.

According to the invention, there is also provided a
method of comparing fired cartridges from firearms com-
prising the steps of:

- illuminating a base of a first fired cartridge from a first
  firearm using axially symmetric light;
- obtaining using a microscope a first image of a breech
  face impression on a primer of the first base with the breech
  face impression in focus;
- illuminating a base of a second fired cartridge from a
  second firearm using axially symmetric light;
- obtaining using a microscope a second image of a breech
  face impression on a primer of the second base with the
  breech face impression in focus;
- rotating the first and the second images relative to one
  another; and
- obtaining a maximum correlation value for the rotated
  first and second images.

The method according to the invention preferably further
comprises steps of: adjusting a focus and magnification of
the microscope to obtain a first image of a firing pin
impression on the first primer with the firing pin impression
in focus; adjusting a focus and magnification of the micro-
scope to obtain a second image of a firing pin impression on
the second primer with the firing pin impression in focus;
rotating the first and the second firing pin images relative to
one another; and obtaining a maximum correlation value for
the rotated first and second firing pin images. Of course, the
invention also contemplates obtaining a combined correla-
tion value based on the maximum correlation value for the
breech face impression images and the maximum correlation
value for the firing pin impression images, as well as a
relative rotation orientation of the first and second breech
face impression images with respect to the first and second
firing pin impression images.

Preferably, the illumination is automatically adjusted by
analyzing each image to determine if the illumination is
right. In the case that it is not right, an adjustment is made
and the image is taken over again.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood by way of the
following detailed description of a preferred embodiment
with reference to the appended drawings, in which:

FIG. 1 is a perspective view of the apparatus according to
the preferred embodiment except for the image processing
computer showing the cartridge mounting device attached to
a main microscope stage and the cartridge microscope and
camera mounted to the optics of the main microscope;

FIG. 2 is a detailed view showing the cartridge micro-
scope and mounting device of FIG. 1;

FIG. 3 is a detailed plan view of the cartridge mounting
device according to the preferred embodiment; and

FIG. 4 is a schematic illustration of a primer from a fired
cartridge.

DETAILED DESCRIPTION OF THE
PREFERRED EMBODIMENT

As shown in FIG. 1, the preferred embodiment has the
cartridge microscope and camera optics mounted to
complementary (main) microscope optics 12 for analyzing fired bullets. The cartridge 21 is viewed using a microscope 14 and images are taken using a CCD (charge coupled device) camera 20. Axially symmetric light is provided by a fiber optic ring light 16. The cartridge 21 is securely held by a mounting device 18, which itself is adjustably mounted on an arm 30 attached to the stage 22 of the main microscope 12.

The microscope 14 is mounted by arm 15 to the microscope optics of the main microscope 12 so that the focusing system 24 (fine vertical height adjustment) can be used. The stage 22 is moveable in the so-called x-y horizontal plane, although such adjustment is not normally used from one cartridge to the next. The focus and x-y movements are computer controlled, as is known in the art.

With reference to FIGS. 2 and 3, the mounting device 18 will be described in greater detail. The cartridge 21 is held in a V-shaped groove 38 between two plates 34 and 36. Plate 34 is connected to arm 15, and plate 36 is slideably connected to plate 34 by pins 40 and springs 42. A handle may be provided as shown. The device 18 is adjustably connected to arm 30 and can be moved along direction 33 as bolts 35 are repositioned in slot 32. The vertical adjustment along direction 33 may be achieved by focusing system 24 (FIG. 1). The horizontal edge member (not shown in the figures for clarity) is mounted to plate 34 and extends over the top of the cartridge 21 to act as an abutment. The edge member fixes the vertical height of the cartridge 21 with respect to the mounting device 18. To insert the cartridge 21 into the device 18, the plate 36 is pulled away from plate 34, and the cartridge 21 is placed from below into the groove 38 until reaching the horizontal edge member. The plate 36 is then released and the cartridge is held securely in place.

A zoom lens 17 is provided to adjust the magnification of the image seen by microscope 14. The useful images gathered using camera 20 are from the primer 31. The primer is the malleable or mobile central part of the rear of the cartridge 21, and is the part struck by the firing pin of the firearm. As shown in FIG. 4, the firing pin itself leaves its mark 41 in the primer 31, and this is one useful image. The primer also contains markings from the breech face of the firearm which are imprinted during firing. The breech face impressions are another useful image. The contour 45 of the firing pin (which can be obtained from either of the previous two images) is another piece of useful information.

When a cartridge is to be tested using the present invention, it is placed in the mounting device 18 as set out above. The image from camera 20 is usually seen on a monitor. Using the zoom lens 17, the magnification is adjusted to view the primer. The zoom adjustment could be manual, but is preferably automatic. The breech face impression surface of the primer 31 is placed in focus using the automatic focusing system 24, and an image of the breech face impressions is obtained and stored in the computer 51 in FIG. 2. An adjustment of the stage 22 may be necessary to bring the primer near the center of the optic axis 11, but this is not necessary when the system was last used for cartridge imaging. An adjustment of the illumination may also be required. The image is analyzed in the computer for contrast. If insufficient contrast is present, or if the image is too bright or too dim, the level of illumination in ring light 16 is adjusted. Next, the magnification is increased to bring the firing pin impression into view. The image is focused as before, and the firing pin impression image is stored. Again the image is checked for proper illumination, and if necessary, the illumination is adjusted and the image is taken over.

Two cartridges will never produce exactly the same image, even if they are from the same firearm. In the analysis of a cartridge, the object is to locate which cartridge or cartridges resemble the test cartridge the most. A numerical correlation factor is computed for each set of images (breech face and firing pin impression images) with respect to the images for the test cartridge 21. The closest images are then compared in greater detail to determine whether the test cartridge was fired from the same weapon as the cartridge whose images are stored in the computer’s memory 53 in FIG. 2 (disk or tape storage).

The process of correlation involves rotation of the images to obtain the correlation value from the relative rotational position which gives the best correlation. Clearly, this relative rotational position should be approximately the same for the breech face impressions (on surface 31 in FIG. 4) as for the firing pin impressions (on surface 41 in FIG. 4), at least with firearms in which the firing pin is not free to rotate. Also, the relative rotational position of the contour 45 of the firing pin (round, oval, triangular, and irregular shapes similar thereto) must correspond with the firing pin impression orientation. The computer 51 in FIG. 2 may recognize the shape of contour 45 using line or object recognition techniques known in the art. Preferably, the contour is extracted when the magnification is larger, for greater precision. During correlation, the breech face and firing pin markings and contour shape are analyzed. The markings may comprise a series of broken lines as shown in FIG. 4. The breech face of the firearm may have markings other than milling lines which are imprinted onto the primer 31. The same is true for the firing pin impressions. Thus, the impressions may include characteristics which are not segments of ordered lines. The correlation software takes into account width, depth, length or other dimensional characteristics of the markings, as well as any order in the markings, and calculates a numerical correlation value between the test images and each of the stored images. The correlation value for a given stored image is taken as the one from the best relative rotational orientation between the test and stored images. As can be appreciated, the axially symmetric light gives a single image which contains information about all surface markings. When direct side lighting is used, better contrast may be obtained, but some information is lost.

The invention allows a single cartridge to be compared with hundreds or thousands of other cartridges using the computer and its cartridge image database in a relatively short time. It will be appreciated that the invention allows for the cartridge image database to be built from individually acquired images stored in the computer. The result is a small number of closest correlated cartridges which can quickly be analyzed further to determine whether a “match” has been found. The further analysis may be done by computer analysis, however, the final judgment is preferably carried out by a ballistician or firearms expert manually using special equipment for comparing or comparing the microscopic images.

What is claimed is:
1. A fired cartridge examination imaging apparatus comprising:
a fired cartridge mounting device for holding said cartridge substantially aligned with a longitudinal axis, a primer surface of said cartridge being substantially perpendicular to said axis;
a cartridge microscope having an optical axis and mounted with said optical axis substantially parallel to said longitudinal axis, the focusing means for focusing said microscope to image a breech face impression on said primer surface and a firing pin impression surface in said primer surface; and
a ring lamp mounted to project axially symmetric light onto said breech face impression and said firing pin impression surface about said longitudinal axis, whereby images of said breech face and said firing pin impressions can be used for comparative analysis independently of an angular orientation of said cartridge held by said mounting device.

2. The apparatus as claimed in claim 1, wherein said microscope has a magnification adjustable between a first setting suitable to view said breech face impression and a second setting suitable to view said firing pin impression.

3. The apparatus as claimed in claim 2, further comprising means for automatically adjusting said focusing means to place into focus said firing pin impression and said breech face impression.

4. A fired cartridge examination imaging apparatus comprising:
   a fired cartridge mounting device for holding said cartridge substantially aligned with a longitudinal axis, a primer surface of said cartridge being substantially perpendicular to said axis;
   a cartridge microscope having an optical axis and mounted with said optical axis substantially parallel to said longitudinal axis, said cartridge microscope being attached to a complimentary microscope, said cartridge mounting device being attached to a stage of said complimentary microscope;
   focusing means being operated for both said cartridge microscope and said complimentary microscope for focusing said cartridge microscope to image a breech face impression on said primer surface and a firing pin impression surface in said primer surface; and
   an axisymmetric light source mounted to project axially symmetric light onto said breech face impression and said firing pin impression surface about said longitudinal axis, whereby images of said breech face and said firing pin impressions can be used for comparative analysis independently of an angular orientation of said cartridge held by said mounting device.

5. The apparatus as claimed in claim 4, wherein said light source is a ring lamp.

6. A fired cartridge examination imaging apparatus comprising:
   a fired cartridge mounting device for holding said cartridge substantially aligned with a longitudinal axis, a primer surface of said cartridge being substantially perpendicular to said axis wherein said mounting device comprise a pair of opposed vertical plates resiliently biased toward one another, one of said plates being provided with a V-shaped groove having a vertical lengthwise extent parallel to said longitudinal axis, one of said vertical plates including a horizontal edge member mounted to a top surface of said one of said vertical plates for engaging an upper edge of a base of said cartridge, said cartridge being held in a fixed vertical position with said base abutting said horizontal edge member, said cartridge being received by said groove and held between said plates;
   a cartridge microscope having an optical axis and mounted with said optical axis substantially parallel to said longitudinal axis, said cartridge microscope being attached to a complimentary microscope, said cartridge mounting device being attached to a stage of said complimentary microscope;
   focusing means being operated for both said cartridge microscope and said complimentary microscope for focusing said cartridge microscope to image a breech face impression on said primer surface and a firing pin impression surface in said primer surface; and
   an axisymmetric light source mounted to project axially symmetric light onto said breech face impression and said firing pin impression surface about said longitudinal axis, whereby images of said breech face and said firing pin impressions can be used for comparative analysis independently of an angular orientation of said cartridge held by said mounting device.

7. A method of comparing fired cartridges from firearms comprising the steps of:
   illuminating a base of a first fired cartridge from a first firearm using axially symmetric light;
   obtaining using a microscope a first image of a breech face impression on a primer of said first base with said breech face impression in focus;
   illuminating a base of a second fired cartridge from a second firearm using axially symmetric light;
   obtaining using a microscope a second image of a breech face impression on a primer of said second base with said breech face impression in focus;
   rotating said first and said second images relative to one another; and
   obtaining a maximum correlation value for said rotated first and second images.

8. The method as claimed in claim 7, further comprising steps of:
   adjusting a focus and magnification of said microscope to obtain a first image of a firing pin impression on said first primer with said firing pin impression in focus;
   adjusting a focus and magnification of said microscope to obtain a second image of a firing pin impression on said second primer with said firing pin impression in focus;
   rotating said first and said second firing pin images relative to one another; and
   obtaining a maximum correlation value for said rotated first and second firing pin images.

9. The method as claimed in claim 8, further comprising steps of:
   obtaining a first and second firing pin contour of said firing pin impression from said first and second cartridge primers, respectively;
   rotating said first and said second firing pin contours relative to one another; and
   obtaining a maximum correlation value for said rotated first and second firing pin contours.

10. The method as claimed in claim 8, further comprising a step of obtaining a combined correlation value based on said maximum correlation value for said breech face impression images and said maximum correlation value for said first and second firing pin impression images, as well as a relative rotation orientation of said first and second breech face impression images with respect to said first and second firing pin impression images.

11. The method as claimed in claim 9, further comprising a step of obtaining a combined correlation value based on said maximum correlation value for said breech face impression images, said maximum correlation value for said first and second firing pin impression images, and said maximum correlation value for said first and second firing pin impression contours, as well as a relative rotation orientation of said first and second contours, said first and second breech
face impression images, and said first and second firing pin impression images with respect to one another.

12. The method as claimed in claim 7, further comprising steps of:
   analyzing said first image to determine whether sufficient or excessive illumination is present; and if necessary adjusting a level of said axially symmetric light before repeating said step of obtaining said first image.

13. The method as claimed in claim 8, further comprising steps of:
   analyzing said first image of said firing pin impression to determine whether sufficient or excessive illumination is present; and if necessary adjusting a level of said axially symmetric light before repeating said step of obtaining said first image of said firing pin impression.

14. The method as claimed in claim 9, further comprising steps of:
   analyzing said first image of said breech face impression to determine whether sufficient or excessive illumination is present; and if necessary adjusting a level of said axially symmetric light before repeating said step of obtaining said first image of said breech face impression.

15. A method of comparing fired cartridges from firearms comprising the steps of:
   illuminating a base of a first fired cartridge from a first firearm using axially symmetric light;
   obtaining using a microscope a first image of a firing pin impression on a primer of said first base with said firing pin impression in focus;
   illuminating a base of a second fired cartridge from a second firearm using axially symmetric light;
   obtaining using a microscope a second image of a firing pin impression on a primer of said second base with said firing pin impression in focus;
   rotating said first and said second images relative to one another; and
   obtaining a maximum correlation value for said rotated first and second images.

16. A fired cartridge examination imaging apparatus comprising:
   a fired cartridge mounting device for holding said cartridge substantially aligned with a longitudinal axis,
   a primer surface of said cartridge being substantially perpendicular to said axis;
   a cartridge microscope having an optical axis and mounted with said optical axis substantially parallel to said longitudinal axis;
   a focus adjustment mechanism for focusing said microscope on a breech face impression on said primer surface and/or a firing pin impression on said primer surface;
   a light mounted to project axially symmetric light onto said breech face impression and/or said firing pin impression about said longitudinal axis, a camera operably connected to said microscope for obtaining an image of said breech face impression and/or said firing pin impression; and
   a computer for storing said image of said breech face impression and/or said firing pin impression, whereby said images of said breech face and/or said firing pin impressions can be used for comparative analysis independently of an angular orientation of said cartridge held by said mounting device.

17. The apparatus of claim 16, wherein said computer is capable of storing multiple images of breech face impressions and/or firing pin impressions and comparing said stored images for likenesses.

18. The apparatus of claim 17, wherein said light comprises a ring light.

19. The apparatus of claim 16, wherein said microscope has a magnification adjustable between a first setting suitable to view said breech face impression and a second setting suitable to view said firing pin impression.

20. The apparatus of claim 18, wherein said microscope has a magnification adjustable between a first setting suitable to view said breech face impression and a second setting suitable to view said firing pin impression.

21. A method of comparing fired cartridges from firearms comprising the steps of:
   illuminating a base of a first fired cartridge using axially symmetric light;
   obtaining using a microscope a first image of a firing pin impression on a primer of said base of said first fired cartridge with said firing pin impression in focus;
   illuminating a base of a second fired cartridge using axially symmetric light;
   obtaining using a microscope a second image of a firing pin impression on a primer of said base of said second fired cartridge with said firing pin impression in focus;
   storing said first and said second images in a computer; and
   comparing said first and said second images for likenesses.

22. The method of claim 21, wherein said comparing includes correlating likenesses of said images in a computer.

23. The method of claim 22, wherein said illuminating comprises illuminating said bases with axially symmetric light from a ring light.

24. The method of claim 23, wherein said correlating comprises:
   rotating said first and said second images of said firing pin impressions relative to one another; and
   obtaining a maximum correlation value for said rotated first and second images.

25. The method of claim 21, further comprising:
   obtaining using a microscope a first image of a breech face impression on said primer of said base of said first fired cartridge with said breech face impression in focus;
   obtaining using a microscope a second image of a breech face impression on said primer of said base of said second fired cartridge with said breech face impression in focus;
   storing said first image of a breech face impression and said second image of a breech face impression in a computer; and
   comparing said first image of a breech face impression and said second image of a breech face impression for likenesses.

26. The method of claim 25, wherein said comparing includes correlating likenesses of said images using a computer.

27. The method of claim 26, wherein said illuminating comprises illuminating said bases with axially symmetric light from a ring light.

28. The method of claim 27, wherein said correlating comprises:
   rotating said first and said second images of said breech face impressions relative to one another; and
obtaining a maximum correlation value for said rotated images.

29. A method of comparing fired cartridges from firearms comprising the steps of:
   illuminating a base of a first fired cartridge using axially symmetric light;
   obtaining using a microscope a first image of a breech face impression on a primer of said base of said first fired cartridge with said breech face impression in focus;
   illuminating a base of a second fired cartridge using axially symmetric light;
   obtaining using a microscope a second image of a breech face impression on a primer of said base of said second fired cartridge with said breech face impression in focus;
   storing said first and second images in a computer; and
   comparing said first and second stored images for likeness.

30. The method of claim 29, wherein said comparing includes correlating likenesses of said images using a computer.

31. The method of claim 30, wherein said illuminating comprises illuminating said bases with axially symmetric light from a ring light.

32. The method of claim 31, wherein said comparing comprises:
   rotating said first and second images of breech face impressions relative to one another; and
   obtaining a maximum correlation value for said rotated first and second images of breech face impressions.

33. The method of claim 29, further comprising:
   obtaining using a microscope a first image of a firing pin impression on said primer of said base of said first fired cartridge with said firing pin impression in focus;
   obtaining using a microscope a second image of a firing pin impression on said primer of said base of said second fired cartridge with said firing pin impression in focus;
   storing first image of a firing pin impression and said second image of a firing pin impression images in a computer; and
   comparing said first image of a firing pin impression and said second image of a firing pin impression for likeness.

34. The method of claim 33, wherein said comparing includes correlating likenesses of said first image of a firing pin impression and said second image of a firing pin impression using a computer.

35. The method of claim 34, wherein said illuminating comprises illuminating said bases with axially symmetric light from a ring light.

36. The method of claim 35, wherein said correlation comprises:
   rotating said first and second images of firing pin impressions relative to one another; and
   obtaining a maximum correlation value for said rotated first and second images of firing pin impressions.

37. In a method of comparing fired cartridges, the method of building a database of images of fired cartridges comprising:
   a. positioning a fired cartridge for imaging;
   b. illuminating with axially symmetric lighting the cartridge for imaging;
   c. obtaining an image of the cartridge; and
   d. storing the image acquired of the cartridge in a computer cartridge image database.

38. The method of building a database of claim 37 wherein the steps a, b, c and d are repeated to build said database containing data relating to a large number of cartridges.

39. The method of building a database of claim 37 wherein the image acquired is the image of a breech face impression of the cartridge case.

40. The method of building a database of claim 37 wherein the image acquired is the image of a firing pin impression of the cartridge case.