

F. James Gerhart,¹ M.S.

Identification of Photocopiers from Fusing Roller Defects

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ABSTRACT: A sampling of 27 photocopiers using the indirect electrostatic process were examined for fusing roller damage of significance to the document examiner. Distinctive indentation patterns were present on some copies produced, which were sufficient for identification and for establishing that the copies had been in physical contact with the copiers. The frequency and nature of the fusing roller defects observed is described.

KEYWORDS: questioned documents, photocopiers, class characteristics, fusing rollers, identification

The examination of a photocopy machine to determine whether or not it was the source of a questioned photocopied document is conducted in the same manner as many of the other examinations confronted by the document examiner, such as typewriter, check-writer, rubber stamp, and other examinations. The first portion of the examination involves comparison of the class characteristics produced by the photocopy machine, followed by a careful evaluation of the identifying characteristics. As with most other mechanical devices, the identifying characteristics present in a photocopier develop over a period of time through use and abuse. These characteristics, in common with one another, serve as a basis for the identification of a particular machine.

The class characteristics exhibited by a suspect photocopy machine must first be examined to determine if that particular make and model of machine was capable of producing the photocopy in question. Observable class characteristics exhibited by various photocopiers have been reported [1-5]. Included in the preliminary examination are such considerations as the type of photocopy process, the method of fixing the toner to the page and its magnetic properties, enlargement and reduction capabilities of the machine, direction of feed, paper sizes and margins, roller marks, distinctive brand markings, gripper and sorter indentations, analog or digital image, toner color, and so forth. The chemical properties of toner have also been examined in an effort to reduce further the population of suspect photocopiers [6-10].

Once the class characteristics of the questioned photocopy have been found to be consistent with a particular machine, the identifying characteristics are examined. Modern photocopiers are designed for a high degree of usage, with the accompanying requirement

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¹Special agent document examiner, Federal Bureau of Investigation, Washington, DC.

of considerable maintenance and replacement of defective and worn-out parts. As a result of accumulated dirt, debris, and scratches on the various components of the photocopier, flaws and blemishes in the form of "trash marks," streaks, smudges, speckles, lines of toner, and white fuzzy lines through the image area may appear on the photocopy product [10–14].

The key components of the electrostatic process most likely to produce distinctive characteristics are as following: (a) the photoconductor drum or belt; (b) the imaging system, consisting of some combination of lenses, mirrors, and a light source; (c) the copy glass or platen; (d) the lid or cover; and (e) corona wires.

Flaws appearing on a questioned photocopy are exhibited in the form of toner particles fixed to the page in a particular pattern and location. A questioned photocopy can be definitely associated with a machine if it and the exemplars taken from the suspect photocopier exhibit the same distinctive flaws in sufficient detail and abundance for examiners to conclude reasonably that this could not have occurred by chance. However, the conclusion of identity with a particular machine may not be possible under the circumstances described. If the identifying characteristics can be reproduced with little loss of resolution, the possibility exists that the questioned photocopy is actually a subsequent copy prepared on a different clean copier with similar class characteristics. In that case, it can be concluded that the questioned photocopy was definitely copied on the suspect photocopier at some point in time, but it cannot be ascertained whether the document examined had come in physical contact with the machine.

The document examiner's opinion that a questioned photocopy was at one point in time copied on a particular photocopier is usually of such evidentiary value that it will suffice. Occasionally, this may not be the case, and it becomes important to show that the questioned document was definitely in physical contact with the machine and not a subsequently prepared copy of a copy on a different machine with the same class characteristics. Kelly [15] has reported one such circumstance in which physical contact of a questioned copy with the machine was established as a result of silicone oil patterns produced from damaged fusing rollers.

Fusing Rollers

Fusing rollers appear to offer promise as a key component in the indirect electrostatic photocopy process which can provide identifying characteristics and also establish that a questioned photocopy was in physical contact with a particular copier. Fusing rollers on dry toner copiers which use heat and pressure in the process of fixing the toner to the page are subject to damage from abuse and wear over a period of time. On the average, fusing rollers are good for 60 000 to 80 000 copies before replacement is necessary [1].

Nature of Defects

Generally, there are two types of damage most frequently encountered by a service repair technician which require that the heat and pressure upper fusing roller be replaced.² One type is the result of a paper jam in the photocopier, in which the operator, in using a convenient tool such as a letter opener to remove the paper, scratches the Teflon coating on the roller. Toner accumulates in these overheated areas and eventually produces a toner line on the copy. The second type of damage is the result of wear. To prevent the paper from sticking to the roller and wrapping around itself, in addition to the nonstick Teflon coating and continual silicone oil lubrication, most manufacturers use

²T. Honeycutt, Service Supervisor, Government Marketing Center, Canon USA, Alexandria, VA, personal communication, 1990.

separation claws which ride on the fusing roller to help ensure that the paper does not wrap. These metal prongs rest on the Teflon and wear away the coating to varying degrees, as has been described by Kelly [15]. Eventually toner piles up in these grooves and produces a toner line on the copy. The Teflon coating can also deteriorate by peeling and scoring from the wiper pads, which produces an uneven surface. Defective fusing rollers are replaced at the discretion of the repair technician, who primarily considers how the copy quality is affected rather than the condition of the roller.

When the wear from the separation prongs or peeling becomes severe and produces an irregular pattern of ridges and valleys in the Teflon coating, the damage becomes significant to the document examiner because its effects can be seen on the copy produced. During the fixing process, in which the toner permanently adheres to the copy paper, the fusing rollers subject the paper to a temperature of 160 to 200°C and a pressure of approximately 640 kg, causing the toner to melt and be forced into the fibers of the copy paper [16]. Under these conditions, the damaged roller with its raised ridges, where the Teflon has been pushed aside or accumulated, forms corresponding indentations in the copy paper. These indentations, which can be quite distinctive, are easily observed on the copy paper with side lighting positioned perpendicular to the direction of movement of the paper through the copier. If the worn area of the roller comes in contact with an abundant quantity of toner, then corresponding depressions and raised areas on the toner surface can also be observed. Since these characteristics cannot be seen under normal lighting conditions, the copy quality is not affected and roller replacement would not be necessary.

Photocopiers Examined

An examination of fusing roller damage was conducted on a limited sample of 27 photocopier machines in order to evaluate the potential of fusing roller defects as a source of identification. Included in the sample was one machine that had been submitted to the laboratory in a case involving a question of origin of photocopied documents. The remaining photocopiers examined were all currently in use in a typical government office environment. In general, these copiers were leased, and serviced through maintenance contracts whenever a malfunction occurred. Those copiers selected for examination used the indirect electrostatic process with dry toner and a heat and pressure fixing method, since this is the most common photocopier process in use today [1].

The photocopier machines examined are listed in Table 1. They were equipped with Teflon-coated upper and silicone-rubber lower fusing rollers, with the exception of the Xerox 1075, which had silicone-rubber upper and lower rollers. In addition, the Konica copiers, 10 through 12 (Table 1), had Teflon-coated upper and lower rollers. By comparing the recommended copy volume per month with the expected roller life, the frequency of roller replacement can be estimated. For example, if the Konica 2803ZMR (Copier 13) copy volume per month is at the low end of the recommended range, the upper fusing roller should last 12 months before it needs replacement. However, if its copy volume is 30 000, the fusing roller would only last 2 months. In this example, the actual average volume was reported to be 11 782 copies per month, with a fusing roller life expectancy of 5.1 months. The usage rate experienced by the copiers examined generally fell within the recommended copy volume per month listed in Table 1.

Method of Examination

A total of twelve copies each were initially obtained from the photocopiers listed in Table 1, with the exception of the Adler-Royal TA220RE, which was examined separately. Letter size samples were obtained with the lid open, the lid closed, blank paper,

TABLE 1—*Listing of photocopiers examined.*

Copier	Brand	Fusing Roller Marks on Copy	Recommended Copy Volume per Month ^a	Roller Life ^a
1	Adler-Royal TA220RE	identifiable	1 to 20	90
2	Canon NP-150	...	1 to 7.5	200
3	Canon NP-150	identifiable	1 to 7.5	200
4	Canon NP-210	identifiable	3 to 10	200
5	Canon NP-3725EF	...	1 to 30	n/a ^b
6	Canon NP-4540EF	(class)	1 to 50	200
7	Canon PC-24	identifiable	1 to 0.55	n/a
8	Canon PC-24	some distinctive	1 to 0.55	n/a
9	Kodak Ektaprint 85	(class)	8 to 40	200
10	Konica 1500	...	1 to 10	60
11	Konica 3290	...	1 to 30	60
12	Konica 3290	...	1 to 30	60
13	Konica 2803ZMR	identifiable	5 to 30	60
14	Konica 2803ZMR	...	5 to 30	60
15	Minolta EP470Z	identifiable	1 to 25	120
16	Monroe RL-920	...	1 to 20	60
17	Monroe RL-925	...	1 to 25	90
18	Monroe RL-940	...	25 to 50	120
19	Monroe RL-717Z	...	1 to 8	60
20	Monroe RL 735Z	...	1 to 30	90
21	Monroe RL 735Z	...	1 to 30	90
22	Olivetti Copia 1810	...	n/a	n/a
23	Ricoh FT4480	some distinctive	1 to 25	120
24	Savin 7020	...	1 to 20	120
25	Savin 7065	...	10 to 10	200
26	Sharp SF-9750	...	20 to 100	400
27	Xerox 1075	...	25 to 100	250

^aExpressed in thousands of copies. The information was obtained from SpecCheck "Competitive Copier Guide" issues dated 1986 through 1989, published by Dataquest Inc.

^bThe information was not available.

and a test pattern positioned on the platen. All copy settings were on normal or automatic, and the direction of paper travel was noted. The copies produced were examined with incident light, and when indentations were observed, the fusing rollers for that machine were inspected for wear. Because of the small diameter of the fusing rollers, the indentations were repeated on a single copy, with the position of the marks migrating from copy to copy. Transparency film made for plain paper copiers was found to be helpful in comparing the relative positions of the distinctive indentations. By making a transparency with the lid open, a detailed pattern of the upper fusing roller damage was reproduced on the clear plastic, which could be superimposed over the copy paper for comparison.

Results and Discussion

The significance of fusing roller damage observed on the 27 photocopy machines examined is listed in Table 1. Eight of the machines produced copies with distinctive patterns of indentations caused by damaged fusing rollers. Six of these copiers displayed such an abundance of reproducible distinctive characteristics that they were considered identifiable. In reaching that conclusion, no consideration was given to the presence of toner patterns. Two of the copiers displayed some distinctive indentations insufficient for identification, either from lack of abundance of characteristics or from lack of ob-

servable detail. However, if these markings happened to fall in an area where there is a large amount of toner, the ability to observe indentation patterns could be enhanced.

Copier 6, the Canon NP4540EF, and Copier 9, the Kodak Ektaprint 85 (manufactured by Canon Inc.), both displayed class characteristics consisting of a series of four parallel indentation lines not caused by the fusing rollers but by other rollers in contact with the paper as it advances through the machine. The spacing between indentation lines was the same for both machines and measured 75, 80, and 45 mm.

The Adler-Royal TA220RE (Copier 1), which was submitted to the laboratory for examination, was found to have fusing roller damage in the form of a distinctive scratch on the upper fusing roller. The scratch was deep enough to remove the Teflon coating from the surface of the cylinder. Subsequent accumulation of toner material in the scratch caused it to become raised above the Teflon surface, except where the separation prong rides over the top (Figs. 1a and 1b). This raised surface produced two corresponding

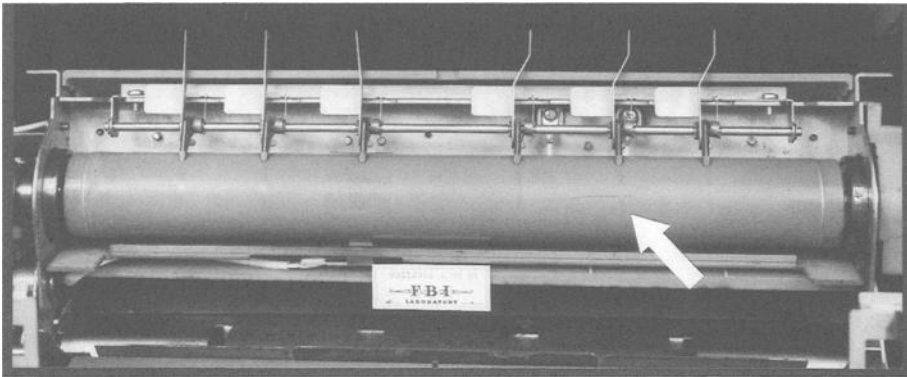


FIG. 1a—Adler-Royal TA220RE (Copier 1): The scratch on the upper fusing roller, indicated by the arrow, initially removed the Teflon coating, exposing the bare metal. Note the coil springs to the right of the six separation claws keeping them in contact with the fusing roller. The Teflon is beginning to show wear from the separation claws, but it is not sufficient to leave marks on copies.

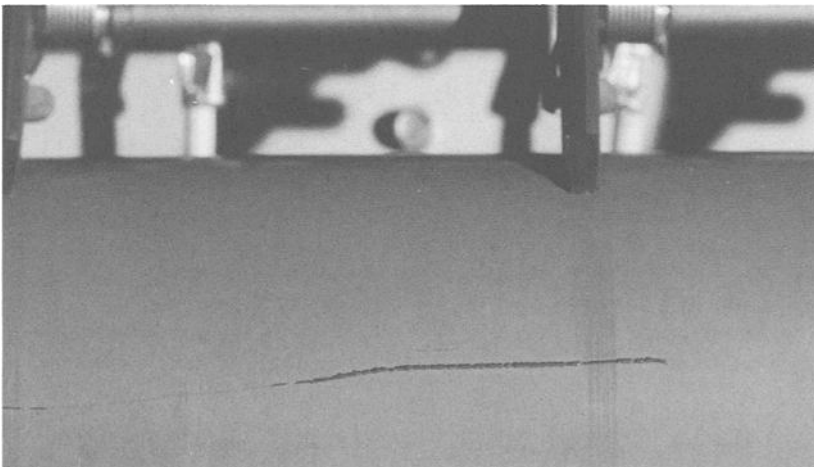


FIG. 1b—Enlargement of the scratch in Fig. 1a has accumulated toner material where the metal is exposed, forming a ridge above the surface of the Teflon except where the separation claw rides over the scratch.

indentation patterns on the questioned copy, with the distance between the marks equal to the circumference of the fusing roller (Fig. 1c).

The distinctive characteristics produced on copies from the remaining photocopiers examined were all the result of wear damage to the upper fusing roller. No damage of consequence was observed on the lower fusing rollers. Figures 2 through 5 depict examples of fusing roller wear and damage that produced copies considered identifiable.

The Canon PC-24 (Copier 8) displayed some indentation lines on the copy as a result of wear from the separation prongs on the fusing roller. The indentation lines appeared in the same relative positions as those in the Canon PC-24 (Copier 7), but they lacked the individuality displayed in Fig. 2. This type of general wear, when observed, would greatly reduce the number of suspect copiers, but it should not be considered unique to a single machine. In conjunction with "trash marks" in common, this type of wear would strongly suggest that the questioned document was in physical contact with the photocopy machine.

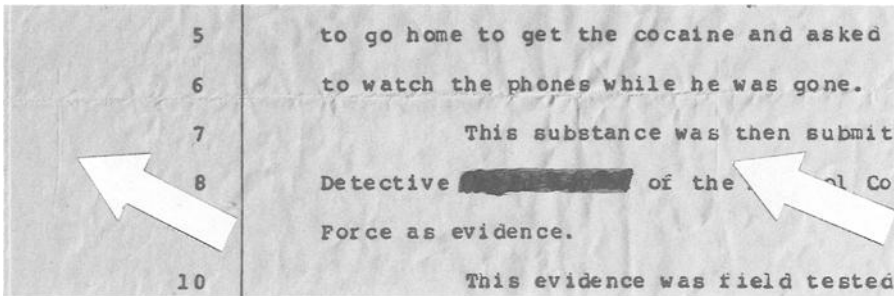


FIG. 1c—Arrows indicate the positions of indentation lines produced from the scratch in Figs. 1a and 1b. The distance between marks is equal to the circumference of the fusing roller.

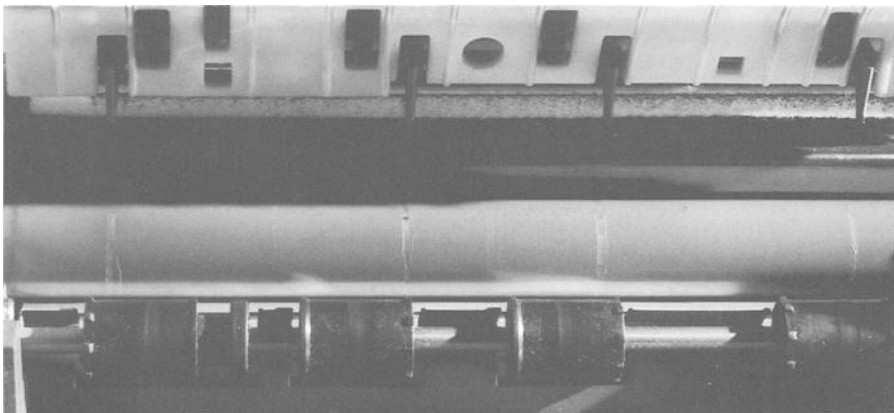


FIG. 2a—Canon PC-24 (Copier 7): Wear damage to the Teflon coating on the upper fusing roller is caused by the rubbing of the separation prongs.

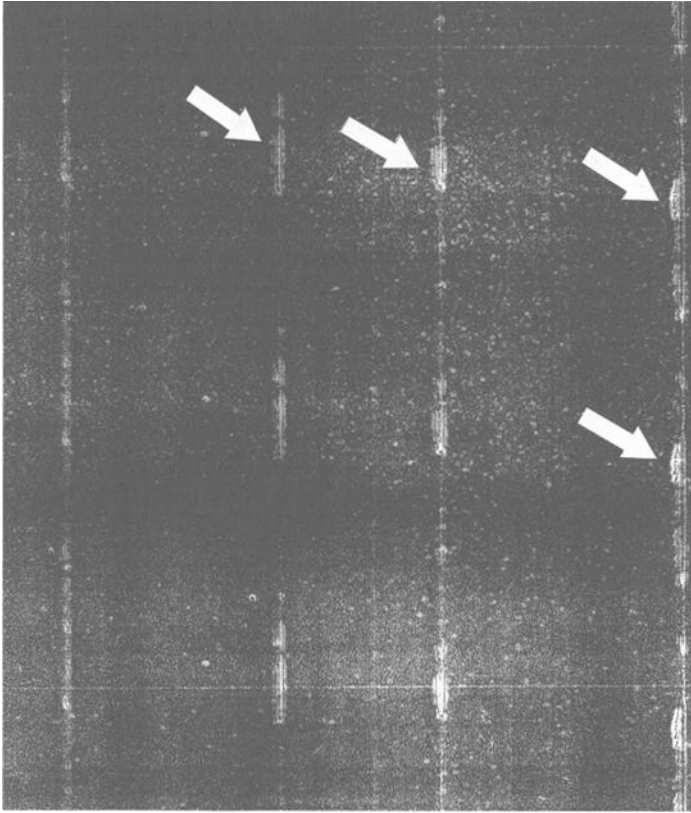


FIG. 2b—Transparency copy made with the lid open, showing the uneven fusing of the toner as a result of the damage depicted in Fig. 2a. The pattern is reproduced three times on an 11-in. (28-cm) page.

Conclusions

Of the 27 photocopiers examined, 22% displayed identifiable indentations on copies produced from worn and damaged fusing rollers. If all machine marks appearing on the copies are included, a positive association could be made 37% of the time. In view of the high degree of potential for association, as well as the opportunity to establish that a questioned copy was in physical contact with a particular copier, fusing rollers should be considered a key component in the identification of photocopier machines. It should be noted that these results reflect frequency of damage to Teflon-coated heat and pressure rollers only.

Since laser printers use the same toner fixing process as photocopiers, worn fusing rollers could produce distinctive marks on laser copies, although none have been identified to date. Some laser printers display class characteristics in the form of roller indentation lines on copies, which may be of assistance as more data are accumulated.

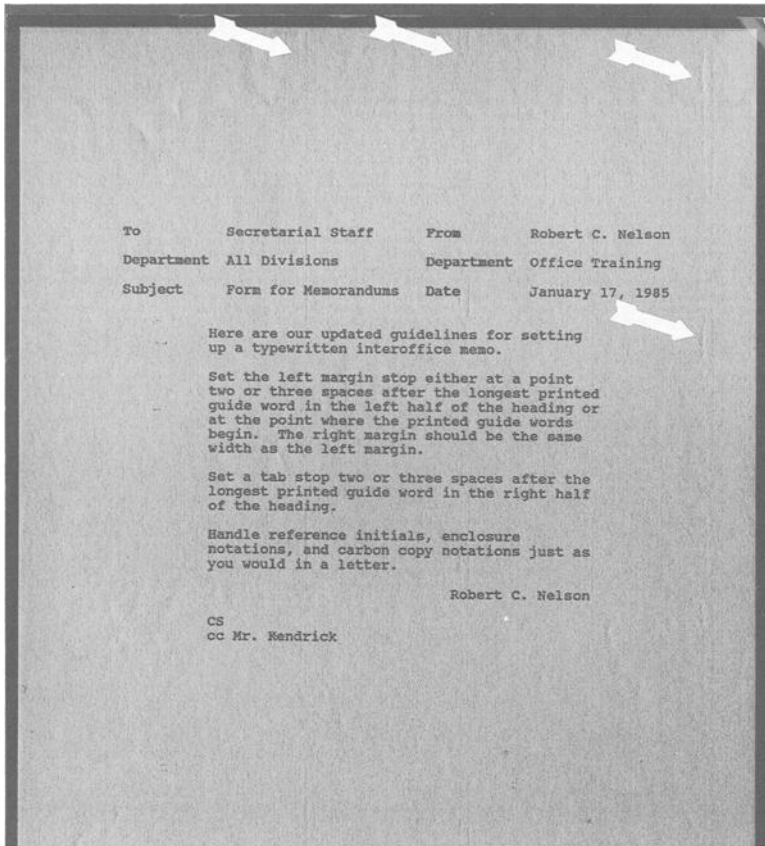


FIG. 2c—Copy paper photographed with side lighting, showing a pattern similar to that in Fig. 2b but in the form of three vertical rows of indentations produced from the worn fusing roller in Fig. 2a.

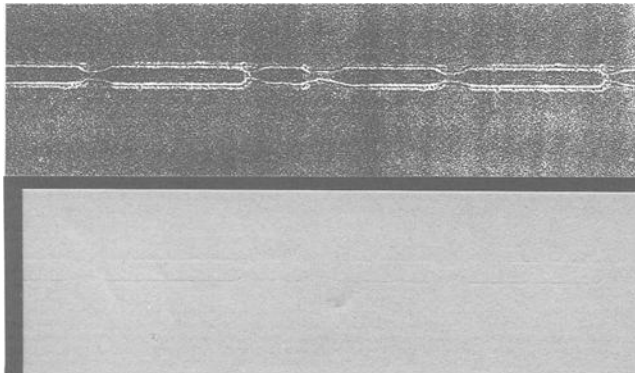


FIG. 3—Konica 2803ZMR (Copier 13): Fusing roller damage from separation claws produced three rows of distinctive patterns. Shown is a portion of one row on copy paper (above) and on a transparency copy (below).

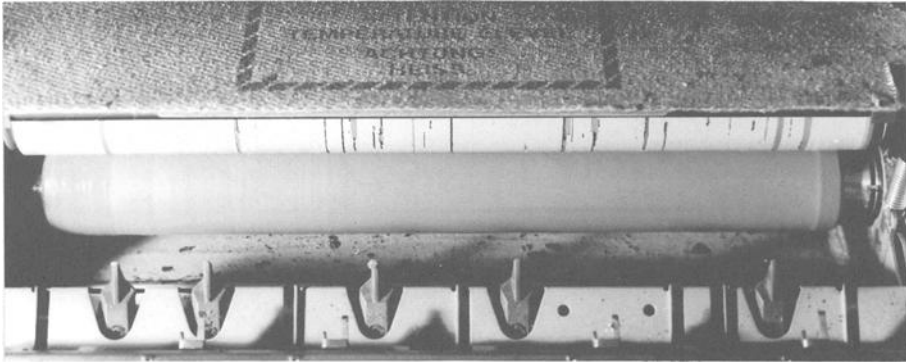


FIG. 4—Canon NP-210 (Copier 4): The peeling of the Teflon coating on the upper fusing roller is extensive, and copies display an abundance of indentations. The separation claws account for only a portion of the total wear exhibited. This fusing roller continues to fuse toner to the page and produce clean copies; therefore it will probably not be replaced by the service technician.

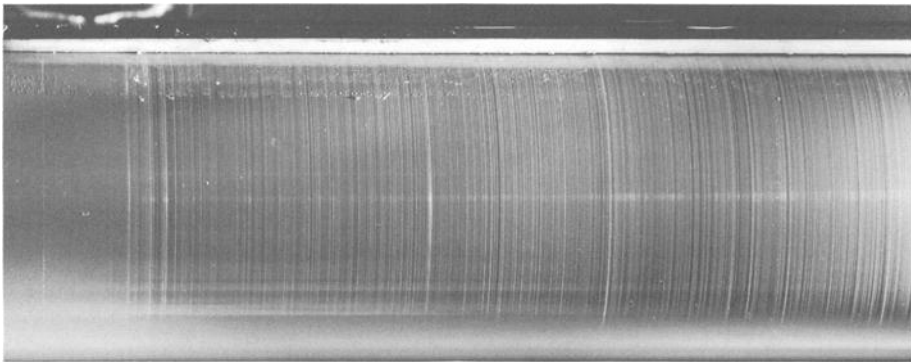


FIG. 5—Canon NP-150 (Copier 3): The striated condition of this fusing roller is probably the result of exposure to the hardened debris from a dry dirty wiping pad above. This roller produces copies with a distinctive pattern of furrows and ridges.

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Address requests for reprints or additional information to
F. James Gerhart
Federal Bureau of Investigation
10th and Pennsylvania Ave., N.W., Rm. 3372a
Washington, DC 20535