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MILITARY STANDARD

VISUAL INSPECTION GUIDE FOR RUBBER O-RINGS



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MIL-STD-413B
28 February 1969

DEPARTMENT OF DEFENSE
WASHINGTON, D.C. 20301

Visual Inspection Guide for Rubber O-Rings
MIL-STD-413B

1. This Military Standard is mandatory for use by all Departments and Agencies of the Department of Defense.
2. Recommended corrections, additions, or deletions should be addressed to Commander, Naval Ship Engineering Center, Center Building, Prince George's Center, Hyattsville, Maryland 20782.

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FOREWARD

Government material procurement specifications have been primarily concerned with detailing composition, construction, and necessary physical requirements. However, little attention has been paid to defining the limits of acceptable quality regarding manufacturing defects other than such generalizations as "the workmanship shall be first class." In such a diverse industry as that of rubber manufacturing, individual plants vary considerably in their production and quality control techniques. Defects are likely to occur from many causes, such as variation in the quality of the basic materials and variations in manufacturing processes and finishing operations. Therefore, the quality generalizations used in this document must of necessity cover a considerable range which represents the best available judgment. This document is issued as a practical yardstick which quality assurance personnel will use to appraise visually the quality of rubber O-rings.

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1. SCOPE

1.1 **Purpose.** The primary objectives of this standard are to provide word descriptions and photographs of possible defects in rubber O-rings that may be presented for inspection; to establish quantitative levels of acceptance for these O-rings relative to surface defect type, size, and quantity; and to provide a training aid for quality assurance personnel.

1.1.1 In general, this document is intended to supplement the inspection procedure of a particular specification for O-rings. Where no such procedure is provided, this document becomes the primary guide. In the event of conflict between this document and the inspection procedure of an end item specification or a specification for O-rings, the basic specification shall govern.

1.2 **Scope.** This document covers only visual defects for O-rings, i.e., circular cross-section gaskets in the form of a continuous circle (doughnut-shaped). Pneumatic tubes and items containing cellular rubber are specifically excluded. Specifically covered are: surface defects; internal defects such as foreign materials, undispersed ingredients or porosity; and out-of-tolerance dimensions.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on the date of invitation for bids form a part of this standard to the extent specified herein.

STANDARDS

MILITARY

- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes...
- MIL-STD-109 - Quality Assurance Terms and Definitions.
- MIL-STD-177 - Rubber Products, Terms for Visible Defects of.

3. DEFINITIONS

3.1 Categories, major and minor defects, are as defined in MIL-STD-109. Critical defects for rubber O-rings are not included in this standard. To classify critical defects for O-rings, the end use must be known; therefore, critical defects must be considered in the basic specification where an O-ring failure could cause injury or a fatality (see definition for critical defects in MIL-STD-109).

3.2 Word descriptions of visible defects used in this standard are in accordance with MIL-STD-177.

3.3 To eliminate any misunderstanding of the terminology used herein, the following definitions are given (see MIL-STD-177 for additional terminology):

- (a) **Backrind** - Torn or gouged condition (recess) occurring at the mold parting lines, caused by thermal expansion over sharp mold edge or by premature cure.
- (b) **Parting Line Indentation** - A shallow, saucer-like recess located on the parting line, caused by a deformity in mold edge.
- (c) **Foreign Material** - Any coarse or undispersed material (contamination, dirt, undispersed pigment, etc.) or depression formed by removal thereof.
- (d) **Excessive Trimming** - Flat spots or nicks producing out-of-tolerance cross section, caused by excessive buffing or trimming of flash.
- (e) **Parting Line Projection** - A continuous ridge of material situated on the parting line, caused by worn or otherwise excessively rounded mold edges.
- (f) **Flash** - Very thin gauge, sometimes film-like, material which extends from parting line projection, resulting from mold separation or inadequate trim.
- (g) **Non-Fill** - An irregular flat spot or ribbon-like strip, generally having a coarser texture than the normal O-ring surface. Also a recessed wedge resembling a half-moon.
- (h) **Mold Deposit Defect** - Surface indentation, irregular in shape, and with rough surface texture caused by a build-up of hardened deposits in the mold cavity.
- (i) **Flow Mark** - A flow line, knit mark, or delamination, caused by poor knitting.
- (j) **Off-Register** - One-half of the O-ring out of line with the other half, due to relative shifting of mold halves.
- (k) **Mismatch** - One-half of the O-ring out of line with the other half, due to dimensional difference in mold halves.

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- (l) Bloom - Material which has migrated from the body of the O-ring to the O-ring surface.
- (m) Porosity - Presence of numerous minute voids or sponginess, showing up usually in a cross-section cut.
- (n) Blister - A void or hole in the body of the O-ring, which may or may not cause protrusion on the surface and may be covered or open, caused by air being trapped during cure.

4. GENERAL REQUIREMENTS

4.1 Quality assurance personnel should be provided with a stepped cone or a set of "go", "no-go" gauges of either cylindrical or spherical shape for measuring internal dimeters of the O-rings. Marginal diameters may be checked with an optical comparator (shadow graph). A special cone can be used in conjunction with the comparator to mount the O-ring, thus preventing out-of roundness.

4.2 Cross sections can be measured with a ball point or tubing micrometer gauge, equipped with 6mm (0.25 in.) diameter hemispherical tips and graduated in intervals not exceeding 0.001 mm (0.001 in.). The optical comparator can also be used to measure cross sections and to determine roundness of the cross section.

4.3 Quality assurance personnel also should be provided with wire gauges of 0.002, 0.005, 0.010, 0.015 and 0.020 inch diameters. Such gauges may be positioned adjacent to defects for size determination and review by comparison. Bloom or surface dust, if present on the O-ring, should be removed before inspection. Minor flexing or bending may be used to reveal defects which are not seen easily. However, appreciable stretching should be avoided. A minimum of 400 foot-candles of illumination should be provided. Instruments for microscopic measuring should be of a type that is capable of scanning the defect through "cross-hairs" by means of perpendicular cross-slides controlled by micrometers. Depths of defects may also be determined by means of a stereo-focus microscope of sufficient magnification. This instrument should have a dial indicator of 0.0001 inch graduations and should reflect the vertical movements. In many cases visual inspection can be accomplished without the use of microscopes.

4.4 Enlarged photographs of representative major and minor defects are included, to aid inspection. The white markings on the O-rings are used to outline the general area of the defect. An arrow or arrows have also been added to the 10X magnification for easy reference, only to help in locating the defect. Comparison of the defect with the product being inspected should be made on the 1X magnification. The grid sizes are 0.1, 0.2, 0.5, and 1.0 inch, for 1X, 2X, 5X and 10X magnifications, respectively. All photographs are indexed in table I according to figure number, type of defect and classification of defect (major or minor).

4.5 It should be borne in mind that this standard has included photographs of only the most common defects that occur during the fabrication of elastomeric O-rings. It is not feasible to obtain examples of all possible defects. Further, the definitions of defects in this standard do not abrogate requirements of a particular specification, contract, or order.

4.6 Quantitative classification of major and minor defects is given in table II. All dimensions are expressed in inches. When any dimension of a defect exceeds the value specified, this constitutes a major defect for any O-ring having a cross-sectional width, "W", within the range shown. Otherwise the defect is classified as minor. In general, dimensional limits of defects are related to the O-ring cross-sectional width. For O-ring sizes appreciably larger than 0.275 inch cross-sectional width, quality assurance personnel should refer to the particular specification involved for quantitative dimensional limits of defects.

5. DETAIL REQUIREMENTS

5.1 Non-destructive tests. The dimensions of O-rings shall be checked with the equipment described in 4.1 and also with the micrometer gauge described in 4.2. In all cases, the requirements of the applicable specification are governing. The dimension check should also detect flat spots due to excess trimming, as well as defects due to backrind, parting line projection, excessive flash, off-register and mismatch. All O-rings sampled (see 5.3), shall be carefully examined for visual surface defects. Refer to 4.3, 4.4 and 4.5 and tables I and II.

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5.2 Rejection of individual O-rings. All O-rings found to have out-of-tolerance dimensions (see 5.1) shall be rejected. Visual surface defects are cause for rejection as follows: any O-ring with one or more major defects; any O-ring with two or more minor defects; any O-ring with a radially oriented flow mark or flow line, regardless of length.

5.3 Sampling. All O-rings shall be subjected to one or more MIL-STD-105 sampling procedures, as specified by the purchaser, except where the material specification includes a sampling plan. Unless specified otherwise in the product specification, purchase order, or contract, an Acceptable Quality Level, (AQL) of 1.5 percent defective shall be used. Acceptance or rejection of the lot, sub-lot or batch shall be on this basis, except where already rejected in 5.1.

Custodians:

Army - GL
Navy - SH
Air Force - 82

Preparing activity:

Navy - SH
(Project 5330-0356)

Review activities:

Army - GL, MU, WC
Navy - SH, AS, OS
Air Force - 82, 11

User activities:

Army - AT
Navy - MC

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Table I - Index to photographs of representative major and minor defects

Defect	Figures
Backrind, major	1, 2, 3, 4, 7, 10
Backrind, minor	5, 6, 8, 9
Flash remaining, excessive, major	42, 43, 44, 47, 49, 51
Flash remaining, excessive, minor	45, 46, 48, 50
Flow marks, major	70, 71, 73, 75, 76
Flow marks, minor	72, 74, 77, 78
Foreign material, major	26, 28, 30, 32, 33
Foreign material, minor	25, 27, 29, 31
Indentation, parting line, major	14, 19, 20, 22, 24
Indentation, parting line, minor	11, 12, 13, 15, 16, 17, 21, 23
Mold deposit defect, major	61, 64, 65, 66, 69
Mold deposit defect, minor	62, 63, 67, 68
Non-fill, major	52, 53, 55, 56, 57, 58, 60
Non-fill, minor	54, 59
Off-register and/or mismatch, major	79, 80, 81, 86
Off-register and/or mismatch, minor	82, 83, 84, 85
Trimming (buffing), excessive, major	35, 37, 39, 41
Trimming (buffing), excessive, minor	34, 36, 38, 40

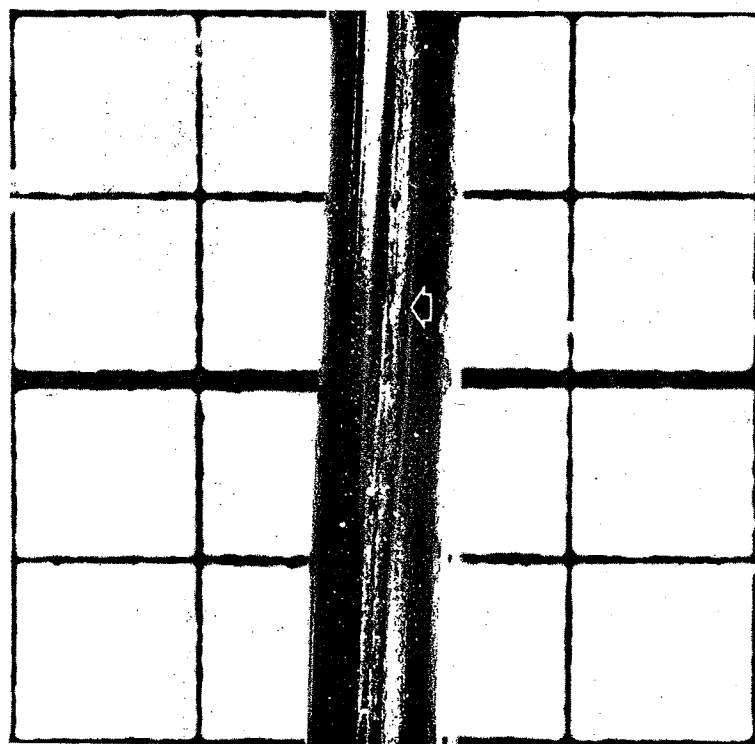
NOTE: O-rings photographed range in size from 0.070 to 0.275 inch cross-sectional width, "W". Size is specified on each individual photograph. On all photographs, grid sizes are 0.1, 0.2, 0.5 and 1 inch, for 1x, 2x, 5x and 10x magnifications, respectively.

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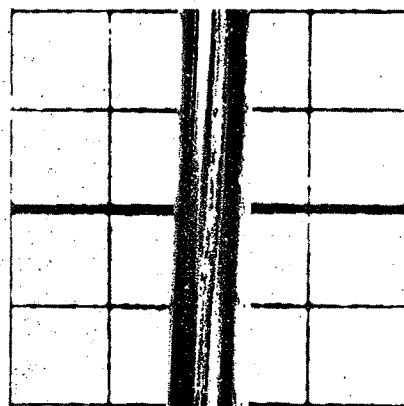
O-ring cross-sectional width "W"	Backrind		Parting line indentation		Foreign material		Parting line projection and excessive flash		Non-fill		Mold deposit defect		Flow mark		Off-register and/or mismatch	O-ring cross-sectional width "W"
	Depth	Width	Depth	Width	Depth	Width	Max. Height	Depth	Width	Depth	Width	Depth	Length	Max.		
0.069 and under	0	0	0.003	0.010	0	0	0.003	0	0	0.003	0.010	0.003	0.060	0.003		0.069 and under
0.070 to 0.102	0	0	0.003	0.010	0	0	0.003	0	0	0.003	0.010	0.003	0.060	0.003		0.070 to 0.102
0.103 to 0.138	0.003	0.005	0.003	0.015	0.003	0.005	0.003	0.002	0.010	0.003	0.015	0.003	0.060	0.004		0.103 to 0.138
0.139 to 0.209	0.004	0.006	0.004	0.020	0.004	0.007	0.004	0.003	0.015	0.004	0.020	0.004	0.180	0.005		0.139 to 0.209
0.210 to 0.274	0.004	0.006	0.005	0.025	0.005	0.010	0.005	0.003	0.025	0.004	0.025	0.004	0.180	0.006		0.210 to 0.274
0.275 and over	0.005	0.010	0.006	0.030	0.006	0.015	0.006	0.003	0.040	0.005	0.030	0.005	0.180	0.006		0.275 and over

^{1/}All dimensions are in inches. When any dimension of a defect exceeds the value specified by 0.001 inch or more, the defect is major; otherwise the defect is minor.

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10X



5X



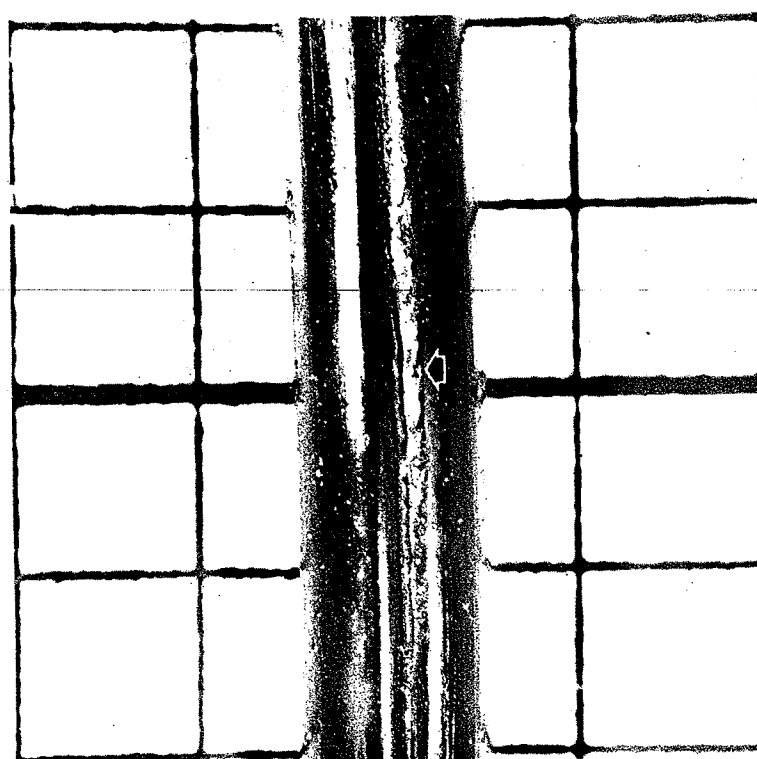
2X



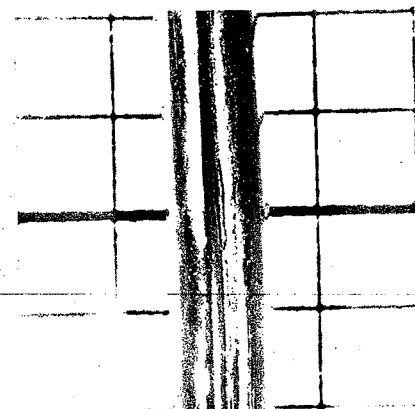
1X

Figure 1 - Backrind, major, W = 0.070 inch.

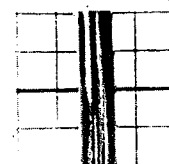
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10X



5X



2X



1X

Figure 2 - Backrind, major, $W = 0.103$ inch.

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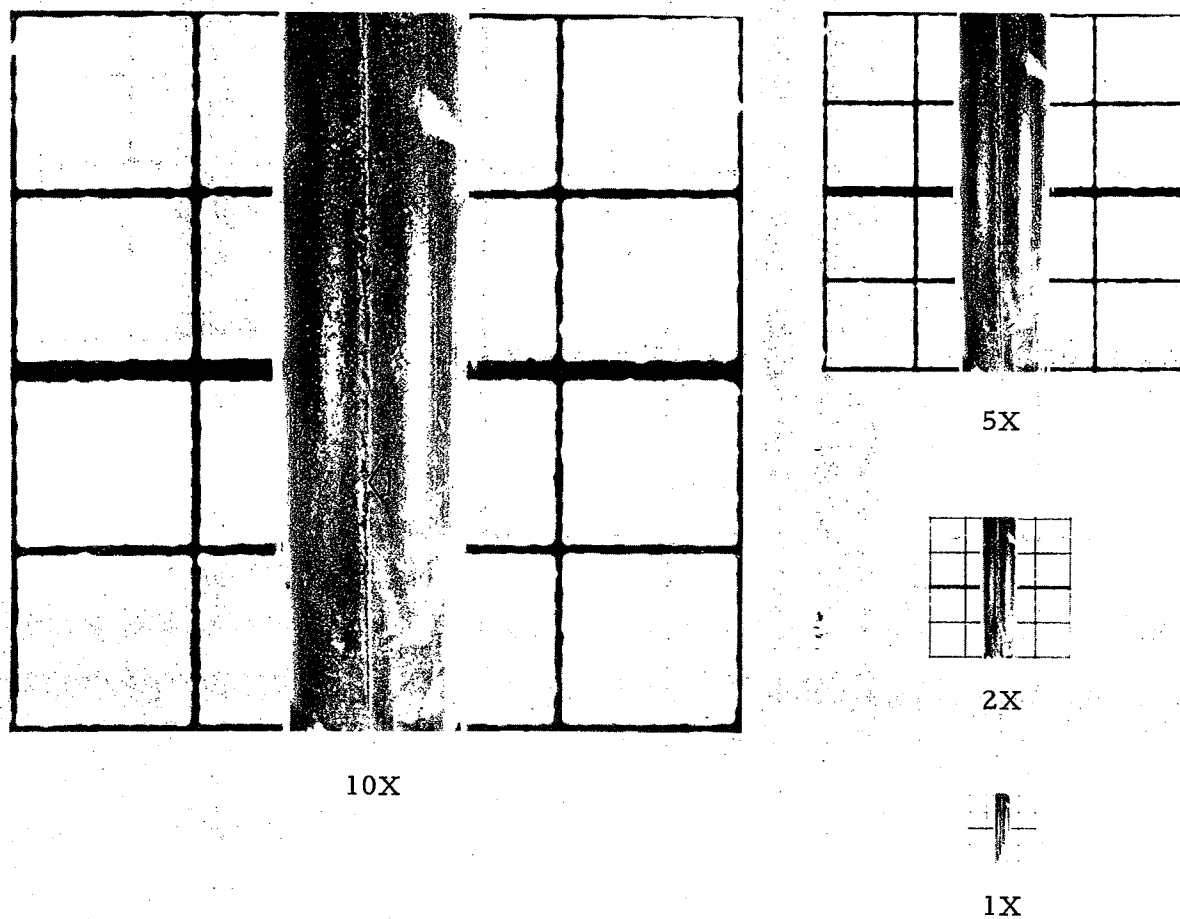


Figure 3 - Backrind, major, $W = 0.103$ inch.

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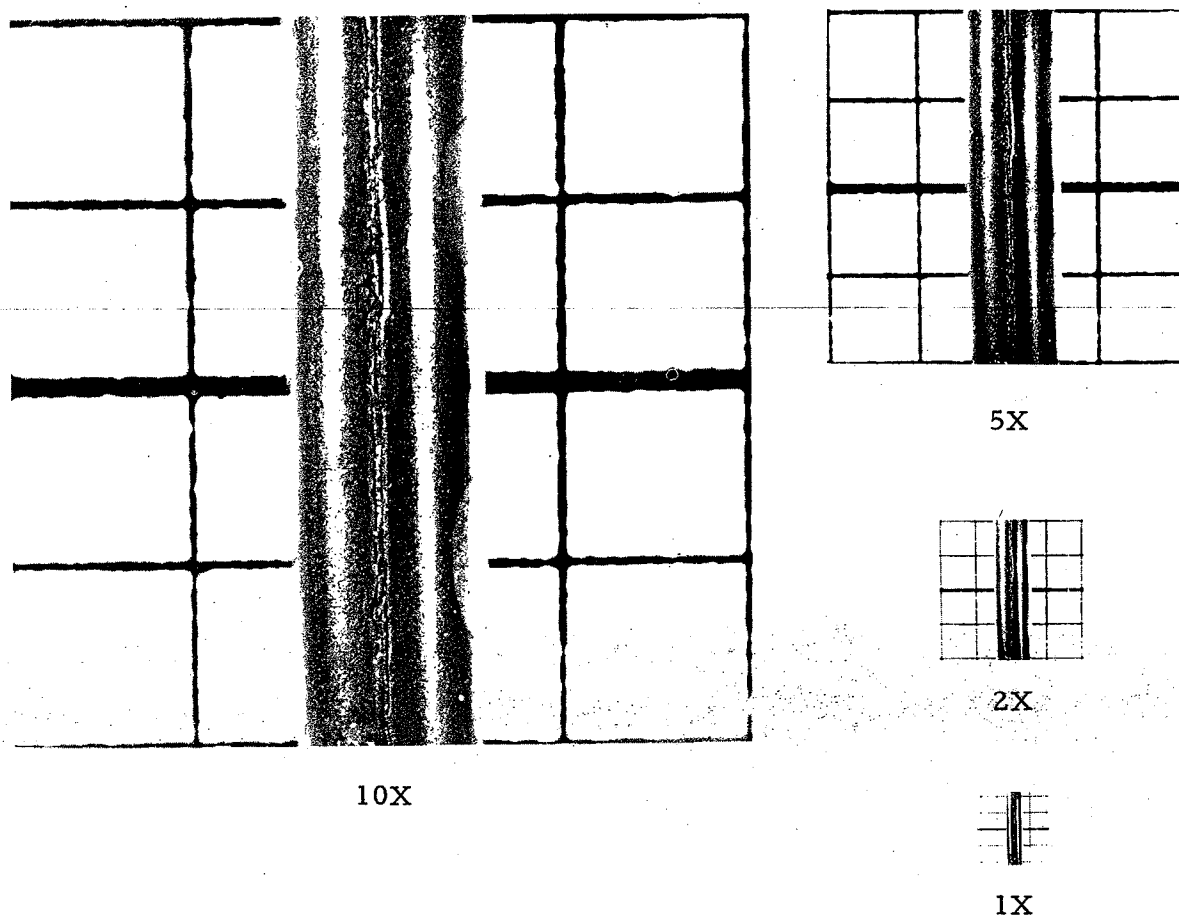


Figure 4 - Backrind, major, $W = 0.103$ inch.

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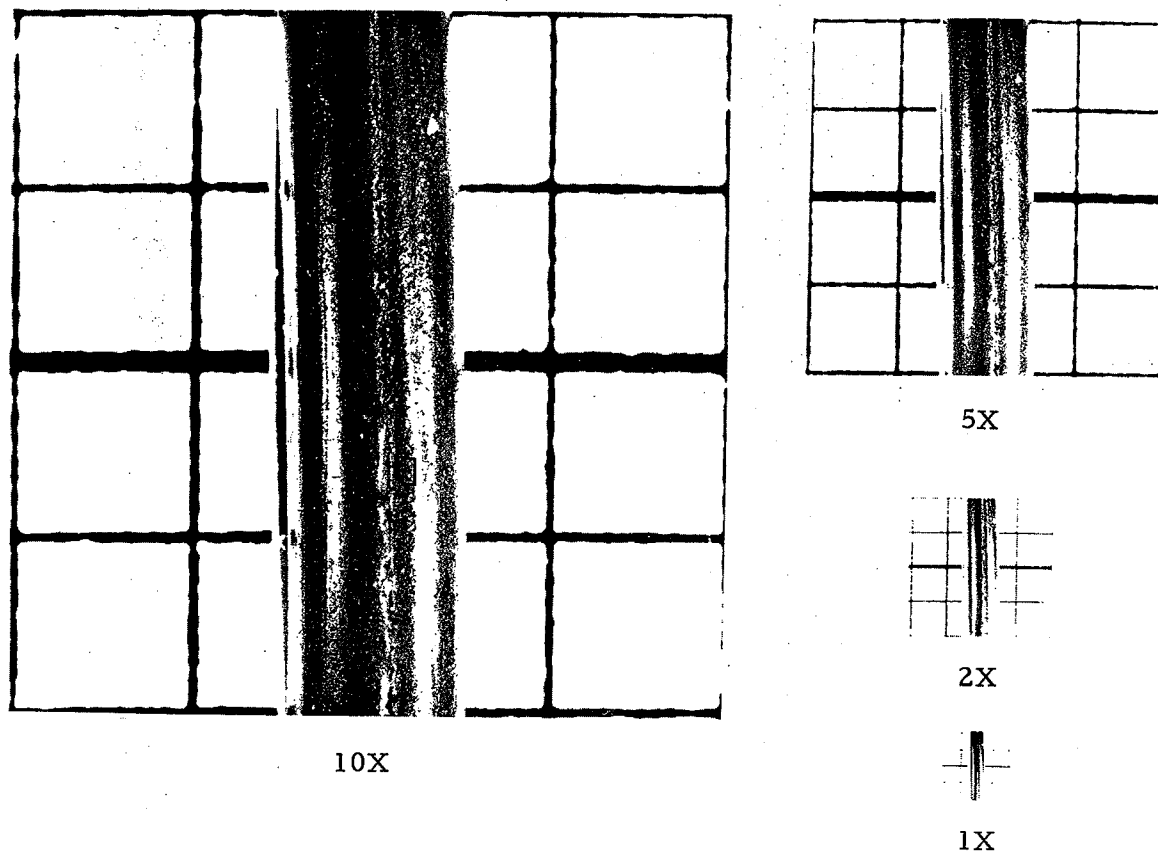


Figure 5 - Backrind, minor, $W = 0.103$ inch.

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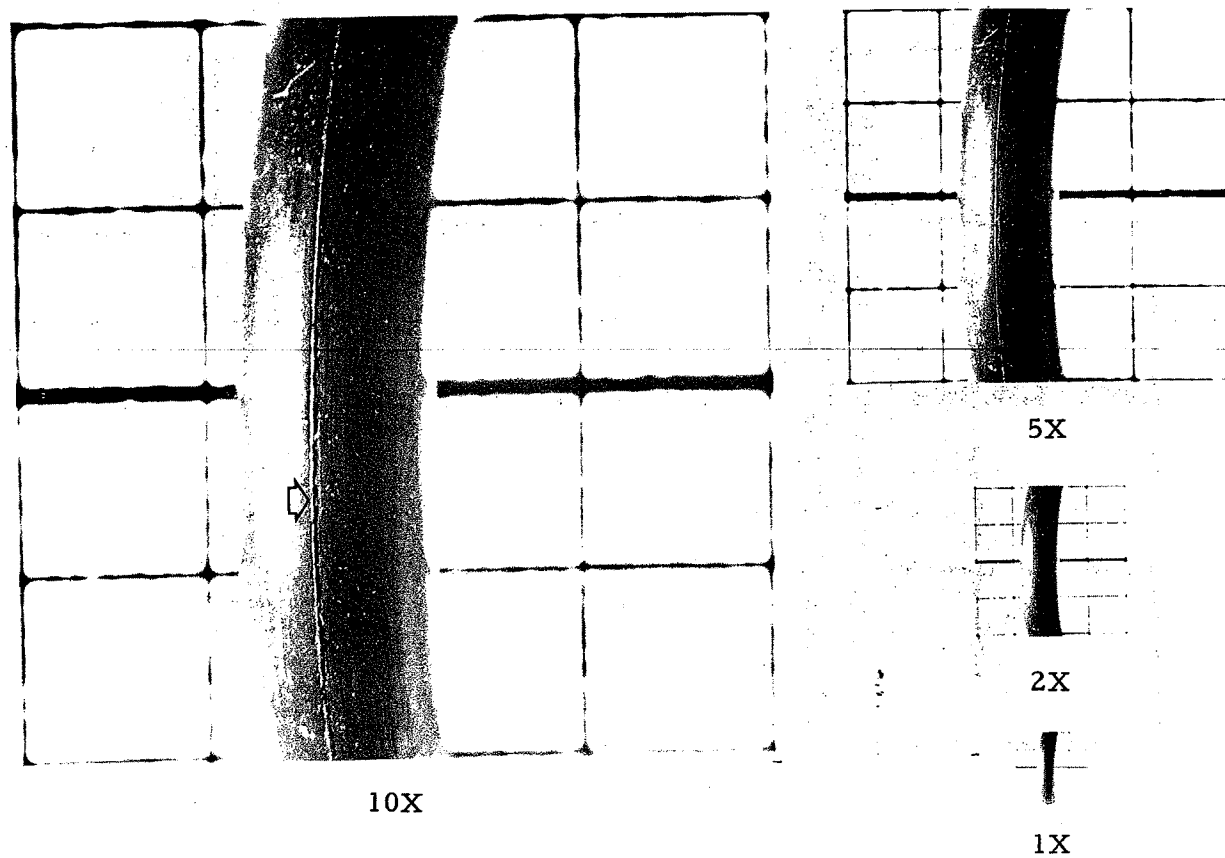
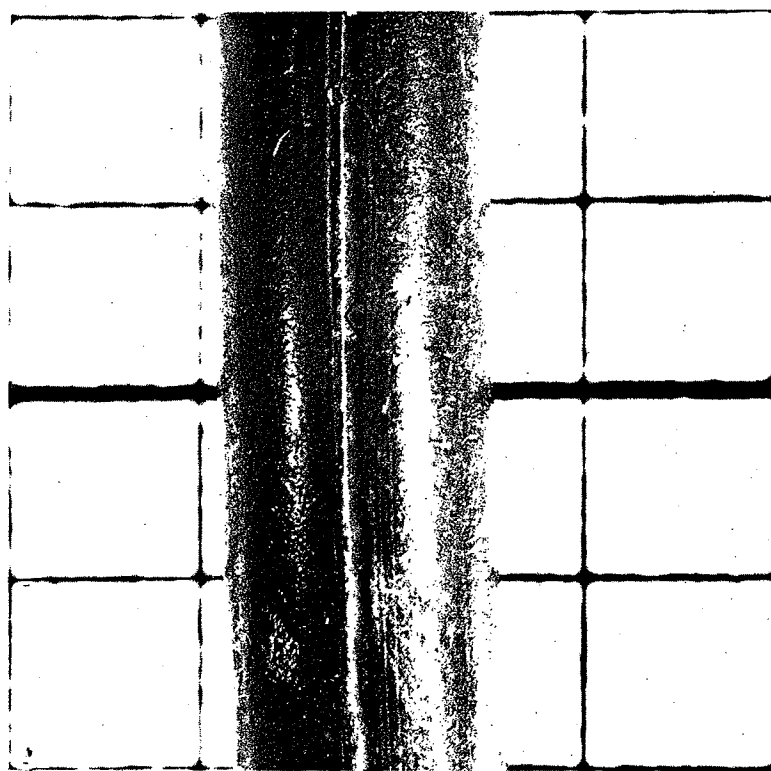
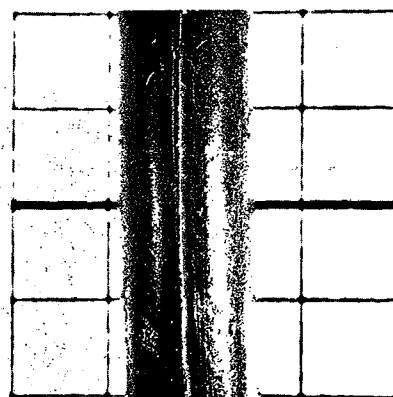


Figure 6 - Backrind, minor, $W = 0.103$ inch.

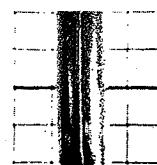
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10X



5X



2X



1X

Figure 7 - Backrind, major, $W = 0.139$ inch.

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3

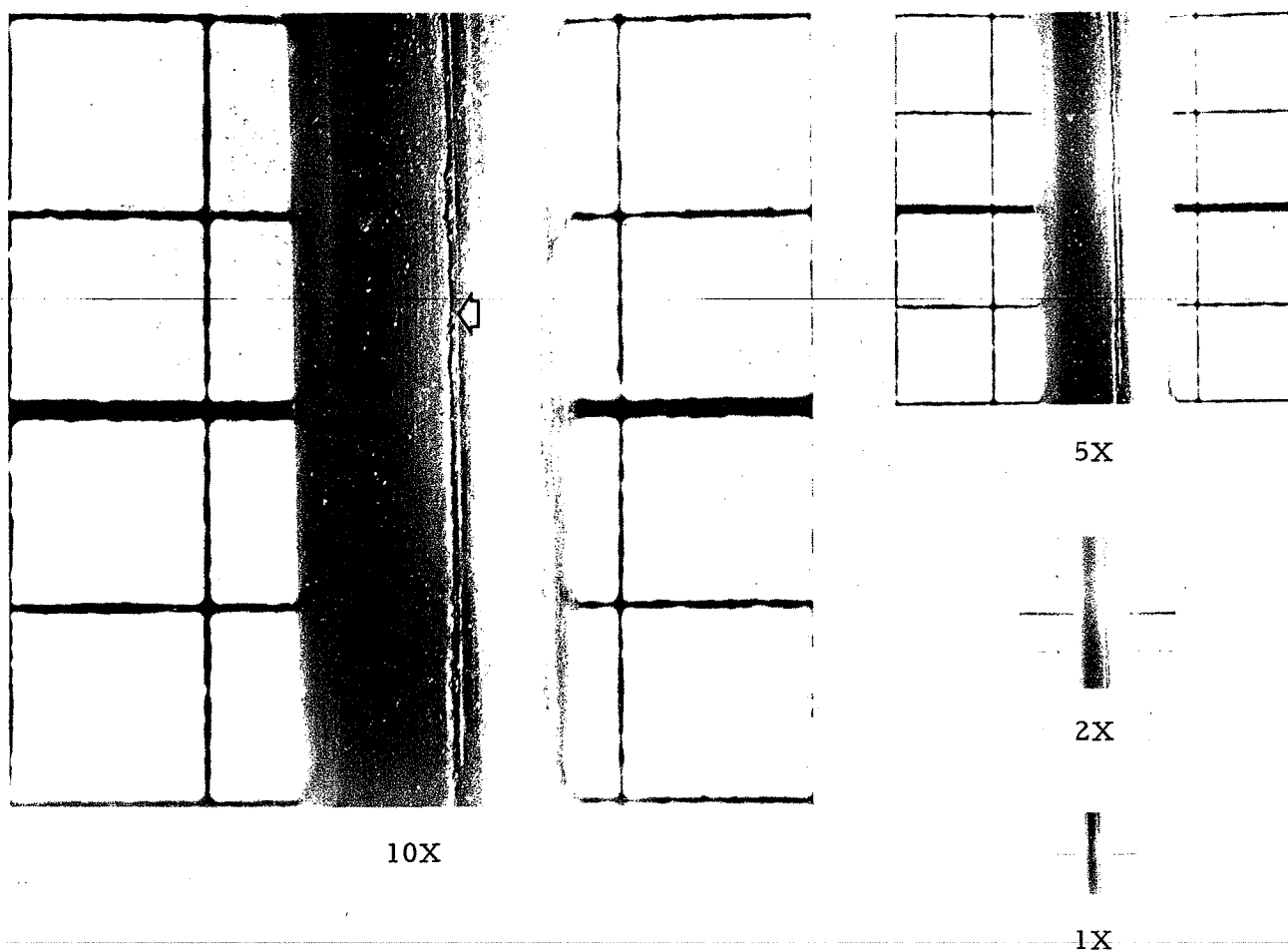


Figure 8 - Backrind, minor, $W = 0.139$ inch.

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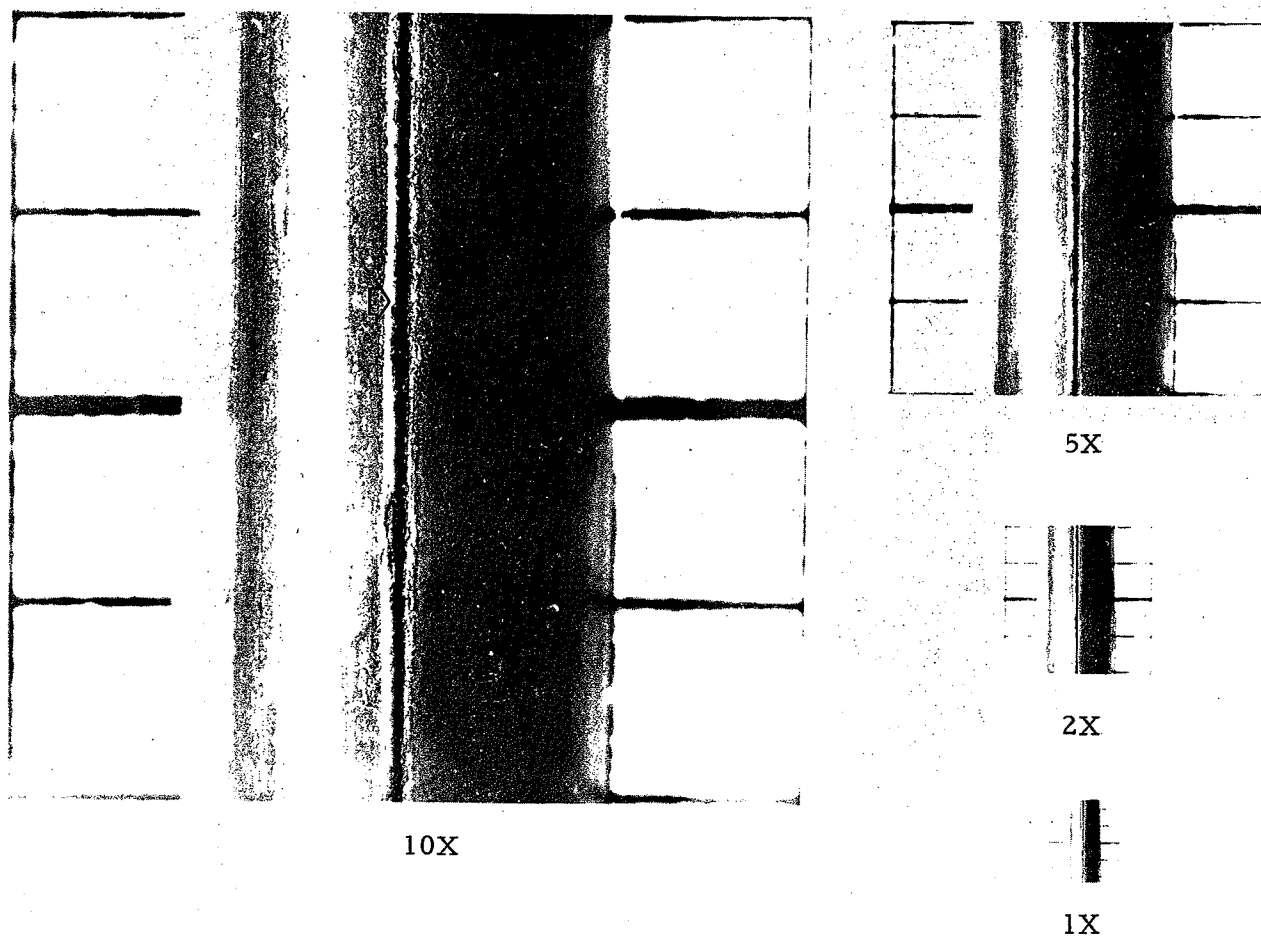
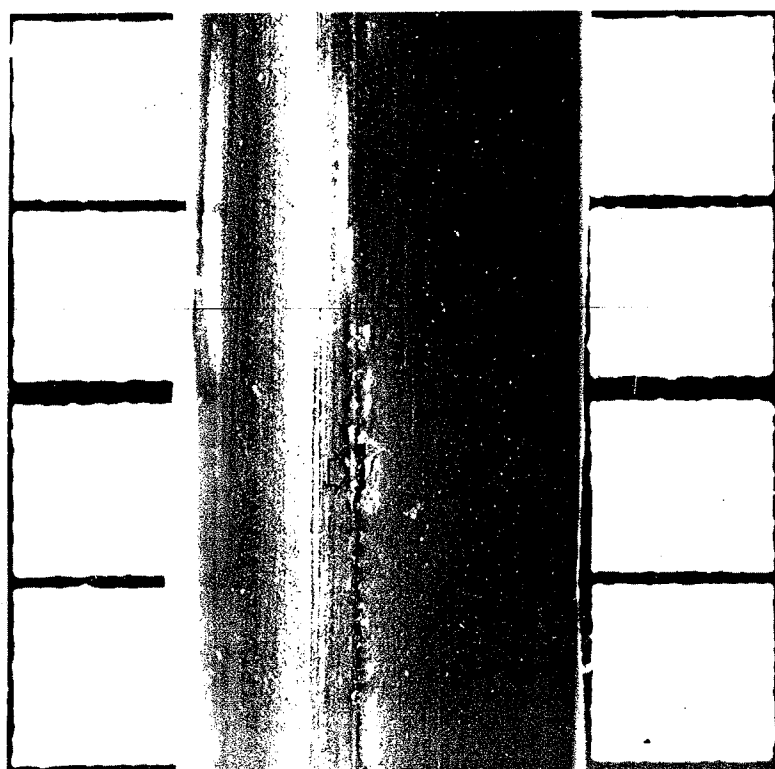


Figure 9 - Backrind, minor, $W = 0.210$ inch.

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10X



5X



2X



1X

Figure 10 - Backrind, major, $W = 0.210$ inch.

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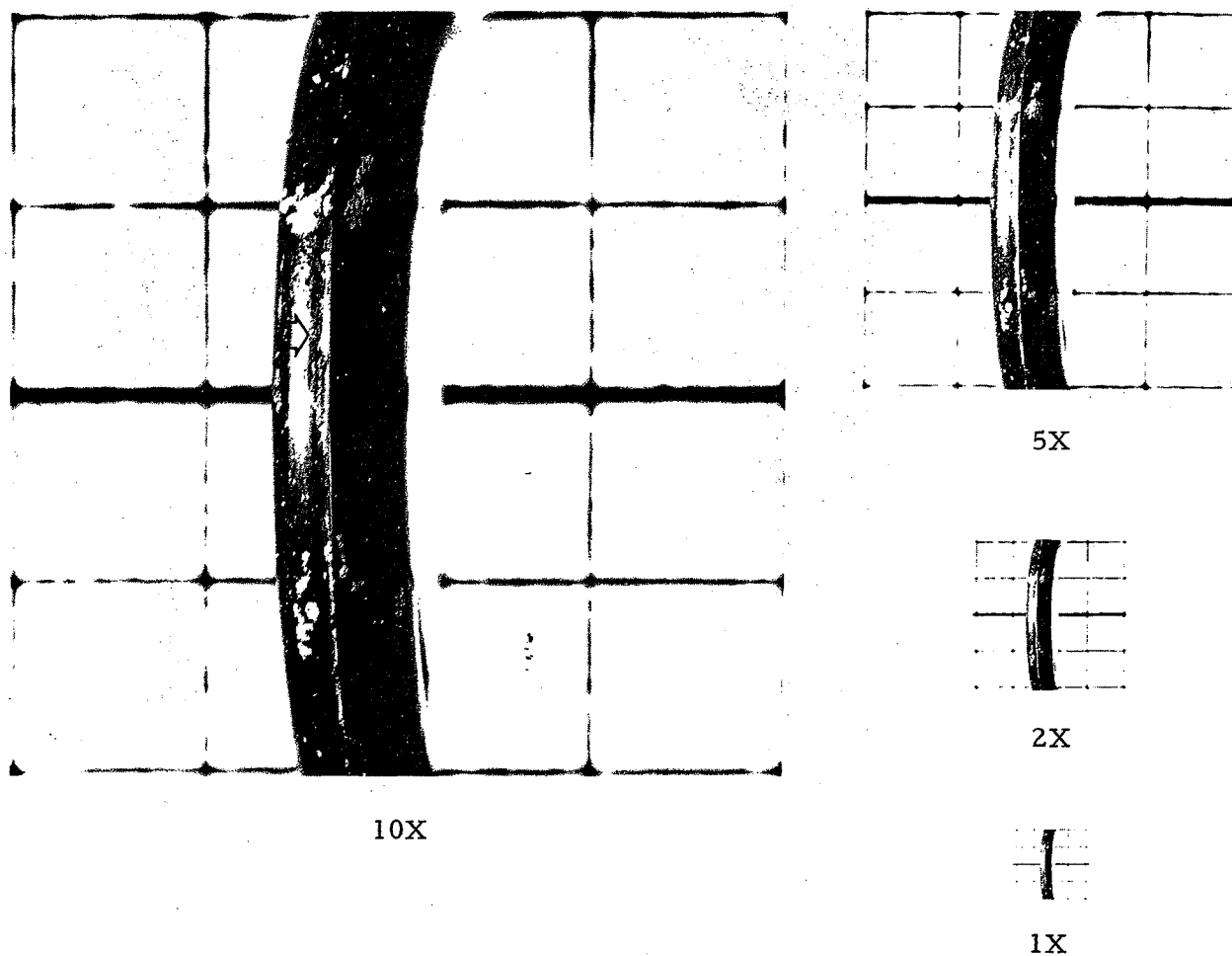
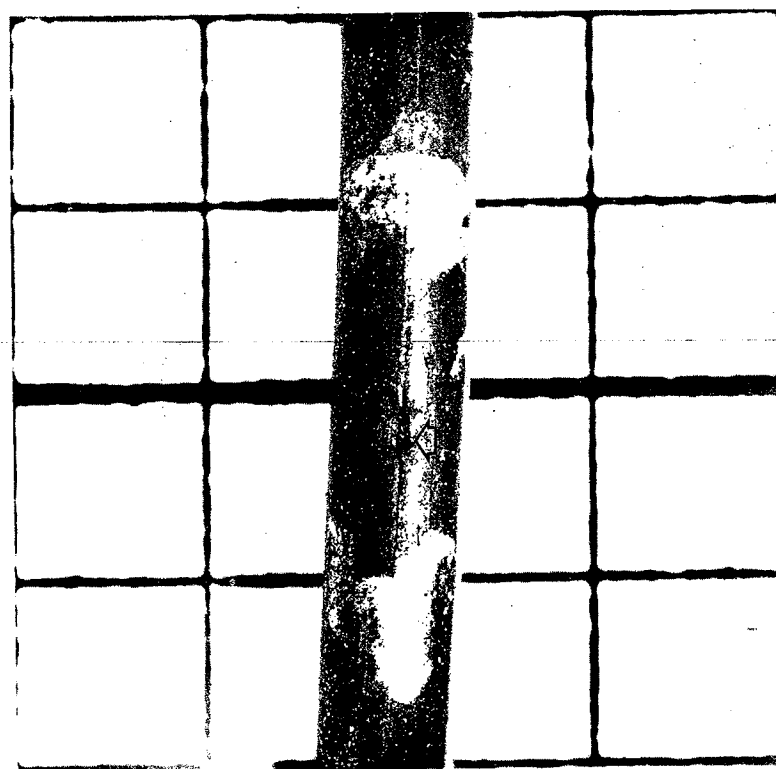
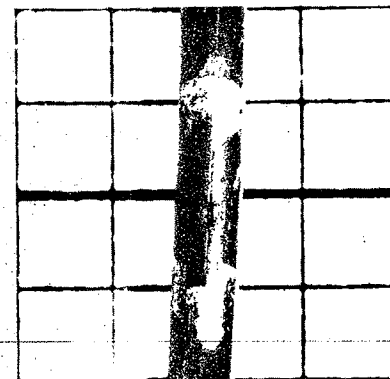


Figure 11 - Parting line indentation, minor, $W = 0.070$ inch.

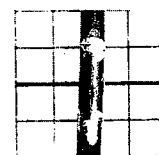
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10X



5X



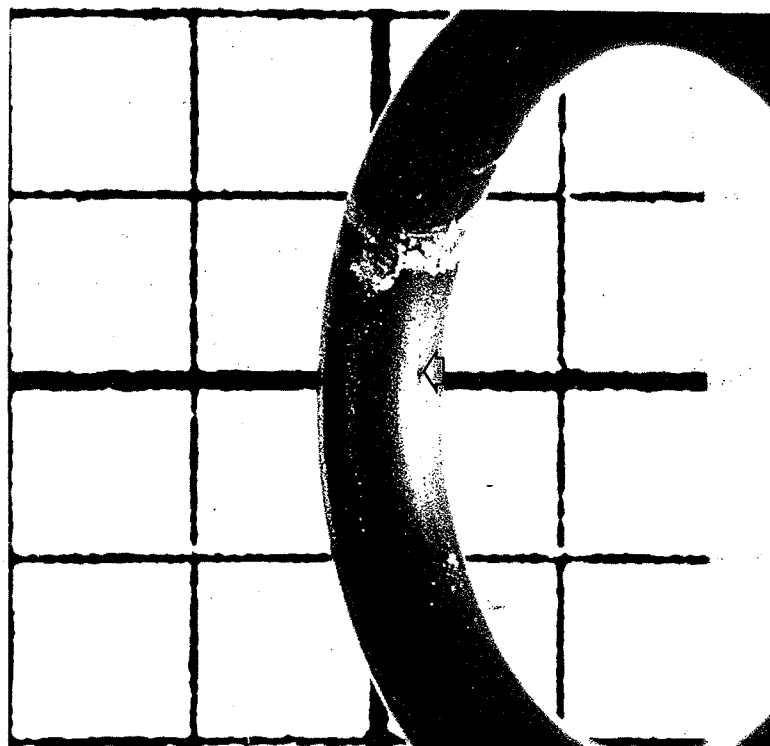
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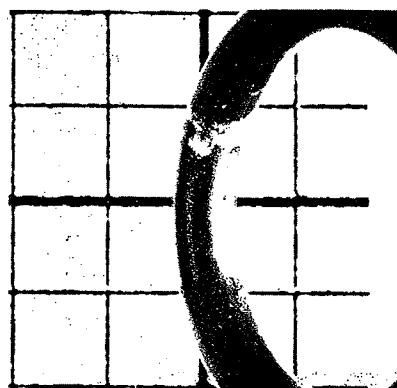
1X

Figure 12 - Parting line indentation, minor, $W = 0.70$ inch.

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10X



5X



2X



1X

Figure 13 - Parting line indentation, minor, $W = 0.070$ inch.

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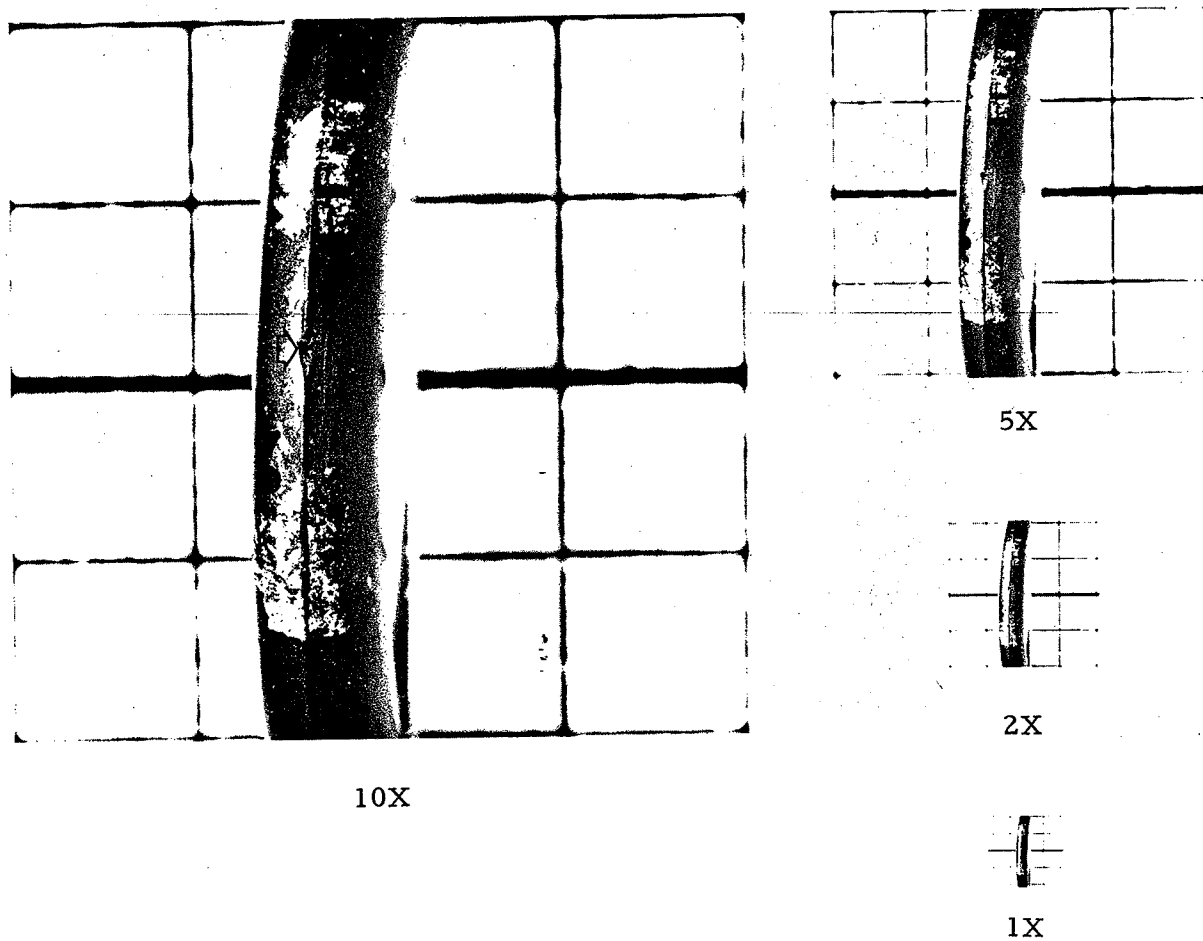


Figure 14 - Parting line indentation, major, $W = 0.070$ inch.

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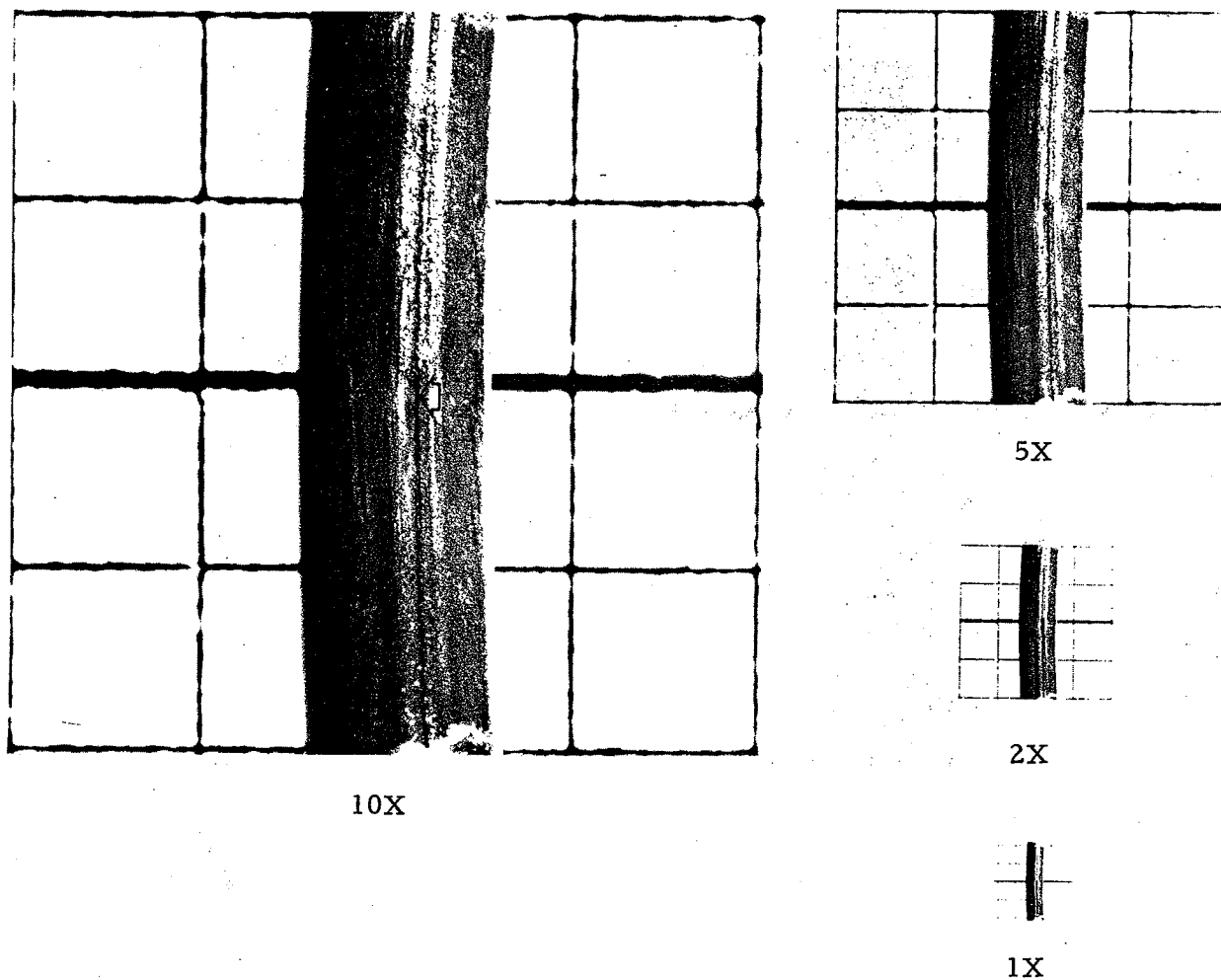


Figure 15 - Parting line indentation, minor, $W = 0.103$ inch.

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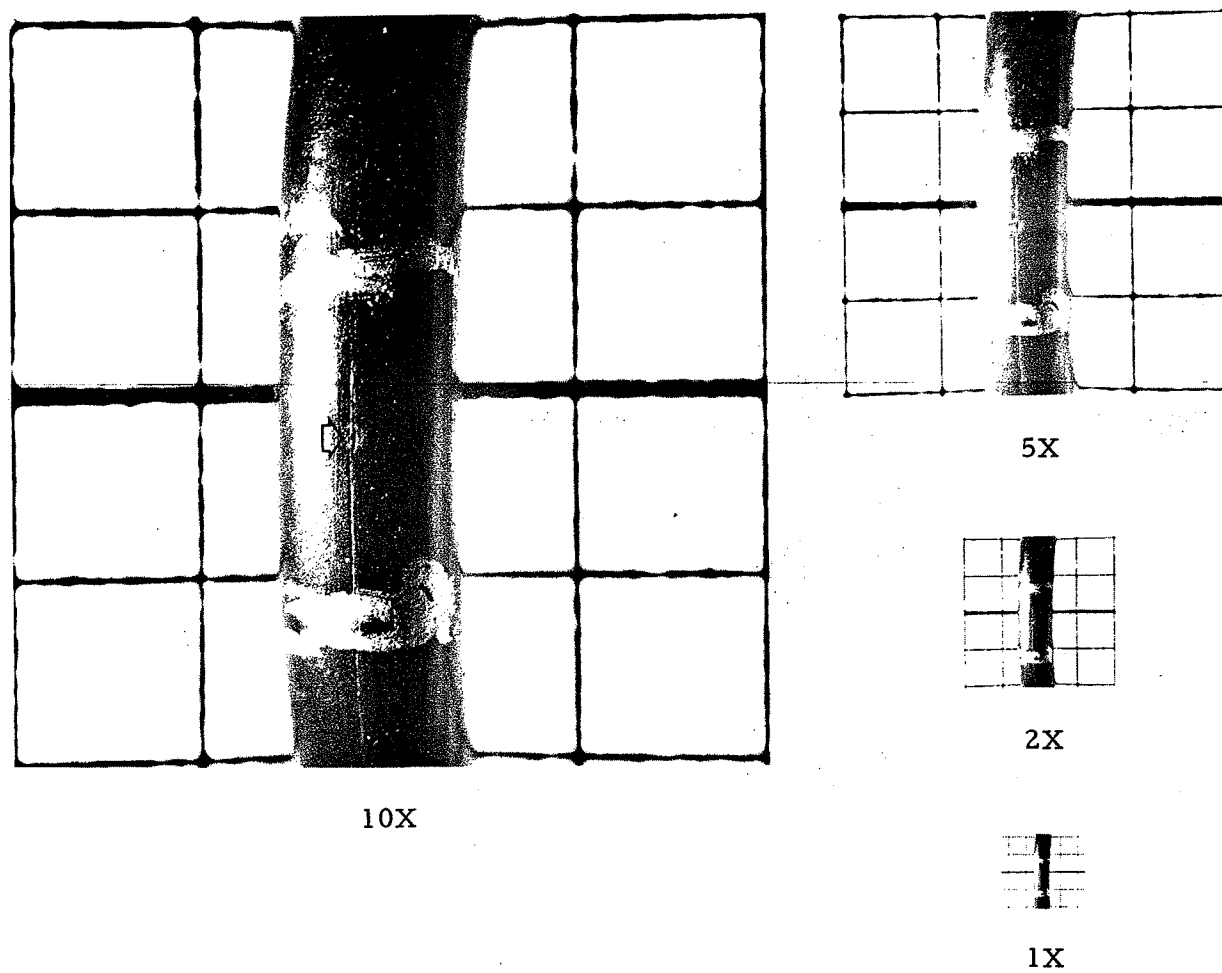
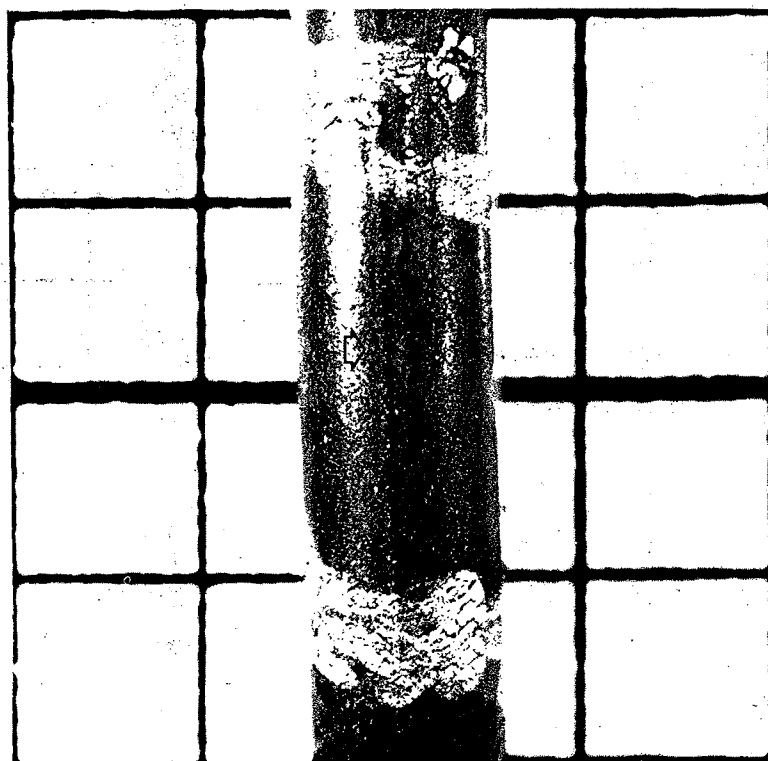
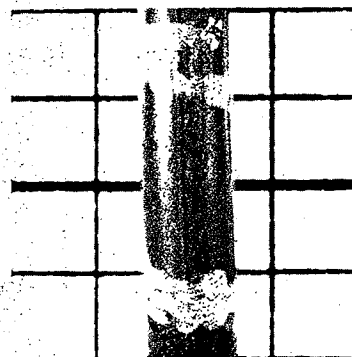


Figure 16 - Parting line indentation, minor, $W = 0.103$ inch.

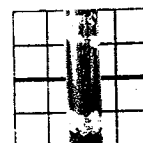
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10X



5X



2X



1X

Figure 17 - Parting line indentation, minor, $W = 0.103$ inch.

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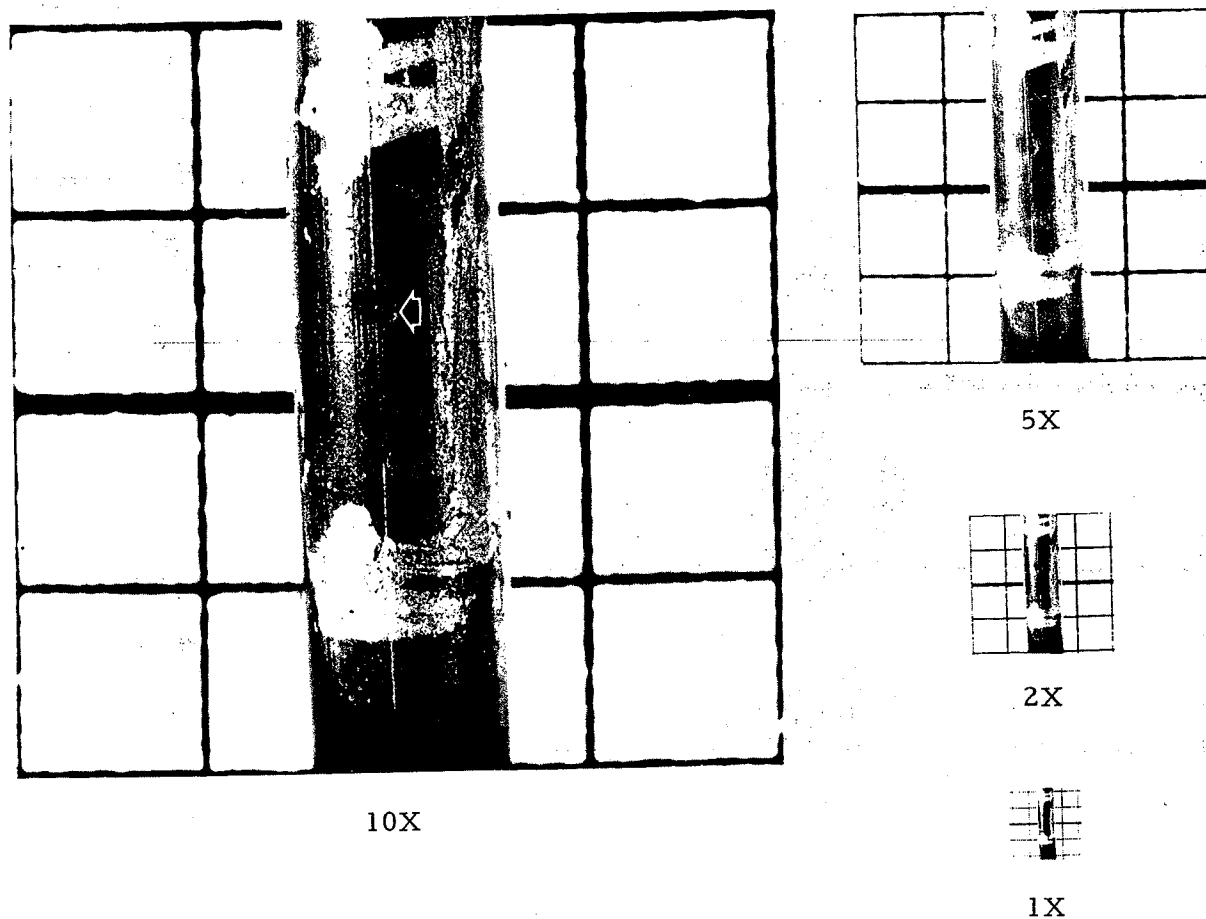
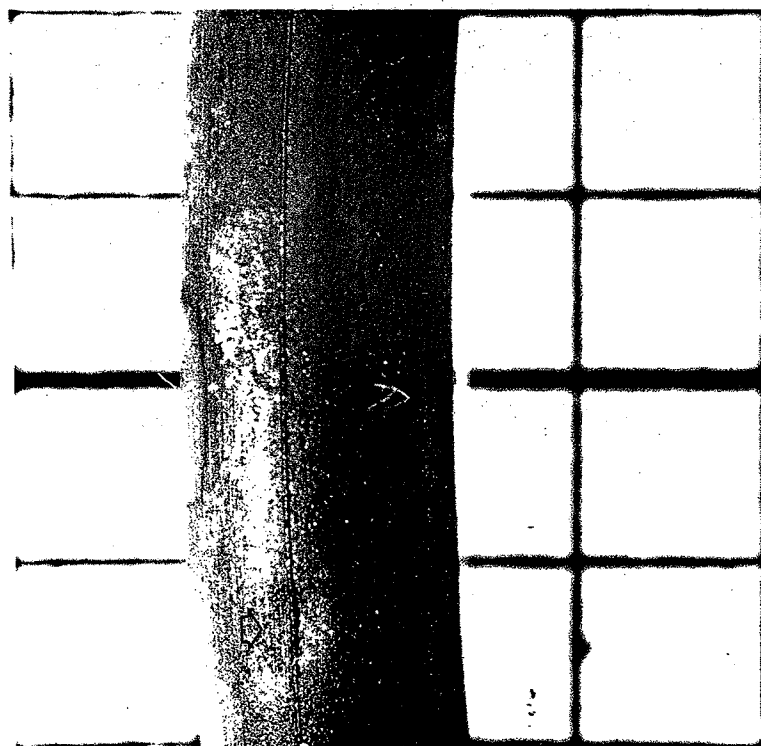
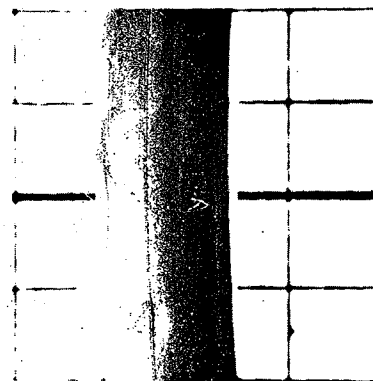


Figure 18 - Parting line indentation, major, $W = 0.103$ inch.

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10X



5X



2X



1X

Figure 19 - Parting line indentation, major, $W = 0.139$ inch.

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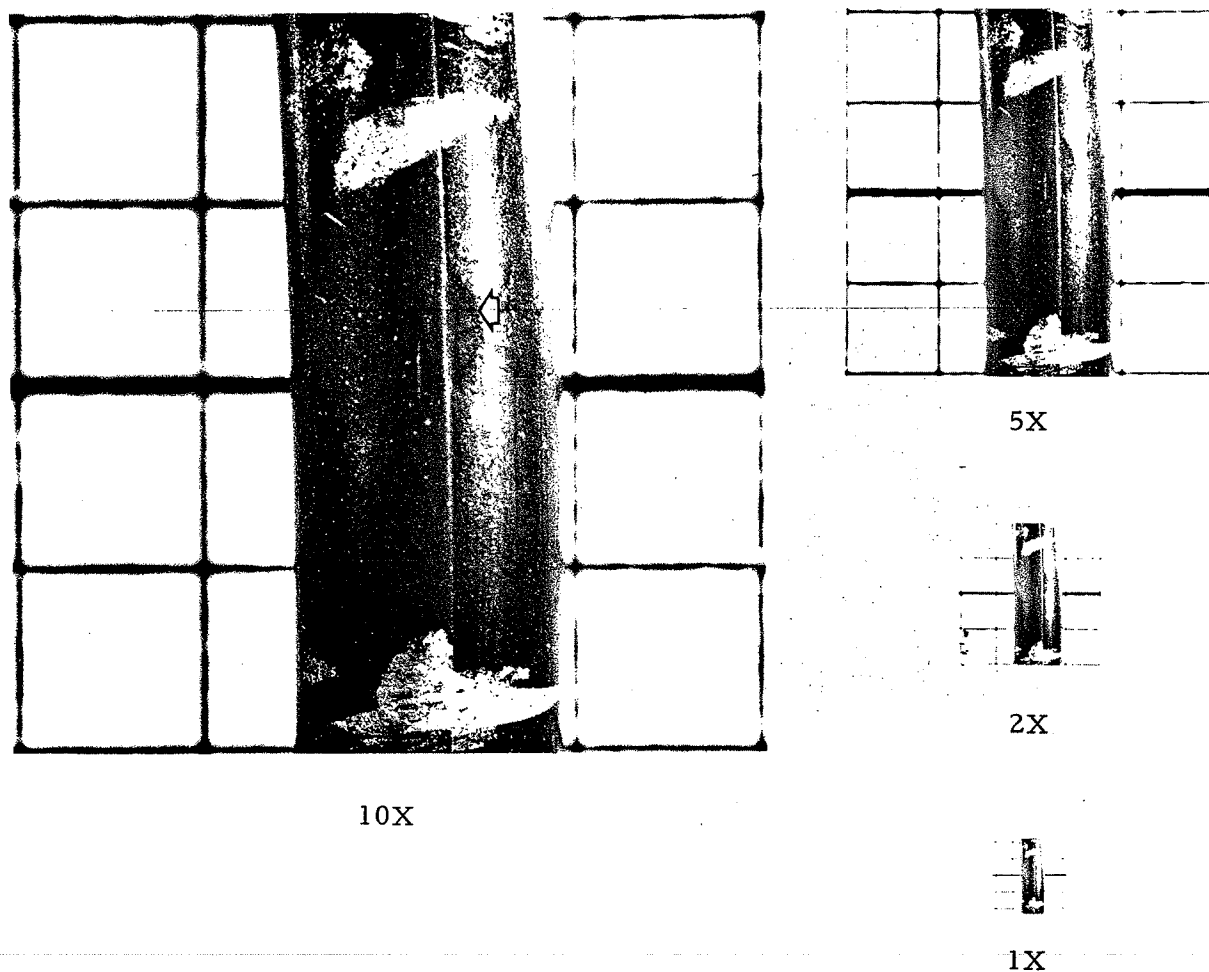
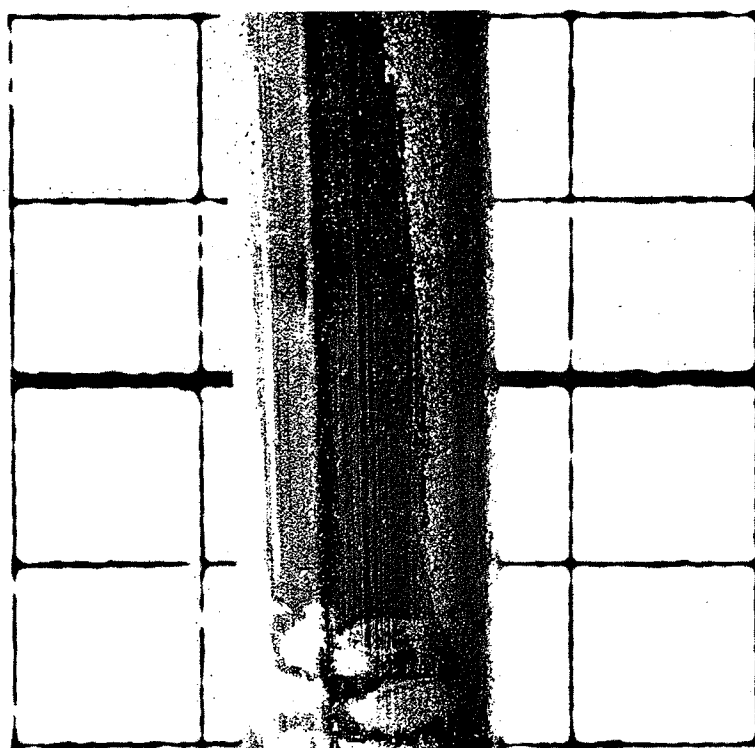
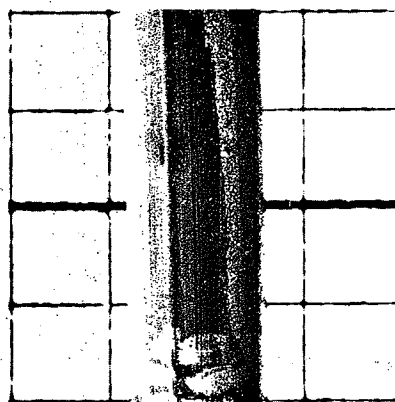


Figure 20 - Parting line indentation, major, $W = 0.139$ inch.

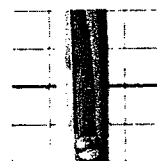
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10X



5X



2X



1X

Figure 21 - Parting line indentation, minor, $W = 0.139$ inch.

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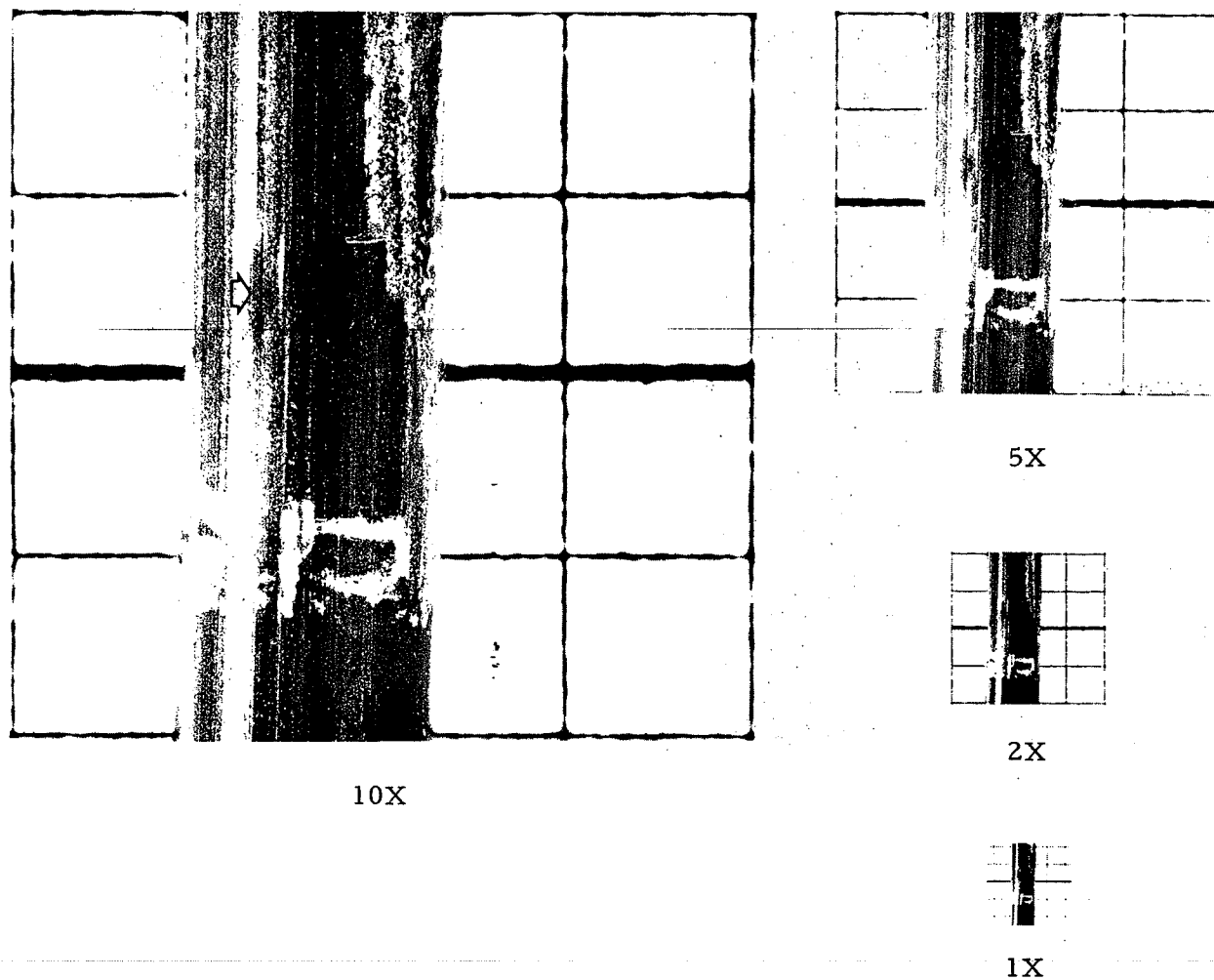
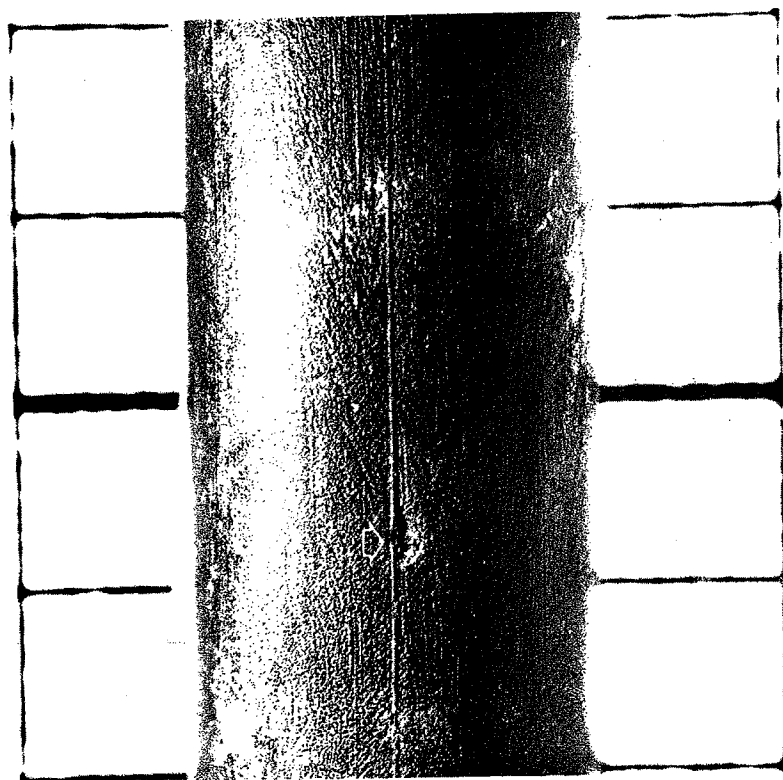
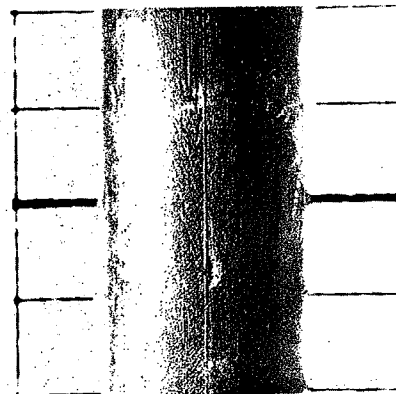


Figure 22 - Parting line indentation, major, $W = 0.139$ inch.

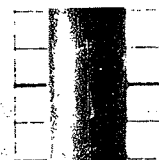
MIL-STD-413B
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10X



5X



2X

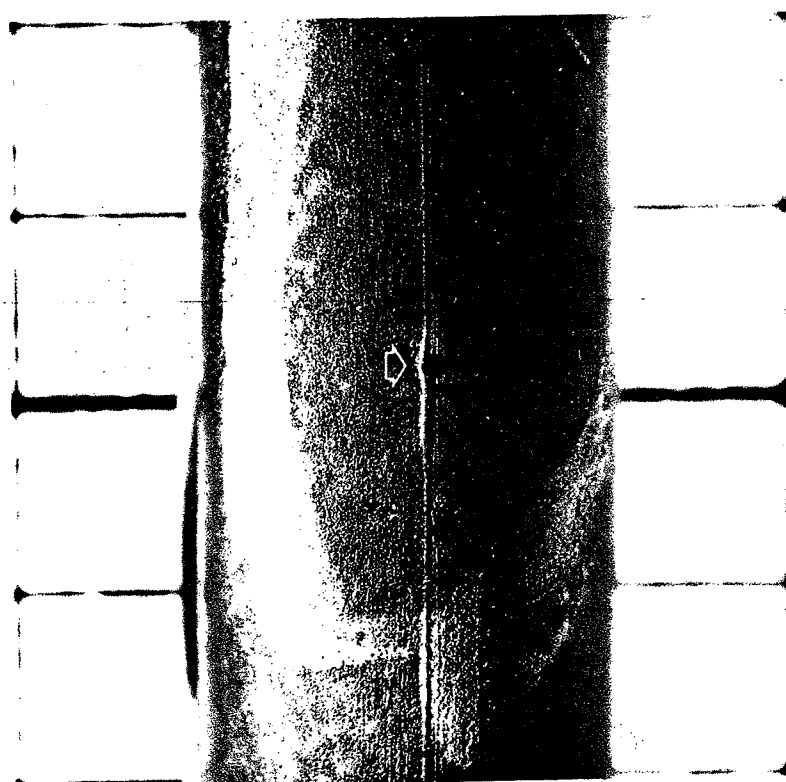


1X

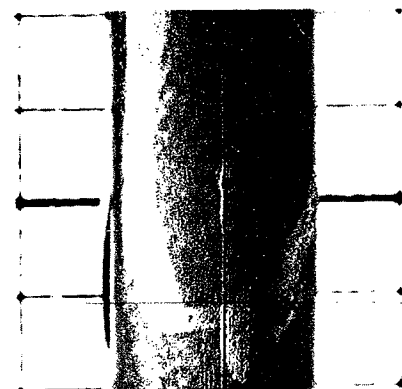
Figure 23 - Parting line indentation, minor, $W = 0.210$ inch.

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4



10X



5X



2X



1X

Figure 24 - Parting line indentation, major, $W = 0.210$ inch.

MIL-STD-413B
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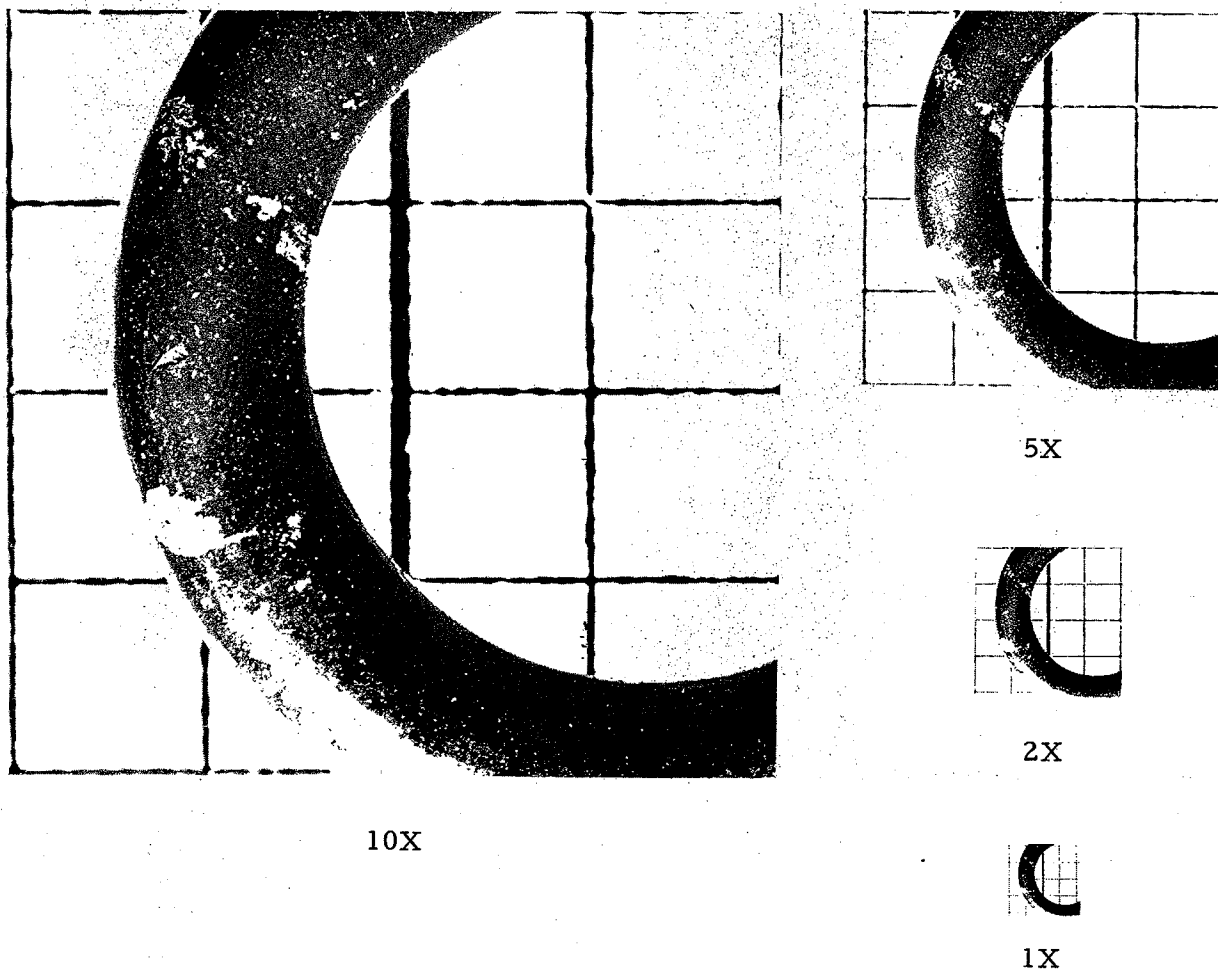
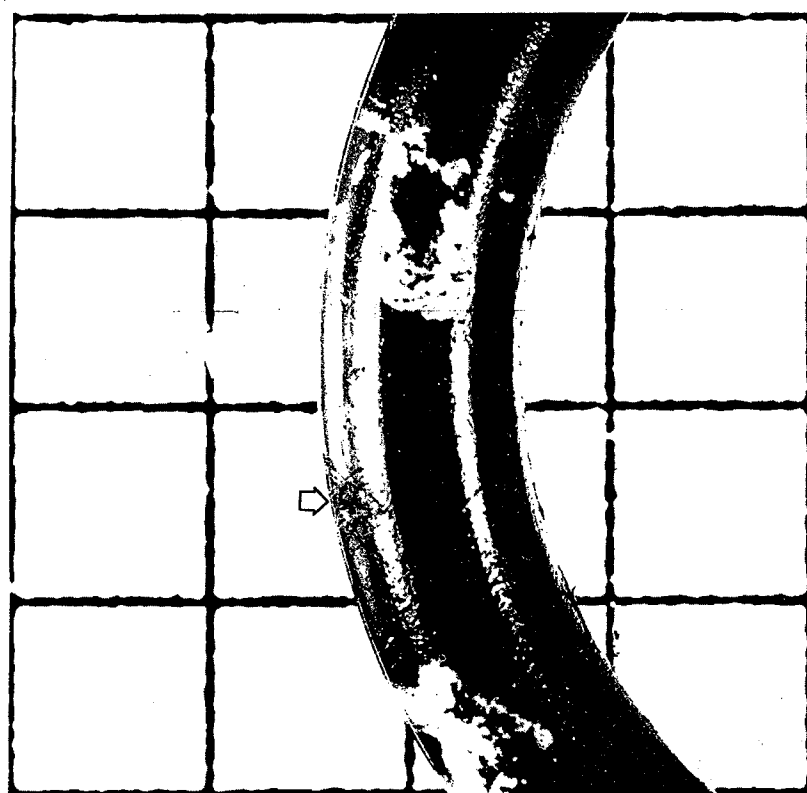
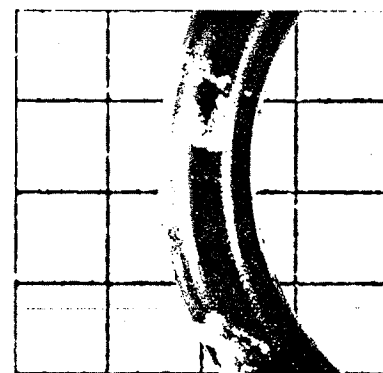


Figure 25 - Foreign material, minor, $W = 0.103$ inch.

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10X



5X



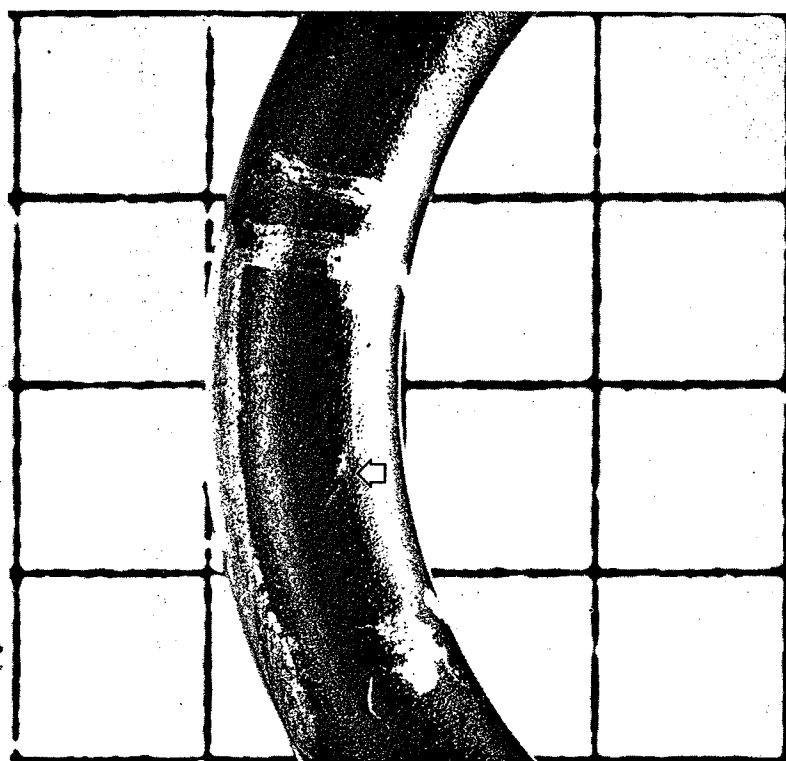
2X



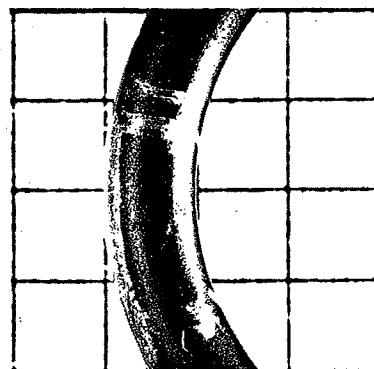
1X

Figure 26 - Foreign material, major, $W = 0.103$ inch.

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10X



5X



2X



1X

Figure 27 - Foreign material, minor, $W = 0.103$ inch.

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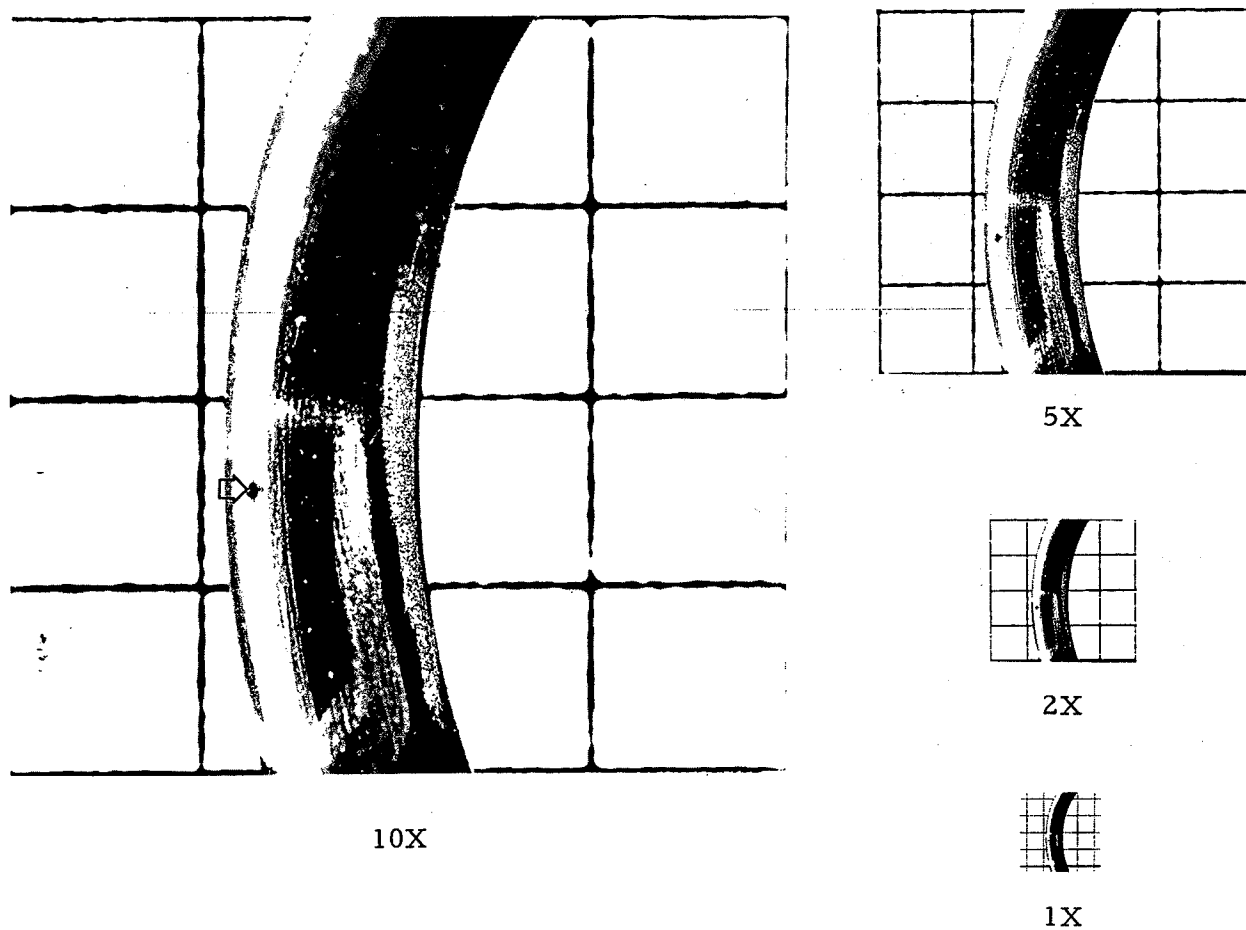


Figure 28 - Foreign material, major, $W = 0.103$ inch.

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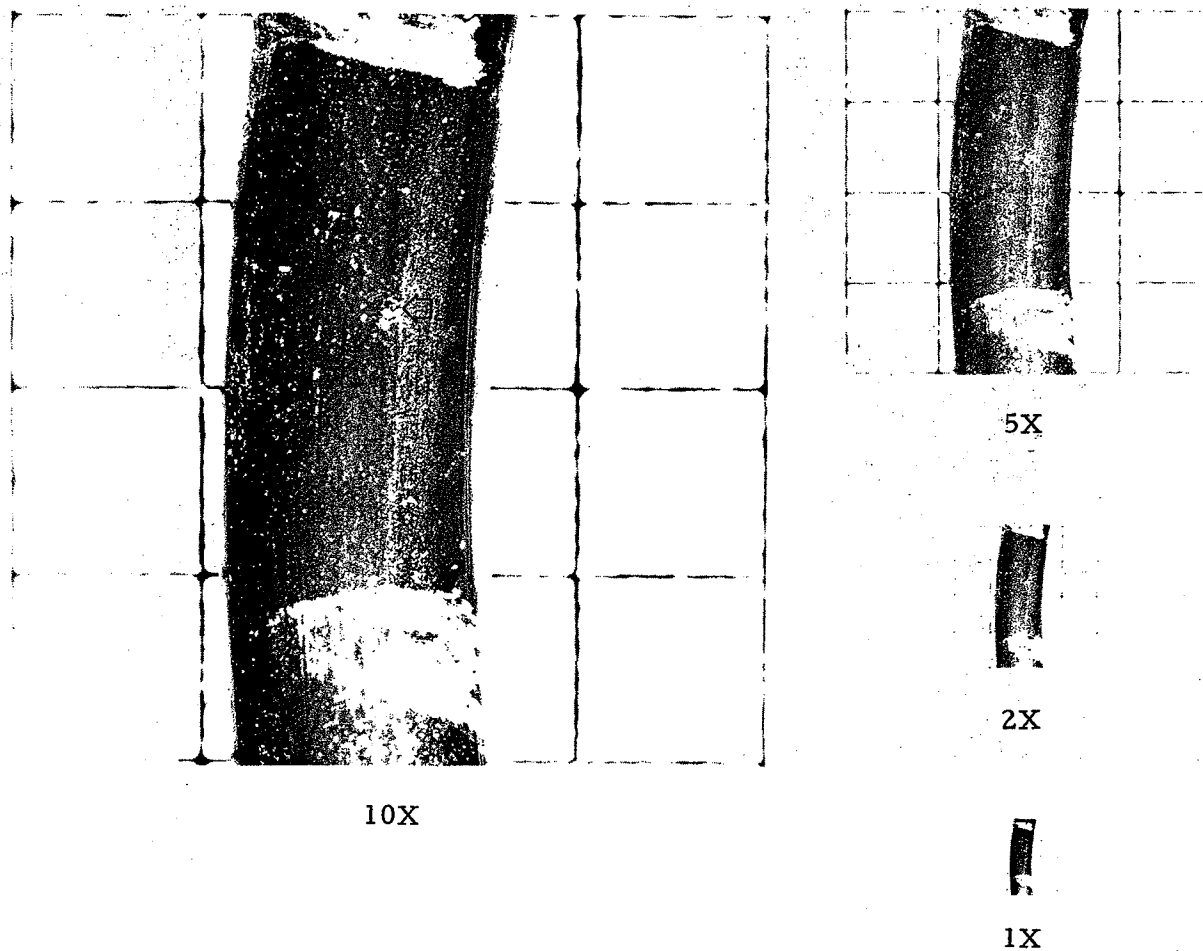


Figure 29 - Foreign material, minor, W = 0.139 inch.

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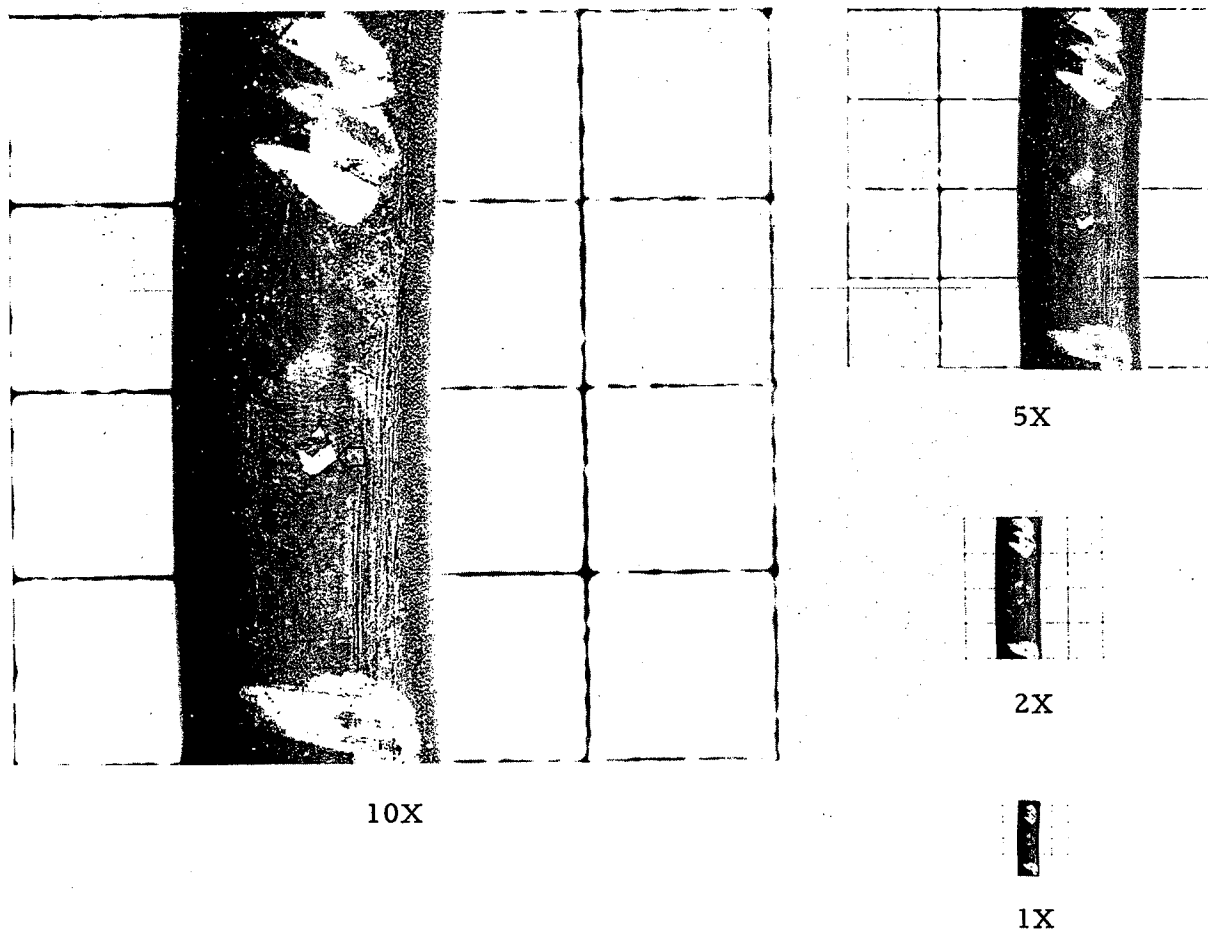
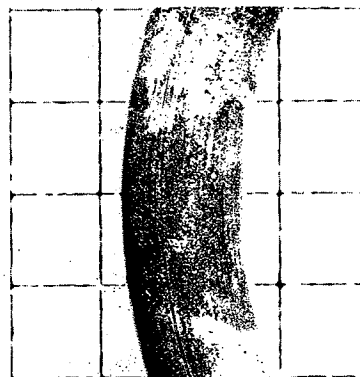


Figure 30 - Foreign material, major, $W = 0.139$ inch.

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10X



5X



2X



1X

Figure 31 - Foreign material, minor, W = 0.139 inch.

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Figure 32 - Foreign material, major, W = 0.210 inch.

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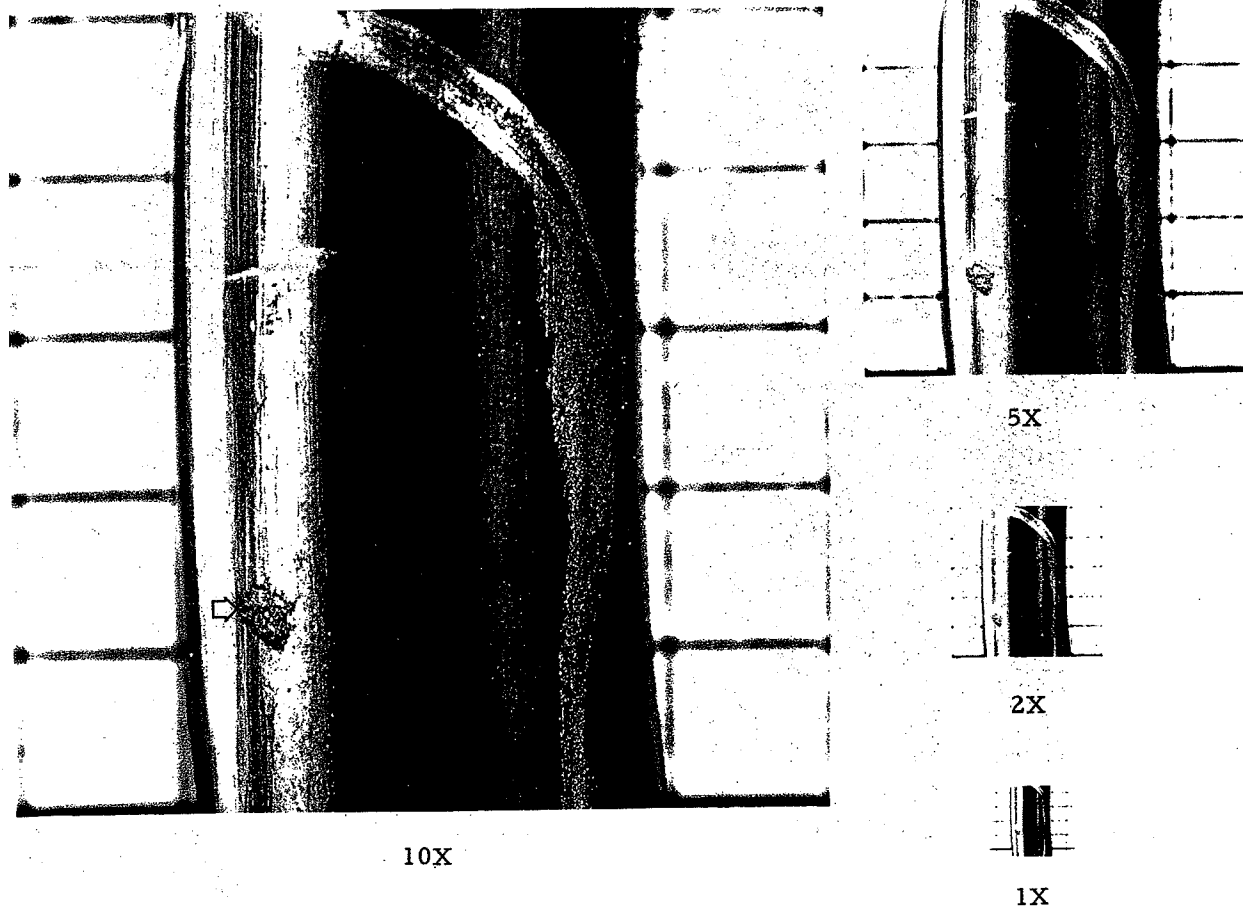


Figure 33 - Foreign material, major, $W = 0.275$ inch.

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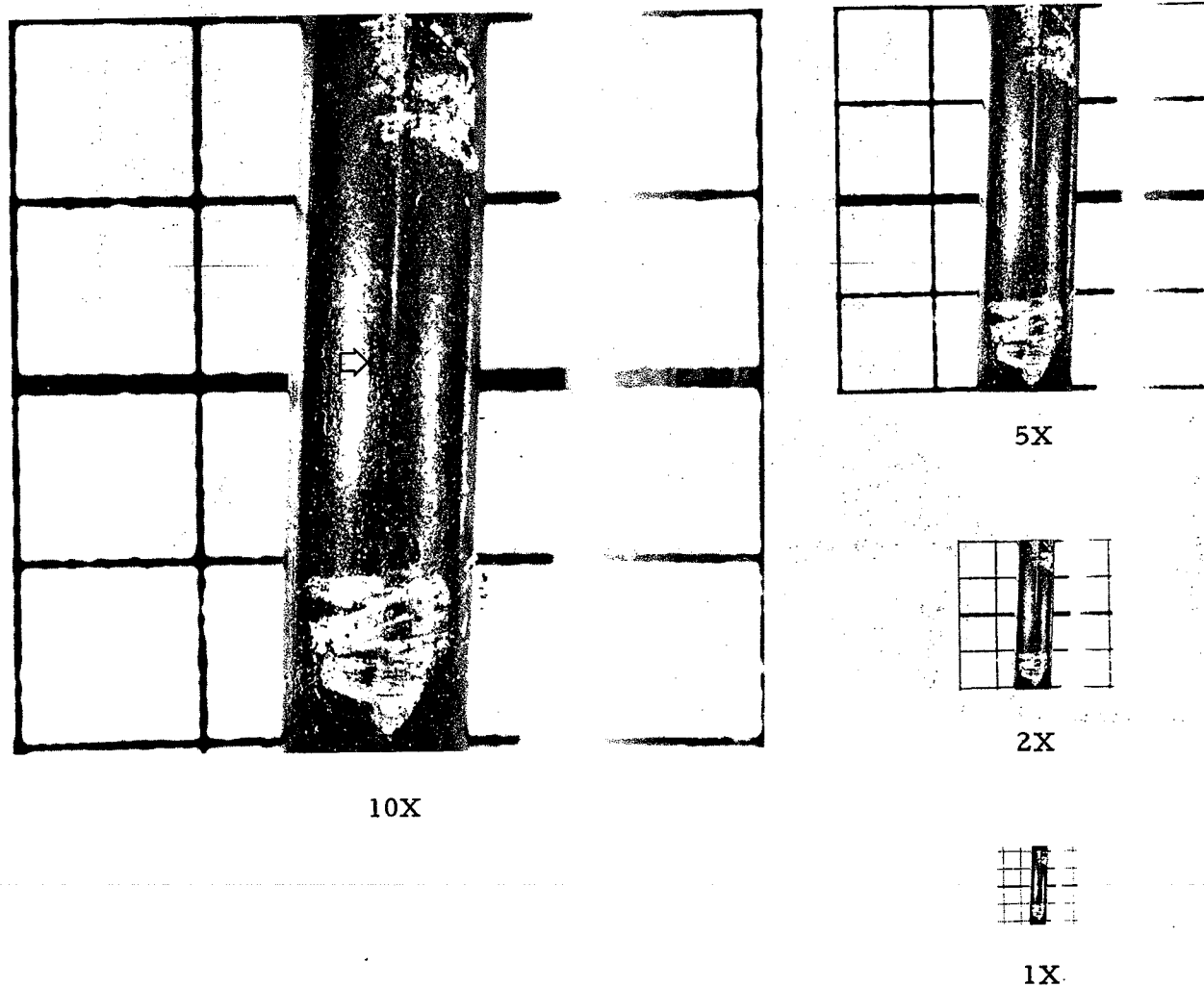


Figure 34 - Excessive trimming, minor, $W = 0.103$ inch.

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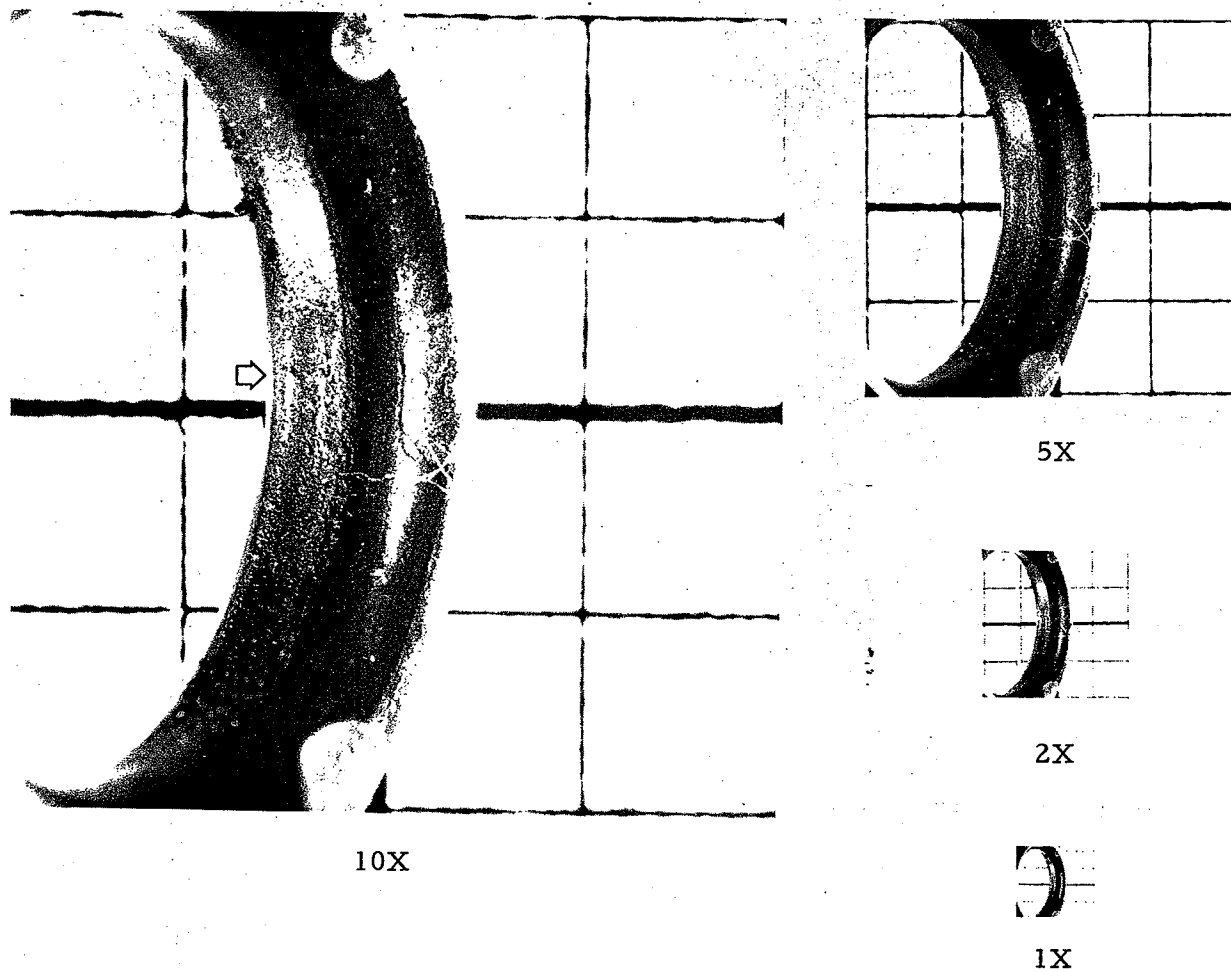


Figure 35 - Excessive trimming, major, $W = 0.103$ inch.

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10X



5X



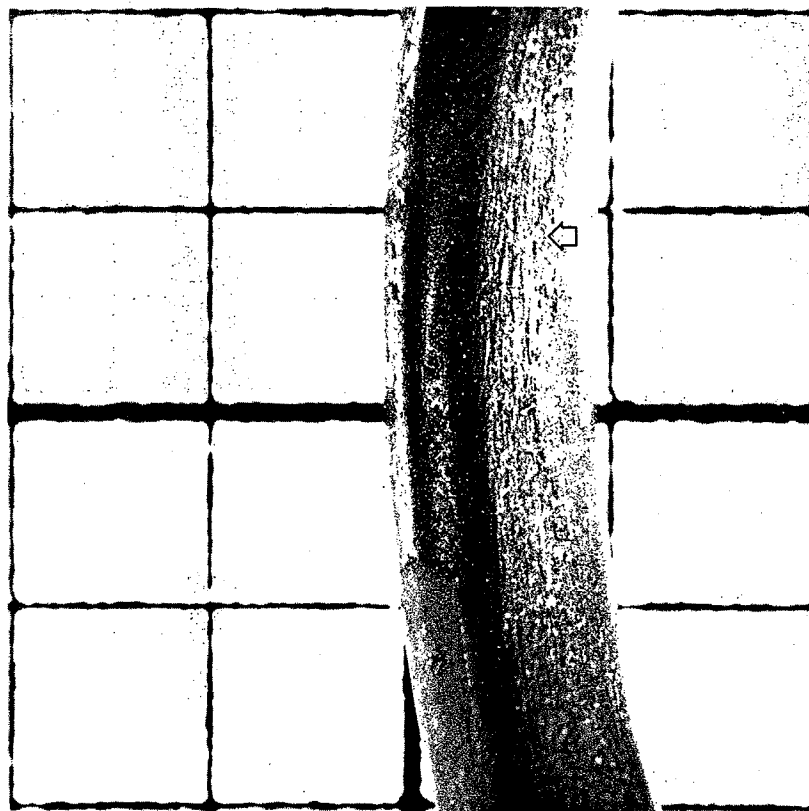
2X



1X

Figure 36 - Excessive trimming, minor, $W = 0.103$ inch.

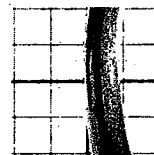
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10X



5X



2X



1X

Figure 37 - Excessive trimming, major, $W = 0.103$ inch.

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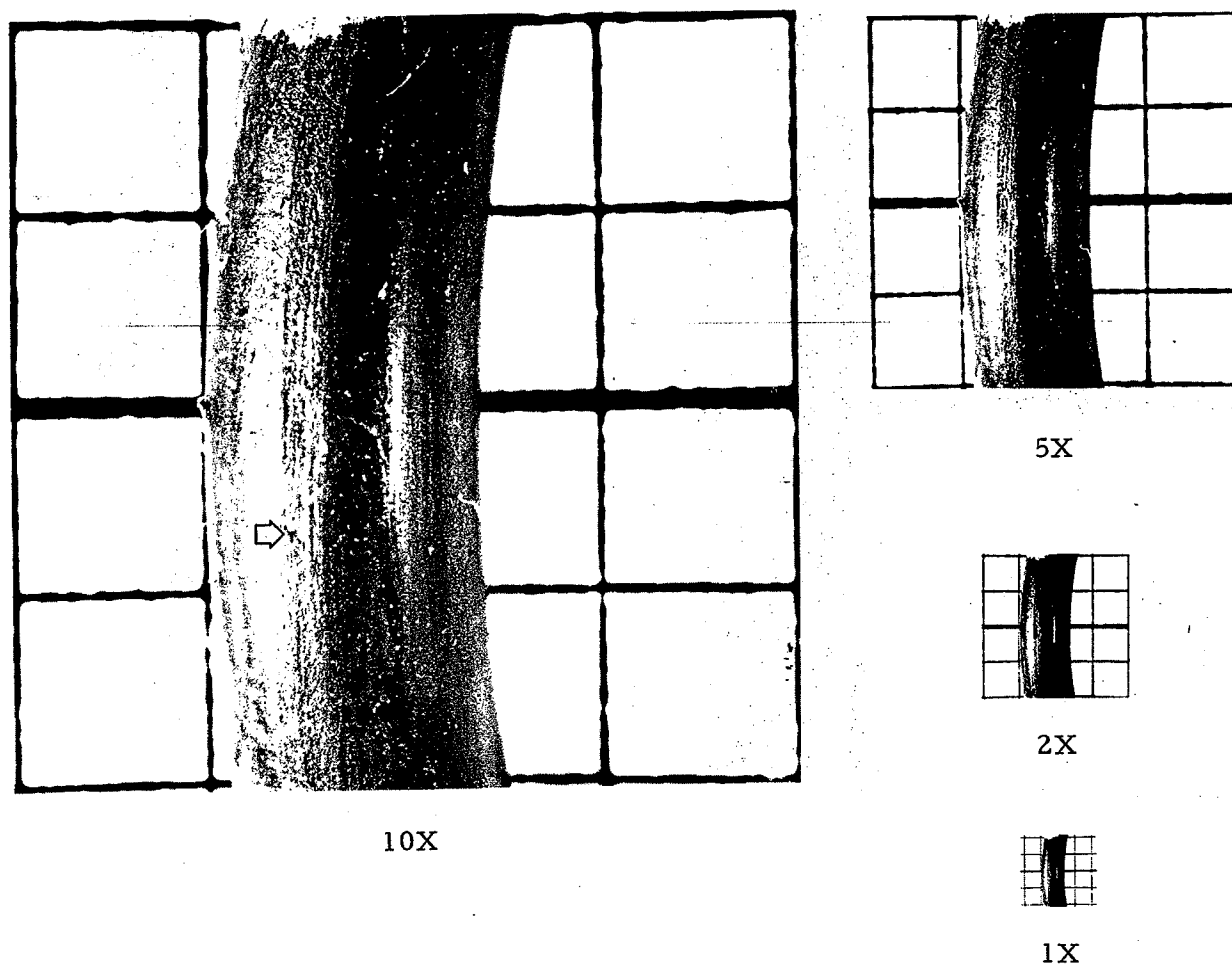


Figure 38 - Excessive trimming, minor, $W = 0.103$ inch.

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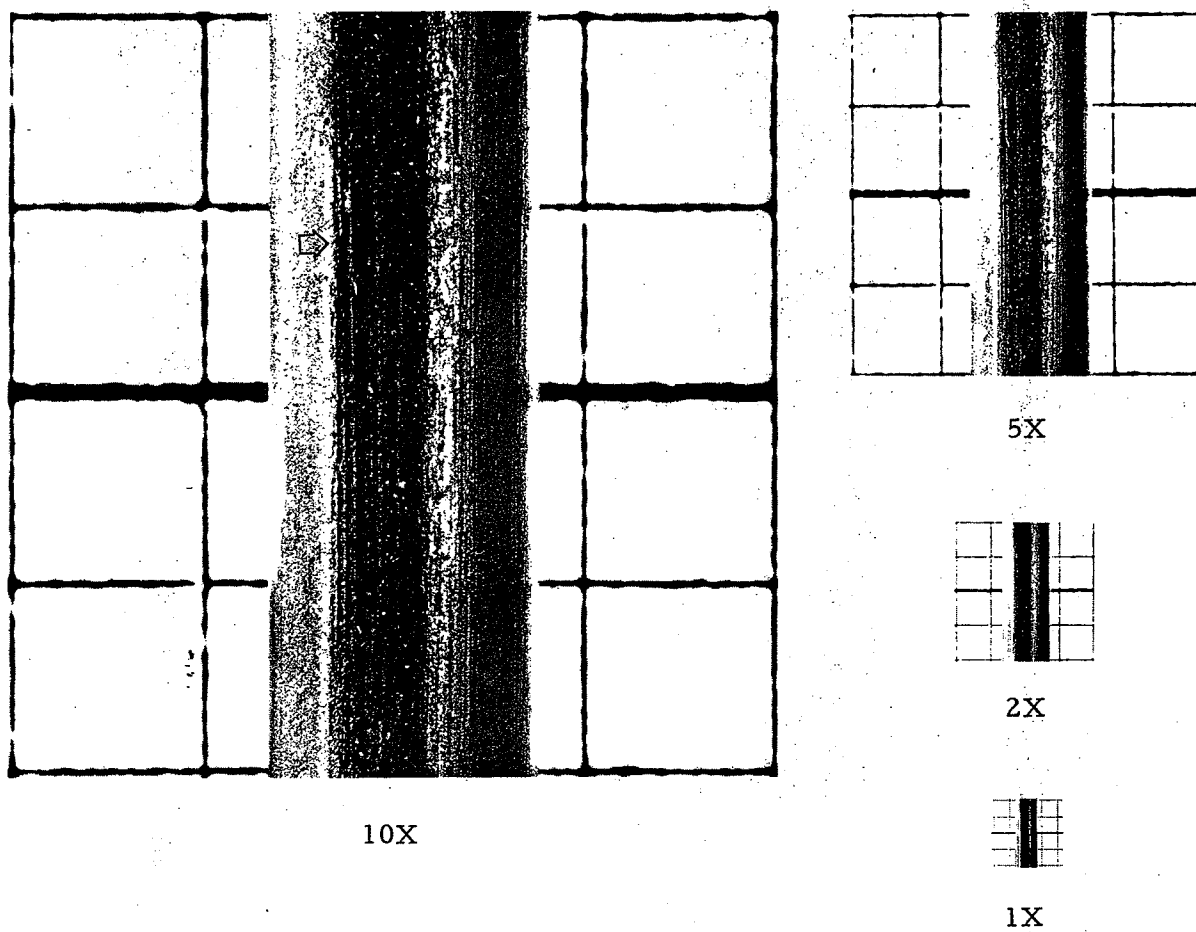


Figure 39 - Excessive trimming, major, $W = 0.139$ inch.

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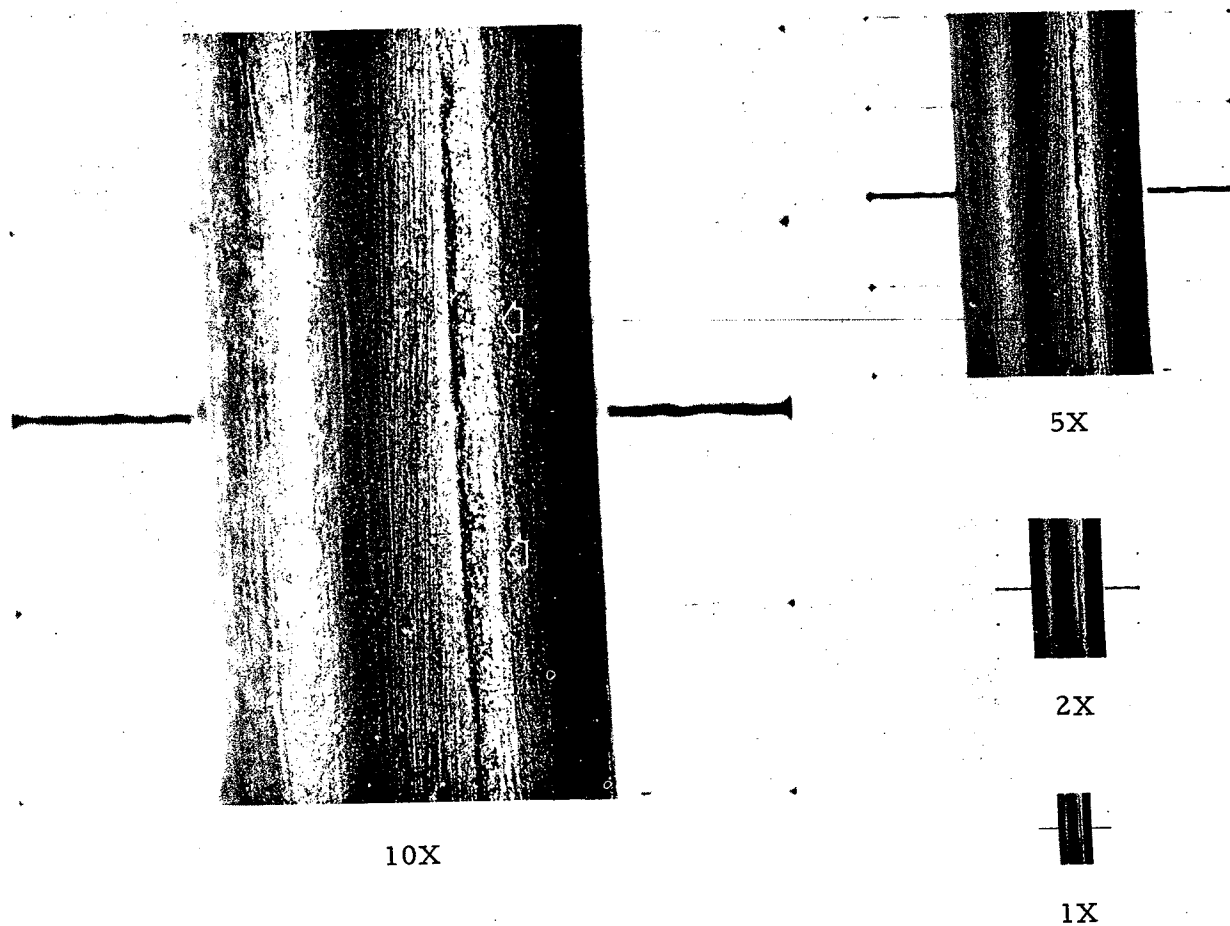


Figure 40 - Excessive trimming, minor, $W = 0.210$ inch.

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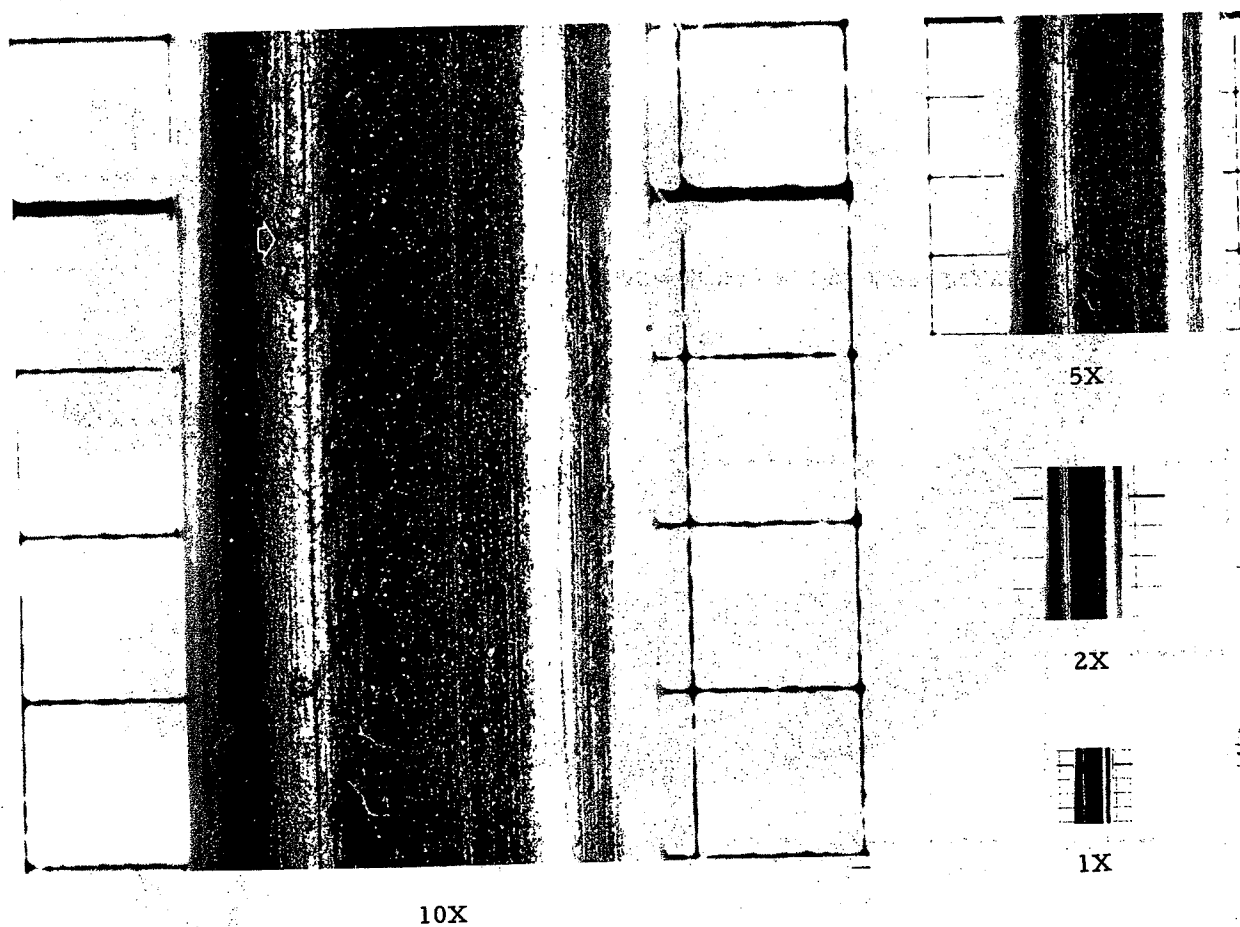


Figure 41 - Excessive trimming, major, $W = 0.275$ inch.

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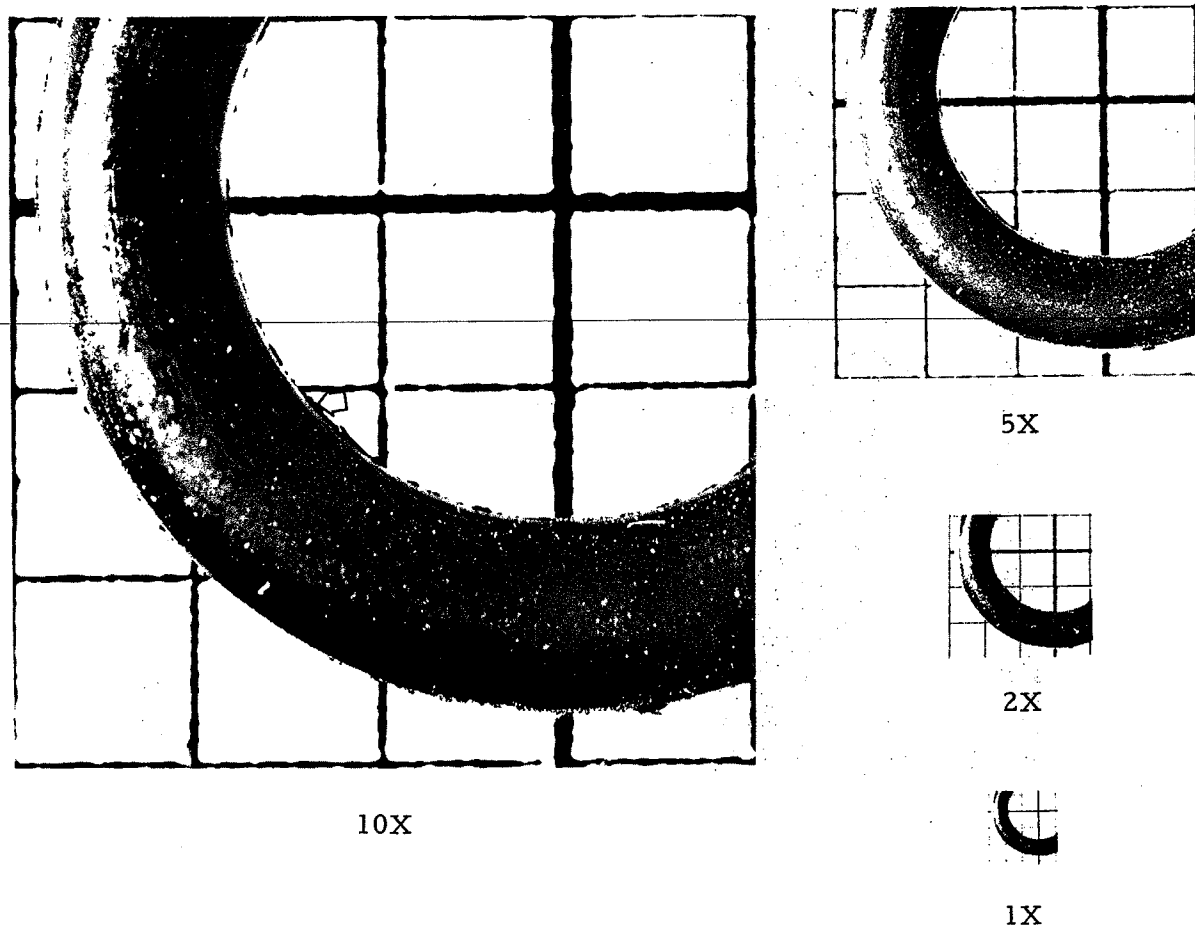
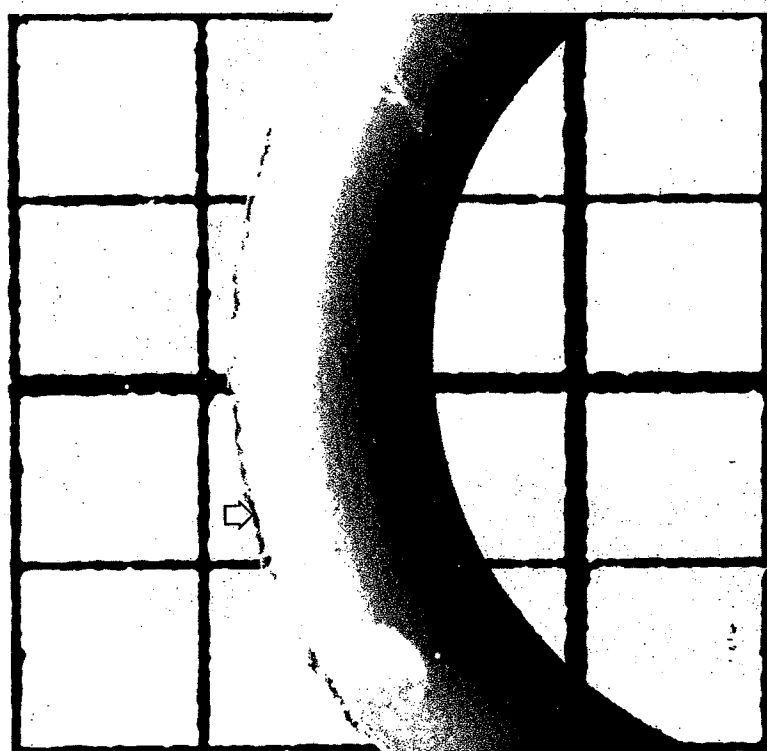
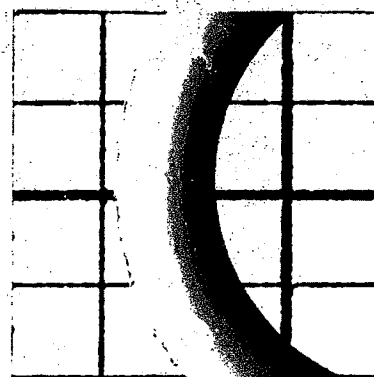


Figure 42 - Excessive flash remaining, major, $W = 0.103$ inch.

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10X



5X



2X



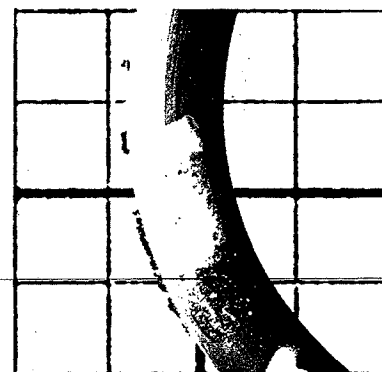
1X

Figure 43 - Excessive flash remaining, major, $W = 0.103$ inch.

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10X



5X



2X



1X

Figure 44 - Excessive flash remaining, major, $W = 0.103$ inch.

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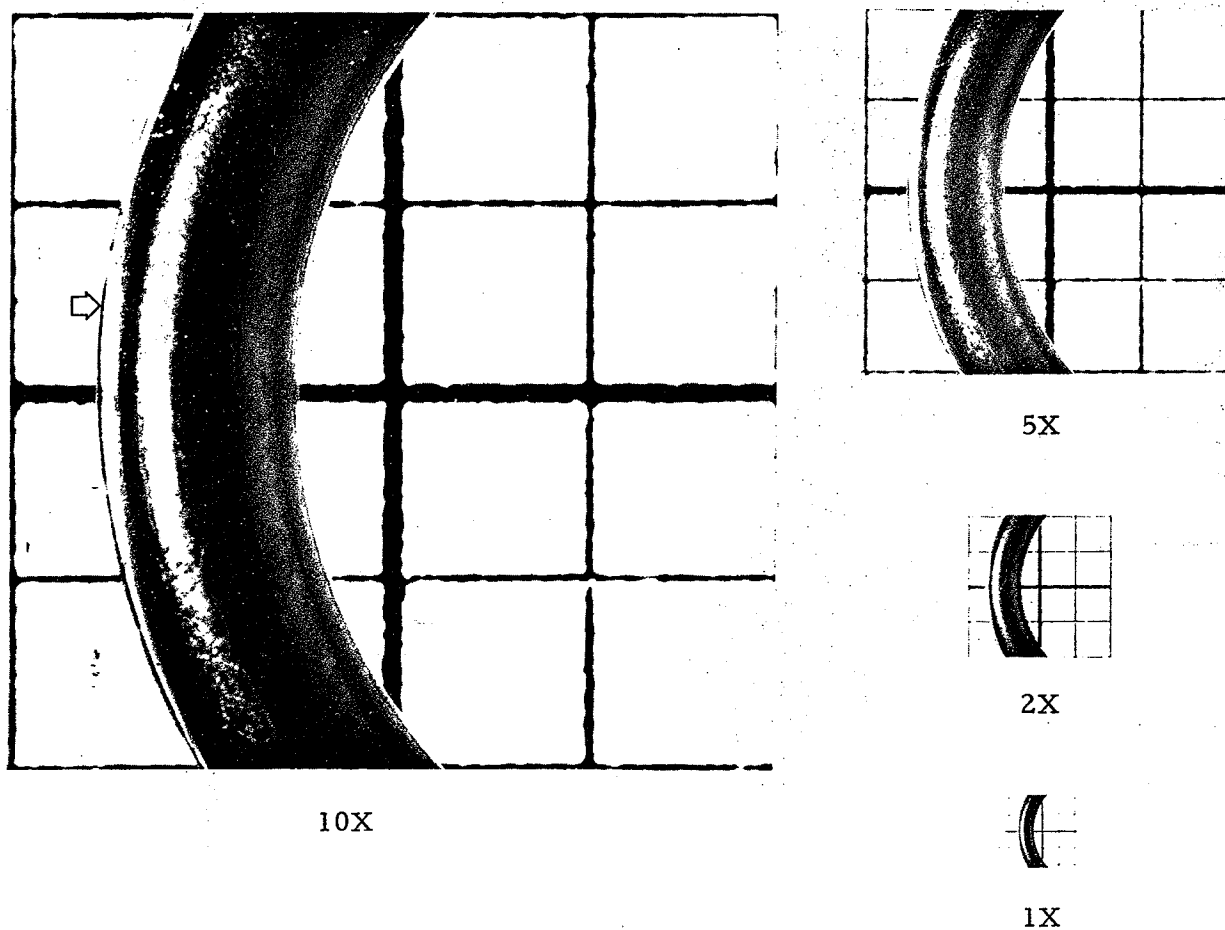


Figure 45 - Excessive flash remaining, minor, $W = 0.103$ inch.

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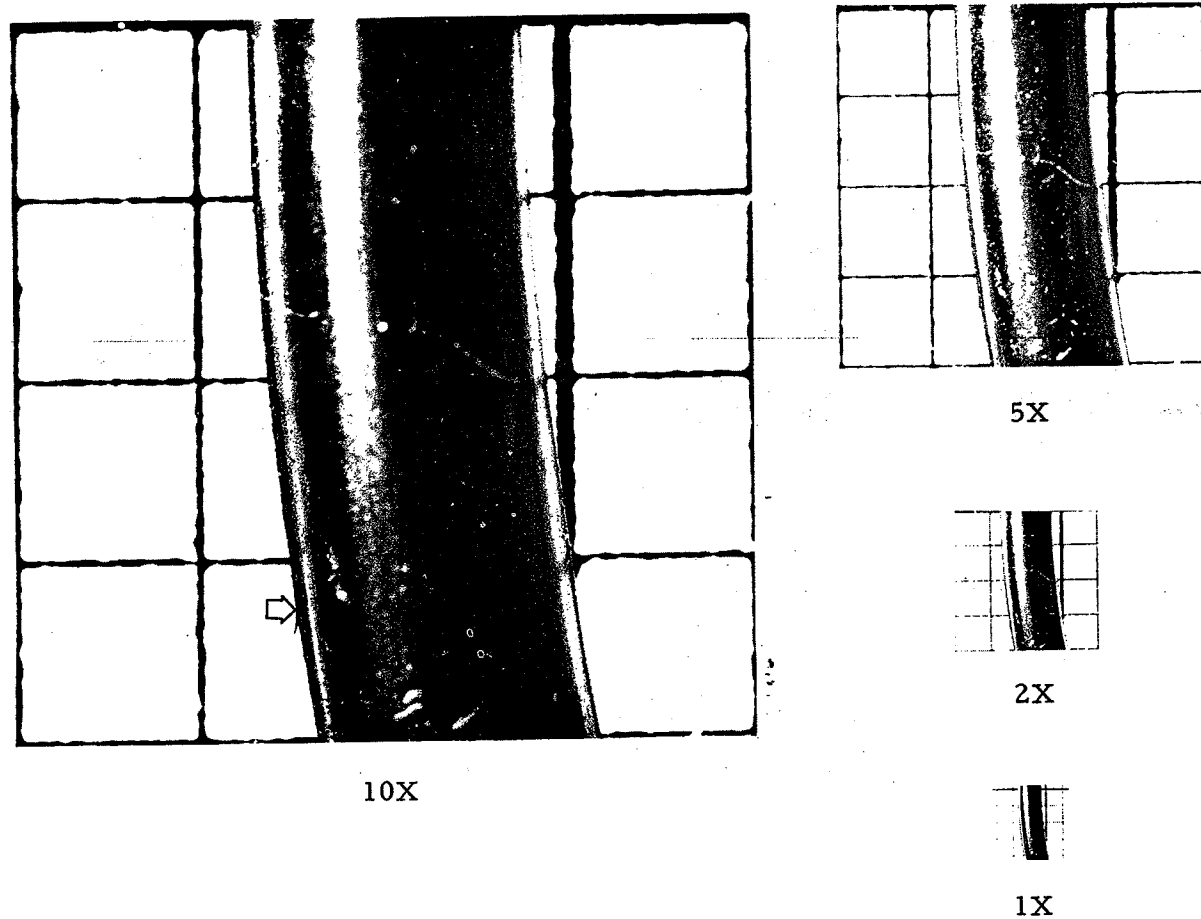


Figure 46 - Excessive flash remaining, minor, $W = 0.139$ inch.

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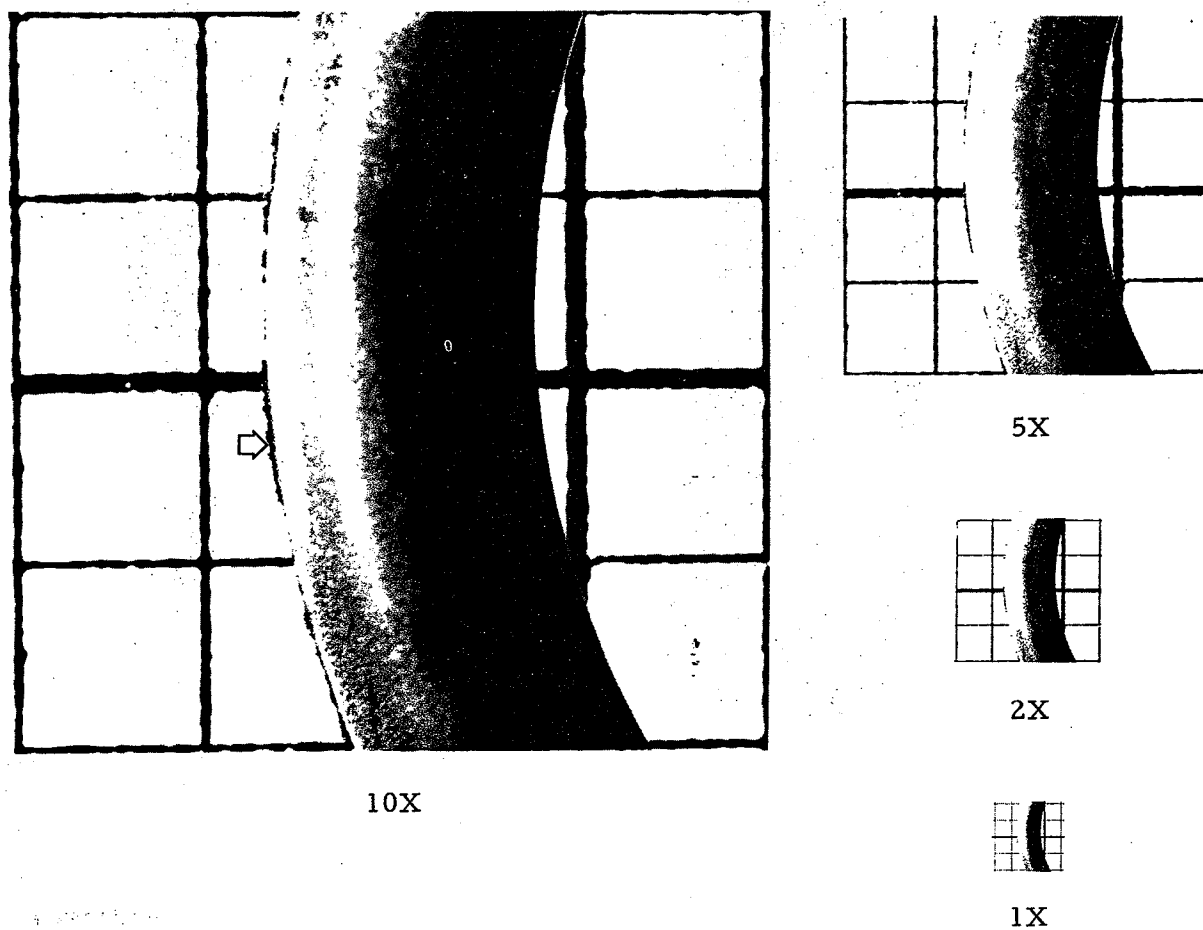


Figure 47 - Excessive flash remaining, major, $W = 0.139$ inch.

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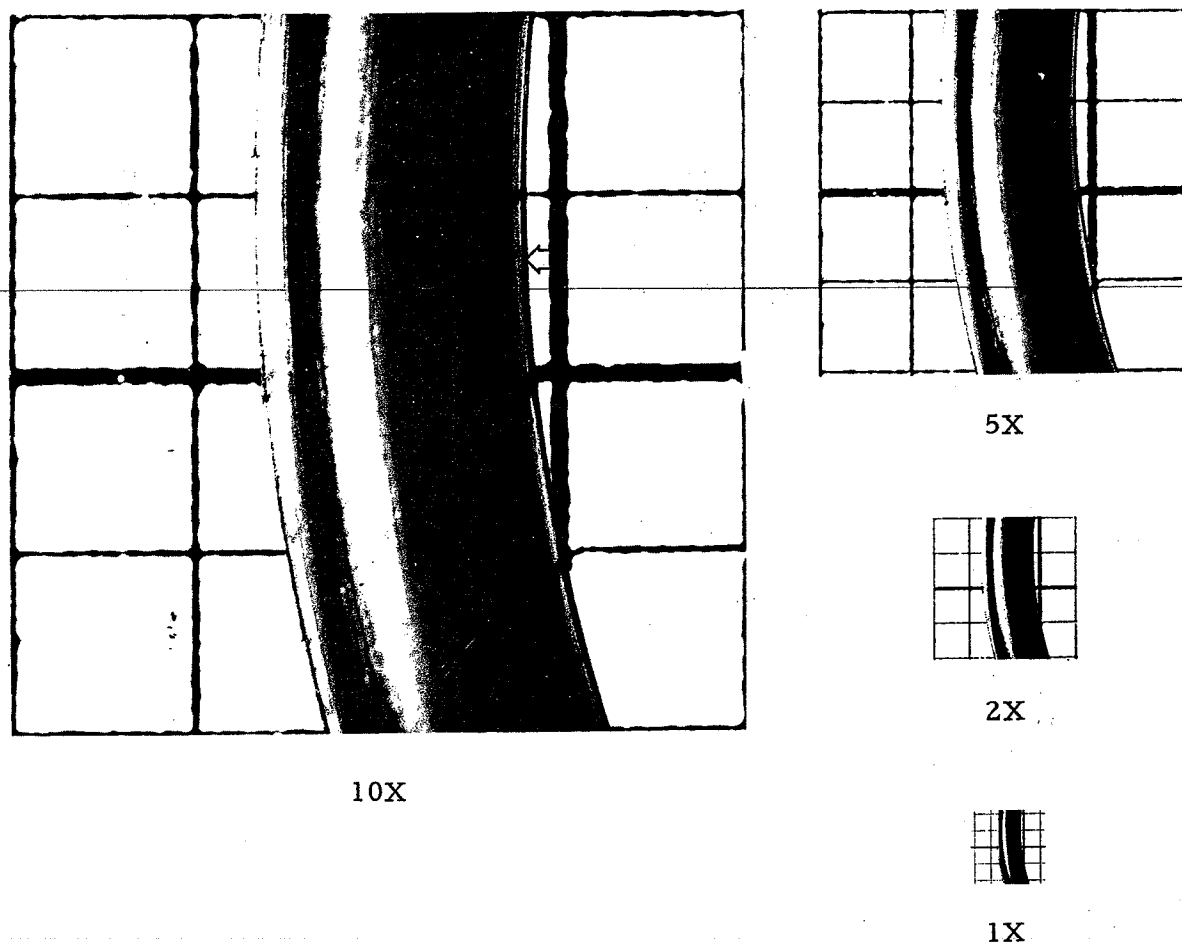


Figure 48 - Excessive flash remaining, minor, $W = 0.139$ inch.

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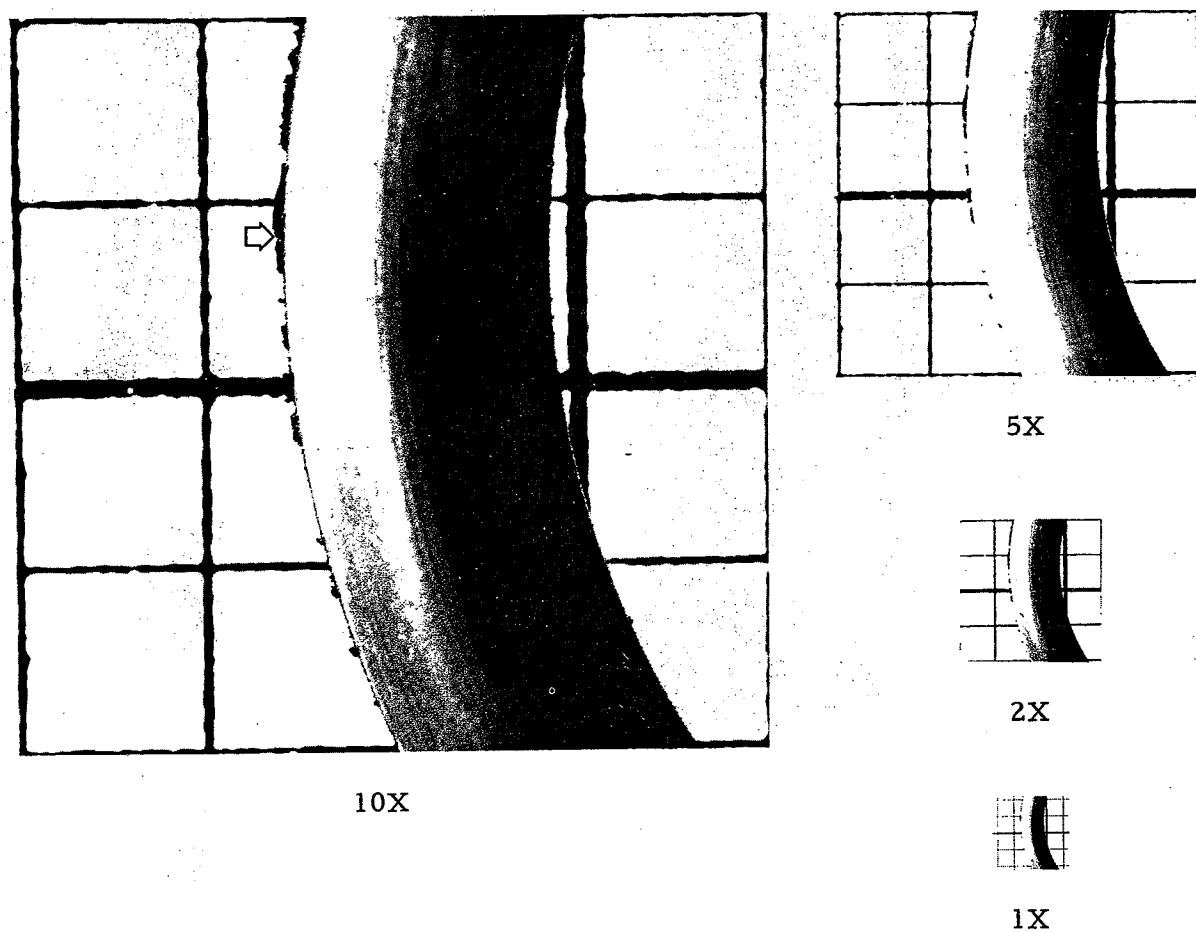


Figure 49 - Excessive flash remaining, major, $W = 0.139$ inch.

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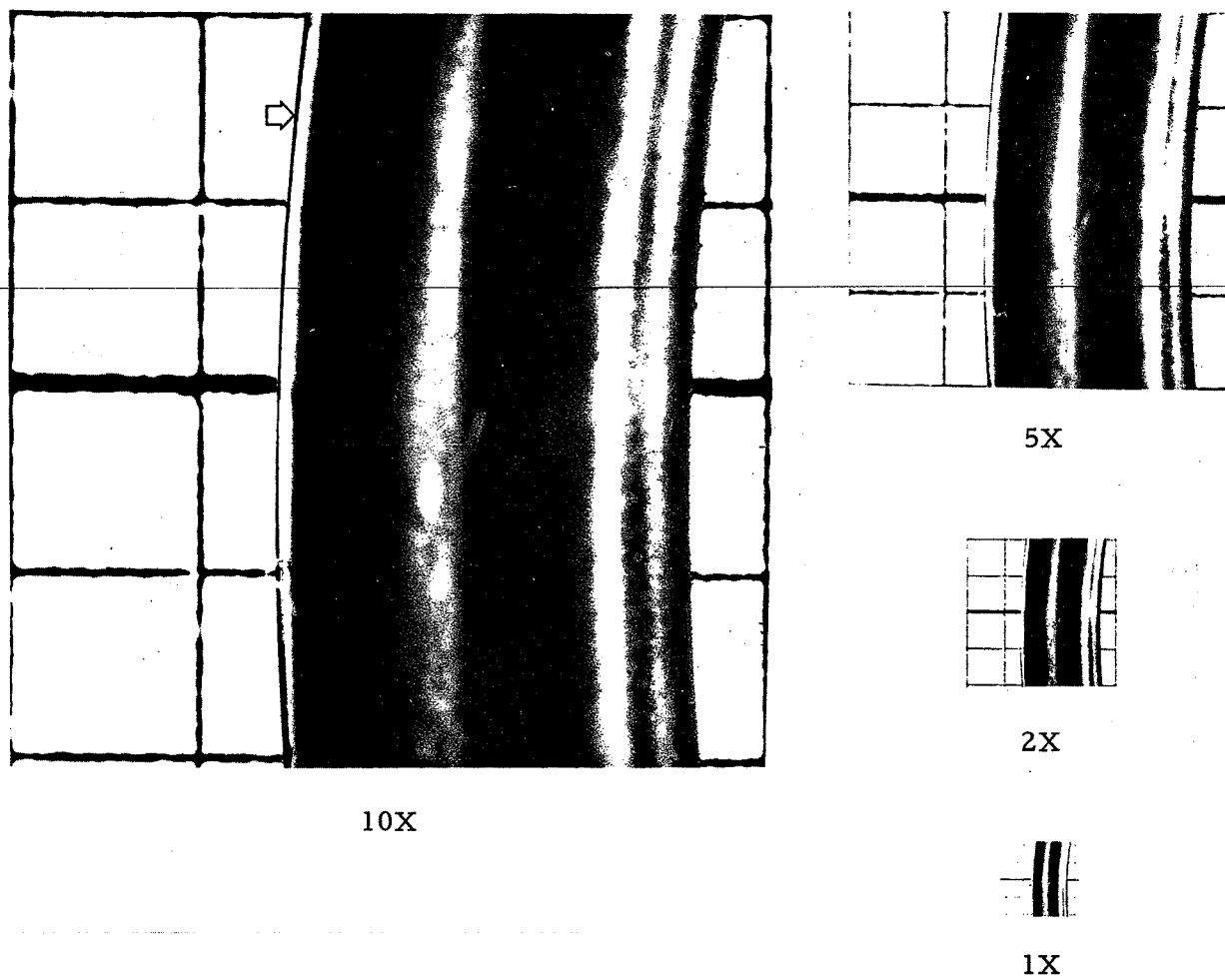
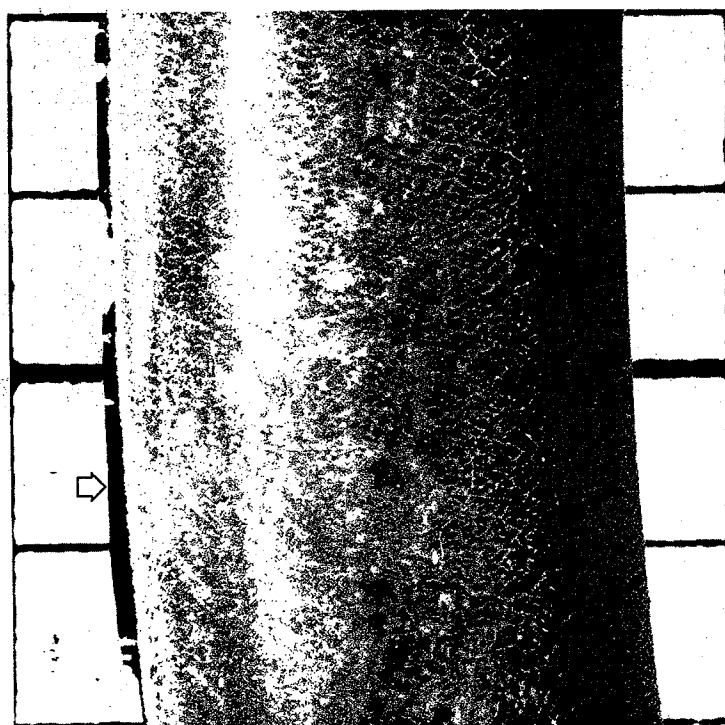


Figure 50 - Excessive flash remaining, minor, W = 0.210 inch.

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10X



5X



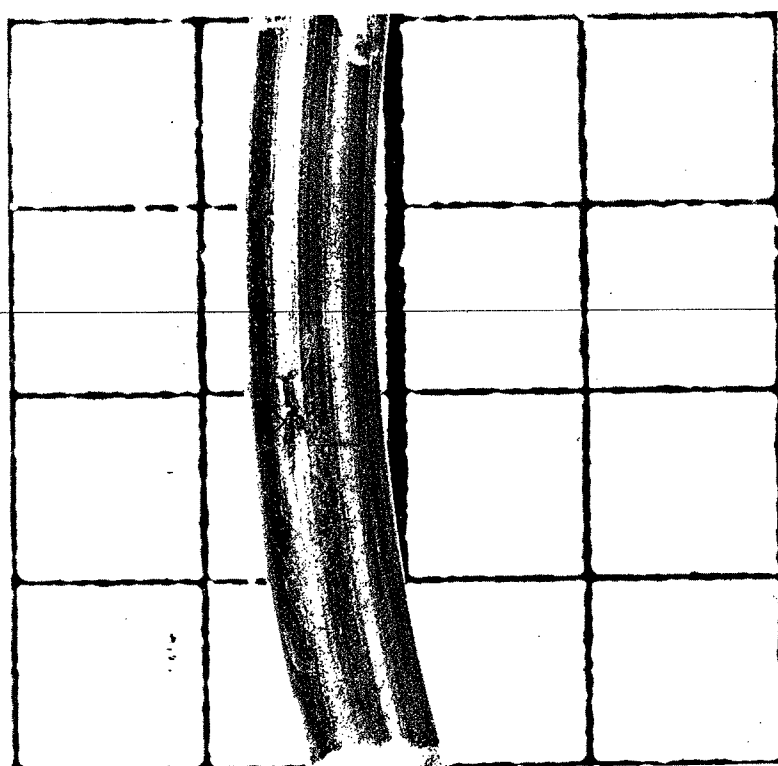
2X



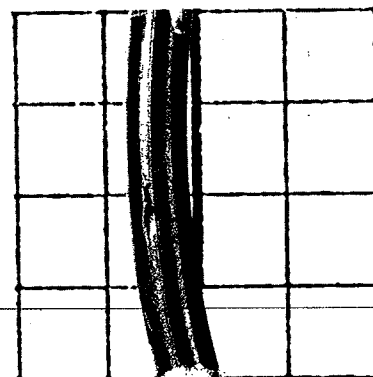
1X

Figure 51 - Excessive flash remaining, major, $W = 0.275$ inch.

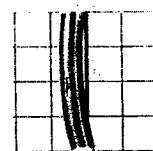
MIL-STD-413B
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10X



5X



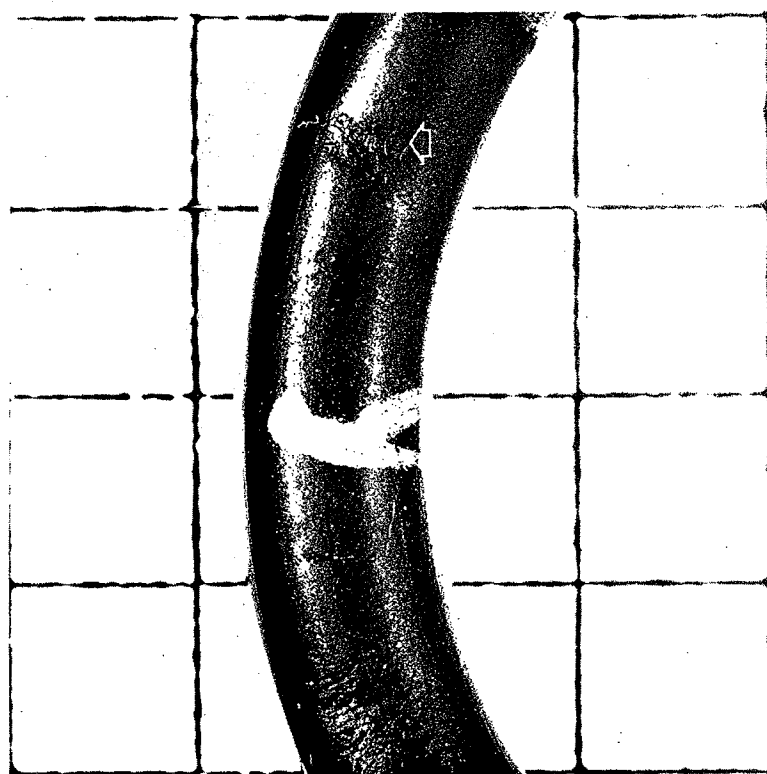
2X



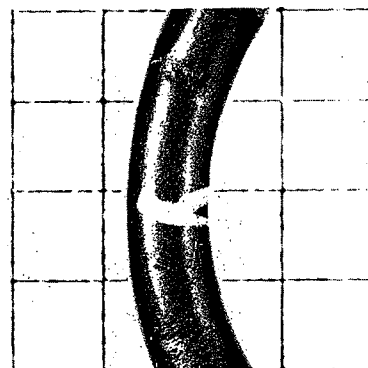
1X

Figure 52 - Non-fill, major, $W = 0.070$ inch.

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10X



5X



2X



1X

Figure 53 - Non-fill, major, $W = 0.103$ inch.

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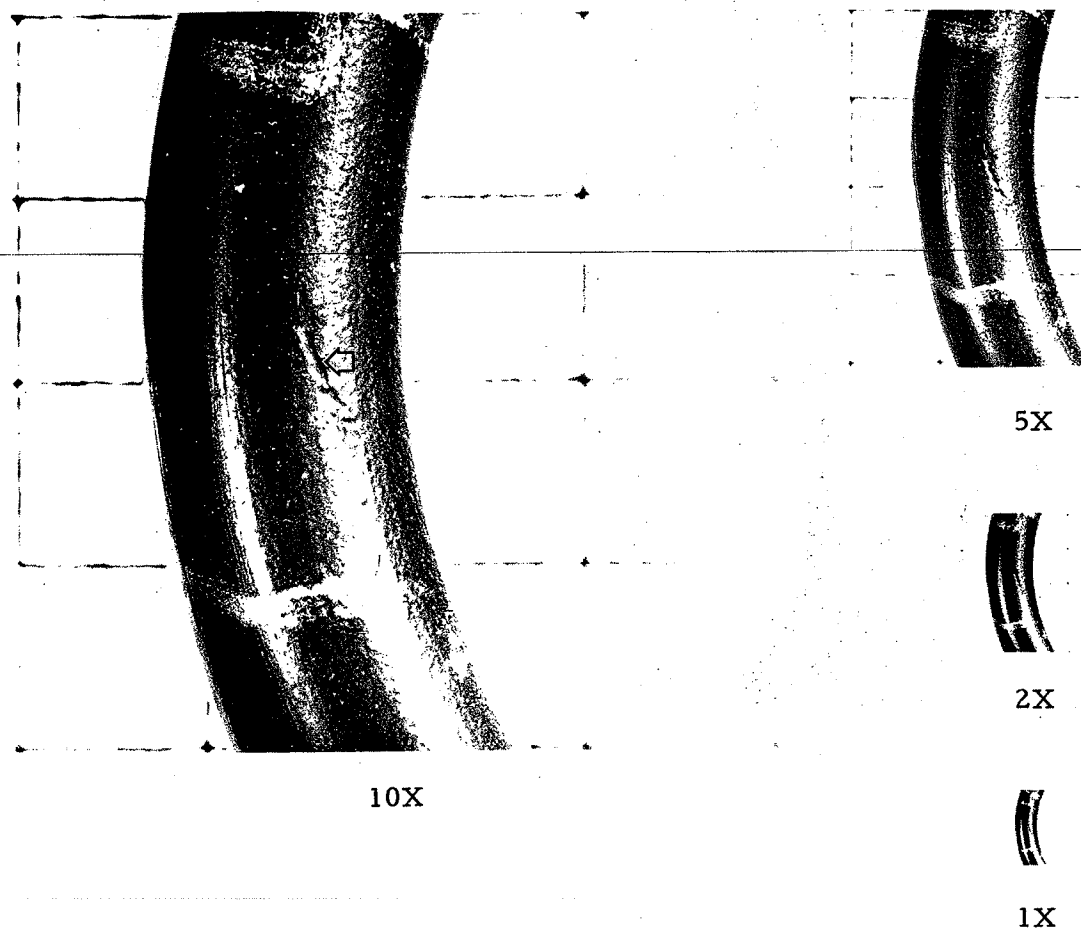


Figure 54 - Non-fill, minor, $W = 0.139$ inch.

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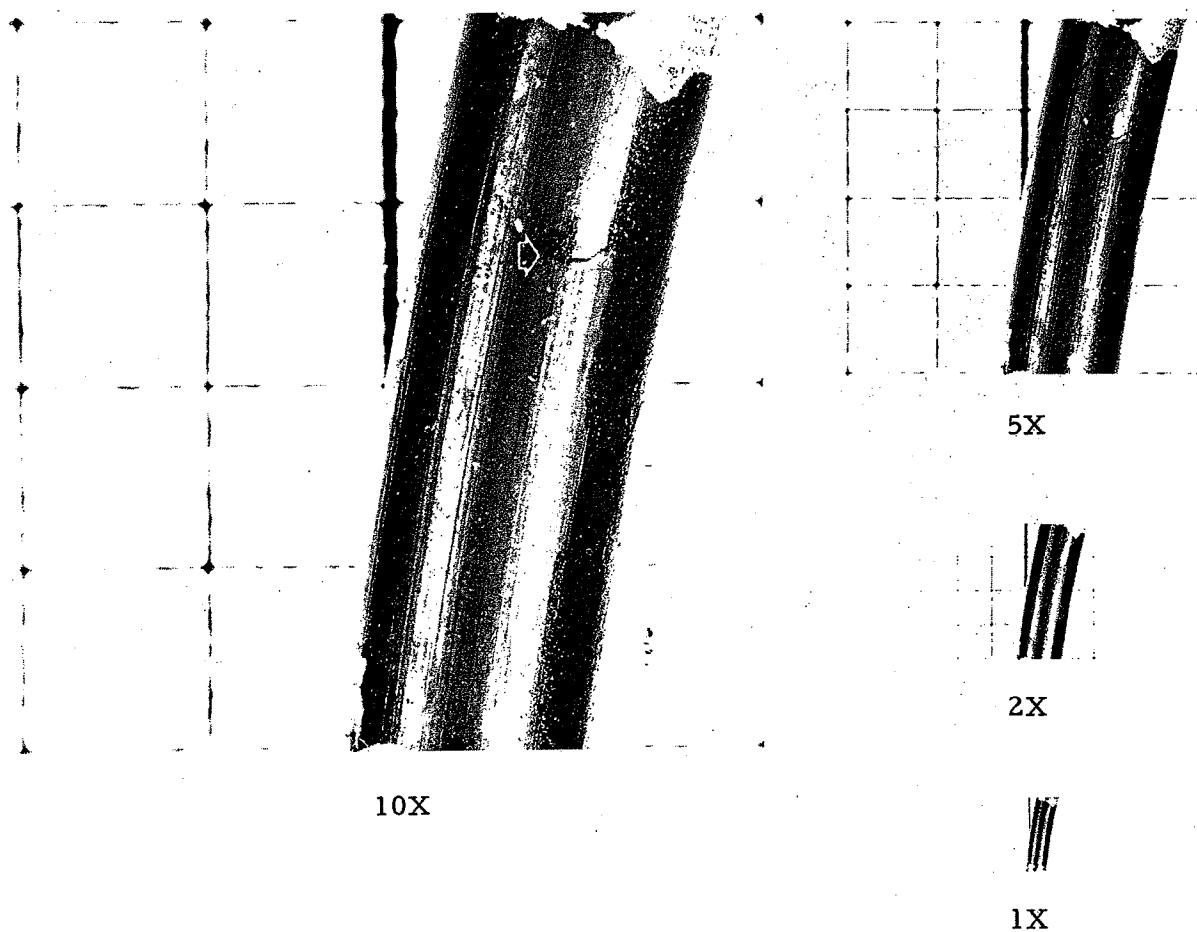


Figure 55 - Non-fill, major, $W = 0.139$ inch.

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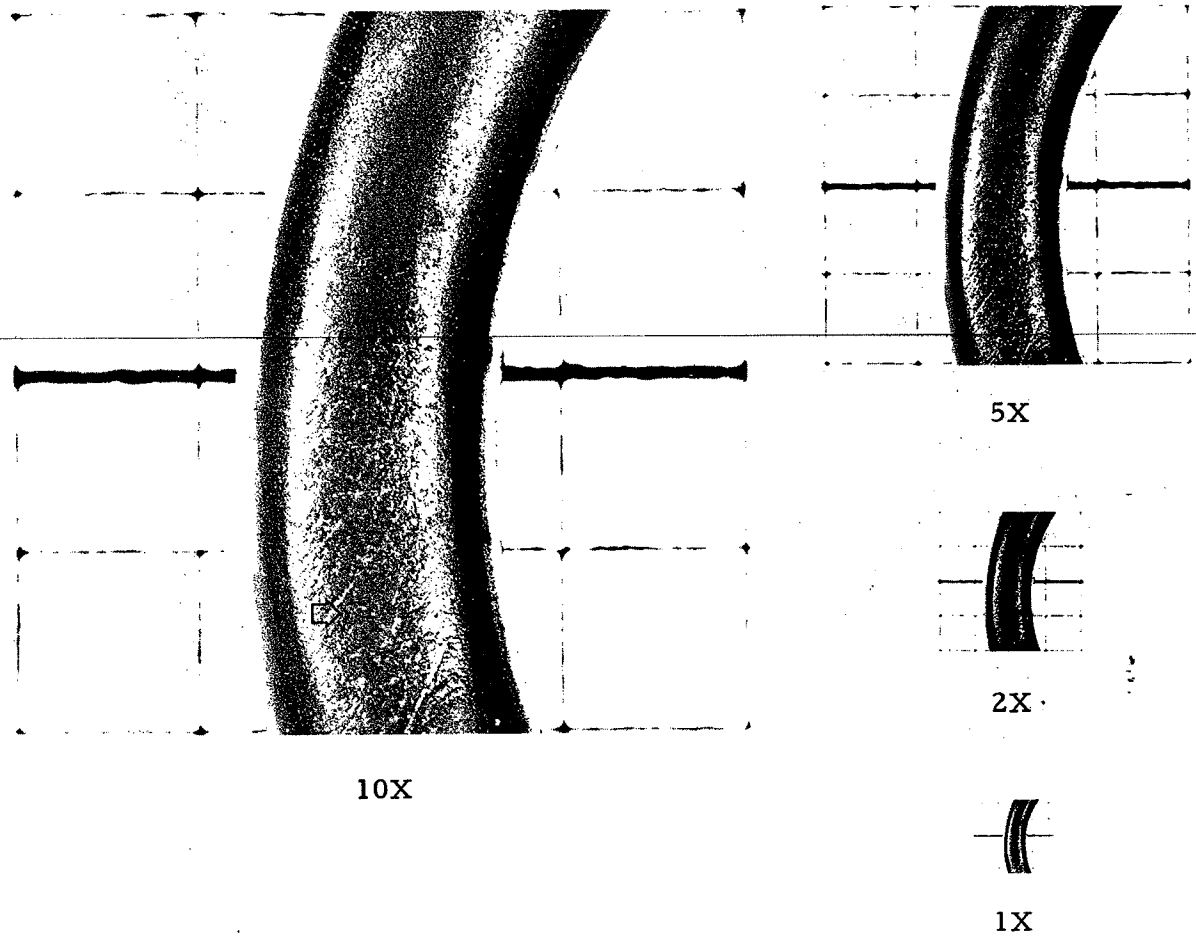


Figure 56 - Non-fill, major, $W = 0.139$ inch.

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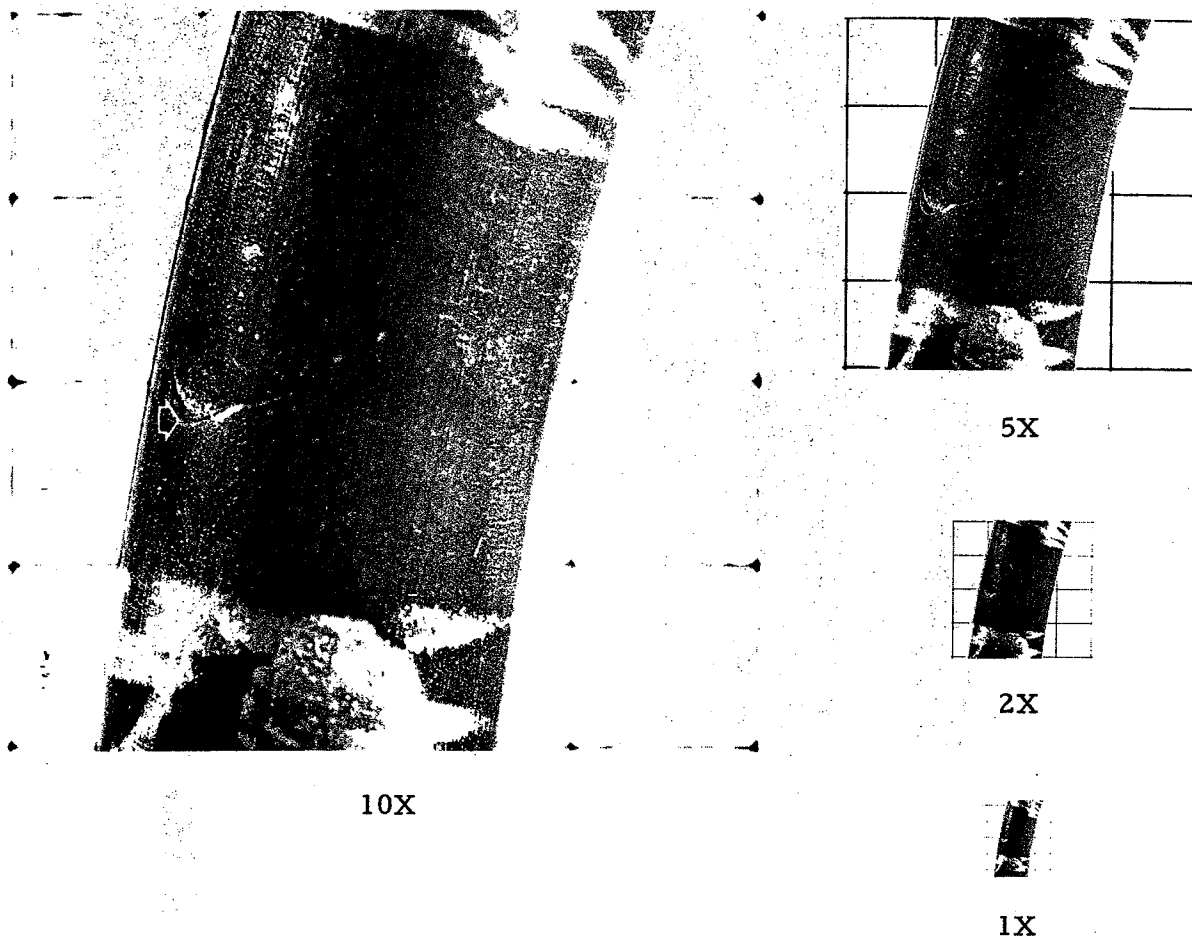


Figure 57 - Non-fill, major, W = 0.210 inch.

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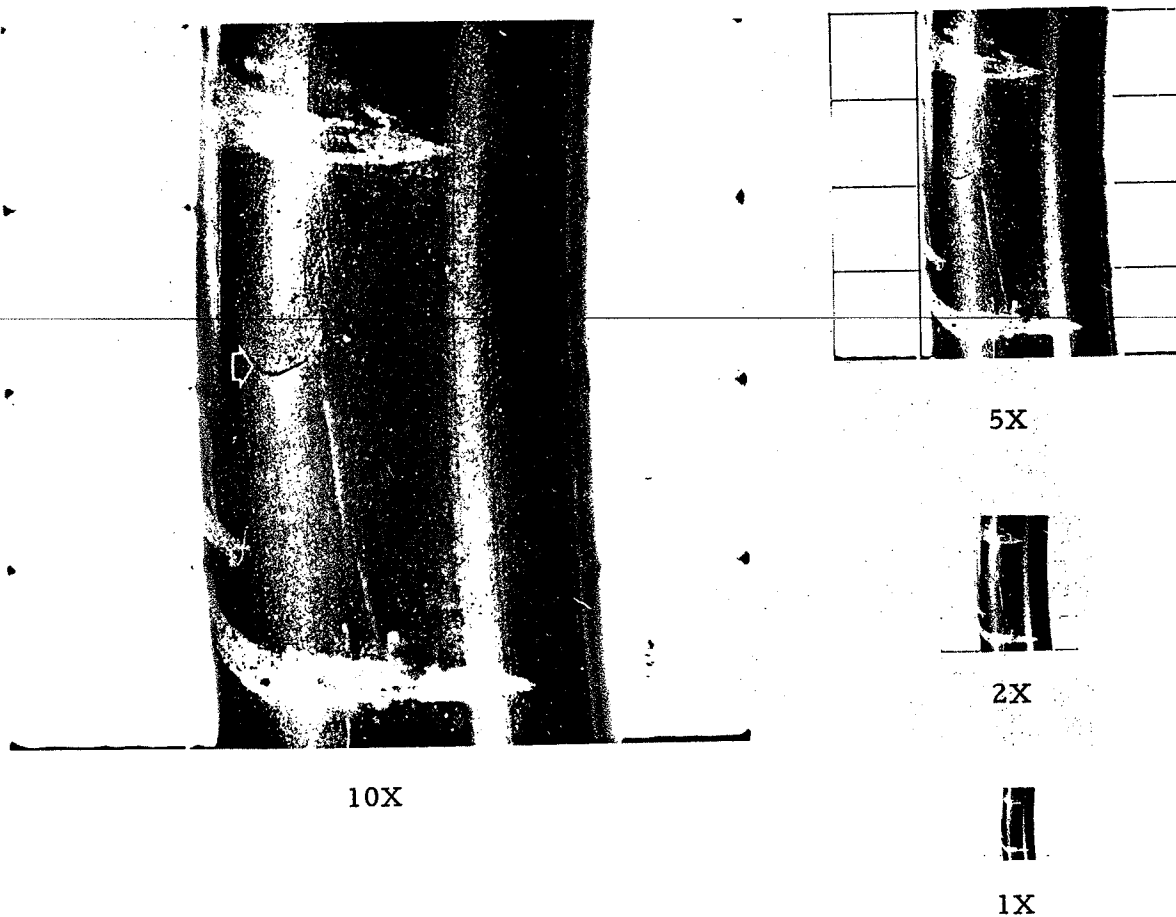


Figure 58 - Non-fill, major, $W = 0.210$ inch.

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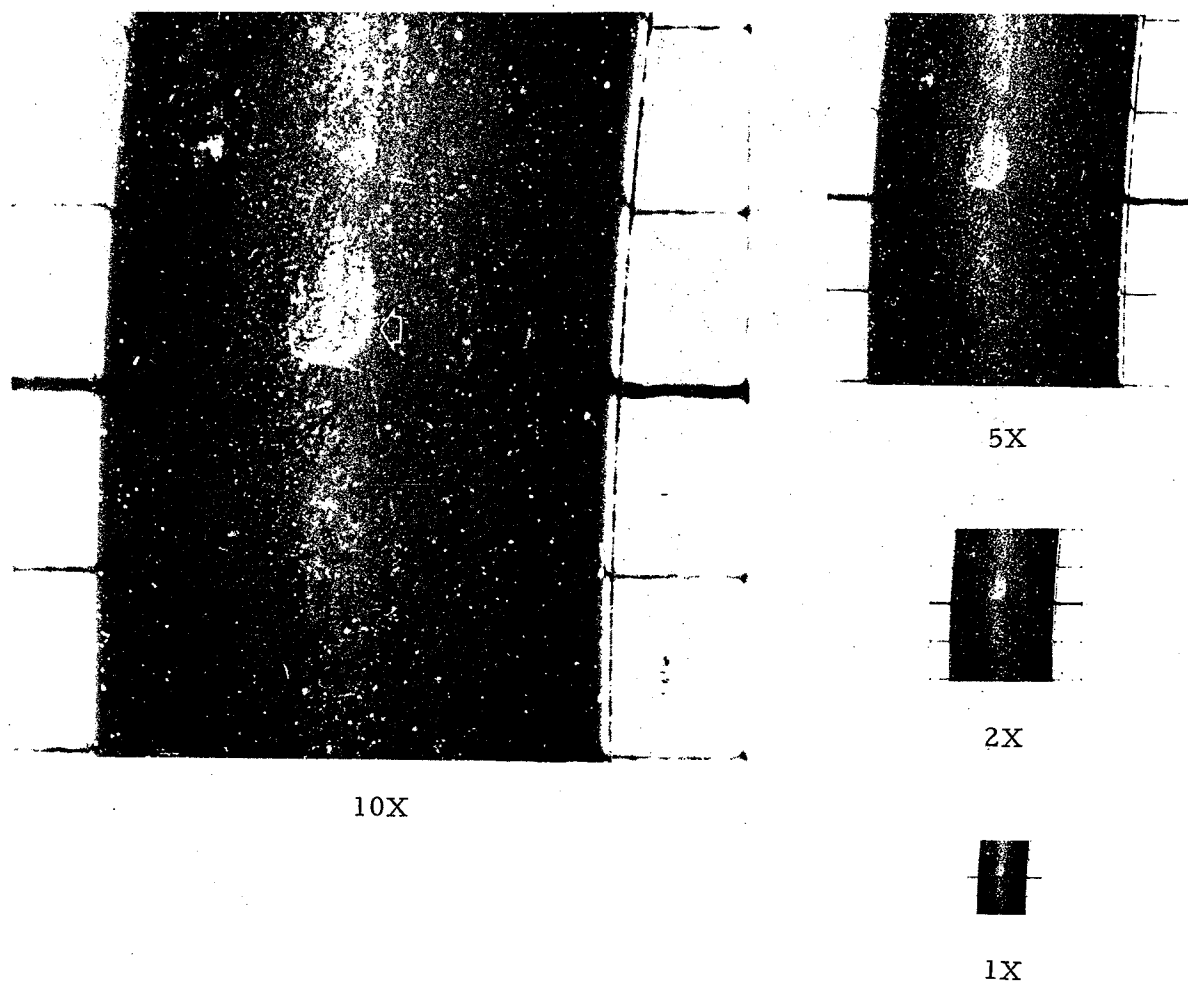


Figure 59 - Non-fill, minor, $W = 0.275$ inch.

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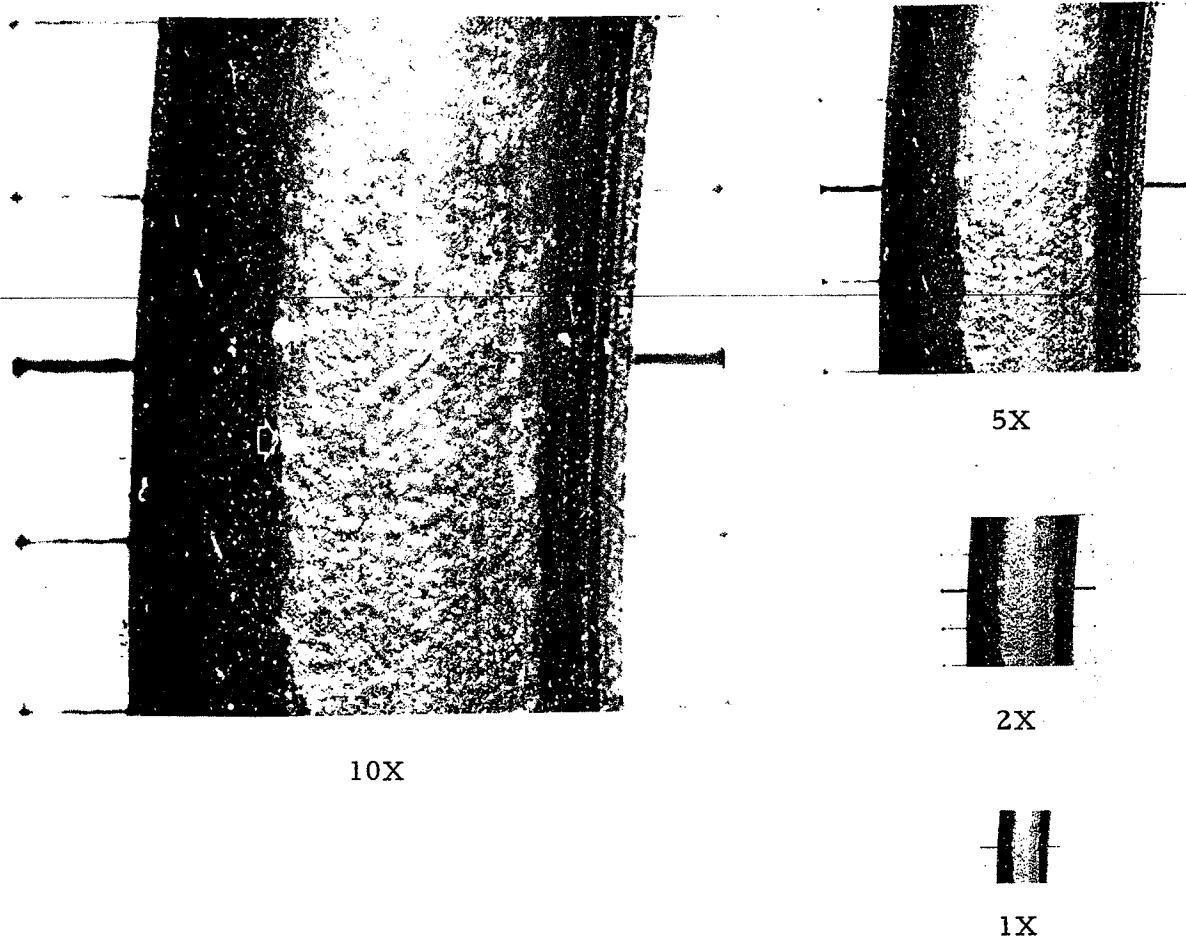
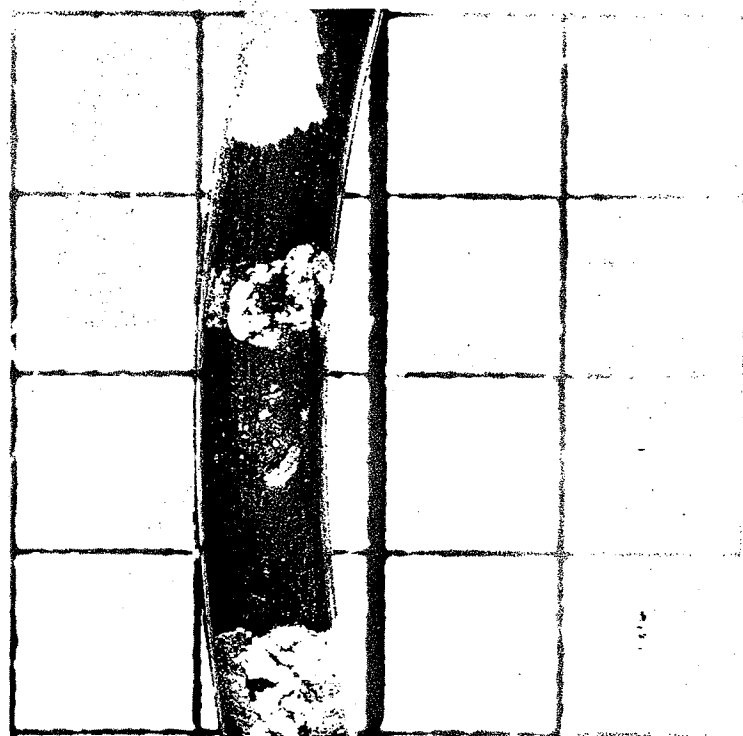
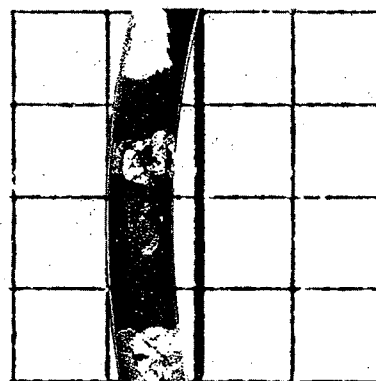


Figure 60 - Non-fill, major, $W = 0.275$ inch.

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10X



5X



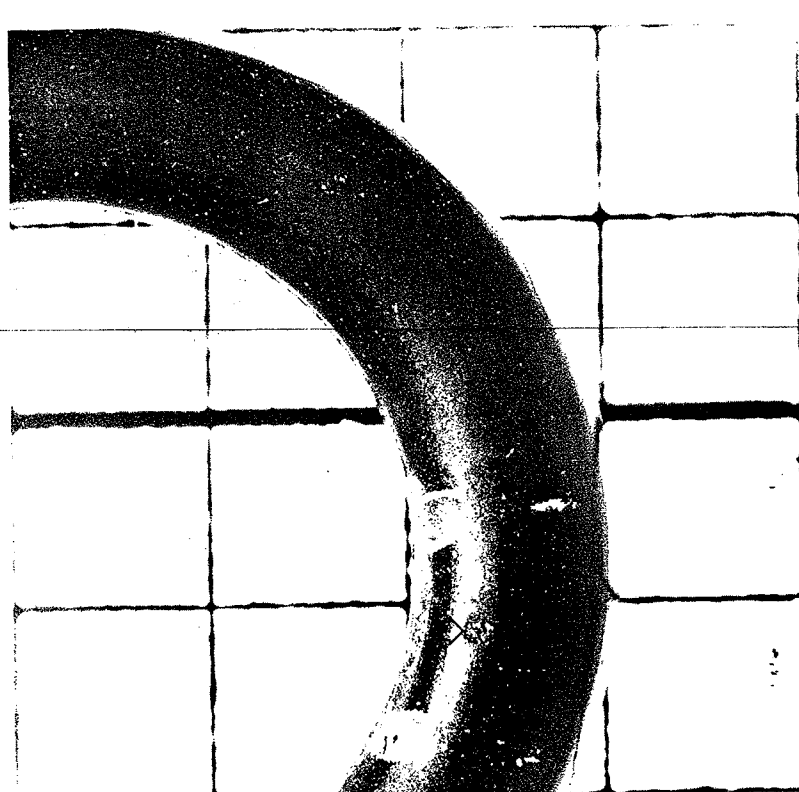
2X



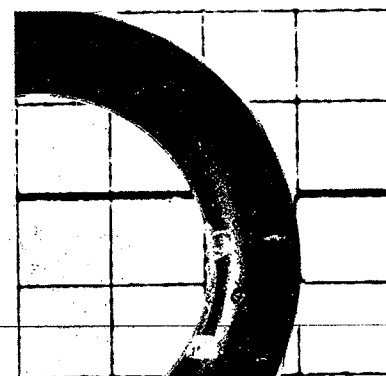
1X

Figure 61 - Mold deposit defect, $W = 0.070$ inch.

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10X



5X



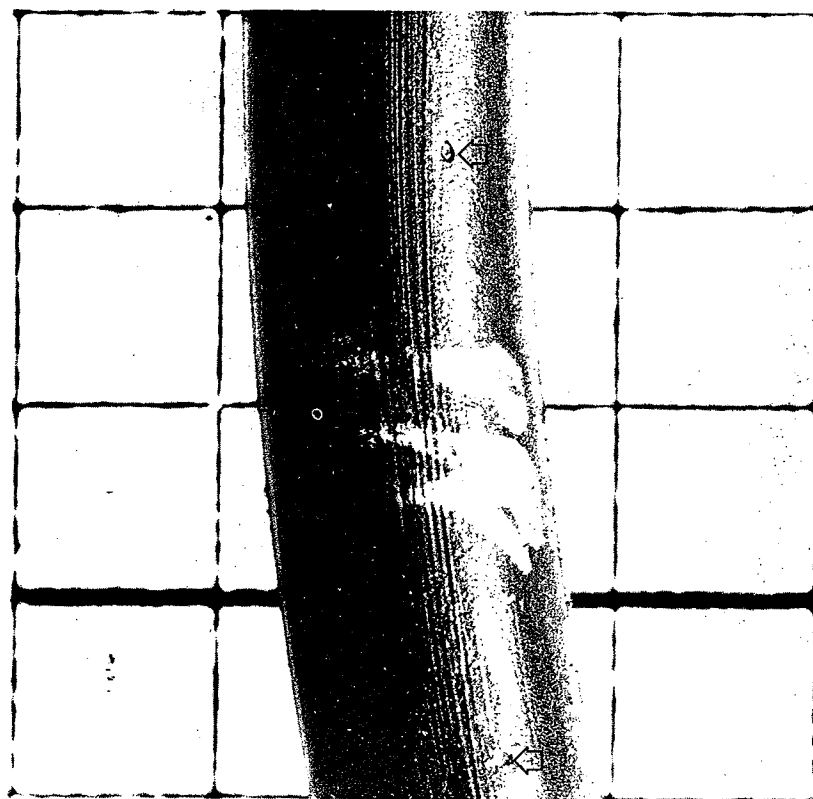
2X



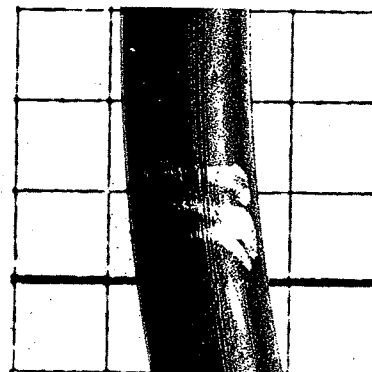
1X

Figure 62 - Mold deposit defect, minor, $W = 0.103$ inch.

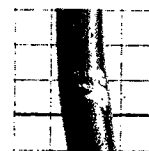
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10X



5X



2X



1X

Figure 63 - Mold deposit defect, minor, W = 0.139 inch.

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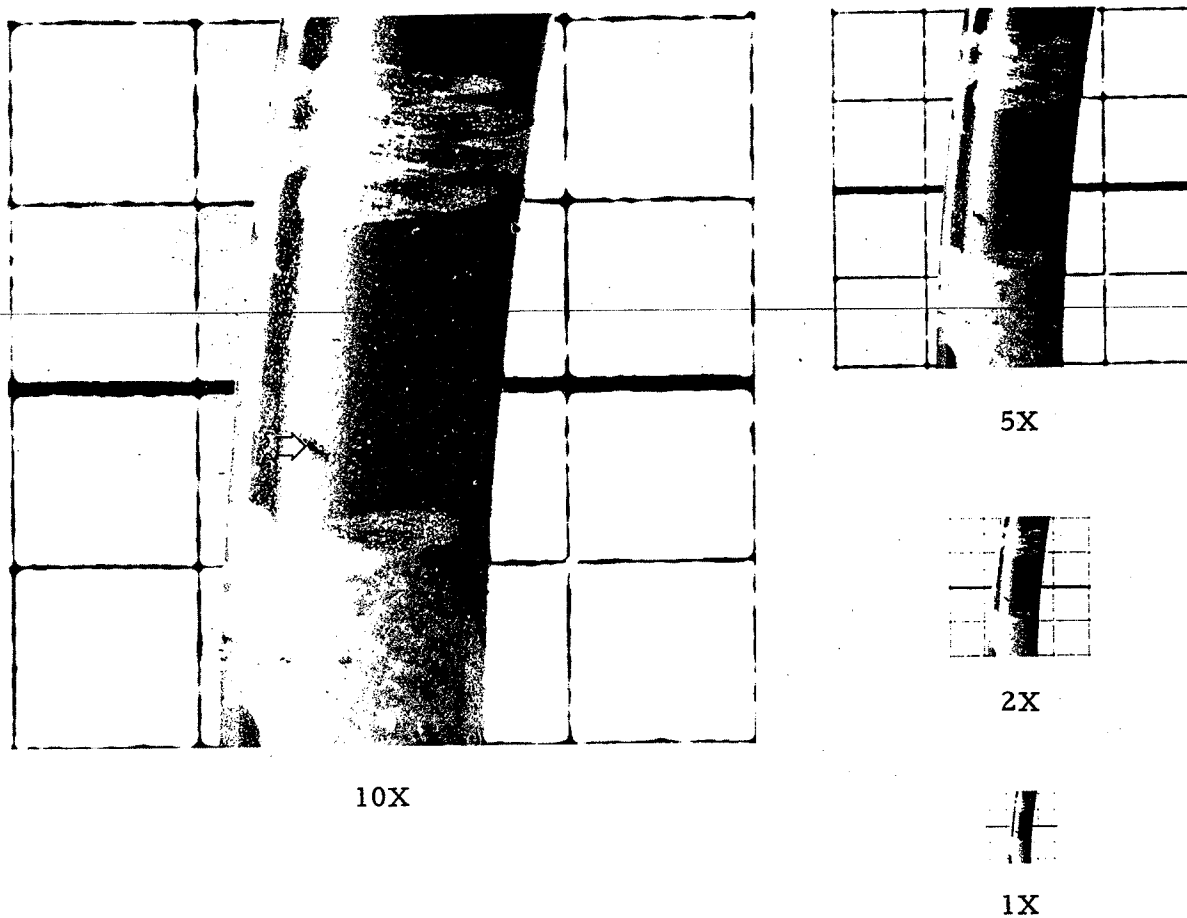


Figure 64 - Mold deposit defect, major, $W = 0.139$ inch.

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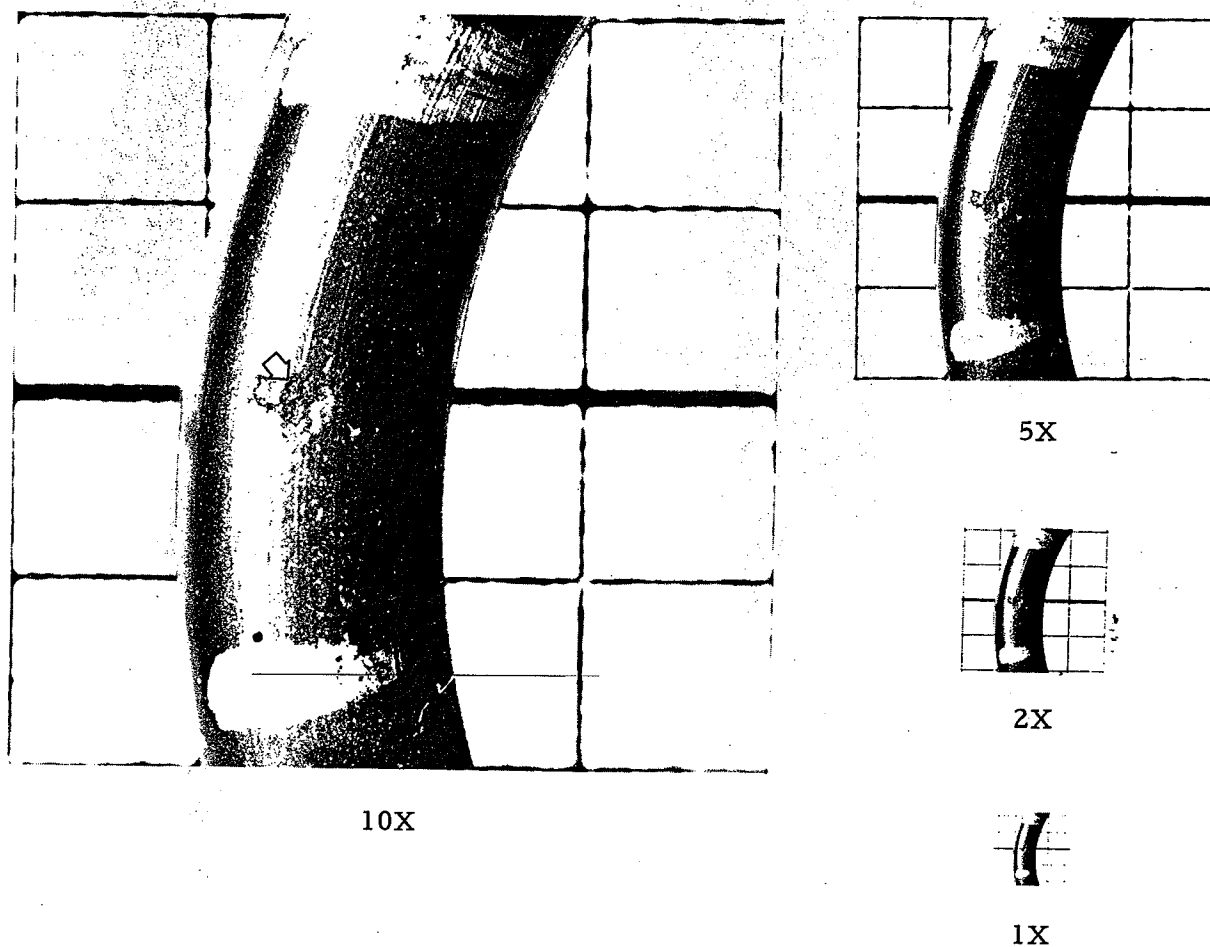


Figure 65 - Mold deposit defect, major, $W = 0.139$ inch.

MIL-STD-413B
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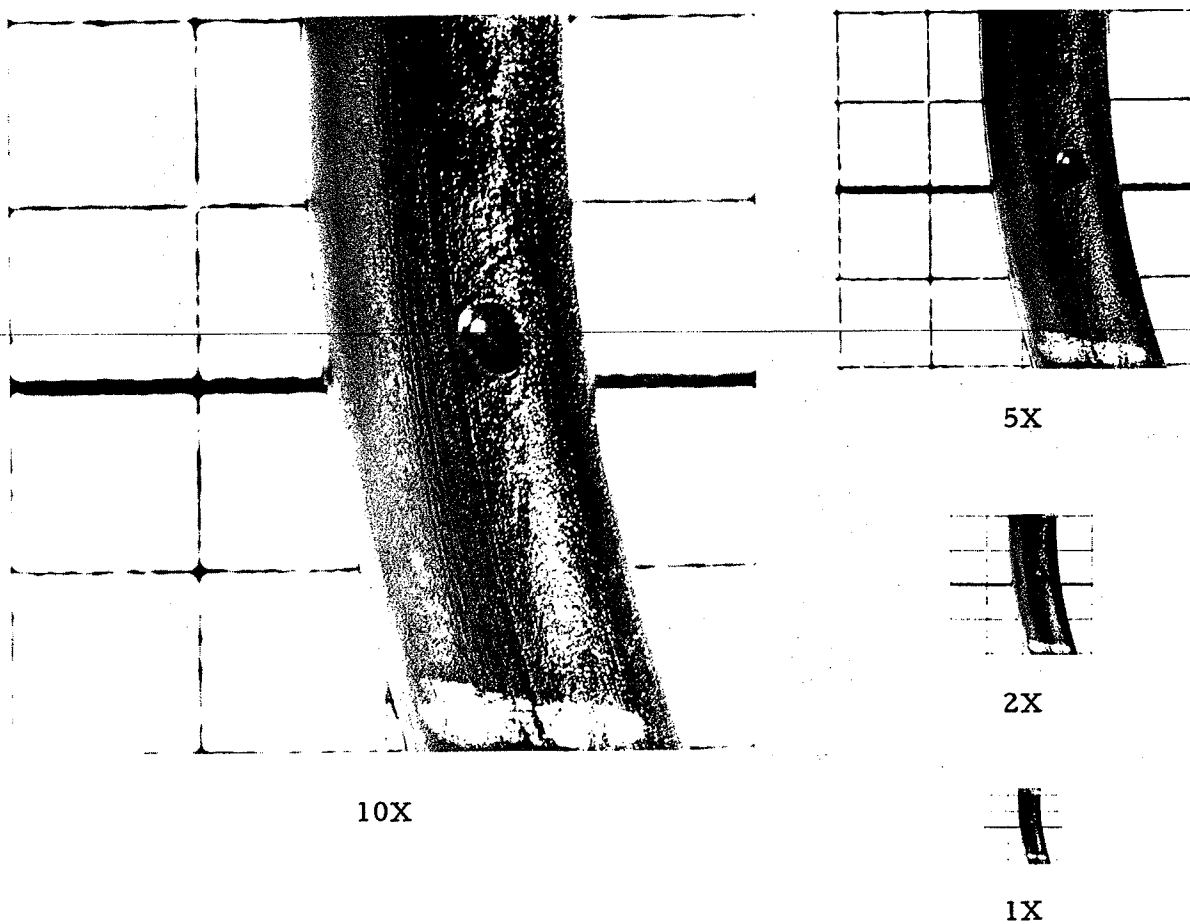
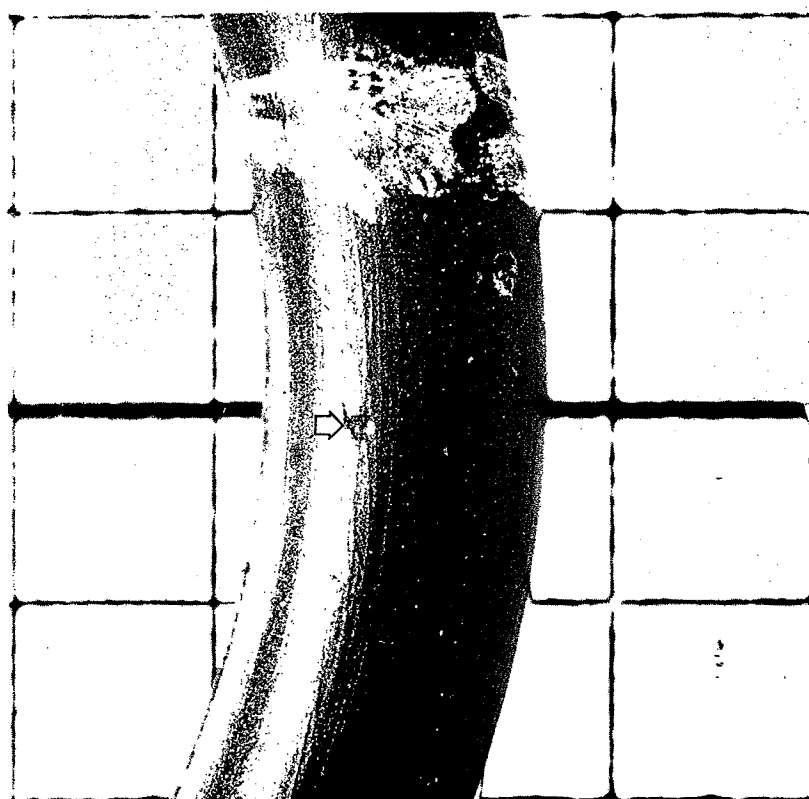
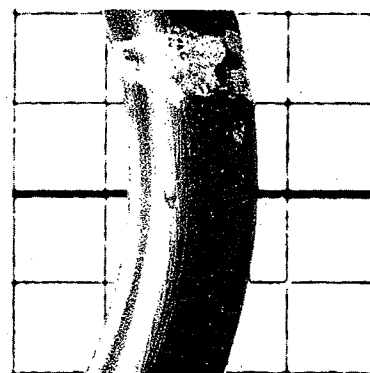


Figure 66 - Mold deposit defect, major, $W = 0.139$ inch.

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10X



5X



2X



1X

Figure 67 - Mold deposit defect, minor, $W = 0.139$ inch.

MIL-STD-413B
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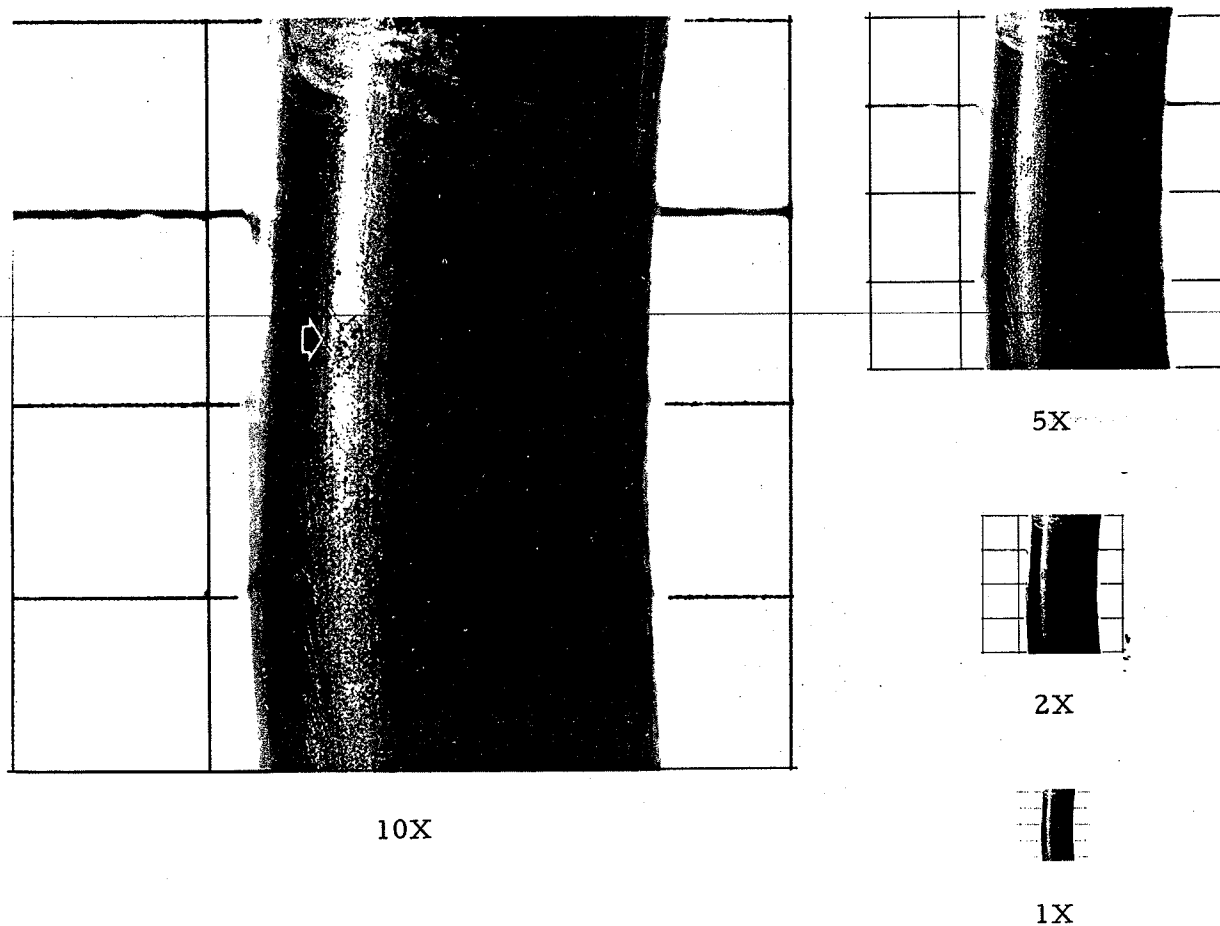


Figure 68 - Mold deposit defect, minor, W = 0.210 inch.

MIL-STD-413B
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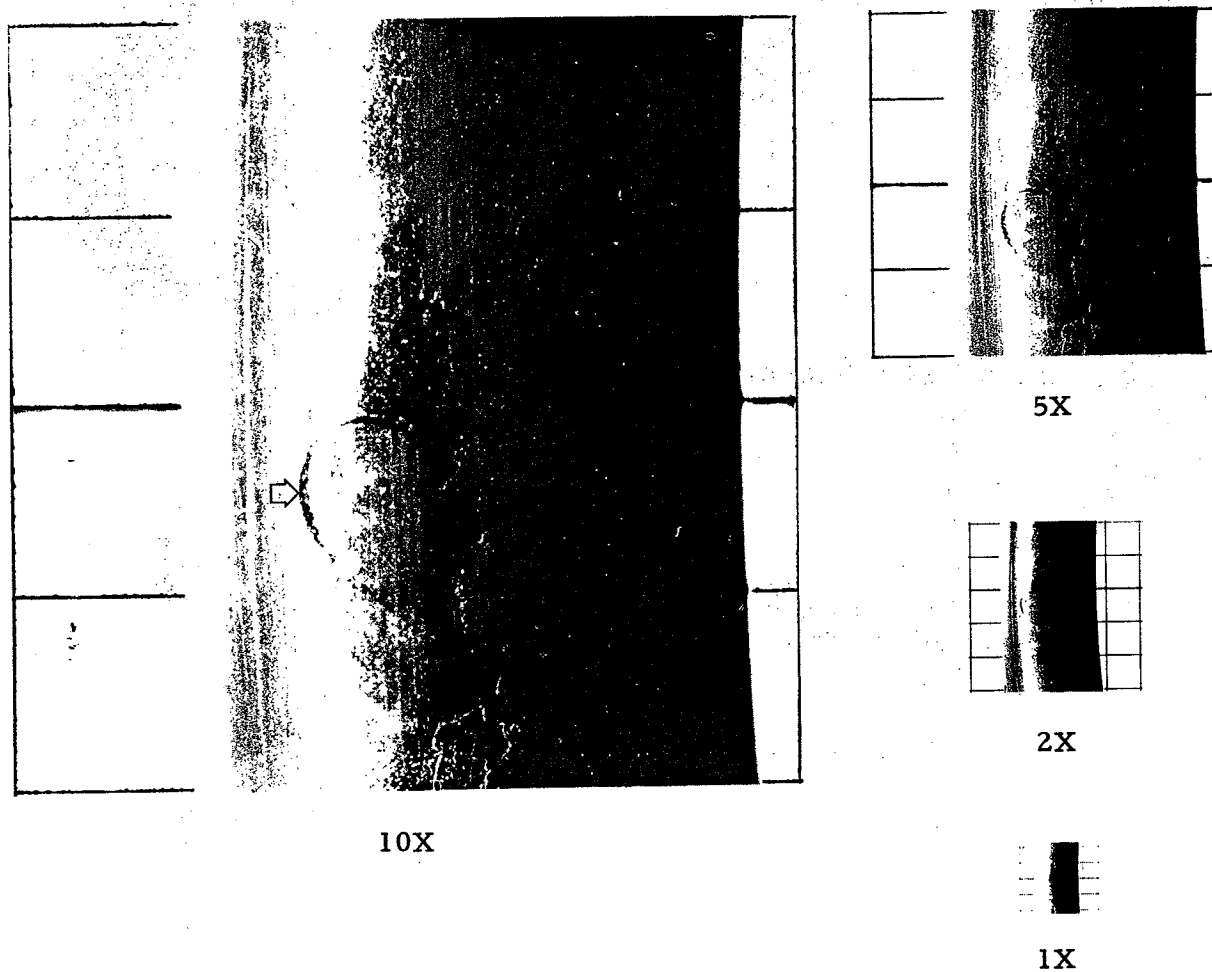


Figure 69 - Mold deposit defect, major, $W = 0.275$ inch.

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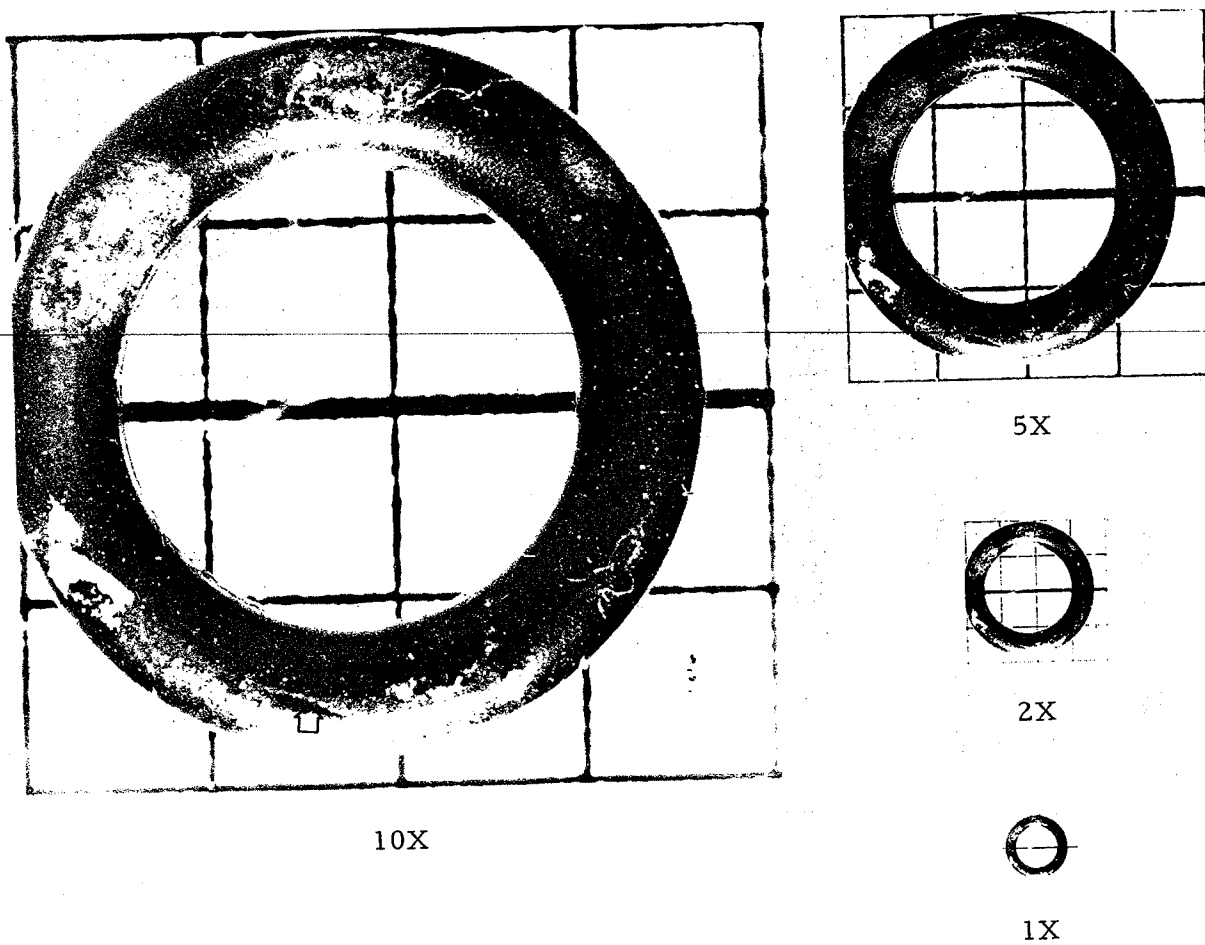


Figure 70 - Flow marks, major, $W = 0.070$ inch.

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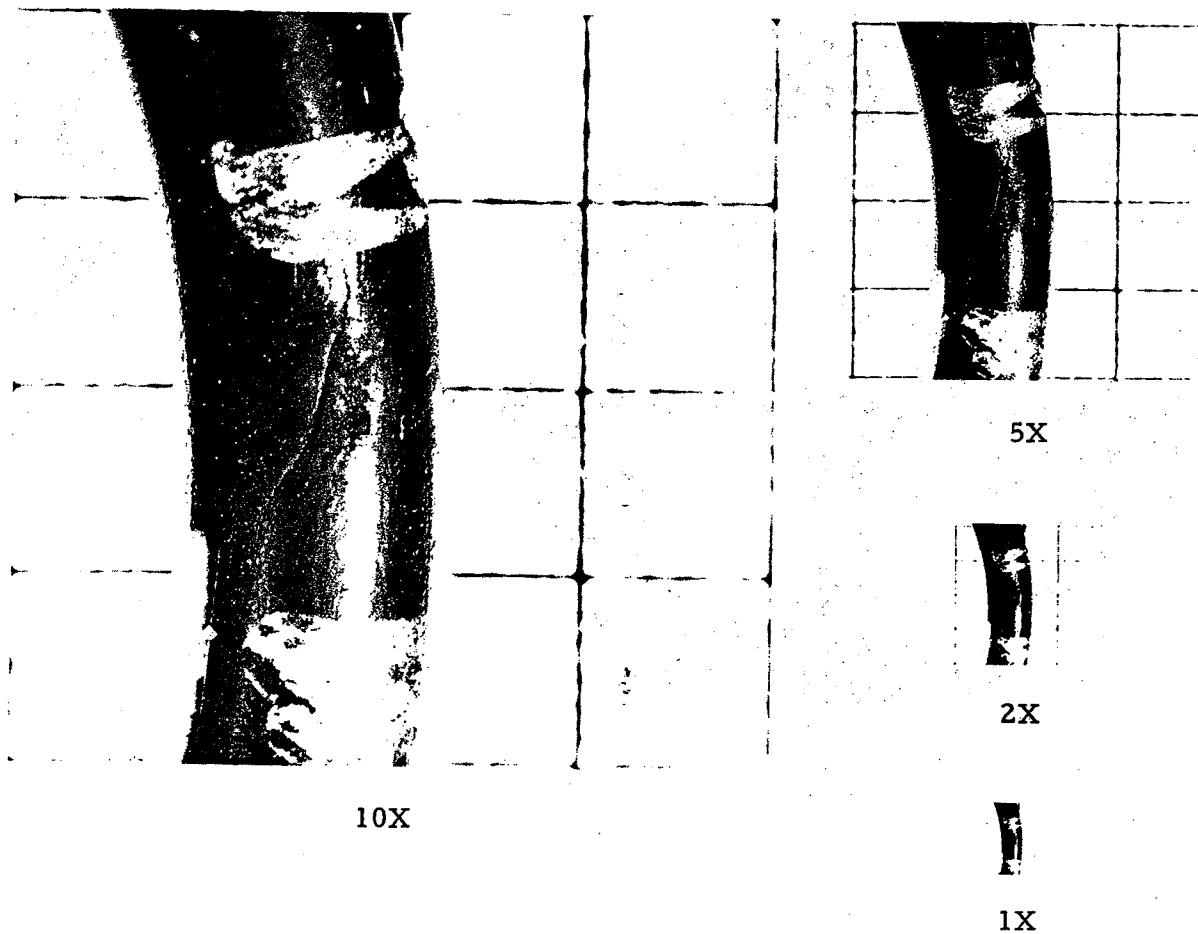


Figure 71 - Flow marks, major, $W = 0.139$ inch.

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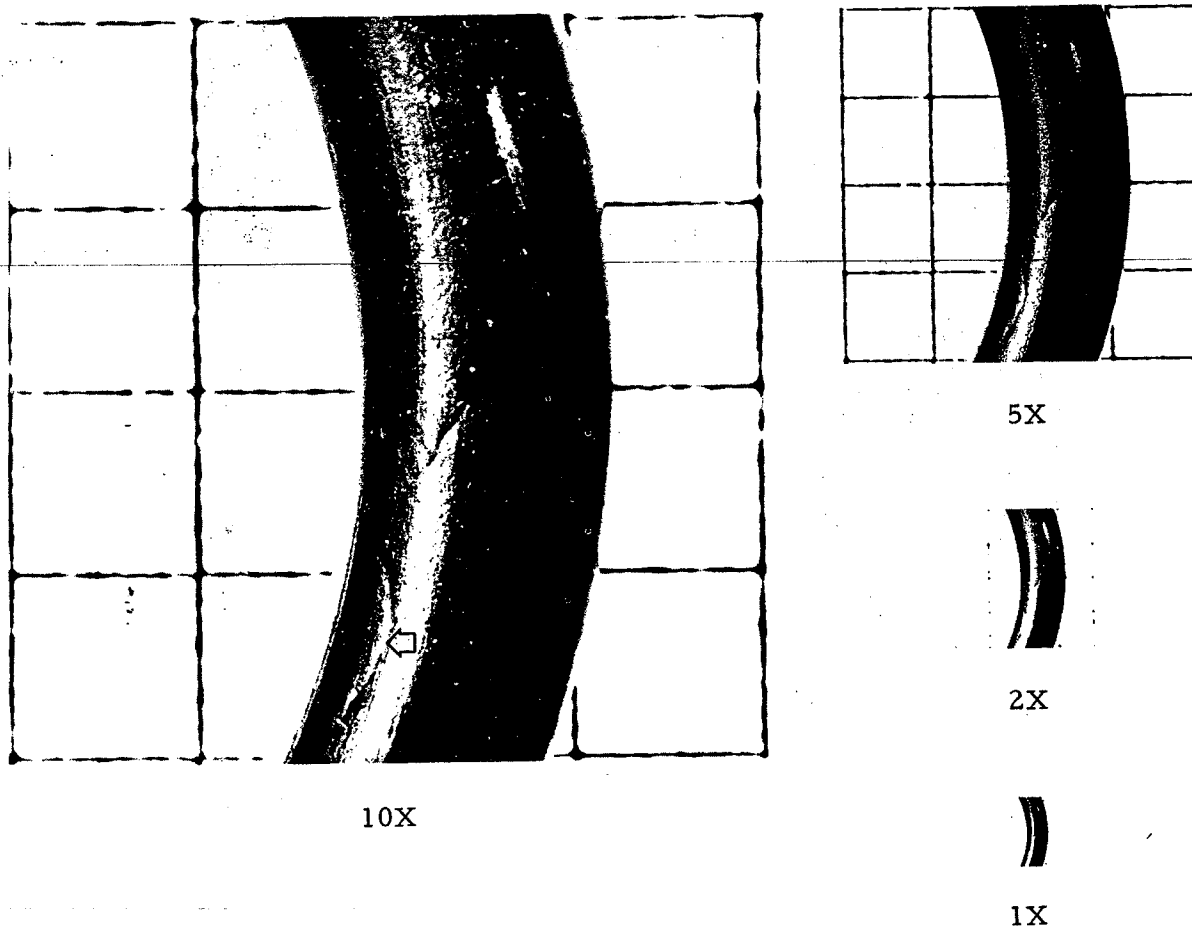


Figure 72 - Flow marks, minor, W = 0.139 inch.

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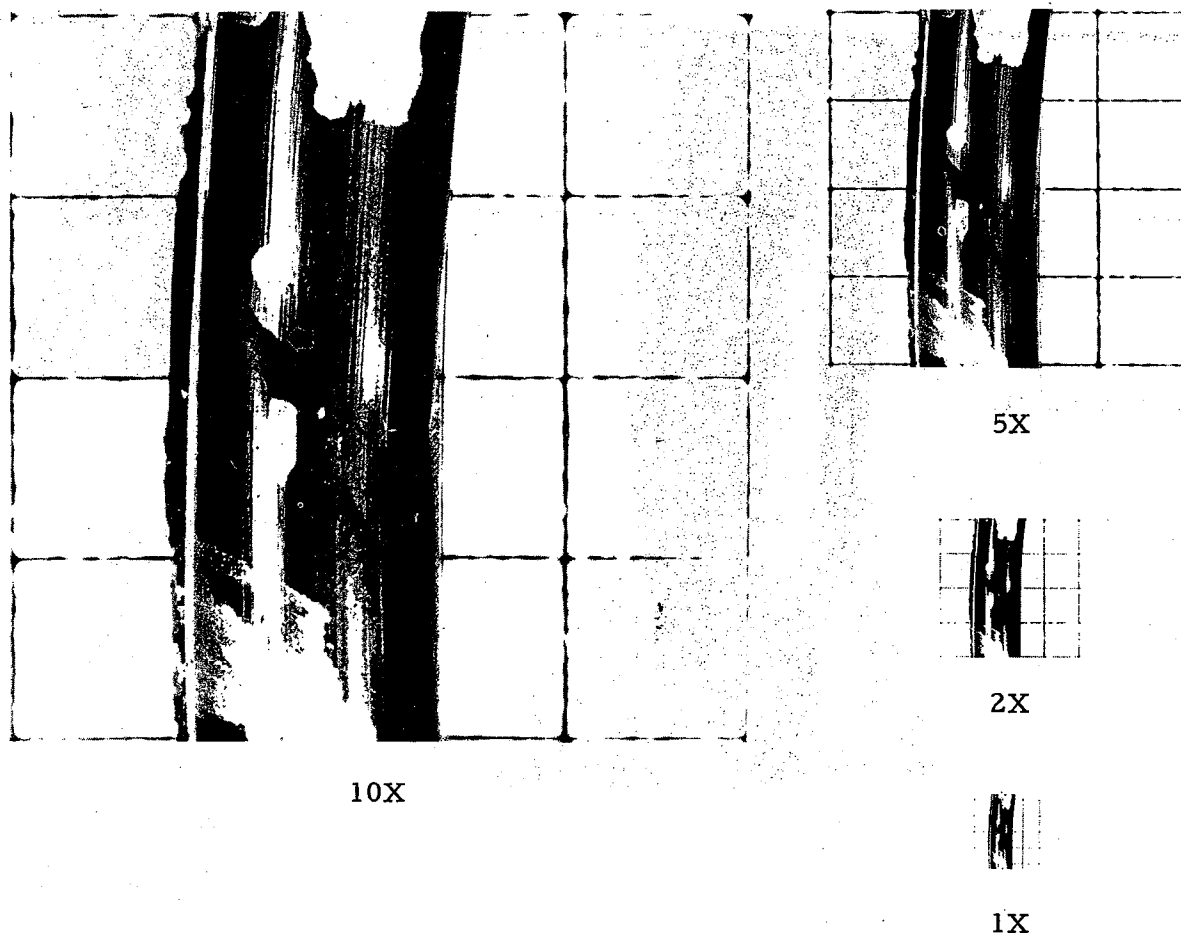


Figure 73 - Flow marks, major, $W = 0.139$ inch.

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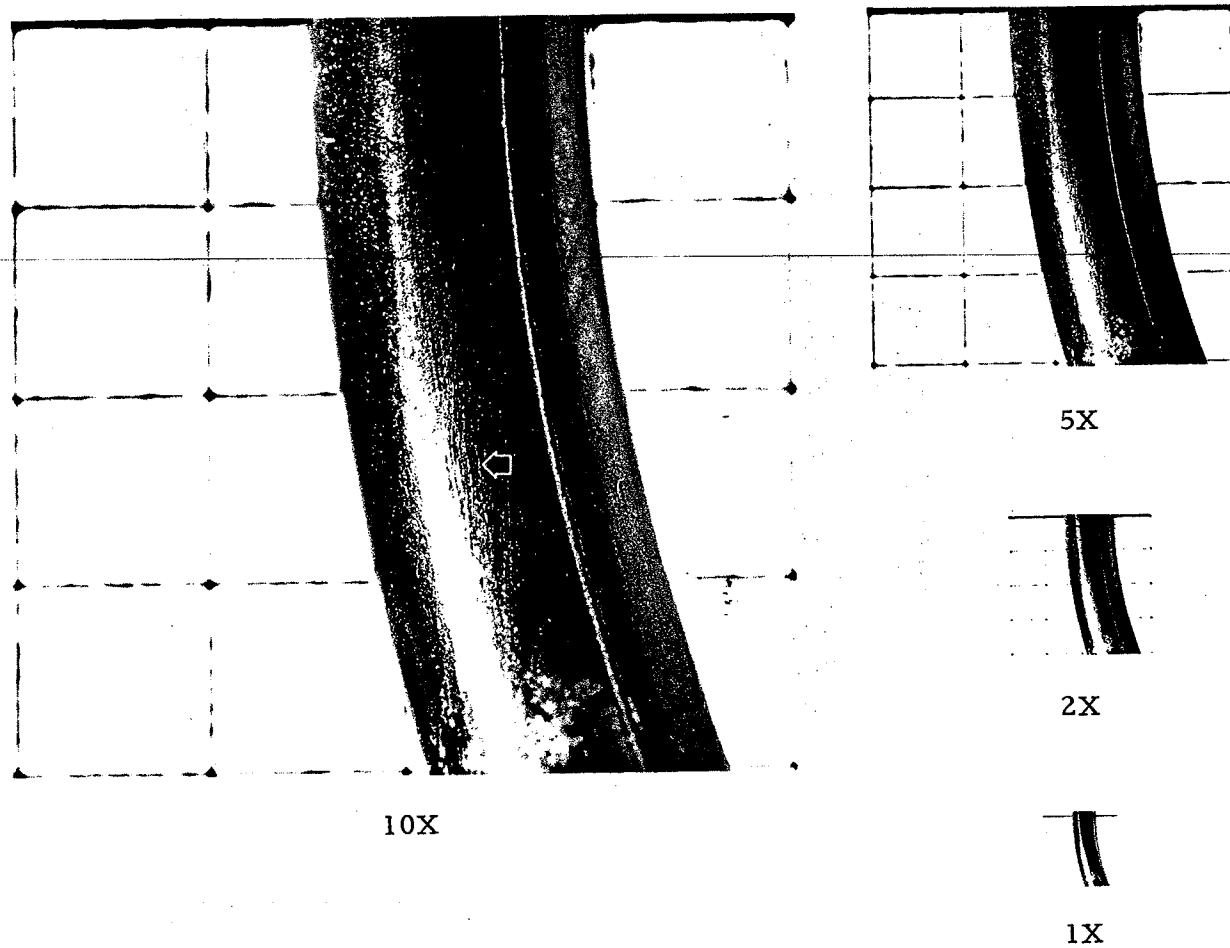
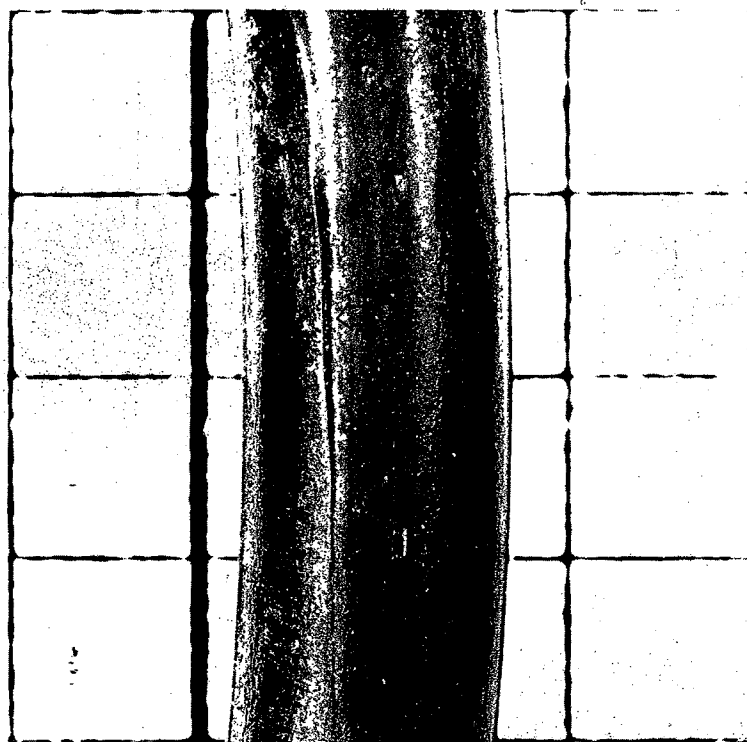
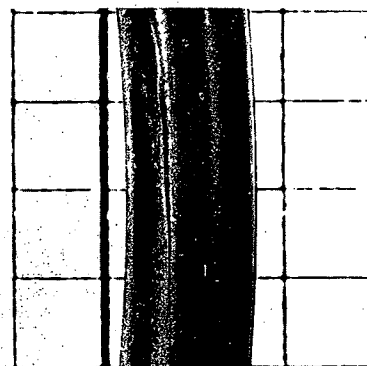


Figure 74 - Flow marks, minor, $W = 0.139$ inch.

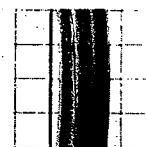
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10X



5X



2X



1X

Figure 75 - Flow marks, major, $W = 0.139$ inch.

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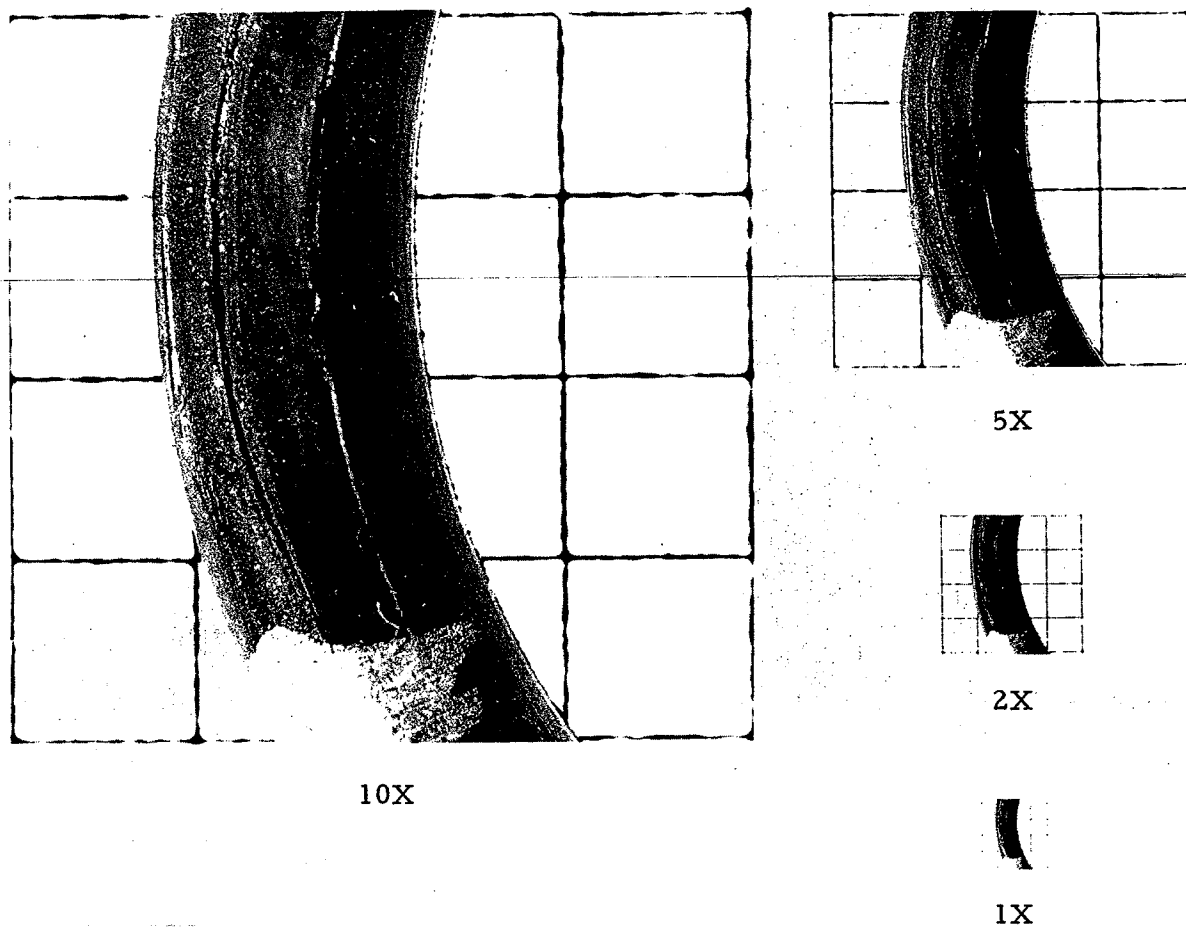


Figure 76 - Flow marks, major, $W = 0.139$ inch.

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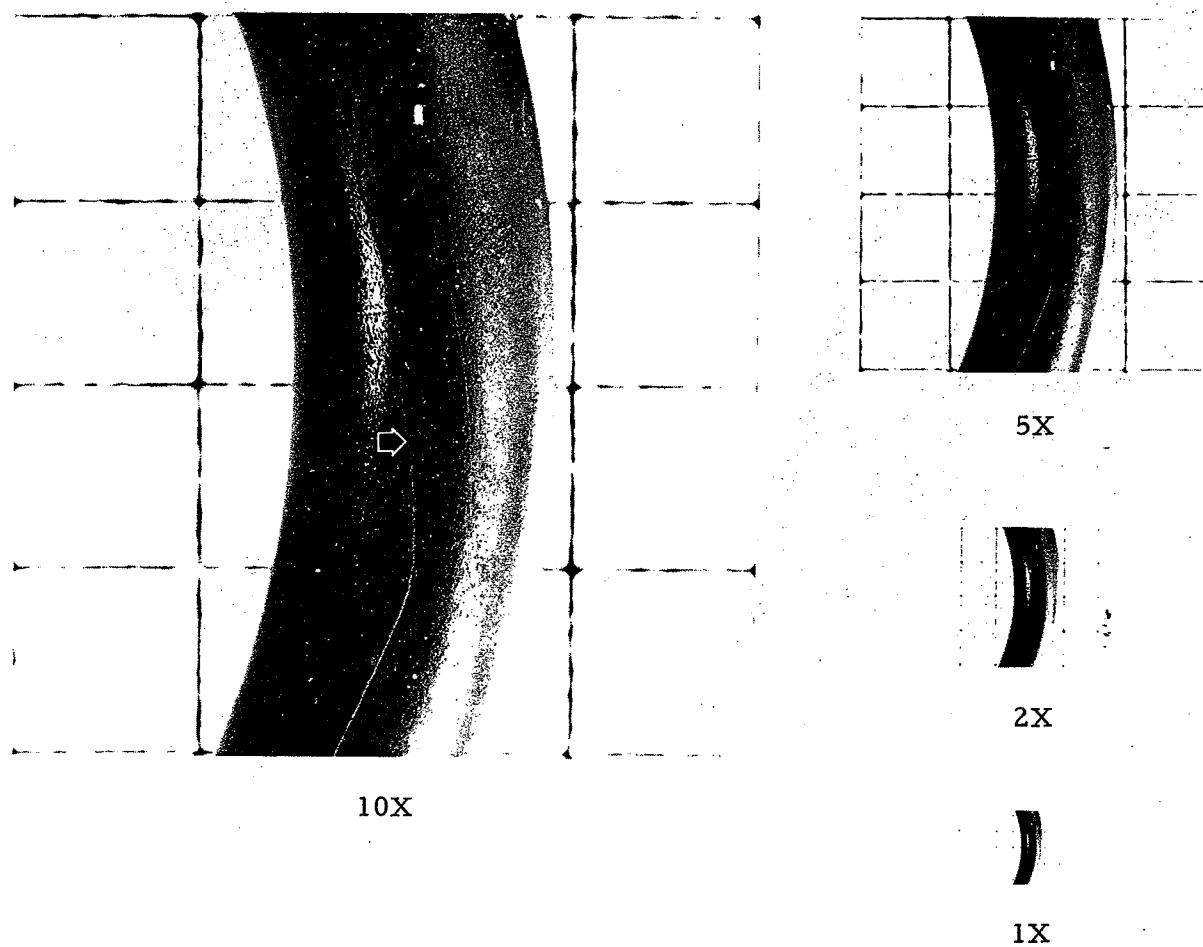
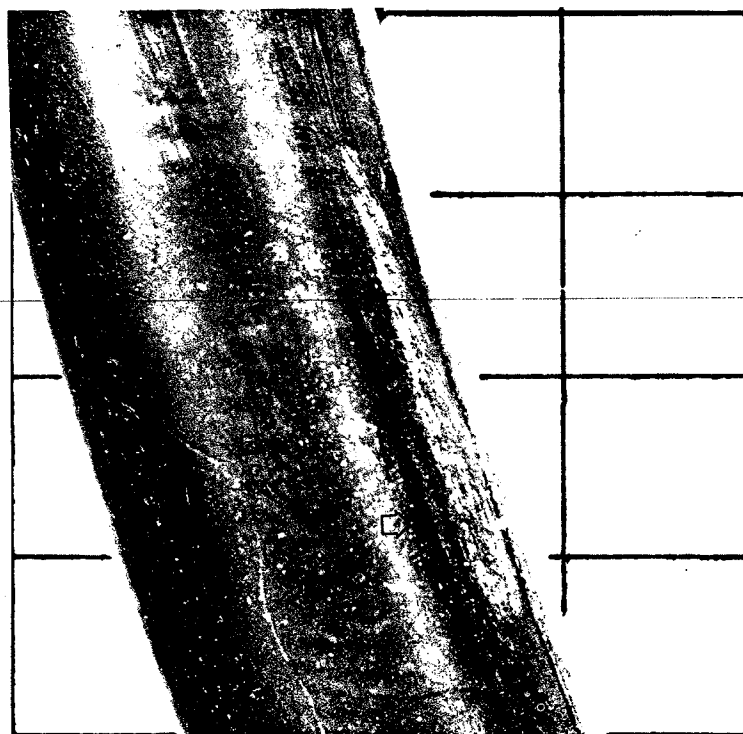


Figure 77 - Flow marks, minor, $W = 0.139$ inch.

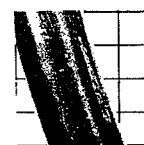
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10X



5X



2X



1X

Figure 78 - Flow marks, minor, $W = 0.210$ inch.

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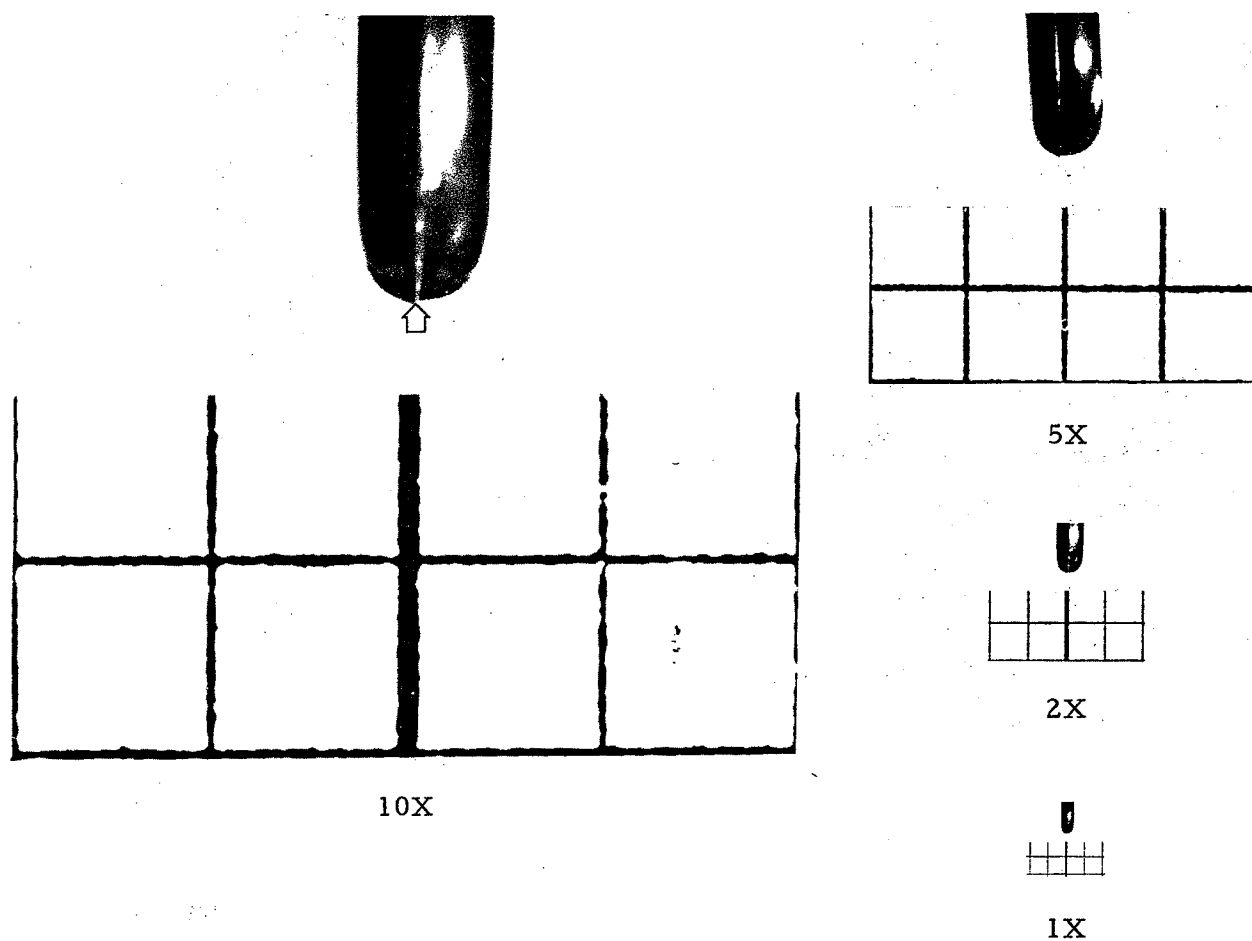


Figure 79.- Off-register and/or mismatch, major, $W = 0.070$ inch.

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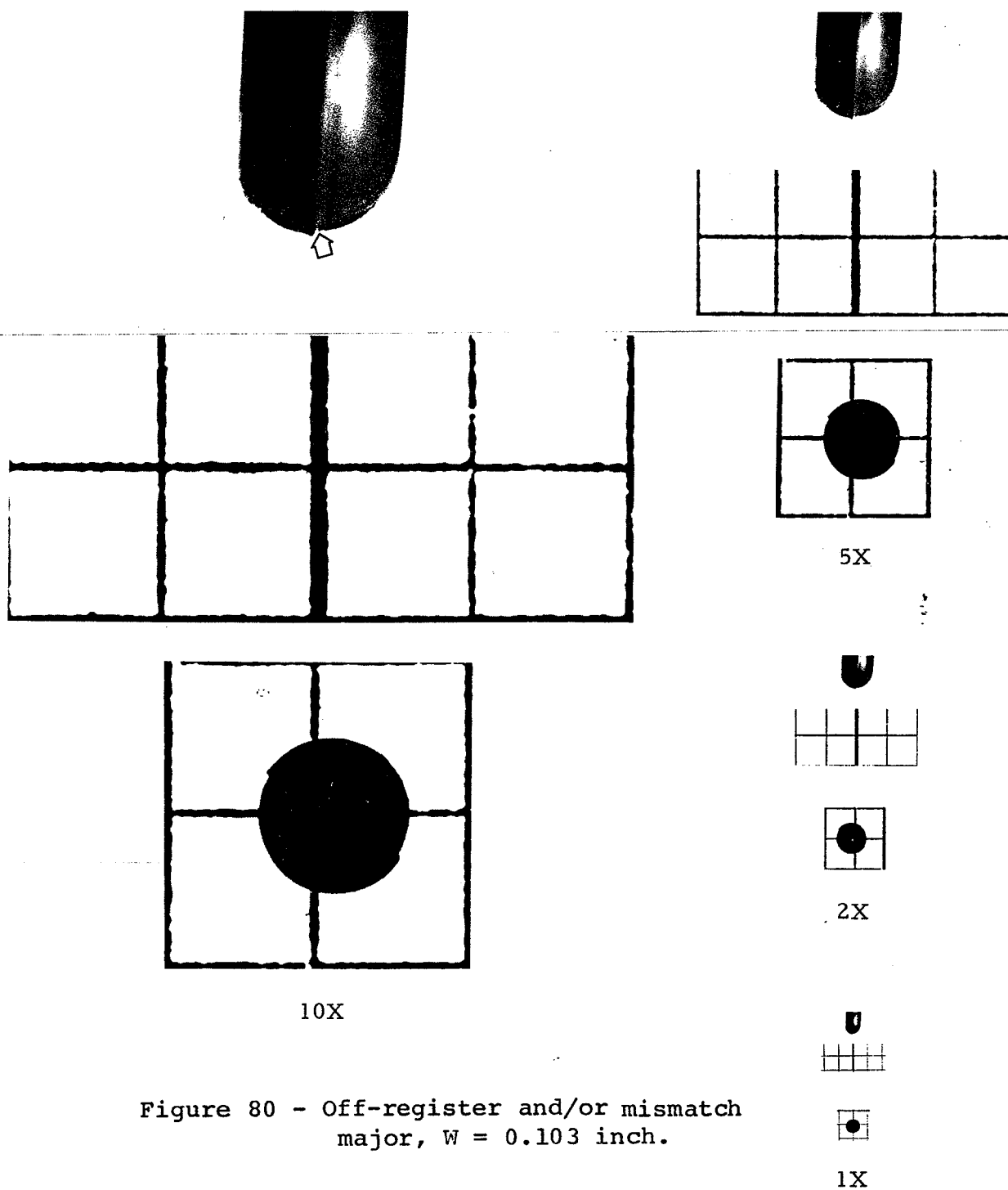


Figure 80 - Off-register and/or mismatch major, W = 0.103 inch.

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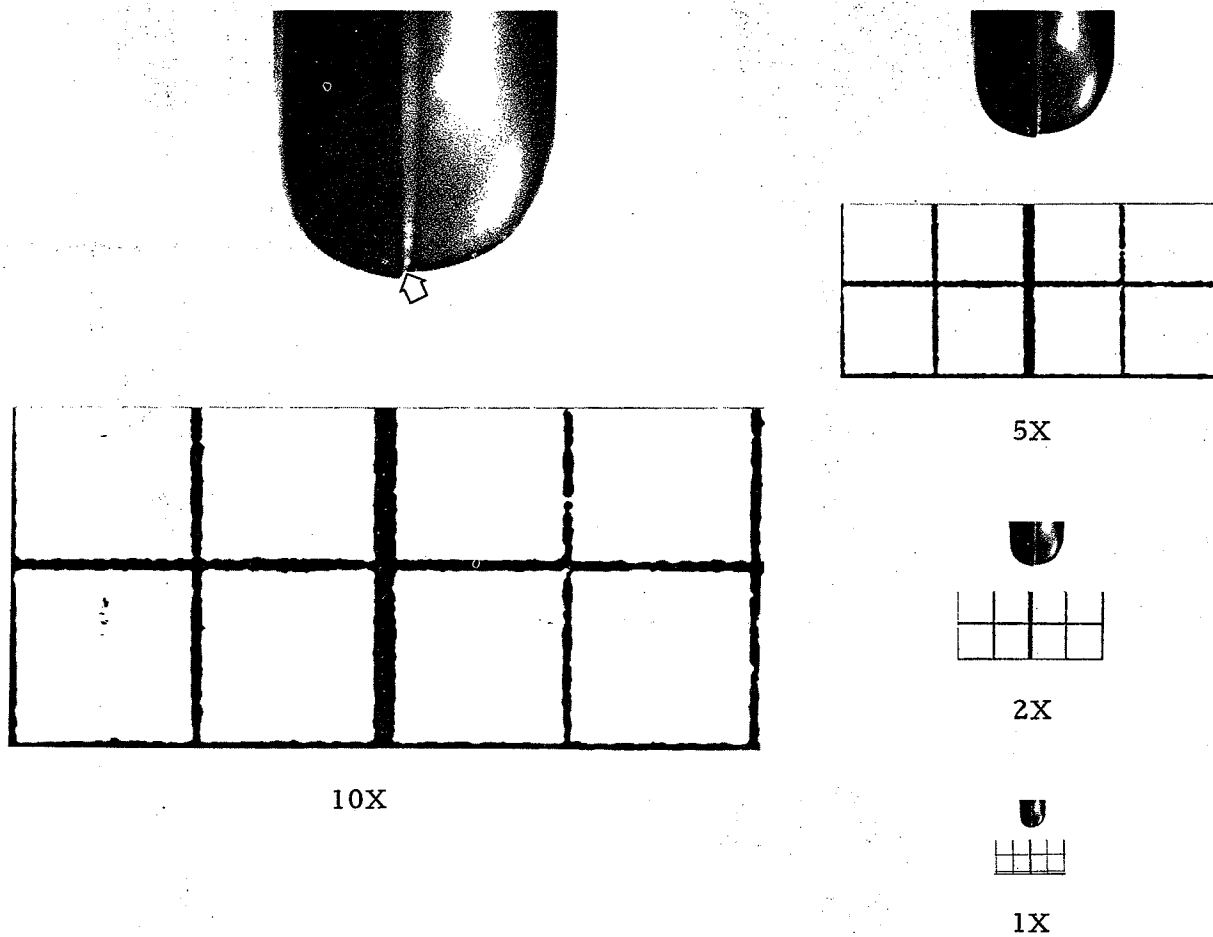


Figure 81 - Off-register and/or mismatch,
major, $W = 0.139$ inch.

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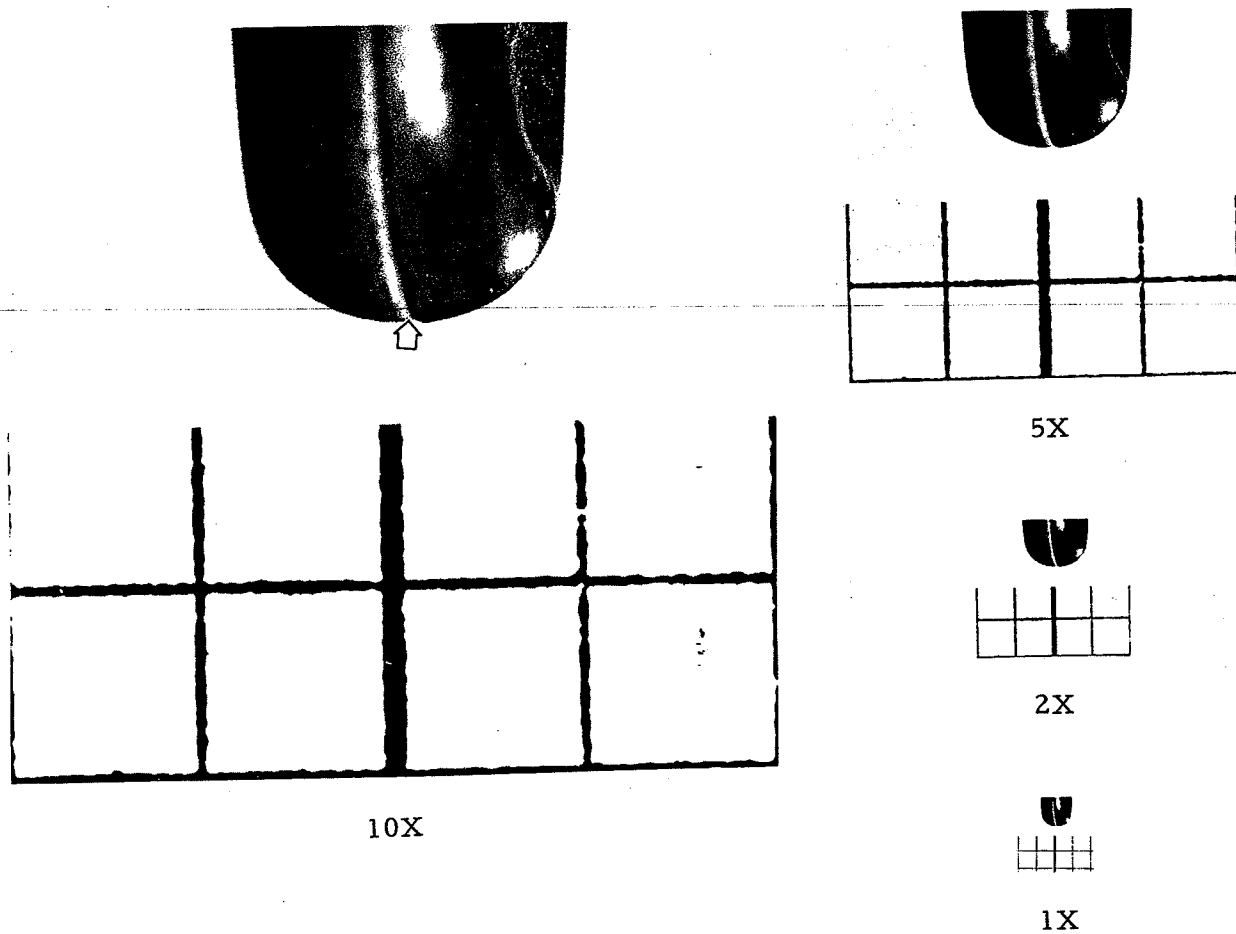


Figure 82 - Off-register and/or mismatch minor, $W = 0.139$ inch.

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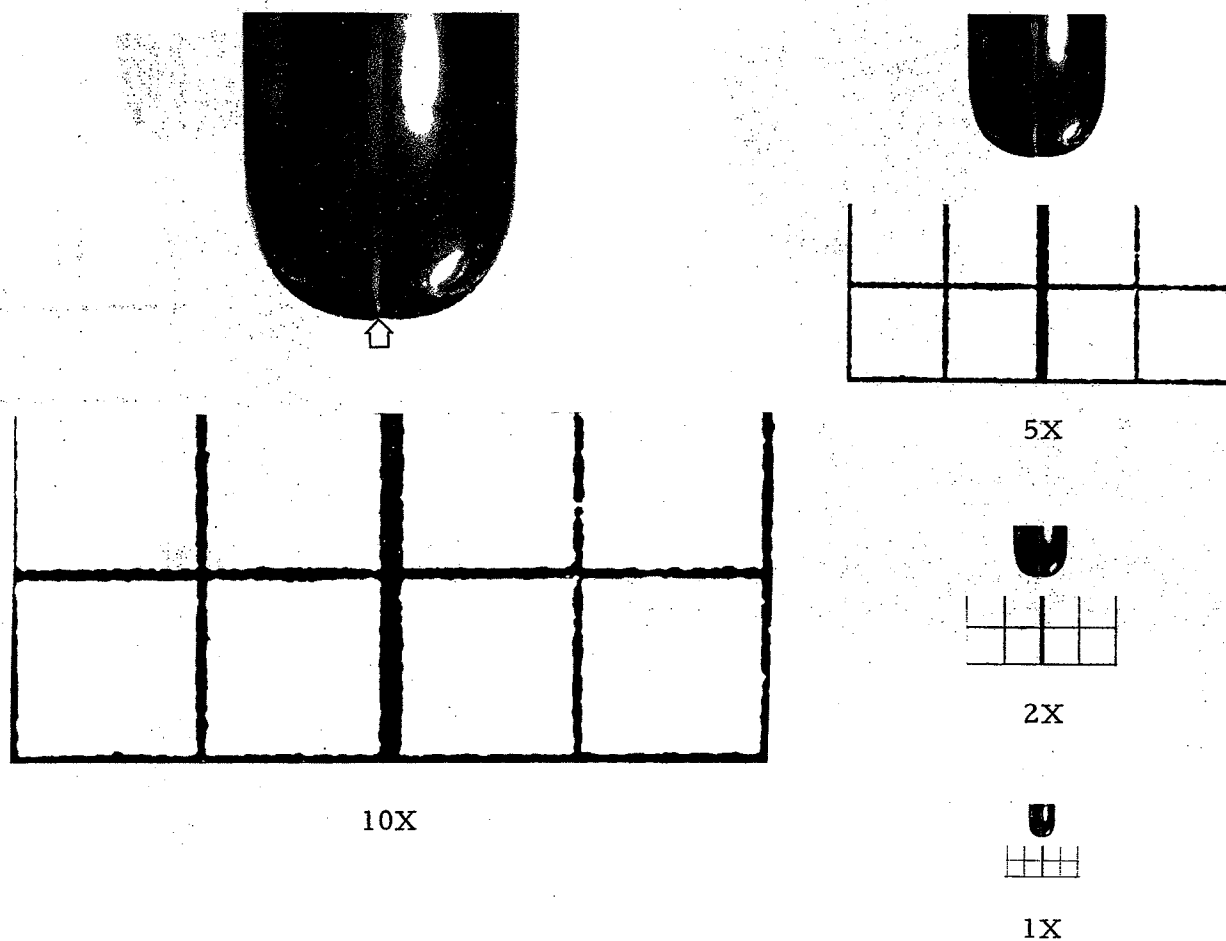
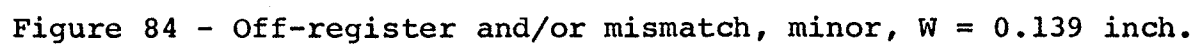


Figure 83 - Off-register and/or mismatch minor, $W = 0.139$ inch.



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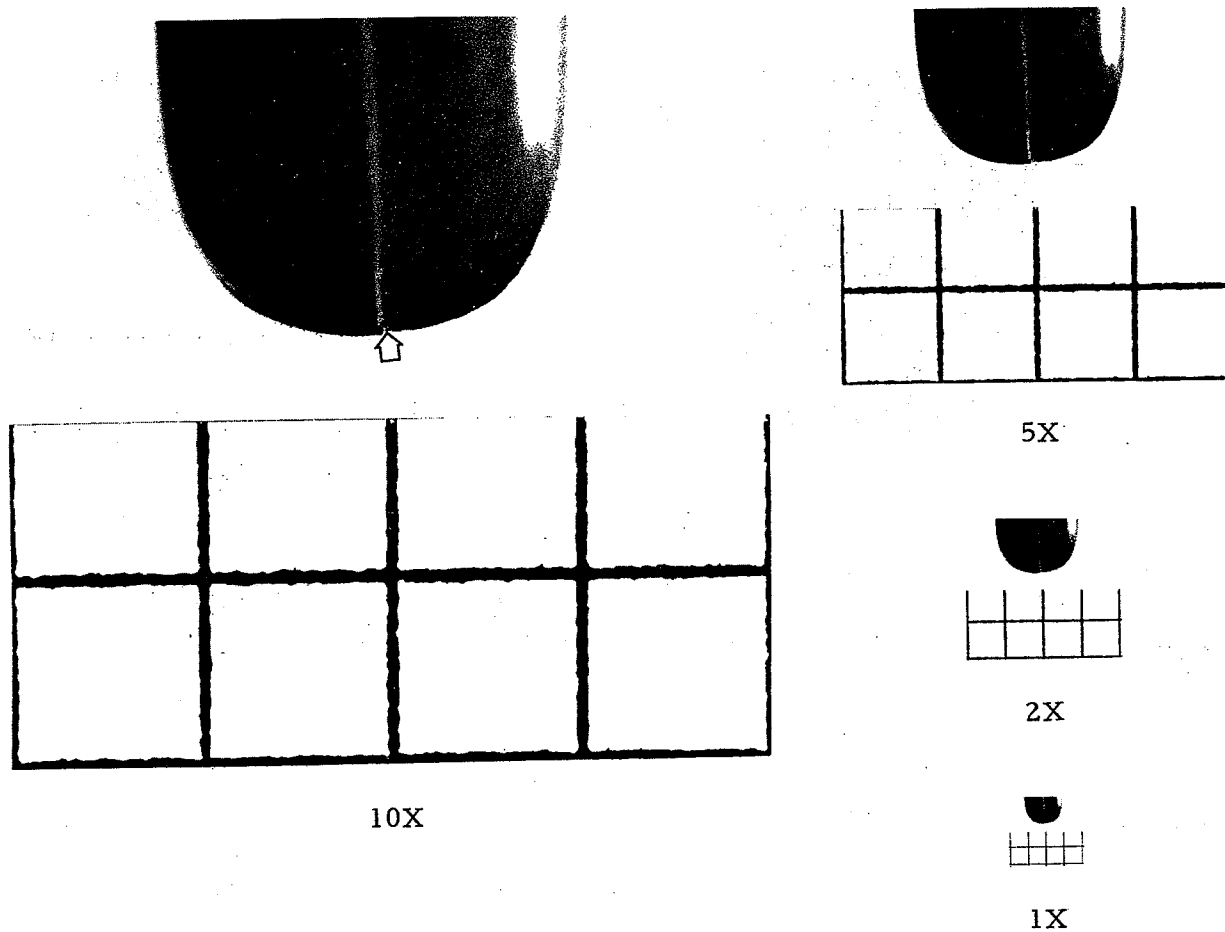


Figure 85 - Off-register and/or mismatch, minor, $W = 0.210$ inch.

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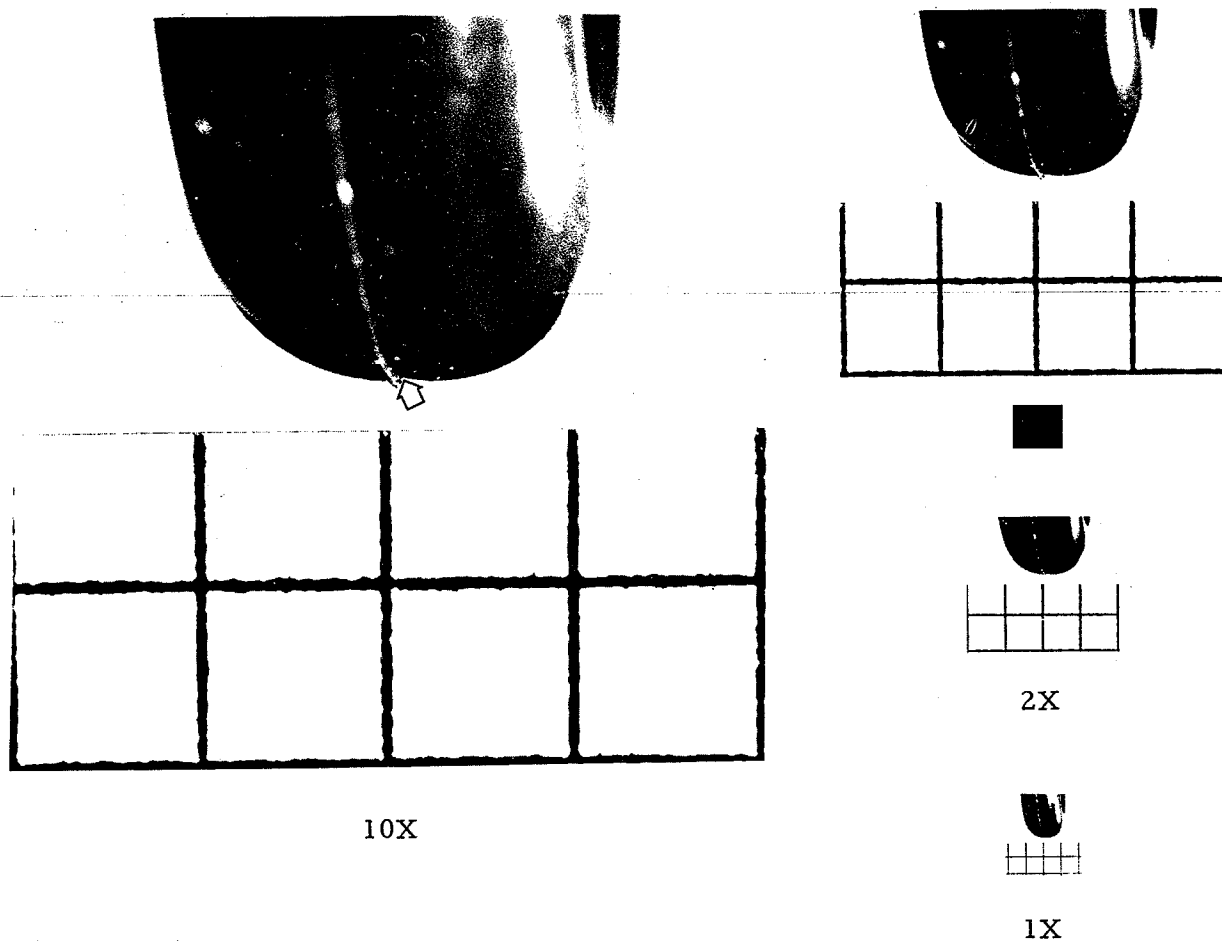


Figure 86 - Off-register and/or mismatch, major, $W = 0.210$ inch.