NATIONAL BUREAU OF STANDARDS REPORT

9588

Examination of

A Cracked 4¢ Lincoln Stamp Printing Plate

By

M. R. Meyerson
and
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To

Electrolytic Section
Bureau of Engraving and Printing

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] provides measurement and technical information services essential to the efficiency and effectiveness of the work of the Nation's scientists and engineers. The Bureau serves also as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. To accomplish this mission, the Bureau is organized into three institutes covering broad program areas of research and services:

THE INSTITUTE FOR BASIC STANDARDS . . . provides the central basis within the United States for a complete and consistent system of physical measurements, coordinates that system with the measurement systems of other nations, and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. This Institute comprises a series of divisions, each serving a classical subject matter area:

—Applied Mathematics—Electricity—Metrology—Mechanics—Heat—Atomic Physics—Physical Chemistry—Radiation Physics—Laboratory Astrophysics[2]—Radio Standards Laboratory,[2] which includes Radio Standards Physics and Radio Standards Engineering—Office of Standard Reference Data.

THE INSTITUTE FOR MATERIALS RESEARCH . . . conducts materials research and provides associated materials services including mainly reference materials and data on the properties of materials. Beyond its direct interest to the Nation's scientists and engineers, this Institute yields services which are essential to the advancement of technology in industry and commerce. This Institute is organized primarily by technical fields:

—Analytical Chemistry—Metallurgy—Reactor Radiations—Polymers—Inorganic Materials—Cryogenics[2]—Office of Standard Reference Materials.

THE INSTITUTE FOR APPLIED TECHNOLOGY . . . provides technical services to promote the use of available technology and to facilitate technological innovation in industry and government. The principal elements of this Institute are:

—Building Research—Electronic Instrumentation—Technical Analysis—Center for Computer Sciences and Technology—Textile and Apparel Technology Center—Office of Weights and Measures —Office of Engineering Standards Services—Office of Invention and Innovation—Office of Vehicle Systems Research—Clearinghouse for Federal Scientific and Technical Information[3]—Materials Evaluation Laboratory—NBS/GSA Testing Laboratory.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D. C., 20234.

[2] Located at Boulder, Colorado, 80302.

[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

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On April 12, 1967 a portion of a 4¢ Lincoln stamp plate was submitted to the Metallurgy Division, National Bureau of Standards for examination. This plate contained a number of fine cracks, barely visible to the unaided eye. A magnified view of one area containing these cracks is shown in figure 1. Additional magnification, figure 2, indicates that the cracks started in the small depressions which form the contours of the Lincoln image.

A small portion containing a crack across the entire width was removed and attempts were made to completely fracture the portion through the pre-cracked surface. This was done in an attempt to open and examine the entire length of the original fracture surface so as to determine the type of fracture and establish a time of occurrence, i.e., prior to or after heat treatment. However, the core was too tough and did not fail under repeated hammer blows.

Another section containing cracks, designated area 1, was removed and prepared for metallographic examination in cross section. The area selected, figure 3, shows one crack starting at or propagating through a small depression and two other cracks in a flat area of the plate. The white layer shown in figures 3 and 4 is essentially all martensitic and very hard, the underlying black and white area is a softer slack quenched structure containing pearlite and some martensite. This duplex structure is normal for case hardened steels of this type and has been observed many times in past investigations. It is interesting to note that the cracks penetrated into the plate only as far as the slack-quenched structure, where the superior ductility of this softer structure provided an effective barrier.

A microhardness survey (Knoop, 200 gram load) was made on the mounted metallographic specimen to establish the degree of hardness in the different portions of the cross section. Hardness in the martensitic case ranged from 632 KHN to 750 KHN which is approximately equivalent to R_c 55 - R_c 61. The base metal had a range of hardness of 304 KHN to 332 KHN approximately equivalent to R_c 29 to R_c 33. These hardness values are considerably greater than those encountered in previous investigations as can be seen from the summary in table 1.

Table 1. Cross Sectional Hardness Obtained in Several Prior Investigations

Date	Report No.	Stamp or Plate	Case Hardness,* R_C	Core Hardness,* R_B
March 1958	5795	15¢ airmail	38	90
March 1958	5795	3¢ liberty	31	90
Feb. 1963	7805	MP2 (plate No.)	-	93
Feb. 1963	7805	M4 (plate No.)	-	93
July 1963	8044	5¢ Washington	46	95
April 1967	9512	Plate evaluation	42	22 R_C
Present investigation		4¢ Lincoln (area 1)	61	29 R_C
Present investigation		4¢ Lincoln (area 2)	55	99

* Converted from Knoop.

Hardness obtained on the original surface was 78.9, 80.0, and 79.1 R_{15N} These values are in agreement with values obtained at the Bureau of Engraving and Printing and are within their normal range.

Because hardness as measured on a cross section was so high, the mounted specimen was reexamined and found to be a cross section through a gripper slot. The thickness of the plate in this area was considerably less than the nominal 1/4 inch-plate thickness because of the gripper slot, and this in turn was believed to have contributed to a locallized increase in cooling rate during quenching. To verify this observation a second specimen was cut from the stamp plate (designated area 2 in table 1), mounted in bakelite, polished, and a hardness survey taken. The maximum case hardness of R_C 55 and minimum core hardness of R_B 99 was much closer to values found on previous plates, but still somewhat high.

The plate had been heat treated in accordance with the standard practice followed at the Bureau of Engraving and Printing. The bent plate was austenitized at 1550° F for 36 minutes, quenched in oil, and double tempered at 450° F for 2 hours (total 4 hours). After heat treatment the plate was chromium plated and fitted to a printing drum. In the fitting process it is probable that some local bending may have been applied. It is believed that cracking occurred during this process, starting in the depressions forming the Lincoln image. The specimens examined had no chromium plate on them; a check with Mr. Paul Krasly indicated that the plate had been stripped prior to submission.

The slightly high hardness found in the cross section of the plate away from the gripper slots indicates a lower degree of ductility and higher notch sensitivity than may be desirable. This condition could contribute to cracking either during fitting or during the printing operation. It is hoped that this type of failure is an isolated case which will not occur again. If it should, steps should be taken in the heat treating process to lower the final hardness levels. This could be done by adjusting either the hardening or tempering procedure.

The high hardness encountered in the areas of the gripper slots was unexpected but can be explained as being due to the faster cooling rates on quenching experienced in the areas of reduced plate thickness. Any bending of these areas after hardening would be particularly subject to cracking, and should be avoided wherever possible. It would not be practicable to reduce the hardness in the slotted areas to that of the overall plate, but the same treatment applied to the entire plate to reduce hardness slightly would be beneficial in the gripper slot area also.

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Figure 1. Surface of the plate in the cracked area. X 5.
Location of one crack is indicated by A.

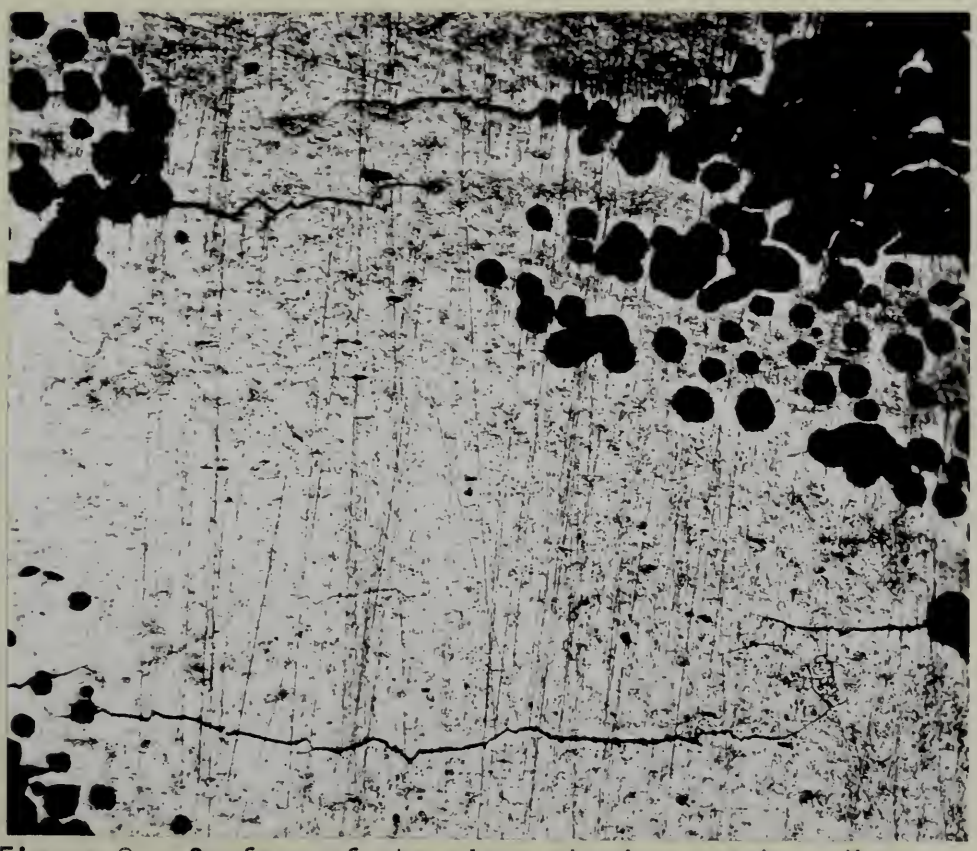

Figure 2. Surface of the plate showing cracks. X 50.

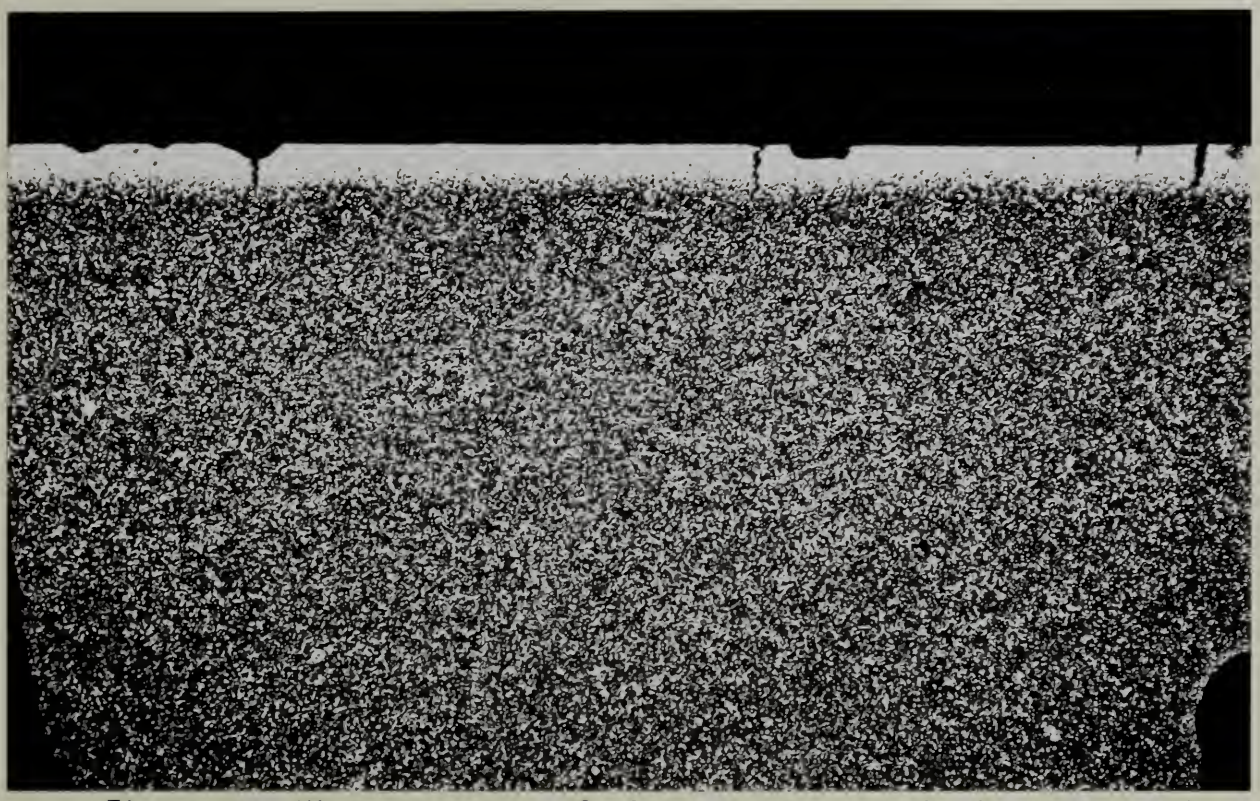

Figure 3. Microstructure of plate showing cracks in martensitic case. X 50.

Figure 4. Microstructure of plate showing crack in martensitic case. X 500.


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