NATIONAL BUREAU OF STANDARDS REPORT

10 040

EXAMINATION OF ELECTROFORMED NICKEL PRINTING PLATE SAMPLES J-1, J-2, 695-B AND 695-T

To

Electrolytic Section
Bureau of Engraving and Printing

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards [1] was established by an act of Congress March 3, 1901. Today, in addition to serving as the Nation's central measurement laboratory, the Bureau is a principal 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 this end the Bureau conducts research and provides central national services in four broad program areas. These are: (1) basic measurements and standards, (2) materials measurements and standards, (3) technological measurements and standards, and (4) transfer of technology.

The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Radiation Research, the Center for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with 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. The Institute consists of an Office of Measurement Services and the following technical divisions:

Applied Mathematics—Electricity—Metrology—Mechanics—Heat—Atomic and Molecular Physics—Radio Physics [2]—Radio Engineering [2]—Time and Frequency [2]—Astrophysics [2]—Cryogenics.[2]

THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; develops, produces, and distributes standard reference materials; relates the physical and chemical properties of materials to their behavior and their interaction with their environments; and provides advisory and research services to other Government agencies. The Institute consists of an Office of Standard Reference Materials and the following divisions:

Analytical Chemistry—Polymers—Metallurgy—Inorganic Materials—Physical Chemistry.

THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations in the development of technological standards, and test methodologies; and provides advisory and research services for Federal, state, and local government agencies. The Institute consists of the following technical divisions and offices:

Engineering Standards—Weights and Measures — Invention and Innovation — Vehicle Systems Research—Product Evaluation—Building Research—Instrument Shops—Measurement Engineering—Electronic Technology—Technical Analysis.

THE CENTER FOR RADIATION RESEARCH engages in research, measurement, and application of radiation to the solution of Bureau mission problems and the problems of other agencies and institutions. The Center consists of the following divisions:

Reactor Radiation—Linac Radiation—Nuclear Radiation—Applied Radiation.

THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides technical services designed to aid Government agencies in the selection, acquisition, and effective use of automatic data processing equipment; and serves as the principal focus for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Center consists of the following offices and divisions:

Information Processing Standards—Computer Information — Computer Services — Systems Development—Information Processing Technology.

THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System, and provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information [3]—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

---

[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.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
3120641

MAY 29 1969

NBS REPORT
10 040

EXAMINATION OF ELECTROFORMED NICKEL PRINTING PLATE SAMPLES J-1, J-2, 695-B AND 695-T

By
I. J. Feinberg
Engineering Metallurgy Section
Metallurgy Division

To
Electrolytic Section
Bureau of Engraving and Printing

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Examination of Electroformed Nickel Printing
Plate Samples J-1, J-2, 695-B and 695-T

Material Submitted: Four strips representative of electroformed plate material described in Table I were submitted for examination of mechanical properties and microstructure. As received, the strips had a smooth as-electroformed finish on the printing face and a ground finish on the back face.

Hardness: Macrohardness measurements obtained on the strips are as follows:

Strip No.	Hardness, Rockwell 15T	
	Printing Face	Back
J-1	87.8	87.6
J-2	87.4	87.6
695-B	89.0	87.6
695-T	87.8	87.6

Microhardness measurements were made on the cross-sectional surfaces of mounted specimens. The values obtained using a Knoop indentor, 200 gram load and 20X objective are as follows:

Strip No.	Adjacent to Printing Face		Mid-Section		Adjacent to Back	
	KHN	Approximate Rockwell B, Equivalent	KHN	Approximate Rockwell B, Equivalent	KHN	Approximate Rockwell B, Equivalent
J-1	220.0	93.8	184.4	86.0	203.0	90.5
J-2	202.0	90.2	178.9	84.2	181.3	85.3
695-B	239.5	97.8	196.8	89.0	193.3	88.3
695-T	235.2	96.8	183.2	85.7	186.0	86.5

Tensile Properties: A tensile test specimen with a nominal 0.400 inch width and 2.00 inch gage length in the reduced section was prepared from each strip. As-received thickness of the strips was maintained in the machined tensile test specimens. Tensile properties obtained are given in Table [illegible].

Metallographic Examination: All of the plate samples had a columnar grain structure characteristic of electroformed nickel. The columnar grains observed in J-1, J-2 and 695-T, Figures 1a, 1b and 1d, respectively, are quite similar in size; while the columnar grains observed in 695-B, Figure 1c, are smaller than that in the other samples. Figure 2, at a lower magnification, shows layers of very fine columnar grains adjacent to the printing faces of the electroformed plates. The layers in strips J-1

and J-2 have no well-defined depth and blend gradually into the coarser columnar grains that predominate in the structure. The layers, approximately 0.002 inch deep, in 695-B and 695-T, are sharply defined and appear to have resulted from some interruption or change in the electroforming process.

Discussion and Conclusions: The average tensile strengths of the "J" and "695" samples are identical and the average yield strengtn of the "J" samples is lower than that of the "695" samples. The yield strength and ultimate tensile strength obtained for the subject samples are lower and the percent elongation higher than that obtained in a previous test on electroformed material produced in a sulfamate bath and reported in Table 3, NBS report No. 9522.

The average Rockwell 15T macrohardness of the printing face of the "J" samples is slightly lower than that of the "695" samples; while the Rockwell 15T hardness of the back faces of all of the samples are identical. Microhardness measurements, Knoop and related Rockwell B equivalents, indicated that the hardness adjacent to the printing face and in the midsection of the "J" material was lower than that in the "695" material.

The structures of all of the samples were free of voids. The characteristic columnar grains of electroformed nickel were observed in all of the samples. Fine columnar grains adjacent to the printing faces of the "J" samples blended gradually into the coarser columnar grains predominating in the structure of these samples. A sharply defined layer of fine columnar grains was observed adjacent to the printing faces of the "695" samples. This layer appears to have resulted from some interruption or change in the electroforming process. It could have been formed by removal of the plate from the electroforming bath, by a change in current density, bath composition or bath temperature.

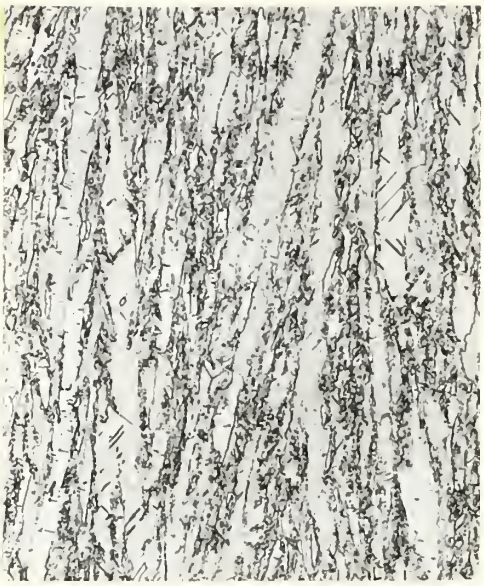
Table 1. Identification of Electroformed Nickel Plate Test Strips

BE&P Identification	Thickness Inch	Bath Type	Strip Origin
J-1	0.0614	Sulfamate	It is uncertain whether J-1 and J-2 are from the same plate or from two different plates.
J-2	0.0593	Sulfamate	
695-B	0.0405	Sulfamate	Bottom of plate 695
695-T	0.0402	Sulfamate	Top of plate 695

Table 7. Tensile Properties of Electroformed Nickel Plate Material

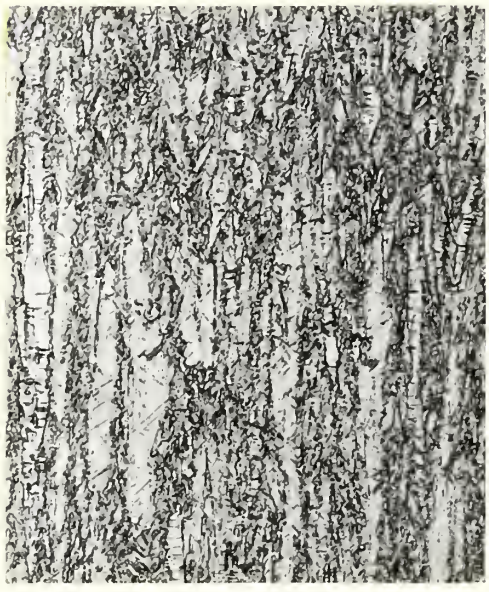
Item	Yield Strength, 0.2% Offset psi	Ultimate Tensile Strength psi	Elongation in 2 Inches %
J-1	45,250	72,550	14.7
J-2	43,250	72,000	14.7
Average	44,250	72,275	14.7
695-B	49,850	75,550	17.3
695-T	42,800	69,000	17.0
Average	46,325	72,275	17.1
BE&P Plate Sample No. 39868B*	61,800	88,100	9.5
BE&P Plate Sample No. 39868T*	53,200	81,100	14.0
Average	57,500	84,600	11.7

* Sample examined in NBS report No. 9522

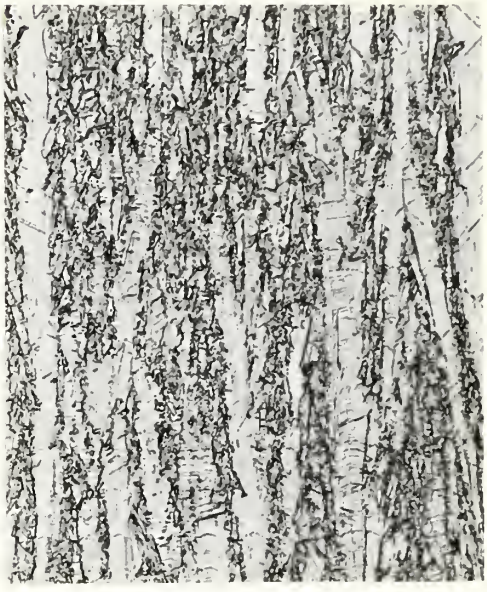


a

b



c.



d

Figure 1. Microstructures in transverse sections of electroformed nickel plates. Principal axes of columnar grains are normal to plate surfaces. Etched with Carapella's reagent. X 250.

a. Plate J-1.
b. Plate J-2.
c. Plate 695-B.
d. Plate 695-T.

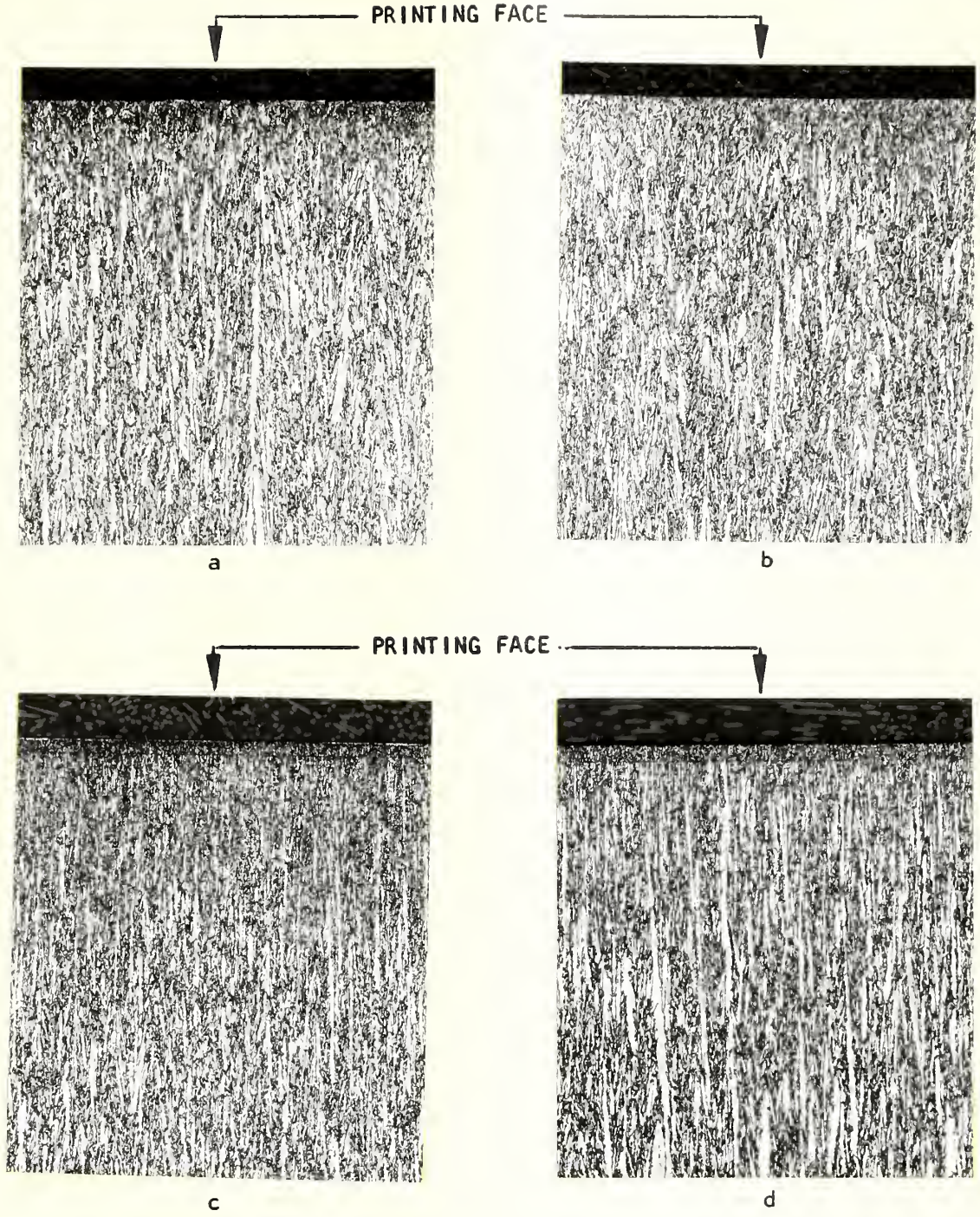
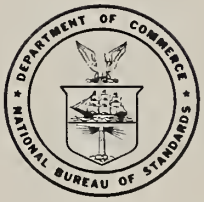


Figure 2. Microstructures adjacent to printing face of plates. Etched with Carapella's reagent. X 50.

a. Plate J-1.
b. Plate J-2.
c. Plate 695-B.
d. Plate 695-T.

Note the well defined layer of fine columnar grains approximately 0.002 inch thick adjacent to the printing face of plates 695-B and 695-T.


DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS