NATIONAL BUREAU OF STANDARDS REPORT

9522

Examination of

Electroformed Printing Plates

By

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To

Electrolytic Section
Bureau of Engraving and Printing

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Examination of Electroformed Printing Plates

Material Submitted: Twelve strips removed from electroformed plates and identified in Table 1 were submitted for examination of mechanical properties and microstructure. As received, the strips were as electroformed (bright, smooth finish) on one face and ground on the other.

The strips were submitted because plates of the types from which they were taken would stretch during usage and eventually exceed a usable size. This indicated that the yield strength of the electroformed plate materials was too low for the loads they were required to bear. Therefore the mechanical property tests and microexaminations were performed to establish quantitatively the nature of the plates.

Hardness: Macrohardness measurements obtained on strip specimens are as follows:

Specimen No.	Hardness, Polished Face	Rockwell A Ground Face
1A	54.0	54.2
1B	51.5	52.3
2A	46.1	45.9
2B	45.9	45.9
3A	52.5	52.0
3B	51.8	53.2
4A	53.0	56.9
4B	49.0	52.5
5A	37.5 (nickel)	39.9 (iron)
5B	38.2 (nickel)	39.2 (iron)
5C	37.4 (nickel)	39.0 (iron)
5D	36.3 (nickel)	38.8 (iron)

Microhardness measurements obtained using a Knoop indentor, 200 gram load and 20 X objective are as follows:

Specimen No.	KHN, Polished Face	Approx. Rockwell B, equivalent, Polished Face
1A	229	96
1B	182	89
2A	210	92
2B	227	95
3A	138	70
3B	225	95
4A	197	89
4B	218	93
5A	195	89
5B	142	71
5C	202	90
5D	202	90

Tensile Properties: Tensile test specimens 1A, 1B, 2A, 2B, 3A, 3B and 4B were prepared with a nominal 0.400 inch width and 2.00 inch gage length in the reduced section. Tensile test specimens 5A, 5B, 5C and 5D were prepared with a nominal 0.250 inch width and 2.00 inch gage length in the reduced section. As-received thickness of the strips was maintained in the machined tensile test specimens. Tensile properties obtained are given in Table 2.

Metallographic Examination: Figures 1a and 1b are photomicrographs of the unetched structures of specimens from plates 2A and 5A, respectively. The black round discontinuities in Figure 1a appear to be pores in the material. The illustration represents the worst condition of this type observed in all of the material. Figure 1b is presented to show the bond between the nickel and iron in 5A. The bond shown is representative of the good bond observed in all of the laminated Ni-Fe material.

Considerable variation in grain size was observed on examination of the etched structures of the nickel plates. An example of the thin relatively short columnar grains observed in plates 1A, 1B, 2A and 2B is shown in Figure 2a. Columnar grains intermediate in length found in plates 3A and 3B are shown in Figure 2b. Relatively long columnar grains observed in plates 4A and 4B are shown in Figure 2c.

Thin columnar grains observed in the nickel element of laminated plates 5A and 5B were similar in length and appearance (Figure 3a). Short columnar grains, not well defined, were observed in the nickel element of laminated plates 5C and 5D (Figure 3b). The unetched layer in the nickel element adjacent to the interface of the nickel and iron elements shown in both Figures 3a and 3b may be due to a composition effect. It appears that an iron rich Ni-Fe alloy in this area resisted attack by the etching reagent.

Discussion and Conclusions: Mechanical properties found for the all-nickel samples varied over a considerable range. There appears to be some correlation between the macrohardness (Rockwell A) on the polished surfaces and the yield strength and ultimate tensile strength of this material; the higher the Rockwell A hardness the higher the yield strength and ultimate tensile strength. It was also found, in general, that the higher the macrohardness the lower the ductility (percent elongation). No correlation between microhardness (KHN) and the other mechanical properties could be established. There was a perceptible correlation between macrohardness found on the polished faces and grain size; the finer the grain size the greater the hardness.

Mechanical properties for the nickel-iron samples showed little range. Except for ductility all mechanical properties in this group were lower than those found in the all nickel samples. The dissimilarity in the structure of the nickel elements in 5A and 5B versus 5C and 5D had no apparent effect on mechanical properties.

Exceptionally low microhardnesses were found on the polished faces of plates 3A and 5B. The porosity observed in the material is not considered to be detrimental.

As a result of these tests, it appears as though plates of the type from which specimens 1A and 1B were taken, would resist stretching to a greater degree than any of the other plates, and that the nickel-iron laminate plates would be the easiest to stretch. An obvious solution to the problem is to make plates with higher yield strengths either by changing plating procedures or going to higher strength metals or alloys. Another possibility involves the strengthening of nickel-iron composite plates by carburizing and strengthening the iron backing. This procedure is being investigated and will be reported separately.

Table 1. Identification of Electroformed Plate Test Strips

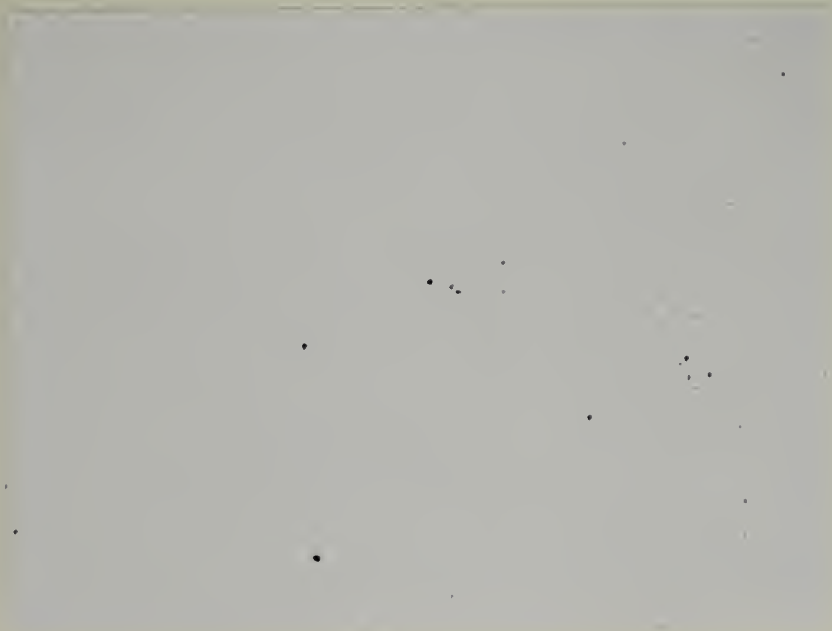
BU E & P Plate No.	NBS Identification	BU E & P Plating Tank	Bath Type	Material
39868 B	1A	1	Sulfamate	Nickel
39868 T	1B	1	"	"
39881 B	2A	3	Mod. Watts	"
39881 T	2B	3	" "	"
28915 B	3A	2	" "	"
28915 T	3B	2	" "	"
28925 B	4A	3	" "	"
28925 T	4B	3	" "	"
No Number	5A	-	- -	Nickel-Iron laminate
No Number	5B	-	- -	" " "
No Number	5C	-	- -	" " "
No Number	5D	-	- -	" " "

Table 2. Tensile Properties of Electroformed Plate Material

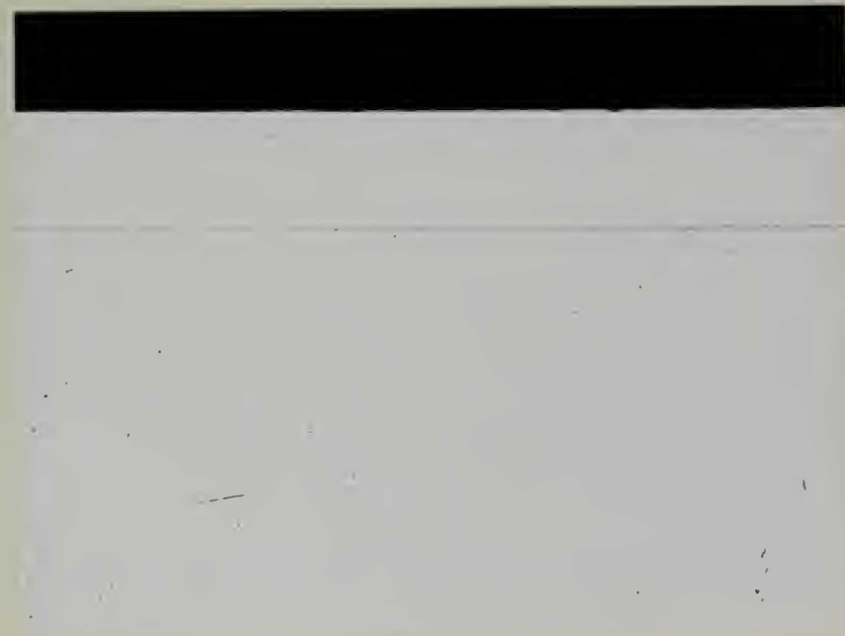
Specimen No.	Thickness of Test Specimen Inch	Yield Strength 0.2% Offset PSI	Ultimate Tensile Strength PSI	Elongation in 2 inches %
1A	0.0309	61,800	88,100	9.5
1B	0.0312	53,200	81,100	14.0
2A	0.0300	46,200	65,000	21.5
2B	0.0302	45,400	64,000	20.5
3A	0.0476	55,100	70,200	15.5 (1)
3B	0.0417	55,200	71,300	16.0
4A	0.0482	55,500	79,600	16.0
4B	0.0455	47,800	69,800	- (2)
5A	0.0661	40,000	50,300	20.5
5B	0.0660	41,200	50,300	20.0
5C	0.0659	42,100	50,100	20.0
5D	0.0659	38,700	48,700	22.5

(1) Broke adjacent to gage mark.

(2) Broke in gage mark.



a

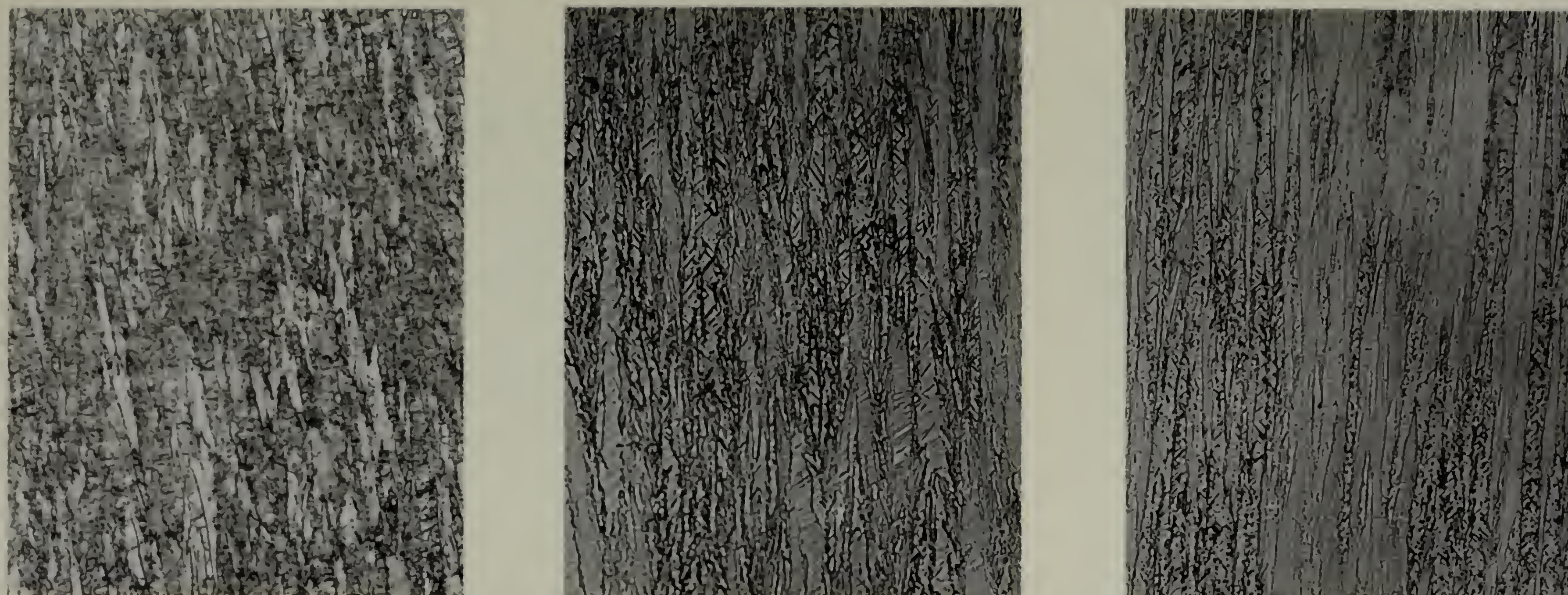


b

Figure 1. Unetched structures of transverse sections of electroformed plates.

a. Shows pores (black round discontinuities) observed in plate 2A. Condition shown is the worst of this type found in all of the material examined. X 100.

b. Shows good bond between nickel and iron elements observed in plate 5A. X 50.



a b c

Figure 2. Microstructures in transverse sections of electroformed nickel plates. Principal grain axes are normal to plate surfaces. Etched with Carapella's reagent. X 250.

a. Structure of plate 1A (smallest grain size). A similar grain size was found in plates 1B, 2A and 2B.

b. Structure of plate 3B (intermediate grain size). Grain size in plate 3A was similar.

c. Structure in plate 4A (largest grain size). Grain size in plate 4B was similar.

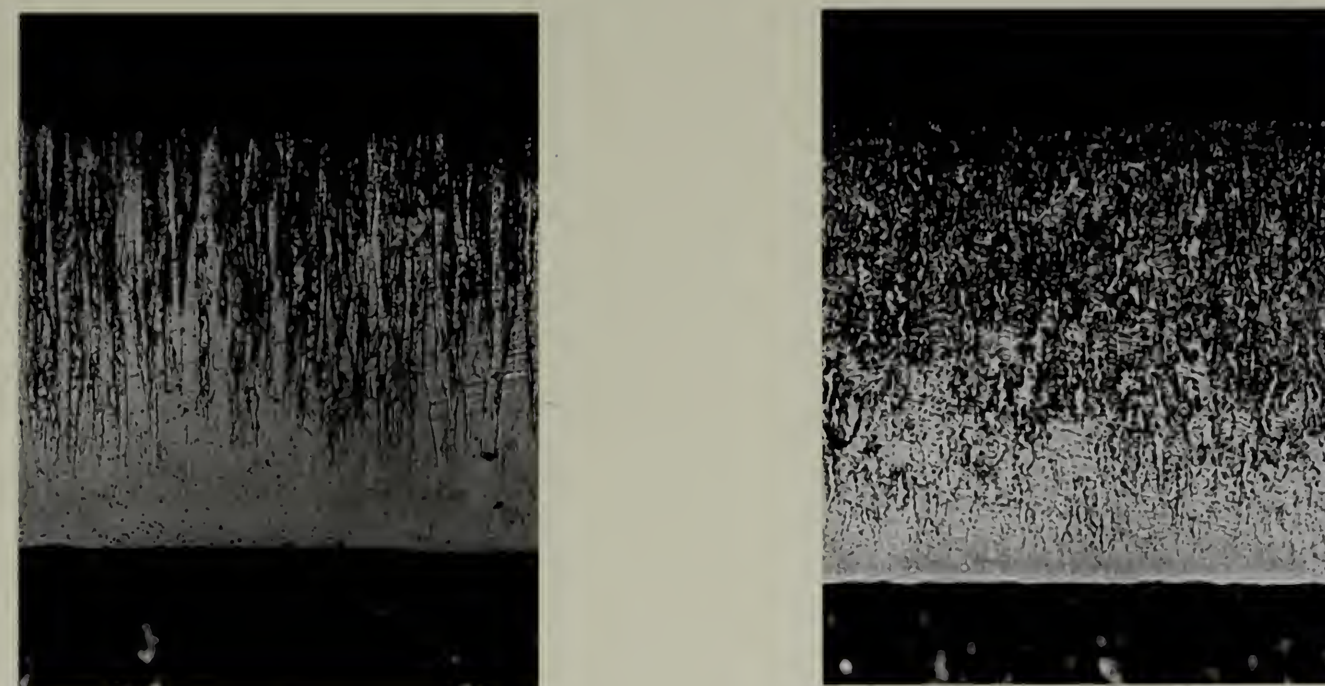


Figure 3. Microstructures in transverse sections of electroformed nickel-iron plates. Nickel deposit is shown. Principal grain axes are normal to plate surfaces. Note unetched iron-rich layer adjacent to nickel-iron interface. Etched with Carapella's reagent. X 250.

a. Structure in plate 5A. Structure in plate 5B was similar.

b. Structure in plate 5C. Structure in plate 5D was similar.

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