Mr. Edwards.

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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 61-114

METALLOGRAPHIC EXAMINATION OF COMMERCIAL GALVANIZED COATINGS

PART III

by

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PHYSICAL METALLURGY DIVISION

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COPY NO. 17

SEPTEMBER 22, 1961

Industrial Confidential

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METALLOGRAPHIC EXAMINATION OF COMMERCIAL GALVANIZED COATINGS - PART III

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J.J. Sebisty* and R.H. Palmer**

SUMMARY OF RESULTS

From metallographic examination of samples of six grades of continuous-strip galvanized coatings, indications were found which suggested that the intermetallic alloy layer in the coatings was a factor involved in the variable resistance welding performance of the materials represented. However, the evidence in this direction was contradictory and the role of the alloy layer could not be conclusively established.

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INTRODUCTION

In two previous investigations covered by Mines Branch Investigation Reports, IR 61-72 and IR 61-89, metallographic examination of twenty-six different grades of commercial galvanized sheet was detailed. These studies were made in response to a request from the Canadian Zinc Research and Development Committee to provide assistance with research on resistance welding of galvanized coatings which forms part of the American Zinc Institute Expanded Research Program.

In extension of the above work, a series of samples from six grades of commercial sheet was received on August 1, 1961. Resistance welding tests on the materials represented had been done by the Welding Development Department of the Ford Motor Company, Detroit, Michigan and the welding performance had been found to vary widely. Information on the metallurgical characteristics of the coatings was desired and metallographic examination of the samples submitted was requested by Dr. S. F. Radtke, Director of Research, American Zinc Institute.

WELDING TEST DATA AND COATING ANALYSIS

Resistance welding data provided are given in Table 1. The acceptance standard for the tests made was 2000 welds without changing the weld schedule or dressing the electrodes. Material represented by sample 48 was considered to be best for welding and under slightly different conditions from that given in the table, up to 3750 welds were obtained before failure.

Coating weight stripping tests and analysis for iron in the coatings, done by the Analytical Chemistry Sub-Division of the Mineral Sciences Division, Mines Branch, yielded the results listed on the right in Table 1. Single values only for samples 66C and 66N are given because at the time the tests were made, it was not known that these materials were differentially coated. These, in effect, average values have been included for information purposes only. The coating weight and iron values for the remaining samples were not significantly dissimilar and failed to give any explanation for the variable welding behaviour. It is to be noted, however, that sample 63, which was rated poorest in welding, also had the lowest iron content.

Analyses for aluminum and lead in the coatings could not be attempted because of insufficient sample materials.

METALLOGRAPHIC EXAMINATION

Two 1-in. pieces from each sample were examined metallographically. Representative photomicrographs prepared are illustrated in Figures 1 to 5 and features pertinent to each material are described in the captions.

All samples were typical of high-aluminum, continuous strip coatings although distinct variations in the continuity and mode of growth of the intermetallic alloy layer were found. Non-uniformity in thickness of the zinc layer was also observed in some samples.

As far as the metallurgical structure of the coatings is concerned, the only factor which appeared to bear some relationship to poor welding performance was the absence or minimum development of the intermetallic layer at the steel surface. This was suggested by samples 63 and 6 which, as shown in Figures 4 and 5, had minimum alloy growth within the series and also had been given poorest welding ratings. On the other hand, sample 47 was rated best in welding but showed equally negligible intermetallic alloy growth. A further anomaly in this connection was the significantly different welding behaviour of samples 66N and 66C, despite the identical microstructures on respective sides of these materials. The markedly different type of alloy crystal formation in these cases is to be noted.

CONCLUSIONS

There were indications that the resistance welding performance of the galvanized sheet materials represented by the samples submitted was related to variation in the continuity and mode of growth of the intermetallic alloy layer in the coatings. However, the evidence in this direction was contradictory and the role of the intermetallic layer could not be conclusively established from the limited number of samples examined.

TABLE I

Welding Data and Coating Analysis

Sample Designation	Gauge in.	Coating Thickness mil	Weld Schedule*			Weld Test Results	Coating Analysis		
			Force lb	Time cycles	Current amp		Weight oz/sq ft-sheet	Thickness mil	Iron Content mg/sq ft
Weirton-47	0.030	1.25	400	10	9,500	Passed, OK to 3000	1.06	0.88	106
Weirton-66N **	0.048	0.8 & 1.4	725	13	15,000	Passed, OK to 2500	1.04	0.87	252
Armco-48	0.063	1.0	850	13	17,000	Passed, OK to 2750	1.01	0.84	153
Dominion-63	0.033	1.0	550	12	13,000	Failed at 500	0.90	0.75	76
Inland-6	0.040	1.0	650	13	15,000	Failed at 1250	1.09	0.91	90
Weirton-66C **	0.048	0.8 & 1.5	725	13	15,750	Failed at 1750	0.99	0.82	275

* Initial electrode size: for sample 47 - 3/16 X45°, Class 2.
: for all others - 1/4 X45°, Class 2.

** Differential coatings .

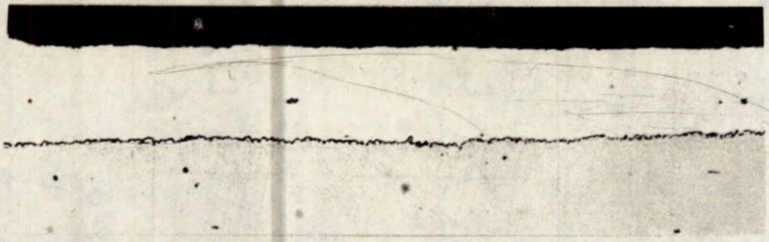
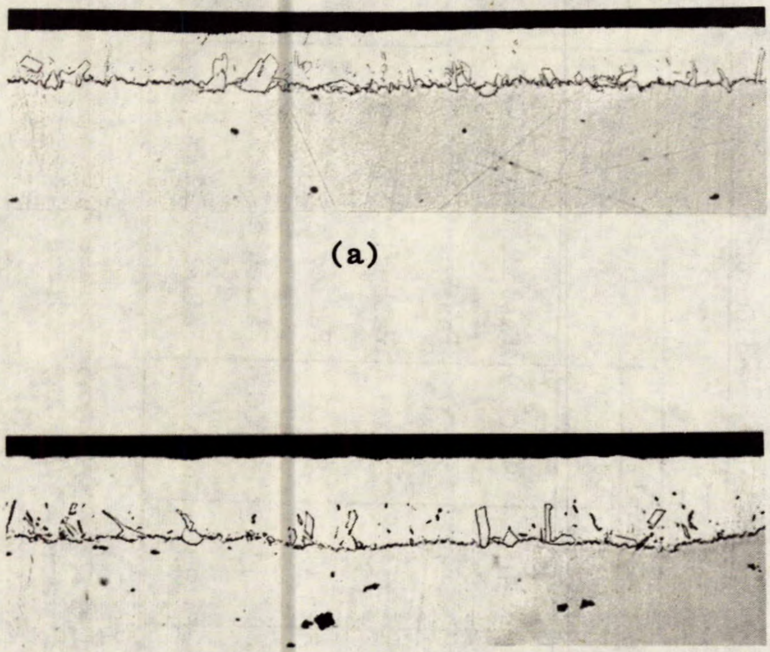


Figure 1. Microstructure of Weirton sample 47. The intermetallic alloy layer at the steel surface was very thin and continuous but local variations in thickness of the zinc layer on the same and opposite sides of the sheet were common.
(X500, nitramyl etch)



(a)

(b)

Figure 2. Microstructures of differentially-coated Weirton sample 66N showing thin and thick sides in (a) and (b) respectively. Block-type growth of individual crystals was characteristic and was much better developed on the thin-coating side. These features, and also good coating uniformity, were duplicated in Weirton sample 66C.
(X500, nitramyl etch)

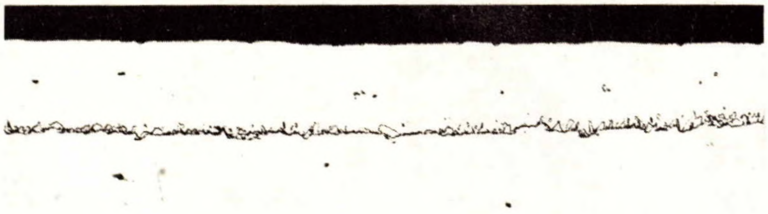


Figure 3. Microstructure of Armco sample 48. The intermetallic alloy layer was well defined and consisted of a more or less continuous band of small crystals. Variations in the zinc layer thickness were similar to that found with Weirton sample 47.
(X500, nitramyl etch)

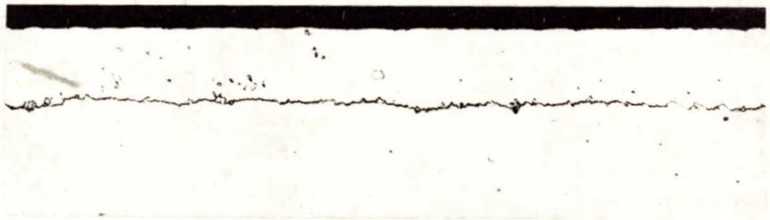


Figure 4. Microstructure of Dominion sample 63. This coating was characterized by almost complete absence of alloy at the steel surface except for randomly-scattered formation of individual, small crystals. Some free-floating alloy particles were evident in the zinc layer which was very uniform in thickness.
(X500, nitramyl etch)

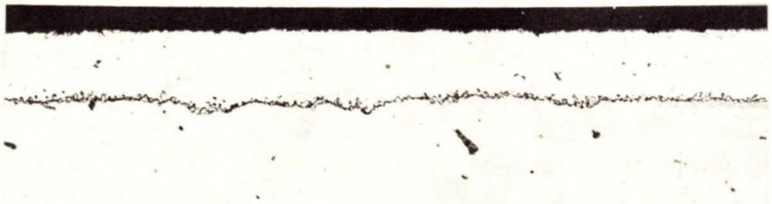


Figure 5. Microstructure of Inland sample 6. A thin continuous band of intermetallic alloy made up of very small crystals was observed in this sample. Coating uniformity was good.
(X500, nitramyl etch)