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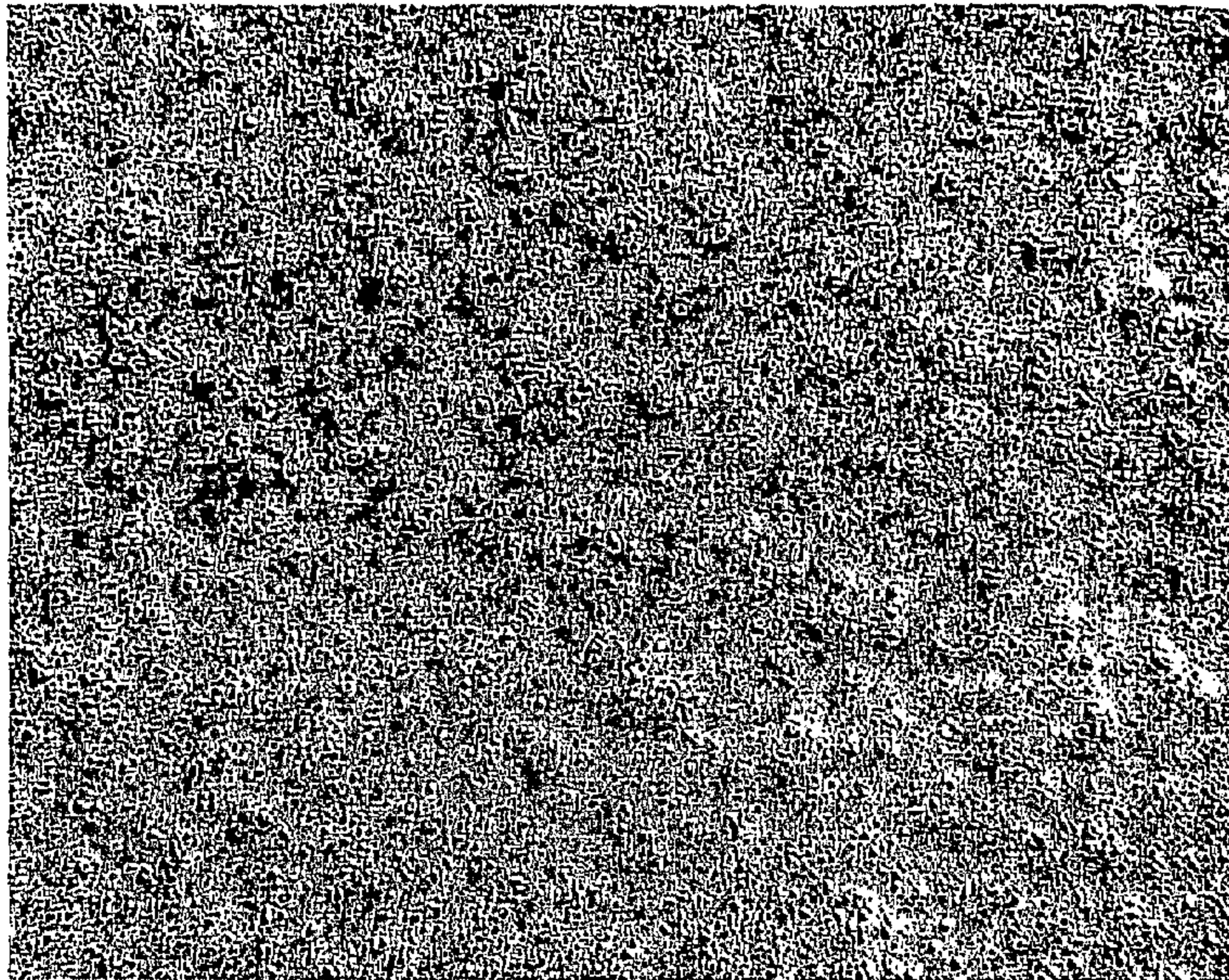
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(54) **Titre : RECOUVREMENTS DE SOUDURE EN ACIER INOXYDABLE A RESISTANCE AMELIOREE A L'USURE**
(54) **Title: STAINLESS STEEL WELD OVERLAYS WITH ENHANCED WEAR RESISTANCE**



(57) **Abbrégé/Abstract:**

Compositions for stainless steel weld overlays having enhanced wear resistance are provided by incorporating second phase Titanium Carbide (TiC) and/or Niobium Carbide (NbC) into matrices of various types of stainless steel such as 316L and 420. Preferably, TiC and NbC precipitates are formed in-situ during the weld overlay process while minimizing the amount of Carbon (C) going into solid solution in the matrix of the weld overlay.

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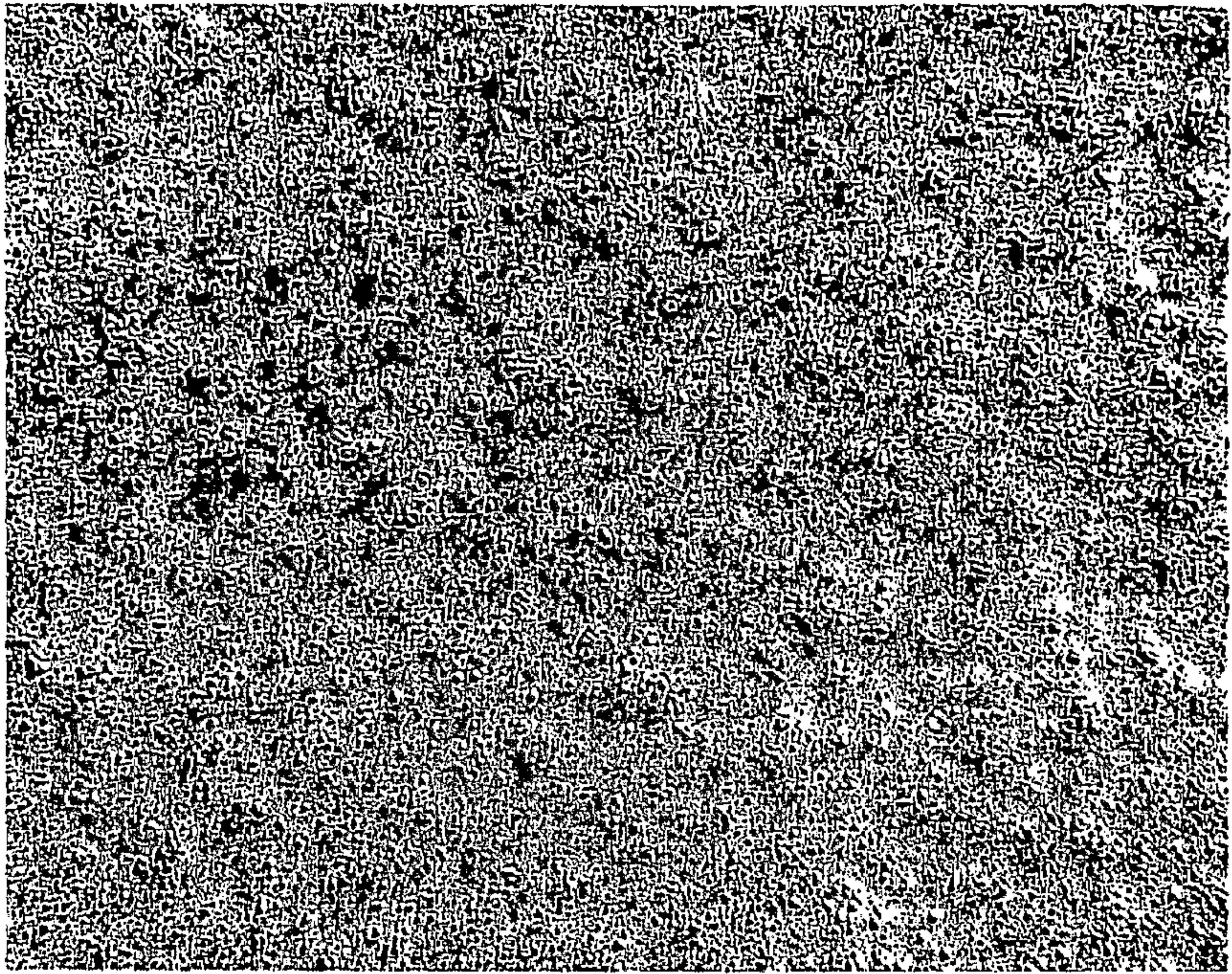
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(54) Title: STAINLESS STEEL WELD OVERLAYS WITH ENHANCED WEAR RESISTANCE



(57) Abstract: Compositions for stainless steel weld overlays having enhanced wear resistance are provided by incorporating second phase Titanium Carbide (TiC) and/or Niobium Carbide (NbC) into matrices of various types of stainless steel such as 316L and 420. Preferably, TiC and NbC precipitates are formed in-situ during the weld overlay process while minimizing the amount of Carbon (C) going into solid solution in the matrix of the weld overlay.

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STAINLESS STEEL WELD OVERLAYS WITH ENHANCED WEAR RESISTANCE

FIELD

5 **[0001]** The present disclosure relates to alloy compositions for arc welding and more particularly to stainless steel weld overlay compositions with enhanced wear resistance.

BACKGROUND

[0002] The statements in this section merely provide background
10 information related to the present disclosure and may not constitute prior art.

[0003] Industrial components are often subjected to operational and environmental conditions that require good corrosion and wear resistance. Examples of such industrial components and their applications include piping, process equipment, and mixing equipment, among others. These industrial components often include a stainless steel weld overlay to improve the corrosion resistance.

[0004] Although stainless steels provide adequate corrosion resistance, their abrasion resistance is relatively poor. In fact, for austenitic stainless steels of the 304 type (hardness HRC 25-35), the abrasion resistance as measured by the ASTM G65 test is lower than that of a plain carbon steel. The martensitic stainless steels of the 410/420 type have somewhat better wear resistance as they are typically at hardness levels of HRC 40-50. Hardened low alloy steels (HRC 50-55) have significantly better wear resistance. These wear comparisons are shown in Figure 1.

25 SUMMARY

[0004a] Certain exemplary embodiments provide a stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass: between about 0.5% and about 1.5 % Carbon; between about 0.1% and about 2.0% Manganese; between about 0.1% and about 0.9% Silicon; between about 14.0% and about 18.0% Chromium; between about 6.0% and

about 10.0% Nickel; between about 1.5% and about 3.5% Molybdenum; between about 0.5% and about 8.0% Titanium and Niobium; and greater than 0% and less than 0.15% Nitrogen, wherein both second phase Titanium Carbide and second phase Niobium Carbide precipitates are incorporated in the stainless steel weld overlay; wherein the composition is adjusted such that the Carbon content in the matrix is at or below 10% of the bulk Carbon content, the balance being tied up as the carbides of Titanium and Niobium.

5 [0004b] Other exemplary embodiments provide a stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass: between about 0.5% and about 1.5% Carbon; between about 0.1% and about 2.0% Manganese; between about 0.1% and about 0.9% Silicon; between about 12.0% and about 18.0% Chromium; between about 0.1% and about 1.8% Molybdenum; between about 0.5% and about 8.0% Titanium and Niobium; greater than 0% and less than 0.15% Nitrogen; and between about 15 0.05% and about 2.0% Vanadium, wherein both second phase Titanium Carbide and second phase Niobium Carbide precipitates are incorporated in the stainless steel weld overlay; wherein the composition is adjusted such that the Carbon content in the matrix is at or below 10% of the bulk Carbon content, the balance being tied up as the carbides of Titanium and Niobium.

20 [0004c] Yet other exemplary embodiments provide a stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass: between about 0.1% and about 1.0% Carbon; between about 0.1% and about 2.0% Manganese; between about 0.1% and about 1.5% Silicon; between about 11.0% and about 18.0% Chromium; less than 6.0% Nickel; 25 between about 0.1% and about 2.5% Molybdenum; between about 0.5% and about 8.0% Titanium and Niobium; greater than 0% and less than 0.15% Nitrogen; and between about 0.05% and about 2.0% Vanadium, wherein both second phase Titanium Carbide and second phase Niobium Carbide precipitates are incorporated in the stainless steel weld overlay; wherein the composition is adjusted such that the Carbon content in the matrix is at or 30

below 10% of the bulk Carbon content, the balance being tied up as the carbides of Titanium and Niobium.

5 **[0004d]** Still yet other exemplary embodiments provide a stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass: between about 0.5% and about 1.5 % Carbon; between about 0.1% and about 2.0% Manganese; between about 0.1% and about 0.9% Silicon; between about 14.0% and about 18.0% Chromium; between about 6.0% and about 10.0% Nickel; between about 1.5% and about 3.5% Molybdenum; between about 0.5% and about 8.0% Titanium and Niobium; 10 and greater than 0% and less than 0.15% Nitrogen, wherein both second phase Titanium Carbide and second phase Niobium Carbide precipitates are incorporated in the stainless steel weld overlay, wherein the amount of Carbon in the composition that is not tied up as the Titanium and Niobium Carbides is at or below 0.1%.

15 **[0004e]** Still yet other exemplary embodiments provide a stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass: between about 0.5% and about 1.5% Carbon; between about 0.1% and about 2.0% Manganese; between about 0.1% and about 0.9% Silicon; between about 12.0% and about 18.0% Chromium; between about 0.1% and about 1.8% Molybdenum; between about 0.5% and about 8.0% 20 Titanium and Niobium; greater than 0% and less than 0.15% Nitrogen; and between about 0.05% and about 2.0% Vanadium, wherein both second phase Titanium Carbide and second phase Niobium Carbide precipitates are incorporated in the stainless steel weld overlay, wherein the amount of carbon in the composition that is not tied up as the Titanium and Niobium Carbides is at or below 0.1%. 25

[0004f] Still yet other exemplary embodiments provide a stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass: between about 0.1% and about 1.0% Carbon; between about 0.1% and about 2.0% Manganese; between about 0.1% and about 1.5% 30

Silicon; between about 11.0% and about 18.0% Chromium; less than 6.0% Nickel; between about 0.1% and about 2.5% Molybdenum; between about 0.5% and about 8.0% Titanium and Niobium; greater than 0% and less than 0.15% Nitrogen; and between about 0.05% and about 2.0% Vanadium,
5 wherein both second phase Titanium Carbide and second phase Niobium Carbide precipitates are incorporated in the stainless steel weld overlay, wherein the amount of carbon in the composition that is not tied up as the Titanium and Niobium Carbides is at or below 0.1%.

[0005] Compositions for stainless steel weld overlays having
10 enhanced wear resistance are provided by incorporating second phase titanium Carbide (TiC) and/or niobium Carbide (NbC) into matrices of various types of stainless steel such as 316L and 420. Preferably, TiC and NbC precipitates are formed in-situ during the weld overlay process while minimizing the amount of Carbon (C) going into solid solution in the matrix of
15 the weld overlay. The alloys of the present disclosure have increased abrasion resistance due to the incorporation of second phase carbides of the TiC and NbC type. The incorporation of these phases results in significantly enhanced wear resistance.

[0006] In one form, a stainless steel weld overlay composition of the 316L type is provided that comprises, by percent mass between approximately 0.5% and approximately 1.5% Carbon, between approximately 0.1% and approximately 2.0% Manganese, between approximately 0.1% and approximately 0.9% Silicon, between approximately 14.0% and approximately 18.0% Chromium, between approximately 6.0% and approximately 10.0% Nickel, between approximately 1.5% and approximately 3.5% Molybdenum, between approximately 0.5% and approximately 8.0% Titanium and Niobium, and less than approximately 0.15% Nitrogen. In additional forms, the Carbon comprises approximately 1.0%, the Manganese comprises approximately 1.3%, the Silicon comprises approximately 0.5%, the Chromium comprises approximately 16.0%, the Nickel comprises approximately 8.0%, the Molybdenum comprises approximately 2.5%, the Titanium and Niobium comprise approximately 6.1%, and the Nitrogen comprises approximately 0.1%.

[0007] In another form, a stainless steel weld overlay composition of the 420 type is provided that comprises, by percent mass, between approximately 0.5% and approximately 1.5% Carbon, between approximately 0.1% and approximately 2.0% Manganese, between approximately 0.1% and approximately 0.9% Silicon, between approximately 12.0% and approximately 18.0% Chromium, between approximately 0.1% and approximately 1.8% Molybdenum, between approximately 0.5% and approximately 8.0% Titanium and Niobium, less than approximately 0.15% Nitrogen, and between approximately 0.15% and approximately 2.0% Vanadium. In additional forms, the Carbon comprises approximately 1.1%, the Manganese comprises approximately 0.75%, the Silicon comprises approximately 0.5%, the Chromium comprises approximately 14.5%, the Molybdenum comprises approximately 0.5%, the Titanium and Niobium comprise approximately 6.1%, the Nitrogen comprises approximately 0.1%, and the Vanadium comprises approximately 0.4%.

[0008] In yet another form, a stainless steel weld overlay composition of the 420 type is provided that comprises, by percent mass, between approximately 0.1% and approximately 1.0% Carbon, between approximately 0.1% and approximately 2.0% Manganese, between approximately 0.1% and approximately 1.5% Silicon, between approximately 11.0% and approximately

18.0% Chromium, less than approximately 6.0% Nickel, between approximately 0.1% and approximately 2.5% Molybdenum, between approximately 0.5% and approximately 8.0% Titanium and Niobium, less than approximately 0.15% Nitrogen, and between approximately 0.05% and approximately 2.0% Vanadium.

5 In additional forms, the Carbon comprises approximately 0.5%, the Manganese comprises approximately 0.7%, the Silicon comprises approximately 0.7%, the Chromium comprises approximately 13.0%, the Nickel comprises approximately 3.0%, the Molybdenum comprises approximately 1.3%, the Titanium and Niobium comprise approximately 2.2%, the Nitrogen comprises approximately 0.1%, and the Vanadium comprises approximately 0.4%.

[0009] According to a method provided herein, a stainless steel weld overlay is formed by producing precipitates selected from the group consisting of Titanium Carbide and Niobium Carbide in-situ during a weld overlay process.

DRAWINGS

15 [0010] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

[0011] Fig. 1 is a chart illustrating the abrasion resistance of Stainless Steels 304 and 410 compared to Hardened Carbon Steel;

20 [0012] Fig. 2 is a chart illustrating test data from compositions according to the present disclosure that were overlaid on a carbon steel plate and tested per ASTM G65 Procedure A;

[0013] Fig. 3a is an electron microprobe scan of 316Ti/NbC in accordance with the teachings of the present disclosure;

25 [0014] Fig. 3b is an electron microprobe scan of 420Ti/NbC in accordance with the teachings of the present disclosure;

[0015] Fig. 4a is a photomicrograph illustrating the microstructure of 316Ti/NbC in accordance with the teachings of the present disclosure; and

[0016] Fig. 4b is a photomicrograph illustrating the microstructure of 420Ti/NbC in accordance with the teachings of the present disclosure.

30 DETAILED DESCRIPTION

[0017] The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.

[0018] Compositions for stainless steel weld overlays having enhanced wear resistance are provided by incorporating second phase Titanium Carbide (TiC) and/or Niobium Carbide (NbC) into matrices of various types of stainless steel such as 316L and 420. Preferably, TiC and NbC precipitates are formed in-situ during the weld overlay process while minimizing the amount of Carbon (C) going into solid solution in the matrix of the weld overlay.

[0019] Referring to Table 1 below, three (3) stainless steel weld overlay compositions (including both target percentages and ranges of percent elements by weight) according to the present disclosure are listed as "Overlay A," "Overlay B," and "Overlay C."

	316L Nb/TiC	316L Nb/TiC	420 NbC/TiC	420 NbC/TiC	420 NbC/TiC	420 NbC/TiC
	Overlay A Target	Overlay A Range	Overlay B Target	Overlay B Range	Overlay C Target	Overlay C Range
Carbon	1.0	0.5 - 1.5	1.1	0.5 - 1.5	0.5	0.1 - 1.0
Manganese	1.3	0.1 - 2.0	0.75	0.1 - 2.0	0.7	0.1 - 2.0
Silicon	0.5	0.1 - 0.9	0.5	0.1 - 0.9	0.7	0.1 - 1.5
Chromium	16.0	14.0 - 18.0	14.5	12.0 - 18.0	13.0	11.0 - 18.0
Nickel	8.0	6.0 - 10.0	-----	-----	3	0.0 - 6.0
Molybdenum	2.5	1.5 - 3.5	0.5	0.1 - 1.8	1.3	0.1 - 2.5
Titanium and Niobium	6.1	0.5 - 8.0	6.1	0.5 - 8.0	2.2	0.5 - 8.0
Nitrogen	0.1	0.0 - 0.15	0.1	0.0 - 0.15	0.1	0.0 - 0.15
Vanadium	-----	-----	0.4	0.05 - 2.0	0.4	0.05 - 2.0

Table 1

[0020] As shown, the composition for Overlay A is of the 316L type of stainless steel, and both Overlay B and Overlay C are of the 420 type of stainless steel. Generally, stainless steel type 316L is an austenitic chromium-nickel stainless steel containing molybdenum. Type 316L is an extra-low carbon

version of type 316 that reduces carbide precipitation during welding. Stainless steel type 420 is a martensitic stainless steel with good corrosion resistance, strength, and hardness. Both types of stainless steel are thus well suited for weld overlays to improve wear resistance. Each element and its contribution to properties of the weld deposit are now described in greater detail.

[0021] Carbon (C) is an element that improves hardness and strength. The preferred amount of Carbon for both Overlay A and Overlay B is between approximately 0.5 and 1.5 percent, with a target value of approximately 1.0% for Overlay A and 1.1% for Overlay B. The preferred amount of Carbon for Overlay C is between approximately 0.1 percent and 1.0 percent, with a target value of approximately 0.5%. The carbon contents are adjusted so that the amount of carbon left in the matrix after the carbides are formed during the solidification is relatively low. Accordingly, the low carbon in the matrix contributes to improved corrosion resistance.

[0022] Manganese (Mn) is an element that improves the strength and hardness and acts as a deoxidizer, in which the deoxidizer also acts as a grain refiner when fine oxides are not floated out of the metal. The preferred amount of manganese for both Overlay A and Overlay B is between approximately 0.1 and 2.0 percent, with a target value of approximately 1.3% for Overlay A and 0.75% for Overlay B. The preferred amount of Manganese for Overlay C is between approximately 0.1 percent and 2.0 percent, with a target value of approximately 0.7%.

[0023] Silicon (Si) is an element that acts as a deoxidizer and also as a grain refiner when fine oxides are not floated out of the metal. The preferred amount of Silicon for both Overlay A and Overlay B is between approximately 0.1 and 0.9 percent, with a target value of approximately 0.5%. The preferred amount of Silicon for Overlay C is between approximately 0.1 percent and 1.5 percent, with a target value of approximately 0.7%.

[0024] Chromium (Cr) is an element that provides improved hardenability, corrosion resistance, and improved high temperature creep strength. The preferred amount of Chromium for Overlay A is between approximately 14.0 percent and 18.0 percent, with a target value of approximately 16.0%. The preferred amount of Chromium for Overlay B is between approximately 12.0 percent and 18.0 percent, with a target value of

approximately 14.5%. The preferred amount of Chromium for Overlay C is between approximately 11 percent and 18.0 percent, with a target value of approximately 13.0%.

5 [0025] Nickel (Ni) is an element that provides improved ductility, which improves resistance to impacts at lower temperatures. Combined with Chromium at high enough percentages, an austenitic stainless steel results. The preferred amount of Nickel for Overlay A is between approximately 6.0 percent and 10.0 percent, with a target value of approximately 8.0%. There is no Nickel in Overlay B, and the preferred amount of Nickel for Overlay C is less than
10 approximately 6.0 percent, with a target value of approximately 3.0%

[0026] Molybdenum (Mo) is an element that provides improved corrosion resistance, tensile strength and hardness to the weld overlay. The preferred amount of Molybdenum for Overlay A is between approximately 1.5 percent and 3.5 percent, with a target value of approximately 2.5%. The
15 preferred amount of Molybdenum for Overlay B is between approximately 0.1 percent and 1.8 percent, with a target value of approximately 0.5%. The preferred amount of Molybdenum for Overlay C is between approximately 0.1 percent and 2.5 percent, with a target value of approximately 1.3%.

[0027] Titanium (Ti) acts as a grain refiner and as a deoxidizer and is
20 also a part of the Titanium Carbide precipitates that improve wear resistance of the stainless steel weld overlay. Niobium (Nb) acts as a carbide former and is present, along with Titanium, in each of the compositions of Overlay A, Overlay B, and Overlay C. The Niobium is also a part of the Niobium Carbide precipitates that improve wear resistance of the stainless steel weld overlay.
25 The preferred amount of Titanium and Niobium for Overlays A and B is between approximately 0.5 and 8.0 percent with a target value of approximately 6.1%. The preferred amount of Titanium and Niobium for Overlay C is between approximately 0.5 percent and 7.0 percent, with a target value of approximately 2.2%.

30 [0028] Nitrogen (N) is an element that stabilizes the formation of austenitic structures and is thus added to austenitic stainless steel to reduce the amount of Nickel needed, which reduces overall cost. The preferred amount of Nitrogen for each of Overlay A, Overlay B, and Overlay C is less than approximately 0.15 percent, with a target value of approximately 0.1%.

[0029] Vanadium (V) is also a grain refiner and thus increases toughness of the weld overlay. Also, Vanadium is present in the compositions of Overlay B and Overlay C. The preferred amount of Vanadium for both Overlay B and Overlay C is between approximately 0.05 percent and 2.0 percent, with a
5 target value of approximately 0.4%.

[0030] Referring now to Fig. 2, compositions according to the present disclosure were overlaid on a carbon steel plate and wear tests per ASTM G65 Procedure A were conducted. The data clearly indicates that the carbide modified stainless steel weld overlays have significantly improved wear
10 resistance over the base stainless steel materials.

[0031] As shown in Figs. 3a and 3b, the carbon content of the matrix is at or below approximately 0.1% by weight, although the bulk carbon content is approximately 1%. The balance of the carbide is tied up as carbides of the NbC and TiC type, thus providing improved wear resistance. The composition of the
15 overlay wires has been adjusted such that the carbon content of the matrix remains relatively low, which is important to preserve the corrosion resistance of the base materials.

[0032] Exemplary microstructures of overlays made according to the teachings of the present disclosure are illustrated in Figs. 4a and 4b. As shown,
20 fine precipitates of TiC/NbC are developed, which enhance the wear resistance of the base stainless steels 316L and 420, respectively.

[0033] The description of the disclosure is merely exemplary in nature and, thus, variations that do not depart from the gist of the disclosure are intended to be within the scope of the disclosure. For example, the weld deposit
25 according to the teachings of the present disclosure may be produced from welding wire such as flux-core wires, metal-cored wires, or solid wires, while remaining within the scope of the disclosure.

The scope of the claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

Claims:

1. A stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass:
- 5 between about 0.5% and about 1.5 % Carbon;
 between about 0.1% and about 2.0% Manganese;
 between about 0.1% and about 0.9% Silicon;
 between about 14.0% and about 18.0% Chromium;
 between about 6.0% and about 10.0% Nickel;
 between about 1.5% and about 3.5% Molybdenum;
10 between about 0.5% and about 8.0% Titanium and Niobium;
 and
 greater than 0% and less than 0.15% Nitrogen,
 wherein both second phase Titanium Carbide and second phase
 Niobium Carbide precipitates are incorporated in the stainless steel weld
15 overlay;
 wherein the composition is adjusted such that the Carbon content in
 the matrix is at or below 10% of the bulk Carbon content, the balance being
 tied up as the carbides of Titanium and Niobium.
- 20 2. The stainless steel weld overlay composition according to
 Claim 1, wherein the Titanium and Niobium comprises about 6.1%.
3. The stainless steel weld overlay composition according to
 Claim 1 or 2, wherein the Carbon comprises about 1.0%.
- 25 4. The stainless steel weld overlay composition according to
 Claim 1 or 2, wherein the Manganese comprises about 1.3%.
5. The stainless steel weld overlay composition according to
30 Claim 1 or 2, wherein the Silicon comprises about 0.5%.

6. The stainless steel weld overlay composition according to Claim 1 or 2, wherein the Chromium comprises about 16.0%.

7. The stainless steel weld overlay composition according to
5 Claim 1 or 2, wherein the Nickel comprises about 8.0%.

8. The stainless steel weld overlay composition according to Claim 1 or 2, wherein the Molybdenum comprises about 2.5%.

10 9. The stainless steel weld overlay composition according to Claim 1 or 2, wherein the Nitrogen comprises about 0.1%.

10. A stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass:

15 between about 0.5% and about 1.5% Carbon;
 between about 0.1% and about 2.0% Manganese;
 between about 0.1% and about 0.9% Silicon;
 between about 12.0% and about 18.0% Chromium;
 between about 0.1% and about 1.8% Molybdenum;
20 between about 0.5% and about 8.0% Titanium and Niobium;
 greater than 0% and less than 0.15% Nitrogen; and
 between about 0.05% and about 2.0% Vanadium,

 wherein both second phase Titanium Carbide and second phase
Niobium Carbide precipitates are incorporated in the stainless steel weld
25 overlay;

 wherein the composition is adjusted such that the Carbon content in the matrix is at or below 10% of the bulk Carbon content, the balance being tied up as the carbides of Titanium and Niobium.

11. The stainless steel weld overlay according to Claim 10, wherein the Titanium and Niobium comprises about 6.1%.

12. The stainless steel weld overlay composition according to
5 Claim 10 or 11, wherein the Carbon comprises about 1.1%.

13. The stainless steel weld overlay composition according to Claim 10 or 11, wherein the Manganese comprises about 0.75%.

10 14. The stainless steel weld overlay composition according to Claim 10 or 11, wherein the Silicon comprises about 0.5%.

15 15. The stainless steel weld overlay composition according to Claim 10 or 11, wherein the Chromium comprises about 14.5%.

16. The stainless steel weld overlay composition according to Claim 10 or 11, wherein the Molybdenum comprises about 0.5%.

17. The stainless steel weld overlay composition according to
20 Claim 10 or 11, wherein the Nitrogen comprises about 0.1%.

18. The stainless steel weld overlay composition according to Claim 10 or 11, wherein the Vanadium comprises about 0.4%.

25 19. A stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass:

between about 0.1% and about 1.0% Carbon;
between about 0.1% and about 2.0% Manganese;
between about 0.1% and about 1.5% Silicon;
30 between about 11.0% and about 18.0% Chromium;

less than 6.0% Nickel;
between about 0.1% and about 2.5% Molybdenum;
between about 0.5% and about 8.0% Titanium and Niobium;
greater than 0% and less than 0.15% Nitrogen; and
5 between about 0.05% and about 2.0% Vanadium,
wherein both second phase Titanium Carbide and second phase
Niobium Carbide precipitates are incorporated in the stainless steel weld
overlay;
wherein the composition is adjusted such that the Carbon content in
10 the matrix is at or below 10% of the bulk Carbon content, the balance being
tied up as the carbides of Titanium and Niobium.

20. The stainless steel weld overlay composition according to
Claim 19, wherein the Titanium and Niobium comprises about 6.1%.

15

21. The stainless steel weld overlay composition according to
Claim 19 or 20, wherein the Carbon comprises about 0.5%.

22. The stainless steel weld overlay composition according to
20 Claim 19 or 20, wherein the Manganese comprises about 0.7%.

23. The stainless steel weld overlay composition according to
Claim 19 or 20, wherein the Silicon comprises about 0.7%.

25 24. The stainless steel weld overlay composition according to
Claim 19 or 20, wherein the Chromium comprises about 13.0%.

25. The stainless steel weld overlay composition according to
Claim 19 or 20, wherein the Nickel comprises about 3.0%.

30

26. The stainless steel weld overlay composition according to Claim 19 or 20, wherein the Molybdenum comprises about 1.3%.

27. The stainless steel weld overlay composition according to
5 Claim 19, wherein the Titanium and the Niobium comprise about 2.2%.

28. The stainless steel weld overlay composition according to Claim 19 or 20, wherein the Nitrogen comprises about 0.1%.

10 29. The stainless steel weld overlay composition according to Claim 19 or 20, wherein the Vanadium comprises about 0.4%.

30. The stainless steel weld overlay composition according to Claim 1, wherein the amount of carbon in the composition that is not tied up
15 as the Titanium and Niobium Carbides is at or below 0.1%.

31. A stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass:

20 between about 0.5% and about 1.5 % Carbon;
between about 0.1% and about 2.0% Manganese;
between about 0.1% and about 0.9% Silicon;
between about 14.0% and about 18.0% Chromium;
between about 6.0% and about 10.0% Nickel;
between about 1.5% and about 3.5% Molybdenum;
25 between about 0.5% and about 8.0% Titanium and Niobium;
and
greater than 0% and less than 0.15% Nitrogen,

wherein both second phase Titanium Carbide and second phase Niobium Carbide precipitates are incorporated in the stainless steel weld
30 overlay,

wherein the amount of Carbon in the composition that is not tied up as the Titanium and Niobium Carbides is at or below 0.1%.

32. The stainless steel weld overlay composition according to
5 Claim 31, wherein the Carbon comprises about 1.0%.

33. The stainless steel weld overlay composition according to Claim 31, wherein the Manganese comprises about 1.3%.

10 34. The stainless steel weld overlay composition according to Claim 31, wherein the Silicon comprises about 0.5%.

35. The stainless steel weld overlay composition according to Claim 31, wherein the Chromium comprises about 16.0%.
15

36. The stainless steel weld overlay composition according to Claim 31, wherein the Nickel comprises about 8.0%.

37. The stainless steel weld overlay composition according to
20 Claim 31, wherein the Molybdenum comprises about 2.5%.

38. The stainless steel weld overlay composition according to Claim 31, wherein the Nitrogen comprises about 0.1%.

25 39. A stainless steel weld overlay having a matrix with a bulk composition comprising, by percent mass:

between about 0.5% and about 1.5% Carbon;
between about 0.1% and about 2.0% Manganese;
between about 0.1% and about 0.9% Silicon;
30 between about 12.0% and about 18.0% Chromium;

between about 0.1% and about 1.8% Molybdenum;
between about 0.5% and about 8.0% Titanium and Niobium;
greater than 0% and less than 0.15% Nitrogen; and
between about 0.05% and about 2.0% Vanadium,

5 wherein both second phase Titanium Carbide and second phase
Niobium Carbide precipitates are incorporated in the stainless steel weld
overlay,

 wherein the amount of carbon in the composition that is not tied up as
the Titanium and Niobium Carbides is at or below 0.1%.

10

 40. The stainless steel weld overlay composition according to
Claim 39, wherein the Carbon comprises about 1.1%.

 41. The stainless steel weld overlay composition according to
15 Claim 39, wherein the Manganese comprises about 0.75%.

 42. The stainless steel weld overlay composition according to
Claim 39, wherein the Silicon comprises about 0.5%.

20 43. The stainless steel weld overlay composition according to
Claim 39, wherein the Chromium comprises about 14.5%.

 44. The stainless steel weld overlay composition according to
Claim 39, wherein the Molybdenum comprises about 0.5%.

25

 45. The stainless steel weld overlay composition according to
Claim 39, wherein the Titanium and the Niobium comprise about 6.1%.

 46. The stainless steel weld overlay composition according to
30 Claim 39, wherein the Nitrogen comprises about 0.1%.

47. The stainless steel weld overlay composition according to Claim 39, wherein the Vanadium comprises about 0.4%.

48. A stainless steel weld overlay having a matrix with a bulk
5 composition comprising, by percent mass:

between about 0.1% and about 1.0% Carbon;

between about 0.1% and about 2.0% Manganese;

between about 0.1% and about 1.5% Silicon;

between about 11.0% and about 18.0% Chromium;

10 less than 6.0% Nickel;

between about 0.1% and about 2.5% Molybdenum;

between about 0.5% and about 8.0% Titanium and Niobium;

greater than 0% and less than 0.15% Nitrogen; and

between about 0.05% and about 2.0% Vanadium,

15 wherein both second phase Titanium Carbide and second phase Niobium Carbide precipitates are incorporated in the stainless steel weld overlay,

wherein the amount of carbon in the composition that is not tied up as the Titanium and Niobium Carbides is at or below 0.1%.

20

49. The stainless steel weld overlay composition according to Claim 48, wherein the Carbon comprises about 0.5%.

50. The stainless steel weld overlay composition according to
25 Claim 48, wherein the Manganese comprises about 0.7%.

51. The stainless steel weld overlay composition according to Claim 48, wherein the Silicon comprises about 0.7%.

52. The stainless steel weld overlay composition according to Claim 48, wherein the Chromium comprises about 13.0%.

53. The stainless steel weld overlay composition according to
5 Claim 48, wherein the Nickel comprises about 3.0%.

54. The stainless steel weld overlay composition according to Claim 48, wherein the Molybdenum comprises about 1.3%.

10 55. The stainless steel weld overlay composition according to Claim 48, wherein the Titanium and the Niobium comprise about 2.2%.

56. The stainless steel weld overlay composition according to Claim 48, wherein the Nitrogen comprises about 0.1%.
15

57. The stainless steel weld overlay composition according to Claim 48, wherein the Vanadium comprises about 0.4%.

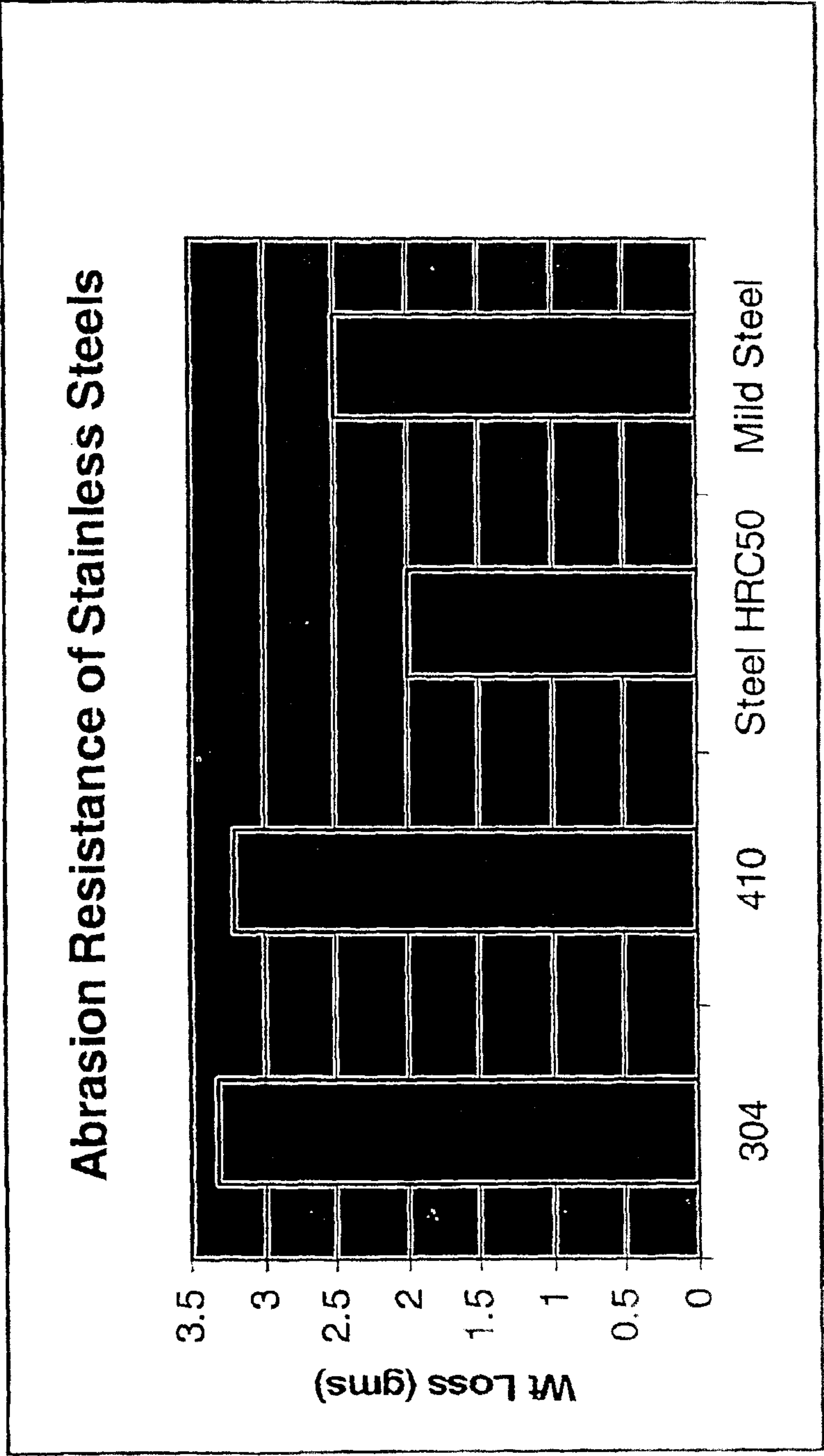


FIG. 1 Prior Art

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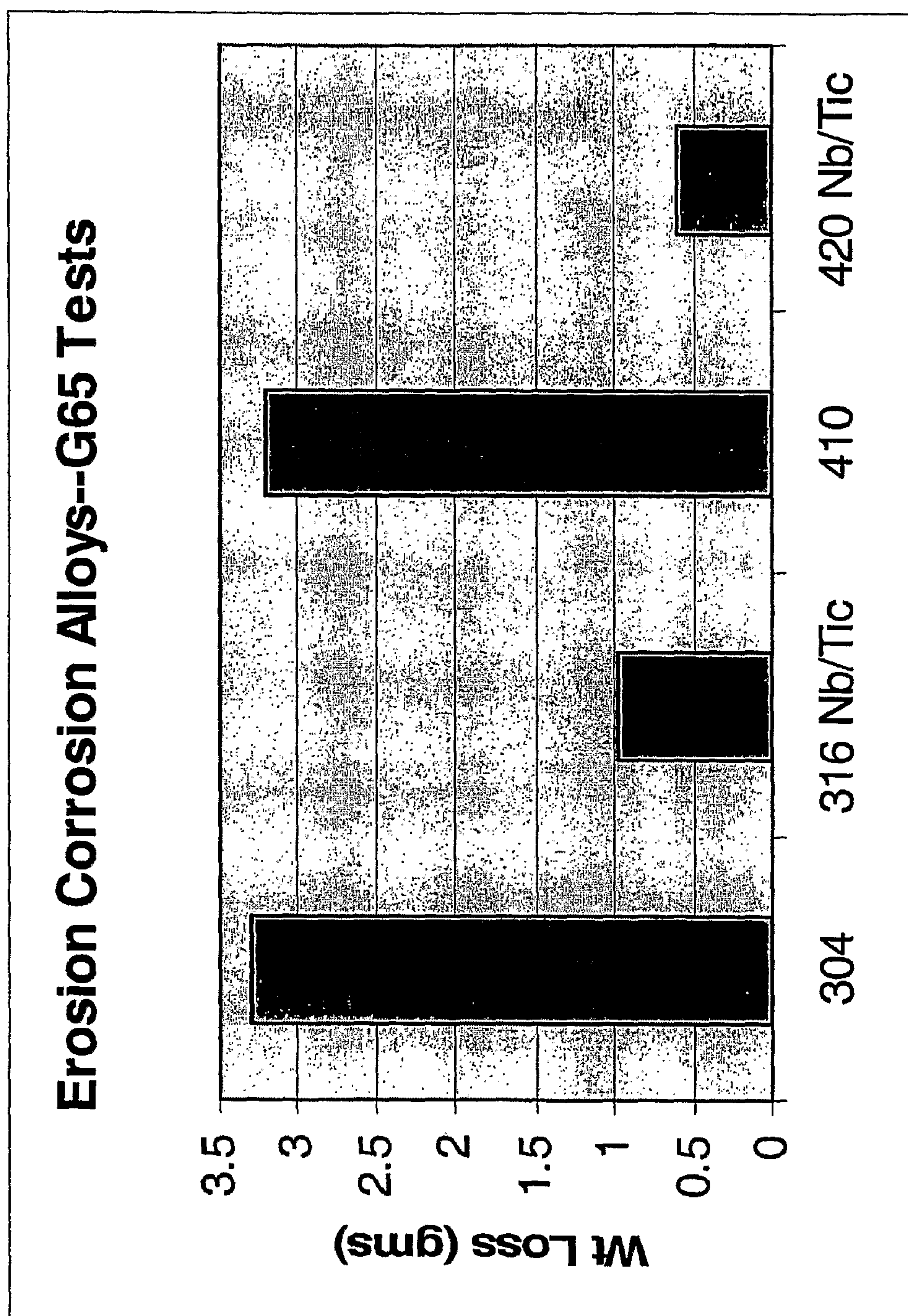


FIG. 2

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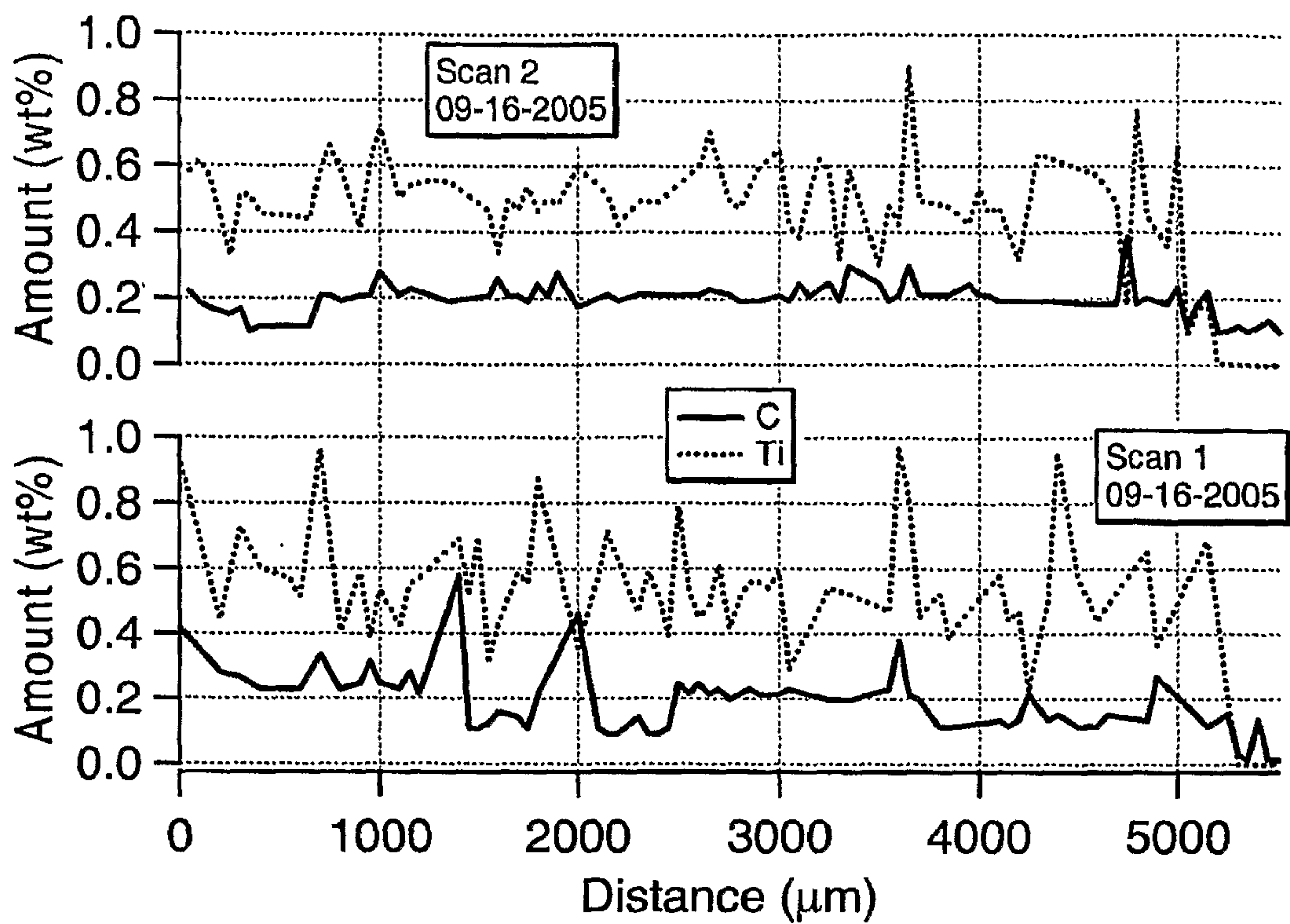


FIG. 3a

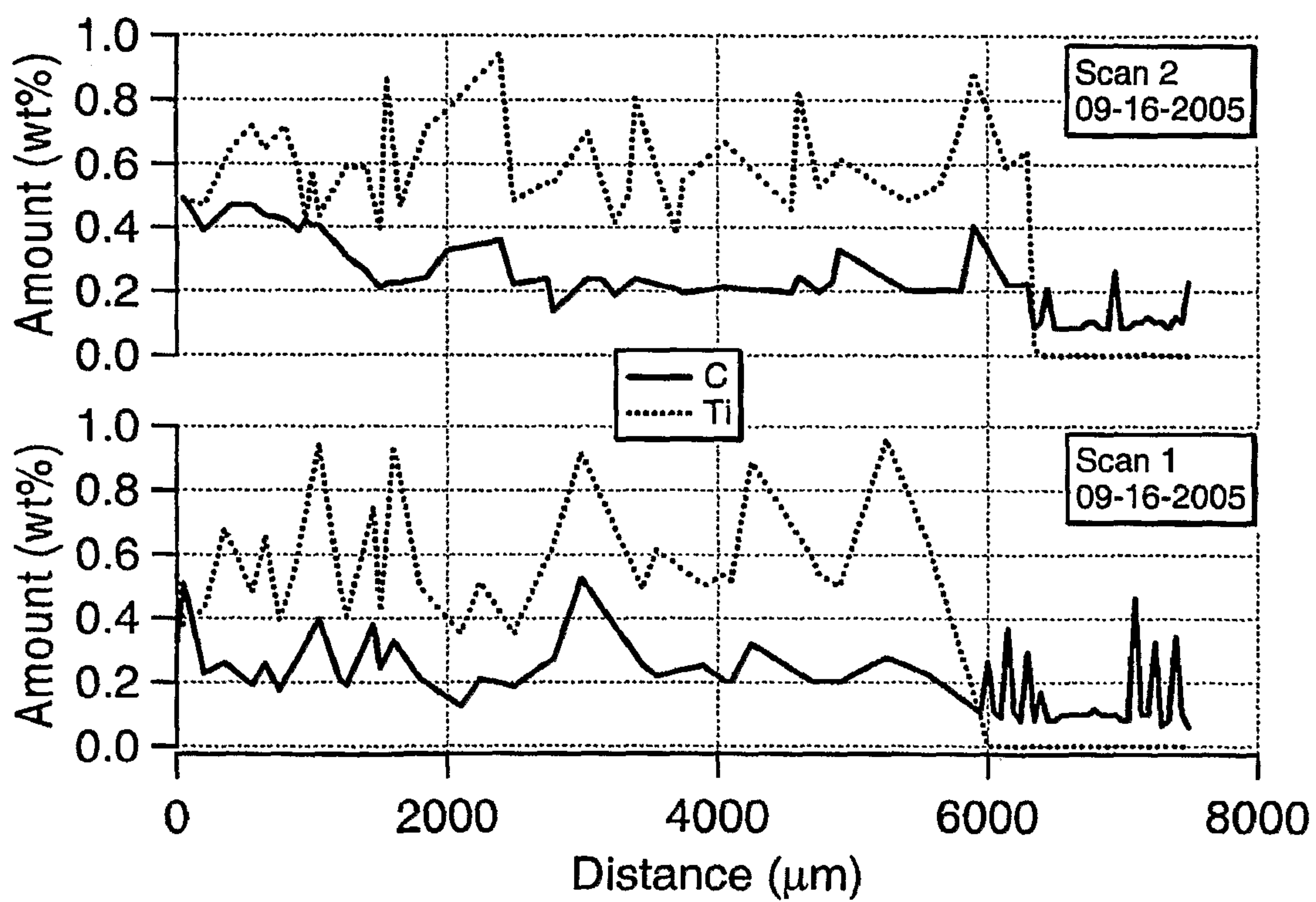


FIG. 3b

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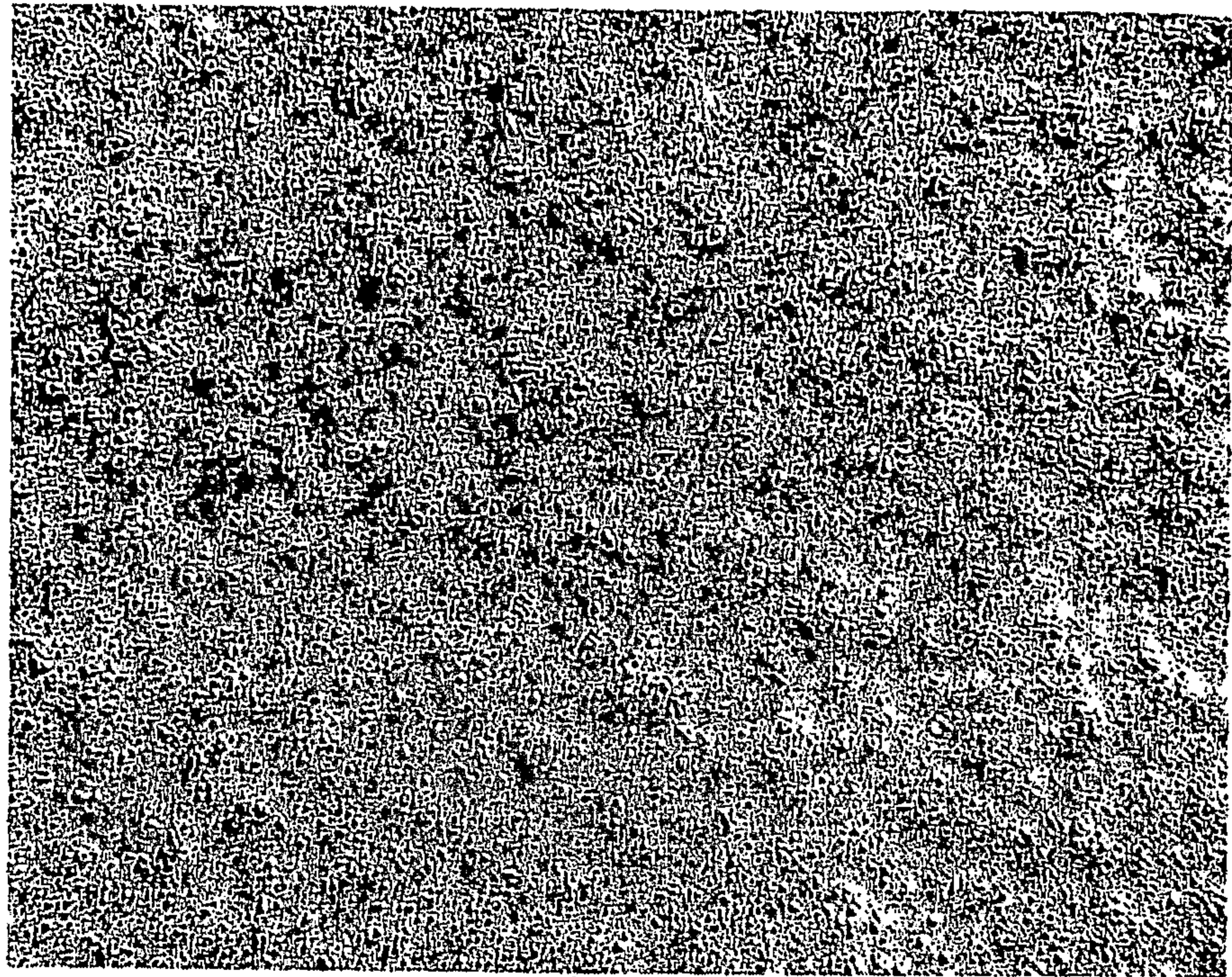


FIG. 4a

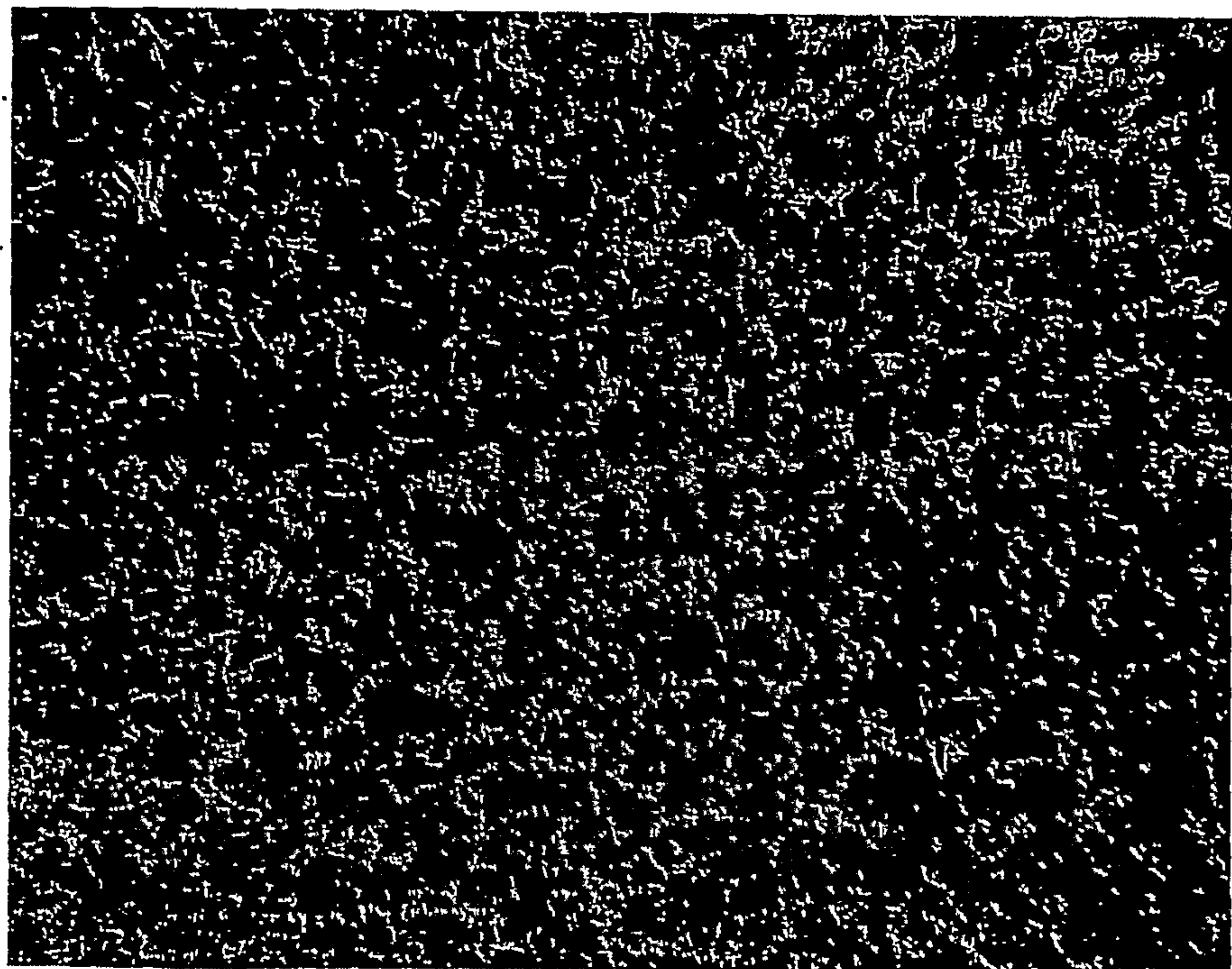


FIG. 4b

