

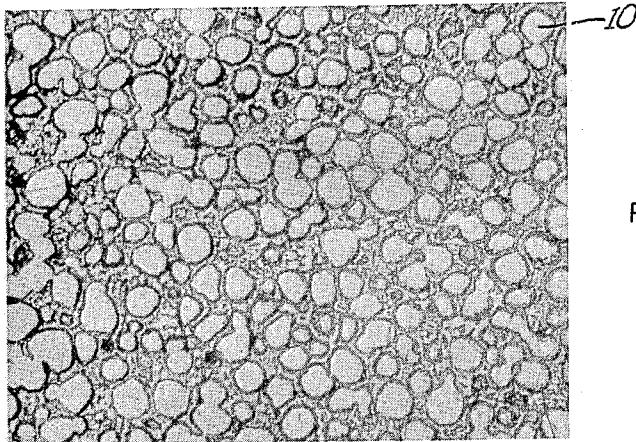
April 19, 1966

J. F. QUAAS ETAL
HOMOGENOUS DUCTILE NICKEL BASE ALLOY WELD
DEPOSIT AND METHOD FOR PRODUCING SAME

3,246,981

Filed Feb. 27, 1964

3 Sheets-Sheet 1



PRIOR ART

FIG - 1.

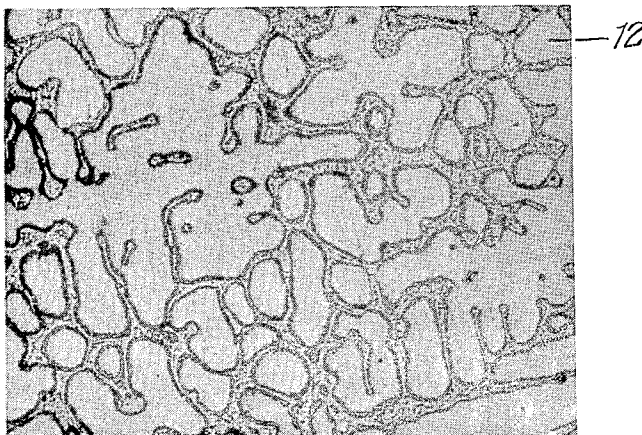


FIG - 2.

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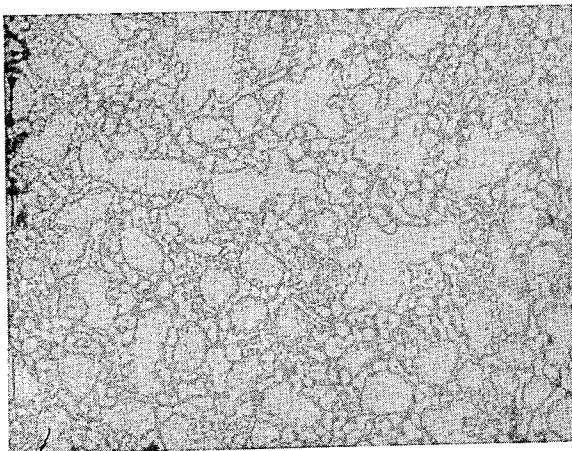
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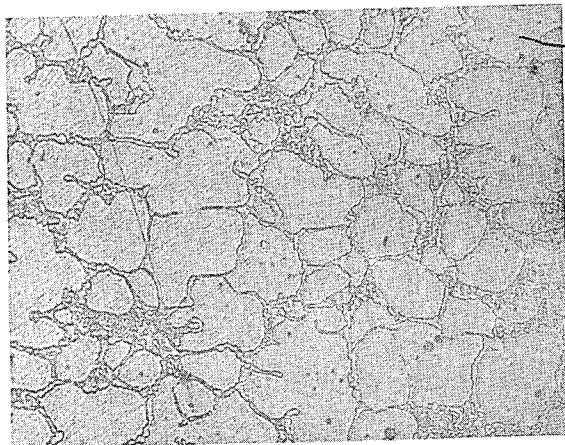
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PRIOR ART

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FIG - 3.



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FIG - 4.

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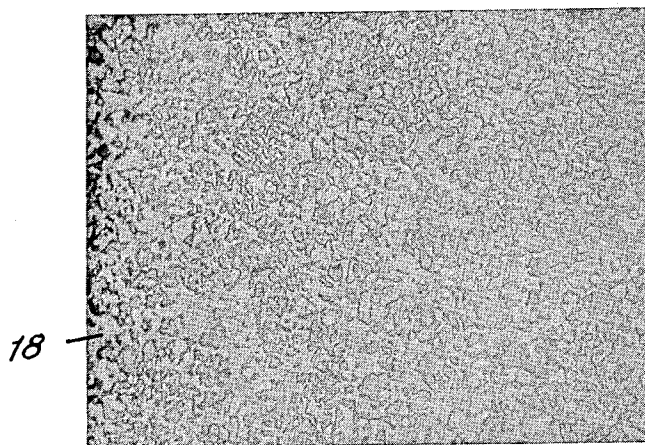
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PRIOR ART

FIG. 5.

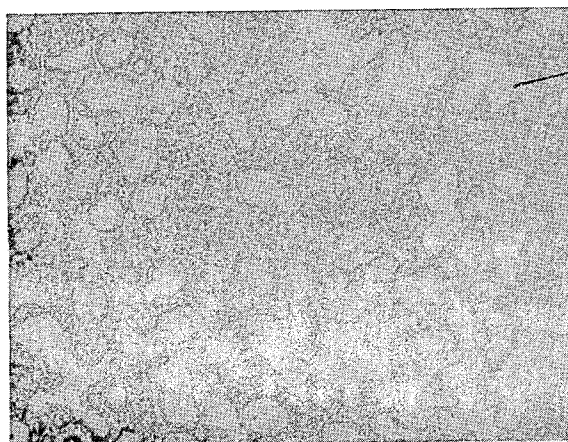


FIG. 6.

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3,246,981
**HOMOGENOUS DUCTILE NICKEL BASE ALLOY
WELD DEPOSIT AND METHOD FOR PRODUC-
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Filed Feb. 27, 1964, Ser. No. 347,945
16 Claims. (Cl. 75-170)

This invention relates to a method and metal powder for welding joints and more particularly to such a method and metal powder for flame spraying joints.

Although conventional metal powders can be satisfactorily deposited on, for example, joints at acceptable temperatures, these deposits are not as ductile as desired.

An object of this invention is to provide a method and metal powder for welding in which the metal powder possesses advantageous characteristics superior to conventional materials with improved ductility also.

A further object of this invention is to provide such a method and a metal power which is applied with low cost deposition.

In accordance with this invention, nickel powders of finer than 150 mesh are added to a lower melting nickel base alloy powder to obtain a heterogeneous mixture in which the nickel powders comprise from 10 to 50% by weight of the mixture. The mixture is simultaneously flame sprayed and fused to obtain a homogeneous ductile deposit. Surprisingly, the melting temperature of the mixture is substantially that of the nickel base alloy although the nickel powder itself has a higher melting temperature and comprises such a relatively large amount of the mixture or filler metal. However, the resultant deposited metal has vastly improved ductility over the nickel base alloy alone. The superior qualities of the pure nickel are thereby obtained in the deposit at lower temperatures because of the interreaction between the pure nickel and the alloy. In an advantageous form of this invention the nickel powders comprise from 30 to 40% of the mixture.

Novel features and advantages of the present invention will become apparent to one skilled in the art from a reading of the following description in conjunction with the accompanying drawings wherein similar reference characters refer to similar parts and in which:

FIG. 1 shows the microstructure of a conventional nickel base alloy;

FIG. 2 shows the microstructure of the nickel base alloy shown in FIG. 1 after deposit in accordance with this invention with nickel powders added;

FIG. 3 shows the microstructure of another nickel base alloy;

FIG. 4 shows the microstructure of the nickel base alloy shown in FIG. 3 after deposit in accordance with this invention with nickel powder added;

FIG. 5 shows the microstructure of still another nickel base alloy; and

FIG. 6 shows the microstructure of the nickel base alloy shown in FIG. 5 after deposit in accordance with the invention with nickel powder added.

In FIG. 1 is shown the microstructure of a nickel base alloy containing the following composition: 2.6% Si, 1.5% B, 0.5% Fe, 0.03% C. FIG. 2 shows the same alloy after a 30% addition of nickel powder and deposit in accordance with this invention. As shown in FIG. 1, the grains 10 of nickel are relatively small as compared with the much larger grains 12 shown in FIG. 2. The proportion of the hard intergranular constituents in FIG. 2 are reduced to a level which permits the alloy to possess greater ductility and lower indentation hardness as a result of the 30% addition of pure nickel powder.

Similarly, FIGS. 3 and 4 show the effect of a 40% addition of nickel powder to NiB-4 nickel base alloy containing the following composition: 3.54% Si, 2.02% B, 0.45% Fe, 0.04% C. As shown in FIG. 4 the resultant nickel grains 14 of the nickel solid solution after deposit in accordance with this invention are exceedingly larger than the nickel grains 16 shown in FIG. 3. The microstructure shown in FIG. 4 indicates the greatly reduced amount of hard intergranular constituents which thereby results in vastly improved ductility.

FIGS. 5 and 6 show the effect of a 30% nickel powder addition to NiB-1, nickel base alloy containing the following composition: 14.9% Cr, 4.3% Si, 3.4% B, 4.2% Fe, 0.68% C. As compared with the very hard deposit having small nickel grains 18 shown in FIG. 5 the large nickel rich grains 20 shown in FIG. 6 of a deposit in accordance with this invention contain boron, silicon, and iron in a solid solution and indicate the improved ductility and lower indentation hardness of the heterogeneous mixture.

This improved ductility is obtained with the retention of the desirable qualities, such as the ability of being deposited at satisfactory melting temperatures, of conventional nickel base alloys by adding from 10 to 50% by weight of nickel powders to the nickel base alloys. Some of the advantageous nickel base alloys are described as NiB-1, NiB-2, NiB-3 and NiB-4 in Table I, page 4 of the American Welding Society Specification A5.8-62T. The resultant nickel mixture is particularly effective when it is sprayed and fused in a single operation on, for example, a joint by using for example a conventional flame spraying torch or a flame spraying torch of the type described in copending application Serial No. 289,474, filed June 21, 1963, or a torch of the type described in U.S. Patent 2,786,779 to obtain a low cost homogeneous nickel deposit having a higher remelt temperature than the temperature at which the heterogeneous powder mixture is applied such as approximately 2400° F. Surprisingly, the nickel mixture has, upon spraying, excellent wetting-on flow characteristics. This result is particularly unexpected when the much higher melting point of the powder is considered. For example, the melting point of the pure nickel is 2652° F. as compared with an alloy melting point of 2400° F. However, where the nickel powders are of particle size finer than 150 mesh, the power is very rapidly taken into solution at the temperature normally used to deposit the nickel base alloy itself. A fluid molten pool is thereby produced which wets the base metal and can be manipulated very similarly to the nickel base alloy involved. That the molten pool dissolves the nickel completely is proven by the fact that no segregation of nickel has been found in the microstructures of numerous deposits made with up to 50% nickel powder addition. FIGS. 2, 4, and 6, for example, show that the microstructure produced by nickel powder additions is characterized by greater solution of the hard constituents.

The following table shows the effect of nickel powder additions on lowering the hardness of the nickel base alloy powder containing the following composition: 2.6% Si, 1.5% B, .5% Fe, .03% C.

Mixture	Weight percent nickel powder	Rockwell B hardness
1-----	0	RB 93-98
2-----	10	RB 90-91
3-----	15	RB 86-89
4-----	20	RB 78-82
5-----	30	RB 75-78
6-----	40	RB 65-70
7-----	50	RB 57-62

As is readily apparent from the preceding table, sub-

stantial reductions of deposit hardness are obtained with the use of the heterogeneous powders, especially where the powders constitute at least 10% by weight of the mixture. Further, the consistency of hardness values along with the length of a given deposit clearly indicates that the powdered nickel has gone completely into solution.

The following examples illustrate mixtures that satisfy the objectives of this invention:

Example 1

	NiB-1	Nickel powder
Weight percent.....	90-50	10-50
Preferred mixture, percent.....	70	30
Mesh size range.....	-150	-150
Preferred mesh size.....	-150+400	-200+400

Example 2

	NiB-4	Nickel powder
Weight percent.....	90-50	10-50
Preferred mixture, percent.....	60	40
Mesh size range.....	-100	-150
Preferred mesh size.....	-150+400	-200+400

Example 3

	Nickel-boron-silicon alloy	Nickel powder
Weight percent.....	90-50	10-50
Preferred mixture, percent.....	70	30
Mesh size range.....	-150	-150
Preferred mesh size.....	-150+400	-200+400

An advantageous nickel base alloy is:

Constituent	Range—to—Preferred range		Example, percent
Cr.....	5.0-15.0	13.0-15.0	14.9
Si.....	2.0-6.0	3.0-5.0	4.3
B.....	1.0-4.0	2.7-4.0	3.4
Fe.....	0.1-8.0	3.0-5.0	4.2
C.....	0.1-1.5	0.6-0.9	.68
Ni.....	Balance	Balance	Balance

Another advantageous nickel base alloy is:

Constituent	Range—to—Preferred range		Example, percent
Si.....	2.0-6.0	3.0-5.0	3.54
B.....	1.0-4.0	1.5-2.5	2.02
Fe.....	0.2-5.0	0.3-1.0	.45
C.....	0.01-0.3	0.01-0.10	.04
Ni.....	Balance	Balance	Balance

Another advantageous nickel base alloy is:

Constituent	Range—to—Preferred range		Example, percent
B.....	1.0-4.0	1.0-2.5	1.5
Si.....	1.0-6.0	1.0-4.0	2.6
Fe.....	0.2-5.0	0.2-1.0	.5
C.....	0.01-0.3	0.01-0.1	.03
Ni.....	Balance	Balance	Balance

What is claimed is:

1. A homogenous ductile nickel base alloy weld deposit of uniform hardness formed from a metal powder mixture consisting essentially of a nickel base alloy powder and nickel powder mixed with said alloy powder to provide a heterogeneous mixture, said nickel powder being in the range of 10 to 50% by weight of said mixture, said mixture having the characteristic of said nickel powder being completely soluble in said nickel base alloy powder whereas said nickel base alloy deposit has a lower hardness

than said nickel base alloy powder in said heterogeneous mixture.

2. A process for depositing a nickel alloy composition upon a base metal comprising the steps of adding nickel powder to a nickel base alloy powder having a relatively lower melting temperature, maintaining said mixture heterogeneous and thereby including separate particles of said powders, said added nickel powder ranging approximately from 10 to 50% by weight of said heterogeneous mixture, and simultaneously spraying and fusing said heterogeneous mixture upon said base metal at a temperature above the said melting temperature of said nickel base alloy powder and below the melting temperature of said nickel powder to obtain a homogeneous nickel alloy composition deposit upon said base metal having a remelting temperature higher than the temperature at which it is simultaneously sprayed and fused.

3. A metal powder mixture as set forth in claim 1 wherein said nickel powder has a particle size finer than 150 mesh.

4. A metal powder mixture as set forth in claim 3 wherein said nickel powder has a particle size less than 200 mesh and greater than 400 mesh.

5. A process as set forth in claim 2 wherein the particle size of said nickel powder is maintained finer than 150 mesh.

6. A process as set forth in claim 5 wherein the particle size of said nickel powder is maintained less than 200 mesh and greater than 400 mesh.

7. A metal powder mixture as set forth in claim 1 wherein said nickel powder is in the range of 30 to 40% by weight of said mixture.

8. A metal powder mixture as set forth in claim 1 wherein said nickel base alloy consists essentially of the following constituents in the indicated ranges of percentages by weight:

Constituent:	Range
Silicon	2.0-6.0
Boron	1.0-4.0
Iron	0.2-5.0
Carbon	0.01-0.3
Nickel	Balance

9. A nickel base alloy metal powder as set forth in claim 8 wherein said ranges of percentages by weight are:

Constituent:	Range
Silicon	3.0-5.0
Boron	1.5-2.5
Iron	0.3-1.0
Carbon	0.01-0.10
Nickel	Balance

10. A metal powder mixture as set forth in claim 1 wherein said nickel base alloy consists essentially of the following constituents in the indicated ranges of percentages by weight:

Constituent:	Range
Boron	1.0-4.0
Silicon	1.0-6.0
Iron	0.2-5.0
Carbon	0.01-0.3
Nickel	Balance

11. A nickel base alloy metal powder as set forth in claim 10 wherein said ranges of percentages by weight are:

Constituent:	Range
Boron	1.0-2.5
Silicon	1.0-4.0
Iron	0.2-1.0
Carbon	0.01-0.1
Nickel	Balance

12. A process as set forth in claim 2 wherein said nickel

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powder is maintained in the range of 30 to 40% by weight of said mixture.

13. A process as set forth in claim 2 wherein said nickel base alloy consists essentially of the following constituents in the indicated ranges of percentages by weight:

Constituent:	Range
Silicon -----	2.0-6.0
Boron -----	1.0-4.0
Iron -----	0.2-5.0
Carbon -----	0.01-0.3
Nickel -----	Balance

14. A process as set forth in claim 13 wherein said ranges of percentages by weight are:

Constituent:	Range
Silicon -----	3.0-5.0
Boron -----	1.5-2.5
Iron -----	0.3-1.0
Carbon -----	0.01-0.10
Nickel -----	Balance

15. A process as set forth in claim 2 wherein said nickel base alloy consists essentially of the following constituents in the indicated ranges of percentages by weight:

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Constituent:	Range
Boron -----	1.0-4.0
Silicon -----	1.0-6.0
Iron -----	0.2-5.0
Carbon -----	0.01-0.3
Nickel -----	Balance

16. A process as set forth in claim 15 wherein said ranges of percentages by weight are:

Constituent:	Range
Boron -----	1.0-2.5
Silicon -----	1.0-4.0
Iron -----	0.2-1.0
Carbon -----	0.01-0.1
Nickel -----	Balance

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