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(54) **Corrosion resistant polycrystalline abrasive compacts**

(57) A supported abrasive particle compact is composed of a cobalt-cemented carbide support integrally bonded to an abrasive particle layer of self-bonded diamond particles or CBN particles. The cobalt content in said supported compact is provided in form of a nickel-cobalt alloy wherein the amount of nickel is such that the cobalt is present in the face center cubic (FCC) or e

phase. The inventive cutters can be made by infiltration of Ni metal into cemented WC substrate and/or the polycrystalline layer bonded thereto. Bonding includes high pressure/high temperature (HP/HT) formation of the supported polycrystalline compact and the brazing of the polycrystalline compact to the support.

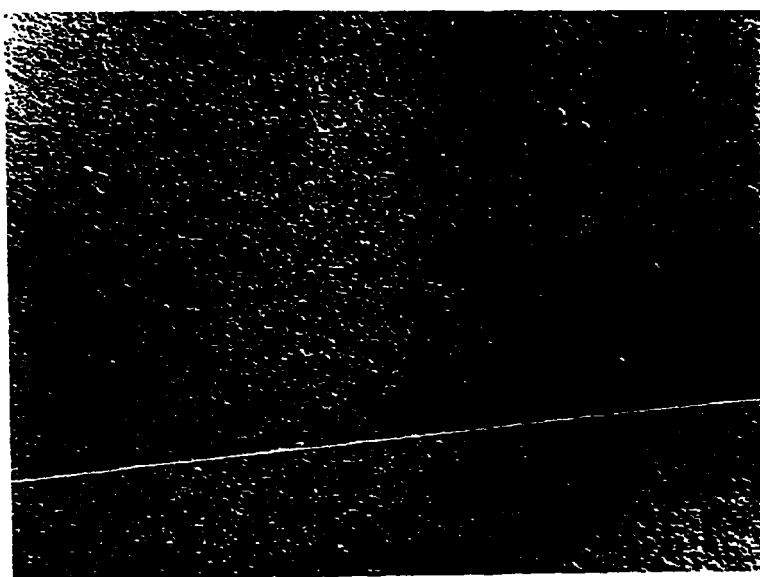


FIG. 2

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Description

[0001] The present invention relates to implements incorporating abrasive particle compacts and more particularly to such compacts having improved properties including, *inter alia*, corrosion resistance, thermal resistance, wear resistance, stress corrosion resistance, and elevated temperature relaxation. Such implements have special utility in, for example, drilling, wire die, and machining applications.

[0002] A compact may be characterized generally as an integrally-bonded structure formed of a sintered, polycrystalline mass of abrasive particles, such as diamond or cubic boron nitride (CBN). Although such compacts may be self-bonded without the aid of a bonding matrix or second phase, it generally is preferred, as is discussed in U.S. Patents Nos. 4,063,909 and 4,601,423, to employ a suitable bonding matrix which usually is a metal such as cobalt, iron, nickel, platinum, titanium, chromium, tantalum, copper, or an alloy or mixture thereof. The bonding matrix, which is provided at from about 5% to 35% by volume, additionally may contain recrystallization or growth catalyst such as aluminum for CBN or cobalt for diamond.

[0003] For many applications, it is preferred that the compact is supported by its bonding to substrate material to form a laminate or supported compact arrangement. Typically, the substrate material is provided as a cemented metal carbide which comprises, for example, tungsten, titanium, or tantalum carbide particles, or a mixture thereof, which are bonded together with a binder of between about 6% to about 25% by weight of a metal such as cobalt, nickel, or iron, or a mixture or alloy thereof. As is shown, for example, in U.S. Patents Nos. 3,831,428; 3,852,078; and 3,876,751, compacts and supported compacts have found acceptance in a variety of applications as parts or blanks for cutting and dressing tools, as drill bits, and as wear parts or surfaces.

[0004] The basic high pressure/high temperature (HP/HT) method for manufacturing the polycrystalline compacts and supported compacts of the type herein involved entails the placing of an unsintered mass of abrasive, crystalline particles, such as diamond or CBN, or a mixture thereof, within a protectively shielded enclosure which is disposed within the reaction cell of an HP/HT apparatus of a type described further in U.S. Patents Nos. 2,947,611; 2,941,241; 2,941,248; 3,609,818; 3,767,371; 4,289,503; 4,673,414; and 4,954,139. Additionally placed in the enclosure with the abrasive particles may be a metal catalyst if the sintering of diamond particles is contemplated, as well as a pre-formed mass of a cemented metal carbide for supporting the abrasive particles and to thereby form a supported compact therewith. The contents of the cell then are subjected to processing conditions selected as sufficient to effect intercrystalline bonding between adjacent grains of abrasive particles and, optionally, the joining of sintered particles to the cemented metal carbide support. Such processing conditions generally involve the imposition for about 3 to 120 minutes of a temperature of at least 1000° C and a pressure of at least 20 Kbar.

[0005] Regarding the sintering of polycrystalline diamond (PCD) compacts or supported compacts, the catalyst metal may be provided in a pre-consolidated form disposed adjacent the crystal particles. For example, the metal catalyst may be configured as an annulus into which is received a cylinder of abrasive crystal particles, or as a disc which is disposed above or below the crystalline mass. Alternatively, the metal catalyst, or solvent as it is also known, may be provided in a powdered form and intermixed with the abrasive crystalline particles, or as a cemented metal carbide or carbide molding powder which may be cold pressed into shape and wherein the cementing agent is provided as a catalyst or solvent for diamond recrystallization or growth. Typically, the metal catalyst is selected from cobalt, iron, or nickel, or an alloy or mixture thereof, but other metals such as ruthenium, rhodium, palladium, chromium, manganese, tantalum, copper, and alloys and mixtures thereof also may be employed.

[0006] Under the specified HT/HP conditions, the metal catalyst, in whatever form provided, is caused to penetrate or "sweep" into the abrasive layer by means of either diffusion or capillary action, and is thereby made available as a catalyst or solvent for recrystallization or crystal intergrowth. The HT/HP conditions, which operate in the diamond stable thermodynamic region above the equilibrium between diamond and graphite phases, effect a compaction of the abrasive crystal particles which is characterized by intercrystalline diamond-to-diamond bonding wherein parts of each crystalline lattice are shared between adjacent crystal grains. Preferably, the diamond concentration in the compact or in the abrasive table of the supported compact is at least about 70% by volume. Methods for making diamond compacts and supported compacts are more fully described in U.S. Patents Nos. 3,142,746; 3,745,623; 3,609,818; 3,850,591; 4,394,170; 4,403,015; 4,797,326; and 4,954,139.

[0007] Regarding the sintering of polycrystalline CBN (PCBN) compacts and supported compacts, such compacts and supported compacts are manufactured in general accordance with the methods suitable for diamond compacts. However, in the formation of CBN compacts via the previously described "sweep-through" method, the metal that is swept through the crystalline mass need not necessarily be a catalyst or solvent for CBN recrystallization. Accordingly, a polycrystalline mass of CBN may be joined to the cobalt-cemented tungsten carbide substrate by the sweep through of the cobalt from the substrate and into the interstices of the crystalline mass notwithstanding that cobalt is not a catalyst or solvent for the recrystallization of CBN. Rather, the interstitial cobalt functions as a binder between the polycrystalline CBN compact and the cemented tungsten carbide substrate.

[0008] As it was for diamond, the HT/HP sintering process for CBN is effected under conditions in which CBN is the

thermodynamically stable phase. It is speculated that under these conditions, intercrystalline bonding between adjacent crystal grains also is effected. The CBN concentration in the compact or in the abrasive table of the supported compact is preferably at least about 50% by volume. Methods for making CBN compacts and supported compacts are more fully described in U.S. Patents Nos. 2,947,617; 3,136,615; 3,233,988; 3,743,489; 3,745,623; 3,831,428; 3,928,219; 4,188,194; 4,289,503; 4,673,414; 4,797,326; and 4,954,139. Exemplary CBN compacts are disclosed in U.S. Patent No. 3,767,371 to contain greater than about 70% by volume of CBN and less than about 30% by volume of a binder metal such as cobalt.

[0009] Heretofore, Packer (U.S. Pat. No. 5,697,994) has proposed to form woodworking cutting tools consisting of a WC substrate to which is bonded a layer of PCD or PCBN under HP/HT conditions. The secondary or catalyst phase of Co includes an alloying metal selected from Ni, Al, Si, Ti, Mo, and Cr; and a refractory material selected from titanium carbonitride and titanium aluminum carbonitride. The alloying metal is stated to retard transformation of Co from the hexagonal-close-packed (HCP) or e phase to the face-centered-cubic (FCC) or a phase, which transformation at high temperature causes microcracks leading to product degradation. The maximum amount of alloying metal tested in Packer's examples was 5%.

[0010] While Packer's cutting tools may be fine for woodworking, the presence of the e phase Co in high performance uses of PCD and PCBN cutting tools was found to be less chemically stable and, thus, more corrosion prone, especially at high temperatures (say, 410° C to 440° C). Thus, a need in the art exists for providing more corrosion resistant supported PCD and PCBN cutting tools.

BRIEF SUMMARY OF THE INVENTION

[0011] A supported abrasive particle compact is composed of a cobalt-cemented carbide support integrally bonded to an abrasive particle layer of self-bonded diamond particles or CBN particles. The cobalt content in said supported compact is provided in form of a nickel-cobalt alloy wherein the amount of nickel is such that the cobalt is present in the face center cubic (FCC) or a phase.

[0012] The inventive cutters can be made by infiltration of Ni metal into cemented WC substrate and/or the polycrystalline layer bonded thereto. Bonding includes HP/HT formation of the supported polycrystalline compact and the brazing of the polycrystalline compact to the support.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] For a fuller understanding of the nature and objects of the present invention, reference should be made to the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a photomicrograph (75 X) of the corrosion that results when a WC support has been immersed in 21° C (room temperature) water for 15 minutes.

Fig. 2 is a photomicrograph (75 X) of an inventive WC support has been immersed in 21° C (room temperature) water for 15 minutes that evidences no sign of corrosion.

Fig. 3 is a photomicrograph of a brazed tool showing the region near the braze line of a Ni-Cr-Pd braze layer.

Fig. 4 is a photomicrograph of the brazed tool of Fig. 3 after it had been immersed in 21° C (room temperature) water for 15 minutes.

Fig. 5 is a side elevational view of a diamond compact bonded to a WC sandwich of two WC compacts brazed together.

Fig. 6 is a composition profile of the brazed tool of Fig. 5 based on EDS analysis (Energy Dispersive Spectrometer, detection limit of 0.01% for all elements and resolution of 1 micron).

[0014] The drawings will be described in detail in the Examples below.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Since e phase Co contains fewer stacking faults compared to the HCP or a phase, it is more chemically stable and more corrosion resistant. Moreover, the Ni enriched FCC structure of the matrix is stable over a wide range of temperatures and the Ni-Co alloy is resistant to the Co phase reverting to the HCP phase. The inventive cutters, then,

are more thermally stable by dint of the presence of the Ni alloying metal. This is true when an effective amount of Ni is alloyed with the Co in the PCD, PCBN, or WC support. Such effective amount of Ni broadly ranges from about 5% to 50% by weight of the Co content being alloyed by the Ni. Other metals that function like Ni in this application include, for example, Pd, Pt, V, Cr, Nb, Mo, and Ta.

[0016] The Ni can be alloyed with the Co by any means convenient to the fabricator. Thus, the PCD or PCBN can be pressed with Ni-Co cemented carbide under HP/HT conditions to produce a dense sintered PCD or PCBN blank by infiltrating Ni-Co through the polycrystalline masses. Alternatively, Ni can be diffused into Co cemented WC supports and/or into the abrasive particle layer of standard PCD or PCBN layers. Further, Ni can be diffused into the WC supports from Ni sheets or Ni bricks into Co-swept cutters that have been previously formed under HP/HT conditions. As shown in the Examples, such infiltration may even come from brazing alloys used to braze WC supports to each other. Thus, any means at hand to the fabricator for alloying an effective amount of Co with Ni can be used in accordance with the precepts of the present invention.

[0017] The polycrystalline layer preferably is polycrystalline diamond (PCD). However, other materials that are included within the scope of this invention are synthetic and natural diamond, cubic boron nitride (CBN), wurtzite boron nitride, combinations thereof, and like materials. The cemented metal carbide substrate is conventional in composition and, thus, may include any of the Group IVB, VB, or VIB metals, which are pressed and sintered in the presence of a binder of cobalt, nickel or iron, or alloys thereof. The preferred metal carbide is tungsten carbide.

[0018] The surface configuration of the diamond layer may also be conical, reduced or increased radius, chisel, or non-axisymmetric in shape. In general, all forms of supported PCD and PCBN inserts used in the drilling, machining, and wire drawing industries may be enhanced by the addition of Ni alloying metal, due to the thermal stability and corrosion resistance imparted.

[0019] Further, the interface between the carbide and diamond layer may be of generally any configuration such as domed, hemispherical, reduced radius, flat, cone-shaped, *etc.* The interface may also be smooth, serrated, or the like. However, an irregular interfacial surface often is preferred since it provides better bonding between the diamond layer and carbide substrate particularly during sintering of the carbide substrate and forming of the diamond layer.

[0020] Supported PCD and CBN compacts have garnered wide acceptance for use in cutting and dressing tools, drill bits, and in like applications wherein the hardness and wear properties of such compacts are exploited. In particular, such compacts have been incorporated into dies for drawing feedstocks of such metals as tungsten, copper, iron, molybdenum, and stainless steel into wires. Typically, these wire drawing dies are surrounded by and bonded to a generally annular, outer mass of a metal carbide support. Provided to extend through the compact along the axial centerline thereof is a hole or other aperture into which the metal feedstock is drawn for its elongation into a wire product of a reduced diameter. Wire drawing dies of such general type and methods for manufacturing the same are described in U.S. Patents Nos. 3,831,428; 4,016,736; 4,129,052; 4,144,739; 4,303,442; 4,370,149; 4,374,900; 4,534,934; 4,828,611; 4,872,333; and 5,033,334.

[0021] With respect to the fabrication of the wire drawing dies herein involved, although a variety of methods may be employed, HT/HP sintering processes as are described in U.S. Pat. Nos. 3,831,428 and 4,534,934 may be considered preferred. As with fabrication of supported compacts in general, the preferred HT/HP processes entail the sweep of a catalytic or binder metal, such as cobalt, through a mass of CBN or PCD particles. For wire die forming processes, the particles are charged within a support of a surrounding metal carbide annulus. At the processing conditions heretofore specified, metal from the support and, optionally, from an axially disposed disc, is made to infiltrate radially and/or axially into the interstices of the crystalline mass. Within the particle mass, the infiltrated metal forms a separate binder phase and, at least with respect to PCD, effects significant intercrystalline bonding. The metal additionally joins the sintered compact to the support to form an integral structure. The wire drawing hole may be formed through the sintered compact as a finishing step by laser drilling or other machining techniques. Alternatively, the hole may be pre-formed by including a wire as axially disposed within the particle mass, which wire is removed after the sintering of the mass by dissolution in a suitable acid or other solvent or by machining techniques.

[0022] As to supported compacts in general, it is speculated, as is detailed in U.S. Patent No. 4,797,326, that the bonding of the support to the polycrystalline abrasive mass involves a physical component in addition to a chemical component which develops at the bondline if the materials forming the respective layers are interactive. The physical component of bonding is seen to develop from a relatively lower coefficient of thermal expansion (CTE) of the polycrystalline abrasive layer as compared to the cemented metal support layer. That is, upon the cooling of the supported compact blank from the HT/HP processing conditions to ambient conditions, it has been observed that the support layer retains residual tensile stresses which, in turn, exert a radial compressive loading on the polycrystalline compact supported thereon. This loading maintains the polycrystalline compact generally in compression which thereby improves the fracture toughness, impact, and shear strength properties of the laminate. In a wire die configuration, the support annulus has been observed, generally, to beneficially exert both a radial and an axial compression against the central polycrystalline core.

[0023] Moreover, in the commercial production of supported compacts in general, it is common for the product or

blank which is recovered from the reaction cell of the HT/HP apparatus to be subjected to a variety of finishing operations which include cutting, such as by electrode discharge machining or with lasers, milling, and especially grinding to remove any adherent shield metal from the outer surfaces of the compact. Such operations additionally are employed to machine the compact into a cylindrical shape or the like which meets product specifications as to diamond or CBN abrasive table thickness and/or carbide support thickness. With respect to wire drawing dies in particular, prior to use, the die generally is brazed into a receiving ring or other support assembly.

[0024] While the invention has been described and illustrated in connection with certain preferred embodiments thereof, it will be apparent to those skilled in the art that the invention is not limited thereto. Accordingly, it is intended that the appended claims cover all modifications that are within the spirit and scope of this invention. All references cited herein are expressly incorporated herein by reference.

EXAMPLE 1

[0025] Abrasive compact blanks were made by brazing an extended WC-Co support to the WC-Co support of a 19 mm cylindrical PCD supported compact cutter (1mm diamond table and 8 mm thick WC support) using a Ni-based brazing disc. Nickel from the brazing disc diffuses into the support and alloys with the Co present. These blanks represent the present invention.

[0026] The fabricated brazed tools along with similar tools not brazed with a Ni-containing brazing disk were immersed into 21° C water (room temperature) for approximately 15 minutes, removed, and dried. Fig. 1 shows the extent of corrosion for a WC-Co support. Fig. 2 of the inventive fabricated brazed tool evidences no sign of corrosion. These results demonstrate the efficacy of the present invention.

EXAMPLE 2

[0027] Fig. 3 is a micrograph of another brazed tool showing the region near the braze line of a Ni-Cr-Pd braze alloy. This tool also was immersed in room temperature (21° C) water for 15 minutes. Thereafter, it was observed under a microscope as shown in Fig. 4. The WC substrate was corroded, except for a layer of around 3-4 micros above the braze line.

[0028] A simplified side elevational view of the brazed tool is shown in Fig. 5 wherein diamond compact 18 is seen bonded to upper carbide compact 14 which in turn is brazed to lower carbide compact 16 via braze layer 12. At circle 10, an EDS (Energy Dispersive Spectrometer) microprobe (detection limit of 0.01% for all elements and a resolution of 1 micron) was used to analyze upper carbide compact 14. These results are displayed graphically in Fig. 6, which shows the locations where EDS analysis was undertaken. The resulting composition profile, then, is displayed in Tables 1 and 2, below.

TABLE 1

Composition (wt-%) Profile Along Line A-D						
Location	W	Co	Ni	Pd	Cr	Fe
A	1.92	8.49	52.17	23.05	7.39	0.061
B	65.46	1.72	13.79	4.06	1.33	0
C	74.21	12.51	0	0	0.0025	0.053
D	75.96	10.81	0	0	0.028	0.022

TABLE 2

Composition (wt-%) Profile Along Line A'-D'						
Location	W	Co	Ni	Pd	Cr	Fe
A'	1.51	5.71	52.79	24.86	8.25	0.065
B'	73.76	1.11	5.56	4.26	1.83	0.0054

TABLE 2 (continued)

Composition (wt-%) Profile Along Line A'-D'						
Location	W	Co	Ni	Pd	Cr	Fe
C'	72.86	10.73	0	0	0	0
D'	74.2	12.19	0	0	0	0

[0029] These results demonstrate that the WC region that had not corroded was the region containing Ni. In this region, Ni had diffused from the braze alloy layer into the WC and had aided in increasing the corrosion resistance of the WC.

Claims

1. A cobalt-cemented carbide support of improved corrosion-resistance, which comprises:

the cobalt content in said support being in the form of an alloy of a metal wherein the amount of said metal is such that the cobalt is present in the face center cubic (FCC) phase, said metal selected from one or more of Ni, Pd, Pt, V, Cr, Nb, Mo, or Ta.

2. The carbide support of claim 1, wherein the amount of said metal ranges from about 5 to 50 wt-% by weight of said alloy.

3. The carbide support of claim 1 or claim 2, wherein said metal is Ni.

4. A supported abrasive particle compact composed of a cobalt-cemented carbide support integrally bonded to an abrasive particle layer of self-bonded diamond particles or cubic boron nitride (CBN) particles, in which the cobalt content in said supported compact is in the form of a nickel-cobalt alloy wherein the amount of nickel is such that the cobalt is present in the face center cubic (FCC) phase.

5. The supported compact of claim 4, wherein the amount of nickel ranges from about 5 to 50 wt-% by weight of said alloy.

6. The supported compact of claim 4, wherein said abrasive particle compact comprises a polycrystalline diamond (PCD) compact or a polycrystalline cubic boron nitride (PCBN) compact..

7. The supported compact of claim 4, wherein said carbide support is one or more of a tungsten carbide, titanium carbide, or tantalum carbide support.

8. The supported compact of claim 4, which is formed as a cylindrical compact, an annular wire drawing die or a drill bit.

9. A method for fabricating a supported abrasive particle compact composed of a cobalt-cemented carbide support integrally bonded to an abrasive particle layer of self-bonded diamond particles or cubic boron nitride (CBN) particles, which comprises:

alloying the cobalt content in said supported compact with nickel wherein the amount of nickel is such that the cobalt is present in the face center cubic (FCC) phase.

10. The method of claim 9, wherein the amount of nickel alloyed with said cobalt ranges from about 5 to 50 wt-% by weight of said alloy.

11. The method of claim 9, wherein said abrasive particle compact comprises a polycrystalline diamond (PCD) compact, or polycrystalline cubic boron nitride (PCBN) compact.

12. The method of claim 9, wherein said carbide support is one or more of a tungsten carbide, titanium carbide, or tantalum carbide support.

13. The method of claim 9, wherein the compact is formed as a cylindrical compact, an annular wire drawing die or a drill bit.

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FIG. 1

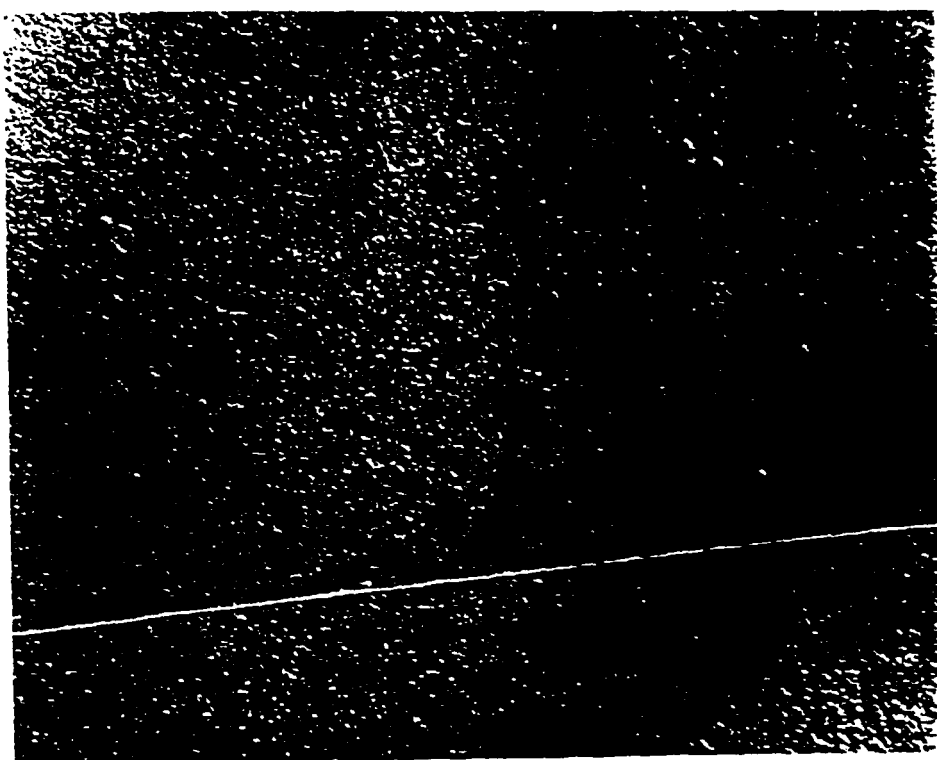


FIG. 2



FIG. 3

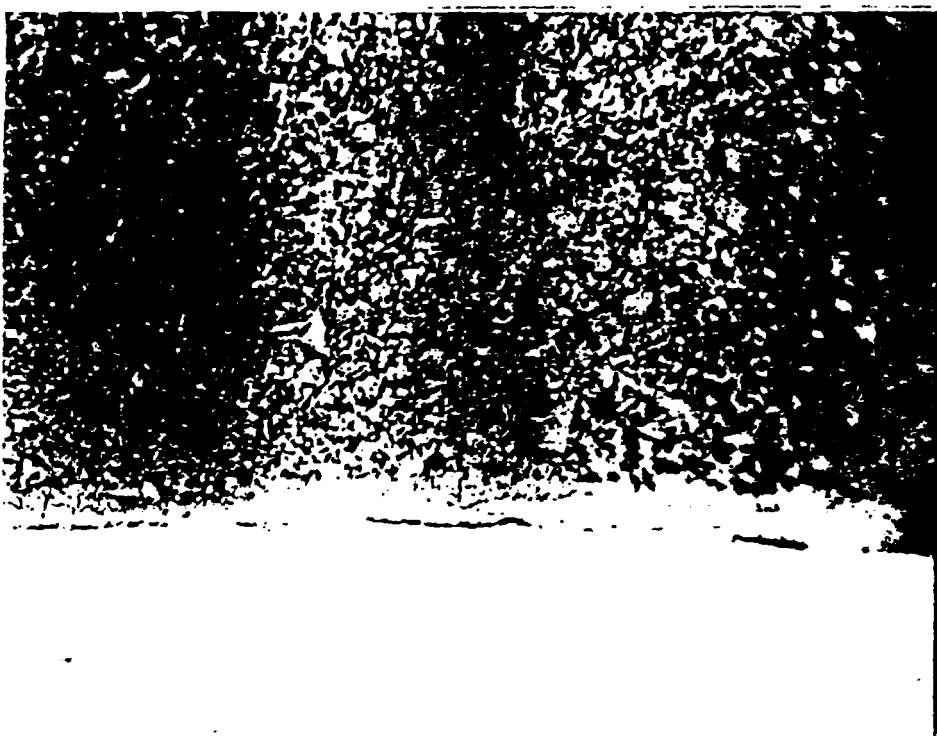


FIG. 4

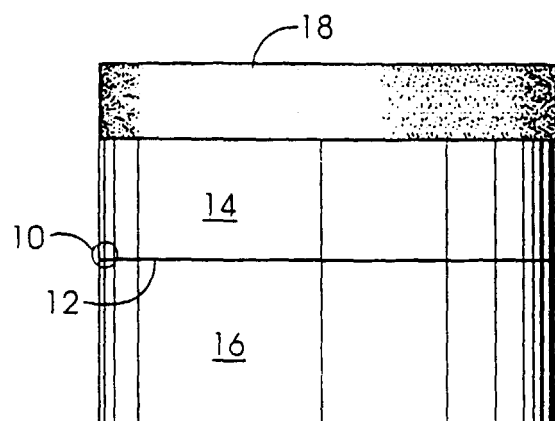


FIG. 5

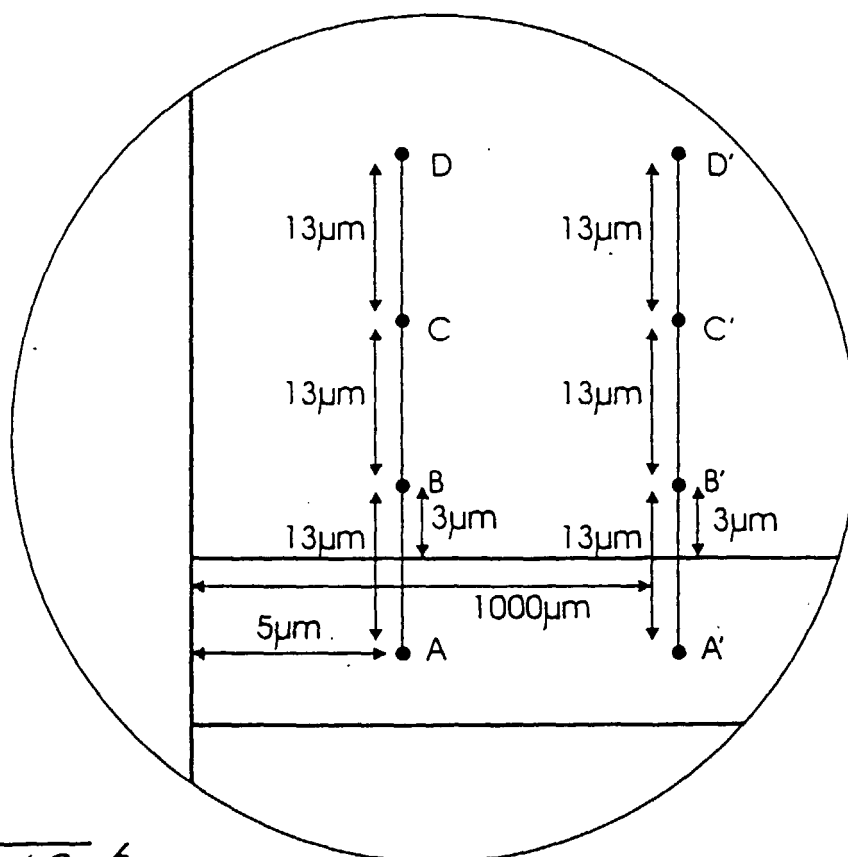


FIG. 6