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(54) **Pencil lead, and methods and apparatus for its manufacture.**

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Description

The present invention generally relates to a pencil lead and, more particularly, to an improved pencil lead, as well as to methods of and apparatus for making the pencil lead.

It is desirable that pencil lead for a variety of forms of pencils including wood-sheathed ordinary pencils and especially spare leads for propelling-type pencils be thinner and stronger, i.e. stiffer and of greater strength to resist breaking, in addition to satisfying their general requisites of lower friction coefficient or greater smoothness to write, suitable wear resistance, highly reflectivity or darkness (e.g. blackness) and less dispersion of powder on writing.

The present invention seeks to provide a novel and improved pencil lead suitable for a wide variety of pencils including wood-sheathed pencils and especially for a propelling pencil, which lead is greater in strength than the conventional pencil lead and can be much reduced in diameter while exhibiting a strength equivalent to or even higher than that of the conventional pencil lead.

The present invention also seeks to provide a novel and improved pencil lead which is thin and stiff, and yet presents a sufficiently soft feeling on writing.

In addition, the present invention seeks to provide a method of making the improved pencil lead and to provide an apparatus for carrying out that method.

In accordance with the present invention, there is provided, in a first aspect thereof, a pencil lead constituted by a plurality of (preferably three or more) lead elements of a solid marking substance individually having a thick ranging between 10 and 250 microns, preferably between 10 and 100 microns and optimally between 30 and 50 microns, and bundled and joined together with a binder material. Specifically, the solid marking substance may consist at least in part of finely divided graphite, and the binder material may consist at least in part of finely divided graphite and may contain a synthetic resin. The pencil led or the bundle of the lead elements when joined may advantageously have a thickness ranging between 0.1 and 0.5 mm. The solid marking substance may advantageously consist of a mixture essentially of graphite particles and at least one synthetic resin uniformly mixed and heat-treated. The graphite particles may be particles of a uniform particle size in a range between 10 and 100 or 200 microns and preferably between 30 and 50 microns, but preferably should include particles of a relatively small, uniform particle size (e.g. between 1 and 10 microns) and particles of a relatively large, uniform particle size (e.g. between 10 and 100 microns or between 150 and 200 microns).

The invention also provides, in a second aspect thereof, a method of making a pencil lead, comprising the steps of: (a) preparing a semi-soft solid marking substance; (b) extruding the said substance to prepare a plurality of lead elements of the said substance individually having a thickness ranging between 10 and 250 microns and preferably between 10 and 100 microns; and (c) bundling the said lead elements and joining them with a binder material to form the said pencil lead.

The method advantageously further comprises the step (d) of heating the said lead elements at least one temperature between 800 and 3500°C subsequent to step (b) and prior to step (c), and further the step (e) subsequent to step (c), of heating the said bundled lead elements at a temperature between 1000 and 2000°C. Preferably, each of steps (d) and (e) is carried out in an inert atmosphere (e.g. argon) or in a graphite powder to prevent the lead elements from being oxidized.

The invention also provides, in a third aspect thereof, an apparatus for making a pencil lead, comprising: a vessel for retaining a semi-soft solid marking substance; means for extruding the said substance in the said vessel to prepare a plurality of lead elements of the said core material having a thickness ranging between 10 and 250 microns; and means for bundling the said lead elements and joining them with a binder material to form the said pencil lead.

US patent specification 2 149 905 discloses a lead pencil whose lead is produced from a number of strands. However, the lead is in the form of such strands only during an intermediate step in the manufacturing process, and not in the final product, merged to form the final lead.

These and other features of the present invention as well as advantages thereof will become more readily apparent from the following description made with reference to the accompanying drawings in which:

Fig. 1 is a cross-sectional view diagrammatically illustrating a texture of a single conventional graphite pencil lead;

Fig. 2 is a graph illustrating the relationship between the thickness of the single graphite pencil lead and the strength thereof;

Figs. 3, 4 and 5 are cross-sectional views diagrammatically illustrating pencil leads embodying the present invention;

Fig. 6 is a diagrammatic view, essentially in elevational or longitudinal section, illustrating an apparatus for making a pencil lead according to the present invention; and

Fig. 7 is a cross-sectional view diagrammatically illustrating a semi-finished lead which develops in the process utilizing the apparatus of Fig. 6.

Referring now to the drawings:

The conventional single graphite-based pencil lead is in the form of a circular rod having a diameter *D* of 0.2 to 0.5 mm, and electronmicrographical observation has revealed that it has a texture generally as illustrated in Fig. 1. It has been observed that the texture has fine graphite grains shown by fine gathers 11 closer to the peripheral surface *S* of the core 1 and coarse graphite grains shown by coarse gathers 12 deeper inside the core 1. It has been found that as

the diameter of such a graphite-based lead 1 is reduced, the grains 11 closer to the peripheral surface approach in size and appearance the grains 12 deeper inside the core 1. It has thus been assumed that the finer the core 1, the greater its strength (i.e. breaking force per cross-sectional area). This has been experimentally confirmed as shown by the graph of Fig. 2 in which the thickness (diameter O) of the lead or graphite element in microns (u) is plotted along the abscissa and the strength thereof in tons/cm^2 (alternatively Newtons/m^2) plotted along the ordinate. Each of the abscissa and the ordinate is plotted in logarithmic scale. The graph of Fig. 2 shows that the logarithm of strength varies in inverse proportion to the logarithm of thickness.

The novel pencil lead according to the invention has been devised with this discovery in mind and, as shown in Figs. 3, 4 and 5 by way of example, example, comprises a plurality of lead elements 10 of a solid marking substance individually having a thickness ranging between 10 and 250 microns, preferably between 10 and 100 microns, and bundled and firmly joined together with a binder material 13. Three, seven and five lead elements 10 are used in the embodiments of Figs. 3, 4 and 5, respectively. In each example, the lead elements 10 circular in section may have a diameter and hence a thickness of 30 to 50 microns. This makes a composite pencil lead having an overall thickness of 0.1 mm in Fig. 3 and composite pencil leads having an overall thickness of 0.3 mm in Figs. 4 and 5. Electron-micrographical observation shows that a graphite-based pencil lead or elements lead of such a thickness has a uniform graphite grain distribution throughout its body. Measurements show also that each of the composite leads of Figs. 3, 4 and 5 has a strength approaching or even greater than 10 tons/cm^2 (i.e. 99.64 $\times$ 10^7 N/m^2). This represents five times or more increase in strength than conventional single leads of 0.2 mm diameter which have at most a strength of 2 tons/cm^2 (i.e. 19.928 $\times$ 10^7 N/m^2). It has been found that the composite lead of Fig. 3 of 0.1 mm in diameter constituted with three lead elements 10 has a strength of 28 tons/cm^2 (i.e. 278.99 $\times$ 10^7 N/m^2), thus being 14 times stronger than the conventional single lead structure of the same diameter.

Referring to Fig. 6 which shows an apparatus for making a novel pencil lead according to the invention, raw solid marking substance 2 retained in a receptacle 3 is forced through a plurality of small extrusion dies or spinneret openings 4 (e.g. individually circular in cross-section) to produce a plurality of continuously formed lead elements 10 and of material individually having a uniform thickness as described. The material 2 may be a semi-soft sdolid or solution of a synthetic resin *R* (e.g. polyacrylonitrile resin monomer) in which graphite particles *G* are uniformly distributed and as conventionally is heated, say, at a temperature of 200°C during extrusion. The graphite particles may be of a uniform particle size of, say, 30 to 50 microns but, according to a preferred feature of the invention, should preferably include particles of a relatively small, uniform particle size of around 5 microns, e.g. 1 to 10 microns, and particles of a relatively large, uniform particle size of 10 to 100 microns or 150 to 200 microns.

The lead elements 10 continuously extruded through the openings 4 in parallel with one another are passed as a group 5 through a heating stage 6 comprising a primary baking heater 6*a* and a further heater 6*b*, then through a joining stage 7 and a final heating stage 8, and are finally squeezed between a pair of compression rollers 9*a* and 9*b* which serve to apply a sufficient tension to each of the lead elements 10 being drawn from the receptacle 3.

The die openings 4 are formed spaced apart from one another with a suitable spacing in a bottom wall of the receptacle 3. The heater 6*a* is provided to heat the lead elements 10 being drawn from the openings 4 at a temperature of, say, 1000°C thereby baking the lead elements 10. The heater 6*b* is used to heat-treat the baked lead elements 10 at a temperature of, say, 3000°C, thereby homogenizing graphite crystallization.

The parallel-running filaments are bundled in the joining stage 7 which includes an opening 7*a*, typically circular in section, defined by the wall of a metal frame 7*b* and an outlet nozzle 7*c* of an injector 7*d*. The latter includes a hopper 7*e* for feeding a binder material 13, e.g. a mixture of graphite particles and 10% by weight stylene solutioned in toluene, into a chamber 7*f* in which a plunger 7*g* formed with a screw 7*h* extends toward the nozzle opening 7*c* and is rotationally driven by a motor 7*m*. As the plunger 7*g* is rotated by the motor 7*m*, the binder material 13 is continuously fed into the nozzle 7*c* and in turn to opening 7*a* to distribute itself around the individual lead elements 10 and to fill the interstices therein. Thus, through the opening 7*a*, a roughly jointed composite lead 20' with a cross-section as shown in Fig. 7 is formed. The coarse lead 20' is then passed through the heater 8 and baked there at a temperature of, say, 1200°C, and thereafter squeezed between the compression rollers 9*a* and 9*b* rotating in the directions shown by arrows to yield a densified or finished composite core 20. Such a composite pencil lead made in the manner so far described has practically the same appearance as a conventional single lead and yet has much greater strength, as described already.

The finished lead 20 is cut by a blade 15 disposed downstream of the compaction stage 9 and intermittently operated by a motor 16 to provide successive pieces of the finished lead of a desired length.

It is desirable to conduct heat-treatment at each of the stages 6*a*, 6*b* and 8 in an inert atmosphere (e.g. argon) or in a graphite powder to prevent the lead elements 10 or the core 20' from being oxidized. The course or finished pencil lead 20' or 20 may be further subjected to impregnation with paraffine to improve its quality.

As mentioned previously, it is desirable that graphite particles in the solid marking substance

2 have particles of a smaller uniform particle size around 5 microns and a larger uniform particle size between 10 and 100 microns or 150 to 200 microns. With these different size grades of particles mixed uniformly to constitute the solid marking substance 2, it has been found that a composite pencil lead excellent in strength and yet relatively soft and smooth to write with is provided.

Claims

1. A pencil lead (20) constituted by a plurality of lead elements (10) of a solid marking substance (2) individually having a thickness ranging between 10 and 250 microns, and bundled and joined together with a binder material (13).

2. The pencil lead defined in Claim 1 wherein said solid marking substance (2) consists at least in part of finely divided graphite.

3. The pencil lead defined in Claim 2 wherein said solid marking substance (2) consists of a mixture essentially of graphite particles (G) and at least one synthetic resin (R) uniformly mixed and heat-treated.

4. The pencil lead defined in Claim 3 wherein said graphite particles (G) have a uniform size of 30 to 50 microns.

5. The pencil lead defined in Claim 3 wherein said graphite particles (G) include particles of a relatively small, uniform particle size, and particles of a relatively large, uniform particle size.

6. The pencil lead defined in Claim 5 wherein said relatively small, uniform particle size is in the range 1 to 10 microns.

7. The pencil lead defined in Claim 5 or 6 wherein said relatively large, uniform particle size is in the range 10 to 100 microns.

8. The pencil lead defined in Claim 5 or 6 wherein said relatively large, uniform particle size is in the range 150 to 200 microns.

9. The pencil lead defined in any preceding claim wherein said binder material (13) consists at least in part of graphite.

10. The pencil lead defined in Claim 9 wherein said binder material (13) contains finely divided graphite.

11. The pencil lead defined in Claim 9 or 10 wherein said binder material (13) contains at least one synthetic resin.

12. The pencil lead defined in any preceding claim wherein said lead element (10) individually have a thickness not greater than 100 microns.

13. The pencil lead defined in Claim 12 wherein said lead elements (10) individually have a thickness in the range 30 to 50 microns.

14. The pencil lead defined in any preceding claim wherein said of said lead elements (10) is substantially circular in cross-section.

15. The pencil lead defined in any preceding claim and having a thickness in the range 0.1 to 0.5 mm.

16. A method of making a pencil lead (20), comprising the steps of:

(a) preparing a semisoft solid marking substance (2);

(b) extruding said substance to prepare a plurality of lead elements (10) of said substance (2) individually having a thickness in the range 10 to 250 microns; and

(c) bundling said lead elements (10) and joining them together with a binder material (13) to form said pencil lead (20).

17. The method defined in Claim 16 wherein said substance (2) consists at least in part of finely divided graphite.

18. The method defined in Claim 17 wherein said substance (2) consists of a mixture essentially of graphite particles (G) and at least one synthetic resin (R) uniformly mixed and heat-treated.

19. The method defined in Claim 18 wherein said graphite particles (G) have a uniform particle size in the range 30 to 50 microns.

20. The method defined in Claim 18 wherein said graphite particles (G) include particles of a relatively small, uniform particle size, and particles of a relatively large, uniform particle size.

21. The method defined in Claim 20 wherein said relatively small, uniform particle size is in the range 1 to 10 microns.

22. The method defined in Claim 20 or 21 wherein said relatively large, uniform particle size is in the range 10 to 100 microns.

23. The method defined in Claim 20 or 21 wherein said relatively large, uniform particle size is in the range 150 to 200 microns.

24. The method defined in any one of the Claims 16 to 23 wherein said binder material (13) consists at least in part of graphite.

25. The method defined in Claim 24 wherein said binder material (13) contains finely divided graphite.

26. The method defined in Claim 24 or 25 wherein said binder material (13) contains at least one synthetic resin.

27. The method defined in any one of the Claims 16 to 26 wherein said lead elements (10) individually have a thickness not greater than 100 microns.

28. The method defined in Claim 27 wherein said lead elements (10) individually have a thickness in the range 30 to 50 microns.

29. The method defined in any one of the Claims 16 to 28 wherein each of said lead elements (10) is substantially circular in cross-section.

30. The method defined in any one of the Claims 16 to 29 wherein said pencil lead (20) is substantially circular in cross-section and has a diameter in the range 0.1 to 0.5 mm.

31. The method defined in any one of the Claims 16 to 30, further comprising (d) heating said lead elements (10) at at least one temperature between 800 and 3500°C subsequent to step (b) and prior to step (c).

32. The method defined in any one of the Claims 16 to 31, further comprising the step (e), subsequent to step (c), of heating said bundled filaments (20') at a temperature between 1000 and 2000°C.

33. The method defined in Claim 31 wherein step (d) is carried out in an inert atmosphere, or in a graphite powder.

34. The method defined in Claim 32 wherein step (e) is carried out in an inert atmosphere, or in a graphite powder.

35. An apparatus for making a pencil lead (20), comprising:

— a vessel (3) for retaining a semisoft solid marking substance (2);

— means (4) for extruding said substance (2) in said vessel (3) to prepare a plurality of lead elements (10) of said substance (2) having a thickness in the range of 10 to 250 microns; and

— means (*7a*, *7b*) for bundling said lead elements (10) and joining them with a binder material (13) to form said pencil lead (20).

Patentansprüche

1. Bleistiftmine (20), gekennzeichnet durch eine Vielzahl von minenelementen (10) aus einer festen Zeichensubstanz (2), die jeweils eine Dicke im Bereich zwischen 10 und 250 µm besitzen und gebündelt und durch ein Bindemittel (13) miteinander verbunden sind.

2. Bleistiftmine nach Anspruch 1, dadurch gekennzeichnet, daß die feste Zeichensubstanz (2) zumindest teilweise aus fein verteiltem Graphit besteht.

3. Bleistiftmine nach Anspruch 2, dadurch gekennzeichnet, daß die feste Zeichensubstanz (2) aus einer einheitlich gemischten und wärmebehandelten Mischung im wesentlichen aus Graphitpartikeln (G) und mindestens einem Kunstharz (R) besteht.

4. Bleistiftmine nach Anspruch 3, dadurch gekennzeichnet, daß die Graphitpartikel (G) eine einheitliche Größe von 30 bis 50 µm besitzen.

5. Bleistiftmine nach Anspruch 3, dadurch gekennzeichnet, daß die Graphitpartikel (G) Partikel von relativ einheitlicher Partikelgröße und Partikel von relativ großer einheitlicher Partikelgröße enthalten.

6. Bleistiftmine nach Anspruch 5, dadurch gekennzeichnet, daß die relativ kleine einheitliche Partikelgröße im Bereich von 1 bis 10 µm liegt.

7. Bleistiftmine nach Anspruch 5 oder 6, dadurch gekennzeichnet, daß die relativ große einheitliche Partikelgröße im Bereich von 10 bis 100 µm liegt.

8. Bleistiftmine nach Anspruch 5 oder 6, dadurch gekennzeichnet, daß die relativ große einheitliche Partikelgröße im Bereich von 150 bis 200 µm liegt.

9. Bleistiftmine nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das Bindmittel (13) zumindest teilweise aus Graphit besteht.

10. Bleistiftmine nach Anspruch 9, dadurch gekennzeichnet, daß das Bindemittel (13) fein verteiltes Graphit enthält.

11. Bleistiftmine nach Anspruch 9 oder 10, dadurch gekennzeichnet, daß das Bindemittel (13) mindestens ein Kunstharz enthält.

12. Bleistiftmine nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Minenelemente (10) jeweils eine Dicke von nicht mehr als 100 µm besitzen.

13. Bleistiftmine nach Anspruch 12, dadurch gekennzeichnet, daß die Minenelemente (10) jeweils eine Dicke im Bereich von 30 bis 50 µm besitzen.

14. Bleistiftmine nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß jedes der Minenelemente (10) einen im wesentlichen kreisförmigen Querschnitt besitzt.

15. Bleistiftmine nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß sie eine Dicke im Bereich von 0,1 bis 0,5 mm aufweist.

16. Verfahren zur Herstellung einer Bleistiftmine (20), gekennzeichnet durch folgende Schritte:

(a) Vorbereiten einer halbweichen festen Zeichensubstanz (2);

(b) Extrudieren dieser Substanz zum Fertigen eienr Vielzahl von Minenelementen (10) aus dieser Substanz (2), die jeweils eine Dicke im Bereich von 10 bis 250 µm besitzen; und

(c) Bündeln dieser Minenelemente (10) und deren Verbinden mit einem Bindemittel (13) zur Bildung der Bleistiftmine (20).

17. Verfahren nach Anspruch 16, dadurch gekennzeichnet, daß die Substanz (2) zumindest teilweise aus fein verteiltem Graphit besteht.

18. Verfahren nach Anspruch 17, dadurch gekennzeichnet, daß die Substanz (2) aus einer einheitlich gemischten und wärmebehandelten Mischung im wesentlichen aus Graphitpartikeln (G) und mindestens einem Kunstharz (R) besteht.

19. Verfahren nach Anspruch 18, dadurch gekennzeichnet, daß die Graphitpartikel (G) eine einheitliche Partikelgröße im Bereich von 30 bis 50 µm besitzen.

20. Verfahren nach Anspruch 18, dadurch gekennzeichnet, daß die Graphitpartikel (G) Partikel von relativ kleiner einheitlicher Partikelgröße und Partikel von relativ großer einheitlicher Partikelgröße enthalten.

21. Verfahren nach Anspruch 20, dadurch gekennzeichnet, daß die relativ kleine einheitliche Partikelgröße im Bereich von 1 bis 10 µm liegt.

22. Verfahren nach Anspruch 20 oder 21, dadurch gekennzeichnet, daß die relativ große einheitliche Partikelgröße im Bereich von 10 bis 100 µm liegt.

23. Verfahren nach Anspruch 20 oder 21, dadurch gekennzeichnet, daß die relativ große einheitliche Partikelgröße im Bereich von 150 bis 200 µm liegt.

24. Verfahren nach einem der Ansprüche 16 bis 23, dadurch gekennzeichnet, daß das Bindemittel (13) zumindest teilweise aus Graphit besteht.

25. Verfahren nach Anspruch 24, dadurch gekennzeichnet, daß das Bindemittel (13) fein verteiltes Graphit enthält.

26. Verfahren nach Anspruch 24 oder 25, dadurch gekennzeichnet, daß das Bindemittel (13) mindestens ein Kunstharz enthält.

27. Verfahren nach einem der Ansprüche 16 bis 26, dadurch gekennzeichnet, daß die Minenelemente (10) jeweils eine Dicke von nicht mehr als 100 µm aufweisen.

28. Verfahren nach Anspruch 27, dadurch gekennzeichnet, daß die Minenelemente (10)

jeweils eine Dicke im bereich von 30 bis 50 µm besitzen.

29. Verfahren nach einem der Ansprüche 16 bis 28, dadurch gekennzeichnet, daß jedes der Minenelemente (10) einen im wesentlichen kreisförmigen Querschnitt besitzt.

30. Verfahren nach einem der Ansprüche 16 bis 29, dadurch gekennzeichnet, daß die Bleistiftmine (20) einen im wesentlichen kreisförmigen Querschnitt und einen Durchmesser im Bereich von 0,1 bis 0,5 mm aufweist.

31. Verfahren nach einem der Ansprüche 16 bis 30, gekennzeichnet durch folgenden weiteren Schritt:

(d) Erwärmen der Minenelemente (10) auf mindestens eine Temperatur zwischen 800 und 3500°C im Anschluß an der Verfahrensschritt (b) und vor dem Verfahrensschritt (c).

32. Verfahren nach einem der Ansprüche 16 bis 31, gekennzeichnet durch folgenden weiteren Schritt:

(e) Erhitzen der gebündelten Fasern (20') auf eine Temperatur zwischen 1000 und 2000°C im Anschluß an den Verfahrensschritt (c).

33. Verfahren nach Anspruch 31, dadurch gekennzeichnet, daß der Verfahrensschritt (d) in einer inerten Atmosphäre oder in einem Graphitpulver durchgeführt wird.

34. Verfahren nach Anspruch 32, dadurch gekennzeichnet, daß der Verfahrensschritt (e) in einer inerten Atmosphäre oder in einem Graphitpulver durchgeführt wird.

35. Vorrichtung zur Herstellung einer Bleistiftmine (20), gekennzeichnet durch:

einen Trog (3) zum Aufnehmen einer halbweichen festen Zeilensubstanz;

eine Vorrichtung (4) zum Extrudieren dieser im Trog (3) befindlichen Substanz (2) zum Herstellen einer Vielzahl von Minenelementen (10) aus dieser Substan (2) mit einer Dicke im Bereich von 10 bis 250 µm; und

eine Vorrichtung (7a, 7b) zum Bündeln der Minenelemente (10) und zu deren Verbinden mit einem Bindemittel (13) zur Bildung der Bleistiftmine (20).

Revendications

1. Mine de crayon (20) constituée par une pluralité d'éléments de mine (10) en une substance de marquage solide (2) ces éléments de mine ayant individuellement une épaisseur comprise entre 10 et 250 microns et étant rassemblés en faisceau et liés entre eux au moyen d'un liant (13).

2. Mine de crayon suivant la revendication 1, caractérisée en ce que la substance de marquage solide (2) est constituée, au moins en partie de graphite finement divisé.

3. Mine de crayon suivant la revendication 2, caractérisée en ce que la substance de marquage solide (2) formant la mine est constituée par un mélange comprenant essentiellement des particules de graphite (G) et au moins une résine synthétique (R) mélangées d'une manière uniforme et traitées à chaud.

4. Mine de crayon suivant la revendication 3, caractérisée en ce que les particules de graphite (G) ont une taille unicorme allant de 30 à 50 micromètres.

5. Mine de crayon suivant la revendication 3, caractérisée en ce que les particules de graphite (G) comprenent des particules ayant une taille uniforme relativement petite et d'autres particules ayant une taille uniforme relativement grande.

6. Mine de crayon suivant la revendication 5, caractérisée en ce que la taille uniforme, relativement petite des particules est comprises dans la gamme allant de 1 à 10 micromètres.

7. Mine de crayon suivant l'une quelconque des revendications 5 et 6, caractérisée en ce que la taille uniforme, relativement grande, des particules est comprise dans la gamme allant de 10 à 100 micromètres.

8. Mine de crayon suivant l'une quelconque des revendications 5 et 6, caractérisée en ce que la taille uniforme, relativement grande, des particules est comprise dans la gamme allant de 150 à 200 micromètres.

9. Mine de crayon suivant l'une quelconque des revendications précédentes, caractérisée en ce que le liant (13) est constitué, au moins en partie, de graphite.

10. Mine de crayon suivant la revendication 9, caractérisée en ce que le liant (13) contient du graphite finement divisé.

11. Mine de crayon suivant l'une quelconque des revendications 9 et 10, caractérisée en ce que le liant (13) contient au moins une résine synthétique.

12. Mine de crayon suivant l'une quelconque des revendications précédentes, caractérisée en ce que les éléments de mine (10) ont chacun une épaisseur qui n'est pas supérieure à 100 micromètres.

13. Mine de crayon suivant la revendication 12, caractérisée en ce que les éléments de mine (10) ont une épaisseur comprise entre 30 et 50 micromètres.

14. Mine de crayon suivant l'une quelconque des revendications précédentes, caractérisée en ce que les éléments de mine (10) ont une section droite sensiblement circulaire.

15. Mine de crayon suivant l'une quelconque des revendications précédentes, caractérisée en ce qu'elle a une épaisseur allant de 0,1 à 0,5 mm.

16. Procédé de fabrication d'une mine de crayon (20) caractérisée en ce que:

(a) on prépare une substance de marquage solide semi-molle (2);

(b) on extrude cette substance pour former une pluralité d'éléments de mine (10) en substance (2), chaque élément de mine ayant une èpaisseur comprise entre 10 et 250 micromètres; et

(c) on forme un faisceau à partir de ces éléments de mine (10) et on les lie entre eux au moyen d'un liant (13) afin de constituer la mine de crayon (20).

17. Procédé suivant la revendication 16, caractérisé en ce que la substance (2) est constituée, au moins en partie, de graphite finement divisé.

18. Procédé suivant la revendication 17, caracté-

risé en ce que la substance (2) est constitutée par un mélange comprenant essentiellement des particules de graphite (G) et au moins une résine synthétique (R) mélangées uniformément et traitées à chaud.

19. Procédé suivant la revendication 18, caractérisé en ce que les particules de graphite (G) ont une taille de particule uniforme comprise entre 30 et 50 micromètres.

20. Procédé suivant la revendication 18, caractérisé en ce que les particules de graphite (G) comprennent des particules de taille uniforme relativement petite et d'autres particules de taille uniforme relativement grande.

21. Procédé suivant la revendication 20, caractérisé en ce que la taille uniforme, relativement petite, des particules est comprise entre 1 et 10 micromètres.

22. Procédé suivant l'une quelconque des revendications 20 et 21, caractérisé en ce que la taille uniforme, relativement grande, des particules est comprise entre 10 et 100 micromètres.

23. Procédé suivant l'une quelconque des revendications 20 et 21, caractérisé en ce que la taille uniforme, relativement grande, des particules est comprise entre 150 et 200 micromètres.

24. Procédé suivant l'une quelconque des revendications 16 à 23, caractérisé en ce que le liant (23) est constitué, au moins en partie, de graphite.

25. Procédé suivant la revendication 24, caractérisé en ce que le liant (13) contient du graphite finement divisé.

26. Procédé suivant l'une quelconque des revendications 24 ou 25, caractérisé en ce que le liant (13) contient au moins une résine synthétique.

27. Procédé suivant l'une quelconque des revendications 16 à 26, caractérisé en ce que chacun des éléments de mine (10) a une épaisseur qui n'est pas supérieure à 100 micromètres.

28. Procédé suivant la revendication 27, caractérisé en ce que chaque des éléments de mine (10) a une épaisseur comprise entre 30 et 50 micromètres.

29. Procédé suivant l'une quelconque des revendications 16 à 28, caractérisé en ce que chacun des éléments de mine (10) a une section droite sensiblement circulaire.

30. Procédé suivant l'une quelconque des revendications 16 à 29, caractérisé en ce que la mine de crayon (20) a une section droite sensiblement circulaire, d'un diamètre compris entre 0,1 et 0,5 mm.

31. Procédé suivant l'une quelconque des revendications 16 à 30, caractérisé en ce qu'il comprend en outre une étape (d) consistant à chauffer les éléments de mine (10) à au moins une température comprise entre 800 et 3500°C, à la suite de l'étape (b) et avant l'étape (c).

32. Procédé suivant l'une quelconque des revendications 16 à 31, caractérisé en ce qu'il comprend en outre une étape (e), faisant suite à l'étape (c), laquelle consiste à chauffer les éléments de mine (20') rassemblés en faisceau à une température comprise entre 1000 et 2000°C.

33. Procédé suivant la revendication 31, caractérisé en ce que l'étape (d) est réalisée dans une atmosphère inerte ou dans une poudre de graphite.

34. Procédé suivant la revendication 32, caractérisé en ce que l'étape (e) est réalisée dans une atmosphère inerte ou dans une poudre de graphite.

35. Appareil pour la fabrication d'une mine de crayon (20), caractérisé en ce qu'il comprend un récipient (3) pour contenir une substance de marquage solide semi-mole (2), des moyens (4) pour extruder cette substance (2) contenue dans le récipient (3) de manière à former une pluralité d'élément de mine (10) en substance (2), ces éléments de mine ayant chacun une épaisseur comprise entre 10 et 250 micromètres, et des moyens (7a, 7b) pour assembler ces éléments de mine (10) en faisceau et pour les lier entre eux au moyen d'un liant (13), afin de constituer la mine de crayon (20).

FIG. 1

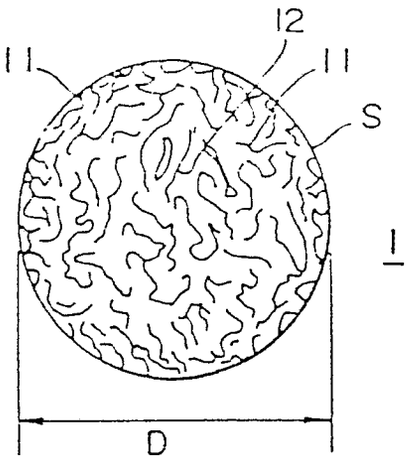


FIG. 3

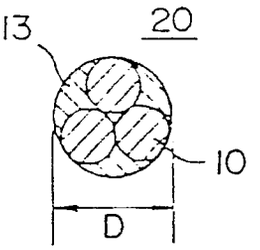


FIG. 4

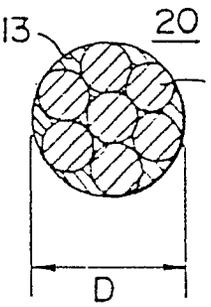


FIG. 5

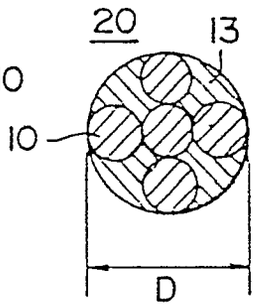


FIG. 2

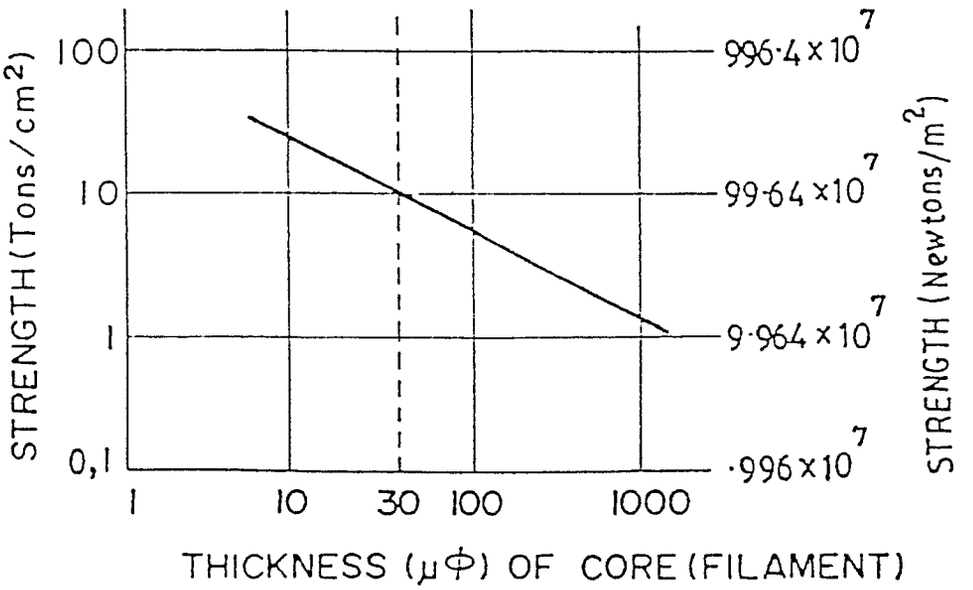


FIG. 6

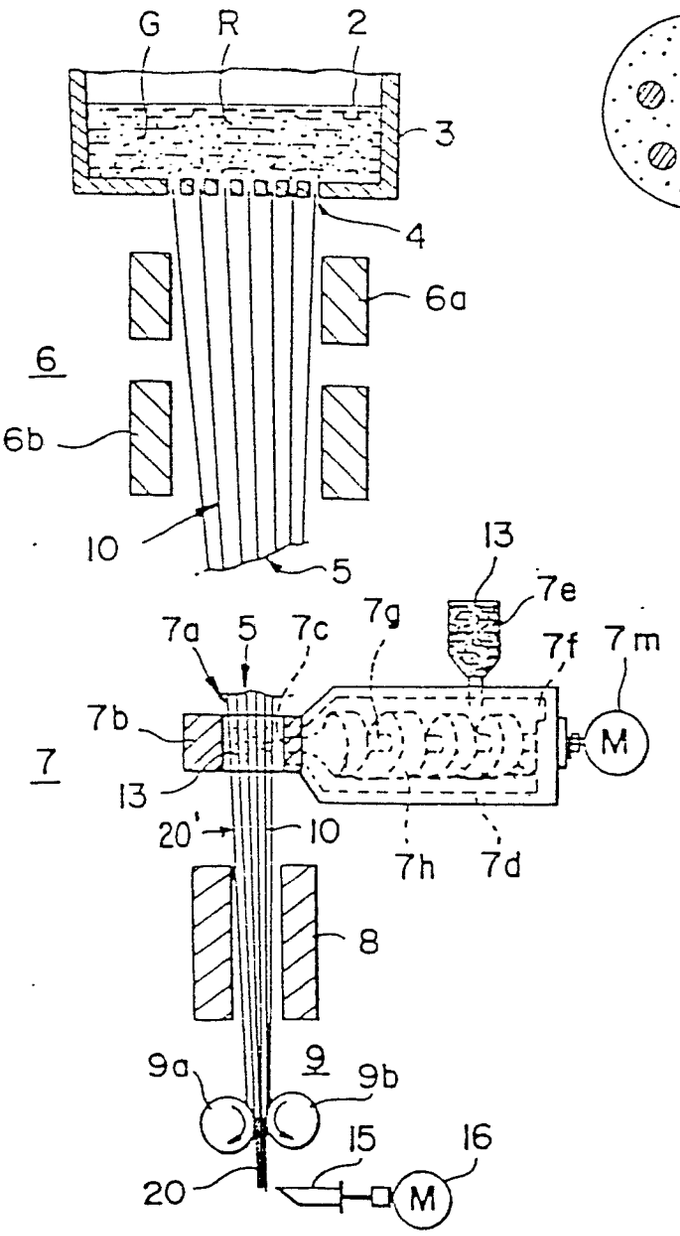
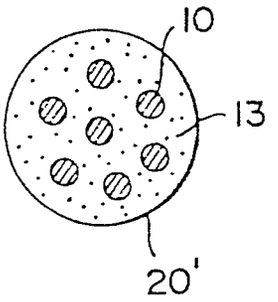

G
R
2
3
4
6a
6
6b
10
5
13
7e
7a
5
7c
7g
7f
7m
7b
7
M
13
20'
10
7h
7d
8
9a
9
9b
15
16
20
M

FIG. 7


10
13
20'