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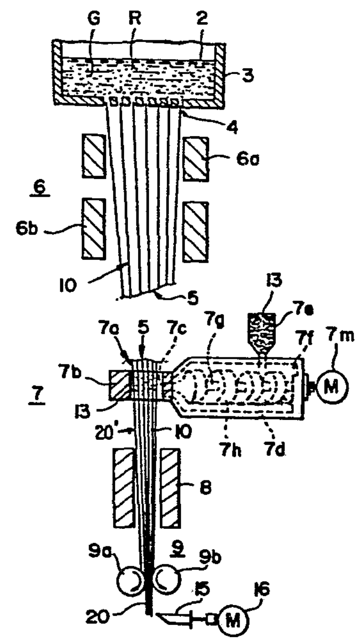
## (54) Pencil core, and methods and apparatus for its manufacture.

(57) A novel pencil core (20) constituted by a plurality of filaments (10) of a pencil core material (2) individually having a thickness of 10 to 250 microns, and bundled and joined together with a binder material (13). Such a pencil core (20) is manufactured by (a) producing a semi-soft core material (2) of graphite and a synthetic resin, (b) extruding said core material (2) through nozzles (4) to produce a plurality of filaments (10), bundling said filaments (10) together in a ring (7b) into which is forced a binder material (13) by a screw-feed device (7c-7m) to encase the filaments, and (d) compressing the bundled and encased filaments (10) between rolls (9*a*, 9*b*) to produce the finished pencil core (20). Heat-treatment is provided by various heaters 6*a*, 6*b*, 8).

FIG. 6

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# PENCIL CORE, AND METHODS AND APPARATUS FOR ITS MANUFACTURE

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

It is desirable that pencil cores for a variety of forms of pencils including wood-sheathed ordinary pencils and especially spare cores 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, higher reflectivity or darkness (e.g. blackness) and less dispersion of powder on writing.

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

The present invention also seeks to provide a novel and improved pencil core 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 core, 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 core constituted by a plurality of (preferably three or more) filaments of a core material individually having a thickness 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 core material 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 core or the bundle of the filaments when joined may advantageously have a thickness ranging between 0.1 and 0.5 mm. The core material 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 core, comprising the steps of: (a) preparing a semi-soft solid substance constituting a pencil core material; (b) extruding the said substance to prepare a plurality of filaments of the said core material individually having a thickness ranging between 10 and 250 microns and preferably between 10 and 100 microns; and (c) bundling the said filaments and joining them with a binder material to form the said pencil core.

The method advantageously further comprises the step (d) of heating the said filaments at 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 filaments 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 filaments from being oxidized.

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

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 core or filament;

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

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

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

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

Referring now to the drawings:

The conventional single graphite-based pencil core is in the form of a circular rod having a diameter D of 0.2 to 0.5 mm, and electron-micrographical 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 core 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 ∅ ) of the core or graphite filament in microns ( $\mu$ ) 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 core 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, comprises a plurality of elementary filaments 10 of a core material 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 elementary filaments 10 are used in the embodiments of Figs.3, 4 and 5, respectively. In each example, the filaments 10 circular in section may have a diameter and hence a thickness of 30 to 50 microns. This makes a composite pencil core having an overall thickness of 0.1 mm in Fig. 3 and composite pencil cores having an overall thickness of 0.3 mm in Figs. 4 and 5. Electron-micrographical observation shows that a graphite-based pencil filament or elementary core of such a thickness has a uniform graphite grain distribution throughout its body. Measurements show also that each of the composite cores of Figs. 3, 4 and 5 has a strength approaching or even greater than 10 tons/$cm^2$ (i.e. 99.64 x $10^7 N/m^2$. This represents five times or more increase in strength than conventional single cores of 0.2 mm diameter which have at most a strength of 2 tons/$cm^2$ (i.e. 19.928 x $10^7$ $N/m^2$). It has been found that the composite core of Fig. 3 of 0.1 mm in diameter constituted with three filaments or elementary cores 10 has a strength of 28 tons/$cm^2$ (i.e. 278.99 x $10^7$ $N/m^2$), thus being 14 times stronger than the conventional single core structure of the same diameter.

Referring to Fig. 6 which shows an apparatus for making a novel pencil core according to the invention, a core raw material 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 filaments 10 of the material individually having a uniform thickness as described. The material 2 may be a semi-soft solid 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 filaments 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 6a and a further heater 6b, then through a joining stage 7 and a final heating stage 8, and are finally squeezed between a pair of compression rollers 9a and 9b which serve to apply a sufficient tension to each of the filaments 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 6a is provided to heat the filaments 10 being drawn from the openings 4 at a temperature of, say, 1000° C, thereby baking the filaments 10. The heater 6b is used to heat-treat the baked filaments 10 at a temperature of, say, 3000° C, thereby homogenizing graphite crystalization therein.

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

The finished core 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 core of a desired length.

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

As mentioned previously, it is desirable that graphite particles in the core material 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 core material 2, it has been found that a composite pencil core excellent in strength and yet relatively soft and smooth to write with is provided.

CLAIMS

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

2. The pencil core defined in Claim 1 wherein said core material (2) consists at least in part of finely divided graphite.

3. The pencil core defined in Claim 2 wherein said core material (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 core defined in Claim 3 wherein said graphite particles (G) have a uniform size of 30 to 50 microns.

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

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

8. The pencil core defined in Claim 5 or 6 wherein said relatively large, uniform particle size is in the

range 150 to 200 microns.

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

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

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

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

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

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

15. The pencil core 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 core (20), comprising the steps of:

(a) preparing a semisoft solid substance constituting a pencil core material (2);

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

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

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

18. The method defined in Claim 17 wherein said core material (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 filaments (10) individually have a thickness not greater than 100 microns.

28. The method defined in Claim 27 wherein said filaments (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 filaments (10) is substantially circular in cross-section.

30. The method defined in any one of the Claims 16 to 29 wherein said pencil core (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 filaments (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 core (20), comprising:

a vessel (3) for retaining a semisoft solid substance constituting a pencil core material (2);

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

means (7a, 7b) for bundling said filaments (10) and joining them with a binder material (13) to form said pencil core (20).

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36. An apparatus as defined in Claim 35, substantially as hereinbefore described with reference to and as illustrated by Figures 6 and 7 of the accompanying drawings, either alone or in combination with Figures 3 to 5 of the accompanying drawings.

37. A method as defined in any one of the Claims 16 to 34, substantially as hereinbefore described with reference to and as illustrated by any one or more of the Figures 3 to 7 of the accompanying drawings.

38. A pencil core as defined in any one of the Claims 1 to 15, substantially as hereinbefore described with reference to and as illustrated by any one or more of the Figures 3 to 7 of the accompanying drawings.

FIG. 1

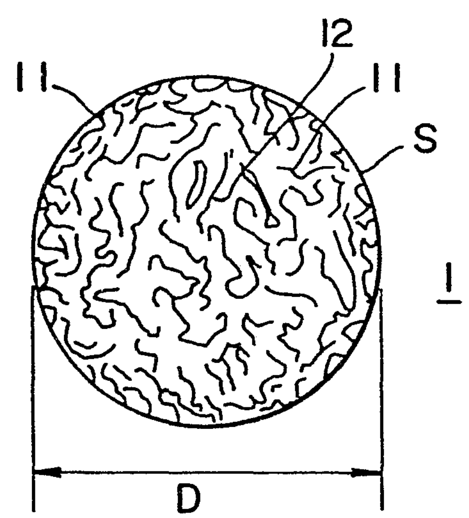


FIG. 3

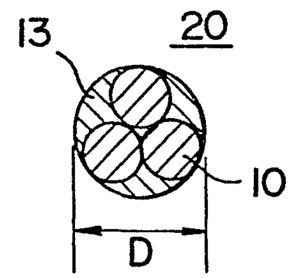


FIG. 4

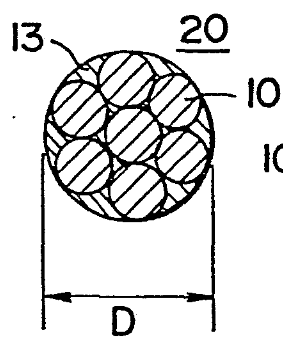


FIG. 5

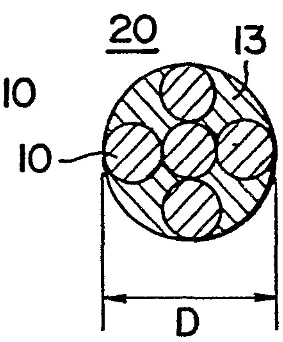


FIG. 2

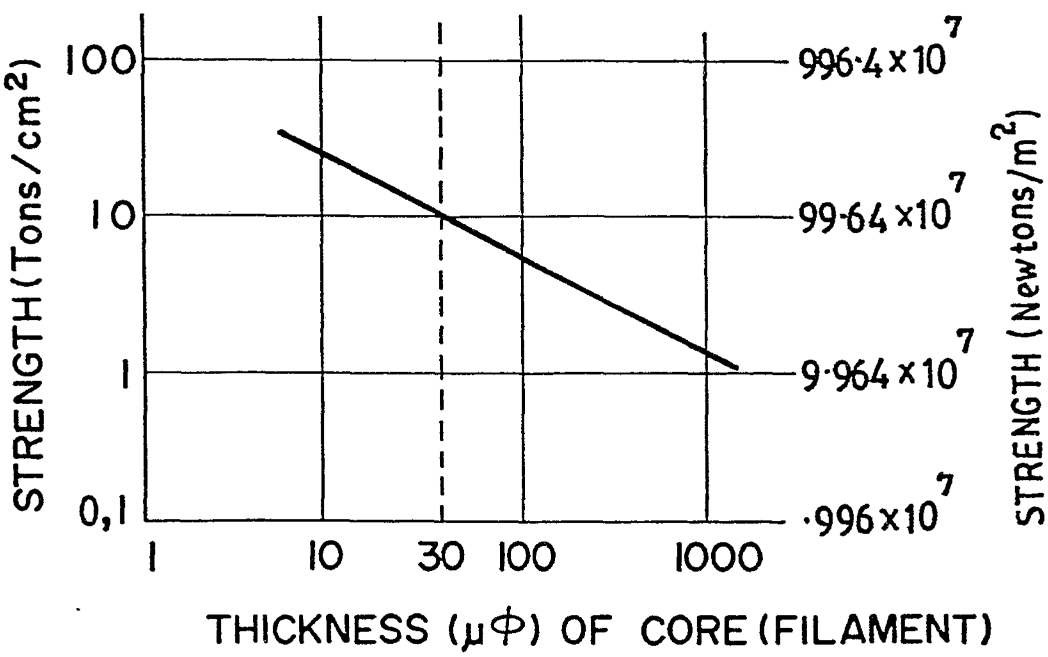

FIG. 6

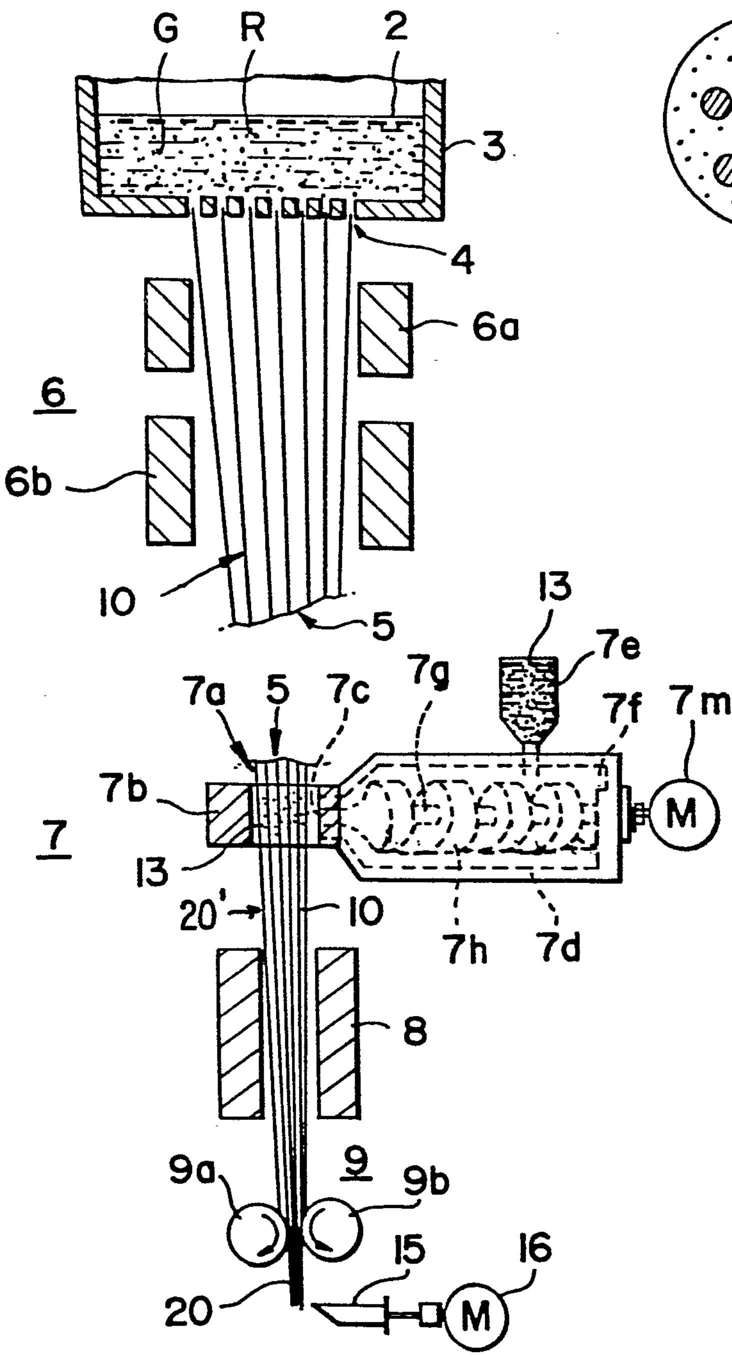
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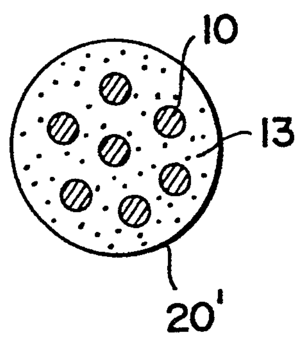
FIG. 7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