

[54] **GRIPPING MEMBER FOR WELL TOOL**
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 [22] Filed: **Feb. 1, 1971**
 [21] Appl. No.: **111,401**

[52] U.S. Cl. **166/216**
 [51] Int. Cl. **E21b 23/00**
 [58] Field of Search 166/138-140, 134, 206,
 209, 210, 211, 214-217

[56] **References Cited**

UNITED STATES PATENTS

3,548,936 12/1970 Kilgore 166/216
 2,638,851 5/1963 Soberg et al. 166/211

Primary Examiner—James A. Leppink

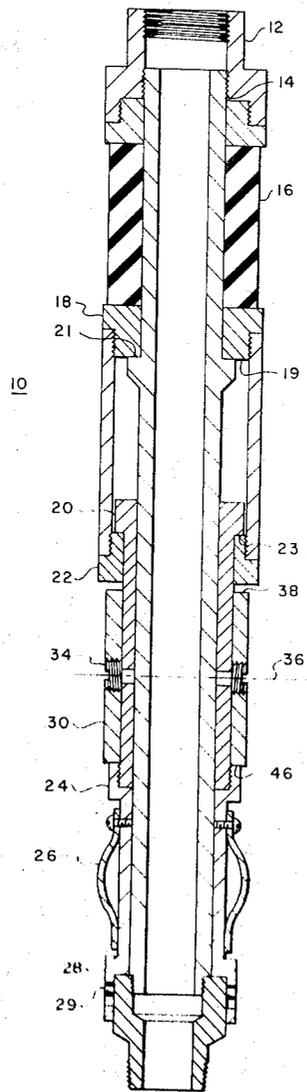
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[57] **ABSTRACT**

A slip or gripping member that is used on well tools to

lock the well tools at a desired location in a well bore. The slip is movably mounted on the well tool and is provided with wall engaging teeth on relatively opposite sides thereof adjacent to each end. The wall engaging teeth are separated on the slip by a distance that is greater than the diameter of the well bore so that movement of the slip to an angular position brings the teeth into engagement with the well bore wall. Relatively movable abutments are provided on the well tool which are brought into engagement with at least one end of the slip to cause the slip to move into the position wherein the teeth are in engagement with the well bore wall. The slip is constructed so that when the teeth are out of engagement with the well bore wall, the tool with the slips thereon is freely movable through the well bore. The slip is useful in connection with well tools such as packers or anchors and may be actuated by fluid pressure or by mechanical means. The slip teeth are curved and adjacent teeth have different radii of curvature, resulting in a curved bounding profile in a plane containing the central longitudinal axis of the slip.

6 Claims, 8 Drawing Figures



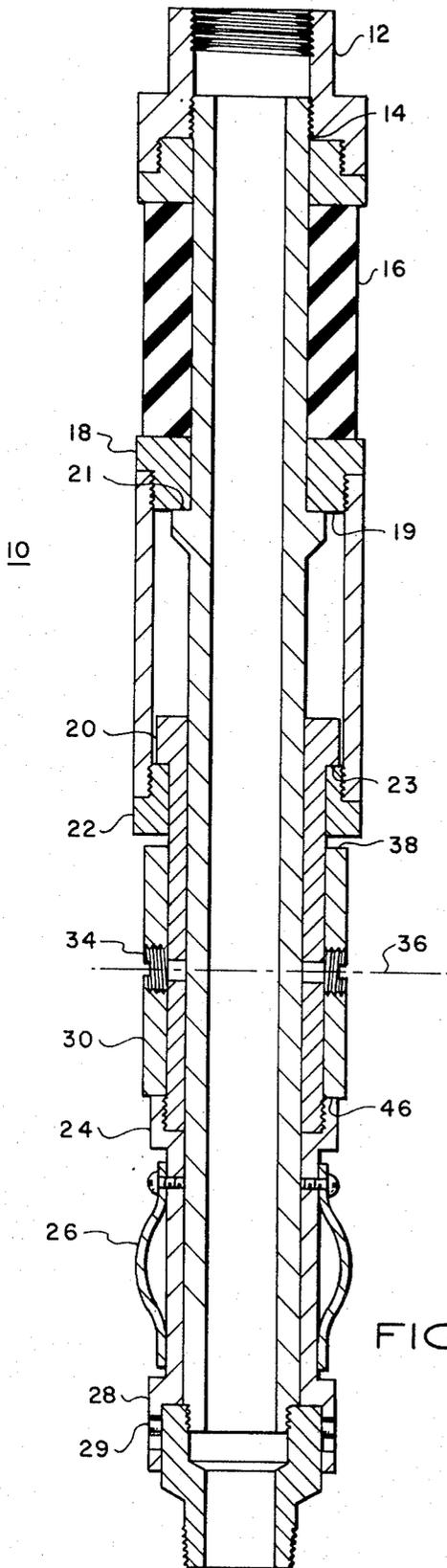
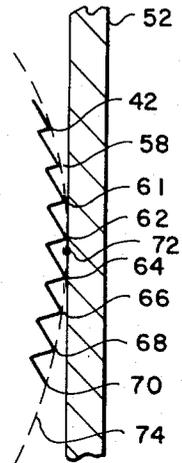


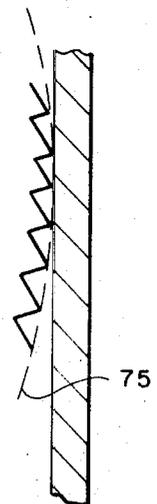
FIG. 1

FIG. 5



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FIG. 5A



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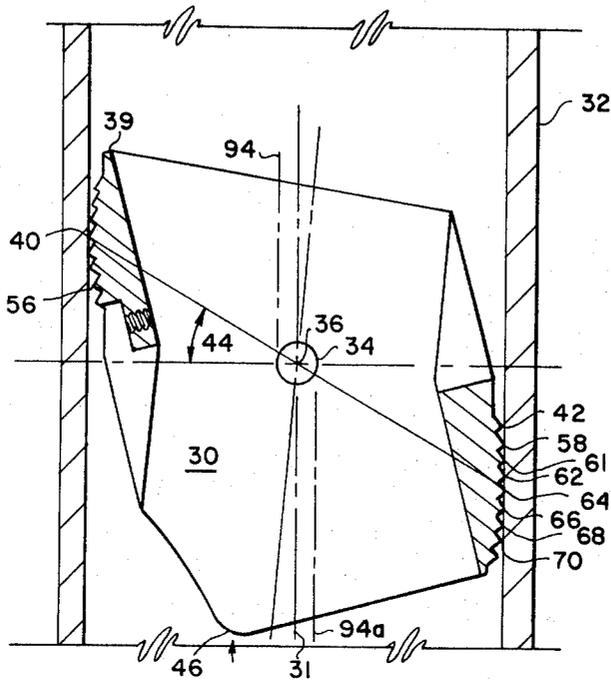


FIG. 2

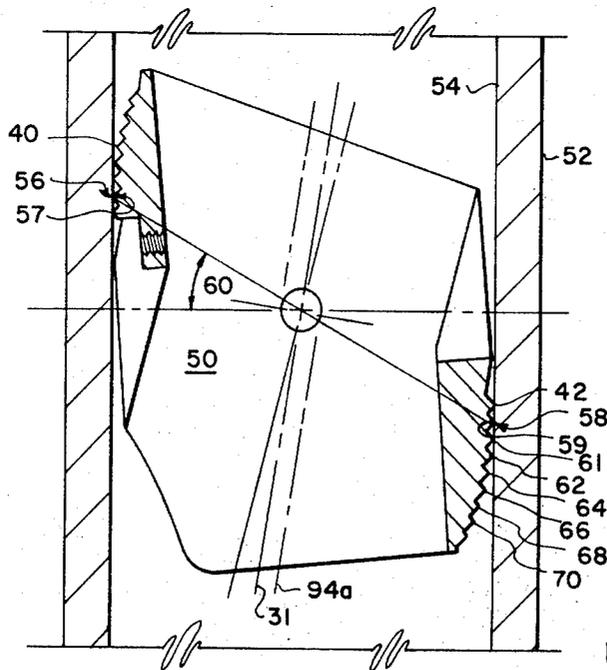


FIG. 3

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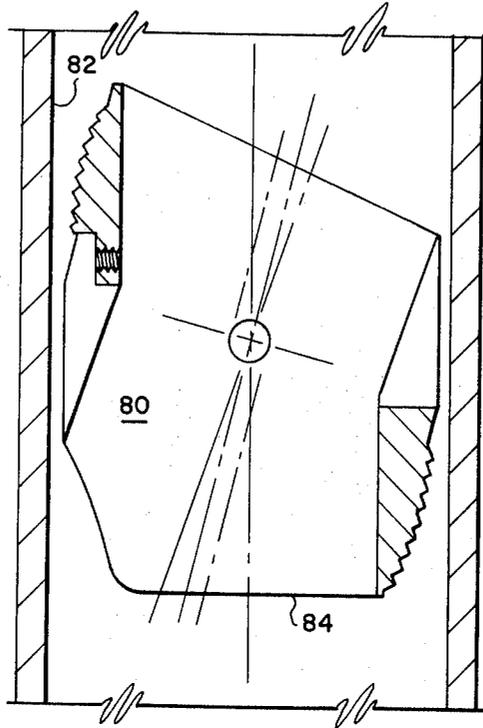


FIG. 4

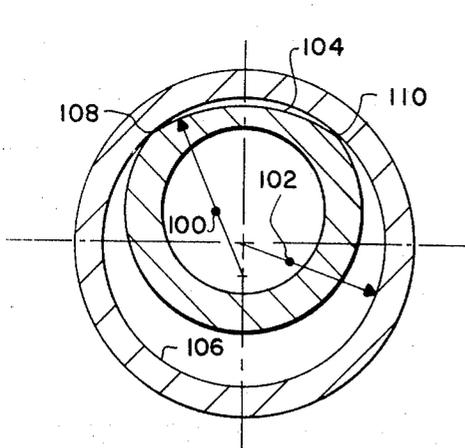


FIG. 7

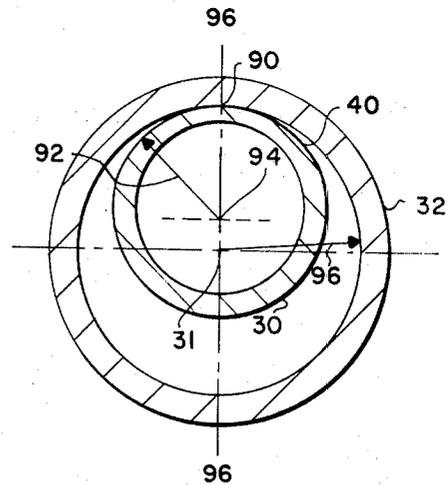


FIG. 6

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CROSS REFERENCE TO RELATED APPLICATION

This improved slip is related to those described in the application of Kilgore and Pumpelly, Ser. No. 776,110 filed on Nov. 15, 1968, now U.S. Pat. No. 3,548,936, issued Dec. 22, 1970.

BACKGROUND OF THE INVENTION

This invention is concerned with an improved gripping device or slip for use on well tools. In particular, this invention is concerned with slips of the type which are tilted or pivoted about an axis to reach or contact the interior wall of a well casing whereby the well tool to which the slip is attached is prevented from movement relative to the axis of the well casing.

In the referenced U.S. Pat. No. 3,548,963, the slips have teeth which are shaped so that the crests form a segment of a circle and the diameter of that circle is the same for each tooth so that the crests lie along a straight line thereby limiting to some extent the range of casing weights (i.e., internal diameters) in which the slip can be used. My invention expands the range of usage by providing that the diameters of the circles defined by the crests of the teeth are not constant; instead the teeth have a continuously varying diameter such that when tilted into engagement with the internal walls of casing of various weights, a plurality of teeth is presented whose diameters will closely match that of the various casing diameters. In other words my improved slip will have a plurality of teeth with a smaller tooth crest diameter for engagement with the minimum internal casing diameter and the largest diameter tooth for engagement with the maximum internal casing diameter corresponding to the different casing weights available in a particular size. As is well known, oilfield casing is available in a rather wide range of casing weights for each size, i.e., external diameter. For example, standard API 4 1/2 inch casing is available in weights ranging from 9.5 pounds per foot, 4.090 inches internal diameter, to 13.5 pounds per foot, 3.920 inches internal diameter, all with a 4 1/2 inch external diameter.

My invention is applicable to the unitary slip construction described in detail in the above-mentioned U.S. Pat. No. 3,548,936.

It is the primary object of this invention to provide an improved unitary slip which will grip various internal diameters;

It is a further object of this invention to provide an improved unitary slip which will grip with a controlled wedging (or action) angle;

It is yet another object of this invention to provide an improved unitary slip which will grip the internal surface of an entire range of American Petroleum Institute casing of a particular outside diameter; and

It is still another object of this invention to provide an improved unitary slip which will grip with a substantially constant wedging (or action) angle in all inside diameters it is designed to fit.

SUMMARY OF THE INVENTION

The objects of the invention are accomplished, broadly, by the provision of an improved gripping device or slip that is arranged to be pivotably mounted on a well tool and arranged to engage the wall of the casing to hold the well tool in the casing. The gripping device comprises a body member having first and second

ends, a wall engaging portion adjacent each of the ends, a distance between the wall engaging portions being greater than the diameter of the well casing whereby the wall engaging portions can engage the well casing, and a portion intermediate the ends having a dimension less than the diameter of the well casing, whereby the well tool can move therethrough. The wall engaging portion adjacent each end of the gripping device is so shaped that when viewed in a longitudinal cross-section, the outer boundary of the wall engaging portion has a curved, rather than straight, profile with the radius of curvature of the profile varying from one end of the wall engaging portion to the other end of the wall engaging portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-section of a packer, typical of well tools which require a pipe gripping device, known in the art as a slip;

FIG. 2 is a cross-section of the slip set in a piece of casing according to the invention;

FIG. 3 is a view similar to FIG. 2 but illustrating the slip in a smaller ID casing;

FIG. 4 is a cross-section view of the slip according to the invention in retracted position for movement through the well casing;

FIG. 5 is a schematic view of a circular bounding curve profile of a slip according to the invention;

FIG. 5(a) is a schematic view of a parabolic bounding curve profile of a slip according to the invention;

FIG. 6 is a top plan schematic view of a slip according to the invention in contact with the casing in the borehole; and

FIG. 7 is a top plan schematic view of a prior art slip making less than complete contact with the casing in the borehole.

Referring now to the drawings in more detail and to FIG. 1 in particular, there is shown therein and generally designated by the reference character 10 a packer of the type commonly used in oil wells. This packer is typical of many well tools which require a pipe gripping device to anchor the well tool against thrust imposed by the tubing string connecting to the well tool and by thrust from differential pressure working against a sealed area at the well tool.

In FIG. 1, the well packer generally shown at 10 is comprised of an upper connection 12 which is threadedly engaged to the mandrel 14. A packing element 16 is disposed in encircling relationship to the mandrel 14. A lower thimble 18 is fitted in encircling relationship about the packer mandrel 14. A sleeve 20 is fitted about the packer mandrel 14 in telescoping arrangement and has lateral holes which accept pins 34 which are threadedly engaged with the slip 30. An upper abutment 22 encircles the sleeve 20 in an abutable relationship to surface 38 on slip 30. A lower abutment 24 is threadedly engaged to sleeve 20 and carries friction springs 26 which frictionally engage the casing to create a frictional drag. A J latch arrangement is shown at 28 which releasably engages pin 29 upon rotation of mandrel 14 by the tubing string (not shown) connected to upper connection 12.

The setting sequence which is well known to those with skill in this art is as follows: The mandrel 14 is rotated to move the pin 29 out of engagement with J latch 28. The mandrel 14 and upper connection 12 are lowered by the tubing string (not shown). Friction springs

26 engage the casing (not shown) and support lower abutment 24. Lower abutment 24 is threadedly engaged to sleeve 20 which has lateral holes that accept pins 34 threadedly engaged to slip 30. Slip 30 is thereby pivoted about horizontal axis 36. On downward movement of upper connection 12, packing element 16 forces thimble 18 and upper abutment 22 in a downward direction. Upper abutment 22 engages surface 38 on the slip and cause slip 30 to rotate about axis 36 in a manner that will be illustrated in greater detail later. Slip 30 engages the casing and supports upper abutment 22 and thimble 18. Tubing weight applied to upper connection 12 compresses packing element 16 into sealing engagement with the casing and mandrel 14.

The packer is released from engagement with the well casing by upstrain on the tubing (not shown), lifting upper connection 12 and mandrel 14. Shoulder 21 on mandrel 14 rises to engage and lift surface 19 on thimble 18. Upper connection 12 moves up away from thimble 18 allowing packing element 16 its original length into which it can relax. Shoulder 21 on mandrel 14 engages surface 19 on thimble 18 and picks up thimble 18 and the upper abutment 22. Upper abutment 22 moves up, engages the shoulder 23 on sleeve 20 and pulls lower abutment 24 upwardly, engaging point 46 on lower end of slip 30, and retracting the slip as will be explained more fully hereinafter. As upper connection 12, mandrel 14 and pin 29 rise to their completely retracted position with respect to J 28, the J latch 28 assumes a position with respect to pin 29 which would allow relative rotation between the J latch 28 and mandrel 14 to engage pin 29 the J latch 28.

Referring to FIG. 2 shown therein and generally designated by the reference character 30 is a single slip that is positioned in a casing 32 located in a well bore (not shown).

The slip as shown generally at 30 in FIG. 2 is shown as it is used to support down thrust in a well tool. In initial setting, the slip having a central axis 31, is supported on pins 34 about axis 36. Down thrust is applied to the slip at point 39. Down thrust at point 39 supported by the pins 34 results in a moment being applied to the slip, causing the slip to rotate into engagement with the casing. A tooth 40 on the upper end of the slip and a tooth 64 on the lower end of the slip will contact the casing. A line connecting teeth points 40 and 64 makes an action angle 44 with a plane perpendicular to the axis of the casing. Action angle 44 is very important because it must be small enough that axial thrust will generate adequate wedging action to cause reliable gripping of the slip 30 to casing 32. Action angle 44 must not, however, be so small that wedging action is so great that an upward force at point 46 will not reliably release the slip, when it is desired to release the slip. The slip teeth are curved and adjacent teeth have different radii of curvature measured from and along the axis 94 for the teeth in the section including the tooth 40 and from and along the axis 94A for the teeth including the tooth 64, the axes 94 and 94A being slightly offset from the center axis 31. This results in a curved bounding profile in a plane containing the central longitudinal axis 31 of the slip.

Referring now to FIG. 3 showing a slip generally at 50 set in casing 52 having the same OD as casing 32 but with a heavier wall and consequently, smaller ID 54. The slip initially contacts the casing ID 54 at point 57

with tooth 56 at the upper portion of slip 50 and at point 59 with tooth 58 at the lower portion of slip 50. Action angle 60 formed by a line drawn between points 56 and 58 and the plane perpendicular to the axis of the casing is very important. The action angle 60 in one weight casing may desirably be the same as action angle 44 in another weight casing, either of which may be gripped by different teeth on the same slip.

FIG. 4 illustrates the slip in retracted position facilitating movement of the slip 80 through the casing 82. An abutment, not shown, below the slip 80 may be used to contact the lower surface 84 of the slip, holding that surface in a plane substantially normal to the axis of the casing, thereby holding the slip in a retracted attitude, and out of engagement with the casing.

Referring now to FIG. 5, due to the finite increment between teeth such as that between tooth 62 and tooth 64, a theoretical curve 74 through the crests of the teeth might make initial contact with the casing at a point 72 between the finite tooth points 62 and 64. In no case, however, can the actual tooth 62 contact point vary from the theoretical contact point 72 on the curve more than one-half the distance between teeth, else the adjacent tooth 64 will be closer to the theoretical point and will actually make contact.

Wall engaging crests of teeth 42, 58, 61, 62, 64, 66, 68 and 70 may be cut on various radii. A properly chosen curve bounding the tooth crests 58, 61, 62, 64, 66, 68 and 70 can maintain the action angle 44 and action angle 60 substantially equal. A properly chosen curve bounding these tooth crests 58, 61, 62, 64, 66, 68 and 70 can maintain the theoretical action angle for the slip in the smallest inside diameter casing equal to the theoretical action angle in the largest inside diameter for a range of casing in which a slip is designed to be used. With my invention, the action angle can be designed for larger inside diameter casing and smaller for smaller inside diameter casing or vice versa, depending upon the performance requirement of a particular slip. Casing internal diameters intermediate those illustrated for casing 32 and casing 52 may also be initially contacted with teeth at the upper and lower ends of a slip so that the action angle is substantially the same as action angle 44 and action angle 60.

A curve through tooth crests 58, 61, 62, 64, 66, 68 and 70 may be chosen as a segment of a parabola, a segment of a circle, or another curve.

Referring now to FIG. 6, a slip 30 is engaging the casing 32, at a point 90 because the radius 92 of the slip tooth 40 about axis 94 is less than the radius 96 to the inside diameter of the casing 32. Such a relationship permits contact of the slip teeth to the casing in a plane 96-96 which also contains the central axis 31 of the slip, axis 94 about which the slip teeth are cut, and which contains a profile of the slip teeth as illustrated in FIG. 5. Such contact at the center of the slip teeth is desirable in contrast to the undesirable condition illustrated in FIG. 7 wherein the slip tooth radius 100 is larger than the radius 102 to the inside diameter of the casing 104. Slip tooth 104 contact with the casing inside diameter 106 occurs at the end points 108 and 110 of the slip tooth 104. Such contact at points 108 and 110 is undesirable because the ends of the teeth are imperfect and may not be sufficiently sharp to grip the casing properly, and additionally may become too tightly engaged with the casing due to wedging action.

The unitary slip on the well tool shown in FIG. 1 anchors down thrust. The same advantages as described hereinbefore are achieved when the improved unitary slip in this invention is used in an inverted position from that shown in FIG. 1, so as to anchor up thrust in a well tool. Such applications are described in the referenced U.S. Pat. No. 3,548,936.

Thus there has been described herein the preferred embodiment of the invention wherein the curved bounding profile of the slip can take several shapes. For example, the profile of FIG. 5 is a segment of a circle, whereas the profile of FIG. 5(a) is a segment of a parabola. However, it should be appreciated that the profile could be various other curves.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An improved gripping slip arranged to be movably mounted on a well tool and arranged to engage the well bore wall to hold the well tool in a well bore or the like, said slip comprising a unitary body member having first and second ends; a bore, having a longitudinal central axis, extending through said body intersecting said ends and sized to encircle a portion of the well tool; a wall engaging portion adjacent each said end located on generally opposite sides of said body member, the distance between said wall engaging portions being greater than the diameter of the well bore whereby said engaging portions can engage the well bore wall; and, a portion intermediate said ends having a dimension less than the diameter of the well bore, whereby the well tool can move through the well bore, said improve-

ment comprising:

each said wall engaging portion having a first curved bounding profile in a plane containing said central axis and a second curved bounding profile about said central axis.

2. The gripping slip of claim 1 wherein at least one of said wall engaging portions has a plurality of teeth formed thereon.

3. The gripping slip of claim 2 wherein said bounding curve is a segment of a circle.

4. The gripping slip of claim 2 wherein said bounding curve is a segment of a parabola.

5. The gripping slip of claim 1 wherein both of said wall engaging portions have a plurality of teeth formed thereon.

6. An improved gripping slip for well tools comprising:

a tubular body having a longitudinal axis, first and second ends,

a pivot axis located midway between said ends and extending generally perpendicularly to and intersecting said longitudinal axis, and

a wall engaging surface adjacent each said end, at least one of said wall engaging surfaces being an arcuate surface, wherein said at least one arcuate surface comprises teeth and the radius of curvature of each said tooth is different from the radius of curvature of an adjacent tooth; and

a pair of lug members projecting into the interior of said tubular body member, said lug members being located on said pivot axis.

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