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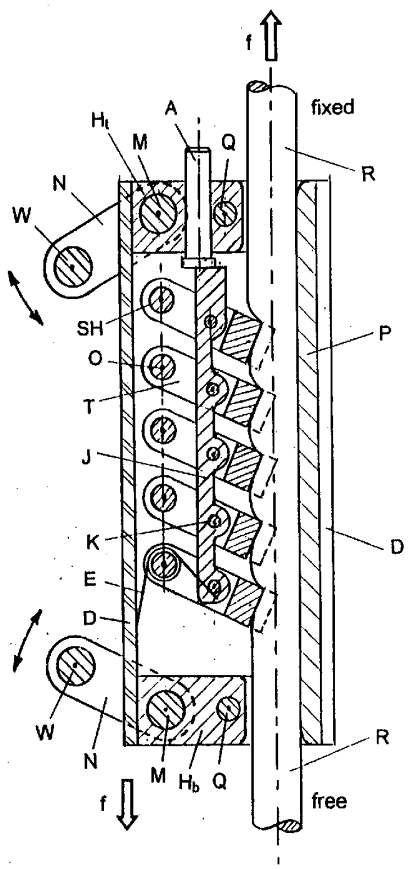
(54) Abstract Title: **Rope clamping device**

(57) A rope clamping device which when attached to a rope R automatically clamps onto the rope R when drawn in one direction but slides along the rope R when drawn in the opposite direction, having means (pin A) for manually overriding the automatic clamping action, the clamping resulting from the rope being gripped between a rotatable sprung pivot tooth T(i.e., the tooth T which is pivoted (at O) and biased by spring E towards the rope) and a static pressure plate P both contained within a rigid enveloping body D. The pivotal action causes the tooth T to progressively indent into the rope's cross-section wherein the profile of the tooth (which may be concave) presented to the rope is advantageous to the initiation and development of clamping without damaging the rope. Preferably there exists a plurality of said teeth T, serially spaced and caused to move in unison by an interconnecting member J.

section zz



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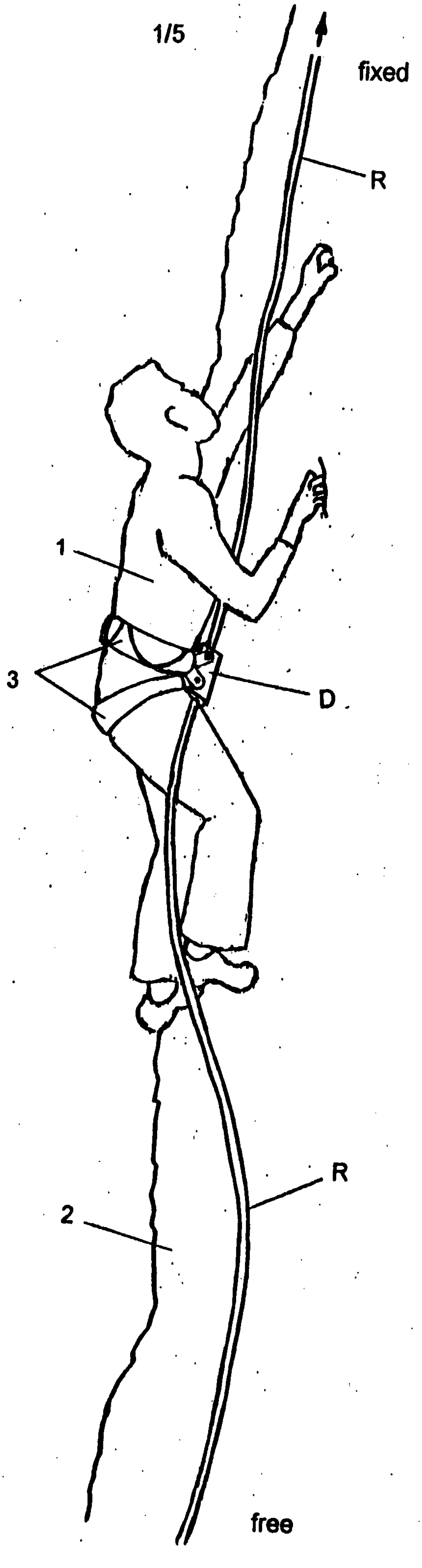

Fig 1

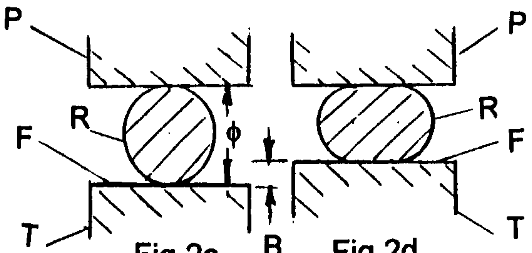

Fig 2c (section xx, Fig 2) Fig 2d (section yy, Fig 2)

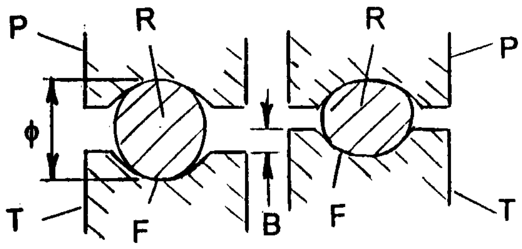

Fig 2e (section xx, Fig 2) Fig 2f (section yy, Fig 2)

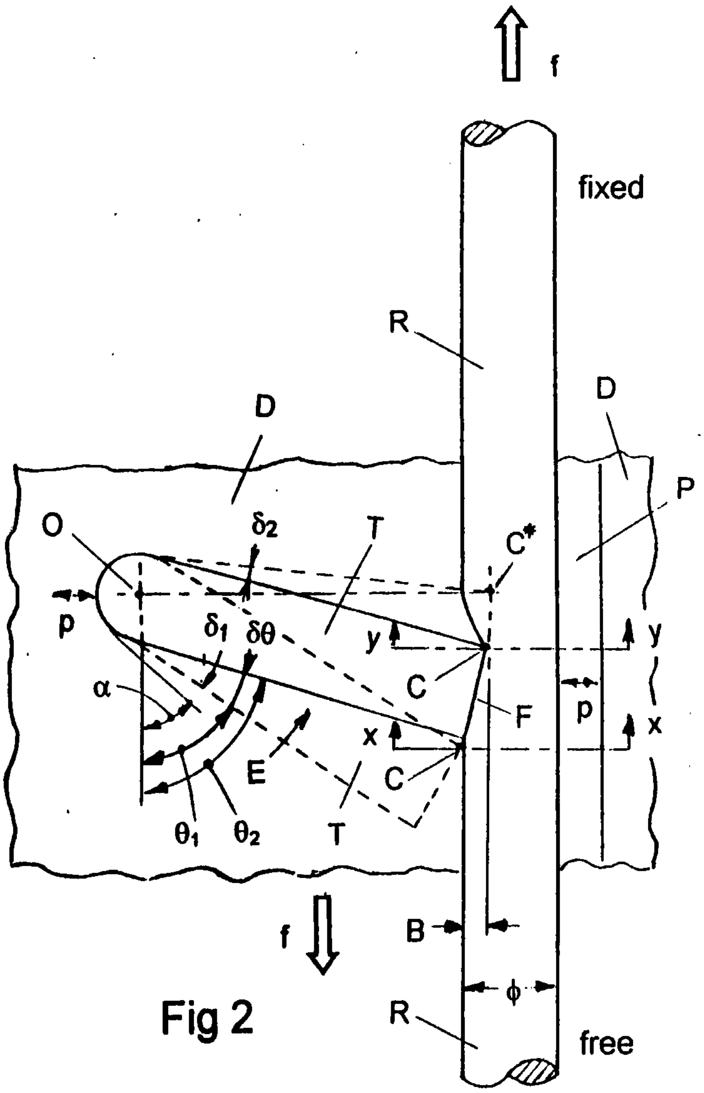

Fig 2

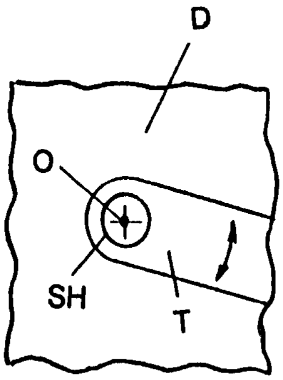

Fig 2a

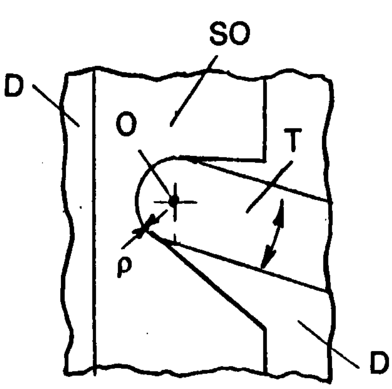

Fig 2b

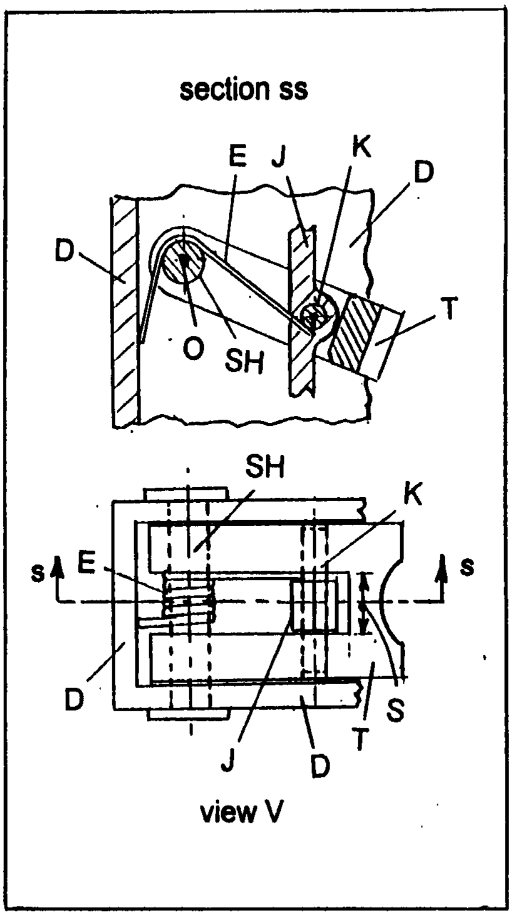
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Fig 3a

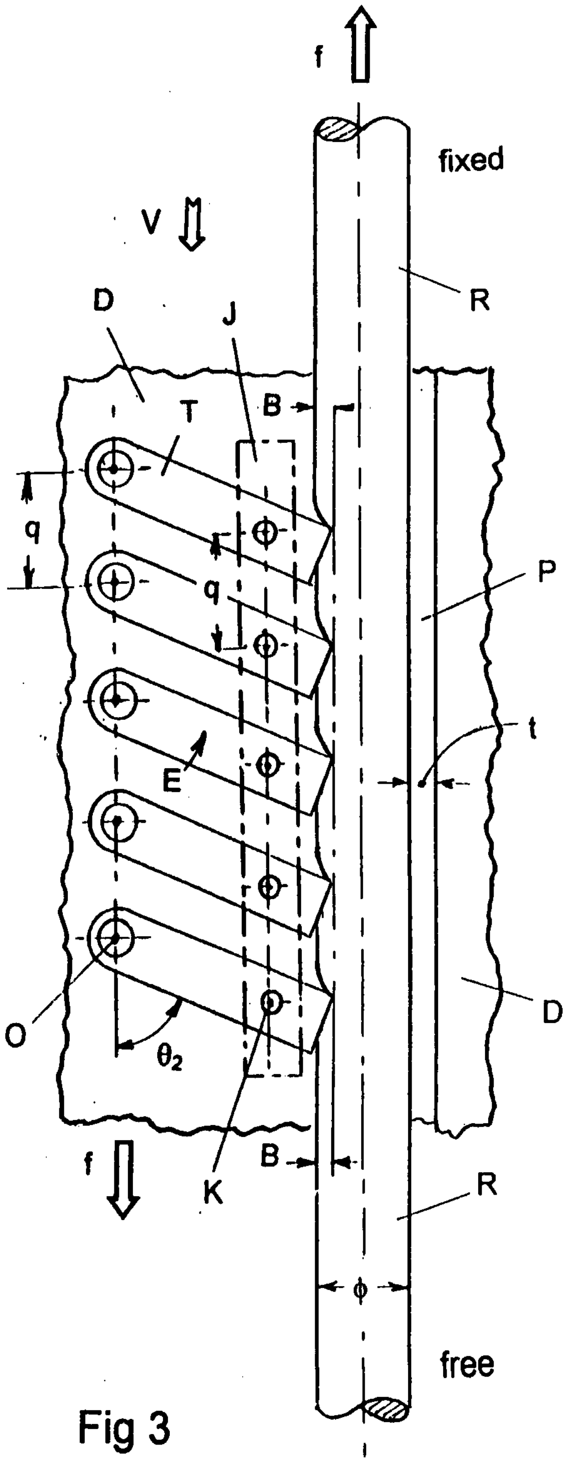
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Fig 3

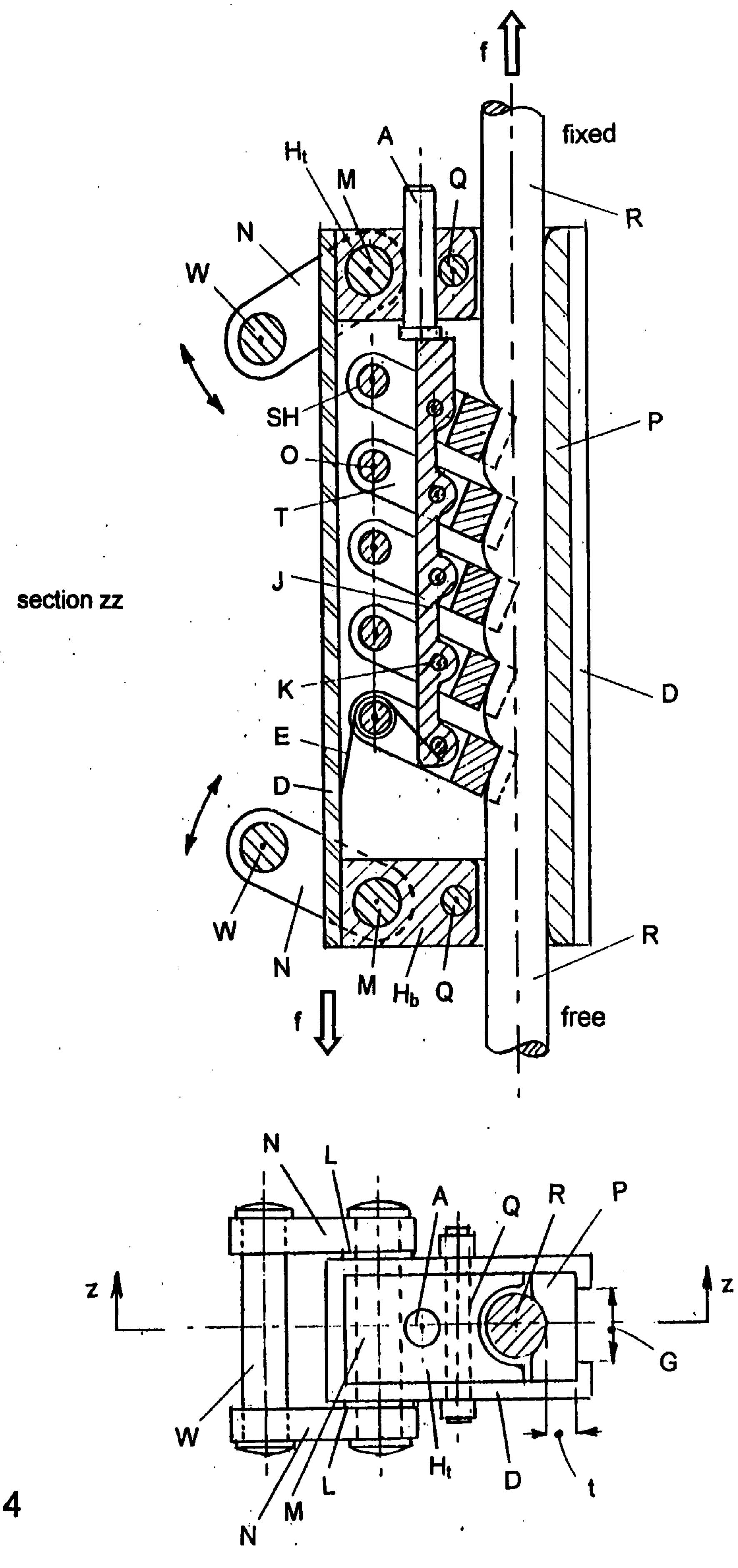

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Fig 4

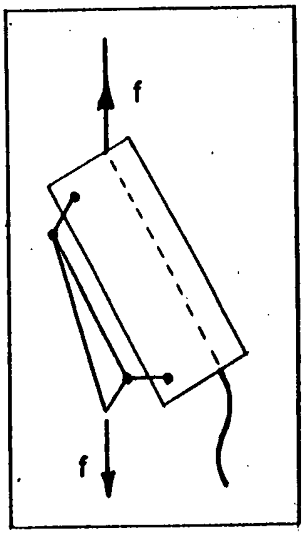

Fig 5a

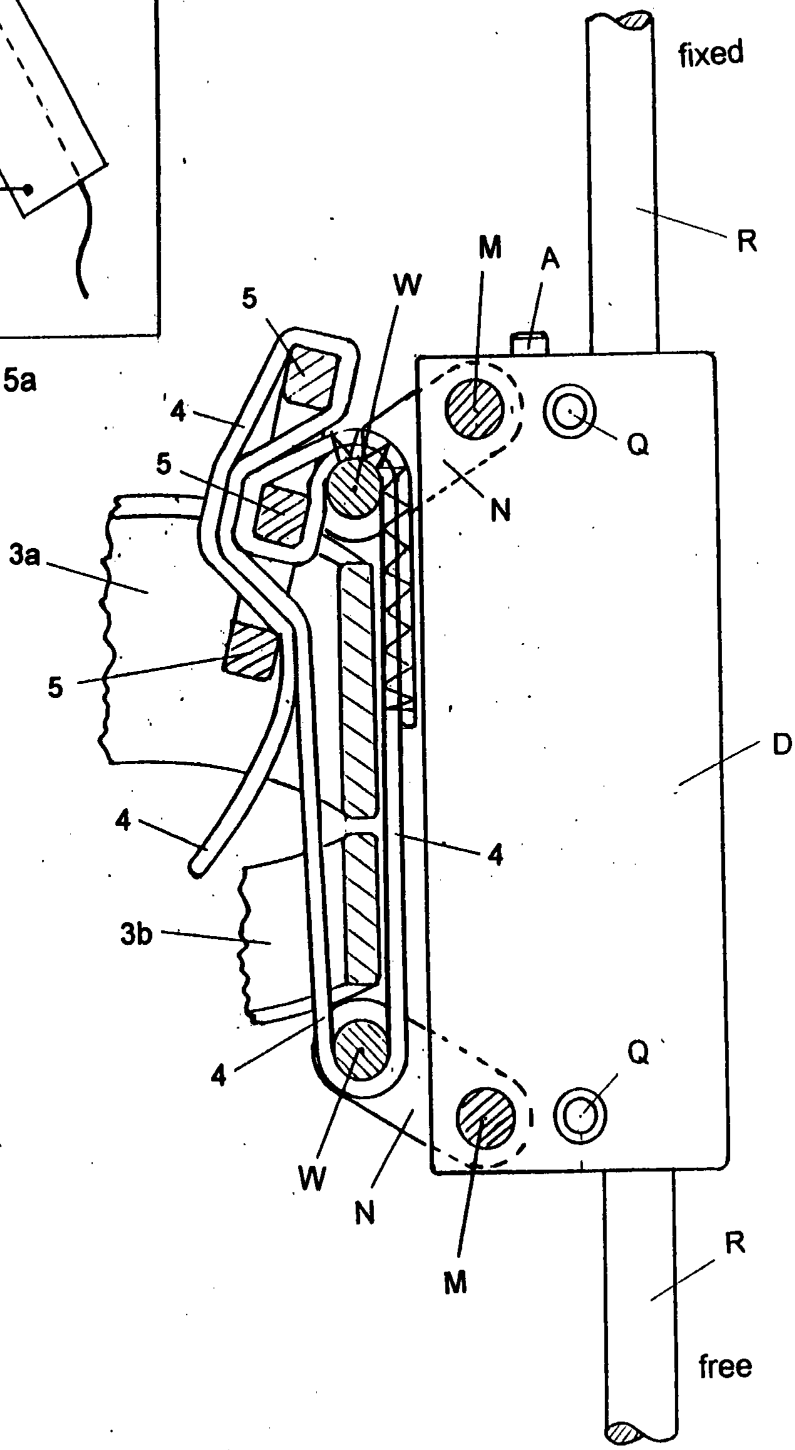

Fig 5

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ROPE CLAMP DEVICE

This invention relates to the design and construction of a movable clamp used for securing a person or object to an anchored rope.

The following describes, in particular, the invention applied for safety protection in the sport of rock climbing, but the invention is not limited to that application, and may find use in the broader field of safety when working with ropes, or even more generally, in the clamping of ropes.

Within the sport of rock climbing, the activity of solo climbing, to which the invention mainly applies, is carried out alone, without direct safety support from another person or persons. At its simplest, solo climbing is conducted in the complete absence of protective safety equipment, but as the risk of injury resulting from a potential fall increases, it is common practice for the solo climber to use some form of safety protection. Usually, when the height of the climb is less than a standard climbing rope length, protection is based on a rope securely anchored just above the top of the climb, to which rope is attached a movable safety device secured to the climber. As the climber ascends the rock face, the safety device is concurrently moved up the top-fixed rope, but is prevented by one means or another from slipping back down the rope. Thus, in the event of the climber accidentally falling from the rock face, the length of fall is limited by the safety device engaging the rope, protecting the climber from serious injury.

Various safety protection methods have been used by solo rock climbers. Broadly speaking such methods can be placed within two categories.

In one category a specially prepared rope is used, with fixed stops in the form of knots or other protuberances arranged at selected intervals along the rope length. A safety device in the form of a catch, attached to the climber, can move freely up or down the rope in the intervals between adjacent stops, and can be manually manipulated over the stops, but in the event of the climber falling, the catch automatically engages the highest stop on the rope below the point of falling, thus limiting the length of fall. Safety devices within this category can be described as being of the non rope-clamping type, are not widely used, and being mentioned for background only, receive no further reference in this Patent Specification.

In the other category of safety methods, to which the present invention relates, a standard smooth climbing rope is used in conjunction with an automatic rope clamp device attached to the climber, the clamp gripping tightly onto the rope in the event of the climber's fall, but otherwise allowing passage of the rope through the device as the climber ascends the rock face. Within this category, commercially available rope clamp devices generally conform to one of two basic types, namely those actuated by an applied downwards force, and those actuated by downwards movement of the device relative to the top-fixed rope. Although the function of these two types may at first sight appear similar, their respective operating characteristics are fundamentally different, as described in the following:

Force actuated rope clamps rely crucially for their action upon the force of the falling climber being transmitted via leverage into gripping the rope, such devices otherwise being capable of running on the top-fixed rope, in both upward and downward directions. When using such devices it is important that the lever action is unimpeded, otherwise there is a risk of malfunction in clamping.

Rope clamps actuated by relative movement between rope and device, to which type the present invention relates, are characterized by allowing the device to run on the top-fixed rope in the upwards direction of ascent only, any downwards movement of the device relative to the rope, for whatever reason, automatically initiating a progressive clamping action. This latter characteristic is in all such devices, including the present invention, brought about by the rope dragging across the face of, and thus drawing in by frictional force, a moving gripping member.

In prior art devices the said gripping member generally takes the form of a cam segment rotationally mounted on a pivot attached to a rigid frame, the cam profile being held by spring action in contact with the rope, which is supported in a grooved part of the frame against the thrust of the cam, the latter being automatically engaged by relative movement of the device on the rope in one direction, and automatically disengaged in the other. To increase the externally applied load which can be transmitted to the rope by the device before slippage occurs in such prior art devices, the profile face of the cam is usually furnished with sharp teeth or spikes that bite into the soft rope outer sheath on engagement, an adverse effect of which is increased rope wear in use. Although the described prior art devices have found limited application in protecting the solo rock climber because of their advantageous rope clamping characteristic, the main intended function of such devices is to provide mountaineers with means of directly climbing up fixed ropes. For this reason such devices are generically known in the sport as 'ascenders', and are intended to carry the static load of the ascending climber rather than the greater dynamic shock loads associated with arresting a falling climber. Moreover, they are not readily adapted for easy use in solo rock climbing.

The present invention overcomes disadvantages of prior art devices as above described by means of a fundamentally different rope clamping principle which concurrently provides increased load transmission sufficient to arrest a dynamic fall, without jamming and without significant damage to or weakening of the climbing rope. Furthermore, the method of connecting the invention to the rock-climber offers advantages in the facility of use over prior art devices, an important feature when the climber is operating near the limits of performance. The present invention is hereinafter described in detail in the particular context of use by the solo rock climber, but by doing so it is in no way intended to limit or restrict potential application to other fields of use involving the clamping of ropes.

According to the present invention there is provided a device for clamping onto a rope secured at one end, clamping being automatically caused by the device tending to move along the rope in the direction away from the secured end but the device being free to move along the rope in the opposite direction, means being incorporated for manually overriding if required the said automatic clamping action, the rope clamping device basically comprising an envelope body containing a pivot tooth caused to move in a circular arc about a fixed centre and a static pressure plate said rope being clamped between a gripping face of said pivot tooth and opposing face of said pressure plate, the clamping force provided by the device being increased by extending the inventive concept to include a plurality of similar spaced pivot teeth caused to move in unison by an interconnecting member.

A specific embodiment of the invention will now be described by way of example with reference to the following drawings in which:-

Figure 1 shows the rope clamp safety device according to the invention in typical use by a solo rock climber.

Figure 2 illustrates the basic functional components and operating principle of the rope clamp safety device according to the invention.

Figure 3 illustrates a typical working arrangement applying the principles of the rope clamp safety device according to the invention.

Figure 4 illustrates components and features of a typical assembled rope clamp safety device according to the invention.

Figure 5 illustrates a preferred method of attaching the rope clamp safety device according to the invention, to the standard waist harness worn by rock climbers.

With reference to the drawings, Figure 1 shows use of the rope clamp safety device D as applied in a typical solo rock climbing situation. The climber 1, ascends rock face 2, by means of natural features providing holds for hands and feet, a particular course of such holds up the rock face being described in the sport as a climbing route. Device D is securely attached to climbing harness 3, and is connected with rope R anchored at the top of the climb as indicated. The connection of device D with rope R is such that the device is able to move up the rope with the climber during ascent, but any downward movement of the device relative to the rope, for example as caused by the climber falling, automatically results in the device clamping tightly onto the rope. Device D is provided with means for direct attachment to climbing harness 3, being securely tied into both waist-band and leg-loop bridge in similar manner to that normally used by climbers for attaching a rope to the harness. Thus device D is firmly located in position as shown in Figure 1 and readily accessible to the climber by either hand. Although device D allows relative passage of rope R in a downwards direction, frictional drag acting against rope passage through the device may cause unacceptable slackness to accumulate in rope above the climber during an ascent, particularly in situations where the length and weight of rope hanging freely below the device is small. The climber continually monitors and removes such slackness throughout the ascent at convenient points, between climbing moves, by manually drawing rope down through the device from below. In this way the climber controls the degree of immediate protection available to suit the currently prevailing circumstances. For example, the climber may in general prefer to operate with a small amount of rope slackness above device D in interest of unrestricted climbing movement, especially if the climb involves some lateral traversing, but conversely, prior to a difficult move with increased risk of falling, a tighter rope may be desired. (An alternative, non-preferred, method of removing rope slackness, commonly applied when using prior art devices, is to suspend a small weight from the bottom of the free rope hanging below the device). The basic safety action of device D is to allow rope passage in one direction only, so that in general during an ascent the length of rope above the climber is reduced but not increased. However under some particular circumstances the climber may require to override this basic action and actually introduce rope into the safety system, for example if the climbing route involves a partial descent, or during an escape from the climbing route. Device D is provided with such an override facility, which for safety reasons may be operated only when the device is not under load, i.e. supporting the climber's weight.

Figure 2 illustrates the basic functional elements and operating principle of the rope clamp device according to the invention. The device consists of an envelope D, containing a pivot tooth T, and a pressure plate P, pivot tooth T and pressure plate P acting on opposed sides of rope R, the latter, of un-tensioned diameter ϕ, being fixed at one end corresponding to the top of the rock climb and free at the other end corresponding to the bottom of the rock climb as indicated. Pivot tooth T is caused to rotate about centre axis O by one means or another, preferably by mounting on a transverse shaft SH housed and retained at each end in bores provided on axis O in envelope D (Figure 2a), or by providing tooth T with an external hemispherical profile of radius ρ set on centre axis O, said profile rotating within a mating profile in a socket SO (Figure 2b) with additional provision being made for tooth retention in socket SO, and socket retention in envelope D. Viewed within its plane of rotation, the end of pivot tooth T, which contacts rope R, is of angular aspect and features a face F of suitable length provided with a leading corner edge C as shown in Figure 2. Rope clamping is brought about by initially presenting pivot tooth T to rope R at acute angular inclination θ_1, by means of spring action E, such that in the direction of the fixed end of rope R, contact point C on the leading edge of face F of pivot tooth T lies rearwards of pivot centre axis O as shown. The magnitude of contact angle θ_1 is such that movement of device D along rope R away from the fixed end direction (as would occur with a falling climber) causes pressure and friction forces acting on pivot tooth T to produce a turning moment about centre axis O, rotating the tooth in a circular arc so as to increase the tooth's rope contact angle by an amount δ_θ from θ_1 to θ_2, and thus causing pivot tooth T to indent rope R by a corresponding amount B. The effect of progressive indentation B is to increasingly resist relative passage of rope R through device D, by the clamping action of tooth face F, such that the device is capable of supporting a suspended force f by generating an equal and opposite tension force in fixed rope R above device D, complementary lateral pressure forces p being internally reacted within device D as indicated. A natural feature of the above-described clamping action is that the contact profile of pivot tooth T presented to rope R changes continuously during the development of indentation B in such a way as to increase the rope clamping action exercised by tooth face F whilst concurrently reducing the tooth's sharpness aspect presented to the rope. Provided there is no force f acting through device D, pivot tooth T may be returned from an engaged position, as depicted by angle θ_2, to the disengaged position depicted by angle θ_1, by drawing rope R through the device towards the 'free' end.

Referring to Figure 2, angular clearance is provided to accommodate maximum rotational movement of pivot tooth T occurring in operational use. Thus, trail angle α is less than tooth-rope initial contact angle θ_1 by amount δ_1, ensuring that pivot tooth T can rotate clear of rope R against spring force E for the purpose of drawing unwanted slack rope through the device from the 'fixed' to 'free' side as the climber ascends the rock face. In Figure 2 maximum possible rope indentation will occur when contact point C attains a value C*, defining the perpendicular condition of tooth dimension O-C to the axis of rope R, occurring at an angular increment δ_2 greater than angle θ_2 of indentation B. Provision is made within the design of the device to arrest pivot tooth T before this said maximum indentation position is attained, to prevent the decrease in rope clamping effect that would otherwise result from further tooth rotation. Thus, in the event of externally applied force f reaching sufficient magnitude to cause pivot tooth T to attain the said arrest position, rope slippage through the device would commence and continue until the force diminished.

The construction of modern climbing ropes comprises a core of continuous longitudinally laid high strength fibres contained within a helically woven fibre outer sheath of circular cross section. Such construction renders the rope strong yet supple, the latter being important for knotting and other manipulations in use. However, this property of suppleness, which results from the ability of the rope's cross section to readily deform, e.g. flatten, under transverse loading, may be disadvantageous from a clamping aspect, unless the clamping device is designed to take account of such flattening tendency. For example, Figures 2c and 2d depict rope clamping between pivot tooth T and pressure plate P both of which are provided with transversely flat clamping face profiles. Figure 2c shows initial contact with rope R of circular cross-section, prior to clamping, corresponding to section xx of Figure 2, and Figure 2d shows the flattened rope cross-section after clamping, resulting from indentation B, corresponding to section yy of Figure 2. It is clear that because of the rope's ability to flatten, and the inability of the flat clamping profiles of tooth and pressure plate to resist rope flattening, indentation B will generate relatively low rope clamping force. By comparison, if hollow clamping face profiles commensurate with rope circularity are provided in pivot tooth T and pressure plate P, as depicted in Figures 2e, 2f, corresponding to Figure 2 sections xx, yy respectively, then the lateral constraint to rope flattening exercised by the hollow clamping profiles in tooth and pressure plate will pro rata with indentation B generate greater clamping force. It is not the purpose of this Patent Specification to lay claim to any particular shape of hollow clamping profile in pivot tooth T and/or in pressure plate P, but rather to elucidate the importance of such profiles to rope clamping, and reserve the position to exploit said profiles within the general inventive concept.

With reference to Figure 2, the degree of sharpness of pivot tooth T at leading edge C is important to successful operation of the device. If edge C is too sharp there is risk of cutting into and weakening the outer sheath of rope R as a result of indentation B when the device is loaded. Conversely, if edge C is too blunt the initial engagement action of the device with rope R may be impaired, leading to a loss of basic functionality. The above described requirements of tooth sharpness are recognised and satisfied within the inventive concept by appropriate means, for example by manufacturing tooth T from a wear resistant material, or by making edge C as a wear resistant insert in tooth T, or by any other methods producing a similar result.

Although the basic embodiment of the invention shown in Figure 2, and its subsidiary Figures, provides a means of rope clamping, a single tooth arrangement may not be ideal for practical application in many cases. A prime disadvantage of the single tooth embodiment as depicted in Figure 2 is that the development of a clamping force f sufficient to arrest a fallen climber may, in worst case conditions, require such a large rope indentation B as to damage and weaken rope R. Furthermore, the size and geometry of the device envelope D necessary to provide such a large indentation may render the device unwieldy in use. These drawbacks may be conveniently overcome by replacing the single tooth with a plurality of similar teeth acting in unison as shown in Figure 3. With reference to Figure 3, the device is depicted by envelope D containing several spaced similar pivot teeth T, rope R of un-tensioned diameter ϕ being clamped between pivot teeth T and pressure plate P as previously described for single tooth clamping with reference to Figure 2. Pivot teeth T are caused to act in unison with respect to their angular inclination and corresponding indentation of rope R, by introducing a connecting member J linked to each tooth by a pin K as shown in Figure 3, ensuring that dimensional similarity exists between centre spacing q in envelope D and connecting member J for adjacent teeth T, and between pivot centre O and the centre of pin K on each tooth, and between tooth pivot centres O and the central axis of rope R. In Figure 3 the minimum value of dimension q between adjacent teeth is dependent on the required range of tooth angular movement as previously described with reference to Figure 2. Figure 3 shows the device in the rope clamping position with pivot teeth T rotated to angle θ_2 developing the same nominal indentation B in each tooth (ignoring the complex effect of rope stretch through the device). The illustrated arrangement is versatile, allowing the number of pivot teeth T and indentation B to be adapted and optimised to carry externally applied force f, the latter being equal to the summation of resistance offered by each clamping tooth, and enabling control over the external size and proportions of the device envelope D. As in the simple embodiment of Figure 2, spring force E is applied to pivot teeth T to initiate clamping engagement. However, because teeth are interlinked by connecting member J, it is unnecessary to provide individual springing on each separate tooth. The arrangement of device D illustrated in Figure 3 is optimised to provide clamping force f by developing nominal indentation B in rope R of diameter ϕ. However, the general usefulness of the device is improved by accommodating a range of rope diameters typically used by rock climbers, the indentation and clamping force on each being optimised relative to rope strength. Achievement of the latter is facilitated by providing pressure plate P as a replaceable member whose thickness t may be varied as shown, dimension t generally bearing inverse proportionality to rope diameter ϕ, and thickness t being the thickness of pressure plate P at its central section in the case of a hollow profile as previously described with reference to Figures 2e and 2f. As in the single tooth embodiment previously described with reference to Fig 2, the multi-tooth embodiment shown in Fig 3 implicitly includes provision for tooth arrest at an angle of inclination θ_2 less than that producing the maximum rope indentation condition, and less than that causing rope damage or jamming, and less than that commensurate with an arrest force f liable to injure the climber. In the event of tooth arrest, rope slippage would commence and continue until the force diminished.

Figure 3a shows detail of a particular embodiment of pivot tooth T, and mating components according to the invention, as depicted in outline in drawing Figure 3. Referring to Figure 3a, when viewed in a direction V in Figure 3, parallel to the axis of rope R, each pivot tooth T is provided with a similar central slot S containing connecting member J and, if required, spring E. Helically wound spring E is carried on pivot tooth shaft SH, the latter being located on centre axis O, and housed and retained in bores provided in device envelope D as shown. The required action of spring E, in maintaining pivot tooth T in contact with rope R, is caused by providing a straight tail at each end of the helical winding, one spring tail being located behind connecting member pin K, and the other spring tail bearing on an internal surface of device envelope D as shown.

Figure 4 illustrates components and features of an assembled embodiment of a rope clamping device according to the invention, incorporating concepts and principles previously described with reference to Figures 1, 2 and 3. Two views of the embodiment are shown in Figure 4, namely, an end view with rope R in circular profile, and a sectional side view taken on central plane zz showing rope R in a clamped state. Clamping device envelope D takes the form of a tubular box of rectangular section housing pivot teeth T, pressure plate P, and top and bottom end-pieces H_t and H_b respectively. Pivot teeth T are coupled in unison by connecting member J as described with reference to Figure 3, transverse movement of the teeth being constrained by the internal sides of envelope box D, whilst keep plates L fitted to the external sides of envelope box D, as shown, retain tooth pivot shafts SH against transverse movement.

As described with reference to Figure 3, spring method E affords the means of deriving overall spring force by incorporating a spring or springs on one, several or all of the individual interconnected pivot teeth T. End-pieces H_t and H_b are each provided with rope guide apertures sufficiently large to allow free passage of the largest diameter rope R used in connection with the clamping device, and are each securely mounted within envelope box D by means of a pin M and a tie-rod Q. Top end-piece H_t incorporates a captive sliding pin A with its ends projecting outside and inside the device as shown. The inner end face of pin A is in sliding face contact with the leading end face of pivot pin connecting member J as shown, enabling the latter to move freely as dictated by the rotational motion of pivot teeth T. By depressing pin A the rock climber is able to rotate and hold pivot teeth T clear of rope engagement, against spring E, thus overriding and preventing the normal rope clamping action of the device. As described with reference to Figure 1, the device's override function allows the rock climber, with discretion, to manually introduce slack rope into the safety system when special climbing circumstances may require such action. However, because of leverage effects within the device, pin A cannot be manually depressed by the climber when the device is supporting load. This inherent safety feature prevents the climber from inadvertently disengaging the device from the rope when in a perilous situation.

As previously described with reference to Figs 2 and 3 the rope clamping device incorporates provision for limiting the maximum rotational travel engagement of pivot teeth T with rope R for various reasons, namely; there is an angle of tooth inclination for any given tooth geometry above which rope indentation (and therefore clamping force) decreases; excessive indentation may cause rope damage; a high angle of tooth inclination increases the likelihood of rope jamming within the device in arresting a fall, with adverse implications for subsequent escape; the clamping force provided by the device in arresting a fall should not exceed that liable to cause bodily injury to the climber. For each and all of the above reasons it is desirable that the rope clamping device incorporates a stop which arrests clamping action at a pre-determined tooth inclination, thus providing a maximum rope clamping force for the particular device/rope configuration, at which rope slippage through the device will occur. With reference to Fig 4, since pivot teeth T are interconnected by member J, various alternatives are available for incorporating the said tooth arrest stop. A single stop acting on tooth connecting member J, or on a single tooth, would in principle achieve the desired result. For example, an enlarged head on the inner end of pin A, as illustrated in Fig 4, could be arranged to stop forward travel of member J (and hence stop tooth rotation) at the desired tooth inclination, the resulting force being transmitted through the sliding interface between member J and pin A into device front plate H_t, and hence eventually to the climber. Alternatively, a headless pin A, travel constrained within front plate H_t, could enable the front face of member J to be stopped directly against the rear face of front plate H_t, thus avoiding transmitting the arrest force via the member J/pin A sliding interface, whilst preserving the teeth retraction 'override' function. Alternatively, a wedge-shaped stop, allowing free passage of pin A and member J, could be positioned between front plate H_t and leading pivot tooth T, the angle of the stop, facing the leading tooth, matching the required arrest angle of the teeth, and the opposite side abutting the rear of front plate H_t, thus completely avoiding transmitting the tooth arrest force via pin A or member J sliding contact faces, and advantageously creating larger contact surfaces for arrest force transmission. Whilst the foregoing provides various alternatives of arrest stop design, this is not meant to be exhaustive, but rather practically illustrative of the importance of incorporating a reliable arrest stop within the general inventive concept.

With reference to Figure 4, Rope R could be connected into the clamping device by threading the free end of the rope through the device at the start of the rock climb, and disconnected from the device by un-threading the rope at the completion of the ascent. However, such a procedure would be laborious, and detract from the general usefulness of the device. Moreover, in the event of the climber abandoning a partly completed ascent, and subsequently descending by sliding down the rope using standard techniques and equipment, it may be convenient to remove the clamping device completely from the rope at the start of descent, once said descent equipment is safely installed. For these reasons it is preferable that the clamping device be capable of connection to and disconnection from the rope at any point on the rope. Such a feature is provided in the embodiment of the invention illustrated in Figure 4 by making a central opening G running the full length of envelope box D as shown, the width of opening G being sufficient to allow passage of the largest diameter rope R to be used in the clamping device, but substantially less than the internal width of box D and the mating width of pressure plate P, as shown. To enable connection or disconnection of rope R to or from the device via opening G, pressure plate P is first completely removed from box D by sliding longitudinally in a direction parallel to the rope's axis. Following rope insertion into the device, pressure plate P is reinstalled by sliding into box D, provision being made to lock pressure plate P securely in position within box D, to prevent sliding, prior to use of the rope clamping device for rock climbing, the means of locking and unlocking pressure plate P being readily accessible to the rock climber at all times. For security in handling, removable pressure plate P is provided on its outside top face with a lug, to which is connected a loosely hung retaining cord tied to the climber's harness. As described with reference to Figure 3, utility of the clamping device is improved by the provision of interchangeable pressure plates P of different thickness t, to suit different rope diameters, such a feature being readily incorporated in the above-described removable pressure plate concept.

Figure 4 shows the rope clamping device fitted with two shackles, one at each end of the device, for connection to the climber's harness, each shackle comprising; a pin M connecting shackle to device, webs N, and a harness attachment pin W, pins M and W being provided with end shoulders for lateral retention, as shown. The brunt of force f developed in arresting a climber's fall, is transferred to the climber's harness via the upper shackle connected through end-piece H_t, the main purpose of the lower shackle being to maintain the clamping device in operating position relative to the climber at all times. Both upper and lower shackles can swing freely on pins M as indicated to accommodate loading conditions in use.

Figure 5 shows a preferred method of attaching the rope clamping device according to the invention, to the standard waist harness worn by rock climbers, so as to provide the positioning of the device illustrated in Figure 1. In Figure 5 the rope clamping device is depicted as an external side view, but shackles and attachment means are shown in section for clarity, such section aligning with the central plane of the device containing the axis of rope R. Although the method of attachment of device to climber has no direct influence on the rope clamping function, it is nevertheless very important in the rock-climbing situation that the device is securely, comfortably and conveniently located, without undue freedom of movement, in a position of ready access, so that operation of the device by the climber is routinely possible at all times. With climbers generally being of widely differing statures, such requirements are best achieved by an adjustable method of device-to-harness attachment, as may be brought about with a buckled belt, the belt being made of strong woven tape as typically used by climbers, to which is secured a stout buckle, belt and buckle being able to withstand maximum forces generated in arresting a climber's fall. As shown in Figure 5, belt 4, which is secured to the centre bar of buckle 5 by an overlap stitched joint, is taken around device upper and lower shackle pins W, and then threaded up behind harness leg loop bridge 3b and harness waist band 3a, before being drawn to required tension and secured in a closed loop by means of buckle 5, the latter being conveniently positioned by the climber for that purpose. Thus, the adjustable loop formed by buckled belt 4 securely ties the rope clamping device into both load supporting elements of the climber's harness, in similar manner to the method widely employed by rock-climbers for attaching the rope end to the harness using a knotted loop. Figure 5 illustrates the rope clamping device attachment means in the unloaded state, corresponding to the situation in Figure 1. However, when transmitting a force f, as in arresting a fallen climber, the rope clamping device attached in the above-described manner automatically adjusts orientation to provide alignment of suspended load with supporting rope force as shown in inset diagram Fig 5a.

CLAIMS

1. A rope clamping device for attachment to an anchored rope providing automatic clamping onto the rope when drawn in one direction but slidable along the rope in the opposite direction and incorporating means for manually overriding the automatic clamping action as required, clamping resulting from the rope being gripped between the profile of a rotatable sprung pivot tooth and the opposing profile of a static pressure plate both contained within a rigid enveloping body, the pivotal action causing the tooth's profile to progressively indent the rope's cross-section and in the course of which the profile of the tooth presented to the rope automatically and continuously changing in a manner advantageous to both initiation and development of clamping without damaging the rope.

2. A device as claimed in Claim 1 in which the inventive concept is extended to include a plurality of similar serially spaced teeth caused to move in unison by means of an interconnecting member thereby multiplying the clamping force exerted by the device and increasing its versatility.

3. A device as claimed in Claims 1 and 2 with means for limiting the angular operating range of the pivot tooth in rope clamping, the tooth angle presented to the unclamped rope being not less than that necessary for initiating automatic clamping and the greatest tooth angle attained in rope clamping being less than that corresponding to the condition of maximum rope indentation.

4. A device as claimed in Claims 1 and 2 in which the rope gripping profile faces of either the pivot tooth or pressure plate or both are of hollow form to inhibit lateral distortion of the rope's cross-section under clamping pressure and thereby increase clamping force exerted by the device.

5. A device as claimed in Claims 1 and 2 incorporating a mechanical stop to restrict maximum rope indentation and or maximum clamping force exerted by the device, rope slippage through the device occurring when the stop condition is attained.

6. A device as claimed in Claims 1 and 2 in which the device envelope body incorporates two end-pieces, one at each end, both end-pieces being provided with a similar aperture for rope guidance into, through, and out of the device.

7. A device as claimed in Claims 1, 2 and 6 in which the rope clamping action manual override function is provided by a pin conveniently located and captively housed in an end-piece of the device envelope body, the depressing of said pin rotating the pivot tooth in Claim 1 or interconnected pivot teeth in Claim 2 out of engagement with the rope against spring pressure but the pin being operable only when the device supports no significant load, the device returning to automatic clamping mode when the pin is released.

8. A device as claimed in Claims 1 and 2 accomodating a range of rope diameter sizes by utilising several replaceable pressure plates each of different thickness, provision being made to securely lock the inserted pressure plate in position prior to device use.

9. A device as claimed in claims 1, 2 and 8 in which the device envelope body region supporting the pressure plate is provided with a full length opening of width

sufficient to allow passage of the largest diameter size rope accommodated by the device, thereby enabling the device to be connected to or disconnected from the rope at any point along the rope's length.

10. A device as claimed in Claims 1 and 2 in which the device envelope body is provided with an external shackle adjacent each end for adjustably securing the device to the safety harness worn by a user person, or otherwise connected object, in a manner facilitating the device's ready operation and control in use.

11. A rope clamping device substantially as herein described above and illustrated in the acompanying drawings.

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Application No:	GB0424789.6	**Examiner:**	Mr Nithi Nithianathan
Claims searched:	1-10	**Date of search:**	27 September 2005

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-6, 8, 9	US4560029 A (WGM); see especially figure 3, movement of part 82 limited by part 42
X	1-6, 9, 10	FR2548913 A (Le Denmat Marc); see especially the figures and abstract, also noting apertures 17 adjacent each end
X	1	GB2192664 A (Petzl); see especially figure 6
X	1	EP0279929 A2 (Heinrich); see especially figure 2 and the abstract
X	1	US4542884 A (Dodge); see especially figures, noting part 14

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

A6M; F2X

Worldwide search of patent documents classified in the following areas of the IPC^{07}

A62B; A63B; F16G

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI