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(54) **Title**: DRAGLINE ROPE FERRULE

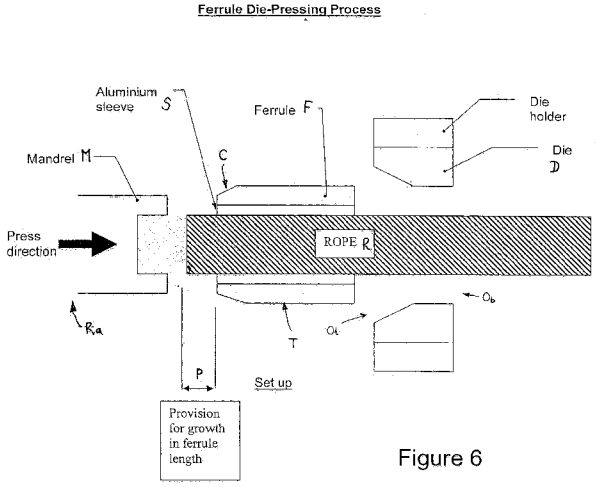

Figure 6

(57) **Abstract**: A method is disclosed for attaching a ferrule to a dragline rope. The method comprises locating the dragline rope in a die of a die-press, locating over the dragline rope a ferrule that is lined internally with a deformable material, and forcing the ferrule longitudinally through the die. The ferrule is caused to be internally expanded and be extruded back over the dragline rope, causing the lining to deform directly against the dragline rope and fastening the ferrule to the dragline rope.

Dragline Rope Ferrule

Technical Field

Disclosed is a method for attaching a ferrule to a dragline rope, as well as a dragline rope comprising a ferrule, and a ferrule for the dragline rope. The method finds particular, though not exclusive, application in relation to dragline dump ropes, and will in part be described in this context. However, it is to be appreciated that the method can be employed to attach ferrules to hoist as well as drag ropes in a dragline. The method can also be employed on other steel wire ropes that are used in both mining and civil engineering applications, where a high degree of ferrule-to-rope securement is required.

Background Art

Large capacity mining draglines subject a dragline bucket to enormous forces and loads. The ropes (also referred to as "cables") are employed in draglines to control the various movements of the bucket, and accordingly experience extreme and rapid wear, especially at the sheaves in components of the dragline. For example, hoist ropes may need to be replaced every 3-6 months, drag ropes every 1-3 months and dump ropes every 1-2 weeks. Rope replacement is time consuming, with "downtime" of the dragline representing a significant cost in mining operations.

Minimizing the rope changeover time and improving rope integrity so as to decrease the incidence of ferrule-to-rope failure can each contribute to downtime reduction and improved operating cost and efficiency.

It is known to connect ferrules to wire ropes by a swaging method or a jaw-pressing method. Such methods have been observed to provide sufficient securement of the ferrule to the wire rope for a number of applications in which wire ropes may be employed. However, such methods are unlikely to provide sufficient securement of a ferrule to a wire rope for dragline conditions.

GB 1,369,211 discloses a ferrule on a wire rope. The ferrule can be secured to the wire rope by swaging or by a type of die-pressing that imparts a shaped profile to the ferrule. In other words, the ferrule is die-pressed by a die set that is laterally directed to press the shaped profile onto the ferrule. The profiling of the ferrule necessitates a

lateral pressing, hence the method of GB 1,369,211 is not concerned with nor able to address the securement requirements of a ferrule to a dragline rope.

GB 2,113,732 discloses a connecting device for the end of a wire rope to enable the end to be connected to a hook or bolt. A ferrule is secured to the wire rope by a swaging operation. The secured ferrule retains a proximal end of a connecting coupling onto the end of the rope, with a distal end of the coupling being internally threaded for receiving therein an externally threaded shank of the hook or bolt. Again, the method of GB 2,113,732 is not concerned with addressing the securement requirements of a ferrule to a dragline rope.

The above references to the background and prior art do not constitute an admission that such art forms a part of the common and/or general knowledge of a person of ordinary skill in the art. The above references are also not intended to limit the application of the method disclosed herein.

Summary of the Disclosure

In a first aspect there is disclosed a method for attaching a ferrule to a dragline rope. The method comprises:

- locating the dragline rope in a die of a die-press;
- locating over the dragline rope a ferrule that is lined internally with a deformable material;
- forcing the ferrule longitudinally through the die whereby the ferrule is caused to be internally expanded and be extruded back over the dragline rope, deforming the lining directly against the dragline rope and fastening the ferrule to the dragline rope.

Such a method has been optimised towards increasing the pull-off strength of the ferrule in relation to a dragline rope (i.e. the force required to pull the ferrule off the rope). Increased pull-off strength means that the dragline rope is able to withstand higher forces when located in e.g. a dump socket, whereby the ferrule is less likely to be pulled off in use, thus decreasing the incidence of dragline rope failure caused by ferrule-to-rope failure. Also, an intact ferrule-to-rope attachment can better facilitate rope changeover, whereby the intact ferrule can be more easily detached from e.g. a dump socket. These two factors contribute towards more dragline "uptime" (i.e. the

dragline spends less non-operating downtime waiting for rope servicing and changeover).

By deforming the lining directly against and into the dragline rope, the method has been observed to provide the ferrule with a pull-off strength of up to 60 – 70% of the rope breaking force. This level of strength has been observed to be effective in reducing the incidence of dragline rope failure at the ferrule, thus increasing dragline uptime. In this regard, premature servicing due to ferrule pull-off can be avoided, with eventual rope wear (e.g. at the sheaves) instead being the cause for rope servicing/replacement.

In one embodiment of the method, the dragline rope is a multi-stranded wound wire rope, with each strand defining a lay length. In such case the ferrule can be die-pressed onto the rope so as to provide a ferrule length that is approximately 70% of the lay length. Further, the ferrule length may correspond to approximately four times a diameter of the rope once the ferrule has been die-pressed onto the rope. Again, by optimising the ferrule length to the lay length of the dragline rope, the method has been observed to contribute to ferrule pull-off strength.

The method has also been observed to provide favourable pull-off results when compared to existing swaging and jaw-press methodologies used to attach ferrules to ropes in other fields. In this regard, as a result of the longitudinal die-pressing of the ferrule onto the dragline rope, the ferrule and its lining are caused to be more evenly extruded over and more significantly deformed against the dragline rope, thereby bringing the ferrule and its lining into more intimate contact with, and causing the ferrule and lining to flow into the interstices/valleys between, strands of the rope, as compared with jaw press/swaging methodologies.

In one embodiment of the method, the ferrule is located over the rope adjacent to but inset from an end thereof. A "rope-end" location is a usual (though not exclusive) ferrule location and, when located at the rope end, the ferrule can assist with rope connection in the dragline (e.g. enabling the ferrule to be positioned in a dump socket).

In one embodiment of the method, the amount of ferrule inset adopted corresponds to an amount the ferrule is caused to be extruded back over the rope to its end during the forcing of the ferrule through the die. In other words, the resultant dragline rope can comprise a ferrule that terminates at the rope end (providing a

"square" end finish) rather than leaving an end of the rope exposed. An exposed rope end can otherwise cause handling issues, and be subject to damage and fraying etc.

In one embodiment of the method, the ferrule can be forced through the die by a mandrel that is initially arranged to oppose the die as well as an end of the ferrule. When the mandrel is advanced against the ferrule (e.g. by a hydraulic ram) to force it into the die, this can cause the ferrule to be internally expanded against and be extruded back over the rope, with the ferrule external diameter reducing accordingly.

In one embodiment of the method, prior to locating the ferrule over the rope, the ferrule can have a number of e.g. fine grooves or threads formed on its external surface. These grooves can assist in the die-pressing process in that they can receive and distribute a lubricant over the ferrule external surface, to facilitate ferrule passage into and deformation by the die.

In one embodiment of the method, prior to locating the ferrule over the rope, the ferrule external surface can be coated with a lubricant (e.g. an anti-friction coating) over the ferrule external surface, to facilitate ferrule passage into and deformation by the die.

In one embodiment of the method, a body of the ferrule is of metal (e.g. of a mild steel, such as a low carbon, low manganese steel). A hollow interior of the body may have a number of fine grooves or threads formed on its surface, prior to locating the ferrule over the rope. These grooves or threads can be adapted for interacting with the ferrule lining of deformable material (i.e. by binding/securing together the ferrule and the lining during and after die-pressing onto the rope).

In one embodiment of the method, the lining of deformable material comprises a metal of lower yield strength than the body. The lining can take the form of a metal sleeve (e.g. an aluminium sleeve), with the sleeve being located within the ferrule body prior to locating it over the rope. Then, during the forcing of the ferrule through the die, the lining can be caused to be forced against and be extruded back over the rope. When so extruded, the lining material deforms and flows into the valleys of the rope, thereby improving the inter-engagement of the ferrule and the rope.

In one embodiment of the method, when the ferrule is fastened to an end of the dragline rope, and after fastening of the ferrule to the rope, the ferrule can have a lug secured to a distal end thereof. Such a lug can e.g. be welded onto the end of the ferrule after fastening.

The lug can allow for towing of the dragline rope into position in a dragline assembly. Further, it can maintain alignment of the ferrule when it is located in a connection socket. In addition, it can prevent the dragline rope from unravelling when e.g. a bolt is placed through the eye of the lug, by preventing rotational movement of the rope (i.e. rope unravelling can lead to premature rope failure).

In a second aspect there is disclosed a dragline rope comprising a die-pressed ferrule thereon.

It has been discovered that where a ferrule has been die-pressed onto a dragline rope it has increased "pull-off" strength, and especially when compared to other ropes having comparable length ferrules secured thereto by known swaging or jaw-pressing techniques.

The ferrule may be die-pressed onto the dragline rope in accordance with a method as set forth in the first aspect.

In one embodiment, when the dragline rope is of stranded wire (such as e.g. a 6 or 8 strand helically wound steel wire rope in which the strands extend around a core or king wire) the resultant length of the die-pressed ferrule can be optimised to the specific lay length of the given rope (i.e. working towards an optimum length of ferrule in contact with each lay of strand).

A primary use of the dragline rope can be as a dump rope, though the ferrule can be adapted for use with a drag rope and/or a hoist rope.

In a third aspect there is disclosed a dragline rope ferrule. The ferrule is adapted for being die-pressed onto a multi-stranded wound wire rope (e.g. a 6 or 8 strand helically wound steel wire rope extending around a core or king wire). Each such strand can define a lay length.

In accordance with the third aspect, the ferrule can be provided with a length that corresponds to a predetermined proportion of the lay length, once the ferrule has been die-pressed onto the rope. In this regard, the ferrule pull-off strength has been found to be related to the length of ferrule in proportion to the lay length (whereby an optimum length of ferrule in contact with each lay of strand is determined).

For example, for a helically wound wire rope, predetermining the ferrule length such that it at least approximately corresponds to up to 70% of the lay length, results in a pull-off strength that is approximately 70% of the rope breaking force. It has been observed that a pull-off strength that is 70% of rope breaking force is sufficient for use in dragline rigging. However, it has also been observed that a ferrule length that is beyond 70% of the lay length can cause interference when fitting the rope into the dragline rigging.

In one embodiment the ferrule can be provided with a length that corresponds approximately to four times a diameter of the rope once the ferrule has been die-pressed onto the rope. It has also been observed that predetermining the ferrule length such that it at least approximately corresponds to four times a diameter of the rope results in an increased pull-off strength.

Again the dragline rope ferrule of the third aspect can comprise a hollow body of e.g. mild steel, and the body can be internally lined with e.g. a metal of lower yield strength than the body metal (e.g. a sleeve of aluminium).

In the ferrule of the third aspect the lining can comprise a sleeve that is flared at one end. The flared end can engage with a respective end of the ferrule when the sleeve is positioned therein, to help guide the rope into the ferrule and to help locate the sleeve. In use, the flared end can be located at that end of the ferrule through which a dragline rope end is introduced prior to die-pressing.

In the ferrule of the third aspect the body can comprise an internal annular constriction located at a body end that in use sits adjacent to the rope end (i.e. an end that is engaged by a mandrel during die-pressing). The constriction can provide increased strength to the ferrule such that it better resists swelling and buckling resulting from the compressive forces induced by die-pressing.

In the ferrule of the third aspect the body can be provided with an external chamfer that is located at the body end that in use sits adjacent to the rope end prior to die-pressing. The chamfer provides a space to receive therein a flow of body metal that occurs along an outer portion of the ferrule during die-pressing, whereby a "square" ferrule end without flashing can result.

In the dragline rope ferrule of the third aspect the body and lining can be adapted such that the lining terminates from an end of body, being that end of the

ferrule which in use is located at or adjacent to an end of the rope. This can prevent the lining from being "squeezed out" of the body during die-pressing.

The ferrule of the third aspect can otherwise be as defined in the first and second aspects.

Brief Description of the Drawings

Notwithstanding any other forms which may fall within the scope of the ferrule and method as set forth in the Summary, a specific embodiment will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a side sectional view of a first embodiment of a ferrule body as set forth in the Summary;

Figures 2 and 3 respectively show side and end views of an embodiment of a ferrule lining as set forth in the Summary;

Figure 4 shows a ferrule comprising the assembled body and lining of Figures 1 to 3 having been die-pressed onto the end of a dragline rope;

Figures 5A to 5D respectively show side, plan, end and perspective views of a second embodiment of a ferrule having been die-pressed onto the end of a dragline rope;

Figure 6 shows a schematic depiction of apparatus and a process for die-pressing a ferrule onto a dragline rope;

Figures 7 and 8 respectively show plots of ferrule pull-off force (in kN) vs die press pressure (Fig. 7) and ferrule length (Fig. 8).

Detailed Description of a Specific Embodiment

Referring firstly to Figures 1 to 3, a hollow ferrule body 10 and a ferrule insert sleeve 12 are shown. The sleeve is inserted into the body to define a ferrule assembly to be die-pressed onto a dragline rope (the assembly is often simply referred to herein as a "ferrule"). A primary use of the ferrule is in a dragline dump rope, though the ferrule can be readily adapted for use with a drag rope and/or a hoist rope in a dragline.

Die-pressing the ferrule onto the dragline rope increases pull-off strength (i.e. increases the force required to pull the ferrule off the rope). For example, die-pressing has been observed to increase the force required to pull the ferrule off the rope by up to

60 – 70% of the rope breaking force. This represents a significant increase when compared to existing ferrule-to-rope attachment methodologies (jaw-press and swaging).

In use, the ferrule length is predetermined to approximately correspond to up to 70% of the lay length. As discussed below, this results in a pull-off strength that is approximately 70% of the rope breaking force, which is sufficient for use in dragline rigging. In use, the ferrule length is predetermined to not go beyond 70% of the lay length as this can cause interference when fitting the rope into the dragline rigging.

In use, with such a pull-off strength, the ferrule is better able to withstand high forces at the sockets employed to connect the rope to the dragline components. This can decrease the incidence of rope "failure" due to ferrule-to-rope failure. Maintaining an intact ferrule-to-rope attachment can also facilitate rope changeover, in that it is rope wear at the sheaves that eventually causes rope changeover, rather than rope failure at a socket. An intact ferrule-to-rope attachment also allows the ferrule to be readily and more easily detached from a socket (e.g. a dump socket).

The ferrule is specifically adapted for being die-pressed onto the dragline rope. In this regard, the ferrule body 10 of can be of an extrudable/deformable metal, for example, a carbon steel alloy such as AISI 1020. In AISI 1020, the "10" designates a basic plain carbon steel and the "20" designates the approximate carbon content. For example, a suitable steel is a hot roll 1020 – which is a general purpose, mild, low-carbon, low-manganese machine steel with good overall, structural steel properties. This steel demonstrates high machineability capacity and excellent welding characteristics.

The sleeve comprises a metal of lower yield strength than the body metal, for example, aluminium. When die-pressed onto a dragline rope of stranded wire (e.g. a 6 or 8 strand helically wound steel wire rope in which the strands extend around a core or king wire) the sleeve 12 is accordingly deformed and extruded to a greater extent than the body 10, and thus tends to be squeezed and flows into the regions (valleys) between adjacent wire strands, thus better securing the ferrule to the rope. The sleeve can thus help increase the ferrule pull-off force (e.g. up towards 70% of the rope breaking force).

An interior surface 14 of the body 10 can be provided therein (e.g. by a threading tool) with a number of fine grooves or threads, prior to locating the sleeve in

the body. Again, during die-pressing, the sleeve 12 is deformed and flows into the grooves/threads at surface 14, thus better binding/securing the ferrule body to the sleeve.

The sleeve 12 is flared (or bell-mouthed) 18 at one end. This initially restricts the amount of sleeve insertion into the ferrule body 10, whereby the flared end 18 is retained at the open insertion end 20 of body 10. The flaring also improves the feeding of the rope into the ferrule/sleeve combination, and further helps to prevent the insert from sliding during rope insertion and as the ferrule is being die-pressed onto the rope.

Further, the hollow interior of the body 10 has an annular constriction 22 located adjacent to its opposing end 24 (i.e. the end that in use sits adjacent to the rope end). The annular constriction inside the ferrule provides an increased area for the mandrel to push against during die-pressing (see Figure 5). The annular constriction also reinforces the end of the ferrule in order to prevent the ferrule from swelling and buckling before and as it enters the die (i.e. resulting from the compressive stresses that occur in the ferrule during the die-pressing operation). It has been observed that ferrules without such reinforcement can become jammed in the die.

The annular constriction 22 also helps prevent the sleeve from sliding and being "squeezed out" at end 24 as the ferrule is being die-pressed, such that a "clean", delimited end of the ferrule results.

Further, the sleeve 12 is provided with a longitudinal passage 26 through its length. Thus, a sleeve diameter can be selected that requires a push-fit of the sleeve into the body 10, with the passage allowing the sleeve walls on either side of the passage to flex, to allow the push-fit to occur. Once inserted, the sleeve again slightly expands within the hollow body to be frictionally retained therein, ready for use in the die-pressing procedure.

Prior to locating the ferrule over the rope, the ferrule body can also be provided with (e.g. by machining) a number of fine grooves or threads on its external surface 30. These grooves can assist in the die-pressing process, in that they can receive and distribute a lubricant over the external surface 30, to facilitate ferrule deformation by, and passage into and through, the die.

The external surface of the body is also chamfered 32 at the opposing end 24. The chamfer provides space for the flow of metal along the outer surface of the ferrule

during die-pressing (i.e. during die-pressing metal flows along the ferrule and fills the chamfer "void"). This reduces or eliminates flash at the end of the ferrule, which must otherwise be ground smooth to eliminate safety concerns during subsequent handling of the ferrule. A square ferrule end thus results at the rope end.

Prior to die-pressing, the ferrule assembly F is located over the rope adjacent to but inset from the rope end (see Figure 6). The amount of ferrule inset adopted (see distance P in Figure 6) typically corresponds to an amount the ferrule is caused to be extruded back over the rope to its end during the forcing of the ferrule through the die. As shown in Figure 4, in the resultant dragline rope R the ferrule F terminates at the rope end E, rather than leaving an end of the rope exposed (which would otherwise be subject to damage and fraying, handling dangers, etc).

Referring now to Figures 5A to 5D, where like reference numerals are used to denote similar or like parts, a second embodiment of a ferrule F' is shown as having been fastened to a dragline rope R', terminating at the rope end. The ferrule F' is similar in most respects to the ferrule F of Figures 1 to 4, and will not be redescribed.

However, the ferrule F' differs in that a lug 50 has been secured to a distal end E' of the ferrule. The lug 50 comprises an annular plate 52 and a loop 54 welded thereto. Typically the lug plate 52 is welded onto the end of the ferrule after fastening. The lug 50 serves three purposes:

1. It allows for towing of the dragline rope into position in a dragline assembly.
2. It maintains alignment of the ferrule when it is located in a connection socket (e.g. a dump socket).
3. It prevents the dragline rope from unravelling when e.g. a bolt is placed through the eye of the lug, by preventing rotational movement of the rope (i.e. rope unravelling can lead to premature rope failure).

Non-limiting examples of a ferrule-to-rope attachment procedure and testing methodology will now be provided.

Example 1 – Die-pressing of Ferrule onto a Dragline Rope

A ferrule die-pressing procedure was employed, which adopted a methodology whereby an assembly of the ferrule and a dragline rope were pushed through a die with

an interference fit. This was observed to effectively extrude the ferrule over the rope, resulting in the ferrule being clamped onto (deformed against) the rope. Referring to Figure 6, the die-press was set up as follows:

1. A dragline rope end was positioned through the die from the back (parallel) opening O_b, exiting through the front (tapered) opening O_t. The rope R was a multi-stranded wound wire rope of e.g. 6 or 8 wire strands, helically wound around a core or king wire. Each such strand defined a lay length, being the linear length of a rope portion corresponding to a strand having spiralled once around the rope circumference.

2. A ferrule F with its inside lined with the aluminium sleeve S was then slid over the rope end, leaving a calculated length of rope protruding P beyond the ferrule (as shown). This positioning allowed for deformation during the press, whereby the resultant deformed ferrule generally aligned with the rope end (see Figure 4).

3. Prior to locating the ferrule on the rope, the ferrule had an edge chamfered C on one of its ends (in-use outermost end). This chamfer functioned to allow the metal to flow and form a square end once the ferrule had been die-pressed onto the rope.

4. The outer surface of the ferrule was coated with a special lubricant (such as Molykote 106 anti-friction coating; trade mark of Dow Corning) to assist the process when the ferrule assembly was being pressed through the die D. Prior to locating the ferrule on the rope, the outer surface of the ferrule had been finely threaded T (e.g. in a lathe) to ensure the lubricant coating entered the die during pressing, to help facilitate passage through and deformation of the ferrule in the die.

5. A mandrel M on a hydraulic ram Ra was then used to press the ferrule, together with the rope, through the die D. The ferrule and sleeve assembly were deformed against and extruded back over the rope end, until they assumed the configuration as shown Figure 4. Generally, for each dragline rope, as a result of the die-pressing

operation, the ferrule was observed to have a reduction in overall diameter, and its overall length was increased by approximately the length of the initial rope protrusion P.

6. With the ferrule now die-pressed onto the rope, the aluminium sleeve was observed to provide improved grip between the rope and the ferrule body. In this regard, a number of pull-off tests were conducted, and the results are presented in the graphs of Figures 7 and 8.

7. Optionally, a lug 50 (as shown in Figure 5) was welded onto the end of the ferrule F, to improve its handling, as well as to improve its interconnectivity with a socket-type connector in a dragline.

Example 2 – Pull-off Testing of Ferrule on Dragline Rope

Various dragline rope products resulting from the general procedure of Example 1 were subjected to ferrule pull-off testing, to determine the suitability of the ferrule for use on a dragline rope, as well as optimum ferrule and die press set-ups and configurations. The results of these tests are presented graphically in Figures 7 and 8.

To test the pull-off force (in kN) of a ferrule die-pressed onto a dragline rope product, so as to indicate the strength of the ferrule-to-rope attachment, the following procedure was implemented:

- Load the dragline rope into an Avery 3000kN testing machine.
- Seat the ferruled rope end into test blocks, specially designed to transfer load onto the end of the ferrule.
- Apply force at a predetermined strain rate.
- Continue until ferrule-to-rope bond breaks, and record the load at breakage.

For each helically wound wire dragline rope, the ferrule had been die-pressed to have a length of up to approximately 70% of the rope lay length. This is indicated in Figure 8, where it can be seen that for a number of rope diameters (58-83mm) the pull-off force increased with the die-pressed ferrule length up to a maximum.

It was observed that the pull-off strength (expressed as percentage of rope breaking force) was directly related to the length of ferrule as a percentage of the rope lay length. It was noted that a pull-off strength of approximately 70% of the rope breaking force would enable the rope to perform well in dragline applications, as compared with existing ropes.

It was further observed that pull-off force generally increased with the pressure employed in the die press up to a maximum, and then did not increase further with increasing die press pressure. This is indicated in Figure 7, where it can be seen for a number of rope diameters (58-95mm), that the pull-off force increased with the die-pressed ferrule length up to a maximum, after which maximum there was no particular increase in the pull-off force.

Whilst specific embodiments of a ferrule, and a method of attaching the ferrule to a dragline rope, have been described, it should be appreciated that the ferrule and method may be embodied in other forms.

For example, when the resultant die-pressed ferrule length approximately corresponded to four times a diameter of the rope the resultant pull-off strength was observed to be increased. This measure provided an alternative means of predetermining ferrule length.

In the claims which follow, and in the preceding description, except where the context requires otherwise due to express language or necessary implication, the word "comprise" and variations such as "comprises" or "comprising" are used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the ferrule and method as disclosed herein.

Claims

1. A method for attaching a ferrule to a dragline rope comprising:

- locating the dragline rope in a die of a die-press;

- locating over the dragline rope a ferrule that is lined internally with a deformable material;

- forcing the ferrule longitudinally through the die whereby the ferrule is caused to be internally expanded and be extruded back over the dragline rope, causing the lining to deform directly against the dragline rope and fastening the ferrule to the dragline rope.

2. A method as claimed in claim 1 wherein the ferrule is located over the dragline rope adjacent to but inset from an end thereof.

3. A method as claimed in claim 2 wherein the amount of ferrule inset corresponds to an amount the ferrule is caused to be extruded back over the dragline rope to its end during the forcing of the ferrule longitudinally through the die.

4. A method as claimed in any one of the preceding claims wherein the dragline rope is a multi-stranded wound wire rope, with each strand defining a lay length, wherein the ferrule is die-pressed onto the rope so as to provide a ferrule length that is approximately 70% of the lay length.

5. A method as claimed in claim 4 that has a length corresponding to approximately four times a diameter of the rope once the ferrule has been die-pressed onto the rope.

6. A method as claimed in any one of the preceding claims wherein the ferrule is forced through the die by a mandrel that is initially arranged to oppose the die as well as an end of the ferrule, whereby the mandrel is advanced against the ferrule to force it longitudinally through the die.

7. A method as claimed in any one of the preceding claims wherein, prior to locating the ferrule over the rope, the ferrule has a number of grooves formed on its external surface.

8. A method as claimed in any one of the preceding claims wherein a body of the ferrule is of metal and, prior to locating the ferrule over the rope, the ferrule has a number of grooves formed on its internal surface, with the grooves being adapted for interacting with the lining.

9. A method as claimed in claim 8 wherein the lining comprises a sleeve of a metal of lower yield strength than the ferrule, with the sleeve being located within the ferrule body prior to locating it over the rope.

10. A method as claimed in claim 9 wherein the metal of the sleeve comprises aluminium.

11. A method as claimed in any one of claims 7 to 9 wherein, during the forcing of the ferrule through the die, the lining is also caused to be extruded back over the rope.

12. A method as claimed in any one of the preceding claims wherein the ferrule is fastened to an end of the dragline rope and, after fastening the ferrule to the rope, the ferrule has a lug secured to a distal end thereof.

13. A method of attaching a ferrule to a dragline rope, the method being substantially as herein described with reference to the Examples and the accompanying drawings.

14. A dragline rope comprising a die-pressed ferrule thereon.

15. A dragline rope as claimed in claim 1 wherein the ferrule is die-pressed onto the dragline rope in accordance with a method as claimed in any one of claims 1 to 13.

16. A dragline rope comprising a die-pressed ferrule thereon substantially as herein described with reference to the Examples and the accompanying drawings.

17. A dragline rope ferrule, the ferrule being adapted for being die-pressed onto a multi-stranded wound wire rope, with each strand defining a lay length, the ferrule having a length of up to approximately 70% the lay length once the ferrule has been die-pressed onto the rope.

18. A ferrule as claimed in claim 17 that has a length corresponding to approximately four times a diameter of the rope once the ferrule has been die-pressed onto the rope.

19. A ferrule as claimed in claim 17 or 18 comprising a body of metal, the body being internally lined with a metal of lower yield strength than the body metal.

20. A ferrule as claimed in claim 19 wherein the lining comprises a sleeve that is flared at one end, with the flared end engaging with a respective end of the ferrule when the sleeve is positioned therein, and with the flared end being located at that end of the ferrule through which a dragline rope end is introduced prior to die-pressing.

21. A ferrule as claimed in claim 19 or 20 wherein the lining comprises aluminium.

22. A ferrule as claimed in any one of claims 19 to 21 wherein the body and lining are adapted such that the lining terminates from an end of body, being that end of the ferrule which in use is located at or adjacent to an end of the rope.

23. A ferrule as claimed in any one of claims 19 to 22 wherein the body has a number of grooves formed on its internal surface, with the grooves adapted for interacting with the lining of metal of lower yield strength.

24. A ferrule as claimed in any one of claims 17 to 23 wherein a body of the ferrule comprises an internal annular constriction located at an end that in use sits adjacent to the rope end.

25. A ferrule as claimed in any one of claims 17 to 24 wherein, prior to die-pressing, a body of the ferrule comprises an external chamfer located at an end that in use sits adjacent to the rope end.

26. A ferrule as claimed in any one of claims 17 to 25 that has a number of grooves formed on its external surface.

27. A ferrule as claimed in any one of claims 17 to 26 wherein, after the ferrule has been fastened to an end of the dragline rope, the ferrule has a lug secured to a distal end thereof.

28. A ferrule as claimed in claim 27 wherein the lug is welded to a distal end of the ferrule.

29. A dragline rope ferrule substantially as herein described with reference to the Examples and the accompanying drawings.

30. A dragline rope including a ferrule as claimed in any one of claims 17 to 29.

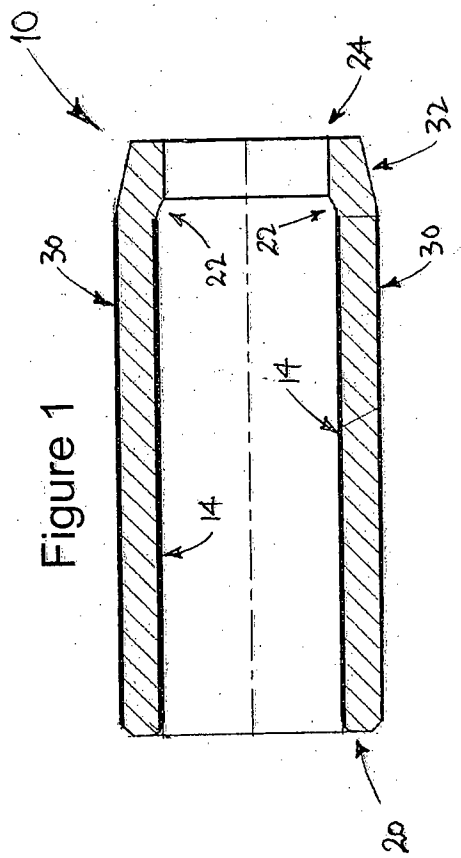

Figure 1

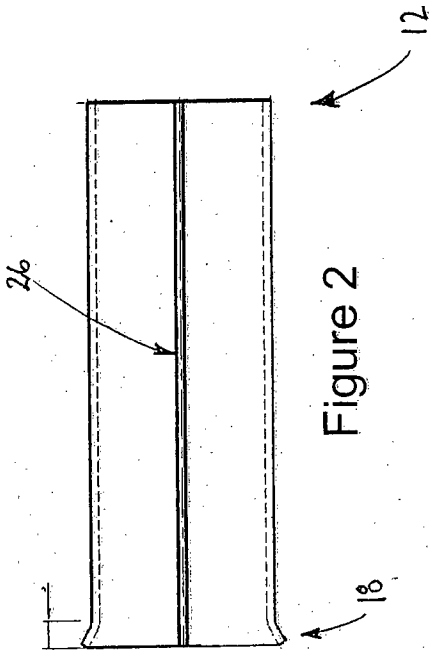

Figure 2

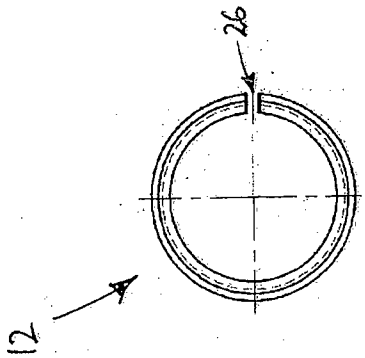

Figure 3

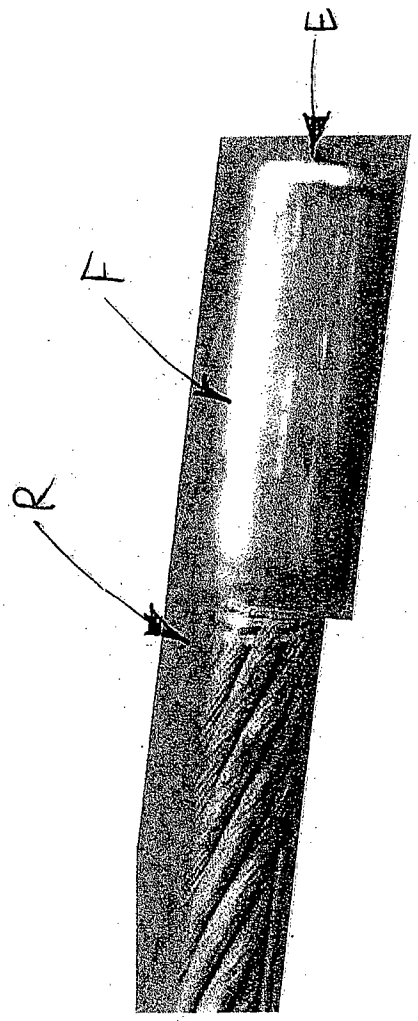

Figure 4

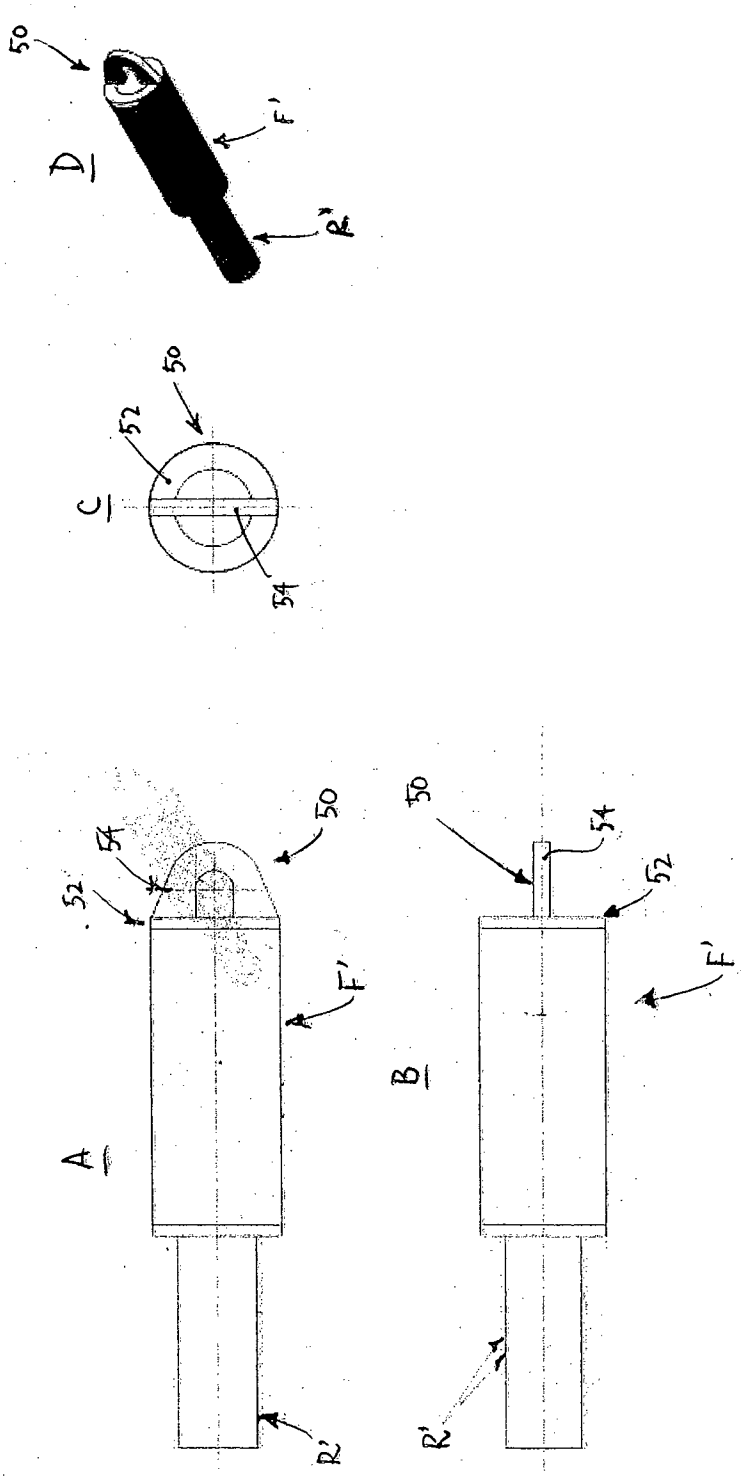

Figure 5

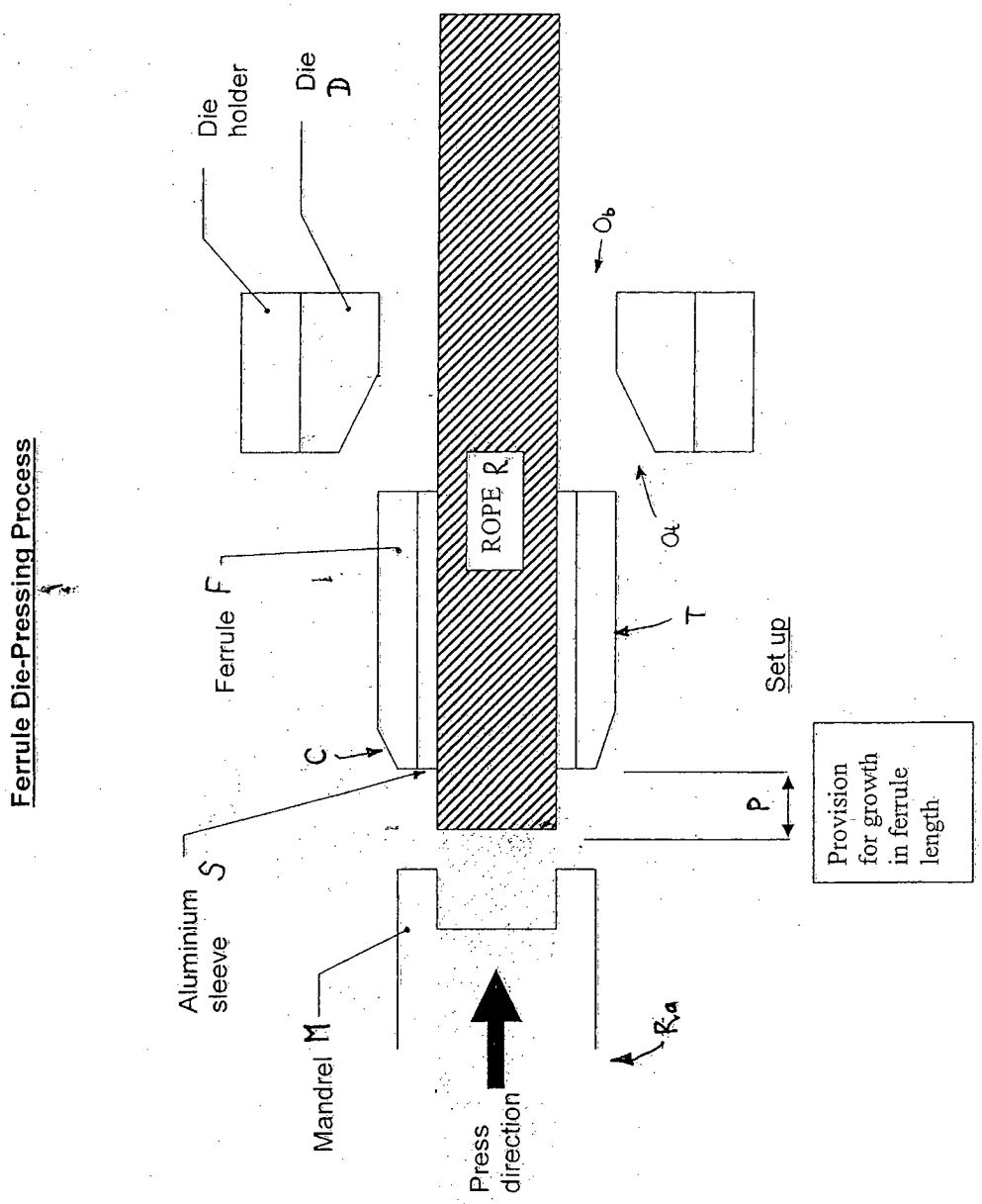
Ferrule Die-Pressing Process
Die holder
Die D
ROPE R
Ferrule F
Aluminium sleeve S
Mandrel M
Press direction
Ra
Ob
Ot
T
C
P
Set up
Provision for growth in ferrule length

Figure 6

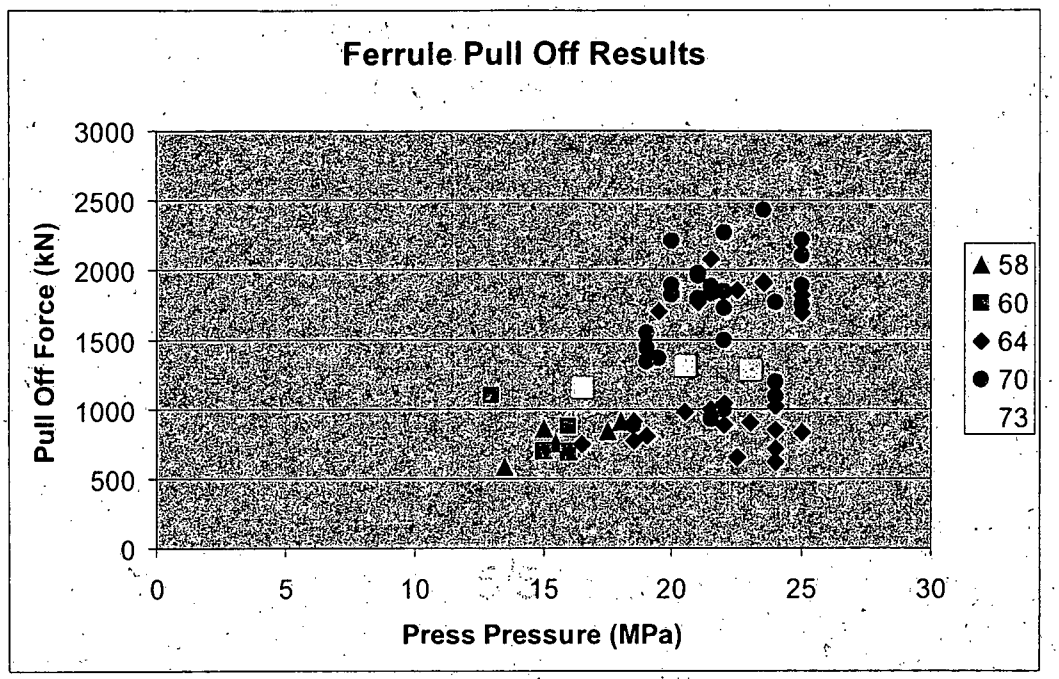

Figure 7

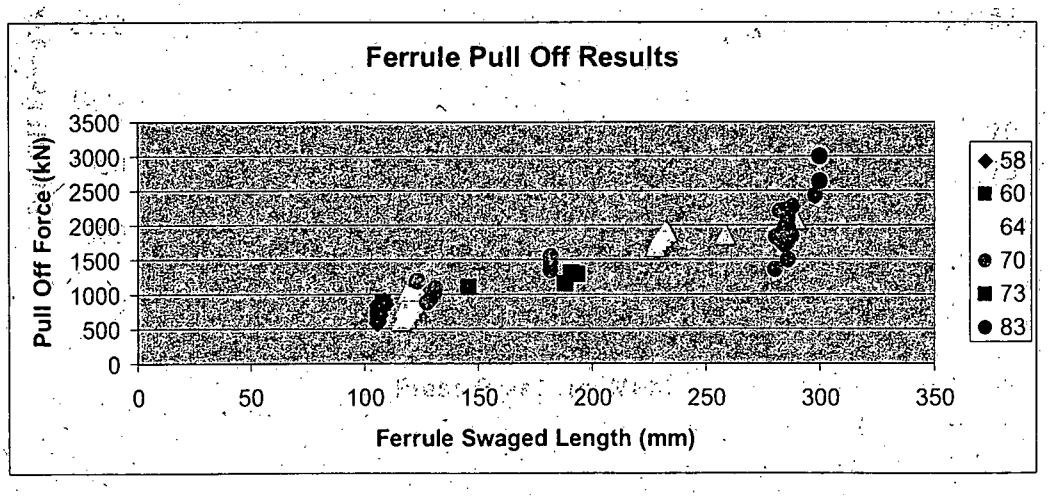

Figure 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/000214

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

F16G 11/02 (2006.01) ***D07B 9/00*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC, WPI: IPC Marks F16G11/-, D07B9/00, B21F15/-, B30B11/22, -/26, 15/02 AND Keywords (+rope+, cable?, wire?, wire_rope?, ferrule, sleeve, collet?, socket?, +clamp+, die?, press+, extrud+, extrusion, mandrel, lining, liner, insert) and like terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	GB 2113732 A (SATO SOICHIRO) 10 August 1983	
X	See figures 1, 4-6 and 10	1, 4-7, 9-11, 14-15, 17-22, 24-26, 30
Y	See figures 1, 4-6 and 10	1-3, 6-12, 15, 23, 27-28
	GB 1249352 A (CESARINI) 13 October 1971	
X	See figures 2-3 and 5	1, 6-11, 14-15
Y	See figures 2-3 and 5	1-3, 6-12, 15, 23
	GB 1369211 A (BRIDON LTD) 2 October 1974	
X	See figures 1-5	1, 6-11, 14-15
Y	See figures 1-5	1-3, 6-12, 15

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 May 2011	6 MAY 2011

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/000214

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	GB 2385065 B (OSBORN STEEL EXTRUSIONS LTD) 10 August 2005	
X	See figures 2 and 4	1, 6-7, 9-11, 14-15
Y	See figures 2 and 4	1-3, 6-12, 15
	DE 3722062 A1 (DYCKERHOFF & WIDMANN AG) 12 January 1989. English abstract retrieved from EPODOC database and machine translation retrieved from http://worldwide.espacenet.com/	
X	See figures 2-5 and abstract	14
Y	See figures 2-5 and abstract	1-3, 6-12, 15
	US 3220074 A (EHMANN) 30 November 1965	
Y	See figures 1-3	8, 23
	US 3638975 A (BUETTNER) 1 February 1972	
Y	See figures 1-3	8, 23
	US 2006/0160435 A1 (CAMPBELL et al.) 20 July 2006	
Y	See figure 7	12, 27-28

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2011/000214

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: **13, 16, 29**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

These claims do not comply with Rule 6.2(a) because they rely on references to the description and/or drawings.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box 1

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box 1
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art.

This International Searching Authority has found that there are different inventions as follows:

- Claims 1-13 and 15(inpart-see Box VIII of Written Opinion) are directed to a method for attaching a ferrule to a dragline rope comprising locating the dragline rope in a die of a die-press, locating over the dragline rope a ferrule that is lined internally with a deformable material, forcing the ferrule longitudinally through the die whereby the ferrule is caused to be internally expanded and extruded back over the dragline rope, causing the lining to deform directly against the dragline rope and fastening the ferrule to the dragline rope. It is considered that this group of claims define a first invention.

- Claims 14 and 15(inpart- see Box VIII of Written Opinion) are directed to a dragline rope comprising a die-pressed ferrule thereon. It is considered that this group of claims define a second invention.

- Claims 17-28 and 30 are directed to a dragline rope ferrule, the ferrule being adapted for being die-pressed onto a multi-stranded wound wire rope, with each strand defining a lay length, the ferrule having a length of up to approximately 70% the lay length once the ferrule has been die-pressed onto the rope. It is considered that this group of claims define a third invention.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

The only feature common to all of the claims is a rope having a die-pressed ferrule thereon. However this concept is not novel in the light of many documents, of which the following are a selection:

DE 3722062 A1 (DYCKERHOFF & WIDMANN AG) 12 January 1989
GB 2385065 B (OSBORN STEEL EXTRUSIONS LTD) 10 August 2005
GB 1249352 A (CESARINI) 13 October 1971
US 3638975 A (BUETTNER) 1 February 1972
GB 1369211 A (BRIDON LTD) 2 October 1974
GB 2113732 A (SATO SOICHIRO) 10 August 1983

This means that the common feature cannot constitute a special technical feature within the meaning of PCT Rule 13.2, second sentence, since it makes no contribution over the prior art.

Because the common feature does not satisfy the requirement for being a special technical feature it follows that it cannot provide the necessary technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention a posteriori.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2011/000214

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
GB	2113732	NONE					
GB	1249352	BE	724589	DE	1812992	FR	1556313
		LU	57391	NL	6817497		
GB	1369211	CA	974035	DE	2230276	FR	2143221
		NL	7208491	US	3861811		
GB	2385065	AU	2003200326	CA	2381695		
DE	3722062	NONE					
US	3220074	NONE					
US	3638975	NONE					
US	2006160435	US	7536754				

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX