

Reel System for a Vehicle

The invention relates to a reel system for a vehicle, especially for a guided missile, comprising an underwater reel that is provided for withdrawal during
5 underwater travel of the vehicle, an air reel that is provided for subsequent airborne withdrawal as far as a target and for remaining on the vehicle until then, and a continuous data line wound on both reels.

10 In the case of vehicles sent on a mission, it can be necessary for the vehicle to remain connected to a guidance or control centre during the entire mission duration in order to be able to exchange image data,
15 state data or navigation data. This can be achieved by means of a data line, which is provided as a data transmission line or signal transmission line for the transmission of signals. Because of the high transmission bandwidth and simultaneous low signal
20 attenuation, such data lines are usually implemented as fibre optic cables. The data line is wound in a reel and connected to a spindle that carries the winding package. During travel or during the flight of the vehicle, the data line is unwound from the reel, so
25 that the data link between a transmission station or a reception station of the control centre and the moving vehicle is maintained. The unwinding reel is normally disposed on or in the vehicle here so that the unwound data line can remain very stationary in the air or in
30 water.

Such a reel system is known from DE 10 2004 024 858 A1. The vehicle is a guided missile that spends a first part of its mission under water and a second part of
35 its mission in the air. Accordingly, the reel system comprises an underwater reel, which remains connected to the guided missile and unwinds the data line during the underwater travel. After the guided missile emerges

from the water, the underwater reel is ejected with a buoy and the data line is unwound from an air reel, which remains on the guided missile during the airborne flight. The buoy forming the transition between the
5 underwater data line and an above water data line falls on a parachute onto the surface of the water while the guided missile is flying to its target.

It is an object of the present invention to improve a
10 reel system in respect of its operability.

This object is achieved by a reel system according to the features of Claim 1, with which the underwater reel according to the invention is attached to the air reel
15 so as to resist being dropped.

The invention is based on the consideration that dropping the underwater reel on the buoy is problematic. The data line should thus also be unwound
20 to the missile during the descent of the buoy in order to compensate for the descent. This not infrequently leads to an entanglement in the parachute or the buoy and thus to kinking of the data line, so that the signal transmission is disrupted or even interrupted.
25 If the buoy has reached the surface of the water, then the data line that has been unwound in the air descends onto the buoy on the surface of the water, becomes entangled on the buoy and is also kinked or torn by waves. The same or similar problems occur if an attempt
30 is made to hold the buoy beneath the surface of the water in order to make its discovery more difficult.

Said problems are avoided by the drop-resistant arrangement of the underwater reel on the air reel.
35 Both reels remain on the vehicle and a buoy can be dispensed with. The data line is initially unwound from the underwater reel and then from the air reel, wherein the line transition from the winding package of the

underwater reel to the winding package of the air reel is advantageously implemented without a canister or buoy. An entanglement in the buoy or a separated underwater reel can be prevented.

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The vehicle is provided to be able to travel both in the water and also in the air, wherein travelling can mean flying and/or diving. The vehicle can be a manned or unmanned flying object and is advantageously
10 provided with an underwater drive and/or an airborne drive or a drive that drives the vehicle both under and also above water, e.g. a rocket drive.

The air reel and the underwater reel are two reels,
15 each with at least one dedicated winding package, which are preferably at a distance from each other. The winding packages are preferably implemented such that during withdrawal the winding package of the underwater reel is initially - especially fully - unwound and then
20 the winding package of the air reel is - especially fully - unwound - if the unreeling of the reel system is carried out fully.

The underwater reel is provided for withdrawal during
25 underwater travel of the vehicle, especially in the case of underwater flight driven by a rocket engine. Such a provision includes that the unreeling of the underwater reel, i.e. the withdrawal of the underwater reel, takes place at said speed without kinking of the
30 data line - and thus without loss of data for normal signal transmission - and even more without damaging the data line, so that the signal transmission can be maintained without errors.

35 The air reel is provided for airborne withdrawal as far as a target. It is also disposed during airborne withdrawal to be fixedly attached to a component of the vehicle. If the vehicle is a guided missile, then the

withdrawal is intended to be carried out smoothly and reliably up to a typical maximum speed for the guided missile, that is e.g. up to a speed of 250 m/s. The length of the data line should be at least five
5 kilometers here, especially at least 20 kilometers.

The underwater reel is attached to the air reel so as to be secure against being dropped. This includes that releasing the underwater reel from the air reel in
10 normal operation is not provided and is also not possible in error-free operation. The underwater reel is hereby advantageously fixed on the air reel such that it can only be separated from the air reel on the ground and especially only with a tool. There is no
15 ejection mechanism for automated or manual ejection. The underwater reel is thus carried to the target while the vehicle is travelling, especially while the guided missile is flying. In other words: the underwater reel even remains attached to the air reel if the air reel
20 is already unwound in flight, especially at least already half unwound.

The underwater reel is advantageously attached at least partly behind the air reel. Such an arrangement is
25 favourable, because generally the data line is advantageously unwound first from the underwater reel and only then from the air reel while the vehicle is carrying out its mission. The direction relates to the direction of travel of the vehicle or its construction,
30 so that the rear is disposed behind the tip of the vehicle.

A reel consists at least of a spindle and at least one winding package and can optionally comprise a housing
35 that at least partly shields the winding package externally. The winding package contains the wound data line in a number of windings. The spindle can be an outer withdrawal spindle or an inner withdrawal

spindle, wherein in the case of an outer withdrawal spindle the winding package is disposed radially outside the spindle, the data line thus being wound onto the spindle, and the winding package is disposed
5 radially within the spindle in the case of an inner withdrawal spindle. As a rule here the data line is initially wound as a winding package and the winding package is then inserted into the inner withdrawal spindle, which envelops the winding package radially
10 and can thus also fulfil a housing function. The inner withdrawal spindle and the outer withdrawal spindle are also referred to below in a simplified form as the inner spindle and the outer spindle.

15 The data line advantageously comprises a data line body, especially a fibre optic conductor body, such as a glass body. The data line body can be enveloped by a shielding body, e.g. another glass body with a different refractive index, so that there is a
20 reflective plane within which the data carrying radiation remains. In the case of an electrical signal, a metallic shielding body is also possible. Moreover, the data line advantageously comprises an externally protective sheath, e.g. in the form of a plastic
25 coating, a textile cover or a cover with fibrous fabric. A stabilisation element can be disposed within the sheath, e.g. a stable filament, which improves the data line in respect of its tear strength.

30 The data line is a continuous line, i.e. it extends from the start of the underwater reel to the end of the air reel without opening into a reception station, such as an amplifier or a different electronic component. It can have a splice here, e.g. between the winding
35 packages of the two reels, i.e. a junction at which the two previously separate parts of the data line are joined together suitably for signal transmission. Advantageously, however, the data line transitions from

one winding package into the other without splicing, especially if the data line is implemented without splicing from the start of the underwater reel to the end of the air reel, so that the winding packages also
5 have no splicing.

The data line can be divided into an underwater line and an air line, wherein the underwater line is advantageously made thicker, e.g. is thicker coated.
10 This enables a greater withdrawal resistance under water to be taken into account. The strict separation of the types of line on the winding packages is, however, not absolutely necessary, so that e.g. the thicker underwater data line can be fed in up to the
15 winding package of the air reel and e.g. form yet more layers of the air reel. This is especially advantageous if there is a possibility of the data line being unwound from the air reel during underwater travel and thereby being subjected to an increased frictional
20 resistance or withdrawal resistance.

The two reels can form a system in which e.g. the spindles of the two reels directly abut one another and for example are only separated from each other by a
25 shoulder. A common one-piece spindle for both reels is also possible. In general the underwater spindle is advantageously screwed or welded onto the housing or the spindle of the air reel, so that more solid cohesion is guaranteed.

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Both reels can form an inner cavity, through which an engine jet is guided during the flight of the guided missile. Especially in the case of the implementation of the underwater spindle as an outer spindle, engine
35 jet guidance through the two spindles can be carried out without a transition. It is, however, also possible that the spindle of the underwater reel is attached to a housing of the air reel. The underwater spindle can

be an inner spindle or outer spindle, depending on the construction of the underwater reel.

5 The underwater reel can protrude out of a housing of the air reel and especially also out of a housing of the guided missile. It is, however, also possible that a housing of the air reel also envelops the underwater reel at least partly in the manner of a housing and thus protects the same. The housing must not be made in
10 one piece here, wherein, however, an external surface of the housing advantageously also forms an external surface of the vehicle or of the guided missile.

In an advantageous embodiment of the invention, the
15 underwater reel is an inner withdrawal reel. Entanglement during unreeling of the underwater reel under water, i.e. in the event of withdrawal under water, is counteracted with said embodiment. This aspect of the invention is based on the consideration
20 that in the case of airborne withdrawal and also in the case of withdrawal under water, there is always a risk of a multiple withdrawal, i.e. of the simultaneous withdrawal of multiple windings, so that there is an open bundle of line. This can easily result in kinking
25 of the line. In order to prevent a multiple withdrawal in the case of an outer reel, the winding package is advantageously tapered to the rear, i.e. in the withdrawal direction, so that a sharp winding edge to the rear is prevented as far as possible. In the case
30 of airborne withdrawal said shaping is sufficient, because at higher speed the effect occurs that the unwinding data line is accelerated outwards by the high unwinding rate and the connected high centrifugal force in the case of rotary unwinding and thus rises up from
35 the layers lying below it. A multiple airborne withdrawal is counteracted by this. In the case of unwinding under water, however, it has been shown that said centrifugal force effect is not sufficient to

raise the data line sufficiently from the winding layers beneath it. A data line that is drawn rearwards is therefore easily unwound with too small a radius, so that it pulls out underlying layers with it. Moreover, 5 small radii result in the signal transmission being hindered or prevented. Said problems can be counteracted by internal withdrawal. A data line that is unwound radially internally has the much greater tendency to lift off from the underlying or radially 10 outside winding layers. The withdrawal resistance is lower and so is the tightest radius of the data line at the position of instantaneous inward separation of the data line from the winding package. Thus trouble-free data transmission operation can be more easily 15 guaranteed by the inner withdrawal reel.

Advantageously, an inner diameter of an output opening of the underwater reel is larger than an outer diameter of an output opening of the air reel to the rear. On 20 the one hand this enables a larger package volume of the winding package and thus in the case of a long line also an axially shorter underwater winding to be achieved. Moreover, the data line can - depending on the construction of the vehicle - be more easily 25 radially separated from an inner engine jet. Here the output opening of the air reel to the rear is the same opening through which the data line is fed rearwards and out of the housing of the air reel during unwinding from the air reel.

30 Another advantageous embodiment of the invention provides that a line transition in the form of a transition segment from a winding package of the underwater reel to a winding package of the air reel is 35 fixed on the winding package of the air reel. The fixing can e.g. be carried out by gluing or fixing using a thread. In the case of gluing, a different, especially stronger adhesive is useful than one with

which the windings of the air reel are glued to one another is useful. With said aspect of the invention the following problem can be solved: In the case of underwater travel of the vehicle, the air reel is also
5 flooded, because a housing of the air reel has to be open to the rear in order to allow withdrawal. In order to prevent flooding from the rear towards the front, it is possible to provide a housing of the air reel with frontal openings, through which the water flows in at
10 the front and can flow out rearwards. Experiments have shown that the water flowing out again rearwards from the air reel drags on the line transition or the transition segment. The line transition is therefore particularly exposed to the water flowing past because
15 it has to be lifted up from the air reel in order to be fed to the underwater reel. In this respect greater forces act on said line transition as a result of the water flowing past than on the other windings of the air reel. If said line transition unintentionally
20 lifts off from the air reel or even from the underwater reel, then there can rapidly be uncontrolled line balling in the region of one or other reel. Said balling disrupts the unwinding of the data line, so that the data line is tangled. If said line transition
25 now sticks on the air reel, then dissolving by water flowing past can be counteracted. Advantageously, an adhesive is used for gluing that is easier to dissolve at a higher separation rate than at a lower separation rate. In this case easier refers to the force with
30 which the line transition can be separated from the underlying windings of the air reel.

It is further advantageous if a line transition from a winding package of the underwater reel to a winding
35 package of the air reel is led at least partly transversely to the windings of the winding package of the air reel. As a result of this the line transition provides lower resistance to the water flowing past, so

that the line transition can be fixed more easily. Transverse here means an angle of at least 70° , especially a right angle, to the windings of the winding package of the air reel. Indeed it can be that
5 the line transition still presents a relatively high resistance to the water flowing past at points that do not run transversely to the windings. However, solid fixing of the line transition on the air reel can be guaranteed over a relatively long distance by the
10 transverse installation, so that unintentional separation by the water flowing past is counteracted.

The withdrawal of the data line from a reel under water is associated with high friction and therefore with the
15 risk of kinking of the data line. Even if said risk can be reduced with an inner reel, it can be advantageous to use an outer withdrawal reel as the underwater reel. Suitable measures can prevent kinking or unwanted multiple withdrawal, such as e.g. slow withdrawal,
20 gluing of the windings of a winding package to one another that is well matched to the withdrawal rate and/or a conical spindle geometry tapering rearwards, whereby the lifting of the data line from the underlying windings of a winding package is
25 facilitated.

Especially in the case of an underwater reel, which is arranged as an external withdrawal reel, it is advantageous if a bottom of the winding of the at least
30 one spindle of the underwater reel is disposed radially within a bottom of the winding of the at least one spindle of the air reel. During withdrawal of the air reel, the data line can be simply fed radially outside the underwater spindle and advantageously contactlessly
35 from it, so that damage to the data line is prevented even in the event of very high withdrawal rates.

It is further advantageous if a diameter of a removal aid or of a guidance means of the underwater reel is smaller than a diameter of the innermost layer of the at least one winding package of the air reel. This enables the data line of the underwater reel to be unwound smoothly from the air reel. It is especially advantageous if the diameter of the radially outermost layer of the at least one winding package of the underwater reel is smaller than the diameter of the innermost layer of the at least one winding package of the air reel. With said embodiment of the invention, a guidance means for guiding the data line withdrawn from the underwater reel away from the underlying windings can protrude radially outwards beyond the outermost layer of a winding package of the underwater reel without adversely affecting the air withdrawal. The data line can also be smoothly unwound from the air reel in this case.

In order to prevent multiple withdrawal of the underwater reel, i.e. the simultaneous withdrawal of multiple windings of the at least one winding package of the underwater reel, and moreover to counteract kinking of the data line, it is advantageous if the underwater reel comprises a guidance means that lifts the data line that is being withdrawn radially outwards from e.g. the underlying layer of windings of the winding package or the bottom of the winding. Although a similar effect can also be achieved by a rearward conical tapering of the winding package, said implementation has the disadvantage of an axially longer construction. By means of the guidance means, therefore, a compact axial construction of the underwater reel can be coupled with reliable withdrawal under water.

As a guidance means, such means are suitable that ensure that at least a part of the data line is lifted

well away radially outwards at the point at which it is released from a winding package. One embodiment of the guidance means is particularly simple in that it is a rear, radially projecting collar. This can protrude
5 e.g. directly from the bottom of the winding of the at least one spindle or from another element of the underwater reel or from a different unit. The collar can be a rear, tangential and circumferential shape that is directed radially outwards and can e.g. be part
10 of the underwater reel. For example, a flange of a type of steel construction is possible. Advantageously, the guidance means protrudes radially beyond the outermost winding of the at least one winding package of the underwater reel.

15 In order to prevent disruption of the air withdrawal from the air reel, it is advantageous if the guidance means is disposed fully radially within a bottom of a winding of the at least one spindle of the air reel,
20 i.e. does not protrude radially beyond the bottom of the winding of the air reel at any point. The axial position is independent hereof. In this way it can be guaranteed that even if the data line is withdrawn from the lowest layer of the at least one winding package of
25 the air reel, contact with the guidance means during an air withdrawal is prevented and thus interference-free signal transmission through the data line is maintained.

30 In order to counteract kinking of the data line during withdrawal under water it is moreover advantageous if the guidance means is inclined relative to the winding package of the underwater reel. Advantageously, the inclination is implemented such that it forms an angle
35 to the bottom of the winding of the at least one spindle of the underwater reel that is greater than 120° , or in other words, an angle between the radial direction and the slope of greater than 30° is formed.

The slope advantageously extends to the bottom of the winding, wherein a small shoulder at the height of a maximum of two winding layers is safe in this case. The slope can be a conical surface, which is advantageously
5 rounded radially outwards in profile. The data line can drag along the slope and the rounded segment without being bent with too small a radius or being kinked.

During underwater travel of the vehicle, both reels are
10 generally wet, because they are also immersed in the water. Depending on the implementation of the data line, the sheath of the data line, e.g. in the case of a textile sheath or wrapping with fibrous fabric, soaks up water. This can cause the thickness of the data line
15 to be increased and thus a winding package of a reel to build up a certain pressure. Whereas the windings will easily withstand such a pressure, the pressure can be problematic for a transition part or a transition segment of the data line from a winding package of the
20 underwater reel to a winding package of the air reel.

In order to counteract an undesirable load on the data line, it is advantageous if the transition of the data line from a winding package of the underwater reel to a
25 winding package of the air reel is inserted into a laying groove. In the sensitive transition region or transition segment, the data line can be protected and prevented from kinking by the laying groove. The laying groove can be machined into the underwater reel, e.g.
30 in a front or rear flange of the underwater reel. Advantageously, the laying groove can be disposed where the winding package of the underwater reel abuts an axial bounding surface, e.g. a flange. Advantageously, the laying groove is led up to the radially upper end
35 of the bounding surface, e.g. of the flange. It is further advantageous if the laying groove reaches to the bottom of the winding, so that the data line can be

fed from the lowest layer directly into the laying groove.

5 It is further advantageous if the direction of the laying groove has a tangential component in order to enable a smooth directional transition to the tangential winding direction of the data line at the bottom of the winding. Advantageously, the orientation of the laying groove is inclined by a maximum of 30°,
10 especially a maximum of 15°, to the orientation of the bottom of the winding at the position at which the laying groove reaches the bottom of the winding. The laying groove can advantageously be implemented at least essentially straight or curved here.

15 Another advantageous embodiment of the invention provides that the underwater reel is disposed relative to the air reel so that the data line is withdrawn radially within a spindle implemented as an outer
20 spindle of the underwater reel and through the same in the case of a normal withdrawal from the air reel. The underwater reel thus forms an inner opening, through which the data line is fed. Such an arrangement has the advantage that a winding package of the underwater reel
25 can be implemented as radially relatively large and thus axially compact and moreover a relatively large radial distance of the unwound data line from an engine jet can be produced.

30 It is further advantageous if the at least one winding package of the underwater reel is disposed partly behind the at least one winding package of the air reel. By means of axial overlapping of the two winding packages, an axially compact arrangement in the system
35 can be achieved so that the vehicle or the guided missile can be made axially compact.

Advantageously, the bottom of the winding of the at least one spindle of the underwater reel lies radially outside the bottom of the winding of the at least one spindle of the air reel, the circumference of the bottom of the winding of the underwater reel thus being larger than the circumference of the bottom of the winding of the air reel. The bottom of the winding of the underwater reel can be disposed here fully or partly behind the bottom of the winding of the air reel.

A compact and mechanically stable construction of the reel system can be achieved if the at least one spindle of the underwater reel is attached to a housing of the air reel. A retaining force flow runs between the reels and thus through the housing. There can be an airspace between the air reel and the at least one spindle of the underwater reel, through which the data line that is withdrawn from the air reel is passed. Such a withdrawal airspace separates the two spindles of the two reels.

Likewise, a compact construction is beneficial if the at least one spindle of the underwater reel forms a housing segment of the air reel. Said housing segment is advantageously conically tapered towards the rear so that the inner diameter of the housing thus reduces inwards, the spindle thus forming a part of the housing, which narrows downwards. The spindle can be implemented with multiple layers, so that the material of the housing is different from the material of the bottom of the winding of the spindle of the underwater reel.

Advantageously, a transition segment of the data line from at least one winding package of the underwater reel to the at least one winding package of the air reel is led from the underwater reel initially

rearwards and then radially forwards through the at least one spindle of the underwater reel. Said arrangement is also advantageously maintained if no segment of data line is yet unwound from the underwater
5 reel, let alone from the air reel.

A large winding package volume and thus a long data line in the underwater reel can be achieved if the bottom of the winding of the at least one spindle of
10 the underwater reel lies radially further out than at least inner parts of the at least one winding package of the air reel.

During withdrawal of the data line from the underwater
15 reel and the air reel, the data line is subjected to a high load because of the high withdrawal rates. Especially during transition of the withdrawal from the underwater reel to the air reel, the withdrawn data line forms waves, which contribute to an increase in
20 the load. In order to keep such waves small, it is advantageous if in a transition region or transition segment from a winding package of the underwater reel to a winding package of the air reel the data line is led in a recess, which can e.g. be implemented in the
25 form of a groove and which is referred to below as a laying groove. The recess or laying groove can be disposed on the rear end of the underwater reel, e.g. in a rear guidance means of the underwater reel, which can be implemented as a flange or generally as a radial
30 elevation above the bottom of the winding. The laying groove is advantageously led up to a radially upper end of the guidance means and is disposed on the side of the guidance means facing the winding package.

35 It is further advantageous if the laying groove comprises a first groove segment facing the winding package and a second groove segment facing rearwards.

Both segments can be disposed in the guidance means.
The data line is advantageously laid in both segments.

5 A particularly high withdrawal loading of the data line
can be avoided if the laying groove passes through a
guidance means as in a valley in the rear part of the
underwater reel in the region of the greatest radial
extent of the guidance means. The data line that is
withdrawn from the laying groove does not form such a
10 large wave as without the laying groove.

In order to keep the wave small, the laying groove
should cut deep into the guidance means. It is
advantageous if the radial elevation of the valley
15 floor protrudes above the bottom of the winding by a
maximum of 30% of the elevation of the guidance means
above the bottom of the winding of the at least one
spindle of the underwater reel. The valley floor can,
however, also lie radially deeper than the bottom of
20 the spindle or the bottom of the winding of the
underwater reel.

During withdrawal from the underwater reel the data
line may be dragged across the edge of the guidance
25 means. In order to keep loadings of the data line
small, the edge should therefore run along the
circumference as smoothly as possible. This can be
achieved if a circularly profiled outer edge of the
guidance means - seen from the rear towards the front
30 of the guidance means - is radially notched by the
laying groove by a maximum of 20% of the elevation of
the guidance means above the bottom of the spindle of
the underwater reel, advantageously a maximum of 5 mm,
especially a maximum of 2 mm.

35 A discontinuity in the course of the data line, such as
a kink in the data line, can result in a wave during a
withdrawal and thus to an increased withdrawal loading

of the data line. In order to keep the loading small, it is advantageous if the base of the laying groove on its rear end is radially curved in such a way that the data line is led in the laying groove without any radial kinks and also emanates from the laying groove without any radial kinks.

If the withdrawal point of the data line passes the rear guidance means and runs in radially inwards behind the guidance means, the data line is slightly deflected in the tangential direction because of the directional change of the withdrawal point. In order to avoid the data line striking an edge of the rear region of the laying groove, it is advantageous if the rearward facing groove segment of the laying groove runs out axially rearwards in the tangential withdrawal direction of the data line.

A smooth course of the data line can be achieved in connection with a smooth outer edge of the guidance means if the groove segment facing the winding package of the underwater reel is oriented at an angle of at least 75° to the axial direction of the reel system, and indeed as far as possible over the greatest part of its entire length, especially over the entire length of the front region or groove segment of the laying groove.

In the case of embodiments in which the rear end of the air reel lies before the rear end of the underwater reel in the axial direction, it is advantageous if the data line is wound on an intermediate reel between the underwater reel and the air reel. The intermediate reel can comprise an intermediate winding that consists of only one layer.

In order not to disrupt the withdrawal from the air reel, the intermediate winding on the intermediate reel

is advantageously disposed fully radially within the bottom of the winding of the at least one spindle of the air reel. Advantageously, the intermediate reel is provided with a laying groove on a front flange in
5 which the data line is laid.

Moreover, the invention is aimed at a vehicle, especially a guided missile with a rocket engine, with a reel system disposed at the rear, especially as
10 described above. It is proposed that an underwater reel of the reel system provided for withdrawal of a data line during underwater travel of the vehicle is attached at the rear so as to be secure against being dropped. Advantageously, the reel system is disposed at
15 the rear of the vehicle and especially around an engine jet chamber. The underwater reel advantageously comprises at least one spindle and at least one winding package.

Furthermore, the invention is aimed at a method for maintaining a data link between a moving vehicle, especially a guided missile in flight, and a control centre, especially a firing station, by means of a data line, with which the data line is withdrawn from an
20 underwater reel during underwater travel of the vehicle, the vehicle enters the air through the surface of the water and the data line is withdrawn from an air reel during travel above water. The control centre can be in a building or a vehicle, e.g. in a submarine.
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30 It is proposed that the underwater reel preferably remains fixedly joined to the air reel during underwater travel and above water travel to a target of the vehicle. The ejection of an interface, e.g. a buoy,
35 can be omitted, whereby entanglement of the data line can be prevented.

The air withdrawal advantageously takes place until the vehicle reaches a predefined target, e.g. following a flight phase. Advantageously, a segment of the underwater reel is still withdrawn in the air.

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Furthermore, the invention is aimed at a method for the winding of a reel system with a data line that is implemented to maintain a data link between a moving vehicle, especially a guided missile in flight, and a control centre, with which the data line is initially wound on a spindle of an air reel and then on a spindle of an underwater reel of the reel system.

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In order to counteract breakage of the data line during unwinding, it is advantageous if the same is wound in one piece on the underwater reel and the air reel. For this purpose both reels must be wound with a continuous data line. In order to achieve this it is proposed that during winding the spindle of the underwater reel according to the invention is held in a position in which an output opening is available between it and the spindle of the air reel for outputting the data line during withdrawal from the air reel.

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Advantageously, the spindle of the underwater reel is held in its winding position by an auxiliary retainer during winding, wherein the auxiliary retainer is removed after winding and the spindle is then attached to the air reel in operational readiness. The spindle can be attached to the air reel directly or advantageously indirectly, especially by means of a housing of the vehicle.

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For attachment of the underwater reel to the air reel, both reels advantageously remain immovable relative to one another during the attachment process. For the attachment a third element is attached to the underwater reel and the air reel to attach them to each

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other. Advantageously, said third element is a housing of the vehicle. Advantageously, the air reel is directly attached to the housing of the vehicle. It is, however, also advantageously possible to attach the air
5 reel to the housing of the vehicle indirectly, i.e. by means of one or more further elements.

The previously given description of advantageous embodiments of the invention contains numerous
10 features, which are reproduced in the individual dependent claims partly combined in multiples. Said features can, however, advantageously also be considered individually and can be combined in further useful combinations. Said features can especially be
15 combined individually and in any suitable combination with the method according to the invention and the device according to the invention according to the independent claims.

20 The above described characteristics, features and advantages of said invention, as well as the type and manner in which the same are achieved, are clearly and unambiguously understandable in connection with the following description of the exemplary embodiments,
25 which are explained in detail in connection with the figures. The exemplary embodiments are used to explain the invention and do not restrict the invention to the combination of features specified therein, nor in relation to functional features. Moreover, features
30 suitable for this of any exemplary embodiment can also be explicitly considered in isolation, removed from an exemplary embodiment, introduced into another exemplary embodiment so as to extend it and/or combined with any of the claims.

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In the figures:

- FIG 1 shows a vehicle that is connected to a firing station by means of a data line,
- FIG 2 shows a reel system with a front air reel and a rear underwater reel implemented as an inner withdrawal reel,
- FIG 3 shows a further reel system with an underwater reel implemented as an outer withdrawal reel,
- Fig 4 shows the spindle of the underwater reel from FIG 3 in a perspective illustration,
- FIG 5 shows the spindle from FIG 4 in a side illustration,
- FIG 6 shows another reel system with a radially outer, outer withdrawal reel as an underwater reel,
- FIG 7 shows the rear part of the vehicle with the underwater reel from Fig. 6 disposed on its rear in a perspective illustration,
- FIG 8 shows a top view from behind onto the vehicle or the underwater reel in the axial direction in the direction of flight,
- FIG 9 shows the spindle of the underwater reel in a side view,
- FIG 10 shows the rear guidance means of the underwater spindle with a laying groove cut into the same,
- Fig 11 shows a rear groove segment of the laying groove and
- FIG 12 shows the spindle of an intermediate reel between the underwater reel and the air reel.
- FIG 1 shows a vehicle 2 that is implemented in this exemplary embodiment as a guided missile with a rocket engine. The guided missile is connected by means of a data line 4 to a control centre 6, which is a submarine in this exemplary embodiment. The data line 4 is a line with an optic fibre core for transmitting optical signals, which is covered by a sheath of plastic.

The guided missile was launched from a torpedo tube of the submarines, which forms a firing station 8 for the guided missile. The guided missile has travelled over a mission-dependent distance 12 under the surface of the water 10, e.g. 400 m. After traversing the underwater distance 12, the guided missile has changed its direction of travel, passed through the surface of the water 10 and now continues its travel above the surface of the water 10 towards a target 14. The target is e.g. at a distance of 25 km from the control centre 6, wherein the major part of said distance is covered by the vehicle 2 in the air.

The data line 4 is attached to an interface 16 in the submarine and is connected to a control unit 18 of the control centre 6 for signalling purposes by means of another data link. The control unit 18 controls the flight of the vehicle 2 both under water and also above water and processes image data produced by a seeker head 20 of the vehicle 2, which accommodates the seeker head 20 during flight. The control unit 18 is connected to a control unit 22, which is disposed within the vehicle 2, by means of the data line 4 for signalling purposes. Said control unit 22 controls the flight of the vehicle 2 by means of rudders 24, wherein the control commands are transmitted from the control centre 6 to the control unit 22 by means of the data line 4. The data of the seeker head 20 are in turn transmitted by means of the data line 4 to the control centre 6, which produces the control commands therefrom.

The interface 16 comprises a not displayed reel for the output of the data line 4 in order to enable the displacement of the control centre 6 relative to the surrounding water to be compensated without the data line 4 being pulled through the water. The greatest part of the data line 4 is, however, output by a reel

system 26, which is disposed at the rear of the vehicle 2 and is illustrated in detail in FIG 2.

FIG 2 shows the rear part of the reel system 26 of the vehicle 2 from FIG 1 in a longitudinal section. In FIG 2 the reel system is provided with the reference character 26a. In the following exemplary embodiments, similar components are characterized with the same reference numbers, but depending on the exemplary embodiment with different reference letters if the components have slight differences, e.g. in dimensions, position and/or function. If the reference numbers alone are mentioned without a reference letter, then this refers to the corresponding components of all exemplary embodiments.

The reel system 26a comprises an air reel 28a and an underwater reel 30a, which in this exemplary embodiment is disposed fully behind the air reel 28a. Whereas the air reel 28a is implemented as an outer withdrawal reel, the underwater reel 30a is implemented as an inner withdrawal reel.

The data line 4 is wound both on the air reel 28a and also on the underwater reel 30a and is continuous on both reels 28a, 30a without interruption, especially without splicing. The air reel 28a comprises a spindle 32a, on which the data line 4 is wound layer by layer. The underwater reel 30 is also fitted with a spindle 34a, which, however, is implemented as an inner spindle in this exemplary embodiment, that is a spindle that radially encloses the winding package 36a - formed by the layers or windings of the data line 4 - of the underwater reel 30a from the outside. In contrast, the spindle 32a of the air reel 28a is disposed radially within the winding package 38a of the air reel 28a.

The data line 4 is divided into three segments: the winding package 36a forms an underwater segment 40 of the data line 4, which starts at the interface 16 of the control centre 6, extends to the winding package 36a and forms the same. A transition segment 42a connects the winding package 36a to the winding package 38a of the air reel 28a. An air segment 44 of the data line 4 forms the winding package 38a and extends to the control unit 22. The transition segment 42a can also form some windings of the air reel 28a. All three segments 40, 42a, 44 are traversed by a single, continuous fibre optic cable, which is led without splicing through the three segments 40, 42a, 44. Only the sheath of the data line 4 varies in the segments 40, 42a, 44. The sheath is implemented thicker in the segments 40, 42a than in the air segment 44. As a result the data line 4 is made more tear-resistant in said two rear segments 40, 42a than in the air segment 44. However, the air segment 44 can be withdrawn faster as a result of its comparatively slimmer and lighter construction, which is especially of advantage for the air withdrawal.

Whilst the guided missile travels through the water at a certain speed during underwater travel and unwinds the underwater reel 30a at the corresponding rate, the withdrawal of the data line 4 is considerably accelerated after breaking through the surface of the water 10, because the guided missile reaches speeds of up to 250 m/s during its flight to the target 14.

During the entire flight, both over water and also under water, the underwater reel 30a with its spindle 34a - up to the unwound part of the data line 4 - remains on the vehicle 2. For this purpose the spindle 34a is fixedly connected to the other components of the vehicle 2, in this exemplary embodiment to the outer housing 48a of the guided missile 2, which also forms

the housing 48a of the air reel 28a at the same time. The spindle 34 is fixedly screwed to the housing 48a and is thus not releasable during the flight of the guided missile. It can only be separated from the rest of the vehicle 2 following removal of the winding package 36a using a tool, which, however, is not provided in normal operation. Alternatively, it is also conceivable that the underwater reel 30a or its spindle 34 is welded to the vehicle 2.

In order to avoid an undesirable multiple withdrawal and to facilitate radial lifting of the data line 4 to be withdrawn from the underlying windings or layers of the winding package 36a, the underwater reel 30 or its spindle 34a is formed with a guidance means 50a in the form of a flange that is connected in one piece with the bottom of the winding 52a of the spindle 34a. In the case of a withdrawal under water, the data line 4 drags over the rounded edge 54a of the flange 50a and as a result is lifted off from the underlying winding layer radially inwards at an angle. In this case the guidance means 50a is implemented as a radially inward facing formation, which protrudes further inwards than the innermost winding layer of the winding package 36a of the underwater reel 30a here, so that the radially innermost layer of the data line 4 is drawn somewhat further inwards during withdrawal. However, the radius of the guidance means 50a at the narrowest point, i.e. at the edge 54a, should be greater than the outer radius of the output opening 60a, so that the data line 4 unwinding from the air reel 28 does not come into contact with the edge 54a. A radius that is at least 1.1 times the outer radius of the output opening 60a is particularly suitable.

Moreover, said guidance means 50a has the effect that the winding package 36a does not have to be radially thinner towards the rear in order to avoid multiple

withdrawals. The guidance means 50a delimits the winding package 36a towards the rear so that an unwanted multiple withdrawal is prevented by this alone. For this purpose, the winding package 36a abuts
5 the guidance means 50a at least essentially without narrowing.

On submerging in the water, the inner space 56 around the air reel 28a or within the housing 48a is flooded
10 with water, which flows in through openings 58 into said inner space 56. The water flows rearwards and through an output opening 60a back out of the housing 48a of the air reel 28a. The flowing water drags on the windings of the winding package 38a of the air reel
15 28a. However, the data line 4 is glued within the winding packages 36a, 38a, the individual windings of the data line 4 thus being glued to each other so that a stable winding package 36a, 38a results. The adhesive is selected here such that the data line 4 is not
20 kinked so much as to endanger the data transmission in the event of a withdrawal. On the other hand, the adhesive is so strong that the corresponding winding package 36a, 38a also remains held together sufficiently under water and a multiple withdrawal does
25 not arise as a result of loose windings.

However, the transition segment 42a is fed a short distance through the air, so that the flowing water pulls harder on said segment 42a. In order to avoid the
30 transition segment 42a of the data line 4 being pulled along with the moving water, a part of the transition segment 42a is more firmly glued to the underlying windings 62 of the air reel 28a than the windings 62 are glued to one another. For this an adhesive is used
35 that enables separation of the glued data line 4 in the case of a rapid separation rate with a smaller force than with a slower separation rate. The adhesive can be

a silicon that is added between the windings 62 and the transition segment 42a.

Moreover, a part of the transition segment 42a is fed
5 transversely, i.e. perpendicularly to the winding
direction of the windings 62 in order to achieve as
long a gluing distance as possible. Even if the water
shooting through the inner space 56 is pulling very
strongly on the rear part of the transition segment
10 42a, the transversely oriented part of the transition
segment 42a still remains fixedly joined to the
windings 62, so that the data line 4 is not separated
in an unwanted manner from the underlying windings 62
of the air reel 28a by the water shooting in.

15
The transition segment 42a extends somewhat into the
winding package 38a of the air reel 28a and forms a
part of the top layer of the windings of the air reel
28a. This enables the air reel 28a to be withdrawn as
20 far as the transition segment 42a reaches under water
without the data line 4 being adversely affected. That
which was mentioned in relation to the transition
segment 42a also applies to the transition segments 42b
and 42c.

25
The air reel 28a is an outer reel containing a number
of winding layers that extend parallel to the bottom of
the spindle or the bottom of the winding 64a. They form
the winding package 38a, which is wound so as to
30 taper towards the rear in order to avoid an undesirable
multiple withdrawal of the rear windings.

When the vehicle 2 is travelling, the same is initially
fired out of the firing station, wherein the data line
35 is essentially unwound from the underwater reel 30a,
but also somewhat from the reel of the interface 16.
The unwinding is carried out here by the traction force

that the moving vehicle 2 exerts on the data line 4 so that this unwinds by itself.

5 The length of the underwater segment 40 of the data line 4 is dimensioned so that the specified distance 12 under water is ± 30 m longer or shorter than the length of the underwater segment 40. On the emergence of the vehicle 2 from the water, the underwater reel is thus at least essentially fully unwound. If on emergence
10 there is still data line 4 on the underwater reel 30a, then this is first unwound by no more than the first 30 m above water, in which the vehicle 2 is not so fast that unreeling or withdrawal from the underwater reel 30a would be problematic. If on the other hand
15 travelling under water has not yet finished, if the underwater reel 30a is being unwound, then the length of a few meters of transition segment 42a or of transition data line can still be unwound from the air reel 28a, which withstands the high mechanical load of
20 the underwater withdrawal.

FIG 3 shows another reel system 26b with an air reel 28b and an underwater reel 30b. The description of the following exemplary embodiments is essentially limited
25 to the differences from the exemplary embodiment in FIG 2, to which reference is made in relation to the features and functions that remain the same. Components essentially remaining the same are in principle numbered with the same reference characters, and
30 features that are not mentioned are assumed in the following exemplary embodiments without being described again.

Whereas the air reel 28b is essentially implemented the same as the air reel 28a from FIG 2, the underwater
35 reel 30b is an outer withdrawal reel. It is essentially disposed outside of the housing 48b, which, as with the openings 58, can be made the same as in the exemplary

embodiment of FIG 2. The winding package 36b of the underwater reel 30b is wound in a number of layers, as with the winding package 36a of the underwater reel 30a, but in the exemplary embodiment from FIG 3 from
5 inside to out, so that the data line 4 is unwound from outside to in.

In the general case the spindle 34b of the underwater reel 30b is directly connected to the spindle 32b of
10 the air reel 28b or else both spindles 32b, 34b are connected to each other in one piece, so that at least the bottoms of their windings 64b, 52b are in one piece. The spindles 32b, 34b can consist of metal or for special applications of plastic.

15 Both reels 28b, 30b are implemented as hollow reels and contain a tubular cavity 68 (FIG 4), so that the blast tube of the guided missile or its rocket engine can lie on the axis of the flying object. The engine jet is
20 also passed through the reels 28b, 30b.

In order to avoid an undesirable multiple withdrawal during a water withdrawal, the underwater reel 30b is implemented with a guidance means 50b on its rear end.
25 This protrudes radially beyond the outermost layer of the winding package 36b over the entire circumference, as shown in FIG 3, which indicates the winding package 36b in dashed lines. During withdrawal, the data line 4 is dragged across the outer rounded edge 54b of the
30 guidance means 50b, so that the radially protruding edge 54b causes lifting of the unwinding data line 4 from the underlying layer. The friction of the data line 4 during withdrawal is kept low in this way, so that the data line 4 is not kinked and the signal
35 transmission can be maintained undisturbed. Moreover, the guidance means 50b causes the winding package 36b also to be bounded towards the rear, so that the rear windings cannot leave the winding package 36b in an

undesirable multiple withdrawal and the data line 4 is not entangled.

5 In order to a guarantee undisturbed air withdrawal, the entire winding package 36b of the underwater reel 30b is disposed radially within the winding package 38b of the air reel 28b. The radially outermost layer of the winding package 36b is thus disposed radially within the radially innermost layer of the winding package 10 38b. Furthermore, the guidance means 50b is also dimensioned in its radial extent so that it protrudes radially no further than the bottom of the winding 64b of the air reel 28b. In this way it is guaranteed that the data line 4 withdrawn from the air reel 28b does 15 not come into contact with the underwater reel 30b and especially its guidance means 50b. For a contact-free withdrawal of the data line 4 from the air reel 28b, an outer diameter d of the guidance means 50b of $d = (0.8 \pm 0.1) D$ has proved successful, wherein D is the 20 diameter of the bottom of the winding 64b of the air reel 28b.

It is, however, also possible that the guidance means 50b does protrude somewhat radially beyond the bottom 25 of the winding 64, but remains overall at least 3 mm radially within the outer circumference of the output opening 60b. This is because during air withdrawal the data line 4 is pulled outwards by means of the rotary withdrawal and the resulting centrifugal 30 forces and rests on the rounded inner edge of the housing 48 in the region of the output opening 60b. If said inner edge is far enough from the bottom of the winding 64b, the data line 4 is thus also led around the underwater reel 30b in the case of an edge 54b or 35 the guidance means 50b protruding radially somewhat beyond the bottom of the winding 64b.

The spindle 34b of the underwater reel 30b is shown in FIG 4 in a perspective view. FIG 5 shows the spindle 34b in a side view. The bottom of the winding 52b is disposed between a front flange 66b and the rear guidance means 50b implemented as a flange, so that the winding package 36b is held between said two flanges 50b, 66b. A winding of the winding package 36b that is not directly withdrawn is thus caught between the two flanges 50b, 66b - even if it were to slip axially. Dropping out of the winding package 36b or multiple withdrawal is therefore not possible.

As can be seen from FIG 5, the side of the flange facing towards the winding package 36b is inclined to the radial direction by the angle α . Said angle reduces the bending radius of the data line pulled over the edge 54b, so that the data transmission takes place undisturbed even in the case of a highly stressed data line 4. The higher is the maximum speed of the vehicle under water, the greater should be the angle α . On the other hand, a larger angle α for a given axial structure length of the underwater reel 30b takes away installation space for the winding package 36b, so that different spindles or reels are useful for different speeds of underwater travel.

In this respect the invention is in general also aimed at a system of at least two waterborne vessels having a different construction-related maximum speed under water. The vehicles are each equipped with a reel system according to the invention, wherein the angle α of inclination of the rear guidance means 50b to the radial direction is greater in the case of the vehicle with the higher maximum speed than in the case of the vehicle with the lower maximum speed.

In order to achieve high positional stability, the winding package 36b is led directly forwards to the

rear wall of the flange 66b, and thus abuts the flange wall. The rear edge of the front flange 66b can run perpendicular to the bottom of the winding 52b, so that a larger winding space results. In said region the data
5 line 4 is led from the radially innermost layer of the winding package 36b radially outwards to the air reel 28b, wherein it must therefore be led up between the winding package 36b and the flange 66b. If the winding package 36b now swells up as a result of the wetting
10 with water, then it exerts a pressure on the rear wall of the flange 66b and thus crimps the data line 4 between the winding package 36b and the flange 66b. This can lead to kinking of the data line 4, especially in the radially inner region.

15 In order to prevent this, the flange 66b limiting the winding package 36b at the front is designed with a laying groove 70b. This is machined as a recess in the rearward facing surface of the flange 66b and extends
20 radially inwards to the bottom of the winding 52b. The laying groove 70b is provided with a tangential component in its orientation, so that the data line 4 can be led while taught radially outwards with a sufficiently large radius from the bottom of the
25 winding 52b through the laying groove 70b. Accordingly, the laying groove 70b opens in a curve 72 with its radially outward facing surface shortly before the bottom of the winding 52b and determines the curvature of the data line 4 led along the curve 72.

30 During withdrawal from the underwater reel 30b, the last layer of the winding packages 36b is thus withdrawn from the back to the front and the piece of the data line 4 is then pulled from the laying groove
35 70b, which directly initiates the withdrawal of the glued-on transition segment 42a.

The laying groove 70b has a depth of at least 0.8 times the diameter of the data line 4 in the transition segment 42a. The underwater segment 40 of the data line 4 running transverse to the laying groove 70b in the winding package 36b is thus not kinked by means of the edges of the laying groove 70b and the breadth of the laying groove 70b should be kept small. It should be no greater than five times, especially only a maximum of twice, the diameter of the data line 4 in the transition segment 42a. A ratio of the width of the groove to the diameter of the data line of between 1 and 2, especially between 1.2 and 1.6, is particularly advantageous.

Advantageously, the underwater reel 30a of the reel system 26a is also provided with a laying groove. This can be implemented as accurately as with the laying groove 70b from FIG 4, wherein it can be machined into the front flange of the spindle 34a and depending on the implementation also in the housing 48a, which would be useful in the case of the exemplary embodiment of FIG 2. In each case the laying groove would be machined into the component that directly abuts the winding package 36a and delimits the same at the front.

Another exemplary embodiment of a reel system 26c is illustrated in FIG 6. The reel system 26c again has an air reel 28c and an underwater reel 30c. The air reel 28c can - up to the housing 48c - again be implemented the same as the preceding air reels 28a, 28b. The underwater reel 30c is implemented as an outer reel, but disposed radially outside the bottom of the winding 64c of the air reel 28c. The bottom of the winding 52c and thus also the entire winding package 36c of the underwater reel 30c is hereby disposed radially outside the bottom of the winding 64c of the air reel 28c.

The data line 4 that is unwinding during a withdrawal is fed radially inwards through the spindle 34c of the underwater reel 30c during the withdrawal from the air reel 28c and contacts the spindle 34c during inner withdrawal, and this contact takes place on the side of the spindle 34c facing away from the winding package 36c.

The spindle 34c of the underwater reel 30c forms a part of the housing 48c of the air reel 28c, along whose inner surface the unwinding data line 4 is led during withdrawal through the output opening 60c. The housing 48c is an element that radially outwardly encloses the air reel 28c and fully encircles the same in the radially outward direction. The spindle 34c of the underwater reel 30c encloses the air reel 28c at its rear end and thus forms a part of the housing 48c. By combining the inner surface of the spindle with part of the inner surface of the housing, a particularly compact construction can be achieved. Moreover, parts and material and hence weight are saved.

The spindle 34c is directly attached to a housing body of the housing 48c, wherein the housing 48c is moreover guided radially over the underwater reel 30c for its protection against external influences. The housing 48c is thus divided into two parallel guided segments in the region of the spindle 34c, which overlap each other radially: the inner parallel part forms the inner wall of the housing in the region of the output opening 60c and of the spindle 34c. The outer region forms the housing of the vehicle and a radial cover for the underwater reel 30c for external protection.

The bottom of the winding 52c of the underwater reel 30c lies radially outside of the bottom of the winding 64c of the air reel 28c along its entire surface, so that the diameter of the winding package 36c of the

underwater reel 30c is greater than at least the inner windings of the winding package 38c of the air reel 28c. In this way a large winding volume and thus a long length of data line 4 can be introduced in relatively little axial installation space. Moreover, the data line 4 moving out of the output opening 74 can be kept radially far from a cavity 68c through which an engine jet is fed to propel the vehicle 2 while the vehicle 2 is travelling.

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The underwater reel 30c is so disposed in relation to the output opening 60c that its spindle 34c lies axially in the region of the narrowest point of the output opening 60c. In this way the overall construction is particularly compact. In particular, the inner surface of the spindle forms the outer wall of the output opening 60c at its narrowest cross-section.

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20 The underwater reel 30c is disposed partly axially behind the air reel 28c, at least some regions of the underwater reel 30c also being disposed axially behind the air reel 28c. In principle, it is also possible to dispose the underwater reel 30c fully axially behind the air reel 28c, or alternatively to allow the underwater reel 30c to terminate at its rear before the air reel 28 so that the air reel 28c reaches axially further to the rear than the underwater reel 30c.

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30 FIG 7 shows the rear part of the vehicle 2, wherein the illustration of the rudder 24 from FIG 1 has been omitted for clarity. The rear part of the housing 48c with the underwater reel 30c disposed therein can be seen. Its output opening 74 forms the radially outermost region within the housing 48c of the rear of the vehicle 2. From FIG 7 it can clearly be seen that the large radius of the underwater reel 30c allows a long data line 4 on the underwater reel 30c for a

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relatively planar construction of the winding package 36c of the underwater reel 30c.

5 Within the output opening 74 in FIG 7, the rear of the spindle 34c of the underwater reel 30c and a spindle 76 of an intermediate reel 78 can be seen, the intermediate reel 78 being disposed radially within the underwater reel 30c. Not illustrated are the winding package 36c of the underwater reel 30c and an
10 intermediate winding 80, which is indicated in FIG 6 by dashed lines. The cavity 68c lying radially within the intermediate reel 78 forms the passage for the engine jet of the vehicle during its flight.

15 FIG 8 shows a perspective view of the vehicle 2 from behind with a direction of view forwards in the direction of flight of the vehicle 2, wherein the rudder 24 has again been omitted from the illustration. The housing 48c, the spindle 34c of the underwater reel
20 30c, the output opening 60c, the winding package 38c of the air reel 28c in front of the spindle 76 of the intermediate reel 78 and the cavity 68 through which the engine jet exits during the flight of the vehicle 2 can be seen - from the outside to the inside. Also
25 shown is the transition segment 42c of the data line 4, in the transition region from the underwater reel 30c to the intermediate reel 78.

The spindle 34c of the underwater reel 30c is shown in
30 FIG 9 in a perspective side illustration without the housing 48c. The bottom of the winding 52c, the front flange 66c, which delimits the only indicated winding package 36c of the underwater reel 30c at the front, and the rear guidance means 50c, which delimits the
35 winding package 36c at the rear, can be seen. As described for FIG 5, the guidance means 50c widens conically rearwards with the cone angle α on its side facing towards the winding package 36c.

A laying groove 70c is formed in said cone surface, comprising a front groove segment 82 and a rear groove segment 84. The front groove segment 82 is cut into the conical, forward facing inclined surface of the guidance means 50c, whereas the rear groove segment 84 is machined into the rearward facing surface of the guidance means 50c. In contrast to the exemplary embodiments from Figures 2 to 5, in this exemplary embodiment the laying groove 70c is thus disposed at the rear end of the winding package 36c, that is in the guidance means 50c.

The data line 4 is led from the bottom of the winding 52c through the front groove segment 82 of the laying groove 70c and from there in the rear groove segment 84 of the laying groove 70c in order to then run in a straight line to the intermediate winding 80, as is illustrated in FIG 8. It passes through the guidance means 50c here without being guided particularly far radially outwards by the guidance means 50c, whereby a wave formation of the data line 4 during its withdrawal and hence any impact on the data line 4 and the loading thereof can be kept low during withdrawal. In FIG 9 it is indicated how the data line FIG 4 is pulled straight out of the front groove segment 82 of the laying groove 70c during above water withdrawal.

The incision of the front groove segments 82 in the guidance means 50c can be seen particularly well in FIG 10. The valley floor 86 is cut deep into the guidance means 50c and in the region of its maximum radial extent only protrudes slightly beyond the radial extent or the radius R_1 of the bottom of the winding 52c. The maximum radial elevation of the valley floor 86 or its maximum radius R_2 protrudes by less than 50 % of the elevation of the guidance means 50c, especially by less than 1/3 of the elevation of the guidance means 50c beyond the bottom of the winding 52c, wherein both

radii R_1 , R_2 are measured from the axis of symmetry of the reel system 26c or of the spindle 34c. In this way an extension of the data line 4 that may occur by overcoming the guidance means 50c can be kept small, 5 whereby wave formation during withdrawal is reduced.

FIG 11 shows a section of the spindle 34c of the underwater reel 30c from behind to the guidance means 50c. The valley floor 86, which is concealed in FIG 11, 10 is shown with a closely spaced dashed line. Widely spaced dashed lines show the bottom of the winding 52c. As can be seen through the radii R_2 , R_1 , the valley floor 86 only protrudes slightly radially beyond the base of the spindle 52c. The valley floor 86 is, 15 moreover, at its outer or rear end radially curved in such a way that the data line 4 is led radially without kinks both in the front groove segment 82 and also in the rear groove segment 84 of the laying groove 70c, and is thus led out of the laying groove 70c, as is 20 illustrated in FIG 11. A wave formation and loading of the data line 4 in a kink, which is to be avoided, are also reduced in this way.

As can be seen from FIG 9, the data line 4 drags across 25 the radially outermost edge 54c of the guidance means 50c or the underwater reel 30c during its withdrawal. Said edge 54c is notched in the region of the laying groove 70c and this obstructs withdrawal of the data line 4, because the data line 4 drags across said notch 30 during each rotation. In order to keep such obstruction as small as possible, the circularly-profiled outer edge 54c of the guidance means 50c - when viewed from behind forwards towards the guidance means 50c - is only very slightly notched by the laying groove 70c, as 35 is illustrated in FIG 11. A small notch 88 still remains and is illustrated in FIG 11. Its depth, however, is less than 2 mm and it is moreover implemented as tangentially rounded on both sides and

very flat on both sides - less than 30° on each side. In this way the dragging of the data line 4 across the notch 88 only leads to a very small additional loading of the data line 4 during withdrawal. The depth of the
5 notch 88 is less than 10% of the elevation of the guidance means 50c above the bottom of the winding 52c of the underwater reel 30c.

As can be seen from Figures 9, 10 and 11, the rear
10 groove segment 84 of the laying groove 70c runs in the tangential withdrawal direction of the data line 4 axially towards the rear. It is thus led rearwards with no edges, so that the laying groove 70c in its rear groove segment 84 in principle loses its groove shape
15 and is embodied as a wedge-shaped recess with the tip of the wedge facing in the withdrawal direction. As a result, the data line 4 withdrawn from the laying groove 70c can swing freely out of the rear groove segment 84 without knocking against an edge. In order
20 not to damage the data line 4 during rapid withdrawal, the rearward-facing groove segment 84 is implemented with a significantly greater tangential breadth than the axial breadth of the forward-facing groove segment 82. The tangential breadth of the laying groove 70c in
25 the rear region 84 is hereby at least ten times the diameter of the data line 4 in the region of the transition segment 42.

Because the data line 4 drags along the guidance means
30 50c during withdrawal under water, and thus also across the laying groove 70c, the orientation of the front groove segment 82 has a tangential component. The tangential component can mean the directional component of the front groove segment 82 in the tangential
35 direction for a side view of the guidance means 50c perpendicularly from above, as illustrated in FIG 9. Advantageously, the angle β between the axial direction of the reel system 26c and the orientation of the front

groove segment 82 is at least 45° , especially at least 60° , wherein at least 75° has proven to be particularly advantageous.

5 In order to protect the unwinding data line 4 that is dragging across the laying groove 70c, it is moreover advantageous if the laying groove 70c is at least partly covered, especially in the front groove segment 82. This can take place by means of a tear-off film or
10 a different element. It is additionally or alternatively possible to at least partly fill the laying groove 70c or the front groove segment 82 thereof with a silicon or a different material.

15 In its further course the data line 4 is led inwards through the underwater reel 30c and forwards to the air reel 28c. It thus runs rearwards with its transition segment 42c in the not unwound state from the winding package 36c of the underwater reel 30c and radially
20 inwards through the rear edge 54c. In the further course it is led forwards again in order to reach the winding package 36c of the air reel 28c through the output opening 60c.

25 In order to improve the withdrawal transition from the underwater reel 30c to the air reel 28c, the transition segment 42c can be wound on the intermediate reel 78. The intermediate reel 78 contains e.g. only a single layer, so that in the transition segment the data line
30 4 is withdrawn only once from behind forwards through the intermediate winding 80. In the further course, the data line 4 is then led to the air reel 28c.

FIG 12 shows the intermediate reel 78 or its spindle 76
35 in a perspective illustration. The data line 4 that is not illustrated in FIG 12 is wound on the bottom of the winding 90 of the intermediate reel 78 and this is done forwards from behind in its segment from the underwater

reel 30c to the air reel 28c. When it reaches the front flange 92 of the spindle 76, it is led in a laying groove 70d, which is machined into the forward-facing flange 92. Said flange can be implemented similarly to
5 the flange 70b of the underwater reel 34b. In the case of the exemplary embodiment illustrated in FIG 12, the laying groove 70d runs in an axially planar way at its radially inward-facing end, so that at its wedge-shaped end the data line 4 does not have to pass any edges in
10 order to pass into the laying groove 70d. The laying groove 70d can also be axially rounded at its radially outer end in order to produce no edges in the transition to the air reel 28c.

15 As can be seen from FIG 6, the radius of the bottom of the winding 90 of the intermediate reel 78 is smaller than the radius of the bottom of the winding 64c of the air reel 28c. This also advantageously applies similarly to the radial extent of the front flange 92
20 and of the rear flange 94 of the intermediate reel 78. In this way air withdrawal from the air reel 28c is not obstructed.

Transitions between the underwater reel 30c and the air
25 reel 28c are compensated or reduced by the intermediate reel 78, so that the data line 4 encounters smaller waves in said transition during withdrawal and is thus loaded less. In order to load the data line less during intermediate withdrawal as well, a front side of the
30 flange 94 can be implemented conically in the forward direction, similarly to the guidance means 50.

The data line 4 should run from the air reel 28c to the underwater reel 30c without a transition, i.e. without
35 splicing. This requires the data line 4 to be wound in one piece on the air reel 28c and on the underwater reel 30c. In order to achieve this, it is advantageous if the data line 4 is initially wound on the air reel

28c and then on the intermediate reel 78 during winding of the reel system 26c. For this purpose, the housing 48c and the spindle 34c are removed.

5 It is now advantageous if the underwater spindle 34c is wound when detached from the housing 48c. For this purpose it is proposed that the spindle 34c of the underwater reel 30c is retained by an auxiliary retainer in a position that at least essentially
10 corresponds to its final mounting position relative to the air reel 28c. Smaller positional fluctuations in the region of a few millimetres can hereby sometimes be tolerated. Following the winding of the underwater reel 30c, its spindle 34c can be attached to the housing
15 48c, which hereby approaches the spindle 34c and is thus brought into its final position. The spindle 34c is then attached to the housing 48c and the auxiliary retainers for retaining the spindle 34c can be removed.

Reference character list

2	vehicle
4	data line
6	control centre
8	firing station
10	water surface
12	distance
14	target
16	interface of 6
18	control unit of 6
20	seeker head
22	control unit of 2
24	rudder of 2
26a,b,c	reel system
28a,b,c	air reel
30a,b,c	underwater reel
32a,b,c	spindle of 28a,b,c
34a,b,c	spindle of 30a,b,c
36a,b,c	winding package of 34a,b,c
38a,b,c	winding package of 32a,b,c
40	underwater segment
42a,b,c	transition segment
44	air segment
48a,b,c	housing
50a,b,c	guidance means
52a,b,c	bottom of the winding
54a,b,c	edge
56	interior
58	opening
60a,b,c	output opening
62	winding
64a,b,c	bottom of the winding
66b,c	flange
68	cavity
70b,c	laying groove
72b,c	rounding
74	output opening
76	spindle

78	intermediate reel
80	intermediate winding
82	groove segment
84	groove segment
86	valley floor
88	notch
90	bottom of the winding
92	flange
94	flange

Claims

1. Reel system (26a, 26b, 26c) for a vehicle (2),
especially for a guided missile, comprising an
underwater reel (30a, 30b, 30c) with at least one
spindle (34a, 34b, 34c) and at least one winding
package (36a, 36b, 36c), which is provided for
withdrawal during underwater travel of the vehicle
(2), an air reel (28a, 28b, 28c) with at least one
spindle (34a, 34b, 34c) and at least one winding
package (38a, 38b, 38c), which is provided for a
subsequent airborne withdrawal up to a target (14)
and for remaining on the vehicle (2) until then,
and a continuous data line (4) that is wound on
both reels (28a, 28b, 28c, 30a, 30b, 30c),
c h a r a c t e r i z e d i n t h a t
the underwater reel (30a, 30b, 30c) is drop-
resistant attached to the air reel (28a, 28b, 28c)
so that both reels remain at the vehicle.
2. Reel system (26a, 26c) according to Claim 1,
c h a r a c t e r i z e d i n t h a t
an inner diameter of an output opening of the
underwater reel (30a, 30c) is larger than an outer
diameter of an output opening (60a, 60c) of the
air reel (28a, 28c) towards the rear.
3. Reel system (26a, 26b, 26c) according to Claim 1
or 2,
c h a r a c t e r i z e d i n t h a t
a line transition in the form of a transition
segment (42) from a winding package (36a, 36b,
36c) of the underwater reel (30a, 30b, 30c) to a
winding package (38a, 38b, 38c) of the air reel
(28a, 28b, 28c) is fixed onto the winding package
(38a, 38b, 38c) of the air reel (28a, 28b, 28c).
4. Reel system (26b, 26c) according to any one of the
preceding claims,

c h a r a c t e r i z e d i n t h a t
the underwater reel (30b, 30c) is an outer
withdrawal reel.

- 5 5. Reel system (26b) according to any one of the
preceding claims,
c h a r a c t e r i z e d i n t h a t
a diameter of a guidance means (50b) of the
underwater reel (30b) is smaller than a radial
10 diameter of the innermost layer of the at least
one winding package (38b) of the air reel (28b).
6. Reel system (26a, 26b, 26c) according to any one
of the preceding claims,
15 c h a r a c t e r i z e d i n t h a t
the underwater reel (30a, 30b, 30c) comprises a
guidance means (50a, 50b, 50c) that lifts the data
line (4) that is being withdrawn radially
outwards.
20
7. Reel system (26b, 26c) according to Claim 6,
c h a r a c t e r i z e d i n t h a t
the guidance means (50b, 50c) is a rear, radially
protruding collar.
25
8. Reel system (26b) according to Claim 6 or 7,
c h a r a c t e r i z e d i n t h a t
the guidance means (50b) lies fully radially
within a bottom of a winding (64b) of the at least
30 one spindle (32b) of the air reel (28b).
9. Reel system (26b, 26c) according to any one of
claims 6 to 8,
c h a r a c t e r i z e d i n t h a t
35 the guidance means (50b, 50c) is slanted towards
the winding package (36b, 36c) of the underwater
reel (30b, 30c), such that an angle (α) between

the radial direction and the slope is greater than 30°.

- 5 10. Reel system (26a, 26b, 26c) according to any one
 of the preceding claims,
 c h a r a c t e r i z e d i n t h a t
 a transition segment (42) of the data line (4)
 from a winding package (36a, 36b, 36c) of the
 underwater reel (30a, 30b, 30c) to a winding
10 package (38a, 38b, 38c) of the air reel (28a, 28b,
 28c) is laid in a laying groove (70b, 70c).
11. Reel system (26c) according to any one of the
 preceding claims,
15 c h a r a c t e r i z e d i n t h a t
 the underwater reel (30c) is disposed relative to
 the air reel (28c) such that during a normal
 withdrawal from the air reel (28c) the data line
 (4) is withdrawn radially within and through a
20 spindle (34c) of the underwater reel (30c) that is
 implemented as an outer spindle.
12. Reel system (26a, 26c) according to any one of the
 preceding claims,
25 c h a r a c t e r i z e d i n t h a t
 the at least one spindle (34a, 34c) of the
 underwater reel (30a, 30c) is attached to a
 housing (48a, 48c) of the air reel (28a, 28c) and
 an air space through which the data line (4) is
30 withdrawn from the air reel (28a, 28c) is disposed
 between the air reel (28a, 28c) and the spindle
 (34a, 34c) of the underwater reel (30a, 30c).
13. Reel system (26c) according to any one of the
35 preceding claims,
 c h a r a c t e r i z e d i n t h a t

the at least one spindle (34c) of the underwater reel (30c) forms a housing segment of the air reel (28c).

- 5 14. Reel system (26c) according to any one of the preceding claims,
c h a r a c t e r i z e d i n t h a t
a transition segment (42c) of the data line (4)
from the winding package (36c) of the underwater
10 reel (30c) to the winding package of the air reel (28c) is led from the underwater reel (30c) initially rearwards and then radially through the at least one spindle (34c) of the underwater reel (30c).
- 15 15. Reel system (26a, 26c) according to any one of the preceding claims,
c h a r a c t e r i z e d i n t h a t
a bottom of a winding (52a, 52c) of the at least
20 one spindle (34a, 34c) of the underwater reel (30a, 30c) lies radially further out than at least some of the winding packages (38a, 38c) of the air reel (28a, 28c).
- 25 16. Reel system (26c) according to any one of the preceding claims,
c h a r a c t e r i z e d i n t h a t
the underwater reel (30c) comprises on its rear
end a laying groove (70c) with a first groove
30 segment (82) facing towards the winding package (36c) and a second groove segment (84) facing rearwards, in which a transition segment (42) of the data line (4) from the underwater reel (30c) to the air reel (28c) is laid.
- 35 17. Reel system (26c) according to Claim 16,
c h a r a c t e r i z e d i n t h a t

the laying groove (70c) cuts through a guidance means (50c) in the rear part of the underwater reel (30c) in the manner of a valley in the region of the greatest radial extent of the guidance means (50c).

5

18. Reel system (26c) according to Claim 17,
c h a r a c t e r i z e d i n t h a t
the radial elevation of the valley floor protrudes
10 above the bottom of the winding (52c) by a maximum
of 50% of the elevation of the guidance means
(50c) above the bottom of the winding (52c) of the
at least one spindle (34c) of the underwater reel
(30c).

15

19. Reel system (26c) according to any one of claims
16 to 18,
c h a r a c t e r i z e d i n t h a t
a circularly-extending outer edge of the guidance
20 means (50c) is radially notched by the laying
groove (70c) - when viewed forwards from behind
towards the guidance means (50c) - by a maximum of
20% of the elevation of the guidance means (50c)
above the bottom of the winding (52c) of the at
25 least one spindle (34c) of the underwater reel
(30c).

20. Reel system (26c) according to any one of claims
16 to 19,
30 c h a r a c t e r i z e d i n t h a t
the valley floor (86) of the laying groove (70c)
is radially curved at its rear end in such a way
that the data line (4) is led in the laying groove
(70c) radially without kinks and also emerges
35 radially from it without kinks.

21. Reel system (26c) according to any one of claims
16 to 20,

5 characterized in that
the rearward-facing groove segment (84) of the
laying groove (70c) emerges axially rearwards in
the tangential withdrawal direction of the data
line (4).

22. Reel system (26c) according to any one of claims
16 to 20,
10 characterized in that
the groove segment (82) facing towards the winding
package (36c) of the underwater reel (30c) is
oriented at an angle (β) of at least 75° to the
axial direction of the reel system (26c).

15 23. Reel system (26c) according to any one of the
preceding claims,
characterized in that
the data line (4) between the underwater reel
(30a, 30b, 30c) and the air reel (28a, 28b, 28c)
20 is wound on an intermediate reel (80), which is
disposed radially within the bottom of the winding
of the at least one spindle (34a, 34b, 34c) of the
air reel (28a, 28b, 28c).

25 24. Vehicle (2), especially a guided missile with a
rocket engine, with a reel system (26a, 26b, 26c)
disposed at the rear, especially according to any
one of the preceding claims, in which an
underwater reel (30a, 30b, 30c) provided for
30 withdrawal of a data line (4) during underwater
travel of the vehicle (2) is drop-resistant
attached at the rear with at least one spindle
(34a, 34b, 34c) and at least one winding package
(36a, 36b, 36c) of the reel system (26a, 26b,
35 26c), especially being attached to an air reel
(28a, 28b, 28c) of the reel system (26a, 26b,
26c), so that the underwater reel (30a, 30b, 30c)
remains fixedly joint to the air reel (28a, 28b,

28c) during underwater travel and above water travel to a target of the vehicle (2).

- 5 25. Method for winding a reel system (26c) with a data line (4), which is implemented for maintaining a data link between a moving vehicle (2), especially a guided missile in flight, and a control centre (6), with which the data line (4) is initially wound on a spindle (32c) of an air reel (28c) and
- 10 then on a spindle (34c) of an underwater reel (30c) of the reel system (26c),
c h a r a c t e r i z e d i n t h a t
the spindle (34c) of the underwater reel (30c) is retained during winding in a position in which
- 15 there is an output opening (60c) between said spindle (34c) and the spindle (32c) of the air reel (28c) for outputting the data line (4) during withdrawal from the air reel (28c).
- 20 26. Method for winding a reel system (26c) according to Claim 25,
c h a r a c t e r i z e d i n t h a t
the spindle (34c) of the underwater reel (30c) is retained in its winding position during winding by
- 25 an auxiliary retainer, which is removed after winding and the spindle (34c) is then attached to the air reel (28c) so as to be operationally ready.