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(71) Applicant(s)

ATLAS ELEKTRONIK GmbH

(72) Inventor(s)

Kristann, Andreas; Schaumburg, Udo; Campen, Helmut; Bauer, Wilhelm; Barg, Ulrich

(74) Agent/Attorney

FB Rice & Co, Level 23 44 Market Street, Sydney, NSW, 2000

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(71) Anmelder: ATLAS ELEKTRONIK GMBH [/DE]; Sebaldsbrücker Heerstr. 235, 28305 Bremen (DE).

(72) Erfinder: KRISTANN, Andreas; Södnerweg 5b, 28307 Bremen (DE). BAUER, Wilhelm; Am Krummwinkel 21, 27711 Osterholz-Scharmbeck (DE). SCHAUMBURG, Udo; An der alten Schale 8, 27801 Brettorf (DE). CAMPEN, Helmut; Sudweyer Strasse 15, 28844 Weyhe (DE). BARG, Ulrich; Kastanienweg 9, 28870 Ottersberg (DE).

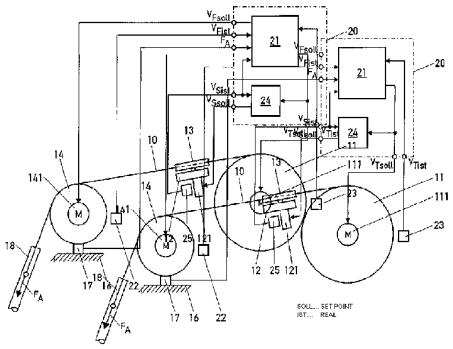
(74) Anwalt: MEUSER, Anke; Atlas Elektronik GmbH, 28305 Bremen (DE).

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(54) Title: DEPLOYING DEVICE FOR AN UNDERWATER TRAILING ANTENNA

(54) Bezeichnung: AUSBRINGVORRICHTUNG FÜR EINE UNTERWASSER-SCHLEPPANTENNE



(57) Abstract: Disclosed is a deploying device that can be installed on a watercraft, particularly a submarine, is used for veering a tubular underwater trailing antenna (10), and comprises a storage drum (11) which receives the trailing antenna (10) and is driven by a motor so as to wind and unwind the trailing antenna (10), and a propulsion unit which grips the trailing antenna (10) and generates a tractive force (F_A) on the trailing antenna (10) in the direction of deployment. In order to veer said trailing antenna (10) in a disturbance-free and unrestrained manner while keeping the mechanical wear thereof to a minimum, the trailing antenna (10) is directed via a motor-driven guide wheel (14) while a regulating device (20) is provided for synchronizing the driving motors (111, 141) of the storage drum (11) and the guide wheel (14) in a manner that is adapted to the tractive force (F_A) acting on the trailing antenna (10) such that the section of the trailing antenna, which is located between the storage drum (11) and the guide wheel (14), is essentially stretched.

(57) Zusammenfassung: Bei einer auf einem Wasserfahrzeug, insbesondere U-Boot, installierbaren Ausbringvorrichtung zum Fieren einer schlauchartigen Unterwasser-Schleppantenne (10), mit einer die Schleppantenne (10) aufnehmenden Speichertrommel (11), die zum Auf- und Abwickeln der Schleppantenne (10) motorisch antreibbar ist, und mit einer an der Schleppantenne (10) angreifenden Vortriebseinheit, die eine in Ausbringrichtung wirkende Zugkraft (F_A)

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Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

an der Schleppantenne (10) erzeugt, ist für ein störungs- und hemmungsfreies Fieren der Schleppantenne (10) mit minimaler mechanischer Beanspruchung der Schleppantenne (10) die Schleppantenne (10) über ein motorisch antreibbares Führungsrad (14) geführt und eine Regeleinrichtung (20) vorgesehen, die die Antriebsmotoren (111, 141) von Speichertrommel (11) und Führungsrad (14) in Anpassung an die auf die Schleppantenne (10) wirkende Zugkraft (F_A)so synchronisiert, daß der zwischen Speichertrommel (11) und Führungsrad (14) sich jeweils befindliche Schleppantennenabschnitt im wesentlichen gestreckt ist.

DEPLOYMENT APPARATUS FOR AN UNDERWATER TOWED-ARRAY ANTENNA

The invention relates to a deployment apparatus, which can be installed on a water craft, in particular a submarine, for paying out an underwater towed-array antenna, which is in the form of a flexible tube, of the type defined in the precharacterizing clause of claim 1.

In a known deployment apparatus for an underwater towed-array antenna which is in the form of a flexible tube (DE 196 52 737 C1), the feed unit which acts on the towed-array antenna and produces a tension force acting in the deployment direction on the towed-array antenna has a paying-out tube through which the towed-array antenna is passed. A large number of inlet nozzles which pass through the tube wall are arranged on the paying-out tube and are connected to a high-pressure water pump. A water flow towards the deployment end of the paying-out tube is produced between the tube inner wall of the paying-out tube and the flexible tube casing of the towed-array antenna by means of the inlet nozzles. The powerful water flow causes that section of the towed-array antenna (which is in the form of a flexible tube) which is located in the paying-out tube at that time to be driven towards the deployment end by means of the surface friction which is produced on the flexible tube casing. In addition, the water flow produces a lubrication effect, since the flexible tube casing of the towed-array antenna is surrounded by a water film and does not touch the tube inner wall of the paying-out tube, so that no significant friction forces occur, which would brake the feeding of the towed-array antenna.

A deployment apparatus having a feed unit, which has two soft-coated winch heads which run in opposite

directions and between which the towed-array antenna which is in the form of a flexible tube is passed, is also already known (EP 0 124 133 B1). The winch heads, which are driven by a motor or motors, act on both sides of the towed-array antenna by friction, and move the towed-array antenna in the direction of the deployment end of the paying-out tube at the stern of the submarine. Since the towed-array antenna, which is in the form of a flexible tube, represents a structure which bends relatively easily and the part of the antenna which is located between the drive apparatus and the deployment end of the paying-out tube is pushed through the winch heads, it is not possible to reliably ensure that the towed-array antenna is always deployed without any disturbances. In addition, the winch heads subject the towed-array antenna to a high mechanical load, which leads to premature wear of the flexible tube casing of the towed-array antenna, thus resulting in the towed-array antenna becoming unusable prematurely.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

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According to the present invention there is provided a deployment apparatus which can be installed on a water craft, in particular a submarine, for paying out an underwater towed-array antenna which is in the form of a flexible tube, having a storage drum which holds the towed-array antenna and can be driven by a motor or motors in order to wind up and unwind the towed-array antenna, and having a feed unit which acts on the towed-array antenna and produces a tension force (F_A) (which acts in the deployment direction) on the towed-array antenna, characterized in that the towed-array antenna is passed over a guide wheel which can be driven by a motor or motors, and in that a control device is provided which, during paying out, synchronizes the drive motors for the storage drum and for the guide wheel, matched to the tension force (F_A) acting on the towed-array antenna, such that the section of the towed-array antenna which is in each case located between the storage drum and the guide wheel is significantly stretched.

The invention may provide a deployment apparatus which allows the towed-array antenna to be paid out reliably without any disturbances or jamming, and with a minimal mechanical load on the towed-array antenna.

More specifically, the deployment apparatus according to the invention has the advantage that, during the paying-out process, the control device matches the rotation angle rates of the storage drum and of the guide wheel to the tension force which acts on the towed-array antenna in the pulling-out direction downstream from the guide wheel such that the tension force is sufficient to pull that section of the towed-array antenna which has been

unwound from the storage drum and is in each case located between the guide wheel and the storage drum off the guide wheel, so that the towed-array antenna does not become jammed between the guide wheel and the storage drum, thus avoiding the risk to the paying-out process associated with this. Only a small amount of mechanical friction occurs on the towed-array antenna, which is caused by the guide wheel and, even in the long term, does not lead to damage to the flexible tube casing of the towed-array antenna.

Expedient embodiments of the deployment apparatus according to the invention as well as advantageous developments and refinements of the invention are described in the further claims.

According to one preferred embodiment of the invention, at least one force measurement device which senses the tension force acting on the towed-array antenna is arranged on the guide wheel. The force which is measured by the force measurement device is supplied to the control device as a reference variable. The force measurement device makes it possible to detect very accurately the force acting on the towed-array antenna, whose magnitude is subject to a certain fluctuation range and, for example, may rise sharply after immersion of the deployment end of the towed-array antenna in the wake behind the water craft.

Since the storage drum has a significant axial length, and the towed-array antenna is wound up in a number of layers on the storage drum in order to allow the towed-array antenna to be wound up completely, the storage drum has an associated winding carriage, which can be moved by a motor or motors parallel to the drum axis and is fitted with a winding wheel, which is mounted such that it can rotate, for guidance of the towed-array antenna. According to one advantageous embodiment

of the invention, the control device also controls the feed rate of the winding carriage as a function of the rotation angle rate of the storage drum.

According to one advantageous embodiment of the invention, during paying out, the towed-array antenna is pulled through a guide tube with an inlet and outlet opening, and the guide wheel is arranged directly adjacent to the inlet opening of the guide tube such that the section of the towed-array antenna which runs out tangentially from the guide wheel is aligned coaxially with the normal to the inlet opening, that is to say coaxially with the guide tube axis, so that the towed-array antenna which runs out from the guide wheel runs directly and unobstructed into the guide tube.

According to one advantageous embodiment of the invention, the feed unit acts on the end of the towed-array antenna and has an antenna end piece which is firmly connected to the towed-array antenna and has a large number of moldings which are separated from one another, are arranged axially on a cable such that they cannot move significantly, and are designed to produce a drag in the wake of the water craft. This has the advantage that, when the end piece is immersed in the wake, the towed-array antenna is permanently subject to a tension force which depends on the speed of the vessel during deployment of the towed-array antenna and which is sufficiently large to pull the towed-array antenna out of the guide tube.

According to one advantageous embodiment of the invention, the moldings can rotate on the cable, so that they do not apply any rotation moment to the towed-array antenna via the cable while being towed in the wake.

According to one advantageous embodiment of the

invention, each molding has a funnel with a funnel opening pointing in the towing direction, and has an end disk which projects beyond the funnel casing and is arranged at the end facing away from the funnel opening, with the external diameter of the end disk preferably being designed to be the same as the external diameter of the funnel at the funnel opening. The funnel shape of the moldings, which is open in the towing direction, with an end disk behind them ensures a sufficiently high drag in the free flow when the speed of motion of the water craft is low, and thus ensures a sufficiently high tension force at the end of the towed-array antenna.

According to one advantageous embodiment of the invention, the feed unit has a flushing tube with an inlet and an outlet opening for the towed-array antenna, in which a water pressure can be produced close to the inlet opening. At the start of the paying-out process, the antenna end piece is inserted in the flushing tube, with its moldings being guided in the flushing tube such that they can move axially and have the water pressure applied to them. This design addition to the feed unit ensures that a tension force acting in the deployment direction is applied to the end of the towed-array antenna right from the start of the paying-out process, and even before the antenna end piece has become partially or entirely immersed in the wake of the water craft, since the external diameter of the moldings is only slightly smaller than the internal diameter of the flushing tube, so that the moldings act like pistons to which water pressure is applied. In order to allow the water pressure to build up in the flushing tube, a flushing pump is, according to one advantageous embodiment of the invention, connected to a water inlet of the flushing tube, and the inlet opening of the flushing tube is closed by a seal, preferably in the form of a labyrinth seal, which

provides a seal against the towed-array antenna which is like a flexible tube.

According to one advantageous embodiment of the invention, axial webs which are offset with respect to one another, preferably through 90°, are fitted to the funnel casing for each molding in the circumferential direction and extend from the funnel opening to the end disk, and their outer web lines, which run parallel to the funnel axis, are at a radial distance from the funnel axis which corresponds to the external diameter of the end disk. A closure cone which has axial aperture openings is fitted to the funnel opening. The conical shape of the closure cone, the axial webs and the end disk whose circumference is rounded ensure that the moldings center themselves in the flushing tube and do not become jammed on tolerance-dependent steps in the flushing tube. The chosen length of the moldings prevents jamming in the flushing tube. The closure cone advantageously assists the process of threading the antenna end piece into the flushing tube during recovery of the towed-array antenna.

Since, according to one advantageous embodiment of the invention, the moldings are produced from a material which slides well, for example Teflon, the friction losses on the moldings in the flushing tube are reduced, thus increasing the proportion of the tension force which can be used for pulling out the towed-array antenna.

According to one advantageous embodiment of the invention, the last molding in the towing direction has a stop, preferably in the form of a truncated conical closure element which is integral with the end disk and is designed to close the outlet opening of the flushing tube. This stop prevents the antenna end piece from being pulled through the flushing tube during recovery

of the towed-array antenna. The moment at which the closure element stops against the flushing tube can be sensed, and can be used to switch off the drive motors after recovery of the towed-array antenna.

According to one advantageous embodiment of the invention, the flushing tube is integrated in the guide tube and can move in an axially limited manner in it against a spring force, so that the striking of the stop or of the closure element on the flushing tube is sprung, before the drive motors are switched off.

The invention will be described in more detail in the following text with reference to an exemplary embodiment which is illustrated in the drawing, in which:

Figure 1 shows an outline sketch of a deployment apparatus for a towed-array antenna,

Figures 2 to 5 each show a graph in order to explain the operation of a control device in the deployment apparatus shown in Figure 1,

Figure 6 shows a perspective illustration of the deployment apparatus shown in Figure 1,

Figure 7 shows an enlarged illustration of the detail VII in Figure 6, without a guide tube,

Figure 8 shows a longitudinal section through a feed unit in the deployment apparatus shown in Figure 6,

Figure 9 shows a perspective illustration of a funnel part of a molding of the feed unit shown in Figure 8,

Figure 10 shows a view of the funnel part in the direction X in Figure 9,

Figure 11 shows a section along the line XI - XI in Figure 10,

Figure 12 shows a view from underneath of a closure cone, which can be fitted to the funnel part, of the molding of the feed unit shown in Figure 8, and

Figure 13 shows a section along the line XIII - XIII in Figure 12.

The deployment apparatus, which is illustrated in the form of an outline circuit diagram in Figure 1 and in the form of a perspective illustration in Figure 6, for an underwater towed-array antenna which is like a flexible tube is installed on a water craft which is not illustrated here, in particular on a submarine. In the case of a submarine, it is installed between the flooded outer casing and the pressure body. The towed-array antenna 10 comprises, in a known manner, a towed section and a traction cable, which connects the towed section to the water craft. The towed section comprises a flexible tube casing which is filled with liquid or gel and in which a large number of electroacoustic transducers are arranged in a row, separated from one another. A damping module, a so-called VIM, is arranged between the towed section and the traction cable.

When not in use, the towed-array antenna 10 is wound up in a number of layers on a storage drum 11 which can be

driven by means of a drive motor 11, with the storage drum 11 having a significant axial length in order to accommodate the quite long towed-array antenna 10. The storage drum 11 has an associated winding carriage 12 which can be moved by a motor or motors parallel to the drum axis and has a winding wheel 13 mounted on it such that it can rotate. The winding wheel 13 guides the towed-array antenna 11 while it is being wound onto or unwound from the storage drum 11, with the winding carriage 12 carrying out a controlled backward and forward movement along the storage drum 11. A guide wheel 14 is arranged at a distance from the storage drum 11 in the direction of the stern of the water craft and is mounted in a stand 15 such that it can rotate, which stand 15 is in turn fixed in a frame or platform 16, which is indicated schematically in Figure 1. At least one force measurement device 17, and in the illustrated exemplary embodiment two force measurement devices 17, is or are arranged between the stand 15 and the platform 16, and measures or measure any change in the contact force applied by the stand 15 to the platform 16. The guide wheel 14 can be driven by a motor or motors, for which purpose at least one electric motor 141 is provided. The towed-array antenna 10 runs from the storage drum 11 over the winding wheel 13 and the guide wheel 14, and is passed through a guide tube 18 with an inlet opening 181 and an outlet opening 182, which is located in the open water behind the stern of the water craft. The guide wheel 14 is arranged directly adjacent to the inlet opening 181 of the guide tube 18, so that the antenna section which runs off tangentially from the guide wheel 14 is aligned coaxially to the normal to the inlet opening 181, so that the towed-array antenna 10 runs coaxially into the guide tube 18. During the paying-out process, a tension force F_A which pulls the towed-array antenna 10 through the guide tube 18 is applied to the end of the towed-array antenna 10, to be more precise to the

end of a damping module (VIM) which is also arranged here and is connected to the towed section. The tension force F_A is produced by means of a feed unit 19 which will be described later.

A control device 20 is provided in order to ensure that the paying-out process or deployment process for the towed-array antenna 10 takes place without any disturbances or jamming, and synchronizes the drive motors 111 and 141 for the storage drum 11 and for the guide wheel 14 matched to the tension force F_A which is sensed by the force measurement device 17, such that the towed-array antenna section which is in each case located between the storage drum 11 and the guide wheel 14 is significantly stretched, that is to say it runs without hanging down. For this purpose, the rotation angle rates v_T and v_F of the storage drum 11 and of the guide wheel 14 are matched to the tension force F_A such that the latter can pull the length of the towed-array antenna 10 which has in each case been unwound from the storage drum 11 by its motor 111 through the guide tube 18, and the towed-array antenna 10 cannot become "jammed" in front of the guide wheel 14 or on the guide tube 18. The pulling-out force F_A which is sensed by the force measurement device 17 is used as a reference variable in the control device 20 for adjustment of the rotation angle rates v_T and v_F of the storage drum 11 and of the guide wheel 14. For this purpose, the reference variable F_A is supplied to a first regulator 21 for the control device 20. This regulator 21 is also supplied with the actual rotation angle rates v_{Fact} and v_{Tact} of the guide wheel 14 and of the storage drum 11 which are sensed by respective rotation sensors 22 and 23, which are arranged on the guide wheel 14 and on the storage drum 11, respectively. The reference variable F_A is used to determine the nominal rotation angle rate v_{Fnom} of the guide wheel 14 and the nominal rotation angle rate v_{Tnom} of the storage drum 11 and to regulate

it via the nominal value outputs of the control device 20 for the drive motors 111 and 141 for the storage drum 11 and for the guide wheel 14. The characteristics for the control process are shown in Figures 2 and 3. When the tension force F_A rises, then both the nominal value for the rotation angle rate v_T of the storage drum 11 and the nominal value for the rotation angle rate v_F of the guide wheel 14 are increased linearly. At the same time, as can be seen from the characteristic in Figure 4, a positive slip s is superimposed on the guide wheel 14, which is reduced as the reference variable increases and ensures that that section of the towed-array antenna 10 which is in each case located between the guide wheel 14 and the storage drum 11 is stretched without hanging down.

A second regulator 24 in the control device 20 is used to control the feed rate v_S of the winding carriage 12 as a function of the rotation angle rate v_T of the storage drum 11. For this purpose, the second regulator 24 is supplied with the nominal rotation angle rate v_{Tnom} of the storage drum 11 and with the actual feed rate v_{Sact} of the winding carriage 12. The latter is detected by means of a rotation sensor 25, which senses the rotation angle rate of a transmission output drive shaft or of the output drive shaft of the motor 121. The nominal feed rate v_{Snom} is controlled in the drive motor 121 via the corresponding nominal value output. Figure 5 shows the characteristics of the second regulator 24, with the characteristic a being applicable while the towed-array antenna 10 is being pulled off the upper of the total of three winding layers, and with the characteristic b being applicable to the two winding layers below this, that is to say to the second and first winding layer. The latter is formed exclusively by the traction cable for the towed-array antenna.

The feed unit 19 for producing the tension force F_A at the deployment end of the towed-array antenna 10 is illustrated in the form of details in Figures 6 and 7, and in the form of a longitudinal section in Figure 8. It comprises an antenna end piece 26, which is firmly connected to the towed-array antenna end, as well as a flushing tube 40 which is integrated in the guide tube 18 and in which the antenna end piece 26 is inserted when the towed-array antenna 10 has been pulled in and is wound up on the storage drum 11. As can be seen from Figure 8, the antenna end piece 26 has a large number of moldings 27, which are arranged at a distance from one another, such that they cannot move significantly axially, on a cable 28 which is firmly connected to the towed-array antenna 10. The arrangement is in this case designed such that the moldings 27 can rotate around the cable 28. For simplicity, Figure 8 shows the end piece 26 connected directly to the towed-array antenna 10, to be more precise to its VIM. In order to allow the end piece 26 and the type of towed-array antenna 10 to be changed easily, the cable 28 is attached to a flexible tube element which is associated with the end piece 26 and is itself connected to the VIM of the towed-array antenna. The flexible tube element comprises an elastic flexible tube casing which is filled with liquid or gel and is stiffened by means of a molding. A loose pulled-in cable prevents unacceptably large expansion of the flexible tube casing.

The moldings 27, which are produced from a material which can slide well, such as Teflon, are physically identical. Each molding 27 is in two parts and is composed of an elongated funnel part 29, which is illustrated in detail in Figures 9 to 11, and a closure cone 30, which is illustrated in the form of a view from underneath and a longitudinal section in Figures 12 and 13. A funnel 31 with a funnel opening 32 which

points in the towing direction, as well as an end disk 33 which is arranged at that end of the funnel part which faces away from the funnel opening 32, are formed in the funnel part 29, with the end disk 33 projecting radially beyond the funnel casing 311. The outline edges of the end disk 33 are rounded toward both disk surfaces. The rounded areas are annotated 331 in Figure 11. A cylindrical annular rim 34 is positioned in front of the funnel opening 32, and the unobstructed diameter of this annular rim 34 is designed to be equal to the diameter of the funnel opening 32, while its external diameter is designed to be equal to the external diameter of the end disk 33, which, in the exemplary embodiment, is approximately half as large as the axial length of the funnel part 13. Four axial webs 35, which are arranged offset through 90° with respect to one another in the circumferential direction, are fitted to the funnel casing 311 and each extend from the annular rim 34 to the end disk 33. The outer web line 351 of the axial webs 35, which runs parallel to the funnel axis, is at a radial distance from the funnel axis which is equal to the external radius of the end disk 33 and the external radius of the annular rim 34. A central aperture hole 36, which opens in the base of the funnel, is incorporated in the end disk 33.

The closure cone 30, which is fitted to the funnel part 29, has three axial aperture openings 37, which are offset through a rotation angle of 120° with respect to one another, as well as a central aperture hole 38. The aperture openings 37 are made sufficiently large that, in practice, only webs remain between them, and these webs are arranged in a star shape. The aperture hole 38 runs at the star point. An annular web 39 projects axially from that end of the closure cone 30 which faces the funnel opening 32, and its external diameter is designed to be slightly smaller than the internal diameter of the annular rim 34 on the funnel part 29,

so that the closure cone 30 can be inserted, with its annular web 29, in an interlocking manner into the annular rim 34 on the funnel part 29. Once the cable 28 has been threaded through the aperture openings 37 and 38, the funnel part 29 and the closure cone 30 are firmly connected to one another, for example by means of a number of screw connections, which are radially offset on the circumference, between the annular rim 34 and the annular web 39. The moldings 27 are prevented from being able to move axially on the cable 28 by means, for example, of knots in the cable 28, with the funnel base and the base area of the closure cone 30 each being supported on one cable knot.

The flushing tube 40 of the feed unit 19 together with an inlet opening 401 and an outlet opening 402 for the towed-array antenna 10 (Figures 7 and 8) is pulled into the guide tube 18 and can move axially to a limited extent in the guide tube 18 against the force of a compression spring 41. The outlet opening 402 of the flushing tube 40 is located at or close to the outlet opening 182 of the guide tube 18. A Y-tube branch 42 is fitted to the inlet opening 401 of the flushing tube 40, and is firmly connected to the flushing tube 40 and to the guide tube 18 by means of a screw sleeve 43. The towed-array antenna 10 is inserted into the tube connecting stub 421 (which is coaxial with the flushing tube 40) of the Y-tube branch 42, with a labyrinth seal 44 providing a seal between the tube inner wall and the flexible tube casing of the towed-array antenna 10 which is largely pressure-tight. The other tube connecting stub 422, which runs at an acute angle to the tube connecting stub 421, of the Y-tube branch 42 forms a water inlet 45, and is connected to a flushing pump 47, which is indicated only schematically here and allows water pressure to build up in the flushing tube 40.

Once the towed-array antenna 10 has been wound up completely on the storage drum 11, the antenna end piece 26 which is attached to the end of the towed-array antenna 10 by means of the cable 28 is pulled, together with its moldings 27, completely into the flushing tube 40. The end of the towed-array antenna 10 and the flexible tube element of the antenna end piece 26 which is connected to the towed-array antenna 10 project into the inlet opening 401 of the flushing tube 40. At the inlet of the towed-array antenna 10 or of the flexible tube element into the tube connecting stub 421 of the Y-tube branch 42, a labyrinth seal 44 seals the tube inner wall against the towed-array antenna 10, which is in the form of a flexible tube, and the flexible tube element. The moldings 27, whose external diameter is only slightly less than the unobstructed diameter of the flushing tube 40, are guided in the flushing tube 40 by means of the end disk 33, the annular rim 34 and the axial webs 35, and can slide well by virtue of the material which is used to produce them. If, for example, a water pressure of 2 - 3 bar is now produced in the flushing tube 40 at the start of the deployment process or paying out of the towed-array antenna 10, then the moldings 27 act like pistons, which are shifted by the water pressure in the direction of the outlet opening 402 of the flushing tube 40, and thus produce the tension force F_A on the towed-array antenna 10 via the cable 28. After reaching the outlet opening 402 of the flushing tube 40, the moldings 27 emerge successively from the flushing tube 40 and enter the wake behind the water craft. The antenna end piece 26 which has been pulled completely out of the flushing tube 40 then produces the tension force F_A owing to its drag as it is pulled through the water, with this tension force F_A being governed by its drag and by the towing speed of the water craft. This tension force also ensures that the towed-array antenna 10 is pulled out through the flushing tube 40 without

any disturbances until its entire length has been deployed in the water and it remains connected at its front end via the traction cable, which has likewise been pulled out, to the storage drum 11 which is fixed on the water craft.

During recovery of the towed-array antenna 10 and while being wound up on the storage drum 11, the moldings 27 on the antenna end piece 26 can be inserted into the flushing tube 40 without any problems owing to the closure cone 30 which precedes the funnel part 29. A truncated conical closure element 46 is arranged on the last molding 27 on the antenna end piece 26 and is designed to close the outlet opening 402 of the flushing tube 40, and to form a stop in order to limit the pulling-in movement of the towed-array antenna 10. The closure element 46 is attached to the end disk 33. Alternatively, it may be attached to the cable 28 or may be formed integrally with the end disk 33. Once the antenna end piece 26 has been pulled in completely, then the closure element 46 stops against the flushing tube 40, and the flushing tube 40 is moved in the guide tube 18 against the force of the compression spring 41. The axial movement of the flushing tube 40 or the increase in the spring force of the compression spring 41 is sensed and this is used to generate a switching-off signal for the motors 111, 121 and 141 for the storage drum 11, the winding carriage 12 and the guide wheel 14.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A deployment apparatus which can be installed on a water craft, in particular a submarine, for paying out an underwater towed-array antenna which is in the form of a flexible tube, having a storage drum which holds the towed-array antenna and can be driven by a motor or motors in order to wind up and unwind the towed-array antenna, and having a feed unit which acts on the towed-array antenna and produces a tension force (which acts in the deployment direction) on the towed-array antenna, characterized in that the towed-array antenna is passed over a guide wheel which can be driven by a motor or motors, and in that a control device is provided which, during paying out, synchronizes the drive motors for the storage drum and for the guide wheel, matched to the tension force acting on the towed-array antenna, such that the section of the towed-array antenna which is in each case located between the storage drum and the guide wheel is significantly stretched.

2. The deployment apparatus as claimed in claim 1, characterized in that at least one force measurement device is arranged on the guide wheel and senses the tension force which is acting on the towed-array antenna, and in that the force which is measured by the force measurement device is supplied as a reference variable to the control device.

3. The deployment apparatus as claimed in claim 2, characterized in that the reference variable is used to determine and regulate the nominal rotation angle rates of the storage drum and of the guide wheel, and in that the nominal rotation angle rate of the guide wheel has slip superimposed on it, which is reduced as the tension force rises.

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4. The deployment apparatus as claimed in one of claims 1 - 3, characterized in that the storage drum has an associated winding carriage, which can be driven by a motor or motors parallel to the drum axis and has a winding wheel which is mounted on it such that it can rotate, for guidance of the towed-array antenna while it is being unwound from and wound up onto the storage drum, and in that the feed rate of the winding carriage is controlled as a function of the rotation angle rate of the storage drum.

5. The deployment apparatus as claimed in one of claims 2 - 4, characterized in that the actual rotation angle rates of the storage drum and of the guide wheel are detected by means of rotation sensors.

6. The deployment apparatus as claimed in claim 4 or 5, characterized in that the actual feed rate of the winding carriage is detected by means of a rotation sensor which senses the rotation speed of the output drive shaft of the drive motor, or of a transmission shaft of a feed transmission.

7. The deployment apparatus as claimed in one of claims 2 - 6, characterized in that the guide wheel is held in a stand such that it can rotate, and the at least one force measurement device is arranged between the stand and a platform on which the stand is mounted.

8. The deployment apparatus as claimed in one of claims 1 - 7, characterized in that the towed-array antenna can be pulled through a guide tube with an inlet and an outlet opening, and in that the guide wheel is arranged directly adjacent to the inlet opening such that the section of the towed-array antenna which runs out tangentially from the guide wheel is aligned coaxially with the normal to the inlet opening.

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9. The deployment apparatus as claimed in the precharacterizing clause of claim 1, in particular as claimed in one of claims 1 - 8, characterized in that the feed unit acts on the end of the towed-array antenna and has an antenna end piece which is firmly connected to the towed-array antenna and has a large number of moldings which are separated from one another, are arranged axially on a cable such that they cannot move significantly, and are designed to produce a drag in the wake of the water craft.

10. The deployment apparatus as claimed in claim 9, characterized in that the moldings are arranged such that they can rotate about the cable.

11. The deployment apparatus as claimed in claim 9 or 10, characterized in that each molding has a funnel with a funnel opening pointing in the towing direction, and has an end disk which projects beyond the funnel casing and is arranged at the end facing away from the funnel opening.

12. The deployment apparatus as claimed in claim 11, characterized in that the external diameter of the end disk is equal to the external diameter of the funnel at the funnel opening.

13. The deployment apparatus as claimed in claim 12 or 13, characterized in that axial webs which are offset with respect to one another, preferably through 90°, are fitted to the funnel casing in the circumferential direction and extend from the funnel opening to the end disk, and their outer web line, which runs parallel to the funnel axis, is at a radial distance from the funnel axis which corresponds to the external radius of the end disk.

14. The deployment apparatus as claimed in one of claims 11 - 13, characterized in that the end disk is

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rounded on its circumference towards both disk faces.

15. The deployment apparatus as claimed in one of claims 11 - 14, characterized in that a closure cone which has axial aperture openings is fitted to the funnel opening, and in that a central aperture hole for the cable is in each case arranged in the closure cone, in the funnel base and in the end disk, whose hole diameter is larger than the external diameter of the cable.

16. The deployment apparatus as claimed in claim 15, characterized in that the funnel opening is preceded by an annular rim which has an internal diameter corresponding to the opening diameter of the funnel opening and has an external diameter corresponding to the diameter of the end disk, and in that an annular web projects axially at the end of the closure cone on the funnel opening side, and can be inserted in an interlocking manner into the annular rim.

17. The deployment apparatus as claimed in claim 16, characterized in that the diameter of the base area of the closure cone is designed to be the same as the external diameter of the annular rim.

18. The deployment apparatus as claimed in one of claims 9 - 17, characterized in that the moldings are composed of a material with a good sliding capability, preferably Teflon.

19. The deployment apparatus as claimed in one of claims 9 - 18, characterized in that the feed unit has a flushing tube with an inlet and an outlet opening for the towed-array antenna, in which a water pressure can be produced at or close to the inlet opening, and in that, at the start of a paying-out process, the antenna end piece is inserted in the flushing tube and its moldings are guided in the flushing tube such that they

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can move axially, and have the water pressure applied to them.

20. The deployment apparatus as claimed in claim 19, characterized in that the flushing tube has at least one water inlet to which a flushing pump is connected.

21. The deployment apparatus as claimed in claim 19 or 20, characterized in that the flushing tube is closed on the inlet opening side by a seal, preferably a labyrinth seal, which provides a seal with the towed-array antenna which is like a flexible tube.

22. The deployment apparatus as claimed in claim 20 or 21, characterized in that the flushing pump can be switched on and off as a function of the process of paying out the towed-array antenna.

23. The deployment apparatus as claimed in one of claims 9 - 22, characterized in that a stop is arranged on the last molding in the towing direction.

24. The deployment apparatus as claimed in claim 23, characterized in that the stop is in the form of a preferably truncated conical closure element for closing the outlet opening of the flushing tube.

25. The deployment apparatus as claimed in one of claims 19 - 24, characterized in that the flushing tube is pulled into the guide tube, preferably such that it can move in an axially limited manner in it against a spring force.

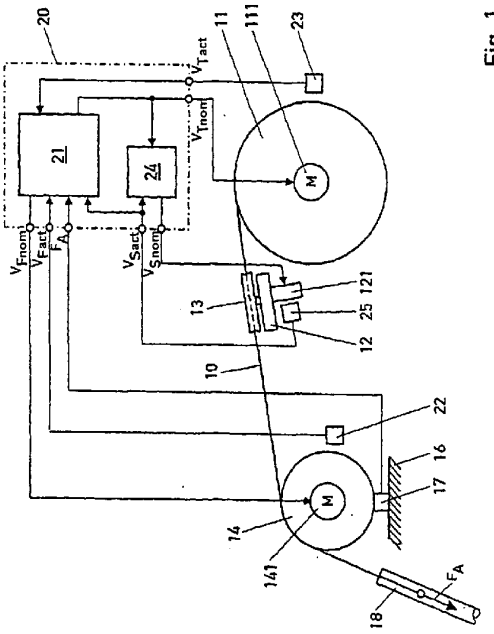

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Fig. 1

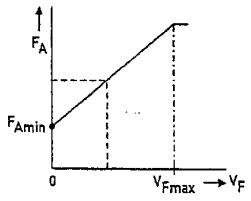


Fig. 2

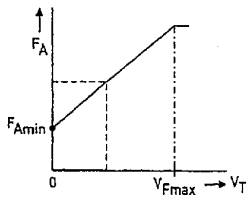


Fig. 3

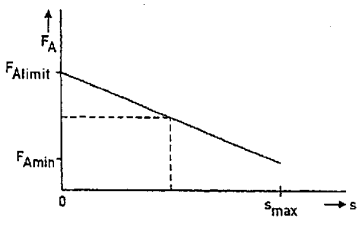


Fig. 4

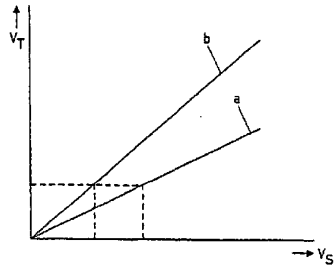


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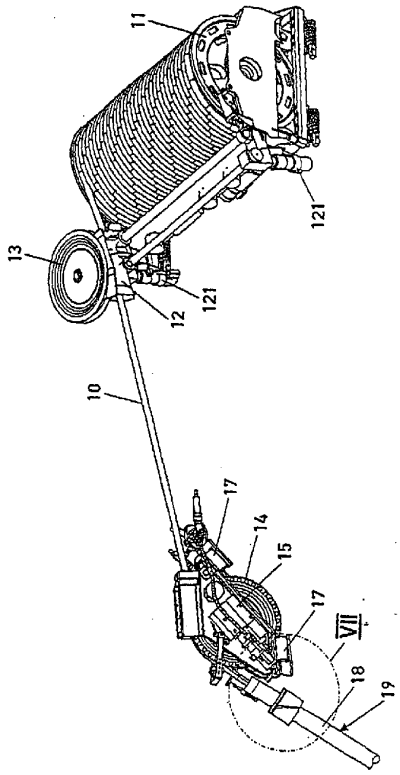


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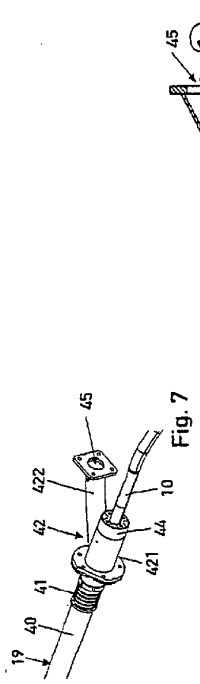

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Fig. 7

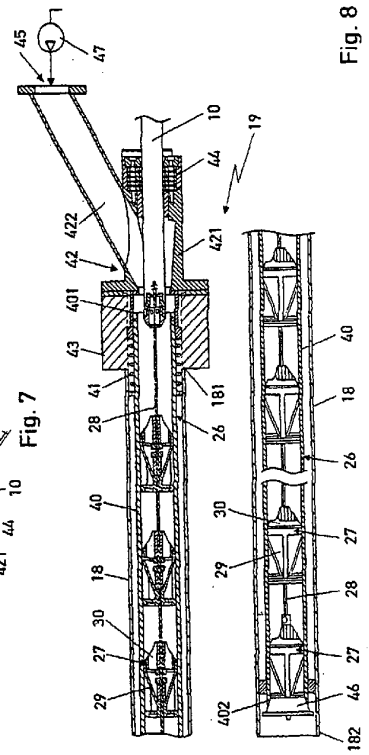

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Fig. 8

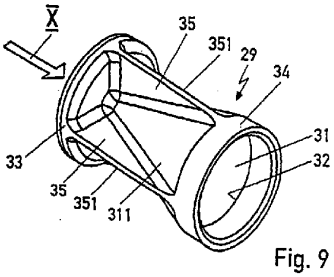


Fig. 9

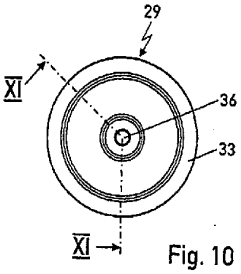


Fig. 10

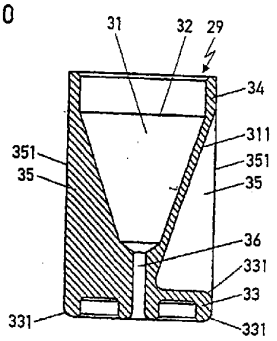


Fig. 11

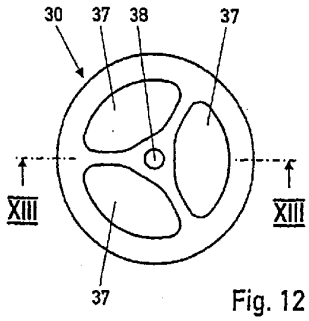


Fig. 12

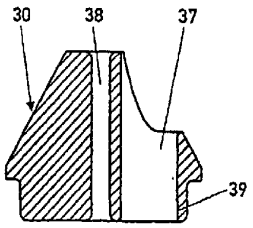


Fig. 13