

April 30, 1968

J. E. BOWKER ETAL
VESSEL ARRESTING APPARATUS

3,380,424

Filed March 17, 1966

4 Sheets-Sheet 1

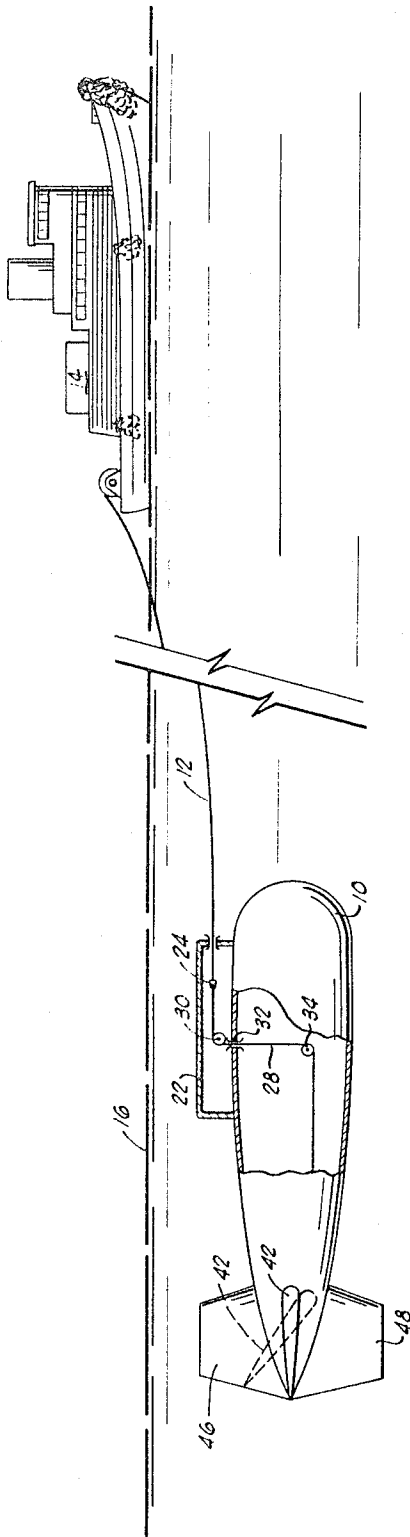


FIG. 1

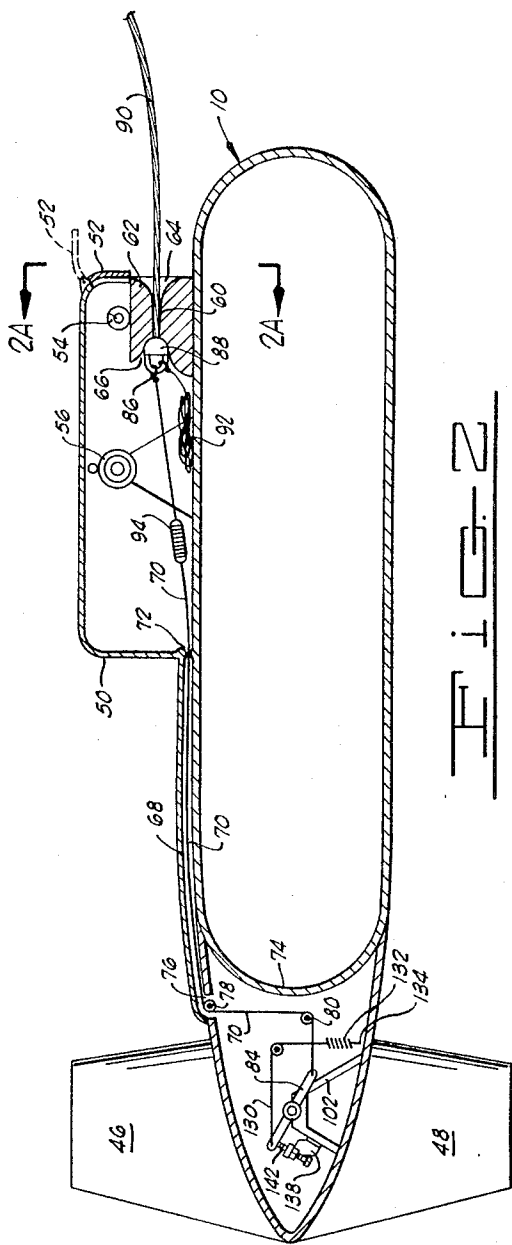


FIG. 2

INVENTORS
JOHN E. BOWKER &
ROBERT M. CASHMAN
BY *David P. Cullen*
ATTORNEY

April 30, 1968

J. E. BOWKER ET AL

3,380,424

VESSEL ARRESTING APPARATUS

Filed March 17, 1966

4 Sheets-Sheet 2

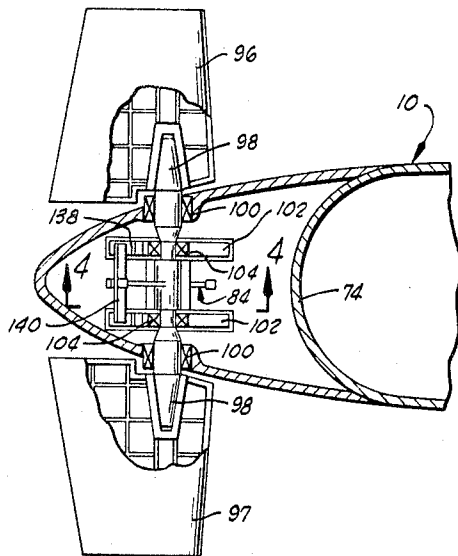


FIG. 3

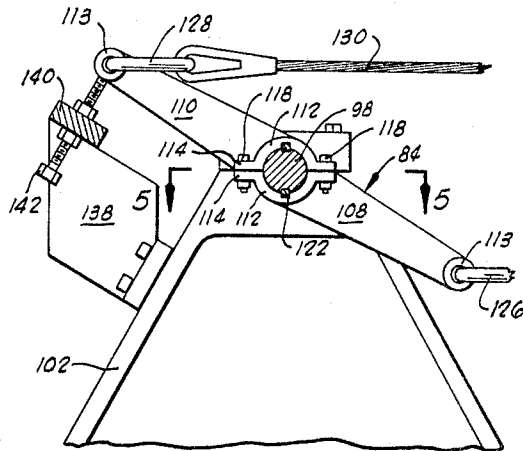


FIG. 4

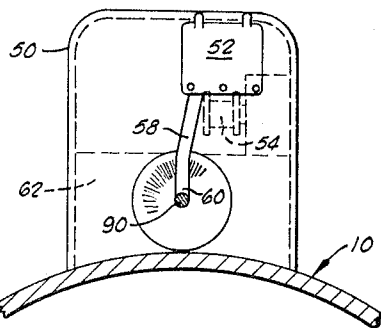


FIG. 2A

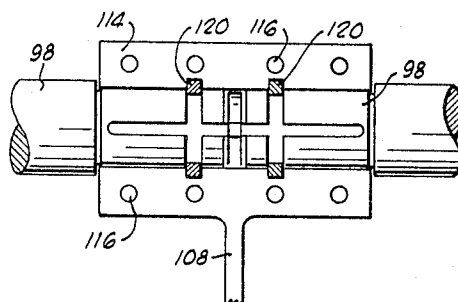


FIG. 5

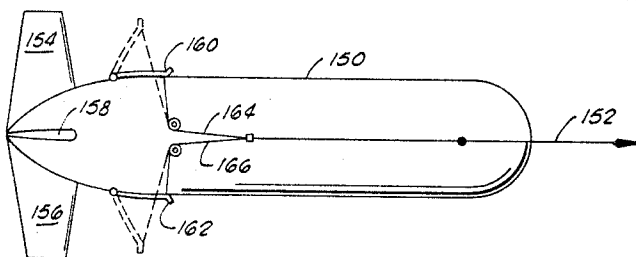


FIG. 6

INVENTORS
JOHN E. BOWKER &
ROBERT M. CASHMAN
BY *David P. Cullen*
ATTORNEY

April 30, 1968

J. E. BOWKER ETAL

3,380,424

VESSEL ARRESTING APPARATUS

Filed March 17, 1966

4 Sheets-Sheet 4

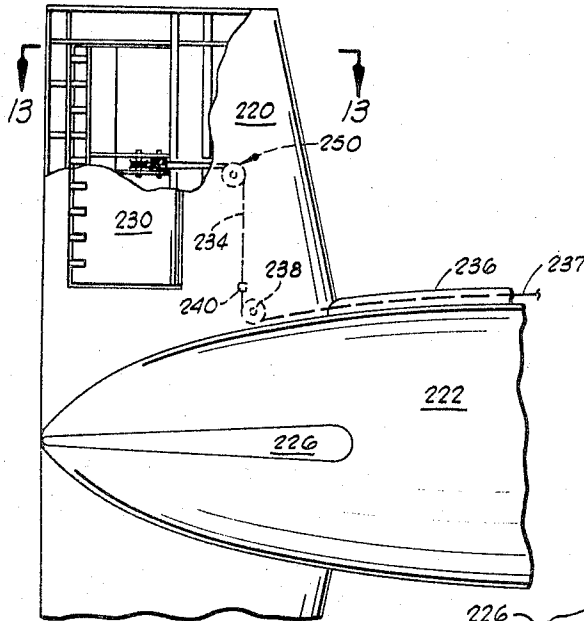


FIG. 12

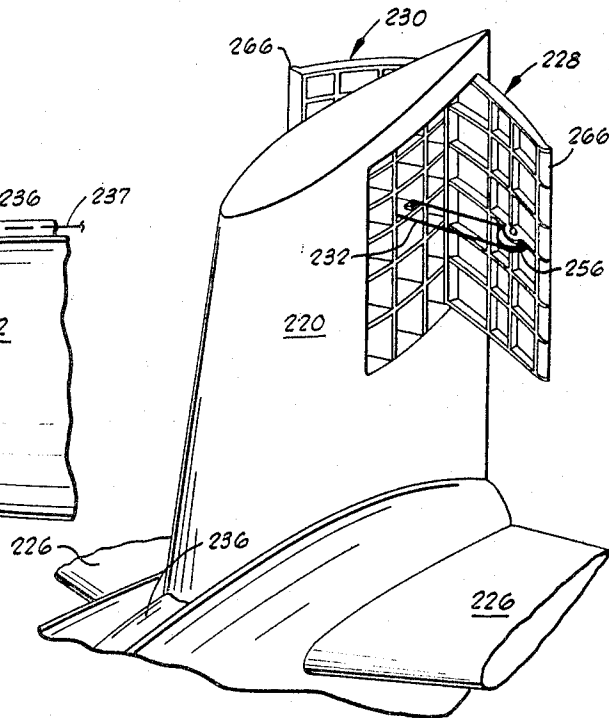


FIG. 11

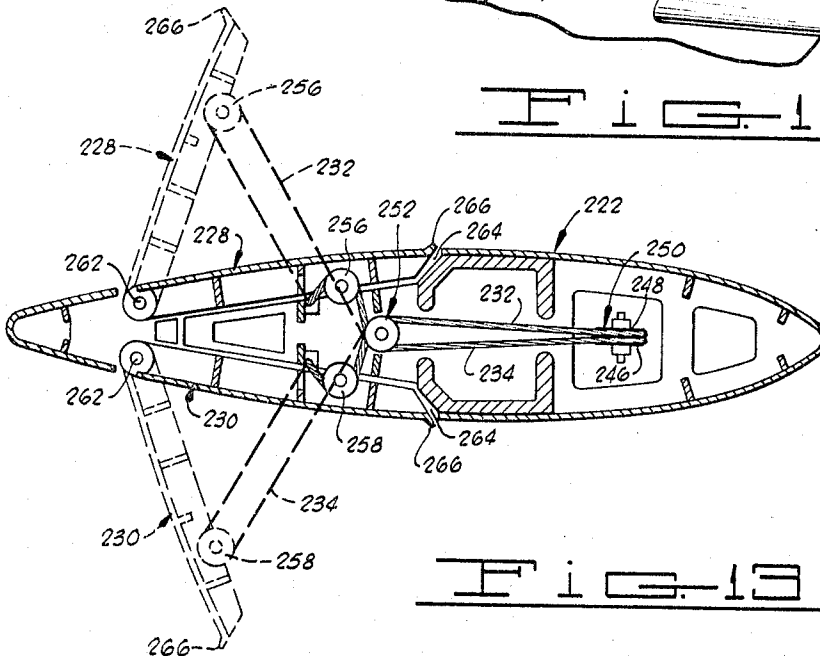


FIG. 13

INVENTORS:
JOHN E. BOWKER &
ROBERT M. CASHMAN

BY *David P. Cullen*

ATTORNEY

1

3,380,424

VESSEL ARRESTING APPARATUS

John E. Bowker, Cohasset, and Robert M. Cashman, Hingham, Mass., assignors to Continental Oil Company, Ponca City, Okla., a corporation of Delaware

Filed Mar. 17, 1966, Ser. No. 535,207

16 Claims. (Cl. 114—235)

ABSTRACT OF THE DISCLOSURE

The present invention contemplates structure for arresting for forward motion of a towed, water-borne vessel. In general the structure disclosed herein includes a water-borne vessel which is moved through the water by means of a towline affixed to a mother ship. Carried by the vessel are pivotal arresting vanes which are connected to the towline so as to move to a position to arrest the forward motion of the vessel when the tension in the towline between the mother ship and the towed vessel is reduced.

It has recently been proposed to construct large submersible cargo-carrying vessels which can effectively be towed behind a cargo ship or other suitable towing vessel, and which move through the water in a submerged status during the towing operation. Cargo transport by this method offers several advantages over surface transport, but also entails several difficulties which have not yet been overcome in an optimum manner. For example, in transporting a cargo such as crude petroleum in this manner, it has been proposed that the towed vessel shall be unmanned, and that substantially the entire available space aboard the tow be used for the accommodation of the cargo. Due to the absence of a crew on the tow, the movements of the tow must be controlled from the towing vessel. It is imperative in such control that means be provided for preventing the tow from overtaking and ramming the towing vessel if it is necessary for the latter to decelerate rapidly or make an emergency stop. A means of slowing or arresting forward movement of the tow is also desirable in order to permit effective maneuvering of the two vessels since a hard or emergency turn by the towing vessel to starboard or to port may otherwise result in the tow swinging far outside of the turning radius of the towing vessel, thereby endangering other ships in the vicinity, or docks and piers that the vessels may be approaching during a docking situation.

The present invention provides a method and apparatus for decelerating a towed vessel in automatic response to a decrease in the effective forward linear speed of the towing vessel, or stated differently, in response to a decrease in the tension applied to the towline interconnecting the two vessels. The invention may be broadly epitomized as comprising pivotally mounting a decelerating vane structure on the towed vessel for pivotation between a position in which the vane structure is feathered or has its major plane extending substantially parallel to the axis of forward thrust of the towed vessel, and decelerating positions in which the vane extends at varying angles to the direction of movement of water over the hull of the towed vessel. The vane structure as thus mounted is connected to the towline linking the tow to the towing vessel, and is made responsive in its pivotal movement to the tension in the towline so that the angle made by the vane structure with the axis of forward thrust of the tow (or with the direction of flow of water over the hull of the tow) is directly related to the tension in the towline. In general, the less the tension in the towline, the more nearly the vane structure approaches per-

2

pendicularity to the axis of forward thrust of the towed vessel and the greater becomes its decelerating or arresting effect.

The apparatus employed in practicing the method of the invention broadly comprises, in combination with the towed vessel, the towing vessel and the towline which interconnects them, a vane structure having at least one substantially flat or monoplanar surface; means movably connecting the vane structure to the towed vessel for movement between a retracted position offering minimum resistance to the flow of water over the hull of the towed vessel and a position in which said substantially monoplanar surface extends into the path of water flowing over the hull of the towed vessel; means for connecting said vane structure to the towline; and means resiliently biasing said vane structure to the retracted, minimum resistance position.

From the foregoing general description of the invention, it will have become apparent that a major object of the invention is to provide an effective method and apparatus for controlling the forward motion of the tow from a towing vessel.

Another object of the invention is to provide a method and apparatus for automatically decelerating a submerged towed vessel when the towing vessel decelerates, or when the towline interconnecting the two vessels is inadvertently parted.

A more specific object of the invention is to provide apparatus for effectively and automatically continuously controlling the rate of forward motion of a towed submersible vessel in correspondence to the tension existing in the towline by which such vessel is towed, such apparatus being relatively simple in construction and characterized in having a long and trouble-free operating life.

In addition to the foregoing described objects and advantages, additional objects and advantages will become apparent as the following detailed description of the invention is read in conjunction with the accompanying drawings.

In the drawings:

FIGURE 1 is a schematic illustration of the manner in which one embodiment of the present invention is used in combination with a towed vessel interconnecting by a towline to a towing vessel.

FIGURE 2 is a vertical sectional view through the towed vessel illustrating in greater detail one embodiment of the present invention.

FIGURE 2A is a sectional view taken along line 2A—2A of FIGURE 1.

FIGURE 3 is a horizontal sectional view taken through the stern portion of the towed vessel.

FIGURE 4 is a sectional view taken along line 4—4 of FIGURE 3.

FIGURE 5 is a sectional view taken along line 5—5 of FIGURE 4.

FIGURE 6 is a schematic illustration of another embodiment of the invention.

FIGURE 7 is a horizontal sectional view taken through the stern portion of the towed vessel illustrating details in the construction of the embodiment of the invention shown schematically in FIGURE 6.

FIGURE 8 is a view in elevation of the stern portion shown in section in FIGURE 7.

FIGURE 9 is a sectional view taken along line 9—9 of FIGURE 7.

FIGURE 10 is a schematic illustration of yet another embodiment of the invention.

FIGURE 11 is a perspective view of the stern portion of a towed vessel depicting parts of the embodiment of the invention illustrated in FIGURE 10.

3

FIGURE 12 is a side elevation of the stern portion of a towed vessel, with parts broken away to better illustrate certain elements of the embodiment of the invention shown in FIGURE 10.

FIGURE 13 is a sectional view taken along line 13—13 of FIGURE 12.

Referring to the drawings, FIGURE 1 is a schematic illustration of a towing arrangement in which a towed vessel 10 is equipped with a vessel arresting gear constructed generally in accordance with the present invention. The towed vessel is connected by a suitable towline 12 to a towing vessel 14 and is shown being towed in a submerged status beneath the surface 16 of the water. The towline 12 is passed into a free-flooding towing superstructure 22 where it is connected by a suitable shackle 24 to an operating cable 28. The operating cable 28 is passed over a sheave 30 into the hull of the towed vessel through a suitable tube or pipe 32. The cable 28 is then passed around a second sheave 34 and aft into the stern of the towed vessel where it is connected by operating means hereinafter described to a pair of arresting vanes 42 which extend outwardly from the port and starboard sides of the towed vessel. Only one of the arresting vanes 42 is visible in the side elevational view of the towed vessel 10 as depicted in FIGURE 1. The horizontal or feathered position of the arresting vane 42 is illustrated in full lines in FIGURE 1 and its arresting position is illustrated in dashed lines. A pair of vertical stabilizer fins or vanes 46 and 48 can suitably be provided on the towed vessel 10 for preventing fishtailing or yawing as the submerged vessel moves through the water.

Before proceeding to a consideration of the figures depicting in greater detail certain specific embodiments of the invention, it may be observed at this point that the contemplated operation of the invention as schematically depicted in FIGURE 1 entails the placement of the towline 12 in tension during the towing operation with the result that the tension forces are applied through the operating cable 28 to effectively pivot each of the arresting vanes 42 from the arresting position shown in dashed lines in FIGURE 1 to the feathered position of minimum hydrodynamic resistance illustrated in unbroken lines. At the time that the towing vessel 14 slackens its speed or commences an emergency or hard turn, the tension in the towline 12 is decreased with a concurrent decrease occurring in the tension in the operating cable 28. This permits the arresting vanes 42 to be pivoted to their arresting position illustrated in dashed lines in FIGURE 1 so that each arresting vane extends at an angle to the direction of flow of water over the towed vessel 10 or, stated differently, at an angle to the axis of forward motion of the towed vessel. The extent to which the arresting vanes pivot into the path of water flowing over the hull of the towed vessel 10 will depend upon the extent to which the tension in the towline 12 is reduced as a result of stopping or turning of the towing vessel 14.

FIGURES 2-5 depict in detail a specific embodiment of the present invention employing the broad principles of operation which have been described in referring to FIGURE 1. The towed vessel 10 is provided with a towing superstructure 50 which is free-flooding during the submergence of the vessel. A bow port 52 is provided in the forward upper portion of the towing superstructure 50 in general alignment with an idler roller 54 which is mounted on one side of the towing superstructure and offset from the center line of the vessel 10. Both the port 52 and roller 54 are also aligned with a hand winch 56. As illustrated in FIGURE 2A, a slot 58 interconnects the port 52 with a narrow channel 60 formed in a heavy towing block 62 located within the forward end of the superstructure 50 amidships of the vessel 10. The channel 60 is provided with flared or enlarged mouth portions 64 and 66 at each end thereof.

Extending abaft the towing superstructure 50 along the center line of the tow is a rigid rope guard 68 which

4

defines with the hull of the towed vessel 10 an elongated passageway of sufficient size to accommodate an operating cable or vane line 70. At its forward end the rope guard 68 is provided with a constriction or beehole structure 72 which closely surrounds the vane line 70 and minimizes the seepage of water from the flooded towing superstructure 50 through the rope guard passageway when the towed vessel is submerged.

Relatively close to the stern of the vessel 10 and abaft a cargo bulkhead 74, a small opening 76 is provided in the hull of the vessel and the vane line 70 is passed over a sheave 78 located in the opening. The vane line is passed inboard in the stern portion of the vessel around a second sheave 80 and is connected to one end of an operating arm 84, the function of which will be hereinafter described in greater detail.

At its forward end, the vane line 70 is secured by a suitable shackle 86 to a baled rope socket 88 which is provided on the end of the towline 90. Also shackled to the baled rope socket 88 is a messenger line 92 shown coiled down on the deck plates of the towing superstructure. A suitable stopper 94 is clamped to the forward portion of the vane line 70 between the beehole 72 and the shackle 86 to limit the distance which the vane line 70 may move aft through the rope guard 68 when slack is developed in the towline 90.

The mechanism through which the vane line 70 actuates arresting vanes provided on the towed vessel 10 is best illustrated in FIGURES 3-5. A pair of arresting vanes 96 and 97 extend outwardly from the port and starboard sides of the vessel 10 and are keyed to an elongated shaft 98 extending transversely through the stern of the vessel in the manner illustrated in FIGURE 3. The shaft 98 extends through suitable bearings 100 mounted in port and starboard stern tubes provided in the hull of the structure, and is freely rotatable in the hull.

Mounted in the stern section of the vessel are a pair of horizontally spaced, vertically extending A frames 102 which support bearing blocks 104 rotatably journaling the central portion of the shaft 98. Keyed to the shaft 98 at a central location between the A frames 102 is a two-part operating arm designated generally by reference character 84 (see FIGURE 4). The operating arm 84 is made up of a pair of complementary sections 108 and 110, each of which carries a hub 112 at one end thereof and an apertured terminal portion 113 at the other end thereof. The hub portion 112 of each of the sections 108 and 110 of the operating arm 84 carries a flange 114 having a plurality of horizontally spaced holes 116 there-through to receive suitable bolts 118 when the hubs are clamped together around the shaft 98. A pair of ring keys 120 are provided for interlocking the hubs 112 against axial movement along the shaft 98 and straight, horizontally extending keys 122 are provided to interlock the operating arm 84 with the shaft for rotational movement therewith. The vane line 70 is connected to the apertured terminal portion 113 of the section 108 of the operating arm 84 by a suitable shackle 126. A similar shackle 128 connects one end of a counterbalance line 130 to the apertured terminal portion 113 located at the end of the section 110 of the operating arm 84. The other end of the counterbalance line 130 is connected through a suitable spring 132 to a padeye 134 welded to the inner face of the hull of the towed vessel 10 opposite the keel thereof, if one is provided.

Bolted or otherwise suitably secured to the after side of each of the A frames 102 are a pair of brackets 138 which are horizontally spaced from each other and support a stop plate 140 extending athwartship in the stern section of the vessel. An adjustable stop screw 142 is passed through an aperture in the stop plate 140 at a point substantially on the center line of the vessel and in direct alignment with the terminal end portion 113 of the section 110 of the operating arm 84. The distance which the operating arm 84 is permitted to pivot, and the shaft 98

to which it is keyed to rotate, can thus be regulated by suitable adjustment of the stop screw 142.

In utilizing the embodiment of the invention depicted in FIGURES 2-5, a messenger line 92 is first shackled to the end of the towline 90 while the towline is on the towing vessel. The messenger line 92 is then led through the port 52 over the roller 54 and around the winch 56. The messenger line 92 is hauled in using the winch 56 until the baled rope socket 88 on the towline 90 has been hauled through the port 52 over the roller 54 and to a position abaft the towing block 62. The towline is then raised out of the offset guide roller 54 and is allowed to fall through the slot 58 into the channel 60 in the towing block 62. The vane line 70 is then shackled to the baled socket 88 on the towline 90 and the messenger line 92 can be made down on the deck of the superstructure 50. Towing is now ready to be commenced.

As the vessel 10 is taken in tow and is submerged, the tension increases in the towline 90 as the speed of the towing vessel increases. The result of this tensioning is to pull the vane line 70 forward so as to move the stopper 94 and baled socket 88 to the positions illustrated in FIGURE 2, and to pivot the operating arm 84 to the position illustrated in FIGURE 4 in which the apertured terminal portion 113 of the arm 110 abuts the adjusting screw 142. A suitable form of spring accumulator is preferably provided on the towed vessel 10 to prevent parting of the vane line or towline 90 due to surging or other forces resulting in excessive tension in the towline which cannot be accommodated by further rotational movement of the operating arm 84.

As the operating arm 84 is rotated counterclockwise as viewed in FIGURE 4 until one end thereof encounters the adjustable stop screw 142, the arresting vanes 96 and 97 are brought into their horizontal or feathered positions in which minimum resistance is offered to the flow of water over the hull of the towed vessel 10. In the event that the towing vessel finds it necessary to make an emergency stop or a hard turn, the tension in the towline 90 will be relieved or substantially reduced, and the spring 132 acting through the counterbalancing line 130 will pivot the operating arm 84 in a clockwise direction as viewed in FIGURE 4. This motion of the operating arm will in turn rotate the shaft 98 to which the arresting vanes 96 and 97 are keyed so as to move these vanes into the path of water flowing over the hull of the towed vessel and decelerate its forward motion. The extent to which the vanes 96 and 97 are permitted to pivot in this direction can be limited by adjusting the position of the stopper 94 on the vane line 70 so that the vane line is permitted to pass only a certain distance through the rope guard 68 before the stopper strikes the beehole 72 and further motion is stopped.

A different embodiment of the invention is illustrated in FIGURES 6-9. The general arrangement employed is schematically depicted in FIGURE 6 in which the towed vessel 150 is connected to the towing vessel (not shown) by means of a towline 152, and is provided with fixed horizontal stabilizing vanes 154 and 156, and a vertical stabilizing vane 158. A pair of arresting vanes 160, 162 are pivotally mounted on the port and starboard sides of the towed vessel 150 ahead of the stabilizing vanes 154 and 156. The arresting vanes 160 and 162 are connected by suitable control cables or vane lines 164 and 166, respectively, to the towline 152 so that the movement of the arresting vanes can be controlled in accordance with the tension in the towline. Thus, when the towline 152 is placed in tension by the forward movement of the towing vessel, the arresting vanes 160 and 162 are pivoted inwardly to the retracted, minimum resistance position illustrated in full lines in FIGURE 6. Upon a reduction in tension in the towline 152, the hydrodynamic force of the water moving over the hull of the towed vessel 150 forces the arresting vanes 160 and 162 outwardly to the dashed line positions in which the vanes offer substantially resist-

ance to the flow of water over the hull of the towed vessel, and rapidly decelerate its forward speed.

A specific arrangement of structure for actuating arresting vanes mounted in the manner schematically depicted in FIGURE 6 is shown in FIGURES 7-9. The main elements of the actuating mechanism are mounted in the stern section of the towed vessel abaft of the cargo bulkhead 170, and include a pair of padeyes 172 secured to the bulkhead, a port control cable 164 and a starboard control cable 166, each of which is dead ended by attachment to the padeyes. The port and starboard control cables 164 and 166 respectively are passed through suitable sheaves 178 mounted on the inner face of the respective port and starboard arresting vanes 160 and 162, and are lead to a pair of outboard sheaves 180. From the sheaves 180, the control cables 164 and 166 are reeved around a pair of inboard sheaves 190 disposed adjacent the center line of the vessel, and are then passed over a pair of sheaves 192 whose rotational axes are disposed at 90° to the rotational axes of the inboard sheaves 190. From the sheaves 192, the control cables 164 and 166 extend upwardly in the stern section and are connected through a spectacle clew 194 to either the towline or to a vane line 196 which passes through a rope guard 197 and interconnects the towline with the spectacle clew. A pair of turnbuckles 198 are preferably provided between the sheaves 192 and the spectacle clew 194 to permit adjustment of the length of the control cables 164 and 166 and facilitate their connection to the spectacle clew.

As will be noted in referring to FIGURES 7 and 8, each of the arresting vanes 160 and 162 is pivotally mounted in a recess 200 formed in the hull of the towed vessel 150, which recess has a forward portion complementary in configuration to the respective arresting vane. An inset hull plate 202 forms the inboard portion of each of the recesses 200 and has mounted therein a pivot pin 204 which pivotally supports the respective arresting vane. In order to accommodate pivotal movement of the arresting vanes 160 and 162, the recesses 200 are made slightly longer than the vanes, and a gap or athwartships extending space 206 is permitted to exist on the after side of the vanes when they are folded to their feathered or non-arresting positions as illustrated in FIGURE 8 of the drawings. The hull plates 202 are suitably apertured to permit the two running portions of the port and starboard control cables 164 and 166 to be passed therethrough, and it is contemplated that in this embodiment of the invention, the stern section abaft of the cargo bulkhead 170 will be free-flooding.

In the operation of the embodiment depicted in FIGURES 6-9, tension applied to the towline 152 will establish a corresponding tension in the port and starboard control cables 164 and 166 with the result that the arresting vanes 160 and 162 will be pivoted inwardly toward the hull of the towed vessel, and at full tension in the towline will be pulled into the recesses 200 so as to be flush with the hull except for the protuberant lips 207. When the tension in the towline is decreased for the reasons hereinbefore described, the hydrodynamic force of the water moving over the hull of the towed vessel 150 from the bow to the stern thereof will push against the protuberant lips 207 to pivot the arresting vanes 160 and 162 outwardly and, as the vanes continue to pivot outwardly, the hydrodynamic force will be brought to bear upon the entire inner surface of the vanes. Thus, the greater the decrease in the tension applied to the towline, the greater will become the hydrodynamic force acting on the arresting vanes, and the further they will be pivoted toward their fully extending positions from the port and starboard sides of the vessel as shown in FIGURE 7. Thus, the maximum arresting or slowing effect will be developed by the vanes when the tension in the towline is reduced by the greatest amount.

Another embodiment of the invention is illustrated in FIGURES 10-13. In this embodiment of the invention,

the arresting vanes are mounted in the vertical stabilizer 220 of the towed vessel 222. The towed vessel 222 is also provided with horizontally extending stabilizing structures 224, 226 mounted on the port and starboard sides of the vessel, respectively. The port and starboard arresting vanes 228 and 230 which open out from opposite sides of the vertical stabilizer 220 are schematically depicted in FIGURE 10. The feathered or non-arresting position of the vanes is illustrated in full lines, while the extended, arresting or decelerating position of the vanes is shown in dashed lines. As in the case of the embodiment of the invention illustrated in FIGURES 6-9, the towline 152 employed for interconnecting the towed vessel 222 to a towing vessel is connected through a pair of control cables 232 and 234 to the port and starboard arresting vanes 228 and 230, respectively.

One form of structure which can be utilized in this embodiment of the invention is illustrated in greater detail in FIGURES 11-13. A suitable rope guard 236 extends fore and aft on the hull along the center line thereof, and terminates just inside the vertical stabilizer 220. A vane line 237 utilized to interconnect the control cables 232 and 234 to the towline 152 in a manner hereinbefore described extends through the rope guard 236 into the hollow stabilizer 220 where it is passed around a first sheave 238 to one of the apertures in a spectacle clew 240. Connected to the other two apertures in the spectacle clew by shackling or other suitable means are the two control cables 232, 234.

The control cables 232 and 234 extend upwardly in the stabilizer 220 and are passed through the two sheaves 246 and 248 of a double block 250. From the sheaves 246 and 248 the control cables 232 and 234 pass over the closely adjacent sheaves of a second double block 252 which is mounted for rotation of the sheaves about a vertical axis. The control cables 232 and 234 then are passed around sheaves 256 and 258 mounted in the arresting vanes 228 and 230 respectively for rotation about vertical axes. The control cables 232 and 234 are connected at their ends to stationary structural members in the vertical stabilizer 220 as shown in FIGURES 11 and 13. The arresting vanes 228 and 230 are each mounted for pivotation about vertical pivot pins 262 positioned on opposite sides of the vertical stabilizer 222 and are configured to mate with receiving recesses or apertures 264 formed in opposite sides of the stabilizer. As will be noted in referring to FIGURE 13, when the arresting vanes 228 and 230 are folded to their feathered or non-arresting positions, they fit in the recesses 264 with their outer surfaces flush with the skin of the vertical stabilizer 220, and the only protuberance which projects outwardly from the general plane of the skin is a protuberant lip 266 formed at the forward vertical edge of each of the arresting vanes.

In the operation of the embodiment of the invention illustrated in FIGURES 10-13, the tensioning of the towline 152 results in the control cables 232 and 234 being pulled over the sheaves 246 and 248 and downwardly so as to swing the arresting vanes 228 and 230 inwardly from the dashed line positions illustrated in FIGURE 13 to the full line positions in which the arresting vanes are feathered and exert no drag or arresting effect on the towed vessel. As the tension is decreased in the towline 152, the control cables 232 and 234 are also relaxed, and the hydrodynamic force of the water moving past the skin of the vertical stabilizer 220 forces the arresting vanes 228 and 230 outwardly to a position extending substantially transversely with respect to the direction of flow of the water. Thus, the towed vessel 222 is decelerated in correspondence to the decrease in tension in the towline.

From the foregoing description of the invention, it will have become apparent that the invention provides a mechanically simple yet highly efficient means for controlling the forward movement of a towed vessel in response to the tension which exists in the towline inter-

connecting the towed vessel with a towing ship. The response of the arresting vanes to changes in the tension of the towline is automatic, and the simplicity of the structure requires minimum maintenance and assures relatively few operational failures.

Although several embodiments of the invention have been described in order to provide examples of several ways in which the invention can be practiced, it is to be understood that various modifications in the structure described and the steps of the method followed in using the invention can be effected without departure from the basic principles which underlie the invention. For example, although by way of illustration the invention has been described as it can be applied to a tow which normally operates in a submerged status, the invention is equally applicable to a surface vessel under tow, with the primary modification required in such case being the location of the arresting vanes in a position on the hull of the towed vessel such that resistance to the flow of water over the hull will be offered by such vanes when they are pivoted from a feathered to an arresting position by a decrease of tension in the towline. All such modifications and changes in the structure described which continue to rely upon the fundamental principles of the invention as herein enunciated are deemed to be circumscribed by the spirit and scope of the invention except as the same may be necessarily limited by the appended claims or reasonable equivalents thereof.

What is claimed is:

1. In combination with a towed vessel, a towing vessel and a towline interconnecting the two vessels, arresting vane means on said towed vessel including at least one arresting vane pivotally mounted on said towed vessel for pivotation between a first position in which the vane structure is feathered with its major plane extending substantially parallel to the axis of forward movement of the towed vessel, and other positions in which the major plane of the arresting vane extends at various angles to the axis of forward movement of the towed vessel and to the direction of movement of water over the hull of the towed vessel; means movably receiving said towline and leading said towline on a path which is athwart said axis of forward movement for connection to said arresting vane means such that said vane means is retained in said first position by towline tension.

2. The combination defined in claim 1 wherein said towline and means receiving it comprises:

a main towline;

a vane line connected to said main towline and extending aft on the towed vessel;

means connecting said two line to said arresting vanes; and

means cooperating with said vane line and connecting means for changing the forwardly acting force applied to said vane lines by said towline to a moment of force acting on said vane to pivot said vanes about their axes toward said first position in which said vanes are feathered.

3. A submersible cargo-carrying vessel for movement by towline comprising:

a hull structure having a fore-and-aft centerline;

an arresting vane pivotally carried by said hull structure for pivotation between (1) a feathered position in which the major plane of said arresting vane extends substantially parallel to the fore-and-aft centerline of the hull structure and (2) positions in which the major plane of said arresting vane extends at various angles to fore-and-aft centerline of the hull structure and to the direction of movement of water over the hull structure of the towed vessel; and

first means movably retained within said hull structure for positive connection to said towline; and

second means movably receiving said first means and leading said first means on a path which is athwart

said axis of forward movement for connection to said arresting vane such that it is retained in said feathered position by towline tension.

4. A submersible cargo-carrying vessel as defined in claim 3 wherein a pair of said arresting vanes are provided on opposite sides of said hull structure; and said first and second means each comprise a pair of means connecting said towline to a respective one of said arresting vanes.

5. A submersible cargo-carrying vessel as defined in claim 3 wherein said first and second means comprises at least one vane line interconnecting said arresting vane and towline; and

at least one sheave supporting and facilitating change of the direction of extension of said towline.

6. A submersible cargo-carrying vessel as defined in claim 3 wherein arresting vanes are provided on the port and starboard sides of said hull structure; and said vessel is further characterized to include

a horizontal shaft extending athwartships and rotatably through said hull structure and having one of said arresting vanes keyed to each end of said shaft outboard of said hull structure.

7. A submersible cargo-carrying vessel as defined in claim 3 wherein arresting vanes are provided on the port and starboard sides of said hull structure, and said hull structure is recessed on the port and starboard sides thereof for positioning said vanes in said recesses when in the feathered position; and said vessel is further characterized to include:

vertically extending pivot pins journaled in said hull structure adjacent the after side of each of said recesses and each pivotally supporting one of said vanes.

8. A submersible cargo-carrying vessel as defined in claim 3 and further characterized to include a stabilizing element extending outwardly from said hull structure adjacent the stern thereof and having a major plane in coincident alignment with a plane containing the fore-and-aft center line of the hull structure;

and wherein arresting vanes are pivotally mounted in recesses in opposite sides of said stabilizing element for pivoting movement between positions in which said arresting vanes are housed in said recesses, and positions in which said vanes extend outwardly at an angle to the major plane of said stabilizing element.

9. A submersible cargo-carrying vessel as defined in claim 6 and further characterized to include an elongated control arm keyed to said shaft intermediate the length thereof, said control arm having end sections spaced from the axis of said shaft on opposite sides of the shaft; and resilient counterbalancing means are connected to one of said end sections and resiliently biasing said arm and shaft in rotation to move the vanes keyed to said shaft to an arresting position in which said vanes each extend at an angle to the fore-and-aft center line of said hull structure;

and wherein said first and second means includes a vane line attached by one of its ends to the other end section of said control arm; and means for connecting the other end of said vane line to a towline.

10. A submersible cargo-carrying vessel as defined in claim 7 wherein said first and second means includes: sheaves mounted in each of said arresting vanes; and a pair of flexible control cables each having one end secured to said hull structure and the other end adapted to be connected to a towline, said control cables each extending around one of said sheaves in the respective arresting vanes for drawing the vanes into their respective recesses when said control cables are pulled in response to an increase in the tension of a towline to which they are connected.

11. A submersible cargo-carrying vessel as defined in claim 8 wherein said first and second means for interconnecting said arresting vane to a towline, includes sheaves mounted in said vanes; and

a control cable having a bight portion extending between and around the sheaves and the arresting vanes; and

means for connecting both ends of the control cable to a towline.

12. In combination with a towed vessel, a towing vessel and a towline interconnecting the two vessels;

arresting vane means on said towed vessel including at least one arresting vane pivotally mounted on said towed vessel for pivotation between a first position in which the vane structure is feathered with its major plane extending substantially parallel to the axis of forward movement of the towed vessel, and other positions in which the major plane of the arresting vane extends at various angles to the axis of forward movement of the towed vessel and to the direction of movement of water over the hull of the towed vessel;

arresting vane control means interconnecting said arresting vane and said towline and responsive to variations in the tension in said towline to pivot said vane between said positions;

a shaft extending through the stern of the towed vessel in an athwartships direction and rotatably journaled in the hull of the towed vessel, said shaft having one of said arresting vanes keyed to each end thereof outboard of the towed vessel; and

a control arm keyed to the central portion of said shaft and having a pair of end sections spaced radially from said shaft with one of said end sections being connected to said arresting vane control means.

13. In combination with a towed vessel, a towing vessel and a towline interconnecting the two vessels;

arresting vane means on said towed vessel including at least one arresting vane pivotally mounted on said towed vessel for pivotation between a first position in which the vane structure is feathered with its major plane extending substantially parallel to the axis of forward movement of the towed vessel, and other positions in which the major plane of the arresting vane extends at various angles to the axis of forward movement of the towed vessel and to the direction of movement of water over the hull of the towed vessel;

arresting vane control means interconnecting said arresting vane and said towline and responsive to variations in the tension in said towline to pivot said vane between said positions; and

a vertically extending stabilizer vane mounted on the stern of said towed vessel and having said arresting vanes pivotally mounted on opposite sides thereof, said stabilizer vane having recesses in the port and starboard side thereof for accommodating the arresting vanes when they are pivoted to their arresting positions.

14. In combination with a towed vessel, a towing vessel and a towline interconnecting the two vessels;

arresting vane means mounted on said towed vessel including at least one arresting vane pivotally mounted on said towed vessel for pivotation between a first position in which the vane structure is feathered with its major plane extending substantially parallel to the axis of forward movement of the towed vessel, and other positions in which the major plane of the arresting vane extends at various angles to the axis of forward movement of the towed vessel and to the direction of movement of water over the hull of the towed vessel; and

arresting vane control means interconnecting said arresting vane and said towline and responsive to variations in the tension in said towline to pivot said

11

vane between said positions, said arresting vane control means comprising:

a vane line connected to said towline and extending aft on the towed vessel;

means connecting said vane line to said arresting vanes, said connecting means comprising at least one control cable reeved around the sheaves hereinafter defined, and connected to said vane line for pivotally drawing said vanes toward the hull of said towed vessel as said towline and vane line are placed in tension; and

means cooperating with said vane line and connecting means for changing the forwardly acting force applied to said vane line by said towline to a moment of force acting on said vanes to pivot said vanes about their axes toward said first position in which said vanes are feathered, said cooperating means comprising sheaves mounted in the stern position of the towed vehicle and in said vanes.

15. In combination with a towed vessel, a towing vessel and a towline interconnecting the two vessels;

arresting vane means on said towed vessel including at least one arresting vane pivotally mounted on said towed vessel for pivotation between a first position in which the vane structure is feathered with its major plane extending substantially parallel to the axis of forward movement of the towed vessel, and other positions in which the major plane of the arresting vane extends at various angles to the axis of forward movement of the towed vessel and to the direction of movement of water over the hull of the towed vessel;

arresting vane control means interconnecting said arresting vane and said towline and responsive to variations in the tension in said towline to pivot said vane between said positions, said arresting vane control means comprising:

a vane line connected to said towline and extending aft on the towed vessel;

means connecting said vane line to said arresting vanes; and

means cooperating with said vane line and connecting means for changing the forwardly acting force applied to said vane line by said towline to a moment of force acting on said vanes to pivot said vanes about their axes toward said first position in which said vanes are feathered;

a towing superstructure positioned topside and gener-

12

ally forward on the hull of said towed vessel, said towing superstructure having a forward bulkhead and a port in said forward bulkhead offset from the center line of the towed vessel;

a slotted towing block within the forward portion of said towing superstructure and having a fore and aft slot aligned with the center line of the towed vessel; channel means in said forward bulkhead placing said port in communication with the slot in said towing block;

winch means in said superstructure abaft said towing block and aligned with said port; and

a rope guard extending aft from said towing superstructure and forming a protective enclosure for said vane line.

16. The combination defined in claim 14 wherein said towed vessel is submersible; and said combination is further characterized to include:

a towing superstructure positioned topside and generally forward on the hull of said towed vessel, said towing superstructure having a forward bulkhead and an after bulkhead and having a port in said forward bulkhead and offset from the center line of said towed vessel, and further having a channel in said forward bulkhead communicating with said port and extending to the plane of the center line of the towed vessel;

a slotted towing block within the forward portion of said towing superstructure adjacent the forward bulkhead thereof and aligned with the center line of the towed vessel, said towing block having a slot extending fore and aft therethrough and communicating with the channel in said forward bulkhead, said slot in said towing block receiving said towline;

winch means in said towing superstructure abaft said towing block and aligned with said port;

a rope guard extending aft from said towing superstructure and enclosing said vane line; and means connecting said vane line to said towline.

References Cited

UNITED STATES PATENTS

727,175	5/1903	Miller	114—209
2,586,003	2/1952	Caslor	114—235 X
3,159,806	12/1964	Piasecki	114—235 X

MILTON BUCHLER, *Primary Examiner*.

TRYGVE BLIX, *Examiner*.