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(54) Integrated towboat system

(57) The invention provides an integrated tow boat system including a tow boat, said system further including a powered bow unit module operable by remote control, a navigation bridge equipment module, and a control telemetry module. The powered bow-module (boat)

(1) equipped with propellers (30) and steering aids in conjunction with a powered push boat (3) is particularly advantageous for moving barges with goods on water. An outstanding feature of the system is the integrated control of all the propulsion and steering machinery of the two boats through radio communication.

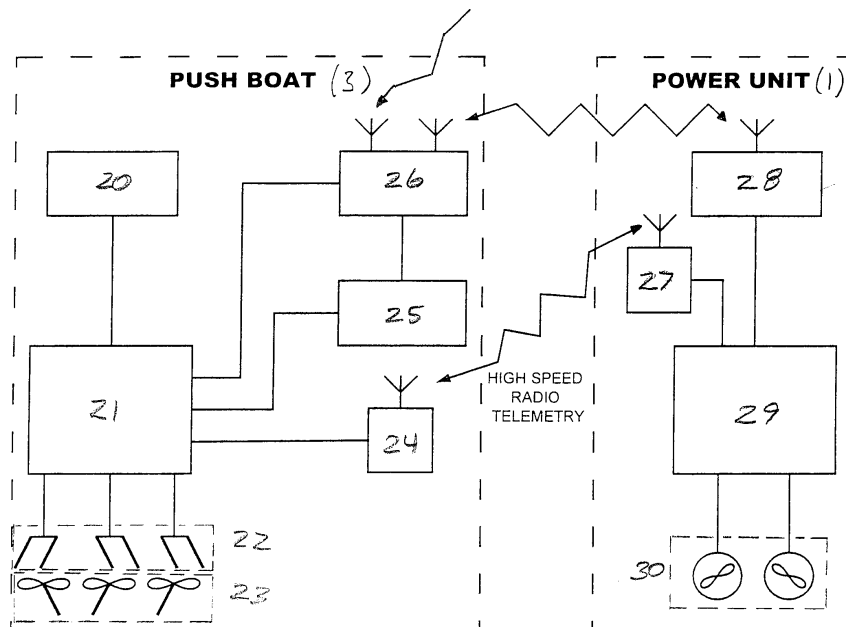


Fig. 7

Description

FIELD OF THE INVENTION.

[0001] The present invention relates to the field of towboats, and particularly to such systems for manoeuvring and hauling barges on waterways.

THE PROBLEM AREAS.

[0002] Freight rates for this market vary widely, depending on conditions. However, revenue is generally lower than earned in the 1970s. Boat operators have creatively slashed costs to realise a profit. The industry is experiencing difficulties recruiting young people who can be trained to be the boat captains of the future. Increasingly, boat companies are being consolidated into a few large companies. Equipment is being operated as efficiently as the industry knows how to do this. As these boat designs have not changed dramatically in 40+ years, and they operate in fresh water, replacing worn out equipment is the norm and new boat building is the exception.

[0003] Revenue from backhauls is a new market. The United States Coast Guard (USCG) estimates that the ports in the USA will double or triple by 2020. Towboat companies need to plan for this.

KNOWN SOLUTIONS AND PROBLEMS WITH THESE.

[0004] Manoeuvring the tow into the desired position is not only practical but may facilitate building or breaking up the tow or may make possible safer traffic separation in restricted channels

[0005] Tows are manoeuvred by steering and propulsion located at the extreme end of the tow. Consequently, the tow must be headed into and tied off to moored barges or willow trees on the bank.

[0006] Flanking a tow southbound range from 3-4 flankings per trip to 1-2 flankings per watch. Flanking a turn is a factor of size of tow, towboat power, towboat weight, river conditions, and operator judgement. The result of flanking is the tow takes longer to go downriver, and the relative cost of operating the towboat increases if it completes less trips that generate revenue per year.

BRIEF DESCRIPTION OF THE INVENTION.

[0007] The integrated towboat system of the present invention is based around a powered and remotely operated unit, along with a control system, which can be placed anywhere in a tow and is fully controlled without cables. This arrangement is applicable for operating on any river with a towboat, which preferably is adapted to the control system.

[0008] The invention provides a an integrated tow boat system comprising a powered bow-module (boat)

equipped with propellers and steering aids in conjunction with a powered push boat. The system is particularly advantageous for moving barges with goods on water. An outstanding feature of the system is the integrated control of all the propulsion and steering machinery of the two boats through radio communication.

[0009] The integrated towboat system according to the invention is identified by the features presented in the accompanying independent patent claim 1. Other advantageous features of the invention are presented in the accompanying dependent patent claims 2 - 5.

BRIEF DESCRIPTION OF THE DRAWINGS.

[0010]

Figure 1 is a side view of an exemplary powered bow unit;

Figure 2 is a plan view of the exemplary powered bow unit of fig. 1;

Figure 3 is a plan view illustration of a system according to the invention making upstream slow turn to port;

Figure 4 is a plan view illustration of a situation with a system according to the invention performing crash stop at upstream voyage;

Figure 5 is a plan view illustration of a powered bow unit of the invention manoeuvring a single barge relative to the tow;

Figure 6 is a plan view illustration of a situation with a system according to the invention performing crash stop at downstream voyage;

Figure 7 is a block schematic drawing of the configuration of the overall integrated towboat system according to the invention;

Figure 8 is a schematic overview illustrating the overall integrated tow boat system according to the invention; and

Figure 9 is an in part plan view of the overall integrated tow boat system according to the invention on a voyage on a river illustrating exemplary paths followed by the drive units.

DETAILED DESCRIPTION OF EMBODIMENTS.

[0011] In the following the invention will be explained in more detail by way of example, and with reference to the accompanying drawings.

[0012] The Integrated Towboat Concept consists mainly of three equipment modules, namely the Navi-

gation Bridge Equipment module, the Powered Bow Unit module and the Control Telemetry module. Each module represents a stand-alone system part that allows the boat operator to build upon each other to provide the vessel sophistication desired.

[0013] When underway, the computer is configured to use the minimum thruster and rudder angle that is required to accomplish desired course changes. This reduces the tow train's drag that is related to steering, and the steering corrections that are the result of operator over and under steering.

[0014] The powered unit is a unit consisting of two-drive propulsion system, steering system and wireless communication system. The system can be operated locally or remotely. When operated remotely, unit becomes part of the main drive unit (the push boat). This is a totally new method of operating a tow as it incorporates the barges into an integrated power tow. This integrated tow is handled as one entity by a unique integrated tow controller that achieves superior steering and propulsion.

[0015] The effective control of two thrusters, two or three propellers, four or five diesel governors, and four to six independent rudders against external forces, due to current and wind, exceeds the ability of the human operator. Therefore, an intuitive joystick is used, a single lever by which the desired force, and its direction, and the yawing moment can be chosen. The joystick's computer calculates the required thrust of propellers and thrusters, and the angle of thrusters and rudders. The joystick aids the operators to accomplish manoeuvres that were not possible before the integrated tow.

[0016] Rudder control is determined by the operator's estimation of the amount of rudder that is required to start or stop a turn, and is based upon what the operator sees on his rate of turn indicator (rate gyro).

[0017] The computer may also be configured to select the optimum Revolutions per minute(rpm) settings for each of the towboat and bow unit's engines when stopping or accelerating the integrated tow into and out of turns. Thus, the joystick controls can significantly decrease fuel burn. Typically, operators operate by pushing the throttle to the rack (limit) or putting the towboat in reverse. The joystick's computer calculates the required thrust of propellers and thrusters, and the angle of thrusters and rudders.

[0018] This system is capable of calculating the required thrust and angles as will cause the integrated tow to perform differently on the lower parts of the water-course. Operators control their tow, as they know how to do it. Some are more skilful than others.

[0019] The joystick aids the operators in bringing the tow upriver in less time and by burning less fuel. Fuel burn is a function of how often the throttles are put to the rack and how often the rudders are moved off of the centreline position.

[0020] Reversing the direction of propeller rotation stops a towboat. The integrated tow is stopped by re-

versing direction of the propeller rotation on the towboat and by diverting each outboard propeller race outwards, one port and the other starboard. Operators now stop the tow by reversing engines and working the flanking rudders to maintain heading against propeller torque and river current.

[0021] Hence, the system according to the invention to a large degree eliminates the need to push the tow into the bank, thereby reducing wear and possible damage to the barges.

[0022] Holding the tow in this position enables assist tug to work both sides of the tow and possibly cut transit times to and from the barge fleet. Tows are now worked from one side then must be turned to work the other side. As a result, this take more time and the cost of the assist tug on charter is longer.

[0023] The effective thrust generated by the bow unit and towboat is roughly equal to that which is produced by a single towboat having the same horsepower of the integrated tow. Thus, the integrated tow is able to increase the back haul load above that of a single towboat.

[0024] The increased stopping and flanking ability benefits will now be explained. When flanking, the integrated tow will be able to more closely approach the apex of the turn before reducing speed to current velocity. Flanking starts further upriver, thereby increasing the elapse time to resume running ahead.

[0025] The powered unit of the integrated towboat system according to a preferred embodiment of the invention will now be explained with reference to figures 1 and 2. The powered unit is a unit consisting of two-drive propulsion system, steering system and wireless communication system. The system can be operated locally or remotely. When operated remotely, unit becomes part of the main drive unit (the push boat). This allows a totally new method of operating a tow as it incorporates the barges into an integrated power tow. This integrated tow is handled as one entity by a unique integrated tow controller that achieves superior steering and propulsion.

[0026] Regarding upstream heavy tow configuration and principle, the integrated tow is used to increase back-haul capacity, improve steering through turns, create effective manoeuvrability, and maximise fuel economy.

[0027] Now, the integrated tow controls will be explained. The effective control of two thrusters, two or three propellers, four or five diesel governors, and four to six independent rudders against external forces, due to current and wind, exceeds the ability of the human operator. Therefore, an intuitive joystick is used, a single lever by which the desired force, and its direction, and the yawing moment can be chosen. The effect upon the integrated tow's control surfaces corresponds to the selection of control parameters by the operator. When underway, the computer is configured to use the minimum thruster and rudder angle that is required to accomplish desired course changes. This reduces the tow train's

drag that is related to steering, and the steering corrections that are the result of operator over and under steering. The computer may also be configured to select the optimum rpm settings for each of the towboat and bow unit's engines when stopping or accelerating the integrated tow into and out of turns. Thus, the joystick controls can significantly decrease fuel burn. The joystick's computer calculates the required thrust of propellers and thrusters, and the angle of thrusters and rudders. This system is capable of calculating the required thrust and angles as will cause the integrated tow to perform differently on the lower parts of the watercourse. The joystick aids the operators in bringing the tow upriver in less time and by burning less fuel. The joystick aids the operators in manoeuvring the tow in a manner, which may reduce turn around time. The joystick aids the operators to accomplish manoeuvres that were not possible before the integrated tow.

[0028] Improve steering benefits of the invention are now elucidated. The maximum steering force that the bow unit exerts upon the integrated tow is typically more than 50% higher than that which a conventionally powered pushboat of equal horsepower will produce. The bow unit is able to achieve higher steering forces at smaller thruster angles; therefore, the tow's speed loss due to steering is less. The remaining net thrust of the bow unit is greater, and the resultant skidding around a turn is dramatically reduced. Thus, the integrated tow is able to negotiate turns more quickly and create opportunities to avoid being held up for downstream traffic. The benefits realised are a decrease in transit time and a reduction of fuel burned for the upstream leg.

[0029] To illustrate the manoeuvring benefits of a system according to the invention, the integrated tow's "slow- turn- to- port" benefits of the invention are now elucidated with reference to figure 3. Figure 3 illustrates the forces applied to the tow when performing slow turns to port. Element 1 in this figure illustrates the new bow-unit with propulsion equipment to be integrated in the tow. Elements 2 and 3 illustrates the existing unit as of today, being the payload (barges) and push boat, respectively.

[0030] Benefits of creating effective manoeuvrings in a system according to the invention are now elucidated. Strictly speaking, the word manoeuvring includes all other conditions of operation with and beyond running ahead or astern at a constant speed and on a straight course. Reversing the direction of propeller rotation stops a towboat. The integrated tow is stopped by reversing direction of the propeller rotation on the towboat and by diverting each outboard propeller race outwards, one port and the other starboard. This is accomplished by flaring independently controlled flanking rudders. Additionally, the bow unit applies powerful braking forces by rotating the two thrusters outwards to a position slightly forward of 90° until the speed drops. Rotating the thrusters to the bow maximises thereafter-thruster braking forces.

[0031] Referring to figure 4, Crash Stop Upstream Configuration will be explained. Figure 4 illustrates the forces to be applied to the tow when performing crash stop at upstream voyage. Element 1 is still the new bow-unit to be developed, and the allocation of forces in the integrated system represent a new and improved method of performing emergency crash-stop of a tow of such a size. Element 2 represents the actual tow, payload (barges) and element 3 is the push boat.

[0032] Now, create effective manoeuvrings benefits will be elucidated. When the tow is holding in the current below a turn awaiting southbound traffic, or when building a tow, the integrated tow will be able to maintain heading and position in the stream. This ability is a function of the Intuitive Joystick that requires little operator input. Eliminates the need to push the tow into the bank, thereby reducing wear and possible damage to the barges. Holding the tow in these position enables assist tugs to work both sides of the tow and possibly cut transit times to and from the barge fleet.

[0033] Back-haul capacity increase benefits of a system according to the invention will be elucidated. The effective thrust generated by the bow unit and towboat is roughly equal to that which is produced by a single towboat having the same horsepower of the integrated tow. Thus, the integrated tow is able to increase the back haul load above that of a single towboat. The barge that is lashed to the bow unit must be an empty in an upstream tow. The deep draft of a loaded barge made up directly behind the bow unit will adversely affect the propeller's slipstream and result in a thrust deduction.

[0034] Referring to figure 5, working the tow in a system according to the invention will now be explained. The integrated tow may easily be moved sideways by way of the powered bow unit and/or the pushboat/towboat. Manoeuvring of the tow into the desired position is not only highly practical, but can facilitate building or breaking up the tow from either side, and can make possible safer traffic separation in restricted channels. Figure 5 illustrates the use of working tugs 4, 4', any of which can be replaced by an additional powered bow unit of the invention, working the tow to build or break up a tow. Elements 4,4' illustrate the working tugs, each manoeuvring a single barge (element 2', 2'') relative to the tow. This method offers simplified, more efficient and safer building and breaking up of tows than what is possible with existing methods.

[0035] Downstream heavy tow configuration and principle is now elucidated.

The integrated tow is used to increase tonnage capacity, improve steering, reduce flanking, and improve safety. In the following, Improvements to Steering Downstream is explained. The ability to move loaded barges downriver is heavily dependent upon the towboat's ability to steer through turns and bridge piers. The integrated tow fully utilises the advantages of its bow unit. Conventional steering procedures require the tow to slide laterally to negotiate turns, as the ratio of stern lateral movement

to that of the leading barges is approximately three-to-one. The consequences of operating in this manner contribute to the techniques and rules-of-the-road that has evolved toward bringing a tow down-river. The integrated tow redefines many of these techniques in a way that applied technology enhance the pilot's ability to perform his job more safely. The integrated tow steers better than conventional tows because it places steering and thrust in front of the tow. The integrated tow's bow unit utilises two Azimuthing Thrusters to move the tow's pivot point forward and to develop sufficient thrust to push the head of the tow through the turn. This allows the operator to slow steer through more bends, even with larger tow sizes. The steering force that the bow unit exerts upon the integrated tow is typically more than 50% higher than that which a conventionally powered pushboat of equal horsepower could produce. As the bow unit is able to achieve higher steering forces at smaller thruster angles; and as this results in less speed loss due to steering drag, the progression of skidding around a turn is dramatically reduced. Consequently, the integrated tow is able to negotiate more turns using the smaller engines of the bow unit as the tow's primary power, thereby reducing fuel consumption of the tow for the southbound trip...and doing it in less time. Many collisions that damage and sink barges are the result of the operator failing to set his tow properly as he attempts to pass under bridge spans. The added steering of the integrated tow and the greater control that is available to the operator will allow him to set up more quickly and make minor corrections as is required. Giving the pilot a more responsive tow is the best way to decrease the risk of collision with bridges.

[0036] In the following, Increased Stopping and Flanking Ability is further explained. Perhaps, some bends require the tow to be flanked. The integrated tow will be able to approach the bend and stop faster. When stopping the tow or reducing the tow's speed below current velocity, the integrated tow is braked by backing down on the towboat's propellers and by diverting each outboard propeller race outwards, one port and the other starboard, by flaring the flanking rudders. Additionally, the bow unit applies powerful braking forces by rotating the two thrusters outwards to a position slightly forward of 90° until the speed drops, then rotating the thrusters toward the bow. Manoeuvring Azimuthing Thrusters in this manner is called Transverse Arrest, and the flanking forces that are applied are 50 -300% higher than what may be achieved with a conventionally powered bow unit. The ability to stop the tow more quickly and either maintain or change heading simultaneously--for whatever the reason is, by itself, a very important safety consideration when this concept is being evaluated. When flanking, the integrated tow will be able to more closely approach the apex of the turn before reducing speed to current velocity. The integrated tow will flank through the turn faster because the barge train is not relying solely on the current to move the head of tow

around the bend. The additional power of the integrated tow will allow the tow to power out of the turn into a smooth and prompt transition back to running ahead. Accordingly, flanking an integrated tow will be accomplished in less time, with more control, and with less fuel burn than is now possible using existing equipment.

[0037] Referring to figure 6, crash stop downstream aspects are now elucidated. Figure 6 illustrates the forces to be applied to the tow when performing crash stop at upstream voyage. Element 1 is the new bow-unit to be developed, and the allocation of forces in the integrated system represent a new and improved method of performing emergency crash stop of a tow of such a size. Element 2 represents the actual tow, and element 3 is the push boat.

[0038] An integrated tow boat system according to the invention provides improved system efficiency. The Integrated controls will control all thrusters, rudder angles, and engine speeds using only the output that is necessary to maintain optimal control without over correcting the tow. This additional control capability enables the tow to be run closer to the bends therein-taking advantage of the stronger currents. The net results will be higher tow speeds without additional fuel burn.

[0039] Now follows a system description of an integrated towboat system according to the invention. The Kongsberg Simrad Integrated Towboat Concept consists of 3 equipment modules. Each is a stand-alone system that allows the boat operator to build upon each other to provide the vessel sophistication desired.

[0040] Module #1 constituting the Navigation Bridge Equipment can present the following features:

- Intuitive Joystick Control System, Planning station with auto-track, Universal Automatic Identification System(UAIS) system and Differential Global Positioning System(DGPS).
- Intuitive Joystick Control System applies information from company in order to implement optimum fuel burn for each tow
- Simplifies operation of all control surfaces into single joystick control.
- Planning station with auto-track will let the company perfect optimal routes and allow operators to customise route to individual preference. (Manual override)
- Real time bottom information, look ahead function, and under keel clearance is displayed on planning station
- UAIS (VTS carriage regulation) integrated into system
- Communication between (commercial carrier) vessel and central office
- DGPS information

[0041] Module #2 constituting the Powered Bow Unit can present the following features:

- Azimuthing Z-drive equipped powered bow unit
- Controlled with Intuitive Joystick Control System with manual override
- Electrical power for navigation lights and other equipment
- Bow module control parameters sent to Navigation Bridge for distribution to engineers control station

[0042] Figure 7 shows a block diagram illustrating the configuration of the overall system in an embodiment of the invention.

[0043] Referring to figure 7, the push boat unit of an integrated tow system according to the invention is the existing tug used for pushing the tow up and down the river. An exemplary towboat is illustrated in this figure (7). Traditionally, this unit typically is equipped with propellers with rudders (element 23), as well as the flanking rudders (element 22). These have been operated manually by the aid of levers, but when part of the integrated towboat system according to the invention, a single joystick will operate these propulsion devices. In addition units to facilitate the wireless communication with, and control of, the new powered bow-unit have been added. All these units together make up the complete integrated towboat system. The numbered elements on the push boat illustrated in figure 7 signifies the following units:

- 20 Operator Terminal with joystick
- 21 Kongsberg Simrad thruster control unit
- 22 Flanking rudders
- 23 Propellers with rudders
- 24 Transponder/Receiver for High-speed telemetry
- 25 Simrad Planning Station, used for voyage monitoring and route planning
- 26 Seatex receiver for reference system (GPS)

[0044] The power unit is the new unit to be integrated to the system. In addition to the unit, this section consists of the following elements: (the numbering refers to the numbering on fig. 7):

- 27 Transponder/Receiver for High-speed telemetry;
- 28 Seatex transponder for reference system (GPS);
- 29 Kongsberg Simrad thruster control unit;
- 30 360 degrees routable thrusters.

[0045] Referring to figure 8, a schematic overview illustrates of the overall system is shown. Element 1 is the new powered bow-unit, 2 is the tow payload including a number of barges, 3 is the push boat unit, 20 - 29 are the units making up the automated control system, and 40 illustrates a satellite of a satellite based positioning system used for navigational purposes.

[0046] In figure 9 is shown an example of the overall system on voyage on a river, with the main elements 1, 2 and 3 representing the main elements of a tow with the integrated towboat system according to the invention, and element 40 is a satellite of a satellite based

positioning system used for navigation.

[0047] Module #3 constituting the Control Telemetry can present the following features:

- 5 • Global Positioning System(GPS) position information
- Continuous operation under bridges
- Heading
- Rate of turn information
- 10 • UAIS
- Telemetry communication between Bow Unit and Towboat
- No cables on barges
- Radio telemetry between bow module and Navigation Bridge.
- 15 • Telemetry handles all information between bow module and Navigation Bridge.
- Telemetry eliminates need for labor intensive and high maintenance cabling.
- 20 • DGPS information sent to bridge.

[0048] Rate of turn information and Heading Information.

Claims

1. An integrated tow boat system including a tow boat, said system further including:
 - 30 a powered bow unit module operable by remote control,
 - a navigation bridge equipment module, and
 - a control and telemetry module in communication with a positioning system.
2. The integrated tow boat system of claim 1, wherein said towboat and powered bow unit are adapted to be arranged on opposite sides of a tow payload.
3. The integrated tow boat system of claim 1, wherein said powered bow unit module includes at least one of:
 - 45 an Azimuthing Z-drive means,
 - a control means adapted to be Controlled with Intuitive Joystick Control System with manual override,
 - electrical power means for navigation lights and other equipment,
 - a parameter transmission means for sending bow module control parameters to navigation bridge for distribution to engineers control station,
 - 50 a 360 degrees rotatable thruster,
 - a Transponder/Receiver for High-speed telemetry,
 - a transponder for a reference system for the

Global Positioning System (GPS), and
a thruster control unit.

4. The integrated tow boat system of claim 1, wherein
said navigation bridge equipment module includes
at least one of: 5

an Intuitive Joystick Control System means for
applying information from a tow boat company,
a Planning station means with auto-track pro- 10
visions,
a Universal Automatic Identification System
(UAIS) system means, and
a Differential Global Positioning System
(DGPS) means. 15

5. The integrated tow boat system of claim 1, wherein
said control telemetry module includes at least one
of: 20

a Global Positioning System (GPS) position in-
formation means,
a Rate of turn information and Heading Infor-
mation providing means,
a UAIS means, and 25
a means for Telemetry communication between
Bow Unit and Towboat.

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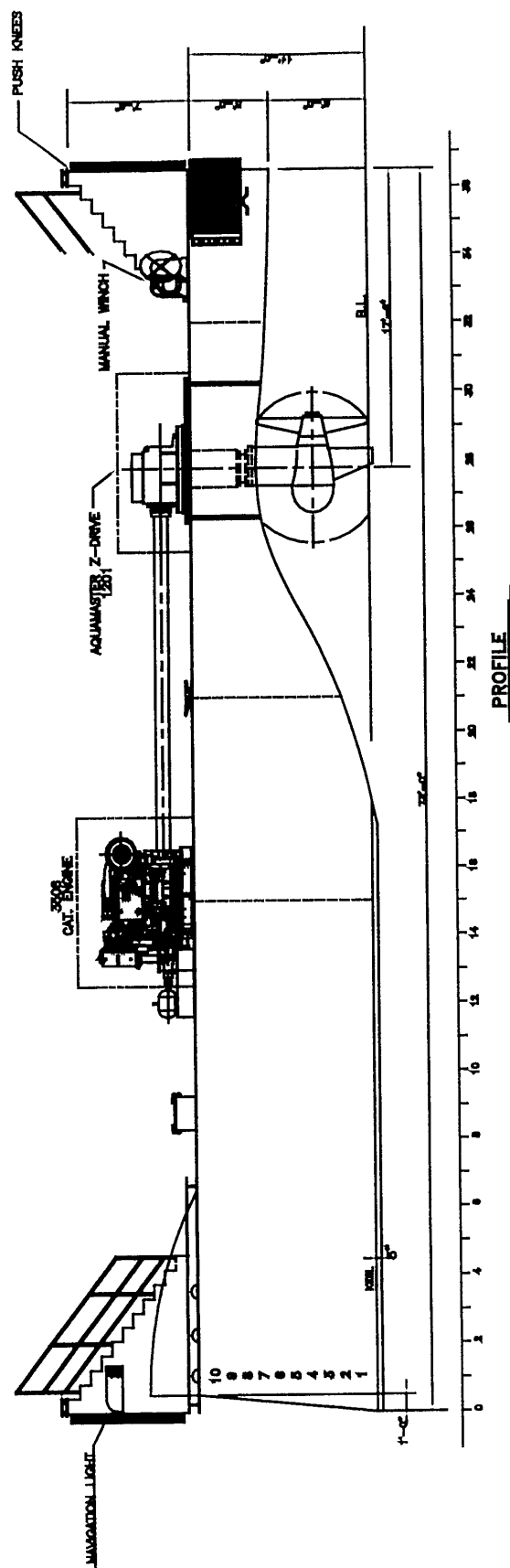


Fig. 1

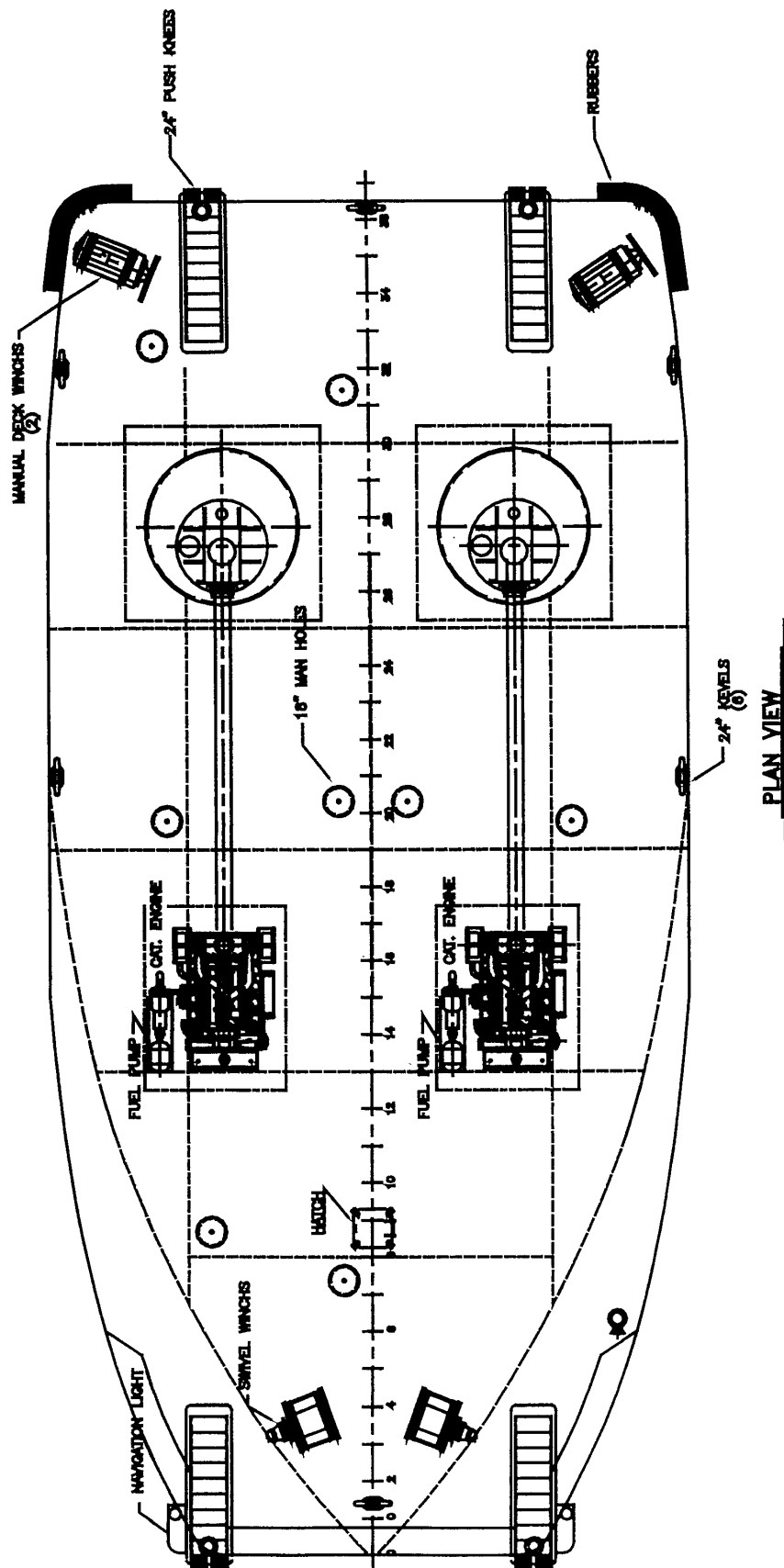


Fig. 2

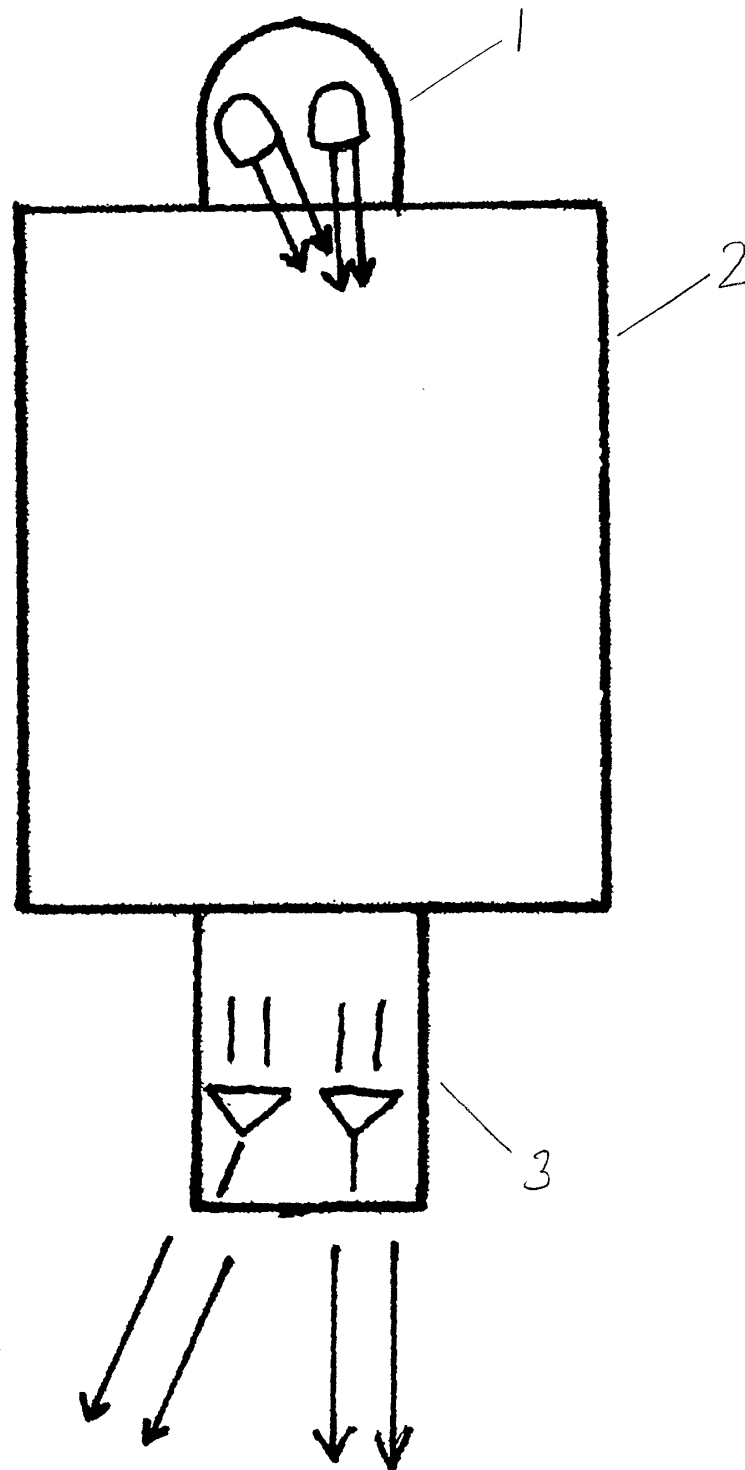


Fig. 3

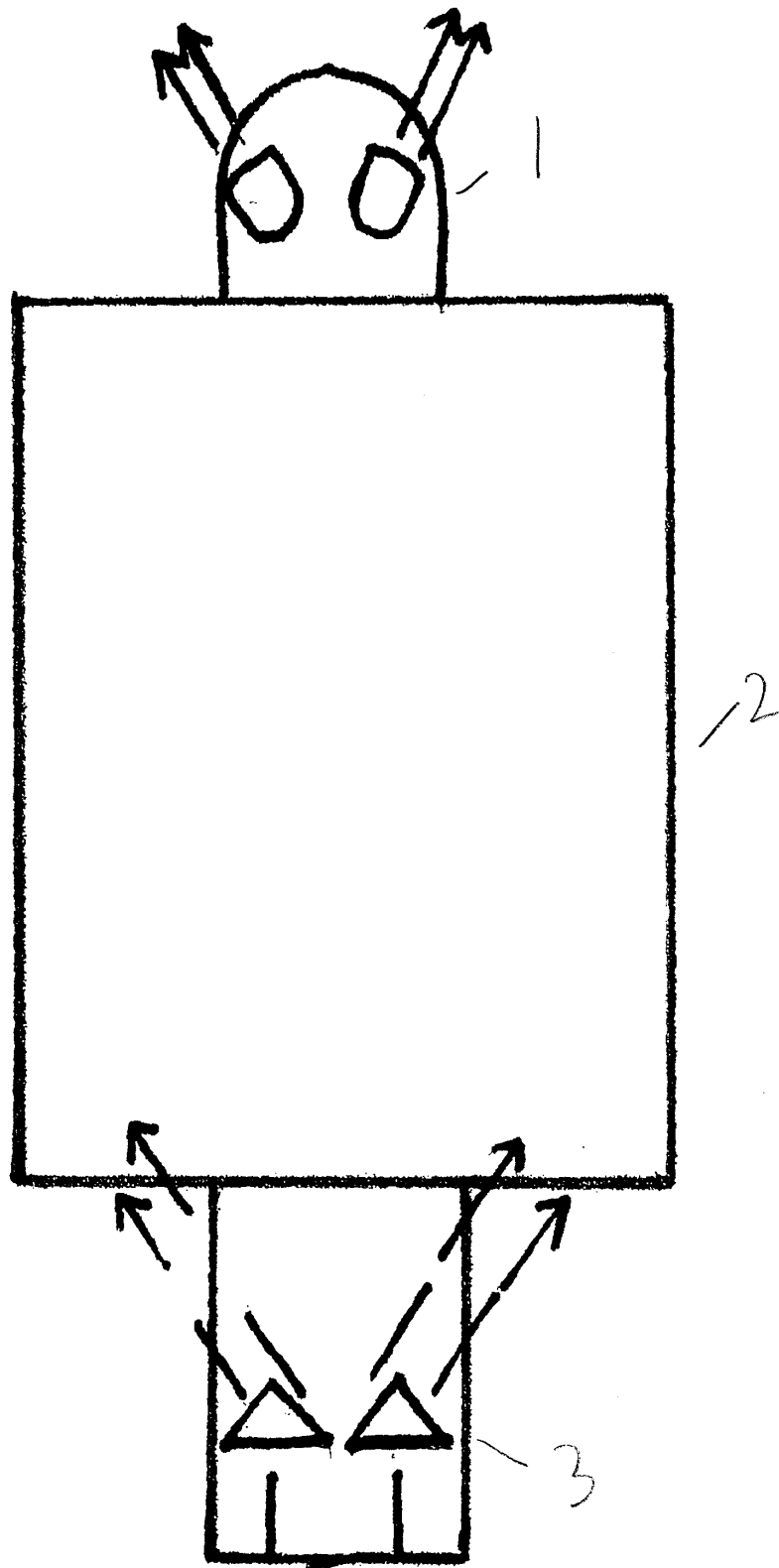


Fig. 4

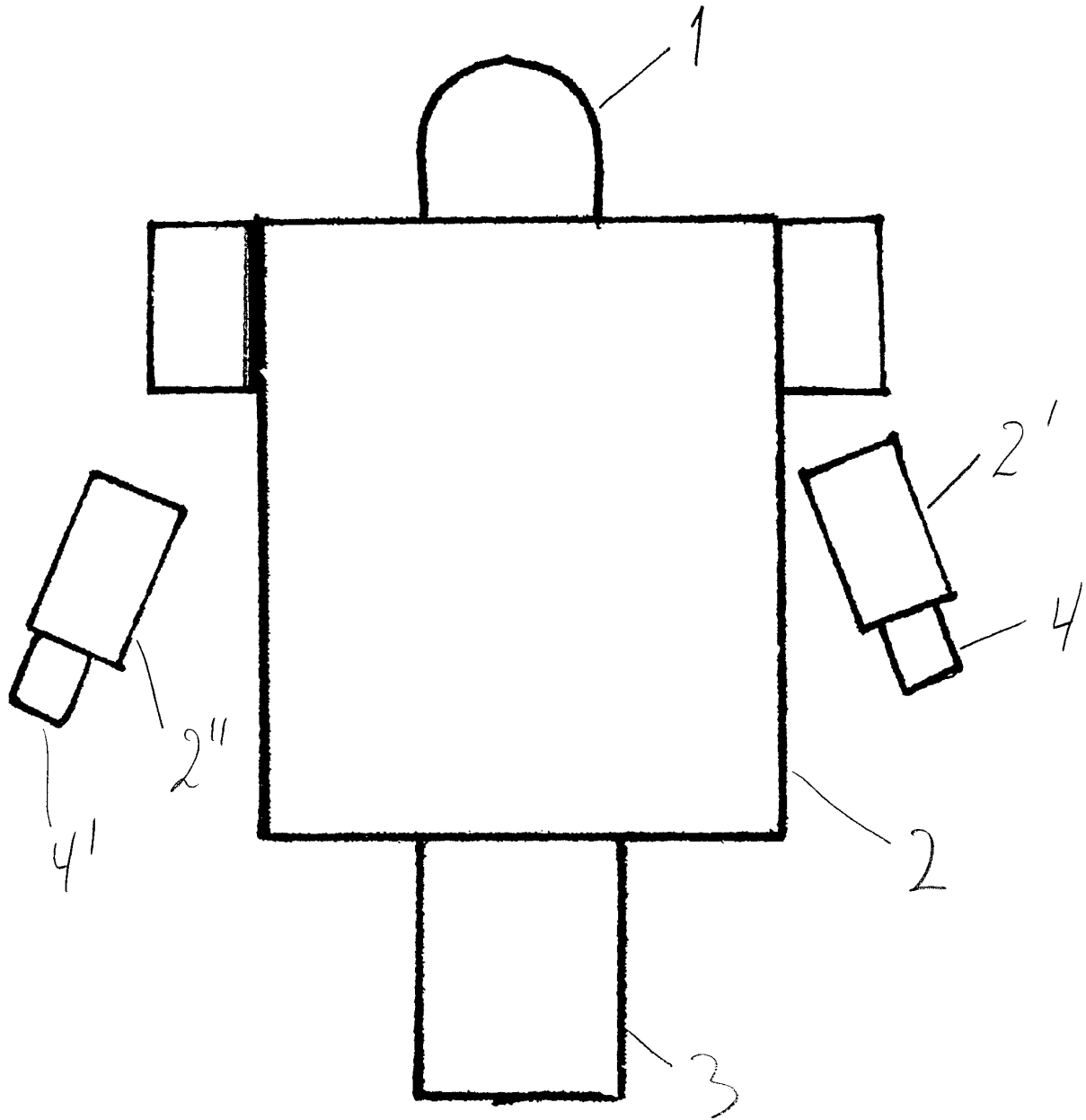


Fig. 5

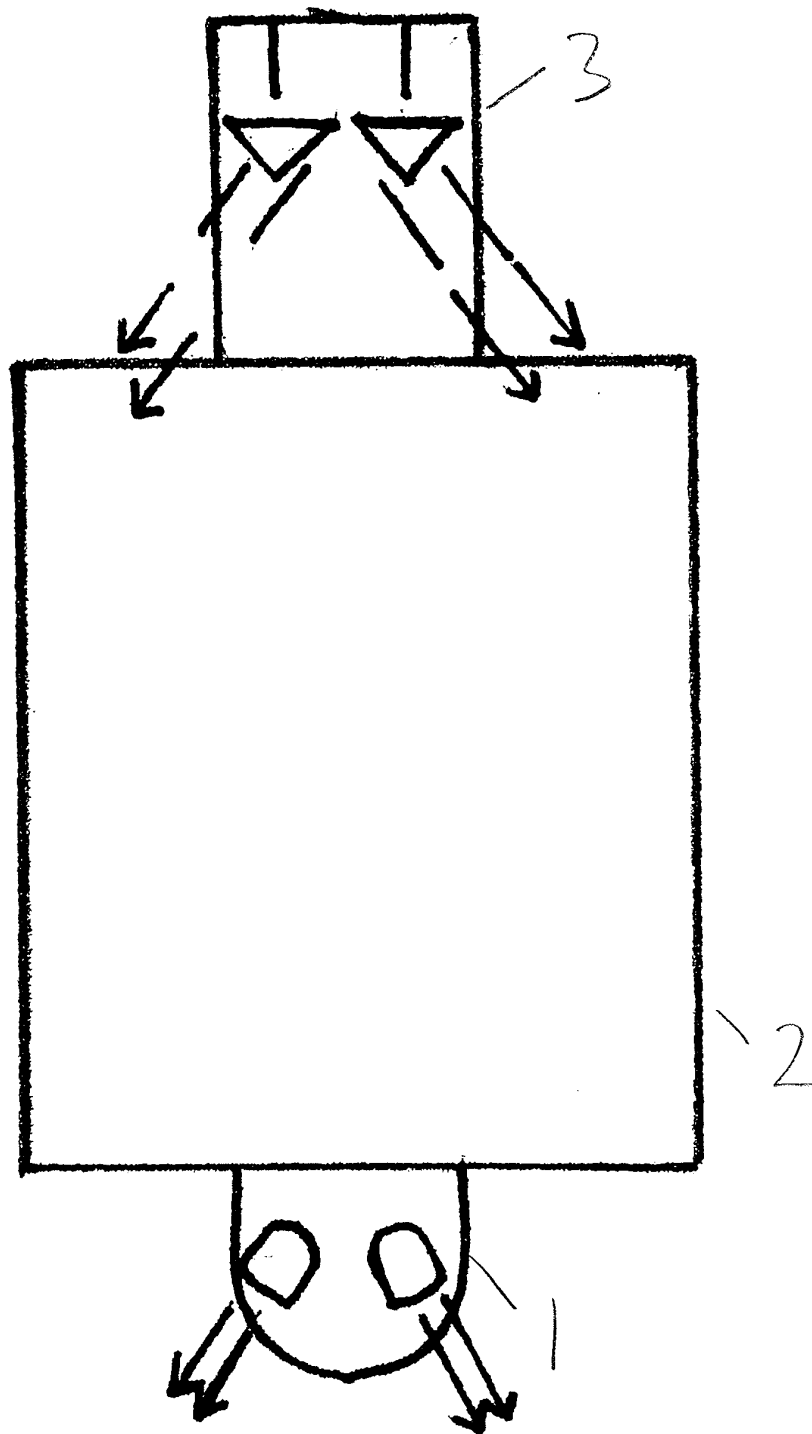


Fig. 6

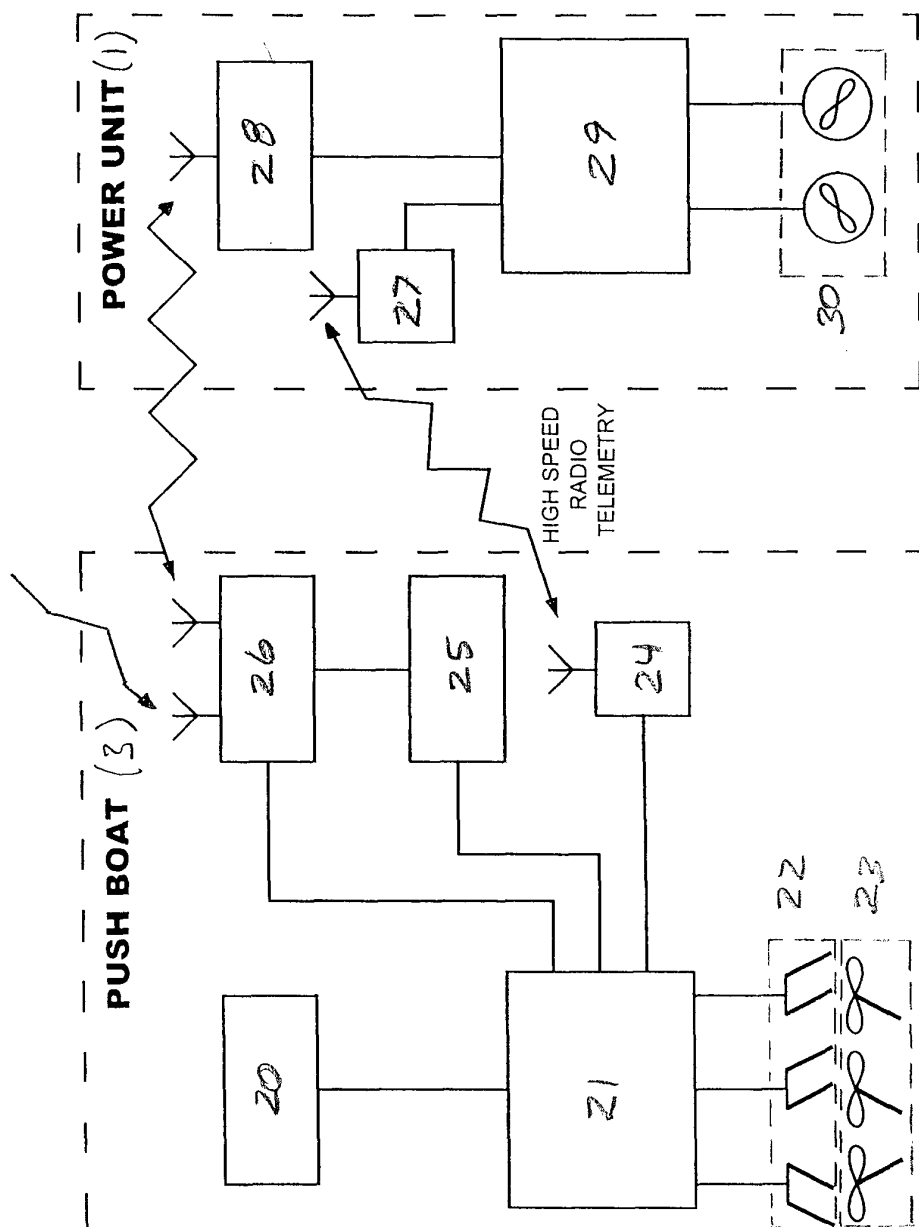


Fig. 7

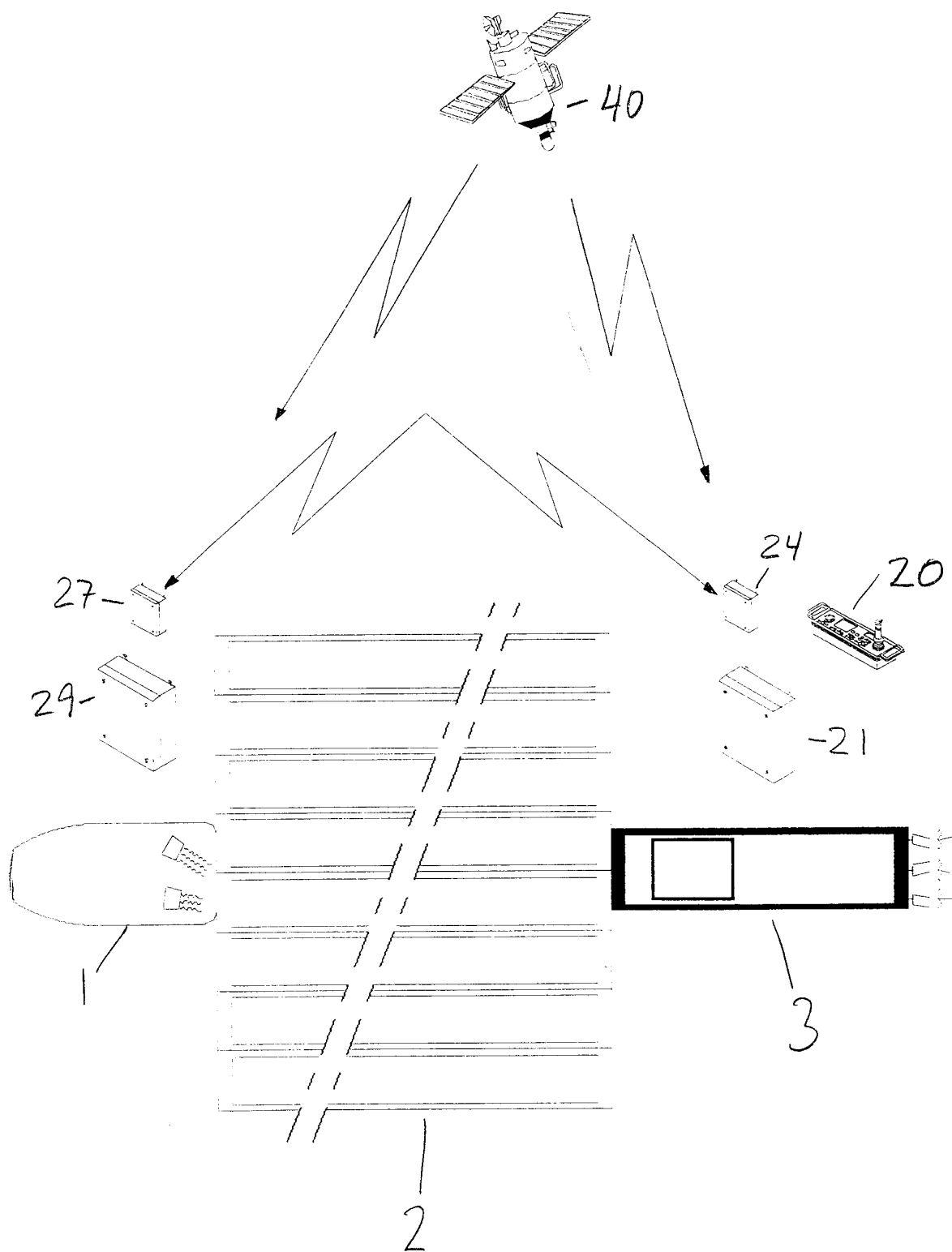


Fig. 8

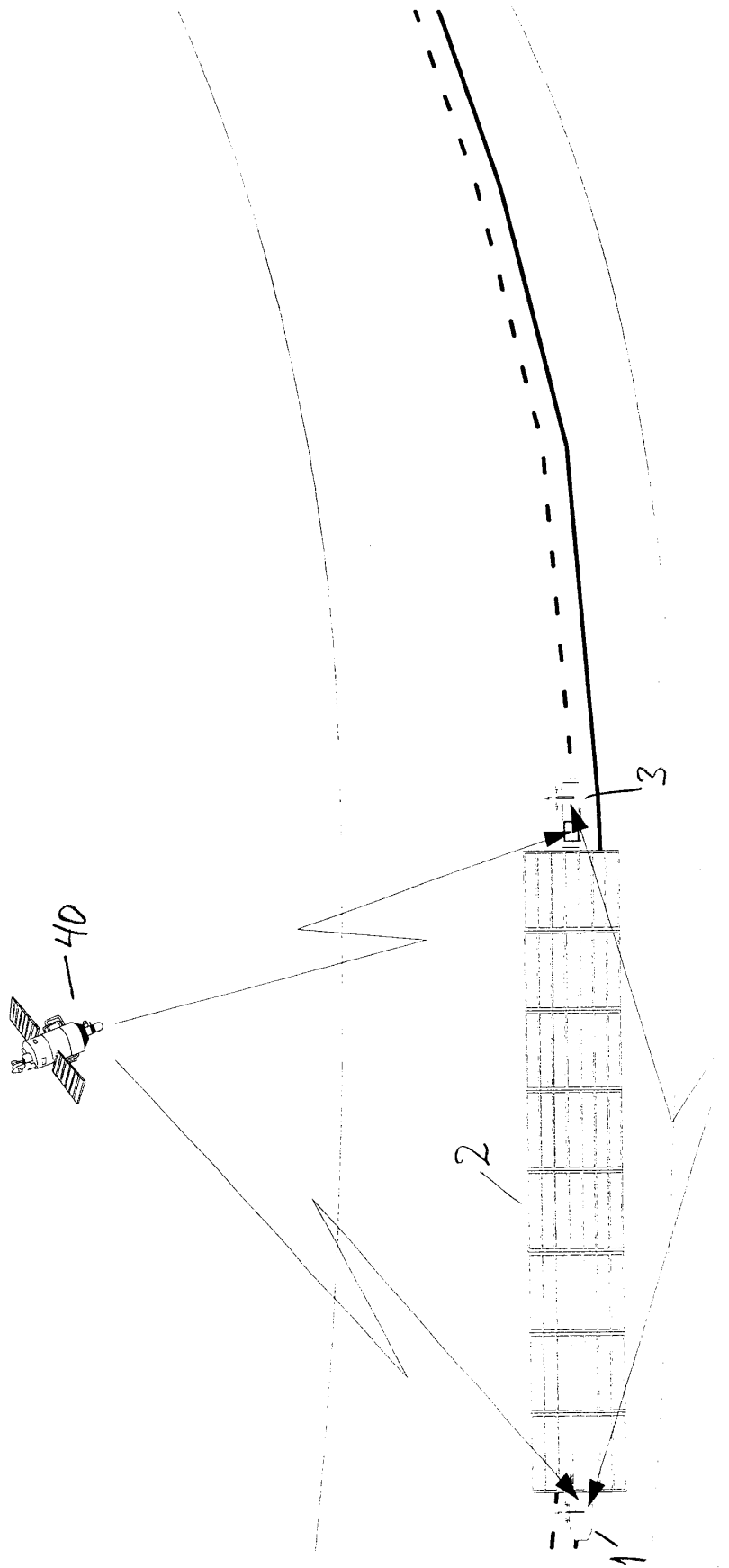


Fig. 9