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Kucik

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(54) **AUTONOMOUS SURF ZONE LINE CHARGE DEPLOYMENT SYSTEM**

(75) Inventor: **Daniel P. Kucik**, Lynn Haven, FL (US)

(73) Assignee: **The United States of America as represented by the Secretary of the Navy**, Washington, DC (US)

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(58) **Field of Search** 102/401, 293, 102/403; 89/1.13, 37.1, 1.1, 1.11; 701/23, 1, 21, 24, 25, 26, 36, 200, 301; 114/255, 1, 312, 18, 258, 44, 56.1, 343, 382; 180/271; 340/901, 984, 985; 441/136; 166/241.1, 352, 353, 354, 355, 356

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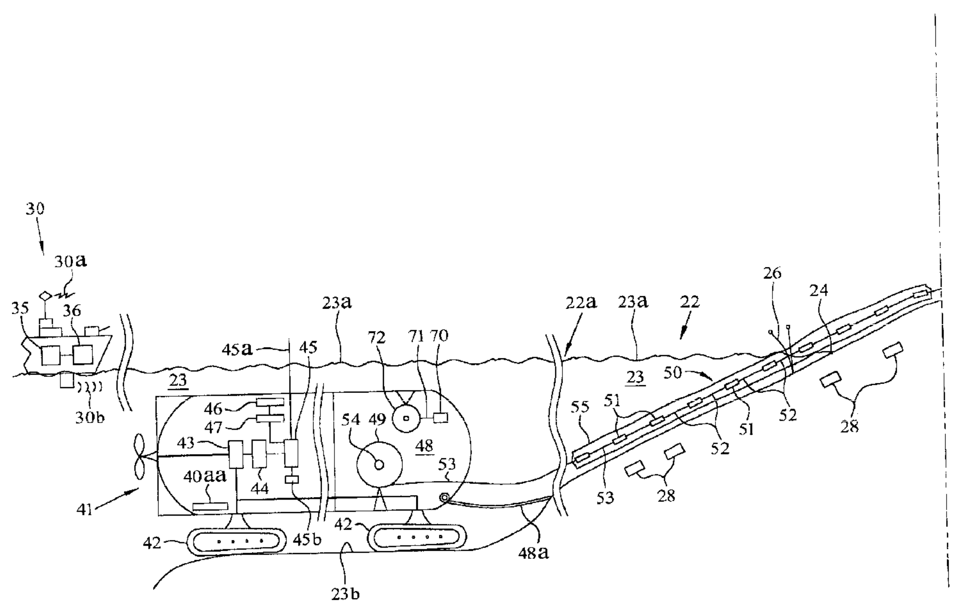
Primary Examiner—Olga Hernandez
(74) *Attorney, Agent, or Firm*—James T. Shepherd

(57) **ABSTRACT**

A system and method autonomously clears obstacles and mines from an approach lane. A ship is distantly located from an approach lane spanning a surf zone and beach portion, and the ship has operator control station software in an onboard computer. At least one system delivery vehicle having a storage bay and propulsion system transits from the ship to the approach lane in response to instructions from the operator control station. A line charge is disposed in each bay and has one end coupled to the system delivery vehicle. A line charge delivery vehicle in the bay is connected to another end of the line charge to pull the line charge from the bay and emplace it in a straight path in the approach lane in response to instructions from the operator control station. Explosives in all line charges are detonated to clear the approach lane.

21 Claims, 4 Drawing Sheets



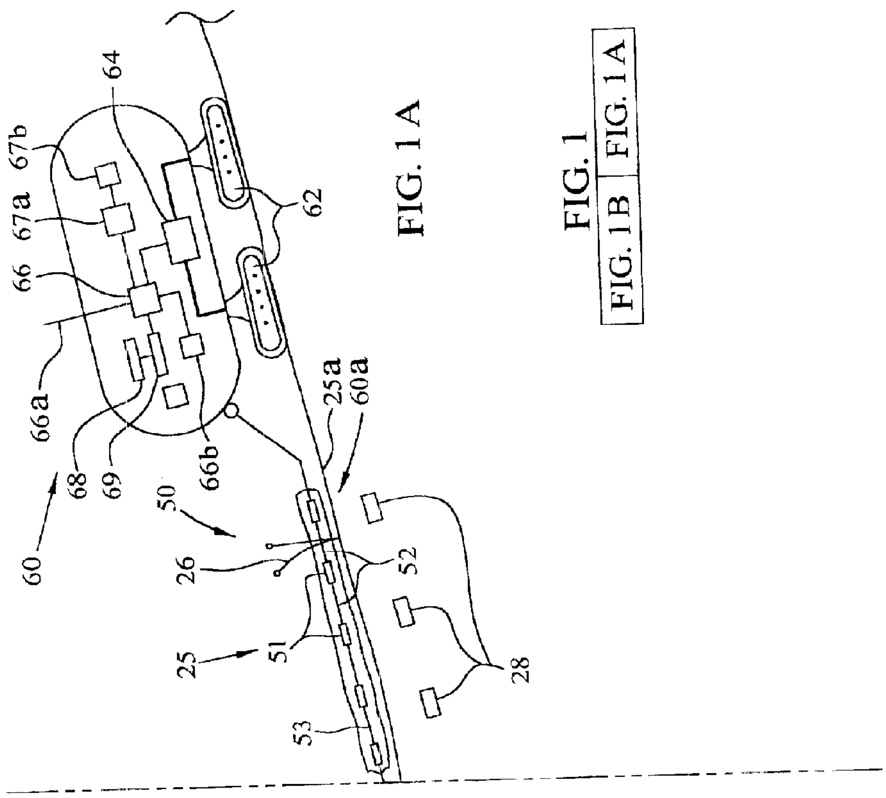
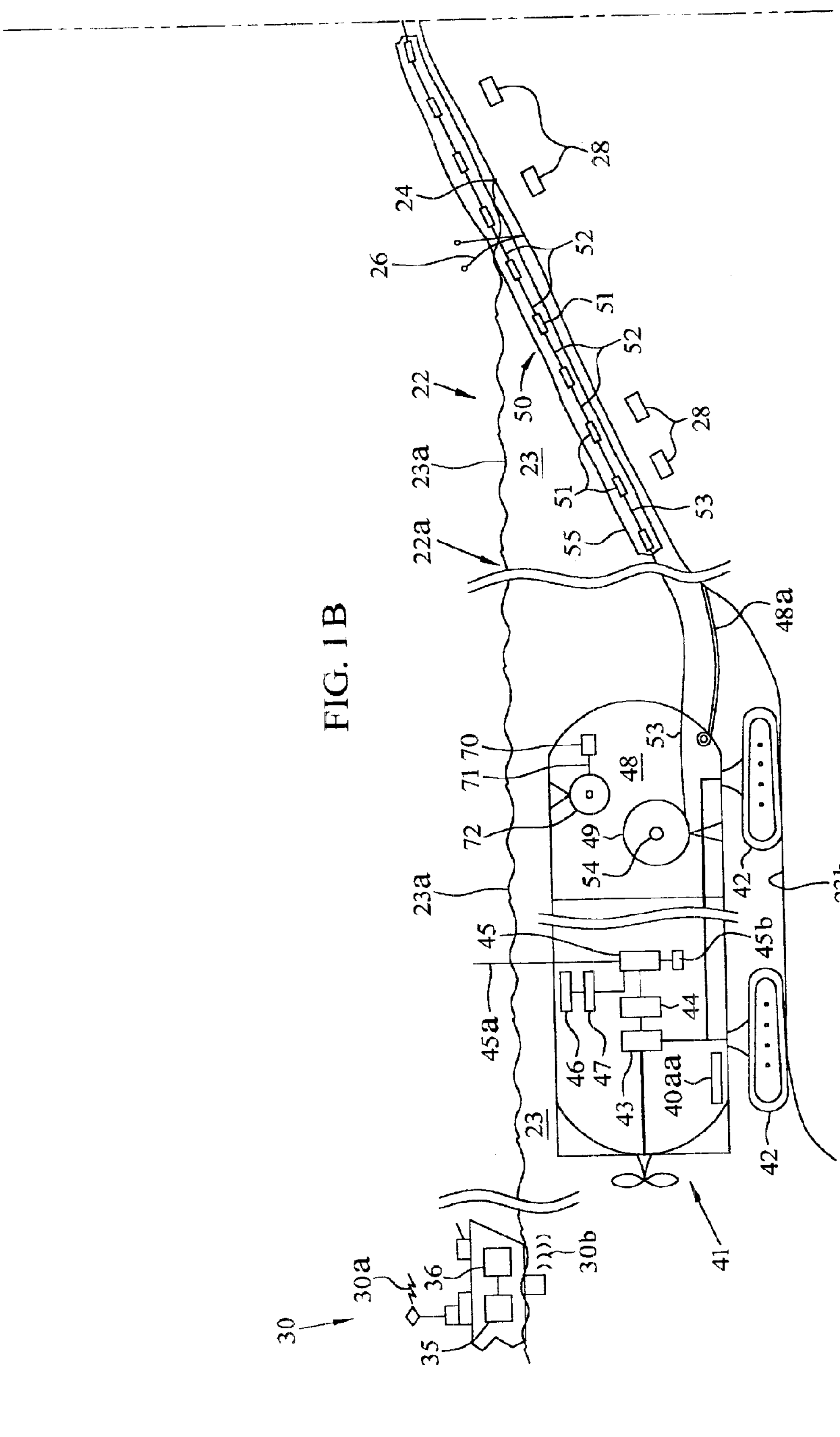


FIG. 1 A

FIG. 1

FIG. 1 B	FIG. 1 A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24
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48a
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71
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72
49
54
23a
42
23b
45
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46
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40aa
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30a
36
30b
30
35

FIG. 1 B

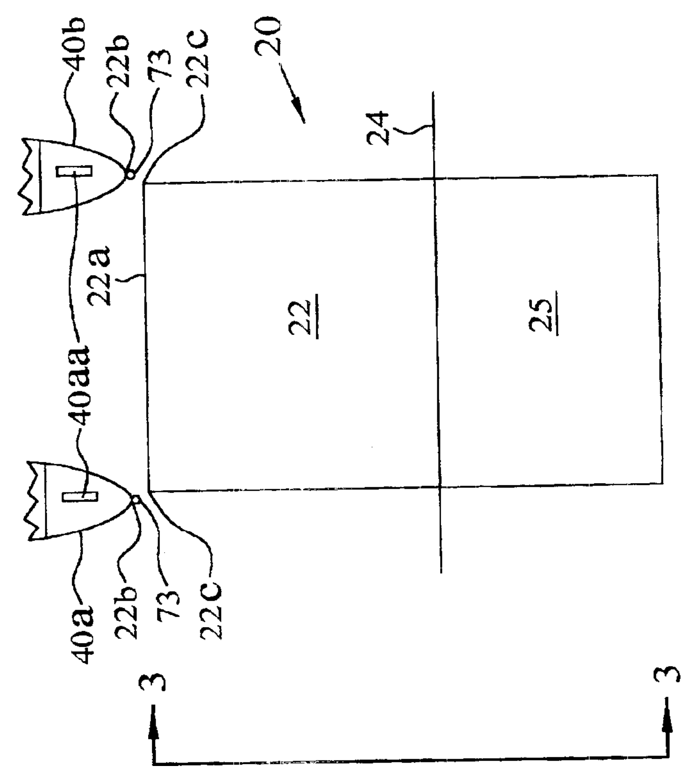
40b
22b
73
22c
20
24
40aa
22a
22
25
40a
22b
73
22c
3
3

FIG. 2

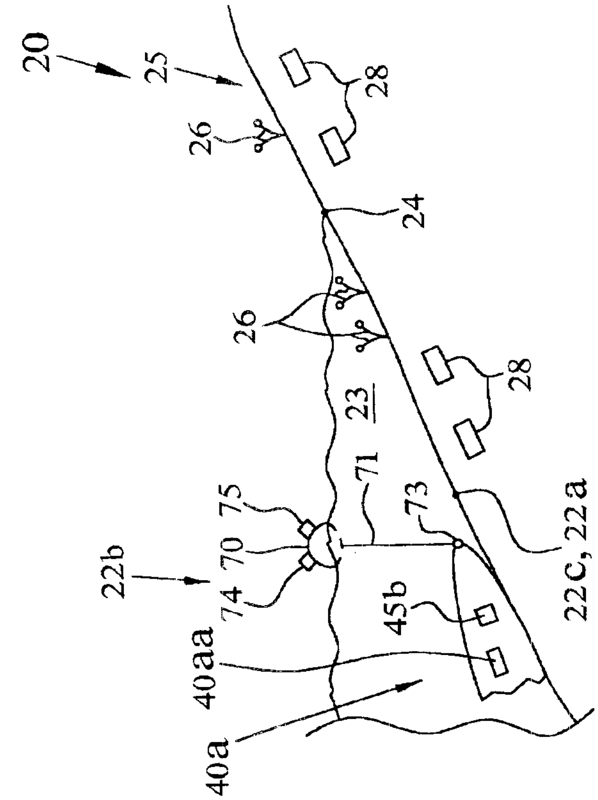
20
25
28
26
24
26
28
23
71
75
70
74
73
22b
22c, 22a
45b
40aa
40a

FIG. 3

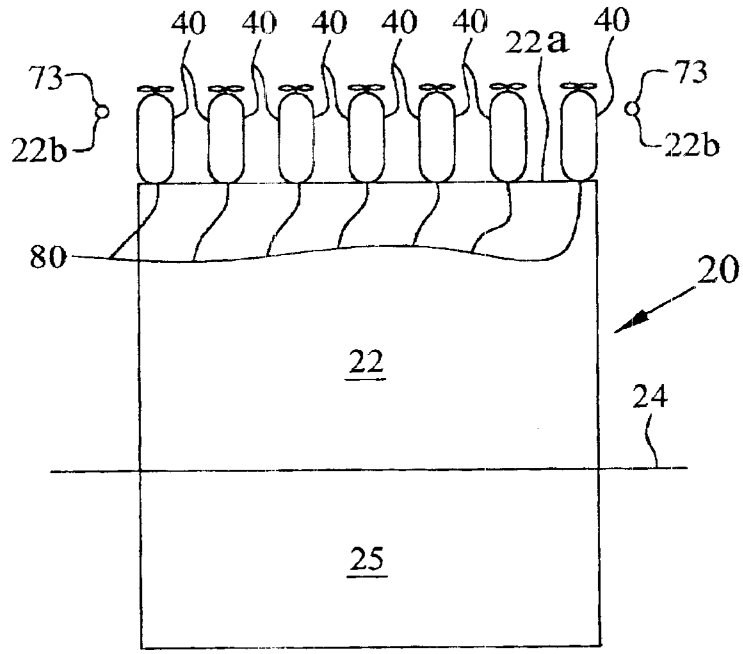
40
40
40
40
40
22a
40
73
22b
73
22b
80
20
22
24
25

FIG. 4

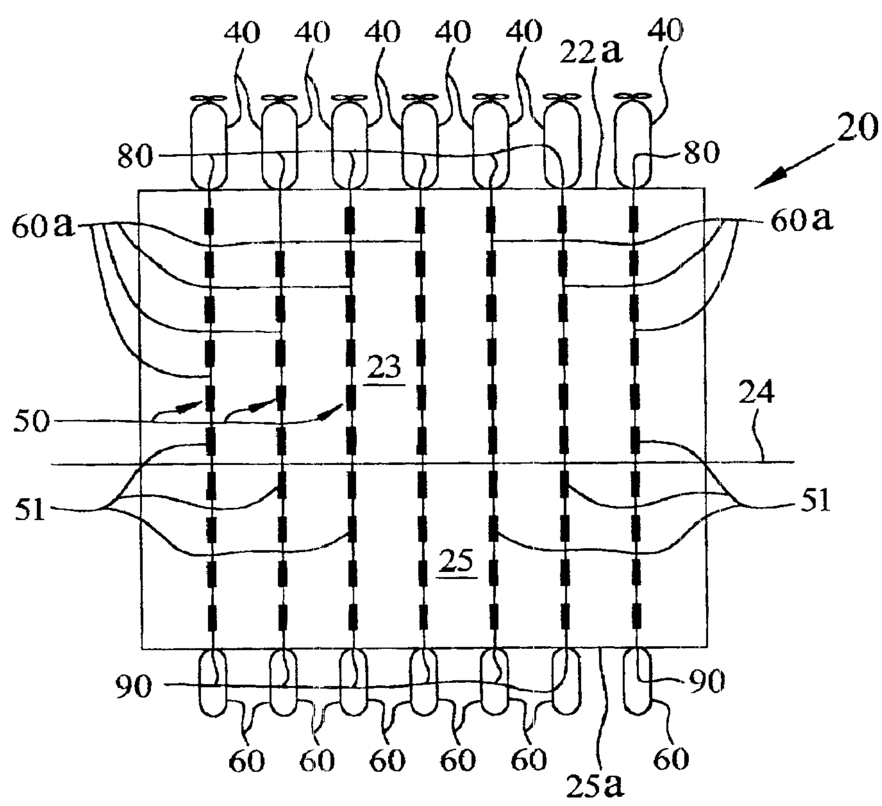
40
40
40
40
40
22a
40
80
80
20
60a
60a
23
50
24
51
51
25
90
90
60
60
60
60
60
25a
60

FIG. 5

AUTONOMOUS SURF ZONE LINE CHARGE DEPLOYMENT SYSTEM

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to clearing mines and other obstacles from an area. More particularly, this invention is to an autonomous system deploying at least one line charge to clear an approach lane.

Access to regions held by hostile forces could require an amphibious assault through an approach lane that extends from the sea and across a beach. Prior to the amphibious assault, mines and obstacles should be cleared from the approach lane so that landing craft can safely make the assault. A more challenging part of this task is the clearance of the surf zone portion of the lane (from 10 to 0 feet of water depth) because of highly dynamic and unforgiving wave action, currents, etc.

Divers in demolition/assault teams have performed this task but they must bring in a substantial amount of explosive charges. By itself carrying in this load is formidable, however, the significant hazards in the dynamic surf zone additionally must be dealt with. During deployment, the demolition teams and the explosive charges often are in exposed positions. This could attract unwanted attention and draw concentrated defensive fires from entrenched, determined defenders. The extreme peril created during manned clearing operations usually means that casualties may have to be sustained among the members of these highly trained teams, and even at this cost, the success of such missions may still be in doubt.

Rocket deployed line charges have been used with some success. But, they usually are launched from exposed positions adjacent to a target area, and neutralization of all mines and obstacles in an area is not assured since the rocket deployed line charges do not always accurately and uniformly cover a designated area satisfactorily.

Thus, in accordance with this inventive concept, a need has been recognized in the state of the art for an autonomous method and means for clearing mines and other obstacles from an approach lane that reduces the hazards to personnel yet assures successful completion of the mission.

OBJECT AND SUMMARY OF THE INVENTION

An object of the invention is to provide an autonomous system to deploy at least one explosive line charge to neutralize mines and obstacles in an approach lane.

Another object of the invention is to provide an autonomous system to deploy at least one explosive line charge to neutralize mines and obstacles in an approach lane extending through the surf zone and partially onto the beach.

Another object of the invention is to provide an autonomous system to neutralize mines and obstacles in an approach lane that reduces the exposure of personnel to danger.

Another object of the invention is to provide an autonomous system to neutralize mines and obstacles in an approach lane to reduce the exposure of personnel to danger and using at least one line charge that can be partially deployed, further deployed, and detonated in a spacedapart sequence.

Another object of the invention is to provide an autonomous system to neutralize mines and obstacles in an approach lane having a buoyancy means on line charges to aid deployment through the surf zone and partially onto the beach.

These and other objects of the invention will become more readily apparent from the ensuing specification when taken in conjunction with the appended claims.

Accordingly, the present invention is to an autonomous system and method for deployment of a line charge extending through a surf zone and/or partially across a beach to clear mines and obstacles from an approach lane. A ship is distantly located from an approach lane spanning a surf zone and a beach portion, and the ship has software of an operator control station in an onboard computer. At least one system delivery vehicle having a storage bay and propulsion means transits from the ship to the approach lane in response to first instructions from the operator control station. A line charge is disposed in each bay and has one end coupled to the system delivery vehicle. A line charge delivery vehicle in each bay is connected to another end of the line charge to pull the line charge from the bay and emplace it in a straight path in the approach lane in response to second instructions from the operator control system. Explosives in all line charges are detonated to clear the approach lane.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic side view, partially in cross section of constituents of the autonomous system of the invention for clearing mines and obstacles in an approach lane extending through the surf zone and partially across a beach.

FIG. **2** is a schematic showing the placement of transducers associated with an acoustic long baseline (LBL) navigation system.

FIG. **3** is a cross-sectional schematic view showing the placement of transducers associated with the acoustic LBL navigational system taken generally along line **3—3** in FIG. **2**.

FIG. **4** shows deployment of system delivery vehicles at base positions along the seaward edge of the approach lane.

FIG. **5** shows line charge delivery vehicles after pulling line charges from system delivery vehicles and emplacing them in parallel paths in the approach lane.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, an autonomous line charge deployment system **10** of the invention has the capability to be deployed from over-the-horizon to where an amphibious assault can be made. The goal of most amphibious assaults is to gain a beachhead on a landmass and go through what is called an approach lane **20**. Approach lane **20** can include a surf zone **22** under water **23** (from ten to zero feet of water depth), shoreline **24**, and beach portion **25** of sand, sediment, dirt, etc. Conducting a successful amphibious assault usually requires clearance of obstacles **26** and mines **28** from both surf zone **22** and beach portion **25** of approach lane **20** to allow safe passage of personnel, materials, and vehicles.

Autonomous deployment system **10** has an over-the-horizon support ship **30**, at least one system delivery vehicle (SYSDV) **40**, at least one line charge **50**, and at least one line charge delivery vehicle (LCDV) **60**. Autonomous deployment system **10** of the invention allows selective, controlled clearing of an area, or approach lane **20** with at least one line charge **50**. Only one SYSDV **40**, line charge **50**, and LCDV

60 are shown in FIG. **1**, it being understood that many of these combinations, to be described, may be needed to clear a wider approach lane **20**. Autonomous deployment system **10** reduces casualties during placement and detonation of line charge **50** by keeping personnel out of a possibly hotly contested beach region and instead, using their talents at a safer remote location on ship **30**, possibly over-the-horizon to plan and execute clearing operations.

Support ship **30** is the staging area of system **10** and has a software control package, or operator control station (OCS) **35** running on laptop computer **36**. OCS **35** is used to plan and execute line deployment missions and allows an operator at a distant command station or at ship **30** to analyze the information of latitudes/longitudes representing the area to be cleared and monitor system status and progress. In accordance with software package of OCS **35** laptop computer **36** can display maps of the area indicating the lane to be cleared in order to confirm the information provided by the operator. Software of OCS **35** on laptop **36** tells the operator the number of SYSDV **40**s and LCDV **60**s pulling line charges **50** that must be deployed in order to clear the area of approach lane **20**.

Next, the software of OCS **35** will initialize each SYSDV **40** and LCDV **60** and provide first instructions **46**, or software on a first single board computer **47** in each SYSDV **40** and second instructions **68**, or software on a second single board computer **69** in each LCDV **60**. First instructions **46** in first computer **47** in each SYSDV **40** effect responsive operation of that SYSDV **40**. For example, first instructions **46** from OCS **35** can control where each SYSDV **40** should deploy its associated LCDV **60**. Second instructions **68** in second computer **69** in each LCDV **60** effect operation of that LCDV **60** in response to second instructions **68**. For example, second instructions **68** can control the elongate path **60*a*** each LCDV **60** should traverse to emplace its interconnected line charge **50** along that path **60*a***.

From laptop computer **36** in ship **30** first and second instructions **46**, **68** in first and second computers **47**, **69** make each SYSDV **40** and its associated LCDV **60** autonomous by providing destination/path and obstacle avoidance instructions. First and second instructions **46**, **68** can also tell each SYSDV **40** where the deployment destination of line charge **50** by each LCDV **60** is and where each LCDV **60**'s path **60*a*** through approach lane **20** is. Accordingly, after each SYSDV **40** is launched, it automatically proceeds to the designated area for deployment of its payload, (LCDV **60** and its line charge **50**), and completion of the mission.

At least one SYSDV **40** and LCDV **60** can have a remote control capability responsive to, for example, electromagnetic control signals **30*a*** and/or acoustic control signals **30**b transmitted from ship **30**, or another remote station to allow remote control of SYSDV **40** and LCDV **60**. Additional communications capabilities can be included in communication/control modules **45** and modules of navigational equipment **66** that interface with antennas **45*a***, **66*a*** and transducers **45*b***, **66*b*** for SYSDV **40** and LCDV **60**, respectively. The remote control capability can be a desirable feature when tactical scenarios change.

SYSDV **40** of autonomous deployment system **10** can be deployed many miles from ship **30** to the seaward edge **22*a*** of surf zone **22** where at least one line charge **50** is to be deployed. SYSDV **40** can have one or more propulsion means having propeller/control fin structures **41** as a swimmer delivery vehicle and/or having several tracked crawler assemblies **42** as a ground crawler vehicle similar to a heavy equipment, earth moving vehicle to propel and steer SYSDV **40** through water **23** from ship **30**. Propeller/control fin structures **41** are more likely to be selected for guided propulsion of SYSDV **40** over long distances or rough marine topography.

Each SYSDV **40** can be relatively large since it must transport considerable equipment and a bulky and heavy payload (LCDV **60** and line charge **50**). SYSDV **40** has propulsion and guidance motors **43** and fuel and/or battery supply **44** for propeller/control fin structures **41** and tracked ground crawler assemblies **42**. Communications/control modules **45** are connected to structures **41** and assemblies **42** via motors **43** and are connected to single board computer **47**. Single board computer **47** can have the capacity of a desktop computer and has software **46** that is responsive to OCS **35** when each computer **47** of each SYSDV **40** is coupled to laptop computer **36** aboard ship **30**. This responsive software **46** entered into computer **47** allows it to generate proper control signals for communications/control modules **45** to get SYSDV **40** to its intended destination while avoiding any obstacles that might be encountered during the transit. En route to the intended destination, corrections and/or changes in course can be made via communications/control modules **45**. Modules **45** additionally have a navigational payload system to receive electromagnetic signals via antenna **45*a*** from the global positioning system (GPS, DGPS, GPS with WAAS) and/or a long baseline acoustic navigational system to receive acoustic signals via acoustic transducers **45*b*** and generate appropriate control signals to keep SYSDV **40** on course or change to a different destination as a tactical situation changes.

Each SYSDV **40** has a spacious storage bay **48** that can be selectably opened and closed by a hinged cover **48**a. Storage bay **48** contains a high-capacity reel **49** having a line charge **50** coiled on it and a line charge delivery vehicle (LCDV) **60**. Optionally, when a system delivery vehicle is to be used to designate an approach lane **20** (such as designator SYSDVs **40*a***, **40*b*** to be described), bay **48** can contain a low-observable float **70** having a tether **71** coiled on a spool **72**. Cover **48*a*** can be opened, bay **48** flooded, and tether **71** paid-out as float **70** is buoyed to surface **23*a*** of water **23** as described below.

Typically, line charge **50** can be a series of explosive charges **51** connected together in a spaced-apart relationship from one another by flexible cord-like strength members **52**. Strength members **52** hold line explosive charges **51** as an elongate unit as it is deployed. A firing means, such as an elongate flexible detonating cord **53** may coextend with strength members **52** to explosive charges **51** to detonate them after line charge **50** has been deployed.

A firing device **54** can be connected to detonating cord **53** and communication/control modules **45** to initiate detonation of line charge at the proper time. Firing device **54** can be located in the components of reel **49** inside storage bay **48** of SYSDV **40**. Optionally, line charge **50** can include a redundant firing device located in LCDV **60** (not shown) that could be actuated by radio frequency, acoustic, or other signals and used in the event the primary firing device fails. The redundant firing device located on LCDV **60** can be used in the event there is unused line charge **50** remaining on reel after the deployment process is complete, which will prevent premature severing of detonation cord **53** at reel **49** when the excess line charge detonates.

Line charge **50** has an elongate sac **55** defining an air plenum that can surround and be connected to explosive charges **51**, strength members **52**, and detonating cord **53**.

Elongate sac **55** makes line charge **50** only slightly negatively buoyant when it is in salt water **23**. Small flotation blocks (not shown) could be spaced among explosive charges **51** for buoyancy instead of elongate sac **55**. The buoyancy feature of elongate sac **55** is important because without it, LCDV **60** may not have sufficient power/traction to drag line charge **50** from reel **49** on SYSDV **40** and pay it out from reel **49** all to way through surf zone **22** and onto beach portion **25**. One option is to have each LCDV **60** bring its interconnected line charge **50** to water's edge at low tide, then later at high tide move onto beach portion **25** that is underwater at high tide. Later when the tide recedes to the next low tide condition, the part of beach portion **25** that is now not underwater can be cleared by detonation of each line charge **50**. As a further option each LCDV **60** may be made more powerful to be able to drag each line charge **50** through surf zone **23** and across beach **25**, but the more powerful LCDVs **60** might have to be larger and consequently may compromise covertness.

LCDV **60** is an autonomous vehicle that will automatically navigate its way from SYSDV **40**, through surf zone **22**, shoreline **24** and onto beach portion **25** (or close to the beach) using a path **60***a* that can be made perpendicular to shoreline **24**. LCDV **60** has several tracked crawler assemblies **62** mounted on it and driving means **64** are coupled to tracked crawler assemblies **62** to impart crawling motion to LCDV **60** as it crawls along exposed floor, or bottom **23***b* under water **23** in surf zone **22** and surface of beach portion **25**. Driving means **64** can be functionally the same as motors **43**, fuel and/or batteries **44** and communication/control modules **45** of SYSDV **40**. However, since the distance LCDV **60** has to travel is less than the distance SYSDV **40** must travel, less fuel or electrical power is required.

LCDV **60** additionally has navigation equipment **66** to successfully navigate through surf zone **22** and beach portion **25** while maintaining the desired path **60***a* to ensure that line charge **50** is properly deployed. Navigation equipment **66** of LCDV **60** includes computer **69** and modules that provide at least the functional equivalent of communication/control modules **45** of SYSDV **40**, and an acoustic long baseline receiver **67***a* is coupled to an acoustic transducer **67***b* in addition to a compass, gyroscopes, etc. In addition to receiving second instructions **68** on second computer **69** for a mission from OCS **35** of laptop computer **36** on ship **30**, second computer **69** of LCDV **60** runs a Kalman filter to calculate position and heading accurately based on information from these sensors. An antenna **66***a* can be connected to equipment **66** to provide a means of receiving electromagnetic control signals, for example, signals **30***a* from ship **30**. Transducer **67***b* provides the capability not only to transmit acoustic signals, but also to receive acoustic control signals **30***b* and other signals, such as LBL navigation signals from transmitter **73**.

Components and connections for modules of communication/control modules **45** and modules for navigational equipment **66** and their appropriate interconnection to responsive machinery are well known in the art. Considerable numbers of off-the-shelf units have long been available for model aircraft and boats, unmanned reconnaissance and drone craft, and full-scale marine and aircraft systems. These applications routinely rely on interfacing with numerous navigational aids, such as GPS and acoustic signals to steer a given course to a preset destination. Therefore, having this disclosure before him, one skilled in the art to which this invention pertains is free to choose and appropriately interconnect suitable components freely available in the art.

Line charge **50** is attached at one end to reel **49** and at its opposite end to LCDV **60**. Since reel **49** is connected to SYSDV **40**, when LCDV **60** leaves bay **48** and exerts a pulling force on line charge **50**, line charge **50** is uncoiled from reel **49** and is pulled straight. LCDV **60** proceeds on its way and may stop in surf zone **22** or extend through it and onto beach portion **25**. Line charge **50** is pulled straight and trails behind to extend along the distance traveled by LCDV **60**. Once LCDV **60** reaches a desired depth in surf zone **22** or the desired distance from SYSDV **40** to shoreline or somewhere on beach portion **25**, reel **49** on SYSDV **40** locks and LCDV **60** continues to drive forward until a predetermined tension is created on line charge **50**. Once this predetermined tension pulls line charge **50** to a desired degree of tightness, it is straightened out and further progress of LCDV **60** is arrested. SYSDV **40** and LCDV **60** serve as anchors to hold line charge **50** in place along path **60***a* until the time it is detonated.

Referring additionally to FIGS. **2** and **3**, to operationally deploy system **10** an operator, user or planner onboard ship **30** designates a particular approach lane **20** that is to be cleared of obstacles **26** and mines **28**. First and a second designator SYSDVs **40***a*, **40***b* are used to place acoustic transmitters **73**, which serve as part of the acoustic LBL system and can optionally serve as a repeater for acoustic communications. The designator SYSDVs **40***a*, **40***b* are like SYSDV **40** but do not transport a line charge **50** or LCDV **60**. OCS **35** instructs designator SYSDVs **40***a*, **40***b* where to place the acoustic LBL navigation transmitters **73**. This deployment of transmitters **73** has operator on ship **30** entering appropriate first instructions **46** from OCS **34** into single board computers in SYSDVs **40***a*, **40***b*. These transmitters **73** are to be placed at seaward corner positions **22***b* seaward of outer corners **22***c* of surf zone **22**. of, approach lane **20**.

The primary purpose of the two transmitters **73** that are placed at the seaward corner positions **22***b* near seaward edge **22***a* of surf zone **22** (depicted in FIG. **2**) is to serve as part of an acoustic long baseline navigation system for the SYSDVs **40** and LCDVs **60**. The communications capability of transmitters **73** is also used to relay the results of the transmitter survey (described below) back to ship **30**. A secondary purpose would be to use them as a relay/repeater for data communications between the vehicles and the ship and/or as lane markers.

The basic principle of a standard passive acoustic LBL system is as follows:

SYSDVs **40**, LCDVs **60** and the two acoustic transmitters **73** are time synchronized, and each contains a highly accurate clock, which minimizes clock drift. The two transmitters **73** are deployed (as shown in FIG. **2**) and surveyed using GPS. This task can be accomplished using either divers or the designator SYSDVs **40***a*, **40***b*. Latitude/longitude pairs for the position of each transmitter **73** are acoustically transmitted back to ship **30** from designator SYSDVs **40***a*, **40***b* or if divers are used to deploy the system, the position information is radioed from the divers to ship **30**. The position of each LBL navigation transmitter is then provided to each SYSDV **40** and LCDV **60** as part of first instruction **46** and second instruction **68**. Each LBL transmission of each transmitter **73** will "chirp" at different intervals (e.g. one transmitter **73** will chirp one second and the other transmitter **73** will chirp the next second, and so on). SYSDVs **40** and LCDVs **60** using the LBL system "listen" for the chirps, and when a chirp is detected the vehicle takes note of the time it was received. The SYSDVs **40** and LCDVs **60** using the LBL system know at what times each transmitter **73** will chirp, so using this information in combination with the time the chirp arrived, the "time of flight" for the chirp can be determined. So, for example, if SYSDV **40** or LCDV **60** knows that one of transmitters **73** was supposed to transmit at time 2025 seconds and it received the chirp at 2025.5 seconds, the time of flight would then be 0.5 seconds. By using the time of flight for the chirps received from each transmitter **73** and the speed of sound in water equation, which is also dependent on water temperature (a temperature sensor is a component of the LBL receiver located in each SYSDV **40** and LCDV **60**), each of SYSDVs **40** and LCDVs **60** can determine its distance from each transmitter **73**. Since the position of each transmitter **73** has been surveyed, and the distance from each of these two points is known, each of SYSDVs **40** and LCDVs **60** can then determine both their relative and absolute positions using simple trigonometry.

Designator SYSDVs **40***a*, **40***b* leave ship **30** and autonomously transit to the seaward edge **22***a* of surf zone **22** of approach lane **20** in accordance with instructions on their first computers **47**. Near seaward edge **22***a*, each SYSDV **40***a*, **40***b* floods ballast tanks **40***aa* and sinks to the bottom to each deploy a long baseline acoustic transmitter **73** and a low-observable float **70** at seaward corner positions **220***b* located just outside of outer corners **22***c* of surf zone **22** of approach lane **20**.

Each float **70** is buoyed upward and has depth sensor **74** and a GPS receiver **75** mounted on it to float at surface **23***a*. Tether **71** is paidout from spool **72** on each SYSDV **40***a*, **40***b* at seaward corner positions **22***b* until each depth sensor **74** detects that float **70** has reached surface **23***a*. Spool **72** is rotated to reduce the slack in tether **71**, to reduce error that might be attributed to watch circle. GPS receiver **75** on float **70** integrates its position for a given length of time to improve the accuracy of the position survey.

After gathering the needed data, each float is retracted below surface **23***a* to maintain covertness. The position data for each acoustic LBL navigation transmitter **73** located at each seaward corner position **22***b* is acoustically transmitted via transmitters **73** back to ship **30** and to any additional SYSDVs **40** or LCDVs **60** currently in the water. The transmitted data can be incorporated into OCS **35** in computer **36** and included as part of instructions **46** and **68** for other SYSDVs **40** and their associated LCDVs **60** that will require these coordinates to utilize the LBL navigational system to accurately emplace several line charges **50**.

Next, the operator on ship **30** enters two latitude/longitude pairs indicating the position of each acoustic LBL transmitter **73** located in designator SYSDVs **40***a*, **40***b* and four additional coordinates representing the corners of approach lane **20** to be cleared into OCS **35**. OCS **35** displays a map of the area of approach lane **20** and requests that the user confirms the field layout of approach lane **20**.

Another way to get the needed data is contrary to the autonomous procedure described above. Transmitters **73** are deployed using divers that are sent out from ship **30**. Divers make their way to the deployment position (seaward corner positions **22***b*), they survey their positions using the global positioning system (GPS), and relay the GPS coordinates of each acoustic LBL navigation transmitter **73** to ship **30**. The GPS coordinates are entered into OCS **35** on computer **36** on ship **30** to initialize SYSDVs **40** and LCDVs **60** for clearing of approach lane **20**.

Actual clearing of approach lane **20** can now begin in earnest. Computer **36** on ship **30** is coupled to first and second computers **47**, **69** on SYSDVs **40** and LCDVs **60**, respectively. OCS **35** on computer **36** initializes first and second computers **47**, **69** on SYSDVs **40** and LCDVs **60**, providing them with first and second instructions **46**, **68** containing the field information necessary for them to complete their mission.

SYSDVs **40** which contain explosive line charges **50**, LCDVs **60**, and other system components needed to deploy line charges **50**, are deployed, or launched from ship **30**. Since each of SYSDVs **40** has different first instructions **46** in their first computers **47**, each of SYSDVs **40** transits to arrive at different designated base positions **80** spaced apart from one another in a side-by-side relationship along seaward edge **22***a* of surf zone **22** and approach lane **20** to be cleared, see FIGS. **4** and **5**.

At positions **80** first computers **47** of SYSDVs **40** initiate flooding of one or more internal compartments **40***aa* and SYSDVs **40** sink through water **23** to bottom **23***b* of water **23**. At a predetermined time that is in accordance with first instructions **46** in first computers **47**, covers **48**a are rotated open, and bays **48** of SYSDVs **40** are flooded. In accordance with the different second instructions **68** in second computers **69** of each LCDV **60**, tracked crawler assemblies **62** of LCDVs **60** in flooded bays **48** are activated and proceed to crawl over opened covers **48***a* and onto bottom **23***b*. Each LCDV **60** pulls on an interconnected line charge **50** that is each wrapped about reel **49** and rotates reel **49** as it drags part of line charge **50** behind. Each reel **49** in each SYSDV **40** continues to rotate as each LCDV **60** unwraps and pulls more and more of its interconnected line charge **50** from its position of coiled stowage. Different second instructions **68** in second computers **69** in each of LCDVs **60** guide each LCDV **60** along a different path **60***a* that are parallel and equal distantly spaced from each other. As each LCDV **60** crawls, or progresses along bottom **23***b* in surf zone **22**, each line charge **50** is dragged along and pulled straight to space and emplace explosive charges **51** apart in their predetermined parallel separation in paths **60***a*. Elongate sac **54** on each line charge **50** partially buoys at least part of the load of line charge **50** upward in surf zone **22** to reduce part of the entrained load created by each line charge **50**, and the amount of force exerted by crawler assemblies **62**.

When only surf zone **22** of approach lane **20** is to be cleared, line charges **50** in paths **60***a* do not have to extend onto beach portion **25** and can be detonated entirely in surf zone **22**. First instructions **46** control SYSDVs **40** to allow LCDVs **60** to reach a predetermined destination (e. g. shoreline **24**) or depth in surf zone **22**. At this predetermined destination, their interconnected reels **49** in SYSDVs **40** are locked to prevent further outward travel of LCDVs **60** that are connected to the opposite ends of line charges **50**. Each of these locked-in-place line charges **50** are stretched tight and each interconnected SYSDV **40** and LCDV **60** serve as anchors to hold the stretched line charges **50** in place along paths **60***a*.

Once line charges SO are appropriately stretched along paths **60***a*, LCDVs **60** can be inactivated to allow line charges to remain in place. Line charges **50** emplaced in surf zone **22** can be detonated now or later to clear surf zone **22**.

In response to a tactical situation, line charges **50** emplaced in surf zone **22** as described above can remain undetected for a prolonged period of time. Later, coiled portions of line charges **50** remaining on reels **49** in SYSDVs **40** can be utilized to enable extension of line charges **50** so that they can additionally reach across part of beach portion **25** of approach lane **20**.

In accordance with a sequence preprogrammed in first instructions **46**, the passage of time, or a remote acoustic signal **30***b*, first instructions **46** can unlock SYSDVs **40** to release reels **49** to unwind more of line charges **50** that are still coiled on them. Second instructions **68** reactivate LCDVs **60** to pull line charges **50** to further extend in paths **60***a* parallel with respect to one another across shoreline **24** and partially onto beach portion **25**. Line charges **50** extend paths **60***a* equally spaced apart from and parallel with each other throughout surf zone **22** and beach portion **25** of approach lane **20**. Detonation of extended line charges **50** can be made in sequences or simultaneously via each firing device **54**.

Line charges **50** also can be emplaced throughout surf zone **22** and part of beach portion **25** of approach lane in a single uninterrupted sequence. Emplacement of the entire lengths of line charges **50** need not have a period of time elapse while parts of line charges **50** are extended in surf zone **22**. This uninterrupted, continuous sequence can include tightening of emplaced line charges **50** that extend from SYSDVs **40** at seaward base positions **80** at seaward edge **22***a* to LCDVs **60** where they have progressed to inland positions **90** at the inland edge **25***a* of approach lane **20**.

First and second instructions **46** and **68** control emplacement of line charges **50** in parallel equally spaced apart distributions **60***a* of explosive charges **51** of line charges **50** in surf zone **22** and beach portion **25**. The separations between distributions **60***a* and the spacing between explosive charges **51** assure the creation of an aggregate intense explosive effect to neutralize obstacles **26** and mines **28** (usually by destruction) within approach lane **20** and make approach lane **20** safe for transit of personnel, materials, and vehicles.

In these or other deployment sequences the locations and paths of SYSDVs **40** and LCDVs **60** can be different. The payloads of line charges **50** can be different to include one or more larger explosive charges or instrumentation packages to accomplish some other desired tactical result. Irrespective of the exact configuration of the constituents of system **10** of the invention, it is a covert and fully autonomous means of clearing obstacles and mines in approach lane **20** that is capable of being safely deployed from over-the-horizon and keeping personnel away from danger.

SYSDV **40** could use tracked crawler assemblies **42** in a crawler mode that allow SYSDV **40** to crawl on bottom **23***b* of water **23** to deliver LCDVs **60** and line charges **50**. SYSDV **40** could use propeller/fin arrangement **41** in the swimmer-delivery mode that propels SYSDV **40** through water **23** above bottom **23***b* and through water **23** to deliver LCDVs **60** and line charges **50**. Both delivery capabilities are schematically depicted for SYSDV **40** and could be used alone or in combination depending on what is found to be the most effective way to successfully complete the mission.

A swimmer-type vehicle could be used instead of a crawler type LCDV **60**, but this might limit deployment of line charges **50** to only part of surf zone **22**. The clock of GPS could be used to synchronize a passive acoustic LBL navigational system, such as described above to simplify the synchronization process.

Another option is to have all of the navigation components installed only on LCDVs **60** instead of on both LCDVs **60** and SYSDVs **40**. The navigation data from such LCDVs **60** would be shared with SYSDVs **40** for use during transit of SYSDVs **40** from ship **30** to approach lane **20** through a temporary umbilical connected to LCDVs **60** in storage bays **48**. Having all of the navigational components in LCDVs **60** reduces the overall system cost since all SYSDVs **40** and LCDVs **60** are destroyed at the time of detonation of their emplaced line charges **50**.

Having the teachings of this invention in mind, modifications and alternate embodiments of autonomous system **10** may be adapted without departing from the scope of the invention. Its uncomplicated, compact design incorporates structures and technologies long proven to operate successfully in the hostile marine environment. Autonomous system **10** lends itself to numerous modifications to permit its reliable use in different ways for different purposes in hostile and demanding environments both on open water and over many different types of land mass, including but not limited to beaches, hard-pack, soft mud, marsh, tidal flats etc. Autonomous system **10** of the invention can be made larger or smaller in different shapes and fabricated from a wide variety of materials to assure resistance to corrosion, sufficient strength for heavy loads, and long-term reliable operation under a multitude of different operational requirements.

The disclosed components and their arrangements as disclosed herein, all contribute to the novel features of this invention. Autonomous system **10** provides a multipurpose and capable means of emplacing elongates line charges **50** to assure neutralization of obstacles and mines irrespective of ambient conditions and terrain. Therefore, autonomous system **10**, as disclosed herein is not to be construed as limiting, but rather, is intended to be demonstrative of this inventive concept.

It should be readily understood that many modifications and variations of the present invention are possible within the purview of the claimed invention. It is to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. A system for autonomous clearance of obstacles and mines from an approach lane comprising:

a ship distantly located from an approach lane spanning a surf zone and beach portion, said ship having operator control station software in an onboard computer;

a system delivery vehicle having a storage bay and means to transit from said ship to said approach lane in response to first instructions from said operator control station software;

a line charge disposed in said bay and having one end coupled to said system delivery vehicle; and

a line charge delivery vehicle disposed in said bay and connected to another end of said line charge to pull said line charge from said bay and emplace said line charge in a straight path in said approach lane in response to second instructions from said operator control station software.

2. The system of claim **1** wherein said storage bay has a reel mounted on said system delivery vehicle and said line charge is wrapped around said reel in coiled storage during transit to said approach lane.

3. The system of claim **2** wherein said line charge delivery vehicle has tracked crawler assemblies to crawl along a surface to emplace said line charge in an elongate path through said surf zone and beach portion of said approach lane.

4. The system of claim **3** wherein system delivery vehicle has a hinged cover to open and flood said storage bay to permit emplacement of said line charge by said line charge delivery vehicle.

5. The system of claim **4** further comprising:

a first computer in said system delivery vehicle to effect operation thereof in response to said first instructions and a second computer in said line charge delivery vehicle to effect operation thereof in response to said second instructions.

6. The system of claim **5** wherein said line charge has a plurality of explosive charges spaced apart from each other on flexible strength members and an elongate buoyant sac along said explosive charges to reduce the load of said line charge through said surf zone.

7. The system of claim **6** wherein system delivery vehicle has propulsion means including propeller/fin arrangements and tracked ground crawler assemblies to transit from said ship to said approach lane in a swimmer delivery mode and crawler mode, respectively, and motors, fuel/batteries, and communications/control modules are provided to responsively operate said propulsion means.

8. The system of claim **7** wherein said system delivery vehicle and said line charge delivery vehicle exert tension on said line charge to straighten out said line charge along a path.

9. The system of claim **8** further comprising:

means for detonating said explosive charges to clear obstacles and mines from said approach lane.

10. The system of claim **9** further comprising:

a plurality of system delivery vehicles each having a storage bay with a reel therein;

a plurality of line charges; and

a plurality of line charge delivery vehicles, each of said system delivery vehicles containing a separate one of said line charge delivery vehicles connected to a separate one of said line charges, each of said line charges being connected to and coiled on a separate reel, each of said plurality of system delivery vehicles having a first computer having different first instructions to position said plurality of system delivery vehicles in side-by-side spaced apart locations along a seaward base portion of said approach lane, each of said line charge delivery vehicles having a second computer having different instructions to open each bay and activate each line charge delivery vehicle to pull a separate line charge from a reel and along a different path in said approach lane.

11. The system of claim **10** wherein said plurality of line charge delivery vehicles emplace said plurality of line charges in said approach lane along parallel equally spaced apart paths.

12. The system of claim **11** wherein each of said plurality of line charges includes explosive charges connected to flexible strength members and a detonating cord and a firing device is suitably connected to detonate said line charge.

13. A method of autonomously clearing obstacles and mines from an approach lane comprising the steps of:

transiting designator vehicles in water from a support ship to seaward corner positions in water outside of an approach lane;

deploying sensors for position and depth at said seaward corner positions in said water outside of said approach lane;

transmitting sensor and position data through said water from said seaward corner positions;

initializing first computers in a plurality of system delivery vehicles with first instructions based partially on said data and second computers in a plurality of line charge delivery vehicles with second instructions at said support ship, said system delivery vehicles each having a storage bay with a reel therein;

containing a separate one of said line charge delivery vehicles and a line charge in each bay, each line charge having one end connected to a separate one of said line charge delivery vehicles and another end connected to a reel and being coiled thereon;

transiting said system delivery vehicles to base positions located along a seaward edge of said approach lane between said seaward corner positions;

rotating covers from each bay;

flooding each bay with water;

deploying a line charge delivery vehicle from each bay;

pulling a line charge behind each line charge delivery vehicle along a separate path in said approach lane; and

emplacing all line charges in said approach lane.

14. The method of claim **13** wherein said step of transiting said system delivery vehicles to base positions located along a seaward edge comprises the steps of:

arriving at different designated ones of said base positions by different ones of said system delivery vehicles, said base positions being spaced apart from one another in a side-by-side relationship along said seaward edge of said approach lane; and

flooding compartments in said system delivery vehicles to sink said system delivery vehicles to bottom of said water to maintain said spaced apart side-by-side relationship at said base positions.

15. The method of claim **14** wherein said step of deploying said line charge delivery vehicles comprises the step of:

crawling tracked crawler assemblies of each line charge delivery vehicle over open covers and onto and across said bottom.

16. The method of claim **15** wherein said step of pulling comprises the step of:

rotating each reel as each line charge delivery vehicle unwraps and pulls more of each line charge from each reel.

17. The method of claim **16** further comprising the step of:

crawling all line charge delivery vehicles from their base positions along said bottom under a surf zone of said approach lane in paths parallel with each other in said approach lane, each line charge being dragged along and pulled straight to space and emplace explosive charges of each line charge apart in a parallel separation in said paths.

18. The method of claim **17** further comprising the step of:

partially buoying each line array in said surf zone with an elongate sac connected to each line charge to reduce part of the entrained load created by each line charge.

19. The method of claim **18** further comprising the steps of:

locking each reel to prevent further outward travel of each line charge delivery vehicle connected to each line charge;

stretching tight each locked-in-place line charge; and

anchoring each stretched tight line charge by each system delivery vehicle and line charge delivery vehicle connected thereto, said step of anchoring holding the stretched line charges in place along said paths.

20. The method of claim **19** further comprising the step of:

extending said step of crawling all line charge delivery vehicles to create continuously extended paths of emplaced line charges across said approach lane from said seaward edge of said surf zone to an inland edge of a beach portion of said approach lane.

21. The method of claim **20** further comprising the step of:

detonating explosive charges in all line charges to clear said approach lane of obstacles and mines.

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