(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 April 2008 (10.04.2008)

PCT

(10) International Publication Number
WO 2008/042166 A2

(51) International Patent Classification:
E21B 47/04 (2006.01)

(21) International Application Number:
PCT/US2007/020689

(22) International Filing Date:
25 September 2007 (25.09.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/536,575 28 September 2006 (28.09.2006) US

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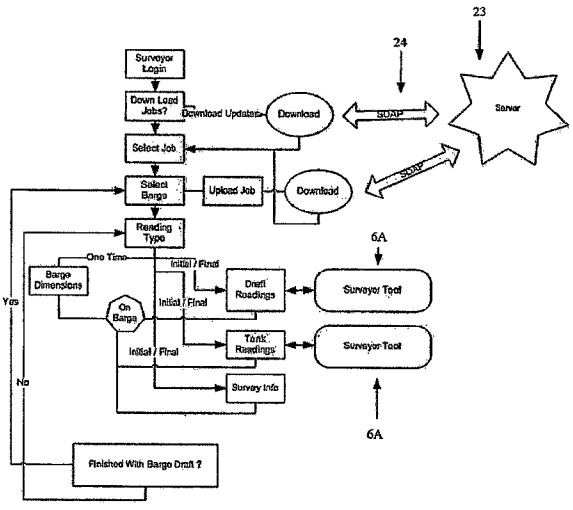
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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

(54) Title: IMPROVED METHODS AND APPARATUS TO DETERMINE VESSEL DRAFT AND AMOUNT OF CARGO LOADED IN A VESSEL



(57) Abstract: The present invention discloses the methods and apparatus to determine the draft and/or amount of cargo loaded in a vessel. The apparatus includes a portable, handheld housing containing an ultrasonic transducer and receiver, or, alternatively, a laser emitter and receiver, that directs sound, or, alternatively light, toward the surface of the water body in which the vessel is placed. Within the housing is electrical circuitry to receive either the sound or light beam signals reflected from the water surface. These signals are processed by a computer programmed to utilize an arraying analytical technique to determine the distance of the vessel above the waterline. Using known vessel displacement characteristics and cargo unit weight, the processed data will then be used by the computer or transmitted wirelessly to a central computer, to determine the amount of cargo that has been loaded in the vessel.

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SPECIFICATION

BACKGROUND OF THE INVENTION

Field of the Invention. This invention relates in general to methods and apparatus to measure, record and analyze data related to the draft of, or the amount of cargo contained in, a water-borne vessel.

Prior Art. Water-borne vessels, such as ships and barges, are commonly used to transport cargo utilizing oceans, navigable rivers, canals and lakes. Their ability to carry large amounts of cargo economically makes them particularly suitable for transporting dry bulk cargo, liquid cargo and other similar type cargo that can be loaded by clamshell buckets, conveyors or pumped into the vessel holds. However, to improve the transportation economics, as well as to be able to determine the amount of cargo that has been loaded onto the vessel, it is important to obtain accurate readings of the vessel draft. It is also important to have accurate vessel draft readings to prevent the barge from bottoming out in the waterway during the transporting of the cargo.

Particular problems exist with current barge drafting measurements. In the current system, barge drafters use modified tape measures to obtain a freeboard height using a theoretical distance from the top of the barge to the water level at six set locations around a barge. According to the Barge Surveying Taskforce, a group of individuals put together by the Fertilizer Institute to standardize barge drafting measurements, variations among readings exceed ±3.5% and are seldom repeatable within 0.5% which can lead to a cost variation of over $10,000 per barge.

Freeboard measurements are an attempt to measure the distance from the molded deck down to the water line. Each barge generally has a published depth, which is measured from the

deck of the barge to the bottom of the barge. However, during the lifetime of the barge, the decks generally become uneven due to stresses and collisions, making it difficult to find the "true" plane of the barge deck. While there are many problems with the current manual system of barge drafting, most errors can be traced back to one of four main areas. These include inaccurate integration of the measurements to the barge, failure to accurately estimate where the "true" water level due to wave activity, data entry, and computational errors resulting from the method of recording the measurements made.

Due to effects that collisions, stress and other factors have on the barge deck, it is difficult to accurately locate the top of the barge for measuring the distance to the top of the water. However, some barge drafting systems work on the assumption that the molded deck has no abnormalities. This assumption is rarely true and the error introduced can throw the calculations off by a number of inches. Other barge drafting systems take advantage of the fact that each barge generally has a series of draft numbers permanently attached to the side of the barge adjacent the four corners of a barge. Each block number has a height of exactly six inches and is calibrated from the bottom of the barge. These numbers generally are not affected by stress or collisions. In these other barge drafting systems surveyors use these numbers to establish a zero point where the "true" top of the deck should be located. The use of these numbers as a zero point allows integration into the barge dimensions regardless of the condition of the deck. In these systems surveyors drop a tape measure down to the water and estimate when the tape's end point is halfway between the peak and valley of the waves intersecting the barge. However, this is simply a visual estimate and can vary a number of inches depending on the surveyor and wave conditions. Conditions typically produce waves in excess of one foot down to an inch in

amplitude. Conditions on oceans and rivers can drastically affect the freeboard measurements when compared to readings taken within an area such as a protected port. Furthermore the exact point along the curve of the wave being measured is currently determined by the surveyor which leads to differences amongst surveyor practices. In addition, the poor visibility at the time the measurement is taken can also create problems with the measurement. This is particularly true if one is measuring vessels, such as barges, that are tied up next to one another. In such instances there may only be one inch separating the adjacent vessels which impairs the surveyor's ability to make visual observations regarding the position of the tape measure, particularly when the barge deck may be six or more feet from the water surface. Additionally, such measurements can be dangerous if the vessels are rocking due to wave action or other forces. The marine surveyor can slip and fall from the vessel, or in some cases his hand, foot or other body part can get crushed between two vessels that rock into one another.

Surveyors measure the barge drafts of the vessel where it is floating in the water. In many cases, the location of the vessel is an isolated area. The surveyors currently manually write down their freeboard values taken from their tape measure observations. These values are later used for computation and then finally for the final survey report. Thus, additional problems occur because of the double entry of the measured distances.

One attempt to obtain more accurate barge draft readings was through positioning of pressure sensors below the water surface of the barge. One such device is described in U.S. Patent 5,547,327 entitled "Method and Apparatus for Continuously Determining the Inclination and Draft of a Waterborne Floating Vessel to Enable Automatic Loading of the Vessel" that issued on August 20, 1996. However, this solution has not found widespread commercial acceptance. Difficulties

in positioning the pressure sensors, taking accurate reading of the sensors, analyzing the sensor readings, and the potential of damage to the sensors during transportation are suspected difficulties that still leave the need for more accurate and reliable methods and apparatus to measure barge draft and the amount of cargo loaded in a barge.

Another attempt to solve these industry problems is the use of multiple ultrasonic sensors to determine the barge draft. One such device is described in U.S. Patent 6,836,746 entitled "Method and Apparatus for Calculating the Payload on a Water-Borne Vessel" and issued on December 28, 2004. However, this solution has also not found widespread commercial acceptance. Again difficulties in positioning such sensors and obtaining accurate readings when the vessel is rocking or measuring the draft of vessels that are closed positioned next to one another still leaves a need in the industry for better methods and apparatus to determine vessel drafts.

OBJECTS AND SUMMARY OF THE INVENTION

Therefore, one object of this invention is to provide an apparatus that can be easily and accurately positioned for use to obtain data to determine a certifiable vessel draft.

Another object of this invention is to provide an apparatus that obtains more accurate and reliable data to determine vessel draft.

Another object of this invention is to provide an apparatus that minimizes errors in barge drafting measurements due to inaccurate integration to the barge, failure to accurately estimate where the "true" water level due to wave activity, computational errors, or data entry errors, as well as create a more reproducible draft value.

A further object of this invention is to provide an apparatus that can be safely used to obtain data to be used for determining vessel draft.

Still another object of this invention is to provide an improved method of obtaining and analyzing data related to vessel draft.

Other objects and advantages of this invention shall become apparent from the ensuing descriptions of the invention.

Accordingly, this invention in one embodiment comprises a method for determining vessel draft including first positioning a surveying device at a first known position relative to a predetermined waterline marker; sending one or more separate signals from the surveying device toward the water body; receiving a reflected signal for each of the signals reflected from the water body; analyzing each of the received reflected signals to determine the vessel draft; positioning the surveying device at a second known position relative to a second predetermined waterline marker; repeating the steps above with the surveying device at the second known

position; and analyzing all received reflective signals to determine the vessel draft. In a preferred embodiment of this invention the positioning of the surveying device is conducted by perpendicularly aligning a focused light beam, such as emitted by a laser, on one of the upper waterline markers, preferably the upper waterline marker. In another preferred embodiment the signals from the surveying device are directed toward the surface of the water body in a direction perpendicular to the focused light beam. In another preferred embodiment a visual postioning device, such as a camera device that can transmit an image indicating when the camera is aligned with the pre-selected waterline marker. In still another preferred embodiment a level can be affixed to the body to indicate that the body is substantially perpendicular to the water surface. In a more preferred embodiment the level will be provided with a transmitter that can emit a sound or electronic signal to indicate when the body is substantially perpendicular to the water surface. In still another more preferred embodiment, the surveying device will be provided with a device apparatus to determine the spatial orientation of the apparatus to indicate the spatial orientation of the surveying device. In an alternate embodiment the surveying device has a thin profile ruler having positioning markings on its surface. The ruler is structured to permit it to be positioned along the side of the vessel hull and is of sufficient length to extend to the desired waterline draft numbering. In a preferred embodiment a magnet is attached to the extending end section of the ruler to permit the attachment of the ruler to the vessel hull at the desired location. It is preferred that a series of measurements be made over a predetermined time interval at one location on the vessel to permit use of an arraying technique analysis of the measurements to calculate the draft. In another preferred embodiment multiple readings are taken at each position that where a vertical series of waterline markers are located.

In another embodiment of this invention a vessel draft surveying device is constructed having a housing and a handle extending from the housing for gripping the device. In one preferred embodiment, alignment of the device for taking measurement is achieved utilizing a laser or other focused light beam emitting device contained within the housing at a position to permit the light beam to be emitted from one side of the housing toward a predetermined vessel waterline marker. In an alternate preferred embodiment, a thin profile ruler having position markings on its surface extends from housing. The ruler has sufficient length to extend from the vessel deck to the desired vessel waterline number. It is preferred that the ruler be collapsible or telescoping to facilitate transporting and storage. In a more preferred embodiment a magnet will be attached at the extending end section of the ruler in a position to attach the ruler to the vessel hull surface at the desired vessel waterline number.

A draft measuring ultrasonic transmitter or laser is also contained within the housing and positioned to direct a sound or light beam toward the water surface when the housing is in the desired operating position. Again, known timer circuitry is used to generate a signal representative of the time between the transmitting and receiving of the sound or light beam. In a preferred embodiment the receiving unit is a computer programmed to be capable of analyzing the time signals to calculate the vessel draft. This computer can be housed in a conventional PDA or PDA-like device. In a preferred embodiment this program includes an arraying analytical process used to determine the vessel draft. This This device can also be provided with a computer chip having preloaded data bases containing the vessel displacement characteristics and cargo unit weight data, or alternatively, if a PDA is utilized this data can be transmitted from a central server located off-site to the PDA. this These embodiments calculates the vessel draft and then transmit the draft

calculation to the central computer that is programmed to calculate the amount of cargo loaded in the vessel utilizing the analyzed time signals and the data stored in the central computer database. In another embodiment the device can be programmed to calculate both the vessel draft and the amount of cargo loaded in the vessel.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate a preferred embodiment of this invention. However, it is to be understood that these embodiments are not intended to be exhaustive, nor limiting of the invention. They are but examples of some of the forms in which the invention may be practiced.

Figure 1 illustrates a surveyor standing on the deck of a barge in the process of positioning the measuring device of this invention.

Figures 2A – 2F illustrate a preferred series of steps used by a marine surveyor to obtain readings with the laser surveying device of this invention for use in calculating barge draft.

Figures 3A – 3F illustrate a preferred series of steps used by a marine surveyor to obtain readings with the ultrasonic surveying device of this invention for use in calculating barge draft.

Figures 4 and 5 are side views of preferred embodiments of the surveying device of this invention illustrating the positioning of aligned lasers.

Figures 6 is a bottom view of Figure 4 illustrating the use of opposing pairs of alignment lasers to provide additional positioning flexibility of the surveying device, in conjunction with an ultrasonic transducer and microphone receivers for determining the barge draft.

Figure 7 is alternate view similar to Figure 6, but wherein the positioning lasers are used in conjunction with a laser emitter and receiver for determining the barge draft.

Figure 8 is a side view of the surveying device handle in a possible collapsed position useful for carrying or transporting to the job site.

Figure 9 is a flow chart illustrating the preferred steps taken by the marine surveyor when utilizing one preferred embodiment of the surveying device of this invention in conjunction with a PDA and a main server.

Figure 1 10 illustrates a surveyor standing on the deck of a barge in the process of positioning the measuring device of this invention.

Figures 2A 11A – 2D 11D illustrate a preferred series of steps used by a marine surveyor to obtain readings with the laser surveying device of this invention for use in calculating barge draft.

Figures 3A 12A – 3B 12B are isometric views of the device.

Figure 13 is a flow chart illustrating the preferred steps taken by the marine surveyor when utilizing one preferred embodiment of the surveying device of this invention in conjunction with a main server.

PREFERRED EMBODIMENTS OF THE INVENTION

Without any intent to limit the scope of this invention, reference is made to the figures in describing the preferred embodiments of the invention.

Referring now to Figures 1, also in Figures 2A – 2F and 3A – 3F, a marine surveyor **1** is illustrated standing on a barge deck **2** near the edge **3** of one side **4** of the barge **5**. The surveyor **1** is shown holding the surveying device **6** used to measure the barge draft (also known as freeboard or ullage) by the upper end **7** of its handle **8** to position the body **9** of the surveying device **6** opposite the desired water line marker **10**. The body **9** is provided with one or more focused light beam emitters, such as lasers **11**, to assist in the alignment of the body **9** opposite the water line marker **10**. Once the light beam **12** is aligned on the water line marker **10**, the marine surveyor **1** then activates an ultrasonic transducer **13** to direct a sound wave **14** perpendicularly to the focused light beam **12** and toward the surface **15** of the water. The ultrasonic transducer **13** will also be contained within the body **9** of the surveying device **6**. Alternatively, a second laser **16** (see Figure 5) could be used in place of the ultrasonic transducer **13** to direct a light beam **17** toward the water surface **15**. In either case the body **9** will also contain one or more receivers **18** to detect the sound wave **19** or light beam **20** reflected from the water surface **15**. Also contained in the body **9** will be conventional electronic timer circuitry (not shown) to generate an elapsed time signal indicative of the elapsed time between the transmission and the receipt of the reflected sound wave **19** or light beam **20** by the receivers **18**. In a preferred embodiment the elapsed time signal **21** will be transmitted to a PDA **22** or PDA-type device equipped with WI-FI and/or broad band wireless or other similar electronic assembly that may permit the transmitting of collected data to a main server **41** (see Figure 9). The PDA is designed to be easily carried by the marine surveyor. In a

preferred embodiment multiple elapsed time signals **21** will be generated at each location of a series of vertically positioned waterline markers **10** that are typically positioned on the aft and bow areas of each side of the barge **5**. To provide for better analyze of the data it is preferred that measurements be taken at four or more locations and that each location at least six or more measurements be taken. The PDA **22** can be in communicative connection with a main server 41 located at the surveyor's office or at such other location as may be desired. The calculations can take place using a processor located in the surveying device, or in the PDA-like device, or in the on-shore computer. In general the surveying device processor will determine whether or not to accept a value based upon an internal stored array filtered by inter quartile range. It will also sample the reading rate and position of the readings with respect to the surveying positions. In most implementations the PDA-like device will be a windows mobile phone allowing continued access to the main server. In this configuration the accepted distance values along with the location sampled are then offloaded through a Bluetooth connection to a PDA-like device. In a preferred embodiment, the PDA **22** will contain software that permits analysis of the received elapsed time signals **21** to determine the barge draft through the use of linear regression evaluations of the array as it is built. The PDA-like device will signal the surveying device when to stop taking sample readings at a location. The sampled freeboard values are combined with downloaded barge characteristics that can then be used to calculate the barge draft. The barge draft calculation is then transmitted to the main server **41** that has been programmed to calculate the amount of cargo that is contained in the barge **5**. This division of computer labor allows for the simultaneous filtering and real time arithmetic analysis of reading while providing information specific to the job and vessel.

The surveying device **6** can be used before, during, and after loading of cargo on the barge

5. The initial draft of a particular barge **5** when unloaded could be measured and this information stored in a database for later comparison against the draft of the same barge **5** when it is loaded. Over time the database will have a valuable knowledge base that may be used in optimizing future operations and prevent extensive damage to barge **5**. The database can also be used to determine if barge **5** may have flooded its ballast tanks since the last recording of the data, which can influence the barge draft.

Referring now to Figures 4 and 5, surveying device **6** comprises handle **8** and body **9**. Handle **8** is preferably collapsible in order to facilitate storage during transport, as well as handling on the job site until the barge draft measurements are to be taken. Handle **8** will be attached at its lower end section **8A** to top plate **25** of body **9**. It is preferred that handle **8** extend upward from the top plate to permit the marine surveyor **1** to more clearly determine when body **9** has been properly positioned relative to the upper water line marker **10**. It is preferred that body **9** having a narrow rectangular profile, such as shown in Figures 4 and 5, be constructed having two pairs of opposing side walls **26, 27** and **28, 29**, top plate **25** and bottom plate **30** to form a generally box shape having an interior water tight cavity **31**. Because the deck edges of adjacent barges can be as close as one inch to one another, it more preferred that the distance between the parallel side walls **26, 27** of body **9** be one inch or less. Side wall **26** will have at least one opening **32** to permit alignment laser **11** to be positioned in the opening **32** in a sealing arrangement permitting the emitting of a narrow light beam **12** perpendicularly from side wall **26**. It is preferred that at least two horizontal aligned lasers **11** be used in order to more easily determine that body **9** is horizontally positioned to the waterline marker **10**. In a preferred embodiment opposing side wall **27** will also have openings **32** to permit a second pair of horizontal aligned lasers **11** to be positioned to emit narrow light

beams **12** perpendicularly from the opposing side wall **27**. This permits greater flexibility where the marine surveyor **1** can stand on the barge deck **2**, as well as facilitates allowing the marine surveyor **1** to hold handle **8** with either hand.

As illustrated in Figures 6 and 7, body bottom plate **30** will be provided with central opening **33** into which ultrasound transducer **13** can be positioned in a sealing arrangement to direct sound wave **14** toward the water surface **15**. Body bottom plate **30** will also be provided with one or more openings **34** to accommodate one or more ultrasound microphones **18** that will receive the transmitted sound wave after it has been reflected from the water surface **15**. In the alternate embodiment illustrated in Figure 7, body bottom plate **30** will have opening **35** to accommodate a laser **11** in a sealing arrangement, as well as second opening **36** to accommodate laser receiver **18** in a sealing arrangement. In both embodiments there will be a known electronic timer circuitry operatively attached to the sound or light transmitting devices **13** and **16**, respectively, and the reflected sound wave **19** or reflected light receiver **20**, respectively, to determine the elapsed time from the transmission to the receipt of the reflected sound wave **19** or light beam **20**. The timer circuitry will be operatively connected to a transmitter that receives an elapsed time signal generated by the timer circuitry and transmits an elapsed time signal **21** to the PDA **22** carried by the surveyor **1**.

As illustrated in Figure 8, in one preferred embodiment handle **8** will comprise multiple segments of tubing **8A-8D** that are attached to adjacent segments by a conventional hinge assembly **37** to permit the tubing segments **8A-8D** to be folded on top of one another when the surveying device **6** is not being used. In a preferred embodiment control panel **38** is affixed to the one of the upper segments, preferable the most upper segment **8D**. The control panel **38** will contain one or

more activation buttons **39** that are operatively connected by wiring **42** to the ultrasonic transmitter **13** or the laser beam transmitter **16** to activate the transmission of the sound wave **14** or laser beam **17**, respectively. If desired, control panel **38** can contain other control buttons **40** operatively attached to the transmitter to activate sending the elapsed time signal **21** to the PDA **22**. Alternatively, the transmitter can automatically transmit the elapsed time signal **21** to the PDA **22** without any need for activation.

Lower segment **8A** of the handle **8** is affixed to top plate **25**. In a preferred embodiment lower segment **8A** is pivotally affixed to top plate **25** to permit greater flexibility in positioning the body **9** opposite the desired waterline marker **10**.

In an alternate embodiment handle segments **8A-8D** can be shaped to telescope within one another to form a more compact shape when the surveying device **6** is not in use. In this embodiment it is still preferred that lower segment **8A** be pivotally affixed to top plate **25** to permit greater flexibility in positioning the body **9** opposite the desired waterline marker **10**. Other known means for compacting a tubular member similar to handle **8** could also be used.

In an alternate embodiment illustrated in Referring now to Figures 110, also and in Figures 2A 11A – 2D11D, a marine surveyor **1** is illustrated standing on a barge deck **2** near the edge **3** of one side **4** of the barge **5**. The surveyor **1** is shown holding thean alternate embodiment surveying device **6A** used to measure the barge draft. (also known as freeboard or ullage) holding its handle **7** of tool body **8** and ruler **9** of the surveying device **6** opposite the desired water line marker **10**. The surveying device **6A** includes a tool body **43**, a handle **44** extending from tool body **43**, a power supply holder **45** containing a conventional power supply (not shown), such as batteries, and

attached to the opposite end of handle **44**, and a ruler **46** extending from tool body **43** whereby it can be positioned opposite the desired waterline maker **10**. The ruler **9 46** is provided with one or more magnets, such as **1147**, to assist in the alignment of the body **8 43** opposite the water line marker **10**. Once the magnetic force **12 47** is used to alignaligned the ruler 9 on the water line marker **10**, the marine surveyor **1** then activates a laser **13 48** to direct a laser light **14 49** perpendicularly to ruler **9 46** and toward the surface **15 50** of the water. The laser **13 48** will also be contained within the body **8 43** of the surveying device **6A** and positioned to direct a light beam **14 49** toward the water surface **1550** when ruler **46** has been positioned on the desired waterline by magnet **47**. In either case the body **8 43** will also contain a receiver **17 51** to detect laser light beam **16 49** reflected from the water surface **1550**. Also contained in the body **8 43** will be conventional electronic timer circuitry and phase shift analyzer for sampling the returning light **16 52** by the receivers **1751**. In a preferred embodiment multiple elapsed time signals will be generated at each location of a series of vertically positioned waterline markers **10** that are typically positioned on the aft and bow areas of each side of the barge **5**. To provide for better analyze of the data it is preferred that measurements be taken at four or more locations and that each location at least six or more measurements be taken. The device can be in communicative connection with a main server **41** located at the surveyor's office or at such other location as may be desired. The calculations can take place using a processor located in the surveying device. In general the surveying device processor will determine whether or not to accept a value based upon an internal stored array filtered by inter-quartile range. It will also sample the reading rate and position of the readings with respect to the surveying positions. In most implementations the device will contain a GSM and or WiFi transceiver to allow wireless communication with a main server. In a preferred

embodiment, the device will contain software that permits analysis of the received elapsed time signals to determine the barge draft through the use of linear regression evaluations of the array as it is built. The device will signal the surveying device **6A** when to stop taking sample readings at a location. The sampled freeboard values are combined with downloaded barge characteristics that can then be used to calculate the barge draft. The barge draft calculation is then transmitted to the main server **41** that has been programmed to calculate the amount of cargo that is contained in the barge **5**. This division of computer labor allows for the simultaneous filtering and real time arithmetic analysis of reading while providing information specific to the job and vessel.

The surveying device **6A** can be used before, during, and after loading of cargo on the barge **5**. The initial draft of a particular barge **5** when unloaded could be measured and this information stored in a database for later comparison against the draft of the same barge **5** when it is loaded. Over time the database will have a valuable knowledge base that may be used in optimizing future operations and prevent extensive damage to barge **5**. The database can also be used to determine if barge **5** may have flooded its ballast tanks since the last recording of the data, which can influence the barge draft.

Referring now to Figures 123A – 3B12B, surveying device **6A** comprises handle **7** and body **8** includes ruler **9** that is preferably collapsible in order to facilitate storage during transport, as well as handling on the job site until the barge draft measurements are to be taken. A detachable battery pack **21 45** is preferably attached to end **53** of the tool's handle **744**, in parallel alignment to the main housing **8 43**and more generally, attached the laser drafting tool **6**. For storage and transportation ease, it is also preferred that the ruler **9 46** be detachable from the main housing **843**. The extending end **46A** of ruler **9 46** is used to establish integration of the **tool 6A** to the

vessel **5**. When attached and fully extended, ruler end **46A** will be, being a known and constant distance from the laser emitter **1348**, laser light beam detector **17 51** and the housing **43**. In a preferred embodiment the attachment of ruler **9 46** to the hull of vessel **5** is achieved by a magnet **11 47** affixed to ruler end **46A** at a position to permit magnetic attachment of ruler end **46A** to the desired barge waterline marking.

It is preferred that the laser emitter **1348**, detector **1751**, viewing screen **18 54** and other main circuit boards be fully contained within the housing **843**. It is preferred that the bodyhousing **8 43** having have a generally rectangular profile, such as shown in Figures **312A** and **12B**, and be constructed having two pairs of opposing side walls **55** and **56** to form a generally cordless drill- like shape having an interior water tight cavity **6** in which the internal components are housed. This water tight cavity, formed by the main housing **843**, preferably has at least three water tight openings. **13, 17, 18,** The first opening is sealed by screen **54** in a manner to permit the surveyor **1** to view screen **54**. The second opening is sealed by laser light beam emitter **48** and the third opening is sealed by laser light beam detector **51**. will allow viewing of the internal screen **18** with a second opening to allow for the laser emitter **13** and detector **17** with It is preferred that the screen **54** and laser light beam emitter **48** openings being be placed at opposing ends **56** and **57** of housing **843**. Because the deck edges **2** of adjacent barges **4** can be closer than an inch to one another, it is more preferred that the distance between the emitting laser **13 48** and detector **17 51** be less than half an inch from the surface **58** of integration ruler's **9 46**surface. As seen in **FIGS. 2 11C** and **11D**, such that the laser beam **14 49** is in parallel to ruler **9 46** and no more than half an inch above ruler's **9** surface **58**. The reflected laser light beam **16 58** returning to the detector **17 51** after reflecting from the water's surface **15 50** produces signals that are used in the distance

calculation. The distance calculation being a result of measurement of differences in phase shift as expressed by the emitted beam **14 49** and measured in the detected reflected **16** beam **52**.

In one iteration, the control of the tool will be made through the three trigger buttons **20 59,** anddirectional buttons **1960A** and **60B** located on the handle **44,** and operational button **61**main function button **20** and the others being directional and operational buttons. A connection point **22 62** for a tether is preferablybeing placed preferably on the handle **7 44** or on power pack **45** as illustrated in **FIGS. 12A** and **12B** for the safety of the operator and to prevent to tool **6A** from being unintentionally dropped off a vessel **5**. The screen **18 54** will displaying a number of different pages havingwith digital tools, such as digital inclinometer **2633**, specific to the tool's internal program. These tools allow for easy selection of job, vessel and reading locations along with other survey specific tasks.

As indicated above the surveying device **6** or **6A** may utilize ultrasound techniques, laser based measurement techniques or other optical measurement techniques to determine the barge draft. Each measurement technique requires different preprocessing techniques.As indicated above the surveying device **6** may utilize laser based measurement techniques or other optical measurement techniques to determine the barge draft. Each measurement technique requires different preprocessing techniques.

Determination of Barge Draft using Ultrasonics

When utilizing an ultrasonic transducer **13** and receivers **18** it is necessary to analyze the reflected sound wave **19** to identify the echo most likely to represent the water surface **15**. An ultrasound echo generally creates a negatively skewed distance distribution where the true reading time value is most likely located in the second quartile (Q2) to the third quartile range (Q3). The

mode within variance region between the second and third quartile range is accepted as the valid reading. For this reason, when ultrasound transducer **13** is used, the echoes returned from a single sound pulse are statistically measured within Q3-Q2. This is expressed by the following formula where y_i is the wave amplitude, m is the accepted array:

$$\frac{\sum_{i=1}^{n} y_i}{2} \leq (m) \leq \frac{3\left(\sum_{i=1}^{n} y_i\right)}{4}$$

Determination of Barge Draft using Laser Beam.

In the laser-based measurement technique, the preprocessing of distances is made. In a preferred embodiment the standard deviation of the measured distance y is expressed by the following formula:

$$= \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(y_i - \frac{1}{n}\sum_{i=1}^{n} y_i\right)}$$

The surveying device **6A** produces reading values associated with the type and location of the reading. The device creates an array that is double or triple the size of the needed requirement. A sample array is selected from the large reading array by selecting sequential values that minimize b in the equation below.

$$b = -\left[\frac{\frac{1}{2}\left[\sum_{i=1}^{n} y^2{}_i - \frac{1}{n}\left(\sum_{i=1}^{n} y_i\right)^2\right] - \left[\sum_{i=1}^{n} x_i{}^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2\right]}{\frac{1}{n}\sum_{i=1}^{N} x_i \sum_{i=1}^{N} y_i - \sum_{i=1}^{N} x_i y_i}\right] \pm \sqrt{\left[\frac{\frac{1}{2}\left[\sum_{i=1}^{n} y_i^2 - y_n\left(\sum_{i=1}^{n} y_i\right)^2\right] - \left[\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2\right]}{\frac{1}{n}\sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i - \sum_{i=1}^{n} x_i y_i}\right] + 1}$$

The time between readings is expressed as x. This value can shift based on the periodic nature of the waves; however, through experimentation variance in the timing was found to only change the results by less than 0.15 inches. Thus, depending on the accuracy desired this may not

be necessary.

Once the valid section of the sampled array is captured with a minimized *b*, the inter-quartile mean is taken of the array after it is sorted. The accepted value can be expressed by the following formula:

$$= \frac{2}{n} \sum_{i=\left(\frac{n}{4}\right)+1}^{\frac{3n}{4}} x_i \ .$$

Finding Accurate Water Levels

In the surveying device we are looking for a relationship between an array of values with two parts: distance and time. When trying to sample waves using the laser device a simpler inter-quartile range is selected for sampling. Linear regression techniques employed allow for the explanation of the correspondence of the points selected in terms of X and Y values. This correspondence is expressed in a straight line where the line's y-intercept and slope b are known.

In a preferred embodiment the surveying device **6** is used to take reading at the following barge locations:

Light Port Forward	Light Tank Bow	Heavy Port Forward	Heavy Tank Bow
Light Port Mid	Light Tank Port 1	Heavy Port Mid	Heavy Tank Port 1
Light Port Aft	Light Tank Port 2	Heavy Port Aft	Heavy Tank Port 2
Light Starboard Forward	Light Tank Port 3	Heavy Starboard Forward	Heavy Tank Port 3
Light Starboard Mid	Light Tank Port 4	Heavy Starboard Mid	Heavy Tank Port 4
Light Starboard Aft	Light Tank Port 5	Heavy Starboard Aft	Heavy Tank Port 5
	Light Tank Starboard 1		Heavy Tank Starboard 1
	Light Tank Starboard 2		Heavy Tank Starboard 2
	Light Tank Starboard 3		Heavy Tank Starboard 3
	Light Tank Starboard 4		Heavy Tank Starboard 4
	Light Tank Starboard 5		Heavy Tank Starboard 5
	Light Tank Stern		Heavy Tank Stern

The flow chart in **FIG. 4 13** illustrates the interaction permitted by the software loaded in

the surveying device **6A** and the rest of the system. Surveyor **1** activates the device and logs in. The surveyor **1** selects the first barge **5** to be surveyed. Main server **23** will then transmit information related to the barges that are to be surveyed to surveying device **6A** through a standard SOAP connection **24.**

Barge readings are then obtained by the marine surveyor **1** and are returned from surveying device **6A** to main server **23.** Main server **23** then uses the following series of formula to calculate the total tonnage of cargo loaded in barge **5**

$$\xi = \left(\frac{\frac{(IPA + ISA)}{2} - \frac{(IPF + ISF)}{2}}{\delta - \gamma - \eta - \phi} \right) \text{ and } \rho = \left(\frac{\frac{FPA + FSA}{2} - \frac{FPF + FSF}{2}}{\delta - \gamma - \eta - \phi} \right)$$

$$\omega = \frac{\left(\left(\chi - \left(\frac{IPF + ISF}{2} - (\xi * \phi) \right) \right) + \iota - \varphi - \left(\chi - \left(\kappa - \left(\frac{\iota + \left(\left(\chi - \left(\frac{IPF + ISF}{2} - (\xi * \phi) \right) \right) + \iota \right) - \chi}{\phi} * (\phi - \lambda) \right) \right) \right)}{\lambda}$$

$$\psi = \chi - \frac{IPF + ISF}{2} \text{ and } \zeta = \chi - \frac{FPF + FSF}{2}$$

$$\upsilon = (\phi - \lambda) - \frac{\left(\chi - \left(\kappa - \left(\frac{\iota + \left(\left(\chi - \left(\frac{IPF + ISF}{2} - (\xi * \phi) \right) \right) + \iota \right) - \chi}{\phi} * (\phi - \lambda) \right) \right) \right)}{\omega}$$

$$\text{Displacement Tonnage} = \frac{\left(\left(\frac{\left(\left(\frac{\left(\frac{\psi}{\omega}+\upsilon\right)}{\left(1-\frac{\xi}{\omega}\right)}\right)+\left(\frac{\left(\frac{\zeta}{\omega}\right)+\upsilon}{\left(1-\frac{\rho}{\omega}\right)}\right)\right)}{2}\right)+(\delta-\phi)\right)*(\beta-\alpha)}{12}*\chi*62.43}{2000}$$

Wherein:
IPA = Initial Port Aft
ISA = Initial Starboard Aft
IPF = Initial Port Forward
ISF = Initial Starboard Forwards
FPA = Final Port Aft
FSA = Final Starboard Aft
FPF = Final Port Forward
FSF = Final Starboard Forward
ζ = Y Intercept Heavy
υ = X Intercept of Rake Equation
ρ = Heavy Trim Factor
ξ = Light Trim Factor
ψ = Y Intercept Light

and wherein:
α = Light Draft
β = Loaded Draft
χ = Hull Depth
δ = Hull Length
ϕ = Distance from headlog to end of rake shear
φ = Rake Headlog Height
γ = Distance from Aft readings to Stern
η = Distance from end of deck shear to Forward Mark
ι = Light measured Freeboard at headlog
κ = Deck to rack bottom at Aft edge of Manhole
λ = Distance from headlog to Aft edge of manhole

There are of course other alternate embodiments that are obvious from the foregoing descriptions of the invention which are intended to be included within the scope of the invention as defined by the following claims.

CLAIMS

What we claim is:

1. An apparatus for measuring barge draft of a barge for transporting a cargo having a known cargo unit weight, the barge having known displacement characteristics and having one or more waterline markers affixed to at least one side of the barge, at least one of the waterline markers being visible when the barge is floating in a water body comprising:

   (a) a housing;

   (b) a first means affixed to the housing for indicating when the housing is positioned opposite a predetermined one of the waterline markers;

   (c) a second means affixed to the housing for transmitting and receiving a signal reflected from the surface of the water body;

   (d) a timer affixed to the second means for measuring time between the transmitting and the receiving of the signal, and for transmitting a time signal indicative of the measured time; and

   (e) a third means operatively attached to the time for receiving the time signal and for calculating the barge draft from the time signal.

2. An apparatus according to claim 1 further comprising a collapsible ruler affixed at a first end section to the housing and having an extending end section, the ruler being of sufficient length to position the extending end section opposite the predetermined one of the waterline markers.

3. An apparatus according to claim 2 wherein means for activating the first means

and the second means is affixed to a second end section of the handle, the second end section being opposite the first end section.

4. An apparatus according to claim 1 wherein the first means is a light source that generates and transmits a light beam.

5. An apparatus according to claim 4 wherein the light source is a laser.

6. An apparatus according to claim 2 wherein the ruler has a thin profile forming opposing substantially flat surfaces, and the first means is a magnet attached to the extending end section in a position to face and attach to the barge at the predetermined one of the waterline markers.

7. An apparatus according to claim 1 wherein the second means comprises a laser beam emitter and receiver.

8. An apparatus according to claim 7 wherein the third means comprises one or more computers that have stored in databases the displacement characteristics of the barge and the cargo unit weight, the one or more computer receiving the time signal, the one or more computer calculating the total cargo in the barge from the time signal, and the displacement characteristics of the barge and the cargo unit weight stored in the databases.

9. An apparatus for determining the total amount of cargo in a barge for transporting a cargo having a known cargo unit weight, the barge having known displacement characteristics and having one or more series of waterline markers affixed to at least one set of opposite sides of the barge, at least one of the waterline markers in each series of waterline markers being visible when the barge is floating in a water

body comprising:

(a) a housing;

(b) a first means affixed to the housing for directing a light beam perpendicularly from the housing;

(c) a second means affixed to the housing for transmitting a signal perpendicular to the light beam and toward the water body, and for receiving the signal reflected from the water body;

(d) a timer assembly operatively affixed to the second means for determining the time between the transmitting of the signal and the receiving of the signal reflected from the water body; the time assembly constructed to transmit a time indicator signal reflective of the time; and

(e) one or more computers constructed to receive the time indicator signal, the one or more computers have the barge displacement characteristics and the cargo unit weight stored in one or more databases, the one or more computers utilizing data comprising the time indicator signal, the barge displacement characteristics and the cargo unit weight to determine the total amount of cargo in the barge.

10. An apparatus according to claim 9 wherein said second means is a transducer or laser and wherein the second means transmits at different known time intervals a signal perpendicular to the light beam and toward the water body and discriminatorily receives each of the transmitted signals reflected from the water body; wherein the timer assembly for each received signal determines a

corresponding time between the transmitting of the signal and the receiving of the signal reflected from the water body, the time assembly constructed to transmit for each corresponding time a corresponding time indicator signal ; and the one or more computers constructed to receive each corresponding time indicator signals, the one or more computers having an arraying program to calculate a representative time indicator signal, and the one or more computers determining the total amount of cargo in the barge from data comprising the representative time indicator signal, the barge displacement characteristics and the cargo unit weight.

11. A method for determining barge draft of a barge having one or more waterline markers and floating in a water body comprising:

(a) positioning a surveying device at a first known position relative to a predetermined barge waterline maker;

(b) sending one or more separate signals from the surveying device toward the water body;

(c) receiving a reflected signal for each the signal reflected from the water body;

(d) analyzing each of the received reflected signal to determine the barge draft;

(e) positioning the surveying device at a second known position relative to a second predetermined barge waterline maker;

(f) repeating steps (b)-(d) with the surveying device at the second known

position; and

(g) analyzing all received reflective signals to determine the barge draft.

12. A method according to claim 11 wherein the first known position is one side of the barge and the second known position is on the opposite side of the barge.

13. A method according to claim 12 wherein the one or more computers determines the total amount of cargo in the barge from the barge draft, the displacement characteristics of the barge and the cargo unit weight.

FIGURE 1A: OPERATOR USAGE

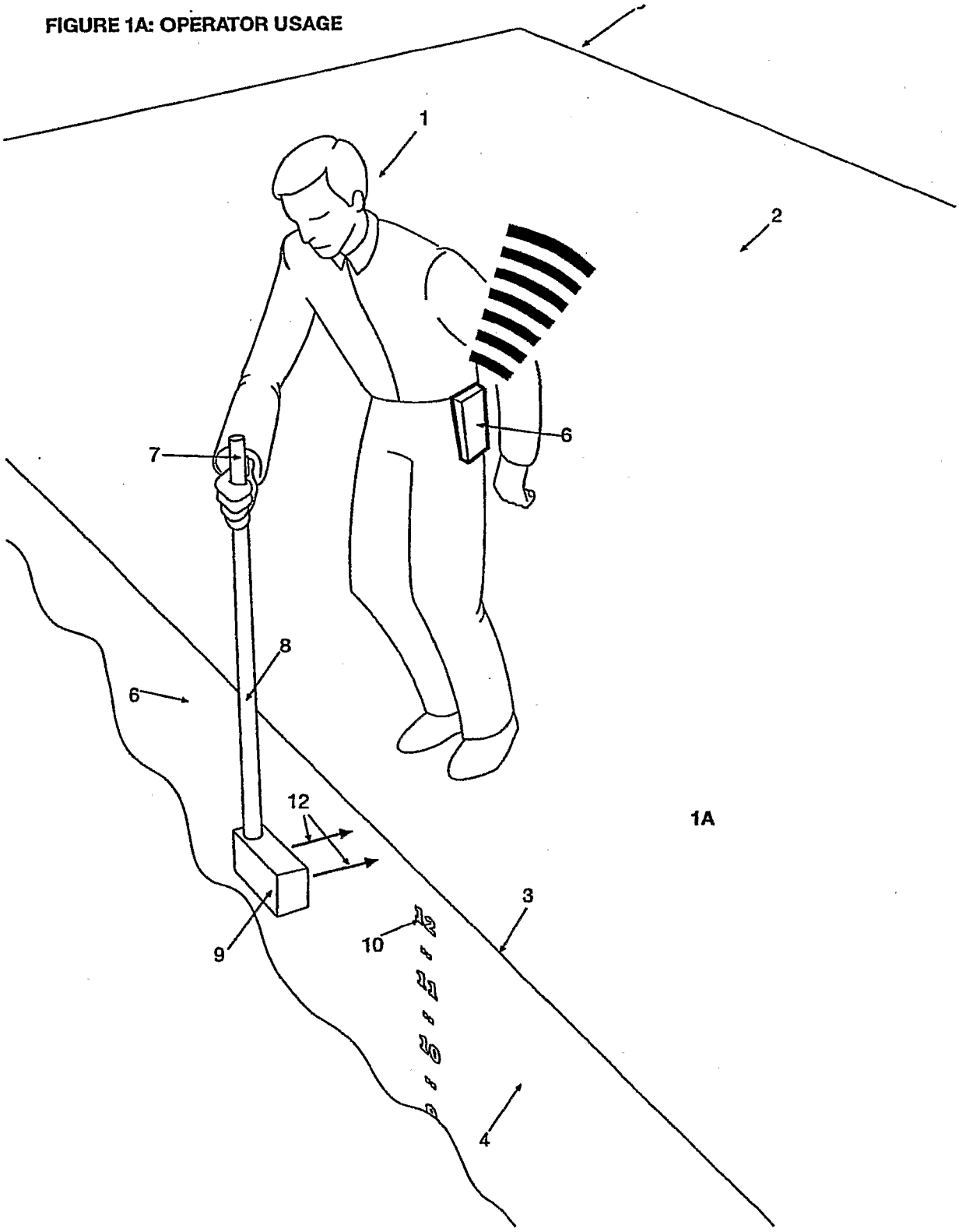


FIGURE 1A–1F: LASERPROCESS

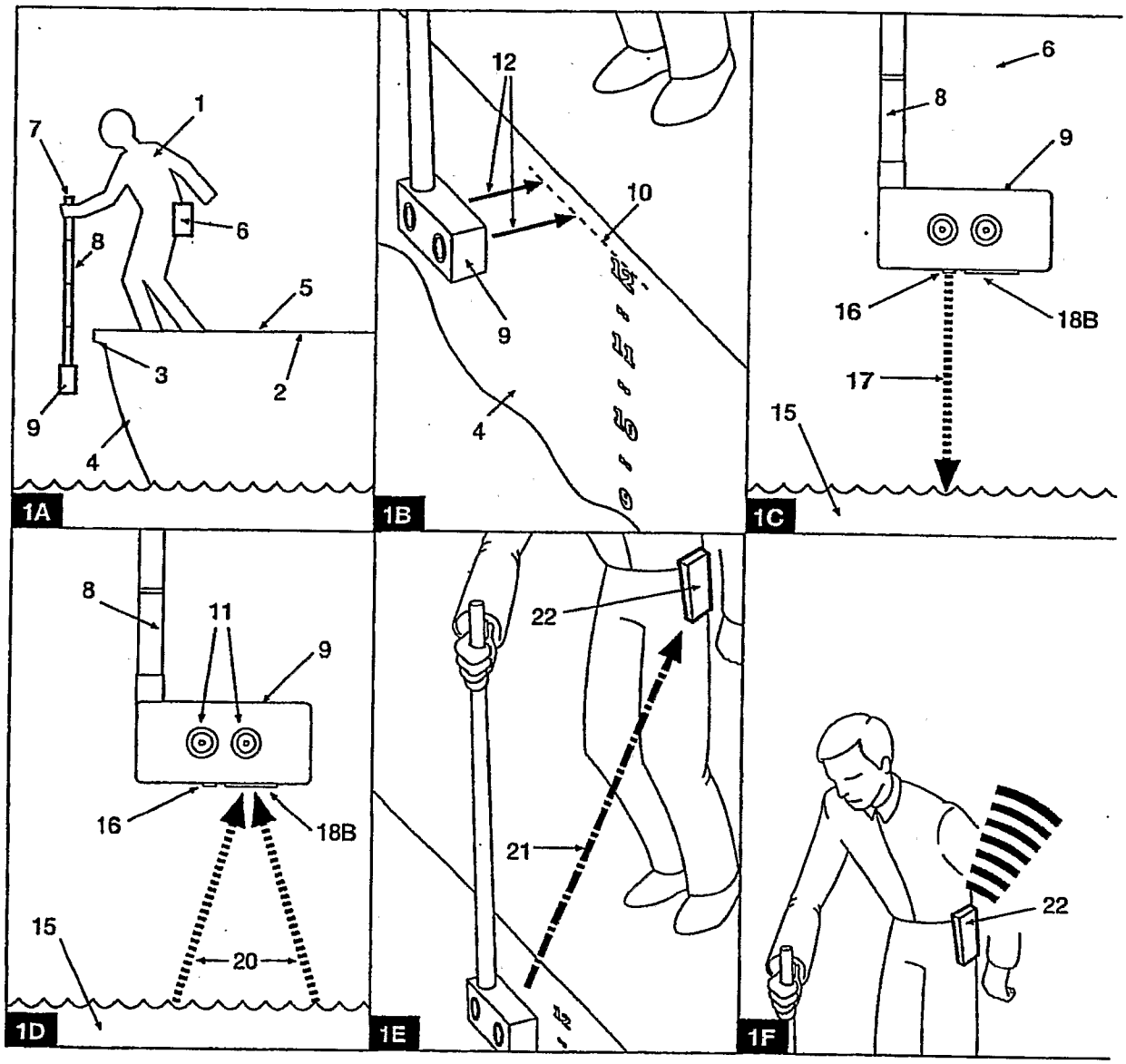
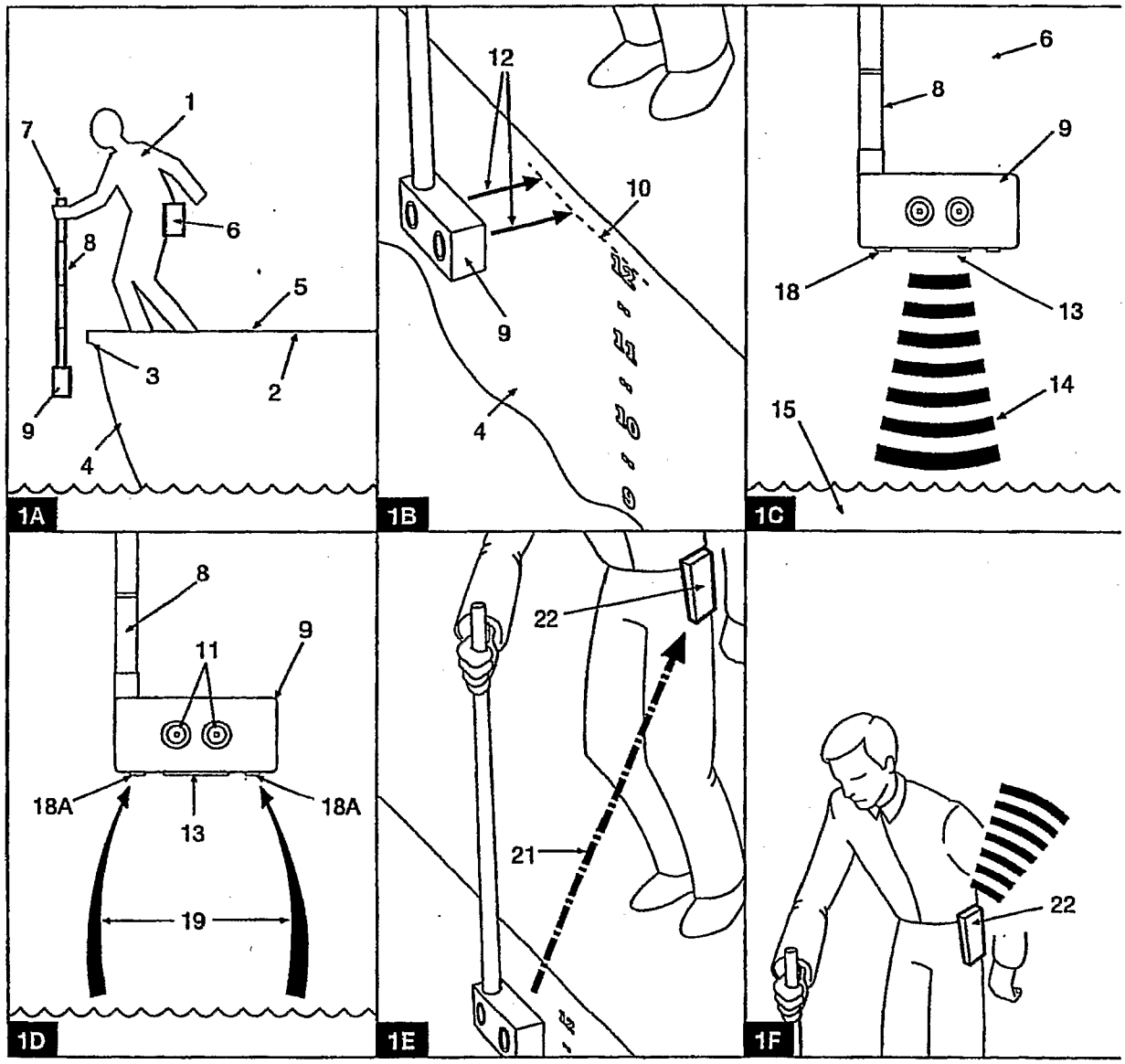
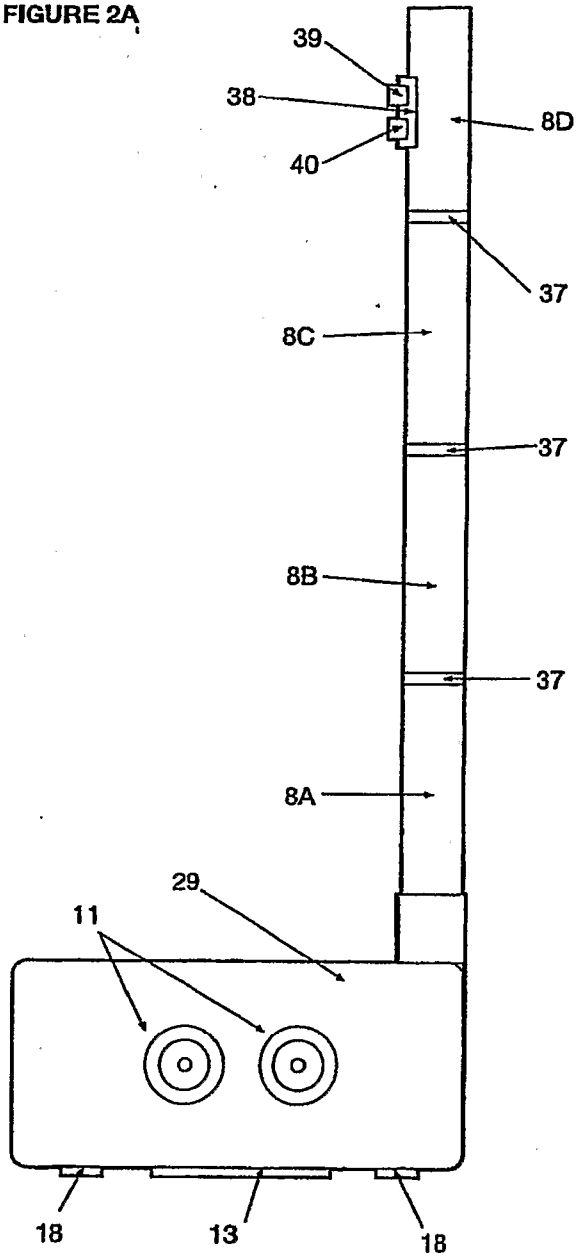


FIGURE 1A–1F: ULTRASONIC PROCESS



ULTRASOUND NOMENCLATURE

FIGURE 2A



LASER NOMENCLATURE

FIGURE 2B

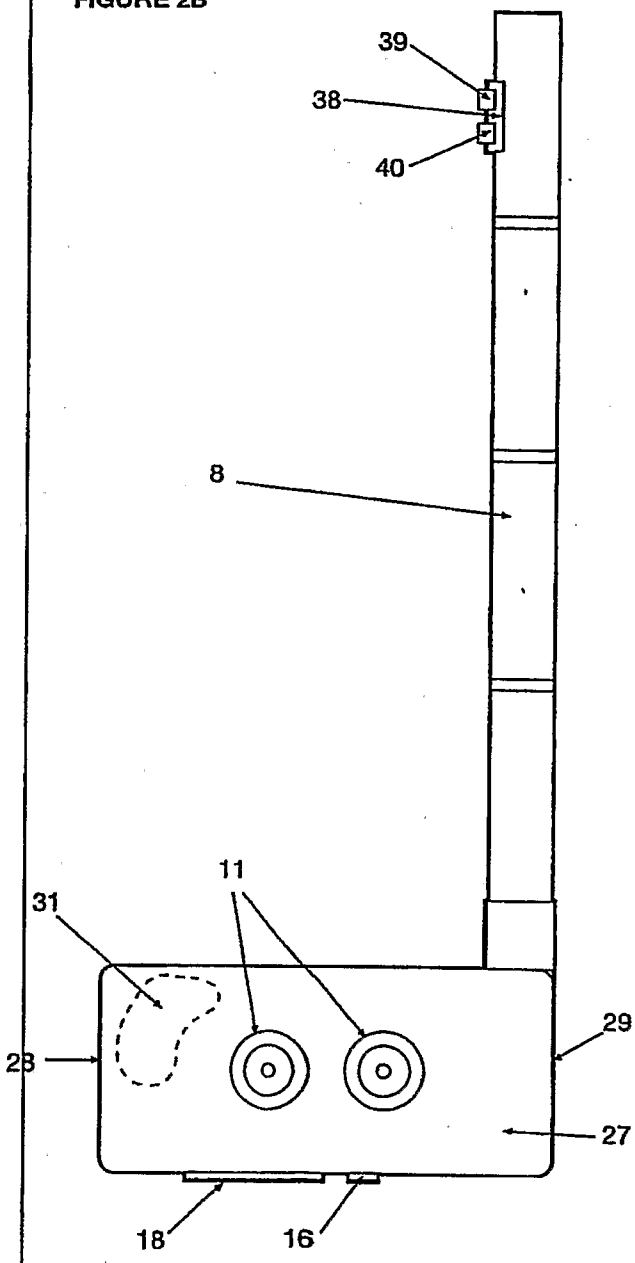


FIGURE 3A

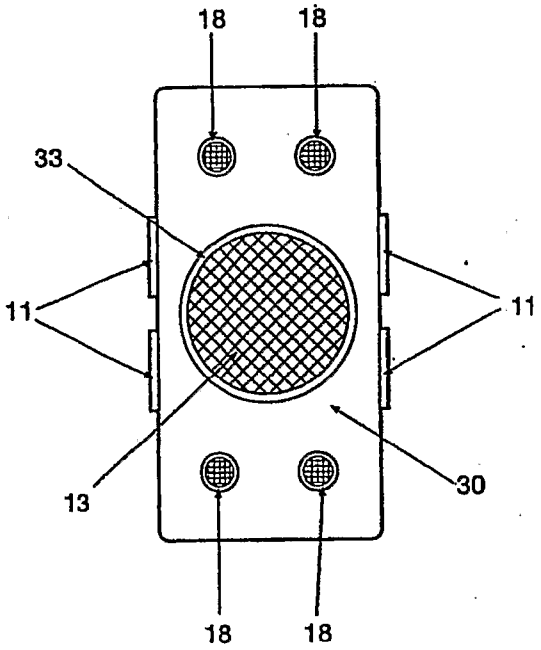


FIGURE 3B

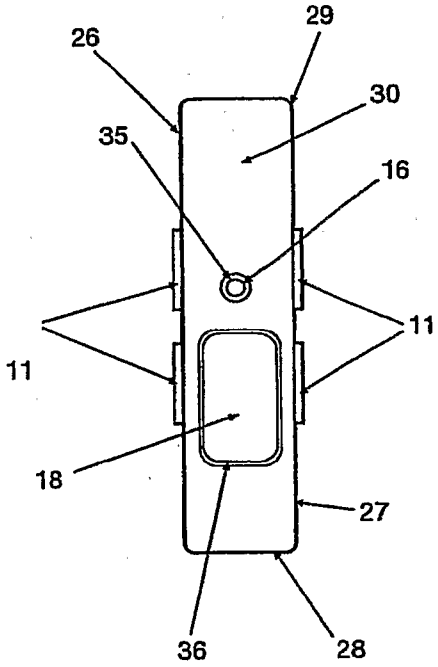
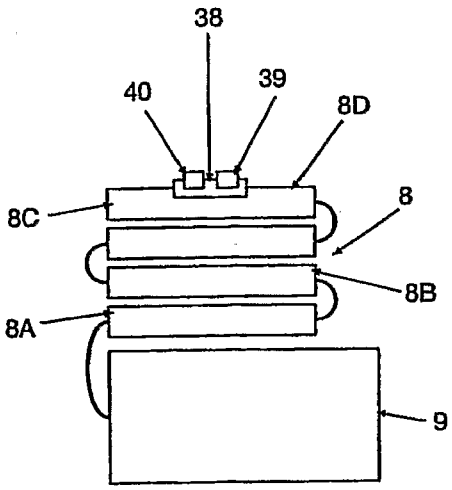


FIGURE 4



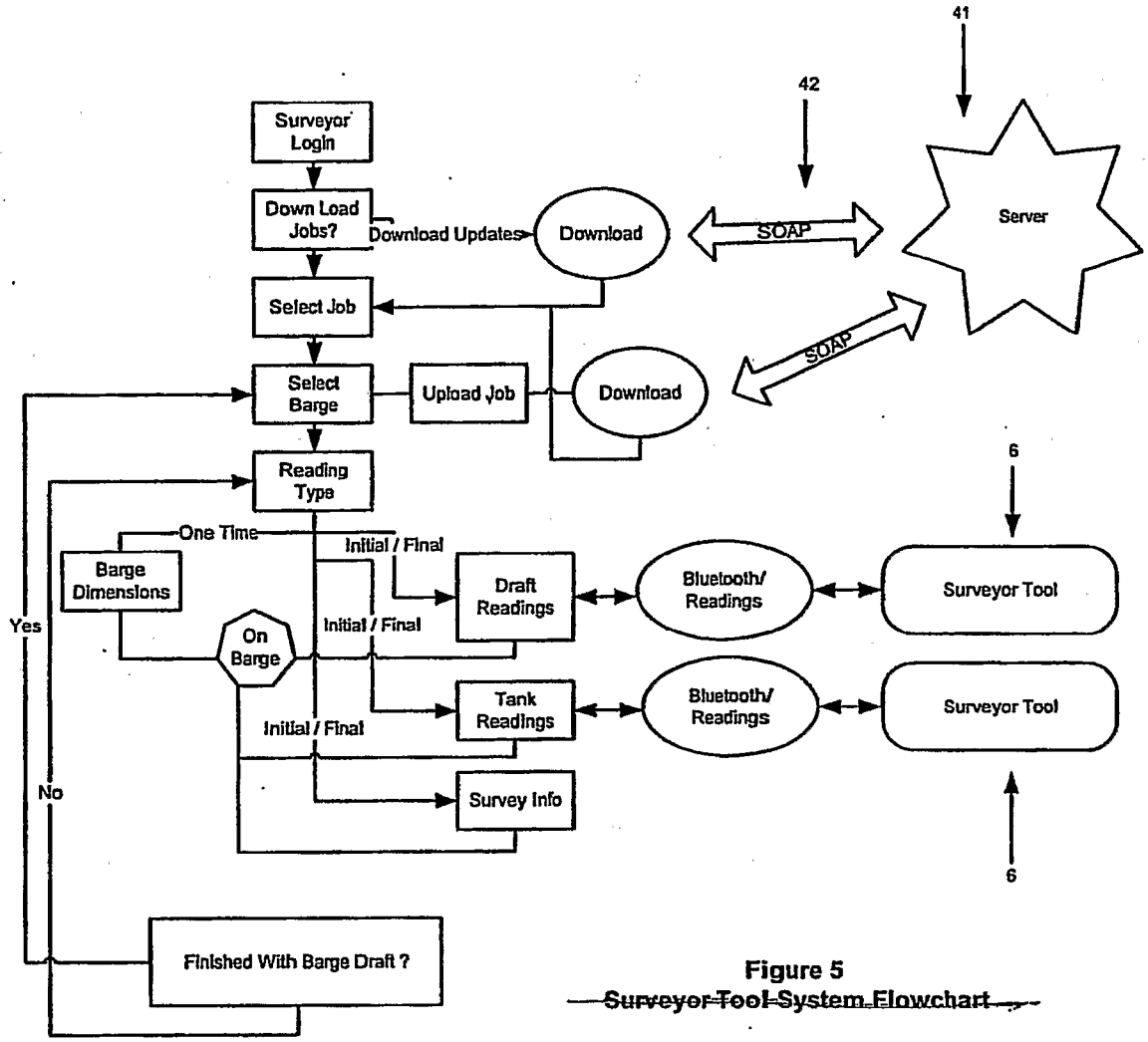


Figure 5
~~Surveyor Tool System Flowchart~~

FIG. 10

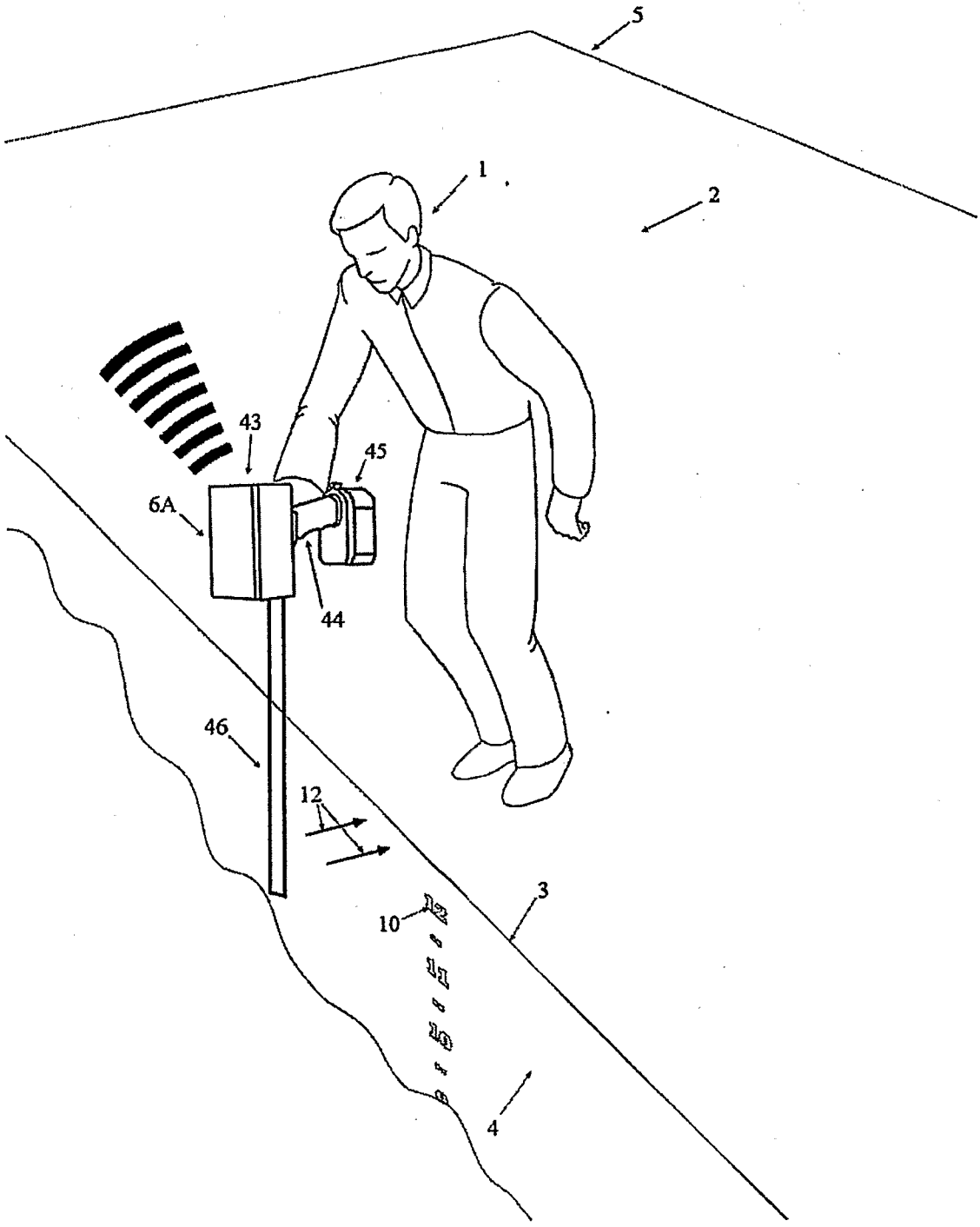


FIG. 11A

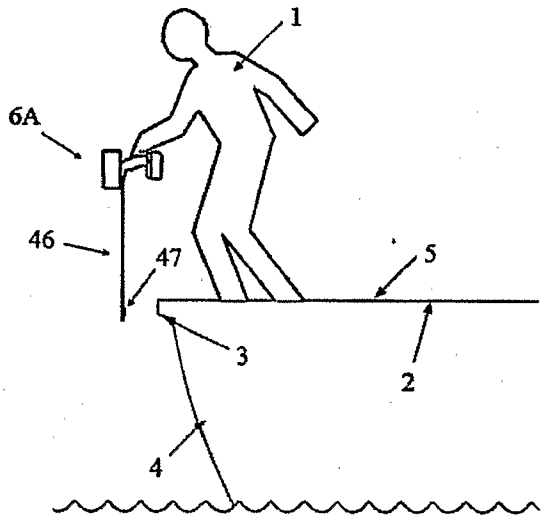


FIG. 11B

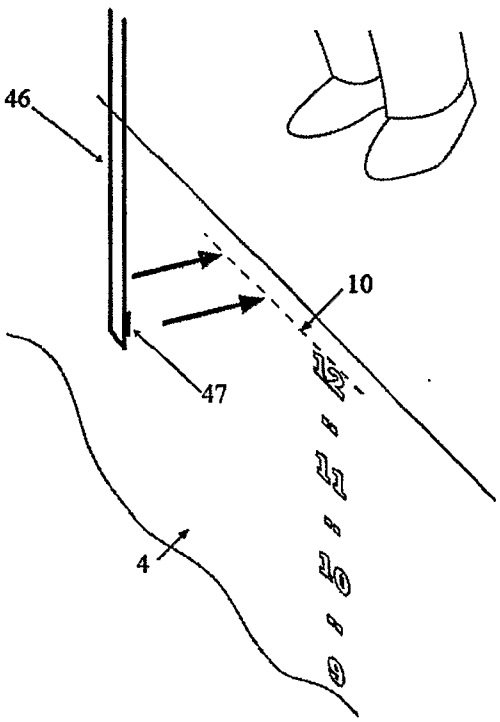


FIG. 11C

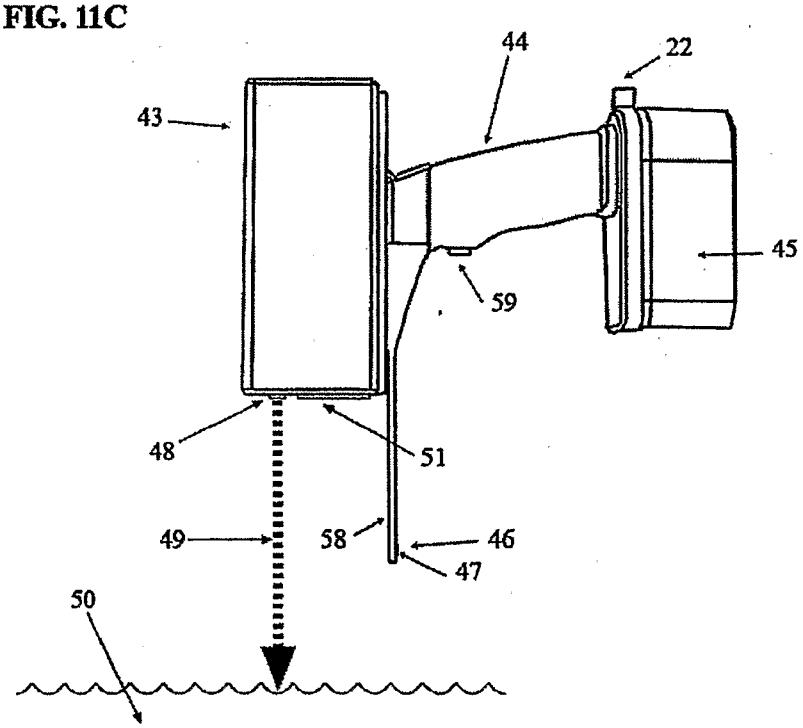


FIG. 11D

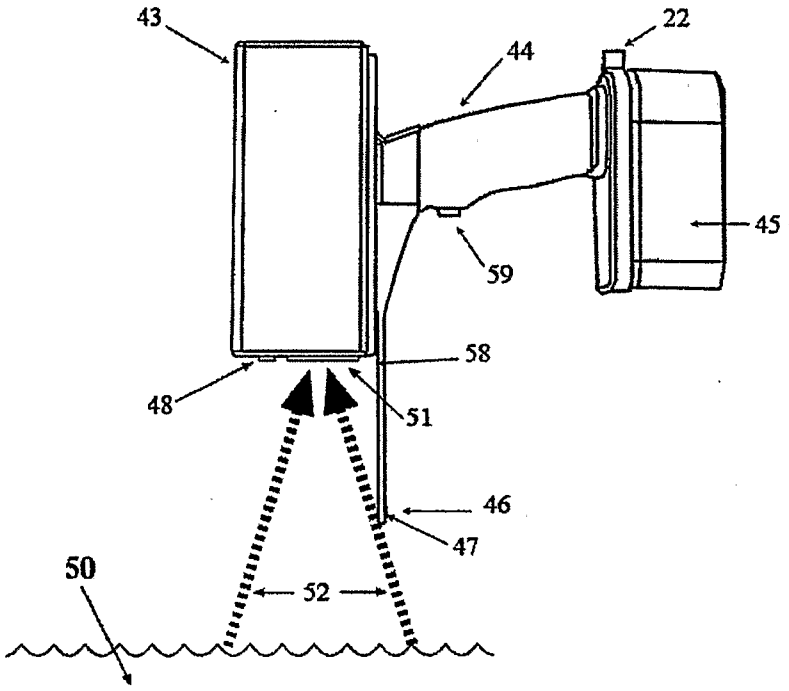


FIG. 12A

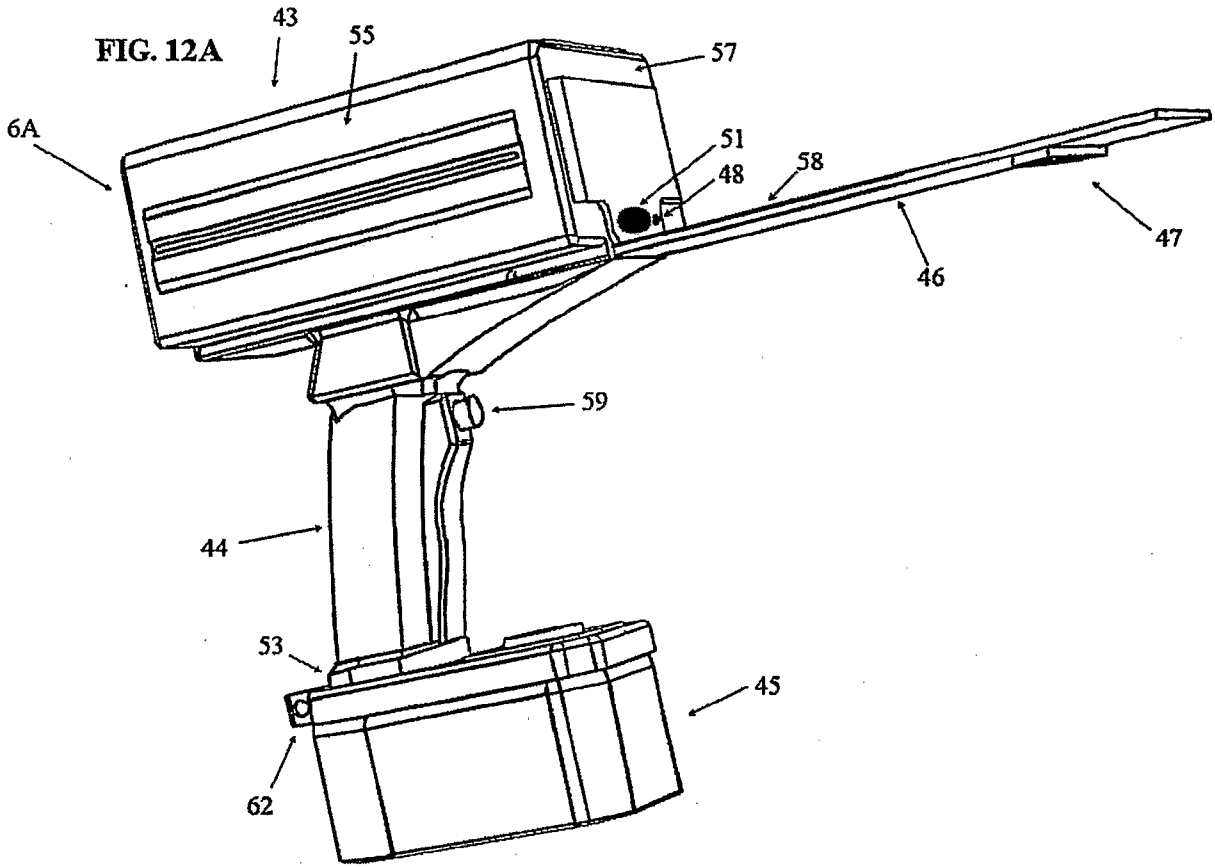
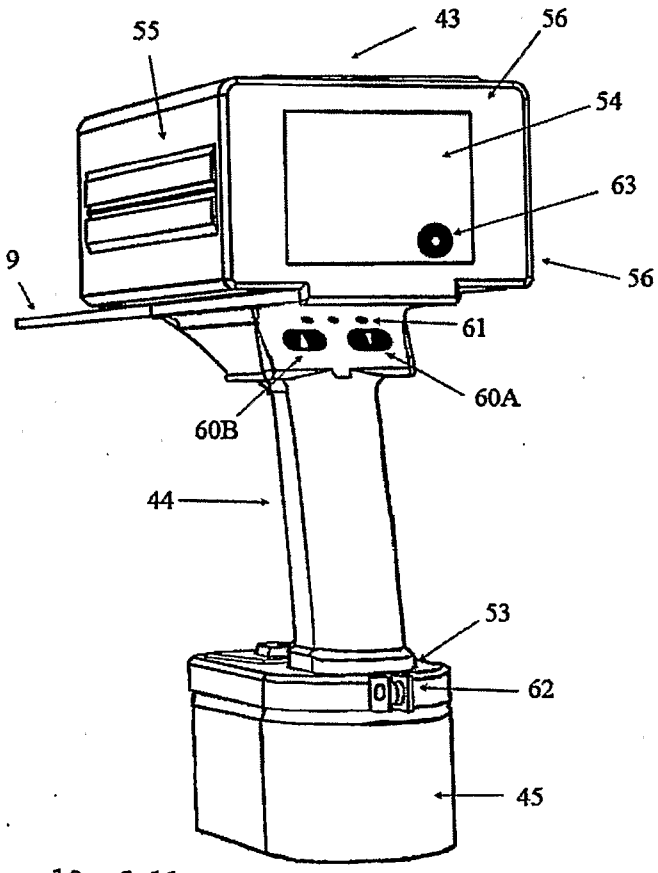


FIG. 12B



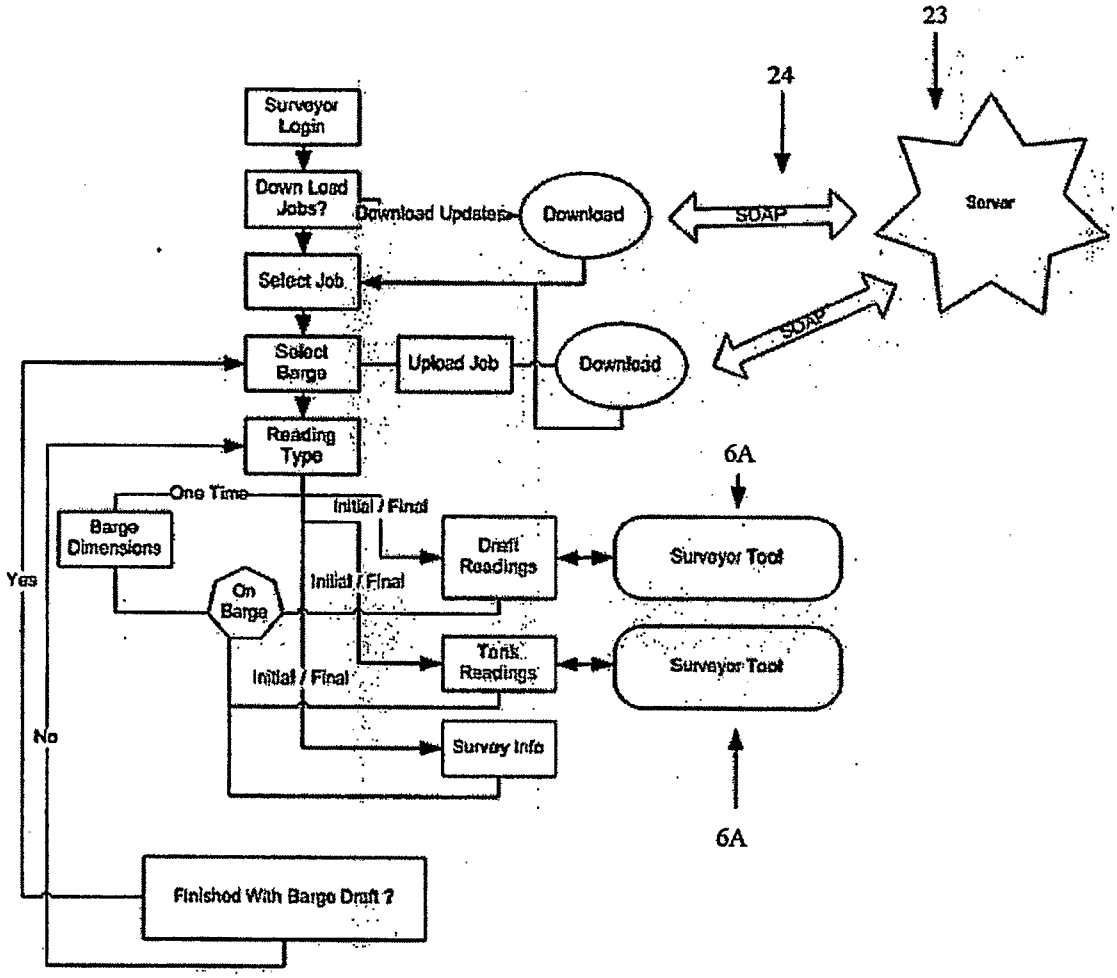

23
24
Surveyor Login
Down Load Jobs?
Download Updates
Download
SOAP
Server
Select Job
SOAP
Select Barge
Upload Job
Download
Reading Type
6A
One Time
Initial / Final
Barge Dimensions
Draft Readings
Surveyor Tool
Yes
On Barge
Initial / Final
Tank Readings
Surveyor Tool
Initial / Final
No
Survey Info
6A
Finished With Barge Draft ?

FIG. 13