Oct. 20, 1970 J. N. NAHAS 3,534,477

METHOD, SYSTEM AND APPARATUS FOR SURVEYING REVETMENTS

Filed Sept. 14, 1967 3 Sheets-Sheet 1

FIG. 5

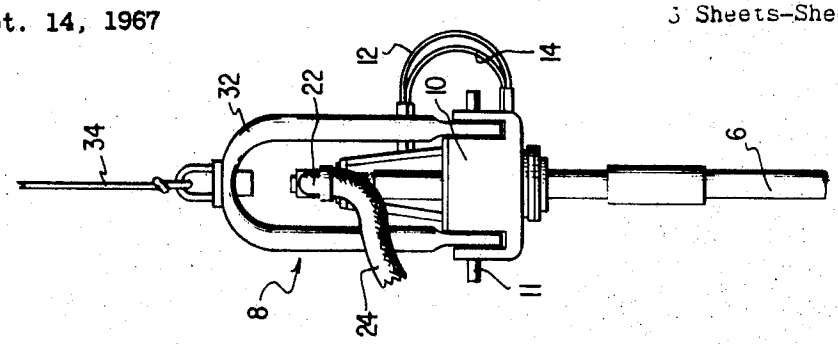


FIG. 2

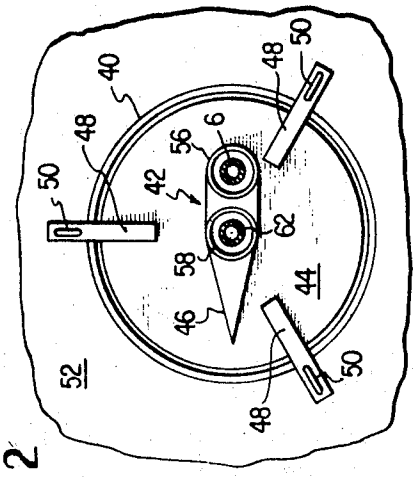


FIG. 3

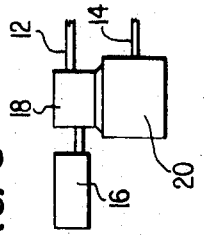


FIG. 4

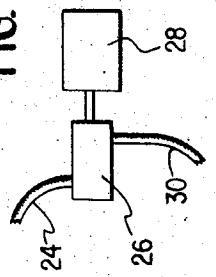
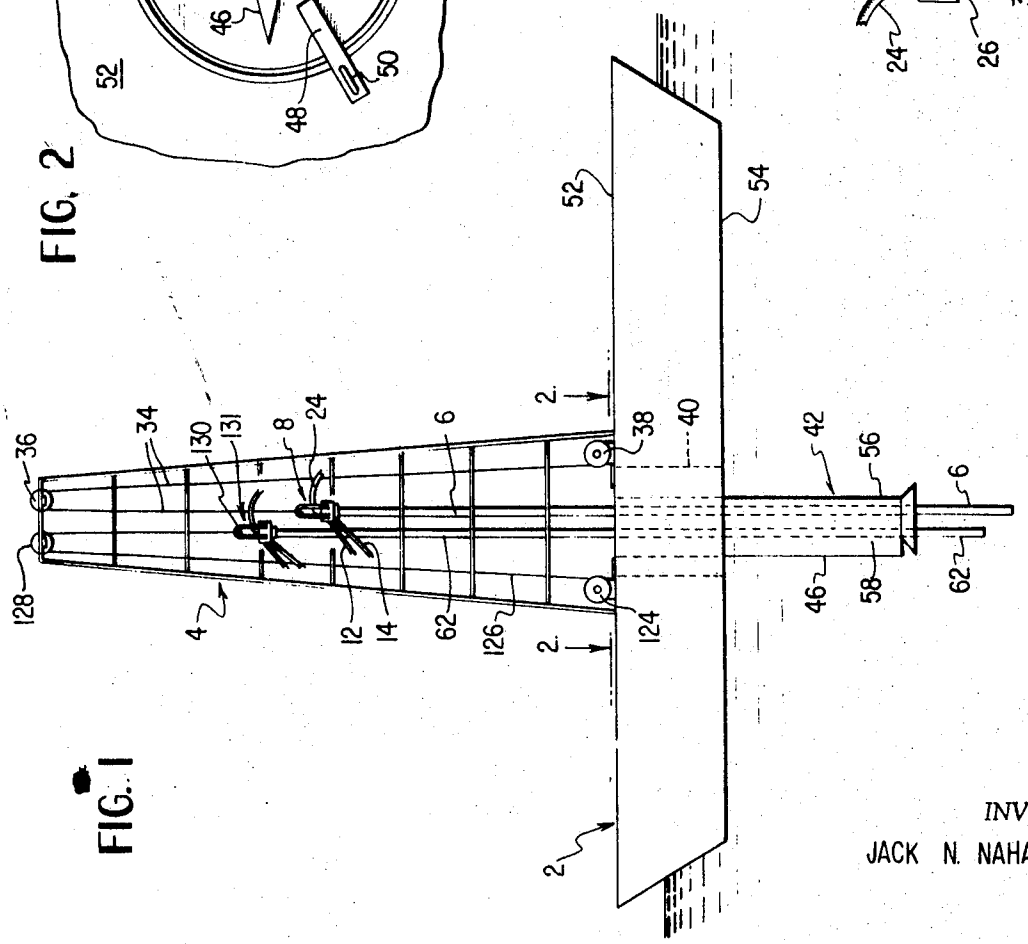


FIG. 1



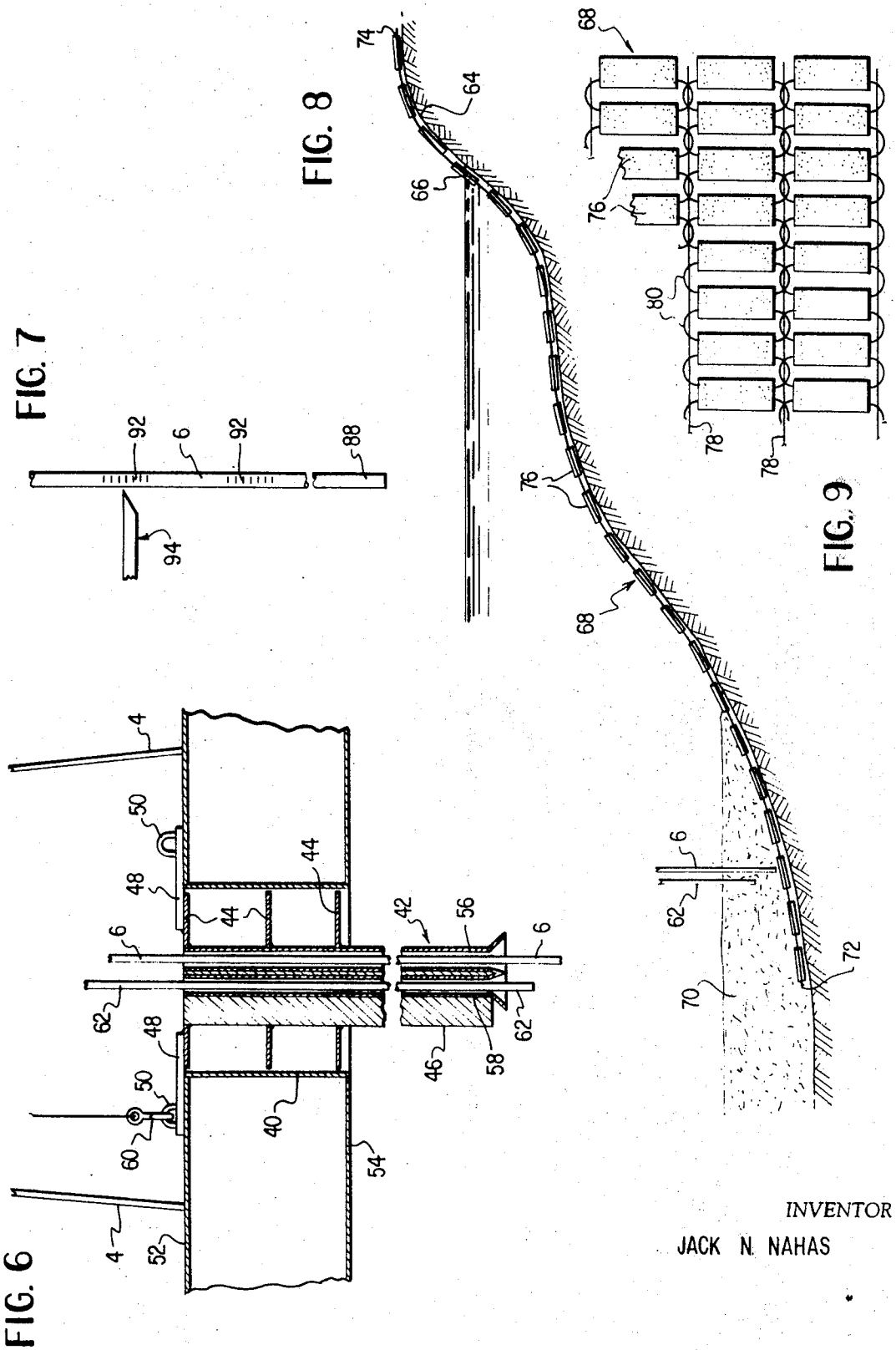
INVENTOR

JACK N. NAHAS

Oct. 20, 1970 J. N. NAHAS 3,534,477

METHOD, SYSTEM AND APPARATUS FOR SURVEYING REVETMENTS

Filed Sept. 14, 1967 3 Sheets-Sheet 2



Oct. 20, 1970 J. N. NAHAS 3,534,477

METHOD, SYSTEM AND APPARATUS FOR SURVEYING REVETMENTS

Filed Sept. 14, 1967 3 Sheets-Sheet 3

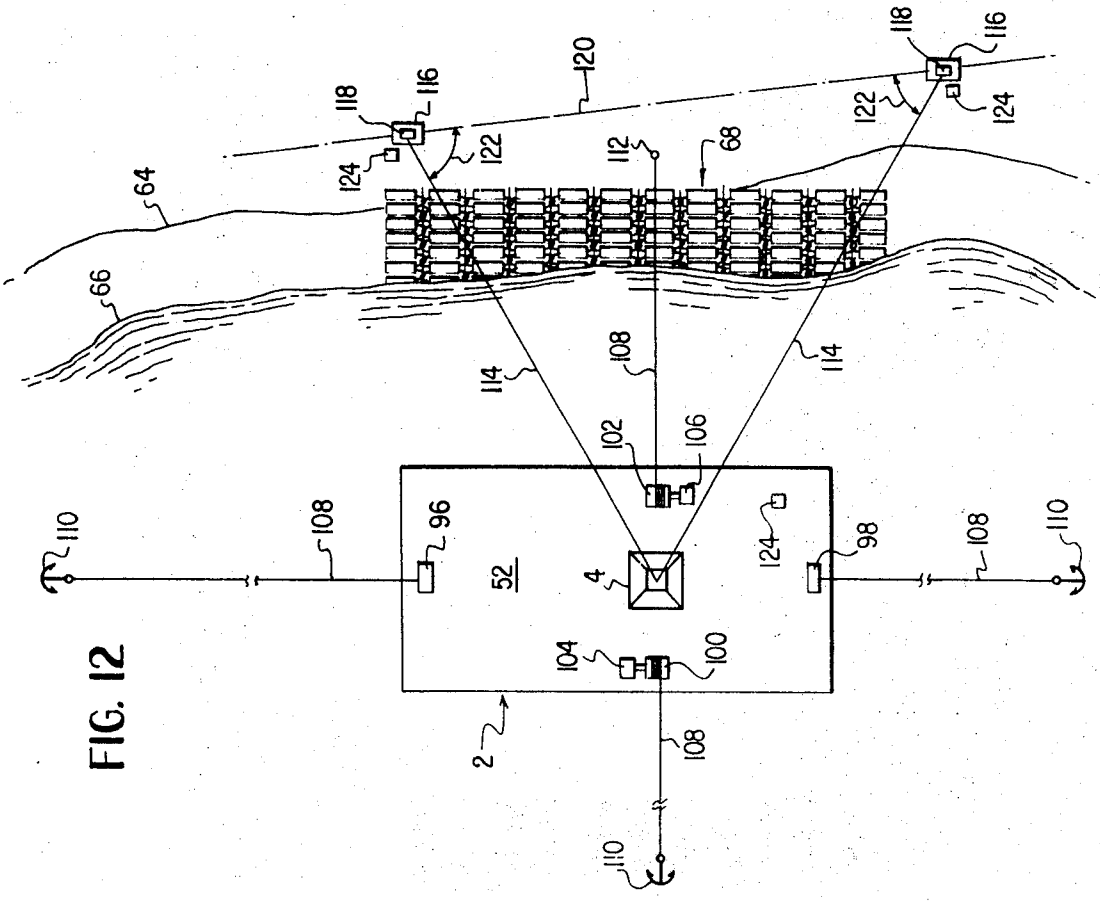


FIG. 12

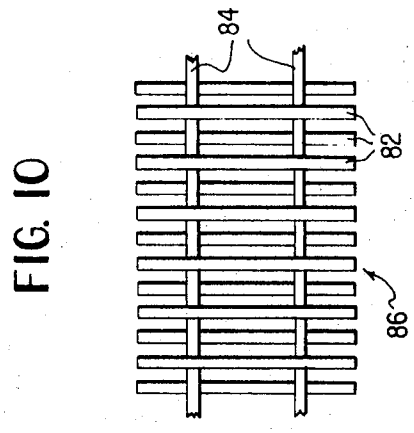


FIG. 10

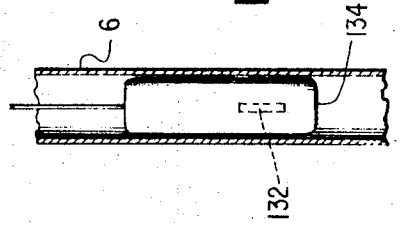


FIG. 11

INVENTOR
JACK N. NAHAS

United States Patent Office 3,534,477 Patented Oct. 20, 1970

3,534,477

METHOD, SYSTEM AND APPARATUS FOR SURVEYING REVETMENTS

Jack N. Nahas, 4835 Gladys Ave., Beaumont, Tex. 77706

Filed Sept. 14, 1967, Ser. No. 673,531
Int. Cl. B431 13/20
U.S. Cl. 33—1 24 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to a method, system and apparatus of surveying with precision, speed, and economy, the extent and underwater location of articulated concrete mattresses and other revetments when in place by extending a probe down to the mattress and measuring the movement of the probe from a reference position in order to locate the mattress.

BACKGROUND OF THE INVENTION

As one means of stabilizing river beds, there has been developed a method using concrete blocks to pave the bottom of a river bank and bed. The blocks are wired together in strips varying in length from approximately 300 feet to 500 feet. In turn, the strips ase wire together in appropriate numbers to form a mattress which is then laid on a prepared bank and river bottom.

Once the revetments are placed, accurate knowledge of their condition or position is no longer determinable. It is known that in the matching of the physical forces of river action and strength of materials, sections of revertment are lost. In extreme cases, the entire underwater section over relatively large areas disappears, exposing during low water stages the ends that are on the bank. Many revetments have, over the years, been replaced a number of times. It is to the credit of those responsible for river stabilization that they have by experience and judgment been able to perform such a fine task of construction and maintenance in the total absence of positive information concerning the underwater portion of the revertment.

A number of methods to survey the unexposed portions of revertment have been tried. Divers have not been successful for a number of reasons. The river currents are very strong, for example, in the areas where revertments are necessary for bank protection, currents of 5 to 7 miles an hour and more are the rule even during low and moderate stages of the river. Furthermore, there is no visability in the silt laden waters. An object lowered approximately six inches into the water becomes invisible. There is total darkness extending to the river bottom. The floating and submerged debris including fully grown trees is a constant hazard. The area a diver can survey on any one submergence is only a few square feet, generally the area he can cover with a sweep of one arm. The overburden of silt, sand and gravel which may exist, negates any accuracy of results. In 60 to 90 feet of water, it is not practical to locate the position of the diver on the bottom of the river closer than 20 to 50 feet. The limit of physical endurance on bottom in these currents is 10 to 15 seconds per dive with about 10 dives in a three hour period being the limit of a day's work. While the technical problems of diving can be overcome, the safety factors, the inaccuracy of information, and the economies of the operations preclude the use of divers in revetment surveys.

As another approach in ascertaining the location of a revetment, sonic depth finder which will measure depth have been tried. Frequently, multiple reflections are obtained which will generally indicate an interface representing a change of velocity of the media through which the energy wave is traveling. If the resolving power of the sonic depth finder were great enough, the readings therefrom would theoretically indicate the top and bottom of the mattress, the thickness of any overburden of deposition and possibly the thickness of some of strata immediately below the mattress. Repeated tests with sonic depth finders do not give results which are subject to accurate interpretation beyond the first reflection from the interface of water and bottom.

Another approach which has been used to locate revetments is the use of conventional geophysical approaches. Thus reflections and refraction seismographs, gravitymeters, magnetometers, and electrical methods of geophysical prospecting have been used but unfortunately are not enough resolving power to solve the problem of revetment location.

In the case of gravity measurements, the differences in densities of the thin layer of concerte and the varying thickness of aggregate deposited above it do not permit of precise measurement within the tolerances required.

The metallic content of the mattress will not, within the narrow limits of tolerance needed, support usable accuracies of magnetic measurement. The area, regional, and diurnal changes in magnetic conditions would introduce correction factors of greater magnitude than the anomolies in the magnetic field caused by the presence of the mattress.

The relatively short vertical distances of 20 to approximately 150 feet and the indeterminate and changing nature of the velacity varying interfaces are not amenable to the effective or economic use of reflection seismography as means of determining mattress location with precision. Generally, the comments concerning sonic depth finder type surveys are also pertnent to refletion seismographing in an application of this type. Composition of the deposited overburden that may cover part of the mattress and extend beyond it is also a factor of significance. Generally, the overburden deposited on the bottom is composed of fine silt, sand, gravel and stone. The velocities of the currents and the depth at different stages of the river will vary the proportions of the deposited material. In areas where the currents were relatively slow, on the order of three miles per hour, the predominate material may be gravel. There is indicated the fact that the river's scouring action and ability to carry silt are subject to rather fine balances of factors including current velocities. The composition of the deposited overburden on the mattress may vary widely in short distances. Water velocity gradients, contour of bottom, and the existence or absence of the revetment or other obstruction at any point can affect the composition and thickness of deposition. This varying composition and thickness of deposition is itself in constant change with a change at any point immediately affecting other areas. The resolving power of the instruments simply is not great enough to cope with the constantly changing unknowns of the problem.

Refraction seismographing also has its limitations within the stringent requirements of accurate revetment location. The non-continuous nature of the articulated mattress in which there is a gap of approximately 2 to 3 inches between each slab complicates velocity determinations. The nearness in densities of the discontinuous mattress and any overburden it may have makes precise measurement difficult. The problem of determining location of energy source and seismometers for each reading would present field procedural problems out of proportion to any accuracy of results obtained and introduce correction factors of greater magnitude and questionability than the significant readings being sought. The blending of the fringes of the mattress with an overburden of essentially the same composition further complicates the problem.

In general, all procedures based on instrumentation are subject to a predictable family of limitations. Among the limitations are the following:

The absence of large regional trends from which local

anomolies can be detected.—The maximum area of an entire revetment is usually on the order of about two miles long by a width of 500 feet or less. At the moment it is placed in position, the mattress is non-uniform in its configuration. The precision of the readings being sought are of a comparable order magnitude as the preparations for the original laying of the mattress. There is no normal from which to make comparison of unknown changes.

The restricted area from which each reading must be made.—The nature of the problem of outlining the articulated mattress revetment leaves no tolerance for averaging. Each reading must be at a point. Each reading must be complete within itself. It cannot depend upon neighboring readings for support, or for trends, or for averaging. Each reading must be absolute within itself since the physical condition at each point need not be similar to that at near or adjacent points. To be effective, the instrumentation must have a resolving power greater than the tolerances within which the articulated mattress is laid. The present means of instrumentation depending on emission and reception of energy or of measurement of physical properties of the revetment simply have not been refined to the degree necessary for the close tolerances needed under unfavorable environmental conditions.

The system of modern revetments was begun approximately 50 to 60 years ago. The revetments serve a number of different uses. They are used to reinforce the levy system and contain the river. The revetments along with dykes and other construction may also be used to divert the river and eliminate some of its meandering thus making the river more navigable and shortening distances between river points. Revetments are also used on bends of the river to prevent scouring action.

Typical of river revetment systems is that on the Mississippi River between Cairo, Ill., and The Head of Passes, La., The distance from Cairo to the Head of Passes is approximately 1,000 river miles which constitutes approximately 2,000 miles of river bank. There are approximately 500 miles of articulated-concrete-mattress revetments along this 2,000 miles of river bank. It will be apparent that the investment in revetments is great.

It is axiomatic that the revetments are placed at stretches where the river is swiftest, is least stable, frequently where it is deepest, and where the greatest amount of sweep and scouring action take place. Currents are swift usually running from 3 to more than 7 miles per hour. The force of the river is possibly best visualized by recognition of the fact that hundreds of millions of tons of silts are carried annular to the Gulf of Mexico by the Mississippi River alone.

These tremendous forces of the river are brought to bear on the revetments. Sections of revetments are carried away; other sections are undermined and eventually collapse; still other sections may be folded and otherwise damaged. In any one year many tens of millions of dollars may be spent in new revetment construction and repair of existing revetments.

Through the years, many plans, systems, and instruments have been tried to determine the status of a revetment after it had been placed on the river bank. For all intents and purposes, the river waters are opaque and visibility is non-existant. As previously stated an object lowered as little as six inches into the water will disappear from sight. Of all the methods to survey the revetments in place to determine if they were intact or damaged and the extent of the damage, which were tried, none was able to give positive information of the existence or condition of the revetment below the surface of the water. At best, a sonic depth finder survey showing the depth of water over the area in which the revetment was originally placed on occasion showed a discontinuity which when compared with previous fathometers charts indicated that failure may have taken place. Visual indication of revetment failure was sometimes possible when low water revealed the ends of the articulated concrete mattress where they had broken off.

According to the responsible officials, until the method system and apparatus described and disclosed herein were developed there has never been a method, system or apparatus used which physically located the mattress in place and gave positive physical information concerning its existence or non-existence at each point surveyed as well as giving the depth of the mattress at that point below a known reference point on the bank, and the thickness of deposition of silt, sediment, and overburden covering the mattress.

The simplicity of the method, system and apparatus about to be described does not detract from the fact it is novel unobvious and constitutes a valuable tool in the maintenance of high cost revetment replacement.

It is therefore an object of this invention is provide a method of surveying revetments in place.

It is another object of this invention to provide a method, system and apparatus for positively determining the existence or absence of the articulated-concrete-mattress at any point.

It is still a further object of this invention to determine the existence of the revetment by positive identification, discernable to the human senses of touch, sight, and sound.

A further object is to be able to record the identification of the data pertaining to the revetment by instrumenting the phenomena which actuate the human senses.

It is yet another object of this invention to provide means of determining the thickness of overburden which may be deposited upon portions of a revetment.

A still further object is to describe means of determining the location of each reading with respect to known survey points.

It is another object of this invention to disclose a method of lowering and recovering a probe through swift currents.

Further yet, another objective of this invention is the location and survey of objects or structures other than the articulated-concrete-mattresses of revetments.

A still further objective of this invention is the conducting of surveys of the physical conditions of the interface between bodies of water and the bottoms upon which they rest.

Yet another objective of this invention is to penetrate the bottom below a body of water for purposes of surveying and accumulating data.

Yet a further object of this invention is to mount the necessary probe and associated equipment on a floating vessel such as a boat, craft, or a barge for the purpose of surveying and accumulating data.

Yet a further object of this invention is to mount the necessary probe and associated equipment on a floating vessel such as a boat, craft, or barge for the purpose of surveying a revetment or other structure or other object.

It is thus apparent that the instant invention is a useful survey device; that its use will provide positive physical information concerning locations of revetments, other objects, or structures, underwater, and in spite of the simplicity of the operation, no previous method used gave results of comparable accuracy and definiteness of identification.

Other objectives, advantages, and important features of the invention will be apparent from a study of the specification following, taken with the drawing, which together describe, disclose, illustrate and show certain embodiments, modifications, procedures and alternatives of the invention and what is now considered and believed to be the best method of practicing the principles thereof. Still other embodiments, modifications, procedures or equivalents may be suggested to those having the benefit of the teaching herein and such other embodiments, modifications, procedures or equivalents are intended to be

reserved especially as they fall within the scope and breadth of the subjoined claims.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational view of a vessel such as a craft, boat, or barge upon which have been mounted parts of the equipment used in this method and system of revetment survey;

FIG. 2 shows a top plan view of a guide assembly through which a probe and other equipment may be lowered through swift currents and generally consists of a section taken along line 2—2 of FIG. 1 looking in the direction of the arrow;

FIG. 3 is a schematic view of a prime mover, hydraulic pump, hydraulic fluid reservoir and hydraulic lines such as used to supply hydraulic power to various parts of the equipment;

FIG. 4 is a schematic view of a prime mover, liquid pump and associated conduits to provide liquid flow through a probe;

FIG. 5 shows a powered swivel such as used to impart rotary motion to the probe and to the probe recovery tube;

FIG. 6 is a longitudinal cross-sectional view of the center portion of the vessel of FIG. 1 illustrating in somewhat greater detail the guide, probe and probe recovery tube;

FIG. 7 is a side elevational view of the probe and illustrates certain features thereof;

FIG. 8 is a cross-sectional view of a typical river bank upon which has been laid an articulated concrete mattress and further illustrates a typical situation wherein an overburden of sediment is deposited on the revetment and extends off the revetment toward the river bottom;

FIG. 9 is a schematic view of a small section of an articulated concrete mattress revetment illustrating the general construction thereof;

FIG. 10 is a schematic view of a timber mattress or revetment;

FIG. 11 is a plan view of an operational installation and illustrates the relationship between the vessel of FIG. 1, the river bank, the water's edge, means of moving the vessel by the use of suitable mechanism, and the like; and

FIG. 12 is a cross-sectional view of the probe illustrating schematically an inclinometer therein for ascertaining the deviation from the vertical of the probe.

SUMMARY OF THE INVENTION

The method and means of the invention accomplish the precise location of the revetment by physically contacting the same with a probe and ascertaining and recording the depth of the probe on impact.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Attention is now invited to FIG. 1 of the drawing wherein there is shown equipment mounted on a vessel or floatable platform **2**, which may be a boat, craft or barge of appropriate size. The vessel **2** may be self-propelled or may receive its motive power from an external source, such as a tug or towboat (not shown). It is to be understood that the equipment may be mounted on a truck, trailer, skids, or other vehicles or framework for overland movement to working locations where it can then be moved onto the vessel **2** at the survey site.

A mast, derrick, frame or other support **4** is provided to support a probe **6** and its associated equipment. The mast **4** is also used to carry the lines, sheaves and accessories for lowering, raising, rotating and otherwise manipulating the probe **6** and associated equipment. Also carried in or on the mast **4** are the appropriate measuring accessories to determine location and depth to which the probe **6** has penetrated in locating a revetment **68**.

The probe **6** comprises tubular material made from metal, plastic, or other suitable stock. It is in convenient lengths with means provided at each end to thread or otherwise connect an appropriate number of lengths together so the probe **6** may be made of sufficient length to reach to the revetment **68** or other object or structure being surveyed. The probe **6** is hollow so that water or other fluid may be pumped through it to assist in penetration or return from any sediment or overburden. The probe **6** may also comprise a number of telescoping or nesting sections of suitable total length to permit surveying in the area under consideration. In the event a telescoping or nesting probe is used hydraulic, mechanical or other means (not shown) are provided to extend the telescoping or nesting sections to the length necessary to reach the revetment **68** in the area being surveyed.

The probe **6** is supported within the mast **4** by a revolving head or power swivel **8** (FIGS. 1 and 5). The revolving head **8** is powered, hydraulically, electrically, mechanically, or otherwise so that it can rotate the probe **6** either clockwise or counter-clockwise. Referring to FIGS. 1, 3 and 5, one embodiment of the revolving head **8** manufactured by Bowen Itco Co., Inc., is shown. The revolving head **8** has an integral hydraulic motor **10** comprising a high pressure hydraulic fluid feed line **12** and a return hydraulic line **14**. Associated with the hydraulic head **8** is a prime mover **16** (FIG. 3) located on the head **8** or the vessel **2**. This prime mover **16** may be either internal combustion such as gasoline or diesel fueled, electric, steam or other suitable power source to drive a hydraulic pump **18**. The hydraulic pump **18** takes hydraulic fluid from a reservoir **20** and forces it at suitable pressure through the high-pressure feed line **12** to actuate the hydraulic motor **10** which in turn imparts a revolving motion to the revolving head **8**. The return line **14** is provided to complete the cycle of travel of the hydraulic fluid back to the reservoir **20**. Not shown are suitable valves, controls, and associated equipment which are used to selectively control the flow of hydraulic fluid between the hydraulic pump **18** and the hydraulic motor **10** thus controlling power transfer from the pump **10** to the motor **18** as well as the speed of rotation and the direction of rotation of the hydraulic motor **18** and consequently the speed and direction of rotation of the revolving head **8** and the probe **6**. Shown in FIG. 5 is a torque arm **11** which when suitably restrained, such as by the use of a stop (not shown) on the mast **4**, prevents rotation of the revolving head **8** thus imparting all the power of rotation to the probe **6** connected to the rotating head **8**.

Also a part of the rotating head **8** (FIGS. 1 and 5) is a fluid connection **22**. In this embodiment the fluid connection extends through the revolving head **8** and connects with the upper end of the probe **6**. Fluid, whether water or other flowable material, may thus be passed through the revolving head **8** and the probe **6** and out of the lower end of the probe **6** thus resulting in a washing action which together with the rotation imparted to the probe **6** by the revolving head **8** assists the probe **6** in penetrating any overburden of deposited sand, silt, gravel or other material which may be resting on the revetment **68**. This washing action and rotating motion is also useful in assisting in removal of the probe **6** from the overburden of deposited sand, silt, gravel or other material through which it has penetrated. The upper end of the fluid connection **22** is connected to a hose **24** (FIGS. 1 and 4) of suitable flexibility, length, and strength to carry water or other flowable material to the revolving head **8**. The water or other flowable material is received by the hose **24** from the pump **26** (FIG. 4) which is preferably located on or about the vessel **2**. The pump **26** can be of any suitable type or construction having appropriate capacity in volume and pressure to meet the needs of the operation. Intake of fluid or water to the pump **26** is through an intake pipe **30**. Most frequently the fluid will be water which is taken from the

river or other body of water in which the survey is being conducted, pumped to proper pressure in the pump **26**, passed into the hose **24**, thence into the fluid connection **22**, through the revolving head **8**, into the probe **6** and out of the probe back to the river or other body of water whence it came. The pump **26** is driven by a prime mover **28** (FIG. 4). The prime mover **28** may be internal combustion, electrical, hydraulic, or of any other suitable type having adequate power and controls to match the requirements of the pump **26**.

A mechanism to elevate and lower the probe **6** and the revolving head **8** is depicted in FIG. 1. The revolving head **8** is fitted with a yoke **32**. An elevating cable **34** is attached to the yoke **32**. The elevating cable passes over a sheave **36** attached to the yoke **32**. The elevating cable passes over a sheave **36** attached to the mast **4** near the top thereof. A winch **38** is provided on the vessel **2** and is associated with the cable **34** which is taken-up and paid-out by the winch **38** thus raising a lowering the revolving head **8** to which is attached the probe **6**. The probe **6** is thus given an up-and-down motion by the winch **38** while it receives rotary motion from the revolving head **8** and also receives water or other flowable fluid of suitable volume and pressure from the pump **26**. The cable **34** may pass over and through multiple sheaves and a suitable block prior to being connected through a suitable hook or clamp to the revolving head yoke **32**. Motive power from the winch **38** may be hydraulic, internal combustion, electrical or other means such as a power takeoff with suitable controls for the means provided.

In actual operations during development of this system it was found that the force of gravity was sufficient to lower the probe **6** rapidly through currents measured at three to seven miles per hour. The rotation and washing action combined with the force of gravity were then found in full scale developmental operations to be sufficient for penetration into unconsolidated deposition on the river bottom to a depth of 30 feet after penetrating up to 90 feet of water, the depth in the development area. Experienced river engineers through the years have always dismissed or never considered that a probe could be used successfully in such swift currents and relatively great depths.

It has been long known in an analogous situation, i.e., the oil well drilling industry, that as little as a foot or less of unconsolidated silt, sand or gravel caving in or sluffing off in a boring or hole can grip and bind anything within the hole or boring thereby preventing recovery of the equipment within the boring or hole. Oil well drilling derricks with a strength to support or withstand stresses of several hundred thousand pounds have been pulled in and collapsed while attempting to recover a drill string seized by a collapsing bore hole. This is one reason why oil field well bores are supported by a pipe cemented to the surrounding bore wall and why expensive drilling fluids are used to prevent sluffing. In the development of this invention, means and methods were found and used to lower a probe through strong river currents, penetrate an unconsolidated river bottom sediment layer and recover the probe without preparing the sediment layer for such recovery.

In order to pass the probe **6** through the vessel **2**, a passageway or well **40** (FIGS 1, 2 and 6) is provided. The preferred shape of the well **40** is substantially cylindrical extending generally from the deck **52** to the bottom **54** of the vessel **2**. The well **40** is constructed and attached to the vessel **2** in such manner as to retain the integrity of the water-tightness of the vessel's compartments, strength of the vessel's structure, and stability of the vessel's center of gravity. The well **40** is open to the atmosphere at deck level and to the water at the bottom of the vessel **2**. A guide **42** is free to rotate within the well **40** so that fairings **46** and conductor tubes **56** and **58** (FIG. 2) may be kept properly oriented with respect to the currents.

The guide **42** is spaced within the well **40** by suitable flanges **44**. One flange **44** is placed at deck **52** level, another flange **44** is placed near the bottom **54** of the vessel **2** while additional flanges **44** may be placed between decks. The flanges **44** and the guide **42** form a single integral unit. Fastened to the uppermost guide are a number of dogs **48** with lifting eyes **50**. The dogs **48** extend beyond the edges of the uppermost flange **44** and rest on the deck **52** to prevent the guide assembly from falling through the well **40**. In this embodiment, the guide **42** is composed of two conductor tubes **56** and **58**. The conductor tubes **56** and **58** are enclosed by the fairing **46** properly shaped to minimize current drag against the guide and to assist debris around the guide. The length of the guide **42** should generally be between one-fourth and one-half the depth of the water in which the survey is being conducted. The guide **42** should not be of sufficient length to rest on or penetrate the bottom, thus being supported at the surface by the craft and restrained on the bottom by the material it has penetrated. In the event the guide **42** rests on or penetrates the bottom any appreciable movement of the vessel **2**, caused for instance by the action of the swift currents, or collision of the guide **42** or the vessel **2** with floating or submerged debris such as a tree being carried downstream, can bend the guide **42**, cause it to collapse, and thus halt operations until the damaged guide **42** can be removed and a new guide provided.

In practice, a number of guides **42** of different lengths may be provided so that a guide of suitable length for the depths and current velocities encountered may be used. The guide **42** is provided with a winch, line sheaves or blocks and hooks to place it in the well **40** and water and remove it from the water and well.

In operation, a hook **60** (FIG. 6) may be passed through the eye **50**. Attached to the hook **60** is a line or cable similar to **34** passing over a sheave or block similar to **36** and being actuated or controlled by a winch similar to **38**. The tops and bottoms of the conductor tubes **56** and **58** are belled or tapered (FIGS. 1 and 7) to allow easy transit of the probe **6** and prevent any protrusions on the probe **6** such as a coupling from hanging-up with the top or bottom of the conductor-tube.

Also contained within the guide **42** is another conductor tube **58**. The conductor tube **58** is similar to conductor tube **56**. While only two conductor tubes **56** and **58** are shown in this embodiment of the concept of revetment survey, additional conductor tubes may be provided if desired. The purpose of the conductor tube **58** is to accommodate a probe recovery tube **62**. In practice, it was found that the probe **6** could be recovered readily from penetrations of river bottom and depositions so long as an upward force plus either rotation or continued flow of fluid was maintained.

In the event of equipment malfunction or human error resulting in the inability to either lift or rotate the probe **6**, and the probe **6** comes to rest in an unprotected portion of sediment, the material surrounding the probe **6** is then free to sluff and cave-in thereby seizing and binding the probe **6** and preventing removal thereof. In this event or in other circumstances when it may become necessary or desirable to free or assist the recovery of the probe **6**, the probe recovery tube **62** is lowered through the conductor tube **58**. The probe recovery tube **62** is similar in construction and appearance to the probe **6** and accordingly need not be described with particularity. The probe recovery tube **62** is powered by a revolving head **96** of the same general type as revolving head **8**. Independent means are provided for raising and lowering the probe recovery tube **62** and comprises a winch **124**, an elevating cable **126**, sheaves **128** on the most **4**, a yoke **130** and a revolving head **131**. Suitable means are also provided for injecting pressurized liquid through the probe

recovery tube 62. A suitable manifold may be provided in conjunction with the pump 26 or a duplicate pump may be provided. It will accordingly be seen that independent means of manipulating the probe recovery tube 62, rotating the probe recovery tube 62 and injecting liquids therethrough are provided.

In the event the probe 6 becomes stuck in the sediment layer, the probe recovery tube 62 is lowered through the conductor tube 58 which is in close proximity to the conductor tube 56. The probe recovery tube 62 is thus lowered and guided in a path immediately adjacent to the stuck or immobilized probe 6. Vertical pull is applied to the probe 6 either through its own winch 38, or in the event its own winch 38 is inoperative, either through the medium of an auxiliary winch similar to winch 38 or through a line similar to line 34 and a cathead provided on the shaft of an operative winch or auxiliary accessory. The rotating motion of the probe recovery tube 62 and the washing action of the fluid in the probe recovery tube 62 in addition to an oscillating, vertical motion of the probe recovery tube 62 acts to free the probe 6 for withdrawal thereof. Cross connections are provided between the several pumps 26 so that fluid motion can be restored or maintained in the probe 6 where such action is indicated. Interconnections are also provided between the pumps 18 so that hydraulic power can be interchanged when indicated.

FIG. 7 shows some features of the probe 6 in greater detail. A renewable tip 88 may be provided at the lower end of the probe 6. As the probe 6 penetrates deposition materials and also as it encounters mattress material such as concrete blocks, rock, or other hard or abrasive material, the tip will wear and become distorted. A renewable probe tip such as 88 will help keep the length and configuration of the probe 6 constant. Probe 6 is also provided with depth calibration markings, some of which are shown at 92. A pointer 94 fastened to the deck 52, the mast 4, or other suitable stationary part of the equipment or vessel 2 is provided as a reference point so that readings indicating the depth of the probe tip 88 can be made and subsequently recorded. An alternate method of determining the depth of the probe tip 88 would be to attach a wire line to the revolving head 8 or other suitable part of the apparatus, the wire line after passing through suitable sheaves and guides would be terminated in a device such as a calibrated dial or a direct reading numbering machine from which could be read directly the depth of the tip 88 of the probe 6.

FIG. 8 shows a cross-section of a river bank 64, which has been prepared for and upon which has been laid the articulated concrete mattress revetment 68. The water level is depicted at 66 and the end of the articulated concrete mattress revetment on the bank is indicated at 74. The end of the articulated concrete mattress within the stream is shown at 72. A sediment layer 70 consisting of silt, sand, gravel and other material carried by the currents eventually accumulates on the revetment 68. Depths of water will vary and generally be on the order of up to one hundred feet or more. The length of articulated concrete mattress from 72 to 74 is generally on the order of 500 feet. The suspended sedimentation in the water limits visibility to the order of six inches below the surface 66 below which light does not penetrate. The amount of sediment or overburden 70 existing at any point at any time is varying depending on current velocities, flood conditions, obstructions, composition of the sediment, contour of the river banks, debris and possibly other factors. Entire islands may appear and disappear as the river carries its sediment to the sea. There is evidence that hills of sediment move downstream with the current much as sand dunes move across a desert with the action of the wind. The great forces exerted by the flowing water not only erode the banks causing the meanderings of a stream but can and do damage and destroy the protective coverings such as the articulated concrete mattress revetment 68 placed upon the banks and bottom. With the rising and falling of the water level 66 the exposed portions of the revetment and mattress 68 can be visually inspected. Any part of the mattress below the water level cannot be seen. Until development of the herein described concept, there has been no means or method of determining the extent and depth of deposition of sediment on the mattress and no means or method of determining the existence or condition of the mattress under the sediment.

Heretofore, revetment surveys have consisted primarily of observing the condition of the mattress in those areas visible above the water level, those areas where revetment failure permitted the currents to wash away or undermine supposedly protected banks, and conjecture based on water depth readings taken with sonic depth finders. This invention was developed and tested in a portion of the Mississippi River with currents up to 7 miles per hour, water depths up to 90 feet and penetration of sediment and river bottom up to 30 feet. The tests were made on and off an articulated concrete mattress and also on and off rock-filled timber lattice cribs sunk to the river bottom to stabilize the bottom prior to the sinking of bridge piers. Contact of the probe 6 with the mattress 68 and cribs was positive as were contacts between probe and rock-filled cribs and other bottom features such as sedimentation 70. The herein described method removes conjecture and educated guessing from such an important function as survey of articulated concrete mattress, other bank coverings, survey of underwater structures such as rock-filled cribs, and objects such as sunken craft, and substitutes positive, physical location and identification through physical contact.

FIG. 9 depicts a plan view of part of the articulated concrete mattress 68. The individual concrete slabs 76 are approximately one foot by four feet in width and length and about four inches thick. The slabs are wired and clipped together with wires such as depicted schematically as 78 and clips such as depicted schematically as 80, to form large mattresses which are then lowered to the river bottom.

FIG. 10 is a representation of a small section of a wooden frame or timber mattress 86. Basically the mattress consists of mattress boards 82 interlaced with weavers 84, binders, clamps, wire and other suitable material may be used to tie the mattress together. Bins or cribs of varying sizes may also be constructed as part of the woven board or timber type mattress. Still other wooden mattresses may be made of willow, brush, or small trees. Generally such a mattress is constructed, floated to the location where it is to be used to stabilize the river bottom, then stones and possibly concrete blocks are placed on the mattress and in the cribs until the mattress sinks to the bottom. Additional stones and rock may then be dropped on and around the timber or willow mattress. Caissons for erection of bridge piers and other construction may then proceed on, under, and over the stabilized river bottom. In the development of this method of revetment survey, a rock-filled timber mattress, laying in approximately 80 to 90 feet of water and with varying degrees of sediment deposited on it, was located and surveyed.

FIG. 11 illustrates a vertical cross-sectional view of the probe 6 during an inclinometer survey to determine the deviation of the probe 6 from the vertical. Since the probe 6 may be deflected by the currents a sufficient amount to impair the accuracy of the survey, it may be necessary to determine the deviation of the probe 6 in order to calculate the true position of the revetment 68. Although this may be done in a variety of suitable manners, one convenient way is to use conventional oil well survey equipment such as a suitable inclinometer 132 carried by a holder 134 which is lowered into the probe 6 by the use of a wire line 136. From the readings obtained by the inclinometer 132, the true vertical distance from the vessel 2 to the revetment 68 may be obtained.

As shown in FIG. 12, there is mounted on the vessel deck 52 the previously described mast 4. The probe 6, the guide 42, the well 40, the conductor tubes 56, 58, and the probe recovery tube 62 are disposed beneath the mast 4 with the pumps 26, associated prime movers 28 and auxiliary equipment being on or under the deck 52. In addition, a bow anchor winch 96, a stern anchor winch 98 and two side anchor winches 100 and 102 are provided. Fairleads, blocks, prime movers and suitable winch control equipment (not shown) are provided. As with the other equipment, power for the anchor winches 96, 98, 100 and 102 may be provided by hydraulic motors, internal combustion engines, electric motors, air motors, power take-offs, shafts or other means. While this embodiment shows single drum winches, other arrangements using multiple drum winches with suitable fairleads, blocks, and sheaves can be used. The side anchor winches 100 and 102 are depicted as being equipped with catheads 104 and 106. The catheads with appropriate lines, sheaves, and blocks may be used wherever a source of pulling or raising or braking power is required such as raising or lowering the guide 42 into the well 40, or as a source of emergency power to raise the probe 6 in the event of failure of the winch 38.

Each anchor winch 96, 98, 100 and 102 is provided with an anchor line 108. Anchors 110 of suitable size and holding capacity are provided for three anchor lines as shown. One of the anchor lines 108 is depicted as being tied or secured to a post, stake, or tree 112, on the river bank. The anchor winches 96, 98, 100 and 102 with their associated anchor lines 108 and anchors 110 or post, stake, or tree 112 are used to secure and maneuver the vessel 2 during the survey of the revetment 68 (FIG. 8). Maneuver of the vessel 2 may be in any of a variety of uniform or random patterns over and around the revetment or structure 68. The patterns may consist of widely spaced reconnaissance readings or of closely spaced detailed survey readings. In the event the method is used to locate an underwater object, a pattern of movement and search adapted to the configuration of the object may be adopted.

In addition to the survey of the revetment 68, additional instrumentation may be provided to measure other phenomena such as water temperature, current velocity, sediment sampling, and silt content of water at various depths in the area being surveyed.

Also shown in FIG. 12 is one means of determining the location of the probe 6 with respect to known terrestrial survey points on the banks or shores. A wire measuring line or lines 114 is provided on the vessel 2. The wire survey line 114 is carried on a reel (not shown) which is powered and controlled to keep relatively constant tension on the wire measuring line as it is paid-out and taken-up with the movement of the vessel 2 through the survey pattern. The wire measuring line 114 is further passed through a measuring device which indicates length of line between reference point at the plane table 116 on the bank or shore and the reference point on the vessel 2. Associated with the plane table 116 is an alidade or theodolite 118. The length of the wire measuring line 114 taken together with the angle 122 between the surveyed reference line 120 and the wire measuring line 114 locates the vessel 2 at each reading of the probe 6. Electronic or other means of distance and angle measurement may also be used. Angle measuring devices or means may also be mounted on the vessel rather than on the bank.

A propulsion system for the vessel 2 is not shown in the drawing. As previously indicated, the propulsion system may be either internal to the vessel 2 or external in the form of a tug or towboat. In either method of propulsion, the propelling force is available to assist in maneuvering the vessel 2 through the survey patterns as well as to move the vessel from survey site to survey site.

Means 124 for radio, wire, or visual communications are provided between the plane tables 116, vessel 2, and any other craft used in the operation.

Having thus described the equipment, a description of a cycle of operation using the equipment follows:

In FIG. 12, the vessel 2 is moved either under its own power or by a tug or towboat to the revetment the mattress 68 of which is to be surveyed. The anchor and tie lines 108 are extended. Anchors 110 are set. A post, stake, or tree 112 on the bank may be used to secure one or more anchor or tie lines 108. A survey party finds an existing surveyed reference line 120 or lays out a surveyed reference line 120 from landmarks or benchmarks in the vicinity. Plane tables 116 with associated alidades or theodolites are set up on the surveyed reference line 120. Wire measuring lines 114 are extended from the vessel 2 to the river bank 64 and secured to a point on the surveyed reference line in proper relationship to the plane table 116. In extending the wire measuring line 114, the line is adjusted or calibrated with reference to its dial or measuring device so that the length of the wire measuring line 114 between the reference point on the vesseol 2 and the reference point on the river bank is known. The survey party measures the angle 122 between the surveyed reference line 120 and the wire measuring line 114. Calculations are then made of the position of the vessel 2 and the probe 6 for each location at which a reading is taken. A small portion of an articulated concrete mattress 68 is also shown in FIG. 12.

Aboard the vessel 2, the guide 42 is lowered into the well 40 until the dogs 48 rest on the deck 52. Lowering of the guide 42 into the well 40 may be accomplished by inserting the hook 60 into the lifting eye 50. The winch line 34 or a soft line (not shown but used in conjunction with a cathead 104 or 106, FIG. 12) may be attached to the hook 60 and used to raise the guide from the deck 52 of the vessel 2 and lower it into the well 40.

The probe 6, having the renewable probe tip 88 thereon, is attached to the revolving head 8. The prime mover 16 is engaged, thus driving the hydraulic pump 18. The hydraulic pump 18 takes hydraulic fluid from reservoir 20, increases the pressure of the hydraulic fluid and exhausts the hydraulic fluid under increased pressure into high pressure line 12. The hydraulic fluid under elevated pressure flows through the controls to the hydraulic motor 10 (FIGS. 1 and 5) causing the hydraulic motor 10 of the rotating head 8 to impart a rotating motion to the probe 6 in a direction and at a speed determined by the setting of the controls and the environmental conditions. The spent hydraulic fluid is exhausted by the hydraulic motor 10 into the return line 14, through which it returns to the reservoir 20.

The prime mover 28 is also engaged thus driving the water or fluid pump 26. The end of the pump intake pipe 30 is lowered into the river. Water is drawn from the river, its pressure elevated within the pump 26 and the water at elevated pressure is exhausted into the hose 24. The water is carried in the hose 24 to the fluid connection 22, thence through the rotating head 8 into the upper end of the probe 6, through the probe 6 and through the renewable tip 88 back to the river. If the probe 6 has penetrated sediment deposited on bottom such as 70 (FIG. 8), the water discharged from the tip 88 will flow partially through the interstices of the sediment and partially through the space between the outer wall of the probe 6 and the material being penetrated. The vertical motion of lowering and raising the probe, the rotary motion of the probe and the flow of water, all tend to keep open the cavity created by the penetration of the probe 6 into the deposited sediment and material. It is recognized in this description that rotary motion of the probe 6 and fluid movement through the probe 6 are not essential as long as the probe is suspended only in water but must be applied when the probe enters the deposited sediment on the river bottom.

When the probe tip 88 comes in contact with the

revetment 68, the fact of contact is positive. It can be felt in the jar transmitted through the probe 6. It can be further felt in the crunch of the rotary movement of the probe on the concrete; the contact and continuing crunch can usually be heard as the sound wave of the impact and continuing rotary crunch are transmitted through the probe; it can be seen in that the downward movement of the probe is suddenly halted. There are characteristic sensings which indicate the contact of the probe with other material such as wood, loose or uneven rock, gravel, sand, silt, clay or other material with which the probe comes in contact or penetrates.

From the depth calibration markings 92, readable at the pointer or reference point 94, the depth of the contact point between the probe tip 88 and the concrete mattress, timber or willow mattress, gravel, stone, silt or other material, structure or object, is obtainable and can be recorded. Where a penetration of the deposited sediment 70 is to be made, the depth where the sediment is first encountered is recorded from the calibration markings 92 read at the pointer 94 and then the final depth is also read and recorded, thus giving the depth of penetration. The location of the probe 6 with respect to points on the surveyed reference line 120 are determined by use of the distance readings from the wire measuring lines 114 and the angles 122 measured by the alidades or theodolites 118.

In the event of a malfunction or equipment failure resulting in sluffing-off or cave-in of the unsupported cavity and seizing or binding of the probe 6 by the material 70 being penetrated, the probe recovery tube 62 is lowered through the conductor tube 58. The probe recovery tube 32 is given a rotary motion and water or other flowable material is pumped through it as previously described. The conductor tube 58 containing the probe recovery tube 62, being in close proximity to the conductor tube 56 containing the probe 6 will result in the probe recovery tube 62 entering the overburden 70 near and in close proximity to the probe 6. The cavity created by the probe recovery tube 62 (FIG. 13) will wash material away from the probe 6, thus opening the cavity so both probe recovery tube 62 and probe 6 can be recovered. Following correction of the malfunction or equipment failure, a reading can be completed. Following completion of the reading, the vessel is moved to the location of the next reading. The movement can be accomplished by manipulation of the anchor and tie lines 108, through the medium of the winches 96, 98, 100 and 102, assisted where necessary by the propulsion unit (not shown). When made secure in the new location, another reading is taken. Thus a succession of readings will determine the existence or absence of the revetment, the depth of water over the mattress, the depth of overburden on the mattress, and other information. One pattern of operation can consist of taking a reading near the bank, moving 20 or 30 feet away from the bank 64, FIG. 8, essentially perpendicular to the bank 64 or surveyed reference line 120, and taking another reading. Thus, with successive readings, a profile of the mattress is made at suitable intervals to the end of the mattress 72. The vessel 2 is then moved up or down stream a suitable distance and another profile taken. A succession of such profiles or other pattern of readings constitutes a survey of the revetment.

What is claimed is:

1. A method of surveying a revetment comprised of a multiplicity of objects which are bound into a mattress-like structure, at least some of the objects being covered by an unconsolidated sediment layer and located beneath a body of moving water, the method comprising the steps of

(1) positioning a movable platform in the water at a first location over the revetment site;

(2) extending a probe downwardly from the platform through the water and into the sediment layer for a substantial distance;

(3) retracting the probe from the sediment layer;

(4) moving the platform to a different location; then repeating steps (2) through (4) a plurality of times; and

taking measurements of the exact position of the platform at least at locations where the probe does not physically contact at least one of the objects at the lowest point of probe movement.

2. The method of claim 1 wherein the probe extending step comprises rotating the probe contemporaneously with the downward movement thereof.

3. The method of claim 1 wherein the probe provides a passage therethrough from adjacent the platform to adjacent the lower probe end and the probe extending step comprises passing a liquid through the passage contemporaneously with downward probe movement.

4. The method of claim 1 further comprising the step of ascertaining the depth of sediment above the revetment at a location where the probe physically contacts at least one of the objects.

5. Apparatus for locating an object at least partially covered by an unconsolidated sediment layer and located beneath a body of water, the apparatus comprising

a floatable platform;

probe means;

means carried by the platform and operatively connected to the probe means for manipulating the probe means between positions adjacent the object and adjacent the platform; and

probe recovery means comprising

a probe recovery conduit;

means carried by the platform and operatively connected to the probe recovery conduit for manipulation between positions adjacent the object and the platform;

means for delivering pressurized liquid to the probe recovery conduit; and

means for guiding the conduit to a position adjacent the lower terminal end portion of the probe.

6. The apparatus of claim 5 wherein

the probe recovery means comprises

means for rotating the probe recovery conduit.

7. The apparatus of claim 5 wherein

the means for guiding the conduit comprises

a conduit rigid with the platform and extending a substantial distance into the body of water.

8. The apparatus of claim 5 further comprising

means carried by the platform and operatively connected to the probe means for rotating the probe means contemporaneously with manipulation thereof between the positions.

9. The apparatus of claim 5 further comprising

means for ascertaining the depth of the lower terminus of the probe means.

10. The apparatus of claim 5 further comprising

means for fixing the location of the platform.

11. The apparatus of claim 5 further comprising

means for determining the deflection of the probe from the vertical.

12. The apparatus of claim 5 wherein

the probe means comprises

a conduit and wherein

the apparatus further comprises

means for delivering pressurized liquid through the probe conduit.

13. The apparatus of claim 5 wherein

the probe means comprises

a first guide rigid with the platform; and

a probe constrained by the first guide for movement in a predetermined generally up and down path;

the means for guiding the probe recovery conduit comprises

a second guide rigid with the platform and constrained in a predetermined relationship with the first guide, the probe recovery conduit being restrained by the second guide.

14. The apparatus of claim **13** wherein

the first and second guides extend below the bottom of the platform a substantial distance into the body of water.

15. The apparatus of claim **10** further comprising

means for accurately determining the position of the platform at the fixed location.

16. The apparatus of claim **15** further comprising

means for moving the platform from one position to another.

17. Apparatus for locating an object at least partially covered by an unconsolidated sediment layer and located beneath a body of water, the apparatus comprising

a floatable platform;

probe means;

probe recovery means comprising

a probe recovery conduit; and

means for delivering pressurized liquid to the probe recovery conduit;

means carried by the platform and operatively connected to the probe means and the probe recovery means for independent manipulation between positions adjacent the object and adjacent the platform; and

guide means extending a substantial distance below the bottom of the platform for constraining the movement of the probe means and the probe recovery means in predetermined paths, the guide means comprising

a first guide constraining the probe for movement in a generally up and down direction;

a second guide constraining the probe recovery conduit for movement in a path generally parallel to the movement of the probe; and

means for securing the first and second guides rigid with the platform.

18. The apparatus of claim **17** wherein

the first guide and the second guide comprise conduit means;

the conduit means being of larger cross-sectional area at the lower terminal end portion thereof than at an intermediate portion of the conduit means.

19. The apparatus of claim **17** wherein

the guide securing means comprises

means for removing the guide means from securement with the platform.

20. The apparatus of claim **17** wherein

the guide means comprises

a fairing secured to the first and second guides below the bottom of the platform for reducing current induced frictional drag on the first and second guides.

21. The apparatus of claim **17** wherein

the guide securing means is arranged to allow rotation of the guide means about a generally vertical axis in order to orient the fairing with respect to currents in the body of water.

22. A method of surveying a revetment comprised of a multiplicity of objects which are bound into a mattress-like structure, the revetment being located at least partially beneath a body of moving water, the method comprising the steps of

(1) positioning a moveable platform in the water at a first location over the revetment site;

(2) extending a probe downwardly from the platform through the water toward the revetment for a distance at least substantially sufficient to reach a sediment layer under the water;

(3) retracting the probe;

(4) moving the platform to a different location;

repeating steps (2) through (4) a plurality of times; and

taking measurements of the position of the platform at least at locations where the probe does not physically contact at least one of the objects at the lowest point of probe movement.

23. The method of claim **22** wherein the probe extending step comprises rotating the probe contemporaneously with the downward movement thereof.

24. The method of claim **22** wherein the probe provides a passage therethrough from adjacent the platform to adjacent the lower probe end and the probe extending step comprises passing a liquid through the passage contemporaneously with downward probe movement.

References Cited

UNITED STATES PATENTS

905,620	12/1908	Agnew	294—66
1,590,020	6/1926	Golden	294—66 X
2,183,492	12/1939	Rabl	33—126.75 X
2,226,060	12/1940	Johnson	33—126.5
2,580,320	12/1951	Quist	33—126.5
3,014,450	12/1961	Castellanos	294—66 X
3,166,123	1/1965	Watkins	294—66 X

WILLIAM D. MARTIN, Primary Examiner

U.S. Cl. X.R.

33—126; 116—113; 175—50

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,534,477 Dated October 20, 1970

Inventor(s) Jack N. Nahas

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 26: change "ase" to --are--; column 1, line 67: change "finder" to --finders--; column 2, line 3: before "strata" insert --the--; column 2, line 10: change "reflections" to --reflection--; column 2, line 13: after "not" insert --of--; column 2, line 27: change "velacity" to --velocity--; column 3, line 6: after "order" insert --of--; column 3, line 49: change "annular" to --annually--; column 3, line 73: change "fathometers" to --fathometer--; column 4, line 17: change "is" second occurrence to --to--; column 5, line 39: change "11" to -- 12--; column 5, line 44: change "12" to --11--; column 6, line 41: change "10" to --18-- and change "18" to --10--; column 6, line 42: change "18" to --10--; column 7, line 19: change "a" to --or--; column 7, line 28: change "from" to --for--; column 8, line 42: change "7" to --6--; column 8, line 70: change "96" to --131--; column 11, line 23: change "energency" to --emergency--; column 13, line 33: change "32" to --62--; column 13, line 40: change "13" to --8--; in Figure 11, add the reference character --136-- and a lead line to the cable.

Signed and sealed this 7th day of September 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents