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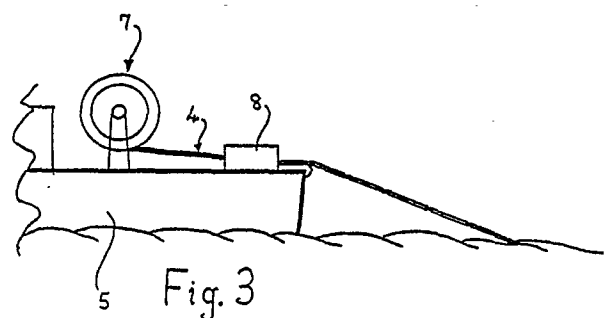
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54 **Magnetic signature simulation apparatus.**

57 Magnetic signature simulation apparatus suitable, for example, for use in magnetic minesweeping, comprises a plurality of magnetisable elements 1 linked together, and magnetising means (8) operable upon each element selectively to set the desired magnetisation state of the element to saturation or to less than saturation in either direction. The elements 1 may thus together reproduce the magnetic signature of a range of different ships. The elements 1 are preferably provided with buoyancy material 2 and encased by a continuous plastics sleeve 3.



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MAGNETIC SIGNATURE SIMULATION APPARATUS

This invention relates to magnetic signature simulation apparatus, usable, for example, in simulating a ship's magnetic signature, especially in minesweeping.

GB-B-2 142 781 discloses a minesweeping apparatus comprising a string of 6 to 10 variable moment magnets, each of which comprises a plurality of magnetisable cores surrounded by solenoids which can be pulsed to set the magnetisation state of the core to positive or negative saturation. By appropriately setting the magnetisation states of the separate cores, the overall magnetic moment of the separate cores may be set to a predetermined value. Setting each magnet in the string to an appropriate value permits the simulation of the magnetic signatures of a range of different ships.

Each of the magnets in the string typically comprises 19 magnetisable cores, each formed of 7 steel rods, with a copper wound solenoid around the core. In order to achieve a large enough maximum magnetic moment, a relatively high core mass is required, and the resulting weight of each magnet, taking into account the cores, the solenoids and casing, is typically about 2.5 tonnes. This weight makes handling difficult.

With a single string of magnets, the swept width is relatively narrow, and thus considerable navigational precision is required to ensure full coverage of any given area of sea. In order to broaden the swept width, the field strength of the magnets could be increased, but this could have two major disadvantages. Firstly, the weight of each magnet might be increased, thereby increasing handling difficulties, and secondly, the field immediately beneath the string might become excessive, permitting the use of magnetic mines designed to distinguish the simulated signature from that of a ship. An alternative would be to use two or more parallel strings of magnets. This would permit each individual magnet to be lighter in weight, but the overall weight of the strings would be greater, thereby again increasing handling difficulties.

A further disadvantage with the use of such strings of magnets is that the cost of each magnet is relatively high, and since the activation of a mine involves the risk of damage to the string and possible loss of magnets, the operating costs can be high.

The present invention provides magnetic signature simulation apparatus comprising a plurality of magnetisable elements linked together and magnetising means operable upon the magnetisable elements selectively to set the resulting field strength of each element to any desired level from zero to saturation in either direction, whereby the

combined field resulting from all the elements together simulates the desired magnetic signature.

Preferably, the or each magnetisable element is provided with buoyancy means for providing the element with a desired buoyancy in water. The buoyancy means may suitably comprise a plastics foam casing, or an inflatable sheath, which could be segmented to reduce risk of loss through puncture.

It has been found that the heat treatment required to achieve in carbon steel the desired magnetic properties, for example a high remanence, preferably at least 9000 gauss, and a coercivity as low as possible, but sufficient to ensure that there will be no influence by the earth's magnetic field or by other magnets, e.g. about 65 Oersted, is effective to a depth of only about 10mm from the surface of the steel. Accordingly, the or each magnetisable element in the apparatus of the present invention is preferably formed as a tube, which need not be of circular cross-section, nor constant wall thickness. The tube is suitably surrounded with buoyancy material, for example foam polyurethane, for use in water, and, where a plurality of elements are linked together, enclosed within a continuous flexible sleeve, which serves to render the tubes watertight and to provide the flexible coupling between adjacent elements. The flexible sleeve is suitably formed from heat-shrunk plastics material.

The magnetising means is suitably a coil arrangement comprising one or more coils preferably arranged so as to be able to surround one of the magnetisable elements (these are conveniently each 1 m in length). Control means supply power to the coils according to the desired magnetisation state for the element. If the element is to be magnetised to saturation in either direction, a short pulse of a relatively high current is fed to the coils in the appropriate direction. It may be convenient to provide this pulse of current from capacitors which can be charged up with a relatively small current from a ship's power supply. A lower current pulse is used where a lower level of magnetisation is required, and the apparatus also preferably comprises sensing means to determine the residual field in the element after the current has been removed from the coils. Control means preferably apply a high current pulse to establish magnetic saturation in the element, followed by a lower current pulse or series of pulse in appropriate direction to bring the magnetisation to the desired level. Where the magnetic signature requires an element with no magnetic moment, or when the string is being returned for storage on board ship, the coils may be fed with an appropriate demagnetising

alternating current.

The coil arrangement may be fixed on the deck of a ship, with the elements being deployed through the coil arrangement to be appropriately magnetised one by one. Alternatively, where the size of ship does not permit storage of the string on board, for example, the coil arrangement may be constructed to float semi-submerged in the water so that the elements may be drawn through it or so that it may be moved along the string. In a further embodiment of the invention, a coil arrangement and magnetic sensing means are permanently located within or around each element.

The size and flexible coupling of the elements facilitate their handling and storage on board ship. For example, they may be wound on to a drum, which may be provided with flat faces corresponding to the size and spacing of the elements. Alternatively, the elements may be formed as self-contained watertight units which can be separated for storage, e.g. by simple stacking on the deck of a ship, and recoupled together for deployment. Such an arrangement would also permit the insertion into the string of non-magnetic elements which serve to space the magnetised elements, if the magnetic signature requires this.

Where the elements are stored on a ship when not in use, the storage facilities, such as the drum, or stacking containers, are preferably provided with active degaussing apparatus, for example degaussing coils extending in three axes and means for controlling the activation of the coils in accordance with the field measured by one or more magnetometers arranged on the ship. This minimises distortion of the ship's own magnetic signature at any instant by the presence of the magnetisable elements together at one location on the ship.

The magnetising means is suitably controlled by a computer which can be arranged to identify the position of an element in the string and to set the magnetisation state according to the desired signature.

As the weight of core material in a typical string is limited by the previously-mentioned handling considerations, two or more parallel strings can readily be deployed, with the same or a different magnetisation pattern, according to the overall desired signature.

The depth at which the string operates can be varied in a number of ways. For example, depressors can be fitted to some or all of the elements to set the depth according to the towing speed and the angle of depression. Alternatively, the buoyancy material may be designed to give an overall buoyancy permitting operation at the desired depth. Where inflatable buoyancy material is used, the degree of inflation may be used to assist in control of the operating depth.

In addition to the magnetic signature simulated by the string, it is possible to adapt the string to simulate other signatures at the same time. For example acoustic transducers can be incorporated into at least some of the elements, or their buoyancy material, or even strapped on to the exterior of the buoyancy material as the string is deployed, the pattern being arranged according to the desired acoustic signature. Instructions for the positioning can be provided by the control computer. Power and modulation for the transducers can be provided by r.f. coupling from a cable passing through the buoyancy material, for example.

In an alternative embodiment, the string of small magnetisable elements is replaced with a smaller number of larger tubular elements, the overall magnetisation state of the element being set to the desired level with a suitably dimensioned coil arrangement.

The magnetic apparatus of the present invention permits greater variation per unit length than apparatus in which the magnetic elements are set only at saturation.

Reference is made to the drawings, in which:

Figure 1 is a perspective sectional view showing a short portion of a string of magnetisable elements forming part of the apparatus according to one embodiment of the invention;

Figure 2 is a diagrammatic plan view of apparatus in accordance with one embodiment of the invention in use in minesweeping;

Figure 3 illustrates the storage and deployment of the string for example as shown in Figure 1; and

Figure 4 is a diagrammatic plan view of apparatus in accordance with another embodiment of the invention in use in minesweeping.

Referring first to Figure 1, each magnetisable element comprises a tube 1 of 6Cr 1C steel, heat treated to ensure that the remanence and coercivity are as hereinbefore specified. The length of the tube 1 will be selected according to handling convenience and magnetic signature required. A convenient length is 1 m, with the tube external diameter being, for example, 80 mm. Figure 1 shows a short portion of one tube connected to another tube, of which again only a short portion is shown, for convenience.

The tube 1 is encased in sufficient polyurethane foam buoyancy material 2 to ensure that it will float in water, and a continuous plastics sleeve 3 is then heat-shrunk on to the elements with a spacing of about 150 mm between them to allow the string of elements so formed to flex. The total length of the strings 4 (Figure 2) thus formed will typically be 137 to 150 m, but can be greater or smaller than this, according to the signature to be simulated.

Figure 2 shows two parallel strings 4 being towed by a vessel 5. Vanes (not shown) are suitably provided at the leading end of each string to counteract the tendency of the strings to move towards each other. For safety reasons, the towing cables 6 may be substantially longer than shown. The vessel 5 carries a drum winch 7 for storage of the strings when not in use, and a magnetising coil 8. These will be described in more detail hereinafter with reference to Figure 3.

In use, the vessel 5, having deployed the strings 4 with the magnetisable elements set to simulate the magnetic signature of, say, a degaussed ship, tows the strings on a predetermined path. A magnetic mine beneath this path will detect the magnetic signature and explode. The flexibility and small size of the strings reduce the risk of their being damaged by any explosion, but since the construction of the strings is simple, the cost of any loss will be relatively small.

Figure 3 illustrates on a larger scale the stern section of the vessel 5 shown in Figure 2. The drum winch 7 is used to store the string or strings 4 when not used, the surface of the drum being divided into flat faces each approximately 1 m long to hold the magnetisable elements. The strings 4 are deployed via the magnetising coil 8, element by element, the number of the element in the string being noted, for example by an externally-marked code readable by the coil arrangement, and the magnetisation state being set by the coil in accordance with a predetermined pattern. On recovery of the strings, each element again passes through the coil arrangement 8, to be demagnetised by application of an alternating current to the coil in a predetermined pattern, before being drawn on to the drum 7 for storage. This ensures that the magnetic signature of the vessel 5 is not substantially increased by the presence of the strings 4 on board.

Figure 4 shows the use in minesweeping of apparatus according to an alternative embodiment of the invention. A string of five large elements 40 coupled by cables 6 is towed by a vessel 5. Each element 40 comprises a steel tube encased in buoyancy material. The magnetising apparatus may suitably be floating on the water and semi-submersible to permit the elements to pass through for the magnetisation to be set. Alternatively, the magnetising apparatus may be built in to or around each of the elements 40.

Claims

1. Magnetic signature simulation apparatus comprising a plurality of magnetisable elements linked together and magnetising means operable

upon the magnetisable elements selectively to set the resulting field strength of each element to any desired level from zero to saturation in either direction, whereby the combined field resulting from all the elements together simulates the desired magnetic signature.

2. Apparatus according to Claim 1, wherein each magnetisable element is provided with buoyancy means for providing the element with a desired buoyancy in water.

3. Apparatus according to Claim 1 or 2, wherein each magnetisable element comprises a tube of magnetisable material.

4. Apparatus according to Claim 1, 2 or 3, wherein the magnetisable elements are flexibly coupled together by means of a continuous flexible sleeve enclosing the elements.

5. Apparatus according to any preceding claim, wherein the magnetising means comprise a magnetising coil arrangement, the coil arrangement and the elements being relatively movable to permit each element in turn to be located within the magnetising influence of the coil arrangement, and control means for activating the coil arrangement in accordance with the desired magnetisation state of each element.

6. Apparatus according to Claim 5, wherein the magnetising coil arrangement is arranged to be at least partially submersible in water whereby the magnetisable elements may be moved therethrough in the water.

7. Apparatus according to Claim 6, wherein the magnetising coil arrangement is movable in the water from one magnetisable element to another.

8. Apparatus according to any preceding claim, wherein measuring means are associated with the magnetising means for determining the magnetisation state of each element before and/or after operation of the magnetising means.

9. Apparatus according to any preceding claim, wherein at least one adjacent pair of magnetisable elements is coupled together via a non-magnetic spacing element.

10. Apparatus according to Claim 9, wherein the or each non-magnetic spacing element is of the same length as the magnetisable elements.

11. Apparatus according to any preceding claim, wherein at least one acoustic or other transducer is provided on or in said plurality of elements to produce an acoustic or other signature in addition to the magnetic signature.

12. Apparatus according to Claim 11, wherein the or each transducer is temporarily secured to the exterior of a selected one of the elements.

13. Apparatus according to Claim 11 or 12, wherein control signals and/or power for the or each transducer are supplied inductively from a conductor extending within at least some of the

elements.

14. Apparatus according to any of Claims 5, 6 and 7, wherein the control means are arranged to supply to the coil arrangement a high current pulse to establish magnetic saturation in the element, followed, if required, by a lower current pulse or series of pulses in the appropriate direction to bring the magnetisation to the desired level.

15. Apparatus according to any of Claims 5, 6, 7 and 14, wherein the control means are operable to supply to the coil arrangement a demagnetising alternating current.

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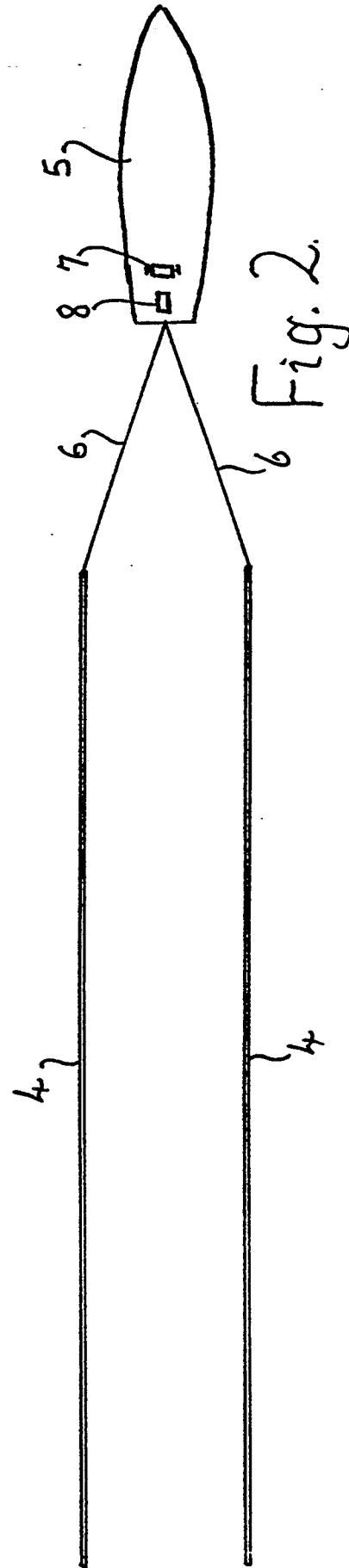
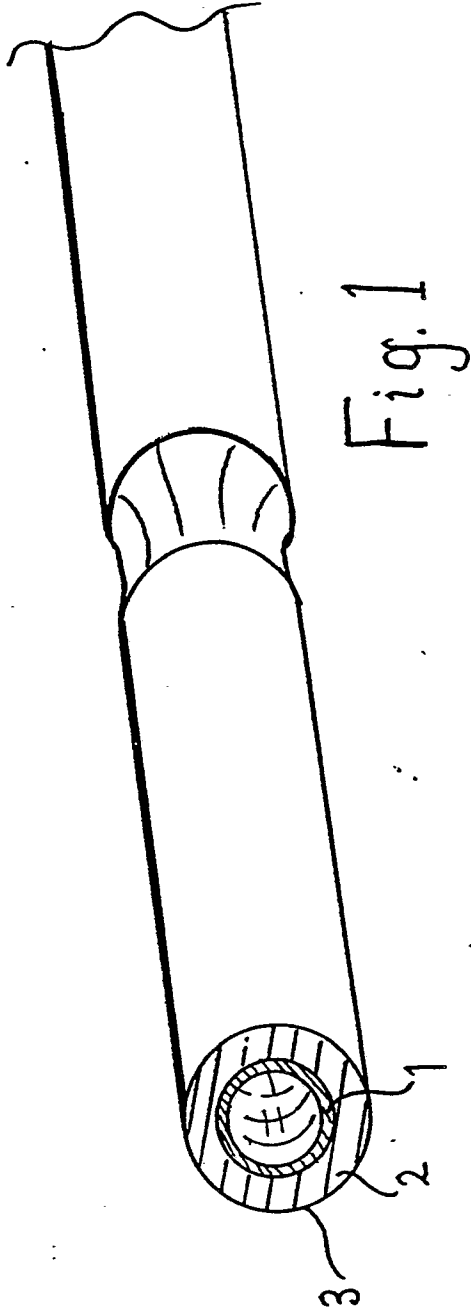
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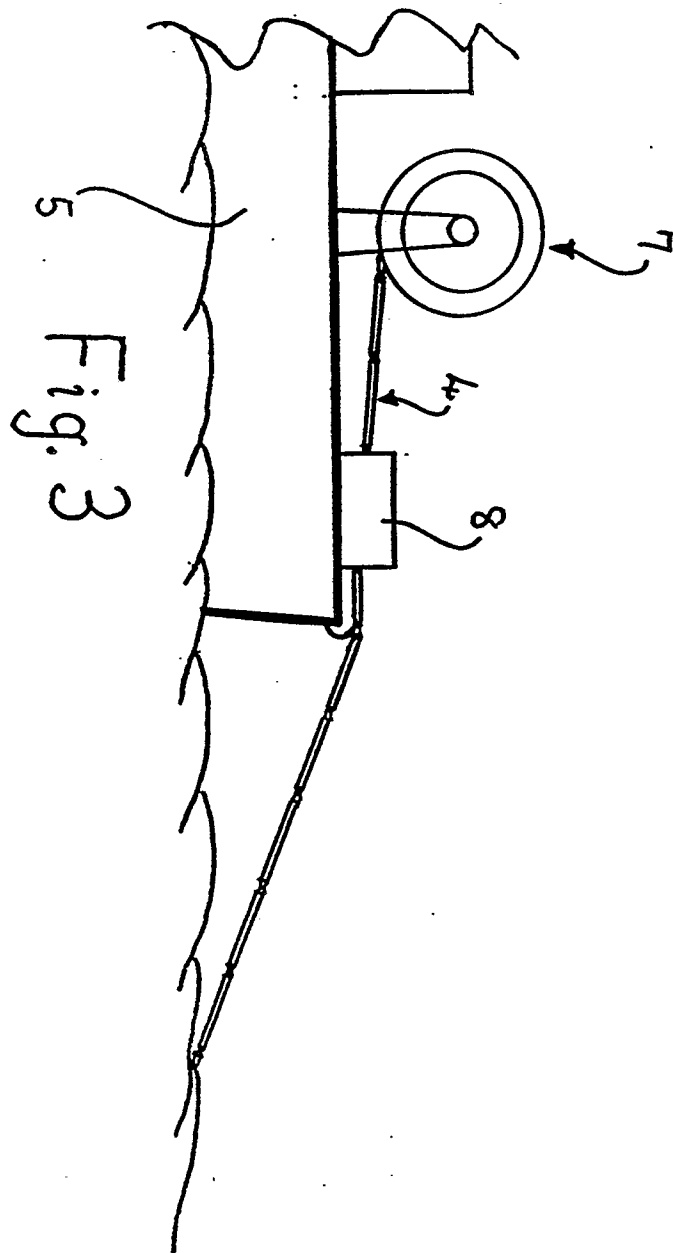
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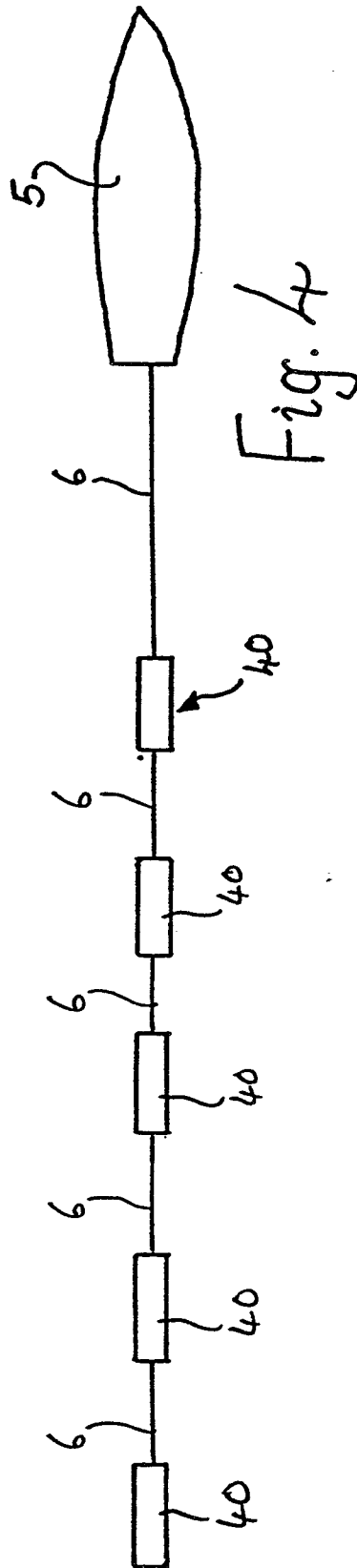
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-3 826 215 (DYJAK) * Whole document *	1,2,5,8	B 63 G 7/06
Y		3,14,15	
A		4,6,7,9,10	
X,D	GB-A-2 142 781 (THE SECRETARY OF STATE FOR DEFENCE)	1,2	
Y		3,4,11-13	
A		9,10	
Y	US-A-2 979 015 (ESTES) * Column 6, line 59 - column 7, line 3; column 9, line 61 - column 10, line 9; figures 1,3,7,8 *	4	
A		9,10-12	
Y	EP-A-0 205 887 (KABELWERKE FRIEDRICH C. EHLERS) * Page 4, last paragraph - page 7, last paragraph; figures 1,2 *	11-13	
Y	WO-A-8 303 849 (GOULD) * Page 5, line 9 - page 7, line 29; figures 1-4 *	14,15	B 63 G
A		1-13	
A	GB-A- 579 801 (JAMIE)		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 10-01-1990	Examiner DE SENA Y HERNANDORENA A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			