

Device for continuous measurement of the density and total weight of material in the hold of a hopper-dredger.

The present invention relates to an installation which can be used to measure continuously the density and the total weights of materials loaded in the course of a dredging cycle into the well of a self-contained dredger.

5 It is known that sea and river sediments have most of the time a very variable particle size distribution within a given site. On the bottom where they rest, they are deposited according to a density gradient decreasing from the bottom up, the heaviest particles naturally sedimenting
10 lower down than the light particles.

 When a water/sediment mixture is dredged, for example by suction through a ladder, and loaded into a well of a self-contained dredger or into a hopper barge, a sedimentation phenomenon occurs in a similar manner: the
15 materials in suspension in the water are deposited progressively, being distributed in the well according to a density gradient.

 At the start of dredging, during a so-called loading phase, the well is filled up to the level of an
20 overflow located in its upper part. In order to take on board a boat a total load representing a sediments content which is as high as possible, the dredging cycle is not interrupted once the level of the overflow is reached. Thereafter, the excess of the dredged water/sediment mixture
25 necessarily overflows, via this overflow. As the heaviest particles are deposited progressively towards the bottom of the well, the total weight loaded into the boat continuous to increase during the overflow phase, that part of the water/sediment mixture overflowing via the overflow
30 containing relatively few materials in suspension. Obviously, the increase in the total weights of materials loaded into the boat per unit time decreases substantially in the course of the dredging cycle, until becoming virtually zero.

When the dredging has been completed, the well of the boat therefore contains a known volume of dredging materials distributed according to a density gradient along the height of the well.

5 For each dredging cycle carried out on a given site, the payment made to the company carrying out the operation is a function of the total load taken on board into the well in the course of this cycle.

10 A method frequently used to evaluate this load consists in placing, in an empty well whose volume is known, and at various heights along a vertical axis, a defined number of containers serving to collect samples of dredged materials. After filling the well and therefore the
15 containers, the samples are taken and weighed or analyzed with a view to determining the density thereof. The average density of the materials loaded into the well is deduced from the results of these analyses, thereby enabling their total weight to be calculated.

20 It is possible, for example, to use three hollow cylinders fitted with a cover at each of their ends. The covers remain open throughout the entire duration of the dredging and are closed at the end of the latter, after which the density measurements are carried out on the specimens thus isolated.

25 This technique has the disadvantage of being very slow. In addition, the specimens can in practice be taken only once per dredging cycle. The reason for this is that once the measurements have been carried out it is not possible to carry out a new measurement, by replacing the
30 containers in the well.

 Furthermore, this long-standing technique only gives quite a rough approximation of the total weight of materials actually loaded into the well since the number of specimens taken is limited and the calculation of the
35 average density is made by assuming a perfectly linear variation in the density gradient between the containers.

Patent Application EP-A-0 013 588 describes an apparatus which allows continuous calculation of the average density of a water/sediment mixture in a well of a dredger boat. The device used comprises a diaphragm arranged close to the bottom of the well. The hydrostatic pressure exerted on one face of the diaphragm is measured by the water/sediment mixture contained in the well, by comparing this pressure with that exerted on the other face of the same diaphragm by a fluid of known density contained in a measurement column. This height of the fluid contained in the measurement column is varied so that the hydrostatic pressures exerted on either side of the diaphragm are mutually compensated for. The height is measured and the average value of the densities of the water/sediment mixture at the various levels in the well are deduced therefrom.

This device is liable to cause not insignificant measurement errors. Patent EP-B-0 049 933 attempts to remedy this problem by providing a similar apparatus which comprises, in particular, means for storing in memory several values of the density, thereby making it possible to make measurements with greater accuracy and with lower risk of error.

The use of a diaphragm in a water/sediment mixture, which may contain relatively large solid particles, remains tricky since this diaphragm runs the risk of being damaged. Furthermore, only an average density value may be obtained, the aforementioned devices providing no indication as regards the structure of the gradient. Since the cross-section of a dredger boat well is not generally constant over its height, the total weight of the water/sediment mixture contained in the well therefore cannot be deduced sufficiently accurately from the average density of this mixture at the various levels in this well.

The object of the present invention is to provide an installation which can be used to measure, accurately and

continuously, taking into account the change over time, the average density of the load of dredging materials taken on board, in the course of a dredging cycle, into the well of a self-contained dredger.

5 Another object of the invention is to provide such an installation which also can be used to determine, with a high degree of accuracy, the total weight of dredging materials loaded into the well in the course of the cycle.

10 Another object of the invention is to provide such an installation comprising a device which does not risk becoming damaged in the well by the sediments themselves.

The object of the invention is also to provide such a device which can be used to monitor the loading and to study the structure of the load.

15 Another object of the invention is to enable optimum productivity to be achieved in the course of a dredging cycle, by determining the moment in the cycle when it is no longer profitable to continue the dredging operations.

20 Another object of the invention is to provide an installation which enables rapid, reliable, automatic and reproducible measurements to be carried out and which produces no turbulence liable to disturb the structure of the density gradient established in the well.

25 The subject of the present invention is an installation for continuous measurement of the density and of the total weight of dredging materials loaded into a well of a self-contained dredger.

This installation comprises:

- 30 (i) one or more devices each comprising:
- a watertight duct, having a substantially U-shaped cross-section, fixed substantially vertically in the well, and the branches of which bordering a sort of semi-open vertical channel;
 - 35 - a transmissive-type radioactive probe, housed in said duct and comprising a radioactive source

transmitting towards a nuclear detector, the radioactive source and the detector being placed facing one another, each in a branch of the U, the nuclear detector being equipped with means for converting the nuclear radiation into photons, and then into electrical pulses, and for subsequently amplifying these pulses;

- guiding mechanisms serving to guide the said probe along a vertical path in the duct;

- mechanisms for causing the said probe to move upwards and downwards along this vertical path in the duct;

- means for determining the position of the said probe in the duct;

(ii) a computer-aided management set, this management set being capable of measuring and recording time, of receiving and processing the data collected by the means for determining the position of the probe or probes in the duct or ducts, of receiving and processing the data collected by the nuclear detector or detectors in the form of electrical pulses counted in the course of preset regular intervals and converted into corresponding measurements of density, of calculating from these measurements the total weight of dredging materials loaded into the well, of keeping all the data in a central memory, of displaying the analysis and the result of these measurements with the aid of a visual display unit, to print the analyses and the result of the measurements and, in accordance with a preselected program, of regulating and controlling the general functioning of the installation;

(iii) means for transmission to the management set of the electrical pulses supplied by the nuclear detector or detectors and by the means for determining the position of the probe or probes in the duct or ducts (1).

The duct is advantageously manufactured in steel.

The radioactive source is preferably a source of gamma rays. This radioactive source may consist, for example, of a ceramic bead of double-encapsulated ^{137}Cs .

The nuclear detector preferably is a scintillation counter. In this scintillation counter, the means for converting the nuclear radiation into photons consists, for example, of a crystal of NaI(Tl). The means
5 for converting the photons into electrical pulses and the means for amplifying these electrical pulses advantageously consist respectively of a photomultiplier and of an electronic unit for supply and for amplification.

According to a particular embodiment of the
10 installation, the probe is mounted on a trolley. The means for guiding the probe may consist of metal rails arranged vertically in the duct and of rollers mounted on the trolley.

The means for causing the probe to move along a
15 vertical path in the duct may comprise, for example, a jack fitted with a piston rod which can move vertically in the duct. In this case, these means may furthermore comprise a transmission mechanism capable of transmitting the movement of the piston rod to the trolley, multiplying the amplitude
20 of this movement. This transmission mechanism may, for example, comprise pulleys mounted on a spindle securely attached to the end of the piston rod, fixed pulleys securely attached to the duct and a metal cable anchored to the trolley and passing over the said pulleys. According to
25 one particular embodiment, the transmission mechanism is such that any movement of the piston rod entails a movement of the probe in the opposite direction.

The means for determining the position of the probe in the duct preferably comprise an angular position
30 encoder fitted with an optically encoded disc and with an internal optical and electronic device, the disc being coupled mechanically to one of the fixed pulleys over which passes the metal cable.

The mechanisms for causing the probe to move
35 along the vertical path in the duct may comprise an electric motor provided with an electromechanical brake, a speed

reducer and a winding drum for the cable.

The installation may be provided with means for regulating the speed of movement of the probe, these means comprising an electronic frequency control; these means may
5 also comprise a four-quadrant regulator and a tachogenerator mounted on the electric motor.

The means for determining the position of the probe in the duct preferably comprise an angular position encoder fitted with an optically encoded disc and with an
10 internal optical and electronic device, the disc being coupled mechanically to a rotary part whereof the movement correlates with the movement of the probe.

Lower and upper end-of-travel switches may be arranged at the ends of the vertical path travelled by the
15 probe in the duct. These switches are then capable of transmitting data to the computer-aided management set.

Advantageously, this management set will be provided with a program enabling in particular the nuclear detector which performs continuous measurements to transmit
20 them to the management set when the probe moves from the lower end-of-travel switch to the upper end-of-travel switch along a vertical path in the duct and returns to its initial position without performing measurements.

The invention is preferably performed as follows:
25 a chamber is provided in the upper part of the duct, this chamber being arranged above the maximum filling level of the well. This chamber is capable of receiving the trolley and the probe and may also serve for the storage of the trolley and of the probe outside the periods of operation
30 of the installation. In an installation according to the invention, the upper end-of-travel switch is preferably located above the level of this chamber.

This chamber preferably comprises a calibration tank located in the extension of the vertical channel
35 existing between the branches of the U-shaped duct. This calibration tank is capable of containing media of known

densities serving for the calibration of the probe.

The installation of the invention preferably comprises a leak detector. This leak detector being capable of detecting the presence in the duct of solid or liquid materials entering it as a result of a leak and of transmitting corresponding information to the management set.

This management set is capable of commanding, in the case of a leak detected by the leak detector, the immediate sending of the probe into the chamber and the interruption of the operation of the installation.

Preferably, the management set further comprises an external memory. It is possible in particular to make use of memory-disc and tape-recorder units which make it possible to study the data elsewhere than on the dredger boat, for example in research establishments.

Other features and advantages of the invention will emerge from the description given by way of non-limiting example, reference being made to the appended drawings in which:

Fig. 1 is a diagrammatic view in elevation, with a break, of the duct of a device forming part of an installation according to the invention. This duct is shown vertical, as it would be arranged in a well of a dredger boat;

Fig. 2 is a section along the line II-II of Fig. 1;

Fig. 3, 4 and 5 are simplified diagrammatic views showing all the elements of the device which are contained in the duct shown in Fig. 1. These elements are depicted at various moments in an operating cycle of this device;

Fig. 6 is a diagrammatic view (with deformations) showing the arrangement of a metal cable which, in the device of Fig. 1, drives a trolley carrying a transmissive radioactive probe and of an electrical cable which collects data from this probe and transmits it to the computer-aided

management set which controls the general operation of the installation;

Fig. 7 is a detailed view in elevation, with breaks, of all the elements of the device which are
5 contained in the duct, in the position depicted diagrammatically in Fig. 3;

Fig. 8 is a section along the line VIII-VIII of Fig. 7;

Fig. 9 is a section along the line IX-IX of
10 Fig. 7;

Fig. 10 is a section along the line X-X of Fig. 7;

Fig. 11 is a section along the line XI-XI of Fig. 7, in which some of the elements have not been depicted, the
15 duct which contains all the elements being, on the other hand, shown in this Fig. 11;

Fig. 12 is a perspective view of the transmissive-type radioactive probe mounted on the trolley which moves inside the duct;

20 Fig. 13 is a detailed view in elevation, with breaks, of all the elements contained in the duct, in the position depicted diagrammatically in Fig. 5;

Fig. 14 is a perspective view showing the inside of the chamber mounted at the upper part of the duct
25 depicted in Fig. 1, and

Fig. 15 is a diagram illustrating the general operation of an installation of the invention.

Fig. 1 depicts diagrammatically part of the installation of the invention; this part will be designated
30 by the name "density measurement device" (or device for short). Several devices may be installed on the same self-contained dredger.

A duct 1, made of steel and perfectly watertight, is installed, substantially vertically, in a well of a
35 self-contained dredger, not depicted in Fig. 1. This duct has a substantially U-shaped cross-section (see Fig. 2) and

extends over the major part of the height of the device, defining, between its two branches, a sort of vertical channel 2.

5 The duct 1 is closed at its lower part and emerges via its upper part into a chamber 3 which has a square cross-section and which terminates, at its upper end, in a flange 4 provided with drillholes for the passage of bolts.

10 A cap 5 of cross-section identical to that of the chamber 3, and similarly provided, at its lower part, with a drilled flange 6, is bolted onto the duct 1. A seal, not depicted, is placed between the flanges 4 and 6.

15 The installation of the invention makes it possible to measure continuously the density of dredging materials which accumulate in the course of dredging in the channel 2 existing between the branches of the duct 1 (see Fig. 11).

20 In the embodiment depicted in Fig. 1 and 2, the walls 7 to 10 of the duct 1 are 12 mm in thickness, while the internal side walls 11 and the wall 12 which together form the channel 2 are only 6 mm in thickness. Two angle sections 13, facing each other inside the duct 1, are integral with the wall 12 and extend longitudinally along the height of the duct 1 (see also Fig. 14).

25 Fig. 3 to 5 illustrate diagrammatically various positions of the main elements of a device of the installation of the invention for continuous density measurement. The duct 1 of this device has not been depicted.

30 It should be noted that the height of the device (approximately 15 m) is much greater than its width (approximately 60 cm) and that consequently the various elements have not all been depicted on the same scale.

35 The measurements of the density of the materials which accumulate in the well of the self-contained dredger in the course of dredging are carried out in the vertical

channel 2 by virtue of a transmissive-type radioactive probe designated by the general reference 14, the operation of which will be explained with reference to Fig. 11 and 12.

This probe 14 is mounted on a trolley 15 which, in operation, moves along a vertical path in the duct 1 along rails 16 (only one of which is visible in Fig. 3 to 5), between a position 15a (Fig. 3) in which it actuates a lower end-of-travel switch 17, and a position 15c (Fig. 5), in which it actuates an upper end-of-travel switch 18. Between the dredging cycles, that is to say during the periods when the installation is not in operation, the trolley 15 remains at rest in the position 15c.

In operation, the trolley 15 can move from the position 15a to the position 15c and vice versa, between the end-of-travel switches 17 and 18, travelling approximately 14 m in 50 to 60 seconds. Fig. 4 shows an intermediate position 15b of the trolley 15.

As will be explained in detail with reference to Fig. 15, the probe 14 performs measurements while the trolley 15 is moving from the position 15a to the position 15c.

In Fig. 3 to 7 and in Fig. 13, the movable elements are designated by their reference number followed by the letter a, b, or c depending on the position in which they are depicted.

The movements of the trolley 15 are controlled by a double-action hydraulic jack 19 via a metal cable (not depicted in Fig. 3 to 5) which passes over pulleys (see Fig. 6) and is anchored to the trolley 15.

The jack 19 is supplied with hydraulic fluid via two pipes 20 and 21 which emerge respectively at its lower part and its upper part. The piston rod 22 moves between a retracted position 22a in the jack 19 (Fig. 3) and a position 22c in which it is extended to the maximum (Fig. 5).

It will be noted that the trolley 15 moves in the

direction opposite to the piston rod 22, at a speed four times greater.

The probe 14 carried by the trolley 15 is connected to the computer-aided management set which controls and monitors the operation of the entire installation and is installed on board the self-contained dredger (see Fig. 15). This connection is made by means of an electrical cable, not depicted in Fig. 3 to 5.

The mechanism of movement of the trolley 15 will be better understood with reference to Fig. 6, which shows diagrammatically the arrangement of the metal cable 23 and of the electrical cable 24 on a series of pulleys.

In Fig. 6, the position rod 22 has been depicted in solid lines, in a position 22_b similar to that of Fig. 4. It has also been depicted in dotted lines in the extreme position 22_a (see Fig. 3) and 22_c (see Fig. 5). Likewise, the trolley 15, which is depicted in solid lines in its position 15_b (which corresponds to the position 22_b of the piston rod) is also depicted in dotted lines in its extreme positions 15_a and 15_c.

The piston rod 22 drives the trolley 15 by means of a metal cable 23 (depicted in dot/dash lines) which is anchored there and which passes over a series of pulleys.

A horizontal spindle 25, on which four pulleys 26, 27, 28 and 29 are mounted, is securely attached to the end of the piston rod 22. The pulleys 30 and 31 (in the upper part of the mechanism) as well as the pulleys 32 and 33 (in the lower part of the mechanism) are each mounted on a horizontal spindle securely attached to the fixed part 34 of the device, depicted diagrammatically in Fig. 6 by a rectangle. The two ends of the metal cable 23 are respectively clamped in two cable clamps 35 and 36 securely attached to the fixed part 34 of the device.

The metal cable 23 passes in succession, from the cable clamp 35, over the pulleys 26, 30, 29 and 31, to the trolley 15 (to which it is anchored) and over the pulleys

32, 28, 33 and 27, in order to terminate at the cable clamp 36.

The electrical cable 24 is depicted in Fig. 6 by broken lines. It is arranged in such a way that its end
5 connected to the probe 14 can follow the movements of the latter. For this purpose, the electrical cable 24 also passes over a series of pulleys. The pulleys 37 and 38 are mounted on a horizontal spindle 39 securely attached to the end of the piston rod 22. The pulleys 40 and 41 (in the
10 upper part of the mechanism) are mounted on a horizontal spindle securely attached to the fixed part 34 of the device.

From the probe 14 to which it is connected and the trolley 15 to which it is fixed, the electrical cable
15 24 passes in succession over the pulleys 40, 37, 41 and 38, next to pass through a sleeve 42 via which it leaves the fixed part 34 of the device, terminating at the management set (not depicted) which controls the general operation of the installation (see Fig. 15).

20 It should be understood that Fig. 6 is a diagram in which the mutual dimensions and positions of the elements depicted do not correspond to reality, the Fig. 6 having the sole purpose of showing the operating principle of the mechanical part of the device.

25 Thus the spindles 25 and 39 have been depicted in the mutual extension of each other, whereas in reality these two spindles 25 and 39 are perpendicular to each other, while at the same time being carried by the same case 43, as may be seen in Fig. 7 to 9 and Fig. 13.

30 Fig. 7 is a detailed elevation view, with breaks, of all the elements contained in the duct 1, in the position depicted diagrammatically in Fig. 3. Fig. 7A and 7B each show part of this device, the part depicted in Fig. 7A surmounting the part depicted in Fig. 7B.

35 Fig. 8, 9 and 10 are respectively sections along the lines VIII-VIII, IX-IX and X-X of this Fig. 7.

Fig. 11 is a sectional view along the line XI-XI of Fig. 7. Some of the elements of the transmission mechanism have not been depicted in this Fig. 11. On the other hand, the duct 1, which was not shown in Fig. 7, has been depicted so as to show the arrangement of the various elements of the device inside this duct 1.

The metal section 44, which consists of two parallel flats of unequal widths joined together by two other flats arranged perpendicularly, carries the two rails 16, each bolted to one of the edges of its wider flat. When mounting the elements inside the duct 1, the metal section 44 is inserted, by its narrower flat, between the two angle sections 13 (shown in Fig. 2 and 12), which serve to guide it. This arrangement makes it easy to mount the device in the workshop and to dismantle it rapidly for maintenance and repair. The fixed elements of the device contained in the duct 1 are connected, directly or indirectly, to this metal section 44 which extends longitudinally over the height of the duct 1. It will be noted that the total length of the section 44 is greater than the length of the angle sections 13 and than the height of the duct 12 and that the trolley 15 can, for maintenance reasons, continue its travel upwards along the rails 16 beyond the upper end-of-travel switch 18.

In the lower part of the device, a C-shaped piece 45 is bolted, on the one hand, to the wider flat of the section 44 and, on the other hand, to a metal structure 46 which serves as a support for the pulley 32 and 33 and as a guide for the case 43 which carries the pulley 26, 27, 28, 29, 37 and 38.

This metal structure 46, which is shown in its entirety as a long perforated cage of rectangular cross-section, is surmounted by a plate 47 which is itself bolted to another plate 48, securely attached to the cylinder of the jack 19. As may be seen in Figure 8, these plates 47 and 48 are penetrated at four take-up points by the metal cable 23, one end of which is blocked in the cable

clamp 35 securely attached to the plate 48.

At the upper part of the device, the jack 19 is fixed to the metal section 44 by means of a set of metal pieces 49, 50, 51 and 52. The piece 52 also carries the spindle of the pulley 31.

The assembly formed by the cylinder of the jack 19 and by the metal structure 46 is thus fixed to the section 44 and parallel to it.

The section 44 carries the two rails 16, each bolted to one of the edges of its wider flat. The trolley 15, which carries the probe 14, may move along these rails 16, bolted to the section 44, by means of the rollers 53, with which it is provided (see also Fig. 12).

The position of the probe 14 in the duct 1 may be determined at any moment by means of an angular position encoder 54 shown in Fig. 7, 10 and 13. This coder 54 comprises an optically encoded disc and an internal optical and electronic device. The disc is coupled mechanically to the pulley 31, the groove of which receives the metal cable 23 which drives the trolley 15. The optical and electronic device produces 1000 electrical pulses for each revolution of the pulley 31 and transmits these pulses to the computer-aided management set (see Fig. 15).

The tension in the metal cable 23 is regulated by means of a tension regulator device 55 depicted in Fig. 7. This tension regulator device 55 is mounted on the metal structure 46 and carries the cable clamp 36. The tension exerted on the metal cable 33 may also be regulated by means of a threaded rod which carries the pulley 30.

The tension in the electrical cable 24 is regulated by means of a tension regulator device 56 mounted at this upper part of the cylinder of the jack 19 and carrying a cable clap 57 (from which the electrical cable 24 leaves the device, passing through the sleeve 42).

Fig. 7 also shows a small grooved wheel 58 mounted on a horizontal spindle carried by a piece 59

securely attached to the piece 51. This small grooved wheel 58 guides the metal cable 23 and, from the pulley 31, brings it into the vertical from its point where it is fixed to the trolley 15.

5 The transmissive-type radioactive probe 14, which is depicted in Fig. 3 to 7, will be described in more detail with reference to Fig. 11 and 12.

 The probe 14, which is mounted on the trolley 15 and which therefore moves with it in the U-shaped duct 1, 10 comprises a radioactive source 60 and a nuclear detector designated by the general reference 61. As shown in Fig. 11, the source 60 is housed in one of the branches of the U, while the detector 61 faces this branch, in the other branch of the U.

15 The source 60 is included in a bolt 62 inserted into a source-holder block 63 which consists of a steel casing filled with lead and which is provided with a collimator hole 64 facing the detector 61. The latter is carried in a similar manner in a metal detector-holder block 20 65 which is provided with a window 66 facing the source 60.

 The gamma rays emitted by the source 60 and passing via the collimator hole 64 pass through the vertical channel 2 and pass through the window 66, to reach the detector 61 by following a horizontal trajectory.

25 The gamma rays pass through the internal side wall 11 of the duct 1, which therefore makes it possible to perform radiation absorption measurements on a material external to the device, this material lying in the vertical channel 2, at the same time keeping this device from direct 30 contact with the medium under study.

 Part of the gamma radiation emitted by the source 60 is deflected or absorbed by the solid particles in suspension in the water/sediment mixture contained in the vertical channel 2 and therefore does not reach, or does not 35 reach directly, the nuclear detector 61 which therefore records mainly that part of the gamma radiation which is not

deflected or absorbed by the medium traversed.

The residual and non-absorbed gamma radiation, emitted by the source 60 and picked up by the detector 61, may then be converted by the computer-assisted management set into a measurement of the density of the water/sediment mixture. The radioactive source 60 consists of a ceramic bead of double-encapsulated ^{137}Cs . This 5mCi source is capable of emitting radiation at 0.661 MeV. Since the half life of ^{137}Cs is 30 years, the reduction in emission of gamma rays is only approximately 2.4 % per year, which amounts to saying that the rates of emission are virtually constant over three or four months.

Other types of radioactive sources may be used. For safety reasons, devices may be provided for closing off the collimator hole 64 when the probe 14 is not in service.

The nuclear detector 61 consists of a scintillation counter. It is provided with a NaI(Tl) crystal, a photomultiplier and an electronic unit for supply and for amplification. These elements are put together in a sealed cylindrical PVC case 67 mounted on the trolley 15.

The crystal, which receives the gamma rays that have not been deflected or absorbed, emits photons in a quantity proportional to the radiation received. The photomultiplier and the electronic unit for supply and for amplification convert these photons into electrical pulses of a suitable shape in order to be sent to an electronic matching unit forming part of the management set (see Fig. 15).

Of course, other types of nuclear detectors may be used without departing from the scope of the present invention.

Fig. 13 is a view similar to Fig. 7, but the mechanical elements of the device are shown there in the position of Fig. 5, that is to say the trolley 15 here is in its position 15c, while the piston rod 22 of the jack 19 and the case 43 that it carries are in their down position

22c and 32c. It will be noticed that the trolley 15 is in contact with the upper end-of-travel switch 18.

Fig. 14 is a perspective view of the chamber 3, seen obliquely from above. In this Fig. 14 (just as is Fig. 2), the duct 1 is depicted devoid of any other element of the device.

The chamber 3 is delimited laterally by four walls 68, 69, 70 and 71 and its bottom is formed by three horizontal walls 72, 73 and 74.

10 The walls 10, 11 and 12 of the duct 1 (see Fig. 2) are extended upwards inside the chamber 3, thus delimiting, with the horizontal wall 74, the vertical wall 68 and part of each of the vertical walls 69 and 71, a calibration tank 75.

15 When it is desired, the probe 14, brought into the chamber 3, may be calibrated using various media of known density, poured into the calibration tank 75.

It should be noted that if, during the operation of the installation, a leak were to occur in the duct 1, the trolley 15 would be immediately brought back into the chamber 3 and that the operation of the installation would be stopped. In fact, a leak detector device (not depicted in Fig. 1 to 14) installed in the duct 1 is connected to the management set which, in the event of a leak being detected, commands the immediate rise of the trolley 15 right into the chamber 3.

20 The general operation of the installation according to the invention will be better understood with reference to Fig. 15, in which a single measurement device has been depicted.

30 The installation is distributed, over the self-contained dredger, in three different places. The duct 1 of the measurement device is in a well of the self-contained dredger, this well being symbolized in Fig. 15 by the letter A. A hydraulic group 76 and a relay junction box 77 are installed on the bridge of the self-contained dredger, this

bridge being symbolized by the letter B. A computer-aided management set, designated by the letter C, is installed on the command bridge where it can be put into operation and controlled by an operator.

5 It will be recalled that the duct 1 contains the mechanism producing the alternating top-to-bottom movement of the probe 14 in this duct 1. This movement is actuated by the hydraulic jack 19 (not depicted in Fig. 15) which is connected to the hydraulic group 76 via the pipes 20 and 21.

10 The duct 1 also contains five detectors, namely:

- the nuclear detector 61;
- the leak detector 78;
- the lower end-of-travel switch 17;
- the upper end-of-travel switch 18, and
- 15 - the angular position encoder 54.

 The hydraulic group 76, which is connected to the hydraulic jack 19, causes the probe 14 to rise and fall by means of electrically-controlled hydraulic distributors 79 which, via relays 80, may be automatically actuated by the
20 control interface 81 of the management set C during normal operation, or manually by means of switches, not depicted in Fig. 15, which may be used during maintenance, repair and test operations. The electrically-controlled hydraulic distributors 79 also make it possible to regulate the speed
25 of movement of the trolley 15.

 The computer-aided management set C receives the signals transmitted to it by the five detectors installed in the duct 1. It commands the rise and fall of the probe 14 in accordance with the signals that it receives from the
30 lower 17 and upper 18 end-of-travel switches and from the leak detector 78.

 The management set C also processes all the signals that it receives from the nuclear detector 61, from the lower 17 and upper 18 end-of-travel switches and from
35 the angular position encoder 54, in order to deduce from them measurements of the densities and of the total weight

of the dredging materials loaded into the well of the boat and it displays the results of these measurements.

This computer-aided management set C principally comprises:

- 5 - a control interface 81;
- an adaptation and supply unit 82;
- a counting interface 83 fitted with a counting-time preselection device 84;
- a position indicator 85 fitted with a position
- 10 preselection device 86;
- start- and end-of-loading switches 87;
- a computer 88 fitted with specific software and provided with various complementary peripheral equipment;
- an input/output interface 89 between the control interface
- 15 81 and the computer 88; and
- an input/output port 90 between the counting interface 83 and the computer 88.

It should be noted that, in the case where the installation of the invention comprises several measurement

20 devices (and not just one, as depicted in Fig. 15), the control interface 81, the adaptation and supply unit 82, the counting interface 83 and the position indicator 85 are multichannel.

The amplified electrical pulses coming from the

25 nuclear detector 61 are received by the adaptation and supply unit 82 which has several functions. Firstly, it serves to supply voltages required by the nuclear detector 61. It also makes it possible to measure and to regulate the supply voltages and the electrical pulses received. Finally,

30 it converts the input electrical pulses, received from the nuclear detector 61, into electrical output pulses adapted for being received and processed by the counting interface 83.

This counting interface 83 is provided with a

35 device 84 for preselecting the counting time during which the pulses coming from the detector are counted. These

counting periods will, for example, be set for a duration of 0.4 s. While the probe 14 is rising in the duct 1, the pulses received by the counting interface 83 will be counted at regular intervals (determined by means of the angular position encoder 54 and of the preselection position indicator), each time for a period of 0.4 s. The pulses counted by the counting interface 83 are transmitted to the computer 88 which converts them into density and total-weight measurements and displays these measurements by means of a visual display unit and possible peripheral equipment.

Before putting the installation into operation, the trolley 15 is in the rest position 15_c, in which it is in contact with the upper end-of-travel switch 18. After a static check of the detector 16 by means of the management set C and the computer, the trolley 15 is sent towards the position 15_a where it actuates the lower end-of-travel switch 17. The counter of the position indicator 85 is then zeroed by the control interface 81. The signal for starting the actual measurements process is given by actuating the start-of-loading switch 87. Consequently, the trolley 15 is sent upwards until it actuates the upper end-of-travel switch 18 and the trolley is sent back downwards in a continuous process.

During the upward movement of the trolley 15, the position indicator 85 totals the electrical pulses received from the angular position encoder 54 and continually displays this total on its digital counter until the trolley 15, in the position 15_c, actuates the upper end-of-travel switch 18 once again. It should be noted that, while the trolley 15 is being lowered, the position indicator 85 continually deducts the pulses received from the angular position encoder 54 from the total number of pulses which it had recorded when the trolley 15 was in the position 15_c.

The angular position encoder 54 emits 1000 pulses for each revolution of the pulley 31. In one example of installation according to the invention, the angular

position encoder 54 emits approximately 24,000 pulses for a travel of 14 metres of the trolley 15 between the time when it is in contact with the lower end-of-travel switch 17 and the time when it actuates the upper end-of-travel switch 18.

The position indicator 85 is provided with a position preselection device 86 which emits a signal at regular intervals, during the rise of the trolley 15, each time that a predetermined number of pulses is received from the angular position encoder 54. The total travel (14 m) of the probe 14 is thus divided into equal-length portions or "windows".

It is possible, for example, to decide to divide the total travel of the probe 14 into 113 equal "windows", each therefore having a height of 12.4 cm. In order to do this, the position preselection device 86 will be set so as to emit a signal after each series of 212 pulses $24,000/113$ received by the counting interface 83.

The output signals emitted by the position preselection device 86 are sent to the counting interface 83 which, after receiving each signal, receives and totals, for 0.4 s, the pulses coming from the adaptation and supply unit 82. The counting interface 83 stores in memory the counting rates recorded in all the "windows". At its output, the counting interface 83 therefore delivers the numbers of pulses counted over a period of 0.4 s in each of the "windows". These pulses are transmitted to the computer 88 via the input/output port 90.

Since the probe 14 moves from the bottom up at a speed of approximately 22 to 25 cm/s, it travels approximately 8.8 to 10 cm in 0.4 s (the counting period in each window). After each counting period, it therefore remains for the probe 14 to travel a distance of from 2.4 to 3.6 cm before the next counting period starts, (in the next "window"). The 0.10 to 0.16 s time that this 2.4 to 3.6 cm travel takes is free for transmitting the data from the

nuclear detector 61 to the counting interface 83.

The control interface 81 transfers to the computer 88 the information from the start- and end-of-loading switches 87, the lower 17 and upper 18 end-of-travel switches and the leak detector 78. Depending on the information thus received and on the program with which it is provided, the computer 88 sends instructions to the control interface 81 in order to move the trolley 15 upwards or downwards. Consequent upon these received instructions, the control interface 81 actuates, in an appropriate manner, the relays 80 which control the operation of the hydraulic distributors 79 of the hydraulic group 76.

Communication from the control interface 81 to the computer 88, and back, takes place via the input/output interface 89 incorporated into the computer 88.

After the start-of-loading switch 87 has been actuated, the computer 88, in accordance with its program, returns the trolley 15 downwards, each time the latter actuates the end-of-travel switch 18, and sends the trolley 15 upwards each time the latter actuates the lower end-of-travel switch 17. This alternating, from top to bottom and back, movement of the trolley 15 continues until the moment when the end-of-loading switch 87 is put into the stop position.

Thereafter, the trolley 15 returns to the position 15_c.

It was stated earlier that, while the trolley 15 is being lowered, the position indicator 85 continually deducts the pulses received from the angular position encoder 54 from the total number of pulses which it had recorded when the trolley 15 was in its position 15_c. Consequently, the digital counter of the position indicator 85 should theoretically be reset to zero when the trolley 15 actuates the lower end-of-travel switch 17. However, each pulse delivered by the angular position encoder 54

corresponds to a movement of the trolley 15 over a distance of approximately 0.58 mm only. It will therefore be understood that, as a result of certain inevitable phenomena (thermal expansion of the metal cable 23, slight slipping of this metal cable 23 on the pulley 31, etc.), the counter of the position indicator 85 is not generally reset exactly to zero when the trolley is actuates the lower end-of-travel switch 17. For this reason, the control interface 81 sends a set-to-zero signal to the position indicator 85 each time that the trolley 15 actuates the lower end-of-travel switch 17.

The computer 88 is provided with various peripherals such as: colour video screen, printer, and memory-disc and tape-recorder units. The last two elements constitute the external memory of the computer 88.

Displayed graphically on the video screen are the state of loading of the well of the dredger boat, as a function of time, and also other parameters such as the moment when loading started, the intermediate times, the rate of loading, the total loading weight, the time when overflow started, etc.

When the loading has been completed and the operation of the installation has been stopped by actuating the end-of-loading switch 87 into the "stop position", the trolley 15 is returned back to the position 15c and the printer connected to the computer 88 than produces a printed report which displays the various parameters and characteristics of the loading cycle.

The description which has been given above with reference to the drawings obviously relates only to one particular embodiment of the installation according to the invention. Numerous modifications may be made to this embodiment without departing at all from the scope of the invention.

Thus, the mechanism with a jack for moving the probe 14 along a vertical path in the duct 1 may be replaced

by other movement mechanisms.

Another embodiment of the movement mechanism may consist of an electric motor provided with an electromechanical brake, a speed reducer, a cable drum and
5 an angular position encoder.

The combination of the electric motor and the speed reducer may be a gear motor. A combined cable, providing mechanical traction and transmission of the electrical signals, is mounted on the drum and is connected
10 to the trolley 15. The electrical signals from the trolley 15 are transmitted to the management set C by means of a slip-ring unit incorporated into the drum.

The electric motor controls the ascending and descending movement of the trolley in accordance with the
15 program and with the end-of-travel switches 17 and 18 provided at the upper and lower parts of the duct 1. The cable is held taut by the weight of the trolley 15. A retaining brake holds the trolley 15 in place when the system has stopped. The trolley 15 is fixed on the rails 16
20 by rollers 53, as in the case of the hydraulic control system.

A mechanical locking device provided on the trolley 15 is actuated in the event of the cable breaking, thereby preventing the trolley 15 from dropping.

25 With a view to regulating the speed, the system may be provided with an electronic frequency control or with a four-quadrant thyristor control with an associated tachogenerator on the motor.

The angular position encoder, as in the case of
30 the hydraulic system, measures the position of the trolley 15 between the upper position 15_c and the lower position 15_a.

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REPLACED

This Sheet Has Been Replaced



C L A I M S

- 1.- Installation for continuous measurement of the density and of the total weight of dredging materials loaded into a well of a self-contained dredger, characterized in that it comprises :
- (i) one or more devices each comprising
- a watertight duct (1), having a substantially U-shaped cross-section, which is fixed substantially vertically in the well, the two branches of the U forming a sort of semi-open vertical channel (2);
 - a transmissive type radioactive probe (14), housed in said duct (1) and comprising a radioactive source (60) transmitting towards a nuclear detector (61), the radioactive source (60) and the nuclear detector (61) being placed facing each another, each in a branch of the U, the nuclear detector being equipped with means for converting the nuclear radiation into photons, and then into electrical pulses, and for subsequently amplifying these pulses;
 - guiding mechanisms (16, 53) serving to guide the said probe (14) along a vertical path in the duct (1);
 - mechanisms for causing the said probe (14) to move upwards and downwards along this vertical path in the duct (1);
 - means (54) for determining the position of the said probe (14) in the duct (1);
- (ii) a computer-aided management set (C), this management set (C) being capable of measuring and recording time, of receiving and processing the data collected by the means (54) for determining the position of the probe or probes (14) in the duct or ducts (1), of receiving and processing the data collected by the nuclear detector or



* C L N S *



detectors (61) in the form of electrical pulses counted in the course of preset regular intervals and converted into corresponding measurements of density, of calculating from these measurements the total weight of dredging materials loaded into the well, of keeping all the data in a central memory, of displaying the analysis and the result of these measurements with the aid of a visual display unit and/or of a printer and, in accordance with a preselected program, of regulating and controlling the general functioning of the installation;

(iii) means for transmission to the management set (C) of the electrical pulses supplied by the nuclear detector or detectors (61) and by the means (54) for determining the position of the probe or probes (14) in the duct or ducts (1).

2.- Installation according to claim 1, characterized in that the duct (1) is manufactured in steel.

3.- Installation according to either of the preceding claims, characterized in that the radioactive source (60) is a source of gamma rays.

4.- Installation according to claim 3, characterized in that the radioactive source (60) consists of a ceramic bead of double-encapsulated ^{137}Cs .

5.- Installation according to any one of the preceding claims, characterized in that the nuclear detector (61) consists of a scintillation counter.

6.- Installation according to claim 5, characterized in that the means for converting the nuclear radiation into photons consists of a crystal of NaI(Tl) .

7.- Installation according to claim 6, characterized in that the means for converting the photons into electrical pulses and the means for amplifying the electrical pulses consist respectively of a photomultiplier and of an electronic unit for supply and for amplification.

8.- Installation according to any one of the preceding claims, characterized in that the probe (14) is



mounted on a trolley (15).

9.- Installation according to claim 8, characterized in that the mechanisms for guiding the probe (14) consist of metal rails (16) arranged vertically in the duct (1) and of rollers (53) mounted on the trolley (15).

10.- Installation according to claim 9, characterized in that the mechanism for causing the probe (14) to move along a vertical path in the duct (1) comprise a jack (19) fitted with a piston rod (22) which can move vertically in the duct (1).

11.- Installation according to claim 10, characterized in that the mechanisms for causing the probe (14) to move along a vertical path in the duct (1) comprise a transmission mechanism capable of transmitting the movement of the piston rod (22) to the trolley (15), multiplying the amplitude of this movement.

12.- Installation according to claim 11, characterized in that the transmission mechanism comprises pulleys (26, 27, 28, 29) mounted on a spindle (25) securely attached to the end of the piston rod (22), fixed pulleys (30, 31, 32, 33) securely attached to the duct (1) and a metal cable (23) anchored to the trolley (15) and passing over the pulleys (26, 27, 28, 29, 30, 31, 32, 33).

13.- Installation according to either of claims 11 and 12, characterized in that the transmission mechanism is such that any movement of the piston rod (22) entails a movement of the probe (14) in the opposite direction.

14.- Installation according to either of claims 12 and 13, characterized in that the means for determining the position of the probe (14) in the duct (1) comprise an angular position encoder (54) fitted with an optically encoded disc and with an internal optical and electronic device, the disc being coupled mechanically to one of the fixed pulleys (31) over which passes the metal cable (23).

15.- Installation according to claim 9, characterized in that the mechanisms for causing the probe



(14) to move along the vertical path in the duct (1) comprise an electric motor provided with an electromechanical brake, a speed reducer and a winding drum for the cable.

5 16.- Installation according to claim 15, characterized in that it is provided with means for regulating the speed of movement of the probe (14), these means comprising an electronic frequency control.

10 17.- Installation according to claim 15, characterized in that it is provided with means for regulating the speed of movement of the probe (14), these means comprising a four-quadrant regulator and a tachogenerator mounted on the electric motor.

15 18.- Installation according to any one of claims 15, 16 and 17, characterized in that the means for determining the position of the probe (14) in the duct (1) comprise an angular position encoder provided with an optically encoded disc and with an internal optical and electronic device, the disc being coupled mechanically to
20 a rotary part whereof the movement correlates with the movement of the probe (14).

 19.- Installation according to any one of the preceding claims, characterized in that it further comprises, at the ends of the vertical path along which the
25 probe (14) travels in the duct (1), lower (17) and upper (18) end-of-travel switches capable of transmitting data to the computer-aided management set (C).

 20.- Installation according to claim 19, characterized in that the management set (C) is provided
30 with a program enabling in particular the nuclear detector (61) which performs continuous measurements to transmit them to the management set (C) when the probe (14) moves from the lower end-of-travel switch (17) to the upper end-of-travel switch (18) along a vertical path in the duct (1) and
35 returns to its initial position without performing measurements.



21.- Installation according to either of claims 19 and 20, characterized in that the duct (1) is surmounted by a chamber (3) arranged above the maximum filling level of the well.

5 22.- Installation according to claim 21, characterized in that the chamber (3) is capable of receiving the trolley (15) and the probe (14) and of serving for their storage during the time when the installation is not in operation.

10 23.- Installation according to claim 22, characterized in that the upper end-of-travel switch (18) is located above the level of the chamber (3).

15 24.- Installation according to any one of claims 21 to 23, characterized in that the chamber (3) comprises a calibration tank (75) located in the extension of the channel (2) existing between the branches of the U-shaped duct (1), this calibration tank (75) being capable of containing media of known densities serving for the calibration of the probe (14).

20 25.- Installation according to any one of claims 21 to 24, characterized in that it further comprises a leak detector (78) capable of detecting the presence in the duct (1) of solid or liquid materials entering it as a result of a leak and of transmitting corresponding information to the
25 management set (C).

 26.- Installation according to claim 25, characterized in that the management set (C) is capable of commanding, in the case of a leak, the immediate sending of the probe (14) into the chamber (3) and the interruption of
30 the operation of the installation.

 27.- Installation according to any one of the preceding claims, characterized in that the management set (C) further comprises an external memory.



A B S T R A C T.

Device for continuous measurement of the density and
total weight of material in the hold of a
5 hopper-dredger.

The installation comprises:
a metal duct (1), having a U-shaped cross-section, in which
is present a transmissive-type radioactive probe (14), which
comprises a source (60) and a detector (61) placed facing
10 each another, each in a branch of the U. The probe (14)
moves along a vertical path and conducts measurements on the
materials comprises between the branches of the U and
transmits data to a computer-aided management set (C) which
transforms the data into density measurements and which
15 controls the general functioning of the installation.

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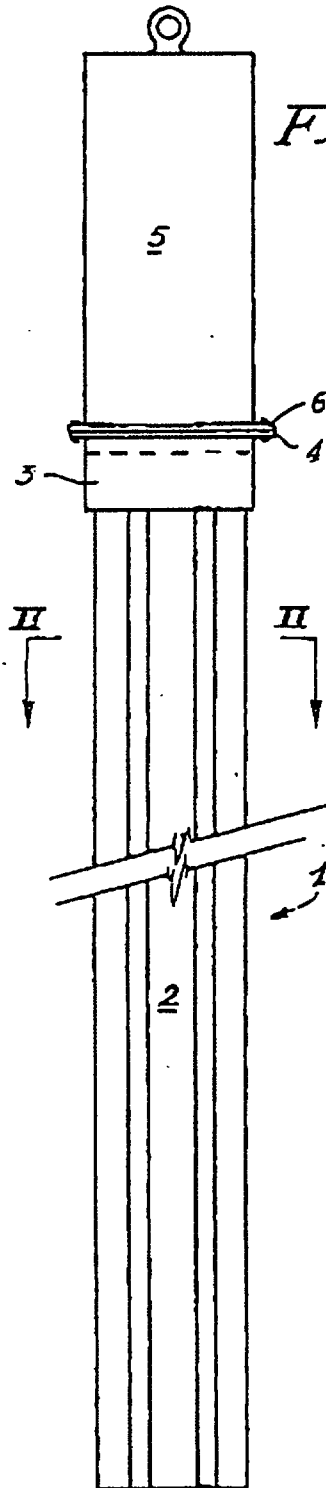


Fig. 1.

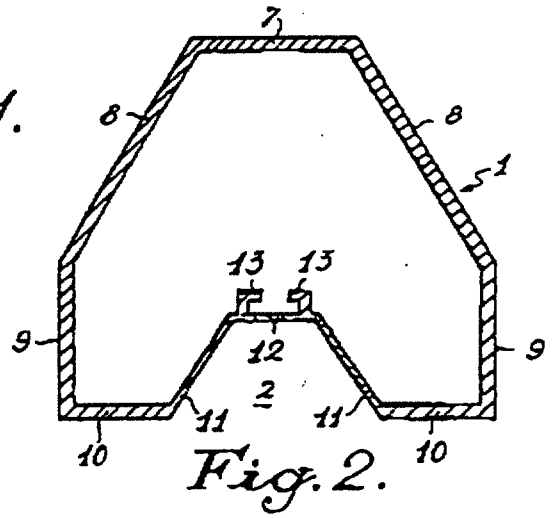


Fig. 2.

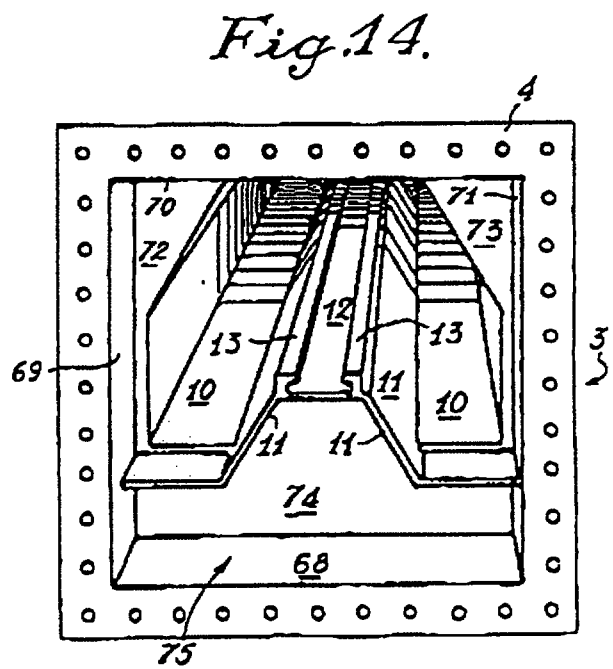


Fig. 14.

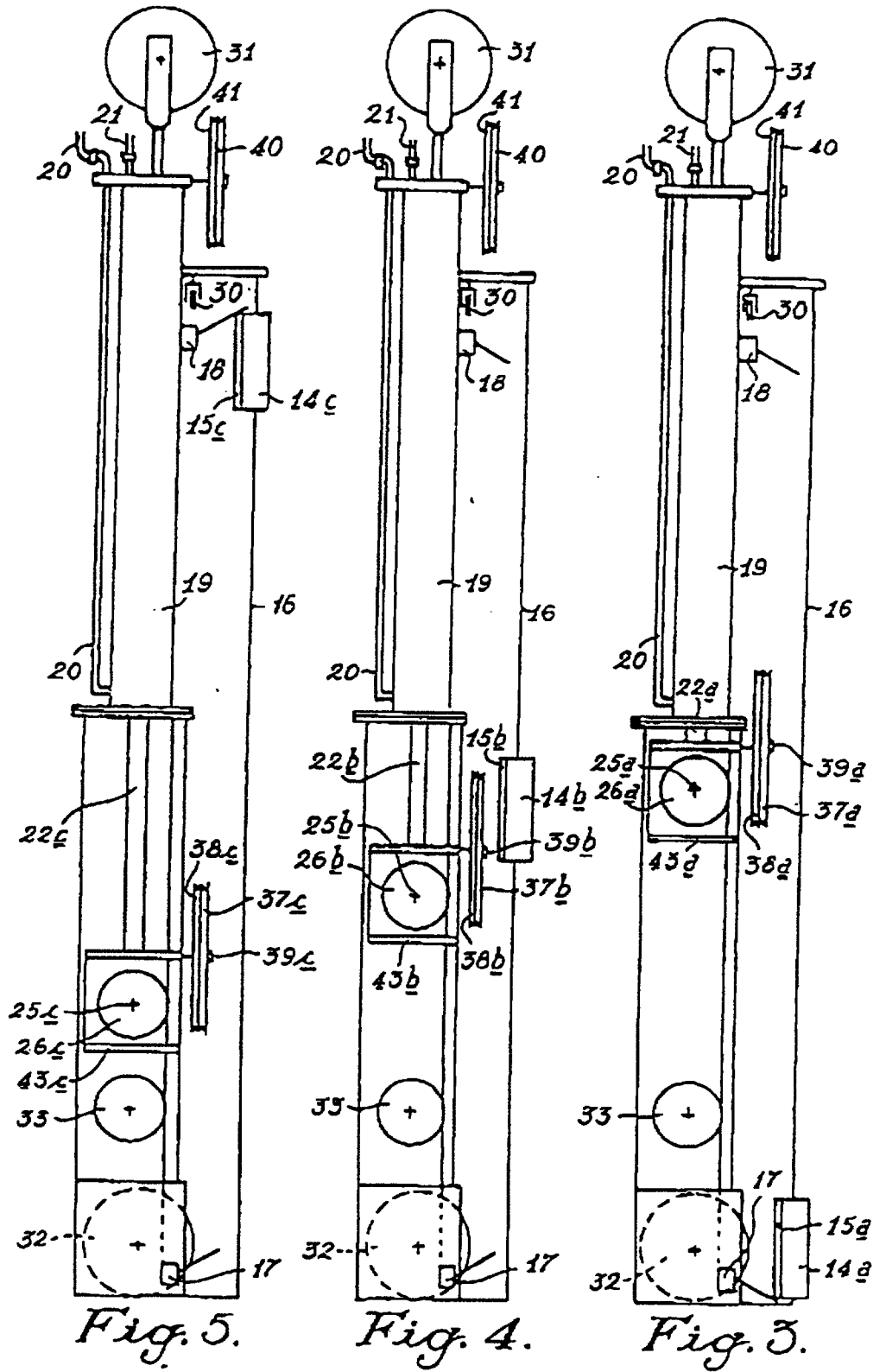


Fig. 6.

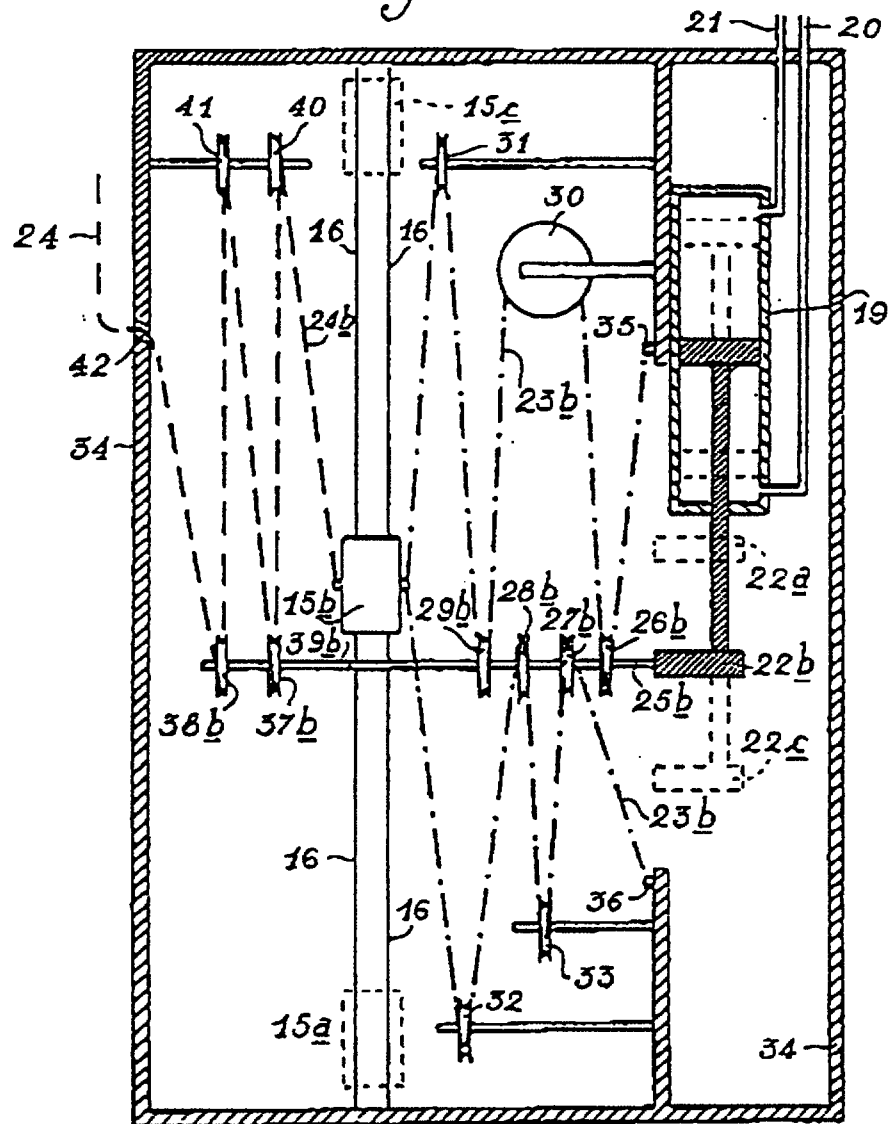


Fig. 7A.

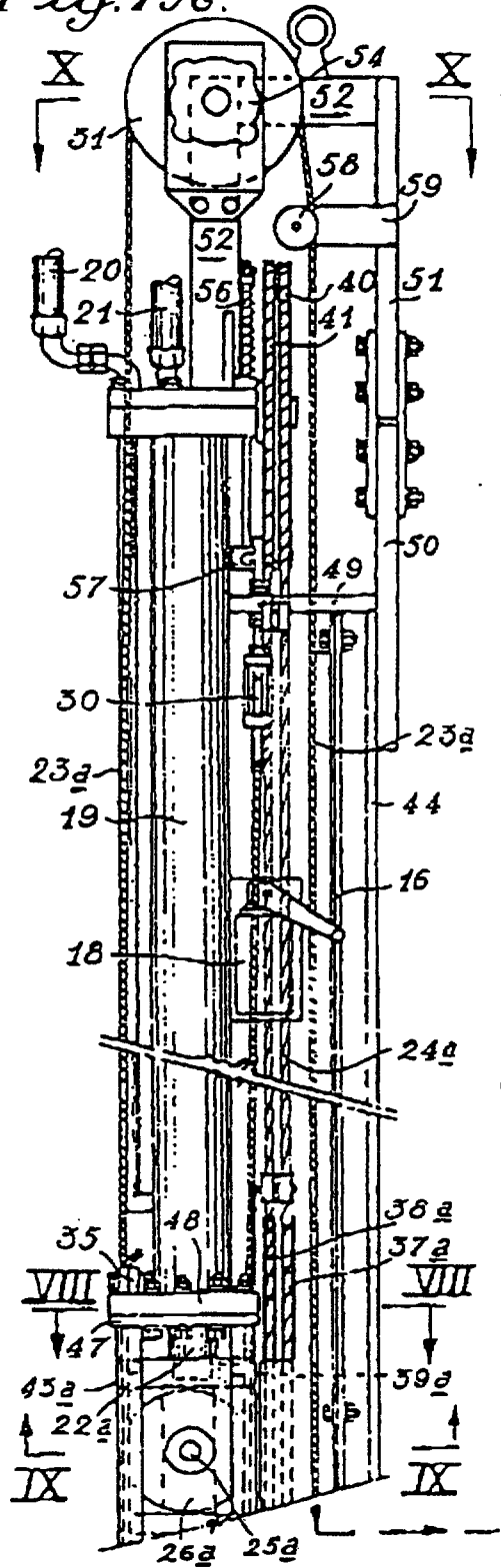
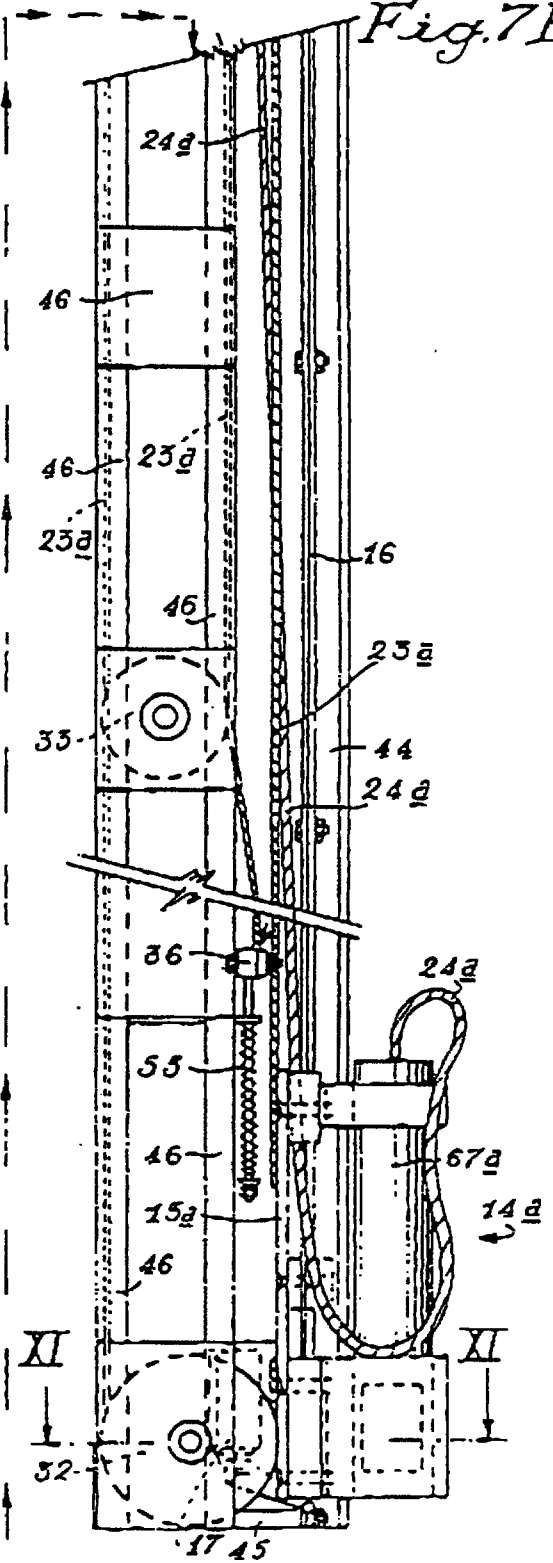


Fig. 7B.



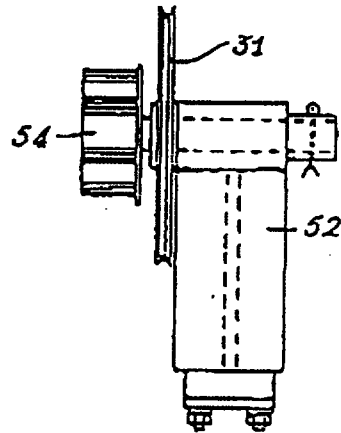


Fig. 10.

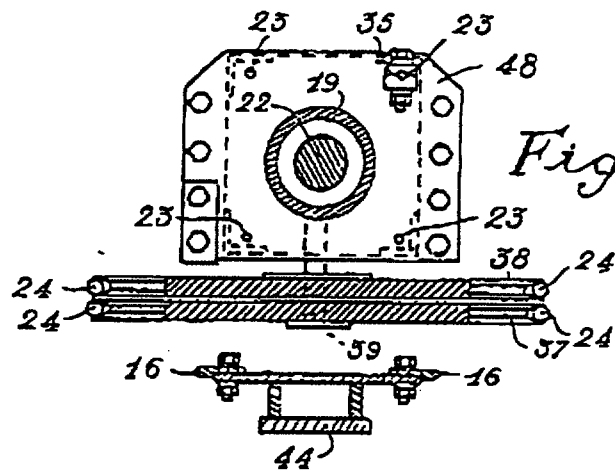


Fig. 8.

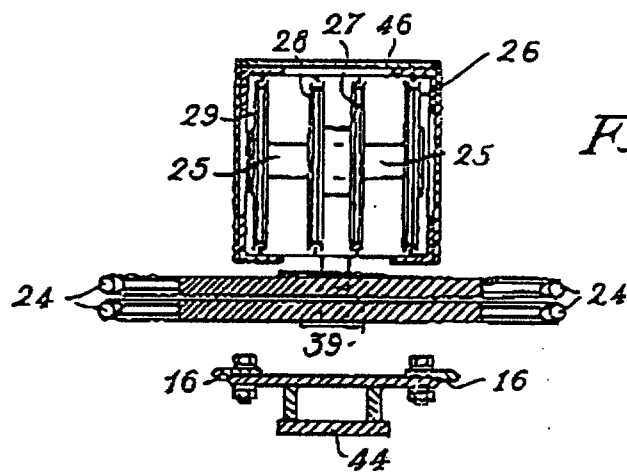


Fig. 9.

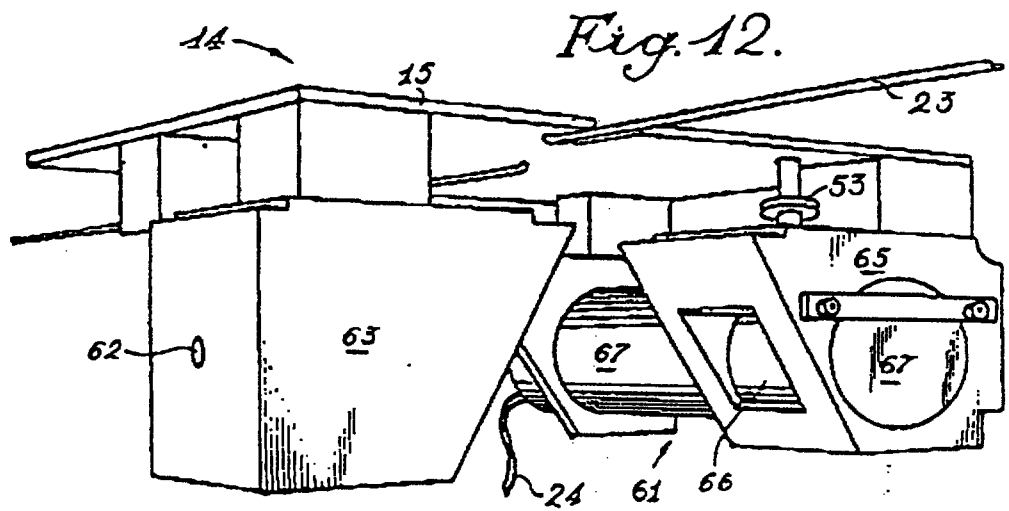
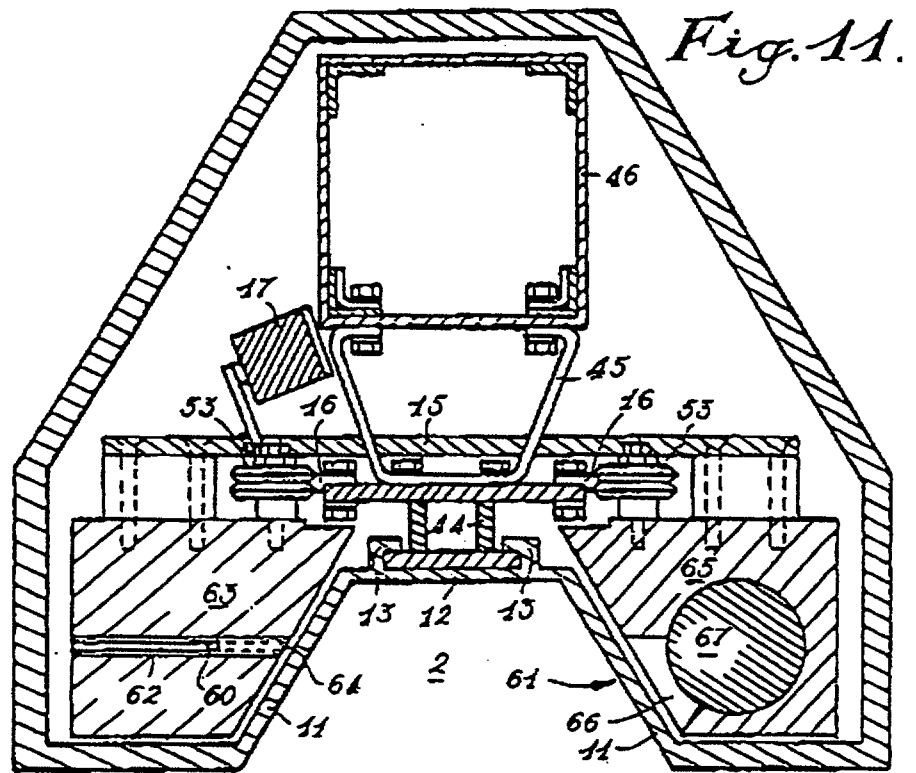


Fig. 13A.

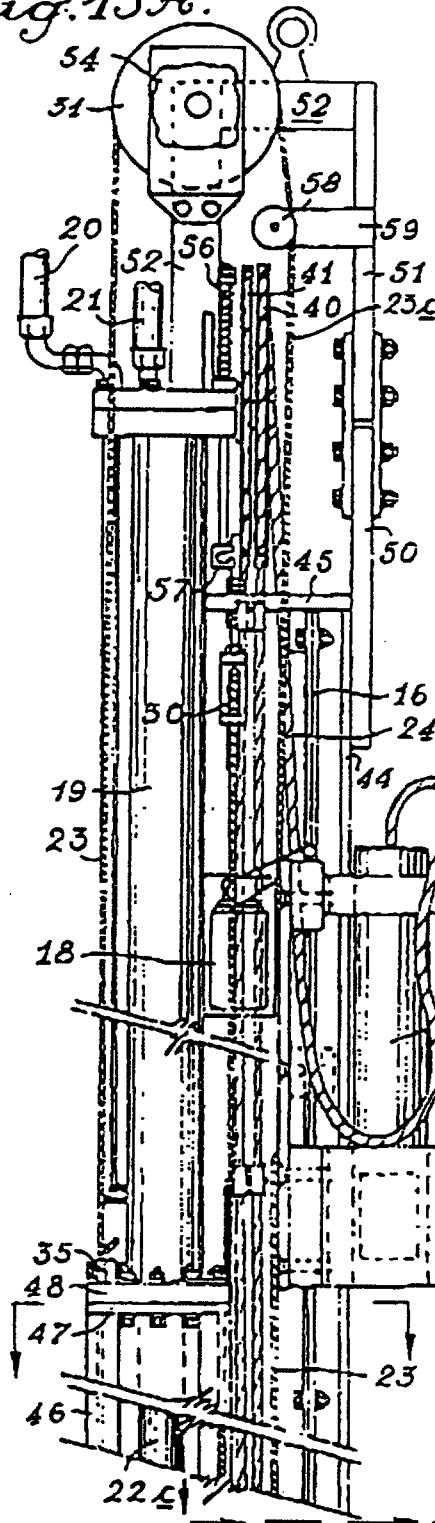
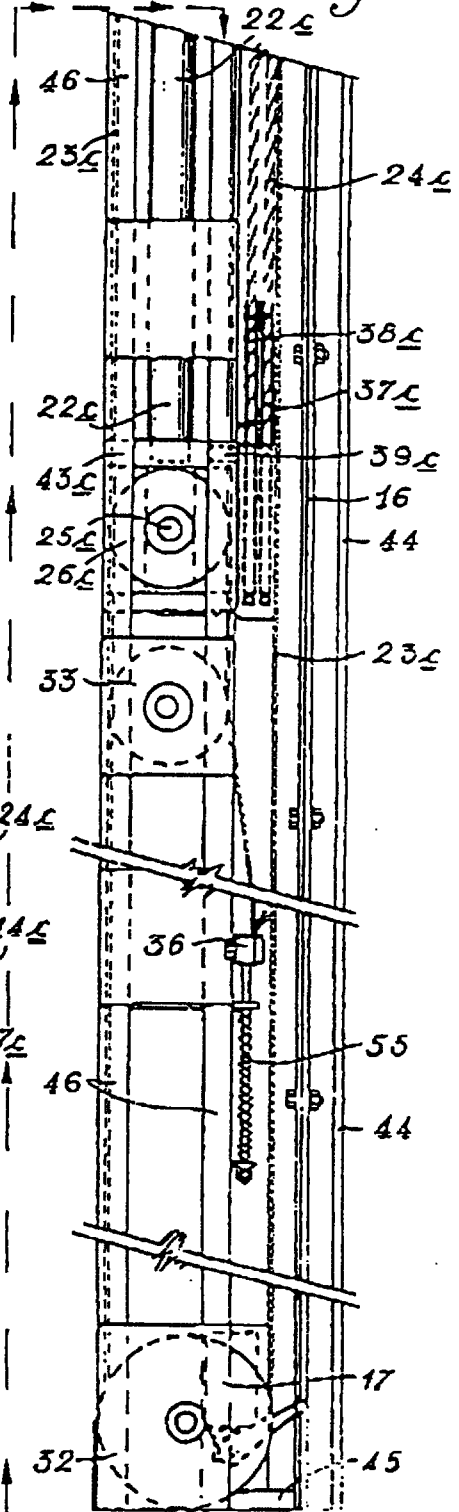


Fig. 13B.



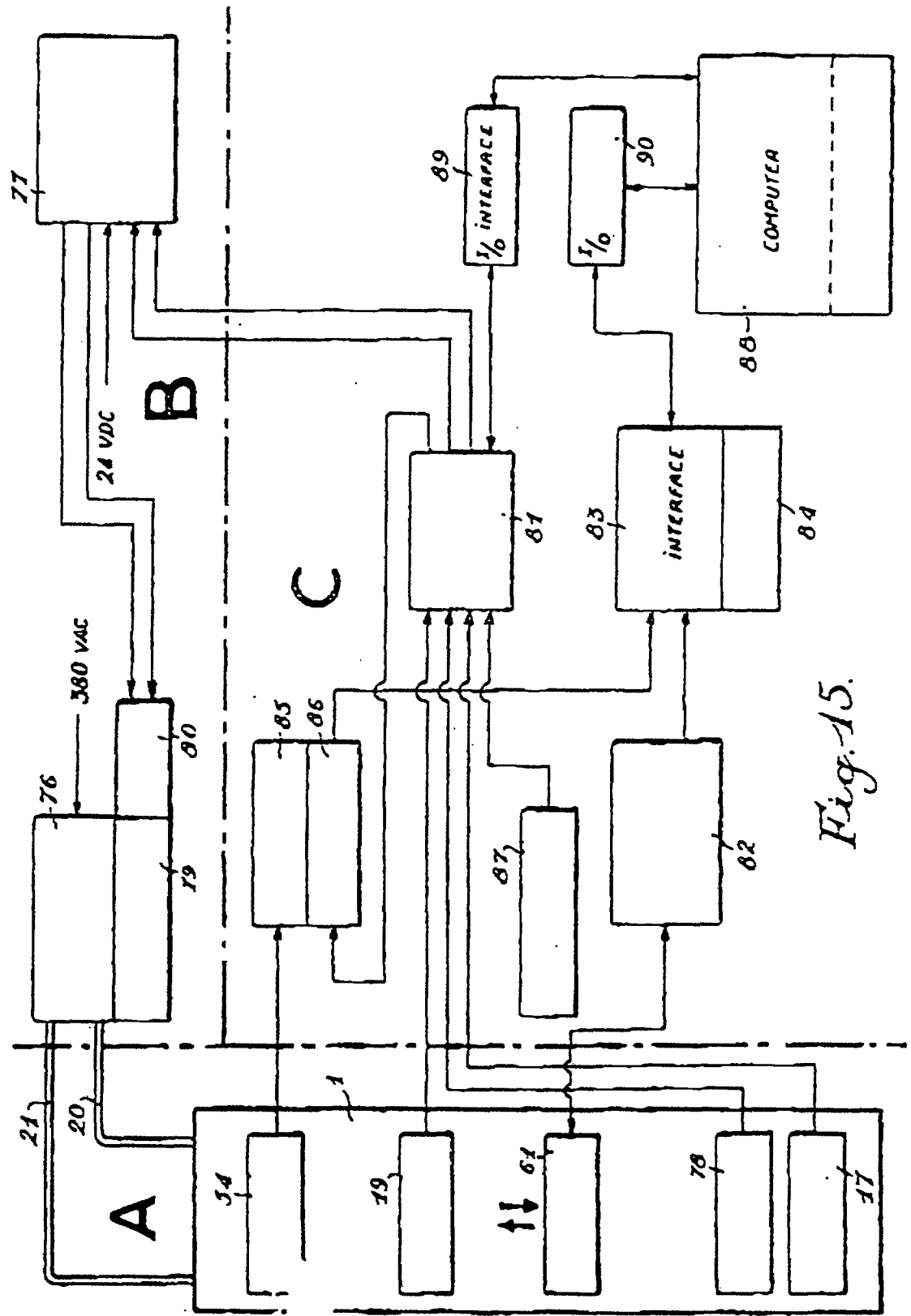


Fig. 15.

AMENDED SHEET

A B S T R A C T.

5 Device for continuous measurement of the density and
 total weight of material in the hold of a
 hopper-dredger.

 The installation comprises:
a metal duct (1), having a U-shaped cross-section, in which
is present a transmissive-type radioactive probe (14), which
comprises a source (60) and a detector (61) placed facing
10 each another, each in a branch of the U. The probe (14)
moves along a vertical path and conducts measurements on the
materials comprises between the branches of the U and
transmits data to a computer-aided management set (C) which
transforms the data into density measurements and which
15 controls the general functioning of the installation.

Figure 11 should accompany the publication of the abstract.

C L A I M S

- 1.- Installation for continuous measurement of
5 the density and of the total weight of dredging materials
loaded into the well of a self-contained dredger, comprising
at least one radioactive probe (14) housed in a watertight
duct (1) which is fixed substantially vertically in the
well, the said probe (14) comprising a radioactive source
10 (60) and a nuclear detector (61), the detector (61) being
equipped with means for converting nuclear radiation into
analysable data, the said installation being characterised
in that it comprises :
- (i) one or more devices each comprising
- 15 - the duct (1), which has a substantially U-shaped
cross-section, the two branches of the U forming a sort of
semi-open vertical channel (2);
- the radioactive probe (14), which is of the
transmissive type, the radioactive source (60) transmitting
20 towards the nuclear detector (61), the radioactive source
(60) and the nuclear detector (61) being placed facing each
other, each in a branch of the U, the nuclear detector (61)
being equipped with means for converting the nuclear
radiation into photons, and then into electrical pulses, and
25 for subsequently amplifying these pulses;
- guiding mechanisms (16, 53) serving to guide said
probe (14) along a vertical path in the duct (1);
- mechanisms for causing said probe (14) to move
upwards and downwards along this vertical path in the
30 duct (1);
- means (54) for determining the position of the
said probe (14) in the duct (1);
- (ii) a computer-aided management set (C), this
management set (C) being capable of measuring and recording
35 time, of receiving and processing the data collected by the



AMENDED SHEET

26b

- means (54) for determining the position of the probe or probes (14) in the duct or ducts (1), of receiving and processing the data collected by the nuclear detector or detectors (61) in the form of electrical pulses counted in
- 5 the course of preset regular intervals and converted into corresponding measurements of density, of calculating from these measurements the total weight of dredging materials loaded into the well, of keeping all the data in a central memory, of displaying the analysis and the result of these
- 10 measurements with the aid of a visual display unit and/or of a printer and, in accordance with a preselected program, of regulating and controlling the general functioning of the installation;
- (iii) means for transmission to the management set (C)
- 15 of the electrical pulses supplied by the nuclear detector or detectors (61) and by the means (54) for determining the position of the probe or probes (14) in the duct or ducts (1).



* C L M S *

~~detectors (61) in the form of electrical pulses counted in the course of preset regular intervals and converted into corresponding measurements of density, of calculating from these measurements the total weight of dredging materials loaded into the well, of keeping all the data in a central memory, of displaying the analysis and the result of these measurements with the aid of a visual display unit and/or of a printer and, in accordance with a preselected program, of regulating and controlling the general functioning of the installation;~~

~~(iii) means for transmission to the management set (C) of the electrical pulses supplied by the nuclear detector or detectors (61) and by the means (54) for determining the position of the probe or probes (14) in the duct or ducts (1).~~

2.- Installation according to claim 1, characterized in that the duct (1) is manufactured in steel.

3.- Installation according to either of the preceding claims, characterized in that the radioactive source (60) is a source of gamma rays.

4.- Installation according to claim 3, characterized in that the radioactive source (60) consists of a ceramic bead of double-encapsulated ^{137}Cs .

5.- Installation according to any one of the preceding claims, characterized in that the nuclear detector (61) consists of a scintillation counter.

6.- Installation according to claim 5, characterized in that the means for converting the nuclear radiation into photons consists of a crystal of NaI(Tl) .

7.- Installation according to claim 6, characterized in that the means for converting the photons into electrical pulses and the means for amplifying the electrical pulses consist respectively of a photomultiplier and of an electronic unit for supply and for amplification.

8.- Installation according to any one of the preceding claims, characterized in that the probe (14) is

