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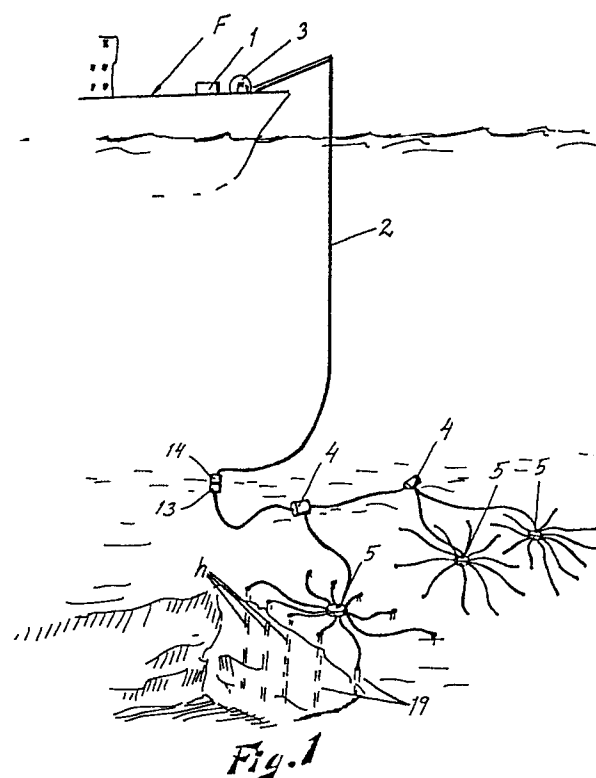
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54 **A blasting system for underwater use.**

57 The disclosure relates to a complete blasting system for underwater use. The blasting system according to the present invention includes an interface unit (9) for control and firing of the charges disposed beneath the waterline, a sea cable (2) departing from the interface unit and passing to the charges, the cable terminating by one or more junction boxes (4, 7-10) which may be interconnected below the waterline and to which a number of charge units (5) each including a plurality of charges may be connected.

The disclosure also includes a specific design of these charge units (5) and a charge frame or jig (6) particularly adapted for these charge units.



## TECHNICAL FIELD

The present invention relates to a complete blasting system which may be initiated electrically and is intended for underwater use, the system comprising a plurality of charges fitted with separate electric detonators, the charges having been connected to a central firing unit by the intermediary of electrically conductive cables. In this instance, the charges are distributed among different charge units which each one comprises a number of charges with their associated connection cables for initiation of the charges. Moreover, each charge unit may be provided with a charge jig which carries the connection cables, and possibly also the charges, ready for laying-out.

## BACKGROUND ART

The blasting system according to the present invention was originally conceived for use in trench blasting for laying pipelines for natural gas or oil on the seabed. To this end, dislodgement of the bed sediment to a limited depth beneath the seabed surface but over large clearly-defined seabed areas was required. It follows, therefore, that the blasting system according to the present invention is also eminently suitable for mining on the seabed and for any other underwater blasting where it is necessary to employ simultaneously a large number of charges distributed throughout a predetermined area. In its turn, this signifies that the blasting system may also have military uses, for example as fixed, rapidly deployed mining devices in harbours, narrow straits, fjords etc. and for activating anti-submarine nets. Moreover, the system according to the present invention can also be used on land in extremely damp environments, for example in mining operations in swamps and wetlands. Finally, variations of the cable systems included in the present invention and the charge jigs utilized to facilitate laying-out or the cable systems may be employed in conjunction with the laying-out of hydrophones - and/or ultrasonic detectors, asdic systems and finally magnetic loops for submarine detection.

Explosives and detonators for underwater use must, first, satisfy extremely stringent safety and reliability requirements, and, secondly, be so simple to handle as not unnecessarily to complicate the already arduous job of drivers who, it must be said, operate today under conditions which border on the superhuman. In the future, it is also to be expected that underwater charges of the type contemplated herein must allow for being armed and connected by specially-designed remote control

underwater robots. For instance, such robots will be necessary for future blasting work at such depths as cannot even be attained today using diving bells. For example, such blasting work may conceivably become a reality when the less accessible areas of the North Sea oil field are to be tapped. The blasting system according to the present invention is intended to satisfy all of the safety, functional and handling requirements which may reasonably be asked of such a system.

## SUMMARY OF INVENTION

In purely general terms, the present invention may be considered as consisting of a blasting system which is initiated electrically and is intended for underwater use, the system comprising a plurality of charges fitted with separate electric detonators, these electric detonators being connected, by the intermediary of electrically conductive cables, to a central firing unit disposed above the waterline and consisting of an interface unit with combined control and firing functions, the communication between this interface unit and the electric detonators of the charges passing via an electromagnetically shielded and protectively earthed sea cable which is terminated by means of interconnectable junction boxes disposed below the waterline and to which a predetermined number of charge units may be connected each by means of their own connection cables. Each such charge unit comprises a number of charges which, by their own connection or ignition cables, have been interconnected to form a unit by the intermediary of special coupling devices which, in their turn, may thus be interconnected to the junction boxes by the intermediary of special connection cables.

All cables employed in the system according to the present invention which are of such length as so requires are shielded against electromagnetic disturbance currents and are earthed. This also applies to the interface unit.

The present invention further includes jigs for grouping all cables included in each respective charge unit so that these cable systems may be kept in readiness for laying-out at the contemplated site of use with the least possible labour input. The jigs may also be employed for grouping the cable systems, if the blasting system is to be relocated before being initiated. The jigs are also provided with short-circuit devices for an internal short-circuiting of all included components up to the point

of final arming connection. Moreover, the jigs may also be designed to carry the entire charges, the booster charges alone, or separate connection devices for each charge.

## BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The nature of the present invention and its aspects will be more readily understood from the following brief description of the accompanying Drawings, and discussion relating thereto.

In the accompanying Drawings:

Figs. 1 and 2 schematically illustrate a workplace for trench blasting on the seabed for laying pipelines for gas or oil;

Figs. 3-5 illustrate different types of junction boxes for the blasting system according to the present invention;

Fig. 6 illustrates a charge unit of the type included in the blasting system according to the present invention;

Fig. 7 illustrates a first embodiment of a laying-out jig with space for tubular charges; while

Figs. 8-9 illustrate, in two projections, a second embodiment of a laying-out jig without space for charges; and

Fig. 10 is an illustration on a larger scale of the ghosted encircled detail of Fig. 9.

## DESCRIPTION OF PREFERRED EMBODIMENT

Referring to the Drawings, the blasting system according to the present invention may, in the assembled state, form two slightly differing fundamental patterns whose constructions in principle are illustrated in Figs. 1 and 2, respectively. Both of these fundamental patterns are realized by different interconnection of the same basic components. These consist, first, of an interface unit 1 disposed above the waterline aboard a diving vessel F or the like for control and firing of the charges. The technical make-up of the interface unit is based on prior art technology and will not, therefore, be discussed in detail in this context. On the other hand, there is some justification in pointing out that the interface unit 1 per se includes a control unit, a computer unit and a triggering unit, in which the control unit ensures that no triggering signal can be emitted before resistance and insulation in the complete circuit and its components both individually and as a unit have been inspected and thoroughly approved, while the computer unit caters for all measurements (transmission of measurement pulses and control to ensure return of such pulses and registration of the values thereof as measured),

data gathering and setting of the time-lag between the different charges, and finally the triggering unit comprises a charging generator of per se known type with associated capacitors and requisite indicator devices and triggering means. The control and initiation pulses generated in the interface unit are transmitted further from the interface unit to the explosive charges by the intermediary of a sea cable 2 which is payed out from a cable drum or other cable magazine 3. The sea cable terminates at a junction box 4 intended to be coupled by divers or a robot below the waterline but at a sufficient distance from the blasting site so as to avoid damage when blasting commences. The present invention also embodies the inventive concept that the different explosive charges are gathered to form charge units 5 each one containing a certain number of sub-charges 19.

Each such charge unit, designated by us OCTOPUS® can be connected up beforehand to all of its different subcharges 19 connected to a transport frame or jig 6 in the manner which is apparent from Figs 6 and 7, whereby they will be available for immediate laying-out.

As will be apparent from Figs. 8-10, a second alternative embodies solely the provision of the cable systems, and possibly booster charges, but not the charges 19 proper coupled on the jig 6'. Both alternatives are adapted for quick laying-out using divers or a submarine robot. Hence, connection of the connection device 15 to the junction box 4 is the last connection which is effected once all charges have been mounted in place in pre-drilled holes h.

The previously mentioned functional requirement imply that each such unit or OCTOPUS® must be provided with its own supply link from the interface unit via the sea cable 2. Thus, this latter contains the same number of separate paired discrete insulated supply leads as the number of charge units it is intended to serve. As a rule, our sea cables are intended for ten charge units in which each charge unit in turn contains a plurality of different charges (for example between 10 and 14 in number).

Furthermore, each respective supply lead of the sea cable is provided with its own protective earth supplemented with a screening shield against electromagnetic disturbance. The shield connected to the earth consists of an aluminium strip. Each supply unit may, moreover, be short-circuited using specially designed short-circuiting devices.

The junction boxes 4 which, thus, constitute the intermediate stage between the reusable or stationary section of the blasting system and the consumption section, may be of a large number of designs. Figs. 3-5 illustrate three different alternative embodiments, all intended for connection of

ten different charge units of the OCTOPUS® type. The type I junction box illustrated in Fig. 3 is intended for the connection of five different OCTOPUS®, each in two different clusters 7 and 8, respectively, arranged in suitable spaced-apart relationships.

This variation is also illustrated in Fig. 1, but in that figure only three of the total of ten inputs on the different junction boxes are employed.

Naturally, more than two junction boxes may be disposed in mutual series, but since it is not advisable to shoot too many charges in the same salvo, ten connections would seem to be sufficient as a rule.

The junction box 9 illustrated in Fig. 4 has ten separate cable connections in the form of spray cables, while the junction box 10 of Fig. 5 has ten inputs 11 disposed on a connection plate. Fig. 2 may also be seen as an example of this type.

Thus, all of these junction boxes are supplied, i.e. connected, below the waterline, with retained shielded. As is apparent from Figs. 3-5, each of the junction boxes is provided with its own connection cable 12 which terminates at a contactor device 13 for connection to a corresponding contactor device 14 on the sea cable. This provision is to enable the ready replacement of damaged junction boxes.

Each charge unit or OCTOPUS® 5 according to the present invention includes a terminal contact 15 for connection to the junction box 4, one main supply cable 16 of sufficient length to ensure that the junction box be placed a sufficient distance away from the blasting site as not normally to be damaged, and a coupling unit 17 whence supply cables 18 depart to the different subcharges 19.

These supply cables terminate by a contactor device 20 to which the subcharges 19 are connected. This connection may be effected above the waterline immediately before the jig with the charges and associated cables are let down to the blasting site below the waterline. The last connection cable 21 from the subcharge 19 to the contactor device 20 is so short (max. 30 cm) that no shielding is at present called for.

The subcharge 19 proper here consists of a tubular charge (blasting rod) provided with an electric detonator and booster, and possibly a time-lag buffer between the electric detonator and the booster. These tubular charges 19 may be jointed for varying drill hole depths. They are intended to be placed each in their predrilled hole h by divers or a loading robot.

As far as the firing of subcharges is concerned, these may be triggered in a mutual time-lag sequence either using pyrotechnical buffers disposed between the electric detonator and booster, or be fired electronically from the interface unit which, it will be remembered, is in separate communication

with each charge unit. A combination of electronic and pyrotechnical time lag may prove to be practical, i.e. the interface unit delays detonation between charge units and the pyrotechnical buffers delay detonation between the subcharges within each individual charge unit.

To facilitate the overall assembly and laying-out of the charge units 5, we have constructed the jig (cassette or transport frame) 6 which is germane to the inventive concept of the system according to the present invention. This is in the form of a trapezoidal "horse" or roof ridge configured frame preferably of steel with two side sections 22, 23 at an angle to one another and preferably also a planar upper frame section 24. Both the side sections 22, 23 and the upper frame section 24 (where applicable, and in its absence the trapezoid becomes a triangle in which the side sections meet at an acute apex) are advantageously designed as open ribbed constructions in which the side sections are designed such that the blasting charge or subcharges 19 - which, it will be recalled, consist of tubular charges - may be anchored in place along each side section. Furthermore, the coupling device 17 is anchored in or beneath the upper section of the jig, preferably immediately beneath that level which forms the uppermost section of the jig - hence in most cases beneath the upper frame section 24. The cables 18 communicating between the connecting device 17 and each respective subcharge 19 by the intermediary of the contactor devices 20 coupled above the waterline aboard the diver vessel F or the like are suspended beneath the jig 6, while the main supply cable 16 is disposed to be readily accessible on the upper face of the jig where there is also provided a blind terminal 25 for earthing and short-circuiting of the current and earth leads of the cable. The hook-up between the connection contactor 15 and the junction box 4 (7-10) is the ultimate operational phase which is carried out after all charges have been placed in their drill holes h. Thus, until such time as the final hook-up is made to the junction box (arming), the connection contact 15 must be short-circuited and earthed in the jig 6 by the intermediary of the blind terminal 25. As has been intimated above, the jig, the coupling device, the cables, the contactor devices, the electrical detonators and the tubular charges have been interconnected and made ready aboard the diver support vessel F.

Once the contactor 15 has been hooked up to the junction box 4 and the jigs have been withdrawn, the appearance of the blasting site will be as one of either of the variations illustrated in Figs. 1 and 2. However, these figures illustrate but three charge units each, but it will be readily apparent to the skilled reader of this specification that this number may be considerably greater, for instance

ten units, at the same time as each charge unit shown on the Drawings may comprise ten tubular charges, but, as shown on Fig. 7, these may be increased to 20 or more in number.

The jig 6' illustrated in Figs. 8-10 for the cable system of the charge unit is of slightly different construction. It consists of a surfaced buoy 26 provided with a dead weight anchor 27 attached with cables 29 and a hauling hauser 28. When the dead weight anchor 27 has been lowered to the seabed, it holds the frustoconical buoy 26 at a predetermined distance above the seabed. The ten connection cables 30 of the charge unit are disposed along the outer periphery of the buoy, with the main parts of the cables each helically wound up in their container 31 from which the cables may readily be paid out (see Fig. 10). All of the cables 30 are connected to the junction box 17' whence a main supply cable 16' leads towards a connection contactor 15' which is ready to be connected to a junction box 4. An earth connection 25' is provided for the connection device 15' on the jig 6'. The connection cables 30 are terminated by contactor devices 20' for connection to each respective charge. The buoy 26 may possibly also be designed with accommodation for booster charges or initiation charges at the end of each connection cable 30.

The apparatus illustrated in Fig. 10 for winding up the connecting cables consists of a cylindrical container 31 divided into two mutually subsequent chambers 34 and 35 which are screened from one another by a partition 32 provided with a through hole 33 for the cable. Suitably, the containing is also secured to the cable in this opening. Each one of the two chambers 34, 35 of the container 31 accommodates approximately half of the cable length which is helically wound and is ready for paying-out, in which instance the cable is quite simply drawn out from the container helice by helice.

The cable system illustrated in Figs. 8-10 may readily be unhooked by stages from the buoy 26 in conjunction with the laying-out procedure, the buoy being then suitably moved aside before blasting takes place.

Relating as it does to a complete underwater blasting system, the present invention should not be considered as restricted to that described above and shown on the Drawings, many modifications being conceivable without departing from the spirit and scope of the appended Claims.

## Claims

1. An electrically detonatable blasting system for underwater use comprising a plurality of charges (19) provided with separate electric deto-

nators, said charges having been interconnected, by the intermediary of electrically conductive cables, with a central firing unit, characterised in that the central firing unit included in the system consists of an interface unit (1) disposed above the waterline and having combined control and firing functions; and that the control and firing pulses thereof are transmitted, via an electromagnetically shielded and earthed sea cable (2) to junction boxes (4, 7-10) connectable below the waterline, to which junction boxes may be connected a predetermined number of charge units (5) each comprising a number of charges (19) interconnected to a common coupling device (17) by means of separate conductors.

2. The blasting system as claimed in claim 1, characterised in that in addition to said sea cable (2), said interface unit (1), said junction boxes (4) and associated connection cables and connecting devices are provided with earth leads and are screened against electromagnetic disturbance currents.

3. The blasting system as claimed in claim 2, characterised in that each charge (19) is connected to each respective coupling device (17) by the intermediary of a separate contactor member (20) where the cable (21) from the electric detonator of the charge to the contactor member (20) is so short that this cable need not be shielded, while said cable, from said contactor member and to said interface unit is shielded against electromagnetic disturbance currents.

4. The blasting system as claimed in claim 3, characterised in that the detonation circuits from said interface unit to each respective charge are coupled such that each charge receives the same detonation current.

5. The blasting system as claimed in claim 4, characterised in that said interface unit is electronically responsible for a predetermined time-lag between said charge units, while the subcharges within said units are mutually subjected to time-lag by pyrotechnical means.

6. The blasting system as claimed in claim 1, characterised in that said charges consist of blasting rods (tubular charges) which may be jointed to the desired length.

7. The blasting system as claimed in claim 1, characterised in that said sea cable includes one twinned double lead and separate earth wire and its own shield for each charge unit said sea cable is to serve.

8. The blasting system as claimed in claim 1, characterised in that each respective charge unit (5) is transported to the blasting site suspended on jigs (6,6') which are made ready above the waterline and which support all cables (16, 18, 16', 30) associated with said charge unit (5), coupling de-

vices (17, 17') interconnecting said cables, and connecting means (15, 15', 20, 20') terminating said cables at both junction box (4) and charge (20), said jig being provided with connecting devices for earthing the cables in said jig until their interconnection with the remainder of the components included in the system.

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9. The blasting system as claimed in claim 8, characterised in that said jig consists of a frame (6) disposable on the bottom, along the outer edges (22, 23) thereof turned to face away from one another the charges (19) of the charge unit may be secured while the cables (16, 18) and coupling device (17) are suspended in said jig.

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10. The blasting system as claimed in claim 8, characterised in that said jig consists of a buoy (6') which may be anchored a distance above the bottom by means of a dead weight anchor (27).

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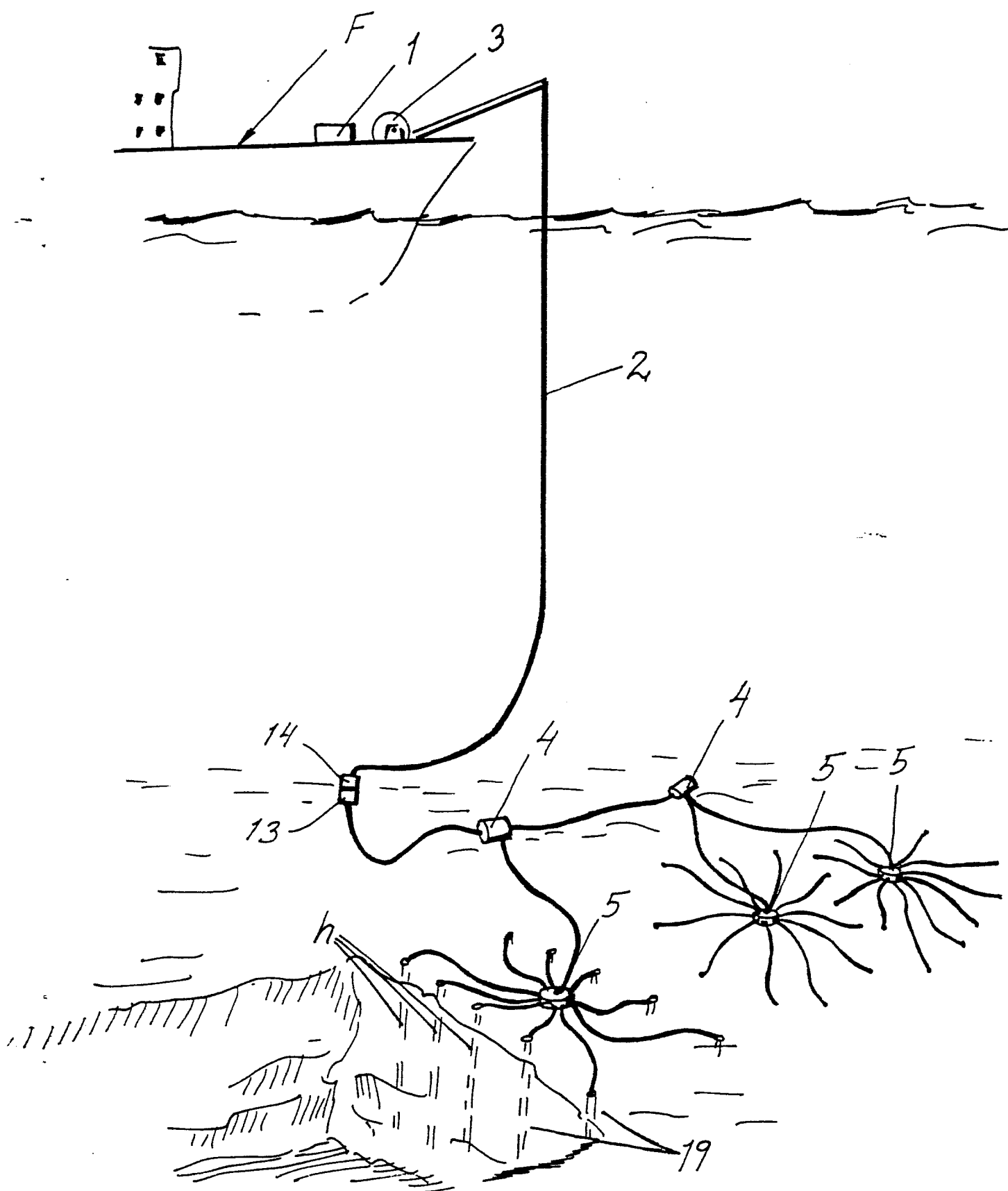
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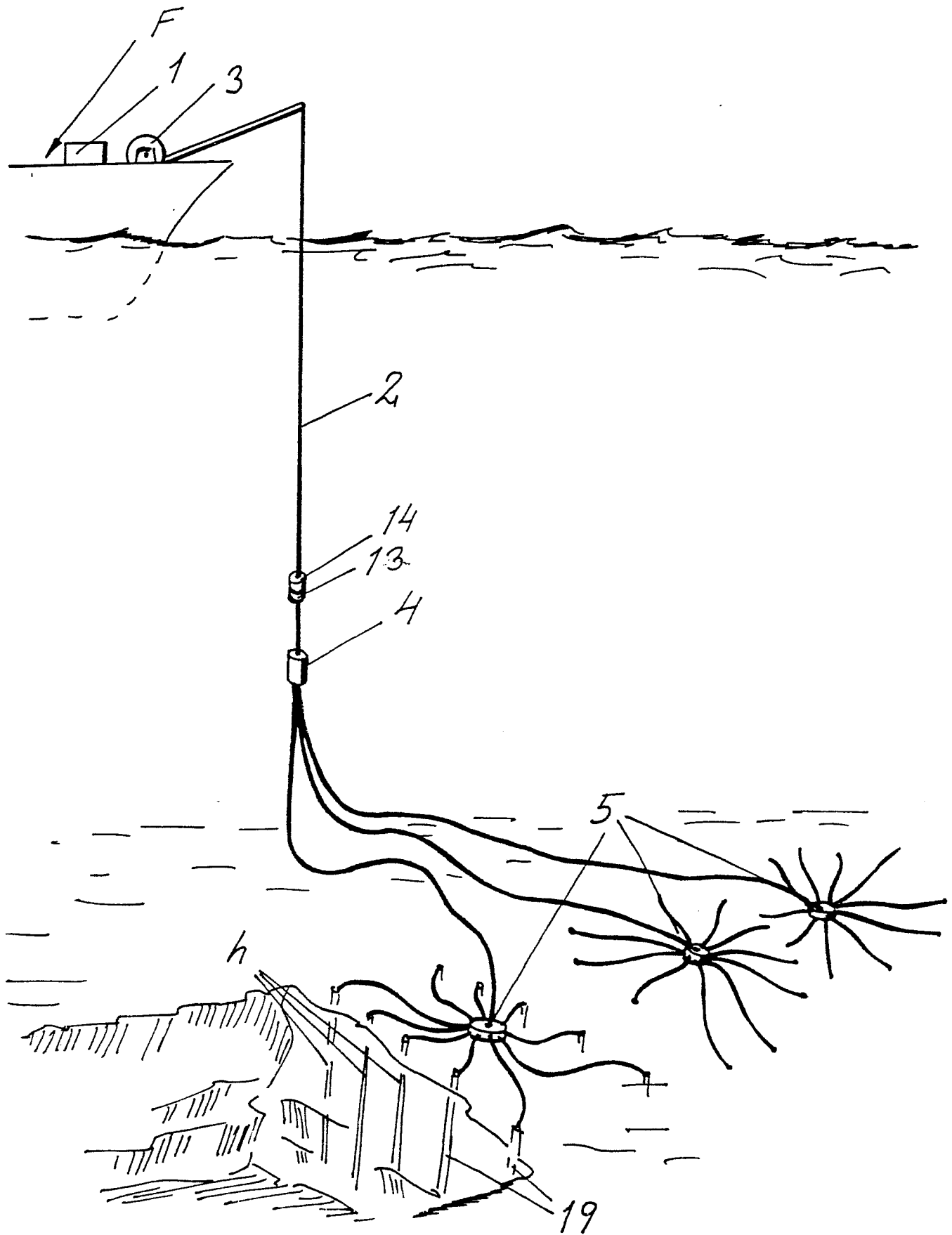
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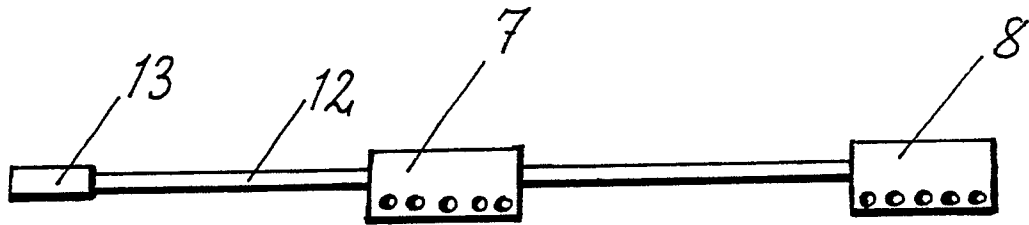
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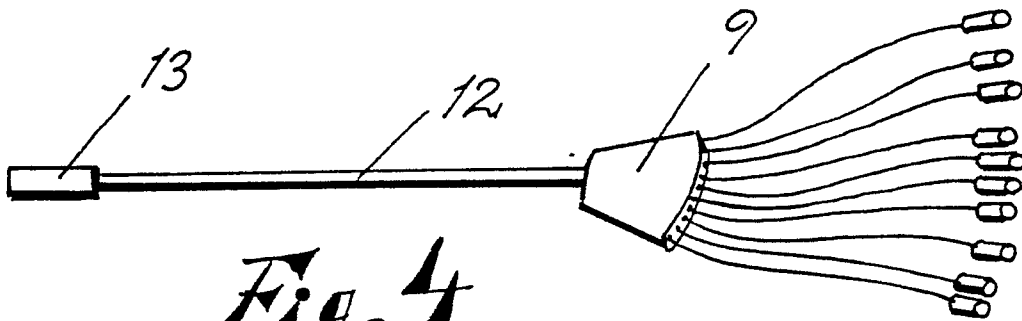
**Fig. 1**

**Fig. 2**

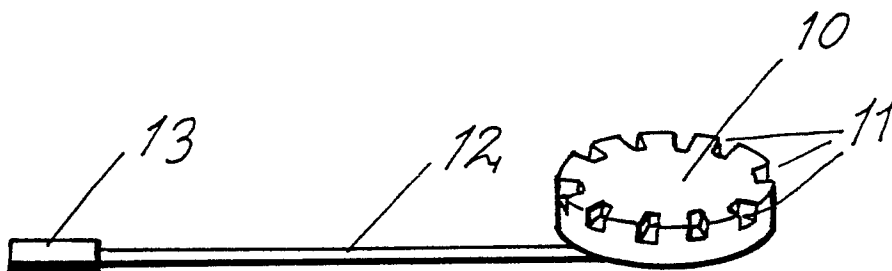




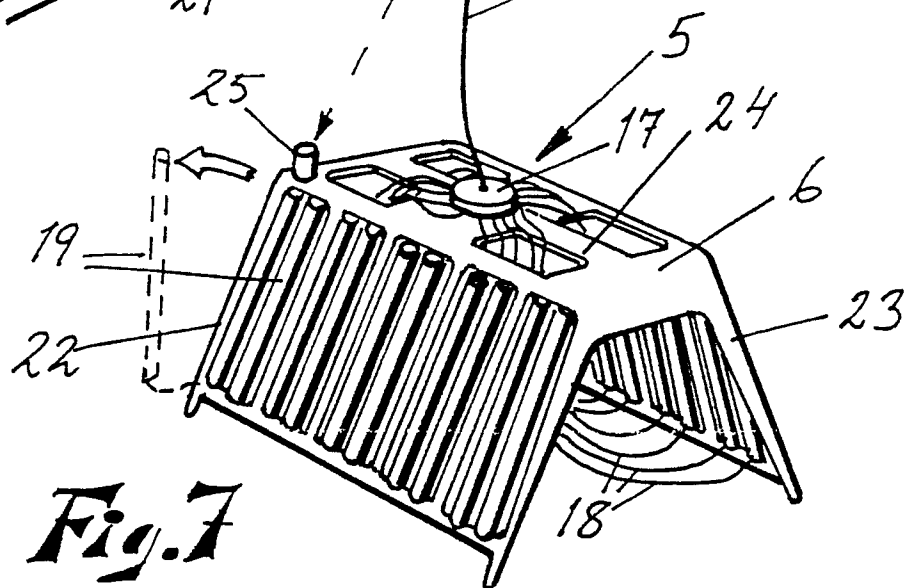
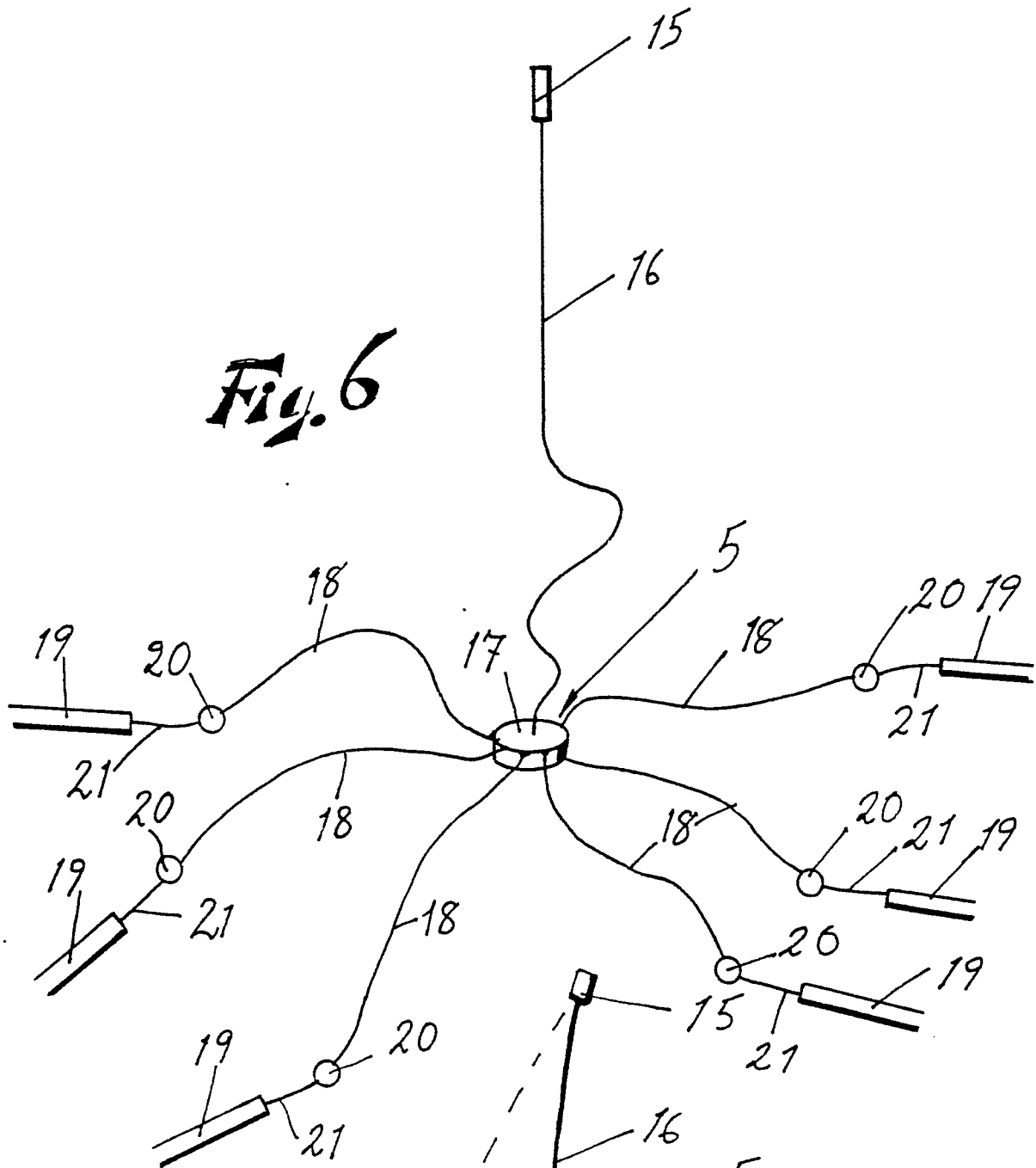
*Fig. 3*

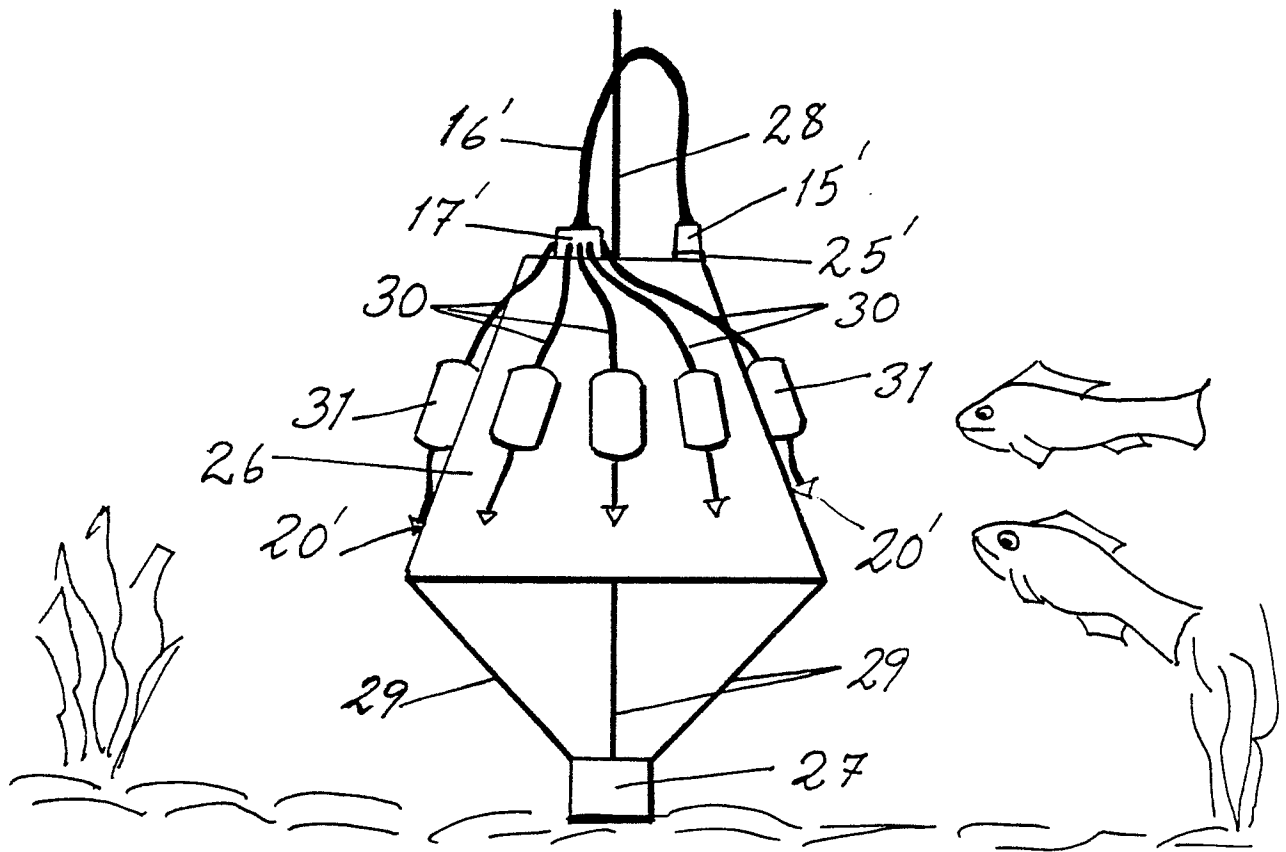


*Fig. 4*

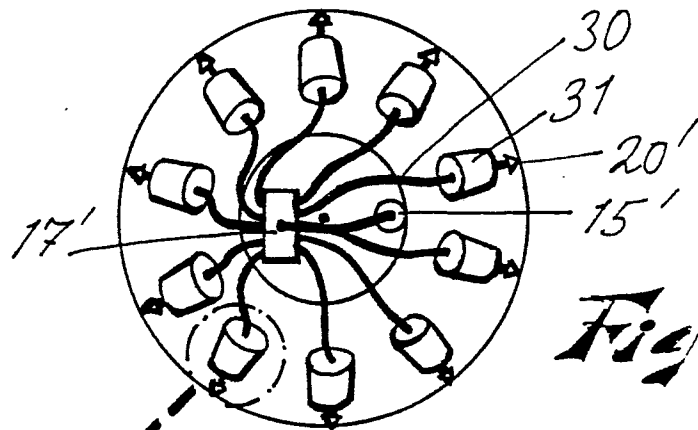


*Fig. 5*

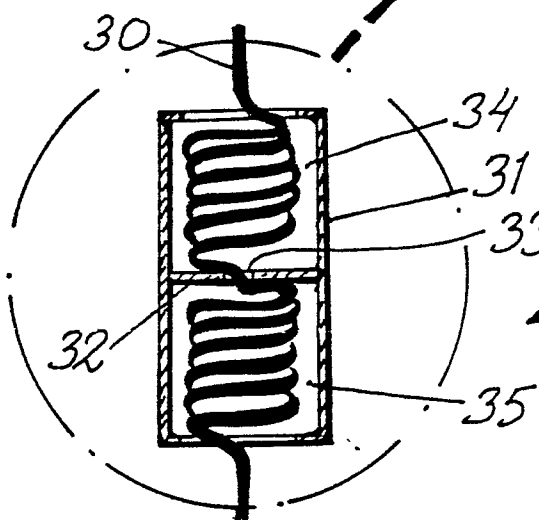
*Fig. 6*



**Fig. 8**



**Fig. 9**



**Fig. 10**



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.4)
A	AT-B- 330 096 (ECKELS)		F 42 D 1/00 F 42 B 3/18
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A	US-A-3 454 907 (RIMSHA)		
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A	US-A-3 982 486 (ECKELS)		
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A	GB-A-1 429 281 (AGENCY OF INDUSTRIAL SCIENCE AND TECHNOLOGY)		
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.4)  F 42 D F 42 B
Place of search THE HAGUE		Date of completion of the search 05-11-1987	Examiner WOHLRAPP R.G.
<b>CATEGORY OF CITED DOCUMENTS</b>			
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	