filled by preference with oil, which terminates in the horizontal spiral glass tube at a point which will vary with the total attractive influence of the earth, and thus furnish a means of reading the instrument. The electric contact arrangement described in the paper is thus rendered unnecessary, and the reading of the instrument much simplified.

II. "On Instruments for Recording the Direction and Velocity of Currents and the Temperature of the Water at different Depths in the Ocean." By J. RYMER JONES, of the Imperial Government Telegraphs, Japan. Communicated by Prof. RYMER JONES, F.R.S. Received January 1, 1876.

The object of these instruments is to register on board ship :—

1st. The direction of currents which flow at different depths in the ocean.

2ndly. The velocity of those currents.

3rdly. The temperature of the sea at all points between the surface and bottom, without requiring the instruments to be hauled up in order to register the results.

The advantages of such results, if capable of being obtained, must appear self-evident; and the following description will, I hope, prove the practicability of those methods which I propose to adopt in order to arrive at the above desiderata.

All three instruments are based on electrical principles.

Diag. 1. fig. 1 represents a full-sized section of the instrument employed for making serial observations of the direction of currents flowing at different depths in the sea; and in the lower part of the same figure is shown the method for taking the temperatures at the same points; but as the description of this instrument will form a separate paragraph, I shall dismiss it for the present with the remark that the same leading-wires are used in connexion with both instruments.

In considering the best method for registering the direction of deep-sea currents, two things seem absolutely necessary :—1st, some point capable of taking up a fixed direction and uninfluenced by the currents; and 2ndly, a movable point taking up the direction of, and regulated by, the current whose direction is required. With these data it appeared sufficiently easy to arrive at the direction of the currents, by measuring the angle between the fixed point and the movable point, which varies with the direction of the current. It is clear that the only available fixed point is that afforded by the unerring magnet, while the employment of a sufficiently large vane will cause the instrument to take up a position in the direction of the current, the rest being only matter of detail, which I now proceed to discuss.

In order to keep the magnet in a perfectly horizontal position and un-

influenced by any unsteadiness of the instrument, gimbals (diag. 1. fig. 1, and diag. 2. fig. 1), *g g*, are employed, as in the case of the mariner's compass; and underneath the card *c c* (diag. 1. fig. 1), to which the magnet is attached, is a copper wire (*w w*) permanently fixed at right angles to the magnet *m m*, along which an electric current is made to pass, and thus has no tendency to deflect the magnet from the magnetic meridian.

Attached to one end of this copper wire (*w w*) on the upperside, and passing through the card, is a fine platinum wire, *p p*, about 3 inches long, and tapering to a mere fibre at the top, and the wire is carefully counterpoised at the other end. The pivot on which the magnet is poised is of brass (*b*) and pointed with platinum (p''), and is in connexion with the sea through the pivots of the gimbals, *g g*. A double casing of thick sheet-copper (A B C D) is strengthened by stays (*i i i*) calculated to stand the great deep-sea pressures; and the air-chamber between the inside and outside casing renders the whole instrument buoyant, and is intended to take off all the strain from the line when being hauled up. *e e* is a section of an ebonite disk, the plan of which is shown in diag. 2. fig. 2; and fig. 1 is a section of the instrument taken through the dotted line B B D D, showing the ebonite disk, gimbals, card, and magnet (*m m*), with the copper wire (*w w*) affixed at right angles to it. Let into the periphery of the disk (*e e*) are sixteen pieces of brass, insulated from one another by the ebonite, but placed in such close proximity to each other that the fibrous end of the platinum wire (*p p*) must always be in contact with the under surface of one of them. Sixteen insulated wires enter the top of the instrument in the form of a cable, which divides into two parts (*h h*), eight wires on either side.

These are conducted through two holes (h', h') in the ebonite disk (*e e*) to the lower part of the instrument, where they pass through a second hole in the centre of the concave bottom of the compass-chamber e'' e'', which renders the compartment $e'' e e e''$ watertight, and to the underside of which the thermometer to be afterwards described is attached. The ends of the wires are finally connected to the sixteen terminals on the back of the thermometer. Before, however, passing through the holes (h', h') short leading-wires are soldered to each and connected to the upper surfaces of the sixteen brass contacts on the ebonite disk (*e e*). These contacts pass through the disk and project a little beyond its lower surface, where they are grooved as in fig. 1, *o o*, in order to prevent the end of the platinum wire *p p*, which is so adjusted as to pass immediately under the centre of the groove, from trespassing beyond the line of contacts, through any unsteadiness of the instrument. These brass contacts are amalgamated on the under surface to render the contact more decided; and the top of the platinum wire *p p* must be so fine and flexible as to reduce the friction to a minimum, while at the same time it ensures perfect contact. A stuffing-box, s' s', with hemp and wax pre-

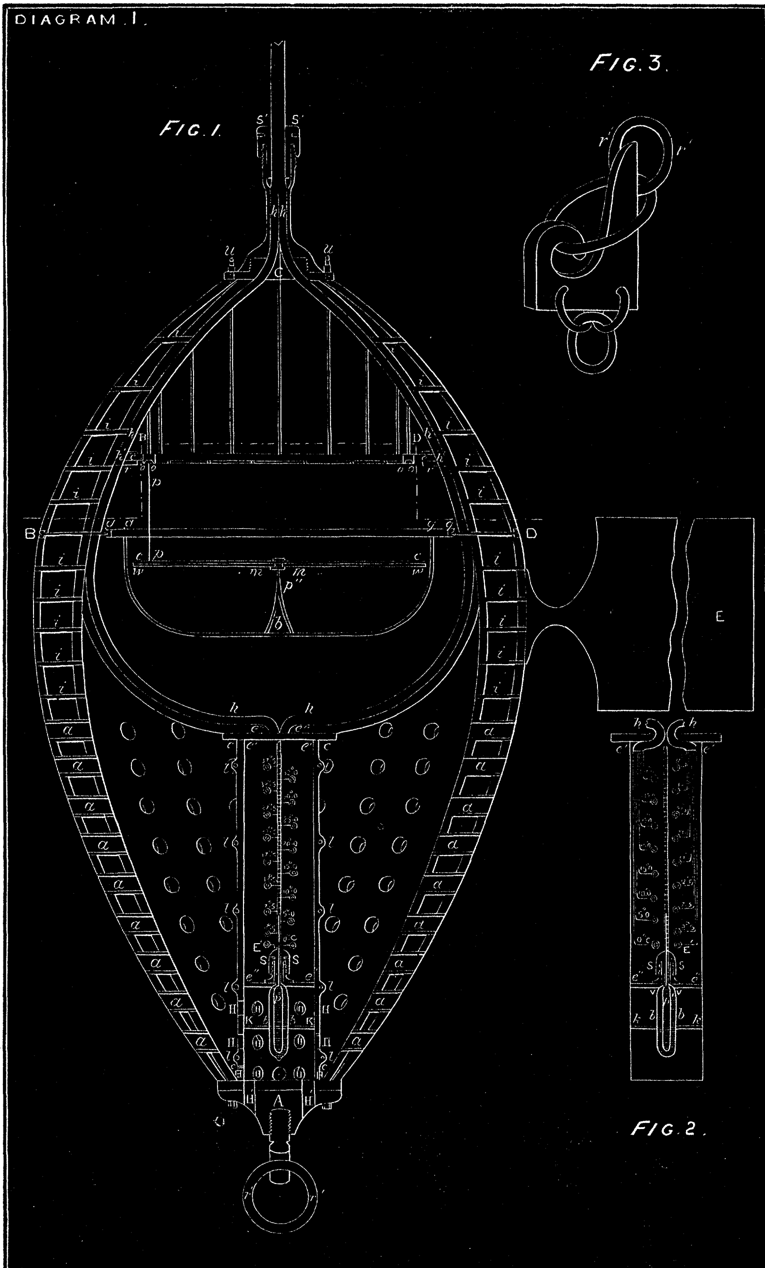
DIAGRAM. I.
FIG. 1.
FIG. 2.
FIG. 3.
E
A
B
D

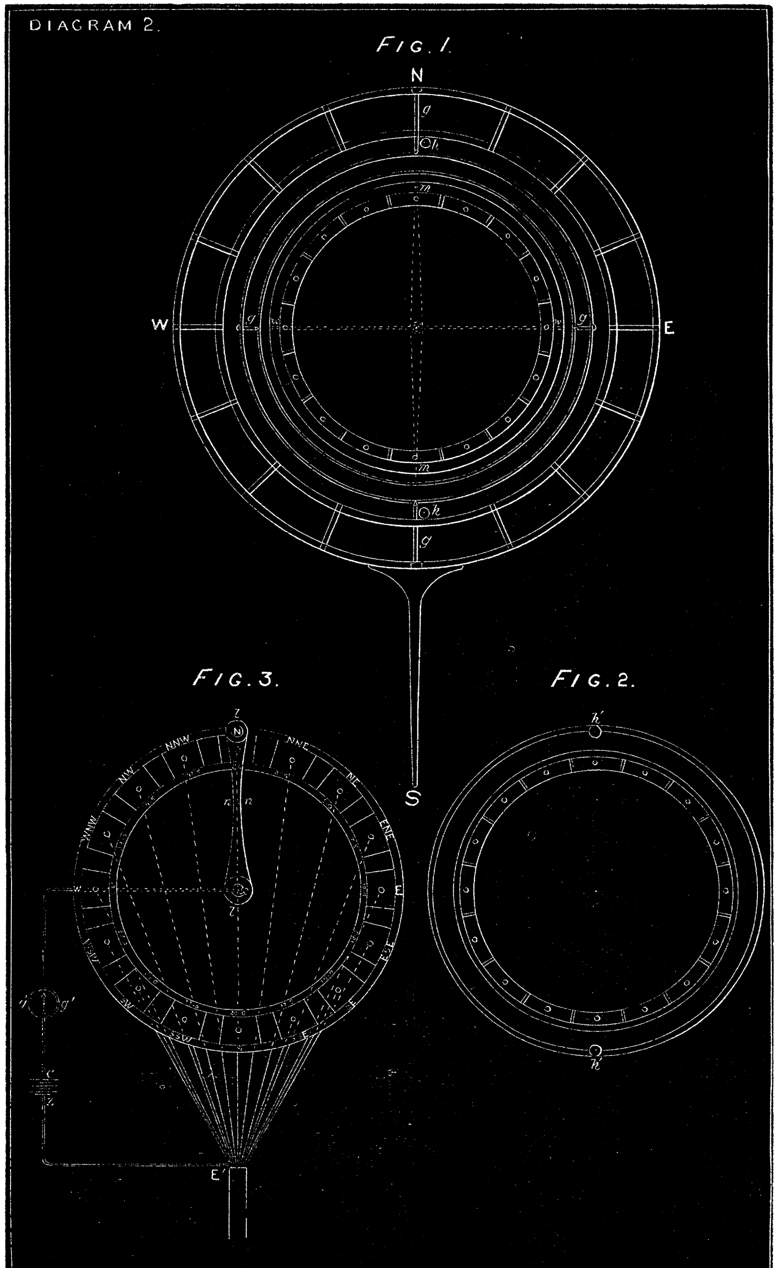
DIAGRAM 2.
FIG. 1.
N
W
E
S
g
h
m
k
FIG. 3.
NNW
NW
WNW
W
NNE
NE
ENE
E
ESE
SW
E'
FIG. 2.
h'

vents the leakage of sea-water through the hole by which the wires enter the top of the instrument; and the compartment *e* C *e* is filled with melted paraffin wax, which consolidates and effectually insulates the wires and contacts from one another, should any moisture find its way in.

The registering-instrument (diag. 2. fig. 3) is exceedingly simple and greatly resembles the dial-plate of Breguet's electro-magnetic dial instrument.

Around the circumference of this dial-plate are sixteen brass contacts, passing through an ebonite disk; and to the under surface of each contact is soldered one of the sixteen wires which form the core of the cable, whose other ends are soldered to the upper surfaces of the contacts on the disk (*e e*), as before mentioned.

Concentric with these metallic contacts are two circles, one on either side. In the outer circle are the rhumbs and semi-rhumbs of the wind, and in the inner circle are the degrees (Celsius) corresponding to those marked in the diagram of the thermometer, this dial-plate being capable of registering the results of both instruments.

l l is a metallic lever capable of being moved round the dial by an ebonite handle N, and the axis *x* of this lever is in connexion, through the galvanometer *g' g'*, with one pole of the battery C, the other pole Z being put to earth, E'.

In the centre of each brass contact is an indentation for dropping the lever into; and when not in use the handle can be turned back on to itself, by means of a hinge (*n n*) in the centre, and thus break the circuit.

The different parts of the instrument having now been explained, I shall proceed to describe the manner in which it is intended to take an observation.

After attaching weights sufficiently heavy to carry the instrument steadily down in an upright position to the detaching-instrument (diag. 1. fig. 3), paying out is commenced; and under the influence of the vane E, the instrument takes up a position in the direction of the current, varying in direction as the currents vary. Whenever it is desired to take a reading, the lowering is stopped, and the instrument in mid ocean will be pointing in the direction of the current, while the magnet (*m m*) is pointing steadily to the north.

In order to understand the arrangement of the sixteen leading wires, let us suppose the instrument to be influenced by a current from the north; the direction then of the vane and magnet will coincide (diag. 2. fig. 1), and the platinum contact *p p* (diag. 1. fig. 1), attached to the copper wire *w w*, and which is always at right angles to the magnet *m m*, will be rubbing against the under surface of the contact pointing due west (W.). If, then, one of the sixteen wires in connexion with the upper surface of this contact be soldered to the under surface of the contact on the registering dial-plate marked N (diag. II. fig. 3), when lever *l l* is moved slowly over this contact, on the upper surface of the

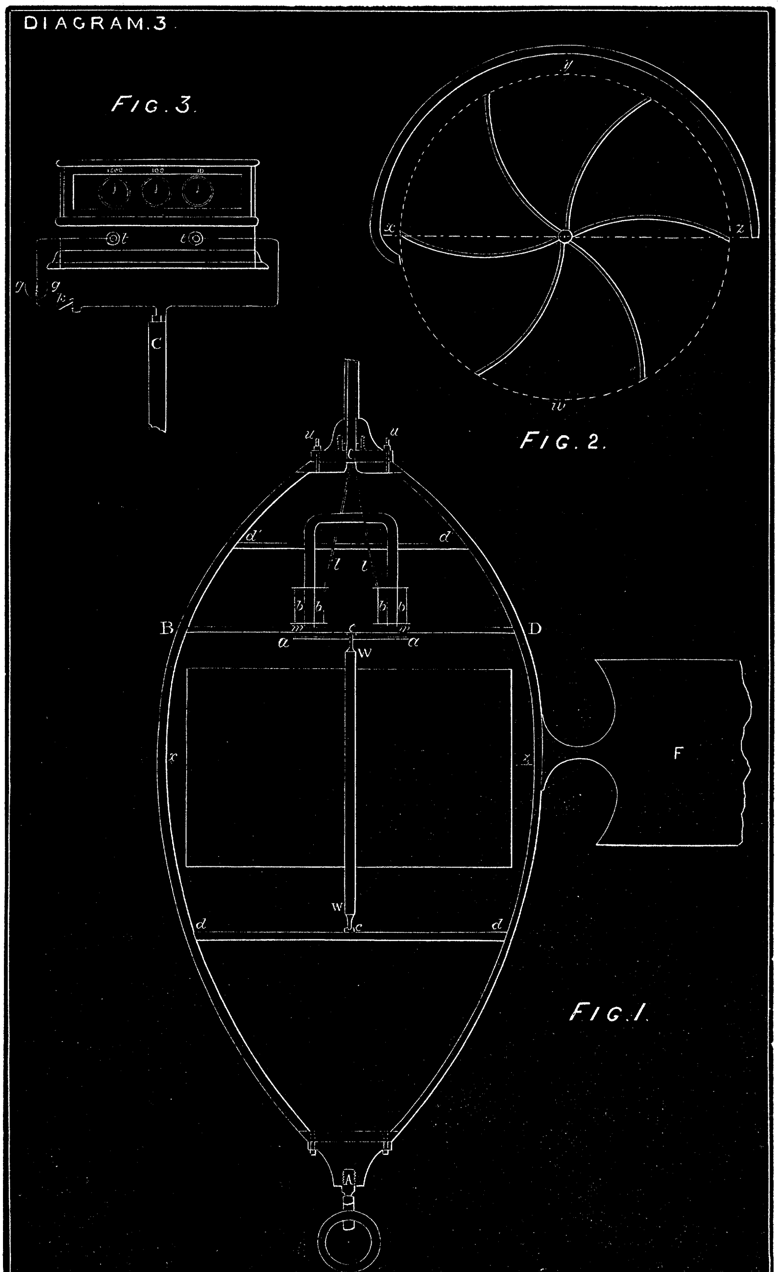
DIAGRAM. 3.
FIG. 3.
FIG. 2.
FIG. 1.
C
t
t
g
k
y
x
z
w
u
u
d'
d
l
l
b
b
B
D
a
a
m
m
W
W
c
c
x
z
F
d
d
A

dial-plate, a current will circulate from the battery C, through galvanometer $g' g'$ (the needle of which is deflected), axis of lever x, lever $l l$, contact N, leading-wire to the contact against the underside of which the platinum wire is pressing, and through it and the pivots of the gimbals to earth E′, and back to the battery-pole Z, which must also be put to earth. It is clear that by calling this contact of the dial-plate north, and soldering the other fifteen wires in order to the under surfaces of the remaining contacts (as in diag. 2. fig. 3), with their other ends attached to the corresponding contacts around the periphery of the ebonite disk ($e e$) in the instrument below, in order to find the direction of any other current than a northerly one, the handle has only to be moved round the dial until the galvanometer-needle is seen to deflect; and when this is the case, the lever will be pressing against the contact whose letter represents the direction of the current which was required to be found. This reading having been duly registered, the instrument is lowered some 100 fathoms or more; and after waiting for a few minutes for the instrument to settle down in the direction of the current, the handle of the dial-plate is again turned round on board, in either direction, over the contacts until the galvanometer-needle again deflects, showing that an electric current passes; and after registering the direction of this current also, the instrument may be lowered to greater depths, and readings taken at any points between the surface and the bottom of the sea. On reaching the bottom the weights detach themselves by means of the apparatus (diag. 1. fig. 3) invented by Mr. Edward Hill, and the instrument (whose weight has been previously adjusted to enable it to float, when there is no sinker attached, and remain in an upright position) offers little weight or strain to the cable when being hauled up. The detaching-apparatus made use of is one designed by Mr. Edward Hill expressly for detaching weights; and after many trials this method has been found to be exceedingly sure and trustworthy. So long as the sinker is in mid ocean, the ring $r' r'$ remains tightly hooked on to the apparatus (fig. 3); but directly the sinker rests on the bottom and the strain is taken off, the ring $r' r'$ falls, and the form of the apparatus effectually prevents the ring $r' r'$ from rehooking the sinker when the instrument is raised; instead of which it slides up the curved surface (cf. fig.) and becomes completely detached. The detaching-apparatus is left at the bottom, after each series of observations, with the sinker; but as this can be made exceedingly cheaply, the loss is very trivial.

The cable containing the core of sixteen insulated wires must be strengthened by strands of steel wire; and it would be well to make the cable with a larger section at the top, and to taper gradually towards the end attached to the instrument below.

The strands of steel wire are intended to be finally attached to the rings in the eye-bolts $u u$, and thus take all the strain off the wires forming the core.

A part of the double casing of the instrument is also capable of being removed by means of flanges and screws, in order to afford access to the compass-box and thermometer, care being taken to readjust the portion removed so as to render it perfectly water-tight after all the internal adjustments have been looked to. The instrument must be made smaller should experience prove the present size too bulky; it will, however, be necessary to have a sufficiently long compass-needle to enable it to overcome the resistance due to the friction of the end of the platinum wire, which presses against the under surfaces of the contacts (*o o*), as above mentioned.

Instrument for measuring on board Ship the Velocities of Deep-sea Currents.

Diagram 3. fig. 1 represents a full-sized section of this instrument; and here, again, the chief characteristic is its simplicity. In outward appearance this instrument is somewhat similar to the previous one, and like it is made to place itself in the direction of the current by means of a vane F.

x z is a section of a wheel with six rays, of which fig. 2 is a full-sized plan, the section representing the part *x y z*, and being made through the centre of the wheel, as shown by the dotted line.

One half only of this wheel (*x w z*) is exposed to the free action of the water at once (cf. fig. 2). The wheel revolves on its axis (W W), which is carefully pivoted on jewels in the small brass cups, *c c*, fixed on the centres of the disks (*d d*, B D).

The upper end of this axis carries a soft armature (*a a*), which rotates with the wheel immediately under the poles of a large horseshoe magnet (*m m*). Around the poles of the magnet are two bobbins of insulated wire (*b b*), wound in opposite directions, and in connexion with them are the two leading-wires, one of which is put to earth, and the other passes up the core of the cable to the registering-instrument on board. Between the poles of the magnet and the armature (*a a*) is a disk of ebonite or boxwood or other non-conductor (B D), strengthened round the edge by a rim of brass, and sufficiently thick to prevent its warping, which is intended to render the compartme .t (B C D) water-tight and protect the magnet and coils.

The reason for not employing a sheet of copper or other metal is to avoid the *magnetism of rotation* discovered by Arago, or the reaction of currents induced in the copper plate by the armature revolving, as explained by Faraday; this reaction, though probably small and insignificant, is better eliminated, as the tendency is to improve the motion of the armature. The wooden disk (*d′ d′*) keeps the magnet firmly in its right place, and a stuffing-box (*s′ s′*) prevents sea-water from entering the compartment, which is also filled with paraffin wax as an additional security. The registering-instrument on board is an ordinary *double-current counter* (fig. 3), similar to those made by the British Telegraph Manufactory,

Euston Road, London, and which are most suitable and trustworthy. When it is required to make an observation, a sinker is put on to the detaching-apparatus, and the instrument lowered to the required depth, where it remains steadily in a perpendicular position in the direction of the current, and the wheel commences to rotate, more quickly or slowly according to the velocity of the current influencing it, carrying round on its axis the soft iron armature (*a a*) which revolves in front of the poles of the magnet (*m m*), causing induced currents to circulate through the coils, which change in direction at every half-revolution. In order that these induced currents may circulate in the same direction through both coils of wire *b b*, the bobbins are wound, one right-handed, and the other left-handed.

These reverse currents are transmitted, on depressing the key (*k*), through the insulated wire of cable, key, galvanometer, counter, to earth E, the other leading-wire being also connected through the instrument to earth, as before mentioned. Thus a succession of reverse currents traverse the counter (fig. 3) so long as the contact-key (*k*) continues to complete the circuit, and both the counter and the wheel in mid ocean keep perfect time together. The counter may be adjusted to zero, or the position of the hands noted; and when the instrument is at the desired depth, the contact-key is held down and the counter begins to indicate the revolutions of the wheel for one minute, or for whatever period of time may be required. Thus by finding the number of revolutions produced in a given time by a current flowing with a certain known velocity, data may be obtained for finding the velocities of other streams or deep-sea currents, a constant being allowed for friction, which must be calculated. On reaching the bottom the weights are detached, and the instrument, whose weight has been previously adjusted to enable it to float and remain in a perpendicular position, offers little strain to the cable when being hauled up.

As the pressure is equally great on the inside and outside of this instrument, it is not necessary to have so strong a casing as the other instrument requires.

Instead of only two poles, as in the diagram, four poles may be used, the principle being the same as adopted by Sir Charles Wheatstone in his extremely beautiful A B C instrument, in order to get rid of the hobbling motion peculiar to other magneto-electric machines. By this arrangement the stronger current induced in the coils as the armature passes off one pole, compensates for the weaker induced current which circulates through the coils when the armature approaches the other pole, and thus makes the reverse currents much more regular. The coils must be wound so that the currents circulate in the same direction. If this method is adopted there will be four reverse currents for every revolution of the armature instead of two, as before mentioned, and the number indicated on the counter will have to be divided by two.

DIAGRAM. I.

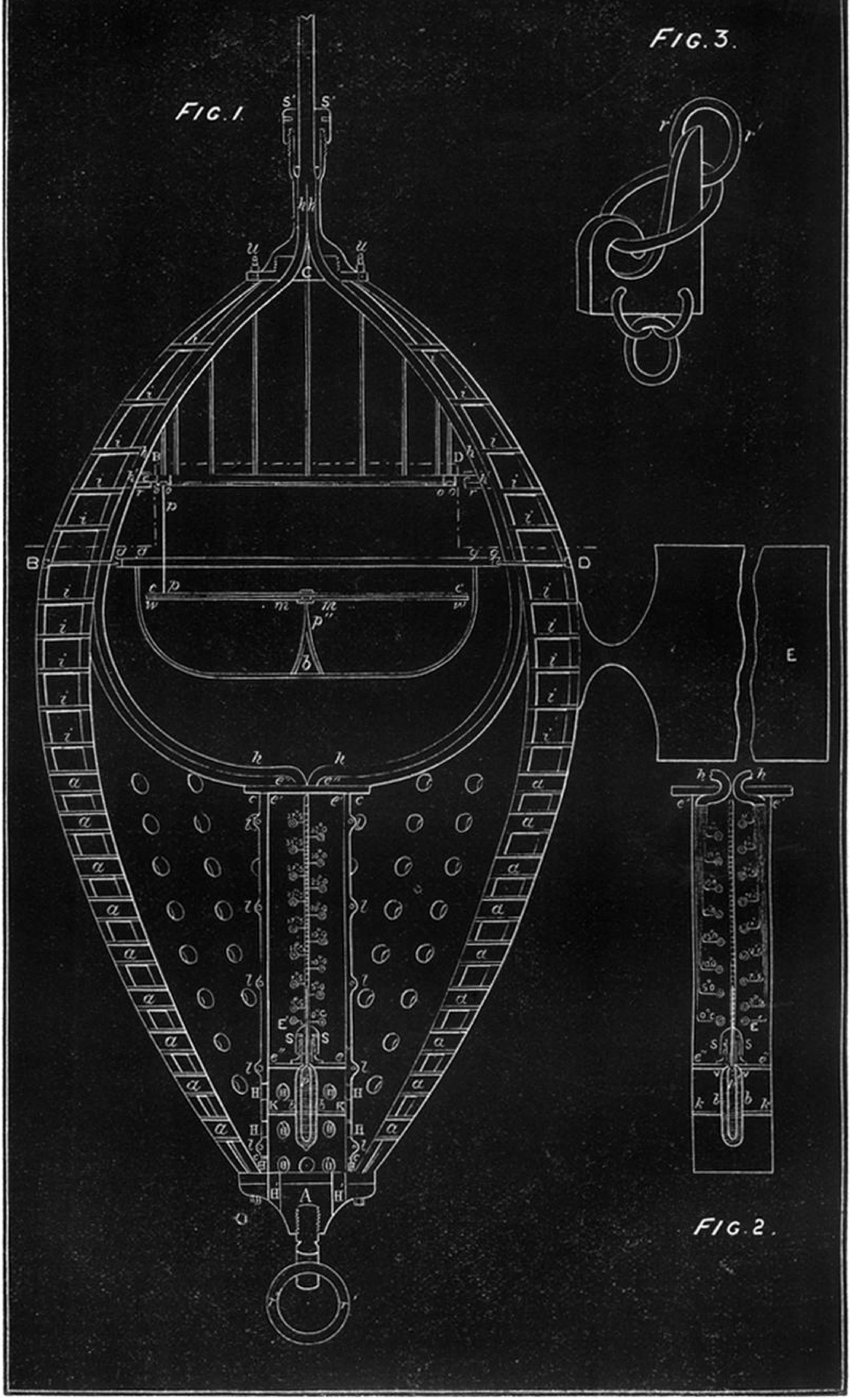

DIAGRAM 2.

FIG. 1.

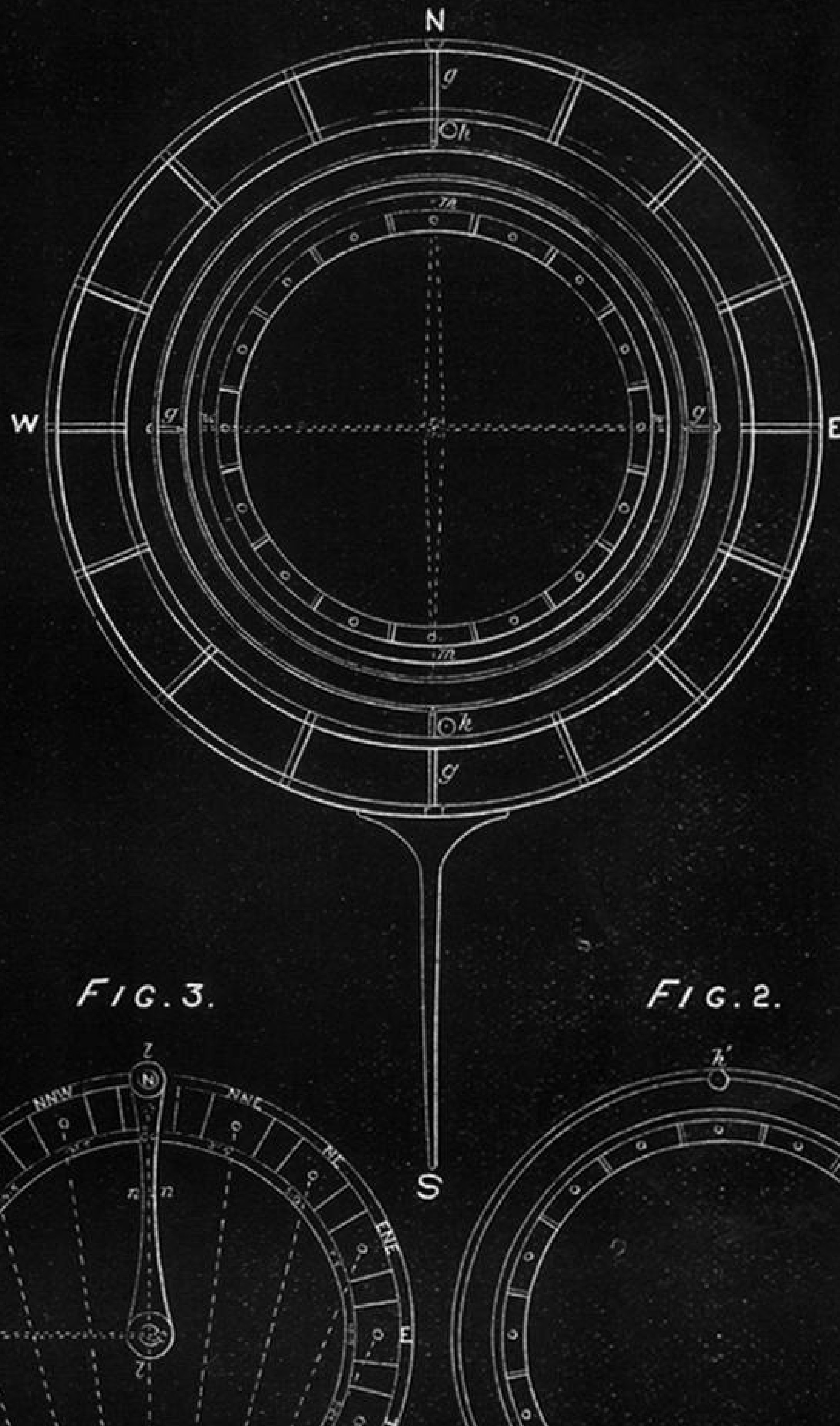

FIG. 3.

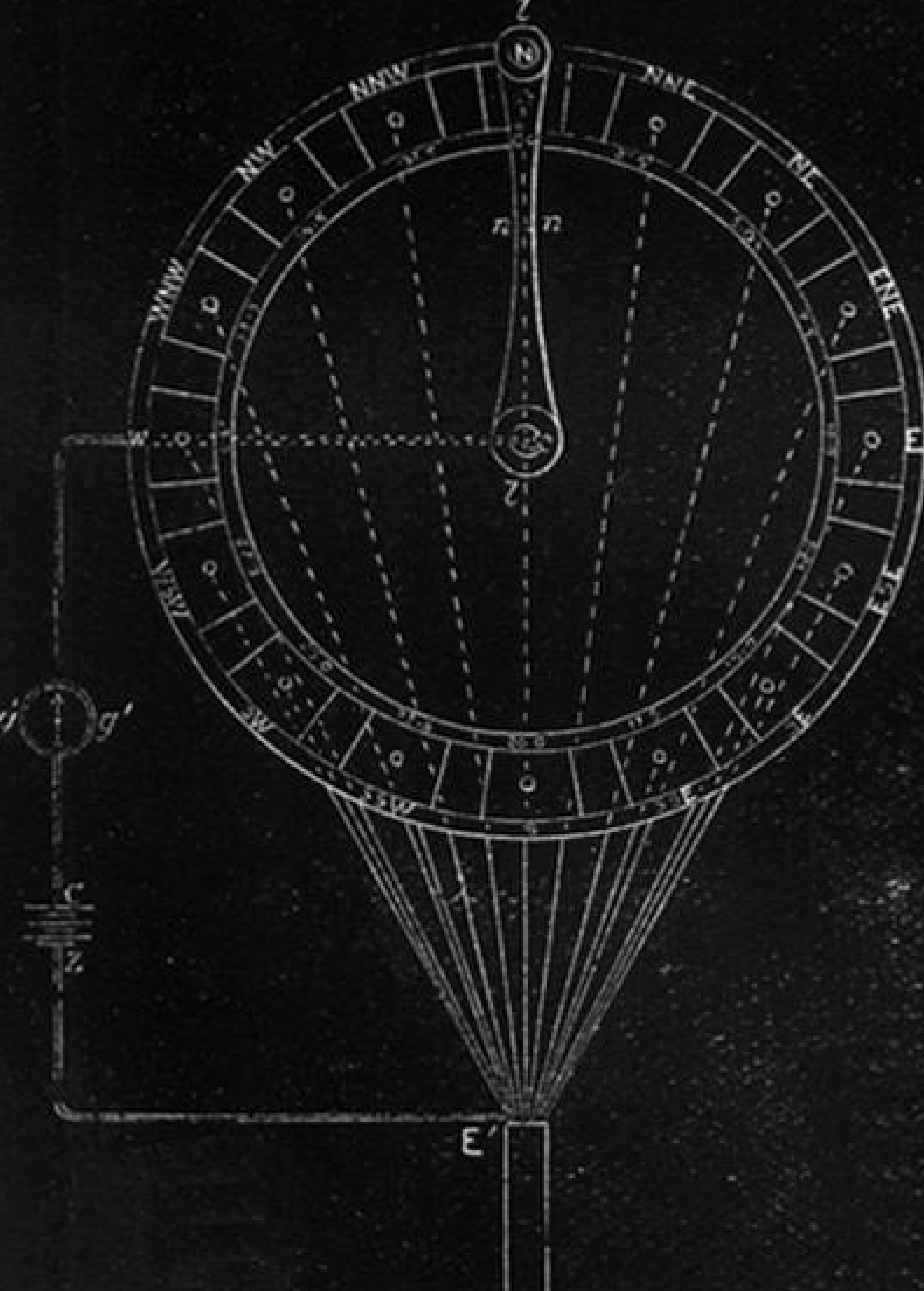

FIG. 2.

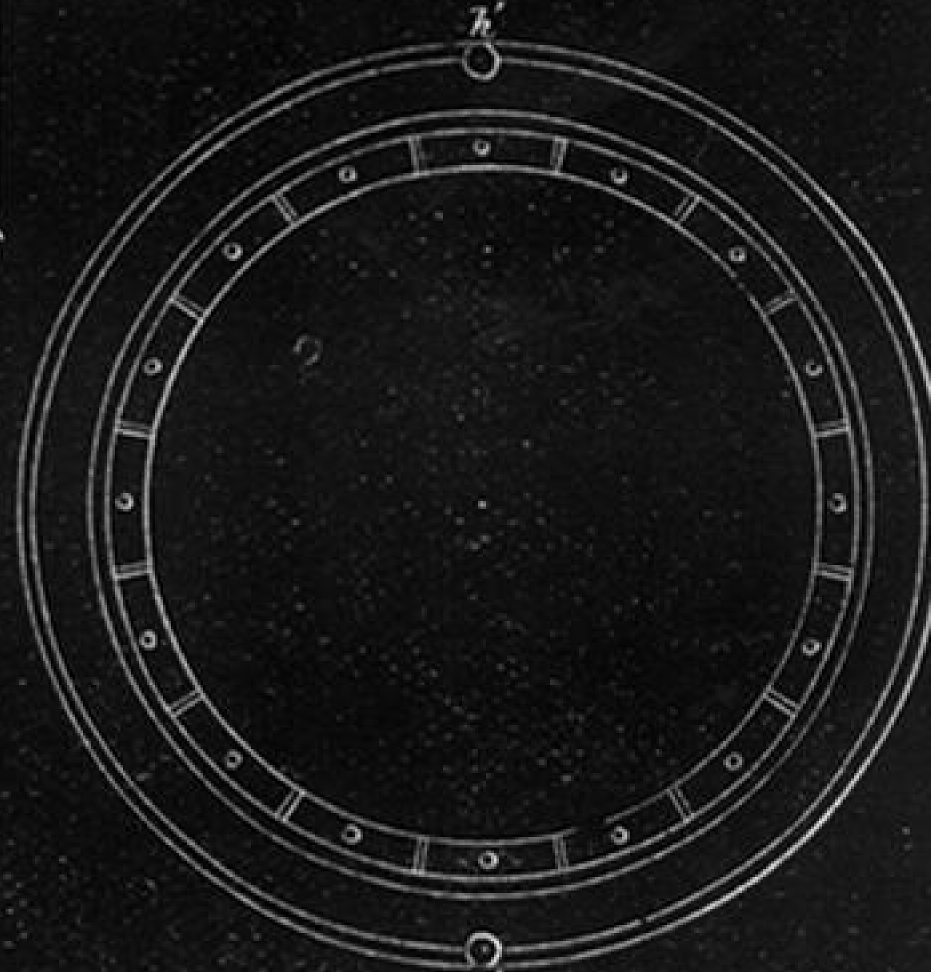

DIAGRAM. 3.

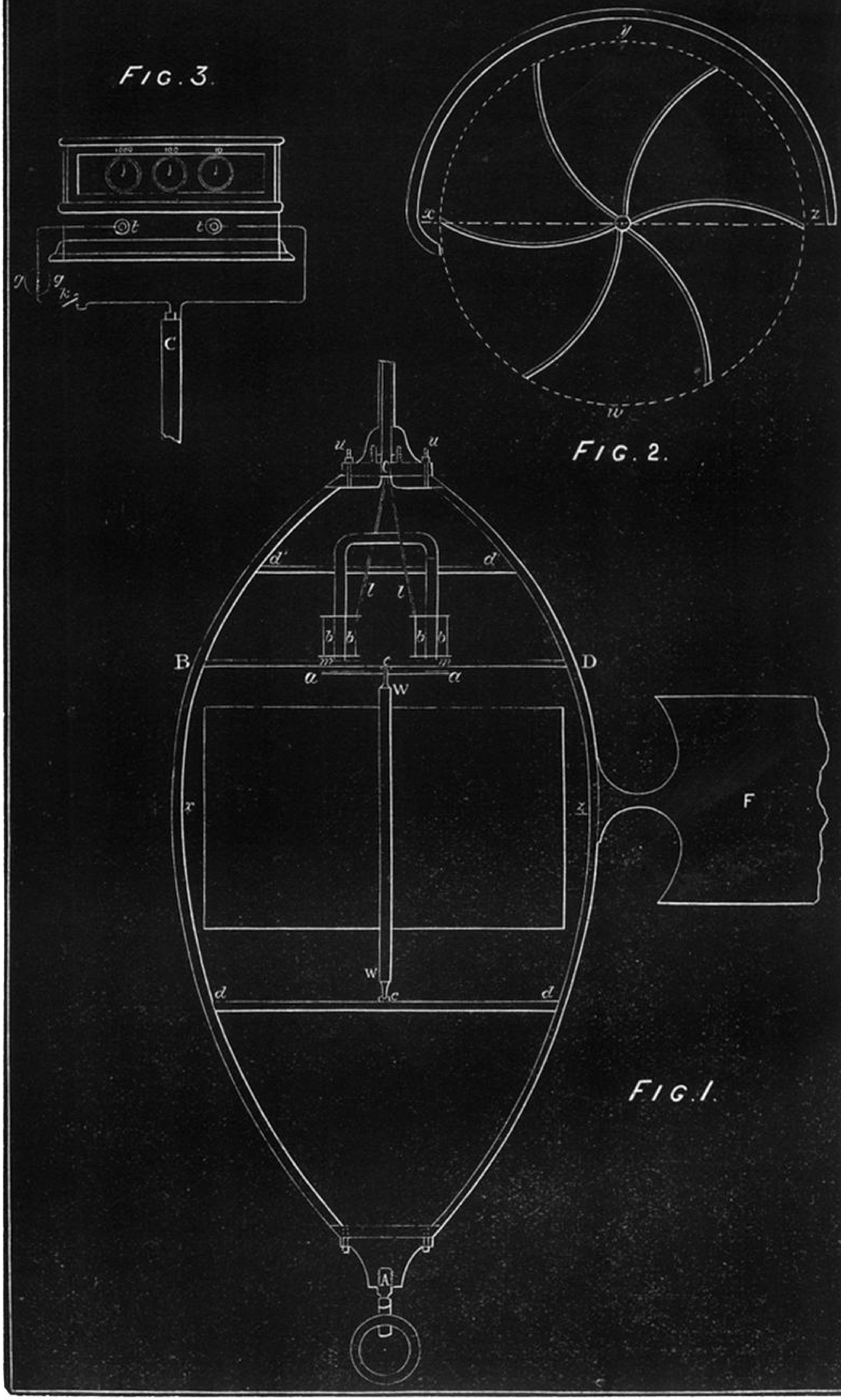
FIG. 3.
1000
100
10
t
t
g
g
k
C
FIG. 2.
y
x
z
w
FIG. 1.
u
u
C
d'
d'
l
l
b
b
b
b
B
D
m
m
c
a
a
W
x
z
F
W
d
c
d
A