(No Model.) 2 Sheets—Sheet 1.

H. FLAD.

RHEOBATHOMETER.

No. 409,780. Patented Aug. 27, 1889.

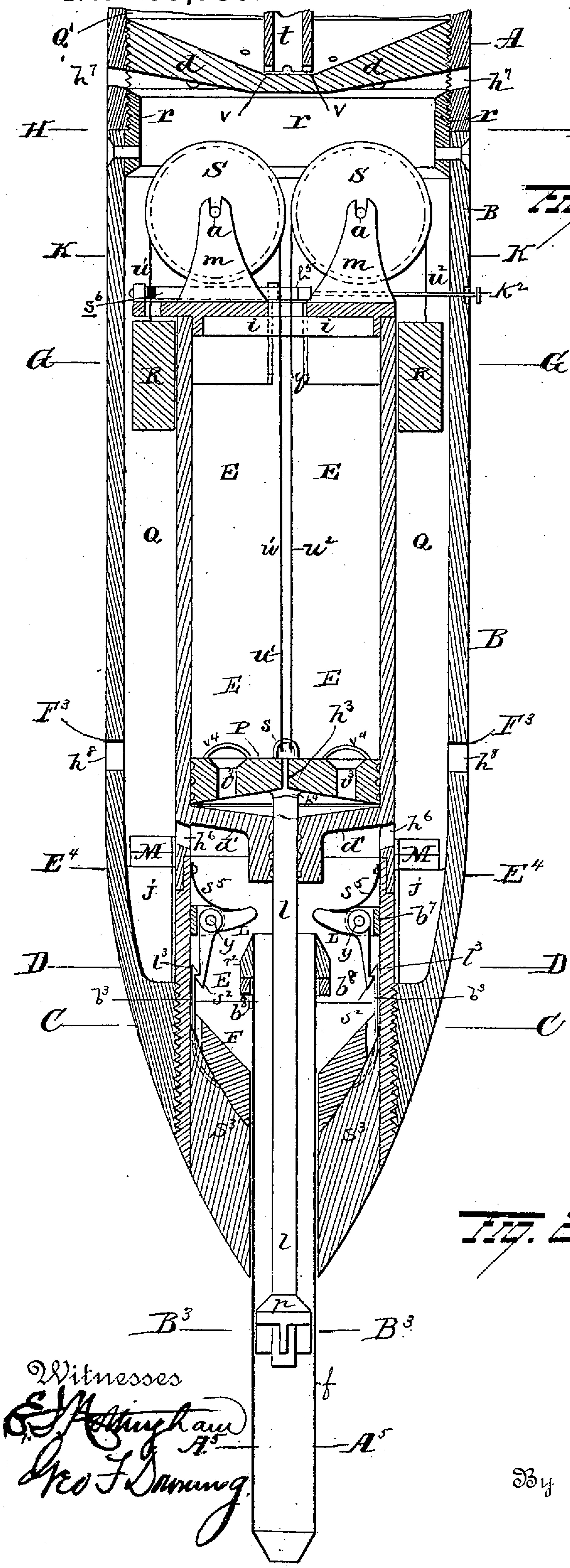

Fig. 1.

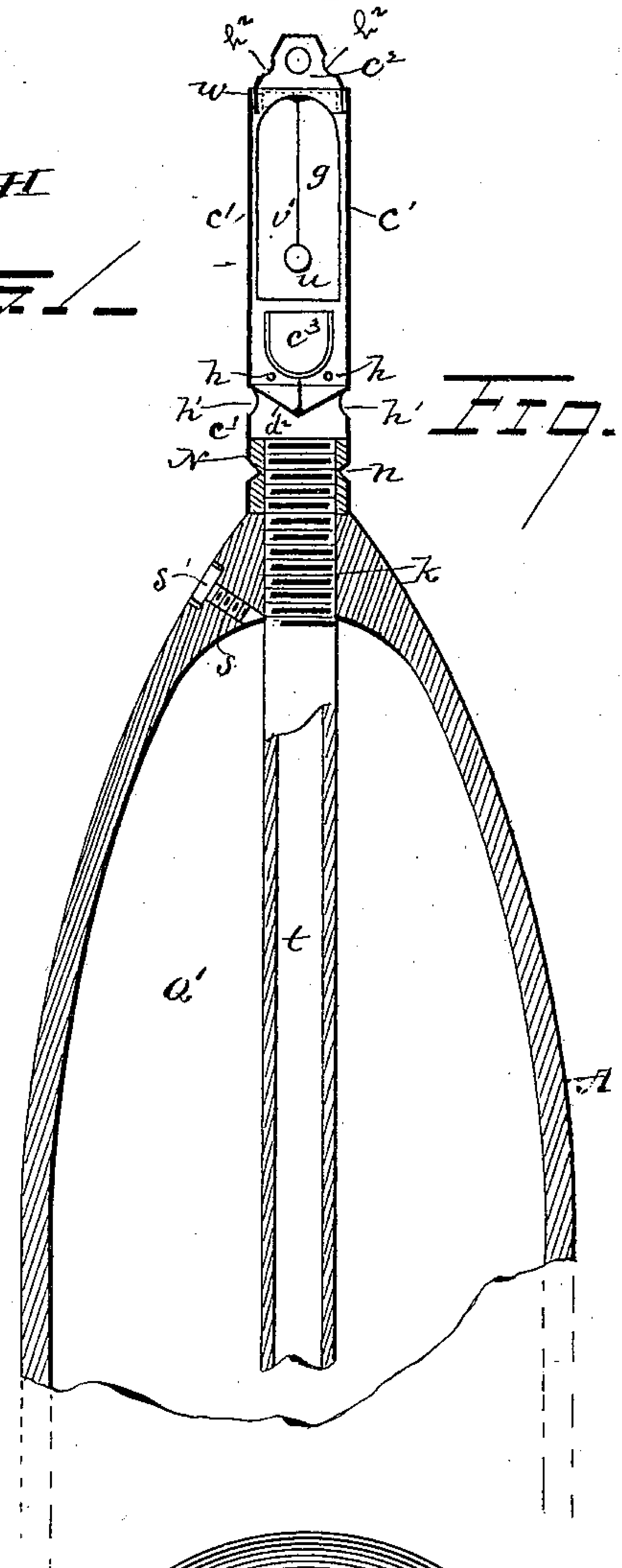

Fig. 1a.

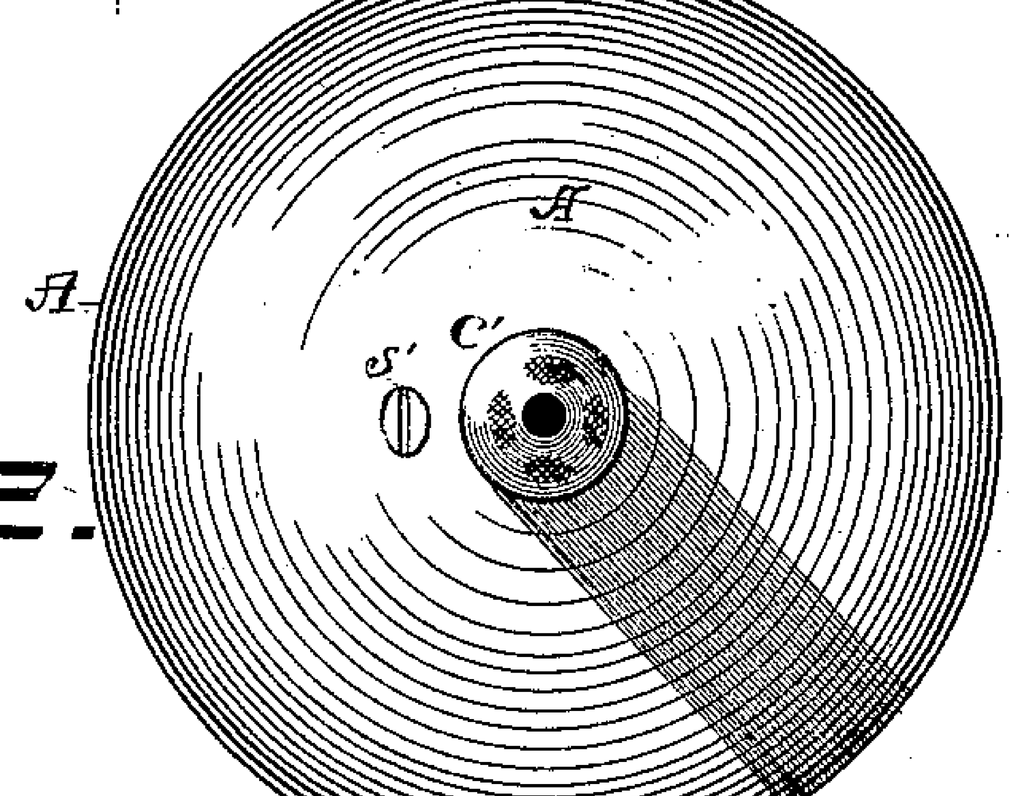

Fig. 2.

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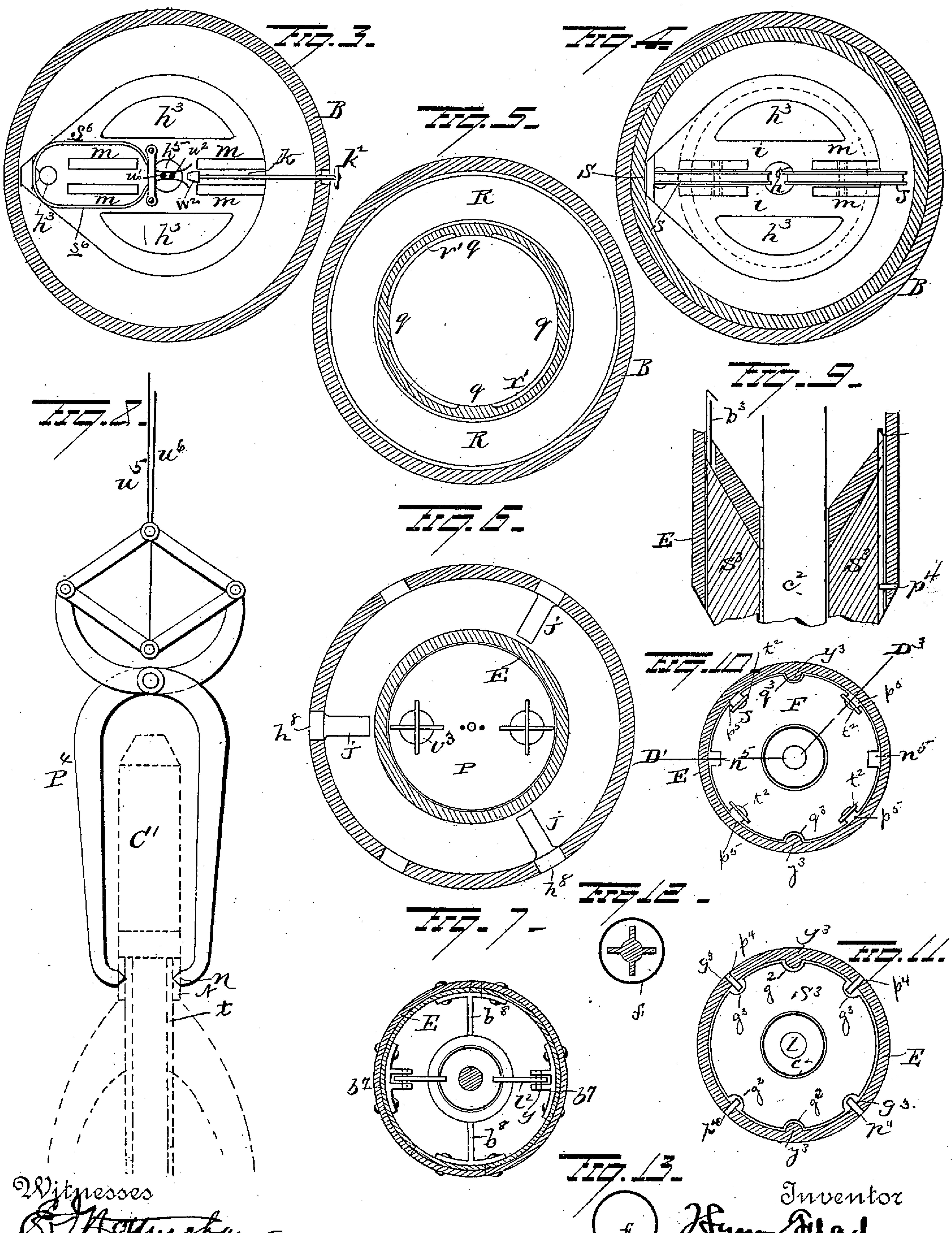

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UNITED STATES PATENT OFFICE.

HENRY FLAD, OF ST. LOUIS, MISSOURI.

RHEOBATHOMETER.

SPECIFICATION forming part of Letters Patent No. 409,780, dated August 27, 1889.

Original application filed June 30, 1887, Serial No. 242,968. Divided and this application filed November 13, 1888. Serial No. 290,701. (No model.)

To all whom it may concern:

Be it known that I, HENRY FLAD, of St. Louis, State of Missouri, have invented certain new and useful Improvements in Rheobathometers; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to an improvement in rheobathometers, by means of which the depth of rivers, lakes, and of the ocean and the direction and velocity of the currents prevailing therein, either at the surface or at any desired depth below the surface, can be ascertained.

In the accompanying drawings, Figure 1 is a view in vertical longitudinal section of the lower portion of a rheobathometer, the upper section being broken away. Fig. 1^a is a similar view of the upper section. Fig. 2 is an end view of same. Fig. 3 is a view on line K K of Fig. 1. Fig. 4 is a view on line H H of Fig. 1. Fig. 5 is a view on line G G of Fig. 1. Fig. 6 is a view on line F^3 F^3 of Fig. 1. Fig. 7 is a view on the line E^4 E^4 of Fig. 1. Fig. 8 is a view of the device for suspending the rheobathometer. Fig. 9 is a view on the lines D′ D^3 of Fig. 10. Fig. 10 is a view on line D D of Fig. 1. Fig. 11 is a view on line C C of Fig. 1. Fig. 12 is a view on line B^3 B^3 of Fig. 1, and Fig. 13 is a view on line A^5 A^5 of Fig. 1.

The form of the rheobathometer may vary; but its external surface must be so arranged around a straight line which forms the vertical axis of the instrument that every part of its surface is symmetrical with reference to that axis, and also with reference to a plane surface passing at right angles through the middle of the axis.

The rheobathometer has an average specific gravity smaller than water when the sinker, arranged inside the buoy, is detached from the instrument, and it has an average specific gravity greater than water when the sinker is attached to the instrument. The weights of the different parts of the instrument are so arranged that its center of gravity, with or without the sinker, lies in the vertical axis and considerably below the center of the horizontal axis of the instrument.

To fit the instrument for the several purposes for which it is designed, the outside shell is divided into two or more compartments, one of which is to contain liquid or fluid, which is to give the necessary buoyancy to the instrument, while the other or others contain the sinker for causing the rheobathometer to descend to the bottom when attached to it. I also provide a releaser, which is to cause the sinker to be detached from the instrument when it strikes the bottom, or when set free by the device, which I have termed a "timer" and which can be arranged to actuate the releaser after the lapse of a predetermined time and before the rheobathometer reaches bottom, and an indicator, a device which indicates the place where and the time when the rheobathometer returns to the surface of the water.

The shell of the rheobathometer is cylindrical in form, with ogival ends, and has cylinders of smaller diameter protruding from the ogival ends. This shell is constructed of two parts—the upper part A, the extreme lower end of which is shown in Fig. 1, while the upper or main portion thereof is shown in Fig. 1^a, and the lower part B, (shown in Fig. 1)—the two parts being joined on line H H, the joint being made by means of a cylindrical ring *r*. This ring is secured to one section by pins or equivalent devices, and is provided with screw-threads which engage internal threads formed on the adjacent end of the other section. At the top of the upper part the shell is perforated to admit the introduction of the tube *t*.

The shell is divided into two unequal compartments Q and Q′ by the diaphragm *d d*, which is secured to the shell a short distance above the joint H H. The length of the upper part or section A is determined by the amount of buoyancy required, and the lower part or section B is made simply of sufficient length to contain the timer, releaser, and other devices required for operating the instrument. In the center of the upper compartment the small tube *t* is fastened, being passed through the hole left for that purpose at the upper apex of the shell. The lower end of the tube *t t* rests on the diaphragm *d*, and at that point is perforated at *v*, to admit communication between the liquids contained in the main body of the compartment Q' and those in the tube $t\,t$. The opening s^7 at the highest point of part or section A serves for the escape of air while the compartment is being filled with naphtha by pouring it into the open upper end of tube t. After the compartment Q' is full of the liquid and the air has all ascended, the opening is closed by screw-tap s'.

The portion of the tube $t\,t$ protruding above the apex of the ogivic shell is re-enforced by a ring N, screwed to it, and at two opposite points of the circumference of this ring indentations $n\ n$ are made, with which engages the device employed for supporting the instrument to lower it into the water, as will hereinafter be described. To this ring N the tube c' is fitted and held in position by friction, so that it may readily be attached or detached. This tube is made of very thin metal. At its upper end a cap c^2, in the form of a truncated cone and perforated at $h^2\ h^2$ on its sides, is placed. Near the base of the cap c^2 wire-netting w is secured thereto. The cap is fitted to the tube so as to be held by friction.

A short distance above the lower end of the tube c' the diaphragm d^2, of the form of an inverted cone, is fixed to the sides of the tube c'. Immediately above the diaphragm the sides of the tube c' are provided with small holes $h\,h$. Larger holes $h'\ h'$ are made in the sides of the cylinder immediately below the diaphragm d^2. To the center of the upper surface of the diaphragm d^2 a stiff wire is attached, which at its upper end carries a small cup c^3. The upper part of the tube c' contains a tube g, of very thin glass, closed at its upper end and open at the lower, its outside diameter being a little smaller than the inside diameter of the tube c'. During the time the rheobathometer is descending and ascending the tube c' is filled with water, except the glass tube g, which is filled with naphtha, the buoyancy of which operates to lift the glass tube against the wire-netting w. Within the glass tube is a globule of potassium, which latter is suspended by a fine wire from the top of the glass tube.

In the lower compartment Q Q of the instrument cylinder E is placed. This cylinder is connected at its lower end with the shell of the rheobathometer, and its upper end is covered with a cap i, which is provided with openings h^3. (See Fig. 4.) The cap i carries the standards $m\ m$, which support the shafts $a\ a$ of the sheaves S. Near the upper end of the cylinder recesses r' are cut on its inside, (see Fig. 5,) ribs $q\ q$ being left to guide the piston P when it reaches that part of the cylinder.

The cylinder E is divided into two parts by a diaphragm d', placed below the middle of the cylinder E. The space above the diaphragm d' contains the piston P, to the lower face of which is secured the piston-rod l, the latter extending downwardly through the diaphragm d' and into the tube f B^3. Both the piston and the opening in the diaphragm d', through which the piston-rod passes, are provided with hydraulic packing.

To the lower end of the piston-rod l a conical ring p is fastened. The piston P has a small hole h^3 bored vertically through its center, and another small hole h^4 is bored horizontally through the upper end of the piston-rod. These holes serve to allow the water in the upper end of the cylinder E to enter the space between the piston and diaphragm when the piston P is being raised. At the middle of the upper surface of the piston a stirrup s is fastened, to which two strings of fine chains of equal length—to wit, u' and u^2—are attached. These strings pass up vertically to a central opening h^5 in cap i, thence onto and around the sheaves S, down the annular space in compartment Q, between the cylinder E and shell of the buoy. The strings or wires are fastened to opposite points of ring-shaped weight R, which fits loosely in the annular space. The piston P is further provided with two vertical holes v^3, which are closed by valves v^4 when the piston is drawn upward, and which readily open when the piston is pushed downward in the cylinder.

The cylinder E is provided with holes h^6 immediately below the diaphragm d', to admit of the escape of air from the cylinder E when the instrument is immersed in water. The shell of the rheobathometer is perforated for the same purpose by holes h^7 below the diaphragm d and by holes h^8.

In the lower part of the space Q of section B are three vertical plates $j\ j$, which are radially arranged and attached to the shell and serve as supports for annular rings of metal M, which are employed when it is desired to reduce the buoyancy of the instrument.

A curved spring s^6 is fastened to the cap i; the free ends of the spring being located on opposite sides of the opening in the cap through which the strings pass and clamps the two strings $u'\ u^2$ when the free ends of the spring are in the position shown in Fig. 3; but when small knob k^2 is pushed in, so as to bring its outer end even with the surface of the shell, the small wedge w^2, attached to the rod connected with the knob, pushes the two branches of the spring apart and allows the strings to move.

The sinker S^3 is placed in the lowest portion of cylinder E. The body of the sinker is cylindrical in cross-section, its diameter being slightly less than that of the cylinder E. The sinker is provided with a central hole formed through its vertical axis to admit the tube f to pass freely through it. Its lower surface is shaped to the same form as the ogival upper end of the rheobathometer, and its top surface is of exactly the same form. At two points of its circumference the sinker is provided with vertical bars b^3, which are flush with the surface of the sinker and project a short distance above the upper outer edge thereof, and at their extreme upper ends carry hooks l^3, pointing inward.

A series of vertical grooves are cut into the surface of the sinker, as shown in Fig. 11, two of which—to wit, g^2—serve to secure the proper position of the sinker when it is placed in the instrument by means of the inwardly-projecting guides p^4, secured to the inner surface of the cylinder E, fitting within the vertical grooves in the sinker, and guide it vertically when it is released, and for the same purpose two vertical ribs y^3, formed on the inner surface of the cylinder E, and which fit into the vertical grooves g^3, formed in the outer surface of the sinker. The four vertical grooves g^3 in the circumference of the sinker are so arranged that the sinker, when detached from and leaving the instrument, will clear the four short pins p^4, which are attached to the inside of the cylinder E near its lower end.

On the top of the sinker rests the follower F, a cylindrical piece of metal having a central perforation of the same diameter as the corresponding hole in the sinker. The outside diameter of the follower is also the same as that of the sinker. Its bottom surface is congruent with the upper surface of the sinker, and its upper surface has the shape of an inverted cone.

The circumference of the follower is provided with two vertical grooves q^3, which are cut at opposite points, and these grooves fit over the vertical guides y^3 on the inside of the cylinder E. These grooves and guides serve to secure the proper position of the follower F and to guide it in its descent after the sinker has been discharged. Two square notches n^5 n^5, cut in the circumference of the follower F, serve to allow the passage of the hooks l^3 through the follower F without touching it when the sinker is discharged. There are other vertical grooves p^5 cut on the circumference of the follower, which allow it to pass by the pins p^4 p^4 without touching. Above these grooves p^5 stirrups of wire t^2 are fastened on the top of the follower, so arranged that they rest on the pins p^4 after the follower has descended, and that the lower surface of it is flush with the surface of the shell of the rheobathometer. The hooks l^3, attached to the sinker, rest while the instrument is descending through the water on two other hooks s^2, placed at the ends of the vertical arms of bent levers L. The bent levers L, with their vertical and horizontal arms, have their pivots on short shafts y, and these latter are supported by brackets b^7, attached to the sides of the cylinder E. Light springs s^5, attached to the sides of the cylinder, serve to press the vertical arms of the bent levers L outwardly and against the inner surface of the cylinder E. The tube f, when not pushed upward by striking the bottom, rests on the cross-bars b^8, attached to the sides of the cylinder E, the upper end of the tube being provided with a conical ring r^2, the lower end of which forms an annular seat which rests on the cross-bars b^3, as shown in Fig. 7. The cross-bar has a centrally-located circular opening of a diameter slightly larger than that of the tube, so that the latter can move freely up and down in it. The conical ring r^2 engages the horizontal arms of the bent lever L when the tube f is raised sufficiently, and serves to lift the arms and disengage the vertical hooked arms from the hooked bars on the sinker. That part of the tube f below the sinker when the latter is attached to the instrument has externally the same form as the portion of the tube c' protruding from the upper ogivic end of the shell. The weight of the tube f must be sufficient to prevent its being raised by the impact of the water on its lower end while the instrument is descending toward the bottom.

In the operation of the device the upper compartment Q′ is filled with naphtha, while the cylinder E is filled with water of the same specific gravity as that of the water in which the instrument is to be used. That part of the tube c' above the diaphragm d^2, including the glass tube g, in which a globule of potassium is suspended, is filled with naphtha. To prevent the naphtha escaping from tube g through the small openings h in the side of tube c', these holes are filled up with some substance—such as gelatine—which is insoluble in naphtha but soluble in water. The glass tube g is fastened to the wire-gauze w by the same kind of substance. The piston-timer, consisting of the weight R, sheaves S S, and strings u' u^2, as hereinbefore described, is shown as having been set to allow the piston to make a full stroke before the weight R causes the sinker to be detached. If it were desirable that the sinker should be detached in a shorter time, the piston would have to be set at some point between the position shown in the drawings and the cap i i of the cylinder. The length of time in which the piston makes a full stroke is ascertained by experiment, and when it is desired to actuate the releaser in a shorter space of time the spring e^6 is opened, which releases the cords u' and u^2 and allows the piston P to ascend the distance it would move in the interval between the time required by the piston to make a full stroke and the time in which it is desired that the releaser shall be actuated. The weight R is held from descending and raising the piston P and piston-rod l by the strings u' u^2 being clamped by the spring s^6 (see Fig. 3) until the instrument is being immersed, when the small knob k^2 is pushed in and the wedge w^2, driven between the ends of the spring, releases the strings and allows the piston P to be pulled up toward the top of the cylinder E by the weight R.

The filling of the tube t with naphtha and the insertion of the glass tube g with its suspended globule of potassium may be performed some time before the instrument is to be used. For this purpose tube c' and its cap c^2, with the glass tube g, glued to the wire-gauze w and containing the globule of potassium, are submerged in the same vessel, which is filled with naphtha until both are full and until all the air has escaped from them. The cap c^2 is placed in the cylinder c' while both are held under the surface of the naphtha. The holes in the cap are then temporarily stopped up to prevent evaporation of the naphtha. The indicator so prepared may be kept separate from the instrument until the latter is to be used.

When the instrument is to be used, the tube c' is placed on the top of the rheobathometer and the holes in the cap c^2 are opened. The instrument is then suspended by inserting the pointed ends of the pinchers P^4 (shown in Fig. 8) into the indentations n n in ring N, which is fastened to the upper end of the tube t. The pinchers are pressed against the ring by the operator pulling on string u^5, which is attached to the upper end of the pinchers, the string u^6 being at the same time held loosely in the hands of the operator. The rheobathometer is then gradually lowered into the water after the knob k^2 has first been pushed in to release the strings. The moment at which the timer is set going by the pushing in of the knob k^2 must be noted. As the instrument is being immersed below the surface of the water the air from the lower part of the buoy will escape through holes h^6 h^7 h^8 and the whole buoy below the diaphragm d will fill with water. As the instrument is still further lowered, the naphtha from tube t will also escape and will be replaced by water. After the instrument has been entirely submerged the naphtha inside cylinder c' will escape through holes h, except what is contained in the glass tube g. The whole cylinder c', with the exception of the glass tube, but including the small cap c^2, will then be filled with water. The rheobathometer is then allowed to depart toward the bottom by the operator pulling string u^6, and, letting loose string u^5, the jaws of the pinchers will open and discharge the instrument. The time when the instrument is released from the pinchers must be noted. The rheobathometer as soon as released from the pinchers will descend through the water and its velocity will be gradually increasing; but the increments of velocity will rapidly decrease as the resistance of the water increases with the square of the velocity, so that after a few seconds the instrument may be considered as having acquired a constant motion. For instruments traveling at a slow velocity no correction need be made on account of the gradual increase of velocity. For rheobathometers constructed to travel at a great speed the correction can readily be made. When the rheobathometer arrives at the bottom, tube f in striking will be retarded by the resistance of the material of which the bottom is composed, and the rheobathometer continuing its travel the horizontal arms of the bent levers will strike the conical piece or ring r^2 at the top of tube f and release the sinker. This cuts the connection between the sinker and the remainder of the instrument, and the gravity of the sinker, which has been the impelling force, ceases to act. The buoyancy of the instrument will cause it to reascend toward the surface, the sinker being, of course, left at the bottom. The piston of the timer has meanwhile been kept moving and will continue to do so until it reaches its highest position, but it can in no wise interfere with the further ascent of the instrument. If the piston of the timer is set so as to reach the upper end of its stroke before the instrument reaches the bottom, the conical ring p, attached to the lower end of the piston-rod, will turn the bent levers and release the sinker. If the rate at which the instrument of a certain form travels under the impulse has been ascertained by experiment and the time elapsing between the moment when the instrument was discharged and when it reappears on the surface has been observed, the depth of water can readily be ascertained. If the velocity due to a given weight of sinker has by experiment been found as being v', and the velocity due to a certain buoyancy has been ascertained as being v^2, and if the time in seconds during which the instrument was submerged is T, the depth d is $d=\frac{(v'+v^2)}{v'v^2}T$. If the force impelling the instrument to descend is equal to the force causing it to ascend, which can be readily arranged by making the weight of the sinker (in water) exactly double the weight in water required to overcome the buoyancy of the instrument without the sinker, the time required for the descent and ascent of the instrument will be equal and the depth $d=\frac{2T}{v}$, provided that the form of the instrument is symmetrical and offers the same resistance to motion in both directions. It is absolutely necessary to make these forces equal when the velocities due to the action of certain weights are to be ascertained by experiments which are instituted in deep water whose depth is known.

There will be certain disturbing causes which affect the uniformity of motion, as, for instance, the changes in the density of water at different depths or from difference in temperature of the water, also the compressibility of naphtha or similar liquid with which the upper compartment Q is filled, and of the material of which the instrument is constructed; but it would be easy to show that proper corrections can readily be made, and that the instrument itself may be used for ascertaining the necessary co-efficients to be used for making such corrections. If the piston of the timer is set at such an elevation in the cylinder E that it will complete its stroke before the rheobathometer reaches the bottom, the velocity of the annular weight R will be accelerated as soon as the piston reaches the lower edge of the recesses cut in the sides of the cylinder, and the conical piece p, attached to the lower end of the piston-rod, will strike the horizontal arms of the bent levers with sufficient force to actuate them and cause the discharge of the sinker and the rheobathometer to ascend to the surface.

The rate of travel of the rheobathometer under the impulse of a certain weight or force being known, and the total time consumed in its ascent and descent having been observed, the depth below the surface to which the instrument has penetrated can be calculated in the same way as in the case where the instrument descended to the bottom. It will not be necessary for this purpose that the timer should act like a regular time-piece, unless it is desirable that the instrument should descend to a certain precise depth, which for the purpose above indicated will rarely be required. When the instrument arrives at the surface of the water on its return from the depth to which it had been penetrated, its upper part will rise above the surface more or less, according to its buoyancy. By this time the gelatine, which has been used for sealing the small holes h and for attaching the glass tube g in the tube c, will have dissolved in the water and the glass tube will, from the buoyancy of the naphtha contained in it, float on the water surrounding it; but when the tube c' rises above the surface of the water the water contained in that tube will escape through the small holes h, and the glass vessel, with its globule of potassium, will follow downward. When the potassium reaches the water contained in the small cup c^3, it will suddenly ignite, break the glass vessel, and set the naphtha which had been contained in the glass vessel on fire. The smoke caused by the burning of the naphtha in day-time and the light emitted from it at night will indicate the place where and the time when the instrument has arrived at the surface. The use of the indicator of course is only required when the instrument is expected to be under the surface of the water for a considerable time. The indicator may, however, also be used to great advantage if soundings are to be taken by a ship traveling at full speed. For such soundings a cheaper form of reobathometer would be used and no effort made to recover the instrument. The time elapsing between the discharge and reappearance of the instrument, as stated, gives the depth, and if the location of the points at which the indicator enters the water and reappears therefrom can be measured from some fixed point a line drawn between these points will give the average direction and the distance between these points, the average velocity of the currents prevailing between the surface and the point to which the instrument had descended. If the total time elapsing between the discharge and reappearance of the instrument is called T, the rate of vertical travel of the instrument (arranged for equal forces and equal resistances in both directions) v, and the distance between the point of discharge and reappearance of the instrument 1, the depth is $d=\frac{Tv}{2}$ and the average velocity of current, $\frac{1}{T}$. The bearing of the line joining the two points on the surface where the instrument was discharged and reappears gives the average direction of the current.

This application is a division of my original application, filed June 30, 1887, Serial No. 242,968.

Having fully described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. A rheobathometer constructed to present an equal resistance to its passage through the water in the direction of its axis both in ascending and descending, and provided with a detachable sinker and sinker holding and releasing devices, the latter being located within the shell of the rheobathometer.

2. A rheobathometer the shell or casing of which is formed to present an equal resistance to its passage through the water in the direction of its axis both in ascending and descending through the water, said shell being divided into two compartments, one to contain liquid, which serves to give buoyancy to the shell, and the other to contain the devices for operating the rheobathometer, substantially as set forth.

3. The combination, with a shell or casing divided into compartments, of a tube open at the upper end and descending to the bottom of one compartment set apart for containing the liquid used for giving buoyancy to the rheobathometer for the purpose of equalizing the inside and outside pressure, the said tube being perforated at its bottom.

4. The combination, with a shell or casing divided into compartments, of a sinker secured to the shell and so shaped that when in place the outside surface of the instrument at its lower end is of the same form as the upper end.

5. The combination, with a shell or casing divided into compartments and a sinker so arranged that when in place the outside surface of the instrument at its lower end is of the same form as the upper end, of a follower for restoring the symmetrical form of the surface of the buoy when the sinker has been discharged.

6. In a rheobathometer, the combination, with shell or casing, a timer, and a sinker, of a releaser for discharging the sinker both by striking bottom and by the timer.

7. The combination, with a rheobathome-

ter, of a timer by means of which the sinker may be discharged after a certain lapse of time, for the purpose heretofore stated.

8. The combination, with a rheobathometer, of the indicator for indicating by light or sound, or by both light and sound, the reappearance of the rheobathometer at the surface.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

HENRY FLAD.

Witnesses:
A. W. BRIGHT,
R. S. FERGUSON.