No. 771,363. PATENTED OCT. 4, 1904.

W. FERRIS.

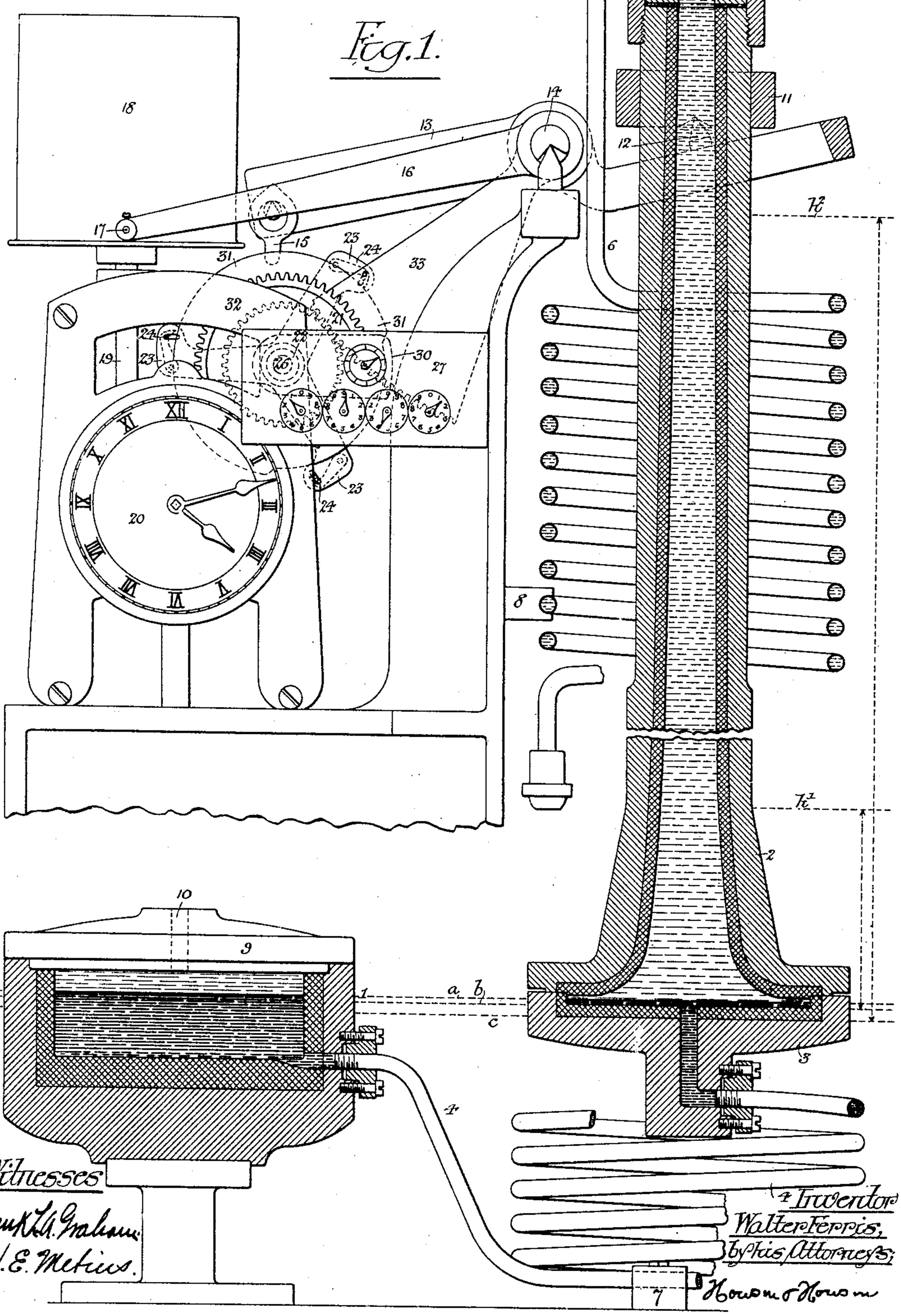
INTEGRATING APPARATUS FOR WATER METERS, &c.

APPLICATION FILED SEPT. 5, 1902.

NO MODEL.

3 SHEETS—SHEET 1.

Fig. 1.



Witnesses

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NO MODEL. 3 SHEETS—SHEET 2.

Fig. 2.

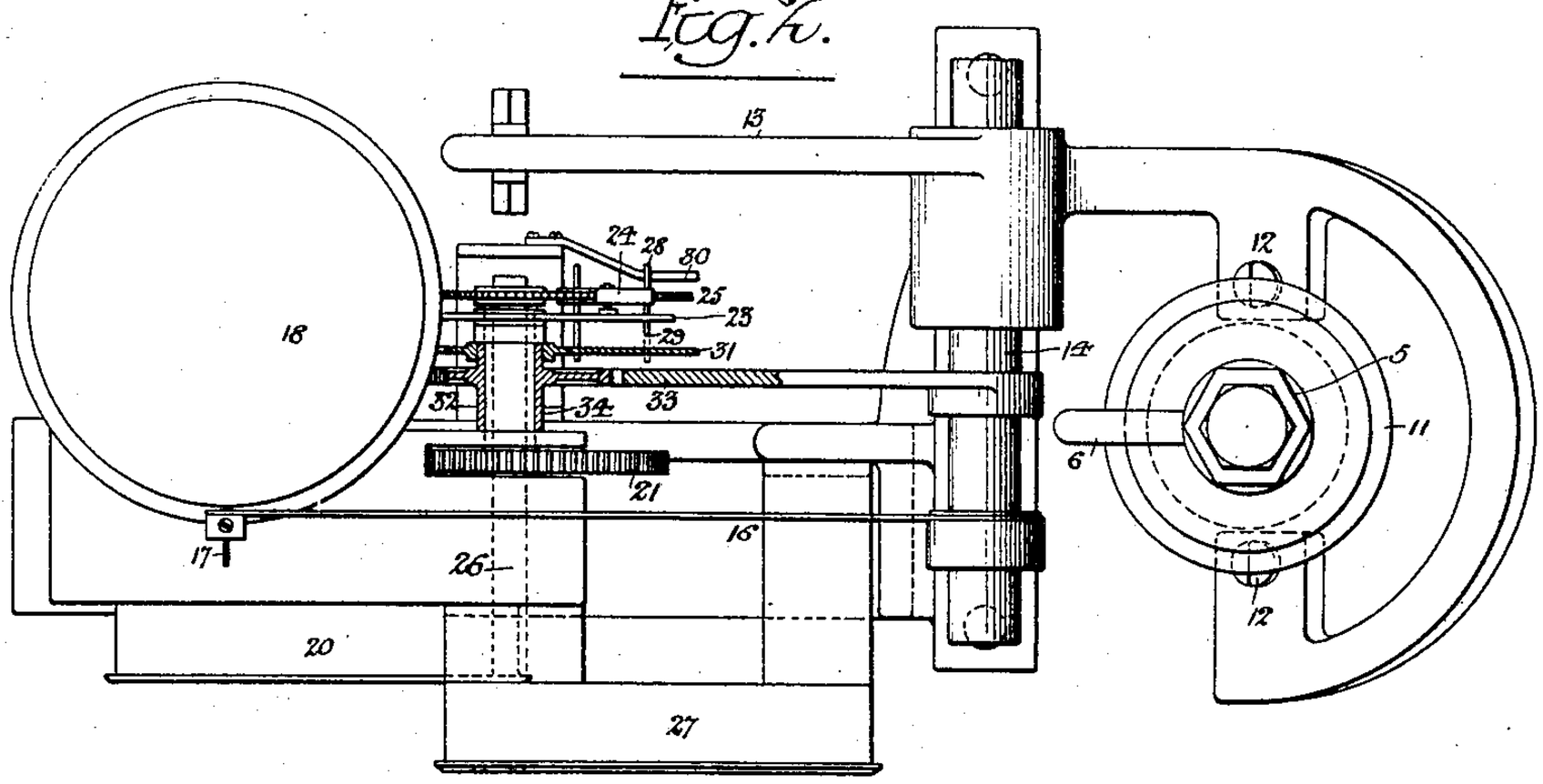

Fig. 5.

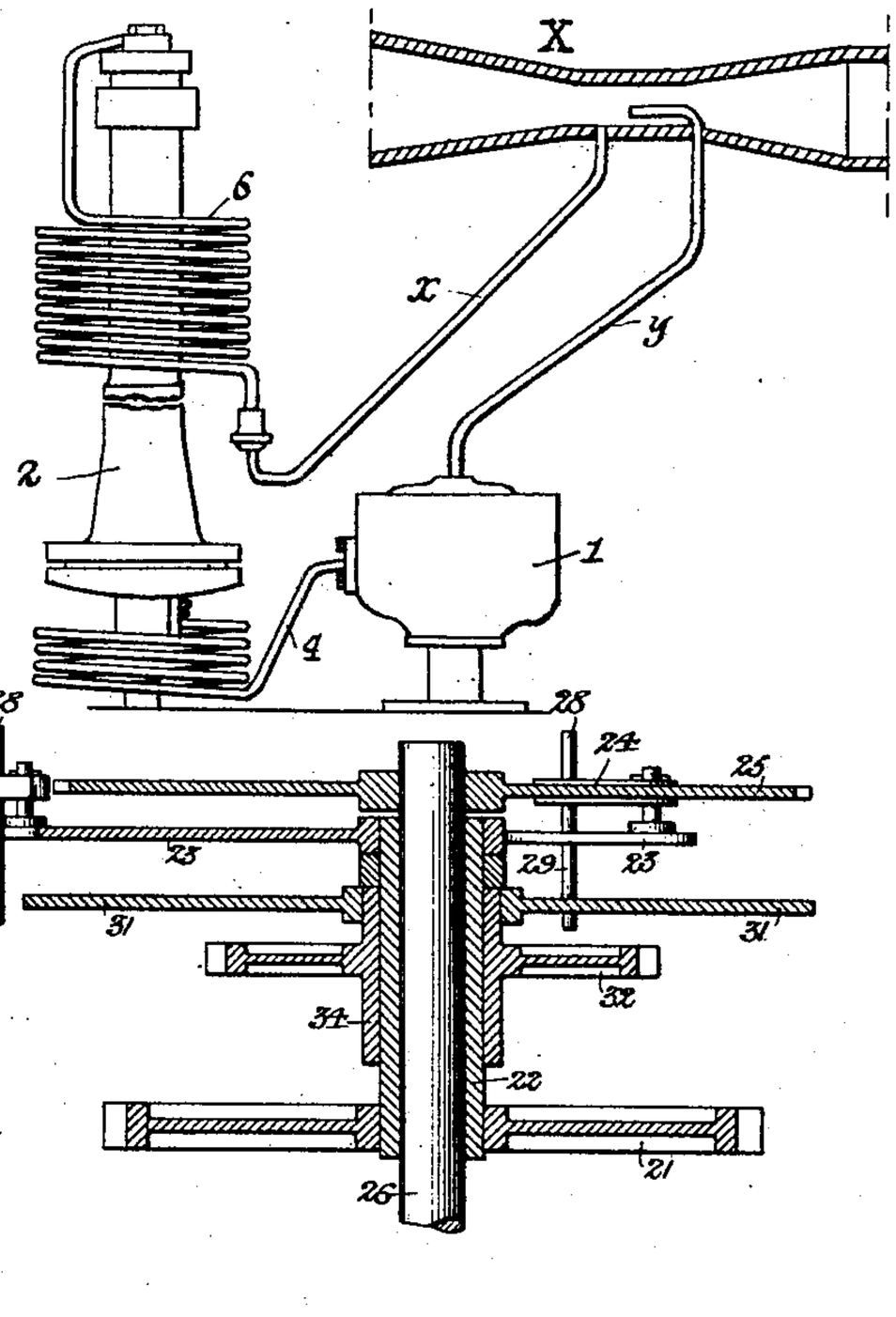

Fig. 3.

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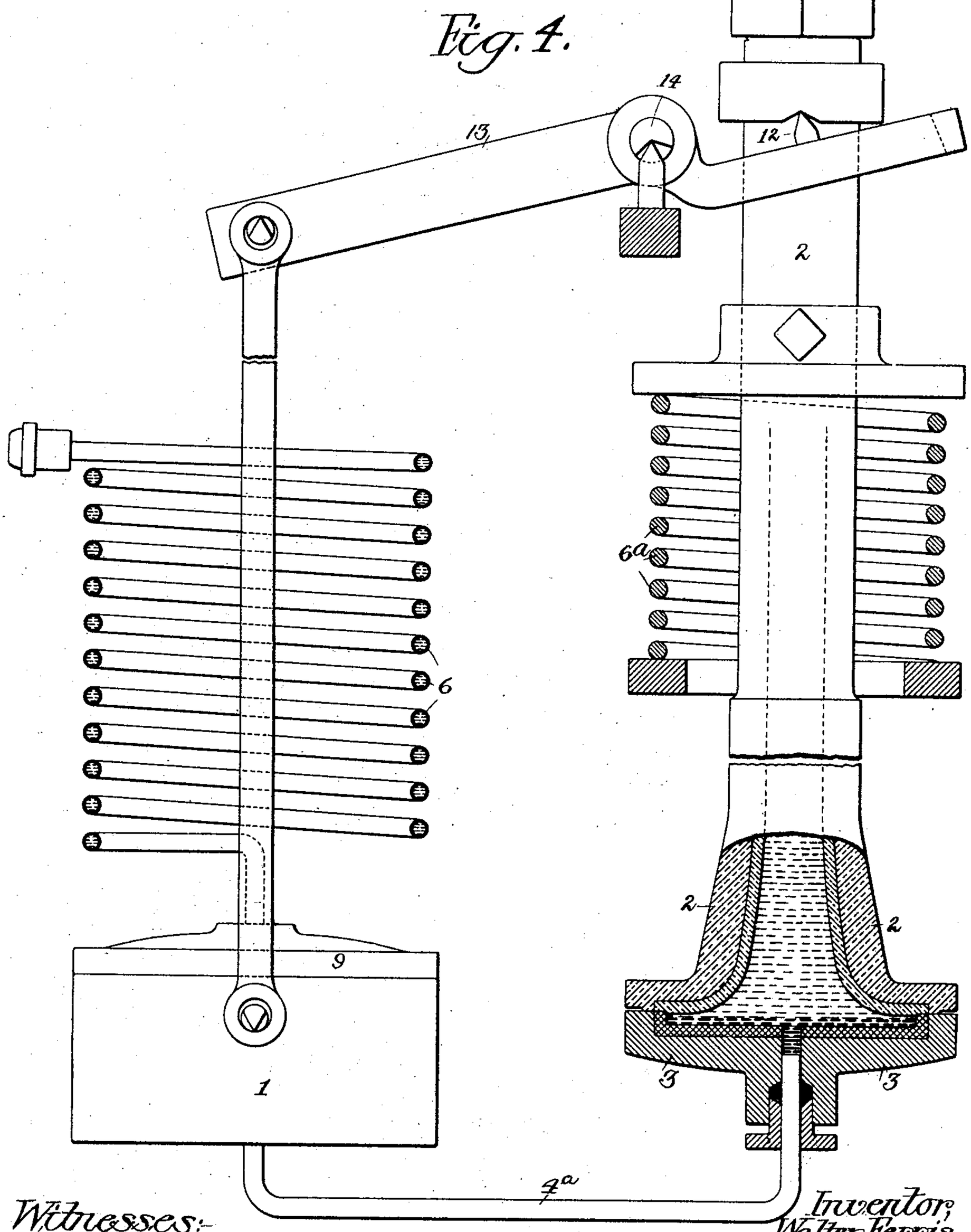
NO MODEL. 3 SHEETS—SHEET 3.

Fig. 4.



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No. 771,363. Patented October 4, 1904.

UNITED STATES PATENT OFFICE.

WALTER FERRIS, OF PHILADELPHIA, PENNSYLVANIA.

INTEGRATING APPARATUS FOR WATER-METERS, &c.

SPECIFICATION forming part of Letters Patent No. 771,363, dated October 4, 1904.

Application filed September 5, 1902. Serial No. 122,218. (No model.)

To all whom it may concern:

Be it known that I, WALTER FERRIS, a citizen of the United States, residing in Philadelphia, Pennsylvania, have invented certain Improvements in Integrating Apparatus for Water-Meters, &c., of which the following is a specification.

The object of my invention is to provide a simple and accurate form of integrating device for use in connection with water-meters and like apparatus for measuring flow or pressure of fluids.

In the accompanying drawings, Figure 1 is a view, partly in side elevation and partly in section, of the main elements of an integrating device constructed in accordance with my invention. Fig. 2 is a plan view of the same. Fig. 3 is an enlarged sectional plan view of part of the device. Fig. 4 is an elevation, partly in section, illustrating certain modifications of my invention. Fig. 5 is a view showing the connection of my improved apparatus to a fluid-conducting tube.

The apparatus comprises two receptacles jointly containing a body of liquid (usually mercury) of greater specific gravity than the fluid to be measured, certain connections between said receptacles and between the same and the tube through which the fluid to be measured flows, and certain weighing and recording apparatus, all as hereinafter set forth.

1 represents a receptacle made of any available material and lined with a substance which will not be affected by and will not affect the mercury or the fluid to be measured, and 2 is a similarly-lined receptacle in the form of a column having an internal profile of the character hereinafter set forth, the bottom head 3 of this column communicating through a tube 4 with the lower portion of the receptacle 1. The top head 5 of the column 2 communicates with a tube 6, and both of the tubes 4 and 6 form coils rigidly mounted at some point in their convolutions, so that all of that portion of each coil which intervenes between its point of rigid support and its point of connection with the column 2 constitutes a spring, which will be compressed by any downward movement of the column caused by an increase of the load which it has to carry. In the present instance the lower tube-spring 4 is supported at 7 and the upper tube-spring 6 is supported at 8; but the point of support is immaterial so long as the desired function of the tube-spring is attained.

The receptacle 1 constitutes a reservoir for the supply of mercury or other liquid of greater specific gravity than that of the fluid to be measured, and this liquid also fills the lower tube-spring 4 and the lower portion of the column 2, the zero-level of the liquid being the same in both reservoir and column.

The cap or cover 9 of the reservoir 1 has an opening 10 therein, whereby when the device is used in connection with a water-meter said reservoir is placed in communication with the flowing body of water which is to be measured, and the lower end of the tube-spring 6 is likewise intended to be in communication with said flowing body of water, the connections being such, however, that the pressure exerted upon the contents of the reservoir 1 will exceed that exerted upon the contents of the column 2, the intensity of said excess pressure depending upon the velocity of the flow through the meter-tube. For instance, the lower end of the tube-spring 6 may be in communication with the static pressure-tube x of a meter, whose Venturi tube is shown at X, of the character set forth in my application for patent filed June 27, 1899, as illustrated in Fig. 5, while the reservoir may be in communication with the pitot-tube y of such apparatus. When there is no flow of fluid through the meter-tube, the level of mercury in the reservoir 1 and column 2 will be the same; but when the fluid is flowing through the meter-tube and the pressure upon the mercury in the reservoir 1 is greater than the pressure upon the mercury in the column 2 said mercury will rise in the column 2 to a certain height above the level of the mercury in the reservoir, depending upon the velocity of flow in the meter-tube, and by imparting a proper profile to the bore of the column the volume of mercury which is transferred from the reservoir thereto may be so proportioned in respect to the velocity of flow through the meter-tube that the weight of the column will give a substantially accurate indication of the

velocity of flow, and this being known the volume of flow can be readily computed therefrom.

The column 2 has near its upper end a ring or collar 11, which is mounted, by means of knife-edge bearings 12, upon a lever 13, whose spindle 14 is likewise mounted upon knife-edge bearings on the fixed structure of the device. The lever 13 is intended to be provided with a suitable weight for counterbalancing the weight of the column 2 when the mercury-level therein is at the zero-point, and in the present instance the lever 13 is provided with a pivoted hook 15 for the reception of such a weight. The scale-lever spindle 14 has a projecting arm 16, the outer end of which is furnished with a pointer 17, intended to produce a graphical record upon a chart-paper carried by a vertical drum 18, which is secured to the upper end of a vertical spindle 19, the latter being driven from some available member of the gear-train of the clock 20 in such manner that the drum 18 will make one complete revolution in a predetermined interval of time. The clock-train is also intended to drive a spur-wheel 21, which in the present instance is secured to a tubular shaft 22, having a frame or spider with three arms 23, each of which carries a pivoted pawl 24, adapted to engage with the teeth of a ratchet-wheel 25, mounted on a shaft 26, which passes through the tubular shaft 22 and operates the gear-train of a registering device 27 of any ordinary type. Each of the pawls 24 is provided with two projecting pins 28 and 29, as shown in Fig. 2, the pins 28 being acted upon by a fixed throw-out cam 30 on one side of the ratchet-wheel 25 and the pins 29 being adapted to bear upon a cam-disk 31, which is located on the other side of the ratchet-wheel 25, this cam-disk 31 having high and low portions bearing such relation to the toothed periphery of the ratchet-wheel 25 that when the pin 29 of either pawl bears upon the high portion of the cam-disk said pawl is prevented from engaging with the ratchet-teeth; but when a low portion of the cam-disk is beneath the pin 29 the pawl is permitted to drop into engagement with the ratchet-teeth. The plate 30 is so disposed as to move the pawl out of engagement with the ratchet-teeth at a certain point in their travel, and the pawls then hang free from the ratchet-wheel and do not engage the same until they rise on the opposite side of the wheel. Hence the time during which a pawl is permitted to remain in engagement with the ratchet-wheel depends upon the distance between the high portion of the cam-disk 31 and the point at which the pawl is disengaged from the ratchet-wheel by the throw-out plate 30. In order that this distance may be governed by the rise and fall of the column 2, the cam-disk 31 is carried by a sleeve 34, which is also provided with a spur-wheel 32, and with the latter meshes a toothed segment 33, carried by the spindle 14 of the scale-lever 13. Hence any rising movement of the column 2, indicative of a decreased rate of flow of fluid through the meter-tube, will cause the high portion of the cam-disk 31 to approach the throw-out plate 30, and thereby decrease the length of its segmental path of travel, during which each pawl 24 can engage with the ratchet-wheel 25, a downward movement of the column, indicative of an increased rate of flow in the meter-tube, causing a reverse action. Fig. 1 shows the column 2 in its highest position or position of zero registry. The end of the high portion of the cam-disk 31 is then immediately opposite to the beginning of the throw-out plate 30, as shown. When the mercury rises in the column, causing the column to descend, the high part of the cam-disk moves away from the plate 30, thus uncovering an arc on the circumference of the ratchet-wheel 25 to the action of the pawls as they pass. The arc is always substantially proportional to the travel of the mercury-column 2, which travel may, as hereinafter explained, be made to bear a variable ratio to the height of mercury in the column by means of a variable horizontal sectional area in the bore of the column. My invention, broadly considered, therefore is to be regarded as a machine for integrating the product of time into some variable quantity which is a function of the difference of two fluid-pressures. In the case of a water-meter the variable factor is the velocity of water flowing through the meter-tube, which is by preference a tube of the Venturi type, and the difference of the two pressures is approximately proportional to the square of this velocity. Hence the function of the difference of pressures is the square root, and the register should be provided with some part whose motion or position relatively to a zero position is proportional to the square root of the pressure difference.

As before stated, when the pressure upon the mercury in the reservoir 1 and that upon the mercury in the column 2 are equal the mercury will stand at the same level in each and the scale will be balanced at zero; but when the pressure on the mercury in the reservoir 1 exceeds that upon the mercury in the hanging column 2 the mercury will rise in the latter until the mercury height balances the excess of pressure and the deflection of the scale-beam will indicate the weight of the mercury which has entered the column from the reservoir. Bearing in mind that the height of the mercury is always proportional to the pressure difference, no matter how large, small, or variable the cross-section of the mercury-column may be, the weight of the mercury can be made proportional to a function of this pressure difference by making the horizontal sections of the mercury-column vary so that the volume of mercury

contained in the column from the zero-point up to any height h^2 is to the volume from zero-point up to any height h' as the value of the given function of the pressure difference which produces the head h^2 is to the value of the pressure difference which produces the head h'. In the case of a water-meter, therefore, it is only necessary to shape the mercury-column so that its volumes above the zero-point are proportional to the square roots of the corresponding heights and the weight of the mercury in the column will be always proportional to the velocity of the water through the Venturi tube and adding these weights together at equal periods of time will give a cumulative sum proportional to the total quantity of water passed. In using this profiled mercury-column it is necessary that all of the variable heights h', h^2, &c., shall be measured from the zero-line or base of the profile, and as these heights are also the distances that the mercury in the column rises above that in the reservoir it is evidently necessary that the base-line of the profile shall always be on the same level as the mercury in the reservoir. This will be understood on reference to the dotted lines *a*, *b*, and *c* in Fig. 1, *a* being the normal zero, *b* the zero for the mercury-height h', and *c* the zero for the mercury-height h^2. The mercury in any reservoir of finite size must fall as the mercury is transferred to the column, and the amount of this fall in a reservoir of constant cross-section is proportional to the weight transferred. The deflection of the spring-coils supporting the mercury-column is also proportional to the weight transferred. Hence it is necessary to make the stiffness of the springs and the diameter of the reservoir in a certain relation to each other in order that the mercury-column may descend just as far as the mercury-level in the reservoir descends.

As the proper operation of the registering apparatus of my improved meter is dependent upon the weight of the displaced mercury, it is evident that either the reservoir or the column into which the mercury is forced from the reservoir may be the element which is weighed, or one of these elements may be carried by one arm and the other by the other arm of the scale-lever by providing suitable flexible connections between them. (See Fig. 4.)

While I prefer in all cases to use a tube-spring both at top and bottom of the mercury-column 2, such spring may be used at one end of the column only, if desired, the tube 4^a at the other end of the column being simply flexible, as shown and described in a divisional application for patent filed by me, or passing through a suitable stuffing-box, as shown in Fig. 4, and although I prefer to cause the mercury-tube to act upon a scale-beam and to cause the movement of the latter to operate registering apparatus the rising and falling column of mercury may be caused to produce a record in other ways. When neither of the tube connections 4 and 6 of the mercury-column is elastic, so as to serve as the spring member of the spring-scale construction, some equivalent spring connection with the mercury-column or with the scale-lever should be provided. Such independent spring-support is shown at 6^a in Fig. 4.

Having thus described my invention, I claim and desire to secure by Letters Patent—

1. The combination in apparatus for integrating a function of fluid-pressures, of two connected receptacles jointly containing a body of liquid of greater specific gravity than that of the fluid to be measured, the area of cross-section of one of said receptacles being definitely varied relatively to its distance from a level of reference, and means whereby differential pressures derived from the fluid to be measured cause flow of said heavy liquid from one receptacle to the other, substantially as specified.

2. The combination in apparatus for integrating a function of fluid-pressure, of two connected receptacles jointly containing a body of liquid of greater specific gravity than that of the fluid to be measured, the area of cross-section of one of said receptacles being definitely varied relatively to the distance from a level of reference, means whereby differential pressures derived from the fluid to be measured cause flow of said liquid from one receptacle to the other, and a scale operatively connected to the receptacles for weighing the liquid so transferred, substantially as specified.

3. The combination in apparatus for integrating a function of fluid-pressure, of two connected receptacles jointly containing a body of liquid of greater specific gravity than that of the fluid to be measured, the area of cross-section of one of said receptacles being definitely varied relatively to the distance from a level of reference, means whereby differential pressures derived from the fluid to be measured cause flow of said liquid from one receptacle to another, a scale operatively connected to the receptacles for weighing the liquid so transferred, and a graphical recording device controlled by said scale, substantially as specified.

4. The combination in apparatus for integrating a function of fluid-pressure, of two connected receptacles jointly containing a body of liquid of greater specific gravity than that of the fluid to be measured, the area of cross-section of one of said receptacles being definitely varied relatively to the distance from a level of reference, means whereby differential pressures derived from the fluid to be measured cause flow of said liquid from one receptacle to the other, a scale operatively connected to the receptacles for weighing the

liquid so transferred, and a counting-register controlled by said scale, substantially as specified.

5. The combination in apparatus for integrating a function of fluid-pressures, of two connected receptacles jointly containing a body of liquid of greater specific gravity than that of the fluid to be measured, the area of cross-section of one of said receptacles being definitely varied relatively to the distance from a level of reference, means whereby differential pressures derived from the fluid to be measured cause flow of said liquid from one receptacle to the other, a scale operatively connected to the receptacles for weighing the liquid so transferred, a graphical recording device and a counting-register, both controlled by said scale, substantially as specified.

6. The combination in apparatus for integrating a function of fluid-pressures, of two connected receptacles jointly containing a body of liquid of greater specific gravity than that of the fluid to be measured, means whereby differential pressures derived from the fluid to be measured cause flow of said liquid from one receptacle to the other, a scale for weighing the liquid so transferred, a registering device having as its initial element a ratchet-wheel, and a rotating pawl-carrier, means for throwing the pawl out of engagement with the ratchet-wheel at a certain point in its rotation, and a cam-plate operatively connected with the scale and determining the point at which the pawl is permitted to engage with the ratchet-wheel, substantially as specified.

7. The combination in apparatus for integrating a function of fluid-pressures, of two connected receptacles jointly containing a body of liquid of greater specific gravity than that of the fluid to be measured, means whereby differential pressures derived from the fluid to be measured cause flow of said liquid from one receptacle to the other, a scale for weighing the liquid so transferred, said scale having as an element a tube which constitutes both a spring for the scale and a conduit for the flow of liquid into or out of the receptacle which is being weighed, substantially as specified.

8. The combination in apparatus for integrating a function of fluid-pressures, of two connected receptacles jointly containing a body of liquid of greater specific gravity than that of the fluid to be measured, means whereby differential pressures derived from the fluid to be measured cause flow of said liquid from one receptacle to the other, and a scale for weighing the liquid so transferred, elements of said scale being tubes each of which constitutes a spring for the scale, and also a conduit for the flow of fluid from and to the receptacle which is being weighed, substantially as specified.

9. The combination in apparatus for integrating a function of fluid-pressures, of two connected receptacles jointly containing a body of liquid of greater specific gravity than that of the fluid to be measured, means whereby differential pressures derived from the fluid to be measured cause flow of said liquid from one receptacle to the other, and a scale for weighing the liquid so transferred, elements of said scale being tubes each of which constitutes a spring for the scale, one of said tubes forming a conduit for the flow of said heavier liquid to and from the receptacle which is being weighed, and the other forming a conduit for the flow of the liquid which is being measured to and from said receptacle, substantially as specified.

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

WALTER FERRIS.

Witnesses:
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JOS. H. KLEIN.