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C. W. GIRVIN

GRADOMETER

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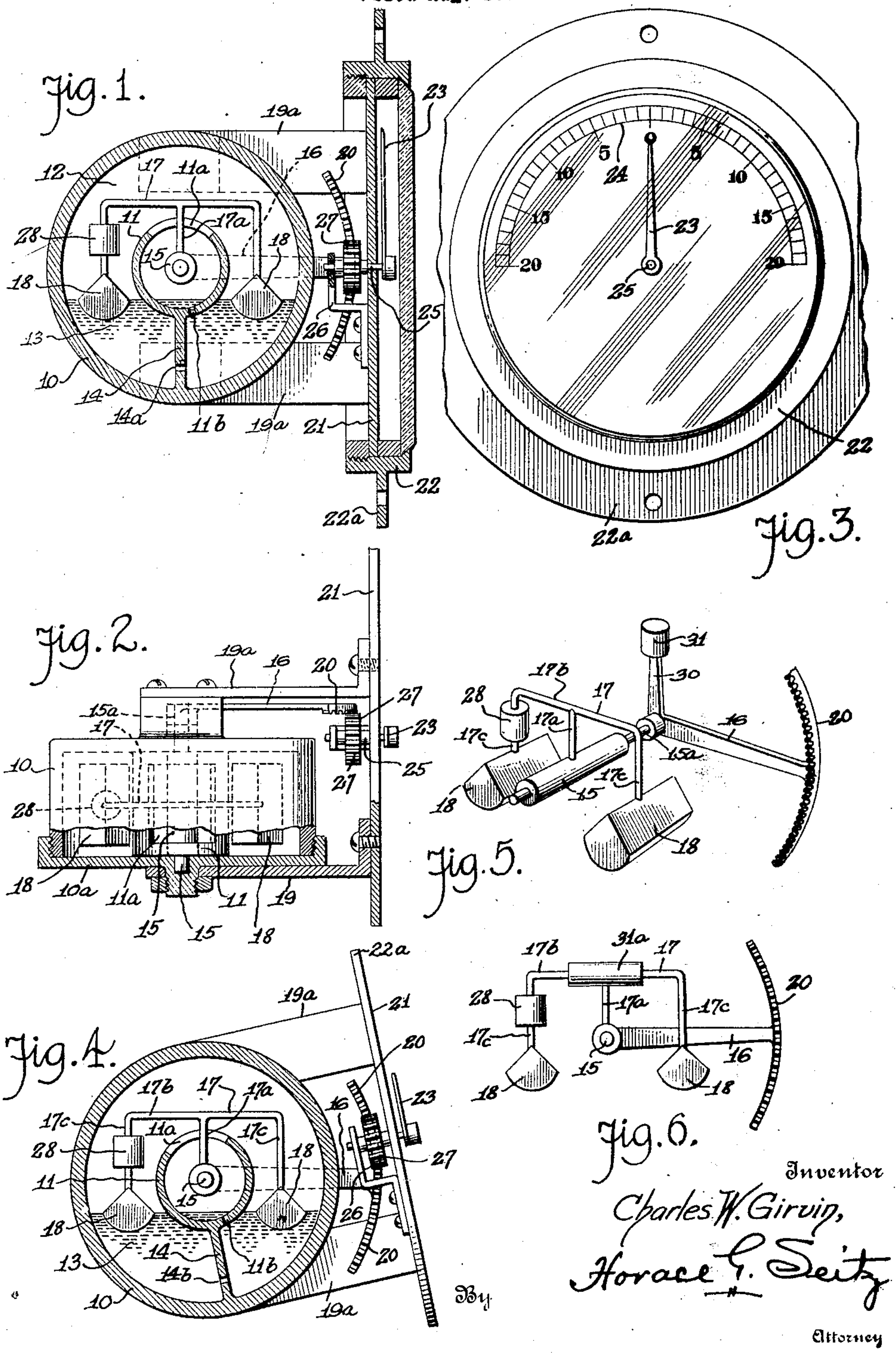

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GRADOMETER.

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To all whom it may concern:

Be it known that I, Charles W. Girvin, a citizen of the United States, residing at Buena Park, in the county of Orange and State of California, have invented certain new and useful Improvements in Gradometers, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to improvements in gradient meters, pertaining more particularly to devices designed to indicate the variations in grades, etc., automatically.

The invention may be employed in various lines of service, as for instance, in submarines, in motor vehicles, or in airplanes, these uses being to ascertain the variation from a normal horizontal plane, but, for the purposes of illustration, the device is shown as employed in connection with a motor vehicle, to indicate the grade over which the vehicle may be travelling.

The objects of the invention are to provide a device of this general character which is simple and efficient in operation, durable in construction, readily installed, and which can be manufactured at a relatively low cost. In addition, the object is to provide a device that is accurate in its indications, and which is sufficiently sensitive to changes in conditions and responsive to such changes as will provide for efficiency in use, and at the same time prevent temporary and abnormal conditions from materially affecting the general operation.

To these and other ends, the nature of which will be readily understood, the invention consists in the improved construction and combination of parts hereinafter more particularly described, illustrated in the accompanying drawings, and particularly pointed out in the appended claims.

In the accompanying drawings, in which similar reference characters indicate corresponding parts in the several views,—

Figure 1 is a vertical sectional view taken through the device, the parts being shown in position when the vehicle is traveling in a truly horizontal plane.

Figure 2 is a top plan view, partly in section, of the same.

Figure 3 is a face view of the same.

Figure 4 is a view of the type of Fig. 1, the parts being in the positions assumed when the vehicle is traveling on a downward grade of a certain angle.

Figure 5 is a perspective view showing a portion of the operating mechanism.

Figure 6 is a side elevation of parts shown in Fig. 5, the same presenting a slightly modified form.

As in devices of this general type, the present invention is designed to set up the conditions of relative movement between two coacting parts of the mechanism, one of these parts being practically held constant relative to a horizontal plane, the other part shifting relative thereto in such manner as to indicate, in some form or another, the angular relation of the line that represents the road over which the vehicle is travelling bears to such horizontal plane.

In the present invention the maintenance of the conditions of the horizontal plane is dependent upon a suitable liquid, preferably mercury, the specific gravity of this liquid aiding in securing efficiency, although other liquids may be used to provide for serviceable results. The shiftable part is carried in a fixed position by some part of the vehicle which changes its angle as the vehicle follows the contour variation of the road.

The device itself, in the particular embodiment shown in the drawings, is in the form of a cylindrical casing 10, having its axis extending in a horizontal direction and transverse to the direction of travel of the vehicle, the casing carrying a wall 11 of materially smaller external diameter than the internal wall of the casing, and concentric therewith, the two walls thus forming an annular chamber 12, the axial length of the cylinder being as desired, being sufficient to permit of the carrying of a sufficient amount of mercury within such chamber as to provide for efficient operation, the mercury being indicated at 13.

The two concentric walls are connected by a partition 14, which may, if desired, be formed integral with either or both walls, this partition extending throughout the axial length of the chamber and preferably extends radially. It is preferred that this partition be positioned within the chamber in such manner that when the device as a whole is indicating that the vehicle is travelling on a truly horizontal plane, the partition will extend in a truly vertical plane. This is not actually essential, however, and may be varied, if desired, the purpose being to divide the mercury into two bodies—the partition being at the bottom of the chamber—and then connect these mercury bodies by a small port 14^a in the partition, the port being adjacent the bottom of the chamber. The two mercury bodies are thus in direct communication through the port, and transference of mercury from one side to the other of the partition can and will take place as the instrument is being used.

Casing 10 may have its ends formed in any suitable manner, one form being that of having one end integral with the casing cylindrical wall, the opposite end being closed by a cap threaded to the casing; this form is shown in the drawing, the cap being indicated at 10^a. Other ways of producing a closed chamber 12 may be employed, the arrangement being such that the partition will properly fit the end walls—or possibly formed integral with one or both—so that transference of mercury around the ends of the partition is practically prevented.

The opposing end walls carry suitable bearings for a shaft 15 which extends in the axis of the concentric walls of the chamber, one of the ends of the shaft, indicated at 15^a, extending beyond the end wall to receive an arm 16, presently referred to. The other end of the shaft may be stepped in or extend through the opposite end wall, as may be desired.

The portion of shaft 15 located between the end walls is provided with an upwardly extending arm 17^a which forms part of a frame 17 formed of the arm 17^b projecting normal to the direction of length of arm 17^a, and having its ends 17^c extending downwardly, preferably parallel to arm 17^a but spaced therefrom a distance sufficient to permit the free ends of the arms 17^c to be located approximately midway of the distance between the circular walls of the chamber. Arms 17^c carry floats 18, of suitable formation, arms 17^c being of the same length so that the floats, when arm 17^a is in a truly vertical position, will lie in a horizontal plane. Arm 17^a extends upwardly from shaft 15, and has a length such as to locate arm 17^b wholly within the chamber, wall 11 having an opening 11^a to permit the passage of arm 17^a, and of an angular length sufficient to cover the angular distances that may be included within the metering limits of the device.

Since the surface of the mercury normally remains on a horizontal plane, it will be readily understood that floats 18, when resting on that surface, will retain arm 17^a in the vertical plane when the mercury is in equilibrium, even though the casing 10 should be shifted rotatively on its axis. If the shift of the casing be gradual and at low speed, the mercury will remain in practical equilibrium due to the transference of mercury through port 14^a—it being understood that shifting of the casing will shift the position of partition 14. Where the shifting of the casing is sudden or with rapidity, there may be a small tendency to lag in responsiveness, since the amount of mercury transferrable per unit of time is limited by the size of the port 14^a. Under these latter conditions, the surface of the mercury in the chamber on opposite sides of partition 14 will momentarily vary from the single horizontal plane, due to the pushing action of the partition on one of the bodies to elevate its surface and the lowering of the surface of the other body due to the increase in space available at the bottom to receive the mercury of the body; but equilibrium is quickly restored by the transfer of mercury from the high surface side of the mercury through port 14^a. As the surface of the mercury changes the position of arm 17^c will change correspondingly due to the action of the floats.

Owing to the possibility of a "splashing" of the mercury, wall 11 may have a port 11^b leading to the chamber at one side of partition 14, this port permitting escape of any mercury that may pass through opening 11^a. As will be understood, splashing confined to shifting mercury within the chamber provides no material damage, since it simply returns to the body of mercury. In this respect, the curvature of the walls is of advantage in that any abnormal splashing effect would tend to throw the mercury drops inward away from the floats and on to the wall 11. A greater advantage however, in the concentric cylindrical wall formation is found in the fact that while the walls may move relative to the floats, the latter always maintain the same relative position with respect to the walls, due to the fact that the walls have their movement on the same axis as the frame 17, and being concentric with such axis the floats will have the same spacing relative to the walls regardless of the position of the casing in its rotative movement.

As will be understood the casing 10, wall 11 and partition 14 move in unison relative to shaft 15 and the parts carried by the latter. To support the casing to permit this result to be obtained any suitable support which will hold the casing rigid with the part of the vehicle on which the device is mounted, is employed. A simple arrangement shown in the drawing is that of a bracket 19 connecting cap 10^a with a part of the indicator portion of the device, and a pair of brackets 19ª connecting the opposite end wall of the casing to such part, thus permanently fixing the relation between the indicator part and the casing. Brackets 19ª are spaced from the casing end wall a distance sufficient to permit the location of arm 16 within such space and outside of the casing.

Arm 16 carries, at its outer or free end, a segmental rack 20, the teeth of which are adapted to engage a pinion of the indicating mechanism which will now be described.

In the embodiment of the drawing, 21 indicates the part to which brackets 19 and 19ª are secured, this part being that shown as the dial plate of the indicator. This plate 21 is carried by a suitable casing 22, which may, if desired, have an annular flange 22ª by which the device can be secured on the instrument board (not shown) of a motor vehicle, the board having an opening of proper dimensions to permit the passage of the casing, etc., therethrough, so that the latter will extend forward of the flange 22ª; obviously, the conditions may be reversed so that the casing may extend rearwardly instead of forwardly, the essential being that the general direction of length of arm 16 shall extend in the direction of general movement of the vehicle, a direction that is generally that of front to rear of the vehicle itself. Where the face of the instrument board is truly normal to the surface on which the vehicle is travelling, plate 21 can be secured within casing 22 in the simple manner shown in Fig. 1; where the face of the instrument board is inclined, flange 22ª may be arranged to compensate, or any other suitable arrangement employed so as to arrange plate 21 normal to a horizontal plane, as in Fig. 1. However, it will be understood that plate 21 need not, in service, be normal to such horizontal plane, Fig. 4 indicating the positions of parts when said plate is out of the position normal to the horizontal plane. Fig. 4 is intended primarily to represent the position of the device of Fig. 1 when the vehicle is traveling down grade, the indicating mechanism indicating the angle of variance from the horizontal of Figure 1; obviously, the indicating mechanism may be set so that in the position of Fig. 4, the indicator may be at the neutral or horizontal plane indicating point. This is referred to simply to indicate that the device can be readily placed in position for proper indicating without special preparation of parts, if necessary or desirable.

Assuming that the mounting of the indicator mechanism is as in Fig. 1, with the supporting face of the board normal to the vertical, the axis of plate 21 is practically in the horizontal plane of the axis of shaft 15, and the indications are provided by the movement of a pointer 23 over a calibrated scale 24 shown as carried by plate 21. Pointer 23 is carried by a shaft 25 extending in the axis of plate 21, and supported by a bracket 26 carried by the plate and by the plate itself. Shaft 25 carries a pinion 27 mounted between the bracket and plate and in position to mesh with the teeth of the segment rack 20. As shown in Fig. 3, the pointer is in the neutral position, this being the position of Fig. 1 under the assumed conditions. Obviously, if the position of the pinion be changed to the position of Fig. 4 while the pointer remains as in Fig. 3, or the pointer be shifted on shaft 25, the position of Fig. 4 may become the neutral position of the instrument.

It will be readily understood that if the flange 22ª of Fig. 1 be shifted to an inclined position, the line which would extend through shaft 25 and the axis of shaft 15 would shift correspondingly, such line being normal to the plane of plate 21. This will be understood from Fig. 4 in which flange 22ª is shown in such inclined position. During the change in position, it will be understood that the casing 10 will also have shifted somewhat—indicated by the change in position of partition 14 relative to a vertical plane. As the shifting takes place, the movement of the partition has tended to change the surface level of the mercury on the opposite sides of the partition, thus shifting floats 18 and rocking shaft 15, so that the initial tendency of the segment 16ª would be to maintain its relation to the pinion as shown in Fig. 1. However, this disturbance of the normal equilibrium of the mercury produces the transfer of mercury through port 14ª, to again bring the surfaces of the mercury bodies to the same level, and this movement of the surfaces causes movements of the floats 18 to return frame 17 to the position of Fig. 1, this movement of the frame being effective on shaft 15 and hence on arm 16 to shift the position of the segment rack 20. This shifting of the segment rotates pinion 27 and causes the pointer to shift its position accordingly, thus indicating the change in angle that has been set up.

As the vehicle returns to its horizontal plane, the reverse operation takes place, the parts resuming the position of Fig. 1. If the grade is in the opposite direction, it will be understood that the relative movement of segment and pinion is such that the pointer will move in the opposite direction.

The responsiveness of the instrument thus far described, will depend upon the size of port 14ª. Should the port be sufficiently large to permit instant response, the sensitiveness of the instrument will be such as to make it difficult to gain an accurate reading of the scale, since any slight or short variation—as for instance the striking of a stone or the running into a road depression, would cause corresponding movement of the pointer. I prefer, therefore, to employ a comparatively small port 14ª; this will permit a fairly close response, and at the same time tend to prevent unsteadiness of the pointer in travelling over rough roads.

In the drawings, I have shown a weight portion 28 on one of the arms 17ᶜ for the purpose of acting as a counterbalance to the arm 16ª and rack 20.

The structure so far described provides for efficient service and produces accurate readings, and for general usage is satisfactory. However, there are certain conditions of service that tend to set up a false indication, this being true in meters of this type generally; the conditions referred to are those of acceleration and deceleration of the vehicle. With either condition, the factor of the inertia of the mercury in the chambers becomes active.

For instance, if the device be mounted in the car as in Fig. 1 with the casing in advance of the indicator, and the car traveling toward the left, acceleration of the vehicle moves the instrument forward at a corresponding increase of speed, but there is a momentary tendency of the mercury bodies to lag; since the position of the partition is not changed there is some transfer of mercury, from one side of the partition to the other, causing a difference in level, the result being that there is a tendency to shift the position of the floats and thus set up motion of arm 16 to actuate the pointer; should the driver scan the indicator at this moment he may be given a false indication. A similar condition exists during deceleration.

The action is due to the mobility of the mercury as compared with that of the casing, it being necessary for the mercury to overcome the conditions of inertia before the surface is restored. The condition rapidly changes to the normal, but during the period the indication made is more or less false, due to the fact that the disturbance of the surfaces has affected the positions of the floats 18.

To overcome this tendency, I preferably employ a body, such as a weight, for instance, also subject to the conditions of inertia and which is positioned to be active in opposition to the conditions of inertia of the mercury. For instance, in Fig. 5, I have shown an arm 30 extending vertically from shaft 15, the upper end of the arm carrying a weight 31. Since shaft 15 is capable of rotating, it will be understood that weight 31 is subject to the laws of inertia, and since the direction of lag of the weight is the same as that of the mercury, and the weight and the mercury are located on opposite sides of shaft 15, it will be understood that the movement of the floats necessary to shift arm 16 must first overcome the resistance of weight 31. As a result, the opposing forces tend to neutralize the effect of each to shift arm 16, so that the latter is less likely to shift position during this period. When the change is in the direction of deceleration, the reverse action takes place and again the arm 16 is held in a more or less stable position. As will be understood the action is temporary, and hence the mercury quickly returns to normal position.

Instead of employing a separate arm or weight, it will be understood that the same action can be provided by placing the proper weight 31ª on frame 17, as indicated, for instance, in Fig. 6.

In either case it will be understood that when the surface of the mercury is on the single plane, the weight 31 is in a state of balance and ready for action when needed whether for acceleration or deceleration conditions.

While the movement of frame 17 in presence of a change in grade will tend to shift arm 30 and move weight 31 in the direction which would seemingly tend to increase the amount of movement of frame 17 to set up a false indication, the weight has a different action, as will be understood from the following:

Assuming the vehicle to be travelling toward the left in Fig. 1, and a sudden change in grade equal to that shown in Fig. 4 is encountered, the initial tendency would be to raise the float on the right through the rise in the level of the mercury, and to lower the float on the left, the level of its supporting mercury being lowered; this action would swing the weight 31 toward the left to add its value toward tilting the frame still farther. When this action is present, the added weight would tend to cause the float at the left to submerge to a greater extent than normal, at the same time tending to decrease the amount of submergence of the float at the right. Obviously, an increase of submergence of the float at the left would act to displace mercury and thus increase the depth of submergence.

Under these conditions the variation thus provided in the buoyancy of the two floats produces a power factor active on the float at the left to raise the latter, this being continued by the mercury being transferred through port 14ª, the result being that the effect of the weight is not only minimized but practically overcome. The moment effect of weight 31 is of greatest value when its distance from its balancing point is greatest, and it is at this point that the maximum buoyancy value is present; as the value of the buoyancy factor decreases the moment effect also decreases since the weight is returning toward its position of equilibrium. As the mercury is approaching its position of equilibrium the weight is approaching its vertical position where the weight is being exerted mainly on the shaft 15, so that the floats are practically in their normal conditions of submergence.

From this it will be understood that the buoyancy factor inherently opposes the weight factor in the attempt to set up false indications. But the presence of the weight tends to dampen the action of the device under sudden and violent changes in grade, etc., due to the fact that the opposing forces of buoyancy and the weight are brought into activity concurrently and tend to neutralize minor tendencies to change, without, however, disturbing the accuracy of the meter. With the weight present, port 14^a may be comparatively small.

To balance frame 17, I preferably place a weight 28 on the arm 17^c opposite the direction of extension of arm 16, the weight counterbalancing the arm and segment.

As shown in Fig. 3, I prefer to calibrate the indicating face in such manner as to indicate the grade on each side of the neutral. I employ the usual bezel glass to protect the pointer and indication face.

Obviously, the calibrations can be controlled as to distance in various ways, as by changing the size of the pinion, by varying the length of arm 16, or both.

From the above description it is believed that the advantages will be more or less obvious. The mercury is within a closed chamber but under no restraint as to splashing effects, the latter not affecting the operations of the device. The wall of the chamber 12 is concentric with the axis of the shaft 15 and is cylindrical in shape so that regardless of the position of the instrument, the level of fluid in the chamber will remain the same. The device is simple and efficient in operation and is of a construction that will withstand the conditions of service.

I prefer to arrange the dimensions such that the level of the mercury is normally somewhat below the axis of shaft 15, thus tending to prevent leakage of mercury through the bearings, which can, if desired, be comparatively loose, thus decreasing the cost of manufacture.

While I have herein shown one or more ways in which the invention may be produced and operated, it will be readily understood that changes and modifications therein may be found desirable or essential in meeting the exigencies of use and service, and I therefore desire to be understood as reserving the right to make any and all such changes or modifications as may be found desirable or necessary, in so far as the same may fall within the spirt and scope of the invention as expressed in the accompanying claims when broadly construed.

Having thus described my invention, what I claim as new is:

1. In grade meters and the like, a cylindrical casing having an annular chamber of uniform cross-section on radii of the casing, a perforated member extending substantially radially of the chamber to divide the chamber below the axis of the chamber, said chamber carrying a liquid on opposite sides of and in communication through the perforated member, a rigid frame pivotally mounted in such axis, floats carried by the frame and located within said chamber on opposite sides of such member, indicating mechanism including a movable indicator, and means operatively connecting the frame and said indicator for translating relative movements of frame and casing into movement of the indicating mechanism.

2. In grade meters and the like, a casing having an annular chamber of uniform cross-section on radii of the casing, the chamber walls including inner and outer concentric walls spaced from the axis of the chamber, a perforated member connecting said walls below such axis to divide the lower portion of said chamber, said chamber carrying a liquid on opposite sides of and in communication through the perforations of such member, a rigid frame pivotally mounted in such axis, floats carried by said frame and located within said chamber on opposite sides of such member, indicating mechanism including a movable indicator, and means operatively connecting the frame and said indicator for translating relative movements of frame and casing into movement of the indicating mechanism.

3. A meter as in claim 2 characterized in that the frame extends through the inner wall of the chamber, said wall having an opening to permit relative movement between frame and wall about the frame axis.

4. A meter as in claim 2 characterized in that the frame includes an arm extending upwardly from the axis of the chamber and an arm carried thereby and extending transversely thereof, said latter arm carrying members extending downwardly within the chamber substantially parallel with the upstanding arm, each of such members carrying a float.

5. A meter as in claim 1 characterized in that the rigid frame member carries an arm rigid therewith and outside the casing, said arm extending in the direction of the indicating mechanism and carrying a gear element co-operative with a companion gear element of the indicating mechanism to operatively connect the frame with the indicator.

6. A meter as in claim 1 characterized in

that the frame includes a pivot portion which projects beyond the casing and carries an arm rigid therewith extending in the direction of the indicating mechanism and forming a part of the means operatively connecting the frame and indicator, a counterpoise carried by the frame within the chamber for balancing said arm.

7. In grade meters and the like, wherein variation in levels of liquid surfaces is operative to produce movements of an indicator, a casing for the liquid, a rigid frame pivoted in the casing floats carried by the casing adapted to be supported by the liquid to provide relative movement between frame and casing during variations in level of the liquid surfaces, means operatively connecting the frame and indicator, and means operatively connected with the frame for opposing float movement tending to be caused by inertia of the liquid.

8. In grade meters and the like, wherein variation in levels of liquid surfaces is operative to produce movements of an indicator, a casing for the liquid, a rigid frame pivoted in the casing, floats carried by the casing adapted to be supported by the liquid to produce relative movement between frame and casing during variations in level of the liquid surfaces, means operatively connecting the frame and indicator, and a weight element carried by the frame above the axis of frame movement and operative to oppose float movement tending to be caused by inertia of the liquid.

9. A meter as in claim 1 characterized in that the frame carries means operative to oppose float movement tending to be caused by inertia of the liquid within the chamber.

10. In a grade meter and the like, a casing, a body of liquid therein, a rigid frame pivotally mounted in the casing and having depending arms equidistant from and on opposite sides of the pivot axis of said frame, floats carried by said arms respectively so as to be buoyed by said liquid, an indicator, means operatively connecting the frame and indicator, and means carried by the frame adapted to oppose movement thereof tending to be caused by inertia of said liquid upon acceleration or deceleration of said meter.

In testimony whereof I affix my signature.

CHAS. W. GIRVIN.