

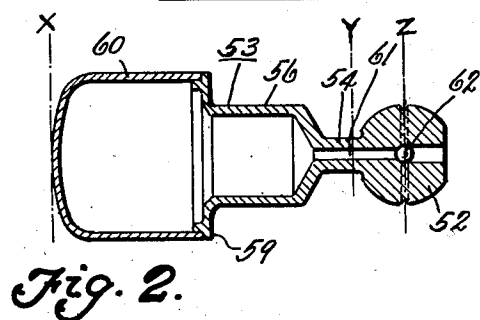
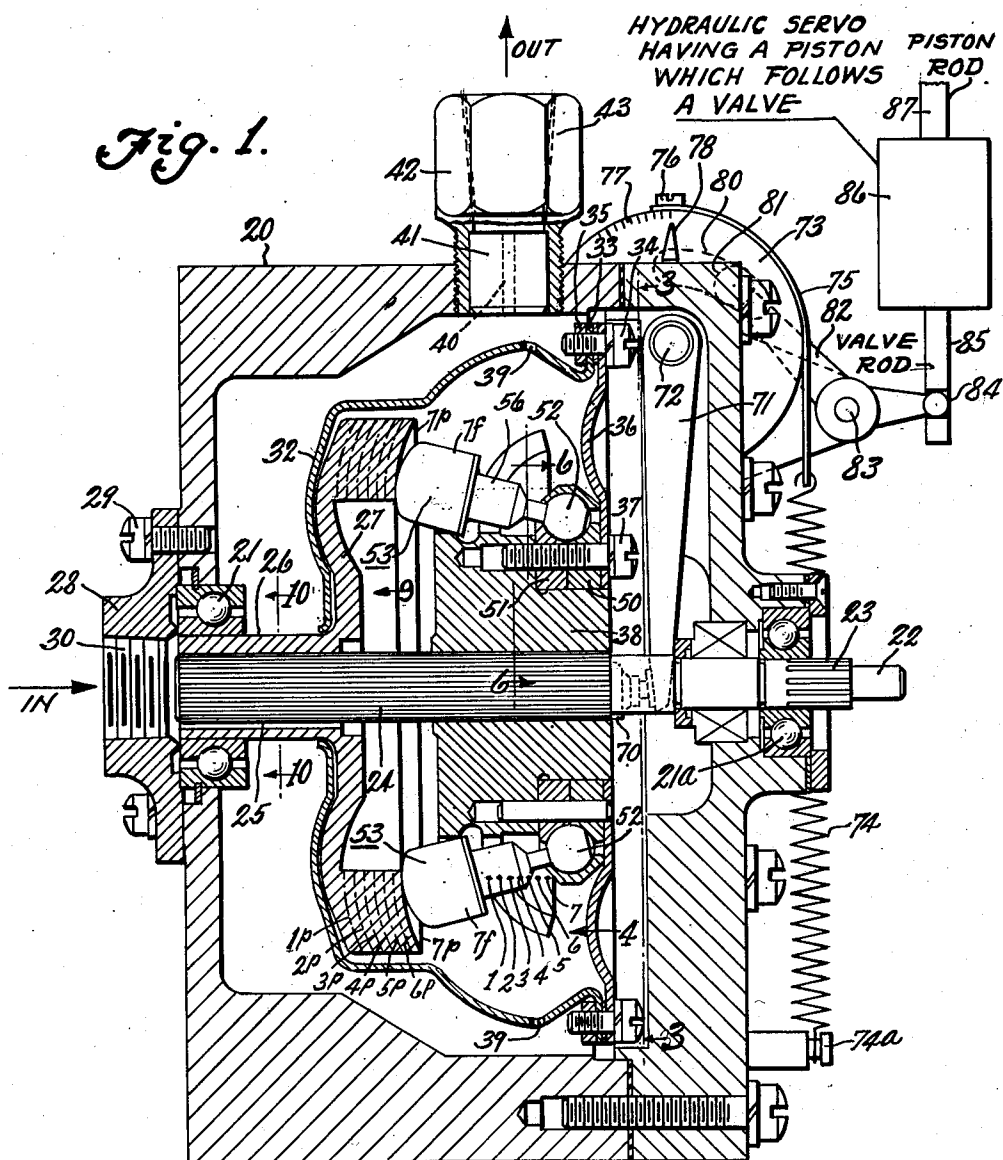
Oct. 28, 1952

J. DOLZA
DENSITOMETER

2,615,328

Filed Aug. 18, 1951

4 Sheets-Sheet 1



INVENTOR
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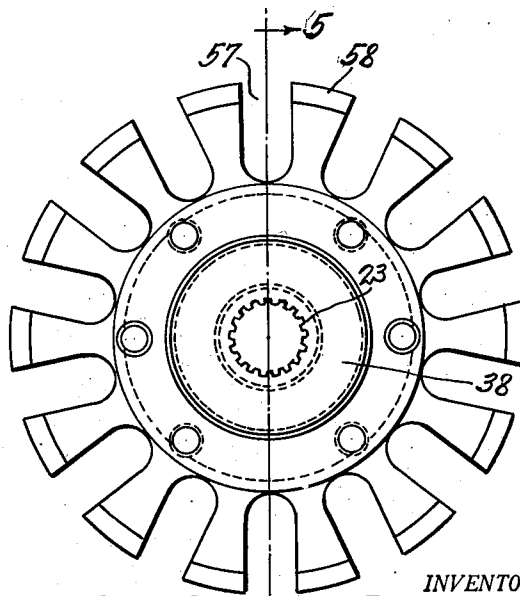
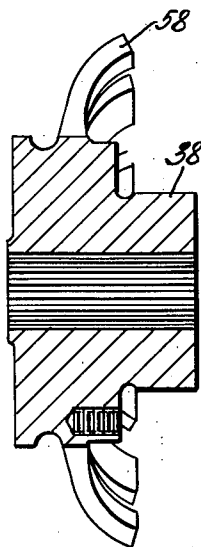
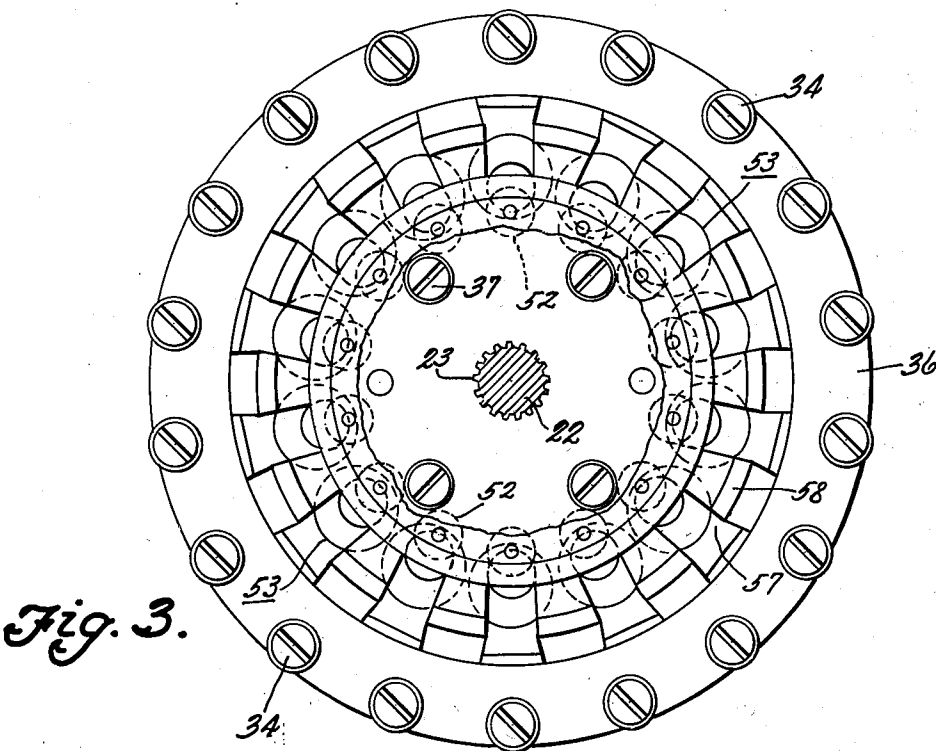
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4 Sheets-Sheet 2



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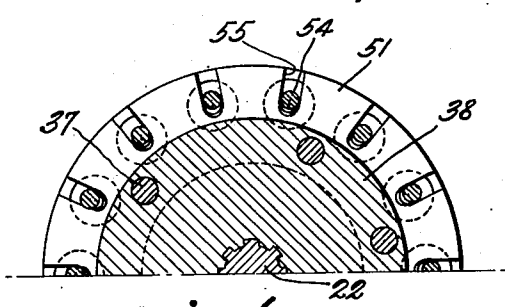
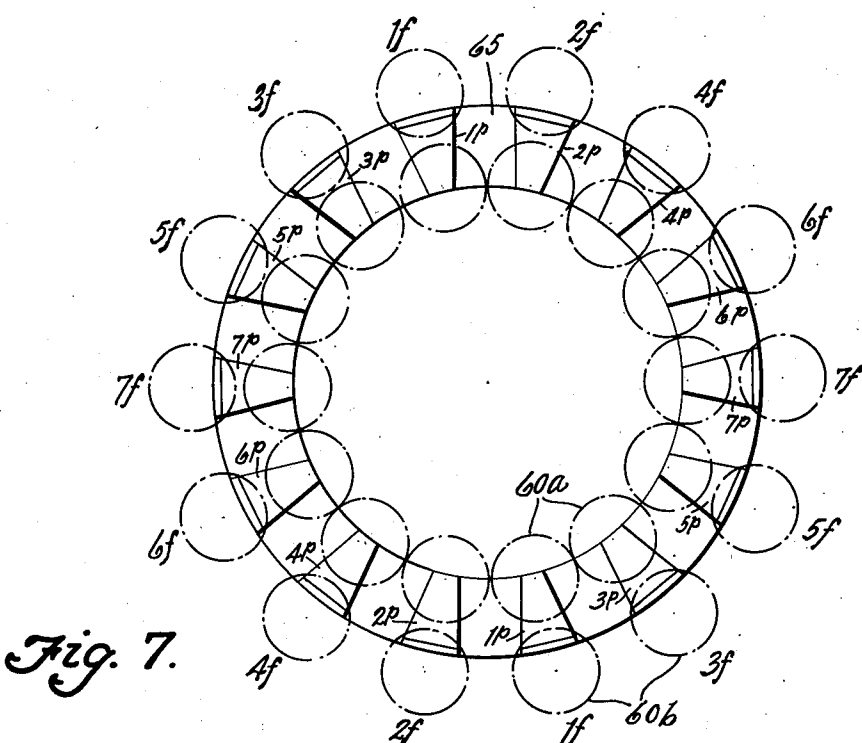
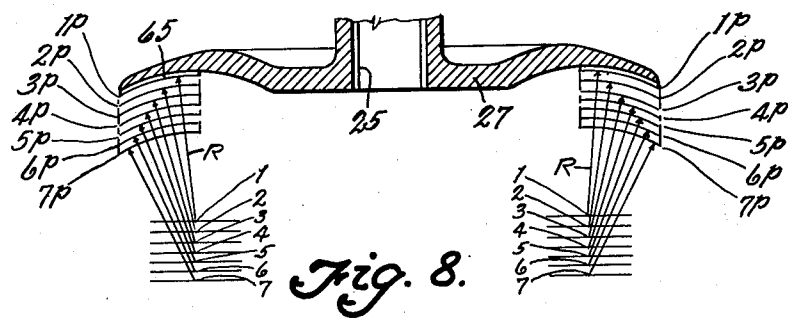
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

Fig. 9.

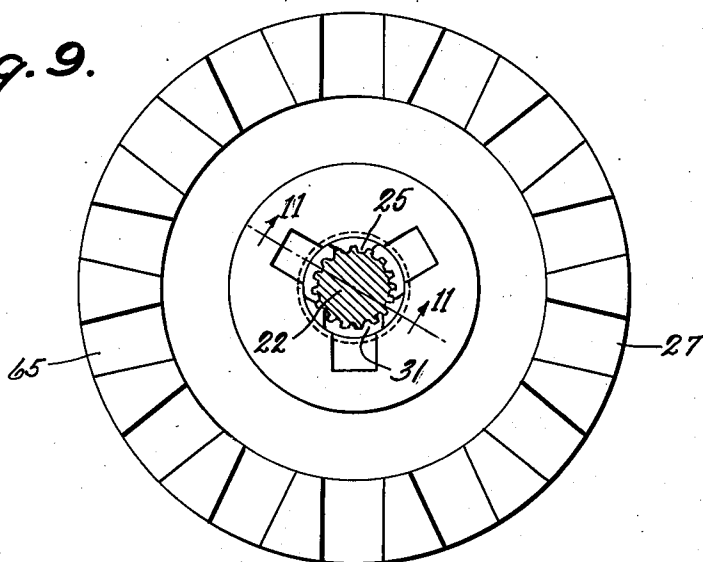


Fig. 10.

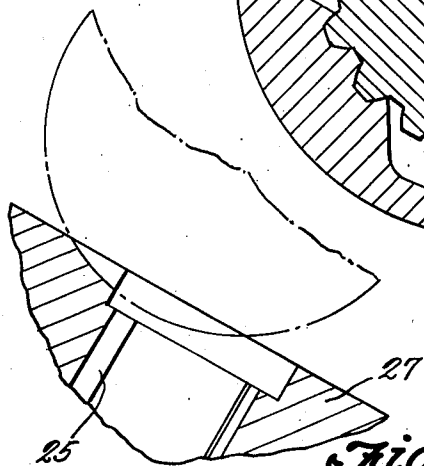
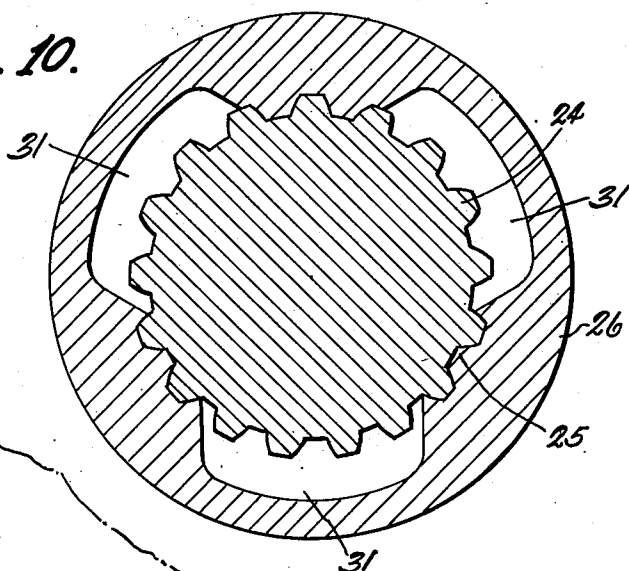


Fig. 11.

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UNITED STATES PATENT OFFICE

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DENSITOMETER

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2 Claims. (Cl. 73—32)

1

This invention relates to liquid density sensing apparatus or densitometer; and its object is to obtain a mechanical movement indicative of the density of a liquid which, for example, may be the fuel used by an internal combustion turbine.

This object is accomplished in the disclosed embodiment of the present invention by the use of floats of different densities all within the range of the density of the liquid. In the case of turbine fuel, these densities might be in the range of .60 to .90. The liquid is continuously sampled by causing it to pass through a rotating densitometer chamber within which the floats are supported for movement radially of axis of rotation of the chamber. The floats having density greater than the density of the fuel move outwardly and those having lesser density move or remain inwardly. As fuel density increases from a minimum, the inward force of the floats of lower density is used to effect a mechanical movement which corresponds to the density of the fuel.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

Fig. 1 is a longitudinal sectional view of a densitometer embodying the present invention.

Fig. 2 is a longitudinal sectional view of a float drawn to a scale larger than in Fig. 1.

Fig. 3 is a sectional view on line 3—3 of Fig. 1.

Fig. 4 is a view in the direction of arrow 4 of Fig. 1 of a float guide.

Fig. 5 is a sectional view on line 5—5 of Fig. 4.

Fig. 6 is a fragmentary sectional view on line 6—6 of Fig. 1.

Fig. 7 is a diagram showing floats in inner and outer positions and the surfaces of a reaction plate which the floats respectively engage.

Fig. 8 is a diagram showing, in section, the float engaging surfaces of the reaction plate.

Fig. 9 is a view in the direction of arrow 9 of Fig. 1 of the reaction plate.

Fig. 10 is an enlarged sectional view on line 10—10 of Fig. 1.

Fig. 11 is an enlarged, fragmentary sectional view on line 11—11 of Fig. 9.

Referring to Fig. 1, a case 20 supports bearings 21 and 21a for a shaft 22 having splines 23 for making connection with a driving shaft and having splines 24 connected with splines 25 of the hub 26 of a reaction plate 27 as shown also in Fig. 10. The hub 26 has a press fit with the inner race of bearing 21 which acts as a thrust bearing. The outer race of bearing 21 is engaged by a ring 28 which screws 29 secure to case 20. Ring 28 provides a tapped hole 30 for receiving a pipe by which liquid is conducted to

2

passages 31 (Fig. 10) of the hub 26 and thence into the space enclosed by a housing 32 whose flange 33 is attached by screws 34, threaded into a ring 35, to a plate 36 which screws 37 attached to a float carriage and guide 38 splinedly connected to shaft 22 and slidable thereon. The housing 32 has holes 39 for the exit of liquid from the housing to the case 20 and thence through a metering or restriction orifice 40 in a block 41 supported by a bushing 42 which provides a threaded hole 43 for receiving a liquid exit pipe. Due to centrifugal force generated by the liquid rotating with housing 32, the outlet pressure is higher than the inlet pressure. The out flow which is regulated by the restriction 40 is such that complete changes of fuel occur at the desired frequency.

The screws 37 secure to carriage 38 two rings 50 and 51 which together provide spherical sockets for the ball ends 52 of hollow floats 53. Each float has a small diameter shank portion 54 (Fig. 2) received by a notch 55 (Fig. 6) of ring 51 and a larger diameter shank portion 56 received by a notch 57 (Fig. 4) between guiding arms 58 of carriage 38. The float shank has a flange 59 to which a cap 60 is attached preferably by soldering. After soldering, the hole 61 in the shank is plugged by a ball 62.

In Fig. 7, the caps 60 are represented by circles 60a in an inner row to represent the innermost positions of the float caps and by circles 60b in outer row to represent the outermost positions of the float caps. There are 14 floats arranged as shown in Fig. 7 in 7 pairs, the floats of each pair being diametrically opposite. The numbers 1f to 7f applied to circles in Fig. 7 indicate the locations of the floats. The float cap-engaging surfaces or pads of plate 27 which respectively are engaged by the caps of these floats are marked 1p to 7p respectively. The pads are separated by notches 65. Fig. 8 shows that each pad is a segment of a cylinder whose radius is represented by arrows R. The centers of curvature of the pads 1p to 7p are respectively located at centers 1 to 7 in Fig. 8.

If, for example, the liquid whose density is to be sensed lies in the range of .68 to .90, densities of the pairs of floats are preferably as follows:

Pairs of floats	Specific gravity
1f	.705-.711
2f	.733-.739
3f	.760-.766
4f	.786-.793
5f	.814-.820
6f	.842-.848
7f	.869-.875

To obtain these different specific gravities, the portions of the floats between lines X and Y (Fig.

2) receive different amounts of chromium plating. Some of the plating at the end of the caps 60 is buffed off so that the distance between lines X and Z will be uniform.

The arrangement of the floats is such that loading of the shaft 22 is substantially in balance.

Fig. 1 shows the status when the liquid in housing 32 has density greater than the density of floats 7f. All of the floats are in innermost positions. Only floats 7f contact pads, which are marked 7p. The other floats do not then engage pads. Floats 7f are pressed against pads 7p by a shoe 70 having a ball-and-socket joint connection with a lever 71 attached to a shaft 72 rotatably supported by the case 20 and supporting a disc 73 which is urged clockwise in Fig. 1 in any suitable manner, for example, by a spring 74 attached to a stud 74a and to a band 75 attached to the disc 73 by a screw 76.

If the liquid has density less than the density of floats 7f and greater than the density of floats 6f, floats 7f move outwardly clear of pads 7p while the other floats remain in. Lift movement of the float carrier and guide 38 is limited by engagement of floats 6f with pads 6p. Therefore disc 73 moves clockwise an amount which represents the density of the liquid. As the density of the liquid decreases, the pairs of floats move out in succession until only floats 1f remain in to engage pads 1p. The angular displacements clockwise of disc 73 take place in steps which represent 7 different indications of liquid specific gravity which, for example, might be .872, .845, .817, .790, .763, .736, .708.

In case the liquid density were less than the density of floats 1f, those floats also move out and float carriage 38 moves left until it engages reaction plate 27. This final movement of carriage 38 provides no indication other than that the liquid is too thin for the use for which it was intended.

As liquid density increases from a value below the useful minimum, the pairs of floats move in sequentially, 1f to 7f, to engage their respective pads 1p to 7p to effect, in steps, counterclockwise movement of disc 73. The inward force applied to those pairs of floats having density nearest to but less than the density of the liquid is sufficient to cause the floats moving in to engage their pads to exert a camming action upon them. To make this camming action possible, as shown in Fig. 1, the center of curvature of the curved part of the float ball cap 60 is closer to the axis of shaft 22 than the loci of pad curvature centers 1 to 7.

The movements of the floats take place under the influence of centrifugal force when the shaft rotates at relatively high speed.

Indication of density may be obtained by providing the disc 73 with a scale 77 movable adjacent a fixed pointer 78. If the densitometer is used to effect control over other apparatus, for example, apparatus for controlling the flow of fuel to burners of an internal combustion turbine jet engine, disc 73 provides a cam groove 80 of suitable contour which receives a follower roller 81 carried by a lever 82 pivoted at 83 and having an arm received by a notch 84 in a valve rod 85 which moves a valve of an hydraulic servo 86 of the type in which a piston follows a valve to whatever position the valve is moved by its rod 85. The piston rod 87 connected with the piston moves according to movements of the rod 85. Rod 87 can be used to impart movements to fuel flow control apparatus in order that fuel flow will

be controlled in accordance with fuel density as well as other parameters.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A liquid density sensing apparatus comprising a driven shaft, floats of different densities in a range of densities of the liquid whose density is to be sensed, a reaction plate having a hub fixed to the shaft and providing pads located in a circular row around the shaft and having surfaces to be engaged, respectively by floats of different densities, said pad surfaces being located, longitudinally of the shaft axis, at different distances from the plate hub, a member supported for movement coaxially of the shaft and operatively connected therewith, means provided by the member for supporting each float for movement radially of the shaft axis from a location in which it may engage its particular pad of the reaction plate when the density of the float is less than the density of the liquid to a location in which the float clears the reaction plate when its density is greater than the density of the liquid, said movement taking place under the influence of centrifugal force when the shaft is rotated at relatively high speed, means for urging the member toward the plate, the distance between the member and the plate depending on which one of the floats engages a pad of the plate, means connected with the shaft and providing a chamber surrounding the plate and floats, said chamber containing the liquid whose density is to be measured, and an element operatively connected with the float supporting member, the position of the element being indicative of the density of the liquid.

2. A liquid density sensing apparatus comprising a driven shaft, a housing surrounding the shaft and providing a chamber for receiving liquid whose density is to be sensed, duct means for directing the liquid into the chamber near the shaft, outlet ducts provided by the housing remote from the shaft, a reaction plate with the housing and driven by the shaft, said reaction plate providing pads having surfaces to be engaged, respectively by floats of different densities, said pad surfaces being located at different distances from a plane at right angles to the shaft axis, a housing support connected with the shaft for sliding movement therealong, floats of different densities in a range of densities of liquid passing through the chamber, means connecting the floats with the housing support and providing for movement of each float radially of the shaft from a location in which it may engage its particular pad of the reaction plate when the density of the float is less than the density of the liquid in the chamber to a location in which the float clears the reaction plate when its density is greater than the density of the liquid in the chamber, said movement taking place under the influence of centrifugal force when the shaft is rotated at relatively high speed, means for urging the floats toward the reaction plate, whereby the position of the housing along the shaft is determined in accordance with which one of the floats engages the reaction plate and a movable member operatively connected with the housing the position of the member being indicative of the density of the liquid.

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No reference cited.