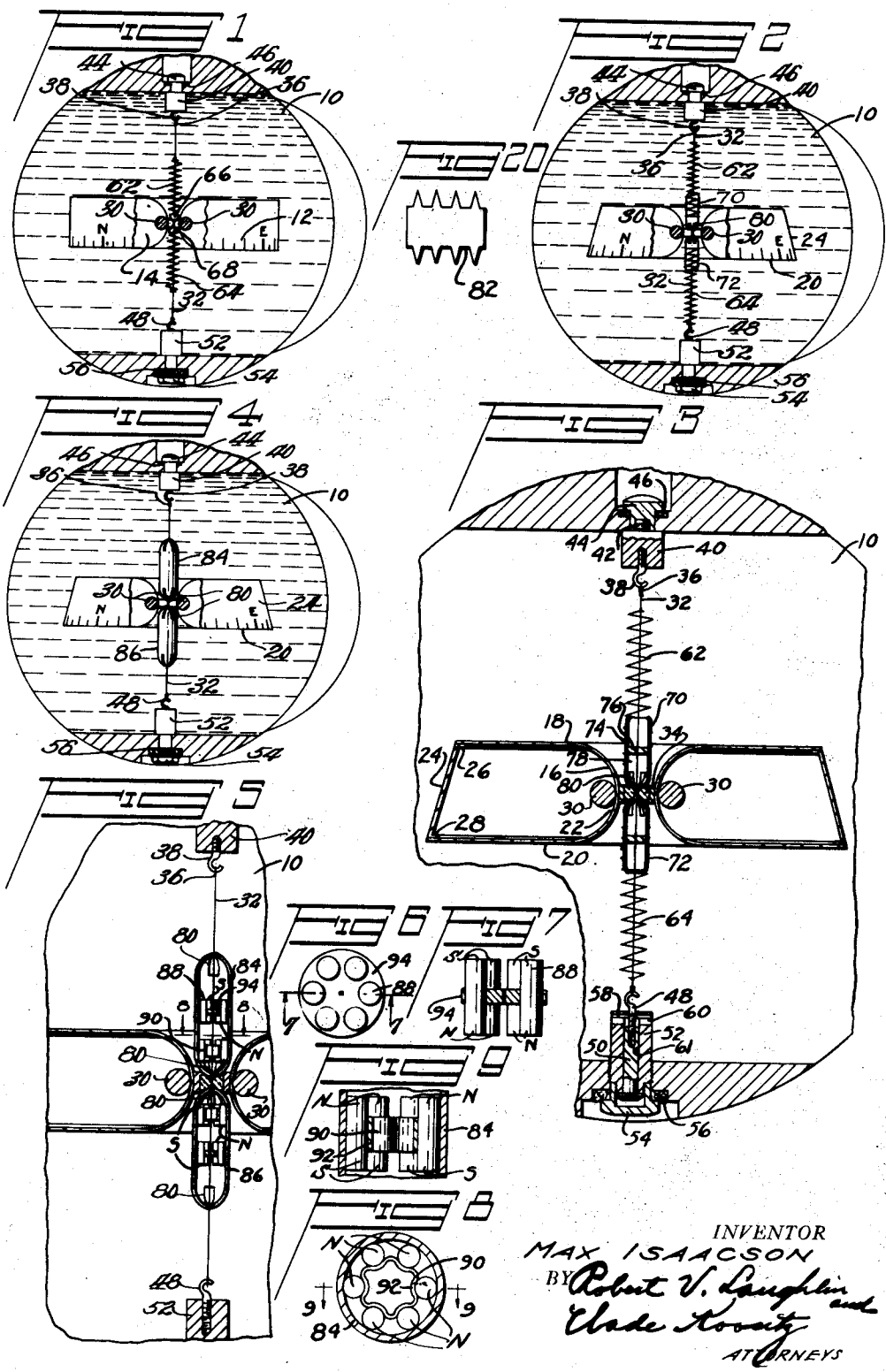
April 11, 1939. M. ISAACSON 2,153,565

MAGNETIC TYPE FLOATING COMPASS CARD

Filed May 26, 1936 2 Sheets-Sheet 1

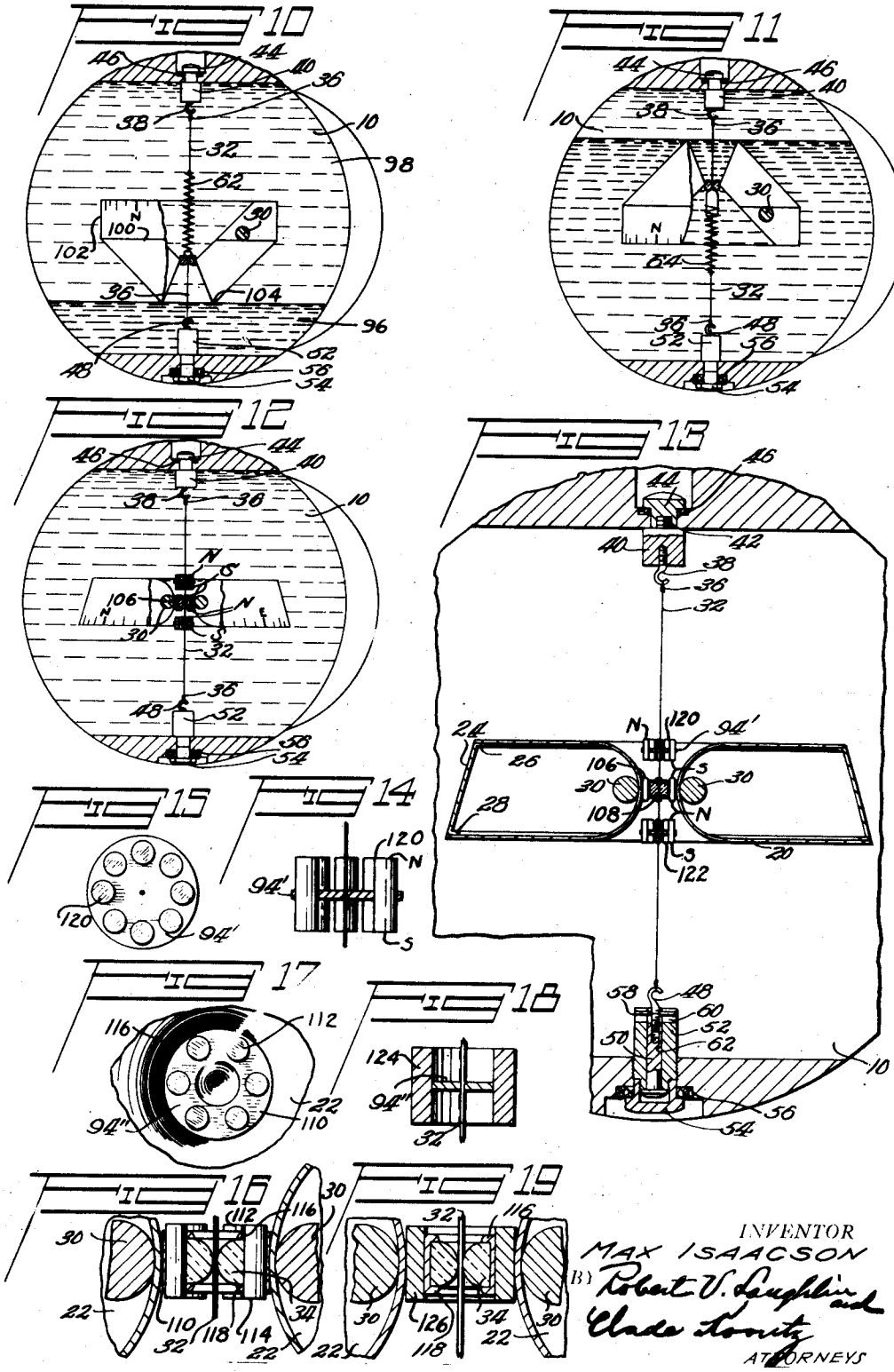


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MAGNETIC TYPE FLOATING COMPASS CARD

Filed May 26, 1936 2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,153,565

MAGNETIC TYPE FLOATING COMPASS CARD

Max Isaacson, Dayton, Ohio

Application May 26, 1936, Serial No. 81,872

23 Claims. (Cl. 33—223)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

In a copending joint application Serial No. 656,708, filed February 14, 1933, we have disclosed a magnetic card in a liquid medium, the primary purpose of said system being to reduce to a minimum the amplitude of the relative displacements of the card, the liquid medium, the centralizing means and the supporting means, other than that which occurs in the normal operation of the instrument, when the instrument is under vibration, by obtaining a condition between a balanced card and the liquid medium, in which it is submerged, such that it will bear against its supporting means with a force not materially in excess of that required to maintain the card in its normal position against its support for all changes in density of the liquid medium that take place within the operating temperature range and by arranging the centralizing means and the supporting means in such a manner that the resultant torque forces tending to rotate the card in addition or contrary to the action of the magnetic control of the card is materially reduced.

It is an object of my present invention to obtain a further improvement in the reduction of the respective amplitudes of relative displacements between magnetic card, the liquid medium, the centralizing means and the supporting means when the instrument is under vibration by providing a magnetic card of a mean specific gravity that is equal as nearly as is practically possible to the specific gravity of the liquid medium in which it is submerged, so that the tendency of the card to rise or sink, as well as the tendency to move laterally, is reduced to the utmost, by providing a centralizing arrangement between the card and the instrument bowl such that the natural vibrational frequency of the centralizing means is substantially in excess of the vibrational frequency impressed upon the instrument so that the various forces—frictional, impact, torque, etc.—between the centralizing means and the card are maintained at a minimum. Consequently, the tendency of these forces to disturb the condition of approximate equilibrium between the card and the liquid is reduced to a minimum and, by providing a supporting means which, while capable of yieldingly counteracting with a minimum of resistance to rotation of the card the slight inherent tendency of the card to rise or sink, is restrained against relative lateral movement with respect to said card and to said centralizing means so that the tendency of the supporting means to vibrate laterally when once displaced or flexed to one side of its neutral position or medial line, is prevented. This is important because if, as illustrated in one embodiment of my invention, the supporting means is yieldably displaceable, it stores up energy when forcibly displaced from its neutral position and, when released, will vibrate in accordance with its fundamental frequency.

If the vibration of the instrument differs appreciably from the natural frequency of the support, the amplitude of the forced vibrations set up in the support will be of the same order of magnitude as the amplitude of vibration of the instrument. If, however, the impressed frequency (due to the vibration of the instrument) and the natural frequency of the support are equal, the amplitude of the vibrations becomes extremely large. Thus, if the support is relatively displaceable laterally and/or vertically with respect to the card, there will be produced frictional and impact forces that are proportional to the existent vibrational amplitude.

In accordance with my invention, while there may be a tendency for the supporting means to vibrate laterally with an amplitude that is equal to or greater than the amplitude of the vibration of the compass instrument, the forced vibrations of the supporting means are so restrained in their lateral movement as to be practically incapable of any lateral independent vibration. This is accomplished by arranging the supporting means in such a manner that its lateral motion is dependent upon the lateral motion of the centralizing means which, in turn, has a natural frequency that is adjusted to be relatively higher than the vibration frequencies to which the instrument may be subjected and therefore relatively rigid therewith.

Since, as has previously been pointed out and noted, the supporting means yieldingly opposes vertical movements of the compass card, it is important that the relative vertical movements between the supporting means and the centralizing means due to forced vibrations be either prevented or reduced to a minimum in amplitude and frequency so that the forces acting on the card as the result of such relative vertical displacements have a negligible effect upon the magnetic control. For this purpose and in accordance with my invention, novel means is provided between the card and the centralizing means for supporting the residual weight of the card and/or

for dampening relative vertical movements between the card and the liquid.

Other and further objects will appear in a more detailed description of the invention hereinafter set forth.

In the drawings, which form a part of this specification and in which several modifications of my invention are shown by way of illustration:

Fig. 1 is an elevational sectional view of one embodiment of my invention showing diagrammatically the bowl of a liquid-damped compass with parts of the magnetic card and the centralizing means in section.

Figure 2 is a view similar to Figure 1, showing another embodiment of my invention.

Figure 3 is an enlarged view of Figure 2 with parts broken away.

Figure 4 is a view similar to Figure 1, showing a further embodiment of my invention.

Figure 5 is an enlarged fractional view of Figure 4 with parts broken away.

Figure 6 is an enlarged detail view.

Figure 7 is a sectional view taken on the line 7—7 of Figure 6.

Figure 8 is an enlarged sectional view taken on the line 8—8 of Figure 5.

Figure 9 is a sectional view taken on the line 9—9 of Figure 8 showing parts broken away.

Figure 10 is a view similar to Figure 1 showing a further embodiment of my invention.

Figure 11 is a view similar to Figure 1 showing a reversal of the relation of the components of the compass shown in Figure 10.

Figure 12 is a view similar to Figure 1 showing a still further embodiment of my invention.

Figure 13 is an enlarged fractional view of Figure 12.

Figure 14 is an enlarged detail view.

Figure 15 is a top plan view of Figure 14.

Figure 16 is an enlarged fractional detail view.

Figure 17 is a fractional top plan view of Figure 16.

Figure 18 is a detail view of a further embodiment of my invention.

Figure 19 is a view similar to Figure 16 showing a further variation of my invention.

Figure 20 is an enlarged undeveloped detail view.

Referring more particularly to the drawings wherein corresponding parts are designated by like numerals throughout the several views, the numeral 10 designates a compass bowl of the well-known type of construction generally used on aircraft and more particularly disclosed in my joint copending application Serial No. 656,708, filed February 14, 1933, hereinbefore referred to.

It will be observed that various component parts, such, for example, as the expansion chamber to permit expansion and contraction of the liquids in the compass bowl with changes in temperature and the compensating magnets, are not shown as they do not constitute a part of the present invention, it being understood, however, that my invention is applicable to compasses embodying such component parts.

The compass bowl is identical in each of the several embodiments of my invention illustrated herein and is completely filled with a damping liquid medium. My invention contemplates the use of a single damping liquid or a plurality of damping liquids of different densities which are immiscible. In the embodiments of my invention in which a single damping liquid is used, the card is adjusted either experimentally or by computation so as to have a mean density which is approximately equal to the mean density for a given temperature operating range of the liquid so that the change in the buoyant force of the card with maximum change in the temperature in either direction from the mean temperature of the temperature operating range is kept at a minimum and yieldable means is provided to oppose the buoyant or gravitational force, as well as other forces tending to displace the card vertically from its normally centralized position.

In certain other embodiments of my invention that make use of two liquids, the compass card is substantially entirely immersed in one liquid and yieldingly supported against vertical displacement by the other in one direction and by a yieldable means in the opposite direction. The yieldable means will, of course, prevent upward or downward displacement depending upon whether the card is immersed in the heavier or lighter liquids, respectively. Two suitable liquids are selected which have a density differential that is greater than the density differential between the mean density of the two liquids and the density of the card over a given temperature operating range but preferably not so great that the relative displacements of the liquids under vibration and acceleration would cause excessive displacements of the card. It is preferable that the density of the card be not lighter than the mean operating temperature density of the liquid in which it is immersed.

In order to reduce the effects of the surface tension drag where two liquids are used, the design of the card and its buoyancy is determined with a view of presenting to the common level of the two liquids a surface portion of the card sufficiently small so as to cause a negligible surface tension drag effect.

In constructing the compass card 12 shown in Figs. 1, 2, and 3, an air-tight float 14 is formed from two pieces of sheet metal of non-magnetic material, the one piece, identified by the numeral 16, being spun or formed in any well-known manner into a shape having upper and lower parallel disc-like portions 18 and 20, respectively, forming the upper and lower walls of the compass card and an integral intermediate tubular portion 22 centrally disposed with respect thereto for supporting the card jewel. This tubular portion is flared outwardly from its mid-portion to the ends thereof to provide sufficient clearance between the card and the centralizing means and thus avoid interference with the tilting of the card required under certain conditions. The other piece, identified by the numeral 24 and which forms the side wall of the card, is in the form of a cylinder and is provided with upper and lower inwardly extending flanged portions 26 and 28 for closely engaging the upper and lower walls 18 and 20 which are secured thereto by soldering along their peripheral meeting edges. The outer circumferential wall of the piece 24 bears the cardinal points of the compass card so as to be be readable from the side thereof. Within the card and adjacent the jewel supporting portion 22, there is attached in any convenient manner, as by soldering, a pair of symmetrically arranged magnetic elements 30. These elements may be in the form of conventional bar mangets or may be any other suitable shape. In order to obtain an efficient response of the card to its magnetic control, the card is balanced insofar as is practically possible about its vertical axis and the relation of the center of gravity of the card and its center of

buoyancy is such as to maintain the card in a relatively stable condition.

In this embodiment the compass card is made cylindrical in shape to effect equal dampening of the vertical displacements of the card in opposite directions and thereby avoid creeping.

The centralizing means of the several embodiments of my invention comprise generally a vertical filament 32 carried by and disposed within the bowl 10 and an open bearing or jewel 34 carried by the card. The latter is provided with a suitable opening to accommodate the filament. The filament is made from a wire of relatively small cross-section in order that the surface contact be small and the consequent friction effects nil. This filament is preferably made from a wire of non-magnetic material having the desired physical properties such as, for example, bronze wire. It will of course be understood that other materials, such as piano wire and "Inconel", can be used. As shown in Fig. 3, this filament has its upper end formed in a loop 36 that is connected to a hook-shaped end of a threaded member 38 which is screwed into a detachable block 40. This block is provided with a threaded stem 42 which is threadedly connected to a cap screw 42 that passes through an opening in the upper wall of the bowl, suitable gasket means being provided as at 46 to prevent leakage of the liquid from the bowl.

The lower end of the filament is looped around the hook-shaped end of a lower threaded member 48 which engages with internal threads provided in the stem of an adjusting screw 50. This adjusting screw is rotatably mounted in a guiding sleeve 52 that is threadedly secured to the lower wall of the compass bowl. The guide sleeve is provided with a reduced threaded portion for threaded engagement with a cap screw 54. A gasket 56 is provided to prevent leakage. The threaded member 48 is provided with a pin 58 that is seated in a slot 60 formed in the guide sleeve 52. The adjusting screw 50 extends only partially through the bore 61 formed in the guide sleeve 52 allowing an adjustment of the filament to an extent approximately equal to the height of the slot 60. Whenever adjustment is found desirable, it is only necessary to remove the cap 54.

By turning the adjusting screw, the tension of the filament may be varied as desired to thereby change its natural frequency of vibration. I intend that the filament be so adjusted that its natural frequency of vibration shall be materially in excess of the natural frequency of vibration of the instrument or beyond the range of any impressed vibrational frequencies to which the instrument may be subject so that the various forces—frictional, impact, torque, etc.—between the filament and the compass card are not only maintained at a minimum but that in addition thereto the lateral motion of the card will likewise be a minimum by reason of the movement of the supporting means being dependent upon the lateral motion of the centralizing filament.

It will be seen that if the yieldable supporting means is carried by and fixedly connected to the filament in such a manner that relative lateral displacements therebetween is practically avoided, then it, in turn, will be practically stationary with respect to the bowl and card. For this purpose and as illustrated in the embodiment in Fig. 1, there is provided a pair of coil springs 62 and 64 that are disposed above and below the card, said coil springs surrounding the filament 32 and being fixedly connected thereto by soldering at their outer ends only and at such points on the filament that the free ends of the coils in the untensioned state terminate substantially centrally of the bowl so that the card will be supported or maintained substantially centrally of the bowl by either coil spring depending upon the existent relative densities of the card and liquid without practically any initial tension exerted by the other. The free ends of these coils have attached thereto perforated caps 66 and 68 which enclose the terminals of the coils and receive the filament in closely sliding relation so as to provide smooth bearing surfaces for the free ends of the coil springs. The coil springs, as well as the caps, are made from suitable non-magnetic materials such as brass or aluminum.

Figs. 2 and 3 show a variation of the invention. In these views the embodiment is identical to that shown in Fig. 1 except that the card 24 is constructed to be trapezoidal in form and that the caps at the free ends of the coil spring are in the form of capsules and serve not only to produce a smooth bearing surface between the jewel bearing 34 and the coil springs but also function in a manner to dampen the natural and-or forced oscillations of the coils. For this purpose the caps 70 and 72, which are preferably made somewhat larger than the caps 66 and 68 in Fig. 1, are constructed to have a cylindrical portion 74 that cooperates with a disc 76 fixedly secured to the filament 32 as by a press fit to produce a dash-pot, the liquid in the work chamber 78, as well as the friction between contacting surfaces of the disc and cylinder, serving to dampen the said oscillations. The liquid contained within the cylinder may be caused to flow chiefly from one working chamber on one side of the disc to another working chamber on the other by providing the disc with an orifice or orifices, or the liquid may be caused to flow mainly from one or both working chambers, respectively, to the bowl chamber exterior thereof by providing the cylinder with orifices 80, as shown in Fig. 3. These cylinders may be formed from a tube having serrated ends that are formed into a rounded end and secured together in spaced relation to provide orifices through which the filament passes or it may be made from a thin sheet-metal stamping, Fig. 20, having serrations 82 that are formed into rounded ends after the stamping is formed into a cylinder. Any suitable bonding material may be used to secure the serrations together. In Fig. 3, the capsules are formed with rounded ends only at the bearing end.

A further embodiment of my invention is shown in Figs. 4 to 9. The construction and arrangement of the constituent elements in this embodiment is identical to that of Fig. 3, except that magnetic means are employed instead of coil springs to yieldingly support or oppose the movement of the card and the capsules 84 and 86. Each capsule is provided with openings 88 at the ends thereof and has confined therein two sets of magnets 88 and 90, one set being carried by and fixedly retained within the capsule by a corrugated retaining ring 92 and the other set is carried by a washer 94 which, in turn, is fixedly connected to the filament by a press fit engagement. The magnetic poles of each magnet of the set of magnets carried by the capsule are correspondingly arranged but in magnetic opposition with respect to the poles of the set of magnets carried by the filament so that the card and the two capsules are floatingly supported between the

two sets of magnets, the card and the capsules being free to rotate relative to each other and to the filament, the bearing surfaces between the card, the capsules and the filament being kept at a minimum and the degree of looseness between the bearing surfaces being consistent with the desired freedom of motion therebetween. Relative rotational effects between the capsules and the filaments by reason of the resultant forces of the opposing sets of magnets in each capsule is reduced to a minimum by arranging the magnets of either or both sets in each capsule closely together so as to form, in effect, continuous cylindrical magnets symmetrically arranged with respect to the filament. The capsules being symmetrically disposed with respect to the card control magnets, the resultant turning movement therebetween is kept at a minimum.

Another embodiment of my invention is shown in Fig. 10. In this view, the constituents of the compass are identical to that of Fig. 1, except that two immiscible liquids 96 and 98 of different densities are made use of instead of one, the heavier liquid 96 serving to support and yieldingly maintain the card in its normal position, which is determined by the relative densities of the card and the two liquids, it being preferable, as illustrated, that the card have density such that it will just sink in the lighter liquid 98 at the mean of the operating temperature range. The properties of the liquids have been fully set forth in my above-referred to copending joint application. The card 100 is constructed with a cylindrical portion 102 to bear the cardinal points and with an obverted conical portion 104 and is arranged so that the minimum surface area will be disposed within the heavier liquid. Thus the surface tension drag effects will not materially affect the magnetic control of the card.

The arrangement of the parts in the embodiment illustrated in Fig. 11 is the reverse of that shown in Fig. 10, it, of course, being necessary to have a greater quantity of the heavier liquid in this instance in order that the card indications will be disposed in the substantially central horizontal plane.

In the still further embodiment, as illustrated in Figs. 12 and 13, the arrangement and construction of the parts are similar to that of Fig. 4, except that one set of magnets 106 is carried by the card instead of two sets of magnets to floatingly or yieldingly support the card in its normal position between the two sets of magnets carried by the filament, the set of magnets 106 being carried directly by the card instead of indirectly as by the capsules in Fig. 4. The set of magnets 106, the jewel bearing 108 and the casing 110 are preferably constructed and assembled as a unit, the several magnets being disposed between the opposing walls of the casing and jewel and having their ends of corresponding magnetic polarity extending slightly through the correspondingly arranged openings 112 and 114 in the flanges 116 and 118, respectively. The magnets of the sets of magnets 120 and 122 carried by their respective disks 94' and fixed to the filament 32 are arranged so that their respective magnetic poles are in aiding-relation with respect to one another, i. e., all of like poles are at either end, and likewise the magnets of the lower set, but all sets of magnets are arranged so that the magnetic poles of the upper set 120 is in magnetic opposition to that of the lower set 122 and also in opposition to the poles of the set of magnets 106.

A variation of the type of card supporting the magnets is shown in Figs. 18 and 19. The magnets 124 carried by the disks 94'' and connected to filament 32 and the magnet 126 carried by the card are cylindrical in shape and formed from a tube instead of from a plurality of magnets. It will be seen in Fig. 19 that the tubular magnet 126 is firmly seated in the tubular portion 20 and it, in turn, has a press fit with and serves as a support for the jeweled bearing.

I claim:

1. In an indicator, the combination with a magnetically controlled card and a support for said card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and means supported by said filament for yieldingly opposing vertical movement of said card from its normal central position.

2. In a liquid damped magnetic compass, the combination with a magnetically controlled card and a support for said card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and means for yieldingly maintaining said card in its normal position centrally of said filament including a member yieldingly movable with said card and slidably mounted on said filament.

3. In an indicator, the combination with a magnetically controlled card and a support for said card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and means for yieldingly maintaining said card in its normal central position, said last-mentioned means being associated with said filament in such a manner as to prevent relative lateral displacement therebetween.

4. In a liquid damped magnetic compass, the combination with a magnetically controlled card and a support for said card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and fluid dampening means carried by said filament for dampening the vertical movements of said card.

5. In a liquid damped magnetic compass, the combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening, and means for adjustably tensioning said filament to be vertically disposed and relatively rigidly connected with the housing of said compass and a member mounted on end in sliding relation with said filament for yieldingly supporting said card.

6. In a liquid damped magnetic compass, the

combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening, means for adjustably tensioning said filament to be vertically disposed and relatively rigidly connected with the housing of said compass, and means for yieldingly supporting said card, said means and said vertical element being connected in such a manner as to substantially prevent relative lateral movements between them.

7. In a liquid damped magnetic compass, the combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and means for yieldingly supporting said card and dampening the movements thereof, said means being carried by and restrained against relative lateral displacement with respect to said filament.

8. In a liquid damped magnetic compass, the combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and a pair of devices co-axially disposed with respect to said filament and arranged to receive therebetween the bearing of said card, one of said devices serving to support the card and both of said devices serving to yieldingly oppose relative vertical displacements of the card in opposite directions.

9. In a liquid damped magnetic compass, the combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, a pair of devices coaxially disposed with respect to said filament and arranged to receive therebetween the bearing of said card, said devices serving to yieldingly oppose relative vertical displacements of the card in opposite directions, at least one of said devices including means for dampening the vertical movements of said card.

10. In a liquid damped magnetic compass, the combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and a pair of yieldable devices having a low vibration period concentrically disposed with respect to the axis of rotation of said card, said devices being carried by said filament and arranged to receive therebetween the bearing of said card and to oppose relative vertical displacements of the card in opposite directions.

11. In a liquid damped magnetic compass, the combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and a pair of coil springs surrounding said filament, each spring having one end connected to said filament at the outer ends thereof, respectively, the inner ends being free and spaced apart to receive therebetween the bearing of said card and having pivot caps attached thereto, respectively, said coils serving to yieldingly oppose relative vertical displacements of the card in opposite directions.

12. In a liquid damped magnetic compass, the combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, a pair of coil springs surrounding said filament, each spring having one end connected to said filament at the outer ends thereof, respectively, the inner ends being free and spaced apart sufficiently to receive therebetween the bearing of said card, and a pair of dash-pots disposed co-axially with respect to said filament and on opposite sides of said bearing, each dash-pot having one of its displaceable elements fixedly connected with said filament and the other with the free end of said coil spring, for dampening the relative vertical displacements between the filament and the coils and the card.

13. In a liquid damped magnetic compass, the combination with a magnetically controlled card and a support for said card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and magnetic means carried by the filament and the card for yieldingly opposing relative vertical displacements of said card and said filament while permitting relative freedom of rotation thereof.

14. The combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a vertical bearing element extending through said opening, and magnetic means so constructed and arranged with respect to said element and the card for yieldingly supporting said card in sliding relation with said filament while permitting relative freedom of rotation due to the card magnets, said magnetic means being restrained against relative lateral displacement with respect to said filament.

15. In a liquid damped magnetic compass, the combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and magnetic means for yieldingly opposing displacement of said card from its normal position comprising, a pair of spaced magnets carried by the filament and at least one magnet carried by the card, said last

mentioned magnet being arranged between and co-axial with said pair of magnets, each of said magnets being symmetrically arranged with respect to the magnetic control of the card with adjacent poles arranged in magnetic opposition to provide substantially unrestrained relative rotation of said card.

16. A magnetic compass having a casing adapted to contain a liquid, the combination with a magnetically controlled card having a mean density approximately equal to the density of the liquid, of centralizing means for said card comprising a guide element supported by and centrally of said card and having a substantially vertical opening therethrough and a vertical element passing through said opening and connected at opposite ends to said casing in highly tensioned relation so that the natural frequency of vibration thereof is greater than that of the forced vibrations to which it may be subject in use, and means disposed centrally of said card and at least on one side of said bearing element for supporting said card in substantially normal position, said means and said vertical element being connected in such a manner as to substantially prevent relative lateral movements between them.

17. A magnetic compass having a casing adapted to contain a liquid, the combination with a magnetically controlled card having a mean density approximately equal to the density of the liquid, of centralizing means for said card comprising a guide element having a substantially vertical opening therethrough and supported by and centrally of said card, of a vertical element passing through said opening and connected at opposite ends to said casing in highly tensioned relation, and liquid displacement means supported by said vertical element for dampening the vertical movements of the card.

18. A magnetic compass having a casing adapted to contain a liquid, the combination with a magnetically controlled card having a mean density approximately equal to the density of the liquid, of centralizing means for said card comprising a guide element having a substantially vertical opening therethrough and supported by and centrally of said card, a vertical element passing through said opening and connected at opposite ends to said casing in highly tensioned relation, and supporting and dampening means disposed between and concentrically arranged with respect to said card and filament and at least on one side of said card, said last mentioned means comprising, a member slidably mounted on said filament and means for yieldingly supporting said slidable member and said card and for dampening the vertical movements thereof.

19. In a liquid damped magnetic compass, the combination with a magnetically controlled card, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass and a card supporting member yieldingly mounted in sliding relation with said filament.

20. In a liquid damped magnetic compass, the combination with a magnetically controlled car, of centralizing means for said card comprising an open bearing carried by and having the opening thereof centrally and vertically disposed with respect to said card, a filament extending through said opening and tensioned to be vertically disposed and relatively rigidly connected with the housing of said compass, and a pair of devices co-axially disposed with respect to said filament and arranged to receive therebetween the bearing of said card, said devices serving to yieldingly oppose relative vertical displacements of the card in opposite directions.

21. A magnetic compass having a casing adapted to contain a liquid, the combination with a magnetically controlled card having a mean density approximately equal to the density of the liquid, of centralizing means for said card comprising a guide element having a substantially vertical opening therethrough and supported by and centrally of said card, a vertical element passing through said opening and connected at opposite ends to said casing in highly tensioned relation and supporting and dampening means disposed between and concentrically arranged with respect to said card and filament at least on one side of said card, said last mentioned means comprising a cylinder member and a piston member constituting a dash-pot, one of said members being fixed to said filament and the other being slidable thereon and means between said members for yieldingly supporting said slidable member against said card and dampening the movements thereof.

22. A magnetic compass having a casing adapted to contain a liquid, the combination with a magnetically controlled card having a mean density approximately equal to the density of the liquid, of centralizing means for said card comprising a guide element having a substantially vertical opening therethrough and supported by and centrally of said card, a vertical element passing through said opening and connected at opposite ends to said casing in highly tensioned relation and supporting and dampening means for said card, said last mentioned means comprising a cylinder member and a piston member constituting a dash-pot that is arranged on one side of said card and co-axial with said filament, one of said members being fixed to said filament and the other being slidably mounted thereon and movable with said card and magnetic means between said members for yieldingly opposing relative displacements of said members.

23. A magnetic compass having a casing adapted to contain a liquid, the combination with a magnetically controlled card having a mean density approximately equal to the density of the liquid, of centralizing means for said card comprising a guide element having a substantially vertical opening therethrough and supported by and centrally of said card, of a vertical element passing through said opening and connected at opposite ends to said casing in highly tensioned relation, and dampening means disposed on at least one side of said bearing element and arranged concentrically with respect to said vertical element for dampening the vertical displacements of the card, said dampening means being connected with said filament in such a manner as to substantially prevent relative lateral movements therebetween.

MAX ISAACSON.