No. 779,624. PATENTED JAN. 10, 1905.

G. SAALER.

ROTARY SPEED INDICATOR.

APPLICATION FILED NOV. 14, 1904.

2 SHEETS—SHEET 1.

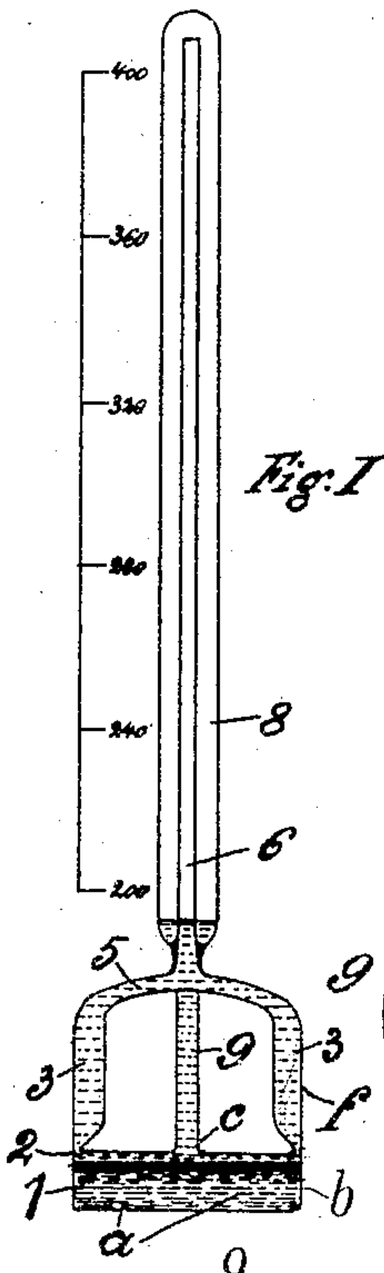

Fig: I

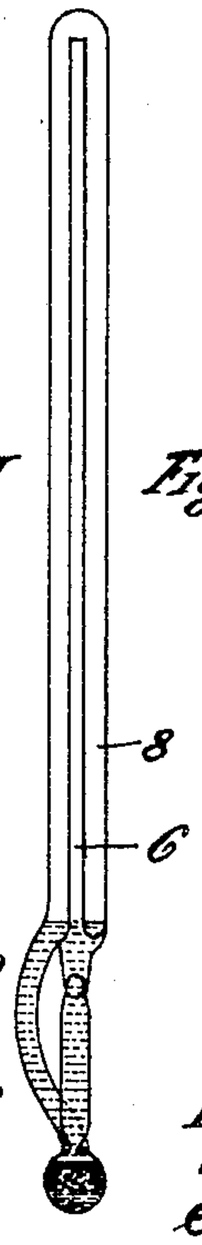

Fig: II

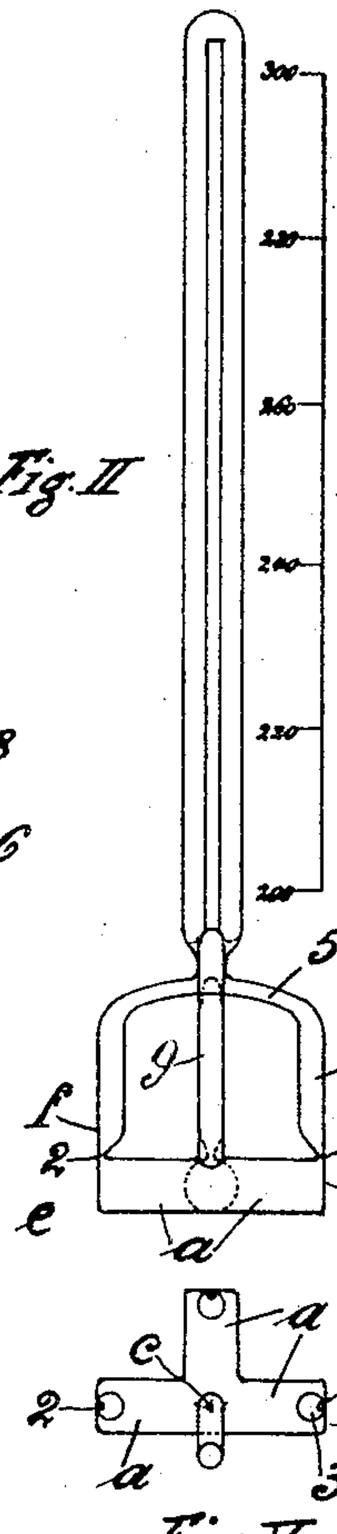

Fig: IV

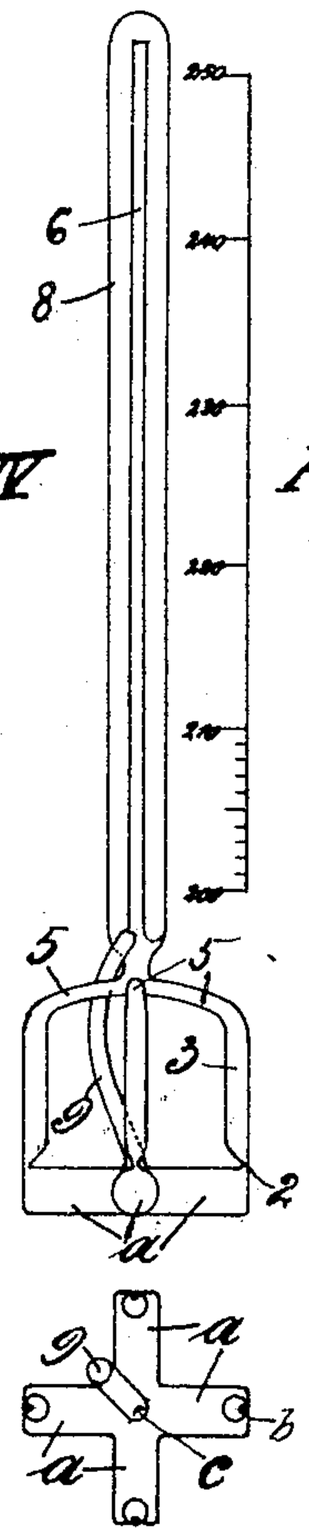

Fig: VI

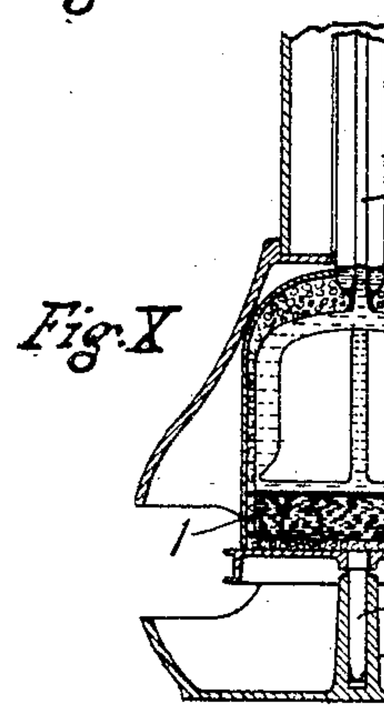

Fig: III

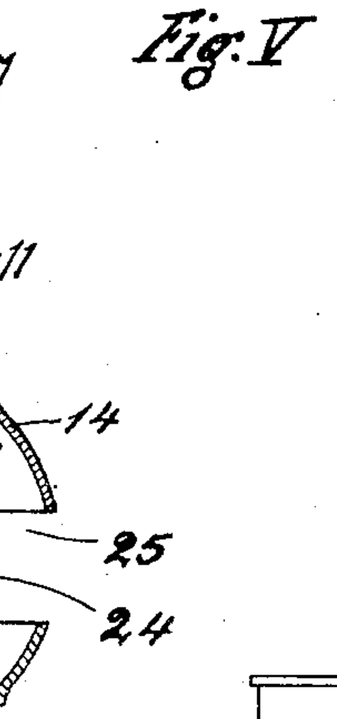

Fig: V

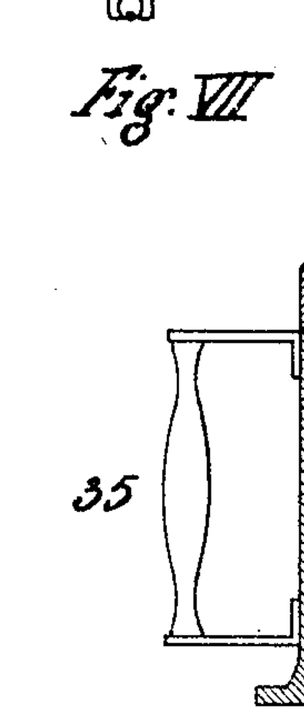

Fig: VII

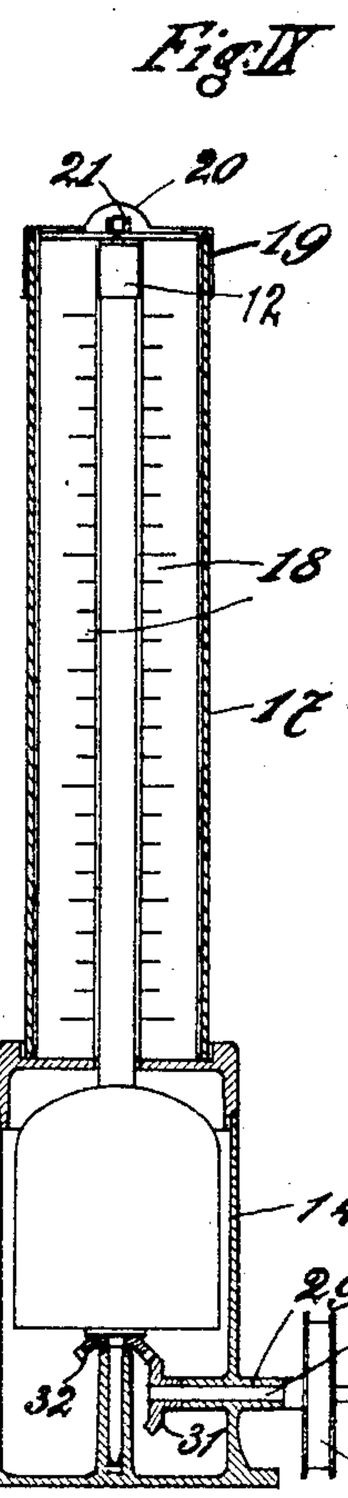

Fig: IX

Fig: X

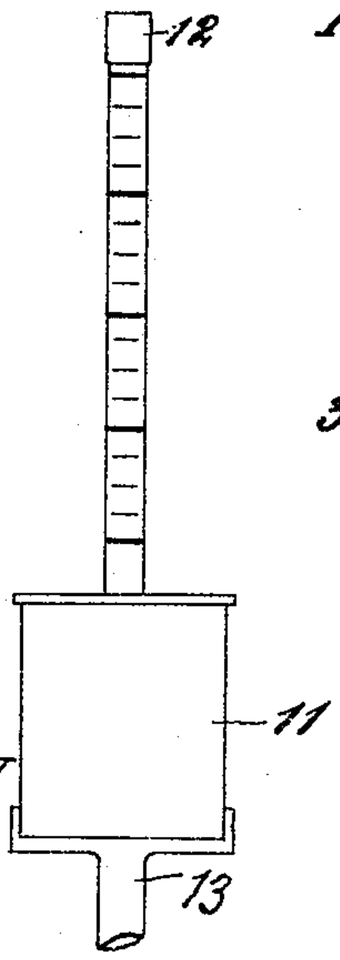

Fig: VIII

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2 SHEETS—SHEET 2.

Fig. XI

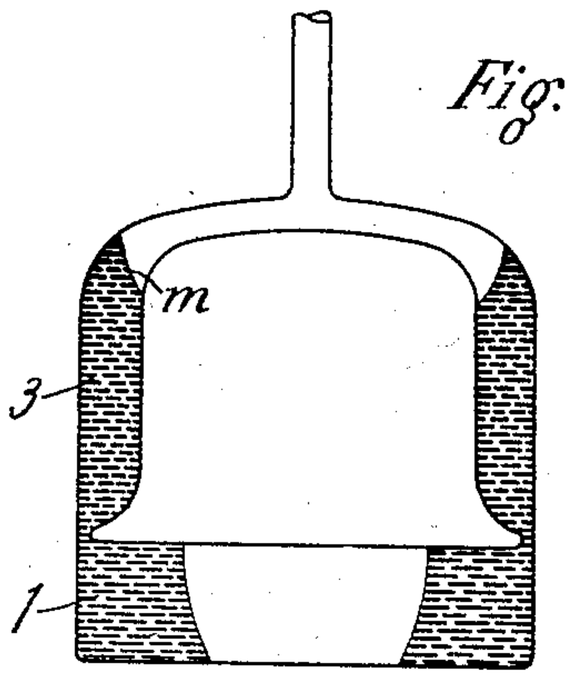

Fig. XII

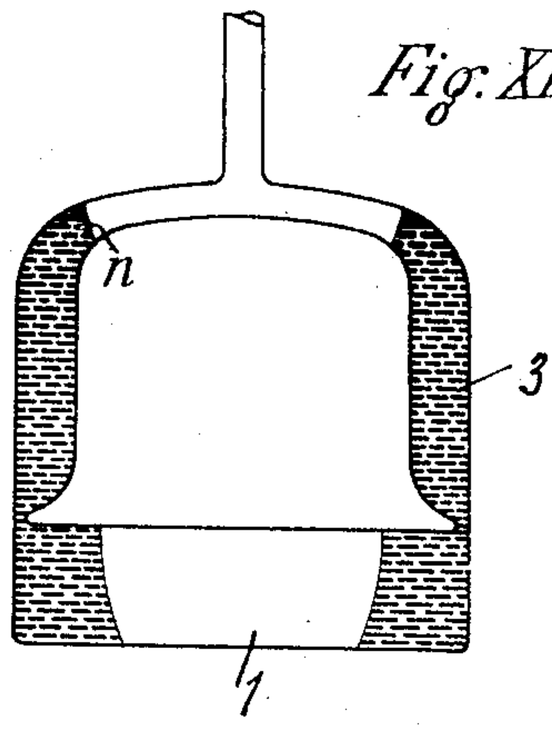

Fig. XIII

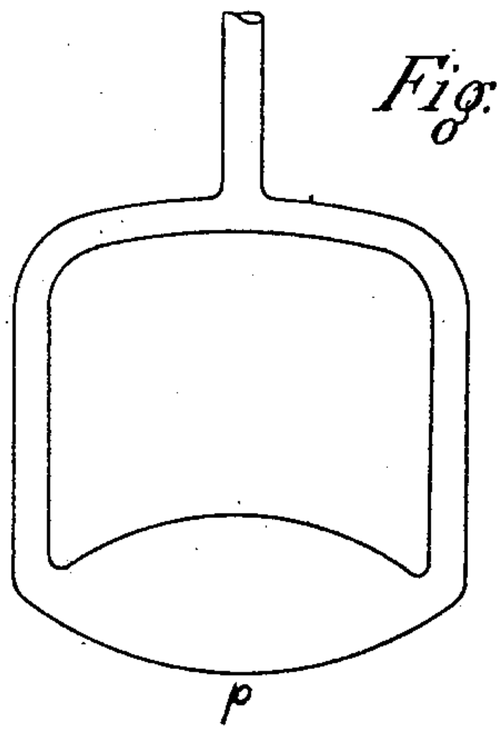

Fig. XIV

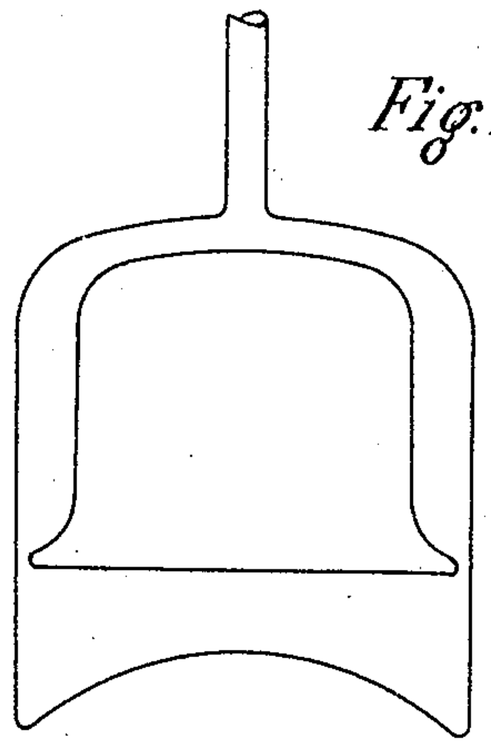

Fig. XV

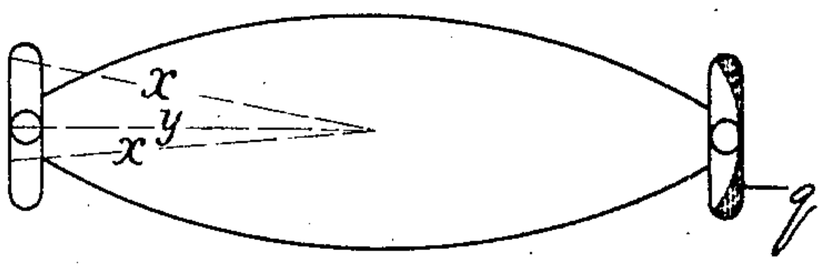

Fig. XVI

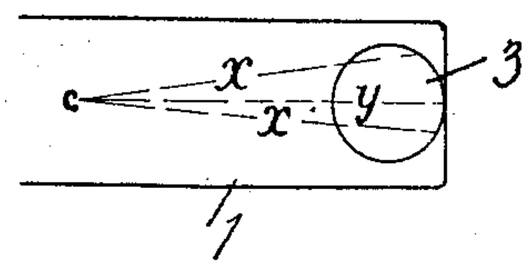

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PHOTO-LITHOGRAPHED BY SACHETT & WILHELMS LITHO. & PTG. CO. NEW YORK.

No. 779,624. Patented January 10, 1905.

UNITED STATES PATENT OFFICE.

GUSTAV SAALER, OF EMMENDINGEN, GERMANY.

ROTARY SPEED-INDICATOR.

SPECIFICATION forming part of Letters Patent No. 779,624, dated January 10, 1905.

Application filed November 14, 1904. Serial No. 232,616.

To all whom it may concern:

Be it known that I, GUSTAV SAALER, a subject of the German Emperor, residing at Emmendingen, in the Grand Duchy of Baden, Germany, have invented certain new and useful Improvements in Rotary Speed-Indicators; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to rotary speed-indicators in which the speed is indicated by an axial column of some lighter liquid forced up in a tube to a height proportioned to the speed by the action of the centrifugal force on mercury contained in a lower chamber; and it consists of a new device of new form, construction, and proportions by which the laws relating to the effect of centrifugal force on liquids are applied to produce a practical device that indicates the speed with exactness and uniformity and can be applied to a variety of uses.

The essential features of my new device are a horizontal container consisting of a plurality of equal, preferably cylindrical, arms uniformly radiating from the vertical axis of rotation. To the ends of the arms are connected by minute holes vertical cylindrical rising chambers, connected at their upper ends by connecting-tubes to the foot of the vertical indicating-tube, set true in the axis of rotation. A parallel return-tube is connected to the upper end of the indicating-tube and extends down about to the foot of the latter, where it is connected to the top of the container by the large return branch. The outer end of each arm and the outer margin of the corresponding rising chamber are arranged substantially in alinement and the small connecting-hole arranged at said outer line—*i. e.*, at the end of the longest radius from the axial center—so that the mercury will enter the rising chamber at the point where it is subjected to the greatest centrifugal force and flow back therefrom freely and unimpeded when the rotation and said force diminish. The container is nearly filled with mercury, leaving a small space at its top for the lighter liquid, which also fills the rising chambers, connecting-tubes, and branch about to the foot of the indicating-tube. The proportions of the various parts of the device or indicating vessel above described are of great importance. The container must be of such a size as to hold a bulk of mercury not substantially less than four times the total contents of all the rising chambers. The total contents of the rising chambers must be at least substantially equal to the contents of the indicating-tube.

My invention will be understood by reference to the drawings herewith, in which I have shown my device, particularly the characteristic indicating vessel, in various slightly-modified forms adapted for different purposes and having a different range of indication. In Sheet 2 I have shown some simple diagrams which explain the operation of the device and why particular forms and proportions of parts are essential.

Figures I, II, and III are respectively front and side elevation and cross-section of an indicating vessel having a two-armed container; Figs. IV and V, respectively elevation and cross-section of a form having three arms; Figs. VI and VII, respectively elevation and cross-section of a form with four arms. Fig. VIII is an elevation showing the indicator sealed in a shell to be directly connected to a rotating body, such as a governor. Fig. IX shows the device of Fig. VIII inclosed within a case provided with a stationary scale. This illustrates my so-called "hand-tachometer" or may be connected by a belt to the rotating body. Fig. X shows another form adapted to receive a belt. Figs. XI and XII are diagrams illustrating the rise of the mercury in my device. Figs. XIII and XIV are diagrams showing, respectively, bad and good forms of container, rising chamber, &c. Figs. XV and XVI illustrate the importance of the cylindrical form of container and rising chambers.

In the figures, 1 indicates the horizontally-arranged container composed of a plurality of equal arms *a a a*, radiating from a center *c*,

which is the axis of vertical rotation. The outer ends of these arms should not be higher than the center of the container for a reason to be explained, and their upper margins are preferably straight. Therefore they are preferably cylindrical, which form is also the best, because its capacity is large and an easy form to make. At the extreme outer end of its upper wall each arm is connected to a vertical rising chamber 3 by small hole 2, arranged against the outer wall *b* of the arm and the outer margin *f* of the rising chamber, which wall and margin are practically in alinement. As shown, these holes are and should be arranged at the point of greatest distance from the center of rotation with reference to the rising chambers, for that is the point where the mercury tends to rise under the influence of the centrifugal force and where it tends to first flow back when the speed decreases. These holes must be made very small, so as to be immediately filled and plugged when the mercury begins to rise and to remain so plugged during the entire operation of the device. If too large, they would permit the lighter liquid to flow down through their inner portions while the mercury is being forced up in their outer, which would at once render the device inoperative. They are as small as the glass-blower can reasonably make them. A desirable size of hole is about one millimeter for smaller devices up to about two millimeters for larger. In forming or blowing from glass the indicating vessel slight variations cannot be avoided; but if the holes were substantially more than three millimeters in diameter there would be danger of the lighter liquid flowing down during rotation, as aforesaid.

The rising chambers are several times larger in diameter than the holes to contain sufficient lighter liquid and are arranged entirely within the ends of the arms, so that they extend radially much inside of the holes. They are preferably cylindrical, because corners should be avoided, permitting the mercury to rise and fall without being impeded and in a manner most desirable to produce a practical result. This is further indicated by the diagrams.

From the upper ends of the rising chambers extend upwardly and inwardly the gradually-diminishing connecting-tubes 5 5, which unite and connect the chambers to the vertical indicating-tube 6, set true in the axis of rotation. This tube should be of sufficient diameter so that the lighter liquid therein shall be visible with distinctness. An interior diameter of three millimeters is desirable for smaller devices up to about eight millimeters for larger. A tube of twelve to fifteen millimeters interior diameter would be excessively large.

Connected to the upper end of the indicating-tube and extending down to about its foot is the return-tube 8 to return the lighter liquid to the container in case of accidental overflow from the top of the indicating-tube by excessive speed. This return-tube is preferably at least of equal capacity to the indicating-tube and may desirably be arranged to inclose the indicating-tube, as shown. It is connected at its lower end to the top of the container by a large branch return-tube or branch 9. This branch should be large, not small, and at least of equal diameter to the indicating-tube, preferably decidedly larger, to permit a free flow of overflowing lighter liquid and particularly to contain a considerable quantity of the lighter liquid, instantly to replace in the container the mercury displaced by and during rotation, to prevent a vacuum in the container, which might crush the device or which would cause a jump in the indicating-column of lighter liquid, if the lighter liquid were impeded in initial downflow, and finally drawn down forcibly to fill the vacuum, which would be the case if the branch were small.

The container is filled as nearly as possible with mercury, as indicated, leaving merely a small space at its top for a portion of the lighter liquid to connect the holes, so that the lighter liquid will flow up and fill the rising chambers when the device returns to a state of rest in case there has accidentally been an overflow from the top of the indicating-tube. This lighter liquid, preferably tinted, fills the rising chambers, connecting-tubes, and branch to stand at a level about at the foot, or a little above the foot, of the indicating-tube.

The relative sizes or proportions of the various parts are of importance, and the operativeness of the device depends thereon. A considerable mass of mercury is necessary to force the mercury outwardly and up into the rising chambers and to leave a considerable surplus thereof in the container to hold up the mercury, so that it will rise throughout substantially the whole rising chamber at substantially a uniform rate, and thereby the lighter fluid be raised at a uniform rate in the indicating-tube, permitting uniform graduation. If there were too little mercury, the rate of rising in the rising chamber would diminish rapidly as the mercury rose therein. Slight variations would cause considerable variations in the indication, and the device would not be practical. I have discovered these facts and that the bulk of mercury in the container should not be materially less than four times the total capacity of all the rising chambers, whether two or more. If the bulk of mercury were as small as about three times the capacity of the rising chambers, the rate of rise and indication at the upper part of the scale would not be so uniform, and if below three times the device would not be practical. A proportion of five to one would not be objectionable, except that an unnecessary amount of mercury would be used; but about and above six to one the indication would not be

uniform, for the mercury would rise too fast in the lower portion of the rising chambers.

The total capacity of all the rising chambers should be at least equal to the capacity of the indicating-tube, or, to be strictly accurate, to the indicating portion of the indicating-tube, which is the longer central portion thereof corresponding to the scale. Said indicating portion and the scale should begin a short distance above the lower end of the tube, which is filled by the lighter liquid during the lower speed rotations, (to indicate these clearly would be difficult and not desirable,) and should terminate a short distance below the upper end of the tube, that a cap may be attached to the upper end and overflow not take place immediately at end of scale, though there is no objection to the overflow in itself. A small surplus capacity of the rising chambers over said indicating portion would not be objectionable.

The foregoing are the more important proportions; but the following should desirably be observed:

The length of the container should be considerably greater than its diameter—preferably not less than three or four to one. About two-thirds the length of the container is a desirable length for the rising chambers. About four times the length of the container is a desirable length for the indicating-tube. The size of the tube should first be fixed suitably for its intended purpose and the other parts then made the proper proportions to the tube. The rising chambers, indicating-tube, and return-tube should each be of uniform diameter from end to end, also generally the container.

Variations in temperature need not be considered ordinarily, as a variation of 50° centigrade in temperature causes my device to vary almost imperceptibly.

The device (indicating vessel) heretofore described may be of any suitable material or materials, but is desirably formed of glass in one piece (preventing leaking in operation) and may be sealed in a shell 11, packed with any suitable packing 7, as shown in Fig. X, and adapted to be mounted directly and axially on the rotating object 13, as shown in Fig. VIII. A scale may be marked on the indicating-tube. Evidently the indicating-tube (and the return-tube where that incloses the indicating-tube) must be made of glass to be transparent; but I prefer for most purposes to inclose the indicating vessel sealed in the shell in a case 14, desirably made of metal and provided with a bearing 15 for the shell-stem 16, with an outer glass tube 17 inclosing the indicating and return tubes and with a stationary scale 18 properly graduated and numbered and arranged adjacent to the indicating-tube, from which the height of the column of lighter liquid may be read easily. The scale is arranged within the outer tube for cleanliness and convenience. Said outer tube is also provided with a metal cap 19, formed with any suitable bearing, as hollow bearing 20, for pin 21 on inner cap 12.

The indicating vessel (and shell) rotates in the bearings within the case, and rotation may be communicated to it by any suitable means—for instance, by a suitable pulley 24 on the shell, which may be connected to rotate with the rotating object by a belt entering through openings 25 in the case, as shown in Fig. X, or, as shown in Fig. IX, a pulley 27 may be arranged externally on a short shaft 28 in a bearing 29 in the side of the case and connected to the indicator by bevel-gears 31 32. By these belts evidently the indicator may be geared down from the rotating object, which is necessary, as aforesaid, when the latter rotates at a high speed—for instance, several thousand per minute. It would also be necessary to gear up the indicator if a device were desired to indicate a very slow speed, as less than one hundred per minute. To indicate such low speed by an indicator secured on the rotating object and rotating at the same speed would require an excessively large container and a short indicating-tube; but this is not a practical question, because such low speeds can be observed in other ways.

In my so-called "hand-tachometer," also illustrated in Fig. IX, the case is provided with a handle 35 and the short shaft with a conical tip, which may be set temporarily in the small axial cavity in the end of a rotating shaft whose speed is to be measured and the indicator rotated by friction.

In Sheet 1 I have shown devices respectively with two, three, and four arms and rising chambers, which variations in form are to adapt the device to indicate different ranges of rotations, as shown in the different scales of Figs. I, IV, and VI. Where a two-armed container is used with two rising chambers, there are two holes only for the mercury to rise through, and its rate of rise, and consequently of raising the lighter liquid in the indicating-tube, is rather slow in proportion to the number of rotations; but with four arms to the container there are four holes for the mercury to rise through, and consequently more mercury is raised in the rising chambers by the same number of rotations than with two holes. Therefore with four holes the lighter liquid is raised faster in the indicating-tube—*i. e.*, a longer distance for each addition rotation—the graduations on the scale are each longer, and slight changes in speed may be observed with greater ease and accuracy. The effect of a device with three holes is evidently intermediate between the devices with two and four. This operation is illustrated by means of the scales in Figs. I, IV, and VI. The indicating-tubes and scales are all of the same length, but with two rising chambers the range of indication is, for instance, from two hundred to four hundred, with three ris-

ing chambers from two hundred to three hundred, with four rising chambers from two hundred to two hundred and fifty. Therefore an increase in the number of rising chambers limits the range, but permits a small increase in speed to be indicated by longer gradations and with more accuracy. An indicator with more than four arms and more than four rising chambers could be made; but it is not practically necessary. A device with one rising chamber and one hole connecting it with the container would not be practical, as the mercury would move unevenly in the container and its rise would be too slow.

The devices here shown are full-size practical devices of correct proportions. It will be understood that in the devices of Figs. I, IV, and VI the indicating-tubes are all of the same size, the containers all of the same capacity, and therefore diminishing in diameter as their arms increase in number, and that each rising chamber diminishes in size as their number increases to preserve the proportion hereinbefore stated. Commercial devices are commonly of larger size than that here shown. The same proportions are maintained in devices of different forms and sizes.

Fig. I indicates about the range of indication possible with the devices of this invention—that is, from one to two—or, in other words, from the minimum speed to be measured up to twice that speed—for instance, from about two hundred to four hundred, about two hundred and seventy-five to five hundred and fifty, or about five hundred to one thousand.

To indicate the higher speeds above twelve hundred or fifteen hundred rotations per minute, the indicator must be geared down, and devices of identical size may be adapted to indicate any speed above or below that speed by variations in the gearing, the scale being varied accordingly, graduated and numbered according to the speed of the object to be measured, and the entire device made of any size convenient for the particular use; but where the device is to be attached directly to the rotating object and to rotate at the same speed therewith a device of larger size will be used to indicate a slower speed and a smaller device a higher speed, because the larger the device the larger will be its peripheral or circumferential speed for the same number of rotations, and therefore the mercury in the larger device will be driven with greater force up through the holes arranged at the periphery and the lighter liquid will be forced to the foot of the scale with fewer rotations, while with a small device the reverse will be the case, and it will take a higher speed to force up the mercury in the container, and thereby the lighter liquid into the lower portion of the indicating-tube.

Fully to explain my invention and the importance of the forms and proportions of the parts I refer to the diagrams Figs. XI to XVI. Figs. XI and XII indicate the positions and curve of the mercury in the container and in the rising chamber when the device is rotating and indicate why a large amount of mercury is necessary to fill the rising chambers and to sustain the mercury therein. At *m* the mercury has about reached the limit of practical indication—*i. e.*, about the top of the rising chamber. By a great increase in the speed it could be driven about to *n*—the dead-point—but more and more slowly from *m* to *n*, so that it would not be practical to make graduations corresponding thereto. They would be uneven and so short as to be confused. Owing to the large bulk of mercury and the push of that portion near the center against the outer portion it rises at substantially a uniform rate up to *m*, and the graduation of the scale may be practically uniform.

Fig. XIII illustrates an inoperative form of device, which shows serious faults, because the container is lower at its center and its lower wall curved, as here shown. The mercury would be forced up this curve into the rising chamber at first very quickly, but then slower and slower, with a rapidly-diminishing speed in proportion to the rate of rotation. The bulk of the mercury would not be freely driven to the ends of the container, because gravity would constantly tend to pull it down to the point *p*. Furthermore, owing to the great cohesion of mercury it would tend to resist separation at this point *p*, and when the cohesion at this point was finally overcome by the centrifugal force the separation would come with a jerk and cause an objectionable jump of the mercury in the rising chambers and of the lighter liquid in the indicating-tube. Another objection is that the holes are too large, and as they are as wide as the rising chambers (measured radially from the axis) the mercury would often be held out against the outer wall thereof, and a space would be left in the inner portion of the hole for the lighter liquid to flow back during rotation.

Fig. XIV shows a desirable form of container, for the upward curve of the bottom would assist in sending the mercury to the ends and prevent the objectionable effect of the cohesion above specified; but this form is difficult to make from glass. Therefore I have adopted the cylindrical form, in which the ends are at least as low as the center, which is easier to make and has large capacity. This is another objection to an elliptical container, that it has only half the capacity of the cylinder for the same length and diameter.

Fig. XV shows the objection to a lateral flattening of the rising chambers. Here the radius *y* from the axis through the hole is shorter than the radii *x x* to or toward the corners of the chamber, and therefore the mercury would be held out in the corners by

the greater centrifugal force, as indicated at *q*, and its return through the hole impeded.

Fig. XVI is a diagram of my construction with cylindrical rising chamber. Here the radius *y* through the hole is the longest. The mercury is driven with the greatest force to that edge of the cylinder immediately above, and therefore tends to reflow readily down through the hole when the speed diminishes.

I am aware that I am not the first to have proposed a rotary speed-indicator having a container, rising tubes, an indicating-tube, a return-tube, and a small return branch and containing a heavier and a lighter liquid; but such prior devices are imperfect and inoperative, because the container and the rising tubes are of improper form, the connecting-holes between the container and the rising tubes too large, also too large in comparison to the width of the rising tubes and improperly arranged with reference thereto, and the branch small instead of large, and in other features whose importance to my invention is explained herein, and particularly because the relative sizes of the parts are not correct for an operative device, and I am not aware that any practical device or device of proper proportions has been made or described before mine.

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

1. As a new article of manufacture, an indicating vessel for a rotary speed-indicator, said vessel being adapted to be rotated on a vertical axis, and having in combination a horizontally-arranged container composed of a plurality of similar arms radiating from the axial center, the lower wall of said arms being at least as low at the ends of the arms as at the axial center, rising chambers connected to the ends of said arms by small holes, a vertical indicating-tube of smaller diameter than the rising chambers, connecting-tubes connecting the upper ends of the respective rising chambers to the foot of the indicating-tube, a return-tube connected to the upper end of the indicating-tube and extending down adjacent to the foot of the indicating-tube, and a branch connecting the lower portion of the return-tube to the upper portion of the container.

2. As a new article of manufacture, an indicating vessel for a rotary speed-indicator, said vessel being adapted to be rotated on a vertical axis and having in combination a horizontally-arranged container composed of a plurality of similar arms radiating from the axial center, the lower wall of said arms being in the same horizontal plane at all points, rising chambers connected to ends of said arms by small holes, a vertical indicating-tube of smaller diameter than the rising chambers, connecting-tubes connecting the foot of the indicating-tube with the upper ends of the respective rising chambers, a return-tube connected to the upper end of the indicating-tube and extending down about to the foot thereof and a branch connecting the foot of the return-tube with the top of the container.

3. In a rotary speed-indicator, an indicating vessel adapted to be rotated on a vertical axis, having in combination a lower horizontally-arranged container composed of a plurality of similar arms radiating from the axis of rotation, the lower margins of said arms being arranged in the same horizontal plane, vertical rising chambers connected to the extreme ends of said arms by small holes in the upper walls of the respective arms, a vertical indicating-tube, of smaller diameter than the rising chambers, arranged higher than the rising chambers and in the axis of rotation, connecting-tubes connecting the tops of the respective rising chambers to the foot of the indicating-tube, a return-tube connected to the top of the indicating-tube and extending down to about the foot thereof, a branch connecting the lower portion of the return-tube to the upper portion of the container, said branch being of larger diameter than the indicating-tube, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube and of the return-tube.

4. In a rotary speed-indicator, an indicating vessel adapted to be rotated on a vertical axis, having in combination a horizontal container composed of a plurality of similar, cylindrical arms radiating from the axis of rotation, vertical rising chambers connected to the tops of said arms at their extreme ends by small holes, an indicating-tube arranged in the axis of rotation above the rising chambers, connecting-tubes connecting the foot of the indicating-tube to the upper ends of the rising chambers, a return-tube connected to the top of the indicating-tube and extending down about to the foot of the latter, a branch tube connecting the lower portion of the return-tube to the upper portion of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube and of the return-tube.

5. In a rotary speed-indicator, an indicating vessel adapted to be rotated on a vertical axis, having in combination a horizontally-arranged container of greater length than diameter, consisting of a plurality of similar arms radiating from the axis of rotation, vertical, cylindrical rising chambers above the arms and connected to the extreme ends of said arms by small holes in the upper walls of the respective arms, said rising chambers being arranged inwardly of the ends of the arms, an indicating-tube of smaller diameter than the rising chambers arranged in the axis of rotation, connecting-tubes connecting the foot of the indicating-tube to the upper ends of the respective ris-

ing chambers, a return-tube communicating with the upper end of the indicating-tube and extending down to about the foot of the latter, a branch tube connecting the lower portion of the return-tube with the top of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube and of the return-tube.

6. In a rotary speed-indicator, an indicating vessel adapted to be rotated on a vertical axis, having in combination a horizontally-arranged container of greater length than diameter, consisting of a plurality of similar, cylindrical arms radiating from the axis of rotation, vertical, cylindrical rising chambers, connected to the extreme ends of said arms by small holes in the upper walls of the respective arms, the diameter of the rising chambers being several times the diameter of the holes, an indicating-tube of smaller diameter than the rising chambers arranged in the axis of rotation, connecting-tubes connecting the foot of the indicating-tube to the upper ends of the respective rising chambers, said connecting-tubes tapering from the larger diameter of the rising chambers to the smaller diameter of the indicating-tube, a return-tube communicating with the upper end of the indicating-tube and extending down and parallel to about the lower end of the latter, a branch tube connecting the lower portion of the return-tube with the top of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube and of the return-tube.

7. In a rotary speed-indicator, an indicating vessel adapted to be rotated on a vertical axis, having in combination a horizontally-arranged container composed of equal arms, radiating symmetrically from the axis, vertical rising chambers connected to the ends of the respective arms and communicating therewith by small holes, an indicating-tube arranged in the axis of rotation, connecting-tubes connecting the upper ends of the rising chamber to the lower end of the indicating-tube, a return-tube communicating with the upper end of the indicating-tube and extending to about the end of the latter, a branch tube connecting the lower end of the return-tube to the top of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube and of the return-tube, the capacity of the container being not less than three times nor more than five times the total capacity of all the rising chambers and the total capacity of the rising chambers being at least nearly equal to the capacity of the indicating-tube.

8. In a rotary speed-indicator, an indicating vessel adapted to be rotated on a vertical axis, having in combination a horizontal container composed of equal, cylindrical arms, radiating symmetrically from the axis, vertical, cylindrical rising chambers connected to the ends of the respective arms and communicating therewith by small holes, an indicating-tube arranged in the axis of rotation, connecting-tubes connecting the upper ends of the rising chambers to the foot of the indicating-tube, a return-tube communicating with the upper end of the indicating-tube and extending to about the foot of the latter, a branch tube connecting the lower end of the return-tube to the top of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube and of the return-tube, the capacity of the container being not substantially less than four times the total capacity of all the rising chambers, and the total capacity of the rising chambers being not less than the capacity of the indicating-tube.

9. In a rotary speed-indicator, an indicating vessel having in combination a horizontal, cylindrical container, two vertical rising chambers connected to the respective ends of the container and communicating therewith by small holes, an indicating-tube arranged in the axis of rotation, connecting-tubes connecting the upper ends of the rising chambers to the lower end of the indicating-tube, a return-tube communicating with the upper end of the indicating-tube and extending to about the foot of the latter, a branch tube connecting the lower end of the return-tube to the top of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube and of the return-tube, the capacity of the container being not substantially less than four times the total capacity of all the rising chambers and the total capacity of all the rising chambers being at least substantially equal to the capacity of the indicating portion of the indicating-tube.

10. In a rotary speed-indicator, an indicating vessel having in combination a horizontal cylindrical container, two vertical, cylindrical rising chambers connected to the respective ends of the container and communicating therewith by small holes, an indicating-tube arranged in the vertical axis of rotation, connecting-tubes connecting the upper ends of the rising chambers to the lower end of the indicating-tube, a return-tube communicating with the upper end of the indicating-tube and extending downwardly, a branch tube connecting the lower portion of the return-tube to the upper portion of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube, the capacity of the container being not substantially less than four times the total capacity of all the rising chambers and the

total capacity of all the rising-chambers being at least substantially equal to the capacity of the indicating portion of the indicating-tube, means to support the vessel so as to rotate on a vertical axis, and means to communicate rotation to said vessel from the rotating object whose speed is to be measured.

11. In a rotary speed-indicator, an indicating vessel adapted to be rotated on a vertical axis and composed of a horizontal container, vertical rising chambers connected to the ends of the container by small holes, an indicating-tube in the axis of rotation, connecting-tubes connecting the upper ends of the respective rising chambers to the lower end of the indicating-tube, a return-tube inclosing the indicating-tube, said return-tube being connected to the upper end of the indicating-tube and extending down to about the foot of the latter, a branch connecting the lower end of the return-tube to the top of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel about to the foot of the indicating-tube, and in combination therewith an inclosing case for the vessel, a bearing in the case on which the vessel is fitted to rotate, rotating means connected to the vessel and adapted to be connected to the object whose speed is to be measured, an outer glass tube on the case to protect the indicating and return tubes, a bearing in said outer glass tube for the upper end of the vessel, and a stationary scale arranged in said outer tube to measure the rise of the lighter liquid in the indicating-tube.

12. In a rotary speed-indicator, an indicating vessel, adapted to be rotated on a vertical axis, and composed of a horizontal container, vertical rising chambers connected to the ends of the container by small holes, an indicating-tube in the axis of rotation, connecting-tubes connecting the upper ends of the respective rising chambers to the lower end of the indicating-tube, a return-tube inclosing the indicating-tube, communicating with the upper end thereof, and being in capacity at least equal to the indicating-tube, a branch connecting the lower end of the return-tube to the top of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel about to the foot of the indicating-tube, and in combination therewith a protecting-shell in which the lower portion of the vessel is inclosed, a metallic inclosing case for said shell provided with a hollow bearing in its base, a bearing-pin on the shell fitting said hollow bearing, an outer glass tube on the case to inclose and protect the indicating-tube and return-tube, a cap on the return-tube, a cap on the outer tube, a bearing in said outer cap forming an upper rotating bearing for the vessel, a stationary scale in the outer tube to measure the rise of liquid in the inner tube, and a pulley connected to the shell to receive a belt from the rotating object whose speed is to be measured.

13. In a rotary speed-indicator, an indicating vessel, adapted to be rotated on a vertical axis, and composed of a horizontal container, vertical rising chambers connected to the ends of the container by small holes, an indicating-tube in the axis of rotation, connecting-tubes connecting the upper ends of the respective rising chambers to the foot of the indicating-tube, a return-tube inclosing the indicating-tube, said return-tube being connected to the upper end of the indicating-tube and extending down toward the lower end of the latter and parallel thereto, a branch connecting the lower end of the return-tube to the top of the container, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel about to the foot of the indicating-tube, and in combination therewith an inclosing case for the vessel, a bearing in the case on which the vessel is fitted to rotate, rotating means connected to the vessel and adapted to be connected to the object whose speed is to be measured, an outer glass tube on the case to protect the indicating and return tubes, a bearing in said outer glass tube for the vessel, and a stationary scale arranged in said outer tube to measure the rise of the lighter liquid in the indicating portion of the indicating-tube, said scale being arranged to extend from a short distance above the foot of the indicating-tube to a short distance below the upper end of the indicating-tube, said scale measuring the indicating portion of the indicating-tube and marking the rise of the lighter liquid therein.

14. In a biliquid rotary speed-indicator, an indicating vessel composed entirely of glass and sealed to inclose the liquids, having in combination a horizontally-arranged, cylindrical container, said container being symmetrically arranged with reference to the vertical axis of rotation on which the vessel is to be rotated, cylindrical, vertical rising chambers connected to said container and communicating therewith by small holes, from about one millimeter to about two millimeters in diameter, said rising chambers being several times the diameter of said holes and several times the diameter of the indicating-tube, an indicating-tube set vertically in the axis and being in interior diameter not materially less than three millimeters nor more than eight millimeters, upwardly-inclined, tapering connecting-tubes connecting the upper ends of the respective rising chambers to the foot of the indicating-tube, a return-tube inclosing the indicating-tube and communicating therewith at its upper end, said return-tube being at least of the capacity of the indicating-tube, a branch tube connecting the foot of the return-tube, to the top of the container, said branch being of larger diameter than the indicating-tube, mercury nearly filling the container and a lighter

liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube and of the return-tube, said container being of a capacity to contain mercury not less than three times the total capacity of all the rising chambers.

15. In a rotary speed-indicator, an indicating vessel adapted to be rotated in a vertical axis, and having in combination a horizontally-arranged, cylindrical container, in length not substantially less than three times its diameter, said container being symmetrically arranged with reference to the axis of rotation, two cylindrical, vertical rising chambers connected to the ends of said container and communicating therewith by small holes not above three millimeters in diameter, said holes being arranged at the extreme outer ends of the container in its upper wall and at the extreme outer margin of the rising chambers, so that said rising chambers, of several times the diameter of said holes, extend inwardly toward the axis from the ends of the container, an indicating-tube set vertically in the axis and being in interior diameter not materially less than three millimeters nor more than eight millimeters, upwardly-inclined connecting-tubes connecting the upper ends of the respective rising chambers to the foot of the indicating-tube, said connecting-tubes tapering down from the size of the rising chambers to the size of the indicating-tube, a return-tube inclosing the indicating-tube and communicating therewith at its upper end, said return-tube being at least of the capacity of the indicating-tube, a branch tube connecting the foot of the return-tube to the top of the container, said branch being of larger diameter than the indicating-tube, mercury nearly filling the container and a lighter liquid resting on the mercury and filling the vessel to about the foot of the indicating-tube and of the return-tube, said container being of a capacity to contain mercury not substantially less than four times the total capacity of all the rising chambers, and the total capacity of the rising chambers being at least substantially equal to the capacity of the indicating portion of the indicating-tube, a scale adjacent to the indicating-tube and shorter in length, the indicating portion of the indicating-tube being equal in length to the scale, said indicating-tube being about four times the length of the container and each rising chamber about two thirds the length of the container.

In testimony whereof I affix my signature in presence of two witnesses.

GUSTAV SAALER.

Witnesses:

F. W. GAERTNER,

ALFRED WILKINSON.