No. 803,770. PATENTED NOV. 7, 1905.

E. M. LOW.

LEVELING INSTRUMENT.

APPLICATION FILED JAN. 20, 1904.

3 SHEETS—SHEET 1.

Fig. 1

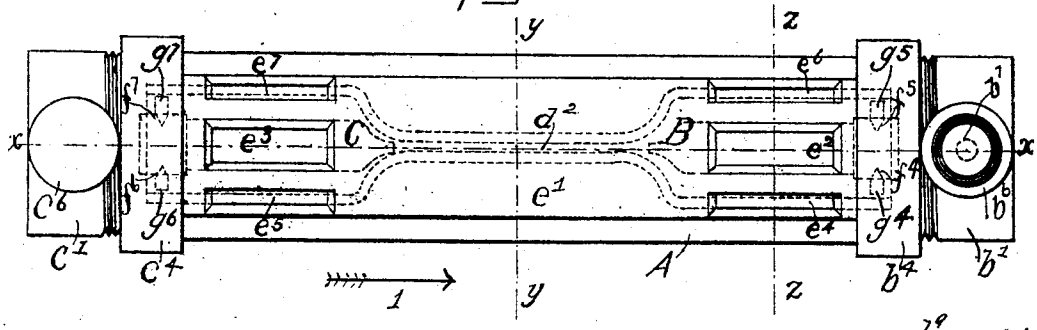


Fig. 2

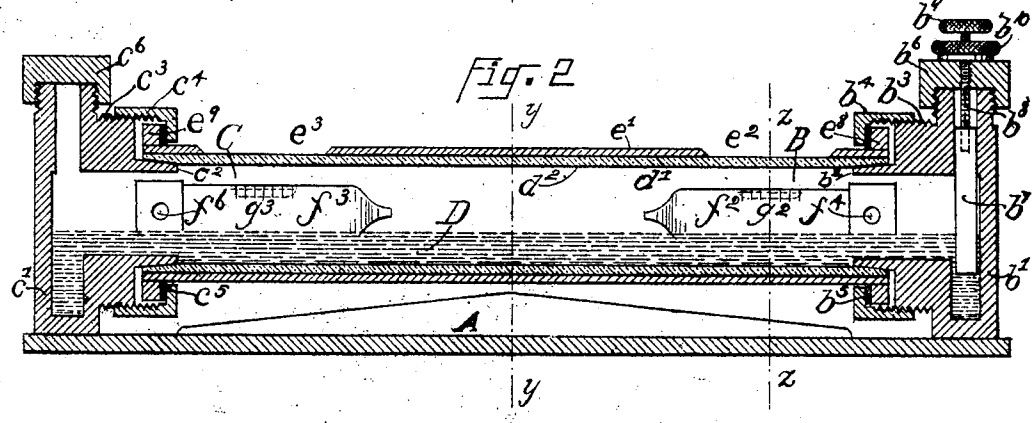


Fig. 3

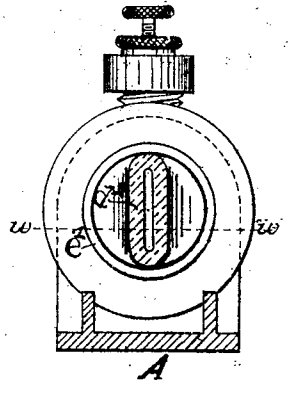
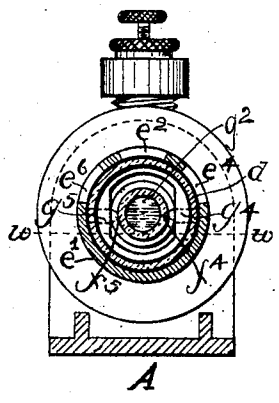


Fig. 4



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Henry W. Rozell

Henry Body

INVENTOR

Everett M. Low

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3 SHEETS—SHEET 2.

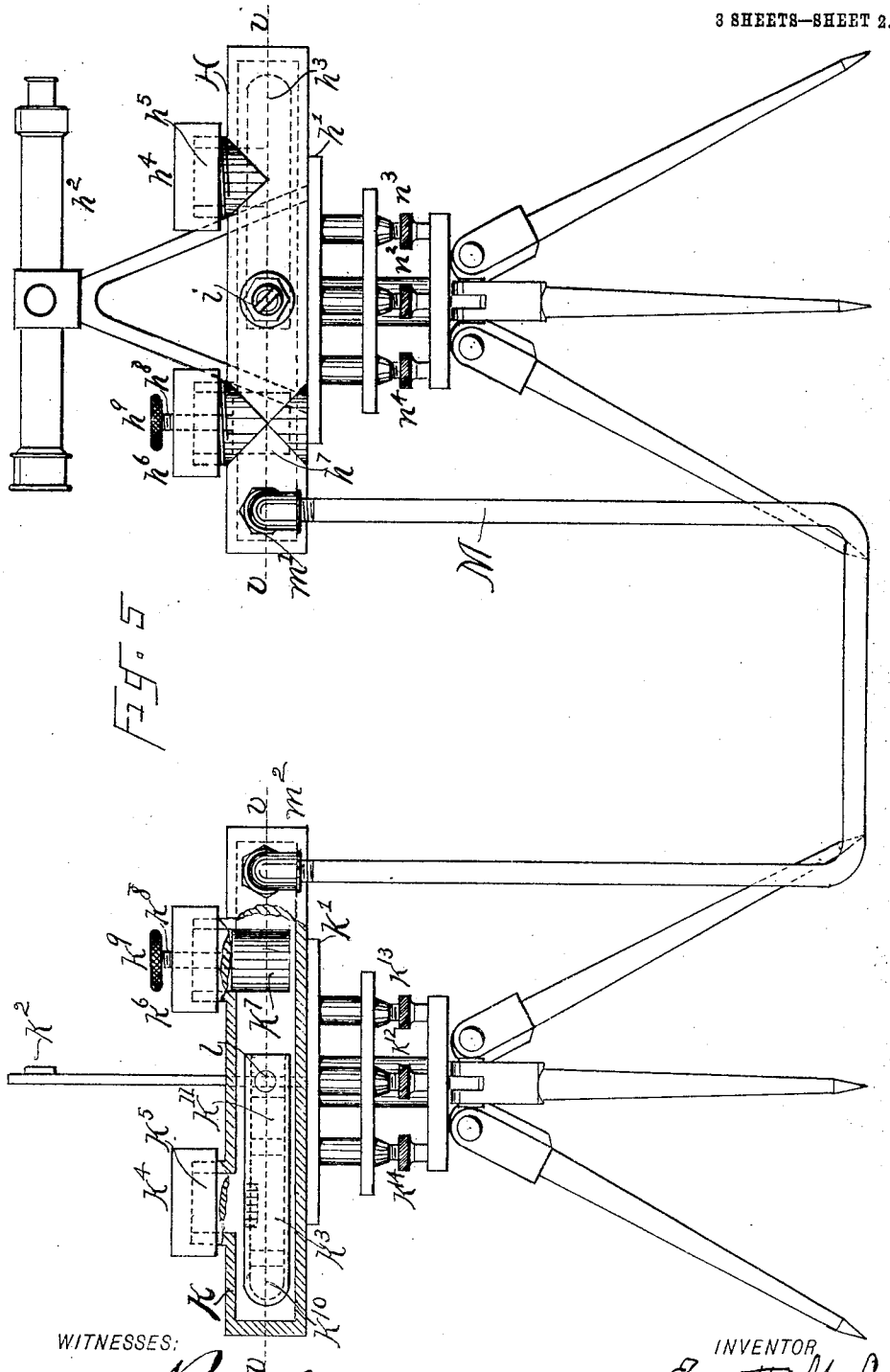


Fig. 5

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3 SHEETS--SHEET 3

Fig. 6

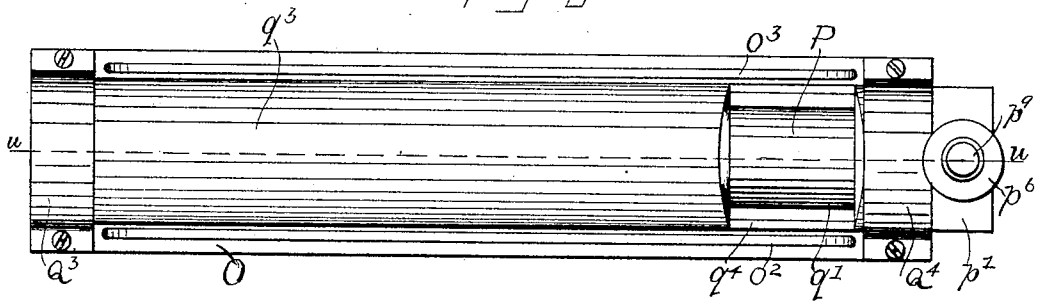


Fig. 7

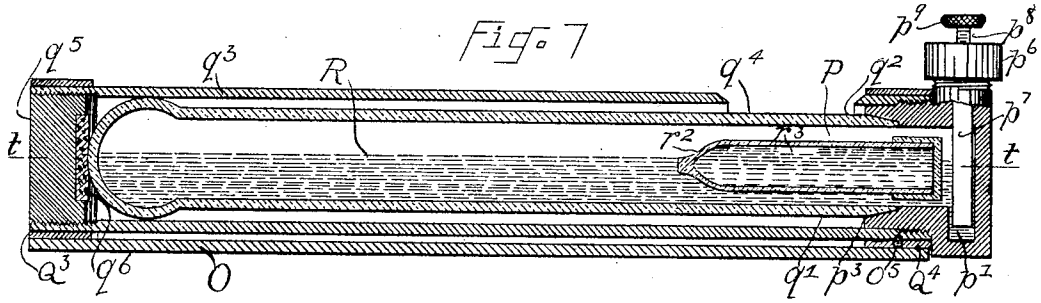


Fig. 8

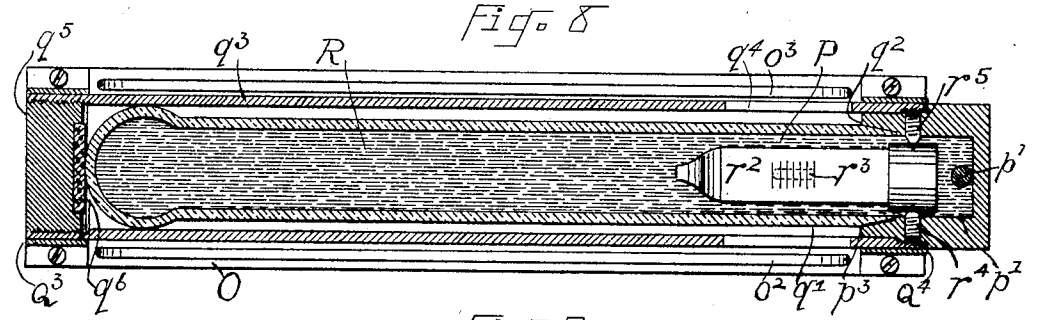
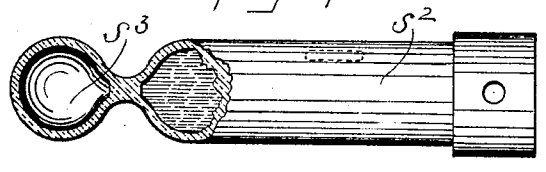


Fig. 9



WITNESSES:

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Augustus H Smith

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UNITED STATES PATENT OFFICE.

EVERETT M. LOW, OF NEW YORK, N. Y.

LEVELING INSTRUMENT.

No. 803,770. Specification of Letters Patent. Patented Nov. 7, 1905.

Application filed January 20, 1904. Serial No. 189,881.

To all whom it may concern:

Be it known that I, EVERETT M. LOW, a citizen of the United States, residing at New York, Brooklyn, in the county of Kings and State of New York, have invented a new and useful Improvement in Leveling Instruments, of which the following is a specification.

The object of my invention is to provide an instrument adapted to any class of work where it is necessary to establish a level line, but more particularly adapted to the use of engineers and astronomers, who require a great degree of accuracy. I attain these objects by the instrument which is hereinafter fully described, and the nature thereof set forth in the claims.

Referring to the drawings, in which like letters refer to like parts, Figure 1 is a plan view. Fig. 2 is an elevation, partly in section, on line $x\ x$, Fig. 1. Fig. 3 is a section on line $y\ y$, Figs. 1 and 2, looking in the direction of the arrow 1. Fig. 4 is a section on line $z\ z$, Figs. 1 and 2, looking in the direction of the arrow 1. Fig. 5 is a side elevation showing the instrument adapted to field and tunnel work. Fig. 6 is a plan view of a modified form of the instrument. Fig. 7 is an elevation of Fig. 6, partly in section, on line $u\ u$, Fig. 6. Fig. 8 is a plan view, partly in section, on line $t\ t$, Fig. 7. Fig. 9 is a view, partly in section, of a modified form of level-vial.

In the accompanying drawings, A is the base-plate of the instrument.

b' and c' are columns secured to the base-plate A, the columns b' and c' being connected by the glass tube d', which fits over the tapered shell b^2 on the column b' and the tapered shell c^2 on the column c'. The glass tube d' has its central portion flattened, as shown in dotted lines in Fig. 1 and in section in Fig. 4. The column b', the column c', and the ends of the tube d' thus form two receptacles B and C, which contain the liquid D, the receptacles B and C being connected by the flattened portion d^2 of the tube d', which allows the liquid D to flow freely from one receptacle to the other. The glass tube d' is inclosed in the metal tube e', having openings e^2, e^3, e^4, e^5, e^6, and e^7 for the purpose of viewing the glass tube d' and the parts contained in it. Attached to the ends of the tube e' are the collars e^8 and e^9. The hub b^3 on the column b' and the hub c^3 on the column c' are threaded to receive the nuts b^4 and c^4. The flange of the nut b^4 engages the collar e^8, and the flange of the nut c^4 engages the collar e^9 on the tube e', drawing the columns b' and c' toward the end of the tube e', and thus forcing the tapered ends of the tube d' onto the tapered shells b^2 and c^2 of the columns b' and c'.

b^5 is a rubber washer interposed between the collar e^8 and the nut b^4, and c^5 is a rubber washer interposed between the collar e^9 and the nut c^4 to allow for the expansion and contraction of the tube d'.

In the receptacle B is a graduated level-vial f^2, and in the receptacle C is the graduated level-vial f^3, the level-vials f^2 and f^3 being supported at one end by conical bearings formed by the conical points of the screws g^4, g^5, g^6, and g^7, which enter the conical holes f^4, f^5, f^6, and f^7, formed in the enlarged end of the level-vials. The screws g^4, g^5, g^6, and g^7 are the same distance above the base A of the instrument, and the conical holes f^4, f^5, f^6, and f^7 in the ends of the level-vials are on a line drawn through the center of said vials. The pivotal point in the length of the level-vial may be at any point in its length between its end and its center, which center is indicated by a central graduation, the only requirement is that when the pivotal points of the two level-vials are the same distance above the surface of the liquid the bubbles in the level-vials shall stand at the center of the level-vials, as indicated by the graduations, and any deviation from parallel lines of the surface of the liquid, and a line drawn through the pivotal points of the level-vials should show the same amount of movement is the bubbles in both level-vials. One end of the level-vials are thus free to move in a vertical plane, and their free ends are supported by the buoyant force of a liquid in or on which the level-vials rest. The liquid or fluxive substance D is contained in the receptacles B and C, to which are attached the fixed ends of the level-vials f^2 and f^3, said receptacles being connected by a passage to allow of the flow of the liquid from one receptacle to the other, but having said passage contracted by the flattening of the central portion d^2 of the tube d' to prevent the too rapid flow of the liquid from one receptacle to the other to avoid shock to the level-vials. The displacement of the level-vials f^2 and f^3 in the liquid D depends upon the construction of the vials and upon the liquid used. In the form described in Figs. 1, 2, 3, and 4 I have designed to use mercury, in which the displacement of the level-vials

would be very little, as shown in Fig. 2 and also by the dotted line $w\ w$ in Figs. 3 and 4.

b^6 is a screw-cap for closing the open top of the column b', and c^6 is a screw-cap which serves the same purpose for the column c'.

b^7 is a plunger for displacing the liquid D and thereby maintaining it at the right height. The upper end of the plunger b^7 is attached to a screw b^8, threaded into the cap b^6. The screw b^8 has a milled head b^9 and a milled nut b^{10} to secure the plunger in place when properly adjusted. The openings e^2, e^3, e^4, e^5, e^6, and e^7 in the metal tube e are for the purpose of observing the bubbles in the level-vials through the glass tube d'.

It is designed that the liquid be maintained at such a height that when the base of the instrument rests on a level surface the center of the bubble g^2 in the level-vial f^2 and the center of the bubble g^3 in the vial f^3 will stand at the central graduation on their respective level-vials. This is not absolutely essential to the use of the instrument, for if the liquid should be lowered the free ends of the level-vials would drop, and the center of the bubbles in the vials would stand at the same distance from the central graduation on their respective vials, and any difference in the position of the bubbles in the two vials from the same relative graduation would indicate that the base of the instrument was not level. The same results are obtained if the liquid is raised and the free ends of the level-vials are raised. So long as the base of the instrument remains level any change in the height of the liquid will move each bubble the same distance from the central graduation in the vial, and consequently does not interfere to any great extent with the use of the instrument; but to maintain the liquid at practically a uniform height I have provided the plunger b', hereinbefore described.

Two level-vials are not absolutely necessary to the use of the instrument, as one level-vial when the height of the liquid is properly adjusted will indicate any deviation from a true level; but with two vials any change of the instrument or of the liquid therein caused by expansion or contraction or any other cause would be at once indicated by the same deviation in the two bubbles from the central graduations and toward or from each other, according to whether the liquid was lowered or raised. In case only one level-vial is used but one receptacle is needed, and it becomes an elongated receptacle with the level-vial pivoted at or near one end of said receptacle. When the instrument is small enough to be conveniently handled and the receptacles are rigidly attached to a base, as illustrated in Figs. 1, 2, 3, and 4, the truth of the instrument may be tested by reversing it, as is done with levels in common use, and but one level-vial would be necessary, although two would be preferable.

It is preferable, but not essential, that the two level-vials be pivoted at either their inner or outer ends rather than to have one pivoted at its inner and the other at its outer end, as it avoids confusion in reading the level.

When the level is placed on a surface to be leveled and the centers of the bubbles in both vials stand at the central graduation, it indicates that the surface is level. If the centers of the bubbles stand the same number of graduations toward the center of the instrument, it indicates that the surface is still level but the liquid is too high. If the centers of the bubbles stand the same number of gradutions toward the ends of the instrument, it indicates that the surface is level, but that the liquid is too low; but if one bubble moves inward from the central graduation and the other bubble moves outward from the central graduation it indicates that the surface on which the instrument rests is not level. The two level-vials thus show any change in the height of the liquid D. The level-vials being free and resting in or on a liquid are not so liable to derangement from expansion and contraction as when rigidly secured, as in the levels of usual construction. The greater the distance between the two level-vials the greater accuracy can be obtained, as the greater will be the difference in the height of the liquid in the two receptacles with reference to the base of the instrument or, what is the same, with reference to the pivotal centers of the level-vials for a given amount of deviation from a true level of the surface upon which the instrument rests.

In Fig. 5 I have shown a form of my improved leveling instrument, to be used where a great degree of accuracy is necessary, as in tunnel-work. H and K are two receptacles which correspond to the receptacles B and C in Figs. 1, 2, 3, and 4. The receptacle H is mounted on a tripod of usual construction, having four leveling-screws of usual construction, three of which, n^2, n^3, and n^4, are shown, by which the base-plate h' and the receptacle H, secured to it, are adjusted vertically. A telescope h^2 is mounted on the base-plate h' in the manner and for the purpose usual on transits and engineers' levels. The receptacle K is secured to the base-plate k', mounted upon a tripod having four leveling-screws, three of which, k^{12}, k^{13}, and k^{14}, are shown. Secured to the base-plate k' is a target k^2, having its center the same height above the plate k' that the axis of the telescope is above the plate h'. h^3 (shown in dotted lines) is a level-vial pivoted at one end at i in the receptacle H, and k^3 is a level-vial pivoted at one end at l in the receptacle K in a similar manner and for the same purpose as the level-vials in the receptacles B and C, Fig. 2. The casing of the receptacle K is broken away in order to show the level-vial k^3 and plunger k^7. h^4 is a removable cap for closing the open-

ing h^5, the opening h^5 being for the purpose of viewing the bubble in the level-vial h^3. k^4 is a removable cap for the opening k^5, which is for the purpose of viewing the bubble in the level-vial k^3. h^6 is a removable cap for closing the opening for the plunger h^7, (shown in dotted lines,) which is attached to the screw h^8, threaded into the cap h^6, and the screw h^8 is operated by the milled head h^9. The cap k^6, plunger k^7, screw k^8, and milled head k^9 serve the same purpose for the receptacle K. The plunger h^7 and k^7 serve the same purpose for the receptacles H and K, as does the plunger b^7 for the receptacles B and C. The receptacles H and K are connected by a pipe M, secured to the receptacles H and K by the unions m' and m^2. The pipe M may be a rubber hose or flexible steel tube and should be of such length as is necessary to attain the degree of accuracy desired, as the greater the distance between the receptacles H and K the greater accuracy can be attained. In this form of my improved leveling instrument I have designed to use water, and to prevent too great a displacement of the water by the level-vials I have provided air-chambers in the level-vials, as shown at k^{10} and k^{11}. The height of the liquid is regulated by one or both of the plungers h^7 and k^7 in the same manner and for the same purpose as the plunger b^7 in the receptacle B. The height of the liquid in the receptacles H and K is shown by the dotted lines $v\ v$. The manner of using this form of my improved leveling instrument is as follows: Set up the tripod upon which is mounted the receptacle H and the telescope h^2, and also set up the tripod upon which is mounted the receptacle K and the target k^2 at any convenient distance, which may be one hundred feet or one thousand feet, according to the character of the work and the degree of accuracy desired. Attach the pipe M to the receptacles H and K, remove the screw-cap h^4 or the screw-cap k^4, or both, and fill the pipe M and the receptacles H and K, as near as practicable to the height indicated by the dotted line $v\ v$, with water. By means of the leveling-screws elevate or depress the receptacles H and K until the bubbles in the level-vials h^3 and k^3 stand at the central graduations on the level-vials or have the same amount of deviation therefrom in the same direction with reference to the free and pivotal ends of the level-vials. The height of the water is now regulated, if necessary, by the plungers h^7 and k^7 to bring the bubbles in the vials to the central graduation. The hereinbefore-described operations may be repeated, if necessary, until the receptacles H and K, and the water therein, are in such relative adjustment as to bring the bubbles in the level-vials to their central graduations. The axis-line of the telescope h^2 and the center of the target k^2 is the same distance above the plates h' and k' and also above the centers of the level-vials, and when the bubbles in the level-vials are central by the graduations on the level-vials the instrument is level and a line drawn through the axis of the telescope and through the center of the target is a true level. It is obvious that if the two receptacles H and K are one hundred feet from each other that the two level-vials can be brought to a level within the limits of the accuracy of the movements of the bubbles in the level-vials and that whatever error there may be is only that much in a distance of one hundred feet, whereas in the form of level in use, the same amount or even greater error exists in a short distance of one inch or less. The levels in use are no more accurate if ten feet long than if three inches long, as it depends on the accuracy of the bubble in the level-vial, which must not be too sensitive or it will not settle, while in my improved leveling instrument I depend for accuracy upon a liquid surface or surfaces, and the level-vials are only a means of adjusting the instrument to the level of the liquid.

In the form of instrument shown in Figs. 1, 2, 3, and 4 the liquid is contained in a closed tube; but to let the air move from one end of the tube to the other, as well as the liquid, I have provided an open space above the liquid throughout the whole length of the tube, and in the form shown in Fig. 5 I have provided removable screw-caps for the double purpose of inspecting the bubbles in the level-vials and to admit the air in order to have no difference in air-pressure in the two receptacles.

In Figs. 6, 7, and 8, I have shown a form of instrument adapted to small levels where great accuracy is not required. Only one level-vial being used, the truth of the instrument may be tested by reversing the level in the same manner as is done with levels now in use. In the levels of this class subject to rough handling it is desirable to use a liquid of a lower specific gravity than mercury in which the displacement of the level-vial would be from one-half to two-thirds of its volume, the level-vial being less liable to shock than if having a slight displacement in a heavy liquid. I may accomplish this end by using a liquid of about the specific gravity of salt water or muriate of zinc, or I may use a liquid of about the specific gravity of alcohol and use a level-vial containing an air-chamber, as illustrated in Fig. 9 and also in Fig. 5. In Figs 6, 7, and 8, O is the base-plate having the strengthening-ribs o^2 and o^3. P is the receptacle formed by the column p' and the glass tube q'. q^3 is a metal tube inclosing the glass tube q' and having an opening q^4 for viewing the glass tube q' and the parts contained therein. The glass tube q' has a tapered end q^2 fitting the inside of the hub p^3,

and the metal tube q^3 is screwed onto the outside of the hub p^3. A plug q^5 is screwed into the end of the tube q^3, the plug q^5 having a piece of rubber, cork, or other yielding material q^6 inserted in a recess in the plug q^5 for the purpose of a yielding contact with closed end of the glass tube q'. The plug q^5 being screwed into the end of the metal tube q^3 forces the tapered end q^2 of the glass tube q' into its seat in the hub p^3, making a tight joint. Q^3 and Q^4 are supports for the metal tube q^3, which are secured to the base-plate O, the tube q^3 being held in the supports and prevented from turning when adjusted with the pivotal points of the level-vial parallel with the base-plate by the screw o^5. p^6 is a screw-cap for closing the open end of the column p', and p^7 is a plunger for displacing and thereby adjusting the liquid R, and thereby maintaining it at the right height. The upper end of the plunger p^7 is attached to a screw p^8, threaded into the cap p^6. The screw p^8 has a milled head p^9, by which the plunger p^7 is moved. The level-vial r^2, having the bubble r^3, is pivoted on the conical points of the screws r^4 and r^5. R is the liquid by which the free end of the level-vial r^2 is supported, the liquid being of such a height that when the surface of the liquid R and the base-plate O are parallel the bubble r^3 in the level-vial will stand at the center of the level-vial, as indicated by the central graduation on the level-vial.

In Fig. 9 I have shown a modified form of level-vial which may be used when it is desired to use a liquid of low specific gravity. s^2 is the level-vial proper, and s^3 an air-chamber which serves to prevent too great a displacement of the liquid by the level-vial. Level-vials containing air-chambers are not new; but the use of air-chambers for this purpose is new so far as I am aware.

Having thus described my invention in such full and clear terms as to enable any one skilled in the art to which it pertains to make and use the same, what I claim, and desire to secure by Letters Patent, is—

1. A receptacle containing a fluxive substance, a level-vial in and pivoted to said receptacle, at a point in the length of said level-vial between its center and one end, the free end of said level-vial being supported by the buoyant force of said fluxive substance, as and for the purpose set forth.

2. An elongated receptacle containing a fluxive substance, a level-vial in and pivoted to one end of said receptacle, at any point in the length of said level-vial between its center and one end, and having its free end movable in a vertical plane and supported by said fluxive substance; the bubble in said level-vial indicating when the base of the receptacle and the surface of the fluxive substance are parallel substantially as described.

3. Two connected receptacles containing a liquid, free to flow from one receptacle to the other and a level-vial actuated by the movement of said liquid, the bubble in said level-vial indicating when the base of the receptacles is parallel with the surface of the liquid in said receptacles.

4. Two connected receptacles containing a liquid, a level-vial in one of said receptacles, one end of said level-vial having a pivotal connection with said receptacle, the free end of said level-vial being supported by the liquid in the receptacle and free to move in a vertical plane, with the rise and fall of the liquid as it flows from one receptacle to the other.

5. A receptacle containing a fluxive substance and a level-vial actuated by said fluxive substance, the bubble in said level-vial indicating when the surface of said fluxive substance is in normal relation with said receptacle, substantially as described.

6. The combination of a receptacle containing a liquid, a level-vial in said receptacle and having a connection therewith by which one end of said level-vial is movable in a vertical plane, substantially as described.

7. An elongated receptacle containing a liquid, a level-vial in said receptacle and pivoted to it, at or near one end of said receptacle, said level-vial being pivoted at any point in its length between its center and one end, its free end being capable of a movement in a vertical plane; said free end of the level-vial being supported by the buoyant force of the liquid in said receptacle, in such a manner that when the pivotal point of the level-vial and the liquid in said receptacle are in normal relation, the bubble in said level-vial stands at the center of the level-vial as indicated by its central graduation, and any change from the normal relation of the said pivotal point and said liquid will cause the bubble in the level-vial to move away from the center of the level-vial toward the pivotal end or toward the free end of the level-vial, according to whether the liquid falls or rises in its relation to said pivotal point, by the lowering or raising of one end of said elongated receptacle, as and for the purpose described.

8. In a leveling instrument the combination of a receptacle containing a liquid, a level-vial in said receptacle, pivoted at one end and supported by said pivot and by the buoyant force of the liquid in said receptacle, and a plunger for displacing said liquid and adjusting its height as and for the purpose set forth.

9. In a leveling instrument the combination of the base-plate A, the receptacle B, the receptacle C, the liquid D, the level-vials f^2, and f^3, and the plunger b^7, as and for the purpose set forth.

10. The combination of the receptacle B, the receptacle C, the tube d^2, the liquid D,

and the level-vials f^2 and f^3 substantially as described.

11. The combination of the receptacle B, the receptacle C, the tube d^2, the liquid D, the tube e' and the level-vials f^2 and f^3 substantially as described.

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

EVERETT M. LOW.

Witnesses:
HENRY W. KOZELL,
HENRY BODY.