Nov. 8, 1960 K. RÄNTSCH 2,959,088

LEVELLING INSTRUMENT WITH MEANS FOR THE AUTOMATIC COMPENSATION OF SMALL INCLINATIONS OF THE INSTRUMENT

Filed Oct. 29, 1957 4 Sheets-Sheet 1

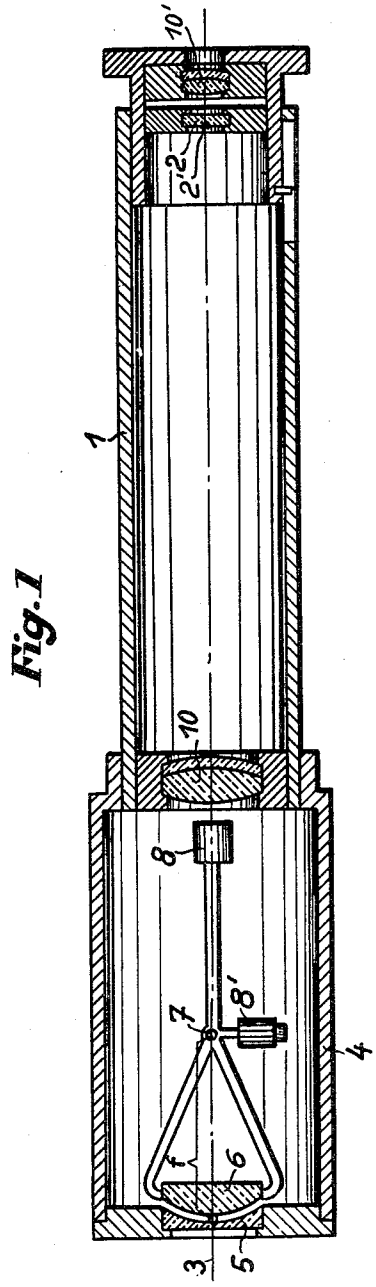


Fig. 1

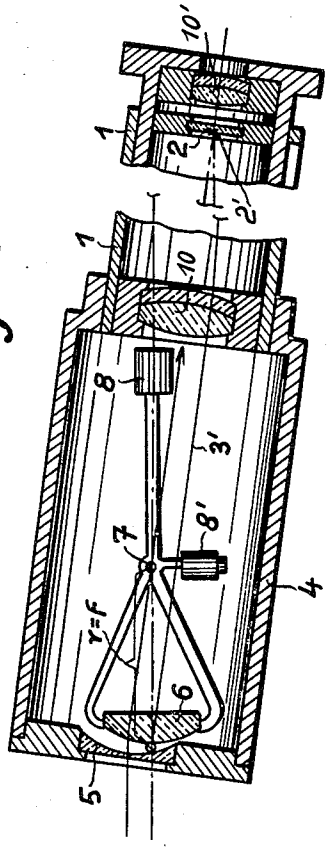


Fig. 1a

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Fig. 2

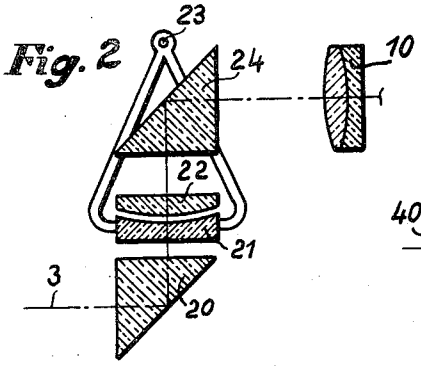


Fig. 4

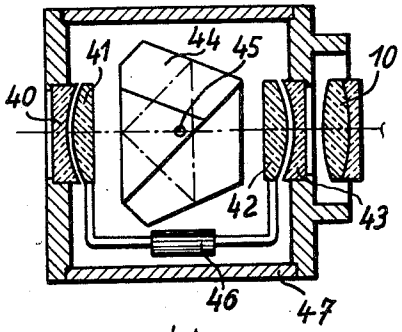
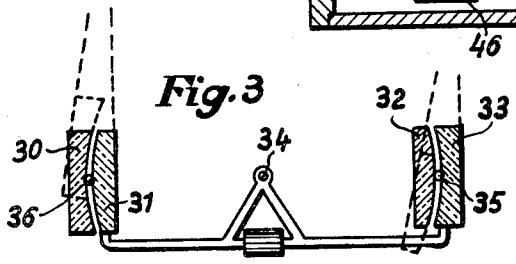


Fig. 3



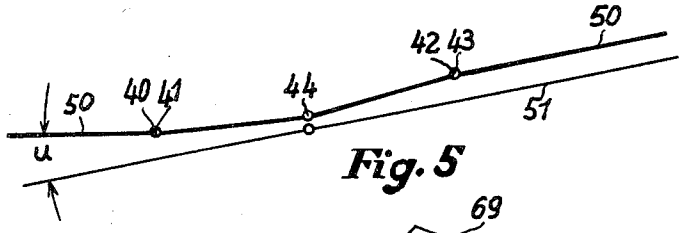
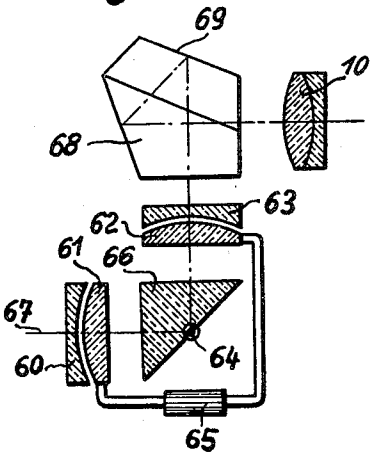


Fig. 5

Fig. 6



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Fig. 7

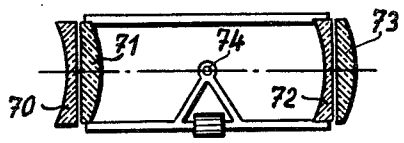


Fig. 8

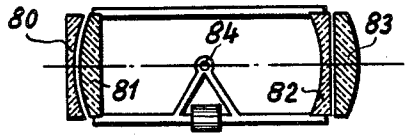
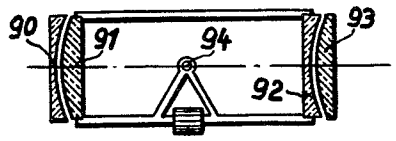


Fig. 9



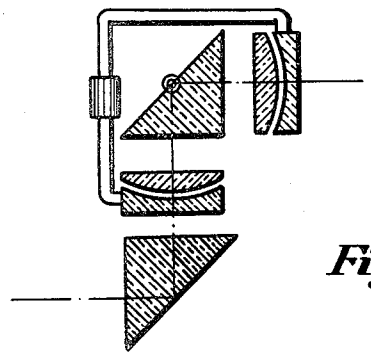


Fig 10

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Fig. 12

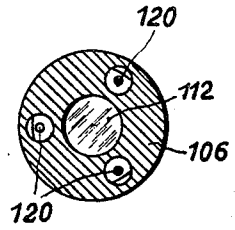
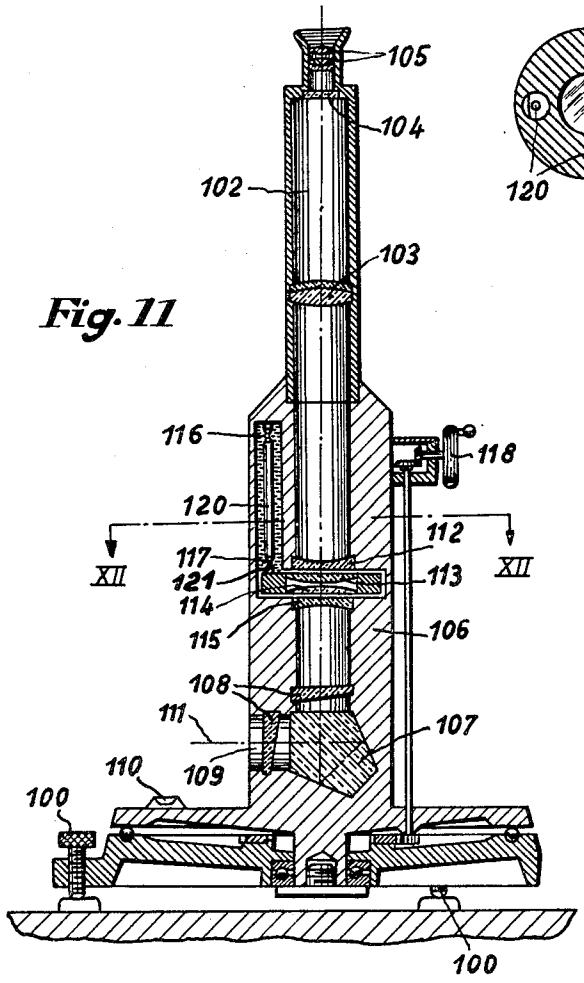


Fig. 11



United States Patent Office 2,959,088 Patented Nov. 8, 1960

2,959,088

LEVELLING INSTRUMENT WITH MEANS FOR THE AUTOMATIC COMPENSATION OF SMALL INCLINATIONS OF THE INSTRUMENT

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Claims priority, application Germany Nov. 2, 1956

21 Claims. (Cl. 88—1)

The invention concerns a levelling instrument with automatic compensation for small inclinations of the instrument. Such devices are of prior art in which for instance in front of the levelling instrument proper or inside it there are arranged pendulously suspended mirrors which upon inclination of the instrument deflect the aiming line correspondingly from its direction. The user sights therefore the same target point in spite of the inclination of the instrument.

The devices of this kind of prior art have however the disadvantage that an exact compensation for the inclinations is possible only in certain conditions. There must e.g. the axis of the pendulously suspended mirrors be adjusted very accurately; or if the mirrors are suspended from articulated quadrilaterals as in prior art, then the lengths of the links of the articulated quadrilaterals must be subjected to very high requirements of accuracy. Furthermore the levelling instruments with automatic compensation for small inclinations of the instrument of prior art require a very great optical precision.

It is an object of the invention to arrange in front of the telescope at least one lens fixed to the instrument and at least one lens suspended pendulous about an axis at right angles to the optical axis of the instrument in such a way that these both lenses upon inclination of the instrument shift relatively to each other on the one hand form an optical wedge.

Upon inclination of the instrument the target ray is then on the one hand deflected by the displacement of the lenses relative to each other and on the other hand by the optical wedge formed. It is possible to obtain that the deflection of the target ray is exactly as large as the deflection of the optical axis of the levelling instrument from the horizontal so that the target ray in spite of the inclination of the instrument always strikes a sighting mark in the focal plane of the objective.

This instrument has the advantage that a compensation of small inclinations of the instrument is possible with comparatively simple optical means, and on the other hand it is possible to construct the pendulous elements as independent as possible of adjustment.

It is a further object of the invention to provide n pairs of lenses in front of the instrument wherein n may also be equal to 1, of which pairs always one lens is fixed in the instrument and the other is pendulously suspended, wherein the lenses of each pair supplement each other to form an afocal system and wherein the pendulously suspended lenses fulfil the condition

$$(1) \qquad \sum_{i=1}^{n} r_i \cdot \varphi_i = 1$$

if r_i is the distance from the principal point of the ith lens from its centre of rotation, and if φ_1 is the refractive power of this lens.

By an afocal system there is here understood a sequence of lenses without a focal point i.e. a system which allows a bundle of rays with parallel incidence to emerge

again also as a parallel bundle of rays. The refractive power itself is as known a function of the refractive index of the glass used as well as of the refractive index of the ambient medium as well as of the radii of the lens and of the lens thickness.

It is a further object of the invention to provide in front of one of the pairs of lenses an afocal system fixedly arranged in the instrument having a magnification N_i, for instance immediately in front of the ith system. Then the formula given above undergoes an alteration; in this case it is

$$(2) \qquad \sum_{i=1}^{n} N_i r_i \varphi_i = 1$$

For all the resulting members in which no N occurs, $N=1$ must be written. If in (1) and (2) one introduces the focal lengths ($\varphi=1/f$) instead of the refractive power, one writes:

$$(1') \qquad \sum_{i=1}^{n} r_i / f_i = 1$$

$$(2') \qquad \sum_{i=1}^{n} N_i \cdot r_i / f_i = 1$$

In an important feature of the invention the lenses of each pair may have opposite but equal focal lengths and may be so designed that in the normal position they unite to form a plane parallel plate; i.e. if one lens has the focal length $+f_i$ then the other lens of the pair has the focal length $-f_i$.

If in one first embodiment one pair of lenses only is provided i.e. $n=1$, then from the Formula 1' it follows immediately that $r=f_1$, i.e. the centre of rotation of the pendulously suspended lens is to be arranged at a distance from its principal point equal to the focal length f_1 of this lens.

The pendulous lens may be constantly held in its position by a balance weight. This may however entail certain disadvantages in that the centre of rotation must then lie very accurately upon the optical axis i.e. deviations, for instance upwards or downwards, falsify the compensation. Shifts of the axis of rotation in the direction of the optical axis do not, however, become noticeable.

Therefore it is a further object of the invention to become largely independent of adjustment and particularly to avoid erroneous compensation by deviations of the axis of rotation from its ideal location e.g. by vibration, shocks and the like.

In a further embodiment of the invention this is effected by arranging the said pairs of lenses so that the rays traverse these lenses in a vertical direction. In this case the centre of rotation of the pendulous lens lies even in vibrations and the like always on the optical axis or in its prolongation. In this embodiment errors can only arise by displacement of the centre of rotation in the horizontal direction which, however, does not in general occur.

Furthermore, the pendulously suspended lens can in this embodiment be held in a constantly fixed position by its own weight.

For the deflection of the ray path into the vertical direction and if required back into a horizontal direction prisms are with advantage provided.

It is a further object of the invention to provide two pairs of lenses whose individual lenses have opposite but equal focal lengths. The axis of rotation of the pendulously suspended lenses is then arranged at a distance from them of half the focal length. With $r_i=f_i/2$ the Formula 1' is then again satisfied.

Upon inclination of the instrument there result in this case two wedges, and the lenses of each pair shift rela-

tive to each other whereby their total effect adds up again.

Since the wedge angles lie above or below the horizontal according to the lens in a pair which upon inclination of the instrument alters its position relative to the instrument, i.e. since the horizontal ray is deflected upwards or downwards, care must be taken in the use of several pairs of lenses to avoid the cancelling out of the effects of the individual wedges. For this reason in this aforesaid embodiment the positive lens of the one pair of lenses is penduously suspended and the negative lens of the other pair of lenses. In the second member of the Formula 1' both r_2 and f_2 then become negative.

It is a further object of the invention to provide between the two pairs of lenses an erector system. In this case the second formula is valid because such an erector system has the magnification $N_i=-1$. Since the erector system is arranged immediately in front of the second pair of lenses $N_2=-1$ must be put in the Formula 2' and also $N_1=1$ since a system not present produces no optical effect. Either r_2 or f_2 must then be positive. Since the lenses are to have a common centre of rotation one selects with advantage f_2 positive so that the positive lenses of both pairs of lenses are penduously suspended.

In a further important embodiment of the invention a rectangular prism is arranged behind the first pair of lenses so that the horizontal ray passes vertically through the second pair of lenses and behind this pair of lenses a pentaprism with a roof edge is provided so that this attachment produces an erection of the image for the following level in addition. The common centre of rotation of the penduously suspended rays may herein with advantage lie at the point of deflection of the horizontal ray and a weight may be provided which holds the pendulous lenses in their position. Here also an image erection takes place between the two pairs of lenses so that the resulting conditions are as described above.

For the arrangement of the lenses in the individual lens pairs there result various possibilities as is evident even from the formulae. Thus in the first embodiment the lenses may lie with their curved surfaces next to each other. Obviously a minimum separation must therein be observed in order to render the relative changes of position possible.

In a second embodiment however the lenses may also lie with their plane surfaces next to each other. Here also a separation must be present between the lenses so that the lenses have sufficient space for their shifts and inclinations relative to each other.

In a further very important development of the invention the penduously suspended lenses of the lens pairs are arranged in such a way that they lie between the fixed lenses. In this case the fixed lenses may simultaneously form the airtight and dusttight cover for the total system for the compensation of small inclinations.

It is an important object of the invention to collect the lens pairs together in a separate attachment which can be used in connection with any known levelling instrument.

It is a further object of the invention to achromatize the lenses of the pairs in those cases in which through large deflections of the target ray or through great magnification of the levelling instrument dispersion produced by the wedges occurs.

It is a further object of the invention to chose the focal lengths of the individual pairs of lenses unequal. Unequal focal lengths may then become necessary when dependent upon the lens thicknesses and their separations an afocal image formation is to be achieved.

In a further very important development of the invention a pentaprism is arranged in front of the lens pairs serving for the compensation of the inclination which prism is capable of rotation around the optical axis of the instrument.

If this instrument is so arranged that the horizontal ray coming from the target enters into the pentaprism and leaves the pentaprism in the vertical direction, then the instrument is suitable for the horizontal adjustment of a surface. It is then merely necessary to place the instrument on any desired part of the surface to be levelled and to arrange several marks upon this surface. If these marks are struck by the target ray of the levelling instrument one after the other upon swivelling of the pentaprism then the surface is horizontal.

Similar devices for checking the flatness of a surface are of prior art. They consist also of a telescope to be arranged at right angles to the surface and of a rotatable pentaprism. By shifting the aforesaid marks on the surface its flatness is determined.

If furthermore one wishes to check with these instruments whether the surface lies horizontal then a level or similar device must be provided in order to adjust the instrument vertically. It is however known that level adjustments of this kind are time-consuming so that the operation of the instrument is rendered much more difficult.

It is an object of the invention to eliminate this disadvantage by applying the rotatable pentaprism of prior art in such instruments to an instrument according to the invention. By this combination the operator is freed of the exact vertical adjustment of the instrument i.e. the telescope of the levelling instrument need only be adjusted approximately vertical.

In an important feature of the invention in such an instrument the pendulous lens is of positive refractive power and the lens fixed in the instrument is of negative refractive power.

It is a further object of the invention to provide a fluid between the lenses serving for the compensation of the inclination for damping the pendulum movement.

By the use of one pendulous lens which furthermore only oscillates in one direction an automatic compensation of small inclinations is achieved only in one direction.

It is a further object of the invention to obtain compensation of inclinations in any direction i.e. in every azimuth and to suspend therefor the pendulous lens in gimbals or more simply from three threads. For the trifilar suspension perlon filaments are used with advantage which show only two definite bending points.

In the drawing embodiments of the invention are represented, and more particularly there show

Fig. 1 a levelling instrument with one pair of lenses for the compensation of small inclinations of the instrument,

Fig. 1*a* the instrument according to Fig. 1 in the inclined position,

Fig. 2 shows an altered embodiment according to Fig. 1,

Fig. 3 a levelling instrument with two pairs of lenses acting as optical wedges,

Fig. 4 the instrument according to Fig. 3 with an erector system,

Fig. 5 the deflection of the target ray in the instrument according to Fig. 4,

Fig. 6 a further instrument with image erection,

Figs. 7, 8, 9 and 10 various arrangements of the individual lenses of two lens pairs,

Fig. 11 an instrument with a turnable pentaprism,

Fig. 12 a section along the line XII—XII.

In Fig. 1 there is designated by **1** a levelling instrument of prior art which has an objective **10** and an eyepiece **10'** and in which a graticule **2** is arranged in the focal plane of the objective. Upon the mark **2'** of this graticule the horizontal ray **3** is incident when the instrument stands exactly horizontally. An attachable device **4**, which has been placed upon the levelling instrument **1**, consists of two lenses **5** and **6**. The lens **5** is a dispersive lens and forms the cover of the attachment device **4** in the front. The lens **6** is a collective lens. The lenses **5** and **6** have equal but opposite focal lengths. The lenses **5** and **6** lie

with their curved surfaces next to each other and form in the position drawn in full lines a plane parallel plate. The lens 6 is suspended capable of rotation about a shaft 7. In order that is may keep its position in space upon inclination of the levelling instrument 1 and of the attachment device 4, it is connected to balance weights 8 and 8'.

The axis of rotation 7 is arranged at the distance from the lens 6 equal to its focal length f whereby since only one pair of lenses is provided the Equation 1 or 1' of the above description are satisfied. If the instrument is inclined by a small angle into the position drawn in Fig. 1*a* then the lenses 5 and 6 form optically a wedge. The horizontal ray is by this and by the shift of the lenses 5 and 6 relative to each other deflected into the direction 3' parallel to the axis of the levelling instrument. It enters into the levelling instrument and is again incident upon the mark 2' of the crossline graticule 2.

Small shifts of the axis of rotation 7 in the direction of the optical axis have no effect upon the compensation of the aiming line 3. Errors may, however, well arise on deviation of the target ray of the axis of rotation 7 in the course of time shifts at right angles to the optical axis as a result of vibrations and the like and thereby disturbs the adjustment. In order to be independent of such errors an altered arrangement has been made in Fig. 2. The target ray 3 is first incident upon a prism 20 which deflects it vertically upwards. It passes through the lenses 21 and 22 which have again opposite but equal focal lengths. In line with the optical axis the axis of rotation 23 has been arranged. A further prism 24 deflects the horizontal ray into the objective 10 of the levelling instrument. Since the horizontal ray 3 reaches the lenses 21 and 22 only after a reflection in the prism 20 there is to be substituted in the Formula 2 of the description $N_1 \times r/f = 1$. Since the prism 20 produces erection of the image, $N_1 = -1$ and there results $r = -f$. The horizontal ray is therefore deflected, upon inclination of the instrument, by a small angle u in the sense opposite to that in Fig. 1. In order to achieve this the dispersive lens 21 is pendulously suspended and the lens 22 is arranged fixedly in the instrument. The lens 21 replaces in this arrangement simultaneously the balance weight 8 of Fig. 1.

In Fig. 3 two pairs of lenses 30, 31 and 32, 33 which are capable of rotation about a shaft 34 are provided for the deflection of the target ray. The focal point of the lenses 30 and 31 lies between the lenses 32 and 33 at the point 35 and the focal point of the lenses 32 and 33 lies between the lenses 30 and 31 at the point 36. The shaft 34 is arranged in the centre between the points 35 and 36 and has therefore from these points distances equal to half the focal lengths of the lenses 30 to 33. The Formula 1 is then again satisfied if upon inclination of the instrument the collective lens 31 and the dispersive lens 33 remain in their positions, while the lenses 30 and 32 however take part in the inclination of the instrument, i.e. upon a shift of the lens 30 upwards and of the lens 32 downwards two wedges are produced whose prism edges lie both above the optical axis (represented in dashed lines). The horizontal ray is therefore deflected downwards as well by the lenses 30, 31 as also by the lenses 32, 33. The effects of both the wedges produced are therefore additive.

In Fig. 4 an erector system fixed in the instrument in the form of a Pechan prism 44 is arranged between the pairs of lenses 40, 41 and 42, 43. The axis of rotation 45 lies again at a distance of half the focal length of the lenses 40 to 43 between them. In order to obtain an addition of the prismatic effects of both pairs of lenses upon inclination the Formula 2 must be satisfied since here required by the erector system 44 the value $N_2 = -1$ must be substituted. This is achieved if both the collective lenses 41 and 42 are pendulously suspended. They are held in their positions by a weight 46. Upon inclination of the levelling instrument by an angle u the horizontal ray 50 is deflected upwards by the lenses 40, 41 as is schematically represented in Fig. 5, is inclined again by the Pechan prism 44 and this inclination is cancelled by the lenses 42, 43 in such a way that the horizontal ray 50 upon emergence form the pair of lenses 42, 43 runs parallel with the axis 51 of the levelling instrument.

It may be seen from Fig. 4 that the lenses 40, 41 and 42, 43 are arranged in a housing 47 attachable on the levelling instrument. The lenses 40 and 43 being not rotatable around point 45 form an airtight and dust-tight cover of the housing 47.

Fig. 6 shows an altered embodiment in which again pairs of lenses 60, 61 and 62, 63 are provided. Of these the collective lenses 61 and 62 are capable of rotation about a shaft 64. The collective lenses 61 and 62 are again held in their positions by a weight 65. The dispersive lenses 60 and 63 are fixed in the instrument. Between the pairs of lenses 60, 61 and 62, 63 a reflecting prism 66 is arranged fixedly in the instrument and deflects the horizontal ray 67 vertically upwards. On emergence from the lenses 62, 63 the horizontal ray reaches a pentaprism 68 which has a roof edge 69. It emerges from the pentaprism 68 in the direction of the axis of the levelling instrument. This arrangement also produces a compensation of small inclinations of the levelling instrument with image erection.

Fig. 7 shows a lens arrangement in which the pairs of lenses 70, 71 and 72, 73 stand with their plane surfaces turned towards each other. In order to obtain an addition of the prismatic effects of the pairs 58 lenses 70, 71 and 72, 73 the collective lens 71 and the dispersive lens 72 are again suspended capable of rotation about a shaft 74.

The lenses 70 and 71 as well as 72 and 73 show small separations from each other so that pendulum movements of the lenses 71 and 72 are possible. As can be recognised the inner lenses are here pendulously suspended and the outer lenses 70 and 73 are arranged fixedly in the instrument. These may simultaneously form a cover for the attachment device so that dust, humidity etc. cannot enter into the device.

Fig. 8 shows a different combination of pairs of lenses 80, 81 and 82, 83. Here also the inner lenses 81 and 82, more particularly a collective and a dispersive lens, are suspended pendulously about a spindle 84, and the outer lenses 80 and 83 are arranged fixedly in the instrument. These lenses may also form the cover for an attachment device. In contrast to the embodiment according to Fig. 7 the lenses 80 and 81 are turned with their curved surfaces towards each other, the lenses 82 and 83 however with their plane surfaces.

In the arrangements according to Figs. 7 and 8 the curve twin lenses produce as afocal systems small telescopic minification corresponding to an inverted Galilean telescopic system. This means that a levelling instrument arranged behind it is somewhat reduced in its magnification. This may in certain circumstances be a disadvantage. If one wishes to compensate this effect it is required to insert between the attachment system according to Figs. 7 and 8 and the following levelling instrument a weak Galilean telescope of exactly opposing effect.

Fig. 9 shows again an altered arrangement of lenses 90, 91 and 92, 93 in which again the inner lenses 91 and 92 are capable of rotation about a spindle 94 and the outer lenses 90 and 93 are arranged fixedly in the instrument. The lenses of the pair 90, 91 as well as the lenses of the pair 92, 93 are in this embodiment turned towards each other with their curved surfaces.

Fig. 10 shows an embodiment in which the negative lenses of two lens pairs provided are pendulously suspended.

Figs. 11 and 12 show another embodiment of the invention.

On feet 100 adjustable in height a telescope 102 is rotatably mounted. The telescope 102 has an objective

103, a graticule 104 and eyepiece lenses 105. In the lower part of the telescope housing 106 a pentaprism 107 with a pair of rotatable glass wedges 108 and a window 109 are provided. With a box level 110 the telescope may be adjusted approximately vertical.

If the optical axis of the telescope is exactly vertical then the target ray 111 leaves the telescope in an exactly horizontal direction. Upon rotation of the part 106 which is fixedly connected to the telescope 102 the horizontal ray 111 describes a horizontal plane.

In order to become independent of the exact vertical adjustment of the optical axis pairs of lenses 112, 113 and 114, 115 are provided in Fig. 11 for the compensation of small inclinations. The lenses 112 and 115 are fixedly attached to the housing. The lenses 113 and 114 are pendulously suspended.

The lenses 113 and 114 pendulate because of their weight about the bending points 116 and 117 on reinforced threads made from material sold under the trademark "Perlon." Three such filaments 120 are provided as seen in Fig. 12. By this suspension a compensation of inclination is achieved for all thinkable deviations of the instrument from the vertical direction. Lenses 113 and 114 as well as the filaments 120 are arranged in a bere 121. This chamber is filled with a fluid for damping movement of the lenses 113 and 114.

By rotation of the hand wheel 118 it is possible to introduce a rotary motion by means of the illustrated conical and spur gear wheels which makes it possible to set the telescope in any desired direction.

I claim:

1. A levelling instrument comprising a telescope with a graticule and means for the automatic compensation of small inclinations of the instrument, said means consisting in at least one pair of lenses arranged in front of said telescope, each pair of said at least one pair of lenses consisting of one lens fixedly arranged in the instrument and of one lens pendulously suspended so as to swing about a fixed axis, thereby forming an optical wedge with said lens fixedly arranged in that instrument when said instrument inclines, the said pendulously suspended lens satisfying the condition

$$\sum_{i=1}^{n} r_i \varphi_i = 1$$

r_1 being the distance of the principal point of the ith pendulously suspended lens from said axis, ϕ_1 being the refractive power of this lens and n being the number of lens pairs.

2. A levelling instrument comprising a telescope with a graticule and means for the automatic compensation of small inclinations of the instrument, said means consisting in at least one pair of lenses arranged in front of the telescope, each pair of said at least one pair of lenses forming an afocal system, said at least one pair of lenses consisting of one lens fixedly arranged in the instrument and one lens pendulously suspended so as to swing about a fixed axis, thereby forming an optical wedge with said lens fixedly arranged in the instrument when said instrument inclines, an additional afocal optical system fixedly arranged in the instrument in front of the ith afocal pair of lenses to change the magnification of the instrument, said additional system having a magnification N_i, said pendulously suspended lenses and said additional afocal systems satisfying the condition

$$\sum_{i=1}^{n} N_i r_i \varphi_i = 1$$

r_1 being the distance of the principal point of the ith pendulously suspended lens from said axis, ϕ_1 being the refractive power of this lens and n being the number of afocal lens pairs.

3. A levelling instrument according to claim 1 characterized in that one pair of lenses is provided, one lens of said pair having the focal length $+f$ and the other lens of said pair having the focal length $-f$, both lenses having a refractive index of approximately 1.5, and r_1 being f.

4. A levelling instrument according to claim 2 characterized in that one pair of lenses is provided one lens of said pair having the focal length $+f$ and the other lens of said pair having the focal length $-f$, both lenses having a refractive index of approximately 1.5 and r_1 being f, a first prism fixedly arranged in front of said pair of lenses to give the entering light rays a vertical direction, a second prism between said pair of lenses and said telescope reflecting the light rays again into the horizontal direction, said pendulously suspended lens being held by its own weight always in a constant position when the instrument inclines.

5. A levelling instrument comprising a telescope with a graticule and means for the automatic compensation of small inclinations of the instrument, said means consisting in two pairs of lenses, each pair of lenses consisting of one lens fixedly arranged in the instrument and of one lens pendulously suspended so as to swing about a fixed axis, thereby forming an optical wedge with said lens fixedly arranged in said instrument when said instrument inclines, one lens of each pair having the focal length $+f$ and the other lens of each pair having the focal length $-f$, said lens pairs having a distance f from one another, a shaft arranged transversally to the optical axis of the instrument between said two pairs of lenses and having the distance $f/2$ from each of said pairs of lenses, said pendulously suspended lenses being mounted for free rotation on said shaft, a weight connected with said pendulously suspended lenses to hold said lenses in a constant position in inclining the instrument.

6. A levelling instrument according to claim 5 characterized in that the lens having the focal length $+f$ of the first pair seen in the direction of the entering light rays and the lens having the focal length $-f$ of the second lens pair are turnable mounted on said shaft.

7. A levelling instrument according to claim 5 characterized by an erector system arranged between said two pairs of lenses and characterized further in that the lens having the focal length $+f$ of each lens pair is freely rotatably mounted.

8. A levelling instrument according to claim 5 characterized by an erector system arranged between said two pairs of lenses and characterized further in that the lens of each pair having the focal length $-f$ is turntably mounted on that shaft.

9. A levelling instrument according to claim 5 characterized by a rectangular prism arranged behind said first pair of lenses to incline the light rays entering the instrument in a vertical direction as well as a pentaprism with a roof edge arranged behind said second pair of lenses to incline the light rays in a horizontal direction before entering the telescope.

10. A levelling instrument according to claim 5 characterized by a lens arrangement of such kind that the pendulously suspended lenses lie between those lenses mounted fixedly.

11. A levelling instrument comprising a telescope with a graticule and means for the automatic compensation of small inclinations of the instrument, said means consisting in at least one pair of lenses arranged in front of said telescope, said at least one pair of lenses consisting of one lens fixedly arranged in the instrument and one lens pendulously suspended about a fixed point so as to swing in two mutually perpendicular directions, thereby forming an optical wedge with said lens fixedly arranged in said instrument when said instrument inclines, said pendulously suspended lenses satisfying the condition

$$\sum_{i=1}^{n} r_i \varphi_i = 1$$

r_i being the distance of the principal point of the ith pendulously suspended lens from said fixed point, ϕ_i being the refractive power of this lens and n being the number of lens pairs, said instrument comprising further a pentaprism fixedly connected with said telescope in front of said at least one pair of lenses and a body carrying said telescope, said telescope being arranged on said body in a vertical direction turnable around its optical axis.

12. A levelling instrument according to claim 11 characterized in that two pairs of lenses are provided, that the pendulously suspended lenses have positive refractive power and the lenses fixedly arranged in the instrument have negative refractive power.

13. A levelling instrument according to claim 11 characterized by three filaments carrying the pendulously suspended lenses.

14. A levelling instrument according to claim 1 characterized by a shaft arranged in the said instrument perpendicular to the optical axis of said telescope, said pendulously suspended lenses being freely rotatable on said shaft, a weight connected with the said pendulously suspended lenses to hold said pendulously suspended lenses in a constant position when the instrument inclines.

15. A levelling instrument according to claim 2 characterized by a shaft arranged in the said instrument perpendicular to the optical axis of said telescope, said pendulously suspended lenses being freely rotatable on said shaft, a weight connected with the said pendulously suspended lenses to hold said pendulously suspended lenses in a constant position when the instrument inclines.

16. A levelling instrument according to claim 1 characterized in that the one lens of said at least one pair of lenses is plano-convex and the other lens of said pair is plano-concave and that the lenses of said at least one pair of lenses lie with their curved surfaces next to each other.

17. A levelling instrument according to claim 1 characterized in that the one lens of said at least one pair of lenses is plano-convex and the other lens is plano-concave and that the lenses of said at least one pair of lenses lie with their plane surfaces next to each other.

18. A levelling instrument according to claim 1 characterized by the use of achromatic lenses.

19. A levelling instrument according to claim 1 characterized by a housing, said at least one pair of lenses being arranged in said housing and said housing being attachable to the telescope of the levelling instrument.

20. A levelling instrument according to claim 1 having at least two pairs of lenses characterized by a housing, said pairs of lenses being arranged in said housing and said housing being attachable to the telescope of the levelling instrument, said fixedly arranged lenses of said two pairs forming an airtight and dusttight cover for the housing.

21. A levelling instrument according to claim 1 characterized by a fluid arranged between the lenses of each pair for damping the movement of the pendulously suspended lenses.

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