Claims

1. A device for determining the location of a first mechanical element (10, 156) and a second mechanical element (12, 154) with respect to each other, with a first measurement unit (14, 114, 214) for positioning at the first mechanical element, a second measurement unit (18, 118, 218) for positioning at the second mechanical element, and an analysis unit (22);~~,~~

wherein the first measurement unit ~~has means~~is configured and arranged (24, 124, 224) for producing a light beam bundle (28, 128, 228);~~,~~

wherein the second measurement unit has a scattering surface (34 134, 234) for scattering of the light impinging on the scattering surface, a camera (36)~~, and means for imaging the scattering surface on the camera~~ configured and arranged to take pictures of the side of the scattering surface facing the first measurement unit;~~,~~

wherein the scattering surface faces the first measurement unit when the measurement units are positioned at the respective mechanical element so as to be impinged on by the light beam bundle;~~,~~

wherein the analysis unit is designed to determine from the image data supplied by the camera, from the pictures taken by the camera, the position of impingement of the light beam bundle, emitted by the first measurement unit, directly onto the scattering surface without reflection and from it the location of the first mechanical element and the second mechanical element with respect to each other~~,~~

~~and wherein the camera is directed at the side of the scattering surface facing the first measurement unit~~.

2. The device according to claim 1, ~~further characterized in that~~wherein the camera (36) is arranged laterally displaced with respect to the scattering surface (34, 134, 234).

3. The device according to claim 2, ~~further characterized in that~~wherein the camera (36) is arranged tilted with respect to the scattering surface (34, 134, 234).

4. The device according to one of the preceding claims, ~~further characterized in that~~wherein the second measurement unit (18, 118, 218) has means for the detachable fastening of the camera (36).

5. The device according to one of the preceding claims, ~~further characterized in that~~wherein the means for imaging the scattering surface (34, 134, 234) on the camera (36) involve a lens with fixed focus.

6. The device according to one of the preceding claims, ~~further characterized in that~~wherein the camera (36) has means (23) for illuminating the scattering surface (34, 134, 234).

7. The device according to one of the preceding claims, ~~further characterized in that~~wherein the camera (36) is mounted on an optical shield forming a scattered light aperture.

8. A device for determining the location of a first mechanical element (10, 156) and a second mechanical element (12, 154) with respect to each other, with a first measurement unit (14, 114, 214) for positioning at the first mechanical element, a second measurement unit (18, 118, 218) for positioning at the second mechanical element, a camera (36), and an analysis unit (22)~~;~~,

wherein the first measurement unit ~~has means~~is configured and arranged (24, 124, 224) for producing a light beam bundle (28, 128, 228)~~;~~,

wherein the second measurement unit has a scattering surface (34, 134, 234) for scattering of light impinging on the scattering surface~~;~~,

wherein the scattering surface faces the first measurement unit when the measurement units are positioned at the respective mechanical element so as to be impinged on by the light beam bundle~~;~~,

wherein the camera can move freely with respect to the two measurement units and is configured and arranged for taking pictures of the side of~~has means for imaging~~ the scattering surface facing the first measurement unit~~on the camera~~~~;~~,

wherein the analysis unit is ~~designed~~configured and arranged to determine from the image data supplied by the camera, from pictures taken by the camera, the position of impingement of the light beam

bundle, emitted by the first measurement unit, directly onto the scattering surface without reflection and from it the location of the first mechanical element and the second mechanical element with respect to each other~~,~~

~~and wherein the camera is designed to be directed onto the side of the scattering surface facing the first measurement unit~~.

9. The device according to one of the preceding claims, ~~further characterized in that~~wherein the scattering surface (34, 134, 234) is provided with measurement markings (50).

10. The device according to one of the preceding claims, ~~further characterized in that~~wherein the analysis unit (22) is designed to rectify the image data supplied by the camera (36) with respect to a tilting of the scattering surface (34, 134, 234).

11. The device according to one of the preceding claims, ~~further characterized in that~~wherein the scattering surface (34, 134, 234) is essentially flat.

12. The device according to one of the preceding claims, ~~further characterized in that~~wherein the second measurement unit (18, 118, 218) has a backlighting (25) for the scattering surface (34, 134, 234).

13. The device according to one of the preceding claims, ~~further characterized in that~~ wherein the camera (36) is designed as a smartphone.

14. The device according to one of the preceding claims, ~~further characterized in that~~wherein the first mechanical element is a first shaft (10) and the second mechanical element is a second shaft (12), with the first measurement unit (14) being designed for positioning at a peripheral surface of the first shaft and the second measurement unit (18) being designed for positioning at a peripheral surface of the second shaft.

15. The device according to claim 14, ~~further characterized in that~~wherein the analysis unit (22) is designed to determine the angular offset and the vertical and horizontal offset of the shafts from the image data taken in different rotational angle positions of the shafts (10, 12).

16. The device according to claim 14 or 15, ~~further characterized in that~~wherein the camera (36) has an inclinometer (29).

17. The device according to one of claims 1 to 13, ~~further characterized in that~~wherein the means (214) for producing the light beam bundle (228) are designed to produce the light beam bundle around a vertical axis (z) rotating in a horizontal plane.

18. The device according to claim 17, ~~further characterized in that~~wherein the analysis unit (22) is designed to determine a vertical level difference between the first mechanical element and the second mechanical element from the image data.

19. The device according to one of claims 1 to 13, ~~further characterized in that~~wherein the first measurement unit (14, 114, 214) and/or second measurement unit (18, 118, 218) is (are) designed so that they can shift along an edge or surface of the first or second mechanical element, and wherein the analysis unit is designed to determine the straightness of the edge or surface of the first or second mechanical element from image data acquired along the edge or surface in different positions of the measurement units.

20. The device according to one of claims 1 to 13, ~~further characterized in that~~wherein the second mechanical element has a concave cylindrically curved body surface (158), wherein the second measurement unit (218) is designed so that it can be shifted in the peripheral direction of the body surface for the purpose of acquiring image data in different rotational angle positions of the second measurement unit, and wherein the analysis unit 22 is designed to determine from the image data the

angular offset and vertical and horizontal offset of the body surface with respect to a predetermined reference direction through the light beam bundle (228).

21. The device according to one of the preceding claims, ~~further characterized in that~~wherein the scattering surface (34, 134, 234) is designed to be non-transparent for the light beam bundle (28, 128, 228).

22. The device according to one of the preceding claims, ~~further characterized in that~~wherein the scattering surface (34, 134, 234) is provided with a plurality of graphic codes (60A, 60B, 60C, 60D), distributed over the scattering surface, for coding of data regarding the scattering surface and/or the measurement unit provided with the scattering surface.

23. A method for determining the location of a first mechanical element (10, 156) and a second mechanical element (12, 154) with respect to each other, ~~wherein~~comprising the steps of:

positioning a first measurement unit (14, 114, 214) ~~is positioned~~ at the first mechanical element and a second measurement unit (18, 118, 218) ~~is positioned~~ at the second mechanical element;~~,~~

producing a light beam bundle (28, 128, 228) ~~is produced~~ by ~~means of~~ the first measurement unit and is directed, directly without reflection, onto ~~the~~a scattering surface or a scattering surface of the second measurement unit facing the first measurement unit~~,~~;

bringing a camera (36), that can move freely with respect to the two measurement units ~~is brought~~, into position and taking at least one picture~~image~~ of the scattering surface ~~is taken~~ or taking at least one picture of the scattering surface by a camera (36) introduced at the second measurement unit and directed onto the scattering surface;~~,~~ and

analyzing the at least one picture~~image is analyzed in order~~ to determine the position of impingement (PV, A1, A2, A3, A4) of the light beam bundle ~~reflected at the reflector arrangement~~ onto the scattering surface and from it the location of the first mechanical element and the second mechanical element with respect to each other.

24. The method according to claim 23, ~~further characterized in that~~wherein the camera (36) is directed onto the side of the scattering surface (34, 134, 234) facing the first measurement unit (14, 114, 214).

25. The method according to claim 23, wherein~~further characterized in that~~ the scattering surface (34, 134, 234) is designed as a matt screen and the camera (36) is directed onto the side of the matt screen facing away from the first measurement unit (14, 114, 214).

~~26. A method for determining the location a first mechanical element (10, 156) and a second mechanical element (12, 154) with respect to each other, wherein~~
~~a first measurement unit (14, 114, 214) is positioned at the first mechanical element and a second measurement unit (18, 118, 218) is positioned at the second mechanical element,~~
~~a light beam bundle (28, 128, 228) is produced by means of the first measurement unit and is directed onto a scattering surface (34, 134, 234) of the second measurement unit facing the first measurement unit,~~
~~at least one image of the scattering surface is taken by means of a camera (36) that is positioned at the second measurement unit and directed onto the scattering surface, and~~
~~the at least one image is analyzed in order to determine the position of impingement (PV, A1, A2, A3; A4) of the light beam bundle on the scattering surface and from it the location of the first mechanical element and the second mechanical element with respect to each other.~~

26~~7~~. The method according to claim 23~~6~~, ~~further characterized in that~~wherein the light beam bundle (228) is produced around a vertical axis (z) rotating in a horizontal plane and, from the pictureimage data~~data~~, a vertical level difference between the first mechanical element and the second mechanical element is determined.

27~~8~~. The method according to claim 26~~7~~, ~~further characterized in that~~wherein the camera (36) is operated in a mode in which, at regular intervals in time, ~~an image~~a picture of the scattering surface is

taken, but wherein only ~~images~~ pictures for which the point of impingement (A3) of the light beam bundle lies in a predetermined region (237) of the scattering surface are analyzed.

28~~9~~. The method according to claim 26~~7~~, ~~further characterized in that~~wherein the camera (36) has a trigger function, which causes the camera to take a picture of the scattering surface (234) in each case only when the point of impingement (A3) of the light beam bundle (228) lies in a predetermined region (237) of the scattering surface.

29~~30~~. The method according to one of claims 26 to 28~~27 to 29~~, ~~further characterized in that~~wherein the camera (36) is joined to the first measurement unit (214) by ~~means of~~ a wireless data link in order to transmit data regarding rotational frequency and rotational angle from the first measurement unit to the camera (36).

30~~31~~. The method according to claim 29~~30~~, ~~further characterized in that~~wherein the camera (36) ~~can~~ is configured and arranged to control the rotational frequency of the light beam bundle via the data link.

31~~2~~. The method according to claim 30~~1~~, ~~further characterized in that~~wherein the camera (36) takes pictures of the scattering surface (234) at a fixed frame rate and the rotational frequency is adjusted by the camera via the data link such that two of the ~~images~~ pictures ~~taken each~~ show a point of impingement (A1, A2) of the light beam bundle onto the scattering surface that is displaced as far as possible horizontally with respect to each other~~from the other point (A1, A2)~~, wherein the horizontal distance between ~~separation of~~ the two points of impingement is determined, and wherein the distance of the second measurement unit from the first measurement unit is calculated from the frame rate, the rotational frequency of the light bundle, and the horizontal ~~separation~~ distance between~~of~~ the two points of impingement.

32~~3~~. The method according to claim 29~~30~~, ~~further characterized in that,~~wherein from an image of the camera (36) in which the point of impingement of the light beam bundle (228) on the scattering surface is

depicted in a horizontally smeared way (235), the horizontal length of the smear is determined and, from this, based on the exposure time of the ~~image~~ picture and the rotational frequency of the light beam bundle, the distance of the second measurement unit (218) from the first measurement unit (214) is calculated.