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(54) ANGLE MEASUREMENT APPARATUS

(71) We, SIEMENS AKTIENGESELLSCHAFT, a German company, of Berlin and Munich, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to angle measurement apparatus.

Angle measurement apparatus for measuring track and camber angles on an automobile vehicle has been proposed previously. Such apparatus is, for example, for use in arrangement also comprising a mirror which is attached, for example, to a wheel hub of the vehicle, the normal to which mirror extends parallel to the relevant wheel axle. The apparatus provides a projector which is mounted opposite the hub-mounted mirror and a projection surface provided with light-sensitive detectors for receiving images reflected by means of the mirror, from a diaphragm, providing light/dark boundaries, situated in the path of the rays from the projector.

Such apparatus is disclosed for example in British Patent Specification No. 1,286,236.

There has been previously-proposed a device for the measurement of track and camber angles in automobile vehicles, wherein a diaphragm situated in the path of the rays from the projector consists of a pattern formed of light-permeable and light-impermeable areas (strips) on a movable plate. For the track and camber angle measurement, the plate is shifted between bars situated in the projector. The movement device naturally permits only a limited speed of displacement, so that angle measurement takes a considerable time even in automated operation. In addition, the resolution of angle measurement, and hence also its accuracy, depend upon the division of the pattern into light-permeable and light-impermeable

strips. Of course, the fineness of the pattern is subject to limitations.

According to the present invention, there is provided an angle measurement apparatus, for measuring a track or camber angle of a wheel of a vehicle, comprising a projector, for directing a beam of light onto a mirror mounted to move with the wheel and to reflect the light back to the apparatus when it is in use, a light-sensitive detector, mounted in a predetermined position relative to the projector, for receiving such light reflected back when the apparatus is in use, a light-interrupting member mounted for rotation relative to the projector so that, when the apparatus is in use, a measurement edge of the light-interrupting member in the course of each revolution of the rotating member cuts across the said beam from the projector without cutting the reflected light passing to the detector, and means connected with the light-sensitive detector for providing a measure of the angle through which the light-interrupting member rotates, when the apparatus is in use, from a predetermined reference position thereof to a position at which an image of the said measurement edge passes across the said light-sensitive detector, that angle, through which the light-interrupting member rotates, being dependent upon the track or camber angle.

The use of the apparatus embodying the present invention can provide for an increase in the speed of track and/or camber angle measurement as compared with a previously-proposed device, so that provision may also be made for forming a mean value from a number of measurements. In addition, the use of apparatus embodying the present invention can provide for an enhancement of the resolution of angle measurement. Further, apparatus embodying the present invention can provide a movement mechanism of great simplicity for the displacement of the light-interrupting

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member.

In an arrangement as mentioned above, in which an embodiment of the present invention is used, in which both track or camber angles can be measured, light/dark boundaries can be provided by measurement edges on arms rotatably mounted in the object plane of the projector.

The rotating arms require only a simple drive, the speed of which can be set substantially as high as desired without any frictional resistances arising, such as arise between the plate and the slide bars in the previously proposed device as described above.

In apparatus embodying the present invention it is possible to use for angle measurement timing signals fed to a time-measuring means and thereby an angular resolution substantially as high as desired can be provided.

The said predetermined reference position, for the measurement edges of arms providing the light-interrupting member, can be provided by means of a photo-electric cell arrangement in the object plane of the projector.

In camber measurement, the angle measurement may, for various reasons, become slightly dependent upon the distance between the mirror and the projector. It is therefore advisable to equip apparatus embodying the present invention so that the distance between the projector of the apparatus and the mirror with which the apparatus is used can be measured using the apparatus itself. For this purpose, the apparatus is provided with two additional light-sensitive detectors (additional to the detector mentioned above) disposed in spaced relationship on a projection surface in a plane through the said predetermined position, so that the angle through which the arms (for example) rotate between the instant when an image, reflected by the mirror, of one of the measurement edges becomes incident in one of the two additional detectors until the image of this edge becomes incident in the other one of the two detectors serves as a measure of the distance of the mirror from the projector.

The angle through which the arms rotate can be determined, with known speed of rotation of an arm drive, with the aid of a timing pulse counter which is opened for counting by signals from the photo-electric cell arrangement in the object plane of the projector with the aid of a gate circuit and closed for counting by signals from a detector by way of the same gate circuit, and which receives pulses from a timing pulse generator between the two signals. For projector-mirror distance measurement, the gate circuit is controlled to open and close by output signals from the two additional detectors.

The measurement edge providing the light/dark boundary on which track meas-

urement is based is desirably a straight edge of one of the rotatable arms providing the said light-interrupting member which edge extends radially in relation to the axis of rotation of the arm.

For camber measurement, a diaphragm or light/dark boundary which does not extend radially in relation to the axis of rotation of the rotatable arms is in most cases sufficient.

It has been found advantageous to employ an edge which follows a curve which at each point therealong intersects a radial line extending from the axis of rotation of the arms at an angle of 45°.

In a preferred embodiment of the invention, the axis of rotation of the arms is situated vertically above the optical output axis of the projector. The two axes extend in parallel.

The arms on which the measurement edges for the track and camber angle measurements are respectively disposed are preferably provided at 180° to one another.

As a preferred drive for the arms, there can be employed a synchronous motor whose speed is preferably made such that more than one measurement result per second is obtained for the track and camber angle measurements respectively. The timing pulse counter is desirably so designed that it can receive a number of signals for use in angle measurements in time multiplex operation, so that two or more angle measures can be produced during respective periods of time that overlap.

In a preferred embodiment of the invention, the photo-electric cell arrangement mentioned above is situated on a vertical line extending through the optical axis of the projector or the axis of rotation of the arms.

As the light source for the projector, there may be used a halogen lamp having a cold light reflector.

The light source may be provided with a lens which images the helix of the halogen lamp close to the objective lens of the projector.

An economical energy supply may be provided for the light source of the projector if a stroboscopic lamp is used as the light source of the projector.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a schematic and diagrammatic representation of an arrangement comprising apparatus embodying the present invention for illustrating operation thereof, and

Figure 2 is a schematic illustration of the construction of an arrangement comprising apparatus embodying the present invention.

In Figure 1, there are situated in the path of the rays from a light source 1 of apparatus

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embodying the present invention a condenser lens 2 and an objective 3 of the apparatus. Situated opposite the objective is a mirror 4, which is shown in two positions. In one position, the mirror 4 is, as shown by a broken line, at right angles to the optical axis 5 of the projector formed by the source 1 and lenses 2 and 3. In the other position, indicated by a solid line, it is inclined at an angle α thereto.

In the object plane 6 of the projector, there is situated a measurement edge 7, which is also shown in two positions. In a first position, the measurement edge is in contact with the optical axis 5 of the projector. In the second position, the measurement edge 7 is situated below the optical axis 5 as shown. The two positions of the measurement edge correspond to an angle of rotation of an arm which carries the measuring edge in apparatus embodying the present invention (c.f. Figure 2). A light-interrupting arm which defines the edge 7 has been omitted from Figure 1 for the sake of clarity. Aligned with the optical axis is a photo-electric cell arrangement 8 consisting of a light transmitter and a light receiver. When the measurement edge comes into contact with the optical axis 5, a start signal is given for a counter which is connected to receive timing pulses. When the mirror 4 is in the normal position, a reflected ray forming an image of the measurement edge simultaneously becomes incident in a detector 9 disposed vertically above the optical axis in the plane of the objective. The counter thus receives a stop signal at the same instant as the start signal is given. No pulses are counted at the counter in this case. The track and camber angles are zero. When a track and/or camber angle is present, that is to say, when the mirror is in a position inclined in relation to the normal position of the mirror 4 as illustrated in Figure 1, the image of the measurement edge is first reflected into the detector when the edge is in the second position, below the optical axis. In this case also, the timing pulse counter has received its start signal at the passage of the measuring edge through the photo-electric device 8. The counter then counts timing pulses until the measuring edge arrives at the said second position, in which its image is reflected from the inclined mirror into the detector 9, and the detector then supplies a stop signal for the timing pulse counter. The number of timing pulses counted into the counter is proportional to the angle α .

Elements of the arrangement of Figure 1 are diagrammatically illustrated in more detail in Figure 2. There proceeds from a lamp 10 of apparatus embodying the present invention a light beam which passes through an objective 11 of the apparatus to a mirror 12, mounted on a hub 13 of a wheel 14 of an automobile vehicle for example. Situated in the plane of the objective is an image plane

or projection surface 15 in which there is provided a light-sensitive detector 16 for track and camber angle measurement and two light-sensitive detectors 17 and 18 for projector/mirror spacing measurement as mentioned above. In the object plane of the projector, there is mounted on an axis of rotation 19 a light interrupting member having two arms 20 and 21 which are provided with measurement edges 22 and 23 at respective ends thereof. There is employed for track angle measurement the measurement edge 22 and for camber angle measurement the measurement edge 23, which is of curved form. There is also provided for camber angle measurement a special start edge, which bears the reference numeral 24. The axis of rotation 19 is situated vertically above the optical axis of the projector and extends parallel thereto. The two arms 20 and 21 are driven by a synchronous motor 25. In rotation, the arms 20, 21 with the measurement edges 22, 23 and 24 pass through a photo-electric cell arrangement consisting of a light transmitter 26 and a light receiver 27. Thus, each measurement edge of the light-interrupting member cuts across a beam of light from the projector in the course of each revolution of the rotating light interrupting member. The arrangement 26, 27 provides a predetermined reference position. A signal conductor extends from the light receiver 27 of the photo-electric cell arrangement to a start input of a gate circuit 28. The start input of the gate circuit 28 is also connected to the light detector 17. A stop input of the gate circuit 28 is connected to the electrical output of the light detector 16 by way of a signal conductor. The light detector 18 is also connected to the said stop input. Counting pulses from a timing pulse generator 29 are passed through the gate circuit 28 to a timing pulse counter 30. Alternatively, the output signal of the light detector 16 may be used as the start signal and the output signal of the light receiver 27 as the stop signal with the aid of a logic circuit (not shown). The sequence of the two output signals then determines the sign of the angle measured with their aid.

The light-sensitive detectors 17 and 18, for projector/mirror spacing measurement are mounted in the image plane or projection surface 15 at spaced locations. When an image of a measuring edge of the light-interrupting member passes across detector 17 gate circuit 28 is started and pulses from generator 29 are thereafter passed to counter 30, and counted. When the image of the measuring edge passes across detector 18 gate circuit 28 is stopped and counting of pulses ceases. The count of pulses so obtained is a measure of the angle through which the light-interrupting member rotates from the position at which the image of the measuring edge passes across detector 17 to

the position at which that image passes across detector 18, which angle in turn provides a measure of the distance from the projector to the mirror.

5 The light detectors or photo-electric transducers may be, for example, photo-diodes or photo-transistors.

10 If the synchronous motor 25 driving the arms 20 and 21 runs at a speed of 300 r.p.m., five measured values are obtained per second for the track and camber angle measurements respectively. Any corrections to the measurement results which may be necessary may be made with the aid of a micro-processor and tables permanently stored therein.

WHAT WE CLAIM IS:-

1. Angle measurement apparatus, for measuring a track or camber angle of a wheel of a vehicle, comprising a projector, for directing a beam of light onto a mirror mounted to move with the wheel and to reflect the light back to the apparatus when it is in use, a light-sensitive detector, mounted in a predetermined position relative to the projector, for receiving such light reflected back when the apparatus is in use, a light-interrupting member mounted for rotation relative to the projector so that, when the apparatus is in use, a measurement edge of the light-interrupting member in the course of each revolution of the rotating member cuts across the said beam from the projector without cutting the reflected light passing to the detector, and means connected with the light-sensitive detector for providing a measure of the angle through which the light-interrupting member rotates, when the apparatus is in use, from a predetermined reference position thereof to a position at which an image of the said measurement edge passes across the said light-sensitive detector, that angle, through which the light-interrupting member rotates, being dependent upon the track or camber angle.

2. Apparatus as claimed in claim 1, wherein the said predetermined reference position is defined by a photo-electric cell arrangement, comprising a light transmitter and a light receiver, mounted in the apparatus so that a beam of light from the transmitter to the receiver is cut by an edge of the light-interrupting member as that member passes through the predetermined reference position.

3. Apparatus as claimed in claim 1 or 2, further comprising first and second additional light-sensitive detectors mounted at respective predetermined positions relative to the projector, spaced apart from one another, and means connected with the first and second additional light-sensitive detectors for providing a measure of the angle through which the light-interrupting member rotates, when the apparatus is in use, from a

first position thereof, at which an image of the said measurement edge passes across the first additional light-sensitive detector, to a second position thereof, at which that image of the said measurement edge passes across the second additional light-sensitive detector, thereby to provide a measure of the distance from the projector to the mirror when the apparatus is in use.

4. Apparatus as claimed in any preceding claim, wherein the said measurement edge is a straight edge, extending radially with respect to the axis of rotation of the light-interrupting member, and the said means of claim 1 provide a measure of the track angle of the wheel when the apparatus is in use.

5. Apparatus as claimed in any one of claims 1 to 3, wherein the said measurement edge is a curved edge, and the said means of claim 1 provide a measure of the camber angle of the wheel when the apparatus is in use.

6. Apparatus as claimed in claim 5, wherein the said measuring edge is so curved that at each point therealong it intersects at 45° a straight line radiating from the axis of rotation of the light-interrupting member to the point concerned.

7. Apparatus as claimed in any preceding claim, wherein the axis of rotation of the light-interrupting member is parallel to the optical output axis of the projector.

8. Apparatus as claimed in claim 7, wherein the said axis of rotation is vertically above the said optical output axis when the apparatus is in use.

9. Apparatus as claimed in claim 7 or 8, read as appended to claim 2, wherein the photo-electric cell arrangement is mounted along a straight line extending perpendicularly through the axis of rotation of the light-interrupting member and the optical output axis of the projector.

10. Apparatus as claimed in any preceding claim, wherein the said light-interrupting member has a further measurement edge, one of the measuring edges serving for camber angle measurement, the other for track angle measurement.

11. Apparatus as claimed in claim 10, wherein the light-interrupting member has first and second arms that extend substantially radially from the axis of rotation thereof and carry respectively the measurement edge of claim 1 and the said further measurement edge.

12. Apparatus as claimed in claim 11, wherein the first and second arms are spaced apart around the axis of rotation of the light-interrupting member by substantially 180°.

13. Apparatus as claimed in any preceding claim, wherein drive means of the apparatus, for driving the said light-interrupting member to rotate, comprise a

synchronous motor.

14. Apparatus as claimed in any preceding claim, wherein drive means of the apparatus, for driving the said light-interrupting member to rotate, are adapted to drive the light-interrupting member to rotate sufficiently rapidly to enable more than one track and/or camber angle measure to be provided per second.

15. Apparatus as claimed in any preceding claim, wherein the light-interrupting member is driven to rotate at a constant speed when the apparatus is in use, wherein the means for providing a measure of the angle through which the light-interrupting member rotates comprise a timing pulse counter arranged and connected for counting timing pulses during rotation of the member.

16. Apparatus as claimed in any preceding claim, wherein the means for providing a measure of the angle through which the light-interrupting member rotates comprise time measurement means operable in a time multiplexed manner whereby two or more angle measures can be produced during respective periods of time that overlap one another.

17. Apparatus as claimed in any preceding claim, wherein the projector has a light source comprising a halogen lamp and a cold light reflector.

18. Apparatus as claimed in claim 17, wherein the projector further comprises a lens which forms an image of the helix of the lamp close to the objective thereof.

19. Apparatus as claimed in any one of claims 1 to 16, wherein the projector has a light source comprising a stroboscopic lamp.

20. A combination of apparatus as claimed in claim 1 with such a mirror mounted on a wheel of a vehicle, normal to the axle of the wheel.

21. A combination as claimed in claim 20, comprising apparatus as claimed in any one of claims 2 to 19.

22. A combination as claimed in claim 20, substantially as hereinbefore described with reference to the accompanying drawings.

23. Angle measurement apparatus, substantially as hereinbefore described with reference to the accompanying drawings.

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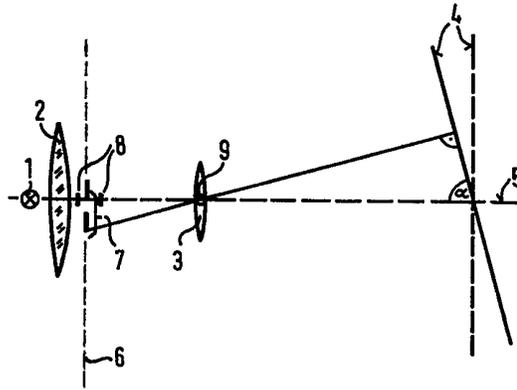


Fig. 1

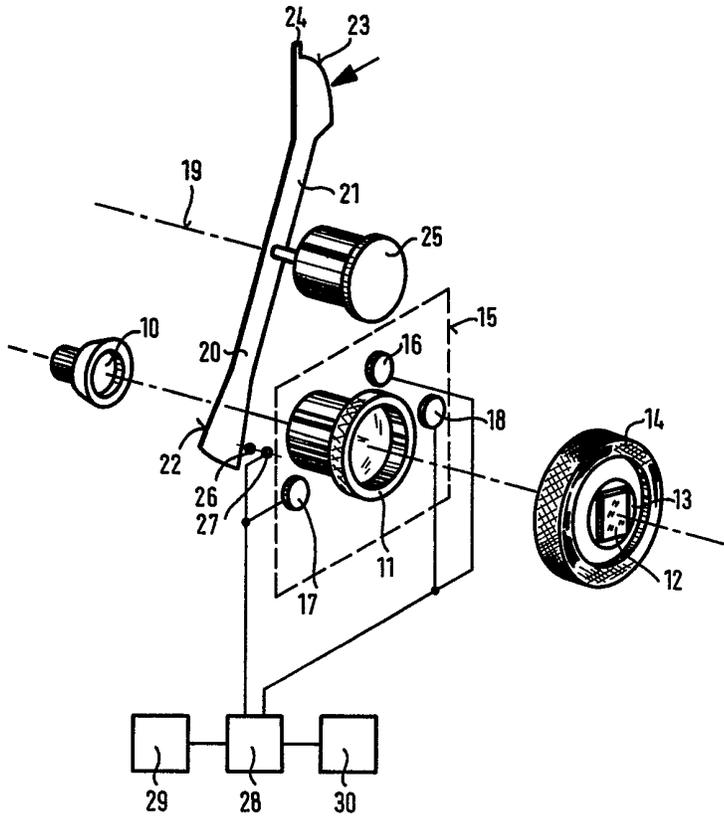


Fig. 2