

[54] MEANS FOR DETERMINING DISTANCE

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[51] Int. Cl. **G01b 11/27, B21b 37/00**

[58] Field of Search 356/170, 3, 9, 15, 356/147, 153, 172, 141, 152, 156; 250/219 TH; 33/125 A; 72/31, 35, 36, 37

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[57] ABSTRACT

In order to determine the distance between the rollers in a rolling mill, there is provided an optical transducer which includes a retro-reflector in a bore within each of the rollers. A laser beam is caused to impinge on one of the retro-reflectors and mirrors and prisms are provided for transmitting this beam to the other retro-reflector, from which it impinges on a detector which detects displacement of the beam and thus determines the distance between the rollers.

16 Claims, 26 Drawing Figures

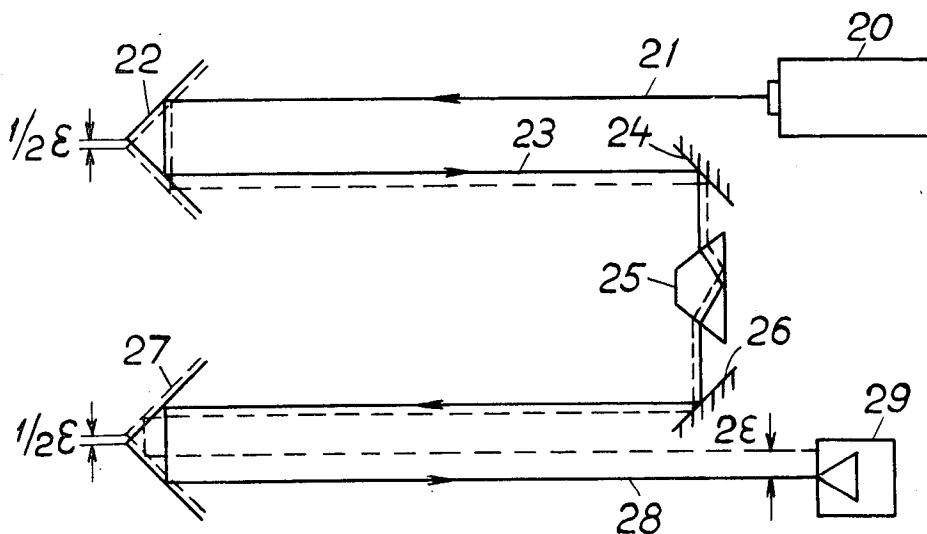


Fig 1

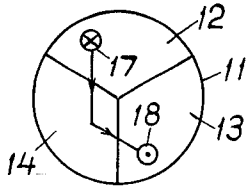


Fig 2

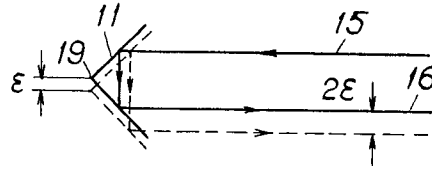


Fig 3

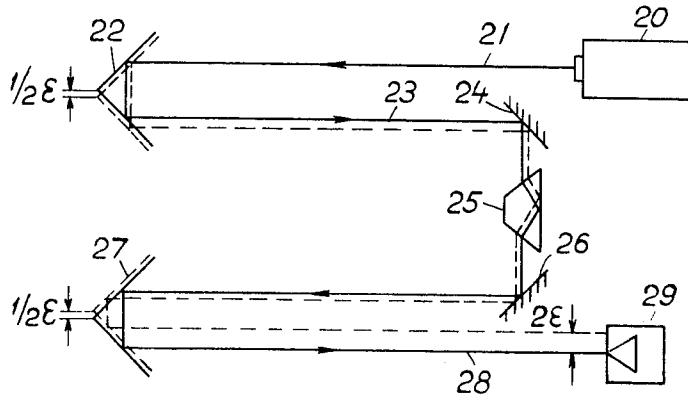


Fig 4

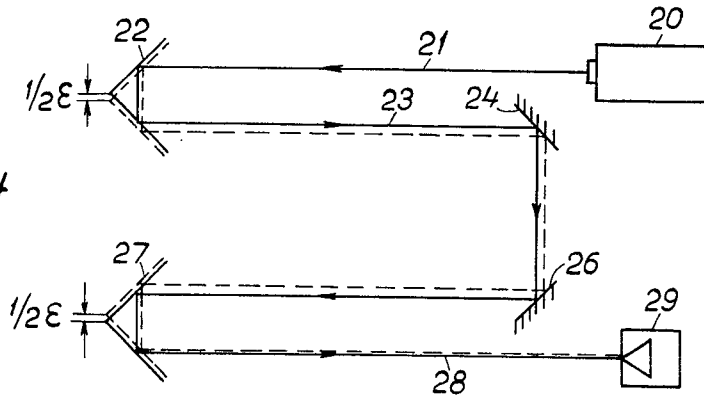


Fig 5a

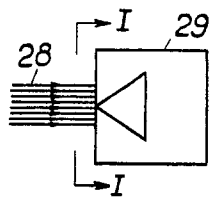


Fig 5b

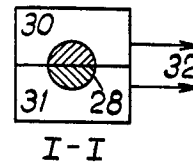


Fig. 6

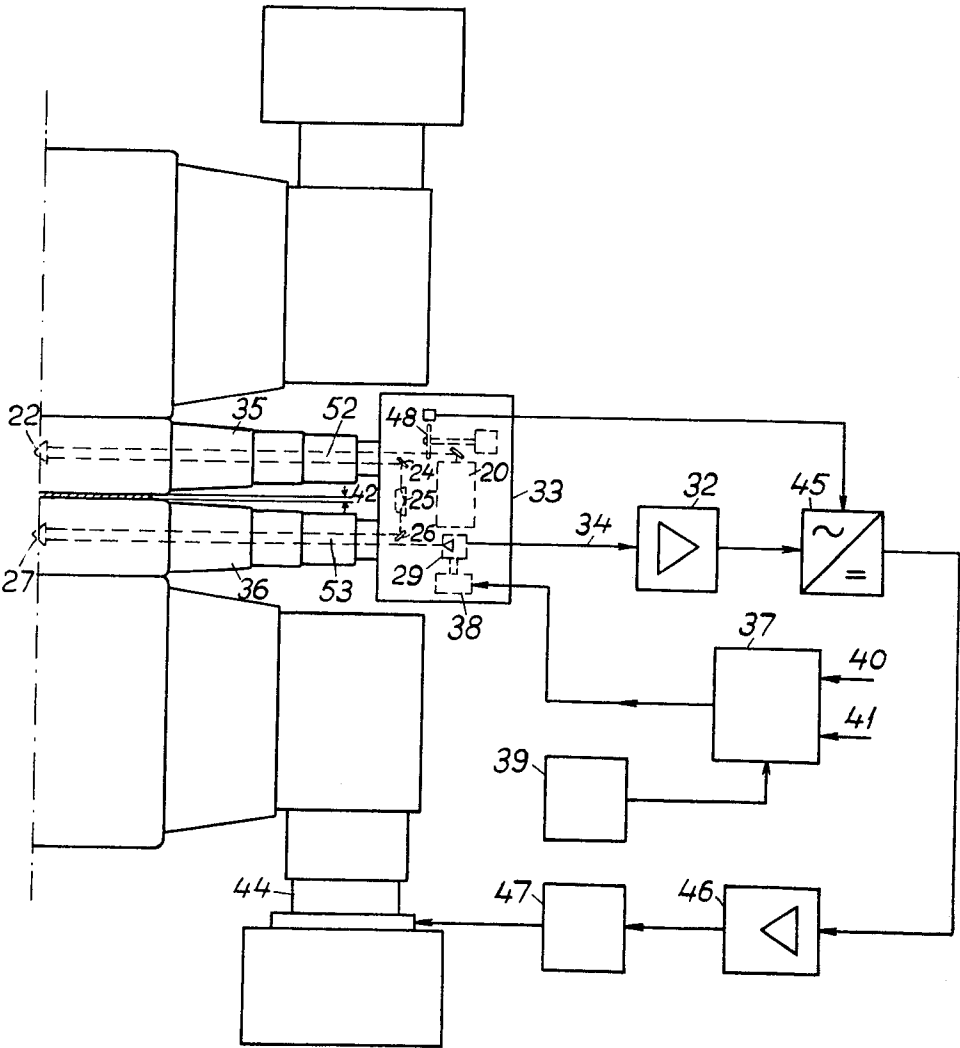


Fig 7

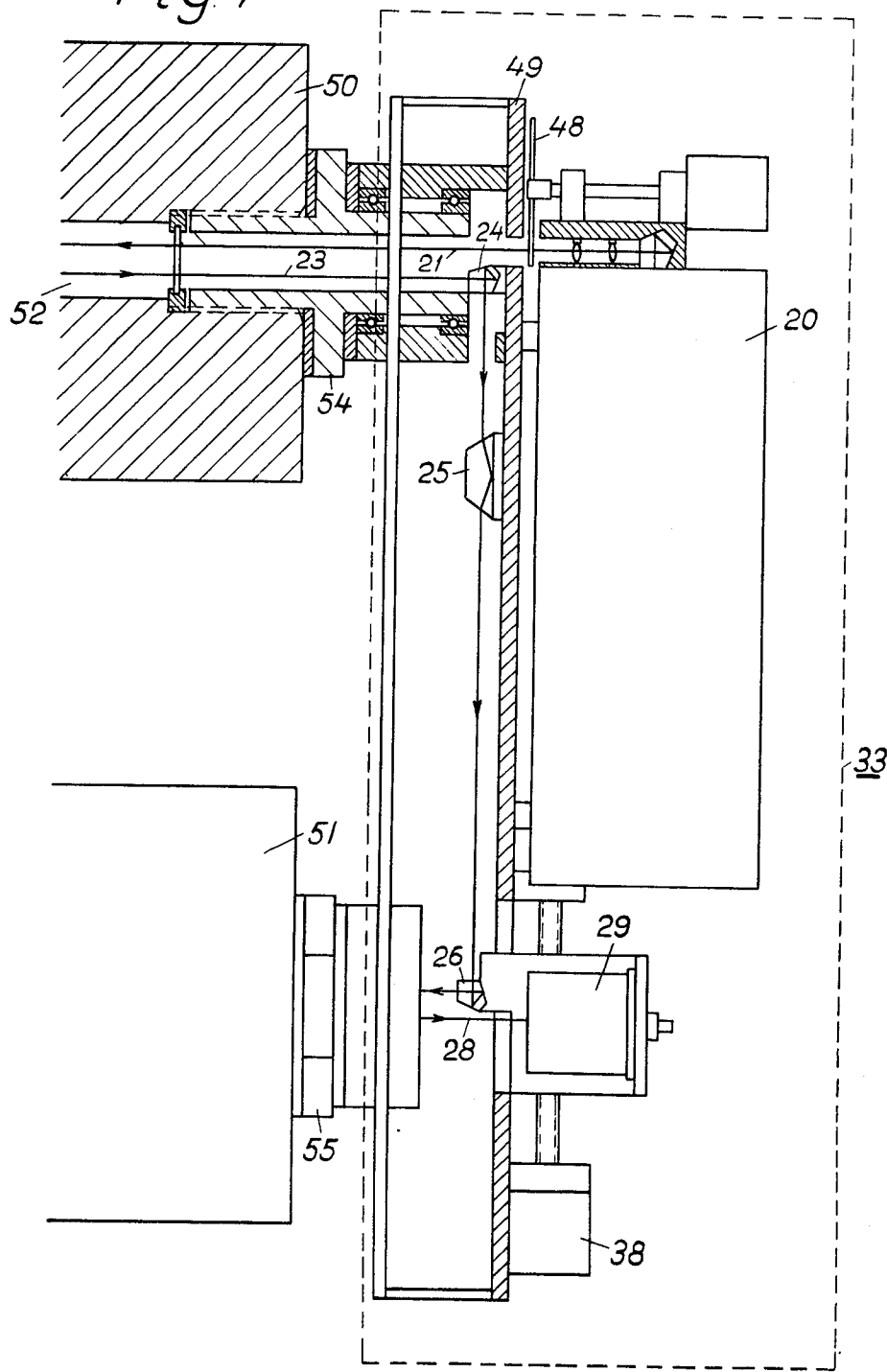


Fig. 8

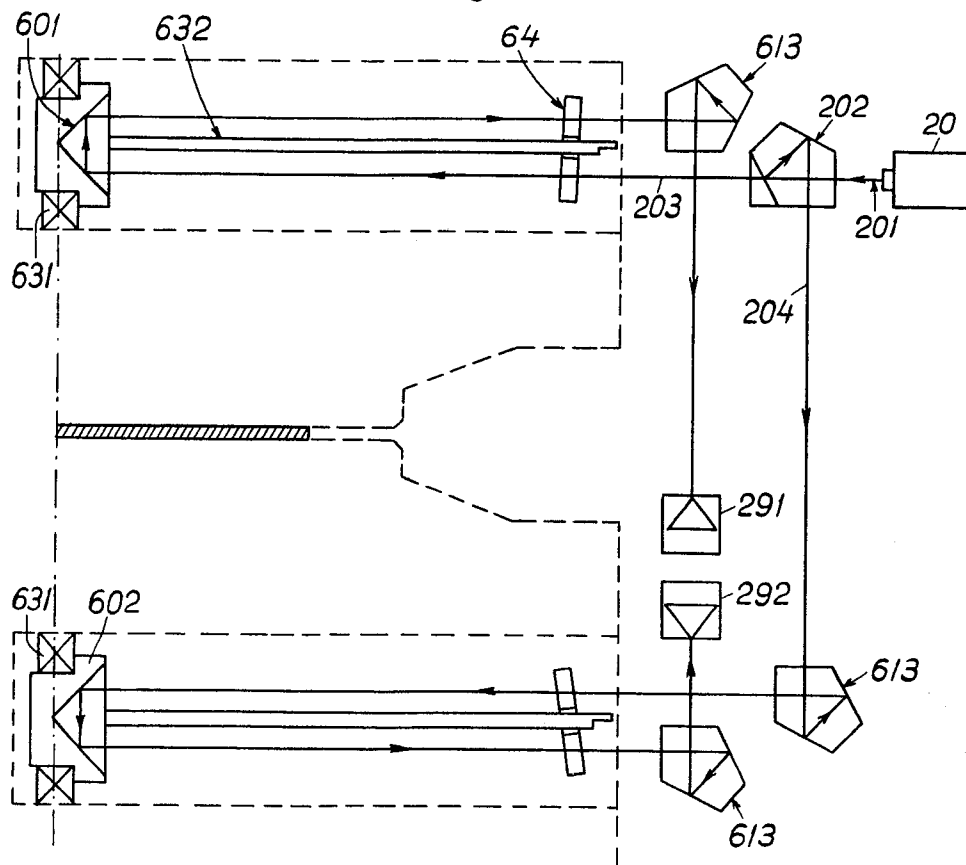


Fig. 9

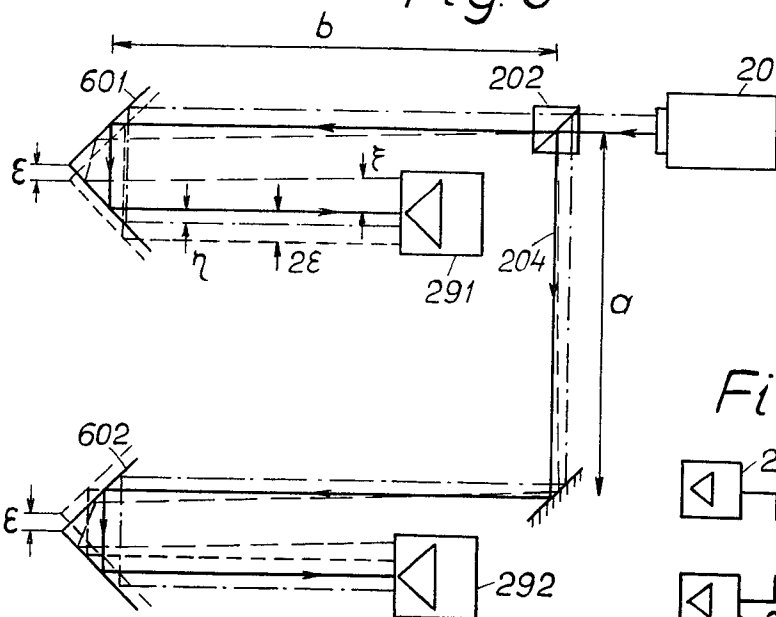


Fig. 9a

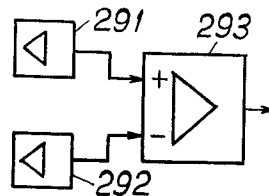


Fig. 10

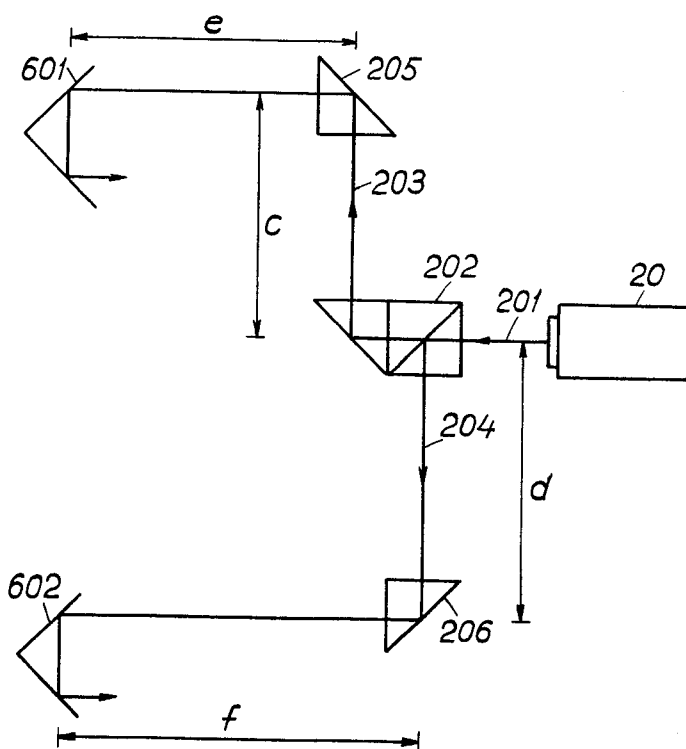


Fig.11a

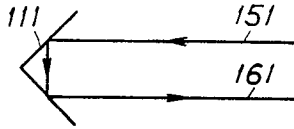


Fig.11b

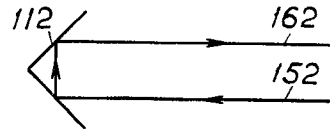


Fig.12a

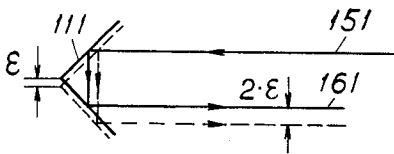


Fig.12b

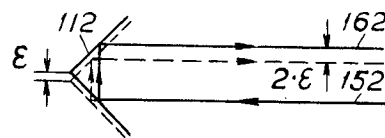


Fig.13a

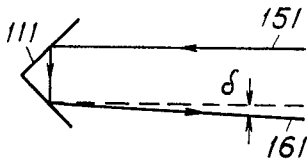


Fig.13b

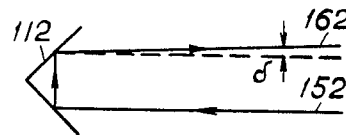


Fig.14

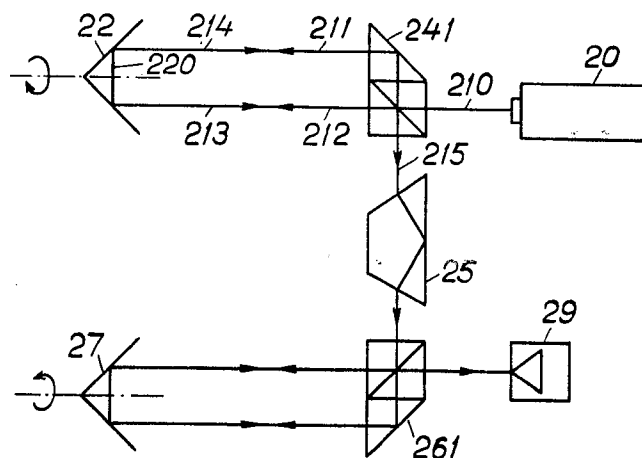


Fig. 15

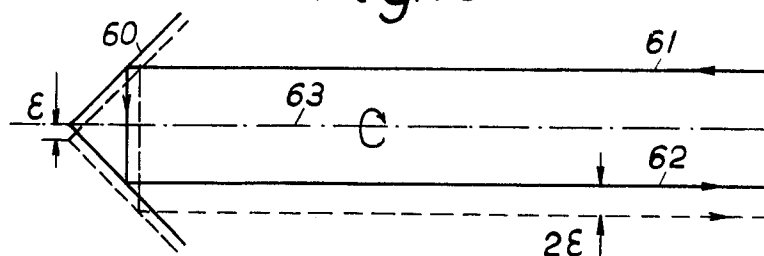


Fig. 16

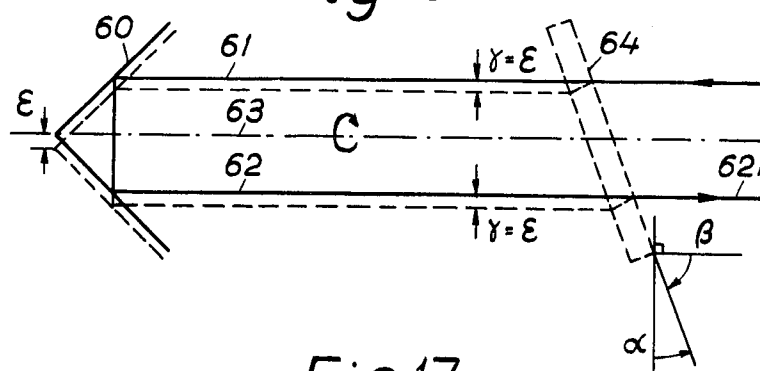


Fig. 17

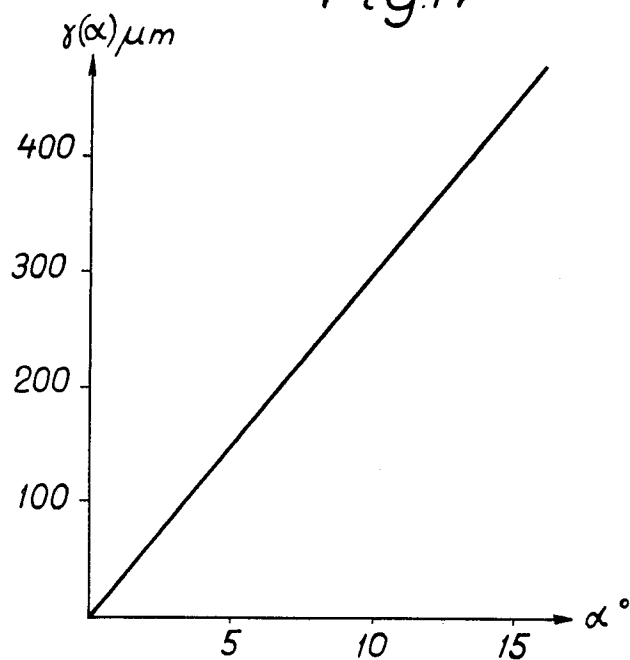


Fig. 18

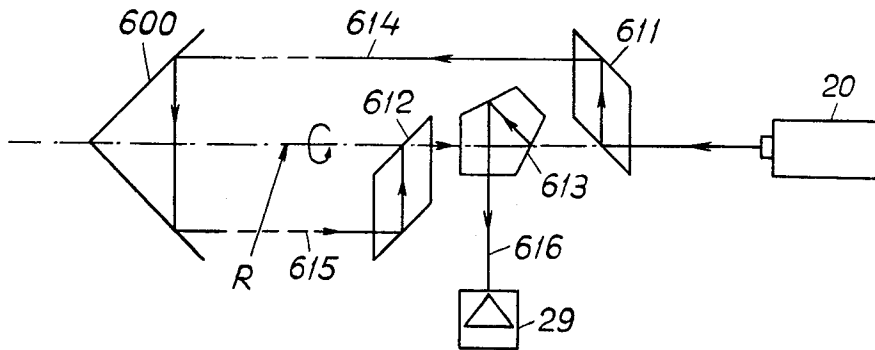


Fig. 19

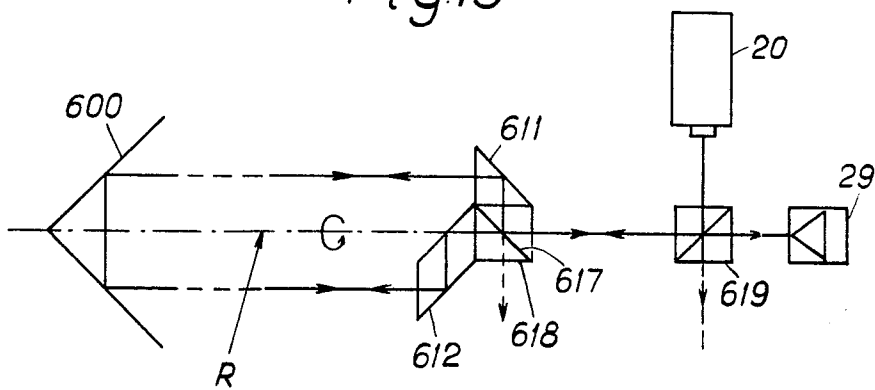


Fig.20a

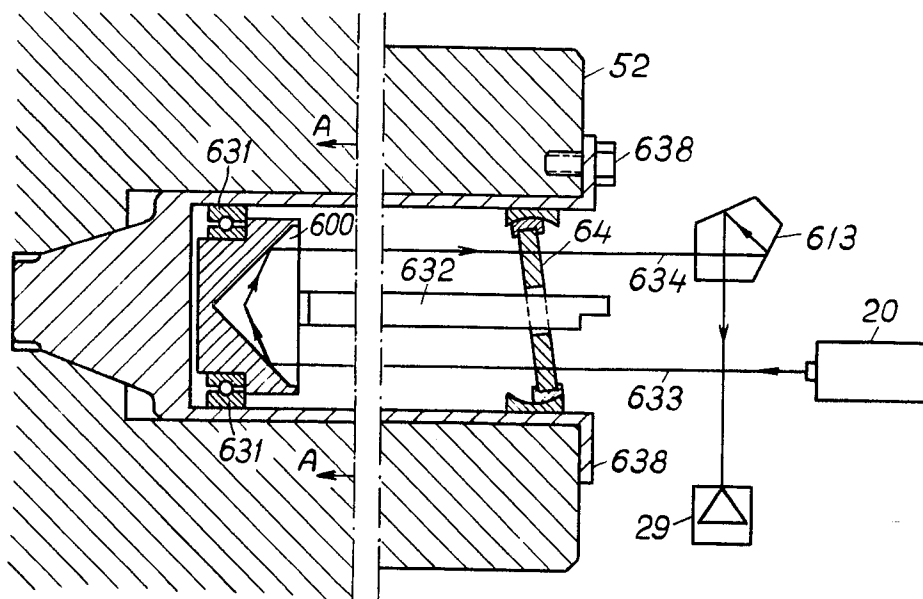
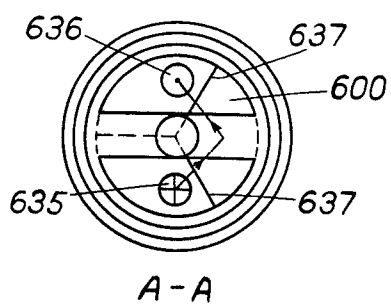


Fig.20b



MEANS FOR DETERMINING DISTANCE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a means for determining the distance between two measuring points.

2. The Prior Art

In many fields it is necessary to be able to determine and regulate distance continuously and very accurately. For the sake of clarity the invention will be described with respect to one of these fields, i.e., that of the rolling mill industry.

In rolling mills steel strip and sheet metal is rolled with very high requirements for thickness tolerances. The thickness of the rolled strip is dependent on a number of factors and is generally regulated automatically during a rolling process. The thickness tolerance of the strip is limited to a great extent by the accuracy of the thickness transducers and their rapidity as well as the speed of the roller setting devices.

The rolling pressure required in a certain case depends on the diameter of the working rollers, the initial thickness of the strip, the thickness reduction, the width of the strip, the tensile stress in the strip before and after the rollers, the friction between the working rollers and the strip and the yield point and rolling speed of the material.

These factors vary more or less during a rolling process, thus causing errors in thickness in the rolled strip. Furthermore, deficiencies of the rolling mill will contribute additional errors.

There are several possible measuring points in a rolling mill where the measuring value can be obtained in relation to the rolled thickness of the strip or variation in thickness. Since the rolling gap is the control factor in a system for regulating the thickness of a strip, a transducer which gives a gauge of the size of the rolling gap is the most desirable. In the following some examples will be given of sources of error which in various combinations may affect measurements of the roller gap, namely thermal alterations in dimension of the roller stand, friction between the bearing housing of the support roller and the roller stand, eccentricity between support roller bearing and rolling surface, irregularity of the support rollers, a varying thickness of oil film in the support roller bearing, deformation of the working rollers, a varying thickness of the film of lubricant between strip and working rollers, etc.

SUMMARY OF THE INVENTION

The object of the present invention is for effect a means to determining the deviation from a predetermined distance, which means can be used with advantage in rolling mills, thus avoiding the majority of the sources of error mentioned above.

In a device according to the invention, there are mounted in bores in the ends of a pair of rollers retro-reflectors each forming a part of a measuring arm of an optical transducer. A light emitter is provided which sends out rays directed towards the retro-reflectors at the measuring points and a detector is arranged to detect displacement of the beam reflected from the light reflectors and to detect displacement in the light rays caused by an alteration in the distance between the rollers.

Since the measuring point for the device according to the invention has been located at the central point of

the rollers through axial holes in the rollers deformation of the rollers cannot affect the measurement since it has been found by experiment that the roller deformation is negligible near the centre of the rollers. An optical transducer based on the principle of measuring the radial displacement of a light ray in a so-called retro-reflector is used. The method requires modification of the work rollers and accurate adjustment of the position of the retro-reflectors but, in comparison with transducers placed outside the roller path, has the advantages that the measuring signal obtained needs no correction for roller deformation, different widths of strip, etc. Thermic alterations in dimension of the work rollers remain, however, and the transducer should therefore preferably be supplemented by an absolute-measuring thickness transducer.

Considerable demands are made on the light emitter forming part of the device if sufficiently accurate measuring accuracy is to be obtained. Particularly when the light emitter consists of a laser, this has some effect on the stability of direction, the parameters primarily consisting of parallelity and angle errors.

The separation of the light ray emitted from the light source into two components, one for each roller, means that measuring errors (i.e. false alterations in roller position) caused by instability of direction of the light emitter are considerably reduced.

The optical emitter is extremely sensitive to angular faults in both the optical parallel-reflecting retro-reflectors which are applied in axial holes in the rollers. A retro-reflector consists of three surfaces which are mutually perpendicular. These surfaces are seldom in practice exactly perpendicular, there being deviations which give rise to errors in parallelity between approaching and reflected light rays.

Parallelity errors in retro-reflectors of good quality are up to a maximum of ± 2 arc seconds. This corresponds to a maximum fault in position of approximately ± 5 microns per metre distance from the retro-reflector when the retro-reflector is rotated one turn around an axis through its point, as occurs in the present arrangement. Totally, for the whole system according to the arrangement, a maximum error is obtained in the order of $\pm 30 - 40$ microns, which is a factor of 10 less than what may be tolerated.

Since the distance measurement is performed using two light rays which are oppositely directed and superimposed, this angular fault can be disregarded.

The optical transducer is extremely sensitive to centering faults in the two parallel-reflecting optical retro-reflectors.

These retro-reflectors must be accurately centred (± 1 micron) in relation to the axis of rotation of the rollers. The centering process is made more difficult as the holes in the rollers are 1.5 - 2 m in depth.

The centering of the retro-reflectors can be considerably simplified by providing an optically transparent obliquely positioned glass plate which rotates with the roller so that said fault does not affect measurement of the roller distance.

The optical transducer comprises retro-reflectors, as described above, consisting of three reflection surfaces at right angles to each other. The retro-reflectors rotate with the speed of the rollers in relation to the approaching light rays, which means that edge lines between different reflection surfaces cut the light rays six times per turn in each retro-reflector.

When a light ray meets an edge line, there is a disturbance in the intensity distribution of the light ray in the form of a dark line and a diffraction pattern with alternate light and dark lines. The dark lines dominate at the bevelled edges of the retro-reflector and the diffraction pattern at the clear-cut edges. On the surface of the position detector the disturbances are seen as lines moving over the surface of the detector when the retro-reflector is rotated. The position detector measures the position of the centre of gravity of the intensity distribution, so that the above-mentioned disturbances in the distribution symmetry are registered as false position alterations. Practical tests have shown that the disturbances correspond to position faults of the order of 0.1 mm, which is a factor 100 above that which can be tolerated.

The edge-line disturbances are eliminated by stopping the relative rotation between light rays and retro-reflector. This is achieved either by the light rays rotating synchronously with the retro-reflector or by means of journalled suspension of the retro-reflector inside the roller.

As well as the edge line disturbances being eliminated, the influence of angular faults on the retro-reflectors is also eliminated since the reflection surfaces are permanently met by the light rays in the same sequence. This ensures a constant parallelity error between approaching and reflected light rays.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described with reference to the accompanying drawings in which

FIGS. 1 and 2 show the principle of a retro-reflector, FIG. 3 shows an optical transducer included in a device according to the invention using a Dove prism,

FIG. 4 shows the device according to FIG. 3 without the Dove prism,

FIGS. 5a and 5b show the principle of a photo-detector included in the device, 5b being in view of 5a from the direction of I—I,

FIG. 6 shows an example of the device in use on a hydraulic system for regulating the thickness in a cold rolling mill to which an optical transducer according to the above is fitted,

FIG. 7 shows an example of how the optical transducer can be suitably applied to a roller pair,

FIGS. 8, 9, 9a and 10 show an alternative design of the optical transducer by which measuring errors due to the stability of direction of the light emitter are reduced,

FIGS. 11a, 11b, 12a, 12b, 13a, 13b and 14 show an alternative embodiment of the optical transducer where the measuring error caused by angular faults in the retro-reflectors has been eliminated, FIGS. 15, 16 and 17 show a centering device for the optical transducer and FIGS. 18, 19, 20a and 20b show a device for the optical transducer by means of which edge line disturbance and angular faults in the retro-reflectors are avoided.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First of all the principle of the transducer will be described in connection with FIGS. 1 - 5b. The transducer is based on an optical method measuring the displacement of reflected light rays in relation to approaching light rays which takes place in an optical so-

called retro-reflector. According to FIG. 1 a retro-reflector 11 has three reflecting surfaces 12, 13 and 14 in the same configuration as the sides adjacent a corner of a cube. The approaching ray 15 is always parallel to the reflected ray 16 (see FIG. 2) and leaves the retro-reflector 11 at a point 18 diagonally opposite to the contact point 17 as shown in FIGS. 1 and 2. The retro-reflector 11 can be rotated about arbitrarily directed axes of rotation through its apex 19 without the distance between approaching and reflected rays 15 and 16, respectively, being altered. If the point 19 of the retro-reflector 11 is displaced the distance ϵ according to FIG. 2, a vertical displacement 2ϵ of the reflected ray 16 will occur.

A retro-reflector 11 is placed in a centred position, i.e. the axis of rotation of the roller through the point 19 of the retro-reflector 11, inside each work roller, after which a light emitter 20 is arranged to emit a light ray 21 which is directed, deflected and detected as shown in FIG. 3 where the light ray 23 from a first retro-reflector 22 is arranged to fall on reflector 24 which lets the ray fall on a so-called Dove-prism 25 in order to achieve yet another reflection of the ray before it falls upon a reflector 26 and is then directed towards a second retro-reflector 27, the reflected ray 28 being supplied to a detector unit 29. A vertical displacement of the two retro-reflectors 22 and 27 of $\frac{1}{2}\epsilon$ gives a vertical displacement 2ϵ of the ray 28 falling on the detector unit 29. The reflectors 24 and 26 may with advantage consist of constantly deflecting penta-prisms.

If the Dove prism 25 shown in FIG. 3 is removed a light path is obtained in accordance with FIG. 4, i.e. although both retro-reflectors 22 and 27 have also been vertically displaced a distance of $\frac{1}{2}\epsilon$ each, no vertical displacement of the ray 28 is obtained, so that the device is insensitive to alterations of the relative distance between the retro-reflectors 22 and 27. In the same way it can be shown that the device according to FIG. 3 with the Dove-prism 25 is insensitive to parallel displacements and twisting of the retro-reflectors 22 and 27 with respect to the emitter 20.

The displacement of the position of the emitted ray 28 will be linear and equal to double the alteration in roller distance. The position of the light ray 28 is sensed by a double photo-detector 29 in which the light ray is divided into two parts 30 and 31 according to FIGS. 5a and 5b where FIG. 5b shows a view in the direction I-I from FIG. 5a. The two halves 30 and 31 of the detector 29 are connected to a differential amplifier 32 (see FIG. 6), the output signal of which becomes non-linear when the intensity of the light ray is normally distributed.

A continuous gas laser should preferably be used as light emitter 20 because of the requirement for parallel light rays.

FIG. 6 shows an embodiment of the invention used in a hydraulic system for regulating thickness in cold rolling mills.

The AC signal 34 from the transducer 33 can be used without correction for roller deflection or the like, to regulate the work roller distance. The time constant of the system is essentially determined by the time constant of the hydraulic system. The optical detector 33 has a useful measuring range which is limited and it is therefore necessary for the position of the detector 29 to be adjustable. The diameter variation of the rollers 35 and 36 due to regrinding should also be taken into

consideration. A simple positioning system 37 with a step motor 38 in combination with an X-ray transducer 39 beyond the rolling mill has been introduced for absolute positioning of the photodetector 29. The X-ray transducer 39 integrates the absolute thickness of the strip and corrects the absolute position of the photo detector 29 via the positioning system 37 for gradual variations in thickness. Such faults arise mainly because of thermal variations in diameter of the work rollers.

Before a new roll pass, the photo detector 29 is roughly positioned by a desired value signal 40 corresponding to the desired strip thickness being supplied to the positioning system 37. This rough positioning may be performed, for example, simultaneously with and in the same way as the rough positioning of the rollers 35 and 36, i.e. by zero-adjustment of the positioning system 37 (zero adjustment signal 41) with the roller gap being equal to zero and a specific roller-pressure setting so that an increase in the roller gap 42 takes place to the desired distance by a certain number of steps from the zero position. The output signal 34 from the transducer 33 is supplied directly to a hydraulic cylinder 44 via a phase-sensitive rectifier 45, a regulator and amplifier 46 and a servo-valve 47. A rotating disc 48 provided with a gap is placed in the path of the ray emitted from the light source 20 and arranged to pulse the light emitted so that the output signal 34 acquires AC character (which gives high signal-noise ratio).

The light source 20, preferably consisting of a laser-emitter as mentioned previously, and the detector 29 are suitably assembled on a plate 49 suspended in the upper shaft pin 50 as shown in FIG. 7. The transducer 33 will thus follow the movement of the upper shaft pin 50, which is permissible since the arrangement is insensitive to slight parallel displacements and twist with respect to the retro-reflectors 22 and 27. The suspension of the transducer 33 on the shaft pins 50 and 51 also facilitates the directioning of the light ray and sealing about the holes 52 and 53 in the shaft pins 50 and 51. The connection to the lower shaft pin is preferably made vertically displaceable in relation to the plate 49 so as to fit varying shaft distances. The connections 54 and 55 are suitably screwed to the shaft pins 50 and 51, respectively, thus enabling quick fitting and dismantling of the transducer 33 during roller exchange.

Due to the positioning of the retro-reflectors 22 and 26 inside the roller track, said optical transducer 33 has the advantage that it is not disturbed by roller deflection control. On the contrary, it can be used as an aid in such control since it measures the thickness variations in a plane through the retro-reflectors and the strip with very little influence due to roller deformation.

An alternative embodiment of the device according to the invention is illustrated in FIG. 8 where a light source 20, preferably a gas laser, emits a light ray 201 which is divided by a light dividing device 202 into two part light rays 203 and 204, one for each roller. With the help of the reflectors 613, the light rays 203 and 204 are arranged to be reflected in retro-reflectors 601 and 602, respectively and then supplied to detectors 291 and 292, respectively.

The retro-reflectors 601 and 602 are suspended in the rollers mounted on an inner ring of the bearing 631 and kept in a stationary position with respect to the roller by means of a rod 632 fixed to and projecting

from the centre of the retro-reflectors to some stationary point outside each roller. The retro-reflectors are thus set so that the partial light rays 203 and 204 do not cut any edge line inside the retro-reflectors in order to avoid undesired diffraction lines during detection. This special arrangement is further described in the following.

A flat, optically transparent glass plate 64 rotating with the roller is arranged in each roller hole in order to remove centering faults of the retro-reflectors. This centering plate is also described later on.

FIG. 9 shows how errors in parallelity (parallel displacement), η , and errors in angle (direction alteration), ϵ , in the light ray emitted affects the measurement. This special arrangement is described in the following.

As shown in FIG. 9, both the parallelity error η and the angular error ϵ give signals to the detectors 291 and 292, where 2ϵ is the alteration in position of the partial light rays 203 and 204, respectively, reflected from the retro-reflectors 601 and 602 due to the alteration in the roller distance.

The errors η and ϵ are in phase after leaving the detectors and can be reduced by a difference formation with the help of a differential amplifier as shown in FIG. 9a where output signals from the detectors 291 and 292 are supplied to a differential amplifier 293.

An alteration ϵ in roller distance, on the other hand, gives output signals from the detectors 291 and 292 which are in counter phase and are added in the differential amplifier, the output signal of which thus provides a gauge of any alteration in roller distance.

Certain conditions must prevail in order for a reduction in said error sources to be able to take place, i.e. the difference between the number of light ray reflections for each partial light ray must be even, the distance between the part light rays 203 and 204 falling on the retro-reflectors must be slight in relation to the distance between the dividing point of said rays in the ray-dividing device and their point of contact in the retro-reflector.

If this latter stipulation is not fulfilled, the ray division can be performed symmetrically as shown in FIG. 10 where the distance c is equal to the distance d and where the distances e and f between the reflectors 205 and 206 and the retro-reflectors 601 and 602 are equal.

Irrespective of how the ray division is arranged, the position sensitivity in the two "measuring arms" must be equal.

Detecting with two separate position detectors gives the advantage that the position sensitivity in each "measuring arm" can be adjusted electrically so that the latter conditions are fulfilled.

By adjusting amplifications in the "measuring arms" any differences in intensity in the partial light rays are compensated so that the "measuring arms" are completely symmetrical.

Another advantage with the device is that faults due to patchy variations in intensity in a laser beam can be reduced since this type of error develops disturbance signals which are in phase and which are subtracted in the differential amplifier.

As mentioned previously, the distance measurement is performed using two light rays which are oppositely directed and superimposed in order to avoid angular faults in the retro-reflectors.

FIGS. 11a and 11b show the two approaching rays separated. One ray 151 (152) falls on a reflector 111 (112) and a reflected ray 161 (162) is produced parallel to the approaching ray 151 (152).

FIGS. 12 and 12b show the displacement of the rays due to alterations ϵ in position of the retro-reflector 111 (112). The reflected ray 161 (162) is thus displaced the distance 2ϵ in accordance with the principle of a retro-reflector.

FIGS. 13a and 13b show the displacement of the rays due to angular faults of the retro-reflector 111 (112). A parallelity fault δ arises in the reflected ray 161 (162) in this case.

FIG. 14 shows how the previously separated rays are superimposed with the help of the separating devices 241 and 261 arranged so that a ray 210 falling on a separating device 241 is separated into two parallel and equal partial rays 211 and 212 which cover the same distance 220 but in opposite directions in the retro-reflector 22. The approaching partial ray 211 is thus directed oppositely and superimposed on the reflected part ray 214 caused by the partial ray 212 and similarly the approaching ray 212 is directed oppositely and superimposed on the part ray 213 which is a reflection of the partial ray 211. The function of the prism 25 has already been explained.

The reflected part rays 213 and 214 are later combined into a single ray 215 by the separating device 241. FIG. 14 also shows how the separating devices 241 and 261 are applied in the device according to the invention, so that the ray conditions at the retro-reflector 27 are analogous with the conditions at the retro-reflector 22 and where the separating devices 241 and 261 are also intended for the reflections produced by the previously used reflectors (24 and 26).

As can be seen in FIGS. 13a and 13b, the displacements δ of the two rays are equally great and directed opposite to each other, which results in any error signals counteracting each other at the photo detector 29 which was described earlier in connection with FIGS. 5a and 5b. The displacements, 2ϵ , shown in FIGS. 12a and 12b are on the other hand alike and cooperate with each other.

This means that the light ray 210 emitted from the light source 20 is divided into two oppositely directed ray components 211 and 212 with the same intensity. The two components 211 and 212 travel the same path 220 through the retro-reflectors 22 and 27 and obtain the same amount of position error at the photo detector 29. The position errors will be oppositely directed, however, which results in the centre of gravity of the total intensity distribution remaining unchanged. The output signal from the photo detector 29 will therefore also remain unchanged. The useful measuring signal (generated by alterations in the distance between the retro-reflectors) remains unaltered since both the components obtain the same displacement.

An example of a centering device for the retro-reflectors is shown in FIGS. 15 and 16.

FIG. 15 shows how a retro-reflector 60 receives a light ray 61 and reflects this ray (62). The retro-reflector 60 is here provided with a centering error ϵ in relation to the axis of rotation 63 of a roller. A periodic position error 2ϵ thus occurs in the reflected light ray 62. FIG. 16 shows how centering of the retro-reflector 60 can be carried out with the help of an obliquely placed, preferably flat, optically transparent plate 64

of, for example glass. The glass plate 64 is adjusted to a certain angle of inclination β ($=90^\circ - \alpha$) in relation to the axis of rotation 63 of the roller and fixed to the roller in such a way that it rotates together with it. The result is thus a rotating deflection of the two light rays 61 and 62.

If the glass plate is correctly adjusted, the two light rays 61 and 62 will exactly follow the eccentric rotary movement of the retro-reflector 60, which means that the reflected light ray 621 to the right of the glass plate 64 is not affected by centering errors of the retro-reflector 60. The position correction γ of the glass plate 64 which in FIG. 16 is equal to ϵ in each ray 61 and 62, is illustrated as a function of the angle of torsion α of the plate 64 in FIG. 17 for a glass plate having a thickness of 5 mm and a reflection index equal to 1.51.

The correction for each coordinate direction is preferably performed separately.

The glass plate is preferably thin (2 - 5 mm), thus giving high step-up when adjusting the position of the plate (small position correction per degree of twist) and low sensitivity for faulty twisting due to roller deflection during rolling.

The greatest error is obtained at so-called cambering checking of the rollers (forced bending). This error has in one case been calculated to $<2.5 \mu$ with a plate thickness of 5 mm. The error assumes the character of a constant average value alteration (with constant loading of the rollers) and will therefore be possible to correct with the help of the absolute-measuring X-ray transducer on the output side of the rolling mill.

The rotating deflection movement mentioned above can also be achieved with other optical components than a flat plate, for example with two wedge-shaped plates, two lenses or mirrors.

FIGS. 18, 19, 20a and 20b give examples of how edge line disturbances of retro-reflectors can be avoided.

FIG. 18 shows a device according to the invention comprising two rotating rhomboid prisms 611 and 612 and a stationary penta prism 613. The prisms 611 and 612 are mechanically connected to the roller so that the rotation occurs synchronously with the rotation of the retro-reflectors 600. The position of an axis of rotation is marked by means of an arrow indicated by R in the drawings. The prism 611 produces a rotating movement in the ray 614 approaching the retro-reflector 600. The movement is transmitted in the retro-reflector 600 to the reflecting ray 615 and ceases in the prism 612. The ray 616 after leaving prism 612 is thus stationary. The penta prism 613 is used for 90° deflection of the light rays 616 towards the position detector 29. Since the retro-reflector 600 is rotation symmetrical in its function, the transducer will function as before in spite of the fact that the light rays are rotating.

FIG. 19 shows a variation of the device in FIG. 1 where the stationary pentaprism 613 has been replaced by a rhomboid prism 611 with a rotating mirror surface 617, preferably included in a ray-separating optical instrument 618. In this case a similar ray-separating optical instrument 619 is placed before the source 20 according to the Figure.

The example shown in FIG. 19 of the device gives a simpler mechanical construction than that of FIG. 18 but with a more advanced optical arrangement.

FIG. 20a shows how the retro-reflector 600 can be suspended in the roller 52. The retro-reflector 600 is in this case mounted on an inner ring in the bearing 631

and held in stationary position by means of a rod 632, for example, attached to and projecting from the centre of the retro-reflector to some stationary point outside the roller 52. The position of the retro-reflector 600 is thus set so that the light rays 633 and 634 do not cut any edge line in it, perhaps in accordance with what is shown in the section A—A from FIG. 20a and FIG. 20b where an approaching ray 635 and a reflected ray 636 are arranged to meet the retro-reflector 600 on the reflecting surfaces so that the edge lines 637 are avoided. The bearing 631 is then applied with its outer ring in an attachment device 638 fixed to the roller 52 in the roller hole.

If the device for measuring the roller distance includes members for eliminating centering faults, in the form of a flat, optically transparent plate 64 of glass, for example, the plate can be provided with a hole for the rod 632 mentioned above, as shown in FIG. 20a.

An important advantage in having retro-reflectors suspended in bearings in the device for measuring the roller distance is that the quality requirement on the retro-reflector can be lowered so that standard types with ordinary parallelity errors between approaching and reflected rays.

We claim:

1. Means for determining the distance between two measuring points, which comprises an optical transducer, said transducer comprising an optical measuring arm arranged at each measuring point, a light reflector arranged at each measuring point, a light emitter for the optical measuring arms, arranged to send out light rays directed towards the light reflectors in the measuring points, and a detector arranged to receive light rays reflected from the light reflectors and including means responsive to the displacement to which these reflected light rays have been subjected by an alteration in the distance between the measuring points, the light reflectors comprising retro-reflectors having means to reflect light rays from these parallel to light rays falling upon them.

2. Means according to claim 1, in which the light emitter consists essentially of a gas laser.

3. Means according to claim 1, including a pulsing device arranged in the path of the ray emitted from the light emitter, said pulsing device including means to separate the light ray into light pulses.

4. Means according to claim 1, in which said optical transducer comprises separating devices arranged in the paths of the light rays falling on and reflected by each retro-reflector, said separating devices separating the light ray falling on each reflector into two parallel and equal partial light rays which in opposite directions cover the same path in said reflector and said separating devices further include means to combine the partial light rays reflected from the reflector to form a single reflected light ray which is not affected by angular faults in the reflector.

5. Means for determining the distance between two measuring points, which comprises an optical transducer, said transducer comprising an optical measuring arm arranged at each measuring point, a light reflector arranged at each measuring point, a light emitter for the optical measuring arms, arranged to send out light rays directed towards the light reflectors in the measuring points, and a detector arranged to receive light rays reflected from the light reflectors and including means responsive to the displacement to which these reflected

light rays have been subjected by an alteration in the distance between the measuring points, the optical measuring arms being parallel.

6. Means for determining the distance between two measuring points, which comprises an optical transducer, said transducer comprising an optical measuring arm arranged at each measuring point, a light reflector arranged at each measuring point, a light emitter for the optical measuring arms, arranged to send out light rays directed towards the light reflectors in the measuring points, and a detector arranged to receive light rays reflected from the light reflectors and including means responsive to the displacement to which these reflected light rays have been subjected by an alteration in the distance between the measuring points, the optical transducer comprising devices arranged to separate light rays emitted from the light emitter into partial light rays, one for each optical measuring arm.

7. Means for determining the distance between two measuring points, which comprises an optical transducer, said transducer comprising an optical measuring arm arranged at each measuring point, a light reflector arranged at each measuring point, a light emitter for the optical measuring arms, arranged to send out light rays directed towards the light reflectors in the measuring points, and a detector arranged to receive light rays reflected from the light reflectors and including means responsive to the displacement to which these reflected light rays have been subjected by an alteration in the distance between the measuring points, the detector comprising a detecting unit for each measuring arm and comparison devices connected to these units, the output signals of the comparison devices constituting a gauge of the alteration in distance between two measuring points.

8. Means for determining the distance between two measuring points, which comprises an optical transducer, said transducer comprising an optical measuring arm arranged at each measuring point, a light reflector arranged at each measuring point, a light emitter for the optical measuring arms, arranged to send out light rays directed towards the light reflectors in the measuring points, and a detector arranged to receive light rays reflected from the light reflectors and including means responsive to the displacement to which these reflected light rays have been subjected by an alteration in the distance between the measuring points, the optical transducer comprising means operable, when the light ray directed from the light emitter falls upon a first measuring arm and the reflected light ray from the first measuring arm falls on a second measuring arm, the reflected light ray from the second measuring arm being supplied to the detector, to reflect the light ray sent out an odd number of times before it is supplied to the detector.

9. In combination with a pair of rollers, means for determining roller distances, which comprises an optical transducer, said transducer comprising an optical measuring arm arranged at each measuring point, a light reflector arranged at each measuring point, a light emitter for the optical measuring arms, arranged to send out light rays directed towards the light reflectors in the measuring points, and a detector arranged to receive light rays reflected from the light reflectors and including means responsive to the displacement to which these reflected light rays have been subjected by an alteration in the distance between the measuring points,

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in which each roller in the pair includes an optical measuring arm, said measuring arm being arranged in an axial hole arranged in the roller, each light reflector being arranged in one of said rollers centrally therein with respect to the roller surface.

10. In a device according to claim 1, in which said light reflectors each comprises a retro-reflector arranged centrally with respect to the roller surface, in an axial hole in each roller, light rays falling on the retro-reflector through said axial hole being reflected back through said hole parallel to the approaching light rays.

11. In a device according to claim 9, including a ray separator for separating the light rays from the light emitter into two partial light rays, each of which constitutes the light ray associated with one of the rollers.

12. In a device according to claim 9, the detector including means to detect the vertical displacement the light rays reflected from the light reflectors have been subjected to due to alterations in the distance between the rollers.

13. In a device according to claim 12, in which the light reflectors comprise a first retro-reflector arranged in a first roller of a pair and a second retro-reflector in the second roller of a pair, a first reflector for reflecting the light ray from first retro-reflector arranged outside said first roller, a second reflector in the path of the light ray reflected from said first reflector arranged out-

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side a second roller in said pair, the light ray reflected from said second reflector impinging on said second retro-reflector, and a detector in the path of the light ray reflected from said second retro-reflector arranged outside said second roller.

14. In a device according to claim 13, an optical member arranged in the path of the light ray between said light emitter and the detector for producing a further reflection of the light ray emitted so that the total number of reflections of the light ray is odd.

15. In a device according to claim 9, the optical transducer comprising centering means arranged in the hollow of each of the rollers in the paths of the light rays falling on or reflected by a retro-reflector, means attaching said centering means to the respective rollers in such a way that the approaching and reflected light rays will follow the eccentric rotary movement of the retro-reflector so that a light ray reflected from the retro-reflector which has passed the centering means is not affected by errors in centering of the retro-reflector with respect to the axis of rotation of the roller.

16. In a device according to claim 15, each of the centering device comprising an optically transparent plate placed obliquely with respect to the axis of rotation of a roller.

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