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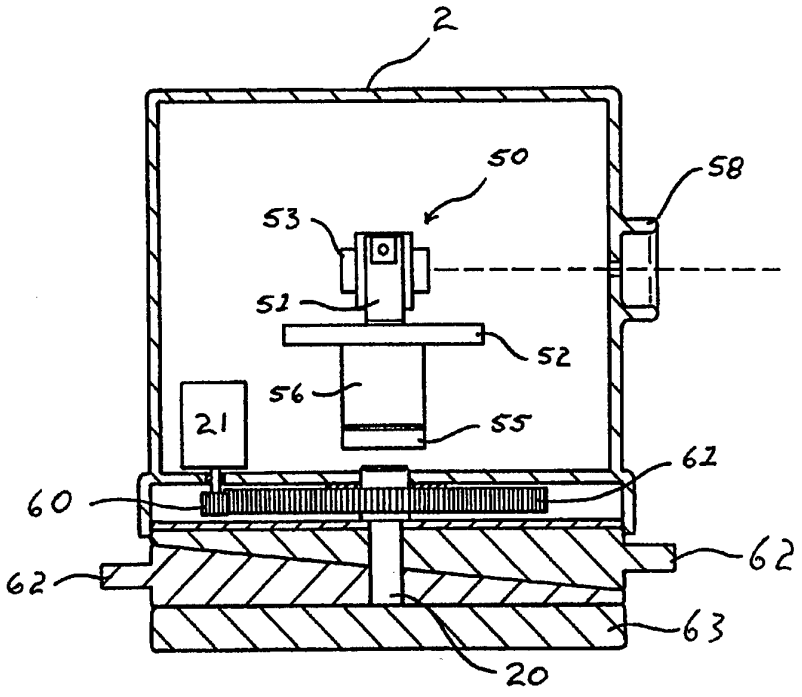
(54) Title: REMOTELY OPERATED LEVELLING DEVICE

(57) Abstract

A remotely operated device by which a single user can perform measurement or levelling tasks comprises an automatically levelling laser beam emitting unit (53) that can be remotely manoeuvred. The laser unit (53) is mounted in a body (50) which is mounted on a rotating base (53). A remote control means transmits signals to a manoeuvring means (21, 60, 61, 62) that controls the rotation of the base (52). A user sets up the device in a central location and moves to a location which must be measured. Using the remote control the laser beam is manoeuvred until directed towards the user and various measurements of height and direction can be made.



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TITLE

REMOTELY OPERATED LEVELLING DEVICE

This invention relates to surveying and building equipment and in particular to remotely operated devices which permit most surveying, building or construction tasks to be performed by a single person.

FIELD OF THE INVENTION

There is a need to obtain comparative height, distance and level information in most building and construction tasks. A number of optical tools exist to perform the required functions. Theodolites are used to measure horizontal or vertical angles and dumpys are used for obtaining an automatic level. Microwave and laser based devices are available for measuring distance.

Since about the early 1970's laser-based levelling tools have been available which provide an infrared or visible reference. The laser levelling tools have increased in sophistication and found broader application in recent years.

One early laser level and squaring tool was disclosed in United States patent number 3897637. This device utilised a helium-neon laser which projected a vertical and horizontal beam. The device needed to be manually levelled.

A later patent, United States patent number 4221483, discloses a laser levelling device which provides for automatic levelling of a vertical beam within a small range of tilt. This is achieved by mounting a collimating lens on a pendulum so that the beam remains vertical as long as the tilt of the instrument is within the range of the pendulum.

A compact device for establishing a precise level, a plumb line or an alignment line is described in United States patent number 4912851 assigned to Spectra-Physics Inc. This device is based upon a laser diode and

includes tilt compensation which allows the device to be used on surfaces up to 5° off level.

The primary advantage of the above mentioned devices is that they project a collimated, visible beam which can be used for alignment. Many provide automatic levelling.

Most of the prior art devices known to the inventor require two person operation to perform surveying tasks in building and construction. One exception is a rotating laser which has a rotating laser head which sweeps a laser beam in a horizontal plane. The device is used in conjunction with a receiver that indicates the direction the receiver needs to move to be centred on the beam. The device is typically used with earth moving equipment to grade or check a level site, by concreters when laying a floor or foundation and by other tradesmen for a variety of applications requiring level.

To lay out a building site, whether using a conventional theodolite, dumpy level requires one person at the device and another person to move around the site with a staff. With a theodolite or automatic (dumpy) level the person at the device focuses on the staff and reads off the height, thus building up a profile of the site by repeated measurement.

Distance measurement also requires two person operation whether using conventional measuring means or modern electronic devices.

A single person can profile a site but repeated movement between the measurement device and the staff is required. This is time consuming and distracting. A remotely operated device that can be operated by a single person is desirable.

BACKGROUND OF THE INVENTION

One object of the present invention is to provide a remotely operated device which can be used by a single person to perform many surveying, building or construction tasks.

Another object of the invention is to offer the public a useful alternative to existing levelling and measuring equipment.

SUMMARY OF THE INVENTION

In one form, although not necessarily the only or indeed the broadest form, the invention resides in a remotely operated device for performing measurement or levelling tasks comprising:

measurement means adapted to measure one or more of distance, direction, height or angle;

manoeuvring means associated with said measuring means and including receiving means responsive to signals from a remote control means;

wherein a user can remotely manoeuvre the measurement means to be directed at a desired location thereby facilitating single user performance of measurement or levelling tasks.

In preference the measurement means may be a conventional dumpy level, theodolite, laser level, range finder (microwave or infrared) or similar measuring device used in the building, construction or surveying industries.

The receiving means is preferably an optical, ultrasonic or infrared receiver/decoder and the remote control means preferably comprises an optical, ultrasonic, microwave or infrared transmitting means and coding means. The transmitting means transmits a coded signal to the receding means which receives and decodes the signal. The manoeuvring means responds to the decoded signal to appropriately position the measurement means.

In an alternative arrangement the remote control means and manoeuvring means comprise an automatic tracking means in which the remote control means is associated with a staff and sends signals which are tracked by the receiving means of the manoeuvring means. In this arrangement the user simply moves around a site with the staff and the measurement means automatically follows and remains directed at the staff.

The automatic tracking means may also comprise a reflector on the staff with transmitting and receiving means associated with the manoeuvring

means.

It will be appreciated that an advantage of the invention is that the manoeuvring means could be fitted as an accessory to existing measurement devices.

In a further form, although again not necessarily the only or indeed the broadest form, the invention resides in a remotely operated levelling device comprising:

a light beam emitting means adapted to emit a beam of collimated light;

said light beam emitting means being mounted on a rotatable base;

wherein the rotatable base rotates in response to signals received from a remote control unit.

In preference the light beam emitting means is a laser diode which may include a collimating lens. In the simplest form the light beam emitting means may be a vial laser level comprising a laser diode aligned to a vial such as contained in a conventional bubble level.

In preference the invention further comprises an optical arrangement adapted to automatically maintain the beam in a horizontal plane. The laser levelling device may further comprise a penta prism adapted to optionally deflect the beam, or a part of the beam, through 90 degrees to produce a vertical and horizontal beam or two orthogonal horizontal beams.

The optical arrangement preferably comprises a pendulous mirror adapted to reflect the laser beam to a deflecting mirror which deflects the beam through an exit port of the device. The pendulous mirror is preferably damped by magnetic damping means or air damping means.

There is preferably a focussing means at the exit port adapted to focus the beam to a spot at varying distances from the device. The focussing means is preferably controllable by the remote control means.

A person can survey a site by locating the device at the centre of the site and moving around the site with a staff and the remote control unit. The person uses the remote control unit to rotate the laser beam until it is detected on the staff. The beam may then be focussed (if required) using the

remote control to provide a small visible mark such as a spot or line on the staff from which a measurement can be read. (For distances up to about 30 metres no focussing of the laser beam is required, beyond this distance the divergence of the beam is such that focussing may be required to maintain accuracy.)

Alternatively, an electronic indicator may be employed to detect the laser beam and provide a digital readout of its location. The electronic indicator may be configured to give an indication (such as left/right/up/down LED's) of the direction of the laser beam away from centre. Electronic indicators of the type described are commercially available and will be known to persons skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

To further assist in understanding the invention reference will be made to the following drawings in which:

FIG 1 shows a schematic of a first embodiment of a laser levelling device;

FIG 2 shows a remote control for use with the laser levelling device;

FIG 3 depicts the use of the laser levelling device by a single person;

FIG 4 shows a schematic of a second embodiment of a laser levelling device;

FIG 5 shows an isometric view of a portion of the device of FIG 4;

FIG 6 shows a third embodiment of a portion of a laser levelling device; and

FIG 7 shows a schematic block circuit diagram for the remote control of the laser levelling device of any of the embodiments.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in detail there is shown in FIG 1 a laser levelling device generally indicated as 1. The device comprises a body 2 housing, a laser diode 3 and an optical arrangement. The laser diode is a visible laser diode operating at around 635 nm (red). The power supply for the laser diode is DC and may be an appropriate number of batteries. Alternatively the DC power supply can be separately contained and connected to the laser levelling device by a power cable.

The optical arrangement comprises a pendulous mirror 4 mounted on a platform 5 suspended within the body by thin flexible wires 6. The thin wires allow the platform to swing freely so as to adopt a horizontal position even when the body 2 is not perfectly level. The pendulum arrangement will permit displacements of the body of up to one degree from horizontal.

A laser beam 7 emitted from the laser diode 3 is reflected by the pendulous mirror 4 to a deflecting mirror 8 which directs the beam through an exit port 9. The pendulous mirror 4 and deflecting mirror 8 together form the optical arrangement.

Damping magnet 13 acts on platform 5 (which is made of ferromagnetic material) with an attractive magnetic force thereby providing a damping force to minimise the time necessary for the mirror to come to rest. Magnetic damping of the pendulum's kinetic energy is conventionally employed in theodolites, dumpys and the like.

An alternative form of damping which would be known to those skilled in the art is air. Air damping employs a piston and cylinder arrangement to trap a small amount of air which is allowed to leak slowly from the cylinder. One half of the arrangement is attached to a fixed base and the other to the platform to be damped. The trapped air acts to limit the movement of the platform at the extremities of its motion. Although the figures only depict magnetic damping means it will be clear to those skilled in the art that air damping or other damping techniques could also be employed.

The optical arrangement of the preferred embodiment is quite

simple. A more complex optical arrangement can be employed for greater precision. An optical arrangement from a conventional dumpy level can be used but with the eye-piece optic being replaced by a laser diode. A conventional dumpy level has an optical arrangement which automatically aligns the view of an operator to the horizontal when the dumpy is coarse aligned to within about 20 minutes of arc of level. A collimated beam from a laser diode directed into the eye-piece of the dumpy will be emitted horizontal under the same conditions.

A telescope 10 is coupled to the exit port 9 of the body 2. The telescope comprises a fixed lens 11 and an adjustable lens 12. The position of the lens 12 relative to the fixed lens 11 is adjustable to change the focal length of the beam emitted from the exit port 9. The lens 12 is coupled to an adjustment means (not shown) which adjusts the position of the lens in response to signals received from a remote control 30. The adjustment means may be conventional pulley system or a rack and pinion arrangement.

The body 2 is mounted on a tilt base comprising a fixed plate 15 and a floating plate 16. The floating plate 16 is held to the fixed plate 15 by a torsion bar 17. The angle of the floating plate 16 relative to the fixed plate 15 is adjusted by threaded adjusting screws 18. A centre bubble is provided on the floating plate to allow coarse levelling of the device to within the range of the automatic levelling provided by the optical arrangement.

The body 2 is free to rotate on axle 20 under the impulse of motor 21 coupled to a wheel 22 which runs against the body 2. To maintain stability of the body 2 a bearing track 23 is provided between the body 2 and the floating plate 16.

The motor 21 is preferably a DC stepping motor. As with the laser diode 3 the power supply for the motor 21 are batteries located in a battery pack close to the motor. Alternatively, the DC power supply may be located separately and connected to the motor by a power cable. The operation of the motor is controlled by the remote control unit 30.

A remote control unit 30 is shown in FIG 2. The unit transmits a coded signal which is decoded by receivers on the motor 21 and telescope 10.

In a simple form the remote control unit has four buttons. The left and right buttons 31 control the rotation of the levelling device. The in and out buttons 32 control the focus of the telescope 10. An on/off control (not shown) may also be included.

FIG 3 depicts a method of operation of the invention to allow a single person to survey a building site. The person 40 holds the staff 41 at a location to be measured. The remote control unit 30 is used to instruct the laser levelling device 1 to rotate until the laser beam strikes the staff. The laser beam, if necessary, is then focussed onto the staff, again by using the remote control unit. A record is made of the reading on the staff and the process is repeated in a new position.

The method of operation depicted in FIG 3 implies a visible laser beam but this is not essential. Various techniques are known to enhance detection of the laser beam. A receiver that gives an audible read-out may be adjustably located on the staff to assist in determining the position of the laser beam. A more sophisticated indication may be provided by a digitial read-out which can also be configured to give an off-centre reading to assist in correctly locating the staff.

The arrangement of FIG 3 can be extended to provide a tracking mode of operation. In tracking mode the laser levelling device automatically follows the staff as it is moved by the user. This requires that the receiver on the staff translate positional information into signals which are received by the laser levelling device to control the motor 21 to rotate the device in response to the offset of the beam from the centre of the receiver on the staff. Feedback and control circuits suitable for achieving this aim are well known to persons skilled in the art of electronics.

The preferred embodiment has been described in terms of a dumpy level type device incorporating an optical arrangement providing automatic levelling. It will be appreciated that the invention is not limited to this specific arrangement. The remote control unit could be used in association with any device for the measurement of distance, direction or angle. In the specific embodiment the provision of automatic levelling is for convenience and not

essential to the operation of the invention.

FIG 4 shows an alternative embodiment of a laser levelling device. A detailed schmetic of the mechanical arrangement for the provision of a level laser beam is shown in FIG 5. In this embodiment the laser levelling device comprises a laser housing assembly generally depicted as 50, including a pair of supports 51 attached to a base 52. The laser unit 53 is mounted on a pair of low friction half axles 54 which are in turn mounted in the supports 51. A pendulous weight 55 extends below the laser unit 53 such that when the pendulum 55 is stationary at the bottom of its arc the laser beam emitted by the laser unit 53 will be horizontal. The pendulum, 55 is made of ferromagnetic material and there are a pair of damping magnets 56 to damp the swing of the pendulum 55. (As mentioned previously, air damping or other damping means may alternatively be employed.)

The laser beam emits from the laser levelling device through exit window 58. FIG 4 shows a simple exit window but the focussing arrangement of FIG 1 could be simply incorporated.

FIG 4 also shows an alternative arrangement for the tilt base and motor drive arrangements. The laser levelling device is free to rotate on axis 20. Motor 21 is mounted within the body 2 and coupled to the axis 20 by drive cog 60 and main cog 61. Tilt is accomplished by rotatable bevel units 62. Rotation of the bevel units 62 relative to the base 63 causes the body 2 to tilt around an axis coincident with the rotation axis 20.

Power is supplied to the laser unit 53 through supports 51 and axles 54. The power leads connecting to the supports 51 are omitted for clarity. It will be appreciated that provision of power in this way ensures that the swinging of the laser unit 53 and pendulum 55 is unimpeded. The base 52 and body of the laser unit 53 are made from electrically insulating material.

It will be noted that a major advantage of the arrangement of the second embodiment is that no additional optical elements are required other than a collimating lens which can be incorporated into the laser unit.

A third embodiment for providing a level laser beam is shown schematically in FIG 6. The third embodiment uses active positioning of the

laser unit 73 whereas the positioning of the laser unit in the first and second embodiments was passive.

In FIG 6 a laser unit 73 is pivotally mounted in a frame 74 attached to a base 75. The base may be attached to either of the course tilt adjustments previously described or any similar arrangement providing course tilt adjustment. An electrolytic potentiometer 76 is mounted in the frame. The potentiometer 76 comprises a vial filled with an electrolyte but leaving an air bubble. A common electrode 77 connects to the centre bottom of the vial and two upper electrodes 78 and 79 are connected to the top of the vial near the edges of the air bubble. As the frame 74 moves from level one electrode, say 78, is covered by the electrolyte and the circuit resistance to the common electrode lowers. Conversely, the other electrode 79 emerges from the electrolyte and the circuit resistance increases. The imbalance between the resistance of each circuit is used to drive a DC stepping motor 80 which adjusts a pivot arm 81 via worm drive 82 to change the angle of the laser unit 73 relative to the frame 74 thereby maintaining the laser beam level.

It will be appreciated that this embodiment can easily be adapted for the setting of a grade. The angle of the electrolytic potentiometer 76 may be adjusted relative to the frame 74 such that when the potentiometer is level the laser unit 73 directs the laser beam at a chosen angle. Alternatively, a grade could be set by simply locking out the compensation system and tilting the frame at an angle according to graduations provided on the vial.

The coded signal of the remote control unit 30 may be optical, radio frequency, ultrasonic or microwave signal. In one embodiment the signal will be an infrared signal and the remote control unit will operate in a manner analogous to the remote control unit of a television or video unit. The block schematic diagram of FIG 7 depicts an alternative arrangement based upon a radio frequency signal.

The block circuit of FIG 7 is for a simplified remote control having only ON/OFF and rotation features. The transmitter comprises an encoder that is activated by push buttons controlling the ON/OFF, clockwise and counterclockwise functions. The encoder passes a signal to an UHF oscillator

for transmission through the antenna. A UHF receiver at the laser levelling device receives the signals which are decoded by a decoder. The decoded signals are passed to a motor driver unit which controls a stepper motor to rotate the laser levelling device clockwise or counterclockwise.

The operation of the remote control can be extended to perform other functions, such as turning the laser on and off, focussing the telescope, tilting the beam or obtaining distance and angles.

Throughout the description of the preferred embodiment the purpose has been to describe the invention and not to limit to any one form. Persons skilled in the art will be able to envisage variations on the embodiment described without departing from the spirit of the invention.

CLAIMS

1. A remotely operated device for performing measurement or levelling tasks comprising;

measurement means adapted to measure one or more of distance, direction, height or angle;

manoeuvring means associated with said measuring means and including receiving means responsive to signals from a remote control means;

wherein a user can remotely manoeuvre the measurement means, with the remote control means, to be directed at a desired location thereby facilitating single user performance of measurement or levelling tasks.

2. The device of claim 1 wherein the measurement means is a dumpy level, theodolite, range finder or other similar measuring device used in the building, construction or surveying industries.

3. The device of claim 1 wherein the measurement means is a laser levelling device;

4. The device of claim 3 wherein the laser levelling device comprises a laser diode emitting optical radiation in a beam, said beam being directed to an optical arrangement comprising a damped pendulous mirror mounted on a platform suspended by thin flexible wires, and a deflecting mirror positioned to direct the beam horizontally.

5. The device of claim 3 wherein the laser levelling device comprises a laser unit mounted within a support structure allowing rotation of the laser unit about a horizontal axis, there being a ferromagnetic pendulous weight extending below the laser unit such that when the pendulous weight is in it's rest position a beam emitted from the laser unit will be horizontal, the device further comprising magnetic dampers disposed adjacent the ferromagnetic pendulous weight.

6. The device of claim 3 wherein the laser levelling device comprises a laser unit pivotally mounted in a frame and an electrolytic potentiometer mounted in the frame wherein the signal from the potentiometer controls a motor to adjust the angle of the laser unit relative to the horizontal.

7. The device of claim 1 wherein the receiving means is an optical, ultrasonic, microwave or radio frequency receiver/decoder and the remote control means comprises an optical, ultrasonic, microwave or radio frequency transmitting means and coding means.

8. The device of claim 1 wherein the user locates a staff at the desired location and the measurement means is directed at the staff by the user operating the remote control means.

9. The device of claim 8 wherein the staff includes electronic indicator means adapted to provide a visible and/audible indication to assist the user to direct the measurement means to be centred on the staff.

10. A remotely operated device for performing measurement or levelling tasks comprising:

measurement means adapted to measure one or more of distance, direction, height or angle;

manoeuvring means associated with said measuring means and including receiving means responsive to signals from a remote control means;

wherein the remote control means and manoeuvring means comprise an automatic tracking means in which the remote control means is associated with a staff and transmits signals which are tracked by the receiving means of the manoeuvring means such that the measuring means remains directed at the staff as a user moves the staff from one desired location to another.

11. A remotely operated device for performing measurement or levelling tasks comprising:

measuring means adapted to measure one or more of distance, direction, height or angle;

manoeuvring means associated with said measuring means and including receiving means responsive to signals from a remote control means;

wherein the remote control means and manoeuvring means are located with the measurement means and comprise an automatic tracking means and there is a reflector on a staff wherein signals transmitted from the remote control means are reflected by the reflector and received by the

manoeuvring means such that the laser levelling means tracks the staff as a user moves the staff from one desired location to another.

12. A remotely operated laser levelling device comprising:

a light beam emitting means adapted to emit a beam of collimated visible light;

said light beam emitting means being mounted on a rotatable base;

wherein the rotatable base rotates in response to signals received from a remote control unit.

13. The device of claim 12 wherein the light beam emitting means is a laser diode incorporating a collimating lens.

14. The device of claim 12 wherein the light beam emitting means is a vial laser level comprising a laser diode aligned to a vial such as contained in a conventional bubble level.

15. The device of claim 12 wherein the laser levelling device comprises a laser diode emitting optical radiation in a beam, said beam being directed to an optical arrangement comprising a damped pendulous mirror mounted on a platform suspended by thin flexible wires, and a deflecting mirror positioned to direct the beam horizontally.

16. The device of claim 12 wherein the laser levelling device comprises a laser unit mounted within a support structure allowing rotation of the laser unit about a horizontal axis, there being a ferromagnetic pendulous weight extending below the laser unit such that when the pendulous weight is in it's rest position a beam emitted from the laser unit will be horizontal, the device further comprising magnetic dampers disposed adjacent the ferromagnetic pendulous weight.

17. The device of claim 12 wherein the laser levelling device comprises a laser unit pivotally mounted in a frame and an electrolytic potentiometer mounted in the frame wherein the signal from the potentiometer controls a motor to adjust the angle of the laser unit relative to the horizontal.

18. The device of claim 12 further comprising a penta prism adapted to optionally deflect the beam, or a part of the beam, through 90 degrees to produce two orthogonal beams.

19. The device of claim 12 further including a focussing means adapted to focus the beam to a spot at a varying distance from the device, said focussing, means being controllable by the remote control means.

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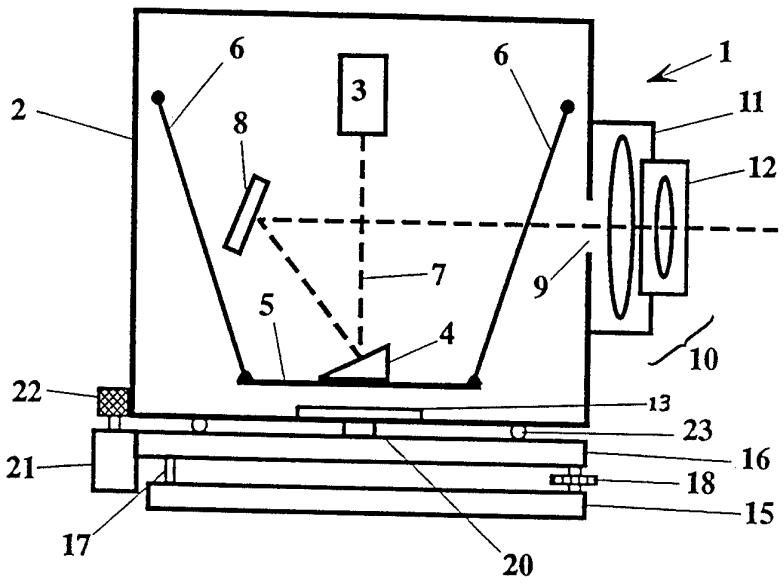

FIG 1

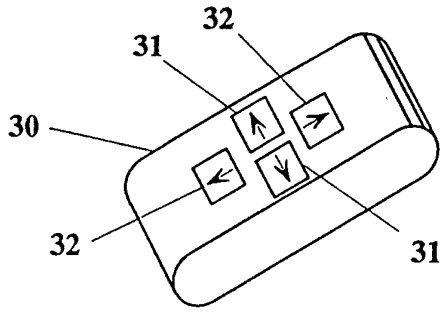

FIG 2

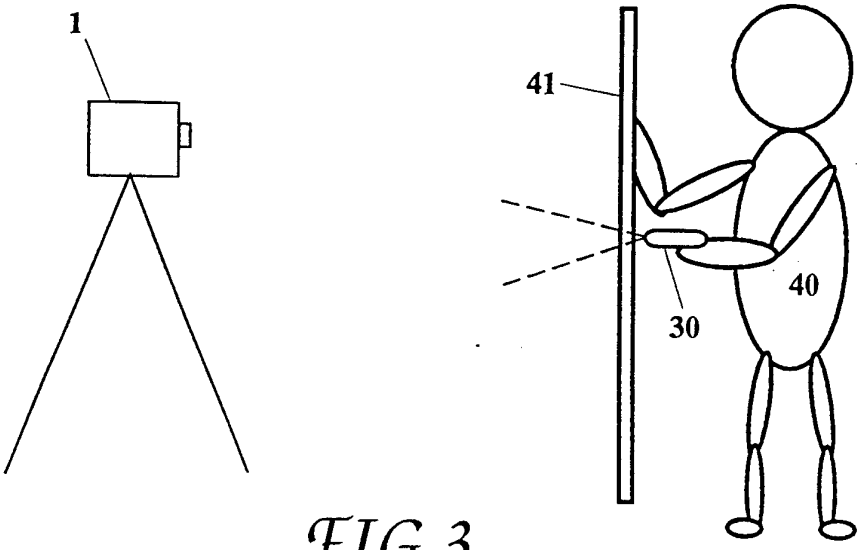

FIG 3

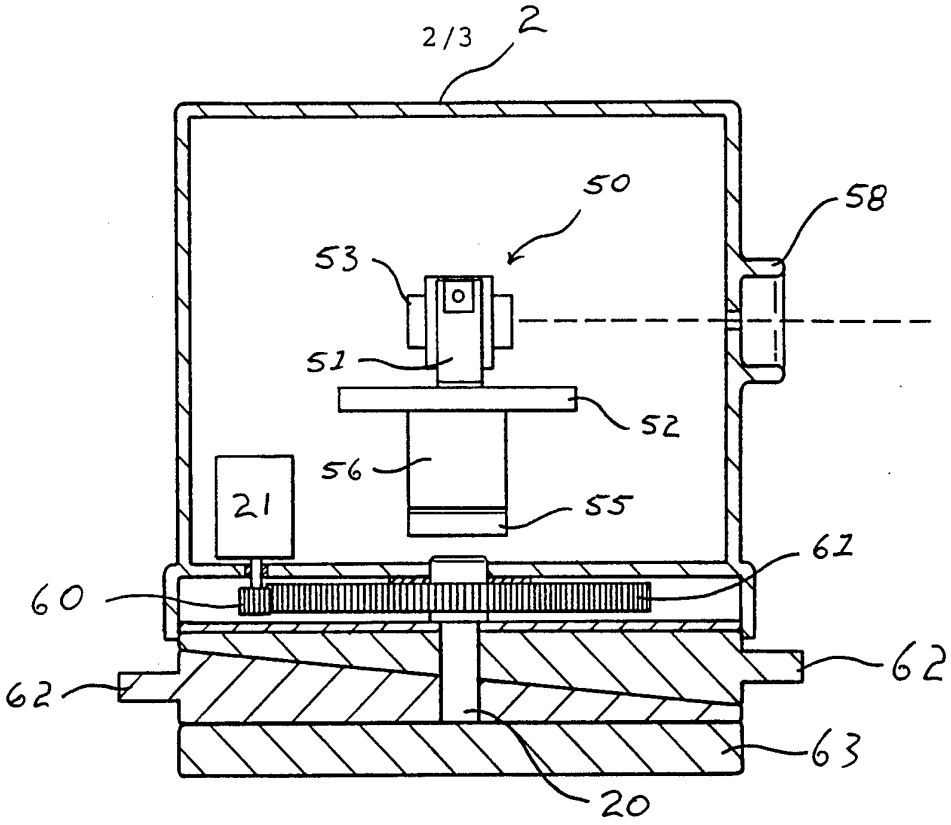

FIG 4

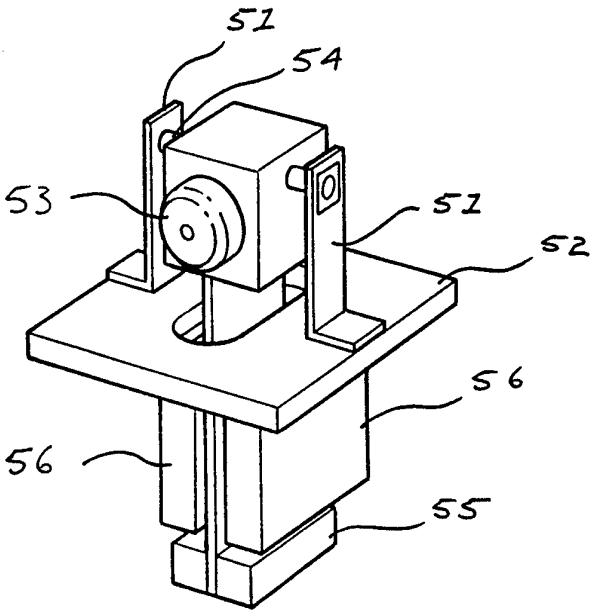

FIG 5

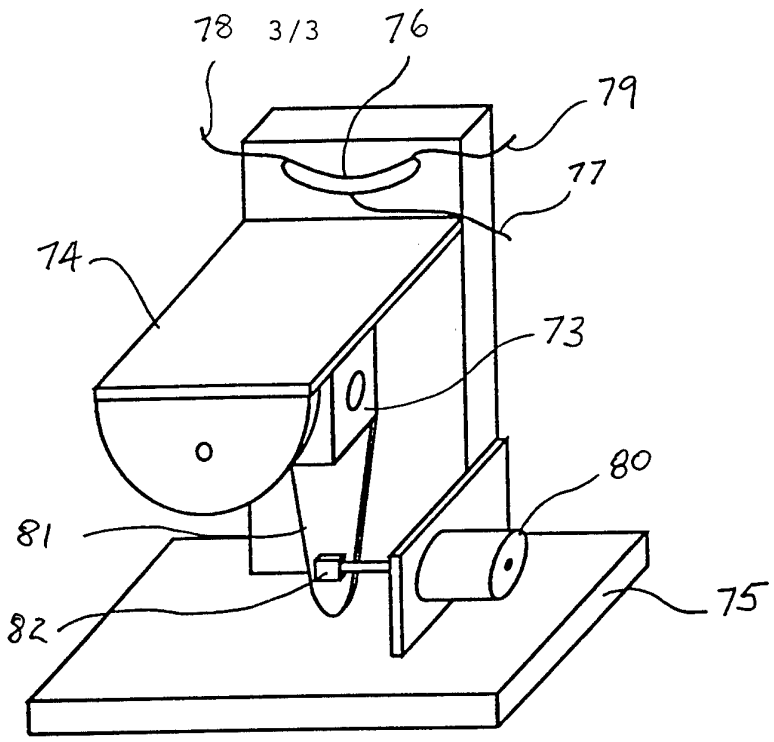
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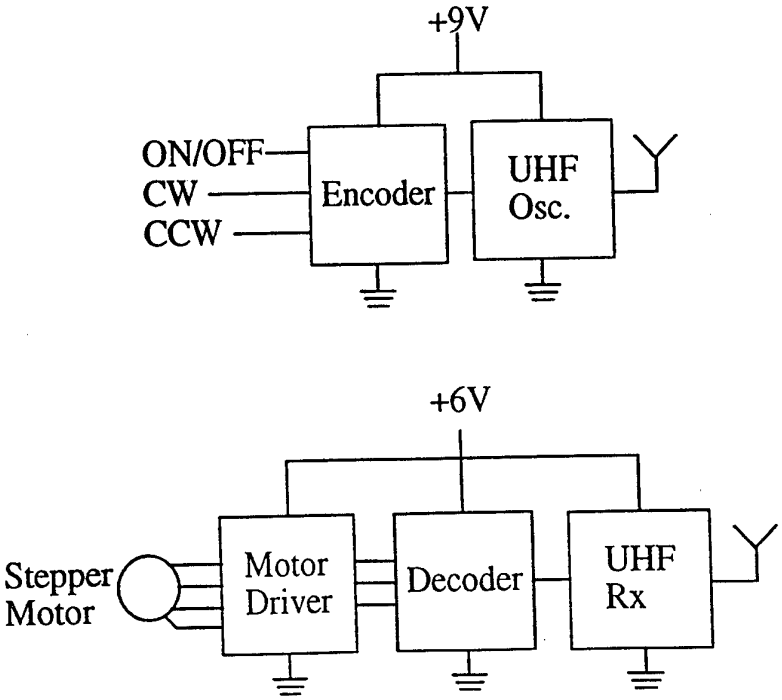
FIG 6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ON/OFF
CW
CCW
Encoder
UHF
Osc.
+6V
Stepper
Motor
Motor
Driver
Decoder
UHF
Rx

FIG 7

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 95/00411

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: G01C 1/00, 3/00, 5/00, 9/00, 15/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC G01C 1/00, 3/00, 5/00, 9/00, 15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Derwent: remote:
Japio: remote:

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO, 91/19165 A (PARKERVISION) 12 December 1991 see whole document	1,7
X	WO, 92/20998 A (LASER LEVEL SWEDEN) 26 November 1992 see whole document	1, 2, 3, 7, 12, 13, 14, 18
X	EP 0051913 A (DELKE) 19 May 1982	1, 2, 3, 7, 8, 9, 12

☐ Further documents are listed in the continuation of Box C

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Date of the actual completion of the international search	Date of mailing of the international search report
20 October 1995	26 OCTOBER 1995

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INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 95/00411

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4907879 A (WEBB) 13 March 1990	1, 2, 3, 7, 8, 9, 12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.
PCT/AU 95/00411

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	9119165 A	AU	81909/91	CA	2084201 A	EP	532694 A
		US	5268734 A	US	5432597 A		
WO	9220998 A	AU	17801/92	SE	9101525		
EP	51913 A	JP	57080515	US	4413907		

END OF ANNEX