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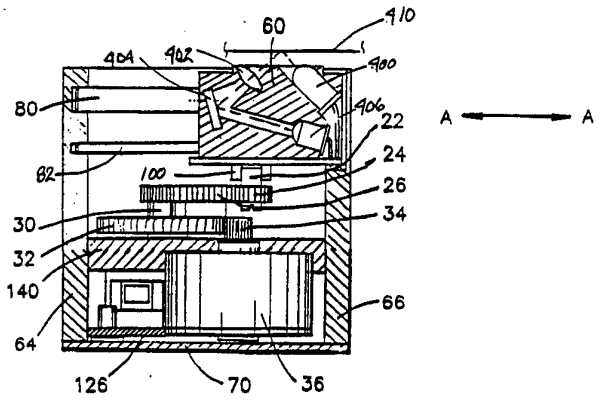

(57) Abstract

In a preferred embodiment, a bar code scanner for reading a bar code on a flat surface of an article (410), comprising: a first light source (400) disposed so as to illuminate the bar code; a second light source (420) disposed so as to illuminate the bar code; photodetector apparatus disposed so as to detect light from the first and second light sources reflected from the bar code; and motive apparatus to cause relative motion (A--A) between the bar code and the first and second light sources and the photodetector apparatus so that the photodetector apparatus can read the bar code, such that the focal length(s) between the photodetector apparatus and the bar code remain(s) constant. In a first alternative embodiment, the photodetector apparatus includes first (406) and second (426) photodetectors. In a second alternative embodiment, there is provided a bar code scanner of generally the foregoing construction, except that a beam splitter (504) is employed to precisely direct light from the first (500) and second (502) light sources at the bar code and a single photodetector (516) is employed to detect light reflected from both light sources. Discriminator slits (460, 462, 514) are provided in front of the photodetectors in both embodiments.

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Description

Bar Code Scanner with Dual Light Sources

Technical Field

The present invention relates to the reading of bar codes generally and, more particularly, to novel apparatus for reading bar codes, particularly those having variable print/contrast ratios, such as are encountered, for example, on silicon wafers during both the manufacture of the wafers and the manufacture of the integrated circuits on the wafers, during the production of heat treated parts such as turbine blades, during the manufacture of nuclear rods, and during the manufacture of compact disks.

Background Art

Conventional means for reading bar codes are generally unsatisfactory for reading bar codes which have variable print/contrast ratios. Such bar codes are encountered, for example, on silicon wafers during both the manufacture of the wafers and the manufacture of the integrated circuits on the wafers, on heat treated parts such as turbine blades during their production, on nuclear rods during their manufacture, and on compact disks during their manufacture. The problem with reading such bar codes is that the print/contrast ratios and reflectivity of the bar codes can change greatly as process steps are carried out and can even vary greatly across a given bar code.

While the present invention is described in detail as being applied to the reading of bar codes on silicon wafers, the teaching of the invention can be applied to the reading of a wide range of bar codes, and particularly difficult to read bar codes as indicated by, but not limited to, the above examples.

Integrated circuits have found extensive use in digital data processing equipment and have permitted the size of such equipment to shrink by many orders of magnitude. In the manufacturing process, a number of such circuits are formed on a silicon wafer disk by successive deposition and etching steps, following which the disk is cut into individual circuits, or chips.

The wafers are marked with identifying bar codes which are typically etched into the surfaces of the wafers by the manufacturer of the wafers. It is critical that such bar codes be accurately read as the wafers move through the circuit manufacturing process to ensure that the proper operations are performed and to identify the wafers before being cut. Conventional bar code reading devices used in such equipment provide poor performance, due to changing print/contrast ratios as the wafers move through the manufacturing process and due to the wide ranging reflectivity of the bar codes, the latter resulting from the fact that the bar codes are not printed on the wafers but are laser-etched into the surfaces thereof. Whether the bar code is acid or alkaline etched also introduces affects the ability of conventional bar code reading devices to read the codes with a single light source.

If the bar code reader is of the scanning type having an oscillating light beam, there is a changing focal point as the bar code is scanned from end to end. The types of readers that have a detector of constant distance from the wafer require the additional complication that the position of the wafer be changed as attempts are made to read the bar code.

The problem of reading bar codes on such wafers is further aggravated by the coating of the wafers with various materials during the manufacturing process thereof. These coatings are sometimes applied over all or part of the bar codes, thus rendering them more difficult to read.

Therefore, it would be desirable to have reliable means by which bar codes can be read during the manufacture of integrated circuits and also as a means of verification in the wafer manufacturing process and in other cases in which bar codes are difficult to read using conventional equipment.

Accordingly, it is a principal object of the present invention to provide means for reading bar codes having variable print/contrast and reflectivities.

It is an additional object of the invention to provide such means that reads the bar codes at a constant focal point.

It is a further object of the invention to provide such means that can be employed to read bar codes on silicon wafers used in the manufacture of integrated circuits both during the manufacture of the circuits and during the manufacture of the wafers.

It is a another object of the invention to provide such means that does not require re-positioning of silicon wafers during the reading of bar codes thereon.

It is yet an additional object of the invention to provide such means that can be retrofitted to existing equipment employed in the wafer and integrated circuit manufacturing processes.

It is yet a further object of the invention to provide such means that provides relatively rapid reading of such bar codes.

Other objects of the present invention, as well as particular features and advantages thereof, will be elucidated in, or be apparent from, the following description and the accompanying drawing figures.

Disclosure of Invention

The present invention achieves the above objects, among others, by providing in a preferred embodiment, a bar code scanner for reading a bar code on a flat surface of an article, comprising: a first light source disposed so as to illuminate the bar code; a second light source disposed so as to illuminate the bar code; photodetector means disposed so as to detect light from the first and second light sources reflected from the bar code; and motive apparatus to cause relative motion between the bar code and the first and second light sources and the photodetector means so that the photodetector means can read the bar code, such that the focal length(s) between the photodetector means and the bar code remain(s) constant. In a first alternative embodiment, the photodetector means includes first and second photodetectors. In a second alternative

embodiment, there is provided a bar code scanner of generally the foregoing construction, except that a beam splitter is employed to precisely direct light from the first and second light sources at the bar code and a single photodetector is employed to detect light reflected from both light sources. Discriminator slits are provided in front of the photodetectors in both embodiments.

Brief Description Drawings

The invention will be better understood if reference is made to the accompanying Drawing, provided for illustration only and not intended to limit the scope of the present invention, in which:

Figure 1 is a top/front/right side perspective view of a bar code reader scanner constructed according to the present invention.

Figure 2 is a top/rear/left side perspective view of the embodiment of the bar code scanner.

Figure 3 is a front elevational view with the front cover removed of the bar code scanner.

Figure 4 is a top plan view of the bar code scanner with the top cover removed.

Figure 5 is a cross-sectional side elevational view taken along line "5-5" of Figure 4.

Figure 6 is a cross-sectional side elevational view taken along line "6-6" of Figure 4.

Figure 7 is a fragmentary top plan view of a portion of the mechanism of the bar code scanner.

Figure 8 is a fragmentary top plan view of another portion of the mechanism of the bar code scanner.

Figure 9 is a perspective view, partially schematic, illustrating the use of the bar code scanner with conventional silicon wafer positioning equipment.

Figure 10 is a front elevational view illustrating the use of the bar code scanner in a desktop embodiment.

Figure 11 is a side elevational view of the embodiment of Figure 11.

Figure 12 schematically illustrates the reading of a bar code with the present invention.

Figure 13 is a fragmentary, side elevation view, partially in cross-section of a bar code scanner constructed according to an alternative embodiment of the present invention.

Figure 14 is a schematic perspective view of the optical elements of the scanner of Figure 13.

Best Mode for Carrying Out the Invention

Reference should now be made to the drawing figures, on which the same or similar elements are given consistent identifying numerals throughout the various views thereof, and on which parenthetical references to figures give the figure(s) in which the element(s) are most clearly seen, although the element(s) may be seen on other figures also.

While Figures 1-4 show more complete views of the bar code scanner of the present invention, generally indicated by the reference numeral 20, reference first to Figure 7 will aid in understanding the means by which motion is provided for linear raster scanning. A guide bar 22 is rotatably fixed to rotating guide bar gears 24 and 26 by means of screws 27 and 28 (also Figure 6), the screws being fixedly

attached to the guide bar while smooth portions of the screw pass through the gears in nonfixed engagement for relative rotational movement between the screws and the gears. Guide bar gears 24 and 26 are mounted on a horizontal support shelf 140. When guide bar gears 24 and 26 rotate as indicated by the arrows shown inside the peripheries thereof, guide bar 22 will have an overall rotary motion but will also have a continuous, back-and-forth, X-axis component of motion as indicated by the arrows "A-A" on Figure 7.

With reference also now to Figure 9, guide bar gears 24 and 26 are driven by the engagement therewith of center gear 30 of drive gear assembly 32. Drive gear assembly 32 is driven by engagement of the outer periphery thereof with a shaft gear 34 on a motor 36.

Referring now primarily to Figure 4, bar code scanner 20 includes a carrier member 60 disposed for X-axis movement in a housing having a front cover 62, side covers 64 and 66, and a rear cover 68. Bar code scanner 20 also includes a base 70 (Figures 5 and 6) and a top cover 72 (Figures 1 and 2). It can be seen that the housing of bar code scanner 20 generally comprises a cube.

Carrier member 60 is partly supported and guided for movement back and forth along the X-axis by a main shaft 80 which is journalled in a linear bearing 86 disposed in the carrier member. Carrier member 60 is further supported and guided for movement back and forth along the X-axis by a guide shaft 82 which passes through the carrier member in closely fitting sliding relationship therewith.

Continuing to refer primarily to Figure 4, the ends of main shaft 80 and guide shaft 82 are fixedly attached to guide rails side covers 64 and 66.

Reference now to Figure 5 and recalling the motion component "A-A" of guide bar 22 in Figure 8 will aid in understanding how X-axis motion of carrier member 60 is achieved. The lower portion 100 of carrier member 60 comprises a channel which engages guide bar 22 in closely fitting sliding relationship. Now, as guide bar 22 rotates, as described above with reference to Figure 7, its "A-A" motion component will cause carrier member 60 to move back and forth along the X-axis. Being guided in the X-axis by means of main shaft 80 and guide shaft 82, any Y-axis component of the rotary motion of guide bar 22 will be negated with respect to carrier member 60 by the sliding motion of the guide bar 22 within lower portion 100 of the carrier member.

Referring now to Figure 5, mounted channels formed in carrier member 60 are a first light source 400, a first lens 402, a first mirror 404, and a first photodetector 406. The foregoing elements are arranged such that light from first light source will illuminate a bar code (not shown) on a surface 410. Surface 410 may be any of those noted above. Light reflected from surface 410 is focussed by first lens 402 onto first mirror 404 which reflects the light to photodetector 406, as will be described in more detail below. It can be seen that light from first light source 400 strikes surface 410 at approximately a 45-degree angle therewith and that first lens 402 focuses light reflected from the surface at approximately a 45-degree angle therewith.

Referring now to Figure 6, mounted in channels formed in carrier member 60 are a second light source 420, a second lens, a second mirror 424, and a second photodetector 426. The foregoing elements are

arranged such that light from second light source will illuminate the bar code on surface 410. Light reflected from surface 410 is focussed by second lens 422 onto first mirror 424 which reflects the light to photodetector 426, as will be described in more detail below. It can be seen that light from second light source 420 strikes surface 410 at approximately a 45-degree angle therewith and that second lens 422 focuses light reflected from the surface at approximately a 45-degree angle therewith.

A flexible flat cable 124 (Figures 3 and 6) connects first and second lights 400 and 420 and first and second photodetectors 406 and 426 to printed circuit board 126 which includes circuitry for speed control and adjustment for motor 36. A receptacle 128 (Figure 2) is provided in rear cover 68 for attachment of a cable (not shown) to supply power to bar code scanner 20 and to receive signals therefrom.

In operation, motor 36 (Figure 3), through the gearing mechanisms described above, provides horizontal X-axis motion for carrier member 60, such that the first and second light sources 400 and 420 and their associated components move with a back-and-forth motion under surface 410 with a constant focal point on the surface placed over a rectangular opening 136 (Figures 1 and 2) defined in top cover 72, under which opening the first and second light sources and their associated components move. For the embodiment of bar code scanner 20 shown, which is preferably on the order of about two inches on each side, the length of the X-axis sweep is on the order of about 0.75 inch.

While bar code scanner 20 may be used in a number of applications, there will be first described the use of the bar code scanner with conventional means for positioning a silicon wafer substrate, to which conventional means the bar code scanner can be easily retrofitted.

Referring to Figure 9, there is shown a wafer 210 positioned above a horizontal disk 212 rotatable by motor 214 and above two, horizontally extending arms 216 and 218 which are movable in and out, that is, toward and away, from the axis of motor 214 and up and down, to lift the wafer from the disk or to place the wafer onto the disk. It will be understood that when wafer 210 is placed on disk 212, the wafer will rotate with the disk. Formed in the periphery of disk 212 is a notch, or flat portion, 224 and formed on the upper surface of the disk, slightly inward from the periphery thereof, and at a known angle with respect to the notch is a bar code 226 which is etched into the disk with a laser (not shown). Motor 214 and arms 216 and 218 are controlled by index controller 230 which is interconnected with robotics controller 232. Robotics controller 232 receives inputs from bar code scanners 20 and 20' through serially connected analog-to-digital converter 250 and bar code decoder 252.

When a wafer, such as wafer 210, is to be positioned, it is moved onto arms 216 and 218 by other equipment (not shown). Arms 216 and 218 then lower wafer 210 onto disk 212 which rotates the disk. Optical sensing equipment (not shown) which provides input to index controller 230 detects the concentricity of, or lack of, the periphery of wafer 210 with respect to disk 212. If the optical sensing equipment detects nonconcentricity of disk 212, index

controller 230 causes the rotation to cease, arms 216 and 218 to lift wafer 210 from disk 212, and the arms to move the wafer in or out from the axis of motor 214 to correct for the nonconcentricity of the disk. Arms 216 and 218 then replace wafer 210 on disk 212 and the wafer is again rotated. The above procedure is reiterated until precise concentricity of wafer 210 is achieved. Wafer 210 is then removed from the positioning operation by other equipment (not shown), while precisely maintaining the position of the wafer, and the wafer is moved to bar code reading equipment (not shown). The bar code reading equipment causes the wafer to continuously rotate. An optical sensor located radially a distance from the center of the wafer at approximately the radial distance of bar code 226 oscillates in and out slightly until the bar code is read. In addition to requiring separate equipment, the conventional method is relatively slow, in that there is a large amount of "no read" time when the bar code is not in proximity to the optical sensor.

Disposed centrally of a horizontal cross-bar 240 which supports arms 216 and 218 is an upwardly facing bar code scanner 20'. Mounted on a frame 244 formed as an extension of cross-bar 240 is a downwardly facing optical bar code scanner 20. Both bar code scanners 20 and 20' may be furnished when bar codes may be placed on either the top or the bottom of wafer 210 or only one or the other may be furnished if bar codes will be placed on only the same side of each wafer.

The distances separating the elements shown on Figure 10 are exaggerated for clarity and whichever of optical sensors 20 and 20' is being used, it would be positioned about 0.010-0.020 inch from the surface of wafer 210 bearing the bar code.

After the positioning procedure described above has been completed with wafer 210, notch 224 is located with the optical sensing equipment (not shown) and the wafer is rotated to place bar code 226, or a similar bar code if printed on the lower surface of wafer 210, in reading proximity to optical sensors 20 and 20' and the wafer is held motionless on disk 212. Index controller 230 is then commanded by robotics controller 232 to move the appropriate one of optical sensors 20 and 20' near the surface of the wafer. If it is unknown whether the bar code is on the upper or the lower surface of wafer 210, the location can be determined by reading with one and then the other of bar code scanners 20 and 20'. A further advantage of the present invention is that bar code scanners 20 and 20' can be automatically moved in or out to compensate for different diameter wafers. After positioning of the appropriate one of bar code scanners 20 and 20', bar code 226 is scanned by the raster scanning of the light source/photodetector in the bar code scanner and the bar code is read and decoded in the conventional manner. Wafer 210 can then be moved to another station.

Figures 10 and 11 illustrate another application for bar code scanner 20, here, in a desktop silicon wafer reader, generally indicated by the reference numeral 300. Reader 300 includes a base member 302, which may be attached to a bench or desktop, and an operating housing 304 selectively rotatable from a

position (not shown) in which the housing is folded around the base member to an inclined position (shown on Figures 10 and 11) as indicated by the arrow marked "C". Operating housing 304 is held in the inclined position by means of a releasable support member 306.

A locating boss 310 is formed on on the upper surface of operating housing 304 to locate thereon a silicon wafer 312 (Figure 11 only) by means of engagement therewith by a notch (not shown) formed in the edge of the wafer adjacent the bar code. To assist in holding wafer 312 in place on operating housing 304, there are provided a plurality of openings, as at 314, defined in the upper surface of the housing and connected to a source of vacuum (not shown). Cutouts 316 and 318 are provided in the operating housing 304 to facilitate the placement and removal of wafer 312.

A keyboard 320 is provided on the face of operating housing 304 to enter such commands as ON, OFF, VACUUM ON, VACUUM OFF, AND READ. An LCD screen 322 is also provided on the face of operating housing 304 to indicate such information as operating status and the decoded bar code. A cable 324 is connected to scanner 300 from a source of electrical power (not shown). Cable 324 may also provide connection to central computer equipment (not shown).

In use of reader 300, wafer 312 is placed on the upper surface of operating housing 304, with an indexing notch (not shown) formed in the edge of the wafer engaging locating boss 310 such that a bar code on the wafer is located over a window 330 in the upper surface. Vacuum is applied at openings 314 and the bar code on wafer 312 read by scanner 20 through window 330. The vacuum is then released and wafer 312 is removed. It will be understood that scanner 20 is

so disposed in operating housing 304 that the plane of scanning is parallel to the plane of the bar code.

Reader 300 may be used in either the folded or the inclined position, the inclined position being most suitable for manual use of the reader and the folded position being most suitable for use of the reader when a robotic arm is used to place and remove the wafers.

If desired, and particularly when reader 300 is used with a robotic arm in a manufacturing environment, the reader operations may be controlled by a remote computer console connected to the reader.

Reader 300 is useful in engineering and development settings and as a secondary checking apparatus during manufacturing processes.

The technique of reading a bar code with the present invention will now be described with reference to Figure 12.

Photodetectors 406 and 426 are of the type that employ therein discriminator slits such as described in US Patent No. 4,816,659, issued March 28, 1989, to James S. Bianco et al., and titled BAR CODE READER HEAD, the disclosure of which patent is incorporated by reference hereinto. As is described in that patent, discriminator slits are provided 514 to sharpen the image seen by a photodetecting element.

Figure 12 schematically illustrates first light source 400 and first photodetector 406 in reading relationship with a bar code 450. First photodetector 406 includes therein a first discriminator slit 460. Second light source 420 and second photodetector 426 are also disposed in reading relationship with bar code 450 and the second photodetector includes therein a second discriminator slit 462. As is shown on

Figure 12, discriminator slits are disposed parallel to each other and to the bars of bar code 450. It will be understood that first and second photodetectors 400 and 420 and first and second photodetectors 406 and 426 will be moved relative to bar code 450 in the directions indicated by the arrows on Figure 12.

First light source/photodetector 400/406 and second light source/photodetector 420/426 may be arranged so that they simultaneously read the area on bar code 450 and the outputs from the photodetectors may be added, by conventional means, so that the bar code signal is amplified to increase the chance of reading the bar code. In such a case, it is preferable to have first and second light sources 400 and 420 produce light of different wavelengths, the two wavelengths being a pair selected from visible, infrared, ultraviolet, or two different wavelengths within the foregoing ranges, so as to further increase the chance of reading bar code 450, especially when a coating has been placed over part or all of the bar code and to compensate for variations in acid and alkaline etching. Most preferably, visible and infrared light frequencies will be used.

Alternatively, first light source/photodetector 400/406 and second light source/photodetector 420/426 may be arranged so that the areas read by the pairs are displaced vertically on bar code 450, so as to increase the chance of reading the bar code.

Figure 13 illustrates an alternative carrier design 60' for use in a bar code scanner, generally indicated by the reference number 20". Since the elements of bar code scanner 20", other than carrier 60" and the optical elements therein, are identical to those described above with reference to bar code

scanner 20, no further discussion thereof will be made here.

It is to be noted here that the above-referenced US Patent No. 4,816,659 describes the use of two light sources and a single photodetector. The arrangement described therein, however, could not be incorporated in bar code scanner 20 or 20" without destroying the compactness thereof.

Carrier 60" includes first and second light sources 500 and 502, respectively, and a mirror type beam splitter 504 arranged so that the first light source illuminates a bar code (not shown) on surface 410 by having a beam of light from that light source reflected from a surface of the beam splitter. Second light source 502 illuminates the bar code by having a beam of light from that light source pass through the beam splitter. The arrangement of these elements, as well as the other optical elements in carrier 60" is also shown schematically on Figure 14.

Light reflected from surface 410 passes through a focussing lens 510 and is reflected from a mirror 512, at approximately a 22 degree angle, to a photodetector 516 through a discriminator slit 514. Mirror 512 is provided to minimize the height dimension of carrier 60".

Since the beams of light from first and second light sources 500 and 502 may not be reflected and transmitted equally by beam splitter 504, the intensities of the light sources may have to be different. For example, if beam splitter reflects 80 percent of the light from first light source 500 and transmits 20 percent of the light from second light source 502, then the first light source may have an intensity of 25 lumens, while the second light source may have an intensity of 100 lumens. The foregoing

assumes that equal intensities of light incident upon surface 410 is required. In some cases, it may be desired to have different intensities and such can easily be provided.

First and second light sources 500 and 502 may produce illumination in the visible, ultraviolet, and/or infrared spectrums.

It is also within the scope of the present invention that the bar code reader of the parent application referenced above be modified, in accordance with the present teaching, for raster scanning with two light sources, so as to even further increase the chance of reading bar codes of low print contrast. This can be simply accomplished by substituting carrier member 60 or 60" described herein for the carrier member of the bar code scanner of that disclosure. However, the use of raster scanning may be avoided, in some cases, by directing two light sources at different elevations on the bar code.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown on the accompanying drawing figure shall be interpreted as illustrative only and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Claims

1. A bar code scanner for reading a bar code on a flat surface of an article, comprising:

(a) a first light source disposed so as to illuminate said bar code;

(b) a second light source disposed so as to illuminate said bar code;

(c) photodetector means disposed so as to detect light from said first and second light sources reflected from said bar code; and

(d) motive means to cause relative motion between said bar code and said first and second light sources and said photodetector means so that said photodetector means can read said bar code, such that the focal length(s) between said photodetector means and said bar codes remain(s) constant.

2. A bar code scanner, as defined in Claim 1, wherein the wavelengths of light from said first and second light sources are wavelengths selected from the group consisting of the visible range, the infrared range, the ultraviolet range, and two ranges within any of the foregoing ranges.

3. A bar code scanner, as defined in Claim 1 wherein said photodetector means includes:

(a) a first photodetector to detect reflected light from said first light source; and

(b) a second photodetector to detect reflected light from said second light source.

4. A bar code scanner, as defined in Claim 3, wherein the plane of the light path from said first light source to said first photodetector is orthogonal to the light path from said second light source to said second photodetector.

5. A bar code scanner, as defined in Claim 3, wherein said first and second photodetectors have discriminator slits parallel to each other and to the bars of said bar code.

6. A bar code scanner, as defined in Claim 3, wherein the areas of said bar code from which said first and second photodetectors detect reflected light are coincident.

7. A bar code scanner, as defined in Claim 3, wherein the areas of said bar code from which said first and second photodetectors detect reflected light are vertically displaced on said bar code.

8. A bar code scanner, as defined in Claim 1, wherein said motive means causes said relative motion in a back-and-forth pattern.

9. A bar code scanner, as defined in Claim 1, wherein said motive means causes said relative motion in a raster pattern.

10. A bar code scanner, as defined in Claim 1, wherein said photodetector means comprises a single photodetector to detect reflected light from said first and second light sources.

11. A bar code scanner, as defined in Claim 10 further comprising a mirror type beam splitter disposed between said first and second light sources and said flat surface and light from said first light source is reflected to said flat surface by said beam splitter and light from said second light source is transmitted to said flat surface through said beam splitter.

12. A bar code scanner, as defined in Claim 10, wherein said single photodetector has a discriminator slit parallel to the bars of said bar code.

13. A bar code scanner, as defined in Claim 1, further comprising:

(a) carrier means in which said first and second light sources and said photodetector means are mounted; and

(b) said motive means comprises:

(i) guide means to move in a circular manner in a plane parallel to the plane of motion of said photodetector, said first guide means comprising an elongate guide bar continuously disposed along a Y-axis; and

(ii) an elongate channel defined in said carrier means along said Y-axis, in which channel said guide means is disposed in sliding engagement;

such that, upon circular movement of said guide means, the X-axis component of motion of said guide means will be transmitted to said carrier means, the effect of the Y-axis component of motion of said guide means being negated by the sliding of said guide means within said elongate channel.

14. A bar code scanner, as defined in Claim 13, wherein said guide means comprises an elongate guide are disposed along said Y-axis.

15. A bar code scanner, as defined in Claim 14, further comprising:

(a) a first end of said elongate guide bar is rotatably attached to a first disk

(b) a second end of said elongate guide bar is rotatably attached to a second disk; and

(c) said first and second disks are operatively connected to said motive means for rotation thereby.

16. A bar code scanner for reading a bar code on a flat surface of an article, comprising:

(a) a carrier member disposed in proximity to said bar code;

(b) a first light source disposed in said carrier member so as to illuminate said bar code;

(c) a second light source disposed in said carrier member so as to illuminate said bar code;

(d) photodetector means disposed so as to detect light from said second light source reflected from said bar code;

(f) first moving means to move said carrier member in an X-axis in a plane parallel to the plane of said bar code;

(g) second moving means to move said carrier member in a Y-axis in said plane parallel to said plane of said bar code; and

(h) motive means to simultaneously provide power to said first and second moving means;

whereby, said photodetector means is moved in a raster pattern at a constant focal length from said bar code.

17. A bar code scanner, as defined in Claim 16, wherein said motive means comprises a single rotary electric motor.

18. A bar code scanner, as defined in Claim 16, wherein said first moving means comprises:

(a) first guide means to move in circular manner in a plane parallel to the plane of motion of said photodetector, said first guide means comprising an elongate guide bar continuously disposed along said Y-axis; and

(b) a first elongate channel defined in said carrier means along said Y-axis, in which channel said first guide means is disposed in sliding engagement;

such that, upon circular movement of said first guide means, the X-axis component of motion of said first guide means will be transmitted to said carrier means, the effect of the Y-axis component of motion of said first guide means being negated by the sliding of said first guide means within said first elongate channel.

19. A bar code scanner, as defined in Claim 18, wherein said first guide means comprises an elongate guide bar disposed along said Y-axis.

20. A bar code scanner, as defined in Claim 19, further comprising:

(a) a first end of said elongate guide bar is rotatably attached to a first disk

(b) a second end of said elongate guide bar is rotatably attached to a second disk; and

(c) said first and second disks are operatively connected to said motive means for rotation thereby.

21. A bar code scanner, as defined in Claim 16, wherein said second moving means comprises:

(a) second guide means to move in a circular motion in a plane parallel to the plane of motion of said photodetector, said second guide means comprising a cylindrical, vertical cam guide; and

(b) a second elongate channel defined in said carrier means along said X-axis, in which channel said second guide means is disposed in sliding engagement;

such that, upon circular movement of said second guide means, the Y-axis component of motion of said second guide means will be transmitted to said carrier means, the effect of the X-axis component of motion of said second guide means being negated by the sliding of said second guide means within said second elongate channel.

22. A bar code scanner, as defined in Claim 16, further comprising positioning equipment to bring said bar code scanner in reading proximity to said bar code on said article.

23. A bar code scanner, as defined in Claim 16, wherein said article is a silicon wafer.

24. A bar code scanner, as defined in Claim 16, further comprising a desktop unit in which said bar code scanner is mounted.

25. A bar code scanner, as defined in Claim 24, wherein said desktop unit comprises:

(a) a base member;

(b) an operating housing in which said bar code scanner is mounted, said operating housing being selectively rotatable from a horizontal position folded with said base member to an inclined position;

(c) said operating housing including an upper surface upon which a silicon wafer can be placed for the reading of a bar code thereon; and

(d) said upper surface including an opening therein through which said bar code scanner can read said bar code, said bar code scanner being so mounted that the plane of scanning is parallel to the plane of said bar code.

26. A bar code scanner, as defined in Claim 25, further including vacuum means in said upper surface to help hold said wafer in place.

27. A bar code scanner, as defined in Claim 16, wherein the wavelengths of light from said first and second light sources are wavelengths selected from the group consisting of the visible range, the infrared range, the ultraviolet range, and two ranges within any of the foregoing ranges.

28. A bar code scanner, as defined in Claim 16 wherein said photodetector means includes:

(a) a first photodetector to detect reflected light from said first light source; and

(b) a second photodetector to detect reflected light from said second light source.

29. A bar code scanner, as defined in Claim 28, wherein the plane of the light path from said first light source to said first photodetector is orthogonal to the light path from said second light source to said second photodetector.

30. A bar code scanner, as defined in Claim 28, wherein said first and second photodetectors have discriminator slits parallel to each other and to the bars of said bar code.

31. A bar code scanner, as defined in Claim 28, wherein the areas of said bar code from which said first and second photodetectors detect reflected light are coincident.

32. A bar code scanner, as defined in Claim 28, wherein the areas of said bar code from which said first and second photodetectors detect reflected light are vertically displaced on said bar code.

33. A bar code scanner, as defined in Claim 28, wherein said photodetector means comprises a single photodetector to detect reflected light from said first and second light sources.

34. A bar code scanner, as defined in Claim 33, further comprising a mirror type beam splitter disposed between said first and second light sources and said flat surface and light from said first light source is reflected to said flat surface by said beam splitter and light from said second light source is transmitted to said flat surface through said beam splitter.

35. A bar code scanner, as defined in Claim 33, wherein said single photodetector has a discriminator slit parallel to the bars of said bar code.

36. Every novel system, bar code scanner, method, or article disclosed herein.

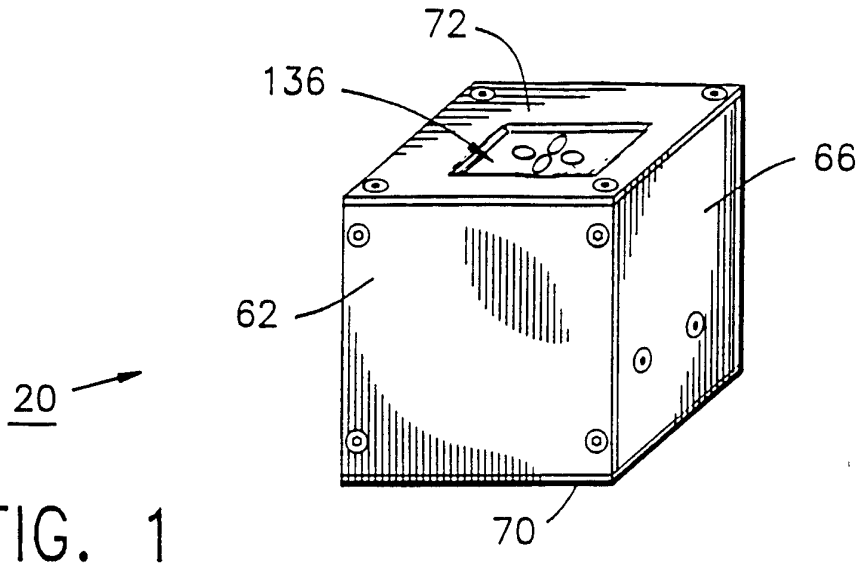

FIG. 1

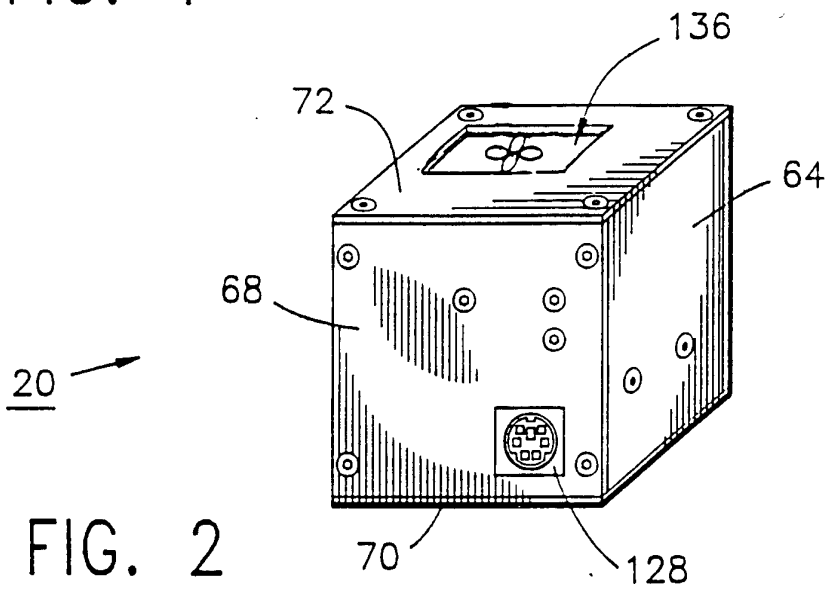

FIG. 2

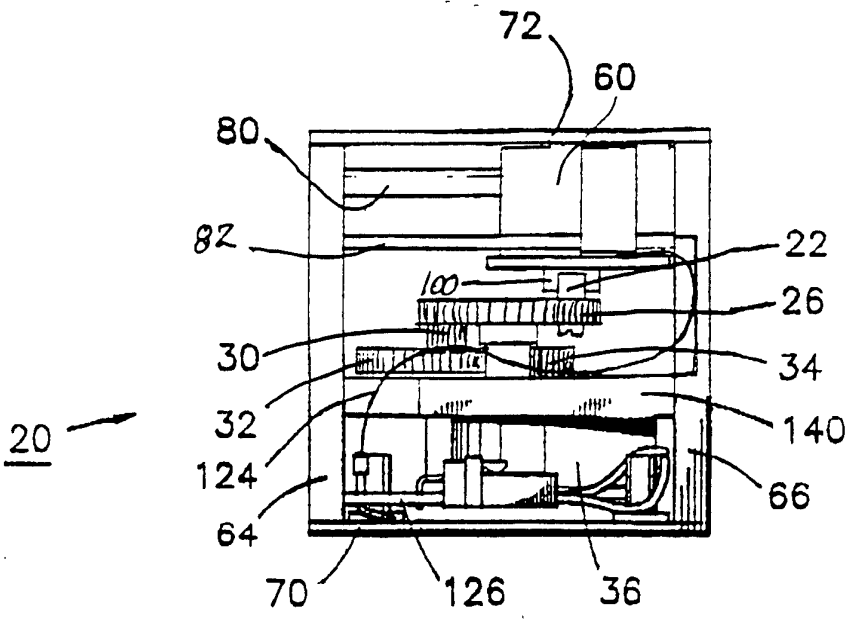

FIG. 3

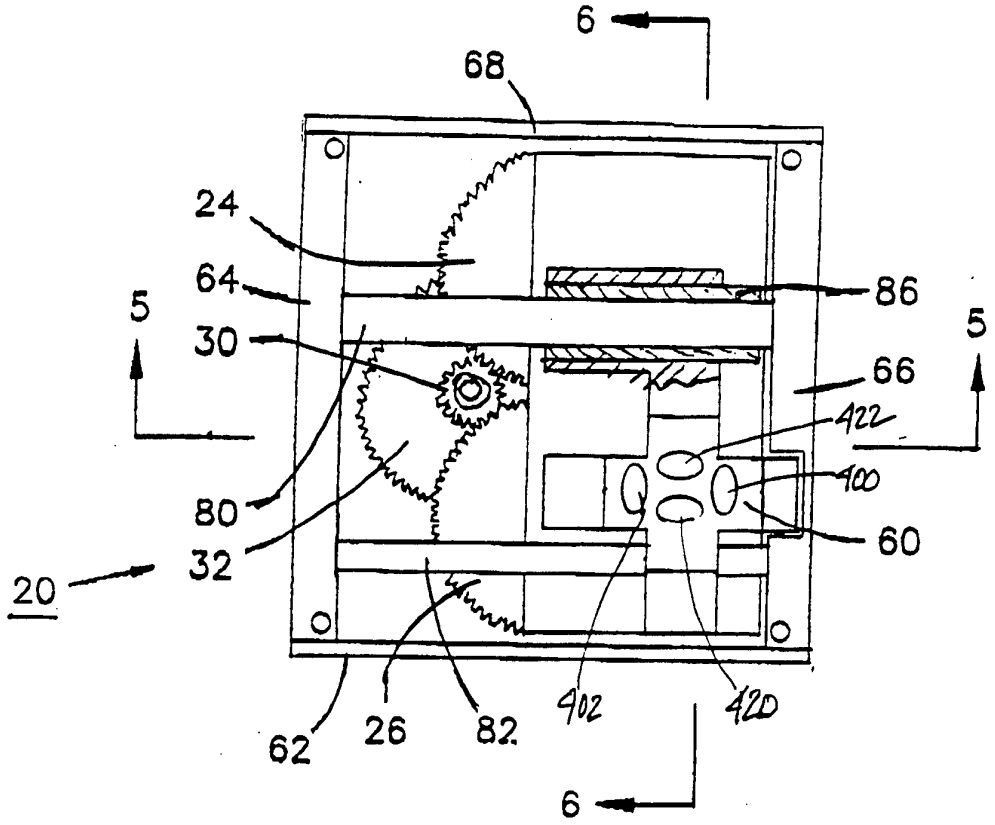
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FIG. 4

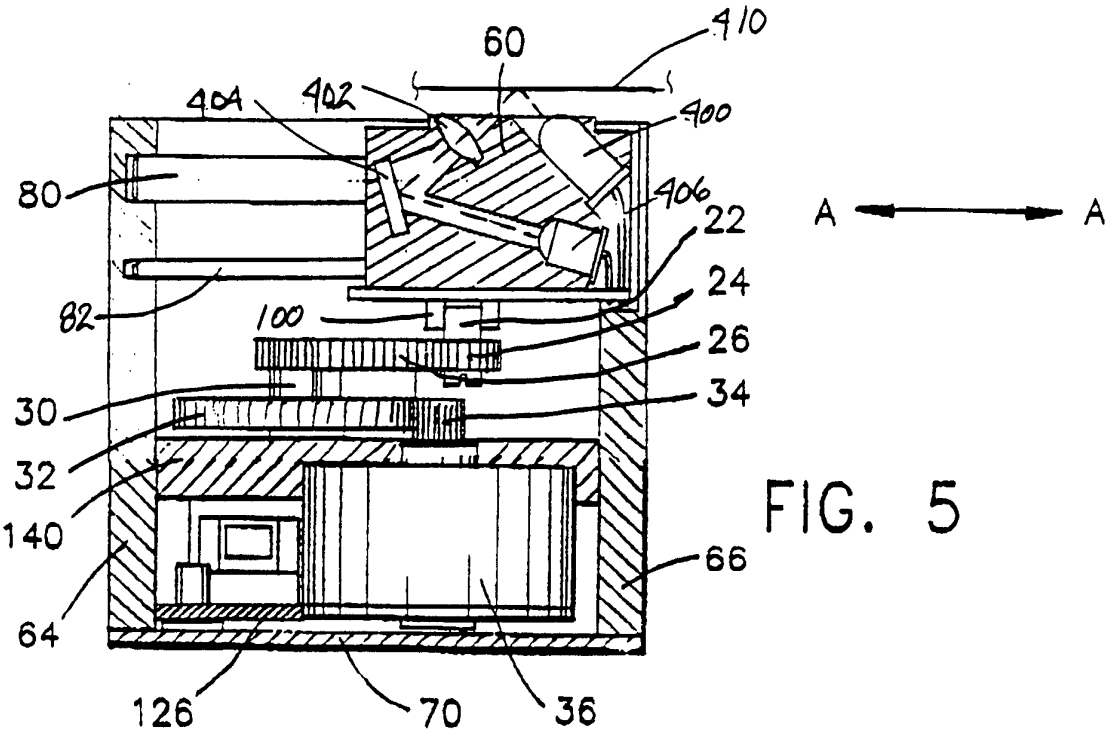
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FIG. 5

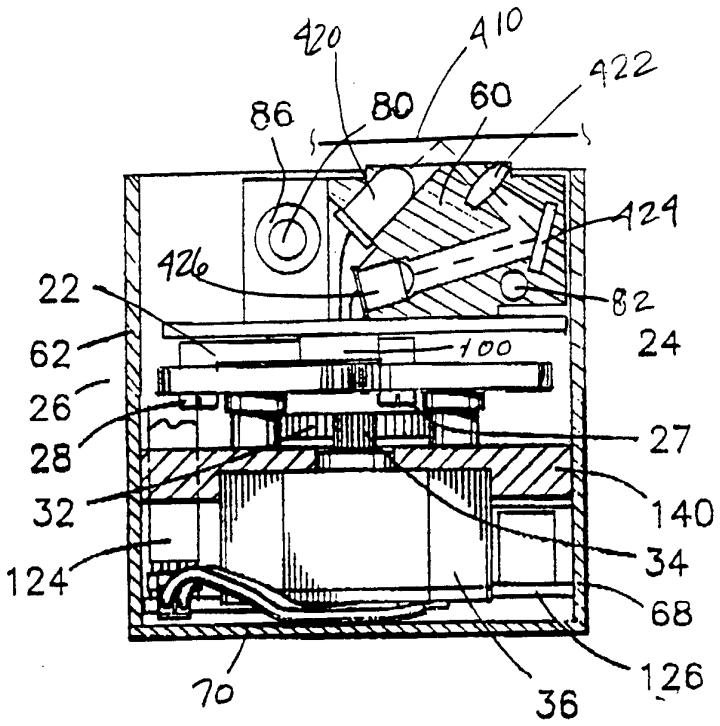
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FIG. 6

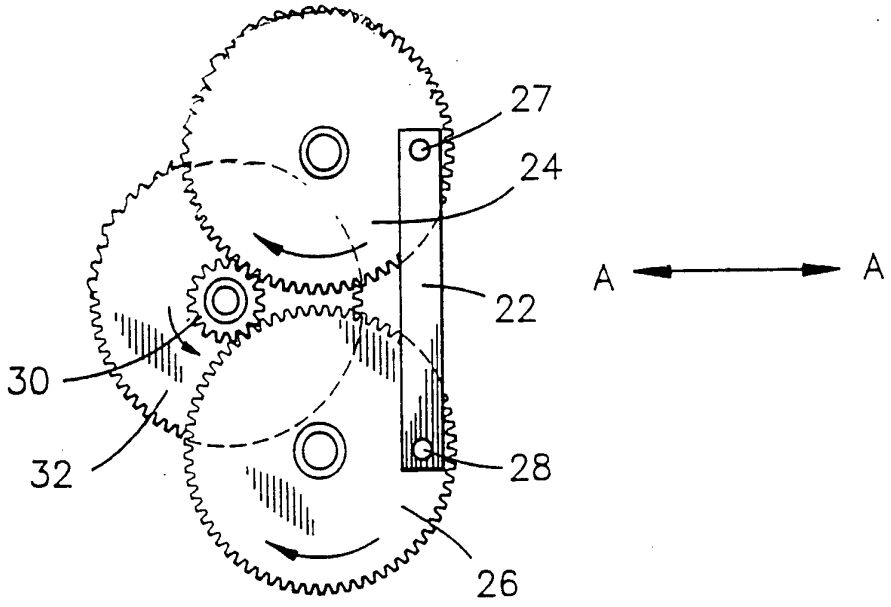


FIG. 7

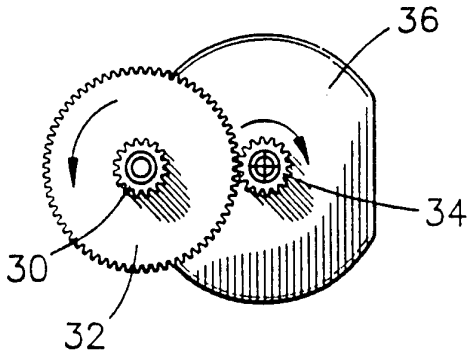
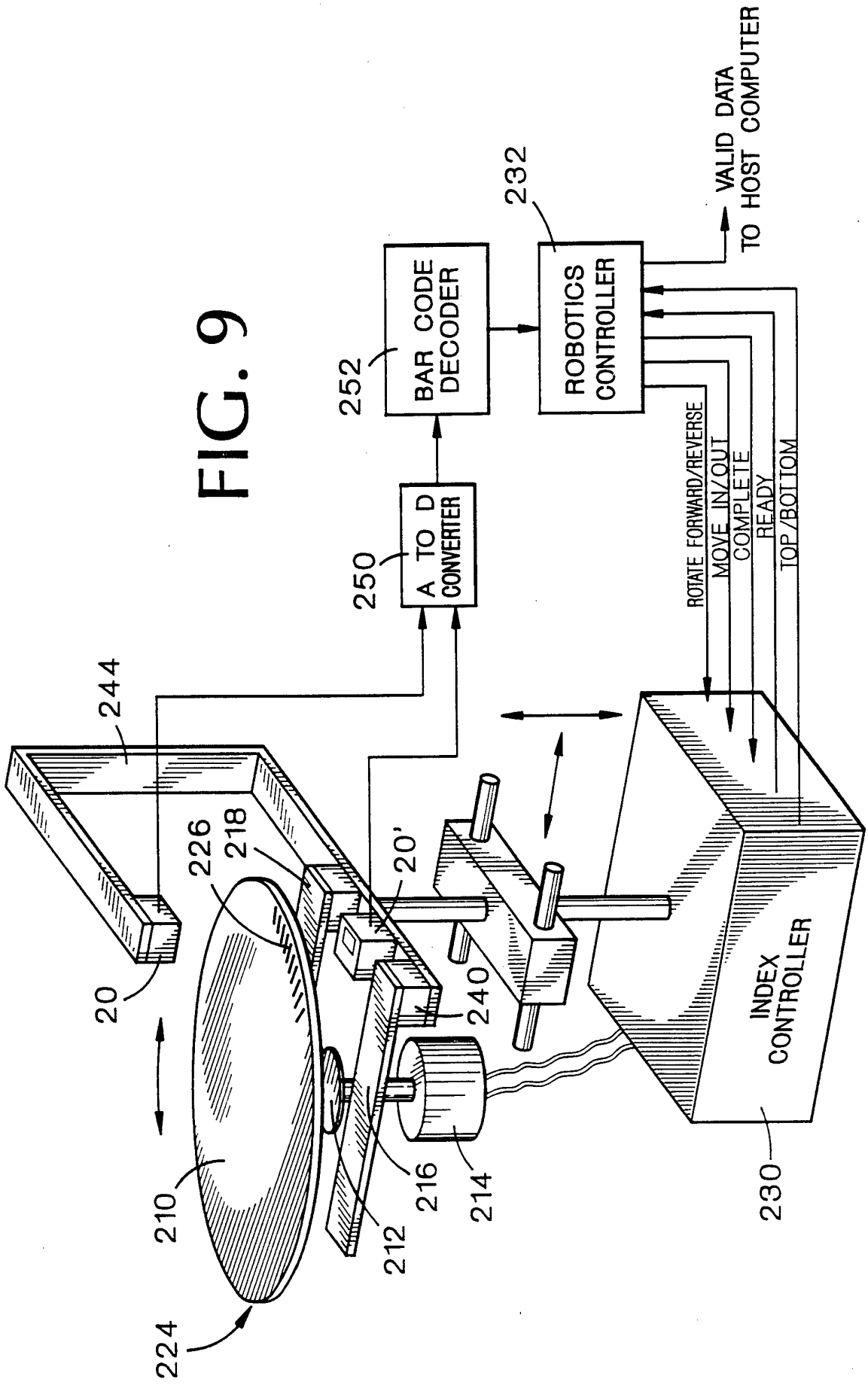


FIG. 8

FIG. 9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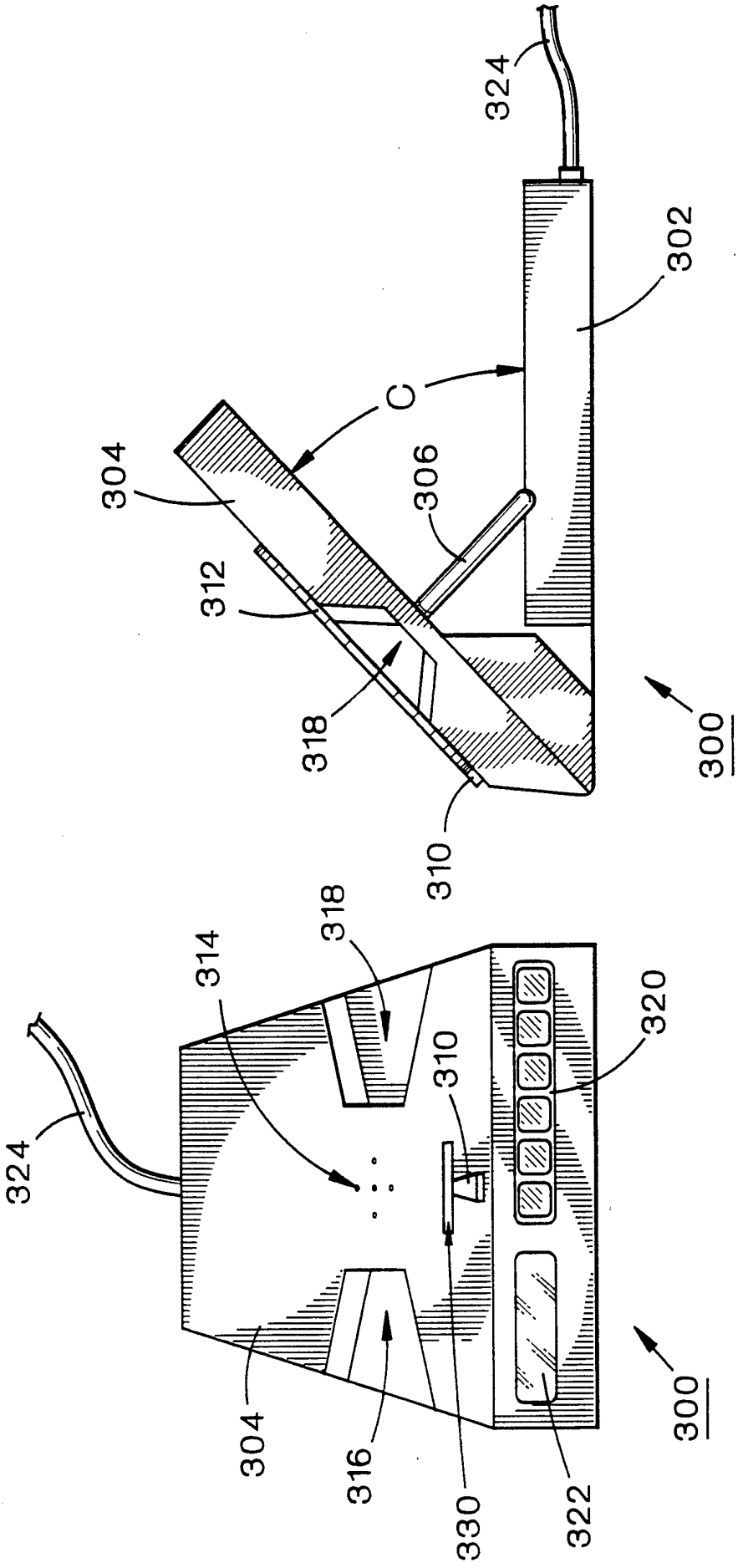
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FIG. 11

FIG. 10

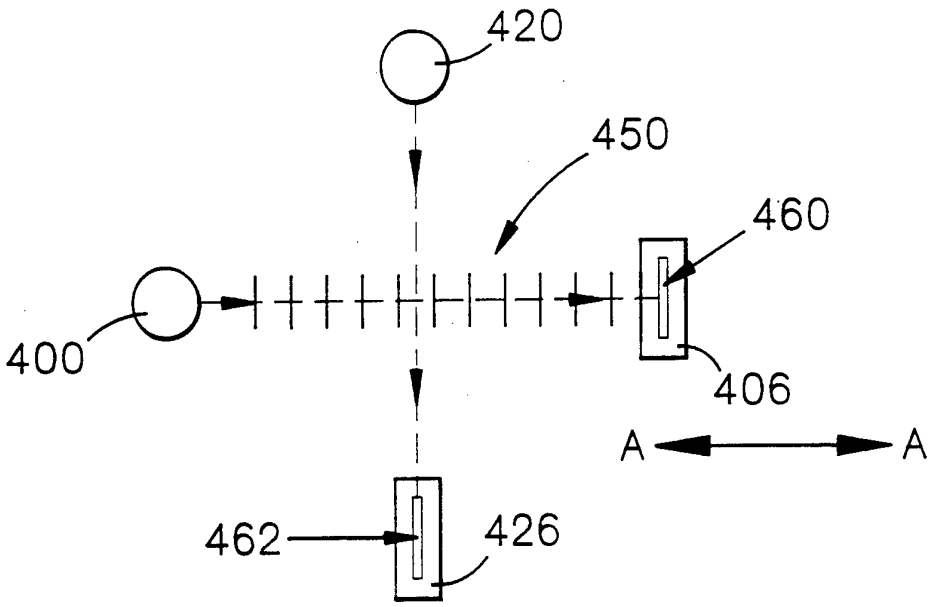
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FIG. 12

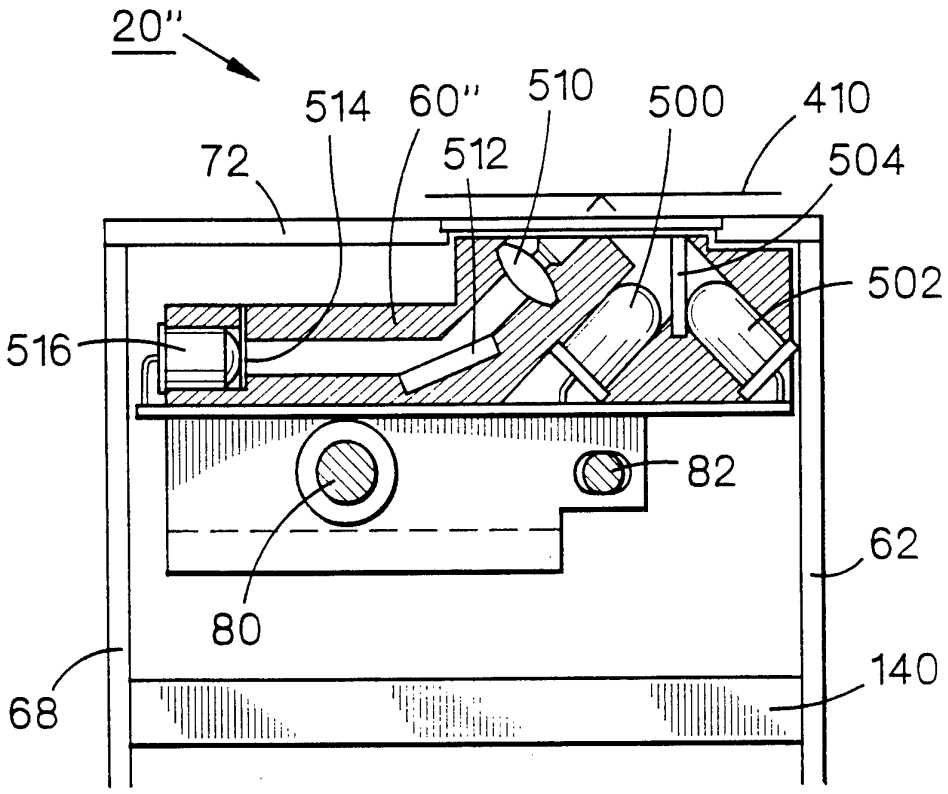
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FIG. 13

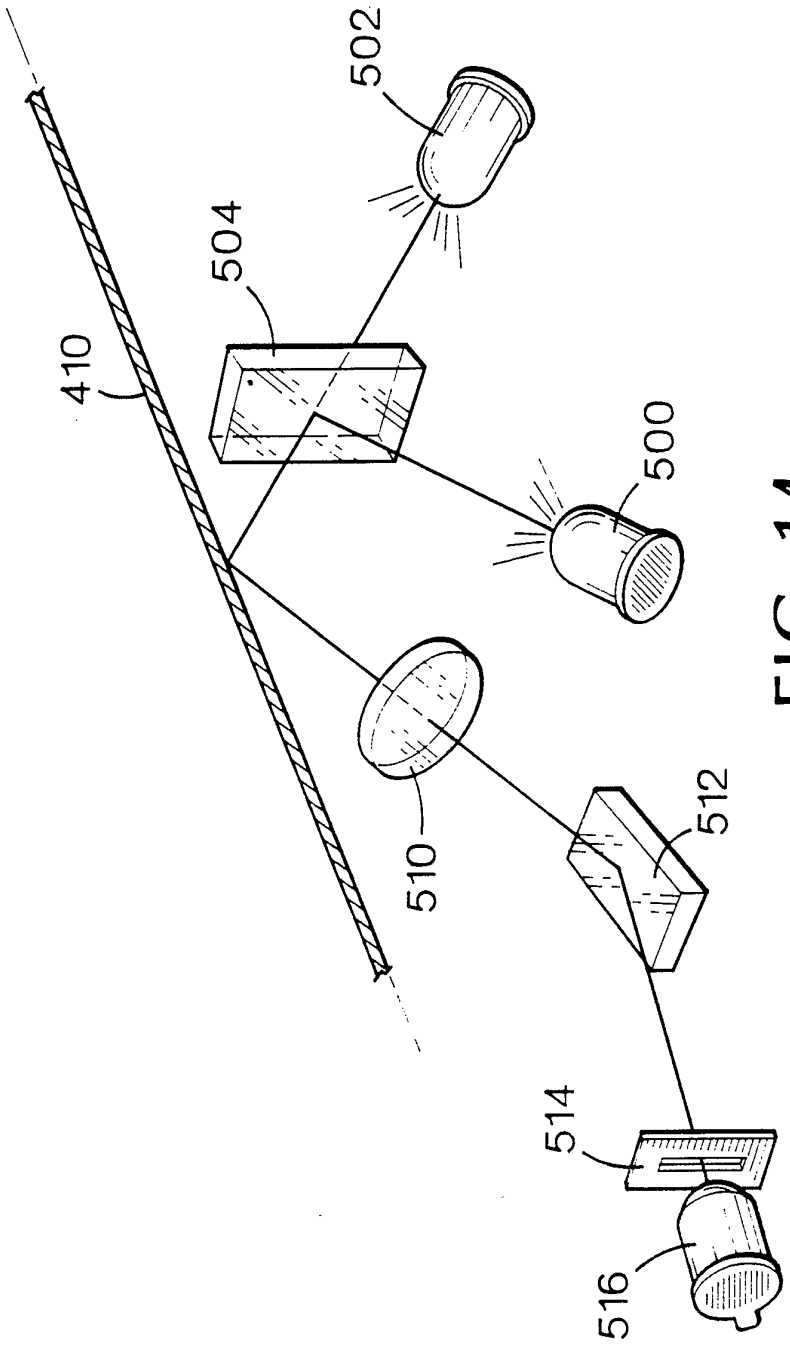

FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/09979

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :G06K 7/10; F16H 21/16; H04N 3/02
US CL : 235/462, 454; 74/27; 358/199, 497
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)

U.S. : 235/439, 461, 462, 454, 467, 480, 435, 475; 74/25, 27, 28, 44, 57; 358/93, 125, 139, 199, 474, 494, 497; 382/66

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US,A,3,812,325 (Schmidt et al) 21 May 1974, figures 1, 3, 4.	1-3,6,10,11 --- 4,5,8,9,12,28, 29,31,34
X --- Y	US,A,4,473,746 (Edmonds) 25 September 1984, Figures 1, 3	1-3, 7 --- 5,8,9,32
X --- Y	US,A,4,816,659 (Bianco et al) 28 March 1989, Figure 1 and Abstract	1,2,10,12 --- 30, 35
Y,P	US,A,5,175,420 (Bianco) 29 December 1992, Figures 4 and 5	13-29, 31-35

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 23 December 1993	Date of mailing of the international search report 07 JAN 1994
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer for EDWARD SIKORSKI Telephone No. (703) 308-1297

Form PCT/ISA/210 (second sheet)(July 1992)*