United States Patent

[11] **3,604,546**

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[54] **ANGULAR REGISTRATION ASSEMBLY AND DRIVING APPARATUS THEREFOR**
4 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** ..... **192/142 R,** 64/306, 74/625, 192/84 P, 318/480
[51] **Int. Cl.** **F16d 71/04**
[50] **Field of Search** ..... 74/625; 64/30 R, 30 C; 192/95, 142, 142 A, 84 P; 318/480

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ABSTRACT: An apparatus for establishing angular registration between a movable object and another object has photoelectric means for generating off-register signals relative to the θ axis. The off-register signals are coupled to a θ motor, which motor drives a driven gear mounted for free rotation on a rotatable shaft mechanically coupled to the movable object. A slip clutch assembly including a friction surface on one side of the driven gear and a compressed spring on the other frictionally engages the motor and the shaft, and a knob or handle is secured to the outer end of the shaft to give a manual adjusting capability to the driving apparatus. Means are preferably provided for adjusting the spring's compression and for preventing the spring from winding up during manual operation.

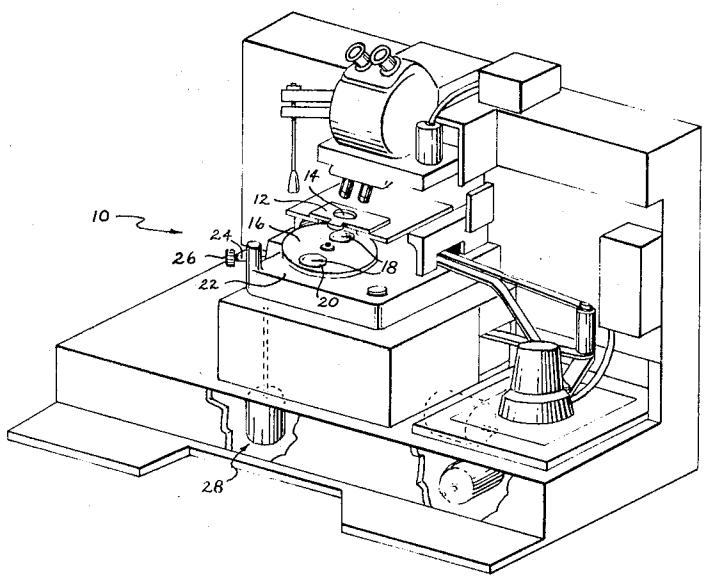
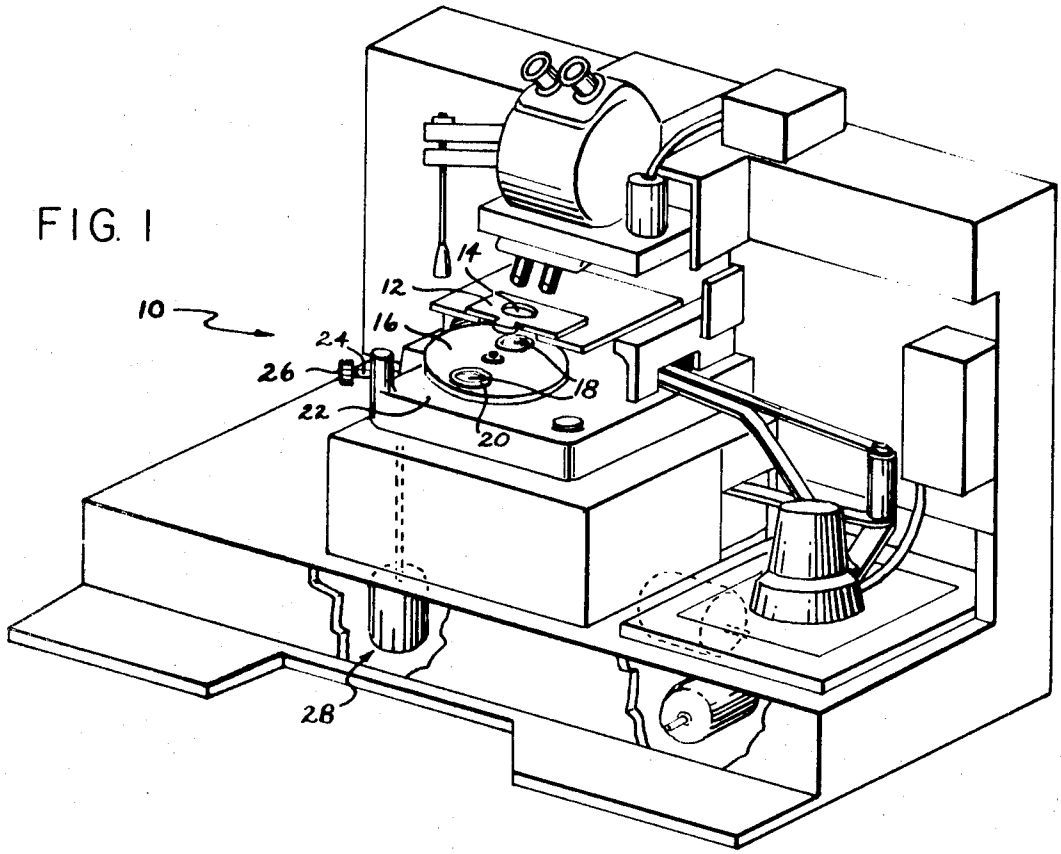


FIG. 1



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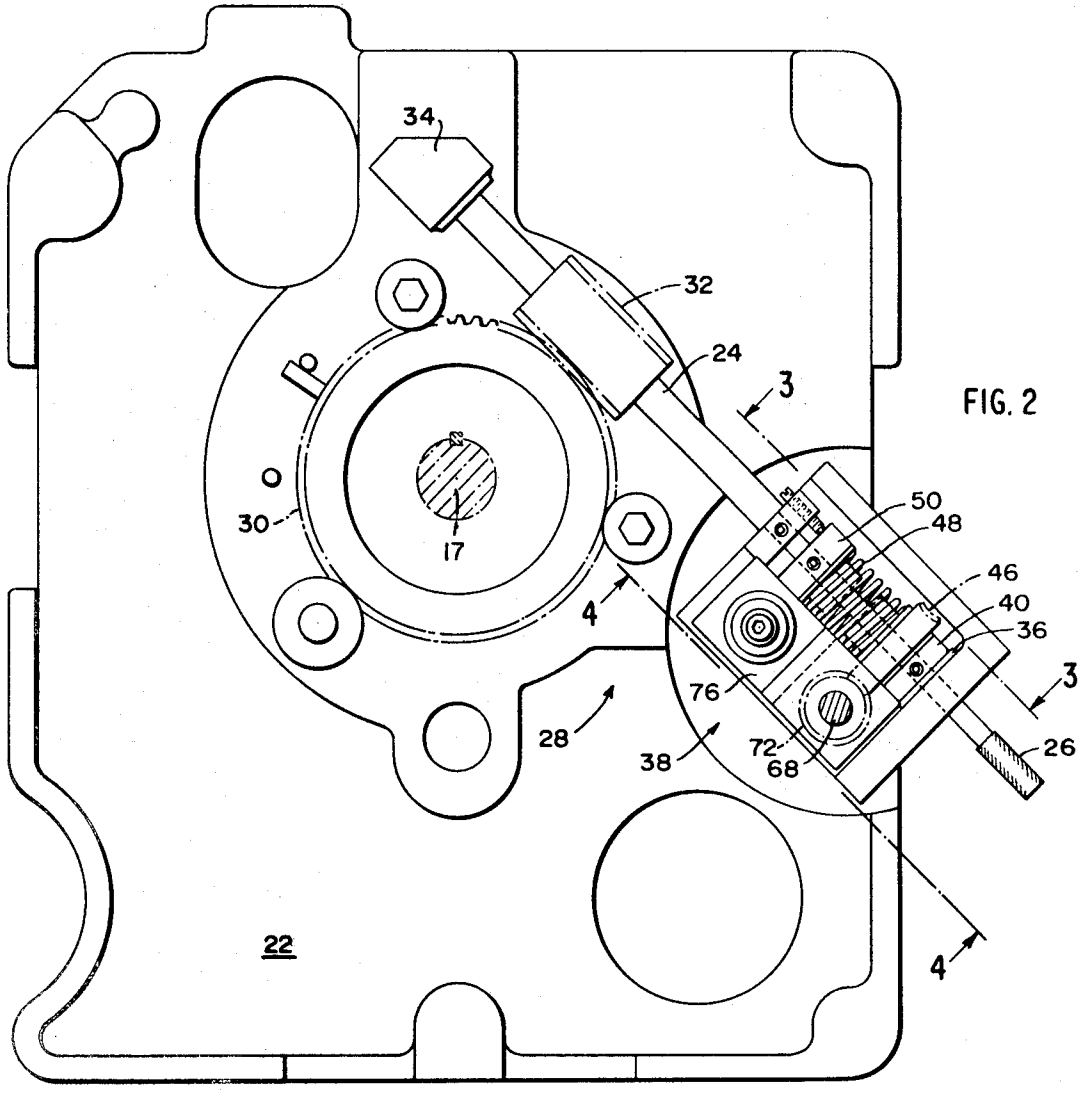


FIG. 2

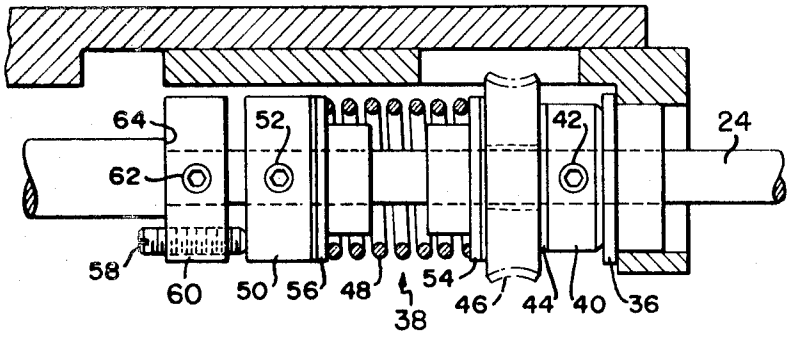


FIG. 3

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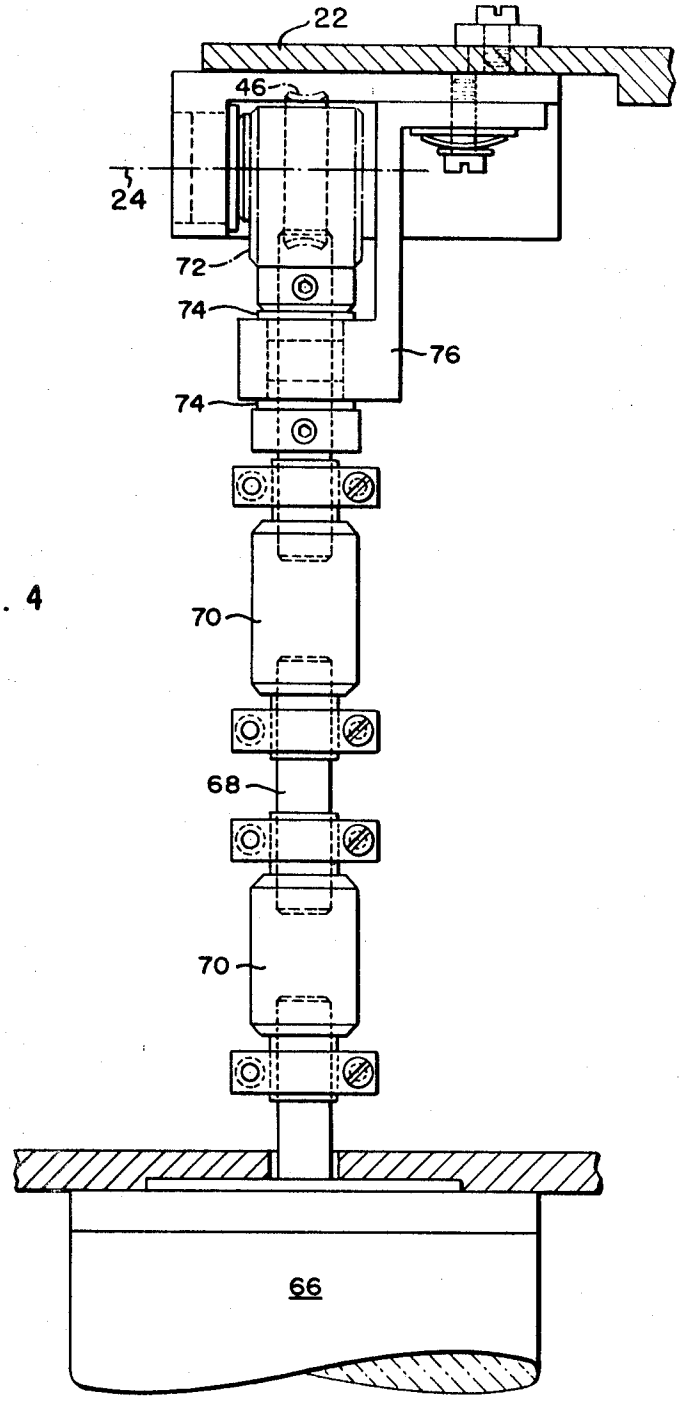


FIG. 4

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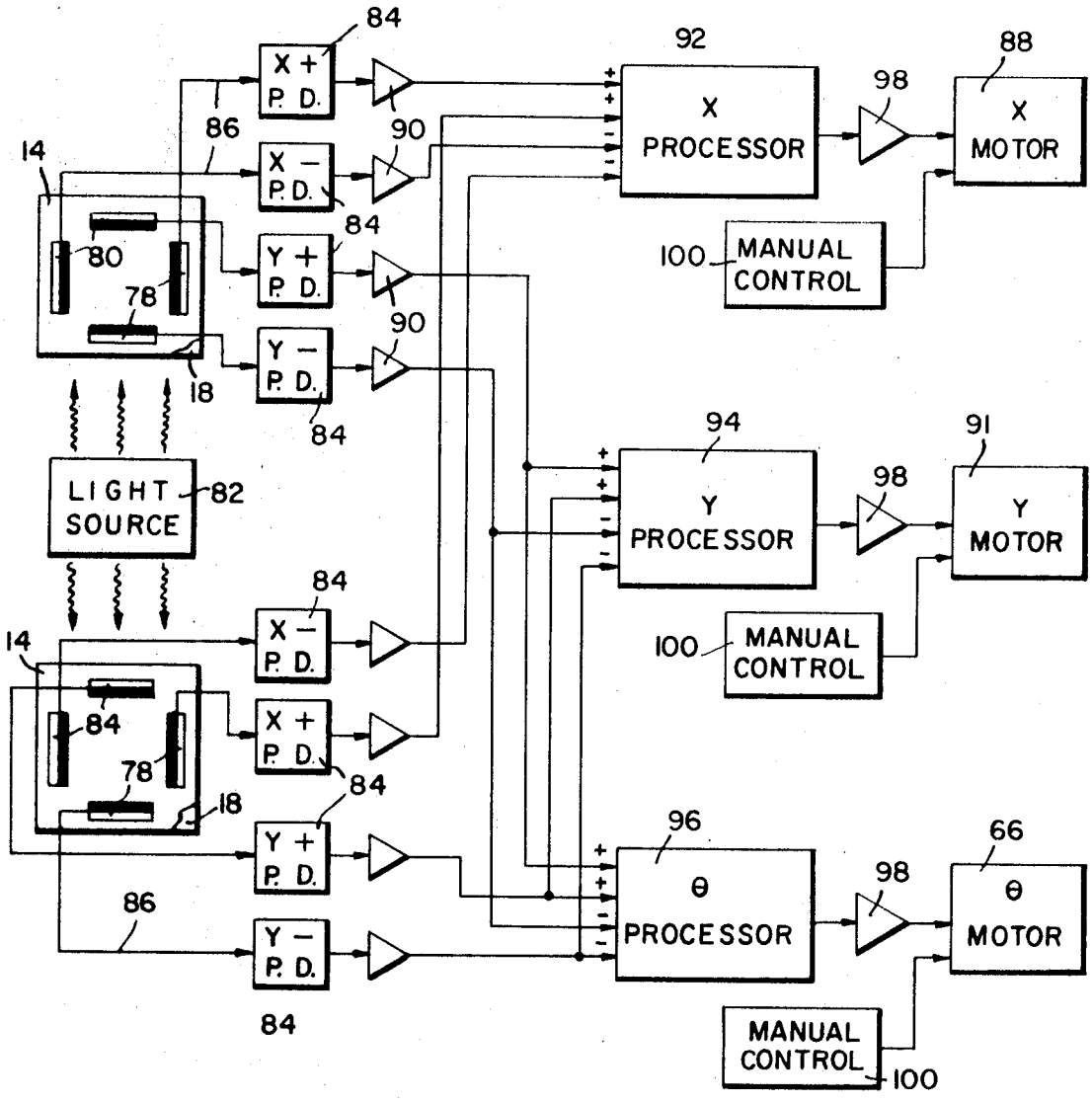


Fig. 5

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ANGULAR REGISTRATION ASSEMBLY AND DRIVING APPARATUS THEREFOR

This invention relates generally to an apparatus for rotating a torque-loaded shaft with alternate driving means and to an assembly utilizing such a driving apparatus to angularly register two objects.

In the production of solid state silicon transistor wafers, it is necessary to bring circuit targets printed on the wafers into precise register with complementary transparent targets provided on an otherwise opaque mask, before exposing the wafer-mask sandwich to ultraviolet light to produce a conductive circuit on the exposed wafer surface. Since the targets are rarely circular, the sandwich must be registered in both an annular and a planar mode. Heretofore known wafer mask registration and exposure devices have accomplished both types of registration manually with the aid of a microscope. More particularly, angular registration has been achieved by manually rotating a shaft to rotate a turntable on which the wafer is held through a gear train to angularly align the wafer with the stationary mask. This manual procedure has been found to be both unduly time consuming and fatiguing to the operator. It is, therefore, highly desirable to provide an assembly for automatically angularly registering the wafer mask sandwich while retaining a manual registering capability for manual registration.

In accordance with the invention, a driving apparatus for a torque-loaded shaft includes a slip clutch assembly mounted on the shaft. The slip clutch assembly includes a motor driven gear freely mounted on the shaft between a friction face secured to the shaft and a compressed spring which urges the driven gear into the friction face to create a frictional back therebetween.

A worm gear drive is preferably employed between the motor and the shaft to avoid any possibility of backdriving the motor during manual registration as well as to provide an inexpensive, compact unit having a minimum of backlash.

Photoelectric detectors are positioned adjacent the wafer-mask sandwich to generate an angular offset signal at any time the targets are not angularly aligned, which signal is coupled to the drive motor to rotate the turntable drive shaft through the slip clutch assembly in a direction to automatically register the targets.

The driving apparatus also has a manual adjusting capability through a knob secured to the turntable shaft, which knob may be rotated to cause the slip clutch assembly to slip to disengage the motor drive. Since the slip clutch is between the driven gear and the shaft, and not between the motor and driven gear as in conventional practice, the operator does not feel the mesh of the motor gears nor does he backdrive the motor during such rotation.

It is accordingly a primary object of the invention to provide a driving apparatus capable of driving a torque-loaded shaft with alternate driving means.

Another object of the invention is to provide an assembly utilizing such a driving apparatus to automatically establish angular registration between two objects.

These and further objects, features and advantages of the invention will become more apparent as the description of the preferred embodiment proceeds with continued reference to the drawings wherein:

FIG. 1 is a schematic representation of a wafer mask registering device incorporating the invention;

FIG. 2 is a bottom plan view taken along line 2—2 of FIG. 1 showing the preferred embodiment of the driving apparatus;

FIG. 3 is a view taken along line 3—3 of FIG. 2 showing a slip clutch assembly;

FIG. 4 is a view taken along line 4—4 OF FIG. 2 showing a drive motor and flexible shaft used in the preferred embodiment; and

FIG. 5 is a diagrammatic representation of the electrical circuitry of the invention.

Referring initially to FIG. 1, a wafer-to-mask alignment device 10 of the type manufactured by Photo-Lithographic Products, a division of Kulicke and Soffa Industries, Inc., under model number 686, is shown as including a mask holder 12 for securely mounting a mask 14 in a generally horizontal plane and a rotatable turntable 16 upon which two wafers 18 are securely mounted on chucks 20 as by a vacuum lock. The turntable 16 is parallel to the mask 14, and is rotatably mounted on a mounting shaft 17 (FIG. 2) journaled for rotation through an underlying turntable mounting plate 22. A turntable drive shaft 24 having a manual knob 26 at its outer end passes under the mounting plate 22, which shaft 24 may be either manually rotated or automatically rotated by an underlying driving apparatus indicated generally at 28.

The driving apparatus 28 for the turntable 16 is best seen with references to FIGS. 2, 3 and 4 wherein a turntable worm wheel 30 secured to the lower end of the turntable mounting shaft 17 is shown in meshing engagement with a turntable worm 32. The worm 32 is in turn fixedly secured to the turntable drive shaft 24 by any one of many conventional means such as a key. The drive shaft 24 is journaled for rotation on the bottom of the turntable mounting plate 22 between a bearing 34 mounted on a bracket at the inner end of the shaft on a bearing 36 provided in a slip clutch assembly generally indicated at 38. The manual knob 26 is secured to the outer end of the turntable shaft 24.

The discussion will now focus on the slip clutch assembly 38 as best seen in FIG. 3. A frictional collar 40 is fixedly secured to the drive shaft 24 as by a set screw 42 adjacent the slip clutch bearing 36 with its frictional surface 44 disposed inwardly away from the bearing. A driven worm wheel gear 46 is mounted for free rotation on the shaft 24 immediately adjacent the frictional surface 44. To provide the axial force necessary to engage the worm gear 46 with the friction face 44 and hence with the shaft 24, a coil spring 48 is disposed around the shaft to bear against the opposite side of the driven gear 46 from the frictional surface and is compressed against the driven gear 46 by a compression member or collar 50 fixedly secured to the shaft as by a set screw 52. The spring 48 is separated from the worm gear 46 and from the spring collar 50 by layers of antifriction material 54, 56 such as Teflon. The spacing between the collar 50 and the worm gear 46, and hence the compression of the spring 48, is determined by an adjusting screw 58 which is threaded through a collar 60 fixedly secured to the drive shaft 24 again as by a set screw 62. To further insure that the adjusting screw collar 60 is maintained in a fixed axial position on the shaft, that collar is positioned in a reduced diameter shoulder 64.

Referring now to FIG. 4, the worm gear is driven by an electrical step motor 66 mounted below the turntable through a flexible drive shaft 68 having at least one and preferably two or more, flexible couplings 70. A driving worm gear 72 is secured to the outer end of the flexible drive shaft 68 and is maintained in meshing engagement with the driven worm gear 46 by journaling the drive shaft through appropriate bearings 74 mounted in a bracket 76 secured to the bottom of the mounting plate 22.

The discussion will now focus on the energizing circuitry for the motor 66 with reference to FIG. 5 which illustrates in block diagram form an electrooptical, light balanced, null seeking, incremental movement mask-to-wafer alignment system. The purpose of the system is to align the semiconductor wafer 18 to mask 14 which is superposed on and in contact with the wafer. To accomplish this, the wafer has printed thereon a target 78, portions of which are visible in FIG. 5 through mask apertures 80.

The target 78 has a different light reflection characteristic from the surrounding background areas of the wafer 18. Thus, when the mask-wafer combination is illuminated by light from source 82, the amount of light reflected back through the mask apertures or windows will be a function of the relative amounts of the target and wafer background that are visible through the windows. It will be appreciated than when the

mask and wafer are aligned, as shown in FIG. 5, equal amounts of reflected energy will be transmitted through the mask windows 80. The reflected light from each mask window is optically coupled to corresponding photodetectors 84. The optical coupling of the reflected light is indicated representationally in FIG. 5 by the light path lines 86.

Two separate mask-to-wafer target alignment stations are employed to obtain the necessary positioning information to actuate the incremental movement drive system, X, Y and θ motors 88, 91 and 66, respectively. The outputs from photodetectors 84 are amplified by amplifiers 90 and inputed to the appropriate X, Y or θ processors 92, 94 and 96, respectively, which perform the following combinational signal processing:

$E_X = \mathrm{Sgn}\,(X_{1+}+X_{2+}-X_{11}-X_{21})$

$E_Y = \mathrm{Sgn}\,(Y_{1+}-Y_{2+}-Y_{11}-Y_{21})$

$E_\theta = \mathrm{Sgn}\,(Y_{1+}+Y_{21}-Y_{11}-Y_{2+})$ where the first subscript represents the Station Number and the second subscript represents the sign of the photodetector and where E_X, E_Y and E are the outputs from the respective processors.

The E_X, E_Y and E_θ error signals from the corresponding processors are amplified by amplifiers 98 and applied as drive signals to the X, Y and θ motors which incrementally step the wafer with respect to the mask in the appropriate X, Y and θ directions. When the mask and wafers are properly aligned with respect to each other, the signal outputs from the X, Y and θ processors are zero.

In certain situations it may be desirable to initially actuate one or more of the three motors 88, 91 and 66 by manual control. Accordingly, a source of suitable drive signals 100 is provided to permit manual control of each motor individually.

Since the targets are rarely circular, registration must be carried out to bring them into alignment with respect to the three major axis. Planar adjustment, i.e., adjustment relative to horizontal plane, is carried out with the motors 88 and 91 in a manner described in my copending application for AUTOMATIC PLANAR REGISTRATION ASSEMBLY AND DRIVING APPARATUS THEREFOR. The flexible drive shaft 68 enables the gears 46 and 72 to remain meshed during any planar movement of the turntable 16. This invention relates to angular registration of the wafer and mask targets in relation to the theta or vertical axis. The operator first manually brings the targets into rough angular register by turning the knob 26 which in turn causes the turntable worm wheel 30 to rotate to cause an angular displacement of the turntable 16. In order to maintain the driving gear 72 in meshing engagement with the driven gear 46 during such manual adjustment, it is necessary that the frictional lock between the friction face 44 and the driven gear 46 be overcome by such manual rotation. To this end, the amount of compression of the spring 48 should be small enough so as to exert a sufficiently small force to create a manually disengageable friction lock between the clutch and worm gear.

After the manual adjustment has been accomplished, the operator turns on the automatic aligning system which in turn energizes the motor 66 with the photoelectrically derived off-register signals. Thus, the frictional lock between the clutch and driven worm gear should be such as to withstand the torque exerted on the drive shaft 24 as a result of the meshing engagement of the gears 30 and 32 and the inertial and frictional load of the motor drive so that the clutch assembly 38 will not slip when the shaft 24 is being driven by the motor 66.

It should thus be apparent that when the coil spring 48 has been compressed to apply the requisite amount of pressure on the driven gear 46, the drive shaft 24 may be manually rotated to cause the frictional connection between the friction face 44 and driven gear 46 to slip, thereby enabling the operator to manually rotate the drive shaft 24 without disengaging the motor 66 from the shaft 24. The Teflon spacers 54 and 56 enable the coil spring to slip during such manual rotation so that the spring 48 does not wind up during manual adjustment. Such manual adjustment may be accomplished with a great deal of ease since the operator does not operate against the action of the motor 66. Thus, the driving and driven gears 72 and 46 need not be disengaged during manual operation and the motor 66 is not backdriven during such rotation.

Having thus described the preferred embodiment of the invention for illustrative purposes, it is my intention to cover all modification and equivalents thereof which fall within the spirit and scope of the appended claims.

I claim:

1. In a system for positioning a movable object in a preselected translational and rotary orientation with respect to first and second coordinate axes, a rotary drive system comprising:

means responsive to the position of the movable object for producing an off-register signal in response to and representative of the angular offset between the object position and the preselected rotary orientation;

a first driving means responsive to said off-register signal generating means;

a rotatable shaft mechanically coupled to said movable object to rotate the movable object into the preselected rotary orientation;

a driven gear mounted for free rotation on said shaft and mechanically coupled to said first driving means to rotate said shaft in response to actuation of said first driving means;

a friction member nonrotatively mounted on said shaft having a friction surface disposed toward said driven gear;

means for urging said driven gear against said friction surface to create a frictional locking force therebetween greater than the loading torque exerted on said shaft; and,

a second driving means for rotating said shaft with a torque greater than the friction locking torque and said loading torque, whereby angular orientation may be accomplished alternately by actuating said second driving means or automatically by coupling said signal generating means and said first driving means.

2. The device of claim 1 in which said second driving means comprises a manually turnable member secured to said shaft to provide manual registering capability.

3. The device of claim 1 in which said resilient means comprises: a compression member and a collar mounted on said shaft on the opposite side of said driven gear from said friction surface, said compression member being secured to the said shaft; a coil spring compressed between said driven gear and said collar and means for adjusting the axial position of said collar on said shaft to provide a fine adjustment for the compressive force exerted by said spring.

4. The device of claim 3 which further includes antifriction means disposed between said spring and said compression member and in which said driven gear comprises a worm gear.

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(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,604,546 Dated September 14, 1971

Inventor(s) Gordon Willis

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, lines 16-18 should be changed to read as follows:

$$E_X = \text{Sgn}\ (X_{1+} + X_{2+} - X_{1-} - X_{2-})$$

$$E_Y = \text{Sgn}\ (Y_{1+} + Y_{2+} - Y_{1-} - Y_{2-})$$

$$E_\theta = \text{Sgn}\ (Y_{1+} + Y_{2-} - Y_{1-} - Y_{2+})$$

line 21, "E" should be changed to read-- E_θ --;

Signed and sealed this 4th day of April 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents