July 15, 1969 R. W. THOMAS ET AL 3,455,067

LAPPING DEVICE

Filed June 21, 1967 2 Sheets-Sheet 1

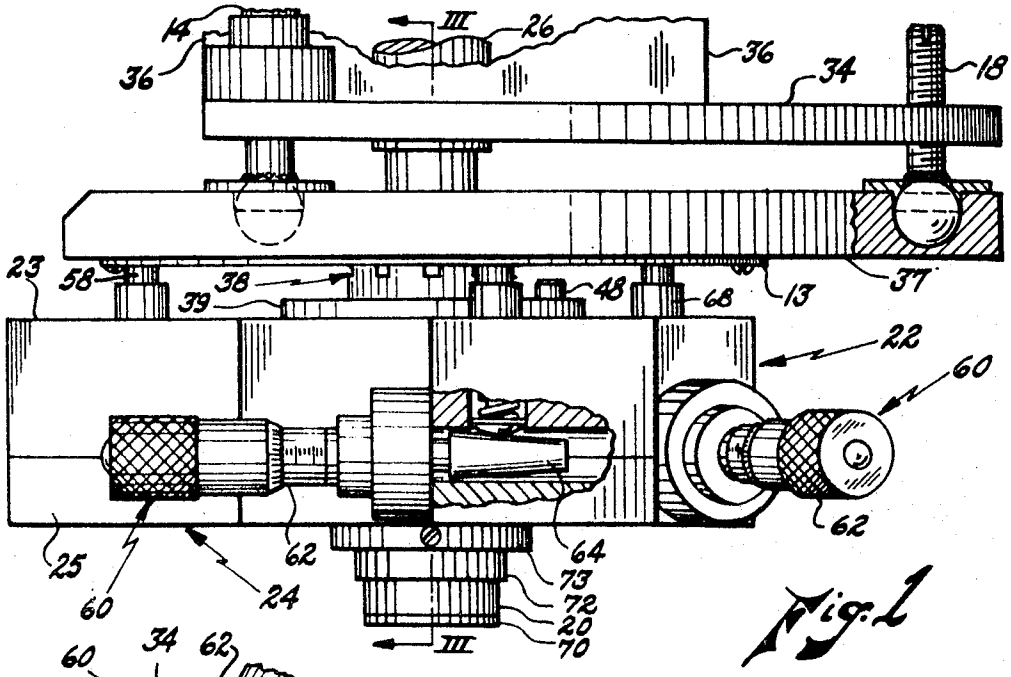

Fig. 1

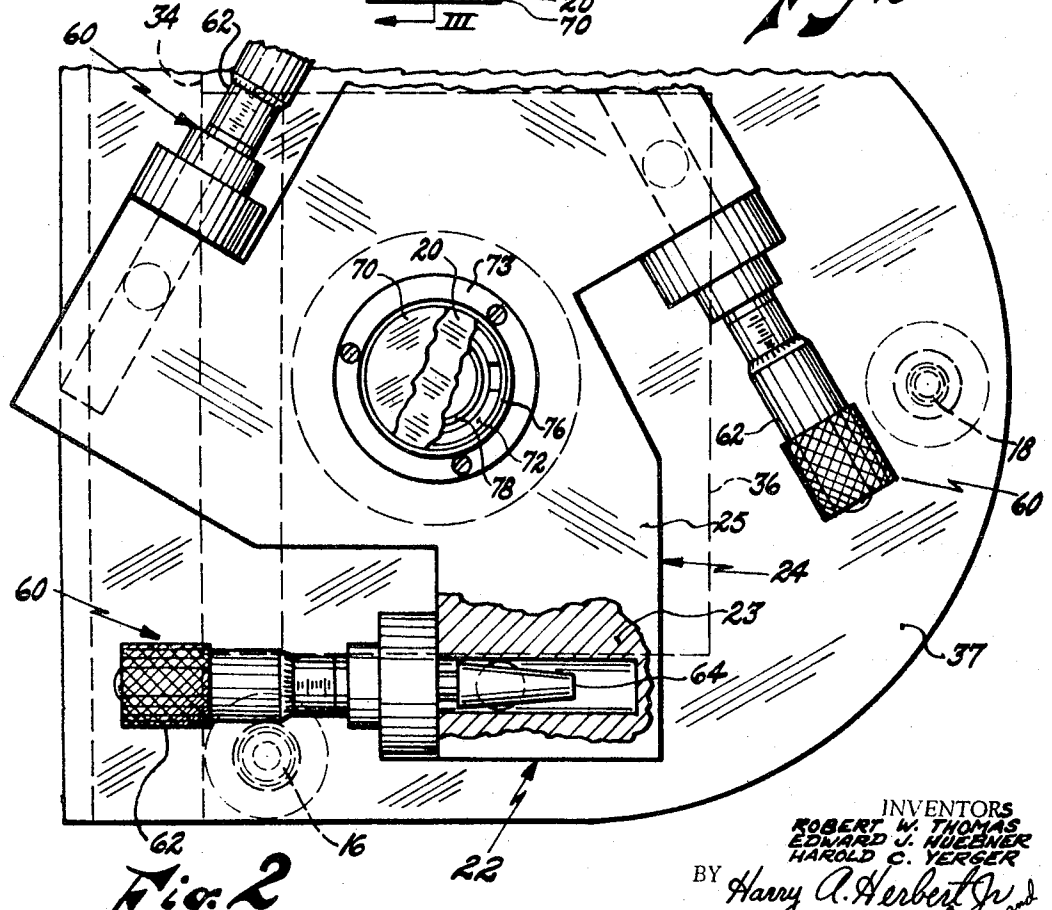

Fig. 2

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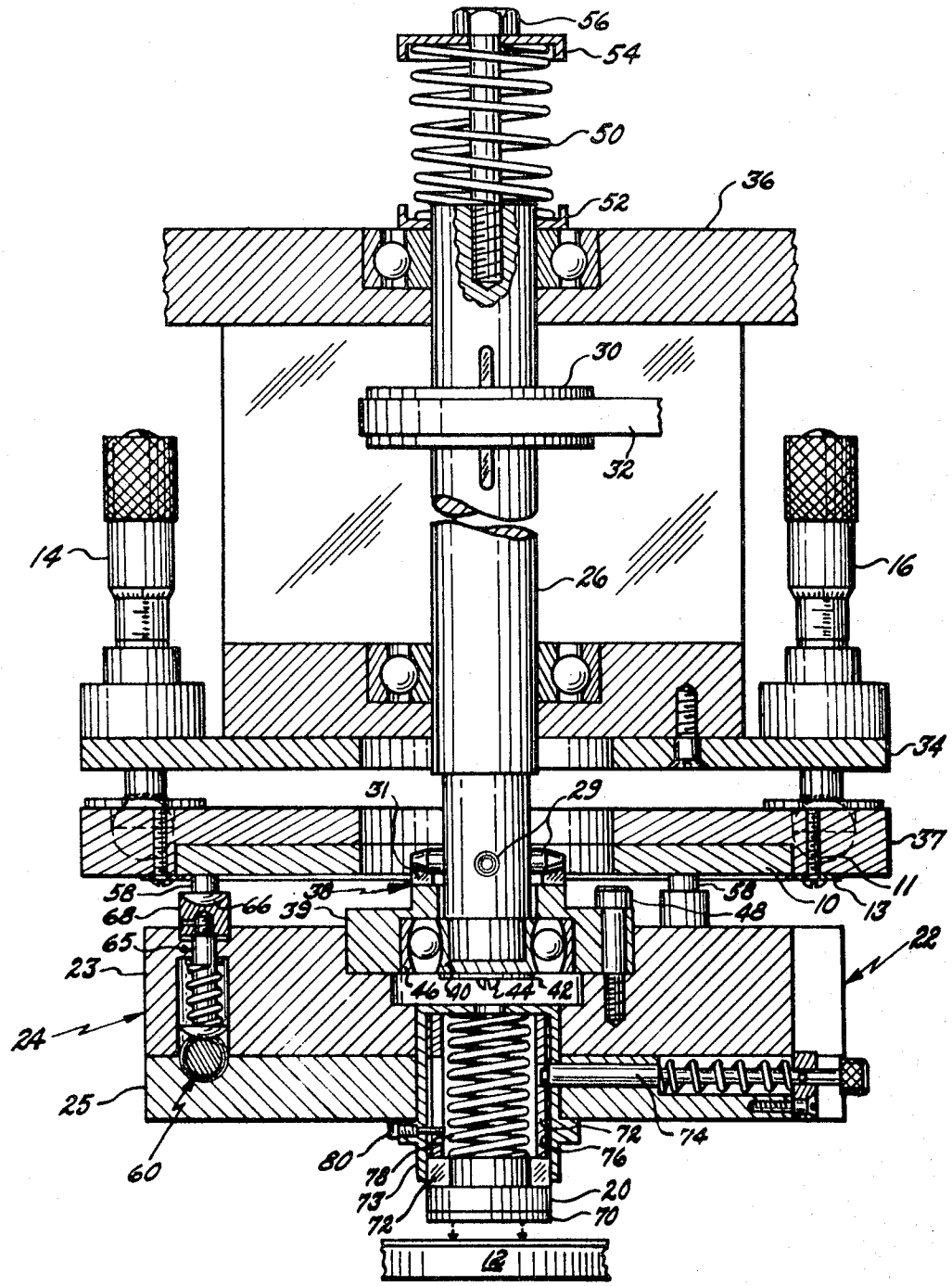

Fig. 3

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LAPPING DEVICE

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U.S. Cl. 51—237 10 Claims

ABSTRACT OF THE DISCLOSURE

A lapping device particularly suited for lapping flat surfaces having an adjustable reference plate and a three point micrometer adjustable platform for holding a wafer to be lapped.

The present invention relates generally to lapping devices, and more particularly, to a device adapted for lapping objects having flat surfaces to within extremely close tolerances.

Lapping may be defined as "precision finishing with abrasive." Specifically, the process, which is performed by hand or machine, improves the geometric accuracy of flat surfaces and holes and refines the surface finish. Lapped surfaces are often required to obtain longer wear of moving parts, to obtain better seals, or to obtain longer life of cutting edges, as in dies.

Modern lapping machines have made possible the quality production of parts, the cost of which would have been prohibited by the old hand-lapping method. Industrial requirements demand lapping machines arranged to use three types of lapping mediums. One uses metal laps and loose abrasive grain mixed with a lubricant and will always find a place in the field of gage manufacture, or for other operations where extreme accuracy is required. Another type of machine uses bonded abrasives for commercial production work. A third and more recent type of machine employs abrasive paper or cloth instead of cast-iron or bonded abrasive sticks. A very bright finish is obtained and a genuine lapped surface is produced.

In lapping flat surfaces, which are usually on hardened steel, a cast-iron plate is used as a lap, with a good abrasive. For rough work or "blocking down," the lap works better if scored with narrow grooves, both lengthwise and crosswise, thus dividing the plate into small squares. The abrasive is sprinkled loosely on the block, wet with lard oil and the work rubbed on it; care is taken to press hardest on the highest spots. The abrasive and oil get into the grooves and are continually rolling in and out, getting between the plate and the work, and are crushed into the cast-iron, thus charging it thoroughly in a short time.

After blocking down, or if the work has first been ground on a surface grinder, the process is different. A plain plate is used with the best quality of flow of emery as an abrasive. Instead of oil, benzene is used as a lubricant, and the lap should be cleaned often and fresh benzene and emery applied as often as it becomes sticky. The work should be tried from time to time with a straight edge and care taken not to let the emery run in and out from under the work, as this will cause the edges to abrade more than the center and will especially mar the corners.

Some shops grind flat work to within 0.0005 inch of size and lap to within 0.0002 inch on a tight-metal lap charged with flour emery.

In the past it has been difficult to produce a finished surface flat to a tolerance of better than 0.0002 inch. Such a tolerance is insufficient to accommodate the fits necessary in the industrial demands of today.

The lapping machine and control system of this invention have solved a major problem in the fabrication of an

advanced microelectronic circuit. In this operation, it is necessary to lap a crystalline silicon wafer to extremely close tolerances. The machine makes practical a fabrication process developed commercially, but abandoned because of the mechanical lapping control problems.

It is, therefore, the primary object of this invention to lap flat surfaces. More particularly, it is the object of this invention to produce a finished flat surface to better than 0.00001 inch over a one-inch diameter wafer with lapping angle adjustments in increments of less than 0.0001 inch.

A further object of this invention is to produce a lapping machine which has little or no wear between the surfaces used to establish the reference plane during the lapping operation.

Another object of this invention is to have a reference plane which is adjustable and which can be positioned exactly parallel to the lapping wheel.

Still another object of this invention is to produce a lapping device which has the ability to adjust the rotating wafer holder with three degrees of freedom.

It is still another object of this invention to provide a lapping device which is economical to produce and utilizes conventional, currently available components that lend themselves to standard mass production manufacturing techniques.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

In the drawing:

FIGURE 1 is an elevation view of the invention;

FIGURE 2 is a bottom view of the invention; and

FIGURE 3 is a cross sectional view of the invention taken mainly along vertical center line III—III of FIGURE 1 and diverted to encompass a section through the ball bearing assembly.

The lapping system, as conceived by the inventors, embodies a three point micrometer adjustable reference plate **10** (shown in FIGURE 3) made of steel or other suitable material, and mounted in a first support **37** by means of any suitable mounting means such as annular retaining ring **13** and screws **11**. The reference plate **10** can be adjusted parallel to the surface of a rotating lapping wheel **12**. These adjustments are made with two micrometers **14** and **16** and a screw **18** (shown in FIGURES 1 and 2) operably connected between the first support **37** and a second support **34**. The support **34** along with a third support **36** rigidly support the lapping device above the lapping wheel **12**.

The reference plate **10** is hand-lapped on a glass plate using a silicon carbide grit (not shown) until an optically flat surface is obtained. This reference plate **10** is then used as an absolute reference for all future lapping operations It is, of course, possible to obtain a cone shaped lap by adjusting the reference plate **10** out of parallelism with the lapping wheel **12** by means of micrometers **14** and **16** and screw **18**.

The substrate mounting assembly **22** comprises of a rotating, three point, micrometer adjustable platform **24** (made of two plates **23** and **25**) which is driven from above by a shaft **26** and a pin arrangement (shown in FIGURE 3). The shaft **26** is driven by means of a pulley **30** and belt **32** from a motor (not shown). If desired, the motor may be directly coupled to the shaft.

The pin arrangement comprises of a plurality of pins **29** fixedly mounted on shaft **26** and in inter-engagement with slots **31** of self-aligning ball bearing assembly **38**, although any other suitable connection may be used between the shaft **26** and the platform **24**.

The pin arrangement allows tilting of the platform **24** about the self-aligning ball bearing assembly **38**. The

inner bearing race **40** of the ball bearing assembly is attached to the drive shaft **26** by means of any suitable means such as a washer **42** and a screw **44**. The outer bearing race **46** is attached to a drive flange **39** which is secured to the rotating platform **24** by any conventional securing means such as bolt or bolts **48**.

The platform **24** is spring loaded against the reference plate **10** by means of spring **50** (shown in FIGURE 3). Spring **50** bears against washer **52** mounted on fixed support **36** and washer **54** mounted on shaft **26** and is held in place by means of bolt **56**. The platform **24** rides on three Teflon feet **58** which are adjustable by at least three platform micrometer tilting assemblies **60** (shown in FIGURE 1). Each micrometer tilting assembly **60** consists of a micrometer **62**; a tapered spindle **64** which positions the top of Teflon feet **58** at the desired distance from the platform **24**; a spring biased socket support **65** and a socket **68** (shown in FIGURE 3). The micrometer **62** and tapered spindle **64** are designed to give one thousandth vertical travel for every complete revolution of the micrometer. The Teflon feet **58** are designed with balls **66** which fit in sockets **68** to allow vertical adjustment of one reference foot without changing the distance to reference plate **10** of the other two reference points.

Before the wafer **70** is mounted on the wafer holder **20**, the flatness of the holder is checked with a Taylor-Hobson-Talysurf with an aboslute accuracy of 0.000001 inch. The wafer **70** is mounted on the wafer holder by shellac or other suitable adhesive. The wafer holder **20** with wafer thereon is inserted into a spring loaded center cylinder **72**, while the cylinder is held in the up position by a spring biased pin **74**. Once the holder **20** is inserted, it is secured to the cylinder **72** by any conventional means such as a bayonet-type fastening arrangement and given a twist with a mounting wrench (not shown). The pin **74** is then retracted and the holder **20** and wafer **70** are lowered to the lapping wheel **12** (see FIGURE 3).

A specially designed Teflon sleeve **76** is used to maintain a zero tolerance press fit between the spring loaded cylinder **72** and the housing **73**. The lapping force can be adjusted by changing the spring **78** used within the cylinder **72**. In order to remove the cylinder **20** from the substrate assembly **22**, a safety pin **80** must first be removed.

A typical operation of the machine will now be described; initially the hand-lapped, optically flat reference plate **10** is inserted into the first support **37** and fastened in place by retaining ring **13** and screws **11**. The reference plate **10** is now adjusted parallel to the surface of the rotating lapping wheel **12** by means of micrometers **14**, **16** and screw **18**. The wafer **70** to be lapped is mounted on a wafer holder **20**. The flatness of the holder **20** was previously checked with an absolute accuracy of 0.000001 inch. The wafer holder **20** with wafer **70** thereon is inserted into spring loaded center cylinder **72**, while the cylinder is held in the up position by spring biased pin **74**. Once the holder **20** is inserted, it is given a twist with a mounting wrench (not shown) to secure the holder **20** to the cylinder **72**. The substrate mounting assembly **22**, containing the wafer **70** to be lapped, is adjusted by means of the three point micrometer adjustable platform **24**. The pin **74** is then retracted and the holder **20** with wafer **70** thereon is lowered to the lapping wheel. If desired the lapping force can be adjusted by changing the spring **78** inside cylinder **72**.

Although the invention has been described with reference to a particular embodiment, it will be understood to those skilled in the art that the invention is capable of a variety of alternative embodiments within the spirit and scope of the appended claims.

What is claimed is:

1. A lapping device comprising a first support, a reference plate mounted on a second support, a driven shaft operably positioned through said supports and rotatably mounted on a third support, pin means mounted at one end of said shaft, a substrate mounting assembly operably connected to said pin means and a holder mounted on said substrate mounting assembly for holding a wafer to be lapped.

2. A lapping device as defined in claim **1** wherein said reference plate is adjustable.

3. A lapping device as defined in claim **1** wherein said substrate mounting assembly is adjustable.

4. A lapping device as defined in claim **2** further comprising at least a pair of micrometers and a screw operably connecting said first support to said second support in order to adjust said reference plate.

5. A lapping device as defined in claim **1** further comprising spring means for biasing said substrate mounting assembly against said reference plate.

6. A lapping device as defined in claim **5** wherein said substrate mounting assembly comprises a platform operably connected to said pin means, at least three adjustable micrometers mounted in said platform and said pin means adapted to allow for the tilting of said platform when said micrometers are adjusted.

7. A lapping device as defined in claim **6** wherein said pin means comprises a plurality of pins mounted on said shaft and in inter-engaging relationship with a self-aligning ball bearing assembly operably connected between said shaft and said platform.

8. A lapping device as defined in claim **4** further comprising spring means for biasing said substrate assembly against said reference plate.

9. A lapping device as defined in claim **8** wherein said substrate mounting assembly comprises a platform operably connected to said pin means, at least three adjustable micrometers mounted in said platform and said pin means adapted to allow for the tilting of said platform when said last mentioned micrometers are adjusted.

10. A lapping device as defined in claim **9** wherein said pin means comprises a plurality of pins mounted on said shaft and in inter-engaging relationship with a self-aligning ball bearing assembly operably connected between said shaft and said platform.

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