

[54] **SEMI-CONDUCTOR WAFER PROCESSING APPARATUS**

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198/148; 248/224; 95/89 D

[56] **References Cited**

UNITED STATES PATENTS

3,641,906	2/1972	Orr	95/89 D
1,625,163	4/1927	Schurr	248/224

3,344,904 10/1967 Kocian..... 198/131

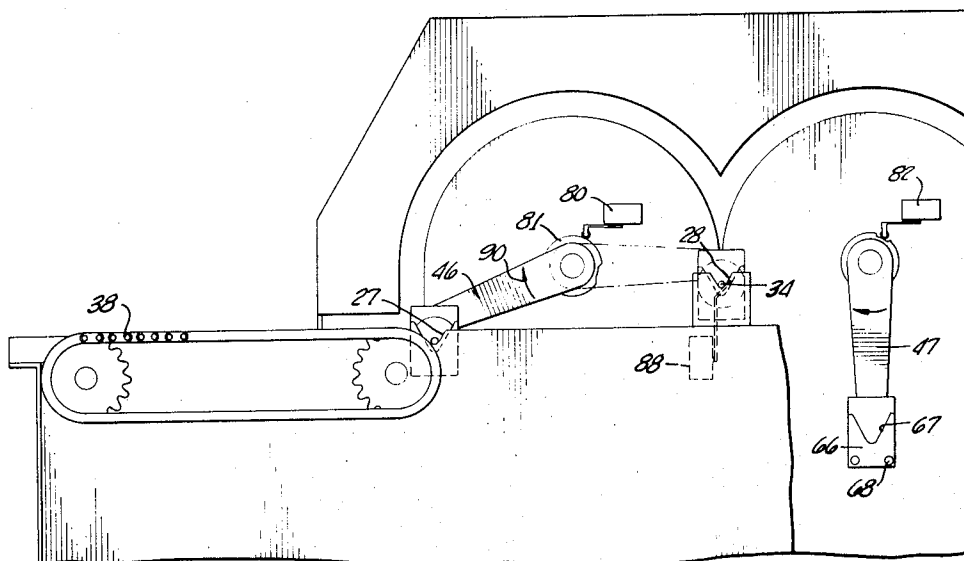
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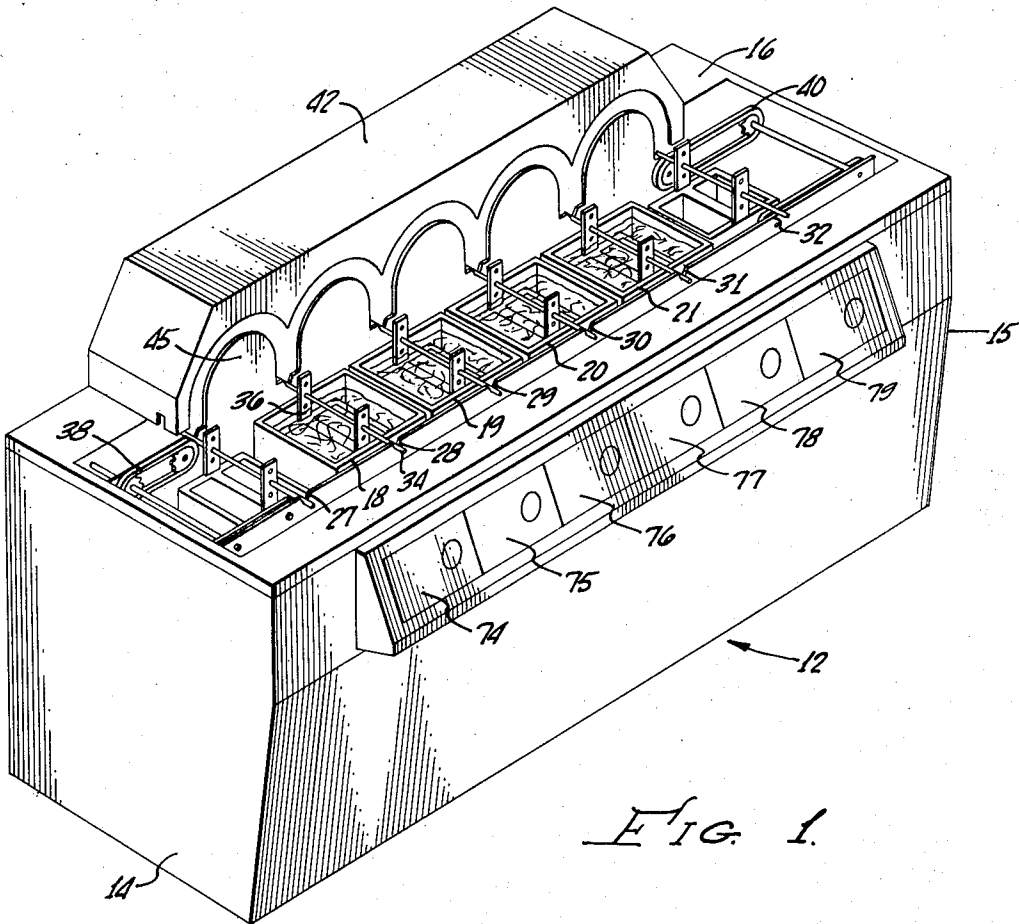
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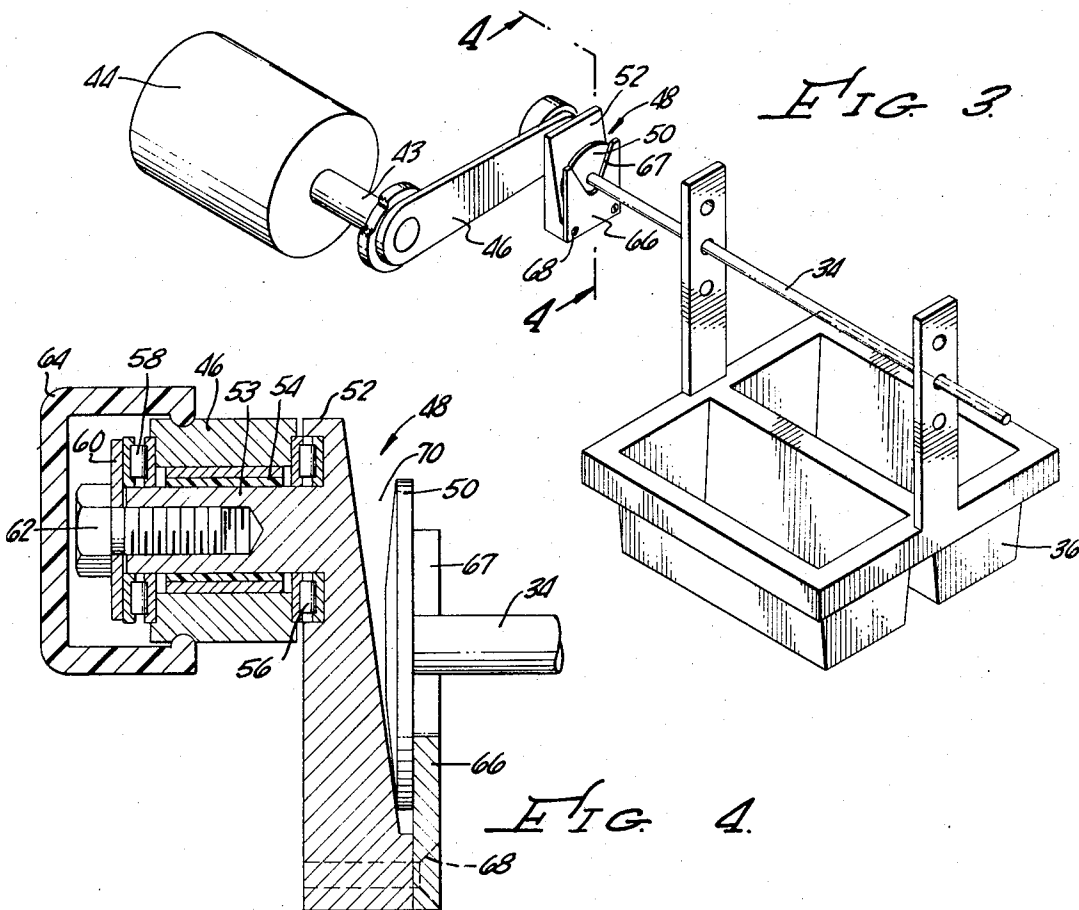
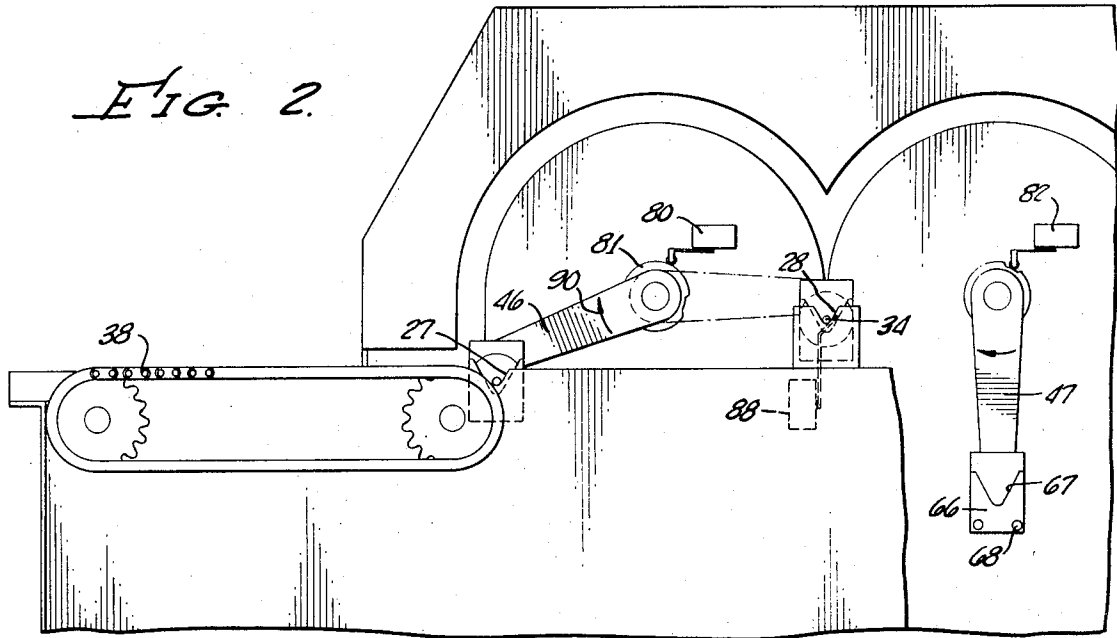
ABSTRACT

A series of transfer mechanisms automatically move a basket of wafers through a series of processing stations as determined by a timer control. Each mechanism includes a cradle pivotally mounted on a rotating arm and aligned to engage a disc mounted on the end of a rod which supports a basket of wafers. As the arm is rotated, the cradle is moved beneath the disc causing the disc to be received and gripped by the cradle so that the disc and basket are moved in cantilever fashion to the next work station. Continued rotation of the arm withdraws the cradle from the disc.

11 Claims, 4 Drawing Figures







SEMI-CONDUCTOR WAFER PROCESSING APPARATUS

This invention relates to apparatus for automatically processing semi-conductor wafers and particularly relates to an improved means for transferring a batch of wafers from one processing station to the next.

In U. S. Pat. No. 3,641,906, entitled "Developing Apparatus" there is disclosed a mechanism for transferring a tray of photographic plates wherein a pair of crank arms are rotatably mounted at opposite ends of a rod from which the tray is suspended. As the crank arms are rotated, they engage the opposite ends of the rod to lift the rod and the tray or basket from one tank to the next as the crank arms are moved about 180°.

The present invention improves that apparatus by eliminating the crank arms along one side of the processing station. Instead, means are provided on the crank arms on one side to grip a rod supporting a tray or basket in cantilever fashion and move it from one station to the next. This results in considerable cost saving due to the elimination of parts and also provides easier access to the processing tanks on the side of the tanks or stations which does not have the transfer mechanism.

In a preferred arrangement, a small disc is mounted on one end of the rod from which the work is suspended, and a cradle is pivotally supported on a crank or transfer arm which includes an upwardly opening slot for releasably gripping the disc with a wedging action to obtain the cantilever support arrangement. Preferably, the faces of the disc and the walls of the cradle defining the slots are sloped in a manner to insure positive gripping while facilitating entry of the disc into the slot and release of the disc from the slot.

For a more thorough understanding of the invention refer to the following detailed description and drawings in which:

FIG. 1 is a perspective view of the overall wafer processing apparatus;

FIG. 2 is a side elevational, partly schematic view of a portion of the apparatus of FIG. 1;

FIG. 3 is a perspective view of the transfer mechanism; and

FIG. 4 is a cross-sectional view of the cradle and the end of the transfer arm taken on line 4—4 of FIG. 3.

Referring to FIG. 1, the processing apparatus of the invention is conveniently housed in a single cabinet 10 having a front wall 12, end walls 14 and 15, and a top wall 16. A series of processing tanks 18, 19, 20 and 21 are positioned within the cabinet open to and accessible from the top wall 16. Support structure having pairs of V-shaped notches is positioned alongside the tanks to define a series of work stations or processing stations 28, 29, 30 and 31 for each of the tanks. Similar notched support structure defining a feed station 27 is positioned adjacent the cabinet end 14. Also support structure is located near the cabinet end 15 to define a discharge station 32.

As can be seen, a rod 34 may be supported in the notches at each of the support stations and a basket 36 is suspended from the rod. The support rod 34 and the basket 36 may be better seen in FIG. 3. To accommodate an additional basket waiting to be processed, there is provided a pair of feed chains 38 leading to the feed station 27. A similar pair of discharge chains 40 are located adjacent the discharge station 32.

Within a housing 42 located on the top wall 16 to the rear of the processing tanks are a series of motors 44, one of which is shown for illustration in FIG. 3. A motor is positioned with its shaft aligned behind each of the motor shields 45 shown in FIG. 1, so that a motor shaft is midway between each of the work stations. Referring to FIG. 3, it may be seen that a crank arm 46 has one end mounted on the motor shaft 43 in a manner such that the crank arm 46 moves in a plane perpendicular to the motor shaft, such plane also being perpendicular to the basket support rod 34. Pivotally mounted on the other end of the crank arm 46 is a cradle 48 which receives a disc 50 mounted on the end of the rod 34.

Referring to FIG. 4 as well as to FIG. 3, it may be seen that the cradle 48 includes a back plate 52 having a stub shaft 53 which is rotatably or pivotally mounted by sleeve bearing 54 on the end of the crank arm 46. Suitable face bearings 56 extend between the backside of the back plate 52 and the crank arm 46. Similar face bearings 58 extend between the backside of the crank arm and a retaining element 60 which is secured to the crank arm by a threaded fastener 62. A cap 64 extends over the fastener and the adjacent bearings to help protect them from fumes and dust.

The cradle 48 further includes a front plate 66 which is attached at its lower end to the lower end of the back plate 52 by a pair of suitable threaded fasteners 68. The plate 66 has a V-shaped notch 67 formed in its upper surface to guide the rod 34 as the disc is received in its cradle. As can be seen, the backside of the front plate 66 and the front side of the back plate 52 together define an upwardly opening slot 70 having a modified V-shaped cross-section. The plate walls defining the slot 70 converge downwardly to a cross-section smaller than the edge of the disc 50, and they diverge at the upper open end of the slot 70 to a dimension considerably greater than the disc edge. This facilitates receiving the disc 50 in the slot 70.

The backside of the front plate 66 is substantially vertically oriented while the front side of the back plate 52 is angled with respect to the vertical to form the converging, diverging relation described. It may also be seen from FIG. 4, that the front or inner side of the disc 50 is completely vertical to mate with the backside of the plate 66, while the backside of the disc tapers from the edge of the disc to a thicker central area. Thus, the disc actually has a flattened, slightly frusto-conical cross-section. Note, however, that the taper of the backside of the disc is at a sharper angle than the angle of the front wall of the back plate 52 of the cradle. Thus, when the disc is positioned as shown in FIG. 4, only the lower end of the disc is wedged in the cradle. This facilitates releasing the disc from the cradle.

The operation of the motors 44 and the feed and discharge chains 38 and 40 is controlled by a series of timers 74—79. Also included in the control circuitry is a switch 80 schematically shown in FIG. 2 as being operated by a cam 81 on the crank arm 46. A similar switch 82 is shown for the adjacent crank arm 47, and the other crank arm operates similar switches (not shown). When the rod 34 is positioned at station 28, it operates a switch 88 and similar switches (not shown) are provided at the work stations 27 and 29 through 32 to be actuated by the presence or absence of a support rod 34. Various additional known circuitry details may be employed to obtain the desired sequence of transfer-

ring. An example of one suitable arrangement is illustrated in the aforementioned U. S. Pat. No. 3,641,906.

In operation, each tank is filled with an appropriate processing fluid. For example, in treating semiconductor wafers, the tank 28 is filled with sulphuric acid, the tank 30 with hydrofluoric acid, and the tanks 29 and 31 with de-ionizing water rinses. The desired duration of processing at each station is selected on the associated timer. A quantity of semi-conductor wafers to be processed are positioned within a basket 36 with a rod 34 extending through its handle as shown in FIG. 3. The basket is positioned in a space between the two feed chains 38 with the rod 34 supported on the feed chains. Assuming there is no rod at the feed station 27, the switch at that location will be closed causing the feed chains 38 to move the basket to the feed station 27. The presence of the rod 34, in the feed station 27 will open the switch to deenergize the movement of the feed chains 38.

When it is desired that a basket 36 be moved from the feed station 27 to the first processing station 28, as determined by the timer 74 and the operator, the motor 44 is energized causing the crank arm 46 to move from a rest position, such as that shown for the crank arm 47, and lift the rod 34 and its basket 36 and move it through an arcuate path to the first processing station 29. More specifically the motor shaft 43 is moved in a clockwise direction as indicated by the arrow 90 in FIG. 2, and the cradle 48 moves beneath the disc 50 on the rod 34 positioned at the feed station 27. As the cradle is moved upwardly while the arm rotates, the disc is received in the slot 70, as guided by the notch 67, and wedged in the cradle in the manner shown in FIG. 4, and the entire rod 34 carrying the basket 36 is lifted and moved in an arc approximately 180° to the station 28. As the rod is engaged by the notched supports at the processing station 28, the disc 50 is released from the cradle 48 upon continued rotation of the arm 46. When the arm reaches a certain position such as shown for the arm 47 in FIG. 2, the switch 80 is actuated by the cam 81, causing the arm 46 to stop.

Note that the bearings 54, 56 and 58 maintain the cradle 48 with the slot 70 opening upwardly due to the fact that the center of gravity of the cradle is below the shaft 53.

The presence of a rod 34 within the processing station 28, actuates the switch 88 to start the timer 75 which will measure the duration of time in which the basket is to be immersed within the tank 18 at the processing station 28. At the completion of the processing time in tank 18, the timer 75 will energize the motor for the transfer arm 47 to move the rod and basket to the work station 29. This process continues through the remaining stations until a basket eventually reaches the discharge chains 40. As the rod 34 is removed from station 28, the switch 88 is actuated, to energize the motor to once more rotate the arm 46 to move a new basket to the station 28.

What is claimed is:

1. Apparatus for processing semi-conductor wafers or similar items comprising:

- a basket containing said wafers;
- a series of tanks containing processing fluid for receipt of said basket;
- a support rod connected to said basket;

support means adjacent each of the tanks for supporting said rod from which said basket is suspended while it is within one of said tanks; and means for automatically transferring said basket from one of said tanks to the next by moving the support rod from one of said support means to the next, including a transfer arm mounted to be rotated adjacent one side of the tank in a plane generally perpendicular to the rod, and means on said arm for automatically releasably gripping one end of the rod to support the rod in cantilever fashion so as to lift the rod with said basket mounted thereon, and move it from one of said support means to the next.

2. The apparatus of claim 1 including a disc mounted on one end of said rod, and wherein said gripping means includes an upward opening slot for receiving said disc in a manner such that the disc is wedged into the slot as the gripping means is moved upwardly during rotation of the arm.

3. The apparatus of claim 2 wherein said slot is formed by a forward generally vertical wall which mates with a generally vertical face on the inner side of the disc, and the other slot wall is angled with respect to the vertical wall, said slot has a modified V-shape cross-section allowing the disc to be wedged into said slot when said slot walls are moved upwardly and said slot releasing the disc from said slot when the rod engages one of said support means and the gripping means is moved downwardly.

4. The apparatus of claim 3 wherein said gripping means includes guide means for receiving said rod as the disc is moved by said transfer arm into said slot.

5. The apparatus of claim 4 wherein said guide means comprise a V-shape notch opening upwardly to receive the rod.

6. Apparatus for transferring a load from a first work station to a second work station comprising:

- a rod supported at the first work station with the load suspended from the rod;
- a disc attached to one end of the rod generally perpendicular to the rod;
- a transfer arm mounted on one side of the first work station adjacent said one end of the rod for rotation in a plane generally parallel to the disc; and
- a cradle pivotally mounted on the arm and aligned to engage the disc as the arm is rotated, the cradle having means formed thereon to receive and grip the disc so that the rod is lifted in cantilever fashion as the arm is rotated and the cradle is moved upwardly into engagement with the disc, said cradle being adapted to release the disc when the rod is moved to the next station and the arm is rotated so as to move the cradle downwardly away from said next station.

7. The apparatus of claim 6 wherein said cradle includes means defining an upwardly opening slot for receiving the disc, the slot walls diverging in an upward direction for ease of receiving the disc as the cradle moves upwardly beneath the disc, and the slot walls converging in a downward direction so that the disc is automatically gripped by a wedging action as it is lifted by the cradle.

8. The apparatus of claim 7 wherein said cradle includes means defining an upwardly opening generally V-shaped notch for receiving and guiding the rod as the disc is received in the cradle slot.

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9. The apparatus of claim 6 wherein said cradle comprises a back plate having a stub shaft integral thereto which is pivotally mounted on said arm, a front plate having its lower end directly attached to the back plate, while the upper ends of the front and back plate are spaced to define a slot for receiving the disc.

10. The apparatus of claim 9 wherein the front side of the disc is generally vertical and the front wall of said slot as formed by the backside of the front plate is generally vertical to mate with the front wall of the disc, the backside of the disc has a slight taper such that the

disc edge is thinner than the center of the disc, the back plate is oriented with respect to the vertical wall of the front plate at an angle greater than the taper of the disc backside to facilitate the wedging of the disc into the cradle as the cradle is moved upward.

11. The apparatus of claim 9 including bearing means extending between the back plate and the rotating arm to facilitate pivotal movement of the cradle with respect to the arm as the arm is rotated.

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