

[54] **WAFER BASKET TRANSFER APPARATUS**

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[51] Int. Cl.² **F16H 25/14**

[58] Field of Search .. 214/1 BC, 1 BD, 1 BH, 1 BT,
214/147 T; 74/63, 69

[56] **References Cited**

UNITED STATES PATENTS

2,832,478	4/1958	Malewicz.....	214/1 BD
3,420,384	1/1969	Youngman	214/1 BD

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Assistant Examiner—George F. Abraham

Attorney, Agent, or Firm—James R. Haller; Palmatier,
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[57] **ABSTRACT**

A wafer basket transfer apparatus particularly useful for transferring baskets of wafers in the semiconductor processing industry from one processing bath to an adjacent bath. The apparatus includes a stationary frame plate to which is slideably mounted for vertical movement a slide plate. A lifting arm with a basket lifting hook at one end is rotatably driven at its other end by a motor. A cam and cam follower are respectively mounted on the slide and the frame plates, the cam rotating with the arm and having a cam edge non-symmetrical with respect to the axis of rotation of the arm. As the arm rotates with respect to the motor, the cam edge engages the cam follower to raise and lower the slide plate with respect to the frame plate, the free-swinging basket lifting hook describing a curved, vertically elongated closed path. The apparatus of the invention lifts a basket containing semiconductor wafers substantially vertically upwardly from one processing bath to a substantial height, and then deposits the basket substantially vertically downward into an adjacent bath.

9 Claims, 5 Drawing Figures

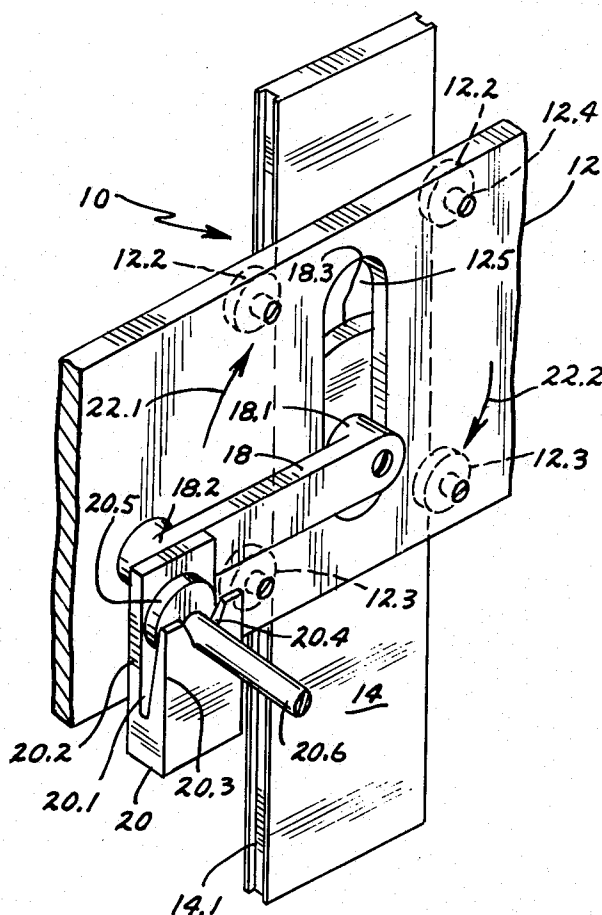


FIG. 1

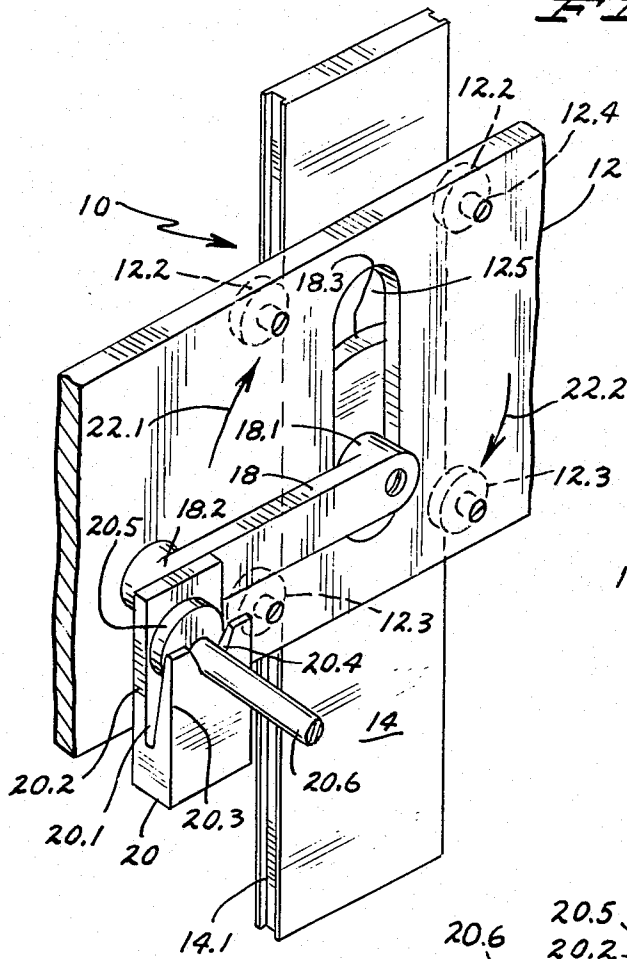
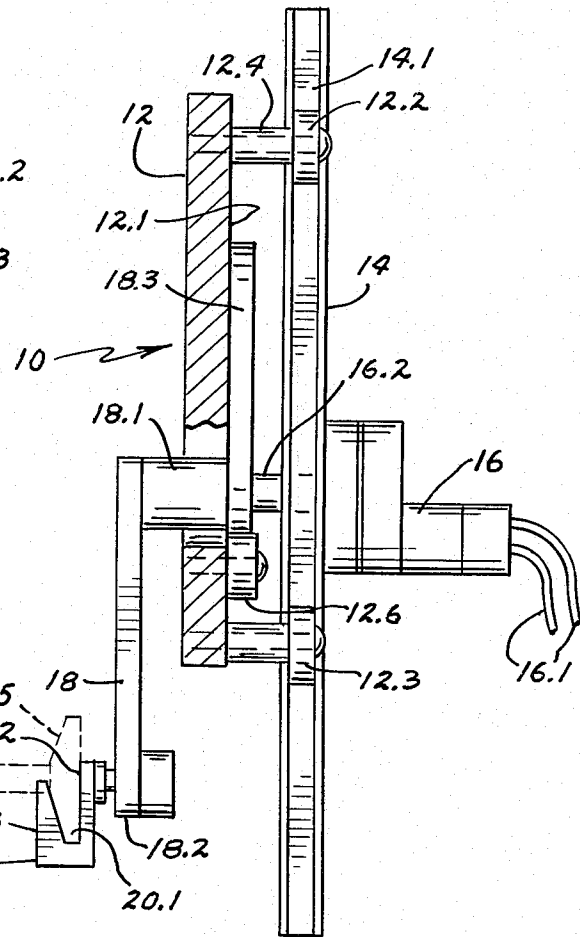
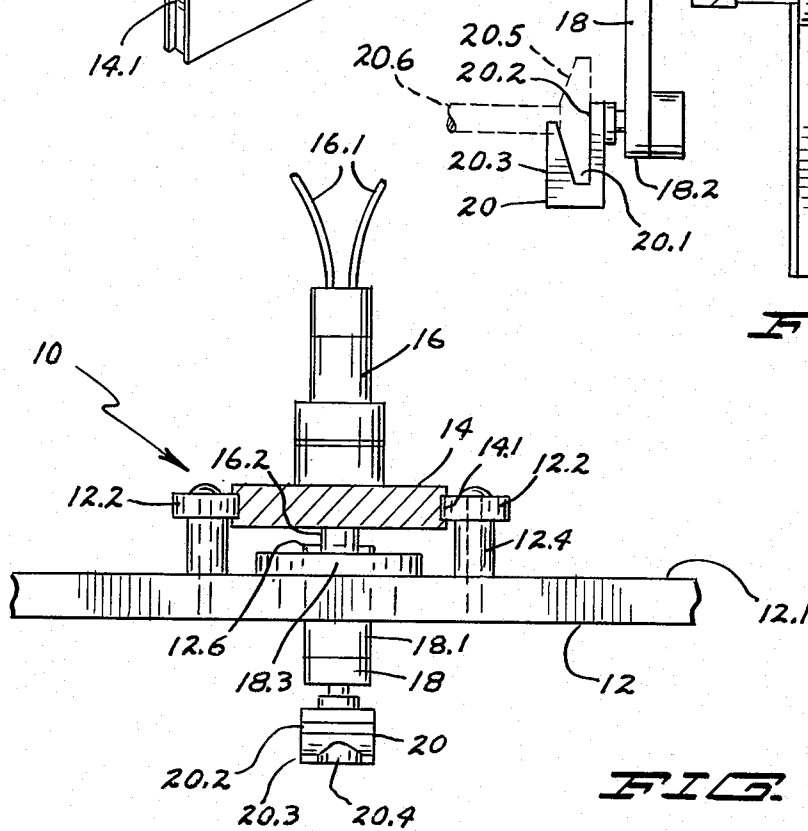
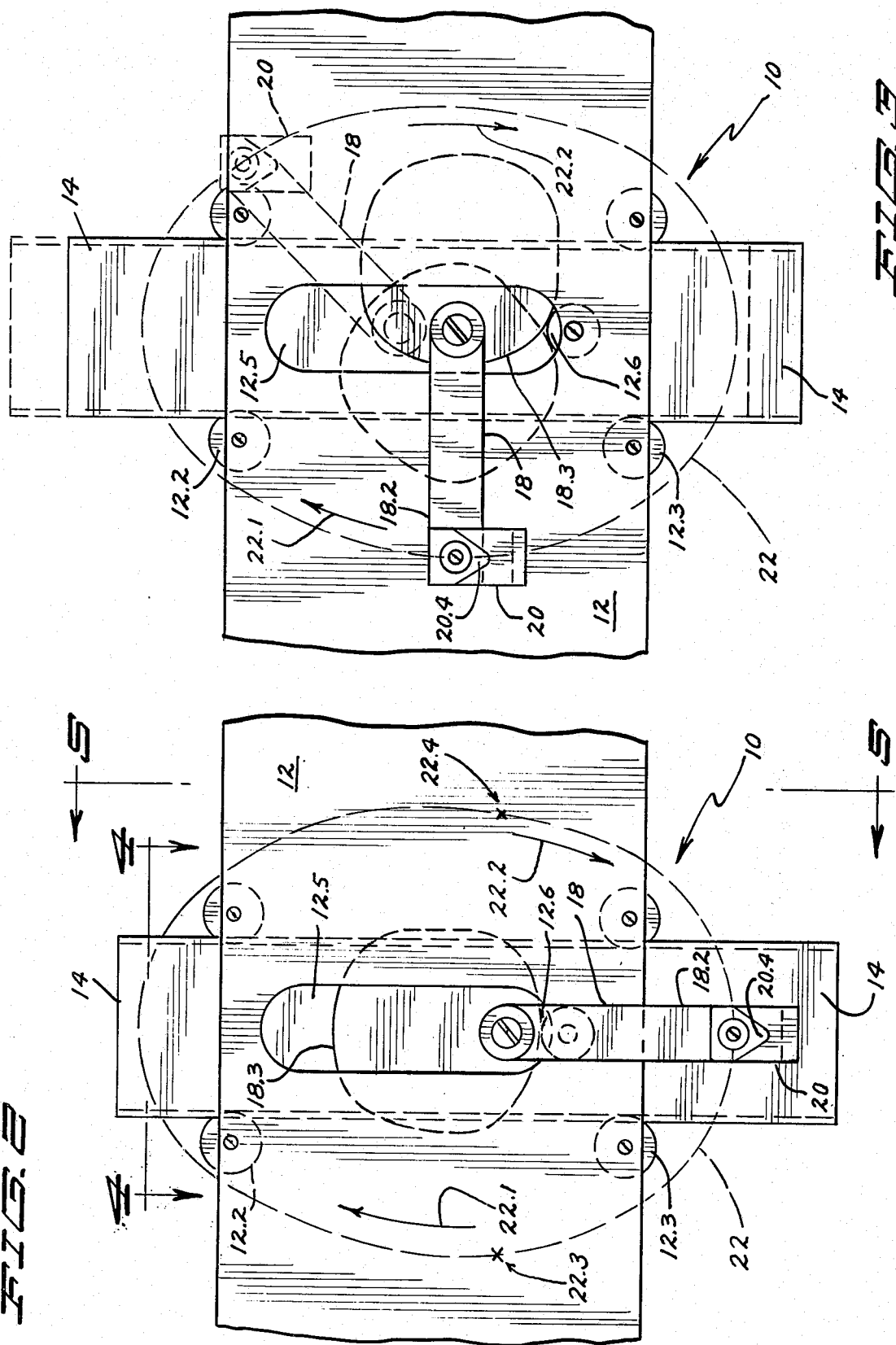


FIG. 5





WAFER BASKET TRANSFER APPARATUS

BACKGROUND OF THE INVENTION

In the semi-conductor industry, thin, fragile wafers of material such as silicon must be treated with a number of processing fluids for cleaning, etching, and the like. The necessary processing fluids are normally arranged in a horizontal line of fluid baths adjacent one another so that a basket holding semi-conductor wafers may be conveniently moved sequentially from bath to bath as processing proceeds. A number of devices have been developed to automatically move wafer baskets from one bath to an adjacent bath, and examples of such devices are reported in, for example, U.S. Pat. Nos. 3,772,980 and 3,782,522. Such prior art devices involved the use of a wafer basket with a horizontal rod attached by brackets to the basket and carried above the basket, the rod having at one end a disc connector. In the first cited patent, a relatively long arm was driven at one end by a motor and carried at its other end a lifting hook, the lifting hook describing a circle as the arm was driven by the motor. The lifting hook was designed to engage the disc of the horizontal rod in one position, and by continued revolution of the arm, carry the rod and basket upwardly in a semi-circular path, depositing the basket in the adjacent bath. In U.S. Pat. No. 3,782,522, an endless track was supported for movement in a generally vertical plane, the chain carrying basket-lifting hooks in a generally oblong path to transfer wafer baskets from one bath to another.

Ideally, a transfer mechanism for wafer baskets as described above should have a large, substantially vertical component of movement as the basket is encountered and lifted to avoid dragging of the basket, with subsequent potential damage, across the edges of the bath tanks as the baskets move from one tank to another. With respect to the patent first above mentioned, a longer movement in the vertical direction may be accomplished only by lengthening the lifting arm so that it describes a circle of greater diameter; the processing baths must, however, be spaced further apart to accommodate the longer lifting arms, and this is undesirable. The device of the latter-mentioned patent, although providing greater movement of the basket in a vertical direction, none-the-less requires many moving parts, all of which must be in proper working order to permit the apparatus to function properly. Moreover, the apparatus of the latter cited patent is quite bulky, and because of its complexity, is quite expensive.

A basket transferring apparatus which would overcome the complexity and high cost of the latter-mentioned patent, and which would overcome the problem of the first-mentioned patent, that is, scraping of the basket on edges of adjacent bath tanks because of the small vertical movement accorded such baskets, is much to be desired and would greatly advance the art.

BRIEF DESCRIPTION OF THE INVENTION

The invention relates to a wafer basket transfer apparatus which includes a stationary frame plate, a slide plate slideably mounted for vertical movement to the frame plate, a basket lifting arm with a basket lifting hook at one end, a motor carried by the slide plate and in driving engagement with the other end of the lifting arm to drive the latter in a circular path with respect to the slide plate. A cam is mounted for rotation with the

lifting arm and co-acts with a cam follower carried by the frame plate, the cam having a cam edge non-symmetrical with respect to its axis of rotation to bear against the cam follower and cause vertical movement of the slide plate with respect to the frame plate as the lifting arm rotates, the cam and lifting arm being so oriented as to carry the basket lifting hook through a closed, curved, vertically elongated path in a vertical plane. The relatively high amount of vertical movement thus afforded the basket lifting hook and resulting from circular movement of the arm coupled with vertical movement of the axis of rotation of the arm, causes a wafer basket to be lifted substantially vertically for a significant distance from a bath, and to be deposited in a substantially vertical direction into an adjacent bath.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective, broken-away view of an apparatus of the invention;

FIGS. 2 and 3 are front views of the apparatus of the invention and depict the basket lifting arm in various stages of rotation, the path followed by a basket lifting hook being shown in dashed lines;

FIG. 4 is a top view taken along line 4—4 of FIG. 2; and

FIG. 5 is a side elevation taken along line 5—5 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, the apparatus of the invention, designated generally as 10, includes a substantially vertical, stationary frame plate 12 which may extend the entire length of a series of adjacent processing baths, or which may be provided as a separate element for each position between adjacent pairs of processing baths, the frame plate 12 being positioned to the side of and slightly above the bath for reasons which will subsequently become evident. To the rear surface 12.1 (FIGS. 4 and 5) of the frame plate are mounted top and bottom pairs 12.2, 12.3 of horizontally spaced rollers, each top roller being in vertical alignment with a corresponding bottom roller. The rollers are mounted for free rotation on posts 12.4 extending to the rear of the frame plate and are spaced from the rear surface 12.1 of the frame plate.

A substantially vertical slide plate 14 is provided with vertical edges with depressed vertical tracks 14.1, the rollers 12.2, 12.3 engaging and riding within the tracks 14.1 as the slide plate 14 moves up and down with respect to the frame plate 12, the slide plate being spaced to the rear of the frame plate by the posts 12.4.

Mounted to the rear of the slide plate 14 is an electric motor 16 connected by conductive leads 16.1 to a controlled power source (not shown). The motor has a drive shaft 16.2 which extends through and is journaled for rotation in the slide plate 14. The drive shaft extends forwardly through a vertical slot 12.5 in the frame plate, permitting the motor and drive shaft to be carried up and down by vertical movement of the slide plate 14.

An elongated lifting arm 18 is provided at one end with a transverse sleeve 18.1 which in turn is mounted to the end of the drive shaft 16.2, 2,782,522, sleeve 18.1 positioning the arm at the front of the frame plate 12, as shown best in FIGS. 1 and 5. A basket lifting hook 20 is rotatably attached to the outwardly extend-

ing end 18.2 of the lifting arm 18 for free swinging movement with respect to the arm. The hook 20 has a deep, V-shaped slot 20.1 in a direction parallel to the plane of rotation of the arm and formed by confronting, spaced, downwardly converging rear and front walls 20.2, 20.3, the rear wall 20.2 presenting a substantially vertical forward surface. The front wall 20.3 has a V-shaped notch 20.4 in its upper surface and parallel to the axis of rotation of the drive shaft 16.2. The notches 20.1 and 20.4 cooperate to firmly grasp a disc-shaped end 20.5 (FIG. 1) of a forwardly extending basket support rod 20.6, the latter being attached along its length to the upright support brackets of a wafer basket (not shown). The construction and operation of the basket hook 20, support rod 20.6 and disc 20.5 in relation to the sequential movement of a wafer basket into and out of series of processing baths has been described in U.S. Pat. No. 2,782,522, and for brevity, the disclosure of said patent is incorporated herein by reference.

With reference particularly to FIG. 1, it will be understood that as the lifting arm rotates in the direction of arrow 22.1, the hook 20 comes into contact with the rod 20.6 and disc 20.5, the rod resting in the V-shaped slot 20.4 and the disc lying in the deeper V-shaped slot 20.1. As the basket hook moves upwardly, the disc and rod, and the attached wafer basket, are lifted upwardly from a processing bath. As the basket hook descends in the direction shown by the arrow 22.2 and the basket comes to rest in an adjacent processing bath, the basket hook disengages the disc and rod 20.5, 20.6. The mating surfaces of the disc, rod and basket hook desirably are substantially identically configured so that when the rod and disc are carried by the basket hook, a rigid union results, preventing the rod 20.6 from sagging downwardly from its normally horizontal position.

A rotatable cam follower roller 12.6 is mounted to the rear surface 12.1 of the frame plate adjacent the lower end of the slot 12.5. A cam 18.3 is fixed by means of a key and keyway or the like to the drive shaft 16.2 and is positioned between the spaced frame and slide plates 12, 14 for rotation in a vertical plane, the periphery of the cam continuously engaging the cam follower roller 12.6. It will be understood that as the drive shaft 16.2 is rotated by the motor 16, the cam 18.3 and the lifting arm 18, which are both fixed to the drive shaft 16.2, are similarly rotated, the cam being urged downwardly against the cam follower by the weight of the slide plate and its associated structure. Since the only freedom of movement permitted the cam axis is in the vertical direction as the slide plate moves up and down, rotation of the drive shaft causes the slide plate 14, carrying the motor, cam and lifting arm, to cycle upwardly and downwardly.

As shown perhaps best in FIGS. 2 and 3, the cam 18.3 is non-symmetrical with respect to the axis of rotation of the drive shaft 16.2 to which the cam is fixed. The axis of rotation of the cam, which is the axis of the drive shaft, passes closely adjacent one edge of the cam, as shown in FIG. 2. The cam 18.3 may be generally circular in shape, as shown in FIG. 2, or may be slightly elliptical or of such other non-symmetrical shape as will yield the desired path of travel of the basket hook 20. It will be understood that changes in the shape of the cam will vary the path followed by the basket lifting hook. The cam, for example, may have a generally elliptical or generally triangular shape with the

cam being non-symmetrical with respect to its axis of rotation.

The cam 18.3 is continuously oriented with respect to the arm 18 so that as the cam rotates, a substantially maximum vertical movement rate of the slide plate is achieved as the arm 18 passes through a generally horizontal position as shown in solid lines in FIG. 3. With the generally circular cam shown in FIGS. 2 and 3, this requirement is generally met if the bulk of the cam body is on the opposite side of the drive shaft from the direction of the arm 18. The vertically oblong, curved path described by the basket hook 20 in a revolution of the lifting arm is designated 22 in FIGS. 2 and 3, and it will be understood cams of other shapes may be employed to change the path of travel of the hook, as noted above.

The frame and slide plates, lifting arm and basket hook are of sturdy, rigid construction and are desirably manufactured with close tolerances and are interfitted to virtually eliminate any forward and rearward movement of the lifting arm or tipping or twisting of the basket hook during operation. The use of spaced rollers 12.2, 12.3 on the frame plate which move in vertical tracks 14.1 at the edges of the slide plate rigidly supports the slide against transverse movement with respect to the frame plate.

In use, the stationary frame plate 12 of the apparatus of the invention is mounted along the side of a row of processing baths with the slide plate 14 at the juncture of two adjacent baskets. The height of the frame plate is adjusted so that as the lifting arm revolves, the basket hook comes into lifting contact with the disc-like end 20.5 of the basket support rod 20.6 at a point where the lifting arm is horizontal or nearing the horizontal, this point generally being located by an "X" labeled 22.3 in FIG. 2.

When it is desired to transfer a wafer-filled basket from one processing bath to an adjacent bath, the motor 16 is energized and the lifting arm 18 is caused to move from its generally downwardly oriented rest position (FIG. 2) to its basket pick-up position 22.3, the basket hook encountering and gripping the disc and rod 20.5, 20.6 from beneath. Continued rotation of the arm causes the basket to be lifted in a substantially vertical direction from the processing bath, the basket clearing the edge of the bath tank prior to any significant movement of the basket toward the succeeding bath. The sturdy, rigid construction of the apparatus and the substantially rigid grip of the basket hook upon the disc and rod 20.5, 20.6 maintains the rod 20.6, and the basket, in a horizontal position so that all of the wafers in the basket are removed from the processing bath at the same instant.

When the basket has cleared the edge of the processing bath in which it was immersed, continued rotation of the lifting arm 18 through its upper-most position swings the basket into general alignment over the next processing bath, the basket descending substantially vertically into that bath as the lifting arm descends into a generally horizontal position and the basket and its supporting rod 20.6 remaining horizontal during immersion so that all of the wafers are immersed at the same instant. Continuing in its rotation, the lifting arm carries the basket hook downwardly out of engagement with the disc and rod 20.5, 20.6 at approximately the point "X" labeled 22.4 in FIG. 2. The arm returns to

its rest position as shown in FIG. 2 in readiness for another transfer operation.

As noted above, the frame plate 12 may extend horizontally the length of the series of processing baths, and the slide plates 14 may be positioned on the frame plate at positions at the junctures of adjacent baths. Since the wafers may be immersed for different time periods in different processing baths, the lifting arms of sequential apparatuses of the invention generally are not synchronized to rotate at the same time. Actuation of each transfer apparatus may be controlled at a central panel, or each apparatus may have its own time control. A safety microswitch (not shown) is usually provided to prevent transfer of a basket into a bath already occupied by a basket. If desired, the timing controls for the apparatus may be set to stop rotation of the arm in a generally upright position to permit drainage and to await removal of a basket occupying the next processing bath.

Manifestly, I have provided an apparatus for transferring a wafer basket from one processing bath to another. My apparatus has few moving parts and provides a curved, vertically elongated path of travel, lifting a wafer basket substantially vertically from a processing bath to a substantial height and lowering the basket substantially vertically into an adjacent bath, the basket clearing the edges of the bath tanks in its primarily vertical travel into and out of such baths. The horizontal orientation of a basket is maintained throughout the transfer process, the wafers in the basket each being lowered into or raised from a processing bath at the same instant.

While I have described a preferred embodiment of the present invention, it should be understood that various changes, adaptations, and modifications may be made therein without departing from the spirit of the invention and the scope of the appended claims.

What is claimed:

1. A wafer basket transfer apparatus for transferring baskets of semi-conductor wafers from one processing tank to an adjacent tank, comprising a stationary frame plate, a slide plate slideably mounted for vertical sliding movement relative to the frame plate, a basket lifting arm having a basket lifting hook at one end, drive means including a shaft in driving engagement with the other end of the lifting arm to rotate the arm in a vertical plane, said shaft being mounted for rotation in the slide plate and for vertical movement with respect to the frame plate, a cam mounted for rotation with the shaft, and a cam follower mounted on the frame plate and cooperating with the cam to raise and lower the slide plate with respect to the frame plate as the lifting arm rotates, the lifting arm being so oriented with respect to the cam as to carry the lifting hook in a curved, vertically elongated overhead path with respect to the frame plate, whereby a wafer basket may be lifted from a processing tank generally vertically upwardly to a substantial height and may be lowered generally vertically into an adjacent tank with the wafer basket clearing the tank edges.

2. The transfer apparatus of claim 1 wherein the drive means comprises a motor carried by the slide plate and connected to said shaft.

3. The transfer apparatus of claim 1 wherein the cam follower comprises a roller rotatably mounted to the frame plate below and in alignment with the cam, the weight of the apparatus borne by the slide plate urging

the cam downward into engagement with the roller during a transfer operation.

4. The transfer apparatus of claim 1 wherein the lifting arm is oriented to travel in a vertical plane spaced forwardly of the frame plate, and the slide plate is spaced rearwardly of the frame plate, the frame plate having a vertically extending slot permitting vertical movement of the motor drive shaft extending through the slot.

5. The transfer apparatus of claim 4 wherein the slide plate has vertical edges with roller tracks formed therein, and wherein the frame plate is provided with rear-mounted rollers rolling in the tracks of the slide plate.

6. The transfer apparatus of claim 5 wherein the cam and cam follower are mounted between the spaced frame and slide plates.

7. The basket transfer apparatus of claim 1 including a horizontal basket lifting rod extending parallel to the axis of rotation of the lifting arm and having a transverse disc at its end engageable by the lifting hook, the lifting hook having a pair of upwardly opening slots configured to respectively engage the disc and rod with the disc-receiving slot rigidly engaging the disc to maintain the rod in a horizontal position during a transfer operation.

8. A wafer basket transfer apparatus for transferring baskets of semi-conductor wafers from one processing tank to an adjacent processing tank, comprising:

a stationary frame plate having a vertical slot therein; a slide plate spaced rearwardly of the frame plate and slideably mounted for vertical sliding movement relative to the frame plate;

a motor affixed to and carried rearwardly of the slide plate, the motor including a drive shaft extending forwardly through the slot in the frame plate;

a basket lifting arm spaced forwardly of the frame plate and having a basket lifting hook swingably mounted at one arm end with the other arm end being affixed to the motor drive shaft extending through the frame plate slot;

a cam mounted to the motor drive shaft between the frame and slide plates, the cam being non-symmetrical with respect to the axis of rotation of the drive shaft;

a cam follower roller rotatably mounted to the frame plate and positioned below and in contact with the cam;

the lifting arm being so oriented with respect to the cam as to carry the lifting hook in a curved, vertically elongated overhead path with respect to the frame plate as the lifting arm is driven by the motor drive shaft, whereby a wafer basket may be lifted from a processing tank generally vertically to a substantial height and may be lowered generally vertically into an adjacent tank without interference of edges of the tank with the wafer basket.

9. The wafer basket transfer apparatus of claim 8 wherein the slide plate has vertical edges with recessed, roller-receiving tracks therein, and wherein the frame plate includes horizontally spaced, vertically aligned rollers spaced rearwardly of the frame plate and riding in the recessed tracks of the slide plate and permitting the slide plate to move only substantially vertically with respect to the frame plate.

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