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(71) Applicant: DYNATEX INTERNATIONAL [US/US]; 5577 Skylane Boulevard, Santa Rosa, CA 95403 (US).

(72) Inventor: FRAZER, Peter, Thomas; 4756 Carissa Avenue, Santa Rosa, CA 95405 (US).

(74) Agent: STEVENS, David, R.; Gray Cary Ware & Freidenrich, 400 Hamilton Avenue, Palo Alto, CA 94301 (US).

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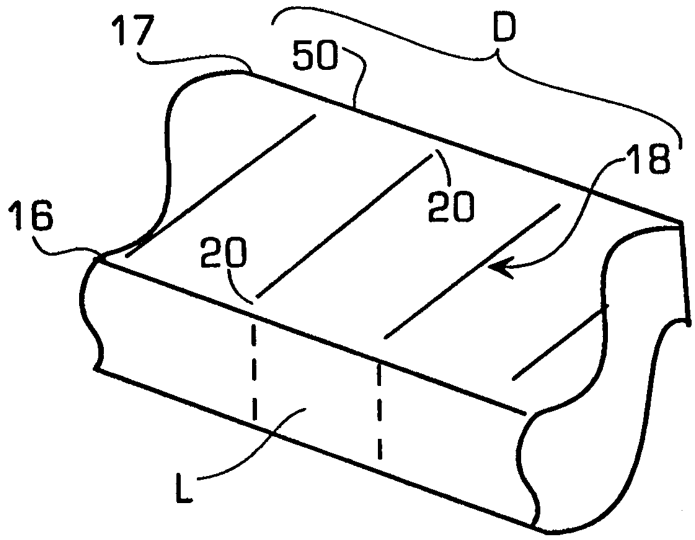
(54) Title: APPARATUS AND PROCESS FOR MEMBRANE MOUNTED DIE BREAKING WITH AUTOMATED VISUALIZATION

(57) Abstract

An automated vision scribing and breaking process for a membrane supported die array (D) on a transfer table wherein the die array is mounted on a membrane (M), the array and individual dies of the array are accurately positioned for scribing or breaking with the assistance of machine vision (C), and the array is scribed by a scribe (S) and/or broken by an underlying breaker bar (B) into individual dies. The dies are individually recognized, angularly aligned to be normal to the underlying and supporting breaker bar. The dies are individually scribed, preferably, by "skip scribing" to avoid edging that might interfere with subsequent chip performance. As each die is independently scribed, automated indexing occurs to compensate for membrane stretching. Once properly scribed to the desired dimension, these dies can be further processed including utilizing the scribes to produce square ends to produce precise reflective laser cavities.



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APPARATUS AND PROCESS FOR MEMBRANE MOUNTED DIE BREAKING WITH AUTOMATED VISUALIZATION

This invention relates to scribing and breaking dies and wafers mounted on and supported by a flexible membrane. A method and apparatus utilizing machine visualization in combination with a scriber/breaker having a breaker bar supporting the flexible membrane is utilized for both scribing and breaking. In one embodiment, the method finds preferable usage in the scribing of lasing diodes from larger dies. Alternately, the automated breaking of dies along sectors delineated by previously scribe "streets and intersecting streets" is disclosed. In this latter case, essentially unpredictable movement of the wafer relative to a broken die supported on a flexible membrane occurs with each break requiring real time readjustment utilizing the machine herein disclosed.

Background of the Invention

We have developed a new scriber breaker set forth in Apparatus for Scribing and/or Breaking Semiconductor Wafers filed April 3, 1996 as U.S. Patent Application Serial No. 08/624,339 now U.S. Patent 5,820,006 issued October 13, 1998. In this apparatus, dies are supported on a flexible membrane. Movement of the flexible membrane occurs between a scribing station and a breaking station. During scribing, the support of the die to be scribed at the scribing station occurs through the membrane by the breaker bar. Further, the breaking of wafers into dies delineated by previously scribed streets and intersecting streets is disclosed.

In this disclosure, I set forth an apparatus and process utilizing machine visualization for the automated scribing of elongate rectangular dies for lasers into laser diodes. The process and apparatus here disclosed is especially adapted for the above scriber/breaker.

Dies for laser diodes are known. These dies are scribed and broken from elongate rectangular crystals which can be in the range of 1½ inches long and 1/8 inches of width. The reader will understand that the disclosed equipment and process can handle dies D of any dimension. Automated scribing of such dies to secure square ends to ensure an accurate lasing cavity within the die is included in the subject matter of this invention.

Summary of the Invention

A membrane supported die array of rectilinear dies having an appropriate dimension of the range of 1½ inches long and 1/8 inches of width is positioned for scribing on transfer table where the membrane is supported only at the edges. Scribing occurs on dies supported through the membrane by an underlying breaker bar. Novelty is set forth in supporting the dies on the membrane so that the major axis of the rectilinear dies extends at right angles to the underlying breaker bar. Initially, the dies are arrayed on the membrane in side-by-side arrays to an angular accuracy in the range of $\pm 3°$ with spacing between the dies being in the range of 200 microns. In this array, the dies are capable of being individually recognized by machine vision, angularly aligned to be normal to the underlying and supporting breaker bar and individually scribed. To avoid either damage to the die edge or extensive forces displacing the die on the elastic membrane to one side, the scribes commence at an inset from the die edge and this extend only partially across the 1/8th inch surface of the die. Scribing occurs at the desired vertical intervals along the major axis of the die - in the exemplary ranger of 0.020 to 0.030 of an inch along the major axis (any dimension can be used). The dies are automatically scribed from the middle to the die ends. As each die is independently scribed, automated indexing occurs to the next available dies - indexing in rows of dies from left to right. The disclosed die alignment is particularly suitable for automated visualization and can be delimited to preselected vision areas on the membrane. Once properly scribed to the desired dimension, these dies can be further processed including utilizing the scribes to produce square ends to produce precise reflective laser cavities.

Alternatively, and utilizing the same machine visualization apparatus, a wafer scribe with streets and intersecting streets to delimit discrete dies in moved to a breaking station. With initial alignment of a street of alley for breaking, breaking occurs. Concomitant with such breaking, inevitable and unpredictable movement of both the broken portion of the wafer and the remaining portion of the wafer occurs as a result of die support on the elastic membrane. A process of machine visualization followed by membrane repositioning of the membrane occurs to align the next available street for breaking. This process is continued until all streets and intersecting streets are broken to delimit from the wafer the discrete dies delimited by the streets and intersecting streets.

Brief Description of the Drawings

Fig. 1 is a schematic of rectilinear laser die arrayed on a flexible membrane illustrating schematically the side-by-side array of dies, a selected group of the side-by-side array for processing, and an underlying "breaker bar" for individually supporting each die during each scribe to separate out upon breaking laser diodes.

Fig. 2A is a perspective enlarged view of a membrane, a supported die, the underlying and supporting breaker bar, and the overlying scribe with a line drawn on the die surface schematically illustrating the start of the scribe from one die edge through to the opposite die edge - this drawing schematically illustrating machine visualization of the membrane and supported dies.

Fig. 2B is an enlarged section of an individual die illustrating the scribe across the material and illustrating in particular the beginning of the scribe inset from the edge of the die - this scribe here continuing through to a point that is the same inset distance from the opposite edge of the die.

Fig. 3 is a block schematic of an automated computer program working form the machine visualization of Fig. 2 for scribing dies within the schematically delimited area illustrated in Fig. 1.

Fig. 4 illustrates a normal die with scribed "streets and intersecting streets" for ultimately isolating delimited dies within the wafer sectors and illustrating automated breaking of the die with inevitable membrane stretching to displace both the main bulk of the unbroken wafer and those sections of the wafer previously separated.

Fig. 5 is a block diagram of automated break visualization necessitated by stretching of the membrane, it being noted that this visualization and corresponding detected required positioning occurs as each wafer sector is broken away.

Description of the Preferred Embodiment

Referring to Fig. 1, membrane M is shown having array A of individual dies D fastened to the membrane. The scribing which is about to occur is for the purpose of delimiting individual lasing diodes L from dies D.

As can be seen from Figs. 1 and 2, dies D are supported on membrane M from peripheral ring R. As set forth in Apparatus for Scribing and/or Breaking Semiconductor Wafers filed April 3, 1996 as U.S. Patent Application Serial No. 08/624,339 now U.S. Patent 5,820,006 issued October 13, 1998, this table is moveable in X, Y, and θ as indicated on Figs. 1 and 2. Such movement occurs relative to underlying breaker bar B, schematically shown through membrane M as a straight line. I will be understood that scribe S overlies breaker bar B at knife edge K.

Referring to Fig. 2, it can be seen that membrane M is supported at the edges only by peripheral ring R. This leaves the bottom of membrane M underlying breaker bar B directly exposed to breaker bar B at knife edge K. It is into this environment that the scribing of dies D with automated visualization is now made possible.

First, a word about the scale of Figs. 1, 2A, and 2B. In one embodiment in which this technique has been used, dies D are about 1½ inches long, 1/8 inches in width, and about 1/16 inches thick. The reader will understand that the scale shown changes from Figs. 1, 2A, and 2B. This is done so that the reader can understand the subject matter set forth.

Visualization is likewise schematically shown. Specifically, video camera C is connected to a computer (not shown), this computer having loaded that software product known as Vision Pro, a product of Cognex Co. of Natick, Massachusetts. It is important to note that the alignments here illustrated are important to the cooperating machine vision. In short, the membrane support here illustrated has been found to make possible the machine visualization which we utilize. Further, the alignments illustrated for the scribing and breaking interact with both the machine vision and the scribing and breaking apparatus to produce the reproducible and automated scribing and breaking illustrated here.

As those having skill in the art understand, the scribes must be normal to the major axis 14 of dies D. Further, and in scribing illustrated in Figs. 1 and 2a, scribe S must be inset form edges 16 and 17 of die D. It will be seen that each scribe line 18 must commence at scribe inset 20 from edge 17. This prevents scribe S from "hanging up" on edge 17 and exerting undue sideways pressure on die D so that either membrane M is unduly stretched or alternatively the die section is dislodged from membrane M. The scribe must end at scribe inset 20 from opposite edge 16 to prevent damage to the lasing diode.

Referring to Fig. 3, a block diagram of the machine vision program of this invention is set forth. Movement of membrane M relative to breaker bar B at knife edge K will be assumed from the above described Apparatus for Scribing and/or Breaking Semiconductor Wafers.

With respect to Fig. 1, presuming start 30 of the illustrated scribing routine occurs, it first must occur that those dies D to be processed must be delimited. Accordingly, and in a video view that is analogous to Fig. 1, center 31 of first die D is identified at centering step 32. Thereafter, the total area containing those dies D to be processed must be delimited. This is done at process delineation step 33 by moving visualization cross-hairs (not shown) between upper left position 34 and lower right position 36 (see Fig. 1). There results a delimited rectangular area of membrane M shown by broken lines 38.

Stopping here, the reader will understand that four dies D are now ready to be processed utilizing the invention here. These individual dies D have been placed on membrane M at a fixed distance apart. This distance is here on the order of 200 microns. Naturally, other increments can be used.

In addition to the side-by-side spacing, the utilization of this technique requires that the angular alignment of dies D occur within certain gross limits. Those limits require that initial placement of dies D to membrane M be within ± 3°. This gross alignment is illustrated in Fig. 1.

Commencing with the automated vision process made possible with this invention, the first question asked is whether the die D is within the area delimited; that is, within broken lines 38. This occurs at die delineation step 40. Assuming a "Yes" answer, accurate alignment step 42 occurs. Specifically, and as shown in Fig. 2A, the position of top 44, and bottom 46 are measured. Presuming that these respective points do no overlie one another, rotation of membrane M supported on peripheral ring R occurs. Thereafter, measurement of top 44 and bottom 46 is repeated to verify that rotation of peripheral ring R in θ has brought die D into alignment; if alignment is not verified, the process is repeated.

Thereafter, first street 50 is scribed at first street scribing step 52. This scribing causes knife edge K of breaker bar B to move underlying first street 50 with scribe tool S descending to scribe first street 50. This scribing of first street 50 is inset from edge 17 by scribe inset 20 and scribes from a position adjacent edge 17 to within inset 20 of opposite edge 16. The direction of movement of membrane M during scribing is indicated by arrow 21.

After first street scribing step 52, scribe remaining streets step 54 occurs. As here shown, scribing commences in the middle and scribes to one end utilizing position information previously gathered in accurate alignment step 42. Thereafter, scribing recommences one street displaced from first street 50 and scribing to the opposite end occurs - again utilizing position information gathered during accurate alignment step 42. In the embodiment here illustrated, scribing from the middle to the top occurs first, with scribing from the middle to the bottom second.

Presuming that die D has been fully scribed, indexing to the next die D occurs at die index step 56. Thereafter, die delineation step 40 is repeated, and presuming a "Yes" answer, repeat automated step scribing occurs. Presuming a "No" answer, unload wafer step 58 followed by end 60 follows.

The reader will understand that the machine vision utilized with this invention can as well be used for the breaking of wafer W into individual dies D_1. The problem encountered in such individual breaking can best be understood by referring to Fig. 4.

In Fig. 4, wafer W. is shown scribed with streets 64 and intersecting streets 62. As can be seen - and as described in Apparatus for Scribing and/or Breaking Semiconductor Wafers filed April 3, 1996 as U.S. Patent Application Serial No. 08/624,339 now U.S. Patent 5,820,006 issued October 13, 1998 - breaking is occurring along streets 64. Such breaking occurs by positioning of a streets 64 overlying knife edge K of breaker bar B. Thereafter, impulse bar I is forced downward on wafer W causing breaking of wafer W of knife edge K. Unfortunately, with each such breaking, relative movement occurs. Specifically, small relative movement X of the bulk of remaining wafer W occurs with larger relative movement X_1 of the immediately broken section of dies 70. Moreover, with each such break - and the relatively elastic membrane M - these relative movements change and become vision control herein provided to substitute such vision for what otherwise would be extremely laborious and tedious operation of the scriber/breaker utilized with this invention.

In this operation of breaking intersecting streets 62 and streets 64, fiducials can be utilized. Specifically, an din the usual case, elaborate patterns of electronic components individually appear on each of the dies D comprising wafer W. By having the machine vision program "tuned" to recognize one such elaborate intersection - a common task which user of Vision Pro undertake - each die will have a discrete fiducial which is recognizable.

Having explained this much, the logic diagram of Fig. 5 may now be set forth. Presuming star 72, indexing to next street step 74 occurs. Thereafter, identify and position fiducial step 76 occurs. This is followed by image capture step 78.

Once image capture step 78 occurs, that image is observed for a fiducial in fiducial step 80. Assuming a "Yes" answer - and using the fiducial as the position information, street alignment query step 82 follows. In the usual case, the "No" answer will cause error calculation step 84 follows by table movement step 86. Thereafter, break current street step 88 will follow.

Thereafter, program interrogation will occur at end of wafer step 90. Presuming the end is reached, program end step 92 will occur.

Those having skill in programming will understand that fiducial present step 80, street alignment query step 82, and end of wafer step 90 are all conditional branches. Where a fiducial is not found at fiducial present step 80, breaking ends. Likewise, and assuming the happy (and unusual) accident that streets 64 are properly aligned - something that usually only happens once or twice in a scribing of a wafer - proceeding to break current street step 88 can occur at once. Finally, and when end of wafer step 90 indicates that wafer W has not been fully broken, looping to indexing to next street step 74 occurs.

It will be seen that I have described an automated vision scribing and breaking process. The reader should understand that this process has been specifically delimited to the use of the scriber/breaker described and set forth in Apparatus for Scribing and/or Breaking Semiconductor Wafers filed April 3, 1996 as U.S. Patent Application Serial No. 08/624,339 now U.S. Patent 5,820,006 issued October 13, 1998. It is the use of the flexible membrane and knife edge K support of wafer W or die D on breaker bar B that makes possible both the scribing and breaking herein set forth.

While the foregoing has been with reference to a particular embodiment of the invention, it will be appreciated by those skilled in the art that changes in this embodiment may be made without departing from the principles and spirit of the invention, the scope of which is defined by the appended claims.

Claims:

1. In the combination of scribing apparatus having a membrane for supporting dies, a breaker bar underlying the membrane for supporting discretely a die, a plurality of elongate dies on the membrane, and a scriber for scribing the dies, the process of scribing the dies comprising the steps of:

providing a membrane supported die array of rectilinear dies;

providing a transfer table for supporting the rectilinear dies at a periphery of the transfer table leaving a central portion of the membrane with the supported die array on top of the membrane and an underlying portion of the membrane exposed below the transfer table;

providing a breaker bar underlying the transfer table and moveable between a position of support of the membrane and a position of non support of the membrane;

arraying a plurality of rectilinear dies on the membrane so that a major axis of the rectilinear dies extends at right angles to the underlying breaker bar;

individually detecting with machine vision and angularly aligning the rectilinear dies to be normal to the underlying breaker bar;

moving the underlying breaker bar and membrane relative to one another to support the rectilinear dies along a path to be scribed;

individually detecting with machine vision the edge of the aligned die; and

scribing the rectilinear dies partially across a width of such dies by commencing the scribing at an inset from an edge of the rectilinear die.

2. The process of scribing dies according to claim 1 comprising the further steps of:

repeating the scribing at discrete vertical intervals.

3. The process of scribing dies according to claim 2 comprising the further steps of:

repeating the scribing at discrete vertical intervals of between 0.020 and 0.030 of an inch along the major axis of the rectilinear die.

4. The process of scribing dies according to claim 1 comprising the further steps of:

arraying a plurality of rectilinear dies on the membrane so that the major axis of the rectilinear dies extends at right angles to the underlying breaker bar within a tolerance of $\pm$ 3°.

5. The process of scribing dies according to claim 1 comprising the further steps of:

providing individual dies having an approximate dimension of a range of (but not limited to) about 1½ inches long and of about 1/8 inches of width.

6. The process of scribing dies according to claim 1 comprising the further steps of:

placing the rectilinear dies in side-by-side arrays with spacing between the dies being in a range of (but not limited to) about 200 microns.

7. In the combination of a scribing apparatus having a membrane for supporting at least one wafer, a bar underlying the membrane for supporting the at least one wafer along a scribe line, and means for breaking the at least one wafer, the process of breaking dies from the at least one wafer comprising the steps of:

providing a membrane for supporting at least one wafer;

providing a transfer table for supporting the membrane at periphery of the transfer table leaving a central portion of the membrane with the at least one wafer on top of the membrane and an underlying portion of the membrane exposed below the transfer table;

providing a breaker bar underlying the transfer table and moveable between a position of support of the membrane and a position of non support of the membrane;

arraying the at least one wafer on the membrane so that a major axis of a first scribe line extends parallel to the breaker bar underlying the transfer table;

determining an identifiable fiducial on a die defined within the wafer;

individually recognizing and angularly aligning the identifiable fiducial of at least one wafer at the first scribe line to be parallel to the breaker bar underlying the transfer table;

moving the breaker bar and membrane relative to one another to support the at least one wafer along the first scribe line;

breaking the at least one wafer across the first scribe line to cause relative movement of a broken portion of the at least one wafer relative to a remainder of the at least one wafer and the transfer table;

indexing the wafer from the first scribe line to a second scribe line on the at least one wafer for support by the breaker bar underlying the membrane;

individually recognizing and aligning an identifiable fiducial to cause the at least one wafer at the second scribe line to be directly above the knife edge to the breaker bar underlying the transfer table; and

breaking the at least one wafer across the second scribe line.

8. In the combination of a scribing apparatus according the claim 7 and wherein:

providing an anvil overlying the breaker bar; and

impacting the wafer on one side of the first or second scribe line to cause the wafer to be broken along the scribe line.

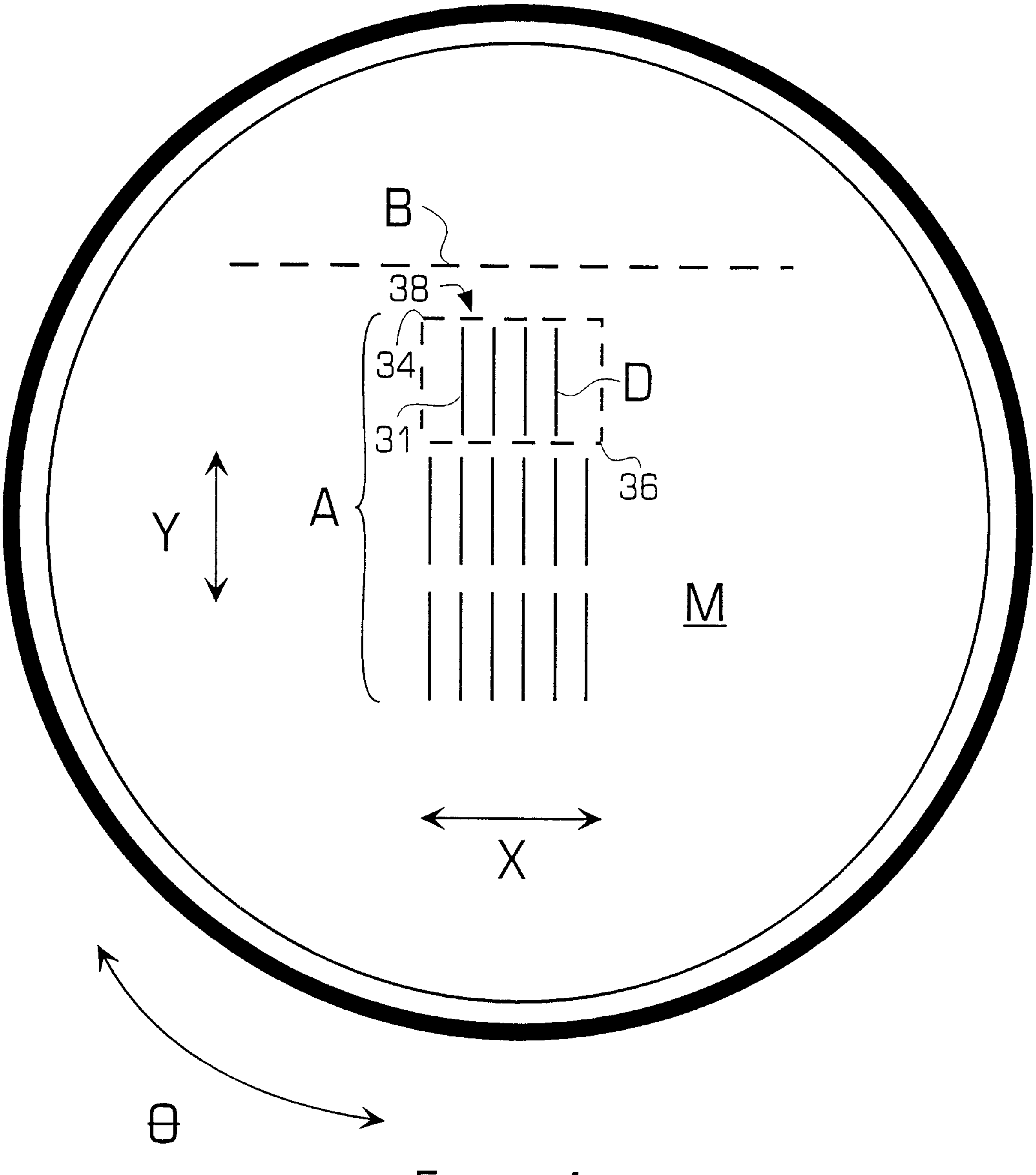


FIGURE 1

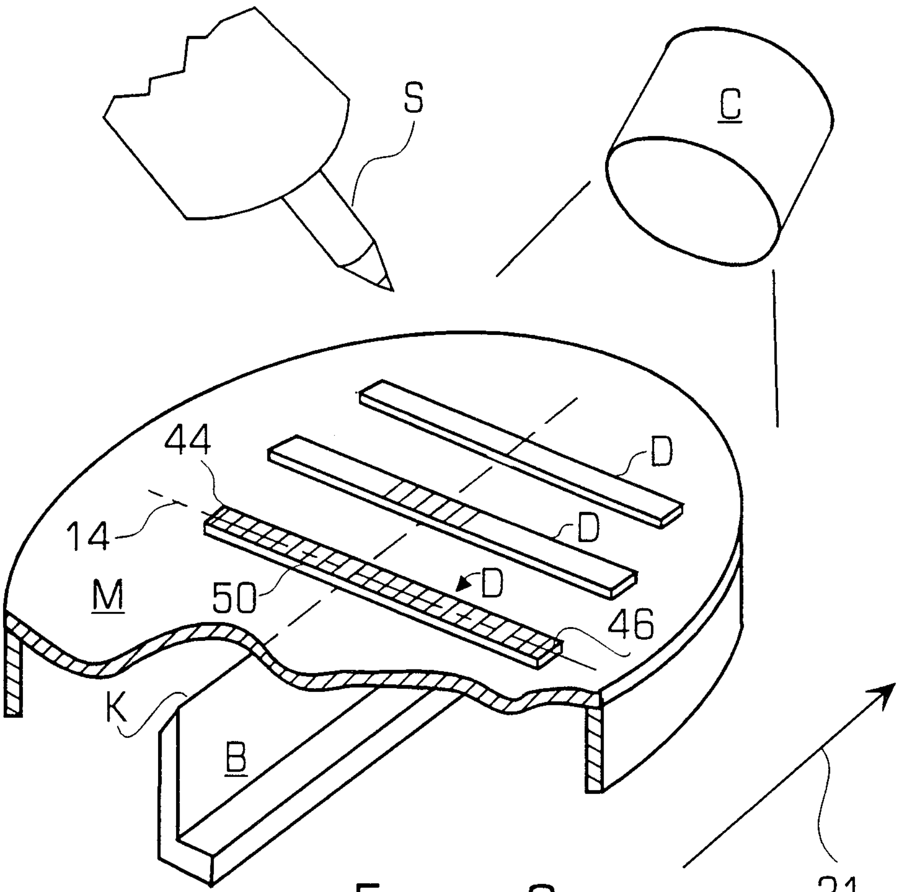


FIGURE 2

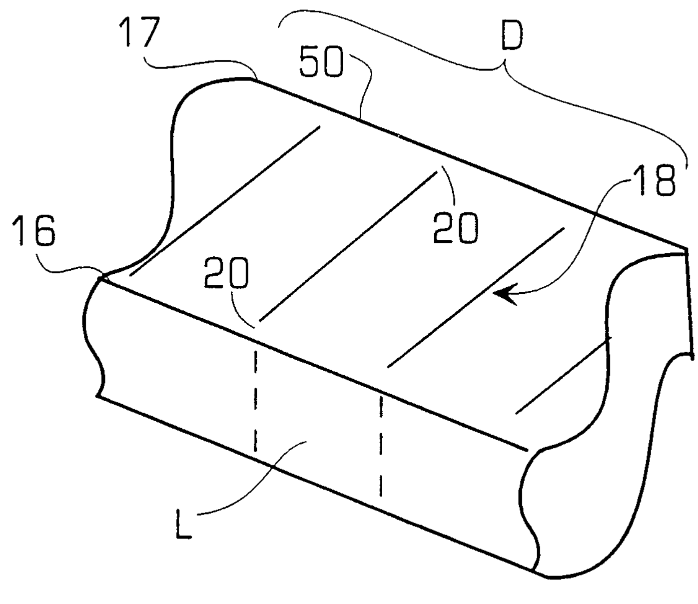
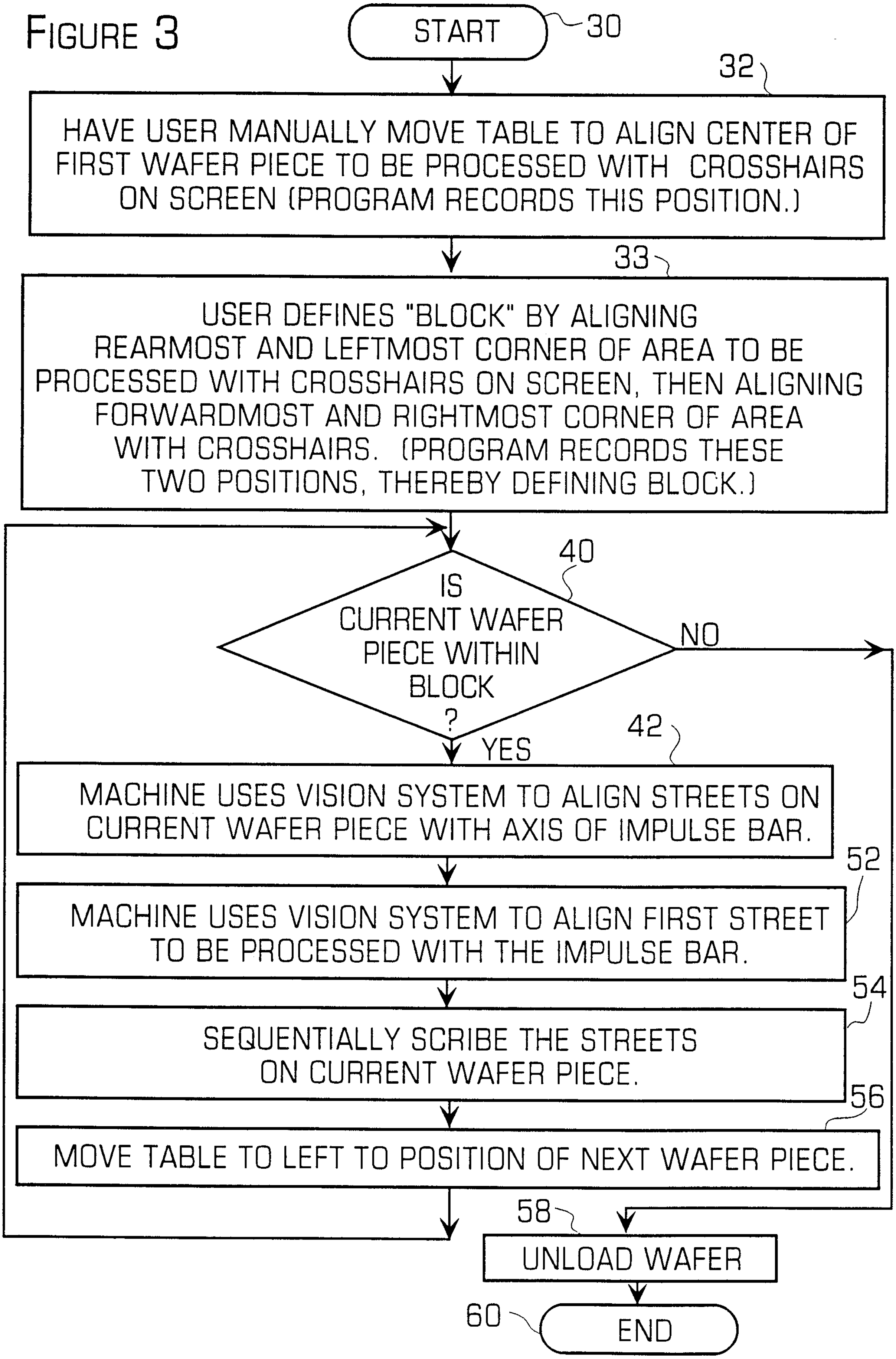


FIGURE 2A

FIGURE 3


START
30
32
HAVE USER MANUALLY MOVE TABLE TO ALIGN CENTER OF FIRST WAFER PIECE TO BE PROCESSED WITH CROSSHAIRS ON SCREEN (PROGRAM RECORDS THIS POSITION.)
33
USER DEFINES "BLOCK" BY ALIGNING REARMOST AND LEFTMOST CORNER OF AREA TO BE PROCESSED WITH CROSSHAIRS ON SCREEN, THEN ALIGNING FORWARDMOST AND RIGHTMOST CORNER OF AREA WITH CROSSHAIRS. (PROGRAM RECORDS THESE TWO POSITIONS, THEREBY DEFINING BLOCK.)
40
IS CURRENT WAFER PIECE WITHIN BLOCK ?
NO
YES
42
MACHINE USES VISION SYSTEM TO ALIGN STREETS ON CURRENT WAFER PIECE WITH AXIS OF IMPULSE BAR.
52
MACHINE USES VISION SYSTEM TO ALIGN FIRST STREET TO BE PROCESSED WITH THE IMPULSE BAR.
54
SEQUENTIALLY SCRIBE THE STREETS ON CURRENT WAFER PIECE.
56
MOVE TABLE TO LEFT TO POSITION OF NEXT WAFER PIECE.
58
UNLOAD WAFER
60
END

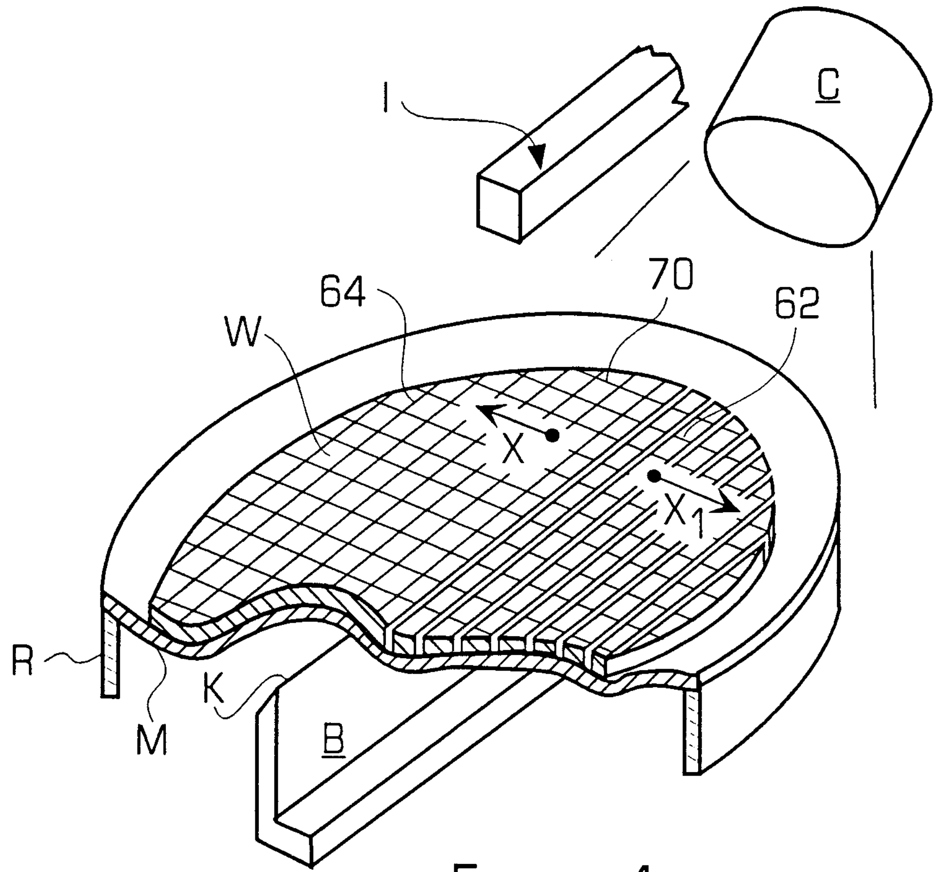
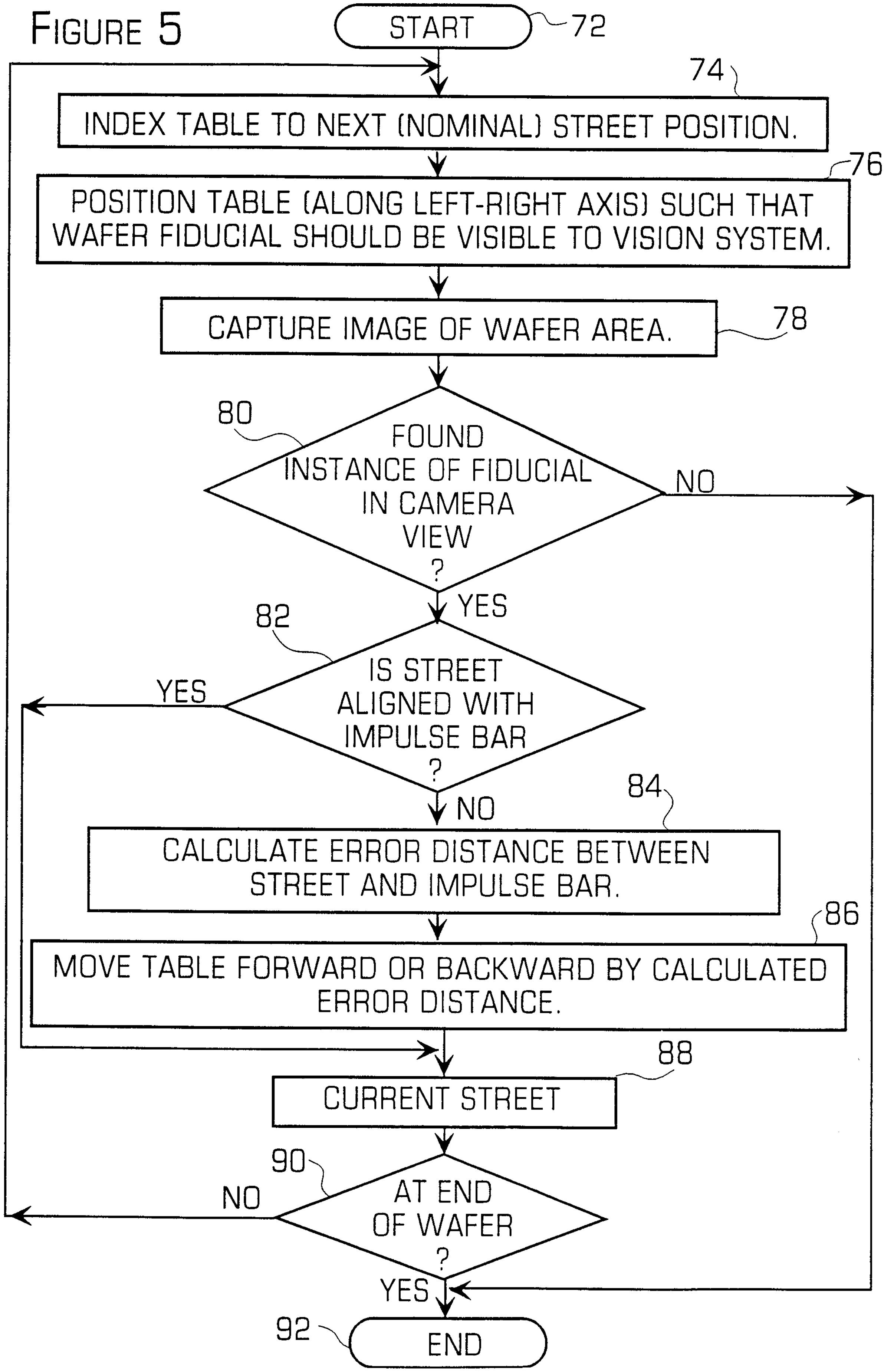


FIGURE 4

FIGURE 5


START
72
74
INDEX TABLE TO NEXT (NOMINAL) STREET POSITION.
76
POSITION TABLE (ALONG LEFT-RIGHT AXIS) SUCH THAT WAFER FIDUCIAL SHOULD BE VISIBLE TO VISION SYSTEM.
CAPTURE IMAGE OF WAFER AREA.
78
80
FOUND INSTANCE OF FIDUCIAL IN CAMERA VIEW ?
NO
YES
82
IS STREET ALIGNED WITH IMPULSE BAR ?
YES
NO
84
CALCULATE ERROR DISTANCE BETWEEN STREET AND IMPULSE BAR.
86
MOVE TABLE FORWARD OR BACKWARD BY CALCULATED ERROR DISTANCE.
88
CURRENT STREET
90
AT END OF WAFER ?
NO
YES
92
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/02605

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B26F 3/00
US CL :225/2
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. : 225/2, 96, 96.5, 103, 104

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, P	US 5,820,006 A (TURNER et al) 13 October 1998, whole document, especially Figs. 1-3B and 6-17.	1-8
Y	US 4,744,550 A (OGLESBEE) 17 May 1988, col. 4, lines 22-49.	1-8
A	US 5,174,188 A (PETROZ) 29 December 1992, whole document.	1-8
A	US 4,653,680 A (REGAN) 31 May 1987, whole document.	1-8
A	US 4,296,542 A (GOTMAN) 27 October 1981, whole document.	1-8
A	US 4,057,184 A (MICHALIK) 08 November 1977, Fig. 8.	1-8

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

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Authorized officer
CHARLES GOODMAN
Telephone No. (703) 308-1148
Sheila Veney
Paralegal Specialist
Technology Center 3700