

# PATENT SPECIFICATION

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## (54) IMPROVEMENTS IN OR RELATING TO ARTICLE POSITIONING

- (71) We, WESTERN ELECTRIC COMPANY, INCORPORATED, of 195 Broadway, New York City, New York State, United States of America, a Corporation organised and existing under the laws of the State of New York, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—
- This invention relates to methods of and apparatus for positioning articles and, although not limited in its application thereto, is particularly useful in the positioning of articles such as beam lead integrated circuits, beam lead diodes, etc. During manufacturing procedures, such articles must be accurately positioned so that multiprobes, bonding tools, etc. may accurately engage contact leads or other portions of them.
- In the past, a wide variety of techniques have been used to position articles with varying degrees of precision. Among the simpler of these techniques are the manual positioning systems utilizing a microscope with cross hairs or similar indicia rigidly fixed in its optical systems. Suitable positioning mechanisms, such as manually operated wormscrews, are operated to move a stage upon which the article is placed to accurately position the article in alignment with the cross hairs. In operations where small quantities of articles of simple geometry are being handled, these systems are excellent both economically and in performance, but as the articles become more complex in detail or larger quantities are handled, these systems become slow, costly, tedious and questionable in results.
- Other known techniques utilize photo-cell or photomultiplier tubes which sense various portions of the article for reflected or transmitted light to control voltages to motors which drive a movable stage. Such systems, while working well with large articles or articles having a simple geometry, are not readily adapted to positioning articles which are microscopic in dimensions or complex in geometry. Also varying reflectivity and/or absorbent characteristics of articles cause such systems to operate with less accuracy.
- Other known positioning systems utilize video signals generated by television cameras for positioning articles. One class of television positioning system utilizes a computer to compare various portions of the field with a programmed memory. The field is divided into many subdivisions. The presence or absence of video signal in each subdivision is compared to the programmed memory to produce signals to position the article. Such systems are complex and expensive where very accurate positioning is required.
- Another class of television positioning systems uses various phase characteristics of the video signal to centre an article with respect to the television camera. While such systems are useful, they do not generally have the accuracy that is necessary for small and complex articles.
- Yet another television positioning system described in U.S. patent no. 3 749 830, senses an article or pattern associated with the article to produce a first pulse having a time relationship relative to the horizontal and vertical sync pulses indicating the actual position of the article. A timing circuit controlled by the vertical and horizontal sync pulses generates vertical cross hair pulses and horizontal cross hair pulses to which the first pulse is compared. The article is moved until the first pulse has a predetermined time relationship to the vertical and horizontal cross hair pulses.

[Price 25p]

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The present invention seeks to provide an improved method of and apparatus for positioning articles.

According to one aspect of this invention there is provided a method of positioning an article wherein a first video signal representative of said article is produced, a second signal representative of a first limit for the position of the, or an edge of, said article is produced, and, if said first and second signals overlap in time, said article is moved until said first and second signals do not overlap in time.

A third signal representative of a second limit for the position of the, or an edge of, said article may be produced, and, if said first and third signals overlap in time, said article is moved until said first and third signals do not overlap in time.

Preferably said article is initially positioned so that said first and second signals overlap in time, and said first and third signals overlap in time.

The second and third signals may represent respectively limits in X and Y mutually perpendicular directions, in which case said article may be moved, if necessary, in said X and Y directions until said first and second and said first and third signals respectively do not overlap in time.

According to another aspect of this invention apparatus for positioning an article includes image pick-up means for generating a first video signal representative of the article, a vertical synchronising signal and a horizontal synchronising signal, means for deriving from said synchronising signals a second signal representative of a limit for the position of the, or an edge of, said article, and means responsive to an overlap in time of said first and second signals for moving said article until said first and second signals do not overlap in time.

The deriving means may be adapted to provide said second and a third signal representative respectively of limits for the positions of the, or an edge of, said article in first and second directions, and said responsive means may be adapted to move said article in said first and second directions in response to said first and second signals overlapping in time, respectively, until said first and second signals do not overlap in time, and until said first and third signals do not overlap in time, respectively.

Said first and second directions may be mutually perpendicular.

The apparatus may include means responsive to said first video signal and said second or each of said second and third signals for initially moving said article so that said first video signal overlaps in time said second or each of said second and

third signals.

The invention will now be described by way of example with reference to the accompanying drawing, in which:

FIG. 1 shows a beam lead integrated circuit, which may be positioned with the aid of the invention;

FIG. 2 illustrates one form of positioning apparatus in accordance with the invention;

FIG. 3 is a block diagram of the video control circuit of the apparatus of FIG. 2.

FIG. 4 shows wave forms generated by various portions of the circuitry of FIG. 3.

FIG. 5 is a block diagram of one type of boundary marker generator which may be used in the circuit of FIG. 3.

FIG. 6 is a block diagram of an alternative form of boundary marker generator for generating both reverse and forward X boundary markers to operate the X drive motor.

FIG. 7 illustrates the use of a pair of boundary markers for positioning an article in a X direction.

FIG. 8 illustrates the use of a pair of boundary markers for positioning an article in a Y direction.

FIG. 9 illustrates the use of four boundary markers to position an article in a  $\Theta$  direction.

FIG. 10 illustrates a simplified version using only two boundary markers for positioning an article in both the X and Y directions.

FIG. 11 illustrates a simplified version using only two boundary markers for positioning an article in the  $\Theta$  direction.

Referring to FIG. 1, an article 10 to be positioned has a body 11 with a plurality of leads or tabs 12-12, such as beam leads extending therefrom. An apparatus for accurately positioning a plurality of such articles 10-10 relative to equipment (not shown), such as bonding tools, testing probes, pickup devices, etc. is shown in FIG. 2 in which the articles 10-10 are positioned on a holder 14 which is held on a rotary table 15 by means such as a vacuum chuck. The rotary table 15 is selectively rotated by a motor 16 driving a wormscrew 17 meshing with a geared edge of the rotary table 15. The motor 16 and the rotary table 15 are mounted on a X and Y movable table 20 which is moved in the X direction by a motor 21 driving a screw 22 and in the Y direction by a motor 23 driving a screw 24. Positioning motors and screw arrangements are well known.

For purposes of illustration in this description, forward direction  $+\Theta$  and reverse direction  $-\Theta$  are shown for the

rotary table 15. Forward directions +X and +Y and reverse directions -X and -Y are shown for the table 20.

A television camera 27 is positioned over the table 15 to view one or more of the articles 10 on the holder 14. The article viewed by the camera 27 is displayed on a suitable monitor 28. The camera 27 may be a conventional television camera which produces video signals along with horizontal and vertical sync signals. The camera 27 is equipped with a lens or optical system to produce a suitably enlarged representation of an article 10.

Three ganged switches 31, 32 and 33 selectively connect the respective motors 16, 21 and 23 to a manual positioning circuit 34, numerical control equipment 35 or a video control circuit 36. The manual control circuit 34 is any conventional circuit which applies suitable signals to the motors 16, 21 and 23 by manually operated switches to drive the motors in selected directions. Such circuitry is conventional and well known in the art and no further description thereof is necessary. The numerical control circuit 35 is also conventional and well known in the art and may include suitable magnetic or punched tape readers along with registers or counters and position feedback indicators to control the position of the tables 20 and 15. The manual control circuit 34 and numerical control circuit 35 are generally used to coarsely position the tables 15 and 20. The video control circuit 36 is used to accurately position an article 10. The switches 31-33 may be replaced by automatically operated equipment. For example, the numerical control 35 may coarsely position the tables 15 and 20 and then automatically actuate the video control circuit to accurately position the article 10. A less expensive system would not include the numerical control equipment, but would rely upon an operator to coarsely position each article 10.

FIG. 4 shows the various time relationships of pulses and signals in the video control circuit shown in FIG. 3. The vertical sync pulses 40 of the camera 27 are applied to a monostable multivibrator 39 which is triggered by the trailing edge of the vertical sync pulse 40 to produce pulses 41. The horizontal sync pulses 44 from the camera 27 are applied to a squaring circuit 43, such as a Schmidt trigger, to produce pulses 45. The pulses 41 and 45 from the respective monostable multivibrator 39 and squaring circuit 43 are applied to respective inputs of a plurality of the boundary marker generators 47-54. Each of the boundary marker generators 47-54 generate video signals 56-56 which are delayed from the vertical sync and

horizontal sync pulses 41 and 45. Referring to FIG. 7, the boundary marker signals produced by the generators 47 and 48 when displayed on the monitor 28 show respective boundary markers 58 and 59. The boundary markers generated by the generators 49 and 50 are shown in FIG. 8 as boundary markers 60 and 61, respectively. The boundary markers generated by the generators 51-54 are shown in FIG. 9 as boundary markers 62-65, respectively. An edge of each of the boundary markers 58-65 defines a limit for the position of the article 10; that is, the video display of the article 10 must not overlap any of the boundary markers 58-65.

Referring to FIGS. 4 and 5, there is shown a boundary marker generator and time relationships of various signals therein. A pulse 41 is applied to the input of a first monostable multivibrator 68 and triggers the latter on its trailing edge to produce a pulse 69 whose length and duration is controlled by a variable resistor 70 part of the monostable multivibrator circuit 68. The value of the resistor 70 determines the vertical position of the boundary marker. The pulse 69 is applied to a monostable multivibrator 71 and triggers the latter on its trailing edge to produce a pulse 72 whose duration is determined by the value of an adjustable resistor 73 which determines the vertical dimension or width of the boundary marker displayed on the monitor 28. The pulse 72 is applied to a first input of an AND gate 74 and pulses 45-45 from the squaring circuit 43 are applied to a second input of the AND gate 74 to produce pulses 75-75 when there is a coincidence of the pulses 45-45 and the pulse 72. The pulses 75-75 from the AND gate 74 are applied to the input of a monostable multivibrator 76 and trigger the latter on their trailing edges to produce pulses 77-77. A variable resistor 78 in the monostable multivibrator 76 determines the width of the pulses 77-77 or the horizontal position of the boundary marker. The pulses 77-77 are applied to inputs of the monostable multivibrator 79 and trigger the latter on their trailing edges to produce the pulses 56-56. The width of the pulses 56-56 or the horizontal dimension of the marker are determined by a variable resistor 80 of the monostable multivibrator 79. A switch 81 may be provided to select either the positive or negative outputs of the monostable multivibrator 79 to provide either a black or white boundary marker.

Referring back to FIG. 3, the video signal 83 is applied to a squaring circuit 84, such as a Schmidt trigger circuit, to eliminate grey areas in the signal and produce a squared signal 85 (see also FIG. 4).

The squaring circuit 84 may be adjusted by a resistor 86 to provide for varying levels of response. For example, the body 11 and leads 12-12, just the body 11, or just the leads 12, may be white or black with the rest the opposite. Also, the desired positive or inverted output of the squaring circuit 84 may be selected depending upon the requirements of the circuitry.

The squared video signal 85 is applied to first inputs of AND gates 87-92. The boundary marker signals generated by the generators 47-50 are applied to second inputs of the AND gates 87-90, the boundary marker signals generated by generators 51 and 52 are applied to second and third inputs of the AND gate 91 and the boundary marker signals generated by the generators 53 and 54 are applied to the second and third inputs of the AND gate 92. The outputs of the AND gates 87 and 88 are applied to a motor drive circuit 93 to operate the motor 21 in forward and reverse directions, the outputs of the AND gates 89 and 90 are applied to a motor drive circuit 94 to operate the motor 23 in forward and reverse directions and the outputs of the AND gates 91 and 92 are applied to a motor drive circuit 95 to operate the motor 16 in forward and reverse directions. The motor drive circuits 93-95 are conventional circuits designed to convert the pulse input signals from the AND gates 87-92 to suitable currents and voltages for the motors 21, 23 and 16. One example of such a circuit is SLO-SYN translator module STM-1800.

Referring to FIGS. 7-9, there is shown the video monitor representation of the article 10 and boundary markers 58-65 generated by the respective boundary marker generators 47-54. The article 10 is represented by a square which could be the outer dimensions of the leads 12-12, or the body 11 which is determined by the squaring circuit 84. If any of the boundary marker signals from the generators 47-50 coincide with the squared video signal 85 of the article 10, a respective AND gate 87-90 will produce an output signal to move the table 20 in a selected direction until there is no coincidence of a boundary marker signal and the video signal 85. For example in FIG. 7, the video signal of the article 10 overlaps or coincides with the boundary marker 58. Thus the AND gate 87 produces output signals to energize the motor drive 93 to operate the motor 21 and move the table 20 in the +X direction. The AND gate 87 will continue to produce signals until the video signal of article 10 no longer coincides with the boundary marker 58 and the edge of the video representation of the

article 10 abuts but does not overlap the edge of the marker 58 as shown in phantom. Similarly, as shown in FIG. 8, overlapping of the boundary marker 60 with the video representation of the article 10 causes the motor 23 to move the article 10 in the +Y direction until the edge of the article 10 is at the edge of the boundary marker 60 as shown in phantom.

If the article is rotated, as shown in FIG. 9, so that it is not properly oriented with respect to the apparatus, the video representation of the article 10 overlaps a pair of the boundary markers 62-63 or 64-65. Overlapping the pair of the boundary markers 64 and 65 causes the AND gate 92 to produce an output signal and operate the motor 95 to move the table 15 in a - $\Theta$  direction until the article 10 is properly oriented with respect to the apparatus.

It is seen that the article 10 may be very accurately positioned relative to the apparatus. Since different articles 10 may vary slightly in dimension, the markers 58 and 59 are spaced sufficiently to allow for this variation. Similarly, the spacing of the markers 60-65 is suitably selected. The accuracy of the positioning may be improved by ensuring that the representations of all the articles are abutting the same boundary markers. This may be done by slightly moving the article in -X, -Y and - $\Theta$  directions after the article has been first positioned and then allowing the article to be moved back into position.

In FIG. 6 there is shown an alternative form for the boundary marker generators 47 and 48 and the AND gates 87 and 88. The circuitry utilizes the monostable multivibrators 68, 71, 76 and 79 and the AND gate 74 to produce the +X marker signal 58 in the same manner as shown in FIG. 5. However, the -X marker signal 59 is produced by two serially connected monostable multivibrators 96 and 97 connected to the output of the monostable multivibrator 76. The monostable multivibrators 96 and 97 have variable resistors 98 and 99 and produce a delayed -X marker signal 59 in the same manner as the monostable multivibrators 76 and 79. The markers 58 and 59 are summed through two resistors 101 and 102 and applied through a resistor 103 to the collector of a transistor 104. The video signal 85 from the squaring circuit 84 is applied through a resistor 105 to the base of the transistor 104. The transistor 104 is normally biased conductive so that only the presence of a 0 level signal indicating the presence of an article in the video signal renders the transistor 104 conductive. If there is a coincidence of a 0 level signal on the base of the transistor 104 and one of the outputs from either the marker signals 58 and

59, an output pulse is produced on the collector of the transistor 104 which is applied to first inputs of the AND gates 108 and 109. The second inputs of the AND gates 108 and 109 are connected to the outputs of the respective monostable multivibrators 79 and 97 to detect which boundary marker 58 or 59 overlaps the article. The outputs of the AND gates 108 and 109 are applied to respective pulse stretching circuits 110 and 111, and amplifier circuits 112 and 113 to the motor drive circuit 93 to operate the motor 21.

Some of the circuitry in FIG. 3 may be eliminated. For example, if it is desirable to only position the X and Y direction, the generators 48, 50-54 may be eliminated along with the AND gates 88, 90-92. As illustrated in FIG. 10, the article would be coarsely positioned by the operator or the numerical control 35 so that it is over the boundary markers 58 and 60. Then the motors 21 and 23 would be operated by signals from AND gates 87 and 89 to move the article 10 into position. Similarly, the generators 51 and 52 and the AND gate 91 may be eliminated, and as shown in FIG. 11, the article 10 would be accurately positioned by the operator or numerical control equipment so that it overlaps both the boundary markers 64 and 65. The motor 16 would then be operated by signals from the AND gate 91 to move the article until it is accurately positioned by the boundary markers 64 and 65.

Other variations will occur to those skilled in the art. For example, gates 87-92, 74, 108 and 109 are described as AND gates. It is well known that with proper selection of logic levels a wide variety of different function gates, such as NOR, NAND, etc., can be made to perform the same function.

#### WHAT WE CLAIM IS:—

1. A method of positioning an article wherein a first video signal representative of said article is produced, a second signal representative of a first limit for the position of the, or an edge of, said article is produced, and, if said first and second signals overlap in time, said article is moved until said first and second signals do not overlap in time.

2. A method as claimed in claim 1 wherein a third signal representative of a second limit for the position of the, or an edge of, said article is produced, and, if said first and third signals overlap in time, said article is moved until said first and third signals do not overlap in time.

3. A method as claimed in claim 2 wherein said article is initially positioned so that said first and second signals overlap in time, and said first and third signals overlap in time.

4. A method as claimed in claim 2 or 3 wherein said second and third signals represent respectively limits in X and Y mutually perpendicular directions, and said article is moved, if necessary, in said X and Y directions until said first and second and said first and third signals respectively do not overlap in time.

5. A method as claimed in claim 4 wherein said first limit is in the forward X direction, said second limit is in the forward Y direction, a fourth signal representative of a third limit in the reverse X direction for the position of the, or an edge of, said article is produced, a fifth signal representative of a fourth limit in the reverse Y direction for the position of the, or an edge of, said article is produced, if said first and fourth signals overlap in time said article is moved in the X direction until said first and fourth signals do not overlap in time, and, if said first and fifth signals overlap in time, said article is moved in the Y direction until said first and fifth signals do not overlap in time.

6. Apparatus for positioning an article, said apparatus including image pick-up means for generating a first video signal representative of the article, a vertical synchronising signal and a horizontal synchronising signal, means for deriving from said synchronising signals a second signal representative of a limit for the position of the, or an edge of, said article, and means responsive to an overlap in time of said first and second signals for moving said article until said first and second signals do not overlap in time.

7. Apparatus as claimed in claim 6 wherein said deriving means is adapted to provide said second and a third signal representative respectively of limits for the positions of the, or an edge of, said article in first and second directions, and said responsive means is adapted to move said article in said first and second directions in response to said first and second signals overlapping in time, and said first and third signals overlapping in time, respectively, until said first and second signals do not overlap in time, and until said first and third signals do not overlap in time, respectively.

8. Apparatus as claimed in claim 7 wherein said first and second directions are mutually perpendicular.

9. Apparatus as claimed in claim 6, 7 or 8 including means responsive to said first video signal and said second or each of said second and third signals for initially moving said article so that said first video signal overlaps in time said second or each of said second and third signals.

10. Apparatus as claimed in any one of claims 6 to 9 including display means

59, an output pulse is produced on the collector of the transistor 104 which is applied to first inputs of the AND gates 108 and 109. The second inputs of the AND gates 108 and 109 are connected to the outputs of the respective monostable multi-vibrators 79 and 97 to detect which boundary marker 58 or 59 overlaps the article. The outputs of the AND gates 108 and 109 are applied to respective pulse stretching circuits 110 and 111, and amplifier circuits 112 and 113 to the motor drive circuit 93 to operate the motor 21.

Some of the circuitry in FIG. 3 may be eliminated. For example, if it is desirable to only position the X and Y direction, the generators 48, 50-54 may be eliminated along with the AND gates 88, 90-92. As illustrated in FIG. 10, the article would be coarsely positioned by the operator or the numerical control 35 so that it is over the boundary markers 58 and 60. Then the motors 21 and 23 would be operated by signals from AND gates 87 and 89 to move the article 10 into position. Similarly, the generators 51 and 52 and the AND gate 91 may be eliminated, and as shown in FIG. 11, the article 10 would be accurately positioned by the operator or numerical control equipment so that it overlaps both the boundary markers 64 and 65. The motor 16 would then be operated by signals from the AND gate 91 to move the article until it is accurately positioned by the boundary markers 64 and 65.

Other variations will occur to those skilled in the art. For example, gates 87-92, 74, 108 and 109 are described as AND gates. It is well known that with proper selection of logic levels a wide variety of different function gates, such as NOR, NAND, etc., can be made to perform the same function.

#### WHAT WE CLAIM IS:—

1. A method of positioning an article wherein a first video signal representative of said article is produced, a second signal representative of a first limit for the position of the, or an edge of, said article is produced, and, if said first and second signals overlap in time, said article is moved until said first and second signals do not overlap in time.

2. A method as claimed in claim 1 wherein a third signal representative of a second limit for the position of the, or an edge of, said article is produced, and, if said first and third signals overlap in time, said article is moved until said first and third signals do not overlap in time.

3. A method as claimed in claim 2 wherein said article is initially positioned so that said first and second signals overlap in time, and said first and third signals overlap in time.

4. A method as claimed in claim 2 or 3 wherein said second and third signals represent respectively limits in X and Y mutually perpendicular directions, and said article is moved, if necessary, in said X and Y directions until said first and second and said first and third signals respectively do not overlap in time.

5. A method as claimed in claim 4 wherein said first limit is in the forward X direction, said second limit is in the forward Y direction, a fourth signal representative of a third limit in the reverse X direction for the position of the, or an edge of, said article is produced, a fifth signal representative of a fourth limit in the reverse Y direction for the position of the, or an edge of, said article is produced, if said first and fourth signals overlap in time said article is moved in the X direction until said first and fourth signals do not overlap in time, and, if said first and fifth signals overlap in time, said article is moved in the Y direction until said first and fifth signals do not overlap in time.

6. Apparatus for positioning an article, said apparatus including image pick-up means for generating a first video signal representative of the article, a vertical synchronising signal and a horizontal synchronising signal, means for deriving from said synchronising signals a second signal representative of a limit for the position of the, or an edge of, said article, and means responsive to an overlap in time of said first and second signals for moving said article until said first and second signals do not overlap in time.

7. Apparatus as claimed in claim 6 wherein said deriving means is adapted to provide said second and a third signal representative respectively of limits for the positions of the, or an edge of, said article in first and second directions, and said responsive means is adapted to move said article in said first and second directions in response to said first and second signals overlapping in time, and said first and third signals overlapping in time, respectively, until said first and second signals do not overlap in time, and until said first and third signals do not overlap in time, respectively.

8. Apparatus as claimed in claim 7 wherein said first and second directions are mutually perpendicular.

9. Apparatus as claimed in claim 6, 7 or 8 including means responsive to said first video signal and said second or each of said second and third signals for initially moving said article so that said first video signal overlaps in time said second or each of said second and third signals.

10. Apparatus as claimed in any one of claims 6 to 9 including display means



for displaying said video signal and said second or each of said second and third signals.

11. A method of positioning an article substantially as herein described with reference to the accompanying drawing.

12. Apparatus arranged and adapted to operate substantially as herein described

with reference to FIGS. 2, 3 and 5, or to FIGS. 2, 3 and 6 of the accompanying drawing.

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