

PATENT SPECIFICATION (11)

1 308 271

DRAWINGS ATTACHED

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- (21) Application No. 14710/71 (22) Filed 13 May 1971
(31) Convention Application No. 39403 (32) Filed 21 May 1970 in
(33) United States of America (US)
(44) Complete Specification published 28 Feb. 1973
(51) International Classification B23Q 7/00 B23K 37/04 19/00
(52) Index at acceptance
B3R 10 17X

(19)



(54) PICK-UP-AND-TRANSPORT MEANS

(71) We, AUTOMATED EQUIPMENT CORPORATION, 3880 North 27th Avenue, Phoenix, Arizona, United States of America, a corporation organised under the laws of the State of California, 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 pick-up-and-transport means especially die bonder apparatus.

Semi-automatic die bonders are presently in use for bonding transistor circuit dice onto transistor strips by the application of heat and pressure. These die bonders perform the steps of picking up a single die at a loading position, moving the die to a bonding position, bonding the die onto the transistor strip, and returning to the loading position to pick up the next die. Since the dice are extremely small and must be accurately positioned and aligned on a small transistor strip (or other element), die bonders must have accurately controlled movements. In addition, they must transport the dice as rapidly as possible. Die bonders heretofore available are typically only capable of producing die bonds at a rate of about 1800 dice per hour, sequentially bonding one hundred dice onto each transistor strip, one transistor strip after the other. Moreover, they utilize high inertia motions resulting in slow performance and high maintenance costs.

It is an object of the present invention to provide an improved, accurate, low-inertia, higher speed, and more reliable semi-automatic pick-up-and-transport means.

The present invention provides means for picking up an object at a pick-up position and transporting it to a delivery position, said means comprising pick-up apparatus for picking up the object, a transfer arm carrying said pick-up apparatus at one end thereof, and first apparatus for moving said transfer arm and pick-up apparatus in a straight line between the pick-up and delivery positions, said first apparatus com-

prising first and second linkage mechanisms each pivotally coupled at one end to said transfer arm and each pivotally mounted at another end at a fixed position, an oscillatory drive link pivotally coupled at one end to one of said first and second linkage mechanisms, a first cam follower mounted on said oscillatory drive link, a first cam for controlling the movement of said first cam follower to drive said oscillatory drive link and in turn said first and second linkage mechanisms and transfer arm, and first drive apparatus for rotating said first cam.

Preferably said first cam follower comprises a pair of rollers rotatably mounted on a common shaft, one of said rollers engaging one side of a groove in said first cam and the other of said rollers engaging the opposite side of said groove.

Preferably the diameter of one of said rollers is larger than the diameter of the other of said rollers.

Preferably means according to the invention includes second apparatus for moving said pick-up apparatus vertically at said one end of said transfer arm to pick up the object. Preferably said second apparatus comprises a push rod mounted for lateral movement on said transfer arm, apparatus for coupling one end of said push rod to said pick-up apparatus to convert forward and backward lateral movement of said pick-up apparatus and a second cam follower comprising a roller engaging a surface of said first cam and further comprising apparatus for imparting lateral movement to said push rod.

Preferably means according to the invention includes an indexing mechanism for feeding a device to the delivery position whereupon the object may be mounted upon the device, said indexing mechanism comprising second drive apparatus for moving the device relative to the delivery position, control apparatus responsive to movement of the device to the delivery position for activating said first drive apparatus and responsive to subsequent operation of said first drive apparatus for operating said sec-

[Price 25p]

ond drive apparatus to move the device relative to the delivery position.

Preferably said control apparatus comprises optical apparatus for sensing the presence of the device at the delivery position.

Preferably said optical apparatus includes a fiber optic bundle positioned at the delivery position for detecting light reflected from the device.

Preferably means according to the invention includes clamping apparatus responsive to movement of the device to the delivery position for holding the device at the delivery position.

Preferably said second drive apparatus comprises at least one pair of rollers for engaging the device and a stepping motor for driving at least one of said last-mentioned pair of rollers. Preferably said clamping apparatus comprises a solenoid, a clamping arm operated by said solenoid to clamp the device in the delivery position, and apparatus operated by said clamping apparatus to disengage at least one of said last-mentioned pair of rollers from the device.

Preferably each of said first and second linkage mechanisms comprises a yoke member pivotally coupled at one end to said transfer arm, a compensating link pivotally coupled at one end to the other end of the yoke member and pivotally mounted at the other end at a fixed position, an oscillatory link pivotally coupled at one end to a mid-portion of said yoke member and pivotally mounted at the other end at a fixed position, and wherein the yoke members of said first and second linkage mechanisms are pivotally coupled to said transfer arm at spaced apart positions thereon.

Means according to the invention in the form of a die bonder sharply reduces the maintenance problems normally encountered with existing die bonders and will produce on the order of 6,000 to 7,200 accurate die bonds per hour. It employs a fast, precise linear drive motion to transport the individual die from the loading position to the bonding position. The transistor strips (or other elements) are fed in automatic indexing fashion to the bonding position, each transistor strip in turn being indexed into position for the attachment of each individual die.

In accordance with an illustrated preferred embodiment of this invention, means according to the invention providing a die bonder comprises a reciprocating ram mechanism operated by a motor-driven cam and provided with a spring-loaded, floating vacuum quill for picking up and holding a die while the die is transported from the loading position to the bonding position. The reciprocating ram mechanism employs a ram arm having a low-inertial, dual,

straight-line modified Scott-Russel motion with a precise linear stroke of, for example, $4\frac{1}{2}$ " within $\pm .002$, obtained through a suitable amplification ratio of, for example, 8:1. The ram arm carries a spring-loaded push rod, which is coupled at its outer end to a bell crank pivotally connected to a housing for the floating vacuum quill. This housing is suspended from the outer end of the ram arm by a pair of leaf springs or reeds. A motor-driven cam operates the push rod, through an oscillating cam-follower and two trip dogs coupled to the push rod and pivotally mounted on the ram arm, at the period in time when the vacuum quill is over the loading position to lower and raise the vacuum quill to pick up a die and at the period in time when the vacuum quill is over the bonding position to again lower and raise the vacuum quill to deposit the die on a transistor strip (or other element). In order to attain functional symmetry with the least functional disturbance, a modified sine-curve cam with higher harmonics eliminated is employed. The oscillating cam-follower, which serves to drive the ram mechanism through an oscillating link, utilizes a double roller, one smaller diameter roller and one larger diameter roller on a common eccentric roller pin. The motor-driven cam has a groove with conjugate upper and offset lower tracks, which allow the smaller diameter roller to contact the upper track and the larger diameter roller to contact the offset lower track, thereby providing positive tracking for both rollers. The conjugate-track cam, double-roller follower, and the oscillating link form a rigid mechanism for amplifying and imparting linear motion to the ram mechanism. The oscillating cam-follower combines with the linear-motion ram mechanism to form a very low torque, low-inertia reciprocating mechanism.

The transistor strip is indexed by a mechanism including two sets of rollers, each set including a motor-driven drive roller and a pressure or nip roller that serves to push the transistor strip against the drive rollers. The drive rollers are driven from a stepping motor pulsed from a photo-electric pulse control mounted on a drive shaft for the cam. A fiber optics strip sensor and hole sensor mounted on the indexing mechanism are utilized to sense the presence of a transistor strip and the presence of an indexing hole in the transistor strip. When the stepping motor is pulsed to move the transistor strip one step between bondings, the applied pulse is on only long enough to move the indexing hole from alignment with the hole sensor, a light source and photocell then serving to continue the motor drive until the hole sensor senses the next indexing hole. Thus, the indexing

mechanism is independent of the constant drive factor, which occurs with the use of strip sprockets, cog wheels, etc. A vertically movable strip locator and clamp positioned near the bonding position allows the nip rollers to be released as it moves downward, thereby allowing the transistor strip to float before locating pins enter indexing holes for positive positioning. A heater unit heats the transistor strip during the bonding and indexing cycle, bringing the transistor strip from ambient temperature to a bonding temperature of 435C to 500C within five seconds.

There now follows a detailed description which is to be read with reference to the accompanying drawings by means according to the invention in the form of a die bonder, it is to be clearly understood that this bonder has been selected for description to illustrate the invention by way of example and not by way of limitation.

In the drawings:—

Figures 1 and 2 are side and front views, respectively, of a die bonder according to the preferred embodiment of this invention;

Figure 3 is a view partly in cross-section of the vacuum quill assembly utilized in the die bonder of Figures 1 and 2;

Figure 4, 5 and 6 are top, side, and front views, respectively, of the reciprocating mechanism utilized in the die bonder of Figures 1 and 2 to transport a die from a loading pedestal to a bonding block;

Figures 7 and 8 are side and cross-sectional views, respectively, of the motor-driven cam utilized in the reciprocating mechanism of Figures 4, 5 and 6;

Figure 9 is a timing diagram illustrating the operation of the die bonder of Figures 1 and 2; and

Figures 10 and 11 are top and front views, respectively, of a transistor strip indexing mechanism utilized in the die bonder of Figures 1 and 2.

Referring now to Figures 1 and 2, there is shown a die bonder comprising a main base 21 supporting left and right hand transistor strip magazine holders 22 and 23, respectively, a transistor strip indexing mechanism 24, a heater unit 25, a wafer holding pedestal 26, a reciprocating mechanism unit 27, a microscope 28, and an electronic logic control compartment 29. A magazine 31 containing ten transistor strips and an empty magazine 32 are placed by the operator in the left and right hand transistor strip magazine holders 22 and 23, respectively. At the start of a bonding operation, the first transistor strip is fed by the operator onto the indexing mechanism. The operator observes all of the dice of a semiconductor wafer lying on a top plate 33 of the wafer holding pedestal 26 through the microscope 28 and controls the stopping

and starting of the die bonder while feeding each of the dice on the top plate 33 under a pick-up mechanism of the die bonder. So long as each die is picked up in turn without a miss and carried to a bonding position on the heater unit 25 of the transistor strip indexing mechanism 24, the operator will maintain the machine in an "operate" mode.

The pick-up mechanism of the die bonder comprises a vacuum quill assembly housing 34 pivotally connected by a pin 35 to a bell crank 36, which is pivotally mounted by a pin 37 on an outer end portion of a ram arm 38 and is also coupled to an end portion 39 of a push rod 41 by a pivot pin 42. The vacuum quill assembly housing 34 is movably affixed to the end portion of the ram arm by a pair of parallel, flexible leaf springs or reeds 43, which permit vertical movement of the vacuum quill assembly housing 34 on the end portion of the ram arm 38 under control of the lateral motion of the push rod 41. The vacuum quill assembly housing 34 carries a hollow capillary tube 44 coupled via a vacuum hose 45 to a vacuum valve operable to apply a vacuum to the capillary tube 44 to pick-up and hold a die on the end of the capillary tube while the vacuum quill assembly housing is moved on the end portion of ram arm 38 to the bonding position on the heater unit 25 of the transistor strip indexing mechanism 24.

As shown in more detail in Figure 3, the vacuum quill assembly housing comprises a tubular quill 34¹ with a capillary tube 44 secured in the end thereof. The quill 34¹ slides vertically in a bushing 34¹¹, the quill being urged in a downward direction so as to exert pressure on the die against the transistor strip in the bonding position by means of a spiral spring 40 mounted on the vacuum quill assembly housing 34. The outer end portion of the spiral spring 40 engages a collar 40¹ affixed to the quill 34¹.

As shown in Figures 4 and 5, the ram arm 38 is supported by a pair of linear motion imparting mechanisms comprising a pair of yoking links 48 and 49 pivotally coupled at one end to the ram arm by pins 46 and 47, respectively, and pivotally coupled at the other end to one end of upper and lower compensating links 51 and 52 by pins 53 and 54, respectively. The upper and lower compensating links 51 and 52 are pivotally affixed at their other ends to the main frame of the die bonder by pivot shafts 55 and 56, respectively. A pair of oscillating links 57 and 58 coupled at one end to the mid-position of the yoking links 48 and 49 by pins 59 and 61, respectively, are pivotally affixed at the other ends thereof to the main frame of the die bonder by pivot shafts 62 and 63, respectively. This

reciprocating mechanism is driven by an oscillating drive link 64 pivotally mounted at one end on the main frame of the die bonder by a pivot shaft 65 and coupled at the other end to the oscillating link 57 by means of a shoe 66, which is affixed to oscillating link 57 by a screw 67 and is slidably captured within a slot 68 in the end of the oscillating drive link 64.

As shown in Figures 4—8, a cam follower comprising a larger diameter roller 69 and a smaller diameter roller 71 rotatably mounted on an eccentric roller pin 72 is affixed by the roller pin 72 to the oscillating drive link 64. The rollers 69 and 71 are driven by the drive cam 73 mounted on a drive shaft 74 and coupled via a belt drive 75 to a main drive motor 76. One complete revolution of the drive cam 73 produces one oscillation of the oscillating drive link 64, which in turn produces one oscillation of the oscillating link 57 and thereby moves the yoking link 48 and, hence, the ram arm 38 first forward and then backward over a $4\frac{1}{2}$ " linear path. As illustrated in Figure 9, the forward movement of the ram arm 38 and the vacuum quill assembly 34 is followed by a first dwell period at the loading position on the top plate 33 of the wafer holding pedestal 26, and the return or backward movement of the ram arm and vacuum quill assembly is followed by a second dwell period at the bonding position on the transistor strip.

During the first dwell period, the vacuum quill assembly is first lowered to pick up a die from the top plate 33 of wafer holding pedestal 26 and is then raised with the die and, during the second dwell period, is lowered to deposit the die at the bonding position on the transistor strip and is then raised again. To accomplish this, two L-shaped trip dogs 81 and 82 are pivotally mounted by pins 83 and 84, respectively, on the ram arm 38 in spaced-apart relationship. The trip dogs 81 and 82 each have one leg pivotally affixed to the push rod 41 by pins 85 and 86, respectively, and another leg positioned for engagement with a cam follower arm. When the ram arm 38 is in its forwardmost position during the first dwell period, the drive cam 73 will operate upon a cam follower roller 87 to rotate an L-shaped cam follower arm 88 in a counter-clockwise direction about a pivot shaft 89, which mounts the cam follower arm 88 on the main frame of the die bonder. In pivoting about the shaft 89, the cam follower arm 88 rotates the trip dog 81 counter-clockwise about the pin 83 to move the push rod 41 forward on the ram arm 38 against the tension of a spring 91. This causes the bell crank 36 to rotate about the pin 37 and the lower vacuum quill assembly housing 34 so as to engage the end of the capil-

lary tube 44 with a die lying on the top plate 33 of the wafer holding pedestal 26. At this time, vacuum is applied to the capillary tube 44 to hold the die against the end of the capillary tube while the die is transported to the bonding position. As the drive cam 73 continues to rotate, the cam follower arm 88 rotates back in a clockwise direction under the urging of a compression spring 93. This permits the push rod 41 to move backwards to its rearmost position under the urging of the compression spring 91 and thereby raise the vacuum quill assembly housing 34 and the die held on the capillary tube 44. When the ram arm 38 is in its rearmost position, the vacuum quill assembly housing 34 is positioned over the heater unit 25 of the indexing mechanism 24 and the cam follower 88 is again operated to rotate the trip dog 82 counter-clockwise about the pin 84. This again moves the push rod 41 forward against the tension of the spring 91 to lower the vacuum quill assembly housing 34 and thereby move the die held on the capillary tube 44 down onto the transistor strip positioned on the heater unit 25. The die is thereupon bonded to the transistor strip by the application of heat and pressure.

The drive cam 73 and the three cam follower rollers 69, 71, and 87 are shown in detail in Figures 7 and 8. The smaller diameter roller 71 engages the upper side 94 of a groove in the drive cam 73, and the larger diameter roller 69 rides on the lower side 95 of the groove. The cam follower roller 87 mounted on the cam follower arm 88 rides on the peripheral surface 96 of the drive cam 73. As shown in Figures 4 and 6, the drive shaft 74 for the drive cam 73 extends through a support bearing 101 and has another cam 102 mounted thereon. The cam 102 operates a vacuum valve 104 through a cam follower 103 to control the application of vacuum to the capillary tube 44 of the vacuum quill assembly at the proper time in the die pick-up cycle. A light housing 105 is also mounted on the drive shaft 74 to control the light passing from three light sources 106, 107, and 108 mounted inside the light housing to three photocells 109, 111, and 112 mounted outside the light housing. The light source 106 and the photocell 109 serve to maintain the die bonder operable to the end of a complete cycle should the operator turn the machine off in the middle of the cycle, the light source 107 and the photocell 111 serve to operate a clamp solenoid described below, and the light source 108 and the photocell 112 serve to provide a start pulse to indexing mechanism 24 described below.

Referring now to Figures 10 and 11, the heater unit 25 is mounted within the indexing mechanism 24 and serves to support a

transistor strip (not shown) to which the dice are bonded. The indexing mechanism 24 includes a stepping motor 116 coupled via a drive belt 117 and a gear pulley 118 to a shaft 119 on which two miter gears 121 and 122 are mounted. The miter gears 121 and 122 serve to drive two transistor strip drive rollers 123 and 124, respectively, via two miter gears 125 and 126 mounted on two roller shafts 127 and 128. Two nip rollers 131 and 132 are mounted on two lever arms 133 and 134 pivotally mounted on two shafts 135 and 136, respectively. These nip rollers are urged against the drive rollers 123 and 124 by the action of two springs 135¹ and 136¹ coupled to lever arms 133 and 134, respectively. The transistor strip is fed by the operator between the drive roller 123 and the nip roller 131, and the drive roller 123 is driven by the stepping motor 116 until a strip of reflecting material on the transistor strip passes under the end of a fiber optic bundle 137. This fiber optic bundle comprises an inner fiber optic bundle and an annular outer fiber optic bundle surrounding the inner fiber optic bundle. Light reflected through the annular outer fiber optic bundle from the strip of reflecting material on the transistor strip signals the presence of the transistor strip at the bonding position, and the die bonder is thereupon energized to start the die pick-up and transport cycle. The inner fiber optic bundle is employed to detect an indexing hole in the strip of reflecting material on the transistor strip as the transistor strip moves across the heater unit 25. Presence of an indexing hole under the inner fiber optic bundle signals the stepping motor 116 to stop and thereby bring the transistor strip to rest. A short time later, a clamping solenoid 141 is operated from the light source 107 and the photocell 111 to rotate a pinion 142, which, through a pinion and rack arrangement, lowers a slide 143 to lower a locating and clamping arm 144 down onto the transistor strip. This holds the transistor strip clamped down on the heater unit 25 during the die bonding. When the slide 143 first starts moving downward, integral pins 143¹ engage the inner ends of the two lever arms 133 and 134, which thereupon pivot about the shafts 135 and 136, respectively, to raise the nip rollers 131 and 132 up off the transistor strip so that the transistor strip is no longer held between the sets of rollers. As the slide 143 and, hence, the locating and clamping arm 144 continues moving downward two pins 145 in the locating and clamping arm engage two indexing holes in the transistor strip and serve to precisely align the bonding point on the transistor strip under the capillary tube 44 of the vacuum quill assembly just before the transistor strip

is firmly clamped by the locating and clamping arm.

WHAT WE CLAIM IS:—

1. Means for picking up an object at a pick-up position and transporting it to a delivery position, said means comprising pick-up apparatus for picking up the object, a transfer arm carrying said pick-up apparatus at one end thereof, and first apparatus for moving said transfer arm and pick-up apparatus in a straight line between the pick-up and delivery positions, said first apparatus comprising first and second linkage mechanisms each pivotally coupled at one end to said transfer arm and each pivotally mounted at another end at a fixed position, an oscillatory drive link pivotally coupled at one end to one of said first and second linkage mechanisms, a first cam follower mounted on said oscillatory drive link, a first cam for controlling the movement of said first cam follower to drive said oscillatory drive link and in turn said first and second linkage mechanisms and transfer arm, and first drive apparatus for rotating said first cam.

2. Means according to claim 1 wherein said first cam follower comprises a pair of rollers rotatably mounted on a common shaft, one of said rollers engaging one side of a groove in said first cam and the other of said rollers engaging the opposite side of said groove.

3. Means according to either one of claims 1 and 2 wherein the diameter of one of said rollers is larger than the diameter of the other of said rollers.

4. Means according to any one of claims 1, 2, and 3 including second apparatus for moving said pick-up apparatus vertically at said one end of said transfer arm to pick up the object.

5. Means according to claim 4 wherein said second apparatus comprises a push rod mounted for lateral movement on said transfer arm, apparatus for coupling one end of said push rod to said pick-up apparatus to convert forward and backward lateral movement of said push rod into upward and downward vertical movement of said pick-up apparatus and a second cam follower comprising a roller engaging a surface of said first cam and further comprising apparatus for imparting lateral movement to said push rod.

6. Means according to any one of the preceding claims including an indexing mechanism for feeding a device to the delivery position whereupon the object may be mounted upon the device, said indexing mechanism comprising second drive apparatus for moving the device relative to the delivery position, control apparatus responsive to movement of the device to the



transistor strip (not shown) to which the dice are bonded. The indexing mechanism 24 includes a stepping motor 116 coupled via a drive belt 117 and a gear pulley 118 to a shaft 119 on which two miter gears 121 and 122 are mounted. The miter gears 121 and 122 serve to drive two transistor strip drive rollers 123 and 124, respectively, via two miter gears 125 and 126 mounted on two roller shafts 127 and 128. Two nip rollers 131 and 132 are mounted on two lever arms 133 and 134 pivotally mounted on two shafts 135 and 136, respectively. These nip rollers are urged against the drive rollers 123 and 124 by the action of two springs 135¹ and 136¹ coupled to lever arms 133 and 134, respectively. The transistor strip is fed by the operator between the drive roller 123 and the nip roller 131, and the drive roller 123 is driven by the stepping motor 116 until a strip of reflecting material on the transistor strip passes under the end of a fiber optic bundle 137. This fiber optic bundle comprises an inner fiber optic bundle and an annular outer fiber optic bundle surrounding the inner fiber optic bundle. Light reflected through the annular outer fiber optic bundle from the strip of reflecting material on the transistor strip signals the presence of the transistor strip at the bonding position, and the die bonder is thereupon energized to start the die pick-up and transport cycle. The inner fiber optic bundle is employed to detect an indexing hole in the strip of reflecting material on the transistor strip as the transistor strip moves across the heater unit 25. Presence of an indexing hole under the inner fiber optic bundle signals the stepping motor 116 to stop and thereby bring the transistor strip to rest. A short time later, a clamping solenoid 141 is operated from the light source 107 and the photocell 111 to rotate a pinion 142, which, through a pinion and rack arrangement, lowers a slide 143 to lower a locating and clamping arm 144 down onto the transistor strip. This holds the transistor strip clamped down on the heater unit 25 during the die bonding. When the slide 143 first starts moving downward, integral pins 143¹ engage the inner ends of the two lever arms 133 and 134, which thereupon pivot about the shafts 135 and 136, respectively, to raise the nip rollers 131 and 132 up off the transistor strip so that the transistor strip is no longer held between the sets of rollers. As the slide 143 and, hence, the locating and clamping arm 144 continues moving downward two pins 145 in the locating and clamping arm engage two indexing holes in the transistor strip and serve to precisely align the bonding point on the transistor strip under the capillary tube 44 of the vacuum quill assembly just before the transistor strip

is firmly clamped by the locating and clamping arm.

WHAT WE CLAIM IS:—

1. Means for picking up an object at a pick-up position and transporting it to a delivery position, said means comprising pick-up apparatus for picking up the object, a transfer arm carrying said pick-up apparatus at one end thereof, and first apparatus for moving said transfer arm and pick-up apparatus in a straight line between the pick-up and delivery positions, said first apparatus comprising first and second linkage mechanisms each pivotally coupled at one end to said transfer arm and each pivotally mounted at another end at a fixed position, an oscillatory drive link pivotally coupled at one end to one of said first and second linkage mechanisms, a first cam follower mounted on said oscillatory drive link, a first cam for controlling the movement of said first cam follower to drive said oscillatory drive link and in turn said first and second linkage mechanisms and transfer arm, and first drive apparatus for rotating said first cam.

2. Means according to claim 1 wherein said first cam follower comprises a pair of rollers rotatably mounted on a common shaft, one of said rollers engaging one side of a groove in said first cam and the other of said rollers engaging the opposite side of said groove.

3. Means according to either one of claims 1 and 2 wherein the diameter of one of said rollers is larger than the diameter of the other of said rollers.

4. Means according to any one of claims 1, 2, and 3 including second apparatus for moving said pick-up apparatus vertically at said one end of said transfer arm to pick up the object.

5. Means according to claim 4 wherein said second apparatus comprises a push rod mounted for lateral movement on said transfer arm, apparatus for coupling one end of said push rod to said pick-up apparatus to convert forward and backward lateral movement of said push rod into upward and downward vertical movement of said pick-up apparatus and a second cam follower comprising a roller engaging a surface of said first cam and further comprising apparatus for imparting lateral movement to said push rod.

6. Means according to any one of the preceding claims including an indexing mechanism for feeding a device to the delivery position whereupon the object may be mounted upon the device, said indexing mechanism comprising second drive apparatus for moving the device relative to the delivery position, control apparatus responsive to movement of the device to the



- delivery position for activating said first drive apparatus and responsive to subsequent operation of said first drive apparatus for operating said second drive apparatus to move the device relative to the delivery position.
7. Means according to claim 6 wherein said control apparatus comprises optical apparatus for sensing the presence of the device at the delivery position.
8. Means according to claim 7 wherein said optical apparatus includes a fiber optic bundle positioned at the delivery position for detecting light reflected from the device.
9. Means according to any one of claims 6, 7, and 8 including clamping apparatus responsive to movement of the device to the delivery position for holding the device at the delivery position.
10. Means according to claim 9 wherein said second drive apparatus comprises at least one pair of rollers for engaging the device and a stepping motor for driving at least one of said last-mentioned pair of rollers.
11. Means according to claim 10 wherein said clamping apparatus comprises a solenoid, a clamping arm operated by said solenoid to clamp the device in the delivery position, and apparatus operated by said clamping apparatus to disengage at least one of said last-mentioned pair of rollers from the device.
12. Means according to any one of the preceding claims wherein each of said first and second linkage mechanisms comprises a yoke member pivotally coupled at one end to said transfer arm, a compensating link pivotally coupled at one end to the other end of the yoke member and pivotally mounted at the other end at a fixed position, an oscillatory link pivotally coupled at one end to a mid-portion of said yoke member and pivotally mounted at the other end at a fixed position, and wherein the yoke members of said first and second linkage mechanisms are pivotally coupled to said transfer arm at spaced apart positions thereon.
13. Means for picking up an object at a pick-up position and transporting it to a delivery position, the means being substantially as herein described with reference to the accompanying drawings.

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