United States Patent

Diepeveen

[15] **3,653,268**

[45] **Apr. 4, 1972**

[54] TOOL MOVING MECHANISM

[72] Inventor: **John C. Diepeveen,** 1737 Kimberly Drive, Sunnyvale, Calif. 94087

[22] Filed: **Mar. 10, 1970**

[21] Appl. No.: **18,153**

[52] **U.S. Cl.** **74/55,** 228/3

[51] **Int. Cl.** **F16h 25/08**

[58] **Field of Search** 74/55, 54, 53, 49, 45, 567; 228/3, 4, 5

[56] **References Cited**

UNITED STATES PATENTS

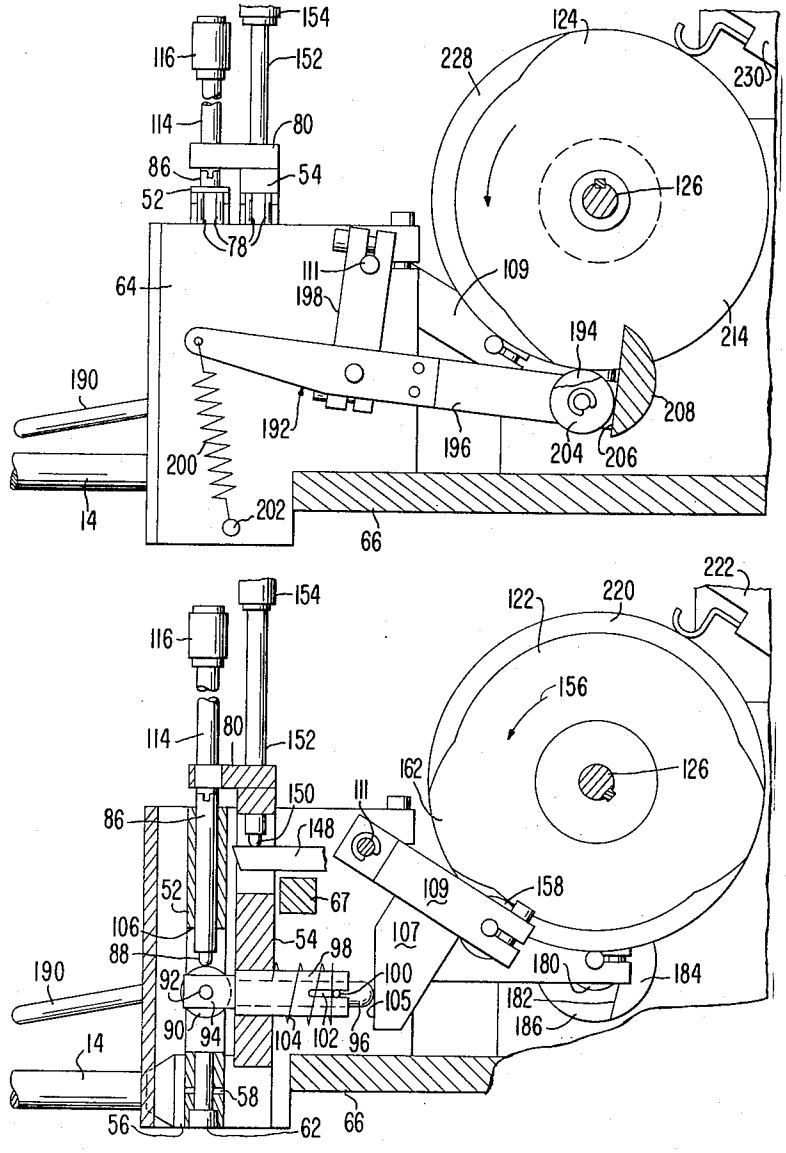
3,199,358	8/1965	Bradlee	74/55
3,306,116	2/1967	Ross et al	74/55
3,341,682	9/1967	Fegley	228/4
3,342,395	9/1967	Diepeveen	74/54

Primary Examiner—William F. O'Dea
Assistant Examiner—Wesley S. Ratliff, Jr.
Attorney—Townsend and Townsend

[57] **ABSTRACT**

Apparatus for moving a tool along a predetermined path and in accordance with a preselected sequence wherein the apparatus includes a slide unit shiftably mounted for movement along a generally vertical path, the slide unit having a pair of relatively shiftable members which are normally releasably interconnected. One of the members of the slide unit is adapted to be coupled to a tool and is released from coupled relationship to the other member when the slide unit is at several positions along the path. The invention is suitable for use with a thermal compression bonding tool for bonding wires to a die and to the terminals of a supporting frame for the die.

20 Claims, 10 Drawing Figures



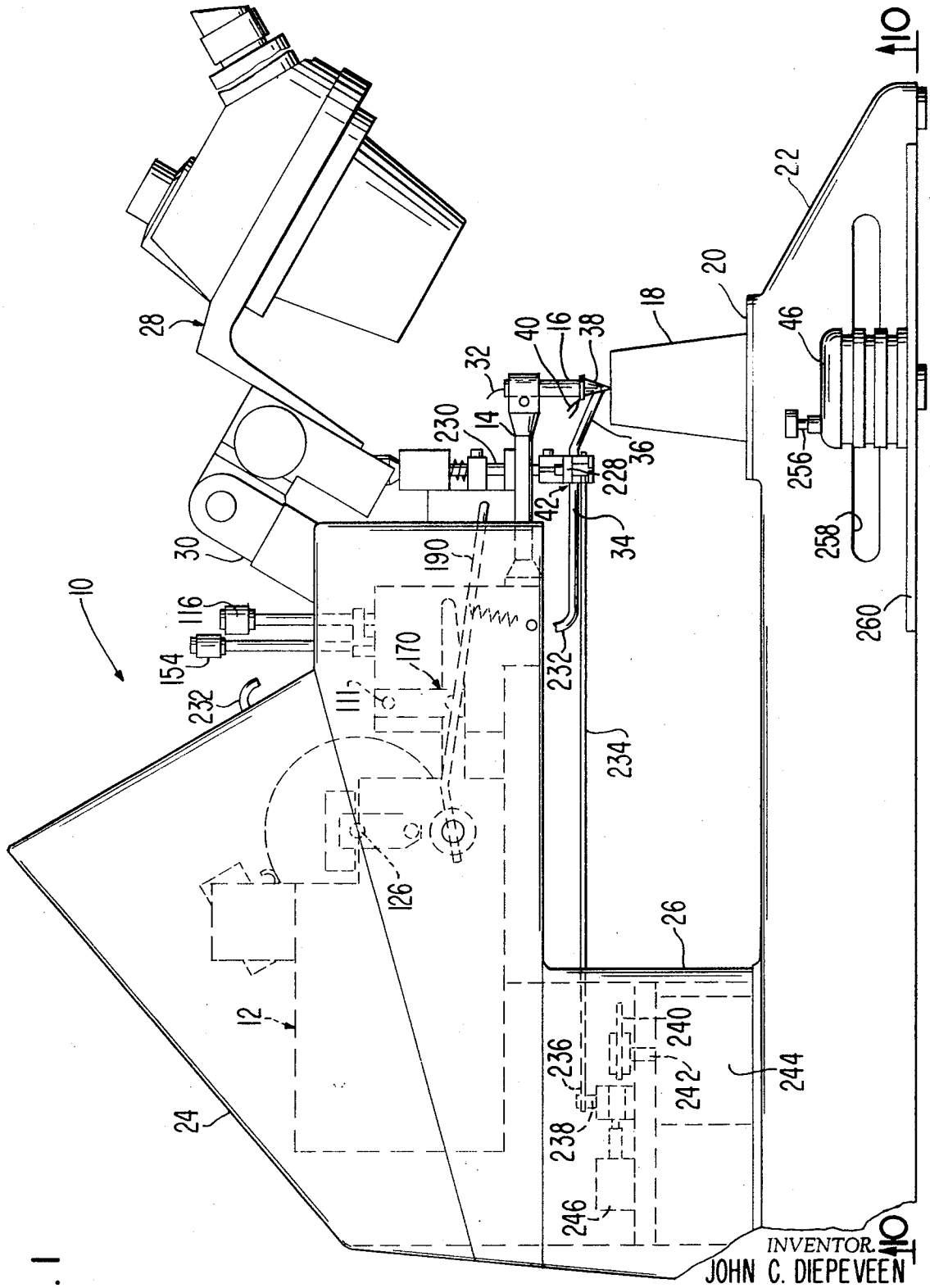


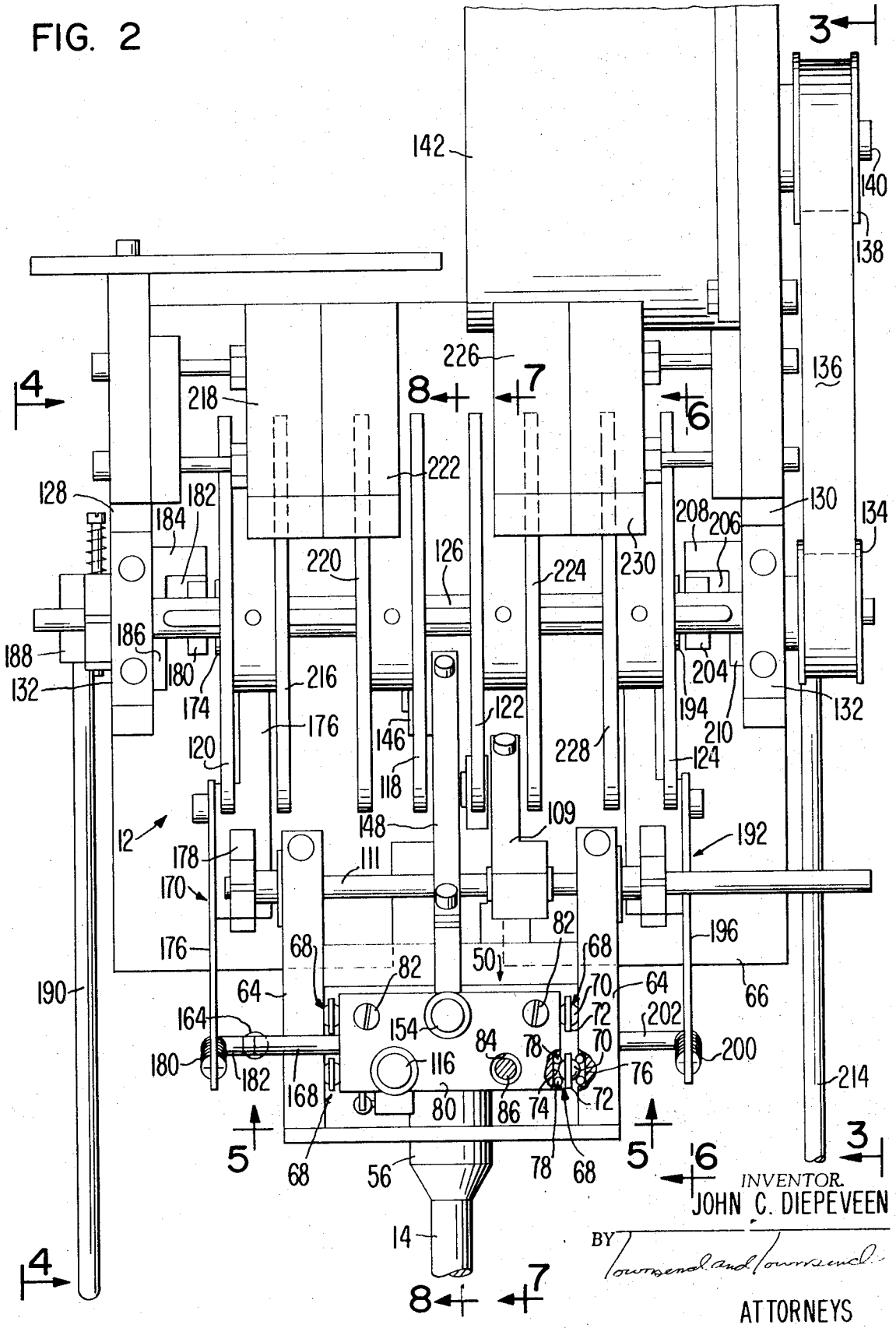
FIG. 1

INVENTOR.
JOHN C. DIEPEVEEN

BY Townsend and Townsend

ATTORNEYS

FIG. 2


142
140
138
136
130
134
128
182
184
208
206
226
218
222
220
126
224
230
186
188
180
174
216
176
122
146
228
124
120
118
132
194
210
204
148
109
192
12
178
111
170
196
176
68
82
50
64
66
190
164
154
84
78
202
180
182
168
116
80
86
74
72
76
200
214
56
14
INVENTOR.
JOHN C. DIEPEVEEN
BY Townsend and Townsend
ATTORNEYS

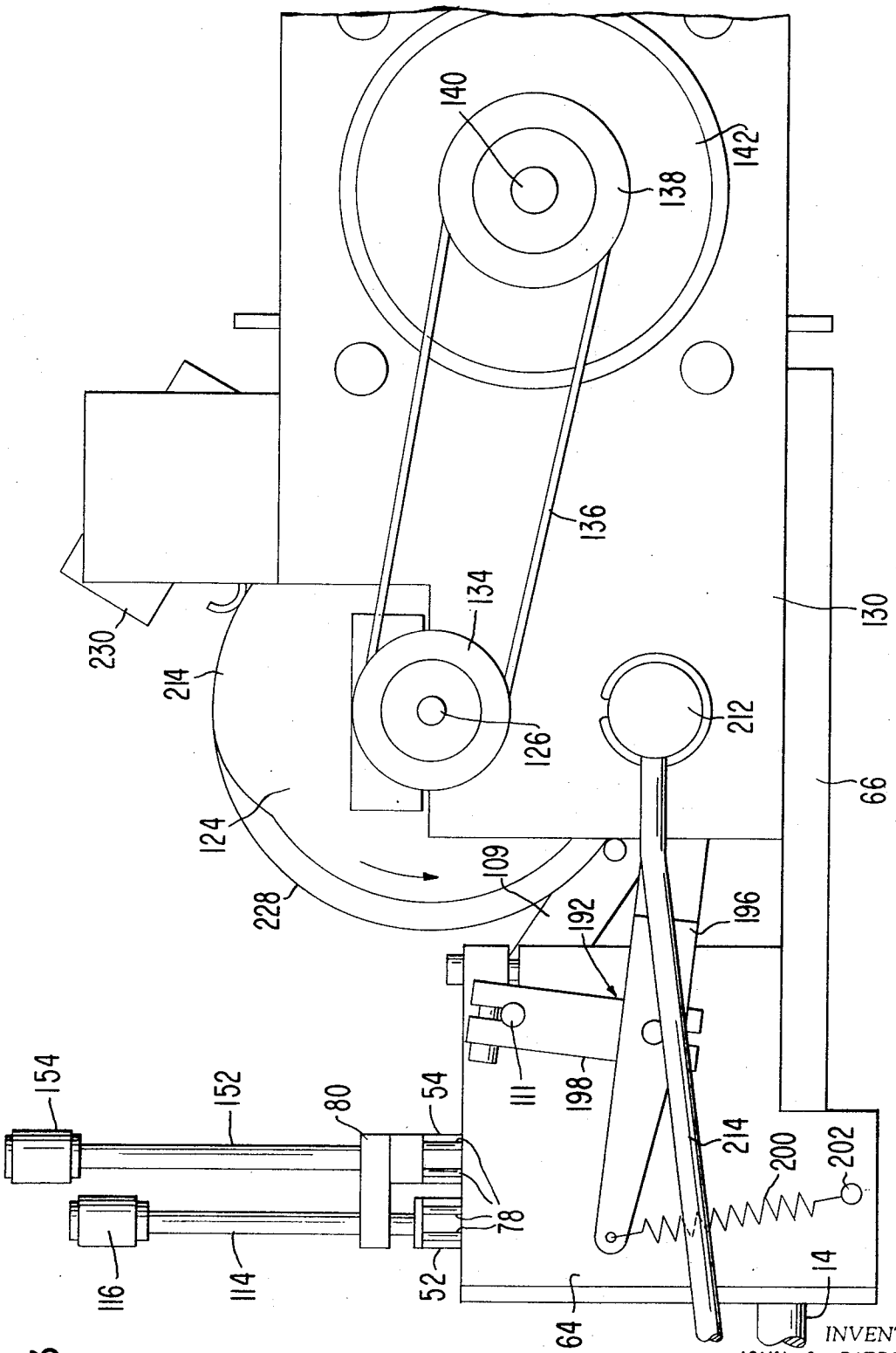


FIG. 3

INVENTOR.
JOHN C. DIEPEVEEN

BY Townsend and Townsend

ATTORNEYS

FIG. 4

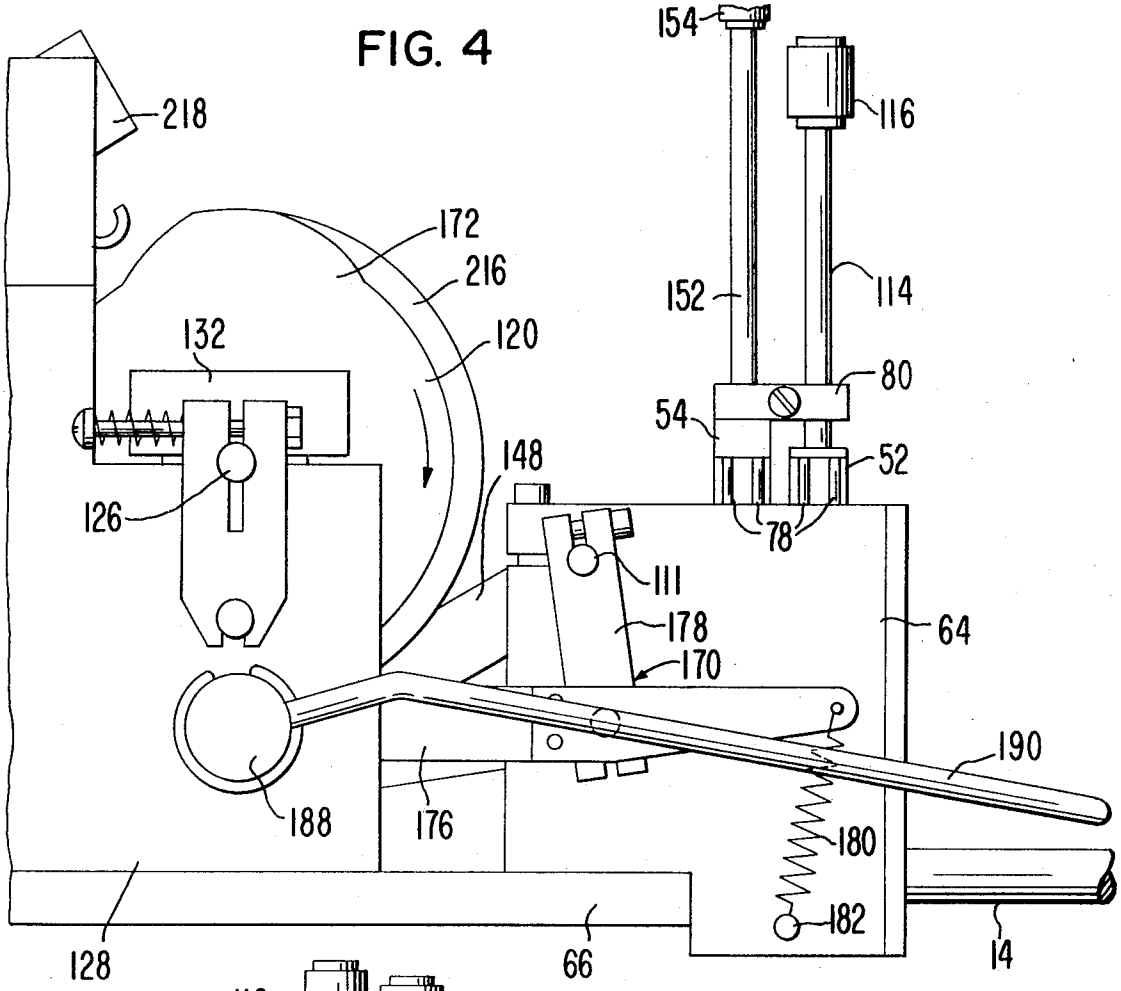
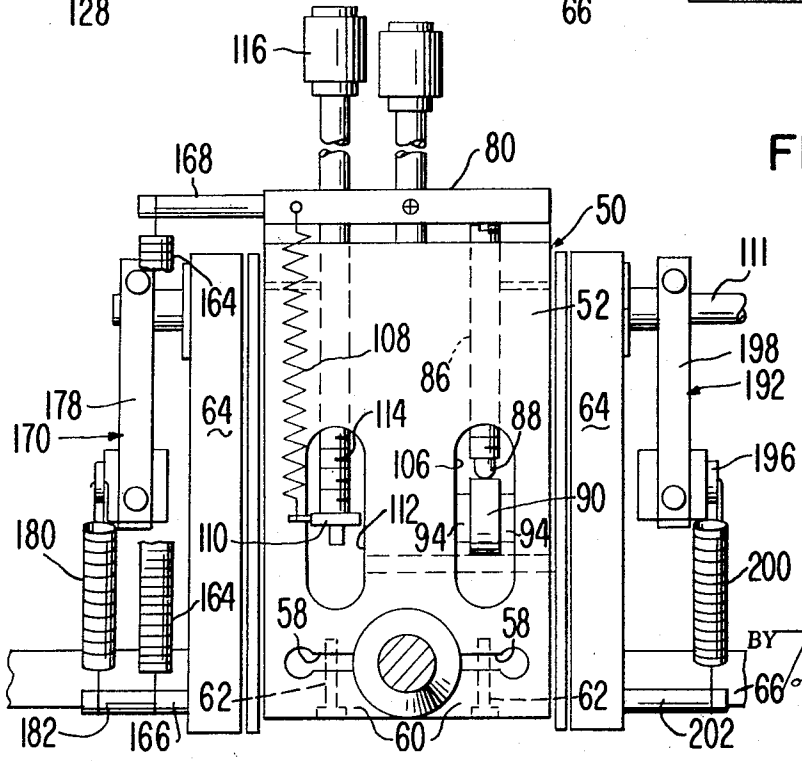


FIG. 5



INVENTOR.
JOHN C. DIEPEVEEN

BY Townsend and Townsend

ATTORNEYS

FIG. 6

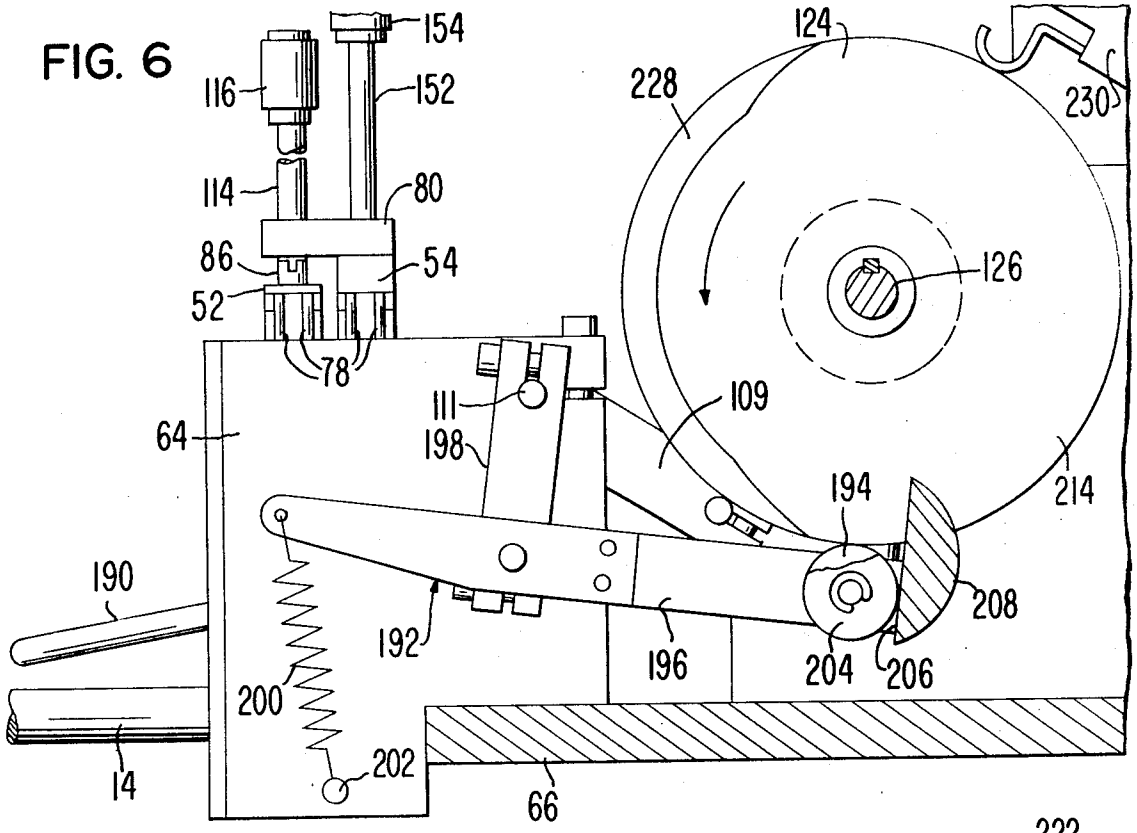
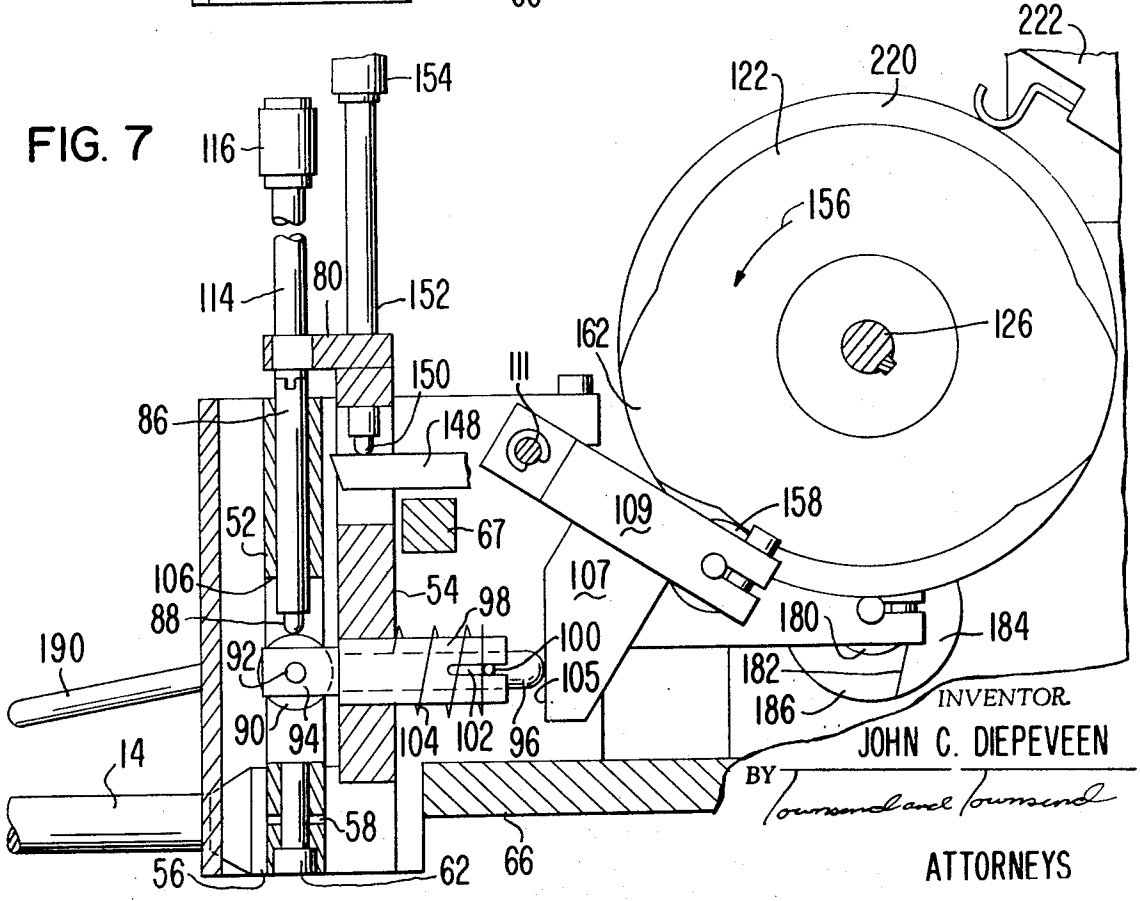


FIG. 7



INVENTOR.
JOHN C. DIEPEVEEN
BY Townsend and Townsend
ATTORNEYS

FIG. 8

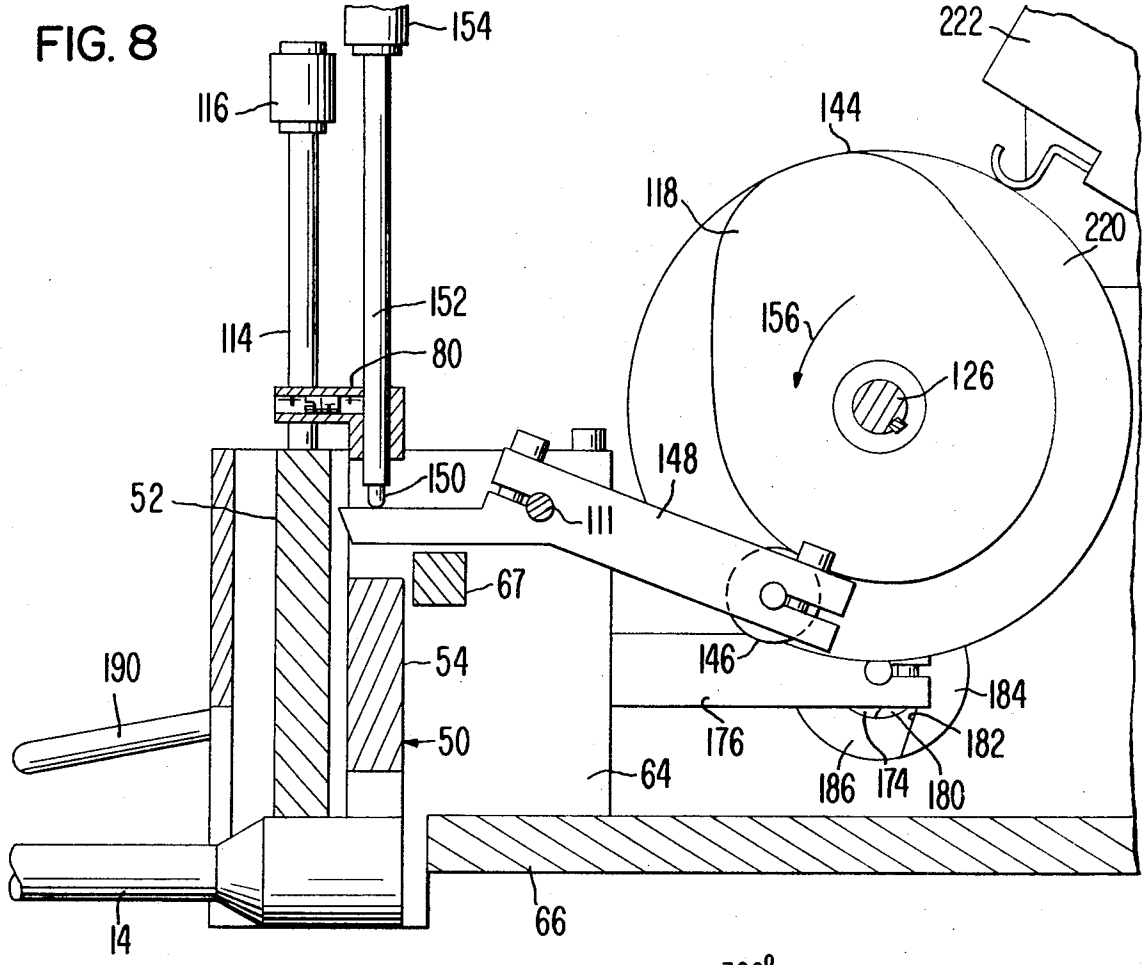
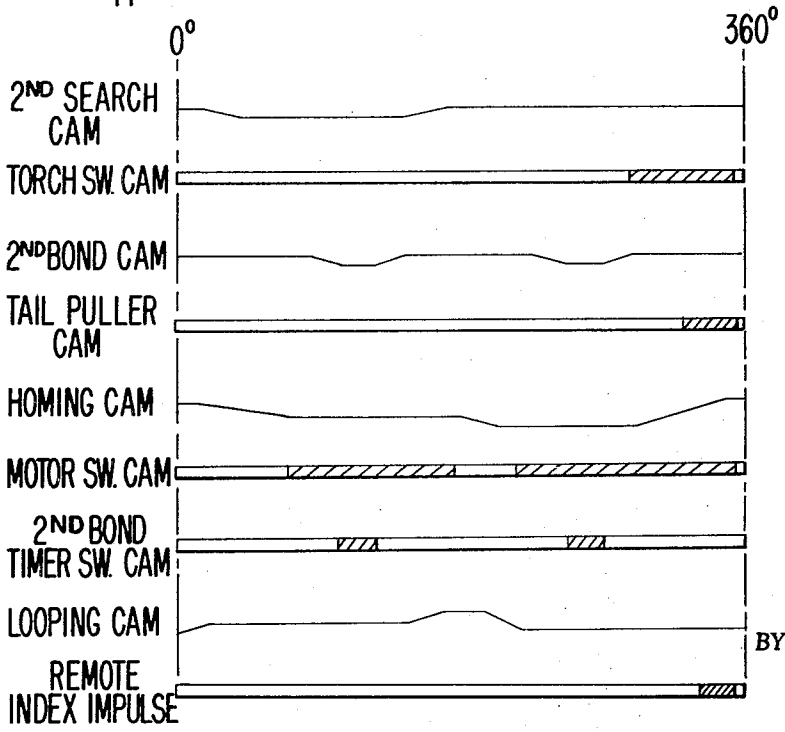


FIG. 9



INVENTOR.
JOHN C. DIEPEVEEN

BY Townsend and Townsend

ATTORNEYS

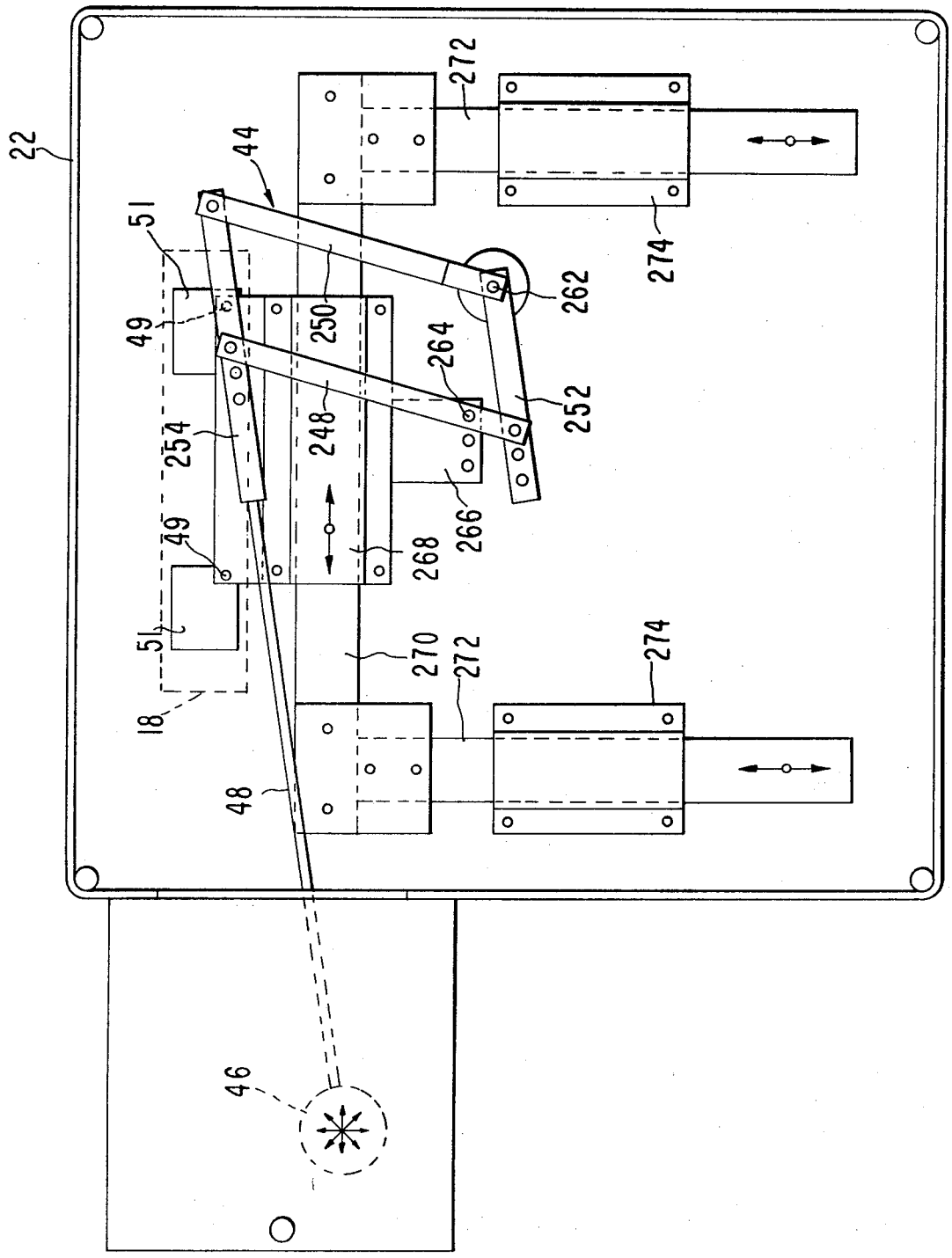


FIG. 10

INVENTOR.
JOHN C. DIEPEVEEN
BY Townsend and Townsend
ATTORNEYS

any suitable manner to the upper portion of base **22** in spaced relationship to surface **20** as shown in FIG. **1**. A microscope assembly **28** is secured to housing **24** by means of a pivot structure **30** whereby the operator of apparatus **10** can view a die carried by mount **18** on a greatly enlarged scale.

In a general way, apparatus **10** operates to bond a number of connecting wires to various locations on a die defining an integrated circuit, a hybrid circuit or other component, the opposite end of each wire being bonded to a post or terminal on the frame which supports the die. Thus, the finished product can then be packaged to form an electronic component for use in electronic circuitry.

Initially, a wire **32** carried on apparatus **10** in some suitable manner, such as on a spool or the like, is caused to extend through tool **16** and to project outwardly from its lower end. A hydrogen torch **34** having a tip **36** is provided adjacent to the bottom of tool **16** so that the frame at the torch tip can be used to heat and melt the lower end of the wire to cut the wire and to form a bead thereon to assure movement of the wire downwardly toward a die upon downward movement of horn **14**. Tool **16** is heated by an electrical resistance heater **38** by means of electrical power supplied in any suitable manner by leads **40** so that tool **16** does not provide a heat sink for the die, the latter being heated in some suitable manner by a heater (not shown) within mount **18**.

Assuming the first bond of the wire to be made on a die held by mount **18**, mechanism **12** operates to cause horn **14** and its mounting means to move downwardly from an uppermost or home position to a first search position with the tool spaced above and in proximity to the die, then to a bond position with the tool forcing the bead at the end of wire **32** into bonding relationship to the die, then upwardly to an intermediate search position which is below the home position whereby the tool moves relative to the wire since the wire is attached at its one end to the die, then from the intermediate search position downwardly to a second search position spaced above and in proximity to a terminal or post on the die supporting frame, then into a second bond position wherein the wire is moved into bonding relationship with the terminal on the frame, then finally upwardly to the home position at which torch **34**, carried by a pivotal structure **42**, is caused to sweep across the wire to cut the same as well as to heat and melt it to form a bead on the outer end of the wire for the next bond operation.

While the foregoing has been described with respect to making the first bond on the die and the second bond on a terminal or post, it is clear that the first bond could be made on a terminal or post and the second bond be made on the die. Also, mount **18** is shifted to permit tool **16** to be in the proper positions directly above the locations at which the bonds are to be made. To shift the mount, a pivot assembly **44** (FIG. **10**) is provided in base **22** below surface **20**, such assembly being hereinafter described in greater detail. The operator of apparatus **10** grasps knob **46** at one side of the apparatus, the knob being secured to a rod **48** which permits manual manipulation of assembly **44**, the latter being connected to mount **18** by two spaced pins **49** which project upwardly through two openings **51** (FIG. **10**) in base **22**. Pins **49** are complementally received within bores in the bottom of mount **18** so that the latter can be shifted about simultaneously in two degrees of freedom, namely, from right to left and forward and backward. Thus, the various locations of the die and the various posts of the die-supporting frame can be properly positioned relative to tool **16**, the movement of the latter being confined to the vertical plane of movement of horn **14**.

Modular mechanism **12** is shown in greater detail in FIGS. **2–8** and includes a slide unit **50** providing the mounting means for horn **14** and formed of a front plate **52** and a rear plate **54** adjacent to and directly behind plate **52**. Horn **14** is secured to and extends forwardly from plate **52** as shown in FIGS. **5** and **7**, horn **14** having an enlarged rear end **56** which is received within an opening in plate **52** adjacent to its lower end. Plate **52** has a pair of slits **58** which extend laterally from the opening so as to render the lower portions **60** of plate **52** yieldable whereby a pair of screws **62** can be used to urge portions **60** against enlarged portion **56** of the horn to releasably hold the latter firmly fixed to plate **52**. Thus, the horn will move with this plate.

Plates **52** and **54** move downwardly together from the home position to the first search position, then plate **52** moves downwardly relative to plate **54** to the first bond position as plate **54** remains stationary. Then, plate **52** returns to the first search position, following which, plates **52** and **54** move upwardly together to the intermediate search positions then downwardly together to the second search position, following which, plate **52** moves relative to plate **54** downwardly to the second bond position as plate **54** remains stationary, then plate **52** returns to the second search position, whereupon plates **52** and **54** move upwardly together back to the home position.

Slide unit **50** is mounted for vertical reciprocation by a pair of spaced side plates **64** (FIGS. **2** and **5**) which are secured in any suitable manner to a generally horizontal base plate **66** and are interconnected by a brace **67**. Bearing means is provided to mount slide unit **50** for movement relative to plate **64**, each of plates **52** and **54** having a pair of bearings **68** on respective opposed sides thereof. Each bearing **68** can be of any suitable construction but, for purposes of illustration, it includes a plurality of balls **70** carried by a perforate strip **72** (FIG. **2**) disposed between the corresponding plate of slide unit **50** and the adjacent side plate **64**. Each strip **72** has a number of holes therethrough in which the corresponding balls can freely rotate. For instance, in FIG. **2**, plate **52** is provided with a longitudinal groove **74** while the corresponding side plate **64** has a groove **76** in alignment with groove **74**. A pair of spaced rods **78** are disposed in and extend along each of the grooves **74** and **76**, respectively. The four rods in the two aligned, facing grooves define tracks for balls **70** to allow for rolling movement of the balls and thereby permit slide unit **50** to move up and down relative to side plates **64**. This type of bearing assured substantially frictionless movement of the slide unit, yet substantially eliminates any lateral movement of the slide unit relative to side plates **64**. As a result, horn **14** is restricted to movement only in a substantially vertical plane and movements in other directions are positively prevented.

Plate **54** has a top plate **80** secured to it by machine screws **82** so that top plate **80** overlies and is spaced above plate **52** in the manner shown in FIGS. **5** and **7**. Plate **80** has a first hole **84** (FIG. **2**) therethrough whereby access to an adjustment screw **86** can be had, screw **86** being threaded into plate **52** from the upper margin thereof and having a lower end provided with a spherical tip **88** (FIG. **5**). Plate **52** has an opening **106** therethrough intermediate the top and bottom margins thereof. Tip **88** of the screw **86** projects into opening **106** and is normally in engagement with a disk-like roller **90** carried on a shaft **92** (FIG. **7**) secured to a pair of arms **94** (FIGS. **5** and **7**) rigid to a plunger **96** (FIG. **7**) which is shiftably mounted in a sleeve **98** secured to and extending rearwardly from plate **54**. A pin **100** on plunger **96** is disposed within a slit **102** in sleeve **98** to prevent rotation of plunger **96** and thereby roller **90** so as to keep the axis of shaft **92** perpendicular to the length of screw **86**. In this way, roller **90** can move freely with respect to screw tip **88** when plunger **96** is moved in a direction toward the left when viewing FIG. **7**. A coil spring **104** engaging the rear surface of plate **54** and coupled with pin **100** biases plunger **96** to the right when viewing FIG. **7** and into engagement with the flat front face **105** of a projection **107** carried by an arm **109** mounted for pivotal movement relative to and about a shaft **111** spanning the distance between and rotatably mounted on side plates **64**.

Roller **90** and arms **94** also extend into opening **106** as shown in FIGS. **5** and **7**. The normal position of roller **90** is the position shown in FIG. **7** wherein shaft **92** is in substantial vertical alignment with screw **86**. When so positioned, roller **92** prevents any downward movement of plate **52** relative to plate **54** so that plates **52** and **54** can move together as a unit. When plunger **96** is moved to the left when viewing FIG. **7**, plate **52**

TOOL MOVING MECHANISM

This invention relates to improvements in tool handling machines and, more particularly, to apparatus for moving a tool in a sequential manner into and out of a number of different operative positions along a predetermined path of travel.

While the present invention might well be suitable for a number of different uses, it is especially suitable for use as the mechanism for moving a thermal compression bonding tool into and out of operative positions at which connecting wires can be bonded to a die and to a number of terminals or posts on a frame for supporting such a die. The die can comprise, for instance, an integrated circuit chip or a hybrid component using semiconductor materials to form an electronic circuit. Since components of this type are extremely small and must be handled with great care, it is important to bond the various wires to the various locations on the die and terminals in a manner such as to assure that good, firm bonds are made without structural damage to the die and terminals.

Bonding devices of conventional construction have structural drawbacks which make them unsatisfactory for one reason or another. For instance, they are generally quite complex in construction and oftentimes difficult to operate without causing structural damage to a die unless very skilled operators are available to operate them. Also, in such a device, the tool often bounces on the workpiece because of the way in which the tool is caused to approach the workpiece.

The present invention provides apparatus which, in operation, circumvents the problems encountered with the operation of conventional thermal compression bonders. To this end, the invention utilizes a mechanism which operates to move a thermal compression bonding tool in a manner such that the tool slowly approaches a die or any of the various terminals from a search position after having been moved at a relatively fast rate from an initial position to the search position. Thus, the tool can be gently moved into bonding engagement with a wire to be bonded to the die or to a terminal, following which the bonding operation can occur, all of which can be accomplished without causing structural damage to the die. Moreover, the mechanism of the invention readily permits adjustments to be easily made in the locations of the search positions relative to the die and the terminals to minimize the need for very skilled machine operators.

All of the foregoing advantages of the mechanism are realized by the provision of a slide unit to which a thermal compression bonding tool can be coupled, the slide unit being formed of two separate parts to represent a relatively large mass with one of the parts being movable through a relatively short distance when the slide unit is in a search position immediately before a bond operation. Thus, the one member can move the tool through the relatively short distance so as to cause the tool to gently approach the die or a terminal without causing the tool to bounce. In effect, therefore, the relatively large mass of the slide unit is moved through long distances and a relatively small mass is moved through a relatively short distance. The result is avoidance of structural damage to the die and terminals and movement of the tool in a manner to assure a positive bond each time the tool moves into bonding relationship to a wire aligned either with the die or a terminal.

Means is provided for sequentially moving the slide unit from a home or initial position to a first search position at which the height of the tool with respect to the die or terminal can be readily adjusted with a simple manual adjustment. The member of the slide unit which carries the tool is then released from coupled relationship with the other member of the slide unit and permitted to move through a limited distance to a bond position and to remain in the bond position for a predetermined bond interval, whereby a wire can be bonded either to the die or a terminal. At the end of this interval, the tool is then elevated to the first search position, following which the slide unit moves to an intermediate search position where another simple manual adjustment of the height of the slide unit can be made. This adjustment provides for a desired length of wire to span the distance between the die and a respective terminal.

From the intermediate position, the slide unit is caused to move to a second search position from which position the member carrying the tool can move further downwardly through a limited distance to move the tool into a second bond position where it remains for a predetermined period of time. At the end of the period of the second bond, the slide unit is returned to the home position. All of the aforesaid movements of the slide unit and tool are under the control of an operator viewing the working area of the die and terminals through a microscope assembly and the operator can readily manipulate the die and the terminals by the use of an improved die shifting assembly which utilizes, among other things, a parallelogram unit for shifting the mount for the die.

The primary object of this invention is to provide a mechanism for moving a tool sequentially into various locations along a predetermined path of travel so that the tool, when coupled to the mechanism, can be used as a thermal compression device for bonding a number of connecting wires to a die and a number of terminals or posts on the frame which supports the die.

Another object of this invention is to provide apparatus of the type described wherein adjustments can be quickly and easily made in the heights of a tool-carrying unit with respect to a die and the associated terminals when the unit is at certain of the positions along its path of travel to thereby facilitate the positioning of the tool with respect to the die and terminals as well as to provide for variations in the lengths of wires which interconnect the same.

A further object of this invention is to provide apparatus of the aforesaid character wherein is included an improved shifting assembly adapted to be coupled to a mount for a die and its supporting frame so that the mount can be moved quickly and easily into and out of any one of a number of operative locations relative to a bonding tool to thereby allow the tool to be limited in its movement to a specific straightline path of travel and to eliminate the need for rotational movements of the tool.

Other objects of this invention will become apparent as the following specification progresses, reference being had to the accompanying drawings for an illustration of the embodiments of the invention.

In the drawings:

FIG. 1 is a side elevational view of the housing for the mechanism of this invention with the mechanism being shown within the housing in dashed lines and illustrating a bonding tool adjacent to a die holder for bonding wires to the die;

FIG. 2 is an enlarged, top plan view of the mechanism of the invention;

FIG. 3 is a side elevational view looking in the direction of lines 3—3 of FIG. 2;

FIG. 4 is a side elevational view of the mechanism looking in the direction of lines 4—4 of FIG. 2;

FIG. 5 is a front elevational view of a portion of the mechanism looking in the direction of lines 5—5 of FIG. 2;

FIG. 6 is a cross-sectional view looking in the direction of lines 6—6 of FIG. 2;

FIG. 7 is a cross-sectional view of the mechanism looking in the direction of lines 7—7 of FIG. 2;

FIG. 8 is a cross-sectional view looking in the direction of lines 8—8 of FIG. 2;

FIG. 9 is a view of a timing sequence showing the relationship between the various cams used to operate the various moving parts of the mechanism; and

FIG. 10 is a bottom plan view of the housing for the mechanism showing the linkage mechanism for moving the die holder with respect to the bonding tool of the mechanism.

The apparatus of this invention is broadly denoted by the numeral 10 and includes a modular mechanism 12 having a reciprocal tool holder or horn 14 which moves in a substantially vertical plane to, in turn, move a die bonding tool 16 coupled thereto toward and away from a die holder or mount 18 carried on a surface 20 on the base 22 of apparatus 10. Mechanism 12 is disposed within an upper housing 24 which is supported by a lower housing 26, the latter being secured in

is allowed to move downwardly relative to plate **54** through a distance determined by the distance by which roller **90** moves forwardly of tip **88**. The force causing this downward movement of plate **52** is determined by the weights of horn **14** and plate **52** less the upward force exerted on plate **52** by a coil spring **108** (FIG. **5**) secured at its upper end to top plate **80** and at its lower end to a rigid, horizontal extension **110** projecting forwardly through a second opening **112** in plate **52** (FIG. **5**) extending parallel to and being of substantially the same size as opening **106**. Extension **110** has a hole through it to receive the tip **112** of a screw **114** threaded into plate **52** from above.

The adjustment in the tension of spring **108** is effected by rotation of screw **114**, the latter being loosely received within an opening (not shown) in top plate **80**. Screw **114** has a head **116** and is adjustable vertically so that the tension of spring **108** can be increased or decreased to, in turn, cause variations in the effective load or weight exerted on the wire during a bonding operation. In this way, the downward force on the wire can be selected as desired and can be as low as **20** grams or less. This relatively small force is exerted on the wire when plate **52** moves relative to plate **54** through a relatively short distance, i.e., from the first search position to the first bond position or from the second search position to the second bond position. Thus, there will be substantially no tendency for tool **16** to bounce on the die or the frame terminal so as to cause structural damage to the same.

When plate **52** is in the first search position, reciprocal movement of plunger **96** causes plate **52** to move into the first bond position and return. When this plate is in the second search position, reciprocal movement of plunger **96** causes the plate to move into the second bond position and return. Return of the plunger to its starting position is caused by spring **94**, resulting in upward movement of plate **52** relative to plate **54** until roller **90** has returned to the position shown in FIG. **7**.

The means for moving slide unit **50** and horn **14** into and out of the various search and bond positions and the home position includes a number of cams and levers operated in timed relationship so that horn **14** and tool **16** mounted thereon will move in a predetermined sequence under the control of an operator of apparatus **10**. The cams include a homing cam **118**, a looping cam **120**, a bond cam **122** and a second search cam **124**. All of these cams are rigidly secured to a shaft **126** spanning the distance between and rotatably mounted on a pair of rear sidewalls **128** and **130** secured in any suitable manner to base plate **66** as shown in FIGS. **2–4**. Bearing blocks **132** rotatably mount shaft **126** on respective sidewalls so that shaft **126** is essentially parallel with shaft **111**.

A pulley **134** is secured to one end of shaft **126** and is coupled by an endless, flexible belt **136** to a second pulley **138** on the shaft **140** of a timing motor **142** secured in any suitable manner to the rear extremity of rear sidewall **130** as shown in FIGS. **2** and **3**. The cams and their associated levers, hereinafter described, operate to move horn **14** and slide unit **50** from the home position through the various search and bond positions and then back to home position for each complete revolution of shaft **126**. This feature is more clearly set forth in diagrammatic form in FIG. **9** wherein timing lines are shown to illustrate the actions of the four above-mentioned cams when they rotate from 0° to 360°, namely, for each revolution of shaft **126**.

Homing cam **118** has a single lobe **144** as shown in FIG. **8** and an outer peripheral cam surface which engages a roller **146** rotatably mounted on one end of a lever **148** rigidly secured intermediate its ends to shaft **111**. The opposite end of lever **148** is forwardly of shaft **111** and underlies and is engaged by the tip **150** of a screw **152** threadably mounted in plate **54** (FIG. **8**) and extending above the same. Screw **152** has a head **154** to permit manual manipulation of the screw relative to plate **154**. The weight of slide unit **50** is supported on the front end of lever **148** and, by rotating screw **152**, the height of tool **16** on horn **14** can be adjusted relative to a die when slide unit **50** is in the first search position.

When lobe **144** of homing cam **118** engages roller **146**, slide unit **50** will be at its highest or home position. As shaft **126** moves in the direction of arrow **156** (FIG. **8**), lobe **144** moves away from roller **146** and allows lever **148** to rock in a counterclockwise sense when viewing FIG. **8** about shaft **111**, whereby slide unit **50** can descend through a distance determined by the configuration of cam **118**. Thus, slide unit **50** moves from the home position to the first search position.

A coil spring **164** (FIG. **5**) is connected at one end to a lateral projection **166** secured to the proximal side plate **64**. The opposite end of this spring is secured to another lateral projection **168** connected to top plate **80**. Spring **164** biases slide unit **50** downwardly and thereby biases roller **146** of lever **148** into engagement with the peripheral cam surface of homing cam **118**.

When slide unit **50** is in the first search position, bond cam **122** will be rotated by continued rotation of shaft **126** so as to urge arm **109** in a clockwise sense when viewing FIG. **7** relative to and about shaft **111**. A roller **158** carried by the rear end of arm **109** normally engages the peripheral cam surface of bond cam **122**. Thus, as arm **109** rotates in a clockwise sense, it forces plunger **96** forwardly or to the left when viewing FIG. **7** to thereby move roller **90** partially out from beneath tip **88** of screw **86**. This movement allows plate **52** to descend through a relatively short distance relative to plate **54** so that tool **16** on horn **14** is moved into bonding relationship to the bead of the wire carried by the tool and the wire bead is forced against a particular location on a die therebeneath. Bond cam **122** has a first lobe **160** representing the first bond position and a second lobe **162** representing the second bond position. As shown in FIG. **7**, the bond cam is in the second search position just prior to moving into the second bond position, assuming rotation of shaft **126** in the direction of arrow **156**.

Looping cam **120** operates through a lever **170** (FIG. **4**) to move slide unit **50** from the first search position to the intermediate search position and then to the second search position. In the intermediate search position, variations can be made in the length of the loop of wire which spans the distance between the die and a corresponding frame terminal. Looping cam **120** has a single lobe **172** (FIG. **4**) which is movable into engagement with a roller **174** (FIGS. **2** and **8**) rotatably carried by a shaft on an arm **176** forming a part of lever **170**. Arm **176** extends forwardly from roller **174** and is pivotally mounted intermediate its ends on a second arm **178** which extends upwardly from arm **176** as shown in FIG. **4**. The forward end of arm **176** is connected to one end of a coil spring **179** whose opposite end is connected to pin **166** projecting laterally from the adjacent side plate **64** (FIGS. **4** and **5**). Thus, spring **179** biases arm **176** in a clockwise sense when viewing FIG. **4** so that roller **174** is urged into engagement with the cam surface of looping cam **120**.

The upper end of arm **178** is rigidly secured to shaft **111**. A second roller **180** (FIGS. **2**, **7** and **8**) is carried on the same shaft as roller **174**. Roller **180** engages a flat surface **182** on a crescent member **184** projecting laterally from a cylindrical bearing member **186** (FIGS. **2**, **7** and **8**) rotatably mounted in any suitable manner in the sidewall **128**. Bearing member **186** has a laterally extending outer portion **188** to which a handle **190** is rigidly secured. The handle extends forwardly from portion **188** and operates to permit manual rotation of bearing member **186** and thereby crescent member **184** so hat the inclination of flat surface **182** can be changed. Normally, surface **182** is at least slightly inclined with respect to the vertical. Also, the common axis of rollers **174** and **180** is substantially axially aligned with the axis of cylindrical bearing member **186**.

As lobe **172** of looping cam **120** moves into engagement with roller **174**, the roller is forced downwardly along surface **182** so that the common axis of rollers **174** and **180** moves out of axial alignment with the axis of bearing member **186**. When this occurs, such downward movement of roller **174** causes a forward movement of arm **176** of levers **170** to, in turn, cause counterclockwise rotation of shaft **111** when viewing FIG. **4**.

In effect, this causes lever **148** to elevate slide unit **50** and this movement commences when the slide unit at the first search position after plate **52** has moved into and out of the first bond position. Thus, initial movement of lever **148** under the influence of lever **170** causes slide unit **50** to move from the first search position to the intermediate search position.

In the intermediate search position, adjustment can be made in the length of the wire to be looped between the die and a respective frame terminal by manually rotating handle **190** which causes rotation of bearing member **186** about its axis. This is done when lobe **172** engages roller **174**, i.e., when the axis of rollers **174** and **180** are out of axial alignment with the axis of bearing member **186**. The effect of this handle movement is to change the inclination of flat surface **182** of crescent member **184** and, when the surface becomes more inclined, such as by rotating handle **190** upwardly, arm **176** is moved further forwardly to, in turn, cause additional counterclockwise rotation of shaft **111** and thereby upward movement of the forward end of lever **148**. This elevates slide unit **50** further upwardly and thereby increases the length of wire to be looped between the die and a frame terminal. Downward movement of handle **190** has the effect of shortening this loop.

After lobe **172** moves out of engagement with roller **174**, the common axis of rollers **174** and **180** returns to substantial axial alignment with the axis of bearing member **186** so that movement of handle **190** will have no effect. However, in most cases, it is desirable to have a constant length of wire in the loop between a die and the various frame terminals; hence, one adjustment of handle **190** is all that is necessary. Also, when lobe **172** of looping cam **120** moves out of engagement with roller **174**, lever **170** is allowed to pivot in a clockwise sense when viewing FIG. **4** so as to allow slide unit **50** to move from the intermediate search position to the second search position.

During the time that slide unit **50** moves into the second search position, second search cam **124** having the single lobe **214** as shown in FIG. **6** is rotated so that lobe **214** moves into engagement with a roller **194** rotatably mounted on a shaft secured to the rear end of an arm **196** forming a part of a lever **192** which is substantially the same in construction as lever **170**. Lever **192** also has a second arm **198** which is pivotally mounted at its lower end to arm **196** intermediate the ends of the latter. The upper end of arm **198** is rigid to shaft **111**. A coil spring **200** is connected to the forward end of arm **196** and to a lateral projection **202** (FIG. **6**) extending from the adjacent side plate **64** to bias arm **196** in a counterclockwise sense when viewing FIG. **6**.

A second roller **204** mounted on the same shaft as roller **194** engages the flat surface **206** of a crescent member **208** rigid to a cylindrical bearing member **210** (FIG. **2**) which is rotatably mounted in any suitable manner in rear sidewall **130**. Bearing member **210** has an outer lateral projection **212** to which a handle **214** is secured, the handle extending forwardly as shown in FIG. **3**, While slide unit **50** is in the second search position, the common axis of rollers **194** and **204** is held out of substantial axial alignment with the axis of bearing member **210** by lobe **214** so that rotation of bearing member **210** upon manual rotation of handle **214** can cause a change in the inclination of flat surface **206**. This, in turn, will cause forward or rearward movement of arm **196** and thereby clockwise or counterclockwise movement of shaft **111**. In this way, the height of tool **16** from a frame terminal can be varied when slide unit **50** is in the second search position prior to movement of the tool into the second bond position. Thus, the tool can be placed at a desired distance from the frame terminal before the wire is bonded to the same.

To effect the proper timing in the sequence of operation of mechanism **12**, a number of timing cams and switches are provided, there being a switch for each timing cam, respectively. As shown in FIG. **2**, such timing cams are rigidly secured to shaft **126** and include a timer switch cam **216** having a timer switch **218** associated therewith, a motor switch cam **220** having a motor switch **222** associated therewith, a torch switch cam **224** having a torch switch **226** associated therewith, and a tail puller cam **228** having a tail puller switch **230** associated therewith. The time intervals during which the various switches **218**, **222**, **226** and **230** are actuated for each cycle of operation of mechanism **12** are shown in hatched areas of the respective timing lines of FIG. **9**. Also, FIG. **9** shows the operational sequences of homing cam **118**, looping cam **120**, bond cam **122** and second search cam **124**.

Switches **218**, **222**, **226** and **230** are secured in any suitable manner to rear sidewalls **128** and **130**. Electrical circuitry (not shown) connects these switches to the appropriate circuit elements for actuating the same when the switches are actuated.

FIGS. **4** and **6** show looping cam **120** and second search cam **124**, respectively, when slide unit **50** is in the home position. FIGS. **7** and **8** show the positions of bond cam **122** and homing cam **118**, respectively, when slide unit **50** is in the second search position.

In FIG. **1**, torch **34** is carried by a horizontally disposed arm which is mounted for swinging movement about the vertical axis of a shaft **230** secured in any suitable manner to upper housing **24**. A flexible hose **232** is coupled in any suitable manner to the source of hydrogen or other suitable gas mixture to support a flame at the tip **36** of torch **34**. Hose **232** may be coupled to a control panel on the upper part of upper housing **24**, the control panel having a number of controls, such as a main "on"-"off" switch, one or more indicator lights, and a switch for heater **38**. Other controls can be utilized, if desired.

To swing arm **228** about the axis of shaft **230**, a linkage **234** is provided, the linkage extending rearwardly to an arm **236** mounted for rotation on a shaft **238** which, in turn, is rotated through a limited arc by an eccentric **240** secured to the vertically disposed shaft **242** of a synchronous motor **244** mounted in lower housing **26**. An impulse of index switch **246** is actuated in response to the rotation of shaft **238** and thereby arm **236**. Each time shaft **238** moves the limited distance, arm **228** moves in a direction to cause torch tip **36** to sweep across wire **32** to cut the same and to form a bead on the lower end of the wire to make the wire ready for the next bond operation. Arm **228** is biased in any suitable manner so that it returns to an initial position after a wire has been cut and after a bead is formed on the end of the wire.

Pivot assembly **44**, shown in FIG. **10**, includes a parallelogram linkage including a pair of rigid side members **248** and **250** and a pair of rigid end members **252** and **254**, the side members and the end members all being pivotally interconnected. Rod **48** is rigid to and extends longitudinally outwardly from end member **254** through a slot **258** in the side of base **22**. Knob **46** on the outer end of rod **48** is hollow and houses a switch which is manually actuated by a push-button **256** carried by knob **46** in a position accessible to a finger of the hand grasping the knob. The switch is used for controlling timing motor **142** to cause cyclic operation of mechanism **12**. Thus, each time the push-button **256** is depressed, slide unit **50** will move from one position to another, such as from the home position to the first search position, or from the first search position to the first bond position and return to the first search position. Suitable wiring (not shown) interconnects the switch in knob **46** with timing motor **142** and a source of electrical power.

A base plate **260** is secured in any suitable manner to base **22** and extends outwardly therefrom beneath slot **258**. Base plate **260** provides a support over which knob **46** moves, the knob being in sliding engagement with the upper surface of base plate **260**.

End members **252** and **254** are pivotally secured to side members **248** and **250**. Also, a pin **262** pivotally mounts the proximal ends of side member **250** and end member **252** on the underside of base **22** for rotation about a generally vertical axis. Side member **248** can be adjustably mounted on end members **252** and **254** and, to this end, a number of holes are provided in the end members, there being a hole in one end member for each hole in the other end member. When side member **248** is connected in the manner shown in FIG. **10**, a

ratio of 6 to 1 is obtained between the movement of knob **46** and the movement of pins **49** which extend through openings **51** and are coupled to mount **18**. When side member **248** is connected by pins to the second or middle set of holes of end members **252** and **254**, a ratio of 5 to 1 is obtained between the movement of knob **46** and pins **49**. A ratio of 4 to 1 between such movements is obtained when side member **248** is connected by pins to the left-hand set of holes in end members **252** and **254**.

Side member **248** is pivotally connected by a pin **264** to an extension **266** rigid to a shiftable member **268** mounted for movement along a rigid bar **270** secured at its ends to a pair of bars **272** disposed in perpendicular relationship to bar **270**, bars **272** being shiftably mounted on respective guides **274** rigid to the underside of base **22**.

By manipulating knob **46**, the operator of apparatus **10** can cause the parallelogram linkage to pivot simultaneously about pins **262** and **264** so as to move pins **49** in any desired direction and thereby move mount **18** coupled with pins **49**. When knob **46** moves to the left as shown in FIG. **10**, side member **48** rotates in a counterclockwise sense and causes extension **266** and thereby shiftable member **268** to move to the left also. This causes pins **49** to move to the left-hand sides of openings **51** when viewing FIG. **10**. When knob **46** is moved upwardly when viewing FIG. **10**, this causes end member **252** to move side member **248** and thereby extension **266** upwardly to, in turn, move pins **49** upwardly in openings **51**. Knob **46** can move diagonally in any direction as well as up and down and left and right. Thus, mount **18** can be moved in any desired direction and such movement is limited only by the size of each opening **51**.

DETAILED OPERATION

With mechanism **12** mounted in upper housing **24** and with tool **16** coupled to horn **14**, a die is placed in mount **18** and the latter is coupled with pins **49** so that the operator of apparatus **10** can manipulate or move mount **18** upon movement of knob **46**. The operator will view the die by means of microscope assembly **28** so as to properly align the tool with respect to the die and the supporting frame therefor so that bonding of wire **32** to the die and the terminals of the supporting frame can be accomplished.

Initially, a flame will be provided at the tip **36** of torch **34** and a bead will initially be formed on the end of the wire by the torch so that the wire can be carried downwardly to the die upon downward movement of the tool.

Assuming that the die is ready to be bonded, the operator manipulates knob **46** until the tool, as viewed through microscope assembly **28**, is directly above the die. The operator then depresses push-button **256** to actuate the switch coupled thereto whereupon timing motor **142** is energized to rotate shaft **126** through a predetermined arc to cause homing cam **118** to be rotated in a direction of arrow **156** so that lobe **144** will move out of engagement with and away from roller **146**. This movement allows member **148** to rock in a counterclockwise sense when viewing FIG. **8** to thereby allow slide unit **50** to move from the home position to the first search position. In the first search position, the height of the tool with respect to the die can be adjusted by rotating screw **152** which will either raise or lower slide unit **50** with respect to lever **148**. When this adjustment is made, no further adjustment is generally necessary since the first search position is constant for a given type of die in mount **18**.

The operator then depresses push-button **256** once again to cause timing motor **142** to be energized for a second time interval to thereby rotate shaft **126** through a second predetermined arc in the direction of arrow **156**. This movement causes lobe **160** of bond cam **122** to move into engagement with roller **158** to, in turn, cause arm **109** and thereby projection **107** to be rocked about and relative to shaft **111**. This action causes plunger **96** to move to the left when viewing FIG. **7**, whereupon plate **52** descends relative to plate **54** so that tool **16** is moved into bonding relationship to wire **32**, forcing the latter against a particular location of the die. The wire is held for a predetermined time interval in engagement with the die so as to effect the desired bond, such time interval being capable of being varied such as by a control carried on the control panel of upper housing **24**. After this time interval has elapsed, shaft **126** will move through a third predetermined arc, whereupon spring **104** returns plunger **96** to its initial position, causing the return of roller **90** to a location beneath screw **86** to thereby elevate plate **52** relative to plate **54**. During this time, rotation of looping cam **120** causes movement of lever **170** in a direction to rotate shaft **111** in a counterclockwise sense when viewing FIG. **4** so that slide unit **50** is moved from the first search position to the intermediate search position. In this position, the operator can manipulate handle **190** to vary the length of the wire extending between the die and the tool so as to vary the loop length of the wire between the die and the terminal on the frame supporting the die. This loop length is varied by changing the inclination of flat surface **182** of crescent member **184**. Generally, a single adjustment is all that is necessary since a uniform loop length is generally desired.

The operator then depresses push-button **256** once again to cause energization of timing motor **142** to cause rotation of shaft **126** about a fourth predetermined arc whereupon rotation of looping cam **120** causes slide unit **50** to move from the intermediate search position to the second search position. In the last-mentioned position, the second search position can be varied relative to the frame terminal by manipulating handle **214** to vary the inclination of flat surface **206** of crescent member **208** since the common axis of rollers **194** and **204** is out of substantial axial alignment with the axis of bearing member **210** when slide unit **50** is in the second search position. Following any needed adjustment of the second search position, the operator again depresses push-button **256** to cause further rotation of shaft **126** and thereby cause second lobe **162** of bond cam **122** to move into engagement with roller **158** to cause rocking movement of arm **109** in a clockwise sense when viewing FIG. **7** to thereby cause plunger **96** to move to the left and allow plate **52** to descend a relatively short distance relative to plate **54**. When this occurs, the tool moves into bonding relationship with wire **32** and forces the latter against the frame terminal for a predetermined period of time. At the end of this time period, timing motor **142** is automatically energized to rotate shaft **126** to cause it to complete its 360° arcuate travel and, when this occurs, homing cam **118** rotates so that its lobe **144** once again engages roller **146** to rotate lever **148** in a clockwise sense and thereby return slide unit **50** to the home position. The operator can then manipulate knob **46** to move mount **18** into a new position for bonding another location of the die to a second frame terminal. However, before this is done, torch **34** is automatically rotated so that its flame sweeps across the wire to cut the same and to form a bead on the wire for the next bond operation.

I claim:

1. Apparatus for reciprocating a tool comprising: a slide unit having a pair of relatively shiftable members, one of the members having means thereon for mounting a tool in a predetermined position; means releasably interconnecting the members and being actuatable to permit limited reciprocation of said one member relative to the other member; means coupled to said slide unit for mounting the same for reciprocal movement along a preselected path of travel; means coupled with said slide unit for reciprocating the same along said path; and means coupled with said interconnecting means for actuating the same when the slide unit is at a predetermined location along said path.

2. Apparatus as set forth in claim **1**, wherein said interconnecting means is shiftably carried by said other member, said actuating means being operable to shift said interconnecting means relative to said other member.

3. Apparatus as set forth in claim 1, wherein said interconnecting means includes structure adjustably coupling said one member to the other member.

4. Apparatus as set forth in claim 1, wherein said reciprocating means includes an operable power device, and cam means coupled to the slide unit for moving the same as a function of the operation of said power device.

5. Apparatus as set forth in claim 1, wherein is provided means adjustably coupling said slide unit to said reciprocating means.

6. Apparatus as set forth in claim 5, wherein said reciprocating means includes a lever, said coupling means including a screw threadably carried on said slide unit, said lever engaging one end of the screw in supporting relationship to said slide unit.

7. Apparatus as set forth in claim 1, wherein is provided means coupled with said slide unit for adjusting the position of the same with respect to said mounting means when the slide unit is at a predetermined location along said path.

8. Apparatus as set forth in claim 1, wherein said reciprocating means includes a rotatable shaft having a cam thereon, and a lever coupled to said cam for moving the slide unit as a function of the rotation of said shaft.

9. Apparatus for moving a tool along a predetermined path comprising: a slide unit having a pair of relatively shiftable members, one of the members having means for mounting a tool thereon; means coupled to said slide unit for mounting the same for reciprocation along a generally vertical path; means releasably interconnecting said members and being actuatable to permit limited downward movement and return of said one member relative to the other member; means coupled with said slide unit for moving the same successively from a first position to a second position below the first position, from the second position to a third position above the second position, from the third position to a fourth position below the first and third positions, and from the fourth position to the first position; and means coupled with said interconnecting means for actuating the same when the slide unit is at the second and fourth positions.

10. Apparatus as set forth in claim 9, wherein said moving means includes a rotatable shaft, power means coupled to said shaft for sequentially rotating the same through predetermined arcs, lever means coupled to said slide unit for moving the same relative to said mounting means when the lever means is shifted, and cam means carried by the shaft and coupled to said lever means for shifting the latter as a function of the sequential rotation of said shaft.

11. Apparatus as set forth in claim 10, wherein said slide unit is biased downwardly, said lever means including first lever structure disposed for supporting said slide unit, said cam means including first cam structure coupled to said first lever structure and operable to permit movement of the slide unit from said first position to said second position when said shaft is rotated through a first predetermined arc.

12. Apparatus as set forth in claim 11, wherein said lever means further includes second lever structure coupled to said first lever structure and disposed for moving the same and thereby said slide unit when said second lever structure is shifted, said cam means further including second cam structure coupled to said second lever structure for shifting the same in a direction and through a distance sufficient to permit the slide unit to move from said second position to said third position when said shaft rotates through a second predetermined arc and from said third position through a third predetermined arc.

13. Apparatus as set forth in claim 12, wherein is provided means coupled with said second lever structure for adjustably shifting the same with respect to said second cam structure when said slide unit is in said third position, whereby the slide unit can be adjustably moved relative to its mounting means.

14. Apparatus as set forth in claim 12, wherein said second lever structure includes a pair of levers, said second cam structure including a cam for each of said levers, respectively, each lever having a pair of axially aligned rollers at one end thereof, one of the rollers being in engagement with the respective cam, and wherein is included a crescent member rotatably mounted adjacent to each cam, respectively, each crescent member having a bearing surface spaced from the axis of rotation thereof, the other roller of each lever being engageable with the bearing surface of a respective crescent member, the rollers of one of the levers being out of axial alignment with the axis of rotation of the respective crescent member when the slide unit is in said third position and the rollers of the other lever being out of axial alignment with the axis of rotation of its respective crescent member when the slide unit is in said fourth position, and including a handle for each crescent member, respectively, for rotating the latter relative to the respective cam.

15. Apparatus as set forth in claim 12, wherein is provided means coupled with the second lever structure for adjusting the operative position of the same relative to said second cam structure when said slide unit is in said second position.

16. Apparatus as set forth in claim 11, wherein is provided means coupled with said second lever structure for adjusting the position thereof relative to said second cam structure when the slide unit is in said fourth position.

17. Apparatus as set forth in claim 16, wherein said adjusting means includes a rotatable member having a bearing surface spaced radially from the axis of rotation of the member, said second lever structure having a bearing element engaging the bearing surface, said bearing element being eccentric with respect to the axis of rotation of said rotatable member when the slide unit is in said fourth position, and means coupled with said rotatable member for rotating the same.

18. Apparatus for positioning a workpiece relative to a tool comprising: a support; a first member; means mounting said first member on said support for movement along a first path of travel, said first member adapted to be coupled to said workpiece for moving the same in response to the movement of the first member; a second member; means mounting said second member on said support for movement relative thereto along a second path of travel substantially perpendicular to said first path of travel; and parallelogram means coupled to said first member for moving the same along said first path and for moving said second member along said second path to thereby vary the position of the workpiece along two directions.

19. Apparatus as set forth in claim 18, wherein said parallelogram means includes a first pair of parallel side members pivotally mounted on said support, a second pair of parallel side members pivotally secured to the first side members and means for moving one of the side members relative to the support to thereby cause movement of the other side members in a manner to cause movement of said workpiece.

20. Apparatus as set forth in claim 18, wherein said first and second members are movable simultaneously under the influence of said parallelogram means.

* * * * *