

July 6, 1954

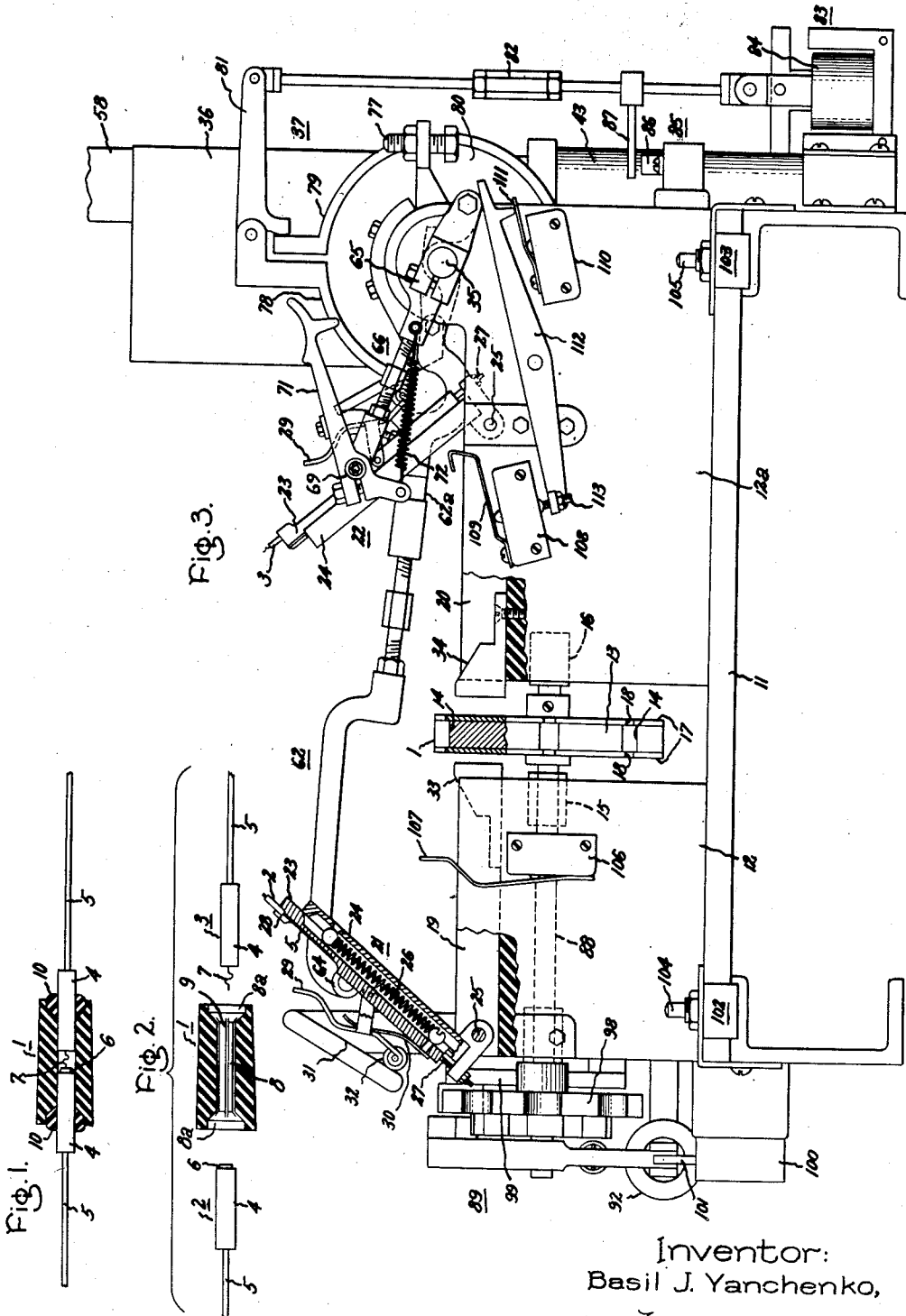
B. J. YANCHENKO

2,683,205

MACHINE FOR MAKING CRYSTAL RECTIFIERS AND THE LIKE

Filed Feb. 7, 1951

4 Sheets-Sheet 1



Inventor:
Basil J. Yanchenko,
by *Merton S. Stone*
His Attorney.

July 6, 1954

B. J. YANCHENKO

2,683,205

MACHINE FOR MAKING CRYSTAL RECTIFIERS AND THE LIKE

Filed Feb. 7, 1951

4 Sheets-Sheet 2

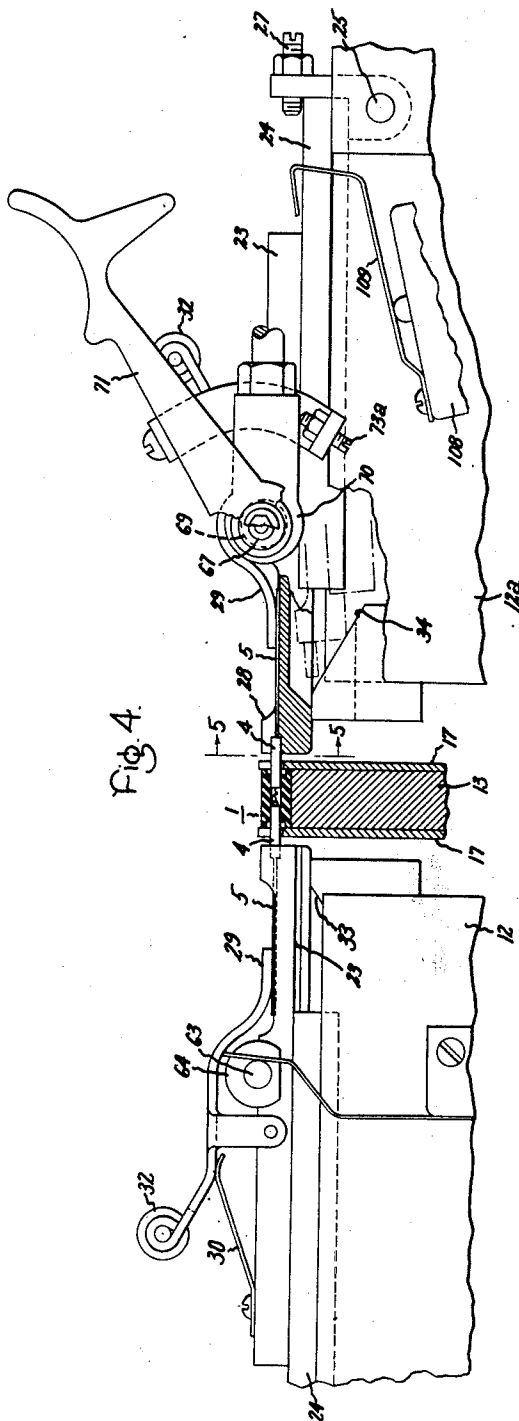


Fig. 4.

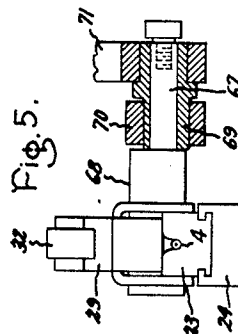


Fig. 5.

Inventor:
Basil J. Yanchenko,
by *Merton S. Moore*
His Attorney.

July 6, 1954

B. J. YANCHENKO

2,683,205

MACHINE FOR MAKING CRYSTAL RECTIFIERS AND THE LIKE

Filed Feb. 7, 1951

4 Sheets-Sheet 3

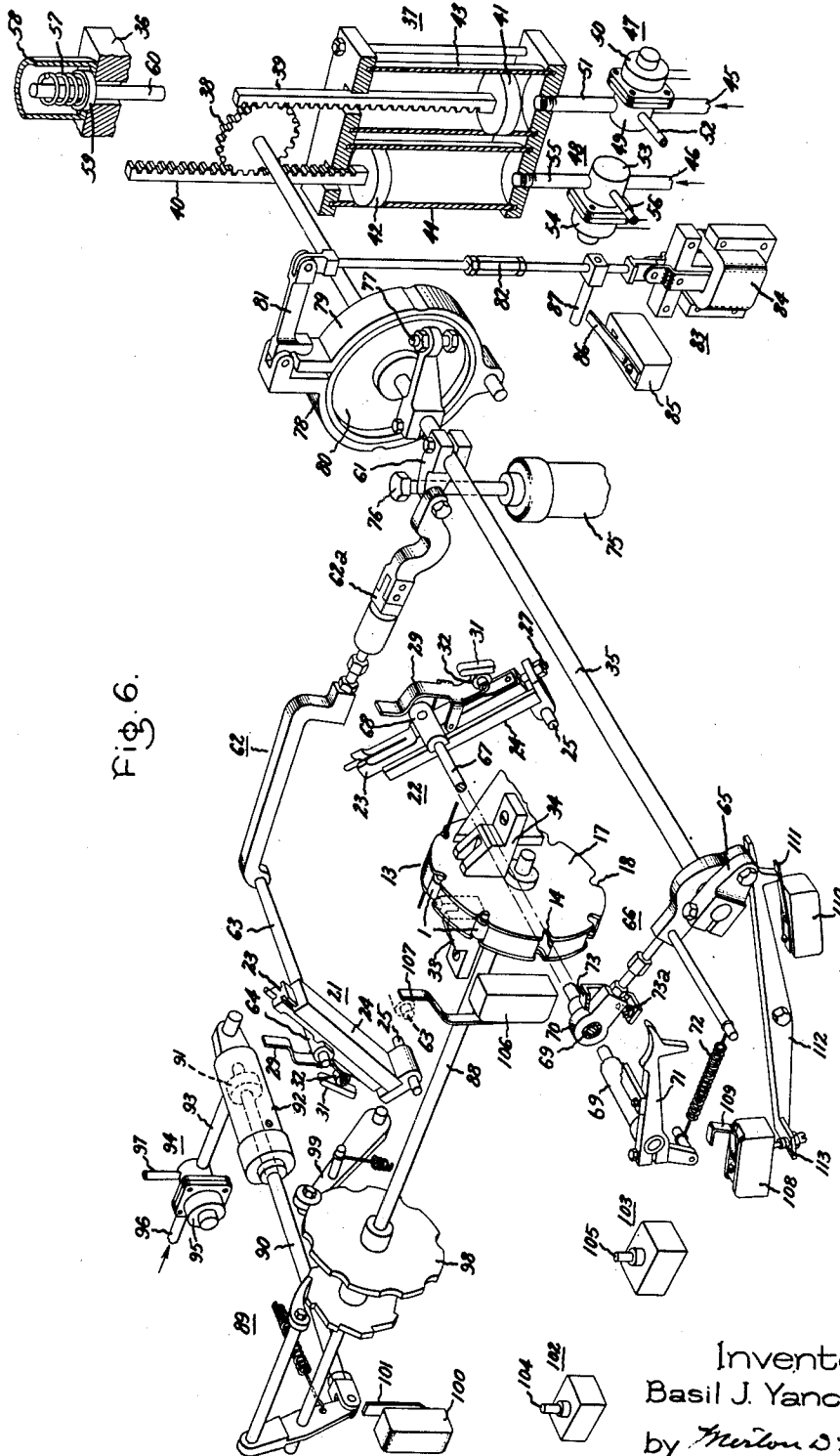


Fig. 6.

Inventor:
Basil J. Yanchenko,
by *Merton S. Moore*
His Attorney.

July 6, 1954

B. J. YANCHENKO

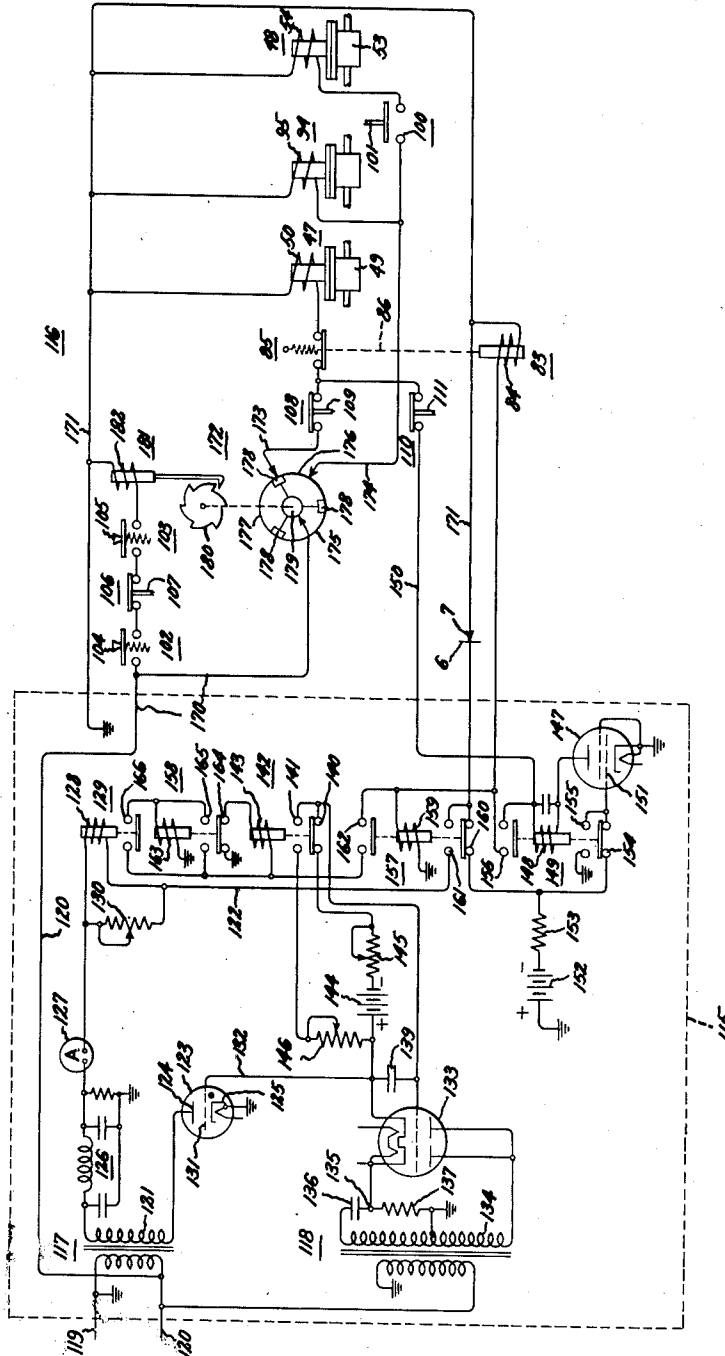
2,683,205

MACHINE FOR MAKING CRYSTAL RECTIFIERS AND THE LIKE

Filed Feb. 7, 1951

4 Sheets-Sheet 4

Fig. 7



Inventor:
Basil J Yanchenko,
by *Merton D. Moore*
His Attorney.

UNITED STATES PATENT OFFICE

2,683,205

MACHINE FOR MAKING CRYSTAL
RECTIFIERS AND THE LIKEBasil J. Yanchenko, Syracuse, N. Y., assignor to
General Electric Company, a corporation of
New York

Application February 7, 1951, Serial No. 209,826

15 Claims. (Cl. 219-4)

1

The present invention relates to an improved method of and semi-automatic machine for making crystal rectifiers and similar devices.

Rectifying devices of the type employing as essential elements, a wafer-like crystal of germanium, silicon or similar material, to the face of which is bonded the end of a fine wire or whisker have recently come into widespread commercial use. In one form of the device the crystal and whisker are connected respectively to suitable terminals received in an insulating case which positions and mutually insulates the terminals of the device. When a device of this general type is connected in an electrical circuit, it exhibits markedly differing resistance characteristics with respect to voltages of opposite polarity.

The present invention relates to an improved method of and machine for assembling devices of the above type including the step of making a weld or bond between one end of the whisker and the crystal of the device. It is an important object of the invention to provide for the more economical production of these devices as well as to insure greater uniformity of the resulting product particularly with respect to its electrical characteristics and its ruggedness.

In accordance with the preferred embodiment of the invention illustrated, the device is first partially assembled into three major subassemblies; one of which includes one terminal and the crystal; a second of which includes the other terminal and the whisker and the third of which includes the insulating case which is suitably apertured to receive at its opposite ends the terminal subassemblies. The insulating case which is in the form of an open ended cylinder is placed in a suitable notch in the periphery of a supporting wheel which may be periodically indexed into a predetermined position. The terminal subassemblies are loaded into suitable work holders which are mounted for pivotal and reciprocating movement with respect to the wheel to insert the terminal subassemblies therein sufficiently to bring the whisker into contact with the crystal. The work holders for the terminal subassemblies are mutually insulated and connected with a suitable control and welding current supply circuit to initiate the flow of welding current in response to contact of the whisker with the crystal. The welding current is automatically controlled to rise and fall in accordance with a predetermined pattern and after the completion of the welding cycle, the jaws or work holders release the terminals which

2

are now permanently assembled in the insulating case and moved to a partially retracted position with respect to the wheel. The wheel is indexed to bring another case into position and the work holder fully retracted to loading position. The operator next loads a new pair of terminal subassemblies in the work holders and the machine then is ready to initiate new assembling and welding operations under the control of the operator.

The features and advantages which characterize the present invention will become more apparent as the following description proceeds reference being had to the accompanying drawing in which Fig. 1 is a longitudinal sectional view of a completed rectifying device of the type that may be assembled in accordance with and by a machine of the present invention; Fig. 2 illustrates the three major subassemblies of the device of Fig. 1; Fig. 3 is an elevational view partially in section of a semi-automatic machine embodying my invention; Fig. 4 is an enlarged elevational view partially in section of a part of a machine of Fig. 3; Fig. 5 is an elevational view, partially in section, of one of the components of Fig. 4; Fig. 6 is an expanded perspective view illustrating the operative relationship of the parts of the machine and Fig. 7 is a schematic representation of the welding and control circuits of the machine.

Referring now to Figs. 1 and 2 of the drawing, a device suitable for manufacture in accordance with my invention includes a cylindrical case 1 of insulating material such as a glass impregnated Bakelite or other resinous material. Terminal subassemblies 2 and 3 each include a terminal member 4 and conductor 5. The subassembly 2 includes a crystal 6 of germanium or the like and its terminal subassembly 3 includes a fine bent wire 7, commonly called a whisker, and secured at one end to the terminal 4. As illustrated the exterior of the casing 1 is tapered for the purpose of proper orientation in the machine as will be described later in the specification. The casing 1 is also provided with a suitable centrally located passage 8 terminating at the end of the casing in counter bores 8a which facilitate the insertion of the subassemblies. In order to increase the frictional engagement of the terminals 2 and 3, with the casing, the inner wall of the passage 8 is provided with suitable ridges 9. The counter bores 8a are filled after assembly of the device with a suitable sealing compound illustrated in Fig. 1 by the numeral 10.

3

Referring now to Fig. 3 of the drawing, the machine there illustrated includes a support or bed plate 11 to which are secured a pair of longitudinally extending insulating plates 12 and 12a positioned in longitudinally spaced relation. A wheel 13 supported between the inner ends of plates 12 and 12a is suitably recessed on its periphery at equally spaced positions as illustrated at 14 for the reception of the casings 1. The wheel is supported in suitable bearings carried by the supporting plates 12 and 12a as illustrated generally at 15 and 16. Plates 17 located on opposite sides of the wheel 13 determine the endwise position of the casings loaded into the recesses 14 and are provided with suitable notches 18 to allow for the passage of the terminal subassemblies therethrough.

The upper edges of the insulating and supporting plates 12 and 12a are recessed as shown at 19 and 20 for supporting in operative relation with respect to the wheel 13 a pair of work holders or work supporting assemblies designated generally by the numerals 21 and 22. These work holders are for the purpose of carrying the terminal subassemblies 2 and 3 of the device and moving them into assembled position with respect to a casing 1 received within one of the notches of the wheel 13. These work holders also provide welding jaws or welding current supply conductors for supplying welding current to bond the whisker and crystal of a device together after they are in position in a casing 1. The work holder assembly designated 21 is shown in section (Fig. 3) and includes a slide bar 23 and a pivoted slide bar guide 24. The guide 24 is pivoted to the side walls of the recess 19 as illustrated at 25 and is shaped to guide the reciprocating movement of the work holder 23. The work holder is biased to a retracted position with respect to the guide 24 by means of a compression spring 26 housed between the work holder 23 and the guide 24 and bearing on suitable surfaces of these two members. The limit of rearward motion of the work holder is determined by an adjustable stop 27. The work holder 23 is suitably recessed at its outer end to receive the terminal subassembly 2 as illustrated at 28.

A spring biased clamping member 29 is pivotally mounted on the work holder 23 and adapted to engage the conductor 5 of a subassembly 2 when the work holder is moved from the loading position illustrated in Fig. 3. The biasing force is supplied by a spring 30 and the work holder is held out of work engaging position in the work loading position of the machine by means of a suitable cam member 31 which cooperates with a cam follower 32 provided on the work clamping member 29. The work holder 22 is in general the same as the work holder 21 and corresponding parts have been designated by the same reference numerals.

Suitable inclined guide blocks 33 and 34 are positioned on opposite sides of the casing supporting wheel 13 and secured to the insulating supports 12 and 12a. The inclined surfaces of the guide blocks direct the forward ends of the pivoted work holder assemblies 21 and 22 upwardly as they move toward the wheel 13 and bring them into alignment with the opening in a casing 1 received within the recess 14 at the top of the wheel.

The mechanism for effecting movement of the work holders 21 and 22 from the loading position shown in Fig. 3 to the assembled position

4

of Fig. 4 will now be described with particular reference to Figs. 3 and 6 of the drawing. The machine is provided with a main drive shaft 35 extending through the support 12a and the casing 36 of a drive unit designated generally by the numeral 37. The drive shaft 35 is driven by a gear 33 engaged by racks 39 and 40 connected respectively with pistons 41 and 42. Piston 41 may be designated the advancing piston and 42 the retracting piston in that actuation of the piston 41 in an upward direction moves the work holders into the position shown in Fig. 4 while actuation of the piston 42 in an upward direction retracts the work holders from the position shown in Fig. 4 to the position shown in Figs. 3 and 6. Pistons 41 and 42 are received within suitable cylinders 43 and 44, the lower ends of which are connected to suitable fluid supply conduits 45 and 46 by solenoid operated valves 47 and 48. The solenoid valve 47 includes a valve casing 49 and an actuating solenoid 50. The casing 49 is connected to the cylinder 43 by means of a conduit 51. An exhaust conduit 52 is also connected with the valve casing to provide an exhaust passage for the cylinder 43 when the valve is actuated to connect conduits 51 and 52. In a similar manner the solenoid valve 48 includes a valve casing 53 and an operating solenoid 54. The valve casing is connected to communicate with the cylinder 44 through a conduit 55 and is alternately connected with the supply conduit 46 and an exhaust conduit 56 on successive operations of the valve. Means for operating the machine toward work loading position, the position shown in Figs. 3 and 6, is provided by a suitable biasing spring 57 supported on the top of the gear housing 36 and within the housing 58. The spring 57 bears on a shoulder 59 of a rod 60 positioned in alignment with the end of the rack 39. As will be described at a later point the spring 57 effects only partial retraction of the work holders from the position shown in Fig. 4.

Rotary motion of the main drive shaft 35 is converted into pivotal and reciprocating motion of the work holder 21 by means of a crank arm 61 and a connecting rod assembly 62 connected between the shaft 35 and a pin 63 secured in fixed relation to a suitable sleeve 64 on the work holder assembly 21. An insert 62a of insulating material is interposed in the connecting rod assembly 62 to maintain the work holders 21 and 22 in mutually insulated relation.

In a similar manner motion is transmitted from the drive shaft 35 to the work holder assembly 22 by means of crank arm 65 connected to the drive shaft, a connecting rod assembly 66 and a pin 67 secured in fixed relation in a suitable sleeve 68 carried by the work holder 22. In order to provide for a movement of the slide member 23 of the work holder 22 independently of the motion of the drive shaft 35 an eccentric or cam sleeve 69 is interposed between the pin 67 and a yoke member 70 of the connecting rod assembly 66. A manual actuating arm 71 for the cam sleeve 69 is secured in fixed relation to the sleeve 69 and is biased by means of spring 72 to a predetermined position to hold the sleeve 69 in a predetermined position with respect to the pin 67. It is apparent that depressing the lever 71 will rotate the eccentric with respect to the pin 67 and move the work holder 22 forward even though the shaft 35 is stationary. Suitable limit stops are provided by the arms 73 and 73a supported from the actuating arm 71.

In order to reduce the speed of the movement of the machine as the work holders 21 and 22 move toward assembled position of a rectifying device a dash pot 75 is provided with a plunger 76 positioned to be engaged by an adjustable stop 77 carried by the drive shaft 35. As the drive shaft moves in a counterclockwise direction the stop 77 engages the actuating member 76 of the dash pot to retard the movement of the machine as it approaches final position.

In order to positively arrest the movement of the drive shaft and to hold the drive shaft and work holders in a predetermined position a solenoid brake is provided. This brake includes a pair of pivotally mounted shoes 78 and 79 which surround a pulley 80 secured to the drive shaft 35. The brake is operated by means of a pivoted bell crank lever 81 and a connecting link 82 connected with the armature of a brake solenoid 83 including an operating winding 84. An electric switch 85 including an operating member 86 is supported to be actuated in accordance with the position of the brake operating link 82 by means of a finger 87 carried by the link 82.

As mentioned earlier in the specification the wheel 13 in which the casings 1 are supported is mounted for rotation with respect to the insulating supports 12 and 12a. The wheel 13 is rotated by means of a drive shaft 88 journaled in the insulating support 12 and carrying on the outer or left-hand end thereof a ratchet mechanism 89. The ratchet mechanism is operated by means of a piston rod 90 and a piston 91 received within cylinder 92. Fluid under pressure is admitted to the cylinder 92 through a conduit 93 under the control of a solenoid valve 94 operable by means of a solenoid 95 which operates the valve to connect the conduit 93 selectively with a supply conduit 96 and an exhaust conduit 97.

The drive shaft 88 for wheel 13 also carries an indexing wheel 98 which cooperates with a suitable pivoted follower 99 for accurately positioning the shaft 88 after each operation of the indexing mechanism.

A control switch 100 for initiating return of the machine to work loading position includes an operating member 101 which is engaged by the piston rod 90 to effect closure of the switch as the piston rod 90 completes the indexing motion. The machine also includes a pair of manually operated switches 102 and 103 including operating members 104 and 105 respectively, which renders it necessary that the operator use both hands to initiate operation of the machine. A switch 106 including an operating member 107 is supported to be engaged by an extension of the pin 63 on work holder 23 when the work holders are in a position corresponding to complete assembly of a device in order to positively prevent indexing of the machine by actuation of the switches 102 and 103 while the work holders remain in work engaging position.

A switch 108 of the type requiring resetting is provided with an actuating member 109 which is engaged by the operating lever 71 when it is depressed to advance the work holder 22. A switch 110 including an operating member 111 is positioned to be actuated by means of a lever 112 engaged by the crank 65 when the work holders 21 and 22 are in work loading position. Lever 112 is also provided with a screw 113 which resets the switch 108 when the parts of the machine are returned to work loading position as shown in Figs. 3 and 6.

The manner in which the electrical devices described above function to effect the desired control will become more apparent from a consideration of the welding and control circuits incorporated in the machine of the present invention. Referring now to Fig. 7 of the drawing the control circuit for the machine includes two major parts, the welding control enclosed within the dotted line of Fig. 7 and designated generally by the numeral 115 and the energizing circuit for the various electrical components referred in the foregoing description shown in the right-hand portion of Fig. 7 and designated generally by the numeral 116.

The welding circuit includes a welding current supply transformer 117 and a control transformer 118 each having a primary winding connected for energization from the alternating current supply conductors 119 and 120. The secondary winding 121 of the welding current supply transformer 117 is connected to supply welding current to a conductor 122 under the control of a gaseous type electric valve 123 having the anode connected to one terminal of the winding 121 and the cathode connected to ground. The other terminal of the transformer winding is connected through a suitable filter circuit 126 and ammeter 127, the operating coil 128 of a current responsive relay 129 to the conductor 122 which as will be described later is arranged to be connected with the work, to be welded automatically in response to the establishment of contact between the electrode assemblies 2 and 3. An adjustable calibrating resistor 130 is connected in shunt with the operating coil 128 of the relay 129.

The control member 131 of the welding current control valve 123 is connected by conductor 132 to the cathode of a control valve 133. As illustrated the control valve 133 is of the high vacuum type having the anode cathode circuit connected between one terminal of the secondary winding 134 of the control transformer 118 and an intermediate terminal 135 on a voltage dividing circuit established across one half of the winding 134 by means of a capacitor 136 and resistor 137. It will be apparent that the voltage of the cathode of the valve 133 and as a result the voltage of the control member 131 of the welding current control valve 123 will vary in accordance with the conductivity of the valve 133 which is in turn determined by the voltage appearing across a capacitor 139 connected directly between the control member and cathode of the valve 133. The voltage of capacitor 139 is determined by charging and discharging circuits therefor controlled respectively by the normally closed contacts 140 and normally open contacts 141 of a relay 142 having an operating winding 143. The charging circuit includes a battery 144 and an adjustable resistor 145 connected in series with the normally closed contacts 140 and across the terminals of the capacitor. The discharging circuit includes an adjustable resistor 146 connected in series with the normally open contacts 141 and across the terminals of the capacitor.

In accordance with one feature of the present invention initiation of the welder operation is accomplished in response to the establishment of a circuit between the crystal 6 and whisker 7 of one of the crystal rectifier devices being assembled. The transfer of the electrode assemblies and work holders in which they are received to the welding circuit is accomplished by means of a control tube 147 having the cathode thereof connected to ground and the anode connected

through the operating coil 148 of a relay 149 to an alternating current supply conductor 150. The control member 151 of the valve 147 is normally maintained at a negative voltage by a biasing circuit including a battery 152, a resistor 153 and the normally closed contacts 154 of the relay 149. The relay 149 also includes normally open contacts 155 and 156.

In addition to the components already described the welding control circuit includes additional control relays 157 and 158. The relay 157 includes an operating winding 159, normally closed contacts 160 and normally open contacts 161 and 162. Control relay 158 includes an operating winding 163, normally closed contacts 164 and normally open contacts 165. The current responsive relay 129 also includes normally open contacts 166. The manner in which these relays operate to effect the desired sequence of operation of the welding circuit and of the electrical components of the assembly machine will become apparent at a later point in connection with the detailed description of the operation of the system.

Referring now to the control circuit 116 the components previously identified in connection with the description of the assembly machine are identified by the same reference numerals. In addition to these elements the control circuit includes an alternating current supply conductor 170 connected for energization from supply conductor 120 and a grounded conductor 171. A stepping relay 172 for connecting the supply conductor 170 alternately with conductors 173 and 174 in response to successive actuations of the manual switches 102 and 103 is provided. This switch includes three conducting segments, 175, 176 and 177 of approximately 120 degrees angular extent separated by suitable inserts of insulating material 173. The supply conductor 170 is electrically connected to the hub 179 so that it is continuously connected with the segments 175, 176 and 177. The conductors 173 and 174 are positioned so that one engages a conducting segment while the other engages an insulating segment and this relationship of conductors 173 and 174 is reversed for each 60 degree rotation of the switch. The rotation of the switch is accomplished in response to successive operation of switches 102 and 103 by a ratchet wheel 180 operated by a solenoid 181 including an operating winding 182.

The features and advantages of the present invention will become more apparent by a consideration of the operation of the machine in connection with the assembly of one complete rectifier device.

It is assumed that the operator has placed casings 1 in a number of the recesses 14 of the wheel 13 and that the top recess contains one of the casings. It is also assumed that the operator has placed the terminal assemblies 2 and 3 in the work holder assemblies 21 and 22. The machine is now ready to assemble the rectifier device and make the weld between the crystal and whisker. The operator closes the manual switches 102 and 103 to complete an energizing circuit for the coil 182 of the switch 172 and to advance the switch 60 degrees in a counterclockwise direction. This completes a circuit from the supply line 170 through segment 176 of the switch to conductor 173, switch 108, switch 85 and the operating coil 50 of the closing solenoid 47 to grounded conductor 171. As clearly shown in Fig. 6 operation of the solenoid valve 47 admits

fluid under pressure to the lower side of piston 41 to effect upward movement of the piston and rotation of the main drive shaft 35 in a counterclockwise direction. Through the cranks 61 and 65 and the connecting rod assemblies 62 and 66 this rotation of the shaft 35 rotates the work holders 21 and 22 downwardly toward the position shown in dotted lines in Fig. 4 (for the holder 22) at which time the movable part of the work holder 23 of each work holder assembly rests on the inclined surface of the blocks 33 and 34 respectively. As the movement of the shaft continues the work holders 23 move forward against the action of the springs 26 and guided by the incline of the blocks 33 and 34 insert the terminal assemblies within the casing 1. As these work holders approach the limit of movement their motion is retarded by the action of the dash pot 75. The instant at which dash pot action is applied to the drive mechanism is determined by the adjustment of the stop 77 which engages the actuating member 76 of the dash pot. The forward motion of the work holders is completely arrested in response to the establishment of an electric circuit between the crystal 6 and the whisker 7 of the particular device being assembled. This circuit is completed from the grounded conductor 171 through normally closed contact 160 of relay 159 normally closed contact 154 of relay 149 to connect the control member 151 of electric discharge device 147 directly to ground. Prior to this time the control member has been maintained at a negative voltage by the connection with battery 152. As soon as the grid is grounded the device 147 conducts through a circuit including supply conductor 170, contact 176, conductor 173, switch 108, switch 110, conductor 150 and the operating coil 148 of relay 149. This current through valve 147 is sufficient to actuate relay 149 to open contact 154 and close contacts 155 and 156. The opening of contact 154 and closure of contact 155 establishes a direct connection to ground for the control member 151 to maintain the valve 147 conducting. Closure of the contact 156 performs two functions: First the operating coil 84 of the solenoid brake is energized by completing a circuit from the conductor 150 to the ground conductor 171. Also the operating coil 159 of relay 157 is energized through a circuit including conductor 150 and the contact 156 of relay 149. The actuation of the solenoid brake clamps the drive shaft 35 in fixed position and restrains any further motion of the work holders. Operation of the solenoid brake also moves the finger 87 from the switch 95 to deenergize the coil 50 of solenoid valve 47. This disconnects the closing piston 41 from the air supply and connects with exhaust conduit 56. Energization of the relay 157 transfers the circuit of the crystal rectifier including the crystal 6 and whisker 7 from the control circuit of the discharge valve 147 to the welding current supply conductor 122 as a result of closure of contact 161. Operation of relay 157 also effects closure of contact 162 to complete an energizing circuit for the operating coil 143 of relay 142. Up to this time no welding current has flowed through conductor 122, the crystal 6 and whisker 7 since the electric valve 123 in the welding current supply circuit has been nonconducting. The control member of this valve is connected with the cathode of the control valve 133 which, during the deenergized condition of relay 142, is also nonconducting. As relay 142 is operated and the contact 141 is closed the

negative bias on the control member of valve 133 decreases at a rate determined by the magnitude of resistor 146 and as the conduction of this valve 133 increases the conduction of valve 123 increases to supply a current of increasing magnitude to the welding circuit including the parts of the crystal rectifier. When the welding current reaches a predetermined value as determined by the characteristics of the current responsive relay 129, and the shunting or calibrating resistor 130, the relay 129 is operated to close contact 166. Closure of this contact in turn completes an energizing circuit for the coil 163 of relay 158. Operation of this relay completes a holding circuit for energizing the coil thereof independently of the contacts 166 and also opens the energizing circuit of the relay 142 by opening the contact 164. Deenergization of relay 142 causes contact 140 to reclose and contact 141 to open, establishing the circuit for charging capacitor 139 back to the negative voltage of battery 144 at a rate determined by the magnitude of resistor 145. After a predetermined interval determined by the magnitude of resistor 145, valves 133 and valve 123 become nonconductive and the welding current ceases. The ammeter 127 provides the operator with a visual indication of the welding current and it is readily apparent when the welding operation is completed.

The operator at this time depresses a lever 71 shown in Figs. 3 and 6 and also shown in detail in Figs. 4 and 5 to effect a predetermined advance of the work holder 22 and as a result further insertion of the terminal assembly 3 into the casing 1 for the purpose of further bending the whisker after the weld is completed. The eccentric 69 is rotated by depressing the lever 71 to move the pin 67 and as a result the work holder assembly 22 to the left by an amount depending upon the eccentricity of the collar 69 and the amount of movement of the lever 71 which is adjusted by means of the stops 73 and 73a.

Depressing lever 71 also engages the actuating member 109 of switch 108 to open the circuit of supply conductor 150 and in this way to deenergize the operating coil of relay 149 which in turn deenergizes the coil of relays 157 and 158. Opening of the contacts of the switch 110 also deenergizes the operation winding 84 of the solenoid brake to release the work holders and associated mechanism. As a result of the compression springs 26 in the work holder assemblies and also the biasing spring 57 connected with the closing piston 41 the work holders tend to retract and drop down to the position indicated in dotted lines in Fig. 4, thus clearing the ends of terminals of the completed crystal rectifier device. This movement of the work holder 21 also allows the contact of switch 106 to close to permit actuation of the stepping relay 172 in response to the closure of the manual operating switches 102 and 103. The closure of these switches by the operator is now effective to operate the stepping switch 172 sixty degrees in a counterclockwise direction (120 degrees in a clockwise direction from the position illustrated in Fig. 7) to establish an energizing circuit for conductor 174 through segment 175 of the rotary switch and thereby complete an energizing circuit for the operating coil 95 of the indexing solenoid valve 94. As will be apparent from an inspection of Fig. 6 operation of valve 94 and admission of air under pressure to the rear of piston 91 is effective to index the wheel 13 one position to bring the next recess in assembly position and carry

with it a casing which has been previously loaded by the operator. As the indexing piston rod 93 moves to the left as viewed in Fig. 6 the switch 109 is operated to closed position to establish an energizing circuit for the winding 54 of the opening solenoid valve 49. Operation of this valve in turn admits fluid under pressure to the upper side of piston 42 to return the main drive shaft and associated mechanism to the position shown in Figs. 3 and 6, at which time the work holders 21 and 22 are ready to receive terminal assemblies 2 and 3. It will also be noted that the spring associated with the work holders 21 and 22 are moved to a retracted position as the machine is moved into the position illustrated in Figs. 3 and 6. Movement of the parts into the position shown in these figures effects the opening of switch 110 which insures that the welding circuit will be deenergized during the loading operation, as the parts return to the positions illustrated in Figs. 3 and 6 the switch 108 is reset to the closed position by means of lever 112.

From the foregoing detailed description it is apparent that the present invention provides an improved semi-automatic machine and method for effecting the assembly and welding together of the components of a crystal rectifier device starting with three major subassemblies. It will also be apparent that in its broader aspect invention is not limited to the specific application but may be utilized where similar assembly movements and operations are required.

While a particular embodiment of the invention has been described and illustrated it will be apparent to those skilled in the art that changes and modifications may be made without departing from the present invention in its broader aspects and it is intended that all such changes and modifications as fall within the true spirit and scope of the present invention shall be covered by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A machine for inserting a pair of electric terminal assemblies into a casing and effecting a weld between said electric terminal assemblies comprising a bed plate, a wheel having a plurality of recesses spaced apart on the periphery thereof for receiving casings, said wheel being journaled for rotation with respect to said bed plate, a pair of terminal holding assemblies mounted on opposite sides of said wheel for pivotal rotation about axes perpendicular to the axis of rotation of said wheel, each of said assemblies including a guide member, a pair of slide bar members respectively positioned on said guide members for linear movement therealong, first spring means provided between said guide members and said slide bars for biasing said slide bars in retracted positions, a pair of cam followers pivotally mounted on said work holders, electric contact means attached to said cam followers, second spring means positioned between said electric contact means and said work holders to bias said electric contact members in a position to make contact with said electrical terminal assemblies located in said work holders, and a pair of cams mounted on said bed plate to coact with said cam followers to remove said electric contact means from engagement with said electric terminal assemblies when said work holders are in the retracted position; a main drive shaft, crank and connecting rod assemblies connected to and operated in response to rotation of said main drive shaft for converting rotary motion of said shaft to recip-

roccating motion of the rod, said rod being pivotally connected to the slide bar of said work holders; a pair of inclined guide blocks located on opposite sides of the wheel and having guides on the surface thereof for accommodating said slide bars, said blocks being positioned to intercept said slide bars in their downward travel and guide said slide bars in their motion against said first spring means, welding jaws provided on said slide bars for holding said electric terminal assemblies and for making good electrical contact therewith, electric circuit means controlling operation of said main drive shaft and for controlling welding current in said electric terminal assemblies including means responsive to electric contact between terminal assemblies mounted in said work holders for interrupting rotation of said main drive shaft and for initiating welding current between said terminal assemblies, and means for rotating said drive shaft to retract said work holders upon completion of said welding cycle and for causing the rotation of said wheel to a position where another of said recesses are aligned with the guides in said guide blocks whereby the machine is ready for inserting another pair of terminal assemblies in another casing and for welding together the assemblies.

2. In a machine for assembling a pair of electric terminal assemblies in a casing, a casing support, a pair of terminal assembly holders positioned on opposite sides of said support, each of said holders including a guide member mounted for pivotal movement toward said support, and a slide bar mounted on said guide member for movement therealong, reciprocating motion means, pivotal connections between said reciprocating motion means and said slide bars, and guide blocks positioned on opposite sides of said casing to intercept said slide bars in their pivotal movement toward said support, whereby electric terminal assemblies carried by said slide bars are inserted into a casing carried by said casing support.

3. A machine for assembling an electric device including a casing and a pair of terminal assemblies comprising a casing support; a pair of electric terminal assembly holders positioned on opposite sides of said casing support, each of said holders including a pivotally mounted guide member, a slide bar positioned for movement along said guide member, and a spring interposed between said guide member and said slide bar to bias said slide bar in a retracted position; reciprocating motion means pivotally connected to said slide bars for moving them toward said casing support; and inclined guides located on opposite sides of said casing support for guiding said slide bars upward in their motion toward said casing support, whereby terminal assemblies carried by said holders are inserted into a casing carried by said casing support.

4. A machine for assembling an electric device including a casing and a pair of terminal assemblies comprising a wheel having means located on the periphery thereof for holding casings; a pair of electric terminal assembly holders positioned on opposite sides of said wheel, each of said holders including a guide member mounted for pivotal movement about an axis perpendicular to the axis of rotation of said wheel, a slide bar positioned for movement therealong, and a spring interposed between said guide member and said slide bar to bias said slide bar in a retracted position; reciprocating motion means pivotally connected to said slide bar; and a pair of inclined

guides located on opposite sides of said wheel for guiding said slide bars upward in their motion toward said wheel, whereby terminal assemblies carried by said holders are inserted into a casing carried by said casing support.

5. In a machine for assembling an electric device, a casing support, terminal assembly holders pivotally mounted on opposite sides of said support, means for pivoting said holders, abutments provided on opposite sides of said casing supports, clamping members pivotally mounted on said holders, spring means interposed between said clamping members and said work holders to bias said clamping members against said holders, and cam followers mounted on said clamping members to coact with said abutments to force said clamping members against said spring means when said work holders are positioned so that the cam followers are pressed against said abutments.

6. In a machine for assembling an electric device, a wheel having means located on the periphery thereof for holding casings, a pair of terminal assembly holders mounted on opposite sides of said wheel for pivotal movement about axes perpendicular to the axis of rotation of said wheel, clamping members pivotally mounted on said work holders, spring means interposed between said clamping members and said holders to bias said clamping members against said holders, cam followers mounted on said clamping members, and abutments located on opposite sides of said wheel to intercept and coact with said cam followers during the pivotal movement of said holders to force said clamping members against said springs, and reciprocating motion means pivotally connected to said holders including a main drive shaft and crank and rod assemblies, whereby electric terminal assemblies carried by said holders are in an assembly position.

7. A machine for assembling an electric device including a support casing and pair of terminal assemblies, a casing support; a pair of work holders for carrying said terminal assemblies, said work holders positioned on opposite sides of said casing support and comprising pivotally mounted guide members, and slide bar members mounted for movement along said guide members, a pair of cams, clamping members pivotally mounted on said slide bar members, and cam followers mounted on said clamping members to coact with said cams to force said clamping members away from said slide bar members when said work holders are positioned so that said cam followers are pressed against said cams, reciprocating motion means, pivotal connections between said means and said slide bars, and guide blocks positioned on opposite sides of said support to intercept said slide bar in its pivotal movement toward said support, to insert electric terminal assemblies carried by said slide bars into a casing carried by said support.

8. In a machine for assembling electrical device including electric terminal assemblies and casings, a wheel having a plurality of recesses spaced apart on the periphery thereof for receiving casings, said wheel being journaled for rotation, terminal assembly holders mounted on opposite sides of said wheel, each of said holders including a guide member mounted for pivotal movement about an axis perpendicular to the axes of rotation of said wheel, a slide member mounted on said guide for movement therealong, first spring means interposed between said members to bias

said slide member in a retracted position; clamping members pivotally mounted on said slide members, second spring means interposed between said clamping members and the associated slide members to bias said clamping member against said slide member, cam followers mounted on said clamping members, cams mounted to intercept said cam followers when said holders are in a retracted position, reciprocating motion means including a drive shaft and crank and rod assemblies connected thereto for converting rotary motion of said shaft to reciprocating motion of said rod, a pivotal connection between said rods and said slide bars to effect pivotal movement of said holders in response to reciprocating motion of said rods, and inclined guide blocks positioned on opposite sides of said wheel to intercept said slide bars in their pivotal movement toward said wheel, whereby electric terminal assemblies carried by said holders are inserted into a casing carried in one of the notches of said wheel.

9. In a machine for assembling a pair of electric terminal assemblies in a casing, a casing support, a pair of terminal assembly holders positioned on opposite sides of said support, each of said holders including a guide member mounted for pivotal movement toward said support, and a slide bar mounted on said guide member for movement therealong, reciprocating motion means, a pivotal connection between said means and said slide bars, and guide blocks positioned on opposite sides of said casing to intercept said slide bars in their pivotal movement toward said support, electric means for arresting the movement of reciprocating motion means when electric contact is made between electric terminal assemblies carried by said work holders, and a welding circuit connected to supply current to the junction of the electric terminal assemblies when contact therebetween is made, whereby electric terminal assemblies carried by said holders are inserted into a casing carried in one of said notches and welded together.

10. A machine for assembling an electric device including a casing and a pair of terminal assemblies comprising a casing support; a pair of electric terminal assembly holders positioned on opposite sides of said casing support, each of said holders including a pivotally mounted guide member, a slide bar positioned for movement along said guide member, and a spring interposed between said guide member and said slide bar to bias said slide bar in a retracted position; reciprocating motion means pivotally connected to said slide bars for moving them toward said casing support; and inclined guides located on opposite sides of said casing support for guiding said slide bars upward in their motion toward said casing support, electric means for arresting the movement of said reciprocating motion means when electric contact is made between electric terminal assemblies carried by said work holders, and a welding circuit connected to supply current to the junction of the electric terminal assemblies when contact therebetween is made, whereby electric terminal assemblies carried by said holders are inserted into a casing carried in one of said notches and welded together.

11. A machine for assembling an electric device including a casing and a pair of terminal assemblies comprising a wheel having means located on the periphery thereof for holding casings, a pair of electric terminal assembly holders positioned on opposite sides of said casing support, each of

said holders including a guide member mounted for pivotal movement about an axis perpendicular to the axis of rotation of said wheel, a slide bar positioned for movement along said guide member, and a spring interposed between said guide member and said slide bar to bias said slide bar in a retracted position, reciprocating motion means pivotally connected to said slide bar and a pair of inclined guides located on opposite sides of said wheel for guiding said slide bars upward in their motion toward said wheel, electric means for arresting the movement of said reciprocating motion means when electric contact is made between electric terminal assemblies, and a welding circuit connected to supply current to the junction of the electric terminal assemblies carried by said holders, whereby electric terminal assemblies carried by said work holders are inserted into a casing carried in one of said notches and welded together.

12. In a machine for assembling an electric device, a casing support, terminal assembly holders pivotally mounted on opposite sides of said support, a pair of cams, clamping members pivotally mounted on said holders, spring means interposed between said clamping members and said work holders to bias said clamping members against said holders, and cam followers mounted on said clamping members to coact with said cams to force said clamping members against said spring means when said work holders are positioned so that the cam followers are pressed against said cams, electric means for arresting the movement of said source of reciprocating motion when electric contact is made between electric terminal assemblies carried by said work holders, and a welding circuit connected to supply current to the junction of the electric terminal assemblies when contact therebetween is made, whereby electric terminal assemblies carried by said holders are inserted into a casing carried in one of said notches and welded together.

13. A machine for assembling an electric device including a support casing and pair of terminal assemblies, a casing support; a pair of work holders for carrying said terminal assemblies, said work holders positioned on opposite sides of said casing support and comprising pivotally mounted guide members, and slide bar members mounted for movement along said guide members, a pair of cams, clamping members pivotally mounted on said slide bar members, and cam followers mounted on said clamping members to coact with said cams to force said clamping members away from said slide bar members when said work holders are positioned so that said cam followers are pressed against said cams, reciprocating motion means, pivotal connections between said means and said slide bars, and guide blocks positioned on opposite sides of said support to intercept said slide bar in its pivotal movement toward said support, electric means for arresting the movement of reciprocating motion means when electric contact is made between electric terminal assemblies when contact therebetween is made, means including an electric circuit for indexing said casing support, and switch means for preventing indexing of said support when said work holders are in work inserting position.

14. A machine for assembling an electric device including a support casing and pair of terminal assemblies, a casing support; a pair of work holders for carrying said terminal assemblies, said work holders positioned on opposite sides of said casing support and comprising pivotally mounted

guide members, and slide bar members mounted for movement along said guide members, a pair of cams, clamping members pivotally mounted on said slide bar members, and cam followers mounted on said clamping members to coact with said cams to force said clamping members away from said slide bar members when said work holders are positioned so that said cam followers are pressed against said cams, reciprocating motion means, pivotal connections between said means and said slide bars, and guide blocks positioned on opposite sides of said support to intercept said slide bar in its pivotal movement toward said support, electric means for arresting the movement of said reciprocating motion means when electric contact is made between electric terminal assemblies when contact therebetween is made, and a welding circuit connected to supply current to the junction of the electric terminal assemblies carried by said holders, whereby electric terminal assemblies carried by said work holders are inserted into a casing carried in one of said notches and welded together.

15. In a machine for assembling an electrical device; a casing support; a work holder, said work holder including a guide member mounted for pivotal motion toward said support, a sliding member mounted on said guide member for motion therealong, and spring means interposed between said members for biasing said sliding member in a retracted position; reciprocating means pivotally connected to said sliding member for

moving it toward said casing support; and a guide block mounted next to said casing support to intercept said sliding member in its pivotal motion and guide it in its motion toward said casing, whereby a terminal assembly carried by said work holder is inserted in a casing carried by said casing support.

References Cited in the file of this patent

UNITED STATES PATENTS

	Number	Name	Date
	723,995	Ellis	Mar. 31, 1903
	1,050,827	Heany	Jan. 21, 1913
	1,213,852	Fagan et al.	Jan. 30, 1917
5	1,462,305	Snyder	July 17, 1923
	1,507,953	Codina	Sept. 9, 1924
	1,867,225	Le Van	July 12, 1932
	1,953,476	Gilbert	Apr. 3, 1934
	2,006,459	Jones et al.	July 2, 1935
10	2,113,664	Simmie	Apr. 12, 1938
	2,137,181	Quackenbush	Nov. 15, 1938
	2,183,600	Werner et al.	Dec. 19, 1939
	2,255,199	Van Hamersveld	Sept. 9, 1941
	2,284,690	Stern	June 2, 1942
25	2,316,597	Kershaw	Apr. 13, 1943
	2,339,807	Rau	Jan. 25, 1944

FOREIGN PATENTS

	Number	Country	Date
30	283,843	Germany	May 1, 1915
	378,774	Great Britain	Aug. 18, 1932