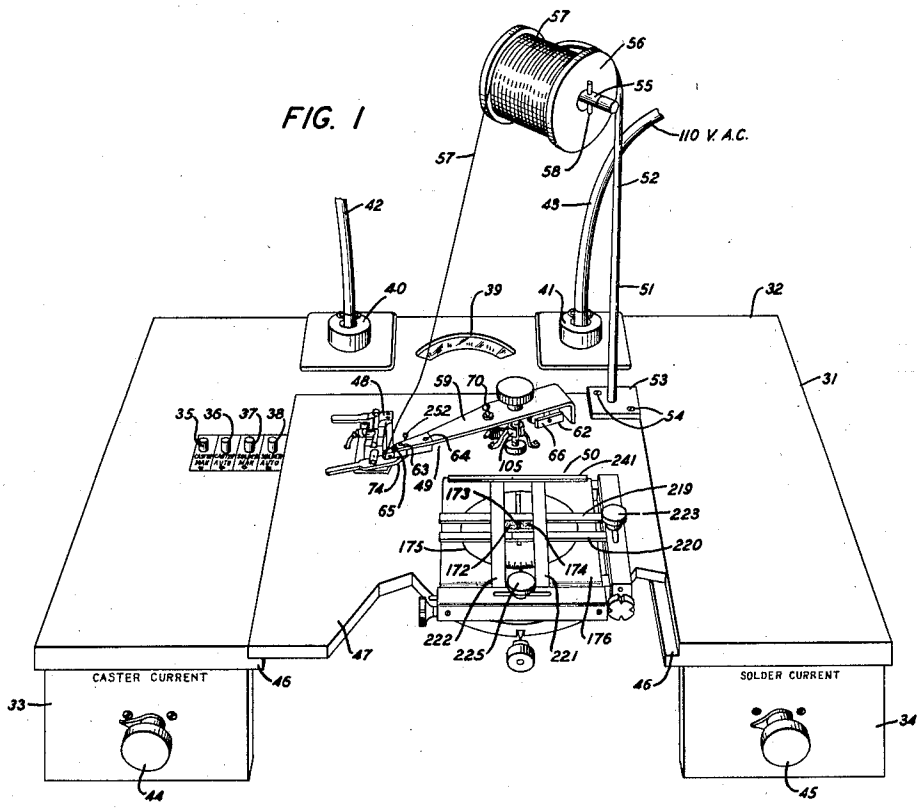
March 30, 1943. R. G. HUMPHREY 2,315,426

SOLDER PELLET CASTER DEVICE

Original Filed Dec. 31, 1940 3 Sheets-Sheet 1

FIG. 1



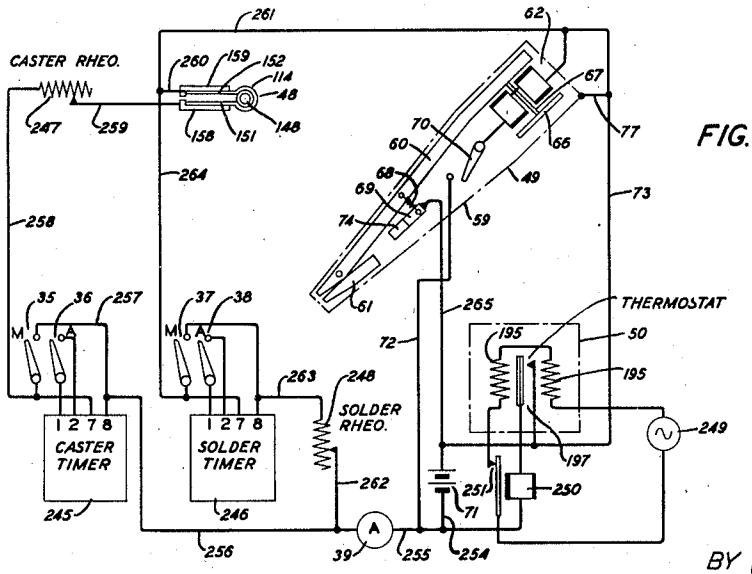


FIG. 2

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FIG. 3

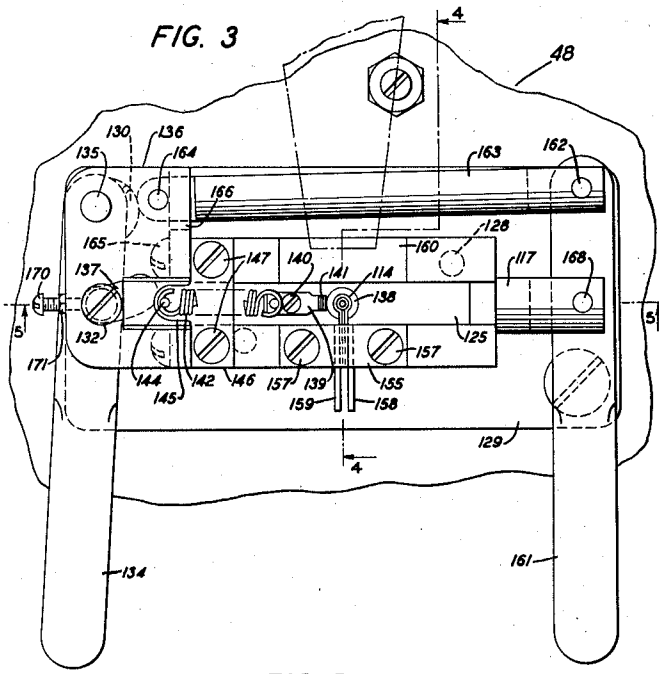

FIG. 4

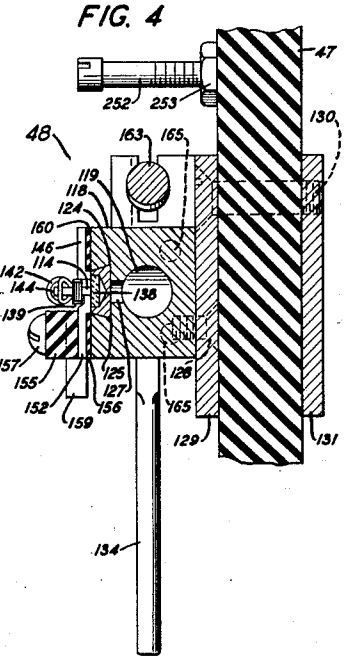

FIG. 5

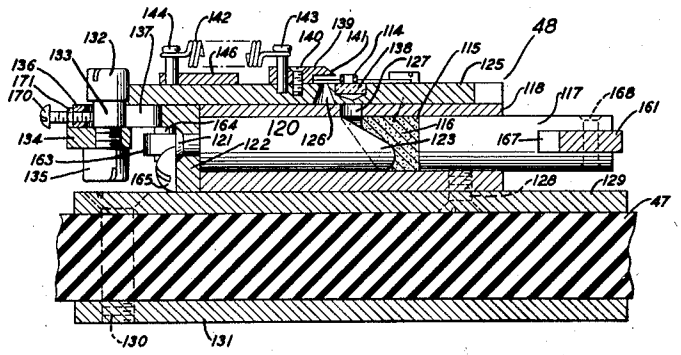

FIG. 8

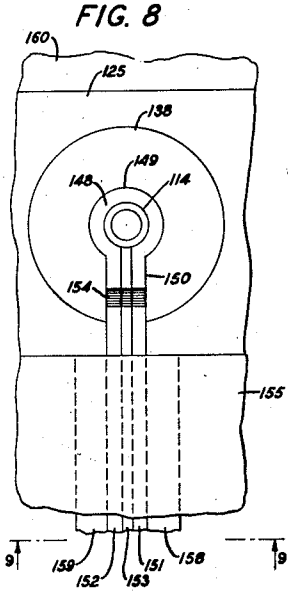

FIG. 7

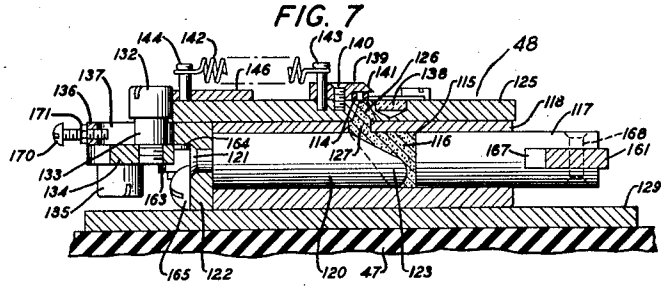

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FIG. 6

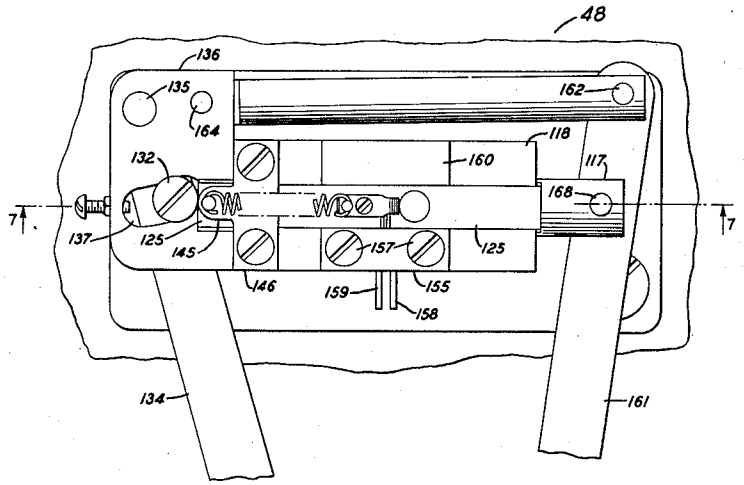


FIG. 9

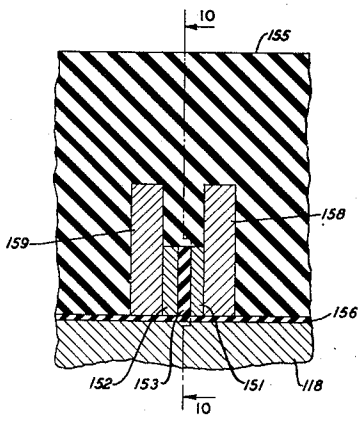


FIG. 10

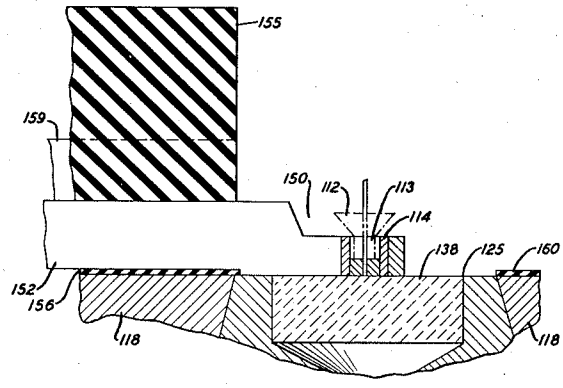
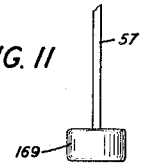


FIG. 11



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UNITED STATES PATENT OFFICE

2,315,426

SOLDER PELLET CASTER DEVICE

Robert G. Humphrey, Pelham, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Original application December 31, 1940, Serial No. 372,528. Divided and this application March 13, 1942, Serial No. 434,573

4 Claims. (Cl. 22—57)

This invention relates to solder-connecting apparatus and although not limited to such use it is adapted for use in solder-connecting wires to metal surfaces on piezoelectric crystals.

The object of the invention is to provide improved means for solder-connecting wires to metal surfaces.

When the invention is used in connecting a wire to a crystal element the solder connection made is of such form and character that the wire may be used not only as a lead-in wire for the crystal element but also as supporting means for the crystal.

In accordance with this invention, a pellet of solder of predetermined size and form is cast on an end of the wire. The pellet is then placed in contact with a suitably prepared metal surface on a crystal element and a solder connection is then made to electrically connect the wire to the metal surface.

The improvement constituting this invention resides in a caster device for casting on the end of the wire a solder pellet of required size and form.

The caster device may be used in conjunction with the chuck device covered in my copending application R. G. Humphrey Serial No. 372,528, filed December 31, 1940, now Patent 2,283,158, dated May 12, 1942 and of which this application is a division. The chuck device is adapted to hold a wire in position in the caster device of this invention while a pellet of solder is being cast on the end of the wire. The chuck device is also adapted to hold the wire with the solder pellet cast thereon in required position on a piezoelectric crystal held in a required position on a hot plate device disclosed in the above-mentioned R. G. Humphrey application, Serial No. 372,528.

In the drawings:

Fig. 1 is a top and front view in perspective of a support with the caster device, the chuck device and the hot plate device mounted in required positions;

Fig. 2 is a schematic diagram of some of the apparatus involved in making the solder connection;

Fig. 3 is an enlarged top view of the solder pellet caster device;

Fig. 4 is a view in section of parts shown in Fig. 3 and taken on the line 4—4;

Fig. 5 is a front view in section of Fig. 3 and taken on the line 5—5;

Fig. 6 is a view corresponding in general to Fig. 3 but with certain of the parts operated to different positions;

Fig. 7 is a front view in section of Fig. 6 and taken on the line 7—7;

Fig. 8 is a greatly enlarged view of a portion of Fig. 3 and shows a crucible employed in the device shown in that figure;

Fig. 9 is a front view in section of Fig. 8 and taken on the line 9—9;

Fig. 10 is a side view, partly in section, of parts shown in Fig. 9 taken on the line 10—10 and showing also a wire and a solder pellet cast in the crucible and a pressure button inserted in the crucible; and

Fig. 11 is an enlarged view of a portion of the wire and the solder pellet cast on the wire.

When the caster device of this invention is used in solder-connecting a wire to a piezoelectric crystal, the caster device is supported on a support on which are also supported the chuck device to hold the wire and the hot plate device to hold and heat the crystal. The arrangement of the devices used in making the solder connection is shown in Fig. 1 in which the devices are supported on a support 31, the support 31 comprising a U-shaped top 32 with downwardly extending walls 33 and 34. On the top 32 are mounted manually operated switches 35, 36, 37 and 38, an ammeter 39, and plug receptacles 40 and 41 to receive electrical supply lines 42 and 43. Manually operated control knobs 44 and 45 are mounted on shafts not shown but which extend through the respective wall members 33 and 34. Set within the space defined by the inner portion of the top 32 and resting on ledges 46 formed thereon is a slab 47 of suitable insulating material on which are mounted the caster device 48, the chuck device 49, the hot plate device 50 and a reel support 51. The various devices by means of which the wire connections are made are so arranged and mounted on the support 31 and the slab 47 that the wire connections can be made in a rapid and accurate manner. The reel support 51 comprises a post 52, secured at its lower end in a flange 53 suitably mounted on the slab 47 by means of screws 54. The upper portion of the post 52 is bent to provide an axle 55 on which is rotatably supported the reel 56 containing a supply of wire 57. The reel 56 is retained against accidental dislodgement from the axle 55 by means of a cross pin 58. The wire 57 is led downward from the reel 56 to the chuck device 49.

The caster device 48 is used to cast a pellet of solder on the end of the wire 57 and as shown in Figs. 3 to 10, inclusive, comprises a crucible 114, a reservoir 115 for holding a supply of solder paste 116 and a plunger 117 for forcing the solder paste

116 into the crucible 114. The reservoir 115 comprises a block 118 of metal or other suitable material longitudinally bored at 119 to receive the plunger 117 which projects into one end of the bore 119. The other end of the bore 119 is closed by means of a relatively long plug 120 which is held in place by means of a screw 121 extending through an apertured end plate 122. The inner end of the plug 120 is shaped at 123 to provide a dished inclined surface. The top of the block 118 is longitudinally slotted and milled out to provide a dovetailed track 124 as shown in Fig. 4, to slidably receive a slide bar 125 having a conical aperture 126 formed therein which may be brought into register with an aperture 127 in the base of the dovetailed track 124, the aperture 127 having communication with the reservoir 115. The block 118 is mounted by means of screws 128 on an apertured base plate 129 resting on the slab 47 and secured thereto by means of the screws 130 and a screw holding plate 131. The slide bar 125 is frictionally engaged at one end by the enlarged head portion 132 of a stud 133, the male-threaded lower end of which is mounted on a manually operated lever 134. The lever 134 is pivotally supported at one end by means of a screw 135 which extends upwardly into an overhanging flange 136 integral with the end plate 122. The flange 136 is provided with an elongated curved aperture 137 designed to accommodate movement of the head portion 132 of the stud 133. The slide bar 125 may be longitudinally moved by operation of the lever 134 and relative to the crucible 114 which is supported in a fixed position as will be subsequently explained. A disc 138 of quartz or other suitable material is mounted in the upper surface of the slide bar 125, the slide bar being suitably recessed to receive the disc and the upper surface of the disc being flush with the upper surface of the slide bar. The disc 138 is of larger diameter than the crucible 114 and serves as a removable closure for the bottom of the crucible 114. A small block 139 is mounted by means of a screw 140 on the upper surface of the slide bar 125 and is undercut to provide an overhanging portion 141 which serves as a removable top closure for the top of the crucible 114. A helical spring 142 is provided to bring the slide bar 125 back to normal position, the spring 142 being attached at one end to a pin 143 supported on the slide bar 125 and being secured at the other end to a pin 144 mounted on a tab portion 145 of a bridge plate 146, the bridge plate 146 being disposed across the slide bar 125 and secured by means of screws 147 to the top of the block 118.

The crucible 114 is electrically heated and comprises a ring 148 made of material suitable for transmitting heat to the solder paste in the crucible and for holding the solder when the solder is in a molten condition. I have found that stainless steel may well be used as the material for the ring 148. The ring 148 has an internal diameter about equal to the diameter of the solder pellet it is desired to cast and is frictionally held in the closed end portion 149 of a U-shaped bar 150 of electrical resistance material. A suitable material for the bar 150 is a nickel-chromium composition known to the trade as Nichrome. The two leg portions 151—152 of the bar 150 are connected to a suitable source of current supply to heat the bar 150 to a sufficient temperature to melt solder paste in the crucible 114, the heat being transmitted through the ring 148 to the solder paste. The ring 143 may be made of electrical insulating material to prevent the electrical current from passing through the ring to the solder paste held therein. It may be made, however, as above mentioned, of stainless steel since the outside of the ring when made of this material soon becomes sufficiently oxidized to prevent the electrical current from passing through the ring. A strip 153 of insulating material is interposed between the leg portions 151 and 152 of the bar 150 to prevent short circuiting of the leg portions, the strip 153 being held in place by means of suitably insulated screws or bolts, not shown, but which extend through aligned apertures 154 provided in the leg portions 151, 152, and the strip 153. The bar 150, as shown in Figs. 9, 10 and 4, is supported in an insulating block 155 and rests on an insulating strip 156 the block 155 and the strip 156 being mounted on the upper surface of the block 118 by means of screws 157. Spaced electrodes 158 and 159 are supported in the insulating block 155 and in electrical contact with the leg portions 151 and 152, respectively, of the bar 150 to carry current to the bar 150, the electrodes 158 and 159 extending outwardly of the block 155 a sufficient distance to permit connection to a suitable source of current supply. An insulating strip 160 is mounted on the block 118 across the insulating strip 156. The strip 160 may be cemented or otherwise secured to the block 118 and serves as an insulating rest for the contact finger 74 on the chuck device 49 when the chuck device is being used over the caster device 48.

The plunger 117 is equipped with a manually operated lever 161 which is pivotally supported at one end on a pin 162 which extends through the lever 161 and through one end of a link 163, the other end of the link 163 being pivotally supported on a pin 164 mounted on the undersurface of the overhanging flange 136 of the end plate 122, the end plate 122 being secured to the block 118 by means of screws 165 and being apertured at 166 to accommodate an end portion of the link 163. The lever 161 extends through a recess 167 in the outer end of the plunger 117 and is pivotally supported therein by means of a rivet 168.

The caster device 48 in cooperation with the chuck device 49 is used in casting a pellet of solder of predetermined size and form on the end of the wire 57. Fig. 11 shows the pellet 169 cast on the end of the wire 57. The size and form of the pellet 169 are controlled by the internal dimensions of the crucible 114, the amount of solder paste projected therein and the extent to which the reduced end portion 113 of the button 112 is inserted in the crucible 114, the button 112 being supported on the chuck device 49 as shown in Figs. 9 and 10 in my original application Serial No. 372,528 above mentioned.

In order to fill the crucible 114 with the solder paste 116 the slide bar 125 is moved by means of lever 134 from the position shown in Figs. 3 and 5 to the position shown in Fig. 7, the head portion 132 of the stud 133 serving to transmit movement of the lever 134 to the slide bar 125. In this operation the spring 142 is elongated to provide sufficient spring tension to restore the slide bar 125 to its former position when the lever 134 is released. In the position shown in Fig. 7 the disc 138 has been removed from the bottom of the crucible 114 and the conical aperture 126 in the slide bar 125 is in register with the aperture 127 in the block 118 and is in register with the crucible 114. The overhanging portion 141 of the block 139 is over the crucible 114 to close the top of the crucible. While the slide bar 125 is in this position the lever 151 is operated to

move the plunger 117 from the position shown in Fig. 5 to the position shown in Fig. 7. In this movement solder paste 116 is forced from the reservoir 115 upwardly through the aperture 127 and the conical aperture 126 and into the crucible 114, emergence of the solder paste from the top of the crucible 114 being prevented by the overhanging portion 141 of the block 139. The levers 134 and 161 are then in the position shown in Fig. 6. Since the stud 133 has reached an end of the slot 137 further movement of the lever 134 in this direction is prevented.

When the lever 134 is manually released the spring 142 returns the slide bar 125 and the lever 134 back to the normal position shown in Figs. 3 and 5. In this position the block 139 is away from the crucible 114 so that the overhanging portion 141 is no longer over the top of the crucible. The disc 138 is directly under the crucible 114 and serves as a bottom for the crucible which is filled with the required amount of solder paste 116 for making the pellet 169. A screw 170 equipped with a lock nut 171 is adjustably supported in the outer end of the overhanging portion 136 of the end plate 122 and may be turned to project into one end of the slot 137 to limit the return movement of the lever 134 and the slide bar 125 and so that the disc 138 will be directly under the crucible 114.

The hot plate device 50 is used to heat a crystal element to a required temperature and to hold the crystal in a required position while a wire is being solder-connected to a metallized surface on the crystal element, the crystal being heated to a temperature slightly below the melting point of the solder to reduce reaction of the crystal when a melting temperature is applied to the point at which the solder connection is being made.

As shown in Fig. 1 the hot plate device 50 is mounted on the slab 47 in such position that the chuck device 49 may be rotated thereover. In this figure a crystal element 172 is supported on the hot plate device 50 in a position to have an end of the wire 57 solder-connected to a stripe 173 of solder on the crystal element. The crystal element 172 may be of any desired size and form and may be made of any required material. It will be assumed, however, merely for the purpose of explaining the invention that the crystal comprises a rectangular slab of quartz coated on its upper and lower major plane surfaces with metal as shown at 174. The metal coatings 174 serve as electrodes for the quartz crystal and may be, for instance, coatings of silver or other suitable material applied to the crystal, for example, by sputtering or by an evaporation process. The stripe 173 is shown as being located at a nodal point of the crystal but may be located at any other desired point, the point of location being determined by the particular character and form of the crystal and the use required.

As shown in Fig. 2 a caster timer 245 is provided to control with time the application of heating current to the caster device 48. A solder timer 246 is provided to control with time the application of heating current to the point at which the wire is being sloder-connected to the strip 173 on the crystal 172. These timer devices may be of any conventional character and form suitable for controlling with time the application of the heating current. The thermostat 197 controls the application of heating current to the heating elements 195 located in the hot plate device 50. Suitable rheostats 247 and 248 are provided to control the strength of the currents applied to the respective caster device 48 and the point at which the solder connection is being made on the crystal, the rheostats being labeled Caster Rheo and Solder Rheo. The switches 35 and 36 are provided for respective manual and automatic control of the duration of the current applied to the caster device. The switches 37 and 38 provide for respective manual and automatic control of the duration of the current applied to the point of solder connection on the crystal.

Method of making solder connection

The crystal 172 with the solder stripe 173 thereon is placed on the hot plate device 50 which is heated by means of the heating elements 195—195 supplied with current from a suitable source 249 over an obvious circuit. The heating current from the source 249 is automatically controlled by means of the thermostat 197 and a relay 250 which will be energized to open its contact 251 and thus open the current supplying circuit when the contacts of the thermostat 197 close at a predetermined temperature.

The wire 57 is placed between the jaws of the chuck device 49 and is held therein. The chuck device 49 is lifted and rotated to bring the projecting end of the wire 57 over the hot plate device 50. The chuck device 49 is then lowered to bring the end of the wire 57 over a desired point on the stripe 173 on the crystal 174. A suitable flux is applied to the end of the wire 57 and the fluxed end of the wire is brought into engagement with the stripe 173 so that some of the flux on the wire will be deposited on the stripe 173.

The chuck device 49 with the wire 57 therein is then lifted and rotated over to the caster device 48 and is lowered to bring the end of the wire 57 into the crucible 114, the end of the wire 57 being thrust into the crucible 114 until the wire 57 touches the disc 138 which at the time serves as a bottom for the crucible. A screw 252 provided with a lock nut 253 is adjustably mounted on the slab 47 as shown in Fig. 4 to limit downward movement of the arm 59 of the chuck device 49 to prevent undue thrusting of the end of the wire 57 into the crucible 114.

The chuck device 49 is operated to hold the wire 57 so that a predetermined length of the wire will project below the button 112, the jaws of the chuck being operated to a closed position by means of the electromagnet 62 which is energized from the source of current supply 71 when the switch 70 is closed. The chuck device 49 is lifted and swung to the position shown in Fig. 1 so that the end of the wire 57 is removed from the crucible 114.

The caster device 48 is operated to fill the crucible 114 with solder paste in the manner above described. The chuck device 49 is lifted again and swung to a position over the crucible 114 and so that the end of the wire 57 is thrust into the crucible, the depth of thrust being limited by the screw 252 against the undersurface of the arm 59. The crucible 114 is electrically heated by current supplied from the source 71. For manual control of the duration of the heating current for the caster device 48 the switch 35 is operated. This closes the following circuit: source of current supply 71, conductor 254, conductor 255, ammeter 39, conductor 256, conductor 257, contact of switch 35, conductor 258, caster rheostat 247, conductor 259, electrode 158, leg

151, leg 152, electrode 159, conductor 260, conductor 261, conductor 73 to source of current supply 71. The crucible is heated to a sufficiently high temperature to melt the solder paste in the crucible 114. The reduced end portion 113 of the button 112 is pressed downwardly within the crucible 114 by the weight of the chuck device 49 while the solder paste is being brought to a molten condition. The ring-shaped form of the crucible 114 and the pressure of the button 112 makes the solder take the form of the pellet 169, shown in Fig. 11, when the operating current for the caster device is shut off by opening of the switch 35. It will be seen, therefore, that a pellet 169 of solder of predetermined size and form is cast on the end of the wire 57. Automatic timing of the duration of the heating current may be obtained by closing the switch 36 instead of the switch 35.

The chuck device 49 is lifted and rotated to bring the wire 57 with the solder pellet 169 cast thereon directly over the stripe 173 on the crystal 172 and the chuck device 49 is then lowered to bring the pellet 169 into engagement with the stripe 173. In this position the contact finger 74 on the chuck device 49 touches the metal coating 174 or the stripe 173 on the crystal to close an electrosoldering circuit as follows: source of current supply 71, conductor 254, conductor 255, ammeter 39, conductor 262, solder rheostat 248, conductor 263, contacts of switch 37, conductor 264, conductor 261, conductor 77, arm 59 and jaws 60 and 61, wire 57, solder pellet 169, strip 173, finger contact 74, conductor 265, to source of current supply 71. Since the hot plate device 50 is maintained at a temperature only slightly below the melting point of the solder in the pellet 169 the current applied to the point of engagement of the solder pellet 169 and stripe 173 is sufficient to raise the temperature at this point of contact to a melting temperature from the solder. The material in the solder pellet 169 and in the stripe 173 is therefore sufficiently heated to make the parts fuse together. The current applied may be regulated by operation of rheostat 248. If it is desired to automatically regulate the duration of the current supplied this may be accomplished by closing the switch 38 instead of the switch 37, the solder timer 245 then functioning to control the duration of the current supply.

After the wire 57 is solder-connected to the stripe 173 on the crystal 172 the wire 57 is severed at a required point to leave a relatively small length of the wire extending from the crystal. This small length of wire may be used as a lead-in wire for the crystal and also as the supporting wire for the crystal.

An explanation in detail of the structures of the chuck device 49 and the hot plate device 50 is given in my original application Serial No. 372,528 filed December 31, 1940 and to which reference may be had for an explanation of parts shown and numbered in the drawings in the present application and not described in that application.

What is claimed is:

1. A solder pellet caster device comprising a reservoir adapted to hold a supply of solder in paste form, a crucible open at its top and bottom and supported above said reservoir, means to heat said crucible, an apertured slide bar operating between said reservoir and said crucible and carrying in spaced relation a closure for the top and a closure for the bottom of said crucible, the aperture in said slide bar being in register with said crucible and said reservoir when the top of said crucible is closed, means to operate said slide bar, and means operating in said reservoir to force the solder paste in said reservoir into said crucible when the bottom of said crucible is open.

2. A solder pellet caster device comprising in combination an apertured block adapted to hold a supply of solder in paste-like form, a plunger supported in said block and operable to move said paste, a crucible supported on said block, said crucible being open at its top and bottom, means for heating said crucible, an apertured slide bar supported in said block and carrying spaced closures for the top and bottom of said crucible, said slide bar being operable to move said closures relative to said crucible, and said plunger being operable to force said paste through the aperture in said slide bar and into said crucible when the top and bottom of said crucible are respectively closed and open.

3. A solder pellet caster device comprising a body member formed to provide a reservoir for a supply of solder in paste form, an apertured slideway formed in said body member, the aperture in said slideway being in communication with said reservoir, a slide bar operating in said slideway and having an aperture formed therein, a crucible open at its top and bottom and supported above and in frictional engagement with said slide bar, means to heat said crucible, a top closure and a bottom closure for said crucible carried by said slide bar, and arranged in spaced relation on said slide bar, said top closure extending in spaced relation over the aperture in said slide bar, means to operate said slide bar to selectively bring said top and said bottom closures in register with said crucible, plunger means extending into said body member and operable to force the solder paste in said reservoir into said crucible when said crucible is open at the bottom and closed at the top, and means to operate said plunger means.

4. A solder pellet caster device comprising an apertured block constructed to form a reservoir for a supply of solder paste, a plunger extending into said block and operable in the reservoir formed therein to apply pressure to the solder paste in the reservoir, means to operate said plunger, an apertured slideway formed into said block, an apertured slide bar supported in said slideway, means to operate said slide bar, a crucible open at its top and bottom and supported above said slide bar, means supporting said crucible, heating means for said crucible, a top closure for said crucible supported on said slide bar, a bottom closure for said crucible supported on said slide bar and in spaced relation with said top closure, said slide bar being operable to bring the aperture in said slide bar into register with the open bottom of said crucible, and said top closure across the top of said crucible, said plunger being operable to force solder paste from the reservoir in said block and through the aperture in said slide bar and into said crucible and said slide bar being also operable to move said top closure away from said crucible and the bottom closure into registry with said crucible.

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