United States Patent

Perrin

[15] **3,685,715**

[45] **Aug. 22, 1972**

[54] **SOLDERING APPARATUS**

[72] Inventor: **Louis R. F. J. Perrin,** Avenue L. - Robert 53, La Chaux-de-Fonds, Switzerland

[22] Filed: **June 29, 1970**

[21] Appl. No.: **50,835**

[30] **Foreign Application Priority Data**

June 27, 1969 Switzerland 9866/69

[52] **U.S. Cl.** **228/37,** 13/26, 118/400, 228/43

[51] **Int. Cl.** **B23k 1/08**

[58] **Field of Search** 228/36, 37, 38, 40; 13/26, 13/5; 29/471.1, 484, 490; 117/113, 114; 118/259, 400

[56] **References Cited**

UNITED STATES PATENTS

1,646,862	10/1927	Hoskins	13/26
1,834,725	12/1931	Northrup	13/26
2,286,024	6/1942	Tama et al.	13/26
2,993,272	7/1961	Carlyen et al.	228/37 X

Primary Examiner—John F. Campbell
Assistant Examiner—R. J. Craig
Attorney—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

Soldering apparatus including a tin bath and means for melting the tin and maintaining it in motion in a molten state, including a ferromagnetic core in a closed frame, a primary and secondary winding mounted side-by-side thereon with a stirrup piece of low-ohmic resistance, the tin bath being contained in an electrically non-conductive crucible placed between the extremities of the stirrup piece which contains a non-conductive guide forming a nappe of tin extending from one edge of the crucible to the other and situated near the bottom of the tin bath, an electrical contact being established between the extension of the stirrup piece and the edges of this nappe.

7 Claims, 3 Drawing Figures

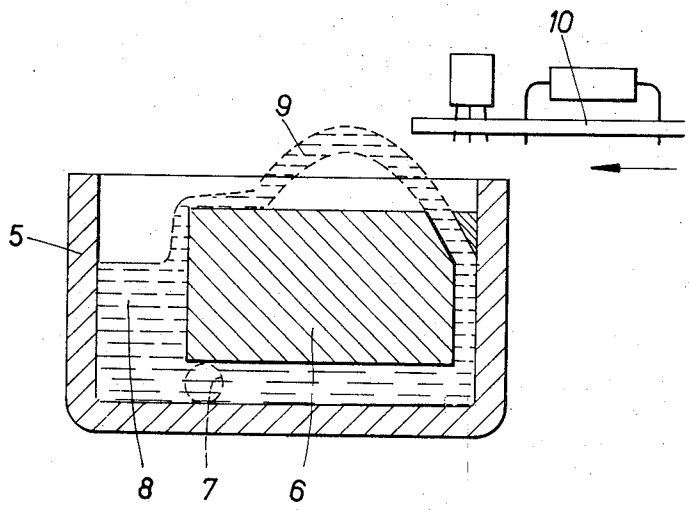


FIG. 1

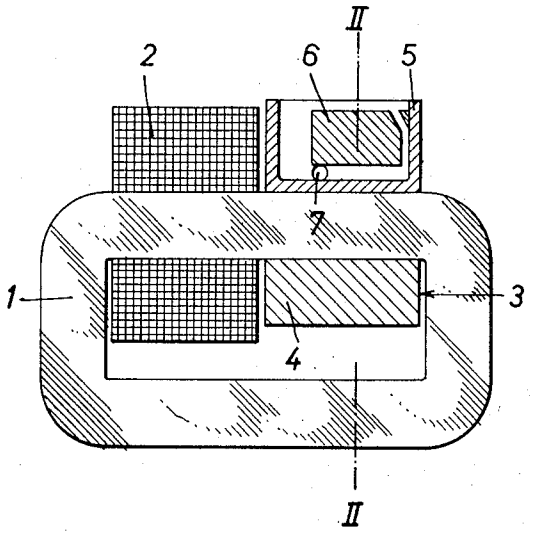


FIG. 2

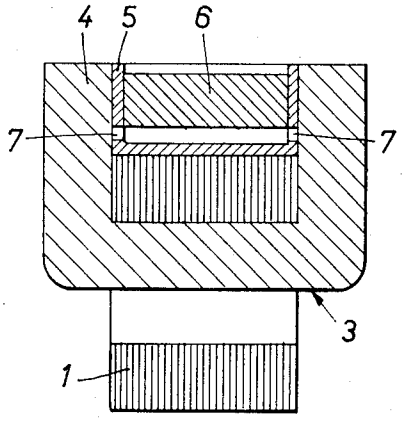
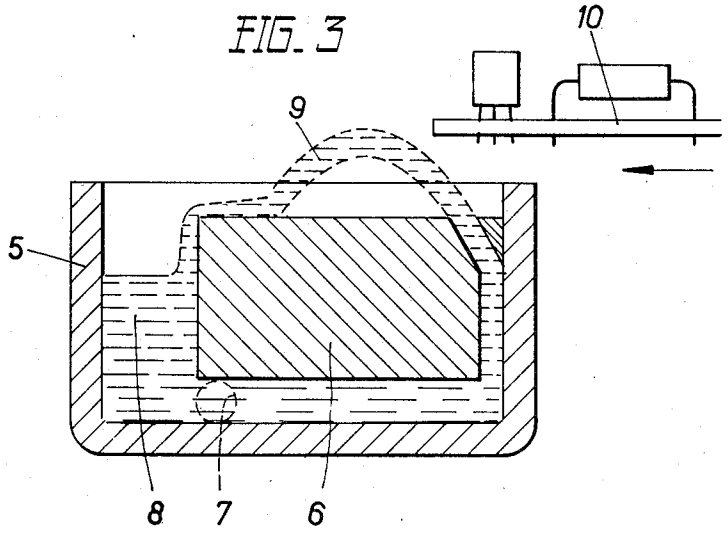


FIG. 3



SOLDERING APPARATUS

This invention relates to soldering apparatus, and in particular to an apparatus for tin soldering circuit elements mounted on a support carrying a printed circuit to the printed circuit. This apparatus comprises a tin bath, means for causing the tin in this bath to melt and maintaining it in a molten state, as well as means for setting the melted tin in motion so as to form, above what would be the upper surface of the bath when at rest, a projection of liquid tin, the envelope of which is an upwardly convex surface, the position and shape of this surface being at least approximately stable and invariable, respectively.

In the known apparatus of this type, the projection of tin is produced by a rotary pump immersed in the bath. These types of apparatus, however, utilized for soldering circuit elements on large series of supports, require equipment which is prohibitive for enterprises which have only small or medium-sized series to handle. What is more, these known types of apparatus are no longer profitable when they can no longer be used continuously.

In any event, those skilled in the art who only occasionally have soldering to do, have up to now been reduced to doing it by hand, with the aid of a conventional soldering iron.

Other means than an immersed rotary pump are known for setting a melted metal in motion. For example, electromagnetic pumps are used to establish a circulation of molten sodium in conduits. In all these cases, a magnetic field is caused to act upon a current. A current is accordingly caused to pass through a section of the conduit, and this section is subjected to a magnetic field perpendicular to the electric current, which has the effect of producing a force in the direction of the conduit upon the length of melted metal situated in the said section. Such a force is also produced by means of rotary fields generated by polyphase currents. However, these pumps involve even considerably more means than the rotary pumps. Thus they have never been used for tin soldering.

The main object of the present invention is therefore to create a simple and inexpensive apparatus which can be utilized advantageously even for the occasional soldering of small series of items to be soldered together.

The apparatus according to the invention is characterized in that the means for causing the tin to melt, to keep it molten, and to set it in motion comprise a ferromagnetic core in the form of a closed frame, on which are mounted side by side a primary winding, and a secondary winding composed of a single closed turn, of which a stirrup or U-shaped piece with low ohmic resistance and the tin bath form part; and this bath is contained in a crucible which is placed between the extremities of the stirrup-piece, which does not conduct the electric current, and which contains a guide, also non-conductive, forming a nappe or layer of tin which extends from one edge of the crucible to the other and is situated in the vicinity of the bottom of the bath, an electric contact being established between the extremities of the stirrup-piece and the edges of this nappe.

This contact will advantageously be established directly by openings filled with tin and contrived in the lateral walls of the crucible, and these walls will be gripped between the extremities of the stirrup-piece strongly enough so that the extremities close said openings and prevent the molten tin from running out.

In order that the crucible may exhibit a mechanical resistance sufficient to stand the pressure exerted by the extremities of the stirrup-piece, and for the purpose of facilitating the stabilization of the temperature of the bath, this crucible will preferably be made of anodically oxidized aluminum.

Finally, the apparatus may advantageously comprise a series of nozzles so that the projection of tin which it produces takes place in the form of parallel thin streams. The soldering which results is preferable to that which is obtained with a projection in the form of a curtain.

An embodiment of the apparatus according to the invention is represented diagrammatically and by way of example in the accompanying drawing, in which:

FIG. 1 is a longitudinal section of the apparatus,

FIG. 2 is a transverse section along the line II—II of FIG. 1, and

FIG. 3 is a larger-scale view of a portion of FIG. 1, with the apparatus in operation.

The apparatus shown in FIG. 1 comprises a ferromagnetic core 1 in the form of a closed frame. A primary winding 2 is mounted on this core 1. Winding 2 is supplied with alternating current which can come from the mains. A secondary winding 3, composed of a single turn, is also mounted on core 1, right beside primary winding 2. The sole turn of this secondary winding 3 is partially formed by a stirrup-piece 4 (FIG. 2) with low ohmic resistance. Stirrup-piece 4 will preferably be made of copper, with a relatively large cross-section. The sole turn of secondary winding 3 is closed in a manner described below.

A crucible 5, parallelepipedal in shape, is placed upon core 1, between the extremities of stirrup-piece 4, which project up above this core. A bar 6, rectangular in section, extends from one of the lateral walls of crucible 5 to the other, which walls are in contact with the extremities of stirrup-piece 4. This bar 6 is rigidly fixed to the walls of crucible 5 by any appropriate means. As is seen in FIG. 1, the distance between bar 6 and the end wall of crucible 5 adjacent to winding 2 is greater than from bar 6 to the opposite wall of crucible 5. Bar 6 is situated at a certain distance from the bottom of crucible 5, and its upper surface is below the level of the upper edge of the crucible. Circular holes 7 are contrived in the portions of the lateral walls of crucible 5 in contact with stirrup-piece 4 which are comprised between the bottom of the crucible and bar 6. The diameter of holes 7 is approximately equal to the distance from bar 6 to the bottom of the crucible. Finally, holes 7 are situated in the vicinity of the edge of bar 6 facing the end wall of crucible 5 which is adjacent to primary winding 2.

For reasons which will become apparent hereinafter, crucible 5 and bar 6 are made of insulating material.

To complete the apparatus described and to make it operational, a mass of tin 8 (FIG. 3) is poured hot into crucible 5 in such a way that the level of the tin comes at least above the lower surface of bar 6. The tin thus poured into crucible 5 fills holes 7 and comes into contact with stirrup-piece 4. In order that the tin does not run out between the crucible and the stirrup-piece, the extremities of the latter are strongly pressed against the lateral walls of crucible 5. In order that crucible 5 may resist this pressure from stirrup-piece 4, it is important that it be made of a material having a sufficient

mechanical resistance. To meet this condition, a crucible made of aluminum, electrically insulated by anodic oxidation, can be utilized.

It follows from the preceding description that the turn constituting the secondary winding described is closed by the mass of tin contained in crucible **5**. The latter remains in contact with stirrup-piece **4** even when the tin is cooled down to ambient temperature.

To use the apparatus described, it suffices to energize primary winding **2**. The AC passing through this primary winding induces a voltage in the secondary winding, which causes a current to circulate in stirrup-piece **4**, as well as in the tin bath. The primary winding is so calculated that the Joule effect of the secondary current causes the tin contained in crucible **5** to melt.

As the magnetic field generated by the primary winding in core **1** and that which is created by the AC circulating in the secondary winding are opposite and almost equal, a leakage field is produced perpendicular to core **1** between the windings, so that the turn constituting this secondary winding undergoes a repulsion effect tending to move it away from primary winding **2**. If stirrup-piece **4**, which is rigidly wedged on core **1**, cannot move under this effect of repulsion, the thin stream of melted tin between holes **7** of the crucible tends itself to move toward the right in FIG. **3**. Before the mass of the tin contained in crucible **5** is moved under this effect of repulsion, it must first become molten, which is accomplished by thermal convection. As soon as the mass is molten, the magnetic leakage field has the effect of bringing about the displacement of the thin stream of tin extending between openings **7** along the nappe or layer of tin between bar **6** and the bottom of crucible **5**. This displacement causes the level of the tin to rise between bar **6** and the end wall, below, of crucible **5**, farther away from winding **2**. The action of the magnetic field upon the molten tin even suffices to bring about a projection of tin **9** over bar **6**.

So that this projection does not overflow crucible **5**, various means can be used. The simplest means consists of tilting the apparatus in such a way that projection **9** drops back on bar **6** or even in the space between this bar and the end wall, above, of crucible **5**, adjacent to winding **2**. If it is desired to leave crucible **5**, as well as the apparatus as a whole, in a horizontal position, a nozzle can also be provided between the end wall, below, of the crucible and bar **6**, at the place where projection **9** originates. This nozzle can have a slanted slit aiming the projected tin toward the interior of crucible **5**.

In both cases, the result of the apparatus described is the projection of a curtain of tin which, under the effect of gravity, takes on a convex shape. The operating specifications of the apparatus described can easily be determined in such a way that this curtain of tin has an invariable shape.

To solder circuit elements on a plate **10** having a printed circuit, it suffices to move this plate along a tangent to the top of curtain **9** so that the latter sweeps the lower surface of plate **10**. As the case may be, this plate may be moved by hand or with the aid of a guide as in the case of the known apparatus.

Instead of utilizing a nozzle with a slit for projecting a curtain of tin over bar **6**, however, a series of nozzles will preferably be used, consisting of a row of small round holes projecting separate thin streams, but close enough to one another so that these streams spread out, meeting on the lower surface of plate **10** when the latter is brought into contact with the projected tin. Indeed, such nozzles have the advantage of producing a thinner film of tin on the underside of plate **10**.

To stop the operation of the apparatus described, it suffices to cut off the current in primary winding **2** and to allow tin bath **8** to cool down.

I claim:

1. An apparatus for tin soldering circuit elements mounted on a support carrying a printed circuit to said support, by setting molten tin in motion and projecting a stream of molten tin in an upward direction from a tin bath so that the upper envelope of the stream of tin has a convex shape which is substantially stable and constant, said apparatus comprising:

a ferromagnetic core in the form of a closed frame;

a primary winding surrounding a portion of said core with which said winding is associated in a linking configuration;

a secondary winding located beside said primary winding and surrounding a portion of said core, said secondary winding comprising a single closed turn including a U-shaped stirrup member having a low ohmic resistance and a tin bath electrically connecting the upright portions of said U-shaped member;

a substantially electrically insulating crucible for containing the tin bath, said crucible located between the uprights of the U-shaped member, said crucible containing a substantially electrically insulating guide bar extending between the sides of the crucible which abut said uprights, said bar being spaced adjacent the bottom of the crucible and at least in part defining an opening directed toward the top of the crucible for projection of a stream of molten tin, and said crucible including means for electrically connecting the edges of the layer of tin which is beneath the bar within the crucible.

2. An apparatus according to claim **1** wherein the means for electrically connecting the edges of the layer of tin beneath the bar within the crucible comprises tin filling openings in the sides of the crucible which abut the uprights of the U-shaped member, which sides are firmly gripped between said uprights so that the uprights close said openings thereby preventing any loss of molten tin.

3. An apparatus according to claim **2**, characterized in that the crucible is made of anodically oxidized aluminum.

4. An apparatus according to claim **1**, characterized in that the said guide bar consists of a prismatic bar of at least approximately rectangular cross-section.

5. An apparatus according to claim **4**, characterized in that the openings in the sides of the crucible extend between the bottom of the crucible and the guide bar, starting from the edge of the guide bar opposite the opening defined by said bar.

6. An apparatus according to claim **4**, characterized in that it additionally comprises a series of nozzles disposed in the opening directed toward the top of the crucible for projection of a stream of molten tin.

7. An apparatus according to claim 1, wherein the opening directed toward the top of the crucible for projection of a stream of molten tin, is defined between the guide bar and an end of the crucible.

* * * * *