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Soldering System and Method

1 This invention relates to soldering systems and
methods and more particularly to a system and method for
5 the vapour-phase heating of a product and separate
application of solder to the heated product.

 Soldering is widely employed for the fabrication
of many different products, especially products in the
electronics field, notably printed circuit boards. For the
10 production fabrication of printed circuit boards and
similar products, wave solder systems have been widely
employed. These systems include a reservoir of molten
solder which is pumped in a wave, with the circuit board
being transported in contact with the wave to cause wetting
15 of the intended areas of the board. The solder wave serves
as a source of heat for heating of the circuit board and
also as the solder source for application of solder to the
board. The wave solder apparatus is relatively complex and
must be carefully designed and constructed to provide a
20 solder wave of the appropriate dimensions and
characteristics to provide the requisite heating and solder
application to the particular product being processed. The
length of the wave must be sufficient to provide sufficient
time of contact to heat the surface to be soldered. The
25 wave design is critical in relation to the product and
speed of the product through the wave. There is a maximum
speed beyond which a product cannot be conveyed through a
particular solder wave and still achieve sufficient
heating. For greater speeds, the wave would have to be
30 reconfigured, which would necessitate a complete system
redesign.

 The height of the solder wave is also a critical
factor and can be a limiting factor to the size of a
product being processed. For example, in a printed circuit
35 board in which leaded components are inserted, the lead
lengths cannot be longer than the depth of the solder or

1 else a board cannot be accommodated in a particular wave
solder apparatus because of interference with the long
component leads. Thus, care must be exercised in the
assembly of components on a circuit board to assure that
5 the lead lengths are less than the depth of the solder wave
for the particular solder apparatus to be employed. Since
the solder wave serves both as the source of solder and
source of heating, the dynamics of the system become
complex in designing a wave solder apparatus for particular
10 purposes. Also, these dynamics make it difficult to alter
the characteristics of the solder wave to accommodate
different types of product.

Another type of production solder system is the
drag solder system in which a reservoir of solder is
15 provided into which a product is dipped and immersed either
partially or completely to apply solder to the product.
Here again the molten solder serves both as the source of
heat for heating the product to a soldering temperature and
as the solder applicator.

20 U. S. Reissue Patent No. Re. 30,399 shows a wave
flow soldering apparatus in which the solder wave is
provided at the bottom of a vessel containing a heated,
saturated vapour. The product is conveyed through the
vapour chamber and is heated by immersion in the vapour
25 phase and soldered by passage through the solder wave.
Solder is applied in an anaerobic atmosphere provided by
the vapour phase but there is little improvement in the
control or performance of the soldering operation by
location of the solder wave apparatus in the chamber. The
30 criticality and relative complexity of the solder wave
remains the same as described above, and the presence of
the solder wave within the heated vapour does not alter the
critical design considerations of the wave apparatus.

An article entitled "A New Soldering Process," by
35 W. R. George, Brazing & Soldering, No. 5, Autumn 1983,
shows a drag soldering system in which the product is

1 initially placed within a heated inert vapour phase prior
to immersion into the molten solder bath.

U. S. Patent No. 3,825,164 shows a soldering
system having a tank containing a pool of molten solder at
5 the bottom and covered by a liquid fluxing bath, with
solder spray apparatus within the fluxing bath. A printed
circuit card is inserted vertically into the fluxing bath
for fluxing and preheating, and solder is sprayed onto one
or both surfaces of the printed circuit card as the card is
10 withdrawn from the tank.

The present invention provides a system for the
soldering of circuit boards and other products in which the
product is heated by an independently controlled vapour
phase system, and solder applied by a separately controlled
15 nozzle applicator system operative to direct controlled and
defined streams of solder onto the product. A vessel is
provided for containing a heated saturated inert vapour
into which the product is introduced prior to solder
application and by which the product is heated to soldering
20 temperature. One or more nozzles are provided within the
vessel for directing one or more streams of molten solder
to the heated product, the impinging solder being retained
by the areas of the product surfaces to which the solder
will adhere. In the case of a circuit board, the solder is
25 adherent to the conductive circuit paths, the
plated-through holes which may be present in the circuit
board, and to the leads or connection pads of components
assembled on or inserted through the board.

Heating of the product is provided substantially
30 by the heated vapour phase atmosphere within the vessel,
and the establishment and control of this vapour atmosphere
is separately provided by the vapour phase apparatus.
Solder application is provided by the applicator nozzles
which, with the associated solder pump and solder source,
35 independently provide the intended solder streams for the
particular product. Thus, the heating of the product and

solder application to the product are separately controlled operations, and these operations are substantially independent of each other. The product can be introduced and removed from the processing vessel in any manner
5 suitable for the particular application. Typically, for a continuous production process, the product is carried on a conveyor into the processing vessel for heating and solder application, and then carried by conveyor out of the vessel.

There now follows a detailed description, to be
10 read with reference to the accompanying drawings, of a soldering system embodying the invention.

In the accompanying drawings:-

Figures 1 to 3 are diagrammatic views illustrating the principle of the invention but without
15 including the means for varying the position of the nozzle means thereof.

Figure 1 shows a diagrammatic elevational view of a soldering system, and Figures 2 and 3 respectively show nozzles disposed below and above a product;

20 Figure 4 is a diagrammatic elevation view of a preferred system embodying the invention;

Figure 5 is a partially cutaway top view of the system of Figure 4; and

25 Figure 6 is a partially cutaway pictorial view of a solder nozzle assembly.

Figure 1 shows a soldering system suitable for electronic circuit boards. A closed vessel 10 defines an interior vapour phase chamber in which a zone of inert
30 saturated vapour is provided at a

predetermined elevated temperature for heating of a product to be soldered. Heaters 12 are disposed at the bottom of vessel 10 and are operative to heat a vapour phase liquid 14, typically Fluorinert FC-70, ("Fluorinert" is a Registered Trade Mark), to a temperature sufficient to provide a heated saturated vapour of that liquid within the chamber. Cooling coils 16 can be disposed around the vessel walls at a position to define the upper extent of the vapour zone within the chamber. Products such as circuit boards 27 are conveyed into the vapour phase chamber by means of an entrance throat 18, and out of the chamber by means of an exit throat 20, each throat outwardly extending from opposite side walls of the vessel 10. A conveyor 22 extends through the entrance throat 18, interior chamber of the vessel 10 and the exit throat 20, and is operative to convey or transport the circuit boards into and out of the vapour phase chamber. The conveyor 22 can be of any suitable form to accommodate the particular product being processed. For circuit boards, the conveyor can include frames for holding the board edges, leaving the board surfaces exposed for soldering. A pair of nozzles 24, 26 is disposed in the vapour phase chamber, each in a position to apply a stream of solder onto respective opposite surfaces of the circuit boards which are conveyed past the nozzles along the product travel path within the chamber.

A solder pump 28 is disposed within the vessel 10 in a sump 30 containing molten solder to provide solder to nozzles 24, 26. The sump 30 collects excess solder which falls or drains from the boards after solder application by the nozzles. The sump also serves as a solder supply or source for the pump 28 and the nozzles. A separate solder source may alternatively be provided. The solder pump can alternatively be disposed external to the vessel.

1 The entrance and exit throats are preferably
configured in conjunction with the vessel to minimize the
outward flow of vapour from the vessel to the atmosphere.
Such configuration can be as shown in U. S. Patent
5 4,389,797. The present invention is not limited to use
with such entrance and exit throats, as many different
forms of product ingress and egress to and from the vessel
can be provided to suit particular product configurations
and specific operational requirements. It is preferable
10 for continuous processing to provide a straight-through or
substantially straight-through system in which the product
can be conveyed continuously through the system for
soldering operations. The entrance and exit throats 18, 20
can be disposed in a substantially horizontal position or
15 can be inclined upward or downward to provide an intended
conveyance path and the requisite minimization of vapour
loss from the throats to the atmosphere.

 The heating of a product entering the vessel
chamber, and the application of solder to the heated
20 product, are separately controllable and are each
substantially independent of the control of the other. The
product entering the chamber is heated by the vapour phase
atmosphere within the chamber. The establishment and
control of the heated vapour atmosphere is provided by the
25 vapour phase apparatus which includes the heaters 12 and
vapour phase liquid 14 and the associated heater control.
The solder application is provided by the applicator
nozzles 24, 26, and associated source e.g. sump 30 and pump
28, which are constructed and adjusted to provide the
30 intended solder streams for the product which has, prior to
solder application, been heated to an intended temperature
by the vapour phase apparatus of the system.

 If only one side of the circuit boards 27 is to
be processed, the system can be implemented with only a
35 bottom nozzle 26, as shown in Figure. 2, or with a top
nozzle 24, as shown in Fig. 3.

1 The system of Fig. 1 is shown in typical
implementation in Figs. 4 and 5. A pair of conveyor chains
31 and 32 are coupled to frames 34 spaced along the chains
and which are operative to retain printed circuit boards
5 for transport through vessel 10. The frames 34 are each
coupled at their forward end by a coupling 35 to the
driving chains 31, 32, and include side members or skids 36
which slide along guide surfaces 38 within the vessel 10.
The guide surfaces within the vessel follow a downward path
10 40 at the entrance portion of the vessel and then follow a
uniform upward path through the vessel which is
substantially colinear with the exit throat 20. A pair of
idler wheels 42, 44 is provided within the vessel for the
respective chains 31, 32 to change the direction of chain
15 motion, as illustrated. After entrance of a frame and the
circuit board carried thereby into the vessel, the frame
and circuit board follow the path of the guide surfaces 38
and assume an upward inclined orientation as shown in
Fig. 4 for linear upward travel through the processing
20 chamber. The circuit board, by this means, is conveyed in
an intended orientation for uniform travel past the solder
nozzles so that an intended relative position between the
board surfaces and the confronting nozzles can be
maintained within the shortest convenient vessel length in
25 order to minimize the length of time that the circuit board
is subject to the high temperatures of the processing zone
within the vessel.

 A pair of hold-down plates 64 is disposed above
the conveyor to resiliently urge the side skids 36 of the
30 conveyor frame into engagement with guide surfaces 38 and
hold the frame and circuit board contained by the frame
down against the guide surfaces. The circuit board is thus
maintained in an accurate guided position and orientation
along its path past the solder nozzles.

35 The solder nozzles 24, 26 are provided on
respective sides of the board transported therebetween

astride the travel path, and each nozzle is adjustable in the angular orientation of the nozzle orifice with respect to the circuit board, and in the offset or spacing of the nozzle from the confronting board surfaces. Typically, the
5 nozzles are angularly adjustable over a range of 45 degrees to either side of an axis normal to the board surface, and are adjustable in offset from the board surfaces in the range of 1/4 - 1 inch (0.64 - 2.54 cm). The lower nozzle 26 is further illustrated in Fig. 6 and comprises an elongated
10 generally cylindrical tubular member 50 having elongated linear orifice 52 along the length thereof and of length sufficient to provide a solder stream across the entire circuit board width. The member 50 has a lip 54 adjustable with respect to a lip 56 to provide an adjustable orifice.
15 Typically, the orifice has a gap in the range of 10 - 30 mils (about - 0.254 - 0.762 mm). The cylindrical member 50 is rotatable about its axis to provide for angular adjustment of the orifice 52 to the intended angle of incidence of the solder stream applied to the confronting
20 board surface. A linkage 58 is coupled to the member 50 for upward and downward adjustment of member 50 to select the spacing between the nozzle and the confronting board surface. The linkage 58 is connected to means for raising and lowering said linkage by means 66 including a horizontal
25 shaft 68, a yoke 70 secured at one end to the shaft 68, and a pin 72 secured to the other end of the yoke 70 and entering a slot 74 in the linkage 58. The slot 74 inclines downwardly from an open end thereof. The upper nozzle 24 is similarly adjustable in offset from the confronting board
30 surface and angular orientation. Molten solder is pumped to the nozzles via piping 60 which is coupled to a supply manifold 62 which in turn is coupled to the molten solder source or sump.

Each of the nozzles is adjustable to provide a

selectable angular orientation of the nozzle with respect to the confronting board surface, and to select the gap or distance between the nozzle and the confronting board surface. The angular adjustability of each nozzle provides
5 an angle of incidence for the impinging solder stream which can be normal to the board surface or at an angle with or against the travel direction of the board. The angular orientation of each nozzle and the distance between the nozzle and board surface is determined to provide the
10 intended quantity of solder and definition of the solder stream for the particular product being processed. The solder streams are separately controlled to provide the intended application of solder. Since the product prior to
15 solder application has been heated by the vapour phase within the vessel to soldering temperature, the solder application nozzles need be controlled only to provide the desired solder application, and not to heat the product.

The system is useful in soldering a variety of circuit board types. The system can be employed for
20 so-called bare boards which are printed circuit boards having circuit patterns on one or both board surfaces without any components thereon, and which can include through-holes interconnecting the circuit patterns. The system can also be employed for circuit boards containing
25 surface mounted components on one or both surfaces thereof, leaded components having leads which extend through the board, or a mixture of leaded and surface mounted components. The apparatus of the illustrative embodiment can be employed with either or both solder nozzles operative
30 for a particular processing run. In some cases, solder need only be applied to one board surface, in which case the other solder nozzle can be deactivated by appropriate valving of the solder supply to that nozzle.

The system can also be employed for solder stream application by a nozzle to one board surface, with reflow soldering provided on the opposite board surface. In some types of circuit boards, it is preferable to attach components on a board surface by reflow solder techniques in which, for example, a solder paste is applied to the board, and the board thereafter is heated to cause the solder paste to reflow and form a bond between the associated component and conductive areas of the board surface. Reflow soldering can be accomplished in known manner by the present system by introduction of the circuit board into the heated saturated vapour within the vessel. The opposite board surface can be soldered by the solder stream from the associated nozzle. The present system is therefore versatile in providing both solder stream and reflow solder capability within a single apparatus, all within the environment of the heated vapour phase.

The vapour phase atmosphere within vessel 10 is heated to a temperature typically in the range of 415 - 450°F. (213 - 232°C). The solder source is maintained typically in the same range. The solder within sump 30 is maintained in molten state by the heated environment within the vessel. Alternatively, separate heaters can be provided in or around the sump to maintain the solder at intended temperature. The vapour phase atmosphere is therefore at a temperature sufficient for heating the circuit boards to soldering temperature so that, prior to solder stream application by the solder nozzles, the product is already at the soldering temperature. The solder stream of each nozzle is determined in relation to the viscosity of the molten solder, the pressure provided by the pump 28 and the orifice dimensions of the nozzle to produce the intended stream configuration for proper impingement of solder upon the board. The product is conveyed through the system at a

speed sufficient to provide heating of the board vapour phase atmosphere within vessel 10 and proper application of solder to the heated product. In typical implementation, the circuit boards are conveyed through the vessel at a speed of 4 - 10 feet per minute (1.20 - 3.05 metres per minute).

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Claims:

1. A continuous soldering system comprising:
5 a vessel for containing an inert saturated vapour,
means for heating a vapour phase liquid contained within said vessel to establish a zone of inert saturated vapour,
10 means for conveying work product through the saturated vapour zone,
horizontally extending nozzle means for directing a stream of molten solder against a surface of work product as it is conveyed through the saturated vapour zone, and
15 means for varying the position of said nozzle means including
piping for supplying molten solder to said nozzle means,
link means connected at one end to said
20 piping, and
means for raising or lowering said link means whereby the vertical location of said nozzle means can be changed.
- 25 2. A soldering system according to claim 1 wherein said link means is connected to said means for raising and lowering said link means by means including:
a horizontal shaft;
a yoke secured at one end to said horizontal
30 shaft, and a pin secured to the other end of said yoke, and entering a slot in said link means.



3. A soldering system according to claim 2, wherein said slot inclines downwardly from an open end thereof.

5 4. A soldering system substantially as hereinbefore described with reference to and as shown in Figures 4 to 6 of the accompanying drawings.

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