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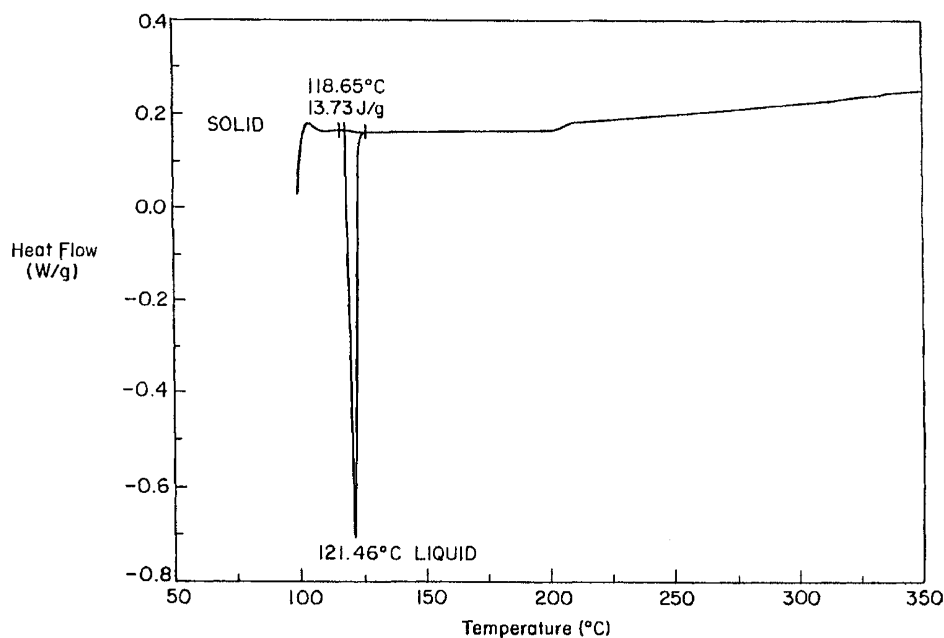

(57) Abstract

The present invention includes a low temperature solder composition having a mixture of elements including indium, tin and silver. Less than about 75% of the composition by weight is tin.

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LOW TEMPERATURE SOLDER

BACKGROUND

Windshields and rear windows of vehicles such as automobiles often include electrical devices located within or on the glass. Typically, the electrical devices are antennas or defrosters. In order to provide an electrical connection to such an electrical device, a small area of metallic coating is applied to the glass which is electrically connected to the electrical device. An electrical connector for connecting to a lead or the lead itself is then soldered to the metallic coating on the glass. The solder typically used has a melting point of about 193°C (380°F) and requires about 750-800 watt seconds of energy to melt the solder. Heat of this magnitude flows to the glass and often damages the glass in regions near the solder joint, for example, causing cracking.

SUMMARY OF THE INVENTION

The present invention is directed to a solder composition that has a considerably lower melting temperature than solder compositions currently available for soldering to glass. As a result, when the present invention solder composition is employed for soldering components onto a windshield or rear window, the amount of heat that flows to the glass is low enough so that the glass experiences little or no damage. The solder composition of the present invention has a mixture of elements including indium, tin and silver. Less than about 75% of the solder composition by weight is tin.

In preferred embodiments, more than about 25% of the solder composition by weight is indium. More typically, less then about 50% of the composition by weight is tin and more than about 50% of the composition by weight is indium. The

solder composition includes the element copper and preferably, the elements within the solder composition have a weight percentage of about 65% indium, about 30% tin, about 4.5% silver and about .5% copper. A preferred range of the weight percentage of the solder composition is 64.35%-65.65% indium, 29.7%-30.3% tin, 4.05%-4.95% silver and .25%-.75% copper. The solder composition preferably contains no more than about .75% antimony, about .08% gold, about .2% lead, about .08% aluminum, about .03% arsenic, about .005% cadmium, about .005% zinc, about .25% bismuth, about .02% iron and about .005% nickel. The solder composition preferably has a liquidus of about 121°C and a solidus of about 118°C.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

FIG. 1 is an inside view of a rear window of an automobile including an electrically operated defroster.

FIG. 2 is a side view of an electrical connector soldered to an electrical contact on the rear window of FIG. 1, with the rear window, electrical contact and solder being shown in section.

FIG. 3 is a graph depicting heat flow versus temperature of the present invention solder composition when heated.

FIG. 4 is a graph depicting the composition of a preferred embodiment of the present invention solder composition.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention provides a solder composition that is suitable for soldering electrical components to glass for electrically connecting to electrical devices within or on the glass. Referring to FIG. 1, the rear window 10 of an automobile is employed as an illustrative example. Window 10 includes a window

defroster 12 consisting of electrically resistive defrosting lines 14 embedded within or deposited on the inner surface of window 10. The defrosting lines 14 are electrically connected to a pair of electrical contacts 16 located on the inner surface of the window 10. The electrical contacts 16 consist of a conductive coating
5 deposited on the inner surface of window 10. Preferably, electrical contacts 16 are formed from silver.

Referring to FIG. 2, the solder composition 20 of the present invention is employed to solder an electrical connector 18 to each electrical contact 16 on window 10. Power lines 22 can then be electrically connected to electrical
10 connectors 18 to provide power to window defroster 12 (FIG. 1).

The present invention solder composition 20 has a solidus temperature of about 118.5°C (245.3°F) and a liquidus temperature of about 121.5°C (250.7°F) as depicted in FIG. 3. This allows solder composition 20 to be melted during soldering with a low energy input level so that the solder composition 20 and electrical
15 connector 18 are at temperatures which are low enough not to damage window 10. While existing solder compositions typically require at least 750-800 watt seconds of energy input in order to melt, the present invention solder composition 20 can be melted with energy input levels as low as 250 watt seconds. However, energy input levels of between about 300-650 watt seconds provide the greatest strength.
20 Although solder composition 20 has a melting temperature of only about 250°F, the melting temperature is still high enough not to melt during the normal use of a car, for example, when the car is in the sun with the windows closed.

The low melting temperature of solder composition 20 is achieved by the particular elements present and the relative amounts of those elements within solder
25 composition 20. In the preferred embodiment, solder composition 20 contains about 65% indium (In), 30% tin (Sn), 4.5% silver (Ag) and .5% copper (Cu) by weight as depicted in FIG. 4. Solder composition 20 also can contain trace amounts of antimony (Sb), gold (Au), lead (Pb), aluminum (Al), arsenic (As), cadmium (Cd), zinc (Zn), bismuth (Bi), iron (Fe) or nickel (Ni). Solder composition 20 preferably
30 has the following composition ranges:

Indium	64.35-65.65%
Tin	29.7 - 30.3%
Silver	4.05 - 4.95%
Copper	0.25 - 0.75%
Antimony	0.750% max.
Gold	0.080% max.
Lead	0.200% max.
Aluminum	0.080% max.
Arsenic	0.030% max.
Cadmium	0.005% max.
Zinc	0.005% max.
Bismuth	0.250% max.
Iron	0.020% max.
Nickel	0.005% max.

Levels of antimony, gold, lead, aluminum, arsenic, cadmium, zinc, bismuth, iron or nickel greater than the above specifications can effect the material properties of solder composition 20.

Cracking of automotive window 10 during soldering is limited by limiting the amount of tin in solder composition 20. At tin levels of about 30%, cracking of window 10 is substantially limited or prevented. High percentages of tin tends to crack automotive glass due to the dissimilar coefficients of expansion of automotive glass and tin. The high percentage of indium causes solder composition 20 to have a low melting point or temperature. The presence of silver in solder composition 20 prevents solder composition 20 from scavenging silver from the electrical contact 16 into the solder composition 20. Solder composition 20 preferably should have at least about 3% silver to prevent silver scavenging from electrical contact 16. Finally, the addition of copper to solder composition 20 raises the melting temperature of solder 20 to the desired level.

As can be seen, no lead is added to solder composition 20. As a result, solder composition 20 is lead-free except for the small level of acceptable contamination allowed for as indicated above. Under normal conditions of use in an automobile, solder 20 does not corrode, pit or melt. The low melting point of the present invention solder is at least about 50°C lower than currently available solders for automotive glass but is still high enough to be above temperatures experienced

by automotive glass during the normal use of an automobile as previously mentioned.

To make solder composition 20, ingots of indium, tin, silver and copper are melted and mixed together in the amounts of about 65% indium, 30% tin, 4.5%
5 silver and .5% copper. The mixed solder composition 20 is then extruded into a ribbon suitable for soldering. Alternatively, the elements can be melted from powder form.

Although particular percentage figures have been given for the present invention solder composition 20, the percentages of the various elements as well as
10 the presence of particular elements can vary, For example, in another preferred embodiment, solder composition 20 is about 64.95% indium, 30% tin, 4.31% silver, .71% copper with the remaining .03% of the solder composition having traces of bismuth, cadmium, iron, magnesium, nickel, lead and thallium. Further, depending upon the application at hand, the amount of indium within solder composition 20
15 can be as low as about 25%. In addition, the amount of tin can be as high as about 75%. However, it is more likely for the amount of tin to be less than 50% and the amount of indium to be greater than about 50%.

In use, soldering of the electrical connectors 18 to the electrical contacts 16 on window 10 with solder composition 20 is preferably conducted by resistance
20 soldering. Alternatively, any conventional soldering apparatus can be employed, for example, a soldering iron. The energy input level for melting solder composition 20 is preferably between 250-650 watt seconds with 300-650 watt seconds being more preferable. This is evidenced by the test results described below from a series of tests where electrical connectors 18 were soldered to a piece of glass and then the
25 force required to pull the electrical connectors from the glass was measured.

EXEMPLIFICATION

Example 1

In the first test, nine groups of four samples were tested. In each group, the electrical connectors 18 were soldered with solder composition 20 to an electrical contact on a glass plate at energy input levels ranging from 250 watt seconds to 650 watt seconds. The electrical connectors 18 were then pulled from the glass and the required force was measured in pounds. The pull strength test was performed at room temperature. The results are listed below as follows:

250 Watt Seconds	300 Watt Seconds
1) 69.0 lbs	1) 89.1 lbs
2) 53.2 lbs	2) 94.4 lbs
3) 54.0 lbs	3) 100+ lbs
4) 59.4 lbs	4) 99.1 lbs
AVG. 58.9 lbs	AVG. 95.7 lbs

350 Watt Seconds	400 Watt Seconds
1) 91.4 lbs	1) 100+ lbs
2) 88.9 lbs	2) 70.6 lbs
3) 99.6 lbs	3) 100+ lbs
4) 100+ lbs	4) 66.5 lbs
AVG. 95 lbs	AVG. 84.3 lbs

450 Watt Seconds	500 Watt Seconds
1) 100+ lbs	1) 100+ lbs
2) 76.6 lbs	2) 98.1 lbs
3) 84.0 lbs	3) 100+ lbs
4) 95.1 lbs	4) 80.1 lbs
AVG. 88.9 lbs	AVG. 94.6 lbs

550 Watt Seconds	600 Watt Seconds
1) 83.5 lbs	1) 94.5 lbs
2) 100+ lbs	2) 100+ lbs
3) 100+ lbs	3) 100+ lbs
4) 94.2 lbs	4) 100+ lbs
AVG. 94.4 lbs	AVG. 98.6 lbs

650 Watt Seconds

1) 79.0 lbs
2) 78.8 lbs
3) 100+ lbs
5 4) 100+ lbs
AVG. 89.5 lbs

Example 2

In the second test, ten electrical connectors 18 were soldered with solder composition 20 to glass at an energy input level of 500 watt seconds with the
10 electrical connectors 18 having a temperature of 407°F and the glass being at room temperature. The pull strength test results are as follows:

1) 100+ lbs
2) 94.0 lbs
3) 89.5 lbs
15 4) 82.9 lbs
5) 100+ lbs
6) 100+ lbs
7) 79.3 lbs
8) 93.0 lbs
20 9) 97.1 lbs
10) 100+ lbs
AVG. 93.6 lbs

Example 3

In the third test, ten electrical connectors 18 were soldered with solder
25 composition 20 to glass at an energy input level of 500 watt seconds with the electrical connectors have a temperature of 407°F and the glass being heated to 220°F when the pull strength test was performed. The pull strength test results are as follows:

1) 58.8 lbs
30 2) 67.2 lbs
3) 80.4 lbs
4) 54.2 lbs
5) 63.3 lbs
6) 57.7 lbs
35 7) 61.8 lbs
8) 48.8 lbs
9) 53.9 lbs
10) 55.4 lbs
AVG. 60.1 lbs

Example 4

In the fourth test, six groups, each containing five samples were tested. In each group, the electrical connectors 18 were soldered with solder composition 20 to an electrical contact on a glass plate at energy input levels ranging from 250-500 watt seconds and employing type R electro-rosin flux. The pull strength test results are as follows:

250 Watt Seconds	300 Watt Seconds
1) 53.9 lbs	1) 104.6 lbs
2) 53.0 lbs	2) 99.7 lbs
3) 79.0 lbs	3) 125.5 lbs
4) 54.2 lbs	4) 119.1 lbs
5) 108 lbs	5) 60.7 lbs
AVG. 69.6 lbs	AVG. 101.9 lbs

350 Watt Seconds	400 Watt Seconds
1) 85.1 lbs	1) 122.6 lbs
2) 121.2 lbs	2) 111.5 lbs
3) 127.5 lbs	3) 108.9 lbs
4) 117.4 lbs	4) 127.0 lbs
5) 138.4 lbs	5) 129.7 lbs
AVG. 117.9 lbs	AVG. 119.9 lbs

450 Watt Seconds	500 Watt Seconds
1) 114.1 lbs	1) 136.1 lbs
2) 100+ lbs (glass broke)	2) 115.1 lbs
3) 100+ lbs (glass broke)	3) 142.9 lbs
4) 100+ lbs (glass broke)	4) 121.7 lbs
5) 137.4 lbs	5) 132.7 lbs
AVG. 00.0 lbs	AVG. 129.5 lbs

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

For example, although the present invention solder composition 20 has been described for soldering to automotive glass, alternatively, solder composition 20 can be employed for soldering to other types of glass such as used in buildings or any other material where a low melting point solder is desirable. In addition, although
5 particular solidus and liquidus temperatures have been given for solder composition 20, such temperatures can vary depending upon the elements present and the percentages of those elements.

CLAIMS

What is claimed is:

1. A solder composition having a mixture of elements comprising indium, tin and silver, in which less than about 75% of the composition by weight is tin.

5 2. The solder composition of Claim 1 in which more than about 25% of the composition by weight is indium.

3. The solder composition of Claim 2 in which less than about 50% of the composition by weight is tin and more than about 50% of the composition by weight is indium.

10 4. The solder composition of Claim 1, the mixture of elements further comprising copper.

5. The solder composition of Claim 4 in which the elements of the composition have a weight percentage of about 65% indium, about 30% tin, about 4.5% silver and about .5% copper.

15 6. The solder composition of Claim 4 in which the elements of the composition have a weight percentage of 64.35%-65.65% indium, 29.7%-30.3% tin, 4.05%-4.95% silver and .25%-.75% copper.

7. The solder composition of Claim 6 in which the composition contains no more than about .75% antimony, about .08% gold, about .2% lead, about
20 .08% aluminum, about .03% arsenic, about .005% cadmium, about .005% zinc, about .25% bismuth, about .02% iron and about .005% nickel.

8. The solder composition of Claim 1 in which the composition has a liquidus of about 121°C.

9. The solder composition of Claim 1 in which the composition has a solidus of about 118°C.

10. A method of forming a solder composition comprising the step of mixing together elements of indium, tin and silver, in which less than about 75% of
5 the composition by weight is tin.

11. The method of Claim 10 in which the step of mixing further comprises mixing an amount of indium that is more than about 25% of the composition by weight.

12. The method of Claim 11 in which the step of mixing further comprises
10 mixing an amount of tin that is less than about 50% of the composition by weight and mixing an amount of indium that is more than about 50% of the composition by weight.

13. The method of Claim 10 further comprising the step of mixing copper within the composition.

15 14. The method of Claim 13 further comprising the step of mixing the elements of the composition with a weight percentage of about 65% indium, about 30% tin, about 4.5% silver and about .5% copper.

15. A method of soldering comprising the steps of:

providing a solder composition having a mixture of elements
20 comprising indium, tin and silver, in which less than about 75% of the composition by weight is tin; and

melting the solder composition with a heat source, the solder composition melting at about 121°C.

16. The method of Claim 15 further comprising the step of providing the solder
25 composition with copper.

17. The method of Claim 16 further comprising the step of providing the solder composition with a weight percentage of about 65% indium, about 30% tin, about 4.5% silver and about .5% copper.

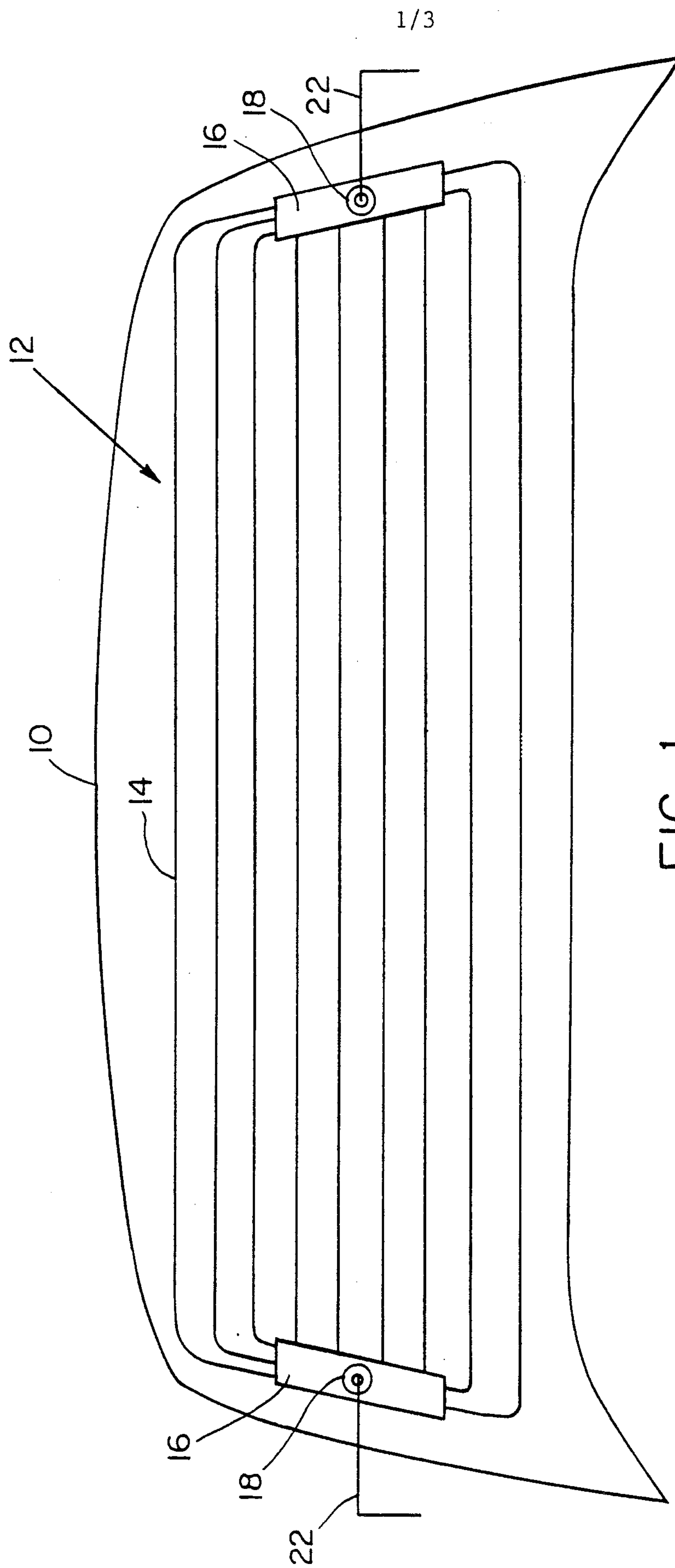

FIG. 1

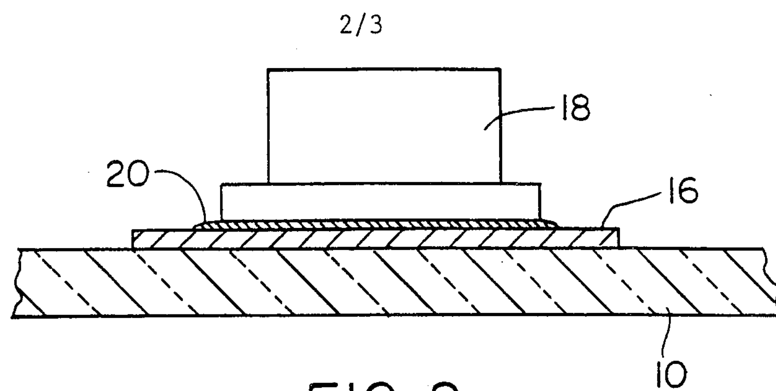

FIG. 2

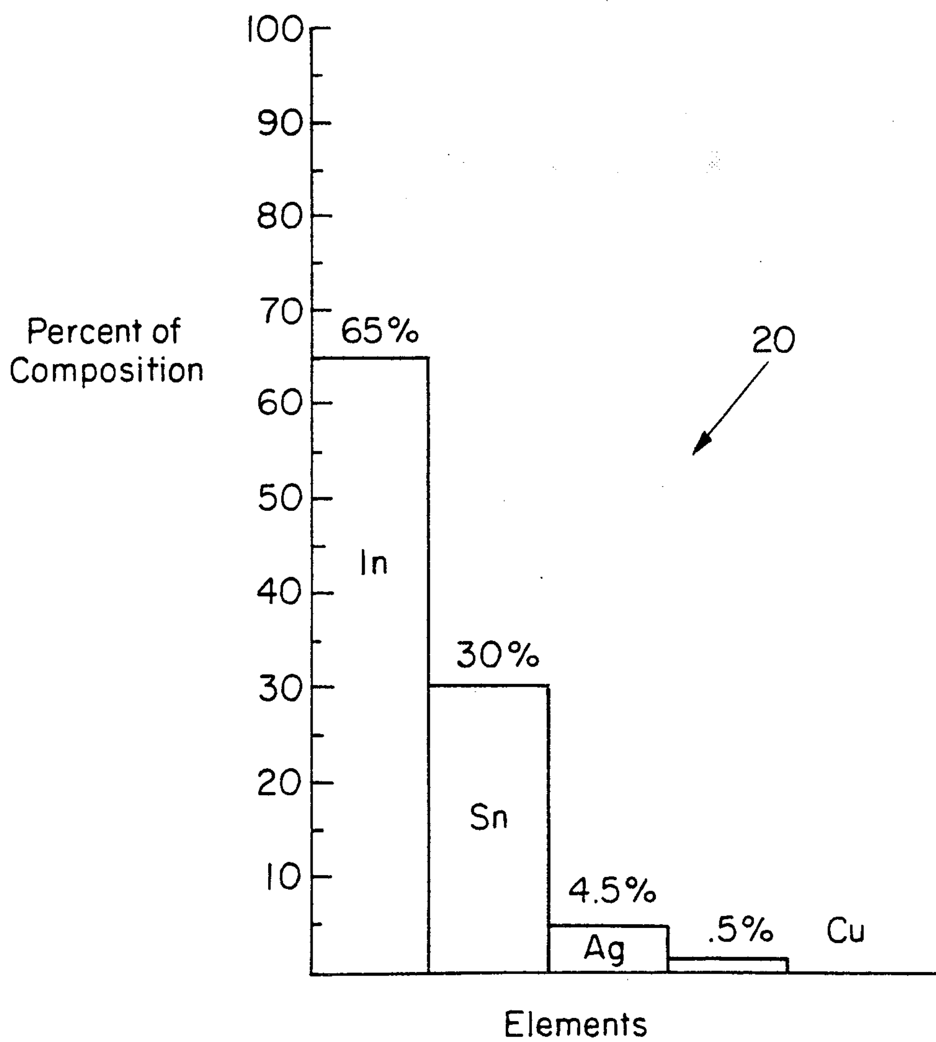

FIG. 4

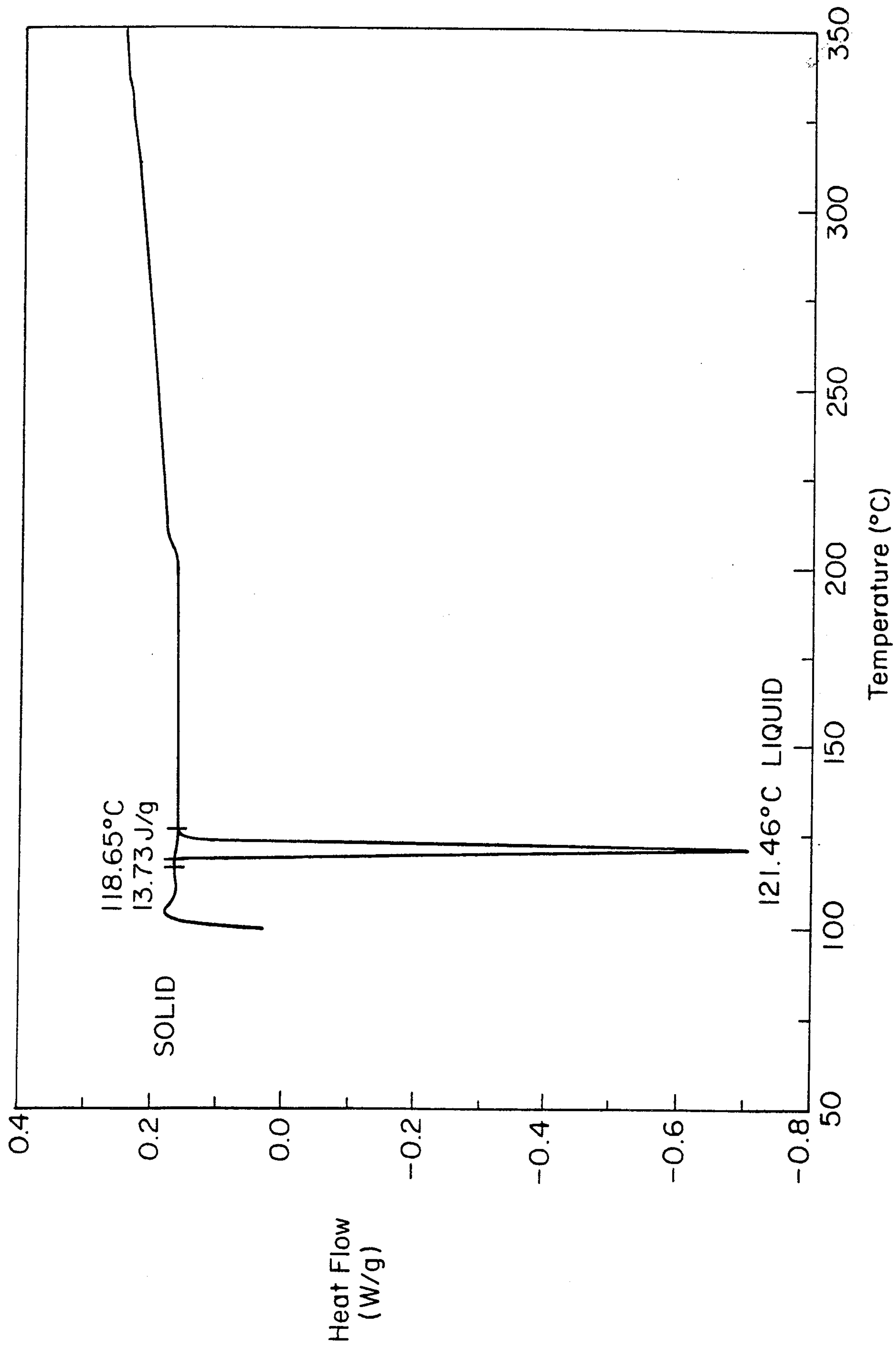

FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/08273

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B23K35/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, CHEM ABS Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CHEMICAL ABSTRACTS, vol. 91, no. 14, 1 October 1979 (1979-10-01) Columbus, Ohio, US; abstract no. 111344, ANDREEVA, L. I. ET AL: "Solder for soldering components of electrovacuum devices" XP002143220 abstract & SU 664 796 T (USSR) 30 May 1979 (1979-05-30)	1-6, 15-17

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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