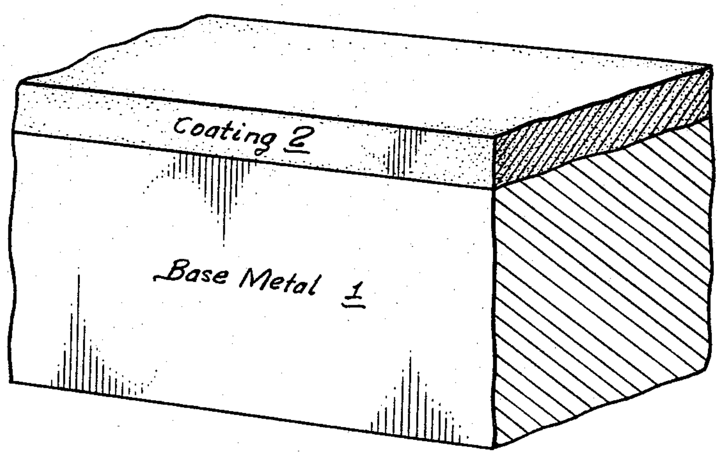
Nov. 12, 1968 A. E. FLANDERS ET AL 3,410,722

WELDING METHOD, COMPOSITION AND ARTICLE

Filed March 23, 1965



INVENTORS.
ANDREW E. FLANDERS,
PARLEY R. PACKER,
JAMES A. PATRICK,
WILSON N. PRATT,

BY [signature]
ATTORNEY.

United States Patent Office

3,410,722

Patented Nov. 12, 1968

3,410,722

WELDING METHOD, COMPOSITION AND ARTICLE

Andrew E. Flanders, Pomona, Parley R. Packer, Alta Loma, James A. Patrick, Montclair, and Wilson N. Pratt, Anaheim, Calif., assignors to General Dynamics Corporation, Pomona, Calif., a corporation of Delaware

Filed Mar. 23, 1965, Ser. No. 442,144
18 Claims. (Cl. 117—227)

ABSTRACT OF THE DISCLOSURE

A material which includes metallic components and which is particularly compatible with surface welding techniques. The metallic components are reduced to powder form, mixed with a binding vehicle, and applied to the base material as a paint or ink, or in a vehicle configured into the form of a grease pencil or crayon. The vehicle for the metal powders is limited only by its ability to provide good adhesion with the base metals and the metallic components without producing a weld contaminating residue, thus organic and certain inorganic vehicles may be utilized.

This invention relates generally to electronic transmission material for interconnecting electrical components, and particularly to material compatible with surface welding techniques, and more particularly to materials and methods for applying the material to a base metal.

As disclosed in U.S. Patent 3,150,288 and U.S. application Ser. No. 294,644, now abandoned, each assigned to the assignee of the present application, electronic transmission material which includes a coating which is fusible under welding operations, particularly surface welding, is desirable because it assures that such a weld joint may be repetitively serviced without a reduction of the mechanical or electrical qualities thereof.

The electronic transmission material having the above qualities has been made by various methods including tank type plating, as exemplified by U.S. application Ser. No. 430,089 filed Feb. 3, 1965, and now Patent No. 3,367,754, also assigned to the assignee of this application.

While satisfactory results have been obtained with conductive or electronic transmission material made by the previous methods, applications arose where it would be either difficult to apply the fusible coating to the base material or economically not feasible to do so. This invention overcomes these problems by providing fusible material and the manner of applying the fusible material to a desired base metal in the form of a paint or ink, or by a grease type pencil or crayon.

As disclosed in the above cited applications, the reparability feature of the electronic transmission material is primarily due to the ratio of the indium by weight to the gold by weight either in the plating solution or in the as-plated condition of the fusible coating. This invention utilizes fusible material but differs from the previous approaches by mixing the desired ratio of indium to gold alone or with other suitable metal powders, such as nickel or gold alone or with nickel, in a suitable binder vehicle which applies a thin coating of the metallic components to the to-be-welded area by merely painting or marking over this area. When subjected to a specified amount of heat, for example, the heat of welding, the binder vehicle will vaporize with little or no residue, leaving the metallic components in the form of a partially or wholly diffused film upon the surface of the base metal or at the interface of materials being joined. The material of this invention provides a simple yet effective mechanical and electrical connection which can be removed and reconnected many times without degradation of the quality of the mechanical or electrical interconnection.

Therefore, it is an object of this invention to provide electronic transmission material.

A further object of this invention is to provide a method of applying a coating of powdered metallic components to a base metal to provide a repairable weld joint.

Another object of the invention is to provide means for applying a coating or film of powdered metallic components in a desired ratio to a to-be-welded area of a base metal.

Another object of the invention is to provide a method to make surface welds possible in an area where it is inconvenient, non-economical, or not possible to use plating methods of applying the coating.

Another object of the invention is to provide a paint or ink for applying a surface-welding material to a base metal.

Another object of the invention is to provide a grease type pencil or crayon for applying a surface-welding material to a base metal.

Another object of the invention is to provide a method which permits very accurate proportioning of the metallic constituents during the formation of the coating on a base metal.

Other objects of the invention, not specifically set forth above, will become readily apparent from the following description and accompanying drawing wherein:

The single figure is a cross sectional view illustrating a coating of metallic components, made in accordance with the invention, on a base metal.

The invention relates to a material which includes metallic components and which is compatible with surface welding techniques. The metallic components are reduced to powder form, mixed with a binding vehicle, and applied to the base material as a paint or ink, or in a vehicle configured into the form of a grease pencil or crayon.

The vehicle for the metal powders is limited only by its ability to provide good adhesion with the base metals and the metallic components without producing a weld contaminating residue, thus vehicles of the organic type are preferred although certain inorganic vehicles may be utilized.

Since the vehicle, described for illustration purposes herein, for applying the powdered metallic components as an ink or paint is different than that used as a grease pencil or crayon, even though the end result is substantially the same, these embodiments will be described separately with the ink or paint approach described first.

With respect to the paint or ink embodiment, the vehicle consists of an organic material of relatively low vaporization temperature which, when subjected to the correct amount of heat, will vaporize with little or no residue, leaving the metallic components in the form of a partially or wholly diffused film upon the surface of the base metal. Examples of such vehicles are paraffin wax, polystyrene varnish, or polyurethane varnish.

An example of the surface-welding compatible alloy with nickel base material is a mixture of powdered forms of gold, indium, and nickel in the following preferred range of composition:

	Percent by weight
Gold	70 to 90
Indium	20 to 8
Nickel	10 to 2

Although the nickel constituent may be reduced to 0% or increased to approximately 20% for nickel base material, the amount of indium with respect to gold, regardless of the percentages of other included metals, should be maintained between about 2% and 20% indium by weight, with the gold between about 98% and 80% by weight to assure good strength and sound metallurgical properties.

Stated in another way with a total weight of indium and gold amounting to 100 parts by weight of a material, the indium should constitute about 2–20 parts by weight and the gold constitutes about 98–80 by weight, any combination of these ranges being usable. This ratio of indium to gold by weight should be maintained regardless of other metals constituting a specific material. When using non-nickel base materials, with mutually diffusable temperature zones, like copper, silver, chromium and nickel-iron alloys, e.g. Kovar, or high nickel content alloys, in combination with or without a nickel base material, the following composition ranges may be used:

	Percent by weight
Gold	38 to 75
Indium	2 to 20
Nickel	60 to 5

Again the nickel can be reduced or eliminated if a low strength bond (surface weld) is acceptable or one of the adjoining members contains nickel; the amount of nickel in the alloy is reduced in approximate proportion to that amount "borrowed" in the specific application.

The desired proportions of powdered metals are mixed into the vehicle to form a thin paste. This paste is applied to the base metal **1** by, for example, extrusion, roller, or silk-screening, depending on the viscosity of the mix, to the desired thickness of the film or coating **2**, as shown in the drawing. The requirement for treating the vehicle is dependent on whether the vehicle is of an air drying type or of a curing type. In certain applications, for example, if the vehicle is a non-curing substance, such as paraffin wax, the coated material is then passed through an oven or flame bath of correct temperature to vaporize the vehicle and partially diffuse the alloy into the surface of the base metal. This procedure may be utilized to provide an electrically conductive coating on a base material. If the vehicle is a curing (hardening) substance such as polystyrene or polyurethane varnish, no further processing for normal applications is necessary; the heat of welding being utilized both to vaporize the vehicle and diffuse the fusible metal into the pieces being joined.

Although a powder mixture of discrete constituents has been described, it may be desirable, in specific applications, to first compound the binary or ternary metal alloy followed by a powdering process prior to mixing with the vehicle.

Referring now to the grease pencil or crayon embodiment of the invention, this approach utilizes the indium and gold powder concept in the ratios set forth above; however, a different vehicle and application method is used to apply the material. The desired metal powders (alloy), prepared in the desired ratio, are mixed into a heated vehicle of material such as crayon (stearic acid, paraffin, beeswax, and carnauba wax), grease pencil (beeswax and paraffin), or lipstick (candelilla wax, beeswax, micro crystalline petrol wax, castor oil, and butyl stearic). The vehicle, loaded with the metal powder is then molded into the form of a grease pencil filler, crayon, or any desired shape.

A surface weld using this embodiment of the invention is made as follows: (1) marking over the to-be-welded area with the molded vehicle, containing the desired ratio of metal powders (alloy), leaving a thin coating of the alloy mixture thereon; (2) laying a strip of metal, such as nickel, over the film; and (3) welding using weld settings compatible with the material being welded.

While the description of the invention is directed to surface welding applications, other types of welding techniques which include cross (resistance) welding, utilizing the novel material of the invention produce satisfactory results.

As in the paint or ink embodiment described above, to surface weld metals other than nickel it is possible to do so by adding nickel powder to the indium/gold mixture Metals such as copper, chromium, silver, and nickel alloys

may be joined by using the gold/indium/nickel mixture. However, the ratio of gold to indium by weight must always be maintained within the range of about 80% gold/20% indium to about 98% gold/2% indium (by weight). The amount of nickel will vary with type of metals to be joined, however, the total amount of nickel in a mixture should not exceed 60% by weight.

It has also been found that gold powder alone or with relatively low percentages of indium can be welded with satisfactory characteristics provided that the weld energy pulse total duration is substantially longer than that utilized in welding the above defined indium to gold percentages by weight.

As pointed out above, one of the novel features of this material is its capability of providing interconnections having effective electrical and mechanical (pull or shear) qualities combined with the capability of being welded to an element, broken or peeled from the element at the welded point, and rewelded at the same point. It has been verified by testing that this sequence can be repeated a relatively large number of times without adverse effect upon the shear or peel strength of the weld, or upon the electrical qualities thereof.

Tests have been conducted to deterimne the proper weld energy range for making welds utilizing the material of this invention and to verify the welding characteristics; namely, tack point, shear or pull strength, and peel strength. By establishing data as set forth hereinafter, it can be determined which weld energy setting for the specific welding equipment being utilized produces the desired shear strength of the type of material being utilized to produce the repairable weld. Practically every different combination of indium and gold by weight utilized in the material of the invention requires a slightly different weld energy setting and produces different shear and peel characteristics. This is also true when utilizing gold powders alone. Also it should be noted that all energy settings vary due to the variations in the power supply and the internal and external conditions of the welding equipment. Thus a weld may show slightly different characteristics when produced by a welding apparatus that has been in operation for a period of time and thus internally "warmed-up" than the characteristics of a weld made of the same material by the same apparatus but at the initial "start-up" of the apparatus. Also, different type of welders have different internal characteristics and thus produce variations in the weld energy setting. In addition, it has been shown by testing that base metals of the same type of material but produced by different manufacturers cause a slight variation in the weld characteristics when utilizing the material of the invention to weld these base metals together. The following is a brief description of the welding characteristics tested:

(1) Tack point—point at which the weld begins to tack, which has been shown to be of a weld energy which is preferably 5.5 to 7.5 watt seconds for a particular weld equipment set up.

(2) Shear (pull) strength—the number of pounds pressure required to shear or break the material. For example, with a power supply at 1.5 times the above, average tack point energy, the welds should preferably test to destruction at a shear strength of 10 lbs. or above, or with a weld energy of 11 watt seconds, each weld should test to destruction at a shear strength of 14 lbs. or above. While the majority of shear tests conducted on welds made with the material of the invention have indicated a shear strength in the range of between 19 to 21 lbs., satisfactory welds have been made which have shear strengths above and below this range.

(3) Peel strength—the number of pounds pressure required to peel the welds made with the material of this invention from the element to which it was welded. For example, with the power supply set at 11 watt seconds, each weld should preferably peel at between 2.5 to 6 lbs. However, as shown by the following test data, good welds

have been achieved which have peel strengths above and below the specified preferred range.

The following test data set forth for illustrative purposes was conducted with material made in accordance with the invention wherein gold powder alone or different percentages of indium to gold powders by weight were mixed with a binder vehicle of polyurethane varnish. Five welds were made at each of the following energy settings and with a weld energy pulse of approximately 9 milliseconds total duration, the shear strength values for each energy setting being an average of the five welds:

With the powder metal composed of 100% gold a peel strength of 4.5 lbs. was obtained at 11 watt-second weld energy with the shear profile points as follows:

Energy (watt sec.):	Av. shear strength (lbs.)
6	Tack point
7	1.0
8	1.9
9	5.2
10	9.0
11	16.0
12	20.2
13	20.4
14	Burn through

Utilizing powders composed of 2% indium and 98% gold by weight a peel strength of 4.2 lbs. was obtained at 11 watt-sec. weld energy and the following shear profile points were determined:

Energy (watt sec.):	Av. shear strength (lbs.)
6	Tack point
7	1.4
8	3.3
9	7.2
10	11.1
11	19.1
12	20.1
13	20.4
14	20.4
14.5	Burn through

Material composed of 10% indium powder and 90% gold powder by weight produced a peel strength of 3.9 lbs. at 11 watt-sec. weld energy with the following shear profile points:

Energy (watt sec.):	Av. shear strength (lbs.)
6	Tack point
7	2.3
8	4.8
9	8.5
10	13.0
11	19.0
12	20.2
13	20.5
14	20.5
15	20.5
16	Burn through

Material composed of 20% indium powder and 80% gold powder by weight produced a weld having a peel strength of 4.1 lbs. at 11 watt-second weld energy with the following shear profile points:

Energy (watt sec.):	Av. shear strength (lbs.)
6	Tack point
7	1.2
8	3.9
9	8.1
10	11.8
11	20.5
12	20.1
13	20.2
14	20.4
15	20.4
15.5	Burn through

This invention thus provides a simple and economical manner of applying a coating or film of fusible metals including gold alone, nickel and gold, or a desired ratio of indium to gold by weight with or without additional metals to a base metal whereby a repairable weld can be made. This manner of applying the desired metallic components to a base metal eliminates the problems involved in the plating processes for applying the fusible metal as well as the equipment involved in the plating processes, while permitting very accurate proportioning of the metallic constituents during the coating formation. Also, small quantities of the material can be produced and applied in areas where it is inconvenient, impractical, or impossible to utilize the plating process, while providing the same repairability feature, and electrical and mechanical qualities of welds made with the fusible metal plated on the base metal.

Although particular embodiments of this invention have been described, modifications and changes will become apparent to those skilled in the art, and it is intended to cover in the appended claims all such modifications and changes as come within the true spirit and scope of the invention.

What we claim is:

1. A conductive material comprising a base metal selected from the group consisting of nickel, copper, silver, chromium, and nickel-iron alloys and a coating of metal powders on at least one surface of said base metal, said coating including a mixture of metal powders selected from the group consisting of nickel, indium, and gold and at least including indium and gold in a suitable vehicle, said indium and gold powders being in a ratio of about 2 to 20 percent indium by weight as compared to the gold by weight.

2. The conductive material defined in claim **1**, wherein said vehicle is paraffin wax.

3. The conductive material defined in claim **1**, wherein said vehicle is polystyrene varnish.

4. The conductive material defined in claim **1**, wherein said vehicle is polyurethane varnish.

5. The conductive material defined in claim **1**, wherein said vehicle is composed essentially of stearic acid, paraffin, beeswax and carnauba wax.

6. The conductive material defined in claim **1**, wherein said vehicle is composed essentially of beeswax and paraffin.

7. The conductive material defined in claim **1**, wherein said vehicle is composed essentially of candelilla wax, beeswax, micro crystalline petrol wax, castor oil, and butyle stearic.

8. A laminar conductive material comprising a base metal selected from the group consisting of nickel, copper, silver, chromium, and nickel-iron alloys and a layer of predetermined mixture of metal powders in a suitable vehicle on at least one side of said base metal, said predetermined mixture of metal powders being selected from the group consisting of nickel, indium, and gold and at least including indium and gold, the indium being in the range between about 2 to 20 percent by weight as compared to the gold by weight, said suitable vehicle functioning for retaining said metal powders and for securing the mixture to the base metal.

9. The laminar conductive material defined in claim **8** wherein said vehicle is polyurethane varnish.

10. The laminar conductive material defined in claim **8**, wherein said vehicle is of a type capable of being molded to a desired configuration.

11. A method of fabricating electronic transmission material compatible with surface welding techniques for repairably interconnecting metallic members selected from the group consisting of nickel, copper, silevr, chromium, and nickel-iron alloys comprising the steps of: preparing a desired ratio of metal powders selected from the group consisting of nickel, indium, and gold, the ratio of metal powders at least including indum and gold in a range of about 2 to 20 percent indium by weight to the gold by weight, mixing the metal powders in a suitable vehicle, and applying the thus made mixture to at least one of the metallic members to be interconnected.

12. The method defined in claim **11**, additionally including the step of molding the mixture of the metal powders and vehicle into a desired configuration for ease in applying the mixture to the base metal.

13. The method defined in claim **11**, wherein the vehicle is polyurethane varnish.

14. The method defined in claim **11**, wherein the vehicle is composed of material susceptible to molding.

15. A mixture of metal powders and polyurethane varnish for application to an area of metallic members subjected to welding techniques, said metal powders including indium and gold with the indium in a range of about 2 to 20 percent by weight to the weight of the gold in the mixture.

16. A mixture of metal powders and an organic material of relatively low-vaporization temperature for application between metallic members being interconnected, said metal powders including at least a ratio of indium to gold in the range of about 2 to 20 percent indium powder by weight to the gold powder by weight.

17. A mixture of metal powders and a vehicle susceptible to molding for application to an area on at least one of a pair of metallic members which will be subjected to welding, said metal powders including indium and gold with the indium in a range of about 2 to 20 percent by weight as compared to the gold by weight.

18. A method for interconnecting metallic members selected from the group consisting of nickel, copper, silver, chromium, and nickel-iron alloys comprising the steps of: applying at the place of interconnection a coating to a surface of at least one of the metallic members which consists of a mixture of metal powders and a binding vehicle of relatively low vaporization temperature

with the powders being selected from the group consisting of nickel, gold, and indium and at least including a ratio of indium to gold in the range of about 2 to 20 percent indium by weight to the gold by weight; positioning the coated surface closely adjacent the surface of the other member at the point of interconnection; and interconnecting the members by welding of same wherein heat from the welding operation causes the coating to coact with the material of the metallic members and forming a repairable interface bond between the members.

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WILLIAM L. JARVIS, *Primary Examiner.*