

3,199,176

2 Sheets-Sheet 1

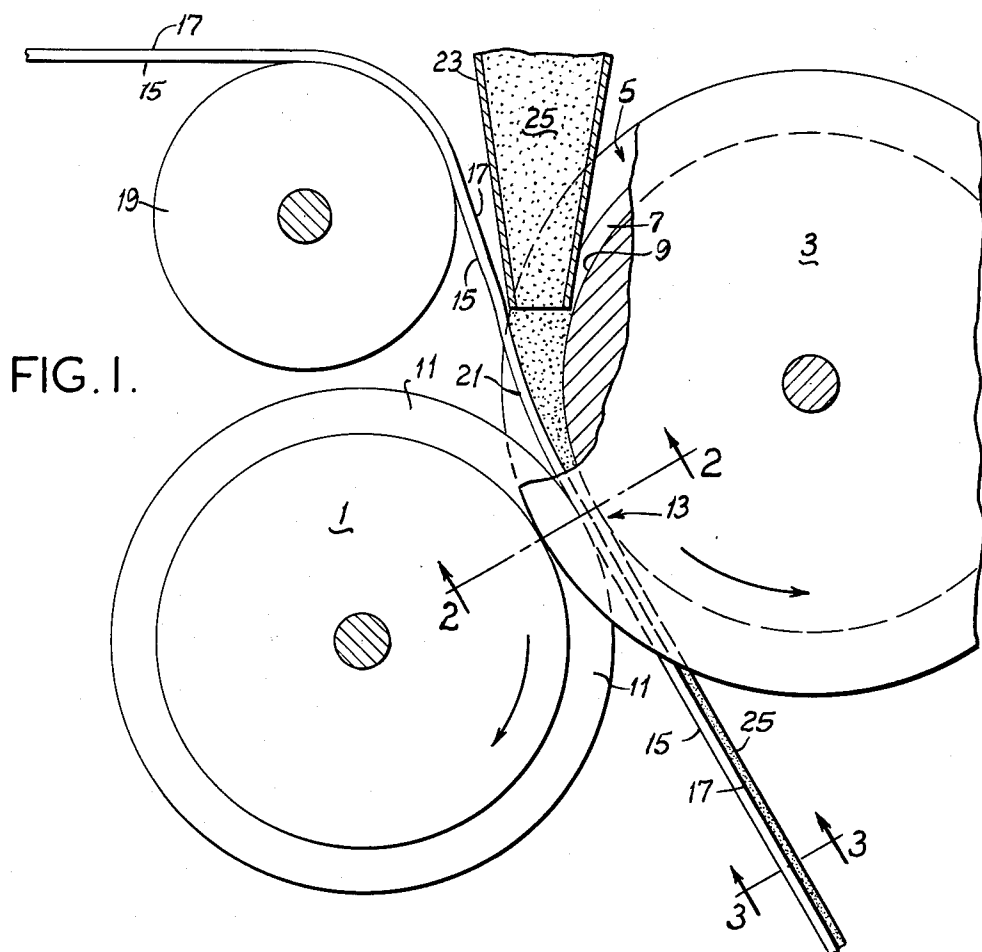


FIG. 1.

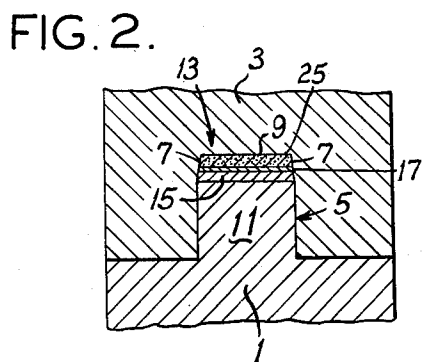


FIG. 2.

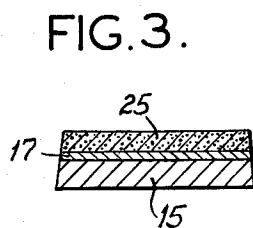


FIG. 3.

Edgar Frendiger,
Paul A. Dixon,
Inventors,
Koenig, Pope, Senniger and Powers,
Attorneys.

Aug. 10, 1965

E. FREUDIGER ET AL

3,199,176

METHOD OF MANUFACTURING ELECTRICAL CONTACTS

Filed Nov. 8, 1961

2 Sheets-Sheet 2

FIG. 4.

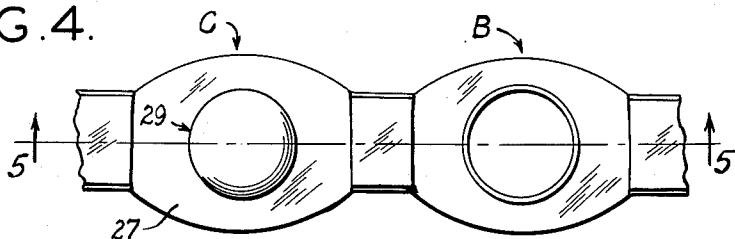


FIG. 5.

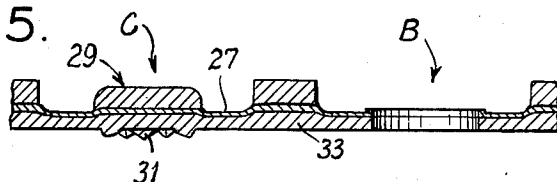


FIG. 6.

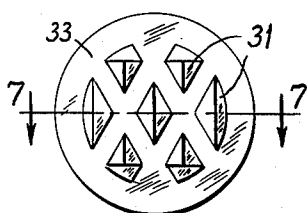


FIG. 7.

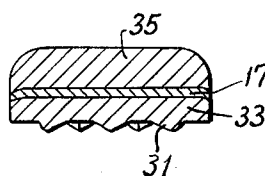
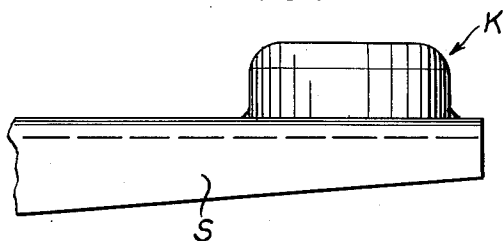


FIG. 8.



Edgar Freudiger,
Paul A. Dion,
Inventors.
Koenig, Pope, Senniger and Powers,
Attorneys.

1

2

3,199,176

METHOD OF MANUFACTURING ELECTRICAL CONTACTS

Edgar Freudiger, Norton, and Paul A. Dion, North Attleboro, Mass., assignors to Texas Instruments Incorporated, Dallas, Tex., a corporation of Delaware
Filed Nov. 8, 1961, Ser. No. 151,419
13 Claims. (Cl. 29—155.55)

This invention relates to electrical contacts, and more specifically to heavy-duty electrical contacts and their methods of manufacture.

Among the several objects of the invention may be noted the provision of uniform heavy-duty electrical contacts and their method of manufacture, said contacts being suitable for circuit breakers subject to short-circuit currents of large magnitudes; the provision of improved metallic structures for contacts such that they may be better attached by welding and will better resist arc erosion; the provision of a method of manufacture of such contacts which may be carried out under more reliable controls than heretofore; and the provision of a simple, low-cost and rapid manufacturing process which may conveniently be automated. Other objects and features will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, ingredients and combinations of ingredients, the proportions thereof, steps and sequence of steps, features of construction, composition and manipulation, and arrangements of parts which will be exemplified in the constructions, products and methods hereinafter described, and the scope of which will be indicated in the following claims.

In the accompanying drawings, in which one of various possible embodiments of the invention is illustrated,

FIG. 1 is a diagrammatic side elevation, partly in section, showing an exemplary continuous type squeezing apparatus for effecting a preliminary strip-forming operation;

FIG. 2 is an enlarged cross section taken on line 2—2 of FIG. 1;

FIG. 3 is a further enlarged cross section taken on line 3—3 of FIG. 1, showing a strip product from which contacts are later coined and blanked;

FIG. 4 is a plan view illustrating coining and blanking operations as performed on the FIG. 3 product;

FIG. 5 is an axial cross taken on line 5—5 of FIG. 4;

FIG. 6 is a bottom plan view of a contact made according to the invention;

FIG. 7 is a cross section taken on line 7—7 of FIG. 6; and

FIG. 8 is a side elevation of a mounted contact.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Silver is an ideal electrical contact metal because of its high electrical conductivity and excellent heat-dissipating properties. However, when subjected to large short-circuit currents, for example, on the order of 5,000 amps, it is subject to severe arc erosion. Consequently, it has been the practice to fabricate such heavy-duty contacts from pelleted and sintered mixtures of powdered tungsten and silver in the ratio, for example, of 65 to 35 by weight of tungsten to silver. Many heavy-duty contacts are generally at least .040" in thickness. The silver chiefly carries the current. The tungsten, while carrying some current, primarily forms a sponge-like skeleton framework for containing the silver. Thus while large currents may melt the silver, the tungsten skeleton, having a very high melting and boiling point, holds melted silver in place by capillary attraction. Therefore, severe arc erosion is avoided, or at least minimized. Thus in general the

silver is employed to carry the current and dissipate the heat; whereas the tungsten skeleton retains the silver and resists its being blown away or eroded. While other materials may be used for certain purposes, as will appear below, the silver and tungsten combination is preferred.

Fabrication of contacts such as described herein from sintered-powder ingots is not practicable because, if the refractory component is present in a substantial amount, the material is so brittle that it cannot be worked from the ingot form by conventional methods. Therefore, according to some prior methods the contacts have been pressed from the powder in the form of individual pieces. Such briquetting, according to some prior methods, has been accomplished by pressing a clean mixture of the silver and tungsten powder into individual pellets or slugs, the tungsten being in excess of the ultimate desired amount. The pieces were then placed in graphite jigs with an extra piece of silver on the top of each contact. The jigs were then placed in a controlled-atmosphere furnace to exclude air and heated above the melting point of the silver. The slugs, due to the tungsten skeleton, retained their shape during this operation and the additional silver was employed to fill the voids which were left in the contact remaining after the pressing operation. Sometimes an excess of silver over that required to fill the voids was applied so as to collect on the bottom surface of the finished contact. This made it easier to braze the contacts to supporting switch members. However, it was difficult to control the amount of excess silver because of variations in the density of the pressed slugs. In any event, the finished contacts could not be welded but were required to be electro-brazed, inducted-brazed, or torch-brazed, all of which are relatively slow operations, not lending themselves well to automation. It is an object of the present invention to retain the general structural advantages of the type of contact above-described, but to avoid its high cost and difficulties of manufacture.

Briefly, the above is accomplished by solid-phase bonding a clean mixture of a powder consisting of a highly conductive metal (such as silver) and a highly refractory metal (such as tungsten) with a conveniently weldable clean base metal strip (such as nickel) and then coining and blanking the strip to form the contacts. The solid-phase bonding process includes the formation of a green bond by roll-squeezing and the perfection of the green bond by sintering in a manner to obtain a sound skeletal structure. While suitable conductive metals are silver, copper or the like, suitable refractory metals are tungsten, molybdenum, nickel or the like, and suitable weldable backing strips are nickel, SAE 1010 steel or the like, the preferred materials are silver and tungsten for the powder, and nickel serving as a base metal strip. The term metal herein includes alloys. Also, for the refractory component, compounds such as tungsten carbide may, in some cases, be used instead of the metal or alloy. The term powder means a finely divided clean metal suitable for sintering after green-bonding.

Referring now more particularly to FIGS. 1—3 of the drawings, there are shown at numerals 1 and 3 rolls of a strip-squeezing mill. In roll 3 is a groove 5 having straight side walls which terminate by converging at 7 to its bottom side 9. A flange 11 of roll 1 is received conjunctively between the straight walls of the groove 5 but does not extend between the converging portions 7. This leaves what may be referred to as a nip space 13, of quadrilateral cross-sectional form. At numeral 15 is shown a clean metal backing strip composed, for example, of nickel, SAE 1010 steel or the like. It is preferable that this backing strip carry a thin bonded facing 17 of clean silver or, in the alternative clean copper. This provides a facing to which an attachment of powder may most readily be made. However, the facing may be dispensed with if ap-

propriate steps such as known in the art are taken for providing and maintaining a clean face on the bare strip 15. The degree of cleaning for bonding as herein described is known in the art and requires no further comment.

At numeral 19 is shown a guide roll over which the strip 15 (with or without its surface layer 17) is guided. It will be assumed in the following description that the layer 17 is employed. From the guide roll 19, the strip 15 with its facing is directed through the nip space 13 in a manner such that curvature of the strip is effected at 21 in a direction around the bottom of the grooves 5 in roll 3. Substantial back tension is maintained in the reach 21 by drawing strip 15 through suitable braking means (not shown). In other words, the strip 1 in its movement to the nip space wraps to some extent around roll 3.

At numeral 23 is illustrated a hopper for directing a clean powder mixture 25 into position between the strip 15 at 21 and the bottom 9 of the groove 5. This arrangement provides a trap for the powder as it enters the nip space 13 with the strip 15, preventing it from being pushed back. As a consequence, the rolls 1 and 3 can strongly squeeze and condense a comparatively large amount of the clean powder mixture against the clean surface 17 of strip 15 with sufficient squeezing force that the powder particles will form green bonds between themselves and between them and the strip. At the same time, some reduction is effected in the thickness of the backing strip 15. Thus the strip 15 leaves the rolls with a compressed layer of powder (lettered 25 in the drawings) green-bonded to its face material 17. The tapers 7 of space 13 facilitate withdrawal of the green-bonded strip. The green-bonded strip has a sufficient bond strength to permit the strip to be wound into a coil for sintering to improve the green bond. Parameters for sintering will be given below. While the above description concerning the squeezing structure for obtaining a thick powder layer, as illustrated in FIGS. 1-3, is sufficient for an understanding of the present invention, if further details concerning this structure and its operation are desired they may be obtained from the co-pending United States patent application of Kenneth B. Clark for Production of Strip Material From Powder, Serial No. 151,420 filed on November 8, 1961, now U.S. Patent 3,152,892, the substance of the same being incorporated herein by reference.

It is preferred that sintering be carried out in a reducing atmosphere such as hydrogen, cracked ammonia or the like, to prevent or at least minimize oxidation of the reactive refractory metal, e.g. tungsten, and of the base metal strip 15, e.g. nickel.

After sintering, the strip is subjected to coining and blanking operations such as illustrated in FIGS. 4 and 5. At the left in each of these figures (lettered C) is illustrated the results of the coining operation, and at the right (lettered B) the results of the blanking operation. The coining operation flattens the strip as at 27, leaving a button-like contact form 29. On the bottom side of the button is embossed a pattern of welding projections 31 of suitable shape. Parts 29 and 31, with any intermediate part of layer 17, if such intermediate layer is used, have the form of a pellet (FIGS. 4 and 5) which is unrelieved from the strip as a whole but has the disc-like shape of the final contact (FIGS. 6 and 7). The blanking operation as at B removes each button 29 with its backing layer 33 formed as shown at 31. Each resulting contact has a weldable backing layer 33 in disc form, it being understood that other than disc forms may be employed. The bottom of the weldable backing layer 33 carries the welding projections 31. The other side of the contact consists of a comparatively thick layer 35 of compressed sintered powder components (FIG. 7). One component of layer 35 is highly conductive and the other is refractory and forms a skeleton for the retention of the conductive component.

In FIG. 8 is shown the final application of a finished

contact such as shown in FIGS. 6 and 7. In this case the contact is lettered K in general and is shown as having been welded to a switch arm S. The welding has been accomplished by placing the contact on the switch arm and, for example, spot-welding them. The welding operation converts the welding pattern 31 into secure surface welds between members K and S.

Other examples of powders that may be used in the layer 35, in percentages by weight, are, for example, 50 to 50 silver and molybdenum; 60 to 40 silver and nickel; 35 to 65 copper and tungsten. A preferred mixture, however, is silver and tungsten in a weight ratio range of 30 to 35 for the silver and 65 to 70 for the tungsten, which provide superior results, particularly under certain conditions of sintering, next to be discussed. In the case of the silver-tungsten mixture, sintering temperatures below the melting point of silver, namely about 1760° F., are inadequate for the resulting contact to withstand heavy short-circuit tests without breaking up. We have found a sintering temperature of 1900° F. or higher forms a tungsten-to-tungsten bond between the tungsten particles necessary for an excellent skeletal structure. Contacts made of strips so sintered for several minutes satisfactorily pass very heavy short-circuit tests without excessive arc erosion losses. The reason that it is desirable to sinter at a temperature above the melting point of silver is that the silver melt appears to have a definite contributory effect in improving the bond strength between the particles of the refractory tungsten which forms the skeletal structure for containing the silver. Also, the higher the sintering temperature above the melting point of silver, the shorter is the sintering time. At the above-mentioned sintering temperature of 1900° F. a sintering time of two minutes or so has been found to be adequate for a 35 to 65 ratio of silver to tungsten contact material. We have found that the lower limit for sintering in the case of a 35 to 65 ratio of silver and tungsten, to avoid unsatisfactory results for very heavy-duty contacts, is about 1800° F.

As mentioned above, the layer 17 may be copper instead of silver, for example, where copper is used as the conductive material instead of silver. Generally it is desirable that the material for layer 17 be the same as the conductive material used for the layer 35. The base layer 33, as stated, may be nickel, 1010 steel or the like, both of which are materials amenable to convenient spot-welding and which do not react or dissolve into the silver or conductive material of the contact layer 35 during the sintering operation. The finished layers 33, 17 and 35 (FIG. 7) may for example be .050" for layer 33; .001" for layer 17 and .032" for layer 35. It will be noted that layer 17 constitutes a facing layer for the initially separate layer 15 for facilitating solid-phase bonding thereto of what ultimately becomes the conductive facing layer 35 (FIG. 1). In the final product this layer 17 appears as an intermediate layer (FIG. 7). Since contacts of the type herein described are required to have substantial bulk, the total thickness of a contact such as shown in FIG. 7 should not be less than about .040", exclusive of the projections 31.

The ability to attach the contacts, particularly in small sizes, by spot-welding or the like (FIG. 8) results in uniform and predictable welding properties which may be carried out at high speed with mass production techniques. This was not possible with contacts of this nature as formerly made, because the brazing types of soldering techniques required applications of fluxes in many cases, and finicky hand operations. By means of our new manufacturing process, tolerances are reduced considerably, a matter of substantial importance in the case of small contacts.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions, products and methods without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. The process of manufacturing electrical contacts comprising squeezing a layer of a clean mixture of respectively highly conductive and highly refractory metal powder materials against a clean metal backing strip to form solid-phase green bonds between the particles of the powders and also between some of them and the strip to form a composite strip, sintering the green bonded composite strip to improve the bonds, coining the composite strip to form pellet-like shapes therein in the form of bonded conductive and refractory material on one side of the backing strip and welding projections on the other side of the backing strip, and blanking out from the composite strip said pellet-like shapes to form individual contacts.

2. The process according to claim 1, wherein the highly conductive material is a metal selected from the group consisting of silver and copper, the highly refractory material is a metal selected from the group consisting of tungsten, tungsten carbide, molybdenum, and nickel and said backing strip is composed of metal selected from the group of nickel and steel.

3. The process according to claim 2, including the provision on and as part of the backing strip prior to squeezing the powder mixture thereon of a solid layer of conductive material for bonding with the powder mixture.

4. The process according to claim 3, wherein said last-named solid layer is composed of metal selected from the group consisting of silver and copper.

5. The process of manufacturing electrical contacts comprising squeezing a mixture of respectively highly conductive and highly refractory metal powder materials against metal backing strip material to form solid-phase green bonds between the particles of the powders and also between some of them and the backing strip material to form a composite strip, sintering the green bonded composite strip at a temperature lower than the melting point of the refractory material, to form a bonded matrix thereof, but above that of the conductive material to melt the conductive material and to improve the bonds, said melted material solidifying in the matrix after sintering, coining and blanking the composite strip to form therein and to release therefrom contacts of desired shapes each comprising a refractory matrix containing conductive material therein connected to and located on one side of the backing material and welding projections formed on the other side of said backing material.

6. The process according to claim 5, wherein the highly conductive material is a metal selected from the group consisting of silver and copper, the highly refractory material is a metal selected from the group consisting of tungsten, tungsten carbide, molybdenum, and nickel and said backing strip is composed of metal selected from the group of nickel and steel.

7. The process according to claim 6, including the provision on and as part of the backing strip prior to squeezing the powder mixture thereon of a solid layer of conductive material for bonding with the powder mixture.

8. The process according to claim 7, wherein said

last-named solid layer is composed of a metal selected from the group consisting of silver and copper.

9. The process of manufacturing electrical contacts comprising squeezing a mixture of respectively highly conductive and highly refractory metal powder materials against a metal backing strip material to form solid-phase green bonds between the particles of the powders and also between some of them and the backing strip material to form a composite strip, sintering the green bonded composite strip at a temperature lower than the melting point of the refractory material to form a bonded matrix thereof but above that of the conductive material to melt the conductive material and to improve the bonds, said melted material solidifying in the matrix after sintering, coining the composite strip to form pellet-like composite shapes therein in the form of bonded and sintered conductive and refractory material on one side of the backing strip and welding projections on the other side of the backing strip, and blanking out from the coined composite strip said pellet-like shapes to form individual contacts.

10. The process according to claim 9, wherein the highly conductive material is a metal selected from the group consisting of silver and copper, the highly refractory material is a metal selected from the group consisting of tungsten, tungsten carbide, molybdenum, and nickel and said backing strip is composed of metal selected from the group of nickel and steel.

11. The process according to claim 10, including the provision on and as part of the backing strip prior to squeezing the powder mixture thereon of a solid layer of conductive material selected from the group consisting of silver and copper.

12. The process of manufacturing electrical contacts comprising squeezing a layer of a clean mixture of silver and tungsten powders against a nickel backing strip to form solid-phase green bonds between the particles of the powders one to another and also between some of them and the strip, sintering the green bonded strip at a temperature in the range of from 1760° F. to 1900° F. to melt the silver to infill the sintered-powder tungsten which forms a matrix therefor, the sintering also improving the bonds, coining the strip to form shapes therein in the form of bonded and sintered conductive and refractory material on one side and welding projections on the other side of the nickel strip, and blanking out from the strip said pellet-like shapes to form contacts.

13. The process according to claim 12, including the provision on the nickel strip of a silver facing layer prior to squeezing the silver and tungsten powders thereon.

References Cited by the Examiner

UNITED STATES PATENTS

1,089,907	3/14	Coolidge.	
1,860,793	5/32	Weiger.	
2,158,461	5/39	Koehring et al.	29—420.5 X
2,216,510	10/40	Burns.	
2,298,999	10/42	Allen.	
2,361,089	10/44	Cox.	
2,406,327	8/46	Friedrich.	
2,439,570	4/48	Hensel et al.	
2,624,820	1/53	Payette.	
2,694,126	11/54	Binstock.	
2,799,081	7/57	Farnham.	
3,026,603	3/62	Zysk et al.	

JOHN F. CAMPBELL, *Primary Examiner.*

MAX L. LEVY, *Examiner.*