July 3, 1956 R. A. SCHAEFER ET AL 2,752,667

BEARINGS

Original Filed Aug. 20, 1947

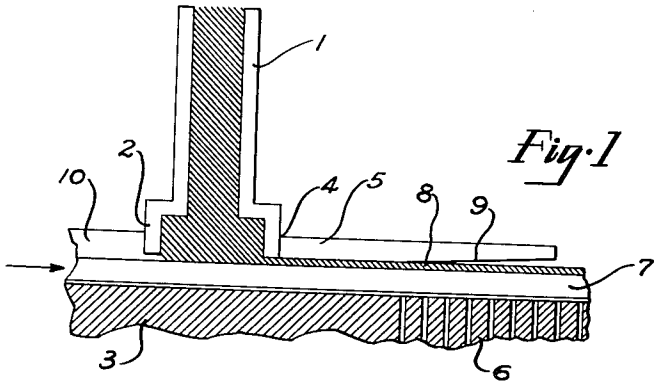


Fig. 1

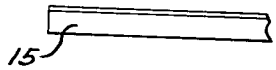


Fig. 2

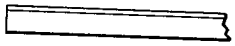


Fig. 3

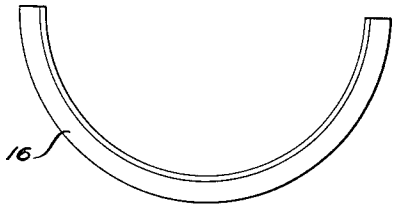


Fig. 4

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BEARINGS

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Original application August 20, 1947, Serial No. 769,616, now Patent No. 2,611,163, dated September 23, 1952. Divided and this application September 6, 1950, Serial No. 188,986

4 Claims. (Cl. 29—196.6)

The present invention, relating as indicated to a bimetallic strip, is more particularly directed to the manufacture of bimetallic strip composed of steel as a backing member and a layer of aluminum integrally united to one surface of the steel through and by means of another layer of extremely thin metal. The composite material thus formed is of such a nature that it is capable of being bent and formed into various shapes, without interruption of the bond between the aluminum and the steel or between either of said metals and the intermediate bonding layer. This application is a division of application 769,616, filed Auguist 20, 1947, now Patent No. 2,611,163, dated September 23, 1952.

It is well known that it is extremely difficult to satisfactorily bond aluminum or aluminum base alloys to a ferrous metal except by means of the very brittle bond which is formed between the two metals and even when such a bond has been secured, it has heretofore been virtually impossible to subject such a bimetallic strip to any subsequent bending or forming operations. Molten aluminum or aluminum base alloys when in contact with iron or ferrous alloys evidence an extremely high reaction rate between the two metals with consequent formation of intermediate phases of iron and aluminum which are positioned between the two layers proper and which are very brittle and tend to fracture along this plane if the composite layer is subjected either to shear or tensile stresses, combined or singly.

It is known that the interposition of a layer of a third or third and fourth metals between layers of steel and aluminum will promote an improved bond when such three or four metals are bonded in such relation and then rolled at rolling temperatures commonly employed for the aluminum and its alloys, and even in such cases tests of the resulting material have not shown satisfactory results for such uses, for example, as for bearings where the life of this composite material is relatively short at high loads.

The present invention is based upon the discovery that if a layer of a metal such as nickel or cobalt is first plated upon the steel strip in a thickness ranging from .00025 to .001 inch, molten aluminum can then be poured or applied to this coated steel strip and if rapidly chilled will bond tightly and uniformly to the interposed layer of the steel with a minimum formation of intermediate phases which are extremely thin and of such metallurgical structure that they do not appear to affect the strength of the bond and the capacity of the resulting composite material to be bent, worked or formed into various articles. Material so formed and produced in a manner and by the method hereinafter more fully described has been found to be capable of being bent flat upon itself through 180° with the aluminum on the outside of the bend without rupture of the aluminum away from the steel and without any visual indication of failure of the bond either at or near the bend.

To the accomplishment of the foregoing and related

ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims; the annexed drawing and the following description setting forth in detail certain means and one mode of carrying out the invention, such disclosed means and mode illustrating, however, but one of various ways in which the principle of the invention may be used.

In said annexed drawing:

Fig. 1 is a diagrammatic view, in section, of the apparatus for bonding molten aluminum to steel;

Fig. 2 is a longitudinal section of the product resulting from the process carried out in Fig. 1;

Fig. 3 is a similar view of the product after further operations, and

Fig. 4 is an end view of a semi-cylindrical bearing formed from the finished material of Fig. 3.

In carrying out the present invention, a steel strip, sheet or separate blanks as may be desired are first plated with a layer of nickel, cobalt or alloys of either or both on one surface of the steel and to a thickness of not less than .00025 up to .001 inch thick. A greater thickness than .001 inch can be employed if desired but is obviously uneconomical since a layer of .001 inch thickness is sufficient to insure satisfactory bond between the aluminum and the steel.

The plated strip, sheet or blank is then passed through a furnace having a temperature of not less than 1200° F., and usually somewhat higher, with a reducing atmosphere maintained therein and molten aluminum is then applied by pouring onto the plated layer of the sheet or other article. The molten aluminum at approximately 1350° F. is poured with a low head. Immediately thereafter the aluminum is solidified onto the plated surface of the strip by the application of a water quench to the lower side of the steel strip at a rate which will provide an initial cooling rate of the aluminum of not less than 200° F. per second. The barrier layer plated onto the steel and formed of nickel, cobalt or an alloy of one or the other in thickness described above prevents penetration through it of the aluminum and therefore prevents the formation of an aluminum-iron intermediate phase. An aluminum-nickel intermediate phase may be formed but its rate of formation is very slow in relation to the formation of the iron-aluminum phases. The molten aluminum constituent of aluminum alloys reacts with nickel, cobalt or its alloys at a considerably slower rate than with iron the primary ingredient of low carbon steel. This slow rate coupled with rapid cooling results in a very thin intermetallic layer which is sufficiently ductile to make bearings from flat composite strip continuously plated, cast, sized and quenched, which has an entirely satisfactory bond between the steel and aluminum. It is important that the cooling rate be maintained as above stated as otherwise increasing amounts of nickel are dissolved by the molten aluminum. This would result in a very thin intermetallic reaction zone between the aluminum and nickel of .000025" to .000070" in thickness as may be readily determined by calculating in view of the time, temperature of contact and the reaction rates of the metals in question.

The above method can obviously be carried out in various types of apparatus but in Figure 1 we have shown a convenient form of apparatus for bonding aluminum to a strip of steel. In this figure there is shown a pouring box 1, into which molten aluminum is poured, provided with an enlarged bottom portion 2, the sides of the box fitting snugly against either the sides of the strip or against the upper edges to prevent molten aluminum from flowing around the edge and onto the back of the strip. The steel strip is moved through the enlarged pouring box 2 and is supported upon a suitable plate 3

maintaining it in a horizontal position. The strip as it passes through the pouring box carries a layer of aluminum 4 which flows onto its upper surface and which is there sized by means of a sizing die or shoe 5, extending some distance from the pouring box proper and in the direction of movement of the strip. A short distance from the pouring box proper and beneath the plate 3 are a plurality of water sprays 6, which flood the bottom of the support and contact directly with the steel strip 7 to rapidly chill the strip and solidify the molten aluminum beginning about the point marked 8 in the sizing die 5. The outer portion of the die 5 has a tapering lower surface 9 from the point 8 to its outer end to facilitate drawing the composite strip through that portion of the die in which the aluminum has solidified and where it might tend to contact and stick to the die proper. The die may be formed in that portion contacting the aluminum of any suitable material resistant to the action of molten aluminum and may be formed, for example, of block graphite or other similar material.

In carrying out the present method a specific example may be given as follows: Low carbon SAE 1010 steel, either hot or cold rolled, and approximately 5 to 6 inches wide and from .040–.080 inch thick, is cleaned and etched in the conventional manner and is then run through an electroplating bath to receive the coating of nickel already specified. The electrolyte in the bath may be a conventional nickel bath such as a Watts bath and the steel is plated with a layer of nickel, which for most purposes will be approximately .0005 inch thick. The strip after being dried is passed into the entrance end 10 of the apparatus shown in Fig. 1 in which a reducing atmosphere is maintained against the nickel layer and gradually brought up to a temperature of approximately 1200° F. by suitable heating means at the point where the strip passes into the pouring box proper. Various reducing atmospheres may be employed but a suitable one consists of 93% nitrogen and 7% hydrogen.

The composite material resulting from the above method is shown in Fig. 2, in which the steel strip 15 is of the order of thickness stated above and carries an aluminum layer on its upper surface having a thickness of approximately .020 to .030 inch, interposted between the two, of course, and bonding the two metals together is the barrier layer of nickel or cobalt of approximately .0005 inch.

By the use of the sizing die 5 we have found it possible to form a layer of aluminum bonded to the steel which in thickness will approximate very closely the thickness desired for subsequent machining operations.

There are, of course, many uses for aluminum coated steel in which the steel will have a coating of the thickness of the order of .020 inch instead of a mere dipped coating in which the thickness is .001–.002 inch and it is unnecessary to list such uses although one example in which such a material is of decided advantage is a bearing 16, which is shown in Fig. 4. In this figure we have shown only a semi-cylindrical bearing but the composite

strip may, of course, be employed with a flat slide or a semi-cylindrical or cylindrical or other suitable bearing forms. As a bearing, the use of certain alloys of aluminum on steel has heretofore not been employed because of the extremely short life of composite aluminum-steel materials heretofore made while aluminum alloys of the type possessing the bearing qualities can only be used alone when employed in a very considerable thickness because of the low tensile strength of the aluminum.

It, of course, will be understood that the process described and the products thereof is useful for articles of pure aluminum bonded to steel as well as alloys of aluminum in which aluminum is the major constituent. For bearing purposes, for example, there are several high aluminum alloys which have been used for bearings which can be satisfactorily bonded to steel by the present method, producing a new, economical and satisfactory composite bearing material.

We claim:

1. An arcuate body comprising a composite, bimetallic strip composed principally of a malleable and ductile cast aluminum alloy and a steel strip united throughout their contiguous surfaces by a ductile and continuous adherent thin bonding layer of nickel electroplated on said steel strip from .00025" to .001" in thickness, the bonding layer being separate and distinct from the steel strip, and the intermetallic zone between the bonding layer and the cast aluminum layer being a minimum, said bimetallic strip being bent to form an arcuate body without rupturing the bonding layer from the steel strip or from the cast aluminum.

2. An arcuate body as set forth in claim 1 characterized by the cast layer of aluminum being of the order of .020" thick.

3. An arcuate body as set forth in claim 1 in which the cast aluminum layer is approximately .020" to .030" thick.

4. The composite, bimetallic element of claim 1 in which there is a reaction layer between the nickel and aluminum which is extremely thin, of the order of .000020" to .000070" thick.

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