

Nickel-based alloys containing 13% by weight of chromium and 10% by weight of phosphorus (melting point 890° C.) and containing only 11% by weight of phosphorus (melting point 875° C.) (trade names and standard designations L-NiCr13P10 and L-NiP11 and, respectively, B-Ni7 and N-Ni6) have also proved particularly suitable as soldering sheets.

Advantageously, in particular in order to increase the resistance to wear of the coatings formed on the material, tungsten carbide or another hard material or a hard alloy can be added to the nickel-based alloys, in an amount of 10 to 20% by volume and in a particle size of about 10-50  $\mu\text{m}$ .

With regard to the composition of the coatings obtained on soldering the alloys onto the material, the coatings probably contain both phases which are in particular oxidation-resistant and composed, for example, of NiAl and Ni<sub>3</sub>Al and also phases which are in particular wear-resistant and composed of, for example, chromium silicides and titanium silicides and/or chromium borides and titanium borides.

The present invention is now illustrated in greater detail with the aid of the following examples.

#### EXAMPLE 1

A plate having dimensions of 100×35×7 mm was separated by spark erosion from a cast block of titanium aluminide containing 45 atomic percent of aluminum and 3 atomic percent of chromium and smoothed on all sides. A 0.2 mm thick, self-adhesive sheet of a solder composed of a nickel-based alloy containing 7% by weight of chromium, 5% by weight of silicon, 3% by weight of iron and 3% by weight of boron (trade name Microbraze LM; in the USA ASTM/AWS B-Ni2) was applied to the surface of the plate. The sheet was composed of 95.4% by weight of spherical solder powder having a particle size of 5 to 35  $\mu\text{m}$  in diameter and of 4.6% by weight of a plasticizing organic binder. The sheet stuck onto the plate was melted on over a period of 5 minutes in a vacuum soldering furnace at a temperature of 1050° C. The solder melt spread on the plate in a very thin layer and extended beyond the original sheet size by only about 2 mm. A uniform, metallic-crystalline glossy coating with a coating thickness of 0.18 mm formed on the sheet-covered area of the plate. A metallographic section showed that the newly formed surface coating was made up of, in total, six layers. Whereas the TiAl material has a hardness of about 300 HV 0.2, hardness measurements on the surface coating formed gave hardness value of up to 750 HV 0.2 in the individual layers.

Tests relating to the stability towards atmospheric oxygen were carried out with the coated plate. To this end, a retort furnace was heated to 950° C. and the plate was placed in the furnace and left there for 23 hours. After removal, the plate was cooled in air at room temperature for one hour to 20° C. The plate was then subjected an additional three times to the heating and cooling operation described above. At the end of the fourth cycle the coated surface of the plate showed only an olive green discoloration. On the uncoated surface of the plate multicolored layers of scale about 0.6 mm thick had flaked off irregularly.

Corresponding tests following the same procedure were carried out using nickel-based alloys containing 13% by weight of chromium and 10% by weight of phosphorus and using a single addition of 11% of phosphorus. The two nickel-based alloys had melting points

of 890° and 875° C., respectively. The results obtained after carrying out the tests corresponded to those obtained when the first tests were carried out. The surface coating formed with the nickel/phosphorus solder was not as stable as the coating with the nickel/chromium-phosphorus solder; nevertheless, it was more resistant to scaling than the TiAl material itself.

#### EXAMPLE 2

The aim of this test was to investigate the improvement in the resistance to wear by friction which is achieved by coating the TiAl materials in accordance with the present invention. Ten valve spring retainers were machined from a cast block of titanium aluminide containing 45 atomic percent of Al and 3 atomic percent of chromium. In an engine the valve spring retainers transmit the spring forces, which close the gas-change valves, to the valve shafts. This spring force is about 900N and the valves of associated cams have to be opened against the forces of these springs. As a result of relative movements, high tribological stresses arise between the valve spring and the valve spring retainer. For this reason, both have to be produced from very hard steels or also be provided with hard surface coatings.

Rings plunged from a 0.2 mm thick, self-adhesive sheet of a solder having a composition according to Example 1 were placed on the annular spring support surfaces of five spring retainers and soldered on using the procedure indicated in Example 1. No corresponding sheet was soldered onto a further five spring retainers. The ten spring retainers were then mounted in an engine (alongside a further 14 spring retainers produced from steel in the standard manner) and the engine was run using the following test program:

10 hours at 1,000 revolutions/min  
50 hours at 2,000 revolutions/min  
50 hours at 4,000 revolutions/min  
50 hours at 6,000 revolutions/min.

This test program was run for a total of five cycles, that is to say 800 hours. After removing the spring retainers from the engine, the coated retainers were completely unchanged. Neither the spring support surfaces nor the associated valve springs showed any wear. In the case of the uncoated spring retainers, material wear of about 0.35 mm was found on the spring support surfaces. No material wear was found in the case of the springs, but these showed traces of scuffing.

The advantages achieved with the invention are, in particular, that components of titanium aluminide material provided with a coating are obtained which have both a high resistance to wear and a high resistance to hot corrosion. The coating can be applied to the material in a technically simple process by vacuum soldering and is readily adherent thereto. A uniform coating on the material is obtained which does not show brittle fracturing or cracking.

Although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example, and is not to be taken by way of limitation. The spirit and scope of the present invention are to be limited only by the terms of the appended claims.

We claim:

1. High-stress bearing, coated components of an intermetallic phase titanium aluminide material, especially for piston engines, gas turbines, or exhaust turbochargers, wherein the components, at least where their sur-