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Baboian et al.

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[54] **OXIDE COATED METAL DISCS AND METHOD OF MAKING THE SAME**

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[52] **U.S. Cl.** ..... **148/31.5,** 29/191.6, 29/195 M, 29/195.5, 148/6.11, 337/53, 337/89, 337/379

[51] **Int. Cl.** **C23f 7/02**

[58] **Field of Search** ..... 148/6.11, 31.5; 117/128, 117/130 R, 223; 29/195.5, 196, 195, 191.6; 337/53, 89, 109, 111, 329, 365, 379

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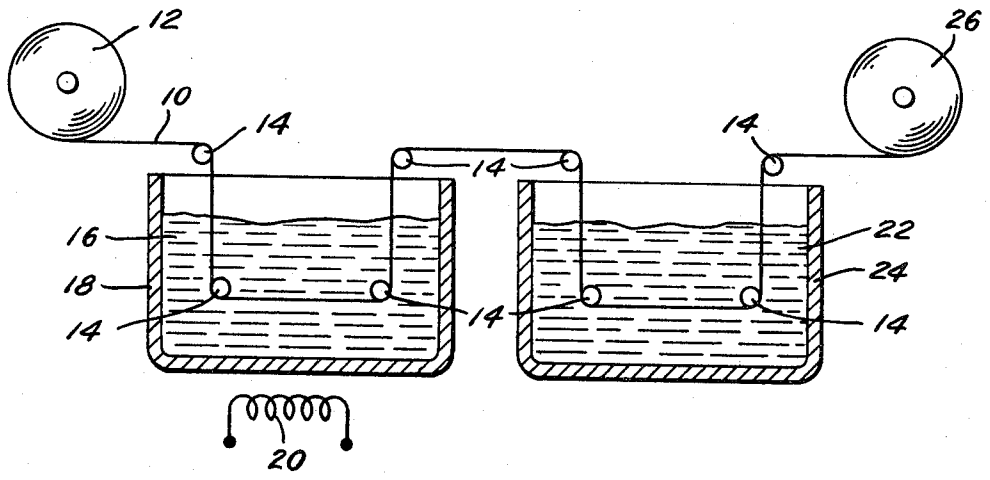
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[57] **ABSTRACT**

Metal materials and elements such as stainless steel diaphragms and the like are immersed in oxidizing, fused, alkali metal hydroxide baths to provide the metal materials with adherent metal oxide coatings to protect the metal materials from abrasion.

9 Claims, 4 Drawing Figures



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SHEET 1 OF 2

Fig. 1.

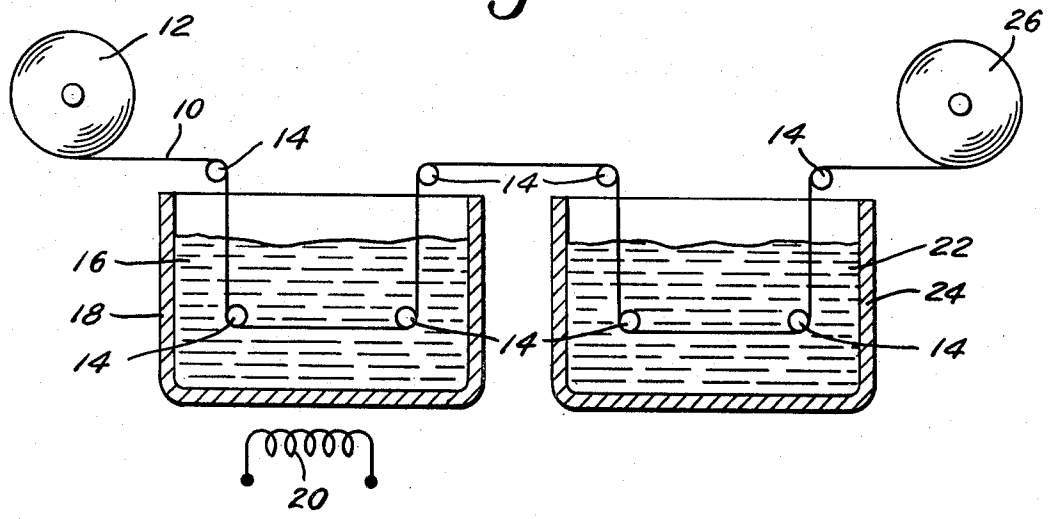


Fig. 2.

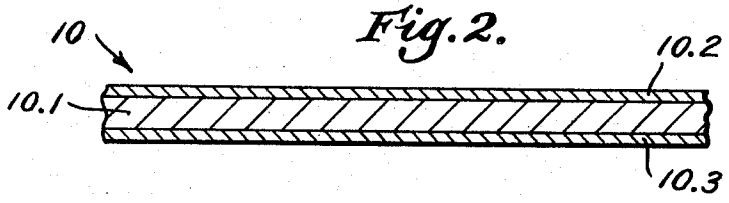
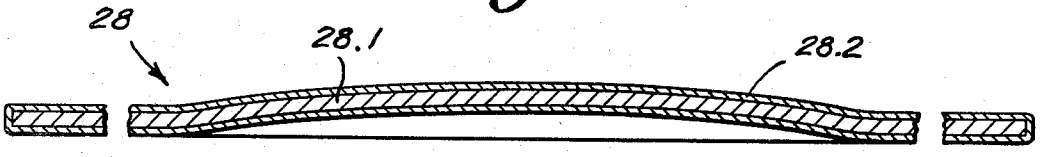
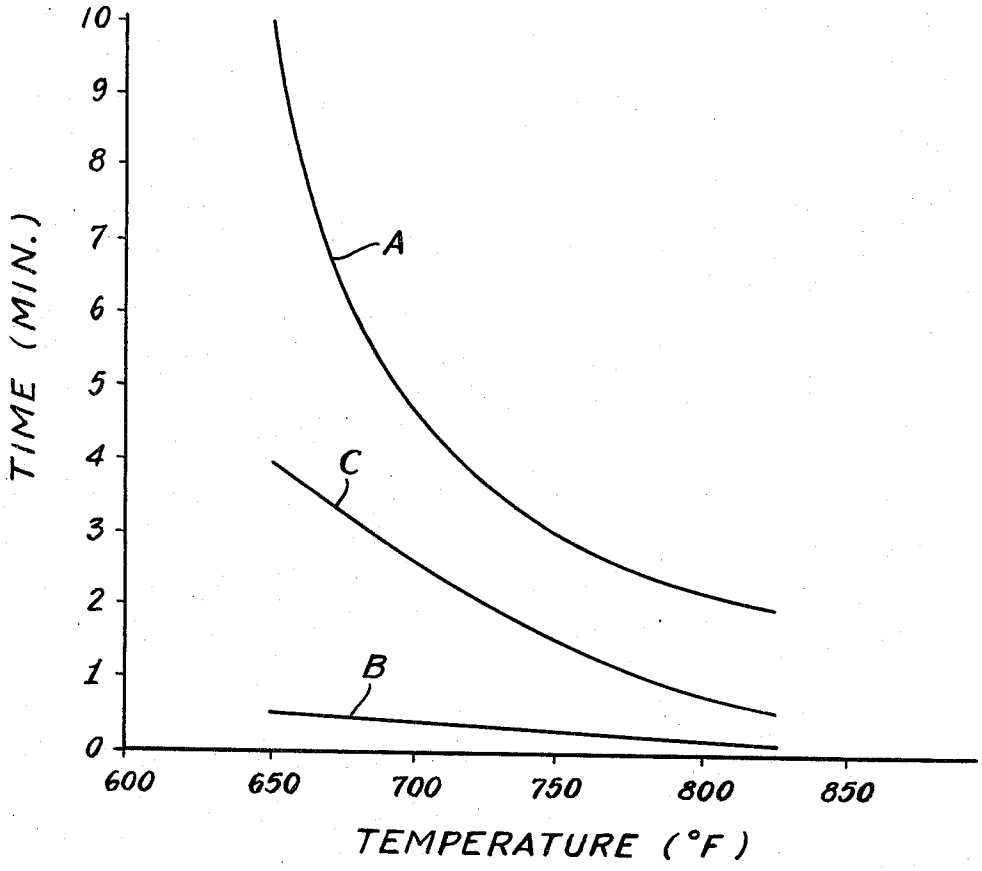


Fig. 3.



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Fig. 4.



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OXIDE COATED METAL DISCS AND METHOD OF MAKING THE SAME

In many commercially available pressure switches, thermostats and the like, metal diaphragms, thermostatic metal elements and the like are used to sense environmental conditions such as pressures and temperatures. In such devices, these metal elements are frequently formed in such a way that precisely controlled stress conditions are established in the metal materials of the elements, whereby the metal elements are adapted to respond with movement to changing environmental conditions. For example, pressure sensitive metal diaphragms incorporated in pressure switches are deformed to provide the diaphragms with a dished configuration such that the diaphragms are adapted to retain their original dished configuration under the force of selected applied fluid pressures but are adapted to move with snap-action to inverted dished configurations in response to selected greater applied fluid pressures. Similarly, bimetallic thermostatic metal discs are frequently provided with deformed portions such that the discs have selected dished configurations under one set of temperature conditions but are adapted to move with snap-action to inverted dished configurations under other temperature conditions. In such devices, these metal elements are frequently engaged with adjusting screws, stops, motion-transfer pins, other metal diaphragm elements and the like and it is found that, when the metal elements move with snap action in response to changing environmental conditions, the surfaces of the elements are sometimes abraded by such screws and the like. It is also found that even very limited abrasion of these elements significantly alters the pressure, temperature or other response characteristics of the metal elements.

It is an object of this invention to provide metal materials such as metal diaphragms and the like which are of novel and improved construction; to provide such metal materials which have adherent metal oxide coatings protecting the surfaces of the materials against abrasion; to provide novel and improved methods for making such metal materials having such metal oxide coatings; and to provide such methods which are economical to perform.

Other objects, advantages and details of the materials, elements and methods of this invention appear in the following detailed description of preferred embodiments of the invention, the detailed description referring to the drawings in which:

FIG. 1 is a diagrammatic view illustrating a preferred embodiment of the method of this invention;

FIG. 2 is a partial section view along the longitudinal axis of a strip of metal material processed according to the method of FIG. 1;

FIG. 3 is a section view along a transverse axis of a diaphragm made in accordance with this invention; and

FIG. 4 is a graph illustrating preferred parameters in the process of FIG. 1.

Referring to the drawings, FIG. 1 illustrates a preferred embodiment of the method of this invention. In this method, as shown, a metal strip **10** is continuously fed from a pay-off reel **12** and is advanced over guide rolls **14** through a first liquid bath **16** in a vessel **18**, the bath **16** being heated by any conventional means diagrammatically illustrated in FIG. 1 by the electric heater coil **20**. The strip material **10** is then preferably

advanced over additional guide rolls **14** through a second bath **22** in a vessel **24** and is coiled upon a take-up reel **26.**

In accordance with this invention, the first process bath **16** comprises an oxidizing bath of fused alkali metal hydroxide materials which can include fused lithium, sodium or potassium hydroxide and the like alone or in combination with each other and which can also include additions of fused alkali metal nitrate and chloride salts. In a preferred embodiment of this invention, for example, the bath **16** has a composition, by weight, from about 7 to 32 percent sodium nitrate, from about 1 to 20 percent sodium chloride, and the balance sodium hydroxide, the preferred bath embodying approximately 70 percent hydroxide, 20 percent sodium nitrate and 10 percent sodium chloride by weight.

In accordance with this invention, the bath **16** is heated to a temperature sufficient to fuse the bath ingredients and to achieve a desirable bath viscosity without heating the bath to a temperature at which the bath materials are volatilized to an excessive extent. The bath temperature is preferably kept low enough so that, at the selected speed at which the strip material **10** is advanced through the bath, the strip material is not significantly altered by such heating of the strip as will occur. Generally, advantageous strip movement speeds are such that the stress characteristics of the metal strip materials do not tend to become significantly altered in passing through the bath **16.** For example, where the strip material **10** comprises any of the various commercially available stainless steels, including 300 Series and 400 Series Stainless Steel such as Type 302 Stainless Steel having a nominal composition, by weight, of 18 percent chromium, 8 percent nickel and the balance iron, and where the bath 16 embodies 70 percent sodium hydroxide, 20 percent sodium nitrate, and 10 percent sodium chloride, the bath temperature and speed of movement of the strip **10** is preferably maintained at values falling on or between curves A and B in FIG. **4,** the bath temperature and strip speed preferably being controlled in the manner indicated by curve C. That is, the bath temperature is preferably maintained above about 650°F. and at this bath temperature the strip speed is preferably regulated to provide a strip dwell time in the bath from about 30 seconds to 10 minutes and, most desirably, to provide a strip dwell time in the bath of about 4 minutes. On the other hand, where the bath temperature is maintained at about 825°F., the strip speed is controlled to provide a strip dwell time in the bath of from about 8 seconds to 120 seconds and, most desirably, a dwell time of about 30 seconds.

In accordance with this invention, the metal strip material **10** should be free of any oxide scale or the like but need not be processed in any particular manner prior to immersion in the bath **16.** However, it is desirable for achieving product uniformity to clean gross contaminants such as oils and greases from the strip prior to bath immersion. Such gross contaminants will be removed from the strip by immersion of the strip in the bath but for product uniformity it is desirable that all portions of the strip surface be exposed to the bath for the same period of time.

In a preferred embodiment of the process of this invention, the strip material **10** is moved from the bath **16** through a water bath **22** for the purpose of removing any of the bath **16** which may be clinging to the strip material. The bath need not be heated but is preferably

maintained at a sufficient temperature, as by the heating resulting from passage of the strip material **10** through the bath, to avoid any significant quenching or chilling of the strip material. That is, the bath **22** can be omitted if desired or can be replaced by other cleaning techniques such as by a steam bath or the like. After passing through the bath **22,** if used, the strip **10** is coiled upon a take-up reel **26** in conventional manner.

In the process of this invention, the strip material **10** is altered so that the material coiled upon the take-up reel **26** comprises a metal core **10.1** of the original strip material and further embodies an adherent surface coating **10.2** of an adherent metal oxide. The coating **10.2** has a significant thickness greater than about 100 Angstrom units thickness sufficient to provide the strip material **10** with excellent abrasion-resistance properties. The coating comprises a somewhat uniform mixture of oxides of the metals embodied in the strip materials **10,** these oxides being in relatively high oxidation states. Where stainless steel strip materials are used, for example, the metal oxide coating **10.2** is readily visible and has a bluish green color, the coating being very hard and resistant to abrasion. The metal oxide coating is strongly adherent to the core element **10.1** such that the strip material is adapted to be subjected to temperatures over a substantial range, similar to the temperatures to which the core element material itself can withstand without tending to loosen the adherence of the metal oxide coating. The coating **10.2** is also such that the strip material **10** coated therewith is readily adapted to be deformed quite severely into a variety of configurations without tending to cause separation of the coating from the core element **10.1.** The strip materials are particularly adapted to be deformed to provide elements of a dished configuration to serve as snap-acting metallic diaphragms and the like.

It will be understood that the process described above is useful in coating various metal materials and is particularly adapted for coating ferrous metal materials. It will also be understood that the process is useful in coating bimetallic strip materials such as are conventionally used in manufacture of thermostatic elements. For example, two or more of the metals and alloys shown in Table I can be metallurgically bonded together in conventional manner to form thermostatic bimetal materials and can then be processed in the manner illustrated in FIG. **1** to provide such bimetallic materials with abrasion-resistant oxide coatings.

In accordance with conventional procedure, the alloys set forth in this table may also include small quantities of additional constituents present as impurities in the alloys.

After providing these bimetallic strip materials with the noted metal oxide coatings, the bimetallic materials are readily cut and deformed in conventional manner to form snap-acting thermostatic elements and the like.

It will also be understood that the method of this invention can be employed for providing abrasion-resistant metal oxide coatings on diaphragm and thermostatic elements and the like which have already been formed. That is, as is illustrated in FIG. **3,** a novel and improved, snap-acting stainless steel diaphragm **28** can embody a core element **28.1** formed of stainless steel, this core element being centrally deformed to provide the element with a dished configuration as shown and to permit the element to move with snap-action to an inverted dished configuration in response to application of sufficient fluid pressure force or the like to the convex side of the element. This core element is then provided with the desired abrasion-resistant metal oxide coating **28.2** by immersing the core element in the bath **16** described with reference to FIG. **1,** the temperature of the bath and dwell time of the element **28.1** in the bath being substantially the same as is employed in coating strip materials. As will be understood, thermostatic snap-acting bimetallic elements of similar construction can be coated in the same manner.

It should be understood that although particular embodiments of this invention have been described by way of illustration, this invention includes all modifications and equivalents of the illustrated embodiments which fall within the scope of the appended claims.

We claim:

1. A method for making an improved snap-acting element comprising the steps of providing a metal material having at least one surface layer thereof formed of a material selected from the group consisting of the metals and alloys set forth in Table I, said surface layer

TABLE I

	NICKEL	CHROMIUM	IRON	MANGANESE	ALUMINUM	MOLYBDENUM	COBALT	CARBON
Alloy B	22.0	3.0	Bal.	—	—	—	—	0.5
Alloy C	19.4	2.25	Bal.	—	—	—	—	—
Alloy D	14.65	—	Bal.	9.5	5.1	—	—	—
Alloy E	25.0	8.5	Bal.	—	—	—	—	—
Alloy G	18.0	11.5	Bal.	—	—	—	—	—
Alloy GA	18.0	10.0	Bal.	—	—	3.0	—	—
Alloy GB	19.0	7.0	Bal.	—	—	—	—	—
Alloy H	14.0	—	Bal.	5.0	—	—	—	0.5
Alloy K	—	—	Bal.	—	—	—	—	—
Alloy L	25.0	—	Bal.	4.0	—	—	—	—
Alloy M	8.0	18.0	Bal.	—	—	—	—	—
Alloy 15	32.0	—	Bal.	—	—	1.0	1.0	—
Alloy 71	—	16.5	Bal.	—	4.5	—	—	—
Alloy 10	36.0	—	Bal.	—	—	—	—	—
Alloy 11	38.65	—	Bal.	—	—	—	—	—
Alloy 12	31.0	8.0	Bal.	—	—	—	8.0	—
Alloy 13	32.0	—	Bal.	—	—	1.0	15.0	—
Alloy 14	38.0	7.0	Bal.	—	—	—	—	—
Alloy 15	32.0	—	Bal.	—	—	1.0	1.0	—
Alloy 20	40.0	—	Bal.	—	—	—	—	—
Alloy 30	42.0	—	Bal.	—	—	—	—	—
Alloy 40	45.0	—	Bal.	—	—	—	—	—
Alloy 50	50.0	—	Bal.	—	—	—	—	—
Alloy 70	—	17.0	Bal.	—	—	—	—	—

being free of oxide scale, and immersing said metal material in an oxidizing bath comprising fused alkali metal hydroxide for forming an abrasion-resistant metal oxide coating on said surface layer, and deforming said metal material to provide said metal material with a portion of dished configuration for forming a snap-acting element.

2. A method as set forth in claim **1** wherein said metal material is deformed to provide said portion of dished configuration prior to said immersion of said metal material in said fused oxidizing bath.

3. A method as set forth in claim **1** wherein said oxidizing bath comprises fused materials selected from the group consisting of alkali metal hydroxides, alkali metal nitrates and alkali metal chlorides.

4. A method as set forth in claim **3** wherein said oxidizing bath comprises, by weight, from 7 to 32 percent alkali metal nitrate, from 1 to 20 percent alkali metal chloride and the balance alkali metal hydroxide.

5. A method as set forth in claim **4** wherein said oxidizing bath comprises, by weight, approximately 70 percent sodium hydroxide, approximately 20 percent sodium nitrate, and approximately 10 percent sodium chloride.

6. A method as set forth in claim **5** wherein said fused bath is maintained at a selected temperature in the range from 650° to 850° F. and said metal material is immersed in said bath for a period of time selected in accordance with FIG. **4**, said time being in the range indicated by curves A and B in FIG. **4** for said selected temperature.

7. A method as set forth in claim **6** wherein said metal material comprises a multi-layer metallic material having at least one surface layer thereof formed of a metal material selected from the group of metals and alloys set forth in Table I.

8. An improved snap-acting element comprising a core formed of a metal material having at least one surface layer thereof of a material selected from the group consisting of the metals and alloys set forth in Table I, said core having at least a portion thereof of dished configuration providing said element with snap-acting properties and having an adherent metal oxide coating of at least about 100 Angstrom units thickness on said surface layer of said core providing said surface layer with improved abrasion-resistance.

9. A snap-acting element as set forth in claim **8** wherein said metal material comprises a multilayer metal material.

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