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ALUMINUM BRONZE ARTICLE FOR USE IN CONDUCTING
STEAM OR HOT WATER
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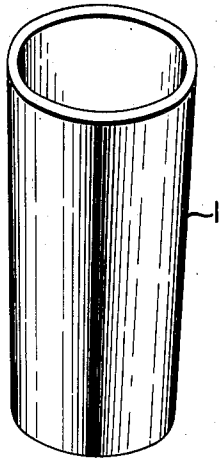


Fig. 1

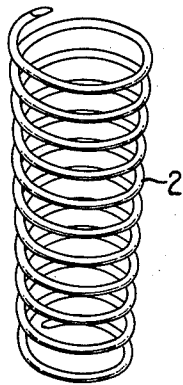


Fig. 2

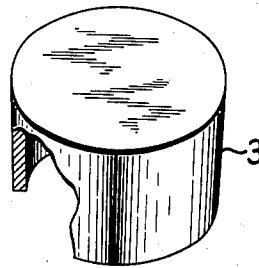


Fig. 3

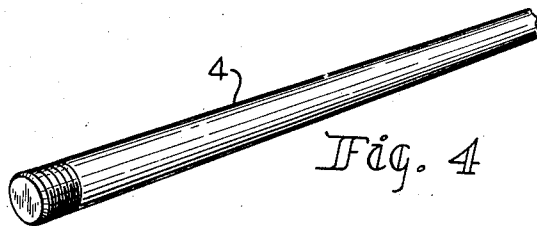


Fig. 4

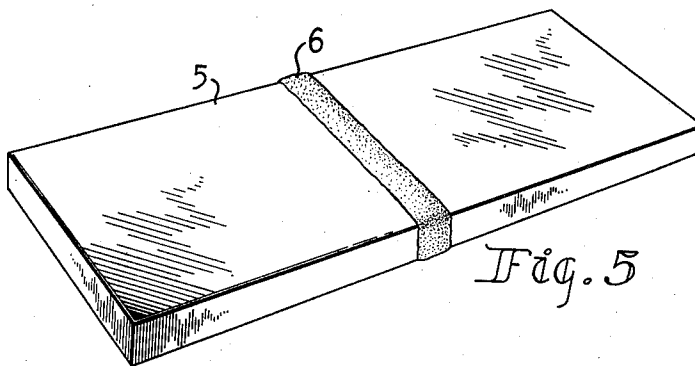


Fig. 5

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ALUMINUM BRONZE ARTICLE FOR USE IN CONDUCTING STEAM OR HOT WATER

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11 Claims. (Cl. 75-162)

This invention relates to an article formed of an aluminum bronze alloy and more particularly to an alpha phase aluminum bronze alloy article having improved resistance to intergranular corrosion when subjected to stress in a steam or hot water atmosphere.

This application is a continuation-in-part of application Serial No. 526,254, filed August 3, 1955, of the same inventor, and now abandoned.

It has been found that alpha phase aluminum bronze alloys, particularly aluminum bronze alloys having from 5.0 to 8.0% aluminum, have been susceptible to stress corrosion cracking under steam exposure. This susceptibility to corrosion cracking is believed to be due to the fact that the aluminum has a larger atomic size than the copper and, as such, the aluminum is pushed to the grain boundaries during solidification of the alloy, thereby resulting in aluminum-rich grain boundaries. As the aluminum is more easily oxidized under steam and stress conditions than the copper, the aluminum-rich grain boundaries are oxidized or corroded and this intergranular corrosion results in premature failure of the article.

The present invention is based on the discovery that intergranular corrosion of alpha phase aluminum bronze alloys under a stress and steam conditions can be substantially prevented by the addition of small amounts of tin or silver or a combination of tin and silver to the alloy.

According to the invention, an aluminum bronze alloy containing 5.0 to 8.0% aluminum, 0.20 to 4.00% iron and 0.01 to 5.00% nickel has added thereto 0.05 to 1.0% tin, or 0.05 to 0.50% silver or a combination of 0.05 to 1.0% tin and 0.05 to 0.50% silver. In theory it is believed that the tin and/or silver, having a larger atomic size than the aluminum, is pushed to the grain boundaries during solidification of the alloy and serves to block the aluminum from the grain boundaries. As both the silver and tin are not generally subject to oxidation under steam and stress conditions, corrosion at the grain boundaries is substantially prevented and the article will not fail prematurely.

The drawings illustrate the best mode presently contemplated of carrying out the present invention.

In the drawings:

Figure 1 is a perspective view of a condenser tube or the like for conducting steam or hot water;

Fig. 2 is a perspective view of a coil spring for use in regulating device for steam or hot water;

Fig. 3 is a perspective view of a bubble cap for a steam distillation apparatus;

Fig. 4 is a perspective view of part of a valve stem; and

Fig. 5 is a perspective view of a pair of baffle plates joined together by welding.

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The drawings illustrate a number of articles for use in conducting or regulating the flow of steam or hot water and which are subjected to stress in service either by an outside force or by the pressure of the steam itself.

Figure 1 shows a condenser tube 1 or the like adapted to conduct steam or hot water under pressure and which is highly resistant to intergranular corrosion.

The tube 1 is formed of an aluminum bronze alloy 10 having the following general composition by weight:

	Percent
Aluminum	5.0 to 8.0
Iron	0.20 to 4.0
Nickel	0.01 to 5.0
Tin	0.05 to 1.0
Copper	Balance

A preferred range of the above composition of the tube is as follows in weight percent:

	Percent
Aluminum	6.00 to 6.75
Iron	1.75 to 2.50
Nickel	0.01 to 0.25
Tin	0.10 to 0.40
Copper	Balance

A specific illustration of a composition for tube 1 falling within the above general composition is as follows in weight percent:

	Percent
Aluminum	6.50
Iron	2.20
Nickel	0.01
Tin	0.40
Copper	90.89

The tin in the above compositions of the tube 1 may be replaced by silver as shown in the following general range of composition by weight:

	Percent
Aluminum	5.00 to 8.00
Iron	0.20 to 4.00
Nickel	0.01 to 5.00
Silver	0.05 to 0.50
Copper	Balance

A preferred range of composition for the alloy composition of tube 1 using silver is as follows in weight percent:

	Percent
Aluminum	6.00 to 6.75
Iron	1.75 to 2.50
Nickel	0.01 to 0.25
Silver	0.05 to 0.20
Copper	Balance

A specific illustration of the composition of an alloy for tube 1 using silver is as follows in weight percent:

	Percent
Aluminum	6.50
Iron	2.20
Nickel	0.01
Silver	0.20
Copper	91.04

The composition of the tube 1 may also include a combination of tin and silver as shown in the following general composition by weight:

	Percent
Aluminum -----	5.00 to 8.00
Iron -----	0.20 to 4.00
Nickel -----	0.01 to 5.00
Tin -----	0.05 to 1.00
Silver -----	0.05 to 0.50
Copper -----	Balance

The alloy composition of tube 1 using the combination of tin and silver has the following preferred range by weight:

	Percent
Aluminum -----	6.00 to 6.75
Iron -----	1.75 to 2.50
Nickel -----	0.01 to 0.25
Tin -----	0.10 to 0.40
Silver -----	0.05 to 0.20
Copper -----	Balance

A specific illustration of an alloy composition for tube 1 employing tin and silver is as follows, by weight:

	Percent
Aluminum -----	6.50
Iron -----	2.20
Nickel -----	0.05
Tin -----	0.20
Silver -----	0.08
Copper -----	90.84

The tin and/or silver in the alloy composition of the tube 1 serves to resist intergranular corrosion of the alloy. It is believed that the tin or silver, having a larger atomic size than the aluminum in the alloy, prevents the aluminum from migrating toward the grain boundaries. As the tin and/or silver are less susceptible to oxidation than the aluminum, corrosion at the grain boundaries, which are tin and/or silver rich, is substantially prevented.

The tube 1 is formed by initially preparing a pre-alloy of copper, aluminum, iron and nickel. This pre-alloy is then alloyed with additional copper and tin and/or silver and cast. It is preferred not to add the tin and/or silver to the pre-alloy because a portion of the tin and/or silver would be lost by oxidation during melting and additional quantities of the tin and/or silver would have to be employed to hold the concentration of the same within the desired limits.

In place of adding metallic tin and/or silver to the melt, it is contemplated that under certain conditions salts of tin and/or silver can be added or fluxing materials containing the pure metals or the metal salts can also be added.

The cast alloy having the proper concentration of tin and/or silver is then heated and extruded to a base size shell. After extrusion the shell is pointed and cold drawn to finished size. The finished tube may then be stress relieved at a temperature in the range of 600° F. to 1150° F., preferably about 850° F. or it may be annealed at a temperature of about 1450° F. to 1650° F., preferably about 1550° F., depending on the specific use and properties desired in the tube.

The ability of the alloy composition of tube 1 to withstand corrosive attack under steam and stress conditions is illustrated in the following tests in which samples were subjected to a deflection test in a steam atmosphere.

Specimen size -----	1/8" x 5/8" x 2 3/4"
Center deflection -----	0.068 to 0.075 inch.
Atmosphere -----	350° F. saturated steam.

Results

Alloy No.	Com-position	Percent	Exposure, hours	Result
5				
1	Cu Al Fe Ni Mn P	90.00 7.10 2.37 0.11 0.01 0.41	157	Specimen failed.
2	Cu Al Fe Ni Mn Ag Cu Al Fe Ni Mn Sn	90.52 6.90 2.21 0.11 0.01 0.34 90.22 7.10 2.21 0.21 0.02 0.34	3,000	No failure.
3	Cu Al Fe Ni Mn Sn Cu Al Fe Ni Mn	91.13 6.48 2.18 0.19 0.02	3,000	Do.
4			157	Specimen failed.

The specimens No. 1 and 4 which did not contain tin or silver each failed after 157 hours of exposure to steam stress conditions, while specimens No. 2 and 3, which contained silver and tin, respectively, were removed from the test conditions after 3000 hours of exposure and subjected to a 50° bend. The specimens withstood the bend test showing a reasonably conclusive indication of stress corrosion cracking immunity in steam.

Figs. 2 through 5 illustrate modified forms of the present invention. Fig. 2 shows a coil spring 2 for use in a valve or the like and is composed of an aluminum bronze alloy having additions of tin and/or silver similar to that of tube 1.

Figs. 3 and 4 show a bubble cap 3 and valve stem 4, respectively, which are adapted to be used to control the flow of steam or hot water and are composed of an alloy similar to that of tube 1.

The plates 5, shown in Fig. 5, are composed of an alloy similar to that of tube 1 and can be welded or otherwise secured together to form a pressure vessel or the like which is adapted to contain steam or hot water. If the plates 5 are joined by a weld, as indicated by 6, the weld should also have a composition similar to that of tube 1. In the case of weld 6, the weld rod from which the deposit is made is formed with a greater concentration of aluminum than the plate 5 due to the loss of a portion of the aluminum during the welding operation.

The present invention is directed to an article adapted for use in conducting, distributing or controlling the flow of steam, hot water or media containing moisture which during treatment may generate steam. The term "hot water" is intended to include hot water solutions and suspensions, and other materials containing hot water as an ingredient, and the term "steam" is intended to include gaseous mixtures of steam and other vapors. The article exhibits increased immunity to stress cracking under the above conditions due to the addition of small amounts of tin and/or silver.

It is contemplated that up to 1% of other metals in the form of impurities may be present in the composition of the present article without effecting the nature or characteristics of the article.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about 5.0 to 8.0% aluminum, about 0.20 to 4.00% iron, about 0.01 to 5.00% nickel, at least one metallic substance selected from the

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group consisting of: (a) about 0.05 to 1.0% tin; and (b) about 0.05 to 0.50% silver, and the balance being copper, and said element being characterized by a decreased tendency for intergranular corrosion by reason of said selected substance therein when said element is subjected to a media containing steam or hot water.

2. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about 6.00 to 6.75% aluminum, about 1.75 to 2.50% iron, about 0.01 to 0.25% nickel, a member selected from the group consisting of about 0.10 to 0.40% tin and about 0.05% to 0.20% silver and mixtures thereof, and the balance being copper, and said element being characterized by a decreased tendency for intergranular corrosion by reason of said selected substance therein when said element is stressed and subjected to a media containing steam or hot water.

3. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about:

	Percent
Aluminum	5.0 to 8.0
Iron	0.20 to 4.0
Nickel	0.01 to 5.0
Tin	0.05 to 1.0
Copper	Balance

and said element being characterized by a decreased tendency for intergranular corrosion by reason of said tin content therein when said element is subjected to a media containing steam or hot water.

4. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about:

	Percent
Aluminum	6.00 to 6.75
Iron	1.75 to 2.50
Nickel	0.01 to 0.25
Tin	0.10 to 0.40
Copper	Balance

and said element being characterized by a decreased tendency for intergranular corrosion by reason of said tin content therein when said element is stressed and subjected to a media containing steam or hot water.

5. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about:

	Percent
Aluminum	6.50
Iron	2.20
Nickel	0.01
Tin	0.40
Copper	90.89

and said element being characterized by a decreased tendency for intergranular corrosion by reason of said tin content therein when said element is stressed and subjected to a media containing steam or hot water.

6. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about:

	Percent
Aluminum	5.00 to 8.00
Iron	0.20 to 4.00
Nickel	0.01 to 5.00
Silver	0.05 to 0.50
Copper	Balance

and said element being characterized by a decreased tendency for intergranular corrosion by reason of said silver content therein when said element is subjected to a media containing steam or hot water.

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7. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about:

	Percent
Aluminum	6.00 to 6.75
Iron	1.75 to 2.50
Nickel	0.01 to 0.25
Silver	0.05 to 0.20
Copper	Balance

10 and said element being characterized by a decreased tendency for intergranular corrosion by reason of said silver content therein when said element is stressed and subjected to a media containing steam or hot water.

15 8. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about:

	Percent
Aluminum	6.50
Iron	2.20
Nickel	0.01
Silver	0.20
Copper	91.04

25 and said element being characterized by a decreased tendency for intergranular corrosion by reason of said silver content therein when said element is stressed and subjected to a media containing steam or hot water.

30 9. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about:

	Percent
Aluminum	5.00 to 8.00
Iron	0.20 to 4.00
Nickel	0.01 to 5.00
Tin	0.05 to 1.00
Silver	0.05 to 0.50
Copper	Balance

40 and said element being characterized by a decreased tendency for intergranular corrosion by reason of said tin and silver content therein when said element is stressed and subjected to a media containing steam or hot water.

45 10. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about:

	Percent
Aluminum	6.00 to 6.75
Iron	1.75 to 2.50
Nickel	0.01 to 0.25
Tin	0.10 to 0.40
Silver	0.05 to 0.20
Copper	Balance

55 and said element being characterized by a decreased tendency for intergranular corrosion by reason of said tin and silver content therein when said element is stressed and subjected to a media containing steam or hot water.

60 11. An element normally subjected to steam or hot water in use and fabricated from an aluminum bronze alloy consisting essentially by weight of about:

	Percent
Aluminum	6.50
Iron	2.20
Nickel	0.01
Tin	0.20
Silver	0.08
Copper	90.84

70 and said element being characterized by a decreased tendency for intergranular corrosion by reason of said tin and silver content therein when said element is stressed and subjected to a media containing steam or hot water.

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