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ENAMEL-COATED ARTICLE.

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My invention relates to a new and useful vitreous enamel which is especially adapted to the protection of iron and steel from oxidation or corrosion at high temperatures by air, steam, flame gases, acids or acid fumes and the like.

A particular application of my enamel may now be described, without, however, limiting myself solely to such use, since there are many other valuable industrial applications that can be made of such enamel. I have found this enamel coating very effective in preventing the oxidation, scaling or other deterioration of the underlying metal frequently caused by flames at high temperature. The coating is particularly effective for protecting from such destructive effects the inner steel or iron or other metal chimneys or cylinders used for heating oil to a vaporizing or gasifying temperature in oil burning stoves. These chimneys are maintained hot by the combustion of the gas formed by vaporizing the oil, said vapors being mixed by suitable devices with the proper amount of air for perfect combustion. Such chimneys, while the stove is in operation, operate at temperatures usually within 1000° F. to 1600° F. I have found that without such enamel coating the useful life of steel or iron chimneys used in such stoves is quite limited, whereas properly enameled ones last almost indefinitely. I have found the enamel herein described to be effective at temperatures higher than such stoves attain, for instance at 2000° F. to 2200° F.

I will now describe the method used in manufacturing and applying one example of my enamel:—A raw batch is weighed out as follows:—Borax, 29%, feldspar, 23.10%, sand, 35.10%, carbonate of soda, 3.10%, fluorspar, 4.96%, nitrate of soda, 3.10%, boric acid 0.92%, nickel oxide, 0.18% and cobalt oxide 0.73%. These materials are mixed in coarsely powdered condition and then smelted in a furnace maintained at 2400° F. to 2800° F. for about 5½ hours. The molten mixture is then run into water to render it brittle by the rapid cooling. After this the material is ground in pebble mills 10 or 15 hours, there being added in the mill 3.25% of clay, 0.4% boric acid and 16% of water. The percentages of these mill additions are calculated on the weight of the raw batch after smelting, due allowance being made for the substances driven off from the raw batch during smelting. The grinding with the pebble mills gives a material of suitable consistency for applying to the work by dipping or spraying. The pieces to be enameled are prepared for the coating by acid pickling, followed by washing and drying. After a coating has been applied of sufficient thickness, it is dried quickly—say within 15 minutes—and then fired for 5 to 12 minutes in a furnace maintained at 1700° to 1900° F. Upon removal from this furnace the pieces are cooled in the air, which completes the manufacturing operation.

I have found the following enamel composition particularly effective for the metal chimney protection above described; this analysis refers to the composition obtained from the raw batch and mill additions above described—in other words to the finished enamel:—

	Per cent.
Silicon oxide (SiO_2)	60.96
Boron oxide (B_2O_3)	13.06
Sodium oxide (Na_2O)	12.23
Aluminum oxide (Al_2O_3)	6.47
Calcium oxide (CaO)	5.81
Cobalt oxide (CoO)	0.86
Nickel oxide (NiO)	0.43

In describing this composition it is to be understood that the proportions given may be varied slightly without materially changing the results or affecting my invention.

I find that the incorporation of these high contents of silica and boric oxide in vitreous enamels for iron and steel, together with the proportions of cobaltic and nickelic oxides described, results in valuable properties new to the art. Thus, very refractory enamels are formed, which resist high temperatures and the eroding and corroding action of flame gases, and there is no cracking or development of blisters or pores in the enamel at high or low temperatures, as is the case when ordinary vitreous enamels different in composi-

tion, are subjected to the high temperatures herein described.

The efficient protective action of my enamel at high temperatures is brought about by the refractoriness of the oxide combinations used, which results in preserving a continuous, non-porous and sufficiently non-plastic or non-flowing coating on the underlying metal.

While I have described materials and proportions which I have found to give an enamel of superior properties, I have found, by many tests and experiments, that there may be certain variations in the amounts and materials of the raw batch and mill additions. While in general, I find that such variations do not give as good results as the enamel above described, nevertheless, there is a distinct improvement over ordinary vitreous enamels for iron or steel which do not protect the metal at high temperatures. Thus, I have made and found fairly satisfactory for flame resistance, enamels for steel and iron in which the proportions of the constituents in the raw batch have varied as follows:—

	Per cent.
Borax	28.15 to 34.72
Feldspar	21.30 to 27.69
Sand	16.90 to 35.10
Sodium carbonate	2.87 to 5.70
Fluorspar	4.56 to 5.93
Sodium nitrate	1.69 to 3.73
Boric acid	0.90 to 1.09
Nickel oxide	0.17 to 0.35
Cobalt oxide	0.70 to 2.02

I have also found iron oxide a desirable constituent in addition to or substituted for nickel or cobalt oxide.

In some cases I have found an iron oxide addition of as much as 16.90% to the raw batch advantageous. In other cases I have added aluminum powder up to 9.10%.

In the mill additions I have also made variations in my experiments as follows:—

	Per cent.
Clay	2.57 to 3.20
Boric acid	0.32 to 0.47
Iron oxide	0.0 to 11.90
Cobalt oxide	0.0 to 1.65
Nickel oxide	0.0 to 0.16

In making these various enamels I have varied the fritting or smelting temperature from 1900° F. to 2800° F. and the temperatures at which the enamels are burned from 1550° F. to 1900° F.

I cite these ranges of composition and practice to illustrate the variations in nature of raw materials, proportions, burning and smelting temperatures that will not depart from the spirit of my invention.

In the claims, where I use the word "enamel", I mean a vitreous composition prepared according to enameling technique as commonly understood in this art. One example of enameling technique is disclosed in this specification.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:—

1. As a new article of manufacture, a heat resistant object comprising a base coated with enamel whose components include 60% silica and an anchoring material.

2. As a new article of manufacture, a heat resistant object comprising a metallic base coated with an enamel whose components include 60% silica and an anchoring material, the ratio of acid oxides to basic oxides exceeding the ratio of 3:1.

3. As a new article of manufacture, a high heat resistant object comprising a metallic base coated with an enamel whose components include at least 40% silica, and also cobalt, nickel and iron oxides the ratio of acid oxides to basic oxides in said enamel exceeding the ratio of 3:1.

4. As a new article of manufacture, a high heat resistant object comprising a metallic base coated with an enamel whose components include at least 40% silica, and also including at least .4% nickel oxide and .8% cobalt oxide the ratio of acid oxides to basic oxides in said enamel exceeding the ratio of 3:1.

5. As a new article of manufacture, a high heat resistant object comprising a metallic base coated with an enamel whose components include at least 40% silica, and the following ingredients in substantially the following percentages:—

Boron oxide	13.06
Sodium oxide	12.23
Aluminum oxide	6.47
Calcium oxide	5.81
Cobalt oxide	0.86
Nickel oxide	0.43

6. As a new article of manufacture, a high heat resistant object comprising a metallic base coated with an enamel whose components include the following ingredients in substantially the percentages specified—

Silica	60.96
Boron oxide	13.06
Sodium oxide	12.23
Aluminum oxide	6.47
Calcium oxide	5.81
Cobalt oxide	0.86
Nickel oxide	0.43

7. A high heat resistant enamel comprising the oxides of boron, sodium, aluminum, calcium, cobalt and nickel, the remainder being chiefly silica, the ratio of acid oxides to basic oxides exceeding the ratio 3:1.

8. A high heat resistant enamel containing 60% silica and an anchoring material.

9. A high heat resistant enamel comprising silica 60.96%, boron oxide 13.06%, sodium

oxide 12.23%, aluminum oxide 6.47%, calcium oxide 5.81%, cobalt oxide 0.86%, and nickel oxide 0.43%.

10. As a new article of manufacture a heat resistant object comprising a metallic base coated with an enamel containing at least 40% silica and an anchoring material, the ratio of acid oxides to basic oxides in said enamel exceeding the ratio of 3:1.

11. As a new article of manufacture, a heat resistant object comprising a metallic base coated with an enamel containing at least 40% silica, 4% boric oxide, and an anchoring material.

12. As a new article of manufacture, a heat resistant object comprising a metallic base coated with an enamel containing at least 40% silica, 4% boric oxide, and an anchoring material, the ratio of acid oxides to basic oxides in said enamel exceeding the ratio of 3:1.

13. As a new article of manufacture, a heat resistant object comprising a metallic base coated with an adherent enamel, to wit, a vitreous material prepared by smelting a raw batch, cooling and pulverizing the smelted material in a mill, with mill additions, applying the milled material to a metallic base, and then firing the coated base, said enamel containing at least 40% silica, and an anchoring material, the ratio of acid oxides to basic oxides exceeding the ratio of 3:1.

In testimony whereof, I affix my signature.

JOHN A. ANDERSON.