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METHOD OF MAKING A DECORATIVE ALLOY

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This invention has for its object the production of an alloy with a microstructure consisting of very fine approximately parallel lamellae, which result in the diffraction of light and produce an iridescent pearl-like effect, rendering the alloy suitable for use in the decorative and architectural arts.

It has long been known that if fine parallel lines are ruled on a polished surface of metal, the so-called diffraction grating resulting will produce a series of spectra showing all colors present in the incident light diffracted at different angles. The effect is customarily explained on the basis of the wave theory of light as being due to the interference of light waves reflected by the successive parts of the surface, the angle of diffraction depending on both the spacing of the rulings and the wave length of the light concerned, according to the well known formula

$$n\lambda = d\ (\sin\theta + \sin\phi)$$

where n is a whole number indicating the "order" of the reflection, λ is the wave length of the light, d the distance apart of the rulings in the grating and sin θ and sin ϕ the sines of the angles made by the incident and diffracted rays respectively. To produce large angles of diffraction for use in scientific spectroscopy, rulings of 10,000 to 25,000 lines per inch are customarily used, although the effect is apparent even with rulings 1/500'' apart and disappears only when the spacing is equal to or less than the wave length of light employed. It is the purpose of this invention to produce a type of diffraction grating by the use of a metallic alloy of such composition that by suitable heat treatment a well developed fine plate structure results. Such an alloy shows different colors at different angles and is very suitable for employment in decorative metal work in building construction and for the production of small objects or parts wherein the intrinsic beauty of the metal is of advantage. Specifically, the structure is developed by heat treatment of an alloy which consists of a uniform single micro-constituent or phase at high temperatures and which breaks down to form an intimate mixture of two phases at a lower temperature. By suitable modifications of heat treatment, such an alloy can be put into the form wherein at least one phase exists as thin plates essentially parallel and equidistant throughout an entire crystal grain, which structure after suitable etching to reveal its nature will diffract light and confer on the surface a delicately colored iridescence. Structures of the type needed have been known to metallographers for some time. Nevertheless no attempt has been made to develop the structures to show iridescence or use it for decorative purposes because of its inherent beauty.

While the striated structure under certain conditions produced in certain alloys due to a change of solubility of a second phase in the principle one produces the effect to some extent, the best results are obtained in the case of the so-called "eutectoid" alloys. The term eutectoid is that given by metallographers to any alloy in the temperature-composition diagram of an alloy series which changes from a homogeneous single solid phase above a certain temperature to two different ones below this temperature. Heat treatment of such an alloy results in the greatest quantity of precipitated material and, if suitably controlled, to the brightest reflection and greatest color after suitable polishing and etching. The structures are not characteristic of only one alloy, but result from a certain type of transformation and occur in many alloy series. The invention is not limited to any one system but refers to the development of such structures in any alloys which undergo the change in phase with temperature, for use as decorative material. For example, successful results have been achieved using the alloys approximating in composition the eutectoids in the copper-aluminum, copper-tin, copper-silicon system, while the ternary eutectoid alloys, copper-zinc-tin and copper-aluminum-silicon, have also shown satisfactory results. The addition of a third or fourth element is often advantageous in modifying the structure. Copper is not an essential constituent and suitable results can be obtained using any other system of two or more metals in which suitable microstructure can be obtained.

In its broadest aspects the method of developing the desired structure comprises heating the alloy to a temperature which produces a single homogeneous phase which can be determined from the equilibrium diagram of the alloy system being considered, then with or without an intermediate cooling to room temperatures bringing the alloy to a temperature which results in the formation of two different phases, and then polishing and etching as later described.

To give a specific example of the treatment required, the following refers to treatment which has been found satisfactory for the copper-aluminum alloy containing 11.9 per cent aluminum. The alloy is first cast, hot rolled, extruded or otherwise fabricated into the desired form and is then heated to a temperature above the

eutectoid temperature, that is according to my investigation approximately 569° C., but preferably to about 900° C., in order to develop large grains of the beta phase stable above the eutectoid temperature. Grains of abnormally large size, up to 3 inches or even more in diameter, may be developed by cooling the alloy quickly to room temperature and reheating to about 900° C. The alloy is then cooled to about 550° C. and held at this temperature for a sufficient length of time to enable the alloy to decompose completely and give rise to well defined lamellar structure. Or stated in another way the single homogeneous beta phase breaks down to form a mixture of the alpha and delta phases in the form of fine approximately equidistant and parallel plates. Treatment at lower temperatures, but above 400° C., will result in quicker transformation but will give a structure too fine for the best results. An alternative and the preferred method is to cool the alloy rapidly, for example by quenching, fom 900° C. to room temperature or considerably below the eutectoid temperature and then to reheat it to a temperature high enough to permit the reaction to take place, but not above the eutectoid temperature, in the above example in the neighborhood of 500° C., when the precipitated plates will be straighter, and more evenly distributed than those resulting from treatment by the first method. Such a structure is commonly called a Widmanstatten structure and does not result from direct transformation at 500° C.

There are several alloys which produce a suitable structure on direct slow solidification from the liquid state and are therefore suitable for use in the form of castings without further treatment. Such alloys are known as eutectics and the use of these on account of their iridescent appearance is included in the present invention. The copper-phosphorus eutectic containing approximately 8.3 per cent. phosphorus has been found to give very satisfactory results, providing it is allowed to solidify slowly.

It is also possible by the use of suitable etching to develop interference colors in alloys of fine duplex structure even if the constituents are not arranged in the form of parallel plates, since interference then occurs between light reflected from the high and low parts of the etched surface.

The surface of alloys in which the structures have been developed in accordance with the method described above need to be polished and etched in order to bring out the effect to its fullest extent. Etching may be accomplished in several ways but is best performed with a reagent which differentially chemically attacks the different phases of the structure and leaves one in relief without producing a film or staining on either. Satisfactory results have been obtained on the aluminum-copper alloys mentioned above by the use of solutions of ammonium hydroxide and hydrogen peroxide; ammonium persulphate with ammonium hydroxide; and mixtures of chromic and nitric acids. However, any etching reagent customarily employed for the development of the structure of the alloys may be employed. Every different composition will obviously require a special study of etching methods.

The etched surface produced as above described may be covered with lacquer or other transparent protective film in order to prevent atmospheric tarnishing, with little detriment to its appearance.

Having thus set forth the nature of my invention, what I claim is:

1. A method of making an architectural or decorative shaped metal object which comprises forming and shaping the object to the desired finished form of an architectural or decorative shape of a copper-aluminum alloy of approximately eutectoid composition, heating the formed and shaped object to a temperature above the eutectoid temperature to develop large grains of the phase which is stable above the eutectoid temperature, cooling the object rapidly to a temperature considerably under the eutectoid, reheating it to and maintaining it at a temperature not exceeding the eutectoid temperature but sufficiently high to permit decomposition of the alloy into two different phases distributed in the form of thin plates, then cooling, and then polishing and etching the surface of the object with a reagent which differentially chemically attacks the different phases of the structure in such a manner as to produce a surface which gives an iridescent effect due to the diffraction of light.

2. A method of making an architectural or decorative shaped metal object which comprises forming and shaping the object to the desired finished form of an architectural or decorative shape of a copper-aluminum alloy containing in the neighborhood of 11.9% aluminum, heating the object to a temperature above 569° C. to develop large grains of the phase which is stable above the eutectoid temperature, cooling the object and maintaing it at a temperature of about 550° C. for a sufficient time to permit decomposition of the alloy into two different phases distributed in the form of lamellae, then cooling, and then polishing and etching the surface of the object with a reagent which differentially chemically attacks the different phases of the structure in such a manner as to produce a surface which gives an iridescent effect due to the diffraction of light.

3. A method of making an architectural or decorative shaped metal object which comprises forming and shaping the object to the desired finished form of an achitectural or decorative shape of a copper-aluminum alloy containing in the neighborhood of 11.9% aluminum, heating the object to a temperature above 569° C. to develop large grains of the phase which is stable above the eutectoid temperature, cooling the object rapidly to a temperature considerably below the eutectoid temperature, reheating the object to a temperature in the neighborhood of 500° C. and maintaining at this temperature for a sufficient time to permit decomposition of the alloy into two different phases distributed in the form of lamellae, then cooling, and then polishing and etching the surface of the object with a reagent which differentially chemically attacks the different phases of the structure in such a manner as to produce a surface which gives an iridescent effect due to the diffraction of light.

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