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IRON AND STEEL ALLOY HAVING CORROSION RESISTANCE

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My invention is addressed to irons and mild steel the useful life of which, under conditions of atmospheric corrosion, has been lengthened. My invention does not pertain to those materials which remain substantially stainless under corrosive influences. My materials will corrode, but the rate of their corrosion under normal atmospheric corrosive influences is very greatly retarded as will be set forth hereinafter.

It has been known that additions of copper to iron or mild steel increased the corrosion resistance thereof. However, the increase in atmospheric corrosion resistance does not remain the same for additional equal increments of copper so that when an iron or steel body contains in the neighborhood of 0.20 per cent of copper, additional increments of copper do not increase its corrosion resistance.

Copper bearing iron or steel can be improved by the addition of phosphorus. The phosphorus in the presence of copper acts more or less as copper alone acts, there being a limit beyond which no important effect is obtained by adding more phosphorus. With phosphorus, however, somewhat more copper can be used to good effect. With copper and phosphorus alone the best corrosion resistance is obtained in a material containing approximately 0.25 per cent copper and 0.06 per cent phosphorus.

The cessation of the influence of copper at 0.25 per cent when used with phosphorus and 0.20 per cent when used alone, led me to investigate the possibility of agents which might be called boosting agents and which might enable one to obtain an effect of copper in producing corrosion resistance beyond the limits set forth above. Nickel serves very well as such a boosting agent. When an iron or steel containing 0.50 per cent of nickel by way of example is used as a base, additional increments of copper produce additional corrosion resistance until the copper content becomes as high as 0.50 or higher. The effect of phosphorus in a copper bearing iron or steel containing nickel is substantially the same as if the base metal contained copper alone.

Because, as has heretofore been set forth, nickel appears to act as a boosting agent, the amount of copper which can be usefully employed varies with the nickel content of the alloy. Thus where, as with iron or mild steel containing no nickel, the useful effect of copper is limited to a percentage 0.20 or 0.25, with steel containing 0.50 per cent nickel the copper may usefully be increased up to 0.50, and with one per cent of nickel the copper may usefully be increased up to 1 per cent. Any ferrous alloy containing nickel and copper within these ranges can be improved in atmospheric corrosion resistance by the addition of phosphorus up to 0.06 per cent.

For the reason that nickel is a comparatively expensive element which when added raises the cost of the iron or steel materially, and since materials of the class with which I have been working must be manufactured and sold cheaply, it will not ordinarily be economical to go beyond the limits of nickel hereinabove set forth. As a consequence, I have sought to improve the atmospheric corrosion resistance of nickel-copper-phosphorous-alloys by the addition of another material. I have found that I can do this by the addition of molybdenum to the base metal.

I have definitely ascertained that molybdenum used with nickel can be caused quite economically to give the effect of very much larger and therefore uneconomical proportions of nickel. By way of example I have found that in a material containing 0.50 per cent of nickel, the addition of 0.10 to 0.20 per cent of molybdenum will give an alloy in which the copper may usefully be increased to that extent which would be possible in a material containing as much as 0.75 to 1 per cent of nickel without molybdenum. I have also found that when using molybdenum together with nickel the percentage of phosphorus may usefully be increased, which apparently is not the case when nickel is used alone.

These conclusions I give as the result of tests carried on alloys ranging from zero per cent of the various elements involved up to the percentages given hereinafter, by small increments, and with widely varying relative percentages of the elements involved, and with and without additions of manganese.

It will be understood in connection with additions of manganese that these vary the characteristics of the metal in other ways than in the matter of corrosion resistance. Where I use the terms iron or steel, I use them without particular reference to definitions based upon manganese content. Ferrous metals low in manganese have a so called "critical point" in rolling operations which means that they must be handled differently on the rolling mill from ferrous metals with a manganese content above 0.25 per cent. Under some circumstances, as is known in the art, it may be desirable to furnish materials with a relatively high manganese content. My investigations have indicated that the presence or absence of manganese does not change

substantially, if at all, the relationships of the other elements as I have developed them above.

For many uses of my corrosion resistant alloys, when formed into sheets, a high yield point is very desirable. My work has indicated that the yield point of materials of this class is raised both by the addition of phosphorus and by the addition of molybdenum. Thus a material containing 0.10 per cent carbon, 0.50 per cent copper, 0.50 per cent nickel, 0.10 per cent phosphorus, and 0.20 per cent molybdenum, when normalized in the form of sheets, showed a yield point of fifty thousand pounds per square inch. Such an alloy has the advantage of increased resistance to atmospheric corrosion, high yield point and sufficiently low carbon that it can be welded and spot welded without embrittlement. Manganese may, however, be added, and will be advantageous where a hot rolled finish is desired and where the requirement for ductility in welds is not so important.

By way of ranges of ingredients in commercially operative and economical alloys the following may be given

	Percent
Carbon (preferably as low as possible)	0.005–0.15
Phosphorus	0.05 –0.15
Copper	0.20 –0.75
Nickel	0.20 –0.75
Molybdenum if used	0.10 –0.50
Manganese if used	0.030–0.80

A typical commercial heat of material falling within the scope of my invention, analyzed in the ladle as follows:

	Percent
Carbon	0.052
Manganese	0.35
Phosphorus	0.094
Copper	0.47
Nickel	0.53
Molybdenum	0.15

As I have indicated above, in the matter of atmospheric corrosion resistance I do not mean a material which will not corrode, but rather a material the corrosion rate of which is usefully retarded. Corrosion tests ordinarily take two forms, in both of which test and control samples are exposed to atmospheric conditions. In the first type of test, sheets or other samples are exposed and the time required for corrosion to perforate the test specimens is noted. In the second type of test, the test and control samples are exposed to corrosive influences for a definite length of time, the products of corrosion are cleaned away and the specimens are tested for loss in weight. The correlation between the two types of tests is not entirely clear.

By time of perforation tests, copper bearing irons and steels have shown two to three times the atmospheric corrosion resistance of ordinary irons and steels. Copper bearing materials containing phosphorus have shown three to five times the atmospheric corrosion resistance of ordinary irons and steels. Loss of weight tests have shown that copper bearing materials containing phosphorus lose less weight than ordinary copper bearing materials which in turn lose less weight than ordinary irons and steels. Materials containing copper and phosphorus together with nickel or nickel and molybdenum lose less weight than do copper bearing steels containing phosphorus; in fact, they differ from copper bearing materials containing phosphorus by at least as much as the copper-phosphorus steels differ from ordinary steels. This difference in loss of weight if converted to time of perforation means that materials containing copper and phosphorus together with nickel or nickel and molybdenum have at least six times the atmospheric corrosion resistance of mild steel and in some cases very much more.

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

1. A corrosion resistant alloy having the following analysis: Carbon 0.005 per cent to 0.15 per cent, manganese 0.030 per cent to 0.80 per cent, phosphorus 0.05 per cent to 0.15 per cent, copper 0.20 per cent to 0.75 per cent, nickel 0.20 per cent to 0.75 per cent, molybdenum 0.10 per cent to 0.50 per cent balance substantially all iron.

2. A corrosion resistant alloy, having substantially the following analysis, carbon 0.05 per cent, manganese 0.35 per cent, phosphorus 0.09 per cent, copper and nickel 0.50 per cent each and molybdenum 0.15 per cent balance substantially all iron.

3. A corrosion resistant alloy in which the ingredients fall within the following ranges: Carbon 0.05 per cent to 0.15 per cent, manganese 0.30 per cent to 0.80 per cent, phosphorus 0.05 per cent to 0.15 per cent, copper 0.20 per cent to 0.75 per cent, nickel 0.20 per cent to 0.75 per cent, molybdenum 0.10 per cent to 0.50 per cent, the balance being substantially all iron, and in which alloy the percentage of copper shall be substantially equal to the combined percentages of nickel and molybdenum.

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