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FERROUS ALLOY

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This invention applies to austenitic ferrous alloys which are difficult to machine, and has for its object improving the machinability of such alloys by the addition of suitable elements as hereinafter described.

Corrosion resisting ferrous alloys are known to the art containing essentially from 4% to 60% chromium; the chromium content being essential in all cases to secure corrosion resisting properties. A subdivision of these ferrous alloys containing the essential chromium element is austenitic in character, usually by reason of the further addition of a metal like nickel or manganese, illustrated by such combinations as:

Chromium	Nickel	Manganese
Percent	*Percent*	*Percent*
18	8	Less than 1.
8	20	Less than 1.
12	12	Less than 1.
25	15	Less than 1.
35	15	Less than 1.
18	Less than 1	8

Chromium, manganese and nickel can be combined in many ways to produce predominantly austenitic alloys, but usually the total content of these metallic alloying elements will fall between 10% and 50%, the principal part of the balance being iron.

Carbon plays no essential part in the effective use of my invention but it is well-known to the art that the percentage of carbon present in a ferrous alloy greatly affects its austenitic nature; it being understood that higher carbon alloys yield stable austenite with lower percentages of metallic alloying elements, but frequently with increased machining difficulty. For the purpose of this invention, a ferrous alloy is considered austenitic when it contains substantial quantities of austenite in the structure, after slow cooling from above its critical transformation points.

My Patent No. 1,835,960 issued December 8, 1931, explains fully how the metalloid sulphur, when added to any corrosion resisting alloy steel containing as an essential element chromium between 7% and 30%, reduces the high-friction character of the alloy and so makes it easier to machine; while other experiments show that the same effects obtain with chromium up to 60%. This use of sulphur is effective in the case of austenitic, high chromium, corrosion resisting alloys, but, owing to the great toughness of these austenitic alloys, I have found it desirable that the machinability be still further improved.

I have discovered that phosphorus or arsenic, or such elements as are known to embrittle a ferrous alloy, can be advantageously employed in connection with the high sulphur described in my said patent to increase the machinability of austenitic alloys beyond the point that is feasible with the use of sulphur alone. I find that the use of an embrittling agent like phosphorus or arsenic, without the high sulphur addition, is comparatively ineffective in realizing the purpose of my invention, which contemplates that phosphorus should always be accompanied by an appropriate content of high sulphur.

In experimenting with the use of phosphorus as an embrittling agent in conjunction with high sulphur, I find that .05% gives slight but noticeable improvement; that excellent results can be secured with phosphorus between .08% and .15%; while a frequently unnecessary degree of brittleness can be introduced with a phosphorus content as high as .50%. I would recommend that a phosphorus content of .20% to .50% be used only where the physical toughness of the resulting alloy is of minor consequence in the purpose for which it is to be used.

My invention is well illustrated by comparing the machinability of four ferrous alloys having the following essential compositions:

	Chromium	Nickel	Sulphur	Phosphorus
	Percent	*Percent*	*Percent*	*Percent*
(*a*)	18.00	9.00	.02	.02
(*b*)	18.00	9.00	.30	.10
(*c*)	18.00	9.00	.30	.02
(*d*)	18.00	9.00	.02	.10

Alloys (*a*) and (*d*) are both quite difficult to machine, whereas alloy (*c*) is noticeably better, and alloy (*b*) is by far the best. In comparing alloys (*a*) and (*b*) for example, machining hexagon nut blanks in an automatic screw machine from 5/8" hexagon bars, production on alloy (*a*) was 3 nuts per minute while on alloy (*b*), production was 6 nuts per minute. In sawing 5/8" hexagon bars of alloys (*a*) and (*b*) in a power hack saw, the time required to make a single cut was 80 seconds and 30 seconds respectively.

My invention applies, not only to austenitic corrosion resisting alloys but also to austenitic ferrous alloys in general, such as the bi-metallic austenitic alloys of iron and manganese, iron and nickel, and any other combination of metallic alloying elements which will produce with iron an austenitic alloy, as manganese and nickel jointly or manganese nickel and chromium.

The embrittling metalloid phosphorus is usually added to the molten bath in the form of ferro-phosphorus, an alloy of iron and phosphorus containing about 20% phosphorus, by manipulation well understood by those familiar with the art.

In the subjoined claims the term "balance substantially iron" contemplates that the balance of the composition is largely iron but may contain percentages of non-ferrous alloying elements of such nature and in such quantity as to not alter the basic nature of the alloy for purposes of my invention. For example, in my "austenitic" group there occurs a steel having the following nominal composition:

C .10% Cr 18.00% Ni 8.00%

Many modifications of this basic composition are well known to the art containing added percentages of other alloying elements as:

C .10%	Cr 18.00%	Ni 8.00%	Ti 1/2.0%
C .10%	Cr 18.00%	Ni 8.00%	Cu 2.45%
C .10%	Cr 18.00%	Ni 8.00%	W 3.80%
C .10%	Cr 18.00%	Ni 8.00%	Mo 3.42%
C .10%	Cr 18.00%	Ni 8.00%	Si 4.59%
C .10%	Cr 18.00%	Ni 8.00%	Al 2.00%

Such modified types are still in need of improved machinability and these added percentages of copper, tungsten, molybdenum, etc., while substantial, do not obscure the basic nature of the austenitic chrome-nickel analysis, or interfere with the applicability of my invention. Therefore, such extra alloys are comprehended in my term "balance substantially iron".

Having thus clearly defined my invention, I claim:

1. An austenitic alloy containing essentially chromium between 4% and 45% and nickel between 5% and 46% with a total percentage of said elements between 10% and 50%, sulphur between .16% and 1.80%, phosphorus between .06% and .50%, the balance being substantially iron and the resulting alloy being distinguished by relatively free machining quality.

2. An austenitic ferrous alloy containing essentially chromium between 10% and 25%, nickel between 5% and 15%, sulphur between .16% and .50%, phosphorus between .06% and .25%, the balance being substantially iron and the resulting alloy being characterized by relatively free machining properties.

3. An austenitic alloy containing approximately 18% of chromium, 9% of nickel, .30% of sulphur, .15% of phosphorus the balance being substantially iron and the resulting alloy being characterized by relatively free machining properties.

4. A corrosion resisting austenitic alloy containing chromium between 4% and 45% and alloy of the group manganese nickel between 5% and 46% with a total percentage of said elements between 10% and 50%, sulphur between .16% and 1.80%, and an embrittling agent of the group phosphorus-arsenic between .06% and .50%, the balance being substantially iron and the resulting alloy being characterized by relatively free machining properties.

5. An austenitic alloy containing between 5% and 50% of metallic alloy of the group manganese-nickel-chromium, between .16% and 1.80% of sulphur, and between .06% and .50% of embrittling agent of the group phosphorus-arsenic, the balance being substantially iron and the resulting alloy being characterized by relatively free machining properties.

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