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ALLOY

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This invention relates to aluminum-nickel-iron base alloys and more particularly to permanent magnets of such alloys having improved mechanical characteristics.

Aluminum-nickel-iron base alloys are known to have excellent properties for use as permanent magnets but poor mechanical characteristics. These alloys are very difficult to finish, as by grinding or sawing by means of abrasive wheels, probably due to the fact that they are composed of relatively large crystals which are rather loosely bound together so that any grinding or sawing operation is likely to snag out the crystals from the body of the article, leaving a very rough, pitted surface.

In addition, this type of alloy, as heretofore known, has very poor resistance to impact stresses, and rather low transverse modulus of rupture.

Heretofore the presence of sulfur has been considered very undesirable in aluminum-nickel-iron base alloys. Consequently the sulfur content of these alloys has been kept as low as possible, with the result that the final alloys have contained only traces of sulfur in the amount of about 0.025 to 0.040%.

I have now found, however, that the presence of effective amounts of sulfur in these alloys will, contrary to expectations, actually increase the impact strength and the transverse modulus of rupture, and improve the grinding and sawing characteristics of the alloys. The sulfur content may vary over a wide range and still be effective. Thus the sulfur content may lie between about 0.075 and 2%, but preferably between 0.075 and 0.3%. The presence of from 0.1 to 0.2% of sulfur is highly effective.

In its broader aspects, my invention relates to the addition of effective amounts of sulfur to alloys having the following general formula:

	Per cent by weight
Aluminum	6 to 14
Nickel	10 to 35
Cobalt	0 to 30
Copper	0 to 8
Iron	Balance

The sulfur may be added in the form of ferrous sulfide (FeS) just prior to pouring the heat, or in the form of pure sulfur as the charge begins to melt. The ferrous sulfide can conveniently be in lump, stick, or granular form. Sulfur itself may be added as flowers of sulfur, or as powdered or lump sulfur.

It is, then, an object of this invention to improve the mechanical characteristics of alloys of the aluminum-nickel-iron base type.

A further object of this invention is to improve the impact strength of aluminum-nickel-iron base alloys.

A still further object of the invention is to provide aluminum-nickel-iron base alloys containing amounts of sulfur effective for increasing the impact strength and transverse modulus of rupture of the alloys, and their grinding and sawing characteristics.

A specific object of the invention is to provide alloys having the following general formula:

	Per cent
Aluminum	6 to 14
Nickel	10 to 35
Cobalt	0 to 30
Copper	0 to 8
Sulfur	0.075 to 2
Iron	Balance

A further specific object of this invention is to provide improved permanent magnet alloys containing about 0.1 to 0.2% of sulfur.

Other and further objects of the invention will be apparent to those skilled in the art from the disclosures of this specification and from the claims.

There are now on the market about five types of aluminum-nickel-iron base alloys, as follows:

	#3	#4	#1	#2	#5
Al	12%	12%	12%	10%	8%.
Ni	25%	28%	20%	17%	14%.
Co	0 or trace	5%	5%	12%	24%.
Cu	0 or trace	0 or trace	0 or trace	6%	3%.
Fe	Balance	Balance	Balance	Balance	Balance.

Cobalt is a desired ingredient in some instances because it improves the magnetic and the mechanical or physical characteristics of the alloy.

The above mentioned commercial forms of alloy contain traces of sulfur, but the prior workers in the field have always thought it desirable to keep the sulfur content as low as possible. As a result of this, the alloys were intended to con-

tain not more than about 0.025 to 0.040% of sulfur.

I have now found, however, that sulfur is a highly desirable ingredient in permanent magnet alloys of the aluminum-nickel-iron base type, in that it materially improves the abrasive machinability, the impact strength, and the transverse modulus of rupture of these alloys. The sulfur content can vary throughout a wide range, such as from about 0.075 to 2%, but preferably is kept within the limits of from 0.075 to 0.3%. The presence of about 0.1% of sulfur is an alloy such as #2 above has so materially improved the abrasive machinability of this alloy that it is now possible to grind the alloy with practical elimination of any difficulty due to the snagging out of crystals. Heretofore, the grinding of such an alloy has always resulted in the production of a very poor, pitted surface. The presence of sulfur, however, makes possible the grinding of the alloy to provide a smooth surface.

In addition, the alloy will effectively resist impact blows when heretofore it was quite apt to crumble or crush upon receiving impact blows of the same magnitude.

The transverse modulus of rupture of the alloys containing sulfur within the above ranges is somewhat increased over the same alloys containing only traces of sulfur.

The following specific examples will serve to illustrate a preferred embodiment of my invention, although it is to be understood that these examples are not intended in any way to limit the scope of the invention.

Example 1

A furnace was charged with the following elements within the proportions indicated:

	Percent
Aluminum	8.25 to 8.5
Nickel	14.00 to 14.25
Cobalt	24.00 to 24.25
Copper	3 to 3.25
Iron	Balance

The furnace was heated to prepare a melt of these ingredients and just prior to pouring the heat, there was added a sufficient amount of sulfur as ferrous sulfide to give 0.1% to 0.2% of sulfur in the final product. As soon as the ferrous sulfide melted down and was thoroughly mixed, the heat was poured into molds of the desired shape.

The resulting cast alloy was then subjected to the usual heat treatment for aluminum-nickel-iron base alloys that are to be made into permanent magnets. The resulting heat-treated article could be ground or sawed with the usual type of abrasive wheel to produce a smooth continuous surface.

Furthermore, the cast alloy would effectively resist impact blows of magnitude sufficient to crush and shatter an identical alloy containing only traces of sulfur.

The transverse modulus of rupture of the alloy was also found to be somewhat increased over the same alloy containing only traces of sulfur.

When the alloy was subjected to a magnetic field of high flux intensity to permanently magnetize it, it was found to be equal in magnetic strength to the same alloy containing only traces of sulfur.

Example 2

A heat was prepared exactly in accordance with the procedure of Example 1 except that after the metal began to melt at the bottom of the crucible, a sufficient amount of sulfur to give 0.1% to 0.2% of sulfur in the final product was added.

The heat was poured immediately after the charge was melted down. The resulting alloy was found to possess improved properties such as referred to above in Example 1.

From the above descriptions it should be understood that this invention now provides alloys of the following general formula:

	Percent
Aluminum	6 to 14
Nickel	10 to 35
Cobalt	0 to 30
Copper	0 to 8
Sulfur	0.075 to 2
Iron	Balance

Within the above range of sulfur content, amounts of sulfur from about 0.1% to 0.2% have been found to be very effective.

I claim as my invention:

1. A permanent magnet alloy of the aluminum-nickel-iron base type containing an amount of sulfur effective to improve the grinding and sawing characteristics of the alloy as compared with the same alloy containing only a trace of sulfur.

2. A permanent magnet alloy of the aluminum-nickel-iron base type containing about 0.075 to 2% sulfur.

3. An alloy comtaining about 10% aluminum, about 17% nickel, about 12% cobalt, about 6% copper, about 0.075 to 0.3% sulfur, and the balance mainly iron.

4. An alloy for use as a permanent magnet, comprising about 8% aluminum, 14% nickel, 24% cobalt, 3% copper, 0.075 to 0.3% sulfur and the balance mainly iron.

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