To all whom it may concern:

Be it known that I, JAMES RAMSEY SPEER, a resident of Trappe, in the county of Talbot and State of Maryland, have invented a new and useful Improvement in High-Carbon Steel-Iron Alloys, of which the following is a specification.

This invention relates to alloys of iron-steel characteristics containing chromium, nickel, and other alloying ingredients. Particularly the invention consists in adding molybdenum to alloys of the class referred to.

In U. S. Patent No. 1,071,364, granted August 26, 1913, to the present applicant and William L. Forster, there is disclosed a certain alloy of iron known as "adamite." The main constituents of that alloy are iron, silicon, carbon, manganese, nickel, chromium, with small quantities of sulfur and phosphorus. These ingredients when combined according to the teaching of that patent produce an alloy of great utility, and remarkable characteristics. It is novel in that its tensile strength closely approximates that of steel, while it has other characteristics which are those of cast iron. The alloy while possessing great toughness and strength, is yet a very hard material, requiring the lowest lathe speed and the highest grade of tool steel to dress it. It has a minimum of elongation and low elastic limit and reduction of area. At the same time it may be forged like ordinary steel. The carbon content is very high, in view of the steel characteristics, but this is kept substantially in the combined form in the alloy referred to.

In Patent No. 1,105,341 granted July 28, 1914, to this applicant, another alloy of iron is disclosed, containing iron, carbon, silicon, manganese, nickel, chromium, sulfur and phosphorus—the carbon content ranging from 1% to 4%, and the chromium being substantially twice the percentage of nickel. Articles made according to that patent are hard and resistant to abrasion and to wear under heat. The life of articles of this alloy is several times longer than the best grade of cast iron. Under the acetylene torch the material is as resistant as cast iron and in its comparative inability to show elasticity or elongation, or reduction of area, it resembles cast iron. It is more brittle than "adamite," which is the alloy of the patent first above mentioned, being intermediate between cast iron and adamite.

In the alloys of the two patents above referred to it has been found that the relatively large amount of carbon is hardened and held in the combined form by the use of chromium, some of the other elements also contributing to this effect. The brittleness resulting from the chromium in combination with the carbon is "controlled" or neutralized by the effect of the nickel. Certain it is that the patented alloys, since their introduction and adoption by all of the principal consumers, have reduced by approximately one-half the consumption of rolling mill cement, and clay mill rolls, bending, hammering and forging dies, glass molding and grinding machinery, and many other parts of equipment and machinery where resistance to wear (especially under the action of heat) is the desired characteristic.

The present invention consists in adding to the high carbon alloys such as those disclosed in the above mentioned patents, molybdenum in amounts varying from a trace up to 1.50%, thus intensifying the combined iron-steel characteristics.

In producing the high carbon alloys covered by the two patents referred to, it is necessary to use considerable exactness in the manufacturing methods employed, for the reason that the quantities of carbon (excessive according to the usual steel practice) acted upon by the chromium, produces a combination which must necessarily be accurately treated in the matter of the rate of cooling and annealing. Otherwise the chance of failure due to the high carbon combination with chromium is great. Although the addition of nickel to this combination as set forth in the patents resulted in a very successful commercial alloy, of great value, nevertheless the exactness of the process of manufacture must be maintained. The temperature ranges within which it is possible to treat these materials is comparatively limited. If this range is disregarded there is a resultant loss of product in the course of manufacture, and also a possible resultant failure of some of the product in use after the manufacturing stage has been passed.

The addition of molybdenum to the alloys of the general nature set forth in said patents, introduces a factor of safety in that the permissible variation in the range of temperatures in the various stages of manufacture...
ture is very much increased, and the likelihood of failure to secure the desired results is decreased. Consequently, not so much skill is required in handling the alloy during manufacture, the loss in production is accordingly decreased, and the chance of failure of the finished product becomes very much less. Molybdenum, when used with such alloys, insures an exactness of the resultant structure of the products, to a reasonable degree of positiveness, which is entirely unattainable without its use. It is considered that the discovery of the value of molybdenum in connection with adamite and iron alloy products of high carbon-chromium-nickel content is a contribution of great value to the art of producing such alloys on a commercial scale.

Although molybdenum belongs to the chromium family of metals, when used with the high carbon alloys referred to it seems rather to intensify the effect of the nickel and further offsets the brittling effect of the chromium. For example, it materially increases the elastic limit of the product, and therefore adds to its power of resistance to fatigue. However, the addition of molybdenum is not in any sense equivalent to the addition of a larger percentage of nickel,—the molybdenum having important and beneficial effects that cannot be secured by varying the percentage of nickel. As above stated, it seems to intensify the effect of nickel, and at the same time it modifies the matrix of the alloy, resulting in a product which is very much more stable at all temperatures, and which is therefore capable of being manufactured, annealed, and worked, at a much wider range of temperatures than the same alloy without molybdenum.

Furthermore, this increased stability, this strengthening of the matrix of the material, continues in its beneficial results in the finished material. Dies, rolls, etc., made of the specified alloys, and containing molybdenum, have a greater resistance to shocks and vibration, as well as to heat, than where the same alloys are used without molybdenum.

Consequently, it is apparent that the addition of molybdenum to the patented alloys results in three very marked advantages; first, the permissible variations in the proportions of the other materials of the alloys is greater where molybdenum is used, it acting as a stabilizer, assisting in compensating for such variations; second, the permissible range of temperature in the manufacture, annealing and finishing of the alloy products is materially greater, it contributing a very desirable factor of safety to insure a larger percentage of production; and third, the matrix of the material is materially strengthened, resulting in a finished product of greater resistance to strains and to wear it adding an intensification of the best qualities to these alloys of already proven high performance record.

From these characteristics it follows that the results in the manufacture of these alloys are much more certain, the chance of failure being reduced both in the process of manufacture and in the use of finished materials made from the alloys. This permits of the manufacture of such products by men less skilled in the art, and permits the use of the finished product made from the alloys in places where the requirements are of the most highly critical nature.

Alloys of the kind referred to comprise silicon, chromium, nickel, sulfur, phosphorus, manganese, carbon and iron. To these ingredients in the practice of the present invention, is added molybdenum. These ingredients may be advantageously combined in substantially the proportions set forth in the above mentioned patents, or the nickel may be entirely compensated for by the molybdenum. For example:

- Silicon .10% to 3.00%.
- Chromium .50% to 1.50%.
- Nickel from a trace to 1.00%.
- Sulfur not exceeding .20%.
- Phosphorus not exceeding 1.50%.
- Manganese not exceeding 1.50%.
- Total carbon 1.25% to 4.00%.
- Molybdenum from a trace to 1.50%.
- Iron approximately sufficient to complete 100%.

It will be understood that the percentages of the above ingredients will be varied within the limits given according to general foundry and steel practice to get the desired results both in the molten and finally finished states. For example, the silicon and carbon contents are varied according to the proposed use and the section of the casting to be made; and, in general, if the proportion of any ingredient is changed, some compensation is necessary in the proportioning of some other ingredient having opposite characteristics. But, in every case, it has been found that the presence of molybdenum exercises a stabilizing influence, and secures the general effect desired, even though the proportion of any one ingredient be varied somewhat, without the compensating change in some other ingredient. Molybdenum adds an additional element of control.

The duplex effect of the molybdenum, in its intensification of the effect of chromium on the one hand, and its restraint upon the chromium content and its adherence to the nickel effect on the other hand, but without in any way tending to soften the resultant product (as is the case with the excessive use of nickel) is distinctive in the presence of a high carbon material. In no sense must the effect of molybdenum in high carbon-chromium-nickel alloys of the kind speci-
fied, be confused with its well known effect upon so-called "steels." The various prior patents for the use of molybdenum in the art have reference to steels of a usual carbon content, the quantity of this ingredient in steels being well known in the trade. In this invention, however, the distinct novelty of composition and effect is based upon carbon in quantity starting well up in the steel range and passing over into the cast iron range. In other words, the effect of molybdenum upon these high carbon products is a distinctive and original feature. This iron-steel alloy is neither steel nor cast iron. It functions with prominent and pronounced characteristics of both steel and cast iron. In it the effects of the molybdenum are distinctive from the effect of molybdenum when added to either a steel or a cast iron mixture.

If desired, small quantities of copper, tungsten, vanadium, or other rare metals, may be added without materially affecting the character of the alloy.

I claim:

1. An alloy having iron-steel characteristics and containing carbon not less than one per cent., chromium, molybdenum, silicon, sulfur, phosphorus and manganese.

2. An alloy having iron-steel characteristics and containing carbon not less than one per cent., chromium, molybdenum, nickel, silicon, sulfur, phosphorus and manganese.

3. An iron-steel alloy containing the following elements in substantially the following proportions:
   Silicon .10% to 3.00%.
   Chromium .50% to 1.50%.
   Nickel from a trace to 1.00%.
   Sulfur not exceeding .20%.
   Phosphorus not exceeding 1.50%.
   Manganese not exceeding 1.50%.
   Total carbon 1.25% to 4.00%.
   Molybdenum from a trace to 1.50%.
   Iron approximately sufficient to complete 100%.

In testimony whereof, I have hereunto set my hand.

JAMES RAMSEY SPEER.

Witnesses:

HELEN WITHERGOTT,
EDNA V. KILLEN.