To all whom it may concern,

Be it known that I, ELWOOD HAYNES, a citizen of the United States, residing at Kokomo, in the county of Howard and State of Indiana, have invented certain new and useful Improvements in Wrought-Metal Articles, of which the following is a specification:

This invention relates to wrought metal articles; and it comprises wrought metal articles of manufacture of the nature of cutlery and edged tools, such articles having polished surfaces of the general character which is termed noble, in that such surfaces are inconceivable, lustrous and of permanent nature; and such articles being composed of a worked down and hard body of an iron-chromium alloy, low in carbon and in other metals, such alloy being stiff, strong and elastic, able to take and retain a cutting edge and having the other general properties of tempered metal; such as, for example, an iron-chromium alloy containing not less than 8 per cent. chromium and, very advantageously, not less than 10 per cent., and not more than 50 or 60 per cent., the best proportion of chromium being between 15 and 20 per cent., which is contained 1 per cent. of chromium (the amount of carbon being advantageously between 0.1 and 0.5 per cent.) with the rest of the alloy consisting mainly of iron, there being no substantial amount, (say, not over 4 to 5 per cent.) of other metals than iron and chromium in said alloy; all as more fully hereininafter set forth and as claimed.

There is a great demand in various arts for strong metals having a noble character, that is, amenable to corrosive agencies; that is for a metal or metallic material which will not tarnish, which shall be workable and which will have a character, like that of stiff and strong steel being, for instance, capable of taking a cutting edge. It is desirable that such a material shall be capable of production on a commercial scale at a moderate cost and shall be capable of being easily worked and manufactured, as by forging, hammering, swaging or otherwise working. It is further desirable that such a material shall be capable of taking a high polish. The various noble metals, gold, silver, platinum, iridium, and the like, from their cost and the considerable, have no great strength of their own and are not suitable for any purpose where strength, stiffness, hardness, etc., are requisite; as in making cutlery, evaporating pans, etc. The noble metals are often used as a facing or ornament for such things as table knives, etc., as in plated ware, but of themselves these metals are absolutely useless for cutting tools and the like. This need of a strong and stiff metal having noble characteristics and suitable for cutting tools, I have heretofore met with certain alloys composed mainly of chromium and nickel and of chromium and cobalt (see Patents 876,745 and 873,746). These alloys, although consisting of two metals which in a separate or pure state are more or less attackable by various reagents, are nevertheless, for all practical purposes, of absolutely noble character; they resist boiling in nitric acid, they are unattacked by atmospheric influences, etc. In addition, they are so hard, strong and stiff as to enable excellent implements to be made from them. These characters they possess in such a measure as to allow them to take and retain cutting edges. For example, the blade of a pocket-knife made of such a cobalt-chromium alloy has excellent cutting properties and is always sharp and smooth and permanent. Such a knife blade is not affected by exposure to air, fruit acids, etc. Its surface is as permanent as that of gold or platinum and more permanent under ordinary household conditions than that of silver.

I have found that I can produce alloys of much the same character, although having somewhat different properties, by uniting chromium and iron together in certain proportions to form what is, substantially, a binary alloy. The alloys so produced have, for all practical purposes, the same noble character as the alloys described and claimed in the stated patents, while they have certain specific advantages of their own. Among these advantages is a high degree of workability, that is, a malleability and ductility at high metal working temperatures, say, between a red heat and an orange heat, which allows ingots or bars of such alloys to be readily worked down into various forms for the production of wrought metal implements or articles. This workability at high temperatures is sufficiently great to permit the easy manufacture of such instruments as auger bits, chisels, table knives, etc. These alloys, being
largely iron, are more readily united to iron and steel by welding and the like than is the case with the chromium-cobalt and chromium-nickel alloys. These alloys have high 5 elasticity.

I find that for the best results in the present invention the amount of chromium in the alloy should not be below 8 per cent, and it is much better that it should not fall below 10 per cent. On the other hand, the amount of chromium should not exceed 50 or 60 per cent. Higher percentages of chromium render the alloys too difficultly workable for general purposes. For most 15 purposes, I find a chromium content of between 10 and 25 per cent. adapted. An alloy containing around 20 per cent. chromium is suitable for most of the purposes hereinafter indicated. The amount of carbon in the alloy should not be higher than around 1 per cent.; and it is better that it should be lower than this amount, say, around 0.1 to 0.5 per cent. In making the present alloy no other metals than chromium and iron should be present in substantial amounts, say, more than about 4 to 5 per cent. of the total alloy. However, additions of rather small amounts of other metals are occasionally advantageous for special purposes. For example, the presence of 2 to 3 per cent. of molybdenum or of tungsten, while not changing the character of the alloy disadvantageously for most purposes, gives it a somewhat different luster and color; and for some purposes this alteration in appearance is desirable.

In order to secure an alloy of the type herein described, that is an alloy relatively high in chromium and low in carbon, special precautions must be taken. The alloy should not be made or melted in contact with carbon; that is, it should not be made, for example, in graphite crucibles unless these crucibles are well lined with some indifferent material. Contact of chromium with carbon must be avoided since chromium has a great affinity for carbon, readily forming carbides. Proximity of carbon to or contact with the alloy during its manufacture is very disadvantageous. For this reason, the use of graphite crucibles even if lined is disadvantageous. The best material for vessels for melting and forming the alloy which I have found is alumina. For example, a crucible composed of aluminum or ignited bauxite with a little kaolin as a binder is suitable. Electric heat or fire heat may be used for melting. As a rule the components, that is the chromium and the iron, should be mixed together in granulated or other comminuted form and the mixture raised to the melting temperature without substantial access of air. After melting the mixture, which may be stirred, it should generally be allowed to remain in a molten state for a few minutes to permit the mixture to quiet. There is little tendency to segregation or the formation of non-homogeneous bodies of metal. After formation and fusion it may be cast into any suitable mold to form ingots of any 70 shape or size desired. It casts readily. The ingots may be worked down in any suitable manner. Hammering or swaging is a desirable method.

The source and character of metals used 75 for making the alloy is not a matter of indifference. It is best to use a good quality of metallic chromium as pure as may be. Ferrochrome cannot be used directly except with sufficient iron, sufficiently free from carbon to make the carbon content of the whole alloy average not to exceed the stated maximum of around 1 per cent. Ferrochrome runs from 4 to 12 per cent. of carbon. In working with ferrochrome substantial carbonless iron must ordinarily be used. Pure carbon-free chromium made by the thermite process (reduction by aluminum) is suitable for the present purposes and may be used with iron containing a little carbon. With pure chromium and with pure low-carbon iron, it may even be desirable at times in the melting operation to add a little carbon in order to prevent oxidation and to reduce oxides present. Other purifying additions, however, such as a little titanium or ferrotitanium, manganese, etc., are ordinarily better. A pure chromium iron alloy suitable for the present purposes may be made by treating commercial ferrochromium 100 with a little oxide of chromium in the electric furnace.

A good alloy under the present invention may be made by uniting about 10 parts of chromium with 90 parts of iron, the amount of carbon present being 0.1 to 0.5 per cent. This alloy is only attacked to a slight extent by hot or boiling nitric acid. Its surface remains permanent under the action of moisture, vegetable acids, air, etc. Such an alloy is malleable when heated and is capable of being readily forged and worked while hot, hardening on cooling. It will take a high polish and will receive and retain a good cutting edge. It can be united in 115 by welding with iron and steel with rather more readiness than the other alloys hereinafter described having a higher chromium content.

In this alloy as a rule I do not use more than 120 or 0.6 per cent. of carbon. With such about 0.6 per cent. of carbon and 10 per cent. chromium the alloy can be forged readily under the hammer, shows no tendency to crack in forging and is capable of taking 125 a keen cutting edge even without "tempering" by the usual methods. As the per cent. of carbon increases the workability diminishes somewhat and the metal becomes more inclined to crack. I regard 1 per cent. of 130
carbon as a practical limit in this class of alloys although the percentage may be raised somewhat above this point for the production of very hard alloys containing a relatively small amount of chromium.

As the percentage of chromium in the alloy rises above, say, 20 per cent., the danger attendant on a high proportion of carbon increases.

Alloys of the type of those herein indicated as containing 50 per cent. or more of chromium are well adapted for non-corrodible cutlery, giving a very hard as well as tough metal, which will take a keen cutting edge; but alloys containing these high percentages of chromium are difficult to work as compared with alloys containing a less amount, say, about 20 to 25 per cent.

As the percentage of chromium in the alloy rises, and particularly with low amounts of carbon, the temperature necessary for fusion in the formation of the alloy increases. With alloys containing 40 per cent. or more of chromium it is usually better to employ electric heating, as by the use of an electric arc.

Without materially modifying the advantageous properties of my alloy as hereinbefore described I can incorporate small amounts of other metals, such as metals of the chromium group, such as tungsten and molybdenum, up to 4 or 5 per cent. In the case of tungsten and molybdenum, this, for some purposes, is advantageous, since it gives a higher luster to a polished surface and a somewhat different but highly ornamental appearance. Small additions, say, up to 4 or 5 per cent. of nickel or cobalt may be used in the same way and with similar results.

An alloy containing 20 to 25 per cent. of chromium and 60 to 75 per cent. iron with 0.1 to 0.5 per cent. carbon is well adapted for the purpose of this invention. Such an alloy is hard, stiff and strong, has good elasticity, works well under the hammer and swages readily, has a high luster, taking an excellent polish and will take and retain a good, smooth, permanent cutting edge, readily renewable by honing or grinding. The polish which can be given rivals that of silver while the metal is not tarnished or affected by sulfurous gases as is silver. This polish is practically permanent against fruit acids, exposure to air and rain, etc.

While I regard my alloys as particularly adapted for the manufacture of cutlery and similar articles, they may of course be used for any other purposes for which they are adapted. They may for example be used for the manufacture of standards of weights and measures, tools, bits, non-corrodible cooking utensils, etc. In sheet or plate form they may be used for the manufacture of evaporating pans and other chemical appa-

ratus of large dimensions, their stiffness and strength well adapting them for this purpose. The alloys may of course be used as a facing layer for a body of iron or steel in making such apparatus. Ingot of these alloys may be readily drawn or rolled into rod, wire, sheet, etc. As previously stated, the higher the percentage of chromium, as a rule, the higher are the working temperatures required in manufacturing the alloy and in working it into form. With alloys containing less than about 20 per cent. of chromium the incorrodibility is not quite as good as with alloys containing 20 per cent. or more of chromium. However with as little as 10 per cent. chromium the incorrodibility is sufficient for many purposes. There is little advantage as regards nobleness of character of the alloy in increasing the amount of chromium beyond, say, 25 per cent., while with amounts of chromium in excess of 25 per cent. the difficulty of making and working is increased somewhat. An increase in the amount of chromium beyond 25 per cent. adds therefore somewhat to the cost of the material, not only because of the relatively high cost of chromium but because of the increased difficulty in working. For this reason, I consider the alloys containing 20 to 25 per cent. chromium with 0.1 to 0.5 per cent. carbon as the best adapted for the present purposes.

The present alloy is well adapted for making pen points for fountain pens, chisels, table knives, forks, and other purposes where hard metal of high temper is required.

What I claim is:

1. A wrought metal tool having polished surfaces of the incorrodible characteristics of surfaces of noble metal and composed of an alloy of iron and chromium, with carbon in amount between 0.1 per cent. and 1.0 per cent., said alloy being malleable at high temperatures, hard, stiff and strong at ordinary temperatures and capable of taking and retaining a cutting edge.

2. A wrought metal tool having polished surfaces of the incorrodible character of polished surfaces of noble metal and comprising an alloy containing from 8 per cent. to 60 per cent. of chromium and from 40 per cent. to 92 per cent. of iron, with carbon in amount between 0.1 per cent. and 1.0 per cent., said alloy being readily malleable and workable and being substantially free of other metals.

3. A wrought metal tool having polished surfaces of the incorrodible character of polished surfaces of noble metal and comprising an alloy of iron and chromium containing from 15 per cent. to 25 per cent. of chromium, and carbon in amount from 0.1 per cent. to 1.0 per cent., and being malleable, ductile and elastic.

4. A wrought metal article having sur-
faces of the incorrodible character of surfaces of noble metal, and composed of an alloy of iron and chromium, containing carbon in amount of 0.1 per cent. to 1.0 per 5 cent., said alloy being readily malleable and workable at high temperatures, and hard, stiff and strong at ordinary temperatures.

In testimony whereof, I affix my signature in the presence of two subscribing witnesses.

ELWOOD HAYNES.

Witnesses:

H. R. PERRY,

R. CRAWFORD.