UNITED STATES PATENT OFFICE.

ISADOR LADOFF, OF CLEVELAND, OHIO, ASSIGNOR, BY MESNE ASSIGNMENTS, OF THIRTY ONE-HUNDREDTHS TO WALTER D. EDMONDS, OF BOONVILLE, NEW YORK.

ALLOY AND PROCESS OF PRODUCING THE SAME.

1,040,699. Specification of Letters Patent. Patented Oct. 8, 1912.

No Drawing. Application filed January 18, 1906. Serial No. 296,650.

To all whom it may concern:

Be it known that I, ISADOR LADOFF, a citizen of the United States, and a resident of the city of Cleveland, county of Cuyahoga, and State of Ohio, have invented certain new and useful Improvements in Alloys and Processes of Producing the Same, of which the following is a specification.

Alloys of metals whose chemical properties are the most dissimilar are often the most useful in the arts on account of the idiosyncratic properties of such alloys rendering them comparable to new elements. Such alloys are, however, the most difficult to produce.

Heretofore alloys have been produced principally in one of the two following ways, viz:—The metals have been molten together in certain proportions at requisite high temperature. It will be observed that by this process in certain cases extremely high temperatures are required—as, for instance, where alloys with titanium are involved. Also, that in certain cases the proportions of the respective metals in the resulting alloy are limited. Another process of producing alloys has been to mix the metals together in powdered state and apply thereto a pressure sufficiently high to effect the production of a resultant alloy at ordinary temperature.

The high pressure method last referred to is preferable to the high temperature method above described because avoiding the aforesaid limitation as to proportions of the respective metals in the resulting alloy and also avoiding oxidation in the case of certain metals, occlusion of gases, etc., often characteristic of the molten metal method. But the pressure method, on the other hand, is too expensive for application on an industrial scale.

The object of my present invention is to provide a more economical, certain and universal method of producing alloys of all grades and proportions, and, more particularly, alloys of metals—such as titanium, for instance—which are particularly rare because of the refractory character of the oxygenated forms in which they are usually found. My researches have enabled me to attain these objects by the process hereinafter described. Such researches have demonstrated that alloy may be produced at a temperature below the melting point of the alloying metals, provided the oxids of the metals, suitably powdered and mixed, are, in the presence of a reducing agent, or, so to speak, in "a reducing atmosphere," raised to a temperature sufficiently high to inaugurate the reduction of the oxid of one of the metals, thus utilizing the catalytic action of the oxids in process of reduction, with the further result that the pure metals, being brought into each other's presence in their nascent state, are susceptible of alloying with each other in proportions unprecedented in former processes—as, for instance, the molten metal method.

My novel process may, generally speaking, be practiced as follows, viz:—The oxids of the respective metals desired to be alloyed together are brought preferably to a powdered condition by any one of the well known methods. The respective metallic oxid powders thus produced are next mixed together in the desired proportions. The mixture is then treated so as to impart coherence thereto. The mass is then subjected, in the presence of the reducing agent, to a temperature sufficiently high to inaugurate the reduction of one of the oxids and thereafter maintained at approximately the same temperature sufficiently long to insure the complete reduction of all the oxids, leaving the resultant metallic products associated together in the alloyed state.

To be more explicit, and selecting, for instance, a case in which it is desired to produce the alloy of iron and titanium. The oxid of titanium, say rutile, is preliminarily reduced to powdered state. The oxid of iron, say ferric oxid, is likewise reduced to similar condition, and the two powdered oxids are then thoroughly mixed together in such proportions as are desired for the metals in the alloy to be produced.

The mixture, being moistened by water, or, if preferred, a binding material such as oil, is charged into molds of any desired form and proportions, and therein subjected to a pressure sufficient to impart coherence to the mass—say a pressure of about six hundred atmospheres, and, after having been dried, is subjected to a temperature of from 600° to 800° C. in an atmosphere of

carbon monoxid in an ordinary gas furnace. The requisite reducing atmosphere is preferably obtained by packing the said shaped masses of the oxids in powdered coke and in maintaining the temperature referred to in the furnace for about twenty four hours, when, after cooling down, said masses, without losing shape, will be found composed of a true alloy of iron and titanium.

It will be observed that by my said process the reduction of the titanic acid and the production of the resulting alloy of titanium and iron has been accomplished at a temperature some thousands of degrees lower than that heretofore regarded as indispensable for such results, and that thus, incidentally also, the electrical furnace may be dispensed with in reducing refractory oxids of the metals and in producing alloys of such metals with others.

It will be understood that the method as above described is applicable to the production of alloys of any desired metals and that in each instance the temperature, proportions of ingredients, time of exposure, etc., will be regulated according to the requirements of the particular case in hand, all of which can be readily determined by those skilled in the art after usual tests made on the lines of the description of my process as herein disclosed.

It follows from the foregoing that, by my procedure, each metal is, at quite lower than its melting temperature, derived from its respective oxid, after which the resultant metals combine with each other to form the alloy. In the example described, resulting in an alloy of iron and titanium, the charge being raised in a reducing atmosphere to a temperature sufficiently high to inaugurate the reduction of one of the metals, *i. e.* from 600° to 800° C., it follows that the iron oxid, being much less refractory than the titanium oxid, is first reduced, thus producing, to an extent, a monometallic iron product before reduction of titanium oxid and resulting formation of the alloy begins.

One of the incidental, but valuable, results of my process consists in its applicability to the production of artistic articles consisting of a desired alloy. For instance, thereby, permanent forms in the most durable alloys may be readily imparted to original artistic work, the plastic mixture of the oxids of the metals being modeled by the artist and the resulting forms permanently transformed without substantial variation in shape to metallic alloys.

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

1. The method of producing an alloy which comprises subjecting the co-assembled oxids of its constituent metals, in a reducing atmosphere, to temperature below the melting points of said metals but sufficiently high to inaugurate, and maintaining such temperature sufficiently long to insure, reduction of said oxids.

2. The method of producing an alloy of iron and titanium which comprises subjecting the co-assembled oxids of iron and titanium, in a reducing atmosphere, to temperature below the melting point of iron but sufficiently high to inaugurate, and maintaining such temperature sufficiently long to insure, reduction of said oxids.

3. The method of producing an alloy which comprises subjecting the co-assembled oxids of its constituent metals together with carbon to temperature below the melting points of said metals but sufficiently high to inaugurate, and maintaining such temperature sufficiently long to insure, reduction of said oxids.

4. The method of producing an alloy which comprises heating the co-assembled oxids of its constituent metals, in a reducing atmosphere, sufficiently long and at temperature sufficiently high to reduce said oxids without melting the resulting metals.

5. The method of producing an alloy of iron and titanium which comprises heating co-assembled oxid of iron and oxid of titanium, in a reducing atmosphere, sufficiently long, and at temperature sufficiently high, to reduce said oxids without melting the resulting metals.

6. The method of producing an alloy which comprises heating the co-assembled oxids of its constituent metals together with carbon sufficiently long, and at temperature sufficiently high, to reduce said oxids without melting the resulting metals.

7. The method of producing an alloy of iron and titanium which comprises heating co-assembled oxid of iron and oxid of titanium, together with carbon, sufficiently long, and at temperature sufficiently high, to reduce said oxids without melting the resulting metals.

8. The metallurgical method which comprises bringing a plurality of oxids of different metals into presence of a reducing agent and subjecting them to temperatures below the melting points of said metals but sufficiently high to insure reduction of one of said oxids by said agent.

9. The metallurgical method which comprises bringing oxid of iron and oxid of titanium into presence of a reducing agent and subjecting them to temperatures below the melting points of said metals but sufficiently high to insure reduction of the oxid of iron by said agent.

10. The metallurgical method which comprises bringing a plurality of oxids of different metals into presence of carbon monoxid and subjecting them to temperatures

below the melting points of said metals but sufficiently high to insure reduction of one of said oxids by said carbon monoxid.

11. The metallurgical method which comprises bringing oxid of iron and oxid of titanium into presence of carbon monoxid and subjecting them to temperatures below the melting points of said metals but sufficiently high to insure reduction of the oxid of iron by said carbon monoxid.

12. The method of producing an alloy or compound of metals which comprises subjecting the co-assembled oxids of its constituent metals, in a reducing atmosphere, to temperatures of from 600 degrees to 800 degrees centigrade and maintaining such temperatures sufficiently long to insure reduction of said oxids.

13. The method of producing an alloy or compound of iron and titanium which comprises subjecting the co-assembled oxids of iron and titanium, in a reducing atmosphere, to temperatures of from 600 degrees to 800 degrees centigrade and maintaining such temperatures sufficiently long to insure reduction of said oxids.

14. The method of producing an alloy or compound of metals which comprises subjecting the co-assembled oxids of said metals together with carbon to temperatures of from 600 to 800 degrees centigrade and maintaining such temperature sufficiently long to insure reduction of said oxids.

15. The method of producing an alloy or compound of iron with titanium which comprises subjecting the co-assembled oxid of iron and oxid of titanium together with carbon to temperatures of from 600 to 800 degrees centigrade and maintaining such temperatures sufficiently long to insure reduction of said oxids.

16. The method of producing an essentially metallic article of predetermined conformation and containing an alloy of metals which comprises mixing together a plurality of oxids of metals, shaping the mixture into the conformation desired in said article and subjecting it in a reducing atmosphere to temperature below the melting points of said metals but sufficiently high to inaugurate, and maintaining such temperature sufficiently long to insure, reduction of said oxids.

17. The method of producing an essentially metallic article of predetermined conformation and containing an alloy of metals which comprises mixing together a plurality of oxids of metals, shaping the mixture into the conformation desired in said article and, in a reducing atmosphere, heating it sufficiently long and at a temperature sufficiently high to reduce said oxids without melting the resulting metals.

18. The method of producing an essentially metallic article of predetermined conformation and containing an alloy of metals which comprises mixing together a plurality of oxids of metals, shaping the mixture into the conformation desired in said article, and subjecting it together with carbon to temperature below the melting point of said metals but sufficiently high to inaugurate, and maintaining such temperature sufficiently long to insure, reduction of said oxids.

19. The method of producing an essentially metallic article of predetermined conformation and containing an alloy of metals which comprises mixing together a plurality of oxids of metals, shaping the mixture into the conformation desired in said article and heating it, together with carbon, sufficiently long and at temperature sufficiently high to reduce said oxids without melting the resulting metals.

ISADOR LADOFF.

Witnesses:
HARRY S. JENKINS,
D. H. KELLY.