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PROCESS OF PURIFYING METALS.

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To all whom it may concern:

Be it known that I, HENRY M. CHANCE, of No. 819 Drexel Building, in the city of Philadelphia and State of Pennsylvania, have invented a certain new and useful Process of Purifying Metals, whereof the following is a specification.

Broadly speaking, processes for the purification of metals may be classified as follows, viz: those whereby the impurities are removed from the metal and those whereby the metal is removed from the impurities. In the former class the metal is exposed to the action of substances having a chemical affinity for the impurities which are to be removed. In the latter class the separation may be affected by volatilization or by electrolysis of the metal and its redeposition.

My present invention relates to the first-mentioned class of processes, in which chemical affinity is the underlying principle. In carrying out these processes where the purifying substances usually consist of or are contained in gases, fused slags, or solids it is often difficult to obtain the most desirable reagent and to preserve, store, and handle it in its most efficient condition, and there is also often difficulty in bringing such reagent into intimate or molecular contact with the impurities themselves. My process is intended to overcome these difficulties; and to that end it consists in developing or disengaging the purifying reagent by electrolytic action in immediate contact with the metal to be purified in a state of fusion. I thus obtain the double advantage of increased chemical affinity, due to the nascent condition of the disengaged substance, and of insuring the most intimate contact with the impurities themselves. Moreover, I am enabled to employ reagents which cannot well be used under other conditions, because of the difficulty of obtaining, preserving, and applying them in what may be termed a "permanent" free state and also because of the difficulty of controlling their action accurately when added *en masse* to the metal to be purified. It is of course a characteristic of my invention that the reagent thus electrolytically disengaged should have at the temperature used greater chemical affinity for the impurities than it has for the metal to be purified. The process may be operated in an ordinary electrolytic cell adapted to contain a fused electrolyte in contact with a fused metal, and hence I do not

deem it necessary to describe in detail any particular type of apparatus.

In carrying out my process the fused metal is maintained in contact with a fused electrolyte containing the desired reagent and is connected, as one of the poles, to a source of electric energy, the other pole being placed in contact with or partly immersed in the fused electrolyte. The passage of the electric current sets free the purifying reagent in a nascent state from the fused electrolyte at its region of contact with the fused metal, and the element or elements thus set free combine with the impurities contained in the fused metal, forming chemical compounds of such impurities, which may remain suspended or dissolved in the electrolyte or if volatile may pass off as gas or vapor.

The metal to be purified may be fused in a crucible or any suitable furnace—such as an open-hearth, reverberatory, or electric furnace—and is subjected to the described treatment with the electrolyte floating upon it if the specific gravity of the metal be greater than that of the electrolyte, or vice versa if the reverse be true.

My process is not a process of electrolytic purification, but merely uses electrolysis incidentally, and it differs from the ordinary electrolytic processes employing fused electrolytes in that the cell is not used for the production and recovery of metal, but for the purification of fused metal forming one of the poles. It differs from electrolytic refining processes, because the metal to be refined or purified is not dissolved by the electrolyte and redeposited on the other pole. It also differs from refining of metals by direct electrolysis of the impurities, (as is aimed to be done by some processes,) because the purification of the metal in my process is effected by the action of elements contained in the electrolyte, which are set free in a nascent state by the electrolysis of the electrolyte at the region of contact of the metal and electrolyte, and because electrolysis of the fused electrolyte is only used to effect the generation in a nascent state at the surface of the fused metal of elements having at the temperature used a greater chemical affinity for the impurities to be removed than for the fused metal.

It is of course evident that in carrying out this process heat will be generated by the electric current, due to the resistance of both

the fused metal and the electrolyte, and while not essential to the process this heat may be utilized as a partial or as the sole source of heat, as is done in practice in the production of metals from fused electrolytes.

The process may be applied in many ways to the purification of metals. It can be used in the purification of iron and steel by employing as an electrolyte fused calcium chlorid or other electrolytes, simple or compound, of the alkalies and alkaline-earth metals not volatile at the temperature used, the fused iron or steel being made the cathode, the electric current freeing in a nascent state calcium or other metal of the groups mentioned at or upon the surface of the iron or steel. Such disengaged metal immediately combines with the carbon, phosphorus, sulfur, oxygen, and other impurities for which it has great chemical affinity, to form carbids, phosphids, sulfids, oxids, and other compounds, which are carried off by the supernatant electrolyte.

The process may be used for the purification of copper from oxygen, sulfur, phosphorus, selenium, arsenic, and other impurities by using an electrolyte similar to that described for purifying iron and steel, making the fused copper the cathode, the impurities being removed as oxids, sulfids, selenides, arsenides, and other salts of calcium or other metal of the above-named groups. It may also be applied to the purification of copper and nickel alloys from sulfur, arsenic, and other impurities by applying the methods above described to be used for iron or steel and copper. In this and similar applications of the process salts (especially the haloid salts) of the alkalies and alkaline-earth metals capable of electrolytic decomposition when fused are the most useful electrolytes, because at the temperature used these metals most readily combine with and remove the elements that constitute most of the objectionable impurities in metals—such as sulfur, arsenic, oxygen, phosphorus, silicon, tellurium, selenium, the halogens, and other elements—as before specified.

The process may be used in removing metallic impurities from metals and alloys by using an electrolyte of such character that the elements set free from it at the surface of the fused metal or alloy have greater chemical affinity for the metallic impurity than for the metal to be purified—as, for example, the removal of iron from copper, which may be accomplished by using an electrolyte containing electrolytically-available oxygen, making the fused copper the anode and oxidizing the iron by the oxygen set free in a nascent state at the surface of the fused-copper anode.

The process may be also used in purifying metals from easily-oxidizable impurities by making the fused metal the anode and using a fused electrolyte containing electrolytically-available oxygen, which is set free in a nas-

cent state at the surface of the metal and selectively combines with and removes easily-oxidizable impurities present, and similarly also by using a fused electrolyte containing electrolytically-available halogens in cases where the chemical affinity of the halogens at the temperature used for the impurities to be removed is greater than their affinity for the metal to be purified.

If the fused metal and impurities act as an electrolyte, and if at the temperature used the impurities to be removed are electro-negative elements, then the fused metal must be made the cathode, and the impurities must be removed by generating in a nascent state from the electrolyte at the surface of the fused metal an electropositive metal preferably of the groups before named.

In cases where the metal to be purified is made the anode a small quantity of metal or electropositive element will be deposited at the cathode, and while this is purely incidental this metal may often profitably be recovered, which may be accomplished by placing the cathode at one side of, and not vertically above, the fused metal to be purified and permitting the metal disengaged at the cathode (if fusible at the temperature used) to drop off into a depression in the floor of the furnace vertically beneath the cathode, or the metal may be recovered in many other obvious ways. If such disengaged metal be the same as the metal undergoing purification, it may be allowed to drop directly into the anode metal, or if it be a metal that can advantageously be added to such anode metal to form an alloy it may be allowed to drop off directly through the electrolytic bath into the anode metal. As the quantity of impurities to be removed is usually by weight only a small percentage of the metal to be purified, it is evident that any metal deposited at the cathode will be correspondingly small in quantity and will usually be of small economic importance, and such metal may be regarded entirely as a waste or by product and not essential to the working of the process; but the value of the metal so obtained, although small in quantity as compared with the metal being purified, if relatively high-priced, may largely decrease the net cost of operating the process.

The purification of many other metals and alloys may be effected by this process by the use of proper electrolytes and by passing the electric current in the proper direction, as indicated by very simple rules, which will be readily understood by any one versed in the electrometallurgical art.

Among the important practical considerations are the following:

First. If at the temperature used the chemical affinity of oxygen, the halogens, or other elements set free from the electrolyte at the anode for the impurities to be removed be

greater than for the metal to be purified, the fused metal may be made the anode, and the electrolyte may be one containing electrolytically-available oxygen, halogens, or other described element.

Second. If at the temperature used the chemical affinity of oxygen, the halogens, or other elements set free from the electrolyte at the anode for the impurities to be removed be less than for the metal to be purified, or if it is not desirable to introduce into the metal to be purified any of these elements set free at the anode, then the fused metal should be made the cathode, and the active electrolyte should be a salt of a metal having at the temperature used greater chemical affinity for the impurities to be removed than for the metal to be purified, this latter method also being applicable to metals containing impurities provided for in the preceding paragraph.

Third. If oxygen be one of the impurities to be removed, the metal to be purified may be made the cathode, and the electrolyte may be of the class described in the preceding paragraph.

Fourth. If the fused metal and impurities act as an electrolyte, then the fused metal must be made the cathode when the impurities to be removed at the temperature used are electronegative elements and must be made the anode when these impurities are electropositive elements. Under these last-mentioned conditions any electrolytic action which may occur in the fused metal will facilitate the elimination of the impurities by bringing them to the surface of the metal, where an element for which they have great affinity is being set free in a nascent state.

If the fused metal and its impurities do not act as an electrolyte, but merely as a conductor of electricity, the conditions described under the above clause marked "Fourth" need not always be observed; but in a majority of cases the best results will be reached by generating in a nascent state at the surface of the fused metal an electropositive element when the impurities to be removed are electronegative and an electronegative element when the impurities to be removed are electropositive.

I am aware of the use of fused slags in electric furnaces in which the fused metal is made one pole and the other pole is immersed in the fused slag floating upon the fused metal, the

slag being used as a resistance for the purpose of transforming electric energy into heat and also of the use of two or more poles in contact with such slag and also of the use of electric currents passed through the fused metal to electrolyze and remove impurities from the metal; but my process differs from these in that it requires the use of a fused electrolyte or electrolytic slag containing elements electrolytically available and set free at the region of contact of the electrolyte and metal, which elements at the temperature used have greater chemical affinity for the impurities contained in the metal than for the metal to be purified, and which elements combining with such impurities eliminate them from the metal. In my process electrolysis is not used for the purpose of purifying or refining metal, but as a means to effect the generation at the surface of the fused metal of elements having at the temperature used a greater chemical affinity for the impurities to be removed than for the fused metal, and my sole reason for using electric energy is because this is the only manner by which I can produce upon the surface of the fused metal the required elements in a nascent state. My process is not intended to recover, as such, the metal or element which is set free in a nascent state from the electrolyte upon the surface of the fused metal to be purified, and when in using my process an element is recoverable from the electrolyte the metal or element so reduced is a by-product and is disengaged not at the pole where the fused metal is being purified, but at the other pole.

I claim as my invention—

The process of purifying metal, which consists in maintaining the metal, in a fused condition, in contact with a fused electrolyte containing a reagent, which, at the temperature used, has greater chemical affinity for the impurities to be removed from said metal than it has for the metal itself; and electrolytically disengaging said reagent at the region of contact between the electrolyte and the metal.

In testimony whereof I have hereunto signed my name, at Philadelphia, Pennsylvania, this 1st day of June, 1905.

HENRY M. CHANCE.

Witnesses:

JAMES H. BELL,
JOS. C. FRALEY.