D. *List of Patents relating to the Kjellin type of Induction Furnace and its later modifications, prepared by the Gröndal Kjellin Company, of London, September,* 1912—continued.

Patentee.	British Nos., with date of application.	United States Nos., with date of grant.	Canadian Nos., with date of grant.	Subject-matter of Patent.
Härden .	3739 Feb. 15, 1910	None	None	Gas fired furnace with terminal plates.
,, .	None	861031 July 23, 1907	None	
,, .	16269 July 18, 1906	None	103815 Feb. 26, 1907	Furnace transformer with hollow conductors.
,, .	8445 Apr. 11, 1907	897203 Aug. 25, 1908	112412 June 16, 1908	Detachable hearth lining.
,, .	26251 Nov. 12, 1909	967908 Aug. 23, 1910	None	Charge heated by arcs, and by passage of current through terminal plates having suitably graded resistance.
,, .	26266 Nov. 12, 1909	967909 Aug. 23, 1910	None	Composite terminal plate.
,, .	8194 Apr. 5, 1909	977303 Nov. 29, 1910	None	Conducting crucible.
Frick . .	4866 Feb. 27, 1904	917040 Apr. 6, 1909	87552 May 31, 1904	Flat coils above or below crucible.
,, . .	29271 Dec. 22, 1906	932013 Aug. 24, 1909	121300 Oct. 19, 1909	Two or more coils around bath.
,, . .	22519 Dec. 18, 1905	933169 Sept. 7, 1909	104156 Mar. 19, 1907	Suppression of leakfield.

III. Abstracts of the Earlier Patents relating to Electric Furnaces for Iron and Steel Production. Collected and Arranged by John B. C. Kershaw.

1879, *No.* 2110. Granted to *Charles William Siemens*, of London, for "*Improved Means and Apparatus for Producing Light and Heat by Electricity.*"

(An Extract from this Patent is printed on p. 12).

1887, *No.* 700. Granted to *Sebastian Ziani de Ferranti*, of London, for "*Improvements in Electric Furnaces and Apparatus for Heating, Lighting, and carrying on Chemical Processes; and in the Working of such Furnaces or Apparatus.*"

I, Sebastian Ziani de Ferranti, of 5, Stanwick Road, West Kensington, in the County of Middlesex, Electrician, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

According to this invention I form an electric furnace in such a manner that the current which circulates in the crucible or container of the furnace is not conducted there from the outside but has local currents induced in it by a varying or alternating magnetic field or it might be by a rotating or moving field. In this way an electric furnace is obtained without electrodes in the crucible thereby avoiding all action of electrodes upon any metal or ore that is being melted or reduced therein.

One way in which the furnace may conveniently be formed is to make the crucible of an oblong annular shape placed horizontally and with magnet core pieces rising up through the open space in the centre and outside each of the two longer flattened sides and with an insulated conductor wound between the pole pieces below the crucible. Preferably I insulate the conductor with fire clay or asbestos or slag.

The central and outer pole pieces are connected at the bottom so as to form two horse-shoe magnets one embracing one of the longer sides of the crucible and the other the other side of the crucible. Connecting pieces are also placed over the tops of the pole pieces but these are removeable so that the crucible may be readily got at and charged with material.

The crucible forms a continuous trough open at the top and a suitable lid is provided by which it can be covered over when the furnace is in operation. The whole furnace may be mounted on trunnions projecting from the centre of its longer sides—so that it may be tilted and the contents of the crucible when liquid poured out from one of its ends.

When the furnace is to be used for melting metal or reducing ores I form the crucible or container or refractory material, and if necessary line it with a lining of any refractory substance.

When a metallic ore is to be reduced in the crucible a strip of wire or blanks or pieces cut from thin sheets of the metal contained in the ore or with which the metal in the ore is to be alloyed may be placed around the interior to give conductivity at starting or a granulated conductor or a flexible carbon stick or carbonized paper may be placed around the interior of the crucible to effect the same object.

When carbon is required to be used in the reduction of the ore thin layers of carbon may be alternated with thin layers of ore—or a gas or vapour rich in carbon might be supplied to the crucible as the process of reduction is being carried on. For some metallic processes a vacuum may when required be formed in the crucible to extract gases.

When several furnaces are used they may be placed in parallel on the circuit of the exciting machine the current may also be fed to each furnace through what are known as distributors.

Induction resistances may also be used to regulate the working of the several furnaces.

If the furnace is to be used for boiling or heating liquids a pot of brass or copper may be substituted for the refractory crucible.

In this way the furnace may be used for boiling water or for heating generally either for cooking or for other purposes as for example for heating water in a pipe or vessel forming part of a circulating hot water heating apparatus. The furnace can also be used for effecting the decomposition of liquids contained in a pot or vessel of insulating material or the precipitation of metal from them in cases where it is undesirable to act upon the liquids by electric currents passing through electrodes.

When the furnace is to be used for obtaining light a shallow crucible left open at the top may be used and powdered charcoal be supplied to it or a metal such as platinum or iridium--the crucible used may in this latter case be conveniently formed of lime.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is :—

1. An electric furnace or apparatus in which metal or material whilst contained in a suitable crucible or vessel is heated or melted by currents induced directly in it.

2. An electric furnace or apparatus composed of a crucible or containing vessel heated by induced currents circulating in it or in the material contained in it without such currents being conducted there from the outside.

3. An electric furnace or apparatus composed of an annular crucible or vessel of refractory material in a varying or alternating magnetic field or in a rotating or moving field.

4. An electric furnace or apparatus composed of an annular crucible or vessel of conducting metal or material in a varying or alternating magnetic field or in a rotating or moving field.

5. The construction of electric furnaces or apparatus substantially in the manner herein before described and illustrated in the drawings annexed.

1898, *No.* 11604. Granted to *Ernesto Stassano*, of Rome, for "*Improvements in and connected with the Electro-metallurgical Production of Iron, Steel, and their Alloys with Chromium, Tungsten, Nickel, Manganese, and the like.*"

I, Ernesto Stassano, of Via Porta Salaria, No. 7, Rome, Italy, Captain of Artillery in the Italian Army, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement :—

This invention relates to improvements in and connected with the electro metallurgic production of iron, steel and their alloys with chromium, tungsten, nickel, manganese and the like and consists in the utilisation of the heat radiating from the voltaic arc for primary determining the reduction of the oxide of iron and other metals, so as to enable the carbon, added to the mineral, to effect the reduction of the oxide, absorbing the oxygen of iron and changing itself in volatile carbonic oxide, the mass afterwards accumulating at the bottom of the furnace from whence it is run into moulds for ultimate industrial use.

For this purpose the ore, prepared as hereinafter described, is introduced into an electric furnace and subjected to the heat which radiates from the voltaic arc produced at the bottom of the furnace.

The said furnace consists of a chamber having the form of a vertical double cone the large bases of which abut against each other. The smaller inverted cone of the said chamber abuts against another slightly conical chamber which forms a pot.

At the joint of the said pot and smaller lower cone are employed two carbons which form the poles for the electric current between which the arc is formed.

The distance between the said carbons may be altered at will in any suitable manner.

The pot is formed with a hole through which the metallic fluid is run out. The top of the furnace is closed by a hopper having at its lower end a valve operated by a pull lever which permits of placing the ore into the furnace without permitting air to enter the same. Near the top two holes are formed in the furnace, furnished with tubes which serve for the escape of the products of reaction and which are connected with a hydraulic valve, adapted to prevent the entrance of air when the internal pressure of the gases is below that of the atmosphere.

The ore is prepared as follows :—

First of all the ore whatever it may be (oxide or carbonate) is carefully selected by hand and then reduced and pulverised by any well known means.

After having sifted and washed the powder to the required extent

and dried, when its nature allows it, it is magnetically refined for the purpose of separating the gangue which may remain mixed therewith, *i.e.* it is well known that oxide or iron such as FeO, Fe^2O^3, is attracted by the magnet and in this invention the mineral is thus, in a pulverised state, passed under a magnet in order to separate it from the gangue as much as possible.

The ore is then carefully analyzed for the purpose of correctly ascertaining its composition and to regulate the amount of carbon, lime, silica necessary to promote fusion.

Calcareous products are added if the mineral is of a silicious nature and silica is added if the mineral is calcareous. Afterwards the substances aforesaid which may be finely powdered, are mixed with the said mass; 5—10 *per cent.* water is then added thereto and the paste subjected to a pressure of about 150—200 kilograms per square centimetre.

The cakes thus obtained when dry are reduced to pieces of about 3—4 centimetres in size and the furnace is then charged with this material.

If it is desired to produce alloys of iron, the ore is mixed and melted with the oxides of metal required for the production of the quality and kind of material desired.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is :—

1st. The utilization of caloric energy of the voltaic arc for primary determining the reduction of oxide of iron and the metals to be combined therewith and afterwards melting the metallic masses reduced, for the purpose of obtaining in a fluid state the product desired, all substantially as set forth.

2nd. The method of preparing the ore, all substantially as described.

3rd. The general construction and combination of parts and method of closing the furnace, all substantially as set forth.

1900, *No.* 18921. Granted to *Gustav Benedicks*, of Stockholm, for "*Improvements relating to Electric Furnaces.*"

I, GUSTAF BENEDICKS, of 4, Birger Jarlsgatan, Stockholm, in the Kingdom of Sweden, Managing Director of a Company, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement :—

For smelting or heating ores metals and the like furnaces have already been employed, in which an electric current sufficient for the

smelting of the ore or of the metals is induced in the material to be heated or smelted, or in a conductor in contact with said material, by means of alternating currents produced in a coil surrounding the furnace, which encloses a core of iron or of other magnetic material. The object of my invention is to arrange the induction coils in such furnaces in such a manner that they become cheaper and more effective.

In order that my invention may be readily understood and carried into effect I will describe the same fully with reference to the accompanying drawings in which :—

Referring to the drawings, the furnace is seen to consist of the following parts :—the refractory walls of the furnace and an annular groove or chamber for the reception of the charge to be smelted or heated; and a central channel, surrounding the iron-core. In furnaces of this kind as heretofore constructed, the conductor connected to the generator for the electric current, is coiled around the furnace, but according to my invention the conductor is coiled directly on the core and thus inside the smelting or heating chamber.

By arranging the conductor in such a manner the advantage is attained that the length and thus the cost, as well as the loss of energy at the passage of the current, is considerably reduced. The surface of the wall between the induction coil and the chamber also becomes considerably smaller than in the case when the conductor is placed outside said chamber, in consequence whereof also the quantity of heat transmitted from the furnace to said conductor, becomes smaller.

The larger diameter the furnace possesses, the larger is the area between the induction coil and the chamber (at the same thickness of the wall), when the coil is placed outside the furnace and the number of the lines of force which escape between the coil and the chamber also becomes larger in consequence whereof the self-induction is increased. By such an arrangement the effect thus is diminished as the diameter of the furnace increases.

In furnaces arranged according to my invention the space between the induction coil and the chamber becomes independent of the diameter of the furnace and always smaller than when the coil is placed outside said furnace-chamber, in consequence whereof the effect becomes considerably greater than in the furnaces as heretofore constructed, and in addition my improved furnaces may also be made in considerably larger sizes than has been possible heretofore.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is :—

An improved electric furnace for smelting or heating by means of

an electric current induced in the material to be smelted or heated or in a conductor being in contact with said material, in which furnace the induction coil is coiled inside the smelting or heating chamber around the central iron core, surrounded by said chamber instead of being coiled outside the furnace substantially as hereinbefore described and illustrated by the accompanying drawings.

1900, *No.* 22584. Granted to *Charles Albert Keller*, of Paris, for "*An Electric Furnace with Two Bed-Plates.*"

The present invention has for its object an improved furnace which obviates the serious drawbacks caused by overheating and combustion of the electrode at the point where it enters the furnace roof, and which operates without electrodes external to the furnace. Its electrodes are formed of two movable sole-plates, the couplings and connections whereof are completely separated from the furnace hearth, the deteriorating action of which can consequently have no effect upon them.

The furnace comprises principally two movable sole-plates of the same shape each of which is composed of a certain number of fixed carbons preferably of rectangular section, which carbons are placed upon a base plate of sheet iron and surrounded at their upper part by a hearth of refractory material. This hearth is formed of little arches of fire-brick supported at one side upon the metallic centre piece having sloping sides and on the other side upon the metallic side plates. The four ends of the fixed carbons rise above the fire-brick-sole for a suitable distance and have the small carbons simply placed upon them. The electric contacts of the connecting pieces are thus completely separated from the melting bed and are heated by conduction of the heat merely to the minimum temperature at which they can be kept. Small copper bars are suitably attached to the faces of the lower part of the fixed carbons by means of coupling-plates and bolts. These bars which are bent at right angles outside the body of the sole-plate, are connected to the conductors of the source of electricity. The coupling-plates bear the sole-plate supports fixed to the bottom of the sole-plates and thus connect the carbons fully to the copper bars carrying the current at the same time as the base on which they rest. The size of the sole-plate are free from the connecting organs of the conductors so as to render the inspection and control thereof easy and to allow of the circulation of air around the conductors of the electric current; this circulation can be rendered more active by means of a fan. The two sole-plates can be separated as may be requisite by means of the melting bed the length whereof is variable according to the

electric power to be employed. This melting bed is preferably of fire-proof brick-work and contains only the material to be treated. Each of the movable sole-plates possesses a metallic bar which engages in the recesses formed in the masonry to prevent the falling down of the current conductors and of the fused material which covers them. The sole-plates are connected together by a system of cables travelling upon sheaves and attached to a wheel upon the shaft of which is a crank and handle. In order to render the grip of the cable upon this organ more effective a drum may be used in place of the wheel shewn and the cable may be coiled thereon two or more times. The upper part of the electric furnace is formed of an arch of fire-proof material having a chimney for the escape of the hot gases. Openings formed in the walls of the furnace admit of the insertion of the sole-plates in the interior thereof; the said openings may be closed or not after the introduction of the said plates.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. An improved electric furnace in which two sole-plates are combined to form electrodes in a single furnace, each of said sole-plates being respectively connected to one of the terminals of the source of electricity, in such a manner that the electric current flowing from one sole-plate to the other through the material to be treated can heat the same to incandescence and fusion substantially as set forth.

2. In an electric furnace of the type set forth, the arrangement upon the two sole-plates of movable carbons supported by the fixed carbons, the said movable carbons being the only replaceable electrodes and preferably composed of the fragments of electrodes otherwise useless in the industry, substantially as set forth.

3. In an electric furnace of the type set forth, a sole-plate formed of a plurality of fixed carbons receiving the electric current by contact on their faces by means of thin copper conductors in the manner set forth and transmitting the same to small electrodes placed loosely upon them, the melting bed of this sole-plate being separated from the chamber containing the electric contacts by means of a floor of refractory material preventing the heating of the contacts by conduction and permitting the said contacts to be accessible and capable of refrigeration if requisite, substantially as set forth.

4. In an electric furnace of the type set forth the arrangement of a melting bed between two mobile sole-plates in such a manner as to admit of the resistance of the furnace being regulated by the moving towards or from one another of the said mobile sole-plates and the avoidance if necessary of contact of the material treated with the carbons

of the sole-plates; said sole-plates having metallic contact pieces passing through channels formed in the brick-work of the furnace bed in such a manner as to prevent the falling down of the conducting body or of the material treated, substantially as set forth.

5. The improved electric furnace constructed as described and illustrated with reference to the accompanying drawings.

1901. *No.* 14486. Granted to "*La Société Electro-métallurgique Française*," of Froges, Isere, France (Owners of the Heroult Patents), for a "*Process and Apparatus for the Manufacture of Wrought Iron, Steel, and Cast Iron, by Electric Heating.*"

This invention relates to an improved process for the production by means of an electric furnace of wrought iron, steel, and cast iron of very definite composition, the separation of the impurities from the ore or the metal with which the process starts being ensured by a methodical operation which also enables the exact content of carbon of the final product to be determined.

For this purpose an electric furnace is employed so arranged that the metal produced is protected against contact with the electrodes, which furnace may be of known construction, but is preferably of the construction hereinafter described.

The characteristic feature of the process is that by means thereof there may be obtained at will from one and the same furnace and even during one and the same operation, various descriptions of cast iron, wrought iron, or steel of any degree of carburisation.

The reduction, fining and purification of the metal are effected successively in the same apparatus, by means of the successive additions of reagents and by variations of the temperature.

The furnace chamber is formed as a rectangular crucible into which project the electrodes ; it is provided with two tapping holes at different levels ; the lower one serves for running off the metal, and the upper one serves for running off the slag and other impurities.

The furnace is closed at top as follows :—Between the electrodes, and on the outer sides thereof are placed arched covers composed of fire-bricks encased in an arched iron framing having an outer rib which is formed with a hole at each end, and one in the middle ; at the ends are angle iron abutments for the fire-brick lining. By means of the holes the one or the other end of either cover can be raised up, as shewn at Fig. 4, thus forming a charging door. The covers can also be entirely removed by lifting tackle by means of a hook engaging with

the middle hole and a chain. The open spaces on the sides and between the electrodes are closed by fire-brick slabs.

For producing metals direct from the ore, the furnace is started in the ordinary way by throwing in a mixture of ore and carbon or a small quantity of metal; the furnace is then fed intermittently with charges of ore mixed with carbonaceous matter in suitable proportions.

The ore is preferably employed in lumps so as to form above the slag bath a permeable layer through which the reaction gases can rise, whereby these heat and partially reduce the ore and then pass away in a cooled condition.

Any kind of carbonaceous fuel can be used, the quality depending only upon the kind of metal to be produced; it is preferably employed in the form of granules.

The quantity of fuel employed per unit of metal will vary firstly according to the proportion of reducible oxide in the ore; secondly according to the proportion of carbon required in the metal to be produced, and thirdly according to the more or less perfect utilisation of the reducing gases given off, that act upon the ore. The proportion of carbon employed must therefore be determined for each particular apparatus and for each kind of ore.

Under the action of the electric current the ore is melted and reduced; the heavier metal collects at the bottom of the furnace while the slag collects on top. When the slag has collected to a certain extent it is discharged through the upper tapping hole, either continuously or intermittently.

The smelting operation consists of several phases which I will describe successively.

Reduction.

According to the proportion of carbon enployed and the temperature attained, there may be obtained at will either wrought iron in pasty or liquid form, or a more or less carburated metal.

Thus wrought iron can be manufactured directly in operating in the presence of an excess of oxidising slag, but this method is less economical than if cast iron be first produced and this be then refined and purified in the same apparatus. The temperature required for the production of cast iron is much lower than that necessary for producing wrought iron, so that a considerable saving of electrical energy will be effected and the uselessly expended heat in raising the slag to the high temperature is also saved. The temperature need only be raised to a higher degree towards the end of the refining and purifying operation.

The process is therefore preferably carried on in the last described manner.

The process may also be carried out with advantage by first reducing the ore and producing cast iron in a furnace which may either be heated electrically or otherwise, and then effecting the refining and purification in the above described electric furnace.

Refining and Purifying.

The furnace being started and a bath of metal having been produced in the bottom thereof, the excess of slag is discharged through the upper tapping hole, and there is added oxide of iron or other suitable oxide which forms on the bath of the ore an oxidising bath. The refining is effected by the reaction of the slag and the carburated metal, and takes place very rapidly on account of the high temperature of the furnace. The refining can be stopped at the desired point, or it can be carried further and the metal be afterwards brought back to the desired condition by suitable additions, in the known manner.

The purification is effected in the same furnace, either during or after the refining. For dephosphorising the slag is rendered basic by the addition of lime ; for the production of special kinds of steel there are added, before tapping off, suitable substances in the known manner.

The process can be employed for the manufacture of wrought iron or steel from cast iron and scrap whether the cast iron be charged in a molten condition from a blast furnace, cupola, and the like or whether it be charged in solid pieces.

In all these operations the quality of the metal can be ascertained by taking samples with a ladle.

All the above described operations are effected according to this invention under economical conditions at least as advantageous as by the ordinary metallurgical processes, and the products obtained are comparable in quality with the best products furnished by the Siemens or crucible processes.

I am aware that Siemens melted steel in an electric crucible in the year 1884 ; but the processes employed heretofore comprised two kinds of apparatus, namely, firstly those in which the metal has not been protected from contact with the electrodes, or where the crucible has been made of carbon ; in this case carburation of the metal has necessarily taken place and consequently products could not be obtained, such as result from the present invention ; secondly, the furnaces in which the contact of the metal with the electrodes is avoided are heated by radiated heat from a resistance, and by this means even a small quantity of material cannot be heated to a sufficiently high temperature, so that no practically useful result is obtained.

Thirdly, none of the processes heretofore proposed have employed an apparatus arranged so as to discharge the slags separately and to effect during a single operation a series of refining and purifying reactions.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is :—

1. The herein described process for the manufacture of all kinds of wrought iron, steel, and cast iron, in an electric furnace wherein the metal bath is protected from contact with the electrodes and the slag or scoria is discharged as may be required at a level above the metallic bath.

2. The herein described construction of electric furnace for carrying out the method of operating referred to in the first claim, which furnace has a second tapping-hole situated above the usual one and serving for the discharge of the slag, scoria and other impurities floating upon the metallic bath.

3. In an electric furnace such as is referred to in the second claim, the use of a movable cover or set of covers for enclosing the top of the furnace and adapted to be raised or tilted up on one side for effecting the charging of the furnace with the ores, pig metal, scrap and other materials to be treated substantially as described.

4. The use of an electric furnace with an upper and a lower tapping hole for the direct production of wrought iron from iron ore, substantially as described.

1901, *No.* 14643. Granted to "*La Société Electro-métallurgique Français,*" of Froges, Isere, France (Owners of the Heroult Patents), for an "*Electric Furnace arranged for being Oscillated or Tipped.*"

This invention relates to an electric furnace that is capable of being oscillated or tipped over for discharging its contents, which allows all the operations that are performed by means of the ordinary electric furnace to be carried on, with the advantage that it can be used for other operations such as the manufacture of steel.

The arrangement of the furnace is such that its contents can if desired be only partially discharged, so as to leave a certain portion in the same for starting a further operation with certainty and rapidity.

Also, for certain purposes only a fraction of the contents of the furnace can be run off practically without interrupting the operation, which in being continued may result in a product different from the

portion previously run off, so that, for example, several qualities of steel can be manufactured from a single charge of the furnace.

If the furnace be provided with suitably arranged tuyeres, steel can be treated according to the Bessemer process, by tilting the furnace backwards so that the metal covers the tuyeres and then admitting the blast. In this case pig metal can be treated which need not contain either phosphorus or silicon, because in this case the necessary heat is not required to be furnished by the phosphorus or the silicon, being supplied by the electric energy either during the blast or during intervals when this is interrupted. For a furnace of the size shown with carbon electrodes measuring 30 cm. × 30 cm. a current of about 100 volts for the two arcs is employed, the strength varying from 2,000 to 5,000 amperes.

The tilting of the furnace can be effected by any suitable means such as a hydraulic motor. The metal may be run from the furnace either into ingot moulds on trucks or into casting ladles.

The furnace consists of a crucible closed by a cover which carries a small chimney and through which the two electrodes pass; a spout is provided for running off the metal on tilting the furnace.

For effecting the tilting, the bottom of the furnace is arched and carries two arched rails, having on one side a flange, like a railway wheel, and formed with cogs on the other side, which engage with corresponding cogs formed on straight rails fixed on the floor. A flat portion of the rails rests upon the flat portion of the rails at the side of the cogs, which only serve for guiding.

Each electrode is carried by an arm projecting from a sliding upright, which can be raised or lowered by means of a rack and toothed gearing worked by a worm and hand wheel, the upright being guided by rollers in a standard which is of a trough-shaped section. These standards are fixed to the back of the furnace casing as shown, with the inter-position of insulating material.

Each carbon electrode is surrounded by a collar or loop of sheet metal, copper wedges being inserted between the two, which wedges serve to convey the electric current to the electrode, conducting tables serving to supply the current to the wedges, to which they are secured by bolts. A screw spindle turned by a hand wheel enables the collar to be tightened up or loosened, the spindle screwing through a nut fixed to the two ends of the collar and thereby drawing the latter and with it the electrode with greater or less force against a plate fixed to the arm. Two doors arranged in diagonal positions at each narrow end of the furnace serve for charging the materials as also for repairs and for clearing the furnace bed and the electrodes from adhering material.

In the modification the carbon electrodes are carried by the arm

fixed to the upper end of the plunger of a hydraulic cylinder whereby the electrodes can be more readily raised up entirely out of the furnace as indicated by the dotted lines. Another hydraulic cylinder, the plunger of which is attached to the rail, serves to tilt the furnace over when required.

When the furnace is to be used for bessemerising, a wind chest is provided at the back of the furnace, from which tuyeres pass through the furnace wall in such a position as to open above the metal bath for ordinary working, but which are submerged in the bath when the furnace is tilted backwards, so that on them sending a blast through them the required bessemerising is carried out.

If the spout of the furnace be formed as a ladle at its end and be provided with a discharge hole and plug, the furnace may be used directly for casting purposes, on being tilted forward, and as the metal is in this case drawn from the bottom of the bath, it will be very free from impurities.

The above construction of oscillating or tipping furnace may also be used with only a single pendant electrode, the second electrode or pole of the circuit being fixed to the interior of the furnace.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. An electric furnace arranged to be oscillated or tipped wherein all the metallurgical operations usually performed in electrical furnaces can be carried on and which can also serve for the manufacture of steel, the said furnace being constructed and operating substantially as herein described.

2. In an oscillating furnace such as is referred to in the first claim, the arrangement of the carbon electrodes within collars or loops which hold them on the supporting arm, the current being conveyed to the electrodes by means of copper wedges pressed against them by the collars which wedges are connected to the electric circuit, substantially as described.

3. In an oscillating furnace, such as is referred to in the first claim, the provision of tuyeres connected to a blast supply for carrying out the same operations as in a Bessemer converter, in employing pig metal, which need not contain either phosphorus or silicon, substantially as described.

4. In an oscillating furnace such as is referred to in the first claim, mounting the carbon electrodes upon the plungers of hydraulic cylinders adapted to raise them entirely out of the furnace when this is to be tipped, substantially as described.

5. The combination with an oscillating furnace such as is referred