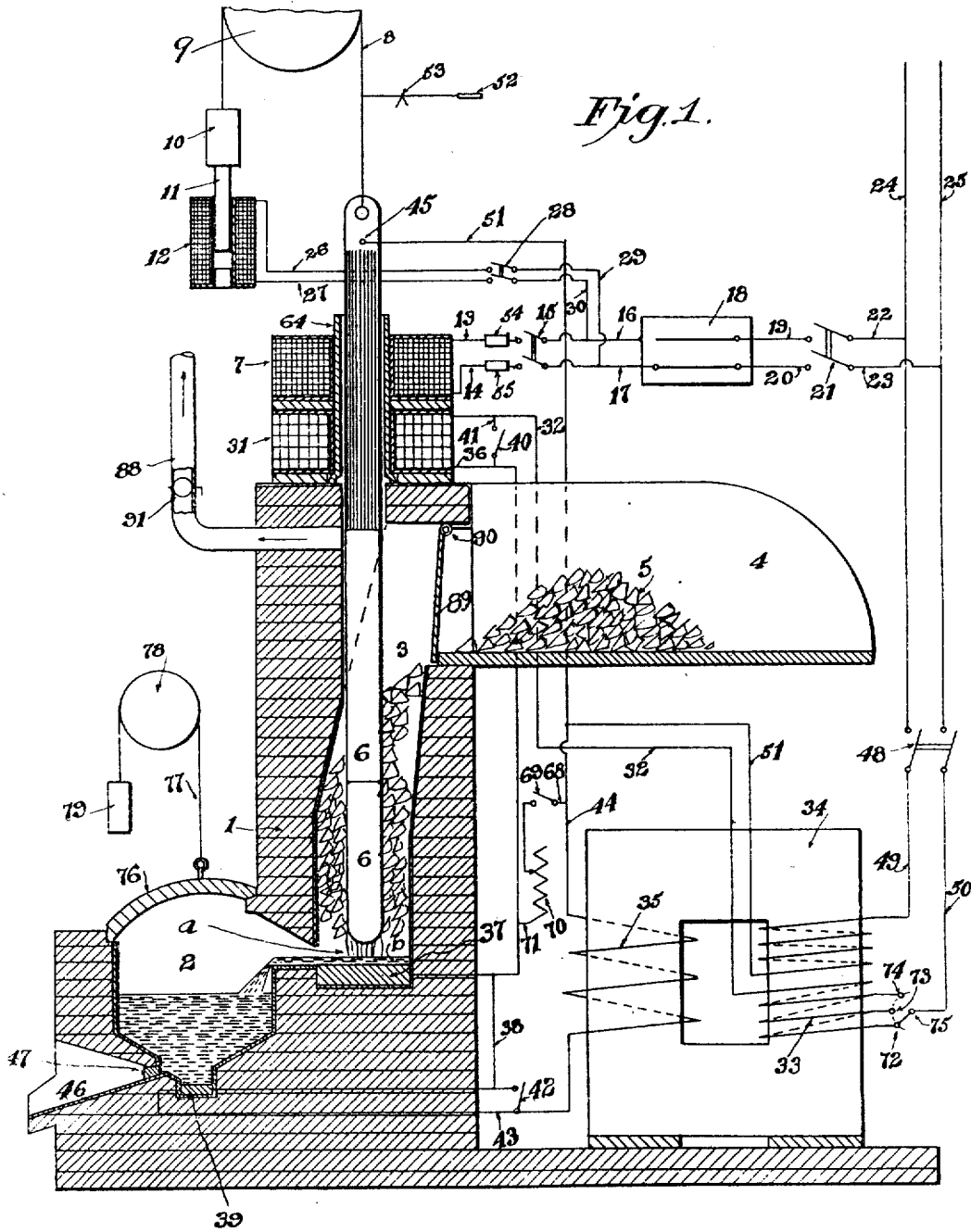


P. & I. B. WRIGHT.
ELECTRIC FURNACE AND METHOD OF MELTING METALS AND SMELTING ORES.
APPLICATION FILED NOV. 21, 1917.

1,296,896.

Patented Mar. 11, 1919.

4 SHEETS—SHEET 1.



WITNESSES
Frank H. Brown
Chas. E. Carmichael

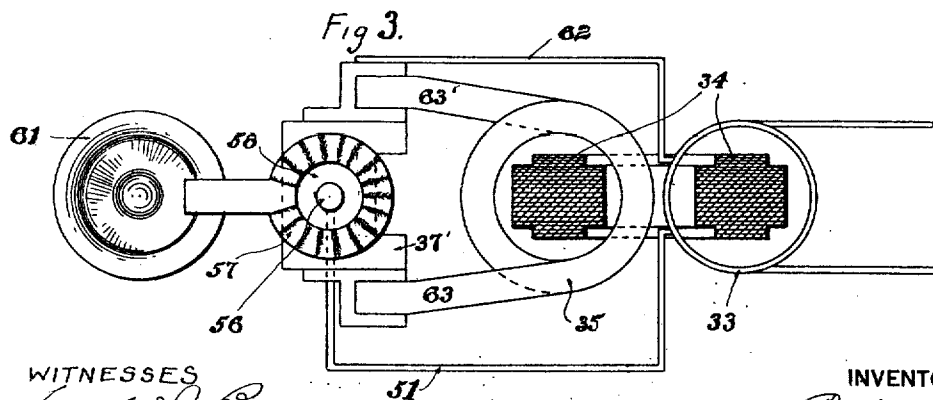
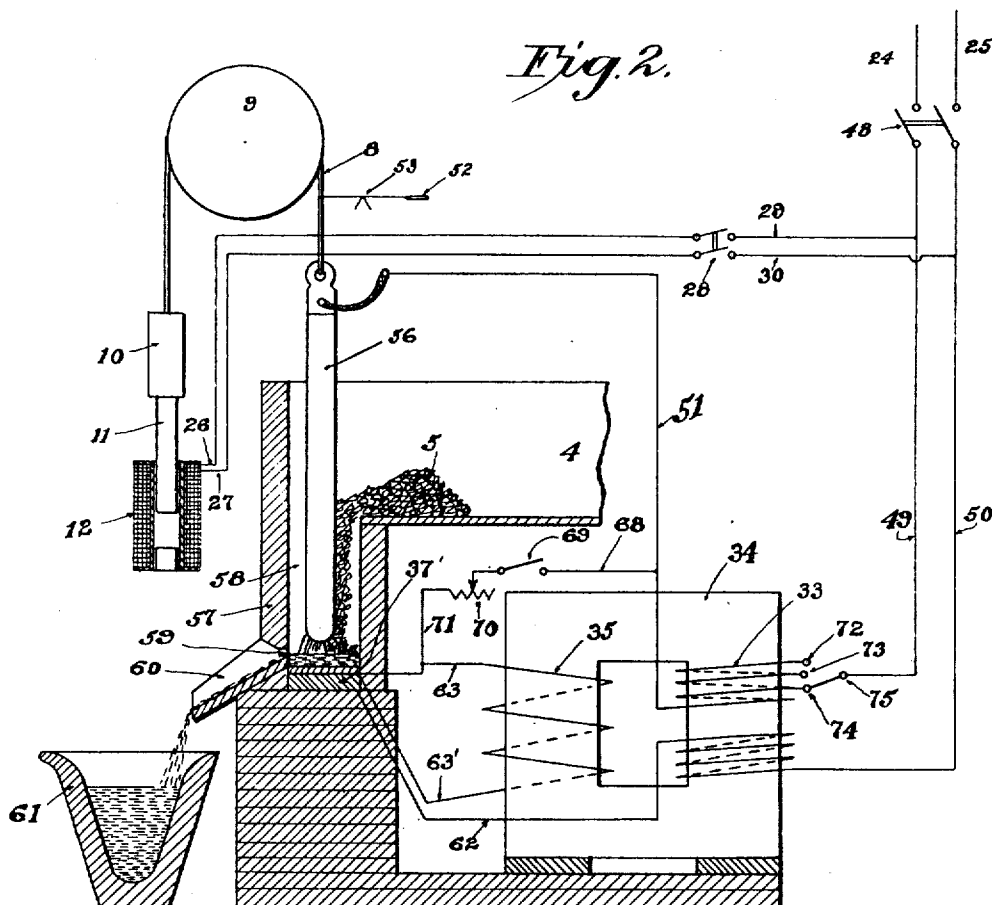
INVENTORS
Patron Wright
Frank Wright
ATTORNEY

P. & I. B. WRIGHT.
ELECTRIC FURNACE AND METHOD OF MELTING METALS AND SMELTING ORES.
APPLICATION FILED NOV. 21, 1917.

1,296,896.

Patented Mar. 11, 1919.

4 SHEETS—SHEET 2.



WITNESSES
Frank O. Brown
Chas. E. Parmelee

INVENTORS
Parvin Wright
Frank Wright

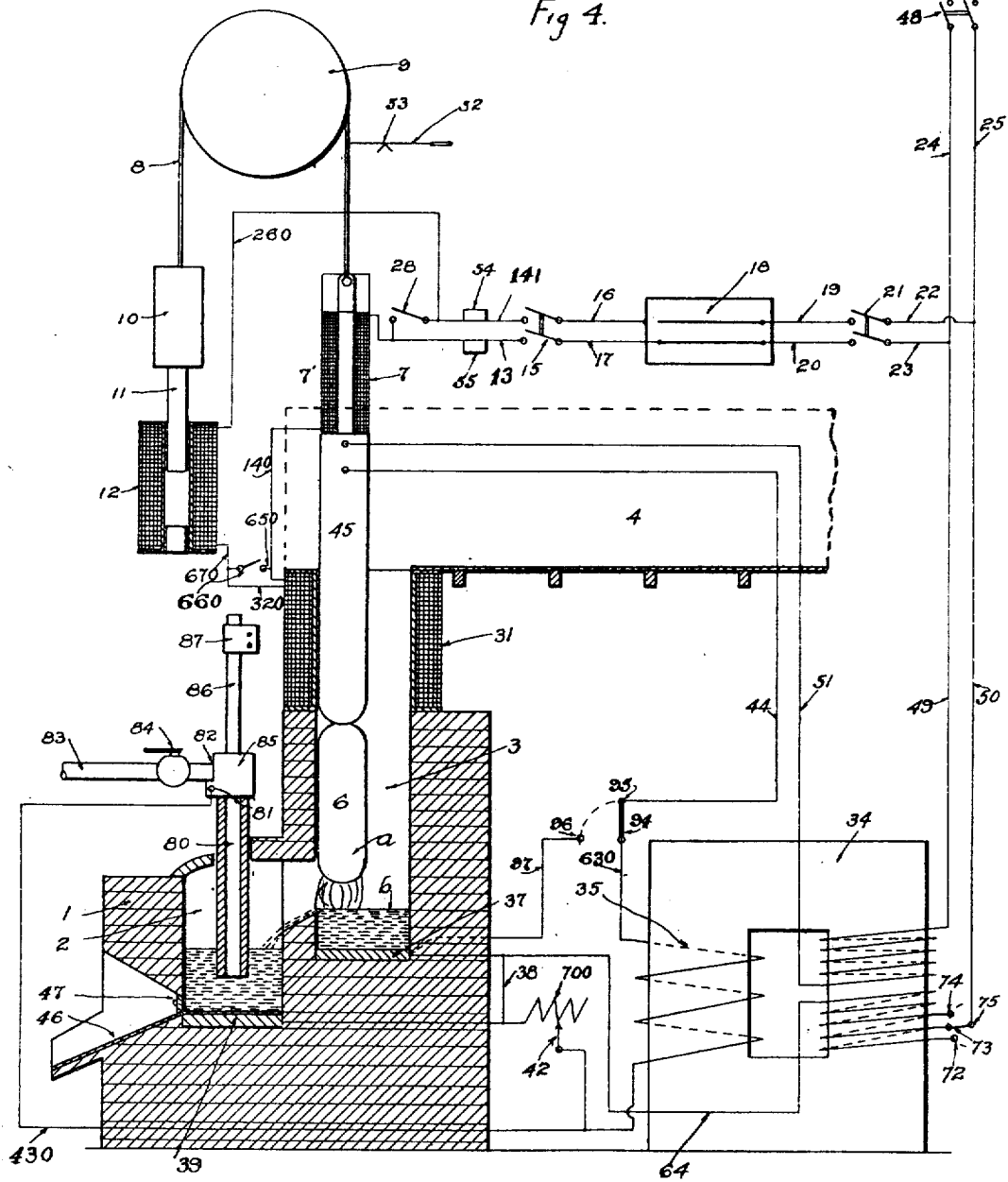
ATTORNEY

P. & I. B. WRIGHT.
ELECTRIC FURNACE AND METHOD OF MELTING METALS AND SMELTING ORES.
APPLICATION FILED NOV. 21, 1917.

1,296,896.

Patented Mar. 11, 1919.
4 SHEETS—SHEET 3.

Fig 4.



WITNESSES
Frank O. Brown
Chas. E. Carmelke

INVENTORS,
Parvin Wright
Charles B. Wright

ATTORNEY

P. & I. B. WRIGHT.
ELECTRIC FURNACE AND METHOD OF MELTING METALS AND SMELTING ORES.
APPLICATION FILED NOV. 21, 1917.

1,296,896.

Patented Mar. 11, 1919.

4 SHEETS—SHEET 4.

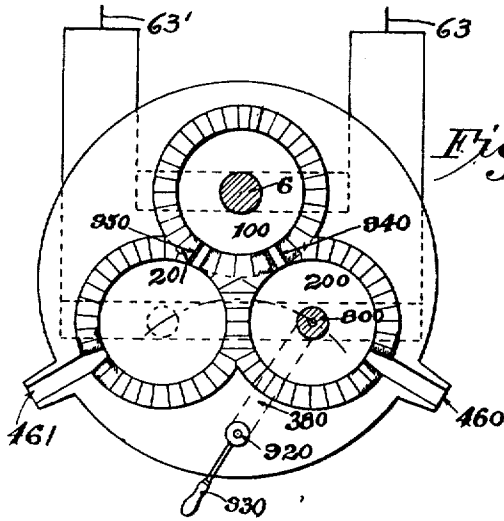


Fig. 5.

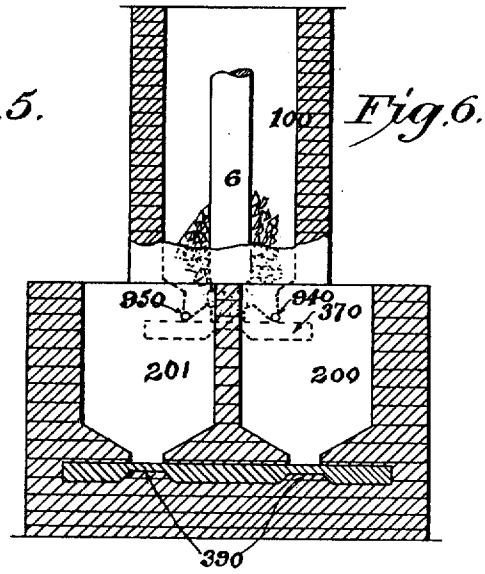


Fig. 6.

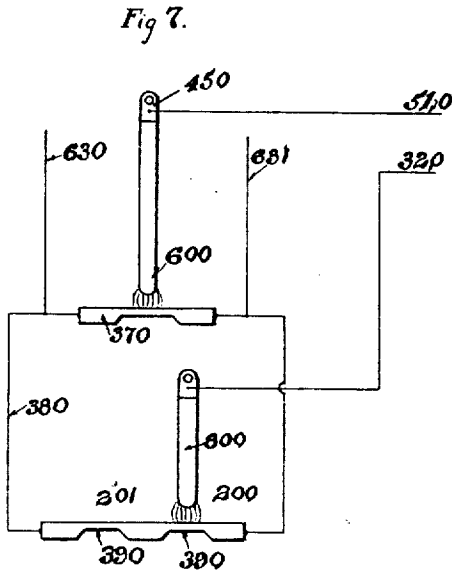


Fig. 7.

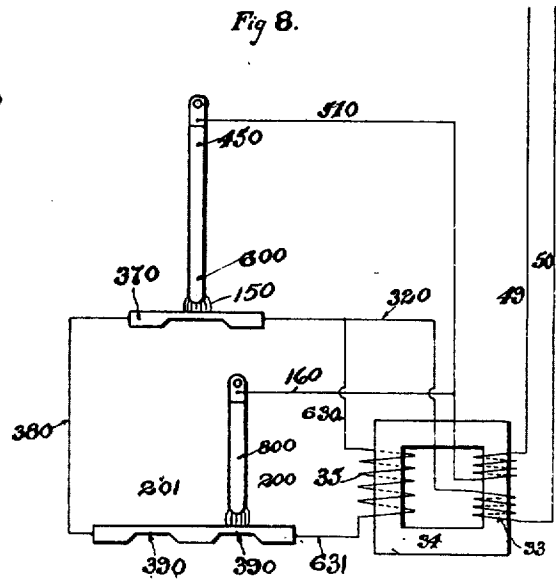


Fig. 8.

WITNESSES

Frank J. Brown
Chas. E. Parmelee

INVENTORS

Parvin Wright
Chas. B. Wright

ATTORNEY

UNITED STATES PATENT OFFICE.

PARVIN WRIGHT AND IVAN B. WRIGHT, OF SEATTLE, WASHINGTON.

ELECTRIC FURNACE AND METHOD OF MELTING METALS AND SMELTING ORES.

1,296,896.

Specification of Letters Patent.

Patented Mar. 11, 1919.

Application filed November 21, 1917. Serial No. 203,154.

To all whom it may concern:

Be it known that we, PARVIN WRIGHT and IVAN B. WRIGHT, both citizens of the United States, residing in Seattle, in the county of King and State of Washington, have invented a new and useful Electric Furnace and Method of Melting Metals and Smelting Ores, of which the following is a specification.

This invention relates to electric furnaces as well as to methods of melting metals and smelting ores, and has for one of its objects to produce a furnace in which the material to be melted or smelted will be acted on with a maximum efficiency as regards the consumption of current.

With this and other objects in view the invention consists in the novel steps and combinations of steps constituting the process and in the novel parts and combinations of parts constituting the apparatus, all as will be more fully hereinafter disclosed, and particularly pointed out in the claims.

Referring to the accompanying drawings forming a part of this specification in which like numerals designate like parts in all the views:

Figure 1 is a diagrammatic side elevational view partly in section of a furnace made in accordance with this invention;

Fig. 2, is a view similar to Fig. 1 of a somewhat modified form of the invention;

Fig. 3 is a plan view of a portion of the parts shown in Fig. 2;

Fig. 4, is a view similar to Fig. 1 of another modified form of furnace;

Fig. 5, is a plan view of a portion of a still further modified form of furnace;

Fig. 6 is a sectional view partly in elevation of the parts shown in Fig. 5;

Fig. 7, is a modified diagrammatic view of circuits suitable for the constructions shown in Figs. 5 and 6; and

Fig. 8 is a still further modified diagram of circuits suitable for the furnace shown in Fig. 5.

The body of the electric furnace Fig. 1, is indicated at 1, it may be of any suitable construction, and is, when desirable, provided with a receptacle 2, to form a converter, or accumulating crucible. It is also provided with a relatively long vertical chute 3, forming an arc chamber into which the ore to be smelted or the metal to be melted, or both, are fed from a hopper 4.

Ore or scrap metal in the hopper 4, is indicated at 5 and pig iron is indicated at 6.

The pig iron 6, and the other magnetizable material is magnetically supported and fed into the arc chamber 3 by means which will now be described. The electro-magnet 7, is provided with a core 45 suitably suspended as by a cable 8 passing around a sheave 9 to a counterbalance 10, which is provided with an armature 11 adapted to be moved by a solenoid 12. Said solenoid and cable also supports the magnetic metal, or ores, suspended from said core 45. The said electro-magnet 7 has its leads 13 and 14 connected to a switch 15, which in turn is connected by leads 16 and 17 to a suitable source of direct, alternating or rectified electric current supply. In the instance shown in Fig. 1, direct current is supplied to the leads 16, 17 by a suitable rectifier 18, which receives alternating current through leads 19 and 20 connected to a switch 21, said switch in turn being connected by leads 22 and 23 to main line conductors 24 and 25 respectively. These main line conductors are supplied with alternating current from any suitable source of supply, not shown.

The solenoid 12 has its leads 26 and 27 connected to a switch 28 which in turn is connected by leads 29 and 30 to the leads 17 and 16 respectively. Thus when the switches 21, 28 and 15 are closed the electro-magnet 7 and solenoid 12 are energized.

Surrounding the upper portion of the arc chamber or chute 3, is an energizing or magnetizing coil 31 wound for alternating currents, and adapted to rapidly change the polarity of the magnet particles of the combined electrode and resistor formed by the magnetizable metals and ores suspended from core 45 of electro-magnet 7, so as to aid in preheating the charge being fed into the furnace. This energizing coil 31 is connected by its lead 32 to a primary coil 33 of a transformer having a core 34 and having a secondary coil 35. The primary coil 33 is a double coil in the instance shown. The transformer 34, having a secondary coil 35, is shown diagrammatically, and it is understood that the same may be constructed in any suitable manner to obtain maximum efficiency as regards electrical losses and consumption of current.

Another lead 36 of coil 31 is connected to a terminal 37 in the bottom of the arc

chamber 3, and has a branch 38 connected to one end of a resister 39 in the bottom of the crucible 2. Connected to lead 36 is a switch 40 which in turn is connected by a lead 41 to the lead 32 of coil 31.

The branch lead 38 is connected to a switch 42 which in turn is connected to a lead 43 that is connected to the other end of resister 39. Thus when the switch 42 is closed the resister 39 is cut out, and when the switch 40 is closed the energizing coil 31 is cut out.

The said lead 43 is connected to one end of the secondary coil 35, and the other end of said coil is connected to a lead 44, and through the latter to a lead 51, connected at one end through a portion of the primary coil 33 to the main feeder 49 and at its other end to the core, or electrode 45, as shown. Accordingly the secondary current from the transformer will pass from the coil 35 through the core 45 through the magnetizable conducting material of the charge, and aid in forming an arc at the terminal 37. In other words, the resistance in this secondary circuit through coil 31 governs the arc circuit. It follows that when the core 45 comes in contact with metal, it only closes the primary circuit. Therefore, by raising said core, or electrode 45, we may form the arc of the melting chamber at *a* and there will be no such thing possible as a short circuit.

A trough 46 leads from the tap hole 47 of the crucible 2. This trough, of course, may be omitted if the crucible is of the tilting type.

The line conductors 24 and 25 are connected to a switch 48 which in turn is connected to the leads 49, 50 and to the primary coil 33.

It is understood that variations may be made in the electrical connections described above without departing from the spirit and scope of the invention as broadly defined in some of the appended claims.

In practice, the operation of the furnace in so far as it has been described is as follows: Assuming that magnetizable ores or metals have been placed in the hopper 4, the line switch 48 will be closed to establish a circuit through the primary coil 33, lead 32, coil 31, lead 36, terminal 37, metal, or ore forming the electrode and resister suspended from the core 45 and through the lead 51 back to and through a portion of coil 33 to main 49, thus producing a magnetic flux in the transformer core 34. The relative number of turns in the transformer coils 33, 35 are such as to produce, in a manner well understood, a current of lower voltage in the secondary coil 35 than the voltage of the current flowing through the primary coil 33. The secondary current thus generated flows through the lead 44, to core 45, through the

metals suspended from said core, through terminal 37, lead 38, resister 39 and lead 43 back to the secondary coil 35.

Electric current also flows from the main line conductors 24 and 25 through the leads 22 and 23, switch 21, leads 19, 20, rectifier 18, leads 16 and 17, switch 15, leads 13 and 14 and electro-magnet 7, so as to energize the latter, thus magnetizing the magnetizable material such as pig iron, iron scrap or iron ore, as the case may be. This magnetization of the magnetizable material prevents said material from packing in the arc chamber 3 thereby preventing any decrease in the resistance to the passage of the electric current through said material, which thus acts as a resister. Further, the material is magnetically fed downward, so to speak, through the arc chamber 3, as it gradually melts or smelts in the lower portion of said chamber.

The flow of electricity through the resister 39 may be continued until said resister heats the crucible hot enough to maintain it at the melting point of the material being melted or smelted. After such melting point is reached, the switch 42 may be closed, thus cutting out the resister 39, thereupon causing current of comparatively heavy amperage to flow through the resister 37 in the arc chamber.

The energization of the electro-magnet 7 causes some of the magnetite or other magnetic material in the chute 3 to hang together to form a sort of combined electrode and resister, and the other portions of said magnetite or other magnetic material to adhere to the electrode thus formed, in accordance with the well known laws of magnetism, with the result that the magnetic material is suspended above the molten bath indicated at *b*. Thus it is clear that as the metals at the lower end of the magnetically suspended metallic body melt, they flow into the bath *b* and that a substantial portion of the metals are in a fused state before entering said bath.

It should be noted in the foregoing described furnace that there are three distinct electrical actions conducive to the production of heat: first, the magnetic action of the energizing coil produces heat in the adjacent portion of the body, or ore, being fed into the arc chamber 3, such heat being incident to the rapid induced change of polarity produced by the alternating current in the coil 31; second, the primary current, which is of higher voltage than the secondary current, passes through the electrode in the direction of the magnetic lines of force therein, and arcs at *a*, causing heat in the center of the magnetic charge; and third, the forcing of the great volume of current furnished by the secondary coil through the terminal 37 furnishes the highest degree of heat, so as to

melt the ore and metal in the arc chamber 3, whence it flows into the crucible 2, where it may be treated, tapped or poured off when desired. It will be observed that the over-
 5 flowing of the molten metal maintains a constant level in the chamber 3, and the electrode 45 does not have to be continually raised as the metal rises in order to maintain the arc.

10 It is understood that either alternating or direct current may be used to energize the electro-magnet 7, but it is preferable to supply direct current to said magnet.

We have diagrammatically shown a lever
 15 52 pivoted at 53 and connected to the cable 8, so that, when desired, the electro-magnet 7 may be raised manually to adjust the lower end 6 of the electrode relative to the bath 5.

An overload circuit breaker 54, and an underload circuit breaker 55 of any suitable construction may be introduced in the ore-feed electro-magnet-circuit for automatic control of said ore-feed by the variation in
 20 voltage of the primary current as indicated in Fig. 1. In the instance shown these circuit breakers are inserted in the leads 13 and 14 respectively.

In the somewhat modified form of our invention shown in Fig. 2, the cable 8, sheave
 30 9, counter-balance 10, armature 11, solenoid 12, primary coil 33, core 34, secondary coil 25, main line conductors 24, 25, switches 28, 48, leads 26, 27, 29, 30, 49, 50, ore and scrap metal 5, hopper 4 and lead 51 are, or may be the same as in Fig. 1. But a resistor 37' is
 35 substituted for the terminal 37 in Fig. 1. The body of the furnace is indicated at 57, and said furnace is provided with a vertical chute or arc chamber 58 in which a nonmagnetic carbon electrode 56 is vertically disposed. The outlet for the molten metal such
 40 as copper ore, for example, from the arc chamber 58 is indicated at 59 and a trough 60 leads from said outlet to discharge into a crucible 61 of any suitable type. This crucible may be heated by the same means as in the form of the invention shown in Fig. 1, or
 45 not, as desired. The primary coil 33 is connected by a lead 62 to the resistor 37' and by lead 51 to the electrode 56. The secondary coil 35 is connected by leads 63, 63' to said resistor as shown.

The lead 51 is in this modified construction connected by a lead 68 to a switch 69
 55 which is connected to a variable resistance 70 that in turn is connected through lead 71 to lead 63.

In both Figs. 1 and 2, 72, 73 and 74 represent taps for coil 33, and 75 represents a
 60 switch coacting with said taps.

In Fig. 1, cover 76 of crucible 2 is conveniently manipulated by a rope 77 passing over pulley 78, and carrying the counterpoise 79.

65 In the still further modified form of the

invention shown in Fig. 4 the construction is similar to that shown in Fig. 1, but the lead 140 of the coil 7 is connected with the coil 31 and the lead 320 of the coil 31 is connected with the switch 660 and through the
 70 lead 670 it is connected through coil 12 and lead 260 to the over-load circuit breaker 54 in lead 141. The lead 140 is connected by a lead 650 to switch 660 which in turn is connected through lead 670 with the lead 320, 75 so that closing of said switch will cut out the coil 31.

The lead 430 from coil 35 connects to terminal 85, which is provided with connections 81 and 82.

80 The carbon, or other refractory tube 80, is attached to terminal 85 for the purpose of conveying carbon monoxid, CO, or other reducing agents below the surface of the slag and molten ore in the crucible 2. At 82 85 a regulating valve 84 is attached, and to this a hose or pipe 83, connects with a supply tank, not shown, containing the reducing agent under pressure sufficient to force the gas below the surface of the slag and molten
 90 metal. The member 87 acts as a guide to keep the gas tube 80 vertical in the crucible.

Some of the features that have been described above are of course not applicable to the melting of non-magnetizable met-
 95 als and smelting of non-magnetizable ores. When copper or other non-magnetizable metals and copper ore or other non-magnetizable ores are to be treated in the furnace, it is understood that a carbon or
 100 graphite electrode 56 will replace the iron electrode 45.

In Fig. 4 the manner of heating the crucible 2 is slightly different from that in Fig. 1. The secondary circuit is led from the
 105 terminal 37 by lead 38 to the terminal 39 in the bottom of the reducing crucible 2, then by means of the molten metal and slag in the crucible, contact is made with the carbon tube 80, which connects by leads 430 to
 110 coil 35, through said coil, lead 630, switch 94 and lead 97 back to terminal 37. Through this circuit a very heavy current flows sufficient to heat the slag and serves to maintain the ore in a molten state. The ore,
 115 which may be iron oxid, is of a high resistance when melted and mixed with only a small percentage of slag, and the iron does not separate from the mass until the reduction of the ore has taken place by the action
 120 of the CO gas or other reducing agent forced into the metal through the refractory tube 80.

As the reduction of the ore takes place the metallic iron gravitates to the bottom, and
 125 below the end of tube 80. Hence, the tube 80 seldom comes in contact with the metal, but is submerged in the melted ore and slag.

Up to this point in the smelting of magnetite ore, or "black sand" for example no
 130

fluxes of any kind have been added. The magnetite ore readily melts and flows into chamber 2 where the reducing agent is introduced, and the reduction of iron ore, into metallic iron, readily takes place by proper manipulation which can best be attained by practice.

Switch 94 shifts the secondary circuit from lead 44 to lead 97; or from the arc circuit through the resistor circuit. In Fig. 4 magnet 7 is shown as a horse-shoe or double pole magnet 7—7'.

Coming now to the still further modified form of the invention shown in Figs. 5 and 6, 100 is the melting chamber discharging into the reduction chamber 200 through the duct 940. When this chamber is filled with molten ore or metal, the flow is switched into duct 950 which then fills chamber 201. The metal in chamber 200 is reduced or treated as may be desired and when finished is drawn off through spout 460. This chamber is then allowed to fill again while the metal in chamber 201 is being treated and drawn off through spout 461 and so on. This chamber 201 it will be observed, is not a mere duplication of parts, but is necessary in order to avoid stopping the continuous operation of the melting furnace.

The stand 920 supports the arm 380 which carries the hollow electrode 800 located in the center of chamber 200 so that by the handle 930 said electrode 800 may be raised and swung as desired. 370 represents a terminal and 390 represents a resistor identical with the parts 37 and 39 respectively as shown in Figs. 1 and 4.

Coming now to the modified diagrams of circuits shown in Figs. 7 and 8, the leads 49 and 50 are the same as in Fig. 2, as is also the converter 34, its primary 33 and secondary 35. One terminal 630 of the secondary joins the terminal 370, which is joined by the lead 380 to one end of the resistor 390, the other end of which is joined by the lead 631 to the other terminal of the secondary 35 as shown. The electrode 450 having a lower end 600 is joined to the lead 49 through a portion of the primary by the lead 510, and is joined to the lead 50, through the arc 150, terminal 370, a portion of lead 630, lead 320 and another portion of primary 33.

The electrode 800 is likewise joined to lead 49 through a portion of the primary, a portion of lead 510, and lead 160.

It thus follows that if electrode 450 is employed like electrode 45 in a melting chamber, while electrode 800 is employed in a crucible such as 200 or 201, then in Fig. 7 the melting chamber terminal 370 fed by the secondary 35 will be in parallel with the resistor 390 in chambers 200 and 201, while the electrodes 450 and 800 fed from the primary 33 through lead 320 will be in series

with their respective terminals and resistors 370 and 390.

In the case of Fig. 8, the terminals and resistors 370 and 390 are in series with each other, and the secondary 35. The electrode 450 and terminal 370 is in series with the primary 33, while the electrode 800 and resistor 390 is likewise in series with said primary through the terminal 370.

It will now be clear from the foregoing disclosure that a magnet electrode such as 45, serves as a means of feeding the iron ore or scrap down to the fusion chamber, gradually and gently, in such a manner that the furnace linings are not gouged or damaged by the sharp corners dropping or being thrown against them.

The gradual feeding is accomplished automatically if alternating current is used to excite the magnets 7 by reason of the change of polarity. Apparently the magnetic flux stops momentarily at each reversal and the magnetized material drops slightly each time until finally it is at the bottom end of the magnet and in the arc.

Main line conductors 24 and 25 for electric furnace operations herein described should work under about 110 volts, single phase. If the supply should be say 2000 volts, two phase or three phase, then a two or three phase transformer would have to be used to transform the supply circuit down to that desired to operate the furnace. This would be accomplished in the usual way common to step down transformers and need not be shown or described here.

Vent pipe 88 Fig. 1, carries off fumes and contains a damper 91 for regulating the draft.

Door 89 may pivot as at 90 and hangs normally closed. The object of this door is to exclude the air which contains oxygen, from circulating through the furnace. It will be observed that the furnace is substantially air tight.

An insulating tile 64 or asbestos tube protects the coils 7 from being damaged by heat passing to the upper end of the core 45.

When the nature of the ore being smelted precludes the use of an iron electrode, then carbon or graphite is used and magnets 7 and their connections may be dispensed with as in Fig. 2.

By the arrangement of parts described we are enabled to obtain the following results:—

(1) We may effect the melting of metals and smelting of ores by a method which will intensify the arc effect in the furnace.

(2) We may make provision for magnetic feeding of magnetizable metals and ores to the melting or smelting chamber.

(3) We may make provision, when magnetizable metals or ores are being treated, for the forming of an electrode from the magnetizable material while said material

is being fed into the furnace and prior to the melting of said material.

(4) We also provide for an automatic feeding of the magnetizable metal and ores to the furnace.

(5) And for an automatic electric feed of the metal and ores to the furnace.

(6) We make provision for the passing of both the primary and secondary currents simultaneously through the heating elements of the furnace:

(7) And make provision for the passing of both primary and secondary currents through the heating elements or resisters in series or in multiple as desired.

(8) We make provision for the forming of the magnetizable charge, previous to its becoming molten, into an electrode.

(9) We cause the magnetizable charge, prior to its becoming molten, to function as a resister.

(10) We make provision for magnetic suspension of magnetizable metal and ores in the furnace.

(11) We effect heating of the charge by magnetization thereof.

(12) We effect heating of the charge by a rapid change of polarity of an alternating current.

(13) We effect considerable heating of the charge by the use of a high voltage primary current.

(14) We prevent packing of the magnetizable material in the furnace, thereby causing greater resistance to the electric current flowing therethrough, and thus increase the heating effect of said current.

(15) We effect automatic control of the feed of magnetizable material in accordance with variations in the secondary circuit.

(16) We may melt the ore in the furnace then flow the same into a reducing crucible, pass the secondary current through the said crucible and metal to keep it molten and then supply CO gas or other reducing substance through a refractory tube below the surface of the metal at varying depths until the reducing action has taken place.

We claim:

1. An electric furnace comprising a chamber, magnetic means for retarding the downward movement of magnetizable material in said chamber, and means to apply heat to the material to melt it.

2. An electric furnace comprising a chamber, magnetic means for suspending magnetizable material in said chamber, and means to apply heat to the material thus suspended.

3. An electric furnace comprising a chamber, means to suspend magnetizable material in said chamber, and means to pass an electric current through the suspended material.

4. An electric furnace comprising a chamber, a resister at the bottom of the chamber,

an electrode suspended in the chamber, and a transformer having primary and secondary coils connected with the resister and electrode.

5. An electric furnace comprising a chamber, a transformer having primary and secondary coils and means to apply the primary and secondary currents from said coils to material in the chamber.

6. An electric furnace comprising a chamber, magnetic means for suspending magnetizable material in said chamber to form an electrode, a resister in the chamber, and a transformer having its secondary coil connected with the electrode and resister.

7. An electric furnace comprising a chamber, magnetic means for suspending magnetizable material in said chamber to form an electrode, a resister in the chamber, and a transformer having primary and secondary coils connected with the electrode and resister.

8. An electric furnace comprising a chamber, a resister in the lower portion of the chamber, means to suspend a body of metal and ores above and spaced from the resister, and means to supply electric current to the resister and body of metal and ores to form an electric arc therebetween.

9. An electric furnace comprising a chamber, a resister in the lower portion of the chamber, means to suspend a body of metal and ores above and spaced from the resister, and means to supply electric current to the resister and body of metal and ores to form an electric arc therebetween and means of regulating the arc by varying the number of turns on the primary coil.

10. An electric furnace comprising a chamber, a resister in the lower portion of the chamber, means to suspend a body of metal and ores above and spaced from the resister, and a transformer having its secondary coil connected with the resister and body of metal and ores to form an electric arc therebetween.

11. An electric furnace comprising a chamber, a resister in the lower portion of the chamber, means to suspend a body of metal and ores above and spaced from the resister, and a transformer having its primary and secondary coils connected with the resister and body of metal and ores to form an electric arc therebetween.

12. An electric furnace comprising a chamber, a resister in the lower portion of the chamber, magnetic means to suspend a body of metal and ores above and spaced from the resister, and a transformer having its secondary coil connected with the resister and body of metal and ores to form an electric arc therebetween.

13. An electric furnace comprising a chamber, a resister in the lower portion of the chamber, magnetic means to suspend a body

of metal and ores above and spaced from the resister, and a transformer having primary and secondary coils connected with the resister and body of metal and ores to form an electric arc therebetween.

14. An electric furnace comprising a chamber, an electro-magnet to suspend magnetizable material in the chamber, a resister in the lower portion of the chamber, and means to supply an electric current to the magnet core and resister.

15. An electric furnace comprising a chamber, an electro-magnet to suspend magnetizable material in the chamber, means adjustably supporting the electro-magnet, a resister in the lower portion of the chamber, and means to supply an electric current to the magnet core and resister.

16. An electric furnace comprising a chamber, an electro-magnet to suspend magnetizable material in the chamber, a resister in the lower portion of the chamber, and a transformer having its secondary coil connected with the resister and magnet core to form an electric arc therebetween.

17. An electric furnace comprising a chamber, an electro-magnet to suspend magnetizable material in the chamber, a resister in the lower portion of the chamber, and a transformer having primary and secondary coils connected with the resister and magnet core to form an electric arc therebetween.

18. An electric furnace comprising a chamber, a resister in the chamber, means to produce magnetic lines of force extending longitudinally of the chamber in the material therein, and a transformer having its secondary coil connected with the resister and with said material to cause the secondary current to flow through the material parallel to the magnetic lines of force in said material.

19. An electric furnace comprising a chamber, a resister in the chamber, means to produce magnetic lines of force extending longitudinally of the chamber in the material therein, and a transformer having primary and secondary coils connected with the resister and with said material to cause the primary and secondary currents to flow through the material parallel to the magnetic lines of force in said material.

20. An electric furnace comprising a chamber, means to suspend material in the chamber and to produce magnetic lines of force extending longitudinally of the chamber in the suspended material, and means to cause an electric current to flow in said suspended material parallel to the magnetic lines of force.

21. An electric furnace comprising a chamber, a resister in the chamber, means to suspend material in the chamber and to produce magnetic lines of force extending longitudinally of the chamber in the sus-

pended material, and a transformer having its secondary coil connected with the resister and with the suspended material to cause the secondary current to flow through the material parallel to the magnetic lines of force in said material.

22. An electric furnace comprising a chamber, a resister in the chamber, means to suspend material in the chamber and to produce magnetic lines of force extending longitudinally of the chamber in the suspended material, and a transformer having primary and secondary coils connected with the resister and with the suspended material to cause the primary and secondary currents to flow through the material parallel to the magnetic lines of force in said material.

23. An electric furnace comprising a chamber, a magnetizing coil surrounding the chamber, a magnetic electrode passing through said coil into said chamber, means to supply an electric current of reversing polarity to the coil to energize magnetizable material in the chamber, and means to heat said material.

24. An electric furnace comprising a chamber, a magnetizing coil surrounding the chamber, a magnetic electrode passing through said coil into said chamber, means to supply an alternating electric current to the coil to produce magnetic lines of force in the magnetizable charge in the chamber and means to cause a flow of electric current parallel to the magnetic lines of force.

25. An electric furnace comprising a chamber, a magnetizing coil surrounding the chamber, a magnetic electrode passing through said coil into said chamber, means to supply an electric current to said coil to magnetize material in the chamber, and means to heat said material to make it molten.

26. An electric furnace comprising an arc chamber, a converter chamber to receive the overflow from the arc chamber, resisters in the lower portions of the respective chambers, and a transformer having primary and secondary coils connected with both resisters.

27. An electric furnace comprising a chamber, an electro-magnet to hold material suspended in the chamber, overload and underload circuit-breakers connected to the electro-magnet, a source of electric current connected to the circuit-breakers, and means to heat the material to melt it.

28. An electric furnace comprising a chamber, an electro-magnet to hold material suspended in the chamber, an overload circuit-breaker connected to the electro-magnet, a source of electric current connected to the circuit-breaker, and means to heat the material to melt it.

29. An electric furnace comprising a cham-

ber, an electro-magnet to hold material suspended in the chamber, an underload circuit-breaker connected to the electro-magnet, a source of electric current connected to the circuit-breaker, and means to heat the material to melt it.

30. An electric furnace comprising a chamber, an electro-magnet to hold material suspended in the chamber, a solenoid, an armature movable by energization of the solenoid and connected with the electro-magnet, means to supply electric current to the electro-magnet and solenoid, and means to heat the material to melt it.

31. An electric furnace comprising a chamber, an electro-magnet to hold material suspended in the chamber, a resister in the chamber, a transformer having its secondary coil connected to the electro-magnet core and to the resister, and means to energize the electro-magnet.

32. An electric furnace comprising a chamber, an electro-magnet to hold material suspended in the chamber, a resister in the chamber, a transformer having primary and secondary coils connected to the electro-magnet core and to the resister, and means to energize the electro-magnet.

33. An electric furnace comprising a chamber adapted to receive a charge of material to be heated, a cable connected to said charge to suspend said charge, a solenoid, an armature movable by the energization of the solenoid and connected to the cable, means to energize the solenoid, and means to heat the material.

34. An electric furnace comprising a chamber adapted to receive a charge of material, a resister in the chamber, a solenoid, means to energize the solenoid, an armature for the solenoid, an electrode inserted in the chamber, means connecting the armature to the electrode to suspend said electrode, and means to supply electric current to the resister and electrode to melt the charge.

35. An electric furnace comprising a chamber adapted to receive a charge of material, a resister in the chamber, a solenoid, means to energize the solenoid, an armature for the solenoid, an electrode inserted in the chamber, means connecting the armature to the electrode to suspend said electrode, and a transformer having a primary coil connected with the electrode and resister and having a secondary coil connected with the resister.

36. An electric furnace comprising a chamber adapted to receive a charge of material, a resister in the chamber, a solenoid, means to energize the solenoid, an armature for the solenoid, an electrode inserted in the chamber, means connecting the armature to the electrode to suspend said electrode, and a transformer having primary and second-

ary coils connected with the electrode and resister.

37. An electric furnace comprising a chamber adapted to receive a charge of magnetizable material, and means to suspend a portion of said charge and to pass an electric current therethrough while suspended to form an electrode of the suspended portion of the charge.

38. An electric furnace comprising a chamber adapted to receive a charge of magnetizable material, and magnetic means to suspend a portion of said charge and to pass an electric current therethrough while suspended to form a magnetized electrode of the suspended portion of the charge.

39. The method of melting metals and smelting ores, which consists in magnetizing the metallic particles of a magnetizable metal or ore, rapidly changing the polarity of the magnetized particles to produce heat in the metal or ore, and passing an electric current through the metal or ore to melt or smelt the same.

40. The method of melting metals and smelting ores, which consists in magnetically suspending the metal or ore in a chamber above a metallic body, and passing alternating currents through said suspended material to produce an electric arc between the suspended metal or ore and the metallic body to make the metal adjacent the arc molten.

41. The method of melting metals and smelting ores, which consists of suspending the metal or ore in a chamber above a metallic body, passing the secondary current from a transformer through the suspended metal or ore and the metallic body to produce an arc therebetween, and producing magnetic lines of force in the suspended metal or ore parallel to the flow of the secondary current in said metal or ore.

42. An electric furnace comprising a chamber, a coil above said chamber, a core for said coil extending down into the chamber, means to energize the coil to magnetize the core, and means to cause an electric current to flow through the core to heat magnetizable material attached to the core.

43. An electric furnace comprising a chamber, an electrode in the chamber, a resister in the chamber, a transformer having primary and secondary coils, leads connecting the primary coil to the electrode and resister, leads connecting the secondary coil to the resister, and a variable resistance connecting one of the primary coil leads to one of the secondary coil leads.

44. An electric furnace comprising a chamber, an electrode in the chamber, a terminal in the chamber, a transformer having primary and secondary coils, leads connecting the primary coil to the elec-

trode and terminal, leads connecting the secondary coil to the electrode and terminal, and a variable resistance connected across the leads of the secondary coil.

45. An electric furnace comprising a melting chamber, an electrode and arc included in the primary circuit of a transformer in said chamber, a reducing chamber adjacent thereto, a carbon tube extending into said chamber to conduct both the secondary circuit and the reducing agents into the molten metal therein.

46. In an electric furnace the combination of a chamber provided with a resister; an electromagnetic coil above said chamber; a core for said coil extending into said chamber above said resister; means to energize said coil with alternating or direct currents at will; and means to pass alternating currents through said core and resister to form an arc.

47. An electric furnace comprising an arc chamber, an electro-magnet to hold material suspended in the chamber, a resister in said chamber, a converter chamber to receive the overflow from the arc chamber, a carbon or other refractory tube extending into said converter chamber and means for forcing a reducing agent through said tube into the overflow molten material and means for keeping the material molten.

48. In an electric furnace an electrode in the primary circuit, a resister in the secondary circuit in multiple with a refractory gas conveying tube, means for varying the flow of current through either circuit.

49. In an electric furnace an electrode in the melting chamber, another electrode in the converter chamber, each connected to transformer leads and connected one with the other through the resisters at the bottom of each.

50. In an electric furnace the combination of a transformer provided with primary and secondary coils; a furnace chamber; an electrode in said chamber; a resister in said chamber coacting with said electrode to form an arc; and connections joining said arc in series with said primary coil and said resister in series with said secondary coil.

51. The method of melting material in an electric furnace provided with arcing terminals one of which is a resister; and with a primary coil and a secondary coil of a transformer which consists in joining said terminals in series with said primary coil and said resister in series with said secondary coil, whereby the current flow in the primary coil is regulated.

52. In an electric furnace an electrode in one chamber, another electrode in another chamber, each connected to energizing leads and forming a circuit through the molten metal and through resisters at the bottom of each chamber.

Signed at Seattle, Washington, this 14th day of November, 1917.

PARVIN WRIGHT.
IVAN B. WRIGHT.

Witnesses:

O. L. WILLETT,
M. M. PREHER.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."