No. 816,554. PATENTED APR. 3, 1906.

A. G. BETTS.

ELECTRIC FURNACE.

APPLICATION FILED MAY 20, 1904.

5 SHEETS—SHEET 1.

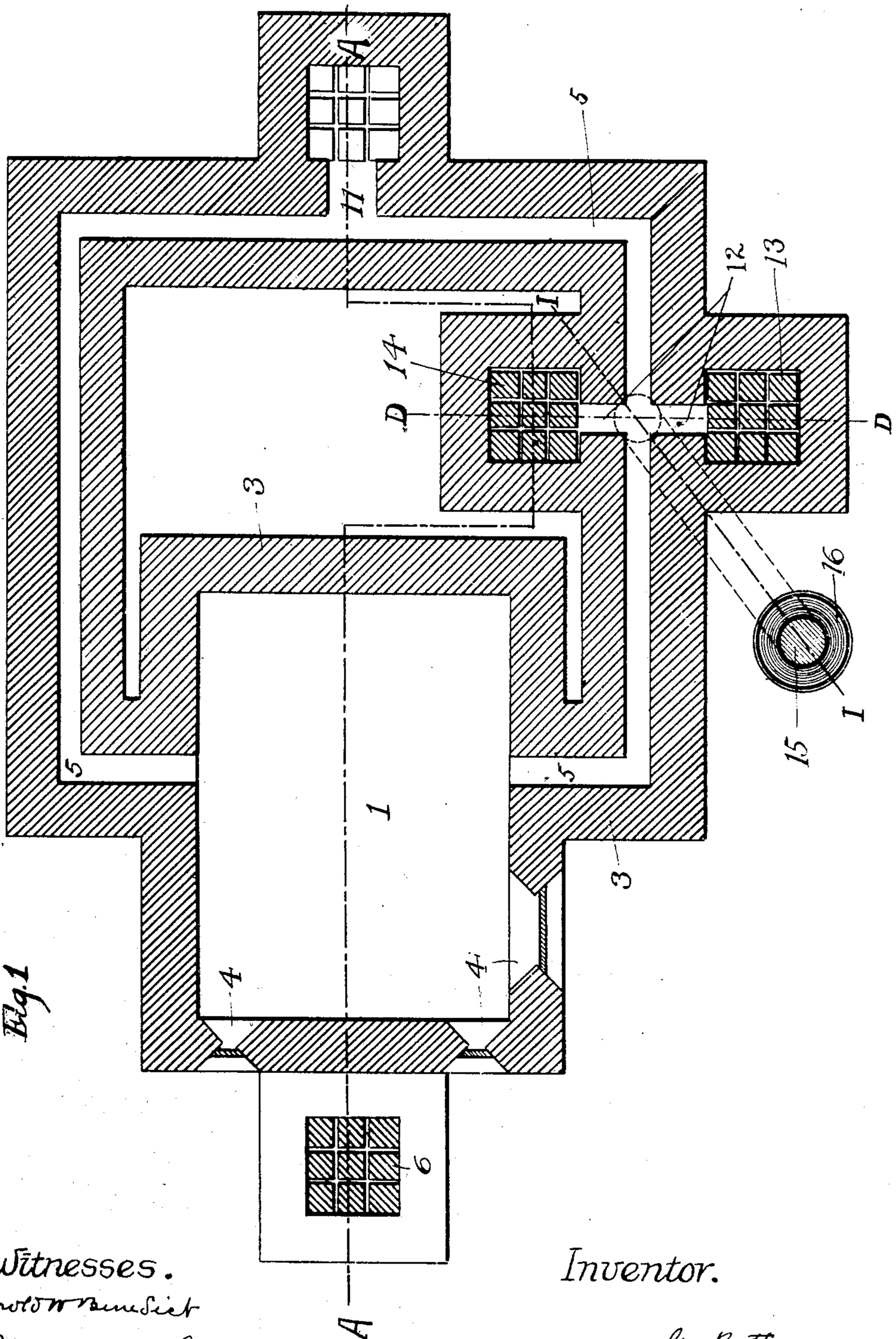

Fig. 1

Witnesses.

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5 SHEETS—SHEET 2.

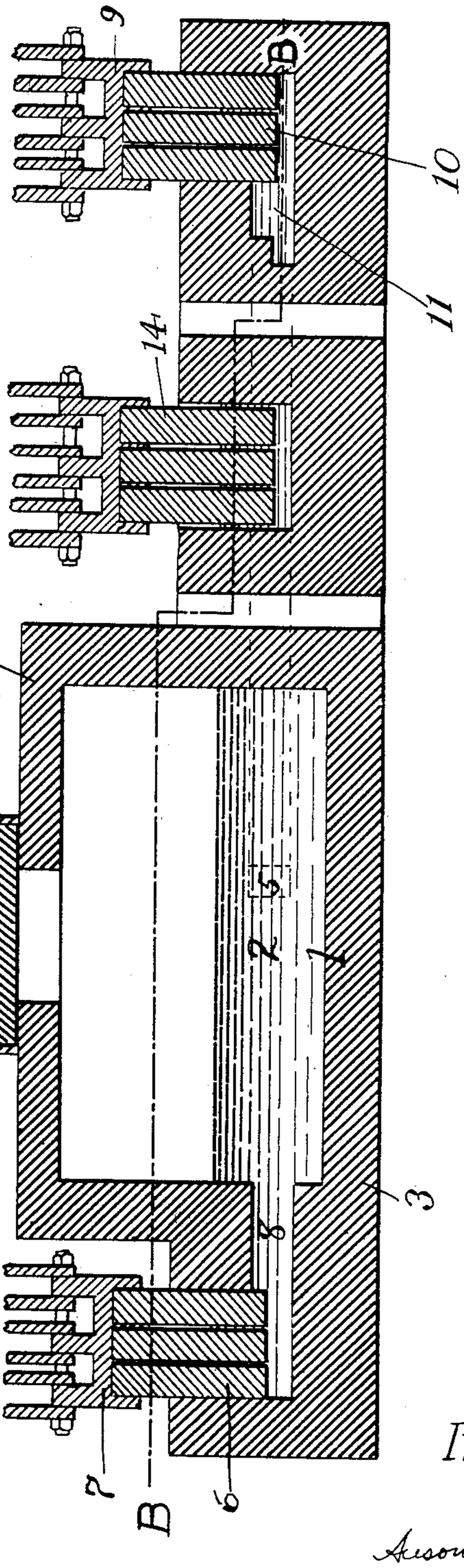

Fig. 2.

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5 SHEETS—SHEET 3.

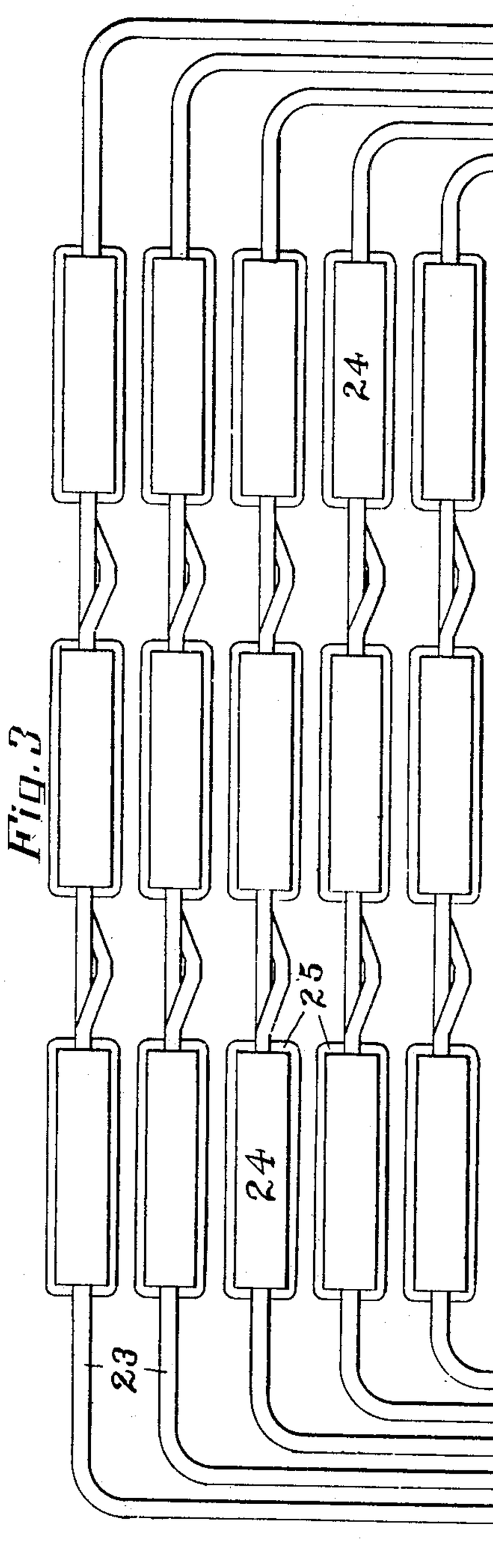

Fig. 3

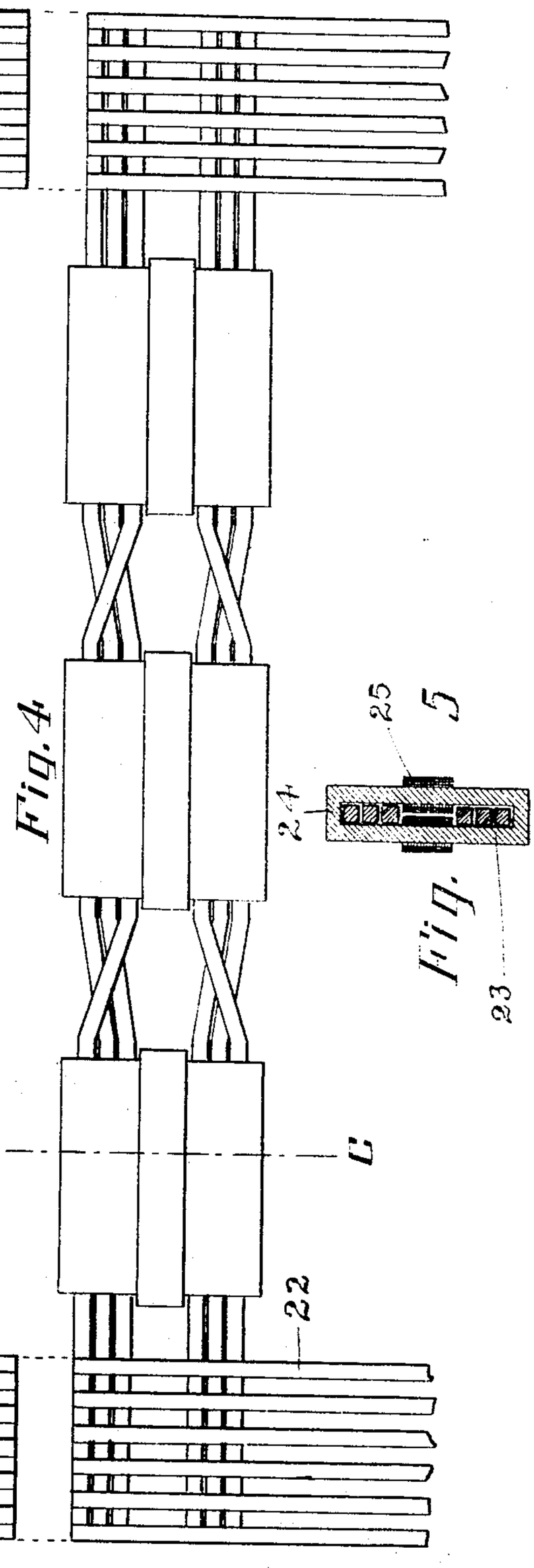

Fig. 4

Witnesses

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5 SHEETS—SHEET 4.

Fig. 6

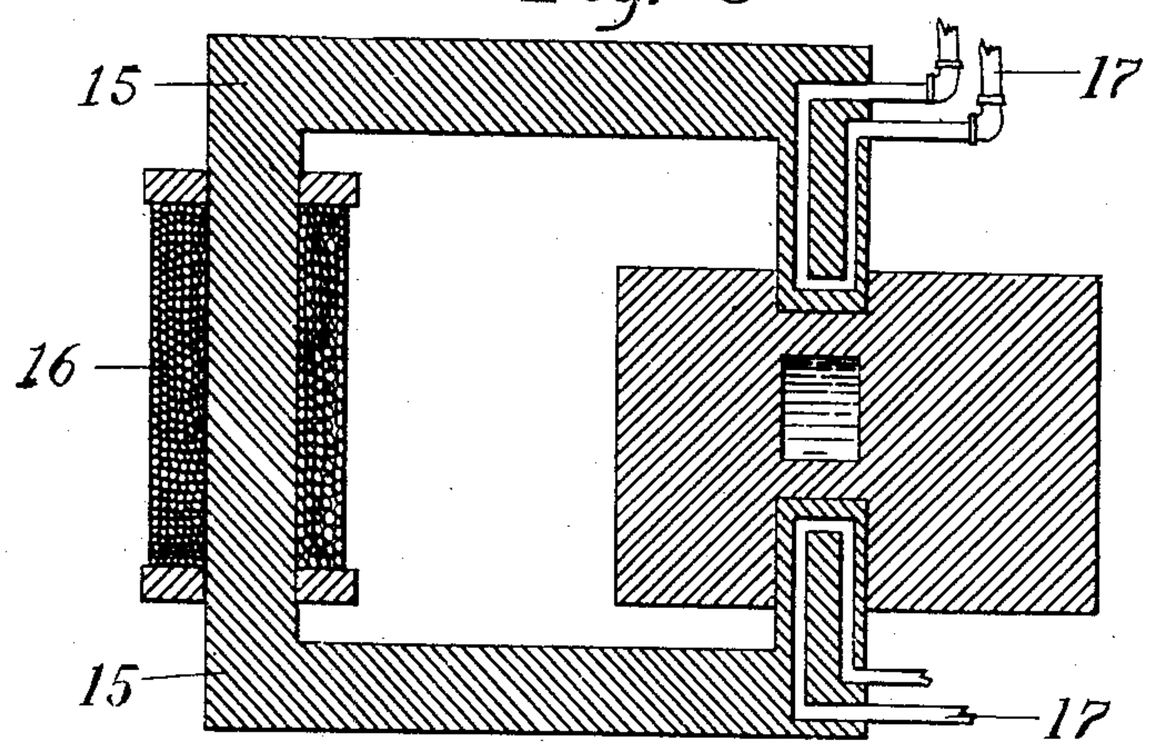
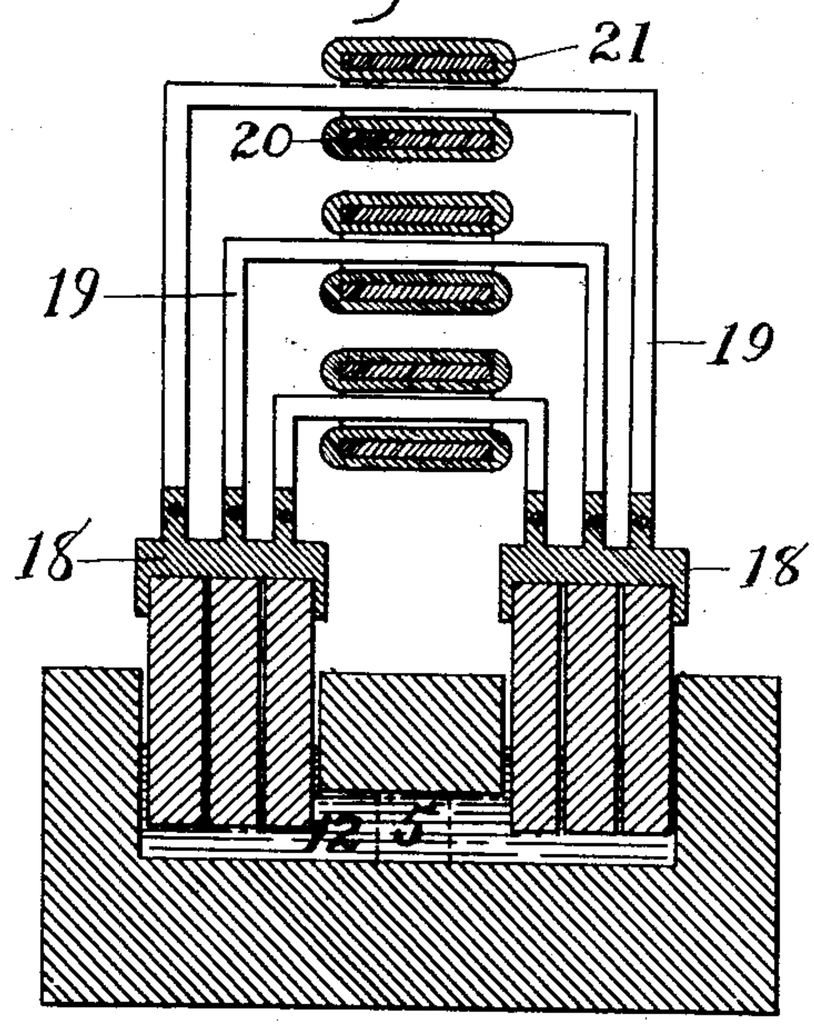


Fig. 7



Witnesses

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5 SHEETS—SHEET 5.

Fig. 8.

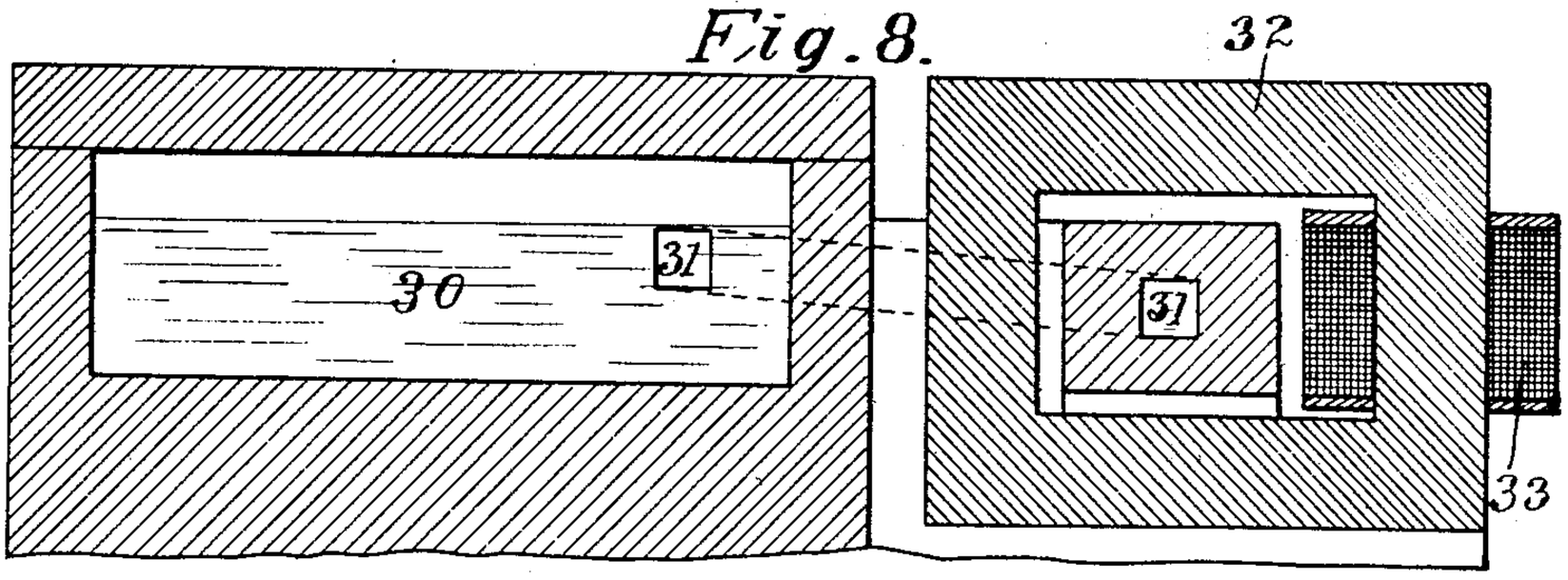


Fig. 9.

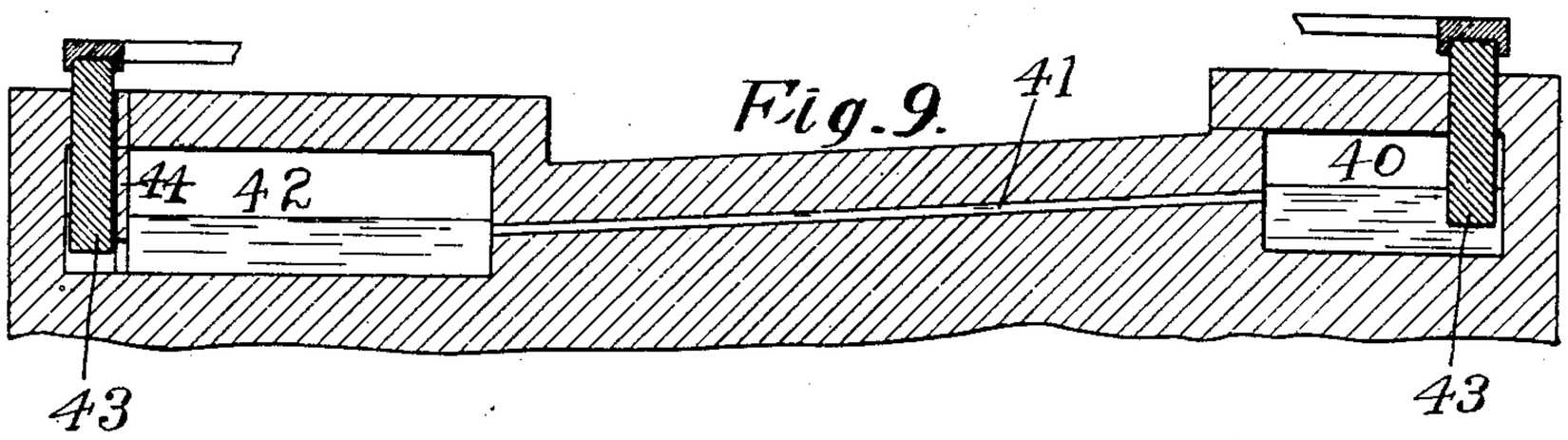


Fig. 10.

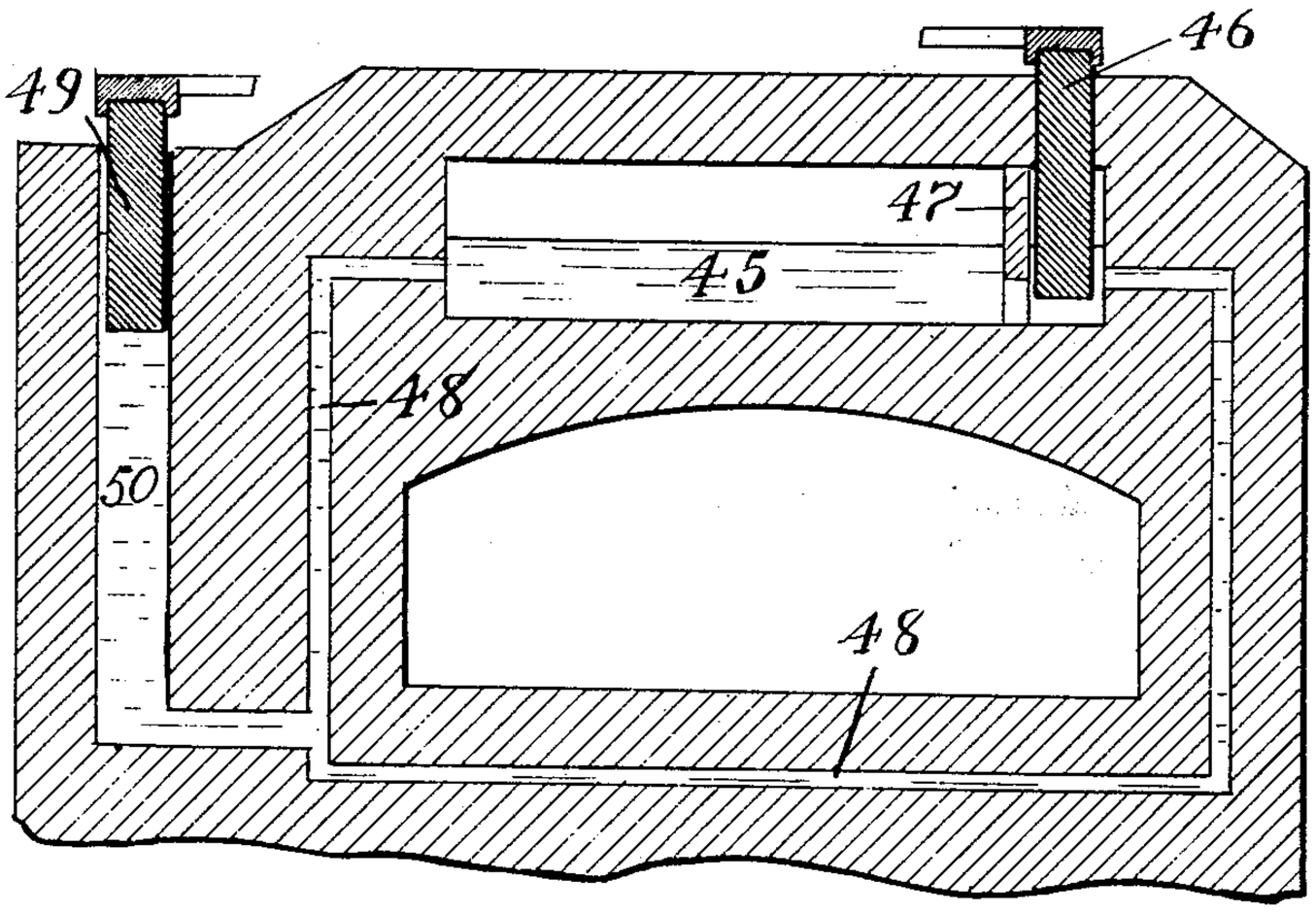
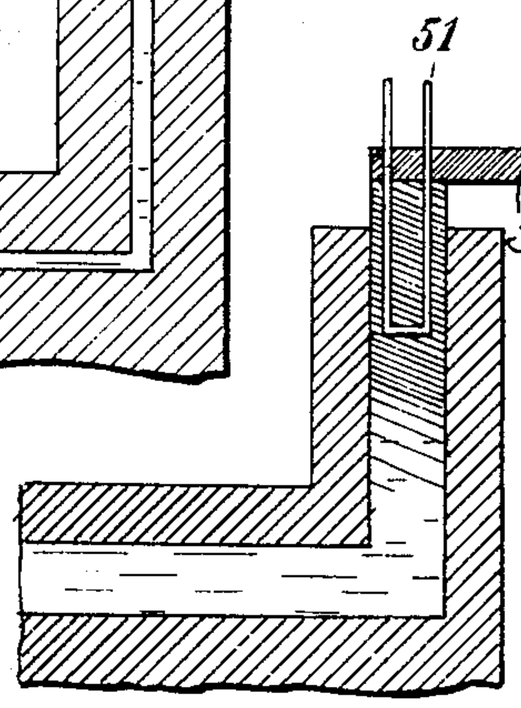


Fig. 11.



Witnesses

Edward F. Kern

William Valentine

Inventor

Anson G. Betts

UNITED STATES PATENT OFFICE.

ANSON GARDNER BETTS, OF TROY, NEW YORK.

ELECTRIC FURNACE.

No. 816,554. Specification of Letters Patent. Patented April 3, 1906.

Application filed May 20, 1904. Serial No. 208,948.

To all whom it may concern:

Be it known that I, ANSON GARDNER BETTS, a citizen of the United States, residing at Troy, county of Rensselaer, and State of New York, have invented certain new and useful Improvements in Electric Furnaces, of which the following is a specification accompanied by drawings.

Figure 1 shows in plan a section through my electric furnace on the line B B in Fig. 2. Fig. 2 shows in elevation a section on the line A A of Fig. 1. Fig. 3 shows in plan the transformer in which the heating-current is generated. Fig. 4 shows the transformer in elevation. Fig. 5 shows a section on the line C C of Fig. 4. Fig. 6 shows a section on the line I I of Fig. 1. Fig. 7 shows a section on the line D D of Fig. 1. Figs. 6 and 7 illustrate in section the electromagnetic apparatus circulating the liquid conductor in my electric furnace. Fig. 8 shows in section another form of my furnace, in which the circulation of the liquid conductor is effected by gravity and in which the heating-current is generated in the liquid conductor itself. Fig. 9 shows another form of my furnace in which the fluid conductor is moved by gravity. Fig. 10 shows another form in which gravity moves the fluid conductor. Fig. 11 shows an electrode which may be used in my electric furnace.

My invention consists of an electric furnace in which the electric current is applied for heating a liquid conductor away from the smelting zone and in which the temperature in the smelting zone is maintained by the inflow of highly-heated liquid conductor.

The principal objects of my invention are to supply an electric furnace, first, in which the electric resistance does not fluctuate rapidly; second, to which repairs can be easily made; third, which will not require frequent changes of electrodes. These objects are attained by applying the electric current to heat a liquid conductor—for instance, copper matte or metallic iron or lead contained in a channel of material practically unacted on by the liquid, so that the cross-section of the channel remains practically constant.

The refractory materials available for the construction of furnaces are practically unacted on by metals or their sulfids; but they are readily dissolved by slags. By excluding slags from the heating-channel it lasts for a long time. The furnace-lining at the slag-line in the smelting-hearth is easily repaired by well-known methods. When the liquid-conductor used has no solvent action on carbon—for instance, metallic lead and zinc and metallic sulfids—the electric current may be introduced through carbon electrodes which dip in the liquid conductor in suitable places away from contact with slags or ores which would act on them, while when the liquid conductor being heated in the channel is a metal, as iron or aluminium, which dissolves carbon, water-cooling is adopted to cool the metal at favorable points to such a temperature that copper conducting-bars supplying the current can be fastened on directly, or I am able to do without electrodes entirely, generating the heating-current in the heating-channel itself by electromagnetic induction.

Figs. 1, 2, 3, 4, 5, 6, and 7 show a particular construction of my furnace. The smelting-hearth 1 contains a bath of molten conductor 2, usually a metal or a sulfid mixture, and may contain both in two layers constructed of refractory material 3, with working doors 4. Leading into the furnace from each side is a heating-channel 5, built of refractory material. Carbon electrodes 6, inserted in a copper terminal 7, are in electrical communication with the pool of liquid conductor 2 by means of the liquid conductor in the channel 8, built into the brickwork and extending outward underneath the electrodes 6. A similar copper terminal 9 and electrodes 10 are connected electrically with the center of the channel 5 by a channel 11, similar to 8. At a convenient point on the channel 5 is built a horizontal cross-channel 12, into the ends of which dip sets of electrodes 13 and 14. The ends of the core of an electromagnet 15 terminate above and below the intersection of the channel 5 and the channel 12. When an electric current is passed through the channel 12 and the electromagnet is magnetized, the liquid conductor is given a tendency to move longitudinally of the channel 5. If an alternating current is used in the channel 12, in order that the tendency to move may be always in the same direction the polarity of the electromagent must be changed with each alternation of the electric current in 12, which result can be accomplished by placing the coil 16 of the electromagnet in electrical series with the primary coils of the transformer, Figs. 6 and 7, which supply the current passing through 12. The electric current passing through 5, acting with the

electromagnet, tends to produce motion of the liquid conductor longitudinally of 12; but as the ends of 12 are closed no motion takes place.

Referring to Figs. 6 and 7, 16 is the coil exciting the electromagnet. 17 represents pipes through which water may be passed to keep the core cool. 18 represents copper terminals. 19 represents copper conductors connecting them, which copper conductors also constitute the secondary conductor of the transformer. 20 represents transformer-cores, and 21 the primary transformer-coils.

In Figs. 3, 4, and 5 I have shown a transformer to generate electric current for heating. The upright copper bars 22 are connected with the copper terminals 7 and 9, Fig. 2, at the lower end and at the upper end with copper bars 23, which serve as secondary transformer-conductors passing through the transformer-cores 24, which are excited by the coils 25.

Fig. 8 shows in elevation a section through the center of another construction of furnace under my invention. The pool of liquid conductor 30 is contained in a furnace constructed of refractory material, which has leading out from it on opposite sides a channel 31, built in refractory material. The channel on one side leads in near the top of the layer of liquid conductor 30 and on the other side (not shown) near the bottom. A transformer-core 32, excited by an alternating current in the primary coil 33; surrounds the channel 31 and excites an alternating electric current therein, which heats the contained liquid conductor. The heat expands the liquid conductor in 31, making it specifically lighter than the mass of liquid conductor 30, so that there is established by gravity a circulation of liquid through the channel, entering at the bottom opening (not shown) and discharging through the top one. The effect of gravity may be increased by making the mass of liquid conductor 30 deeper and increasing the vertical distance between the ends of the channel 31.

Fig. 9 shows a construction of furnace in which relatively cooler liquid conductor is stored at a higher level in the furnace 40, from which it flows by gravity through the channel 41, in passing through which it is heated by an electric current introduced through the electrodes 43. The liquid conductor can be removed from 42 as it accumulates and be taken back to 40 by tapping into a ladle or by other means. A bridge of refractory material 44 prevents the electrode from being attacked by any slag which might be floating on the liquid conductor in 42.

Fig. 10 shows a pool of liquid conductor 45, into which is introduced an electrode 46, access to the electrode by slag, which may be floating on 45, being prevented by a bridge 47, of refractory material. A channel 48 is built in refractory material beneath 45, to which electrical communication is established through the electrode 49 and channel 50, of greater cross-section than 48. On account of the less electrical resistance of the shorter column more electric current passes through it, resulting in a higher temperature and lower specific gravity, so that the liquid conductor rises in the shorter arm and falls in the longer one, thus establishing a circulation. The circulation is aided by the fact that the liquid conductor supplied to the shorter arm from the longer one is at a higher temperature than that supplied to the longer arm from the bath 45.

When it is not desired to use carbon electrodes, the electrode shown in Fig. 11 may be used. A solid block of the same material which constitutes the liquid conductor is used. A current of water running through the pipe 51 keeps the extremity cool, so that the copper bar 52, supplying the electric current, may be fastened on directly. The other extremity is melted off by the highly-heated liquid conductor, the dividing-line between liquid and solid being of no importance.

My furnace is adapted for a great variety of metallurgical operations, such as melting and distilling zinc, smelting ores of lead, zinc, copper, iron, nickel, and aluminium, cupelling lead, and converting pig-iron into steel.

What I claim as new, and desire to secure by Letters Patent, is—

1. In combination, an electric furnace comprising a furnace-chamber adapted to contain on its hearth a bath of liquid conductor; a channel leading into said chamber, and adapted to contain liquid conductor; electrodes arranged to supply electric current to pass through the liquid conductor in the channel; and means for causing motion of liquid conductor through the channel to the bath on the hearth.

2. In combination, an electric furnace comprising a hearth adapted to contain a bath of liquid conductor; a channel, both ends of which lead into the hearth, and adapted to contain liquid conductor; electrodes arranged to supply electric current to pass through the liquid conductor in the channel; and means for causing a circulation of liquid conductor from the hearth through the channel and back to the hearth.

3. An electric furnace, comprising in combination; a furnace-chamber adapted to contain on the hearth thereof a bath of a liquid conductor; a channel leading into said chamber and adapted to contain liquid conductor; an electrode placed to make electrical connection with the conducting liquid on the hearth; and an electrode placed to make electrical connection with conducting liquid in said channel; an exterior source of electric current to supply an electric current of suitable volume to said electrodes; and means for

causing motion of liquid conductor through the channel to the bath on the hearth.

4. An electric furnace, comprising in combination; a furnace-chamber adapted to contain on the hearth thereof a bath of liquid conductor; a channel with both ends leading into said chamber and adapted to contain liquid conductor; an electrode placed to make electrical connection with the conducting liquid on the hearth, and an electrode placed to make electrical connection with conducting liquid in said channel; an exterior source of electric current to supply an electric current of suitable volume to said electrodes; and means for causing a circulation of liquid conductor from the bath on the hearth, through the channel and back to the hearth.

5. An electric furnace, comprising in combination, a furnace-chamber adapted to contain on the hearth thereof a bath of liquid conductor; a channel with both ends leading into said chamber and adapted to contain liquid conductor; an electrode placed to make electrical connection with the conducing liquid on the hearth; and an electrode placed to make electrical connection with conducting liquid in said channel; an exterior source of electric current to supply an electric current of suitable volume to said electrodes; and electromagnetic means for causing a circulation of liquid conductor from the bath on the hearth, through the channel and back to the hearth.

6. An electric furnace, comprising in combination, a furnace-chamber adapted to contain on the hearth thereof a bath of liquid conductor; a channel with both ends leading into said chamber and adapted to contain liquid conductor; an electrode placed to make electrical connection with the conducting liquid on the hearth; and an electrode placed to make electrical connection with conducting liquid in said channel; an exterior source of electric current to supply an alternating electric current of suitable volume to said electrodes; and electromagnetic means for causing a circulation of liquid conductor from the bath on the hearth, through the channel and back to the hearth.

7. In combination with an electric furnace, in which the heating effect of the electric current is applied to liquid conductor contained in a channel communicating with a bath of liquid conductor on a hearth, an electromagnetic circulating device which consists of; means of creating a magnetic field at some point of the channel; a cross-channel adapted to contain a conductor and intersecting the main channel in said magnetic field; and means for causing an electric current to pass through the cross-channel.

8. In combination with an electric furnace, in which the heating effect of an alternating electric current is applied to liquid conductor contained in a channel communicating with a bath of liquid conductor on a hearth, an electromagnetic circulating device which consists of; means for creating a magnetic field at some point of the channel; a cross-channel adapted to contain a conductor, and intersecting the main channel in said magnetic field; and means for causing an alternating electric current to pass through the cross-channel alternating substantially synchronously with the current in the main channel.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ANSON GARDNER BETTS.

Witnesses:

WILLIAM VALENTINE,

EDWARD F. KERN.