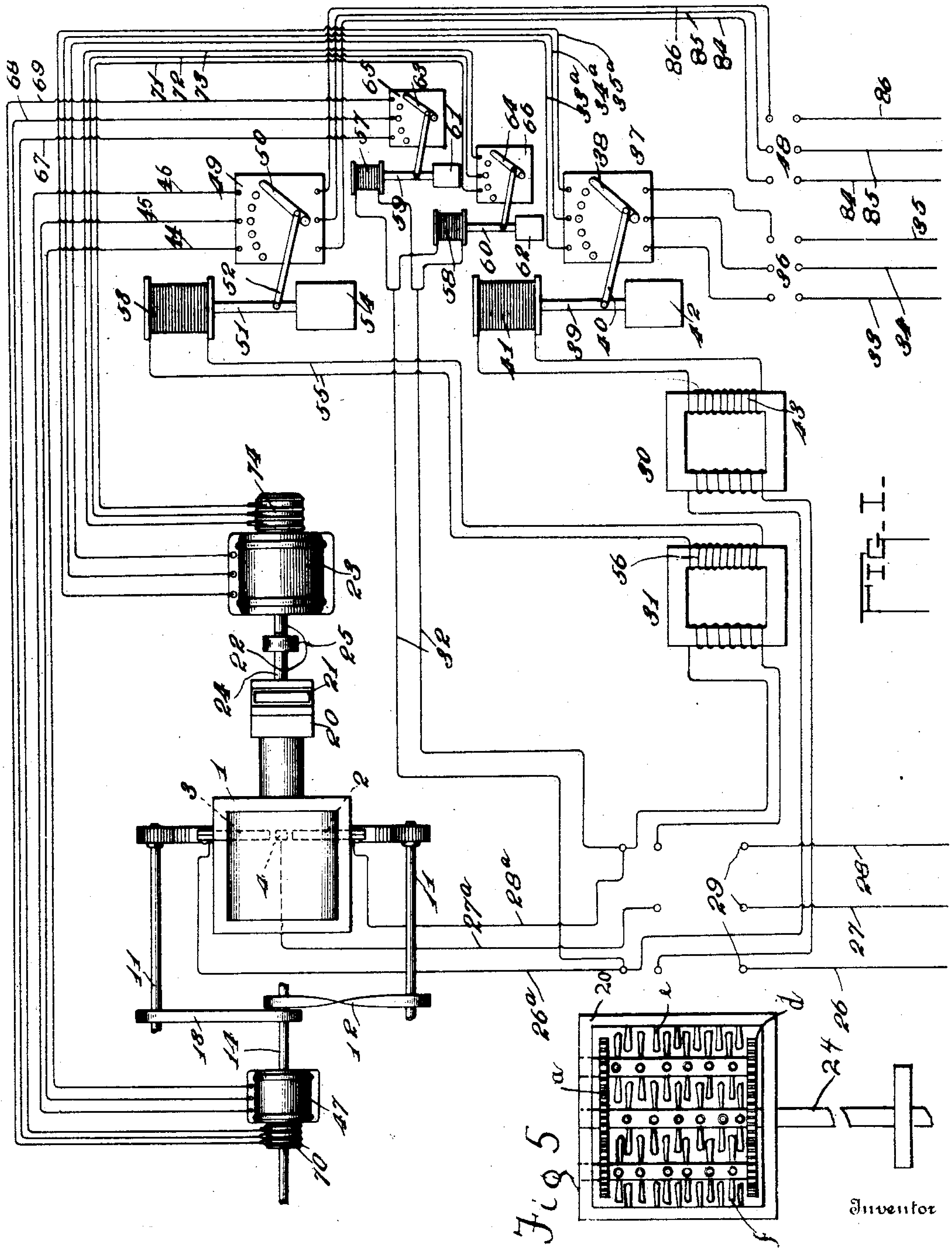
No. 790,226. PATENTED MAY 16, 1905.

I. S. PRENNER.

ELECTRICAL FURNACE.

APPLICATION FILED MAR. 21, 1903.

2 SHEETS—SHEET 1.



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2 SHEETS—SHEET 2.

FIG-2.

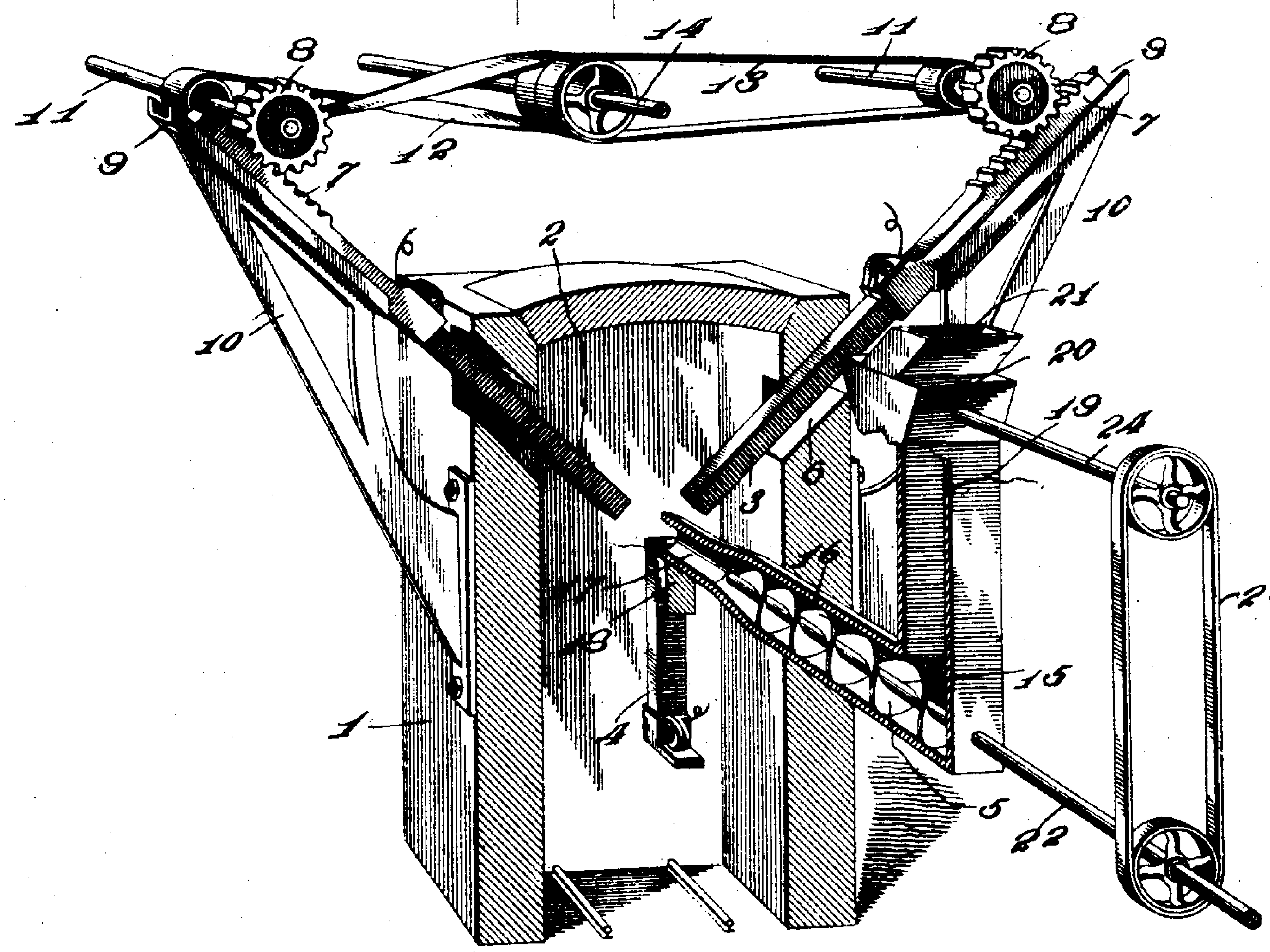


FIG-3.

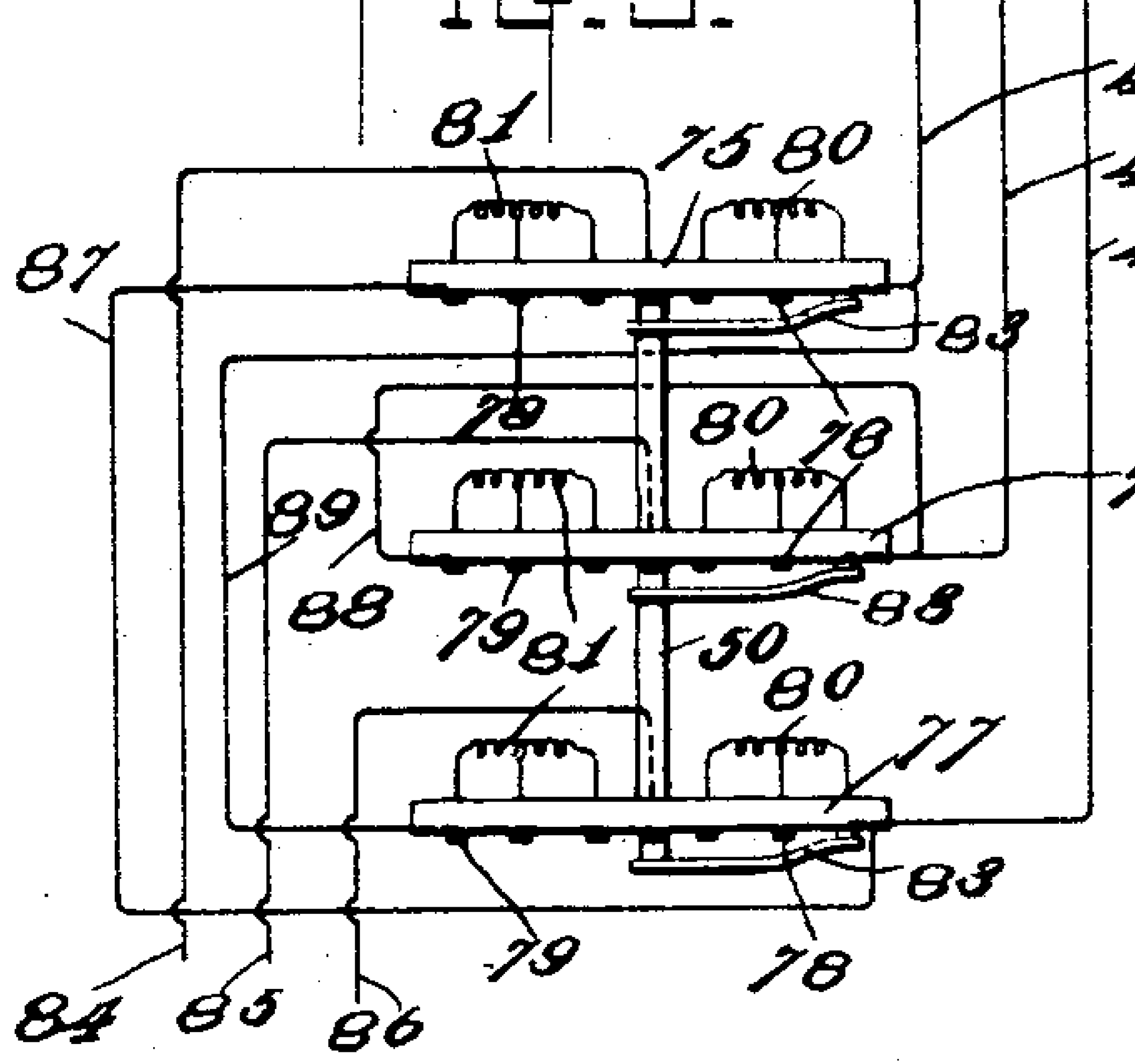
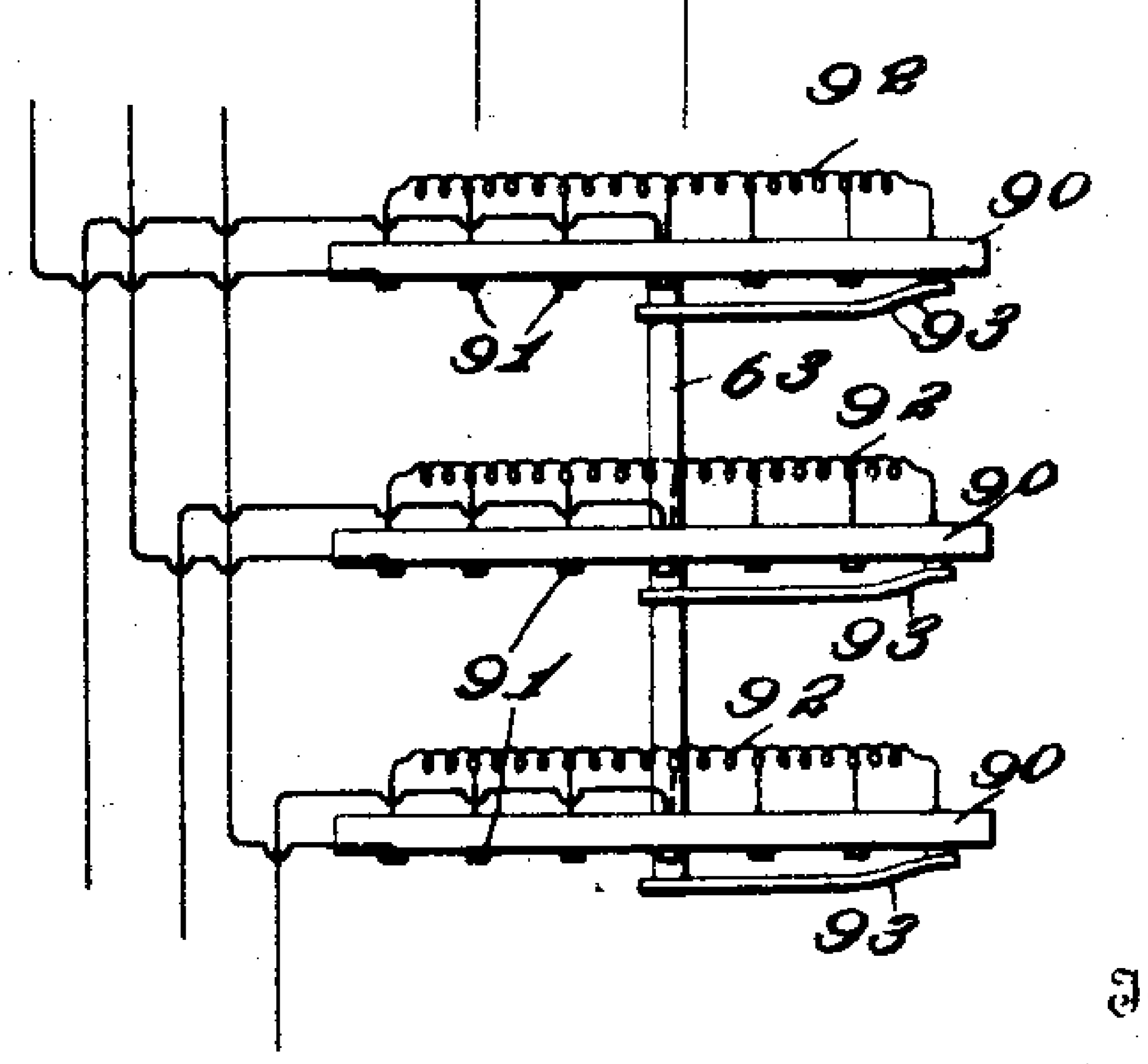


FIG-4.



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UNITED STATES PATENT OFFICE.

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ELECTRICAL FURNACE.

SPECIFICATION forming part of Letters Patent No. 790,226, dated May 16, 1905.

Application filed March 21, 1903. Serial No. 148,985.

To all whom it may concern:

Be it known that I, ISEDORE S. PRENNER, a citizen of the United States, residing at Scranton, in the county of Lackawanna and State of Pennsylvania, have invented certain new and useful Improvements in Electrical Furnaces; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to improvements in smelting or converting mechanisms, and particularly to electrical furnaces for thoroughly smelting and converting ores or materials of various kinds.

The invention consists in an electrical converter provided with a smelting-chamber which is formed by the adjacent points of electrodes, the end of said points constituting the only walls of said chamber, the said chamber being raised to a smelting temperature by arcs formed between the electrode-points.

The invention also consists in an electrical furnace provided with electrodes arranged to form arcs between them, means for moving the electrodes toward or away from each other in accordance with the size of the arc, and means for delivering the material to the arcs for conversion or smelting.

It also consists in a furnace provided with means for forming a suitable electric arc or arcs and means for delivering material to be acted upon by the said arc to the same in accordance with the capacity of the arc for converting the material.

It further consists in a furnace provided with electrodes, means for adjusting them with respect to each other to maintain suitable arcs between them, means connected with the arc-circuits for controlling the electrode-feeding mechanism in accordance with the size of the arcs and the amount of current flowing across the same.

It still further consists in a furnace provided with a suitable closure within which are arranged electrodes so as to form arcs and means for maintaining the electrodes at a proper distance from each other to form arcs of a proper size and strength, means for delivering materials to be operated upon into the furnace and between the ends of the electrodes, and mechanism for controlling the action of said feeding mechanism, so that if the arcs have not reached their normal condition less material will be fed to them, the amount being increased as the arcs reach their normal condition, the mechanism also being such that the feed of the material will cease altogether if the arcs are broken or there is no current passing through the electrodes or when there is an excessive current due to the electrodes being too near each other or when the arc or arcs are first established.

It also consists in certain other novel constructions, combinations, and arrangements of parts, as will be hereinafter fully described and claimed.

In the accompanying drawings, Figure 1 is a top plan view of my improved furnace, the means for controlling the action of the motors being shown in diagrammatic form and the direction of the circuits being also shown in such diagram. Fig. 2 is an enlarged perspective view, partially in section, showing the interior of the furnace, the means for feeding the electrodes back and forth, and means for delivering the material to the electrodes which is to be smelted. Fig. 3 is a diagrammatic view of a circuit-changing switch employed for affecting one of the motors. Fig. 4 is a diagrammatic view of one of the resistance mechanisms employed for cutting out or in resistance in the circuits of the furnace-operating mechanism. Fig. 5 is a detail view of an agitator suitable to be used in connection with this mechanism.

To operate successfully and economically an electric-arc furnace for smelting purposes or for the conversion of ore materials, it is necessary that the materials should be fed through the arc of the furnace at such a rate as to be completely converted by the arc, and the speed with which the material is fed must vary with the strength of the arc. The strength of the arc of course is dependent

upon the current passed from electrode to electrode and is affected by the distance between the electrodes. As the electrodes are consumed in use, in order to keep the distance between them constant they must be moved toward each other from time to time.

It is the object of the present invention to supply an arc-furnace in which electrodes may be employed for maintaining a smelting or converting arc and in which the position of the electrodes with respect to each other is controlled by the strength of the current flowing through the arc. It is desirable to have such a furnace that a direct current may be employed or an alternating single-phase or polyphase current.

In the accompanying drawings I have illustrated my invention, showing the parts properly arranged for using a three-phase alternating current.

In the drawings the furnace-closure 1 is formed of a suitable size to receive three electrodes 2, 3, and 4, together with a feeding apparatus 5, there being room below these parts for the insertion of a suitable car or receptacle for receiving the material smelted. I prefer to calcimine the carbon electrodes heavily, so that the small portion exposed to the hot gases will not be acted upon thereby, these gases having a tendency to combine with the carbon of the electrodes. The electrodes 2 and 3 preferably enter the furnace 1 through passages 6 in the side walls thereof, while the electrode 4 is supported within the structure, preferably in a vertical position. In using three electrodes, as shown in the drawings, the electrodes are arranged at angles of one hundred and twenty degrees from each other, and two of the electrodes, as 2 and 3, are preferably capable of being fed toward or away from each other and the third electrode 4. A convenient manner of mounting and operating these electrodes has been shown in Fig. 2, where the carbon points are clamped in sliding holders 7, which are formed with racks or gear-teeth upon one of their surfaces, preferably the upper, for engagement with actuating-pinions 8. The said holders 7 move in guideways 9, supported by brackets 10 upon the side furnace-walls. The electrodes are held thus in such position that they can be moved readily in and out of the furnace, so as not to alter the degree of the angles between them and adjacent electrodes. The pinions 8 are carried by suitable shafts 11, which are connected by belts 12 and 13 with pulleys upon a motor-shaft 14. The belt 12 is preferably crossed, as shown in Figs. 1 and 2, while the belt 13 is straight, and thus the movement transmitted by the motor-shaft 14 will turn the shafts 12 and 13 both in opposite directions simultaneously for feeding both of the electrodes inwardly or retracting them at the same time and to the same extent. When the electrodes are fed to a suitable distance from each other to produce a strong arc, a space is formed between the ends of the electrode-points of a proper size to receive the material to be smelted or converted. In Figs. 1 and 2 I have illustrated a means for delivering the material to this space between the electrodes within the furnace, it not being necessary to open the furnace to accomplish the result. This feeding mechanism consists of a conveyer 15, preferably of the screw type, which is inclosed in a casing 16, which extends through one of the walls of the furnace and is provided with a mouth or delivery-nozzle 17, which leads material fed by the conveyer to a point opposite the space between the electrode-points. The material discharged from this mouth may, if desired, be caught upon a small hearth 18 adjacent to the upper portion of the stationary electrode 4. The material is delivered to the conveyer through a vertical chute 19, which is provided with a hopper 20 at its upper end, in which any suitable agitator (see Fig. 5) may be employed for stirring the material and preventing its packing in the hopper or chute. The material to be smelted is pulverized and inserted in the hopper 20 through an upper chute 21, where the material is thoroughly agitated and passes downwardly through the chute 19 to the conveyer-casing. The screw conveyer is carried by a shaft 22, which projects outwardly from the conveyer-casing and is connected with an actuating mechanism, preferably a shunt-wound motor, as 23. (Shown in Fig. 1.) The shaft 22 is preferably connected with the shaft 24 of the hopper-agitator by suitable belting 25, which runs over pulleys upon both of said shafts. By this construction the agitator in the hopper will not be operated when the conveyer-screw is not operated, but will be actuated whenever said conveyer-screw is rotating and to a corresponding degree.

The action of the motors which regulate the feeding of the electrodes and of the material to be smelted is controlled by various resistances and magnets, which are connected up with the electrical circuits employed in operating the device. In Fig. 1 will be found a diagrammatic view showing the circuits employed in connection with the furnace and the motor-controlling devices. As shown in this view there are three line conductors 26, 27, and 28 for supplying a current to the electrodes, the said electrodes being provided with conductors 26^a, 27^a, and 28^a, which are in position to be connected by a suitable switch bridging the space at 29 with the line conductors 26, 27, and 28. In the arrangement of the conductors illustrated 26^a is connected with the electrode 3, while 27^a is connected with the electrode 4, and 28^a with the electrode 2. The conductors 26^a and 28^a also form the primary windings or coils of the transformers 30 and 31, which control the mechanism for affecting the fields of the mo-

tors above mentioned. There is also a shunt-circuit made by the conductors 32, which is connected with the conductors 26^a and 28^a. This shunt-circuit affects the magnets for controlling the current supplied to the armatures of said motors.

In Fig. 1 will be found also line conductors 33, 34, and 35 for supplying a current to the field of the motor 23. Field-conductors, as 33^a, 34^a, and 35^a, are so arranged that they may be connected by a suitable switch for bridging the space 36 with the conductors 33, 34, and 35, respectively. A resistance box or instrument, as 37, is interposed in the conductors 33^a, 34^a, and 35^a, and its armature 38 is controlled by a plunger 39, with which it is connected by a link 40. The plunger enters a magnet 41 of the solenoid type at one end and a suitable dash-pot 42. The coil of the magnet or solenoid 41 is electrically connected with a secondary winding or coil 43 of the transformer 30. The magnet 41 is thus seen to be in position to control the resistance interposed in the conductors of the field of the motor 23 in accordance with the strength of the current induced in the transformer 30 by the current of the electrodes.

In Fig. 1 will be found line conductors 44, 45, and 46, which introduce a current which is to be led to the field of the motor 47, which controls the feeding of the electrodes. This field is also supplied with corresponding conductors 44^a, 45^a, and 46^a, which are so arranged that they may be connected by a suitable switch capable of bridging the space at 48 with the line conductors 44, 45, and 46. In the field-conductors 44^a, 45^a, and 46^a is interposed a reversing mechanism 49, provided with suitable resistances, the armature 50 of which is operated by a solenoid-plunger 51, the said armature being connected with said plunger by a link 52. The plunger 51 extends up into the solenoid-magnet 53 at one end and at the other end extends into a suitable dash-pot 54. The solenoid-magnet 53 is connected by a conductor 55 with the secondary winding or coil 56 of the transformer 31. Thus it will be seen that the solenoid-magnet 53 is in position to control the reversing of the motor 47 and the resistance in its conductors in accordance with the strength of the induced current produced by the transformer 31, and hence in accordance with the strength of the current traveling through the electrodes. In the above-described manner the strength of the fields of the two motors will be automatically controlled in accordance with the strength of the arcs in the furnace. Means is likewise provided for controlling the strength of the armature-currents of the motors 23 and 47 in accordance with the strength of the arc-currents. This means consists in magnets, preferably solenoids 57 and 58, which actuate plungers 59 and 60. The windings of these solenoid-magnets are connected in parallel with the shunt-conductors 32. Each of the plungers 59 and 60 is also provided with a dash-pot 61 and 62, respectively, and the said plungers are connected with the armatures 63 and 64 of resistance-boxes 65 and 66. The resistance-box 65 is interposed in the conductors 67, 68, and 69 of the armature 70 of the motor 47, while the resistance-box 66 is interposed in the conductors 71, 72, and 73 of the motor-armature 74.

As shown in Fig. 3, the pole-changing device or reversing mechanism employed at 49 in connection with the field of the motor 47 may be constructed with a series of bars 75, 76, and 77, which carry a series of contacts 78 and 79. The contacts 78 are connected by means of resistances 80 at one end of the said bars, while the contacts 79 are connected by resistances 81 at the other end of the bar, the central contact being neutral and disconnected. The armature 50 of this mechanism carries a series of spring-contacts 83, which may be moved into engagement with any of the contacts carried by the said bars. Each of the contacts 83 is connected with one of the line conductors by wires 84, 85, and 86, while one of the contacts 78 of each bar is connected with the motor field-wires 44^a, 45^a, and 46^a. One of the conductors 79, also on the opposite end of each bar, is connected with said field-wires by conductors 87, 88, and 89. These latter conductors are used in order to effect the reversing of the current, so that the conductor 87 connects the outer contact 79 of the bar 75 with the outer contact 78 of the bar 77. The conductor 89 also connects the outer contact 78 of the bar 75 with the outer contact 79 of the bar 77. The conductor 88 merely connects the two end contacts 78 and 79 of the central bar 76. It will be evident that when the armature 50 of the reversing-box is in the position shown in Fig. 3 there will be no resistance cut into the field of the motor 47, so that when its armature is energized the motor will begin to operate at once, turning in one direction either for feeding the electrodes toward each other or away from each other. As the armature 50 is moved farther and engages the next contact 78 part of the resistance 80 will be cut in and the motor will run slower. Upon reaching the next contact 78 all of the resistance 80 will be cut in and the motor will stop. As the armature moves farther it will engage the contacts 79 and the resistances 81 will be cut in, but the current will be reversed, so that the motor will begin to operate slowly, but in an opposite direction. Of course as the armature 50 moves farther the resistances 81 will be cut out, and the reversal of the motor will proceed with greater speed. The armature 50, as above described, is controlled by the action of the solenoid 53, which receives its current from the transformer 31, which latter is in the arc-circuit of the furnace, and it will

be readily seen that the strength of the induced current of the transformer may thus be made to control the action and the reversal of the motor 47 in exact accordance with the strength of the current in the arc-circuit, and therefore automatically control the feeding of the electrodes toward or away from each other. The field of the motor 47 is thus used for reversing the motor, while the armature of the motor is energized or deënergized also in accordance with the strength of the arc-currents. As above described, the solenoid-magnet 57 is connected in the shunt-circuit 32. Thus when the current is broken through the electrodes it will all pass into the shunt-circuit and energize the magnet 57, pulling up its plunger 59 and operating the armature 63 to cut out the resistance in the conductors of the armature 70. As soon, however, as the motor 47 has been actuated to bring the electrodes into proper position for forming a normal arc between them the current will have been established through the said electrodes and the resistance so far decreased through said electrodes that no current will pass through the shunt-circuit and the plunger 59 will be retracted by the dash-pot 61, thus cutting in the resistance of the box 65 in the armature-circuit and stopping the motor 47.

A preferable form of constructing the variable resistance of the box 65 is illustrated in detail in Fig. 4, where it will be found several bars 90 are provided with a series of contacts 91, connected with each other by a series of resistances 92. The contact at one end of each bar is connected with the wires leading to the armature of the motor. The resistance-armature 63 is also connected with the line-wires and carries a series of spring-contacts 93. As the armature 63 is moved to the left, as illustrated in Fig. 4, under the action of the magnet 57 the resistances will be successively cut out, so as to permit the operation of the motor 47. When the solenoid becomes demagnetized, the dash-pot will return the armature to the position shown in Fig. 4 for cutting in the resistance again and starting the motor. The interior structure of the variable resistances shown at 66 and 37 is practically the same as illustrated in detail in Fig. 4; but the operation of the armature in the box 66, which is controlled by the magnet 58 in the shunt-circuit, is in the opposite direction, so that when the magnet is demagnetized the motor 23 will be furnished with current for operation in feeding the materials to the furnace. Should the arcs in the furnace be broken or the electrodes too near each other, as at starting, the feeding-motor will be stopped. If the resistance of the electrodes 2, 3, and 4 be too great or too small, the feeding-motor will be caused to run more slowly or speed up, as the case may be.

In the resistance mechanism 37 the structure is the same as in the box 65 and the action of the transformer and the solenoid 41 is such that the field of the motor 23 will be deprived of a current until an arc is properly formed between the electrodes, after which the resistance in the box 37 will be cut out in proportion to the strength of the arcs for supplying a current to the field of the motor 23 and permit its operation for feeding a proper amount of material to the smelting-arcs.

From the above description the operation of the furnace will be readily understood. The material which is to be smelted or converted is conveyed to the hopper and chute of the conveyer, ready to be fed to the furnace. The electrodes are preferably separated to such an extent as to prevent an arc being formed between them before the operation is started. Next the switches at 36 and 48 are closed, and then the switch at 29 is closed, so that all the circuits are connected up with the line conductors. Since the arcs have not been formed in the furnace yet, as the electrodes are separated with too great a space for forming the arcs, the plunger 39 will operate to cut out the resistances of the field in the feeding-motor 23, holding the same from moving. At the same time the current in the line-wires 26 and 28 will flow through the shunt 32 and energize the magnet 57, so that the motor 47 will be caused to operate through the cutting out of its resistance-box in such a direction as to feed the electrodes 2 and 3 toward each other and toward the electrode 4. After they have approached a sufficient distance to permit of the current flowing from one to the other the arcs will be formed, though the electrodes will be too close together for working purposes. The current thus being formed through the electrodes, the amount of current passing through the shunt 32 will be reduced and the motor 47 will be caused to operate more slowly. As the resistance in the electrode-current decreases and the full current is flowing through the arcs, the shunt-circuit will be deprived of its current, while the series circuit will operate the reversing mechanism, so as to cause the motor to revolve in the opposite direction, stretching the arc to its proper length, thereby causing the current to decrease, thus demagnetizing the magnet which operates the reversing mechanism, and the dash-pot 61 will pull the plunger down, so as to reverse the motor, ready for feeding the electrodes toward each other as they become consumed. As the electrodes are consumed in use their ends will be separated more and more, and thus the resistance of the arcs will be increased, which will cause a current in the shunt-circuit again, and the motor 47 will be energized again and will feed the electrodes toward each other for assuming their normal condition for maintaining arcs of the proper strength. As above intimated, before the formation of the arcs the exciting-current of the field in the

feeding-motor 23 has been withheld; but when the arcs have been properly formed the said field is provided with a current through the action of the transformer 30 and the magnet 41 in proportion to the strength of the arcs. At the same time the magnet 58 is controlling the application of a current to the armature 74. Before the arcs have been formed the current passing through the shunt-circuit will energize the magnet 58 and cut in the resistance of the box 66 in the armature-circuit 74. As soon as the arcs are formed and the current weakens in the shunt-circuit the dash-pot 62 will operate to cut out the resistance in the armature-curcuit; but the feeding-motor will not begin to operate until the electrodes have been moved apart sufficiently to decrease the current through the arc-circuit, so as to demagnetize the solenoid of the resistance-box 37, which holds the resistance in the field-coil of the motor 23. As soon as the field resistance has been cut out the motor will begin to feed material to the arc between the electrodes. While the arcs are small the material will be fed slowly; but when the arcs attain their normal size and a full current is flowing through them, so as to prevent the current flowing through the shunt-circuit, the resistances of the armature 74 will be cut out and the motor 23 will feed a normal supply of material to the furnace. As the arcs lengthen through the burning off of the electrodes the resistance in the arc-circuit will increase somewhat and the shunt-circuit will again receive some of the current, causing the magnet 58 to cut in some of the resistances in the circuit of the armature 74, so that the feeding operation will slacken correspondingly until the electrodes have been fed forward again to their normal positions by the motor 47, as above described. Of course if the arcs be broken in any way the shunt 32 will be immediately energized and the motor 23 stopped for preventing the feeding of material to the furnace when there are no arcs to receive the same. It will thus be seen that when the switches are once closed for the operation of the mechanism the maintaining of the electrodes at the proper working distance and the feeding of a corresponding amount of material to the furnace will be automatically regulated by the action of the currents themselves.

Any variation in the arc-circuits will be immediately corrected and the feeding of the material correspondingly changed at any time. The result of this mechanism in use is the steady maintenance of good working arcs and the feeding of all the material thereto which the arcs are able to convert or smelt. It will be evident that the third electrode 4 might be adjustably mounted in the furnace, if desired, as are the others; but since this electrode is arranged so that the material smelted falls upon its end the said materials will build up the end of the said electrode to the proper height. The control of the feeding mechanism automatically in accord with the strength of the arcs makes the handling of ores or other materials smelted in such a furnace exceedingly economical, since the arcs will always be supplied with just the amount of material which they are able to convert. There will also be no waste of material, since upon the reducing of the strength of the arcs the feed of the material will be reduced and upon the breaking of the arcs the feed of such material will cease altogether. It is also of advantage to be able to keep the electrodes and arcs formed between them inclosed during operation, since it prevents the chilling of the furnace. In the present invention the material is fed to the arcs within the furnace without having to open the same to introduce it.

Although I have described carefully certain preferred devices for introducing resistances or controlling means in the various circuits and magnets or solenoids for operating them, as well as transformers, I do not wish to be understood as limiting myself to these mechanisms for this purpose, as it will be evident that I may use other kinds of resistance and other means for cutting in or out the said resistances without departing from the spirit of the invention. While I may arrange the furnace and the circuits so that a direct current may be employed, substituting, of course, other means in place of the transformers, yet I preferably employ alternating currents, which may be either a single phase or a polyphase current. I find in practice that a three-phase current, such as that illustrated and above described, is admirably adapted for the purpose set forth.

Having thus fully described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. An electrical furnace, comprising electrodes projecting into said furnace to form arcs between them and electrically-actuated propelling operated means for moving the electrodes farther into the furnace or withdrawing them therefrom in accordance with the strength of the current flowing through the arcs.

2. An electrical smelting or converting apparatus, comprising means for holding electrodes to form arcs between them, the said electrodes projecting into the apparatus so as to form arcs surrounding a smelting space or chamber, and electrically-actuated means for moving the electrodes toward each other to establish said arcs, the said means also maintaining the electrodes at a distance from each other in accordance with the strength of the current passing through said arcs.

3. In an electrical furnace, the combination of electrodes, means for maintaining them at a proper distance from each other to form

electric arcs, the said arcs surrounding a smelting space or chamber, and electrically-operated means for delivering the proper amount of material to the arcs for smelting or conversion, and means actuated by the current of the arcs for controlling the current delivered to the said electrically operated means.

4. An electrical smelting or converting apparatus comprising electrodes, electrically-propelled means for holding them a proper distance apart to form smelting-arcs, and electrically-propelled means for delivering material to the space surrounded by the said arcs, the said means being controlled by the strength of the arc-current to move both of said propelling means in accordance with the capacity of the arcs for smelting the material.

5. A mechanism for smelting or converting ores or like materials comprising electrodes, electrically-propelled means for adjusting them in respect to each other, to maintain working arcs between them, and means controlled by the strength of the arc-circuits for varying the electrode-adjusting mechanism in accordance with the amount of current flowing across the arcs.

6. An electrical smelting or converting mechanism, comprising movable electrodes, electrically-operated means for propelling the electrodes toward or away from each other, resistance devices for controlling the operation of said means, and means dependent upon the strength of the arc-current for regulating said resistance devices.

7. An electrical smelting and converting mechanism comprising movable electrodes arranged to form arcs between them, means for inclosing the said arcs, and an electrically-operated means regulated by the strength of the current and flowing through the arcs for feeding material into said closure and to the said arcs without opening the closure.

8. An electrical smelting or converting mechanism, comprising a suitable closure, means for adjustably holding electrodes in suitable relation to each other within said closure, means for feeding material to the arcs formed between said electrodes, electrically-operated means actuated by the arc-current for varying the position of the electrodes and the feeding of the material to the electrodes and means controlled by the arc-circuit for regulating the current used by said electrically-operated means in accordance with the strength of the arcs.

9. An electrical converting mechanism, comprising adjustable electrodes and a material-feeding mechanism, electric motors for controlling the feeding of the electrodes and the feeding of the material, resistance devices for varying the action of the motors, and means controlled by the arc-circuit of the motors for varying the said resistances.

10. An electrical smelter, comprising a closed chamber, adjustable electrodes extending into the same, so as to form an arc within the chamber, gearing for moving the electrodes toward or away from each other, electrically-operated means for operating said gearing, and means controlled by the arc-current for regulating the strength of the current of the said electrically-operated means in accordance with the strength of the arcs.

11. An electrical smelter, comprising a closure, electrodes for forming arcs extending into said closure, means for adjustably holding the electrodes in position comprising rack-bars, pinions engaging the said rack-bars, and an electric motor for turning said pinions in one direction or the other in accordance with the strength and size of the arcs.

12. An electrical converting mechanism for ores and the like, comprising a closure, a stationary electrode mounted therein, movable electrodes projecting into said closure in suitable relation to each other and to the stationary electrode, gearing for adjusting the movable electrodes, shafting operating the said gearing, an electric-motor shaft connected with said shafting, means for varying the action of the electric motor for feeding the movable electrodes toward or away from each other in accordance with the flow of current through the arcs, and means for feeding material to be acted upon to the arcs formed between said electrodes.

13. An apparatus for converting ores or the like comprising a closure, a stationary electrode mounted therein, movable electrodes projecting into said closure and into suitable proximity to each other and to the stationary electrode, a hearth supported adjacent to the end of the stationary electrode, electrically-operated means for feeding material to be converted to said hearth, and modifying means controlled by the strength of the arc-circuit for delivering a current to the electrically-operated means in accordance with the size and strength of the arcs passing between the electrodes.

14. An apparatus for smelting or converting ores and the like, comprising electrodes and means for maintaining them in suitable relation to each other to form working arcs, means for delivering material to be acted upon to said arcs comprising a conveyer, the said conveyer having a discharge-mouth adjacent to the space between the electrodes, means for supplying material to the conveyer outside the closure of the apparatus, electrically-operated means for controlling the feed of the material to the electrodes, and means affected by the arc-circuits for regulating the current delivered to said electrically-operated means in accordance with the strength of the arcs.

15. An electrical furnace, comprising a closure, electrodes mounted therein to form suitable converting-arcs, a delivery mechanism projecting into said closure for supplying ma-

terial to the arcs, the said delivery mechanism comprising a casing, a screw conveyer mounted therein, a chute for delivering material to the conveyer, and an agitator adapted for preventing the packing of said material in the chute together with electrically-operated means in the electrode-circuit for rotating the screw conveyer in accordance with the strength of the arcs in the furnace, substantially as described.

16. An electrical furnace, comprising a closure, electrodes for forming arcs therein, a motor for controlling the position of the electrodes with respect to each other, a mechanism for feeding ore or like material to the said arcs, a motor for controlling the same, a shunt-circuit for controlling the supply of current to the armatures of the said motors, and means connected with the arc-circuit for controlling the supply of current to the motor-fields, substantially as described.

17. An electrical furnace, comprising a closure, electrodes projecting into the same, a motor for controlling their position with relation to each other, means for supplying material to the furnace and a motor for controlling the said supply, resistances interposed in the field-circuits of said motors, resistances interposed in the armature-circuits of said motors, and magnets connected with the arc-circuit for controlling and varying the said resistances to modify or stop the action of the motors in accordance with the amount of current through the electrodes, substantially as described.

18. An electrical furnace, comprising a closure, movable electrodes mounted therein, a motor for controlling the position of the electrodes relatively, means for feeding material to be acted upon to the said furnace, a motor controlling the said feed, a reversing-switch interposed in the field-circuit of the electrode-controlling motor, means connected with the arc-circuit for controlling said reversing means, means interposed in the armature-circuit of said motor for controlling the current supplied thereto, and resistances interposed in the circuits of the field and armature of the feed-motor, substantially as described.

19. An electrical furnace, comprising a closure, movable electrodes mounted therein, a motor for controlling said electrodes, resistances interposed in the armature-circuit, a magnet for controlling the same and connected with the arc-circuit of the furnace by a shunt, a resistance-reversing mechanism interposed in the field-circuit of said motor, a magnet for operating the same, and a transformer interposed between the said magnet and the arc-circuit for supplying the magnet with an induced current in accordance with the strength of the current in the arc-circuit, substantially as described.

20. In an electrical furnace, the combination with electrodes, of means for supplying an arc-forming circuit thereto, a motor for adjusting the said electrodes to vary the arc, means for supplying material to be acted upon to said furnace, a motor for operating said means, resistances interposed in the field of the feed-motor, a magnet controlling the same, a transformer for supplying an induced current to the said magnet, the transformer-primary being connected with the arc-circuit, the resistance-magnet being thus actuated in accordance with the strength of the arc-circuit, substantially as described.

21. An electrical furnace, comprising a closure, electrodes arranged therein, means for supplying an arc-forming current thereto, means for supplying materials to be operated upon by said arcs, a motor for operating the said supplying means, resistances interposed in the field of said motor, a magnet controlling said resistances, a transformer affected by the arc-circuit for supplying an induced current to the said magnet in accordance with the strength of the arc-circuit, the said resistances being operated to control the field of the feeding-motor or for stopping it when the arcs are broken, and means for supplying current to the armature of said motor, substantially as described.

22. An electrical furnace, comprising a closure, electrodes arranged within the same and supplied with an arc-forming current, means for supplying material to said arcs, a motor operating said feed mechanism, resistances interposed in the field-circuit of the motor and resistances interposed in the armature-circuit of the motor, a magnet controlling the field resistances, a transformer for supplying an induced current thereto in accordance with the strength of the arc-circuit, a magnet controlling the armature resistances, and a shunt controlling the same in accordance with the resistance in the arc-circuit, substantially as described.

23. An arc-furnace, comprising a closure, electrodes arranged therein and supplied with an arc-forming current, a motor controlling the relative positions of the said electrodes, a mechanism for feeding material to the said furnace for smelting or conversion, a motor operating the said feed mechanism, resistances arranged in the field-circuits of said motors, resistances arranged in the armature-circuits of said motors, and a series of solenoid-magnets for varying the said resistance in accordance with the strength of the arc-circuit, substantially as described.

24. A smelting or converting furnace, comprising a closure, electrodes mounted therein, means for supplying an arc-forming current thereto, a motor controlling the relative positions of the said electrodes, mechanism for feeding ore or similar material to said furnace, a motor controlling the same, resistances mounted in the armature-circuits of said motors, solenoids controlling the said resistances,

a shunt-circuit connecting the said solenoids with the arc-circuit, and means for controlling the fields of the said motors, substantially as described.

25. A smelting or converting furnace, comprising a closure, electrodes mounted therein, means for supplying an arc-forming circuit thereto, a motor controlling the adjusting of said electrodes, a feeding device for delivering material to the furnace, a motor controlling the same, resistances interposed in the field-circuits of said motors, solenoids controlling the same, transformers for varying the action of the solenoids in accordance with the strength of the arc-circuits, and means for controlling the armature-circuits of said motors, substantially as described.

26. An electrical converter having a smelting-chamber formed by the adjacent points of electrodes, the ends of said points constituting the only walls of said chamber, the said chamber being raised to a smelting temperature by arcs formed between the electrode-points.

In testimony whereof I hereunto affix my signature in presence of two witnesses.

ISEDORE S. PRENNER.

Witnesses:

W. W. BAYLOR,

MAY JOSEPH.