No. 713,923. Patented Nov. 18, 1902.

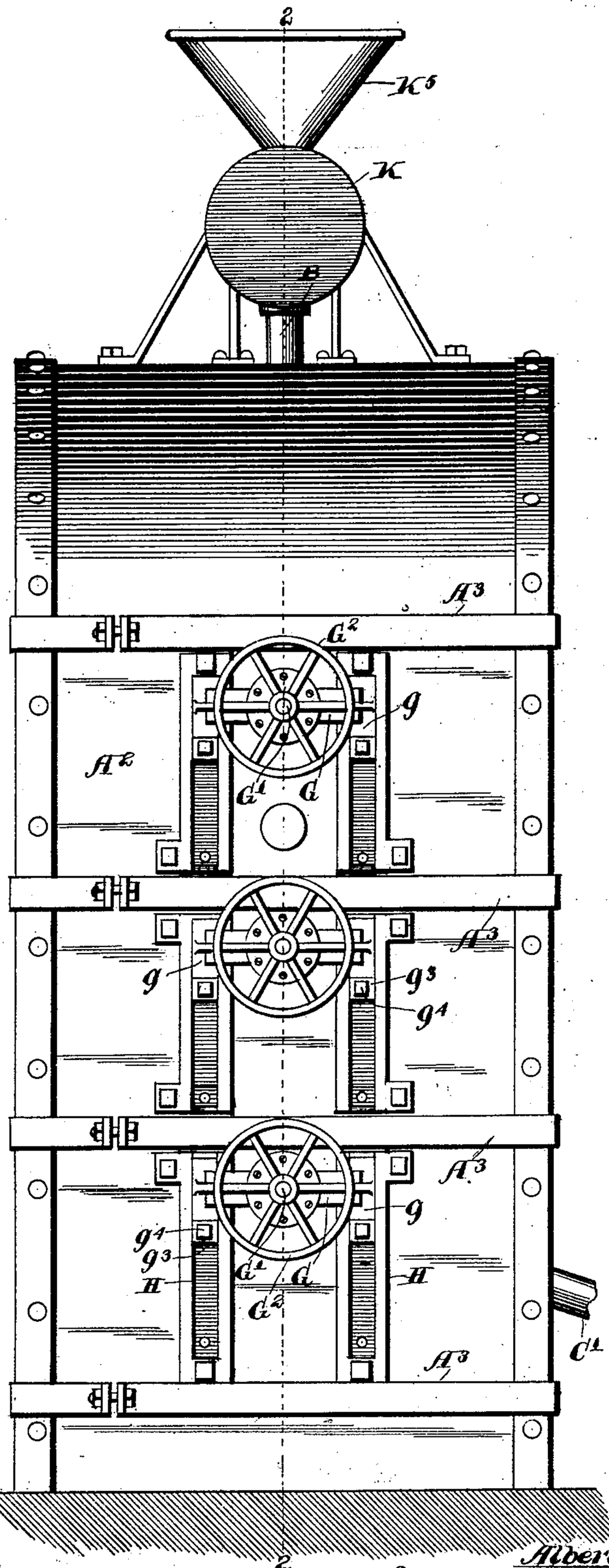
A. A. SHADE.

ELECTRIC FURNACE.

(Application filed Dec. 28, 1901.)

(No Model.) 4 Sheets—Sheet 1.

Fig 1



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George R. Wilkins.

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No. 713,923. Patented Nov. 18, 1902.

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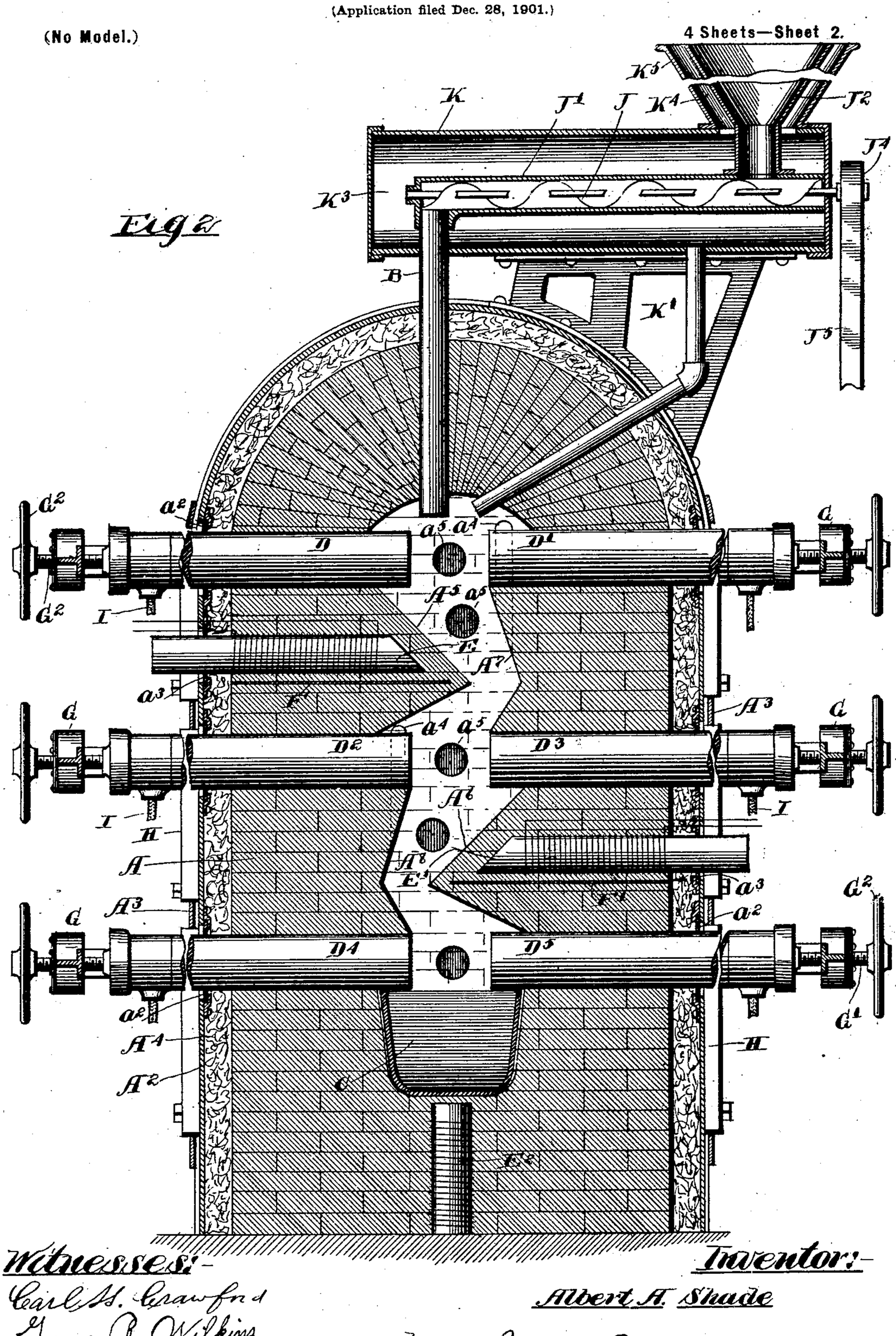
(Application filed Dec. 28, 1901.)

(No Model.)

4 Sheets—Sheet 2.

Fig 2.



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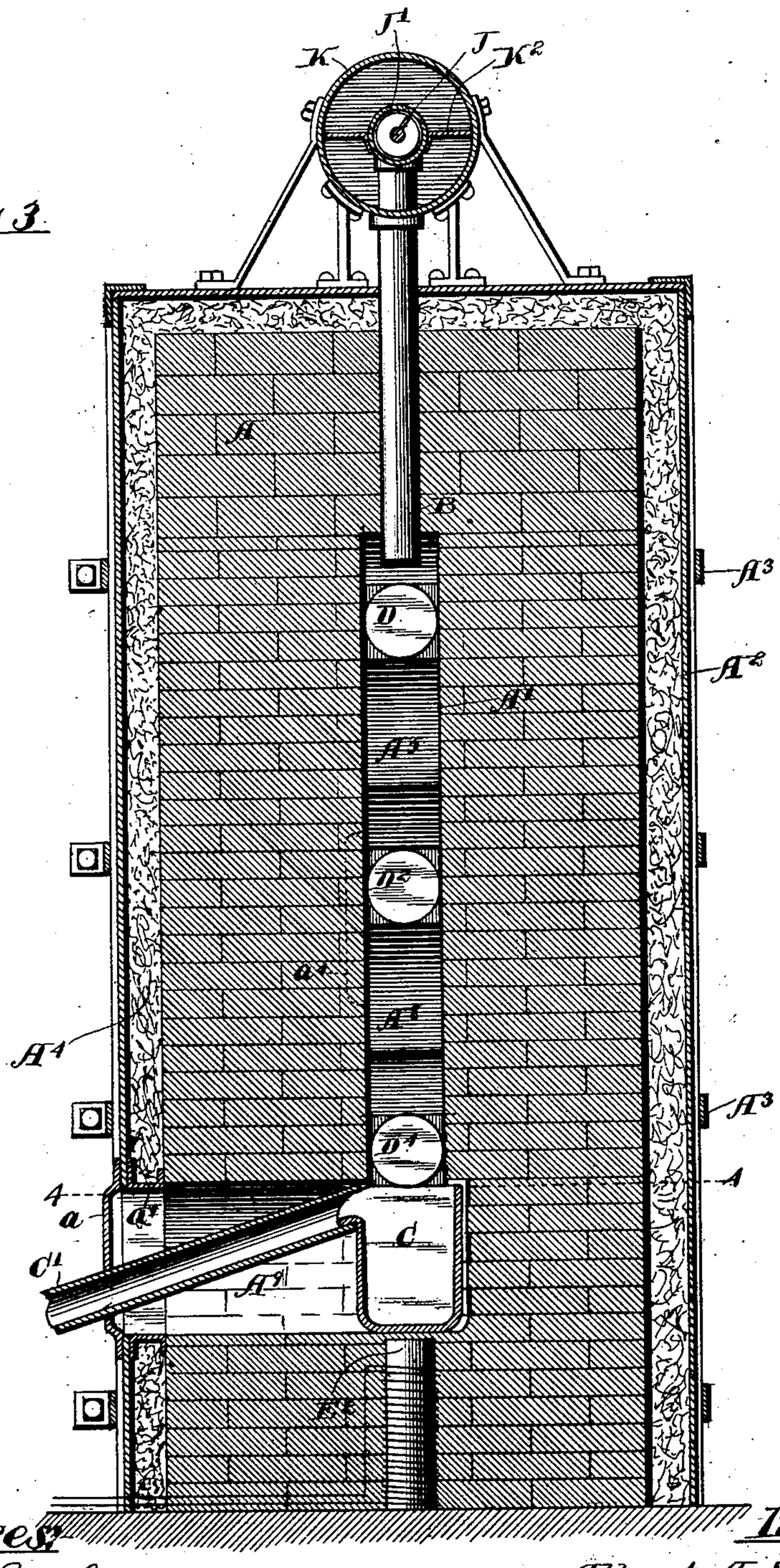
(No Model.) 4 Sheets—Sheet 3.

Fig 3.



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No. 713,923. Patented Nov. 18, 1902.

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ELECTRIC FURNACE.

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(No Model.) 4 Sheets—Sheet 4.

Fig 4

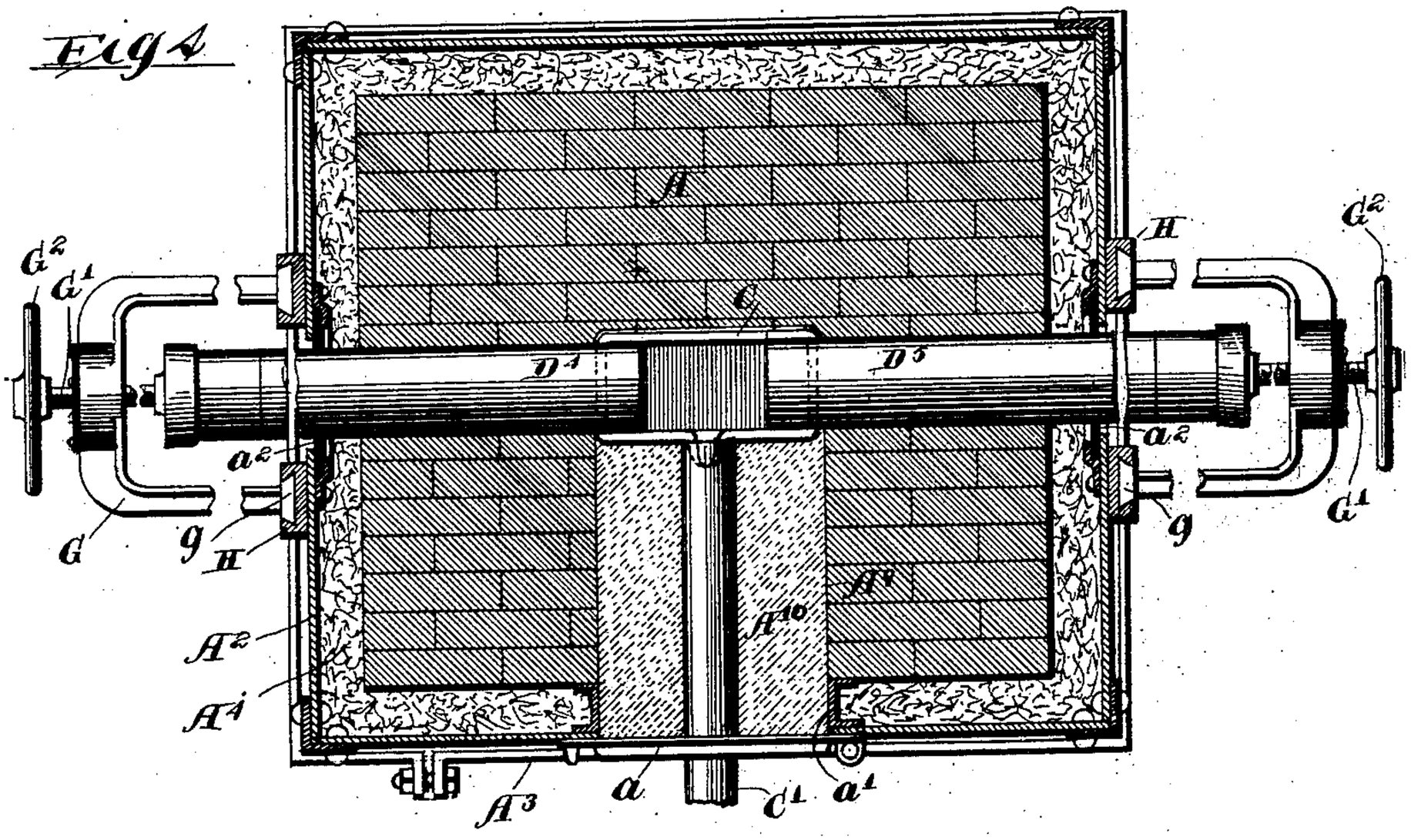

Fig 5

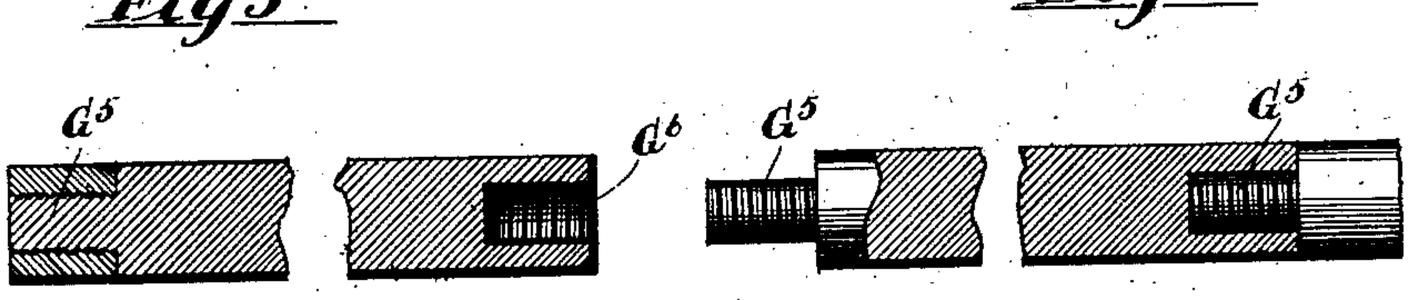

Fig 6

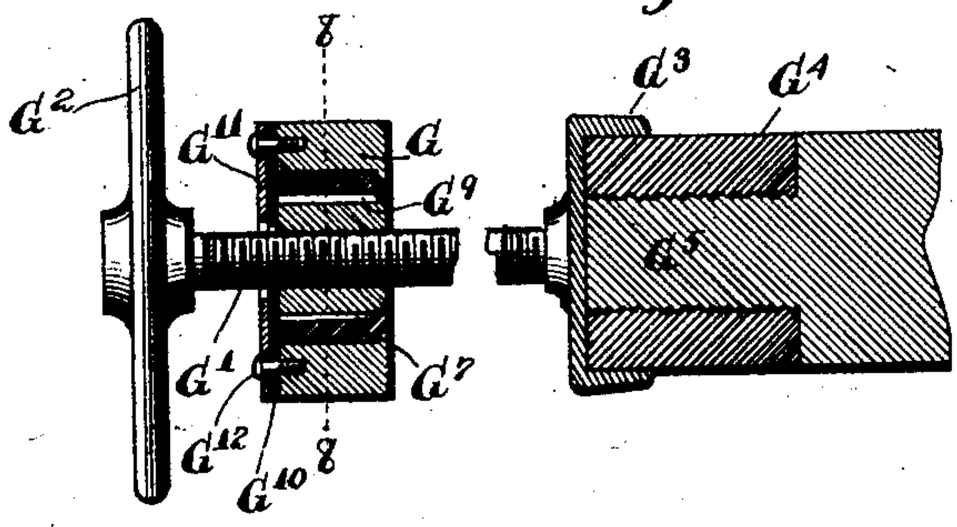

Fig 7

Fig 8

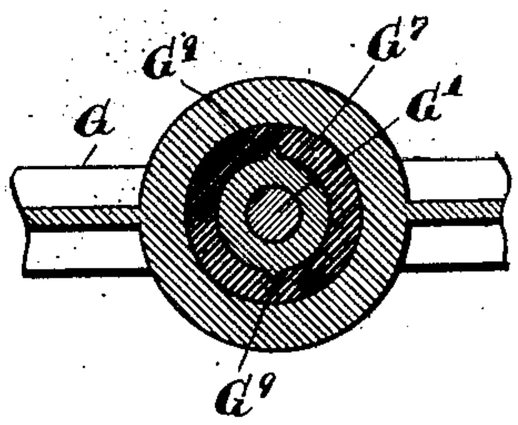

Fig 8

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UNITED STATES PATENT OFFICE.

ALBERT A. SHADE, OF CHICAGO, ILLINOIS, ASSIGNOR OF ONE-HALF TO EUGENE HOWARD MOORE, OF CHICAGO, ILLINOIS.

ELECTRIC FURNACE.

SPECIFICATION forming part of Letters Patent No. 713,923, dated November 18, 1902.

Application filed December 28, 1901. Serial No. 87,536. (No model.)

To all whom it may concern:

Be it known that I, ALBERT A. SHADE, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Electric Furnaces; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to improvements in electrical furnaces for smelting or reducing ores and other fusible substances; and the invention consists in the matters hereinafter set forth, and more particularly pointed out in the appended claims.

In the drawings, Figure 1 is a side elevation of a furnace embodying my improvements. Fig. 2 is a vertical section taken on line 2 2 of Fig. 1. Fig. 3 is a vertical section of said furnace in a plane at right angles to the plane of Fig. 2. Fig. 4 is a horizontal section taken on line 4 4 of Fig. 3. Fig. 5 is an axial section, broken away, of one of the carbon electrodes used in said furnace, showing applied thereto a metal collar by which the circuit-wire is connected with said electrode. Fig. 6 is a view, partly in elevation and partly in section, of two adjacent electrodes, showing the manner of connecting the same. Fig. 7 is a plan section, on an enlarged scale, of the outer end of one of the carbons and the devices for thrusting the same into the furnace. Fig. 8 is a cross-section taken on line 8 8 of Fig. 7.

The furnace herein shown, in which my improvements are embodied, is provided with an interior vertical passage, to the upper end of which the material to be smelted is fed in a granular form and provided at its lower end with a crucible from which the molten material is withdrawn. Extending through the walls of the furnace and into said passage are a plurality of pairs of electrodes, between each pair of which in said passage is adapted to be formed an electric arc. Said pairs of electrodes are located one above the other, so that the material passes successively through the arcs until it is deposited into the crucible, from which the molten material is withdrawn as desired. Means are provided beneath each arc, excepting the lowermost one, for momentarily retarding the progress of the material as it passes through the furnace, and means are provided for elongating or deflecting the arcs toward the places at which the material is momentarily retarded, whereby the heat of the arcs is more effectively applied to fuse or smelt the material. The lowermost arc is located immediately above the open end of the crucible, and means are provided, as a magnet, located below said crucible, to deflect said arc into the crucible, so as to impinge upon the body of the molten material therein. The final fusing of the material takes place in said crucible, and the molten material is withdrawn from said crucible to the molds or other place for the use of said molten material.

The foregoing general outline of the furnace herein shown has been presented for the purpose of facilitating an understanding of the detail description which follows and is not to be understood as limiting the invention to the construction therein briefly set forth. As shown in said drawings, the furnace consists, mainly, of a mass or body A, of fire-brick and of suitable form, which is provided with an interior vertical passage A′, into the upper end of which is fed the material to be smelted through a pipe B, and C designates an open-topped crucible embedded in the wall of the furnace at the lower end of said passage and in which the final fusion of the material takes place. Said body of the furnace is surrounded by a metallic shield A^2, consisting of metal plates suitably secured together and confined by bands A^3 A^3. The space between said shield A^2 and the fire-brick body of the furnace is filled with a body of insulating material A^4, such as mineral wool, asbestos, or the like. Extending through the wall of the furnace and projecting into said passage A′ are a plurality of carbon electrodes arranged in pairs D D′ D^2 D^3 D^4 D^5. The electrodes of each pair are disposed in axial alinement with respect to each other and are separated at their inner ends, so that when a current is passed through the same an arc is formed in the passage between each pair of electrodes. The pairs of electrodes are arranged one above the other, so that the

arcs formed between the same are all located in the path of the material through the furnace, said material passing successively through the arcs of the series.

The walls of the passage A′ are so formed as to provide below the pairs of electrodes D D′ and D^2 D^3, respectively, oblique ledges A^5 A^6, which project into the path of the material through the furnace. The ledges A^5 A^6 project from opposing side walls of the passage, and the walls of said passage opposite said ledges are provided with shallow recesses A^7 A^8, thereby giving to the passage a zigzag form. The pipe B is preferably arranged with its discharge end closely adjacent to the electrode D of the uppermost pair. The upper ledge A^5 terminates short of the vertical plane of the inner end of the electrode D^3, which is located below and extends through the wall of the furnace opposite to the said ledge A^5, and the ledge A^6 bears a like relation to the electrode D^4 of the lowermost pair, which extends through the wall of the furnace opposite to the said ledge A^6. The material, therefore, passing from the pipe B first strikes the ledge A^5, which acts to momentarily retard or arrest the progress of the same, and said material drops off the point of said ledge closely adjacent to but not in contact with the electrodes D^3 and falls upon the ledge A^6, from whence it drops into the crucible C, closely adjacent to but not in contact with the electrode D^4 of the lowermost pair. Preferably the electrodes D, D^3, and D^4 are the positive electrodes, while the electrodes D′, D^2, and D^5 are the negative electrodes, and the construction above described is such that the material in its descent through the furnace passes closer to the positive electrode of each pair than the negative electrode thereof, and thereby receives the most effective heat of the arcs.

In conjunction with the means herein described for momentarily retarding or arresting the progress of the material in the effective areas of the arcs I have provided means for elongating or deflecting the arcs between the two upper pairs of electrodes toward said ledges A^5 A^6, whereby the material passing through the arcs will not only be subjected a greater length of time to the heat of the arcs, but said arcs act to heat said ledges A^5 A^6, which in turn give off their heat to more effectively fuse said material. The means for elongating or deflecting the arcs in the manner described consists of magnets E E′, the former of which extends through the wall of the furnace and has its inner end located closely adjacent to the ledge A^5, while the latter occupies a like position with respect to the ledge A^6. Said magnets are herein shown as bar-electromagnets; but it will be understood that horseshoe-magnets may and desirably will in practice be employed and that I may employ either electromagnets or permanent magnets. I prefer, however, to use for this purpose the electromagnets for the reason that I am enabled thereby to vary the strength of the magnets, and therefore accurately adjust the same to the strength of the current used to form the arcs between said electrodes.

In order to localize to an extent the fields of force of the magnets, so that said magnets will act effectively upon the arcs of their associated electrodes D D′ and D^2 D^3, respectively, metal plates F F′ are embedded in the walls of the furnace between said magnets and the subjacent electrodes of the other pairs. The plates F F′ each prevents the lines of force of the magnet above the same from influencing the arcs next subjacent said magnets, so that the force of each magnet acts to draw or elongate each arc downwardly toward or upon the ledge next beneath the same. In practice the magnets associated with each pair of electrodes will be located such distance from the magnets of the next subjacent pair as to minimize the effect of said magnet upon said latter electrodes. The localization of the fields of force of said magnets is more perfect in the use of horseshoe-magnets, and by the employment of a horseshoe-magnet and the proper use of magnetic metal for diverting or localizing the field of force practically the entire strength of the magnets may be brought to bear to deflect the arcs toward their proper ledges.

The lower pair of electrodes D^4 D^5 are situated immediately above the open-topped crucible C. The arc formed between said electrodes is elongated or diverted into the crucible by means of a magnet E^2, which is embedded in the wall of the furnace beneath said crucible. Said magnet, as the others before described, is herein shown as a bar-electromagnet, but may be made of other form, as indicated hereinbefore. The molten metal is carried off from the crucible through the medium of an inclined spout C′, which extends through the wall of the furnace and communicates with the crucible at the upper end thereof. It will be seen, therefore, that the arc formed between the lower pair of electrodes is brought into contact with or impinges upon the upper surface of the molten material in the crucible, so that said material is subjected to the heat of the lower arc as it first passes into the crucible and thereafter, as the material passes off the top of the molten mass through the spout C′, again brought into contact with or impinged upon by said lower arc.

The crucible C is adapted to be inserted into place in the furnace through an opening A^9 in the furnace-wall at one side thereof, as shown in Fig. 3, and through which opening the discharge-spout C′ of the crucible extends. Said opening is shown in Fig. 3 as being empty to illustrate the manner of forming the opening; but in practice after the crucible has been located in the lower end of the furnace said opening is filled with a suitable refractory filling A^{10}, as shown in Fig. 4.

When it is desired to remove the crucible and replace the same with a perfect one, the material A^{10} must first be removed, so as to permit the removal of the crucible and the insertion of a new one. The metal shield surrounding said furnace is provided with a removable door *a*, through which the spout C′ extends, and is provided inside said door with a ring or frame *a′*, which acts to hold or confine the body of insulating material A^4 in place around said opening.

The electrodes D to D^5, respectively, fit snugly in suitable openings in the furnace-walls and the shield. The shield is provided around the openings therein through which the electrodes extend with insulating-rings a^2. The magnets are severally seated in suitable recesses in the walls of the furnace, and the magnets E E′ extend through openings in the shield, and the shield is provided around said openings with similar insulating-rings a^3. The electrodes are thrust through said openings in the furnace-wall by the following-described devices. The devices which are associated with each electrode are similar to each of the other devices, so that the following description of one device will serve for all of the other devices.

G designates a yoke the ends of which are inserted in vertical grooved bars H H, attached to the side walls of the shield of the furnace, one on each side of each electrode. Said bars are provided with undercut grooves, and the arms of the yoke are provided with flanges *g*, which are of dovetail form in cross-section, as clearly shown in Fig. 4, and which fit the undercut grooves of the bars and form interlocking connections which prevent separation of said yoke and bars laterally and permit said yoke to slide vertically with respect to said bars. G′ designates a screw-shaft which has screw-threaded engagement with an opening in the transverse member of said yoke and is adapted to exert pressure at its inner end upon the adjacent electrode to force the same inwardly into the furnace. Said screw-shaft is provided on its outer end with a hand-wheel G^2, by which the same may be properly rotated. The screw-shaft G′ is provided on its end opposite the wheel G^2 with a flanged cap G^3, adapted to fit over a ring G^4, which latter surrounds the reduced extension G^5 of the electrode. The shaft G′ is insulated from the yoke G by a collar G^7, of rubber or other suitable insulating material, which fits within a suitable aperture in the yoke and which in turn is provided with a central aperture through which the interiorly-screw-threaded nut G^8 is passed. The nut G^8 is provided with radial ribs or feathers G^9, fitting in a suitable recess in the insulating collar G^7 to prevent the nut G^8 from turning with the shaft G′. The collar G^7 is held in position by a centrally-apertured insulating plate G^{10} and a centrally-apertured retaining-plate G^{11} by screws G^{12} or otherwise. Said ring is connected in any suitable manner with a circuit-wire I and by which said electrodes are brought into circuit with a source of electrical energy. The arms of the yoke G are made of considerable length, somewhat greater than the length of an individual electrode, so that the pressure of the screw-shaft G′ may be applied to said electrode when the latter is being inserted into the opening in the furnace-wall. In this manner the electrodes are forced inwardly as the inner ends of the same are consumed. The yokes are supported in said bars at the level of their associated electrodes by means of stop-blocks g^3 in the grooves of said bars, which are held in place by set-screws g^4, Fig. 1, which pass through said blocks and into said bars. When an electrode is to be inserted into the furnace, the stop-blocks are shifted downwardly and secured in the lower ends of said bars, the bars being provided at their lower ends with apertures to receive the set-screws g^4, after which the yoke is slipped downwardly below the level of the electrode. A new electrode is thereafter inserted in place and the yoke raised to bring the screw-shaft in position to properly engage the electrode to force the same into the furnace. After the yoke is raised the blocks g^3 are set into their upper positions to hold the yoke in place.

As a further and separate improvement I propose to so form the electrodes that they may be fed into the central passage of the furnace continuously without the necessity of withdrawing the unconsumed portions of the electrodes from the furnace when supplying new electrodes. For this purpose the end of each electrode remote from the reduced extension G^5 thereof is provided with an axial socket G^6, which is adapted to fit over the reduced extension of another or adjacent electrode, as clearly shown in Fig. 6. With this construction when one of the electrodes has been forced almost entirely into the opening in the furnace-wall the ring G^4, to which the associated electric wire I is attached, is detached from said electrode, another electrode fitted thereto, the latter electrode being slipped over the reduced extension of the partially-consumed electrode, the ring G^4 applied to the outer or reduced end of the new electrode, and pressure applied to both of said electrodes through the screw-shaft G′. The inner ends of the first electrodes are made solid, as it is not required that they have interfitting connection with other electrodes.

If desired, the overlapping ends of the electrodes may be provided with screw-threads or other interfitting connections, as shown in Figs. 5 and 6, so as to form a connection between said electrodes which will permit the same to be drawn outwardly as well as forced inwardly. The rings G^4 are similarly screw-threaded to engage said reduced extension. It will be desirable to move said electrodes in both directions when the operation of the furnace is started, for the reason that the elec-

trodes of each pair should be moved toward each other in first establishing the arc and thereafter withdrawn the required distance to produce the proper length of arc. By the use of the interfitting connection shown I am enabled to manipulate the electrodes in the manner described.

The means herein shown for feeding the granular material to the furnace consists of a horizontal spiral screw J, mounted in a suitable shell J′, which is connected at one end with the feed-pipe B of the furnace and at its other end with a hopper J^2, through which the material is fed to the conveyer-shell. The shaft of the conveyer is provided with a pulley J^4, which is operated from any suitable source of power through the medium of a belt J^5. As a further and separate improvement and one which is capable of application to other furnaces wherein is employed devices for feeding a granular substance to the furnace the conveyer-shell is located within a suitable chamber K, which completely incloses the same, and said chamber is connected with the upper end of the furnace through the medium of a pipe K′. The purpose of said chamber and pipe is to direct the heated gases from the furnace around the shell of the conveyer, so that the granular material passed therethrough will be to an extent heated before it is discharged into the furnace proper. As a means of more effectively heating said shell the chamber K is divided by a horizontal partition K^2 into an upper and lower part, which are connected by a transverse passage K^3 at the end of the chamber remote from the entering end K′ of the pipe thereinto, and the other end of said passage communicates with an exit-opening K^4, which surrounds the lower end of the hopper J^2. The hopper J^2 is desirably surrounded by a suitable flaring casing K^5, made similar in shape to that of the hopper, so as to confine the gases around said hopper, and thereby transmit a maximum amount of heat to the material on its way to the furnace. The walls of the furnace are provided with passages a^4 a^4, located one at the side of the electrode D′ at one side of the furnace and the other at the side of the electrode D^2 at the opposite side of the furnace. Said passages are provided to permit the furnace-gases to pass upwardly through the furnaces without being required to pass through the arcs.

The walls of the furnace adjacent to the walls through which the electrodes extend are provided with peep-holes a^5, through which the operations of the furnace may be observed. Desirably one peep-hole will be located at the level of each arc and one at the level of each ledge A^5 A^6, the former to enable an attendant to properly regulate the arcs and the latter to determine the action of the arcs upon the ledges and to know the condition of the material which is passing over said ledges.

The furnace herein shown may be used for smelting or fusing all kinds of materials requiring an intense heat to reduce the same. When the fused or molten material is drawn continuously from the crucible, the operation of the furnace may be continuous, the granular material being fed continuously to the furnace and the molten material drawn in in like quantities therefrom. The withdrawal of the molten material from the crucible may, however, be intermittent, as when in the use of the furnace in a glass-factory the molten material is withdrawn by the use of pontils. In the latter use of the furnace the crucible may be made of greater capacity or may discharge into a refining-crucible, from which the molten material is drawn, and the material may be fed to the crucible in reduced quantities to correspond with the rate of withdrawal, or the feed of the material may be intermittently suspended. In the latter event the upper arcs may be discontinued and only the lower arc employed for keeping properly heated the mass of molten material in the crucible.

In the use of the furnace in a glass-making plant the silica or silica compound is thoroughly dried during its passage through the conveyer-shell and feed-pipe B and is considerably heated when deposited upon the upper ledge in the passage of the furnace. The material is by said ledge momentarily retarded and in such momentary stoppage is subject not only to the heat of the arc above the ledge, which is elongated toward the ledge by the adjacent magnet, but also to the radiated heat of said ledge, the latter being heated to an intense degree by the impingement of said arc thereagainst. The heated material drops from said first ledge through the second arc upon the second ledge, where its progress is momentarily arrested, and from said ledge the material, which is at this time in a partially or wholly molten condition, drops into the crucible C. From the crucible the molten material passes off through the spout C′, so that upon leaving the crucible the molten material is subjected to the highest temperature of the adjacent arc, which insures a free-flowing consistency to the molten material. The length of the interior passage of the furnace and the number of ledges therein may be increased or decreased, as found necessary or desirable, to produce the required smelting of the material in its passage therethrough, and a less number than all of said arcs may be used at a given time, as found necessary or desirable. Any suitable means (not shown) may be employed for disposing of the molten material as it is discharged through the pipe C′.

Many changes may be made in the structural details without departing from the spirit of my invention, and I do not wish to be limited to such details except as hereinafter made the subject of specific claims.

I claim as my invention—

1. In an electric furnace, means for feeding

the material thereto, means for withdrawing the molten material therefrom, electrodes arranged to form an arc through which the material is passed, an oblique ledge or wall located in the path of the material below said arc against which the material impinges after passing through said arc, and a magnet for deflecting the arc toward said ledge or wall.

2. In an electric furnace, means for feeding the material thereto, means for withdrawing the molten material therefrom, electrodes arranged to form an arc through which the material is passed, and an electromagnet located below and adjacent to said arc, so as to elongate the arc in the direction of travel of the material through the furnace.

3. An electric furnace provided with an interior passage, means for feeding the material to one end of the passage, means for withdrawing the molten material from the other end of said passage, electrodes arranged to form an arc in said passage, the wall of the passage being provided below said arc with an oblique ledge which extends into the path of the material, and a magnet embedded in said wall adjacent to said ledge.

4. In an electric furnace provided with an interior passage, means for feeding the material to one end of the passage, means for withdrawing the molten material from the other end of said passage, electrodes arranged to form a plurality of arcs in said passage, one in advance of the other and through which the material successively passes, the wall of the passage adjacent to each pair of electrodes being inclined, and means for elongating the arcs toward the inclined parts of the passage.

5. An electric furnace provided with an interior passage, means for feeding the material to said passage, means for withdrawing the molten material therefrom, electrodes arranged to form a plurality of arcs in said passage, one in advance of the other, and through which the material successively passes, and magnetic means for elongating each arc in the direction of travel of the material through the furnace.

6. An electric furnace provided with an interior passage, means for feeding the material to one end of the passage, means for withdrawing the molten material from the other end of said passage, electrodes arranged to form a plurality of arcs in said passage, one above the other and through which the material successively passes, means for laterally elongating each arc, and means located on that side of each arc toward which it is elongated for momentarily arresting the material.

7. An electric furnace provided with an interior passage, means for feeding the material to one end of the passage, means for withdrawing the molten material from the other end of said passage, electrodes arranged to form a plurality of arcs in said passage, one above the other and through which the material successively passes, the wall of said passage being provided beneath certain of the arcs with oblique ledges extending into the path of the material and means for elongating said arc or arcs toward said ledge or ledges.

8. An electric furnace provided with an interior passage, means for feeding the material to one end of the passage, means for withdrawing the molten material from the other end of said passage, electrodes arranged to form a plurality of arcs in said passage, one above the other and through which the material successively passes, the wall of said passage being provided beneath certain of the arcs with oblique ledges extending into the path of the material, and a magnet embedded in the wall of the furnace adjacent to each ledge or ledges.

9. An electric furnace provided with an interior passage, means for feeding the material to one end of said passage, a crucible located at the other end of said passage, electrodes arranged to form a plurality of arcs in said passage through which the material successively passes, one of said arcs being located immediately above said crucible, and means for deflecting said arc into said crucible.

10. An electric furnace provided with an interior passage, means for feeding the material to one end thereof, a crucible at the lower end of the passage, electrodes arranged to form a plurality of arcs in said passage, one above the other, one of said arcs being located immediately above the open end of said crucible, oblique ledges below certain of the arcs and extending into the path of the material, magnets in the wall of the furnace adjacent to said ledges and a magnet below said crucible.

11. An electric furnace provided with an interior passage, means for feeding the material to the upper end thereof, a crucible at the lower end of the passage, electrodes arranged to form a plurality of arcs in said passage, one above the other, one of said arcs being located immediately above the open end of said crucible, oblique ledges below certain of the arcs extending into the path of the material, magnets in the wall of the furnace adjacent to the ledges, a magnet below said crucible, and a spout communicating with the upper end of said crucible adjacent to the lower arc for drawing off the molten material therefrom.

12. An electric furnace provided with a crucible open at its top, means for continuously feeding the material thereto, electrodes arranged to form an arc over the open end of said crucible and through which the material passes into the crucible, means for continuously withdrawing the molten material from the crucible, and a magnet located below said crucible.

13. A furnace provided with a crucible open at its top, means for continuously feeding the material thereto, electrodes arranged to form

an arc over the open end of said crucible and through which the material passes into the crucible, a draw-off spout communicating with the upper end of said crucible adjacent to said arc, and a magnet located below said crucible.

14. An electric furnace provided with an interior passage, means for feeding the material to the upper end thereof, a crucible located at the lower end of the passage, electrodes arranged to form a plurality of arcs in said passage, one above the other, one of said arcs being located immediately above the open end of said crucible, oblique ledges located below certain of the arcs and extending into the path of the material, magnets in the wall of the furnace adjacent to said ledges, a magnet below said crucible, and means acting to localize the effect of the upper magnets to elongate the adjacent arcs toward said ledges.

15. An electric furnace provided with an interior passage, electrodes arranged to form a plurality of arcs in said passage through which the material successively passes, magnets in the wall of the furnace and associated with certain of the electrodes for laterally deflecting the arcs, and metal plates in the wall of the furnace between each of said magnets and the unrelated electrodes adjacent thereto.

16. An electric furnace provided with an interior passage, means for feeding the material to the upper end thereof, a crucible at the lower end of the passage, electrodes arranged to form a plurality of arcs in said passage, one above the other, one of said arcs being located immediately above the open end of said crucible, oblique ledges below certain of the arcs extending into the path of the material, magnets in the wall of the furnace adjacent to said ledges, a magnet below said crucible, and metal plates in the wall of said furnace adjacent to said upper magnets.

17. A furnace provided with a passage, means for delivering a granular material to said passage comprising a spiral conveyer, a pipe communicating with the shell of said conveyer and with said passage, a chamber surrounding said shell, and a pipe leading from the upper end of said passage and discharging into said chamber around said shell, said chamber being divided by a partition into two communicating parts, one of which communicates with said pipe and the other with an exit-opening.

18. An electric furnace provided with a passage, means for feeding the material to said passage, means for withdrawing the material therefrom, electrodes arranged to form an arc in said passage through which the material is passed and means located at the outside of the furnace for continuously feeding said electrodes to said passage as they are consumed, comprising yokes connected with the walls of the furnace and rotative shafts having screw-threaded engagement with the yokes and adapted for connection at their inner ends with the electrodes, and means for raising and lowering said yokes on the walls of the furnace to permit new electrodes to be inserted into the openings in said furnace which receive the electrodes.

In testimony that I claim the foregoing as my invention I affix my signature, in presence of two witnesses, this 24th day of December, A. D. 1901.

ALBERT A. SHADE.

Witnesses:
TAYLOR E. BROWN,
C. CLARENCE POOLE.