J. THOMSON.

ELECTRIC FURNACE.

APPLICATION FILED SEPT. 1, 1909.

950,879.

Patented Mar. 1, 1910.

5 SHEETS—SHEET 1.

Fig. 1.

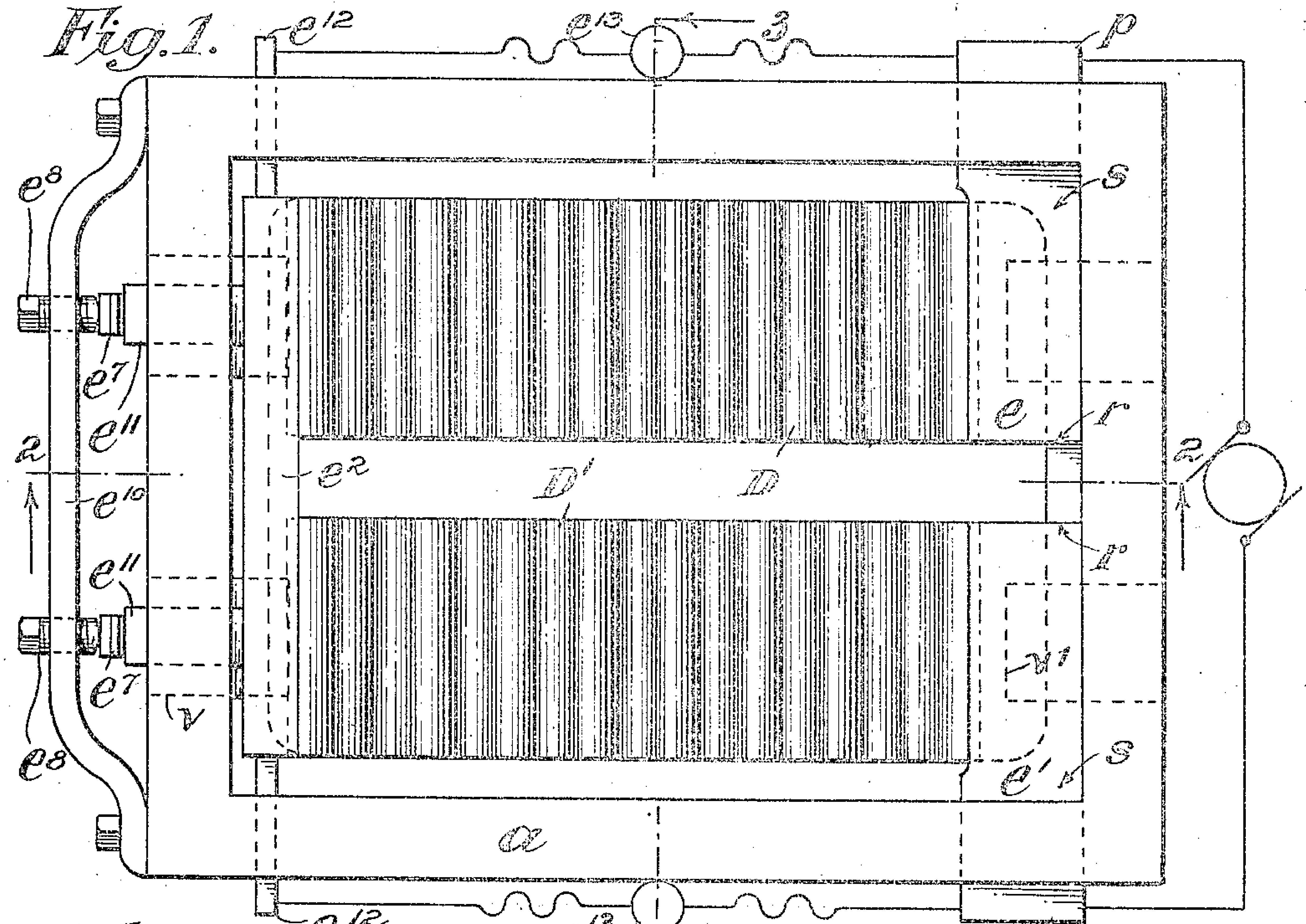
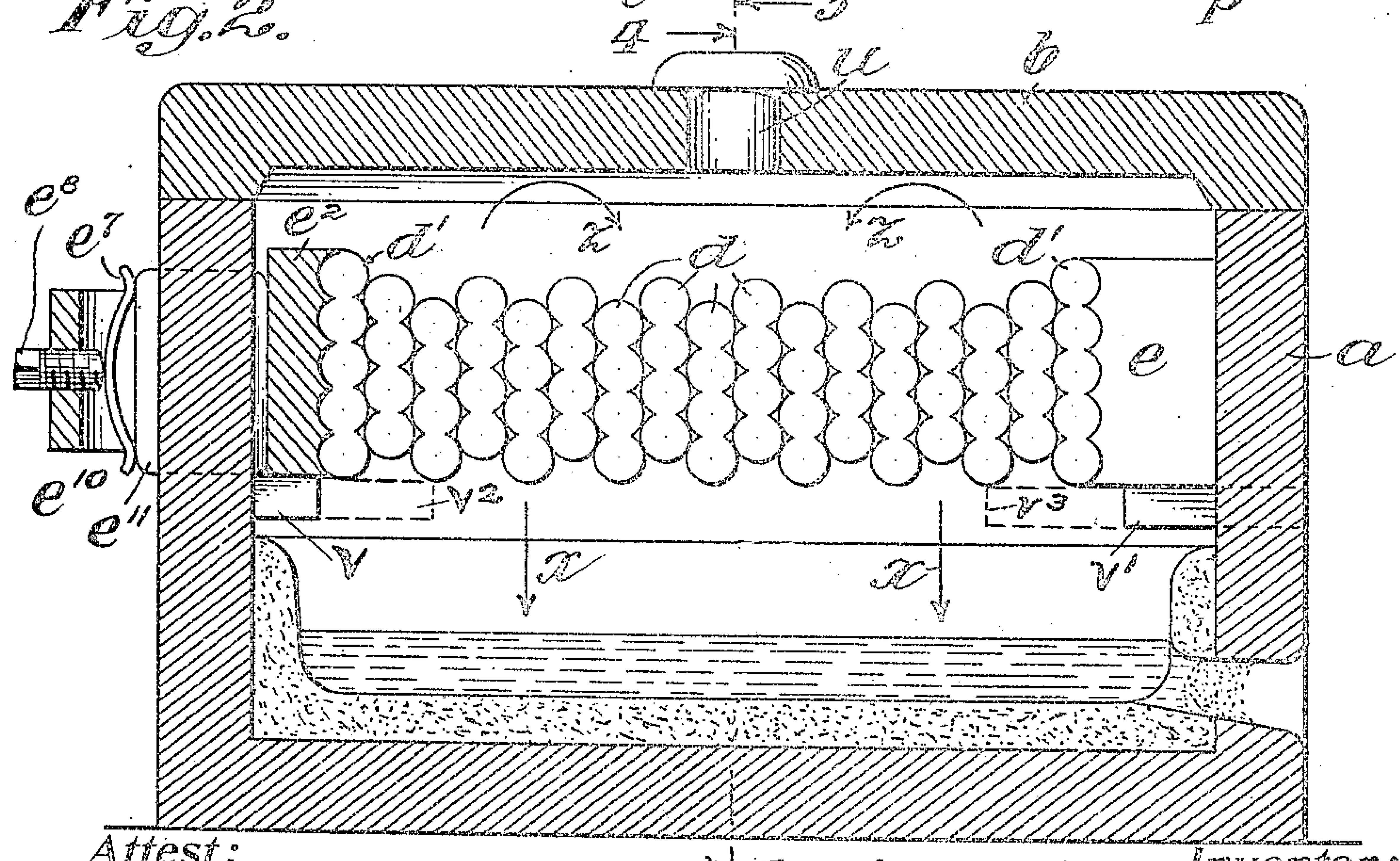


Fig. 2.



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5 SHEETS—SHEET 2.

Fig. 3.

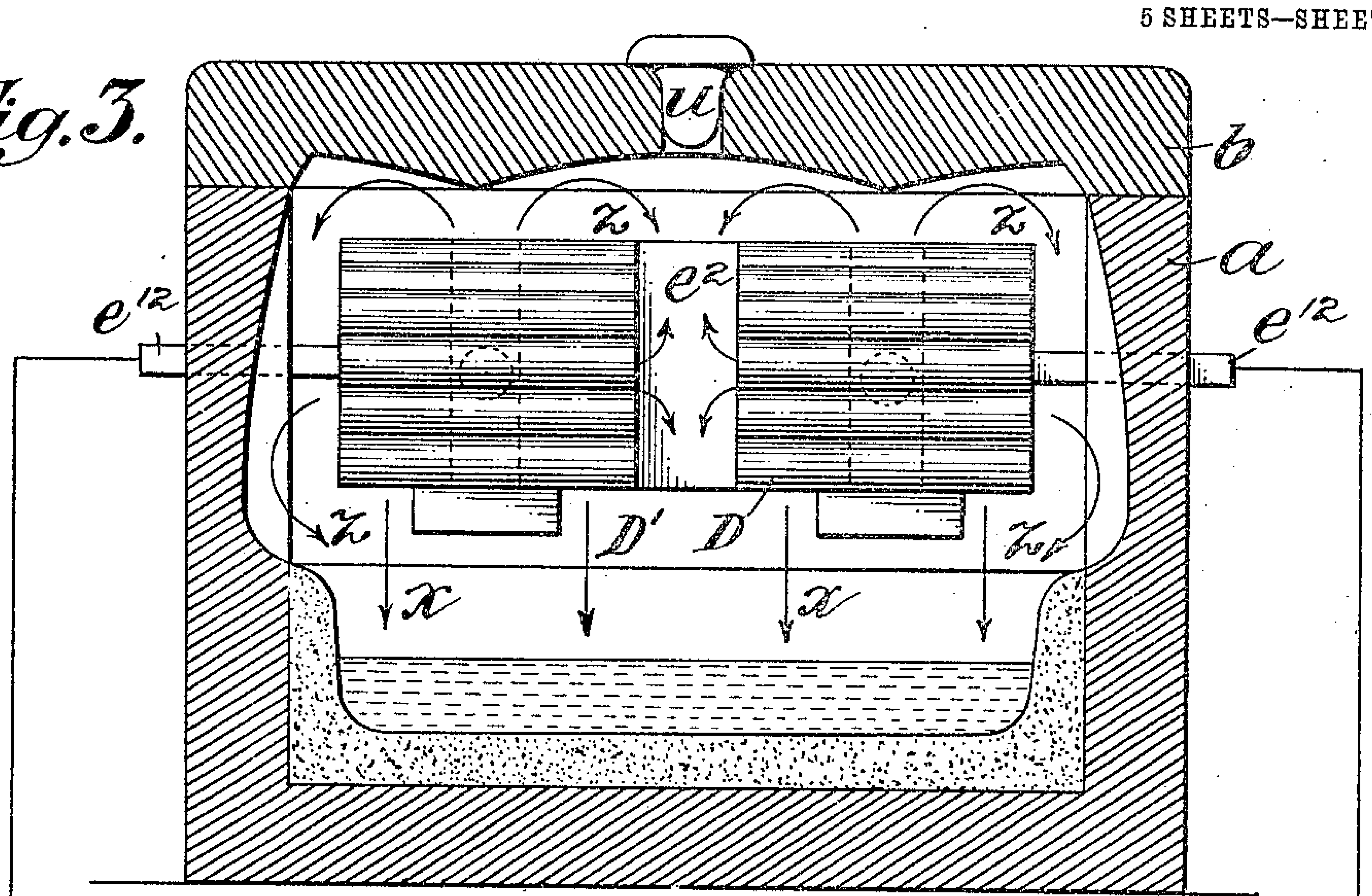
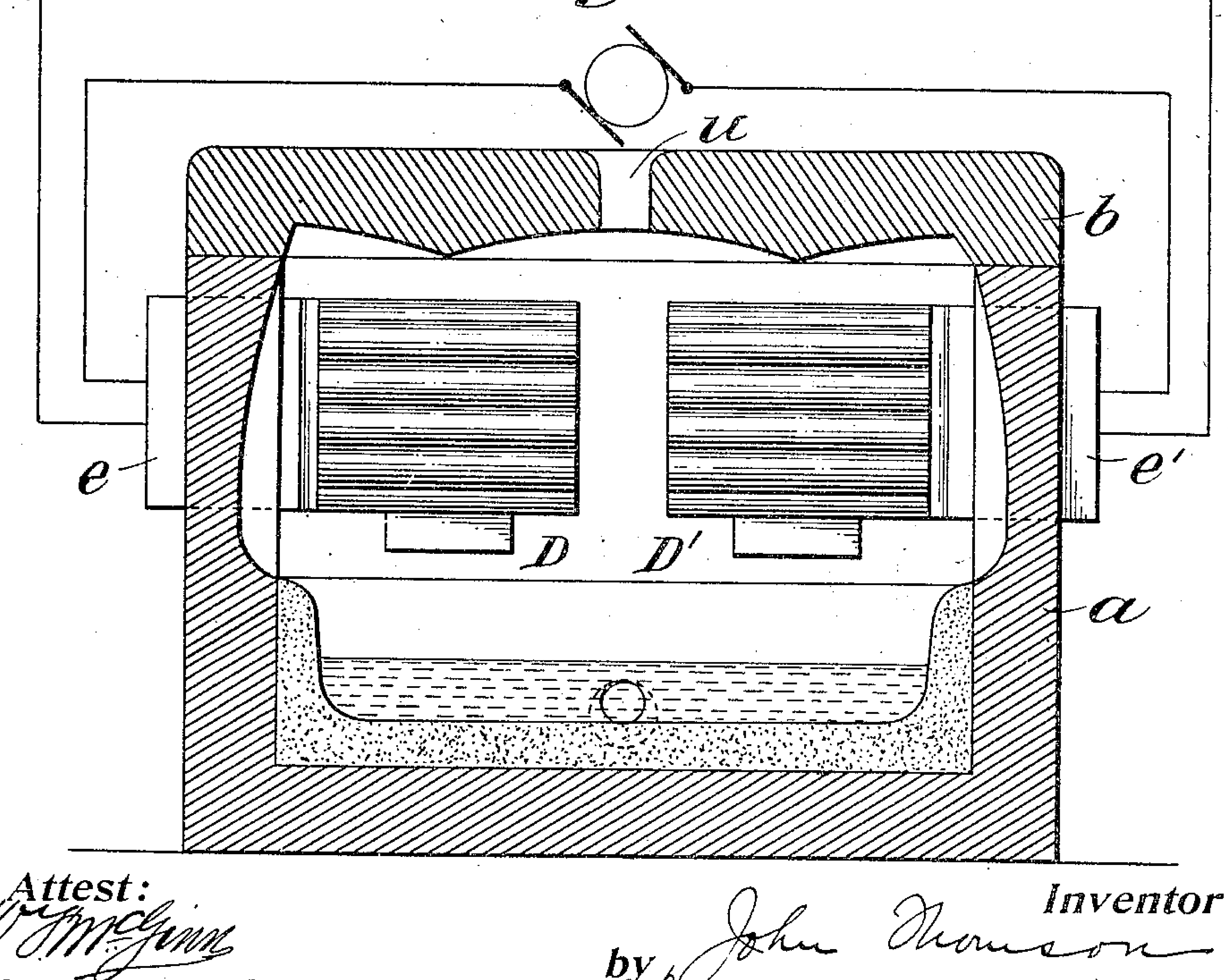


Fig. 4.



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5 SHEETS—SHEET 3.

Fig. 5.

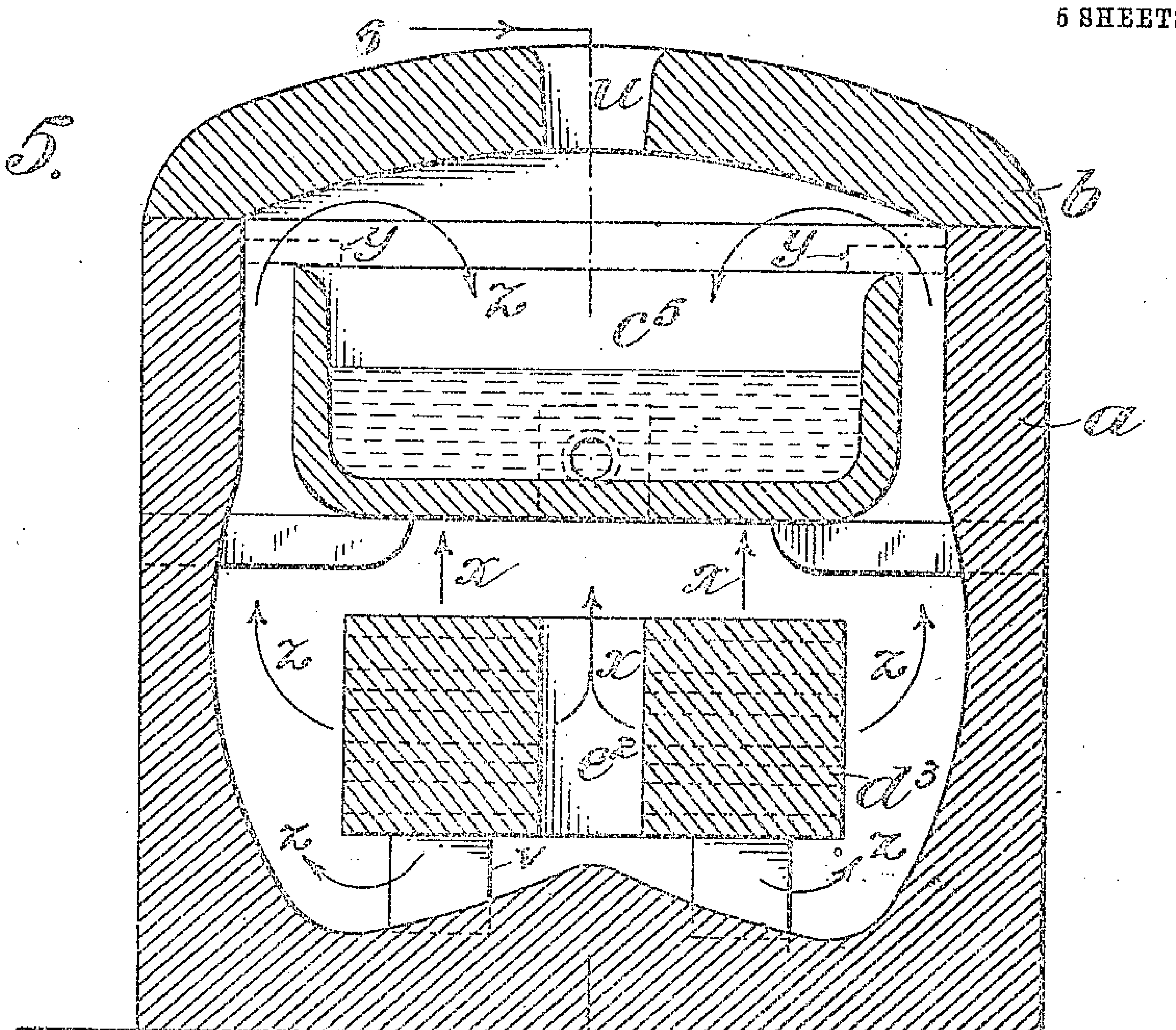
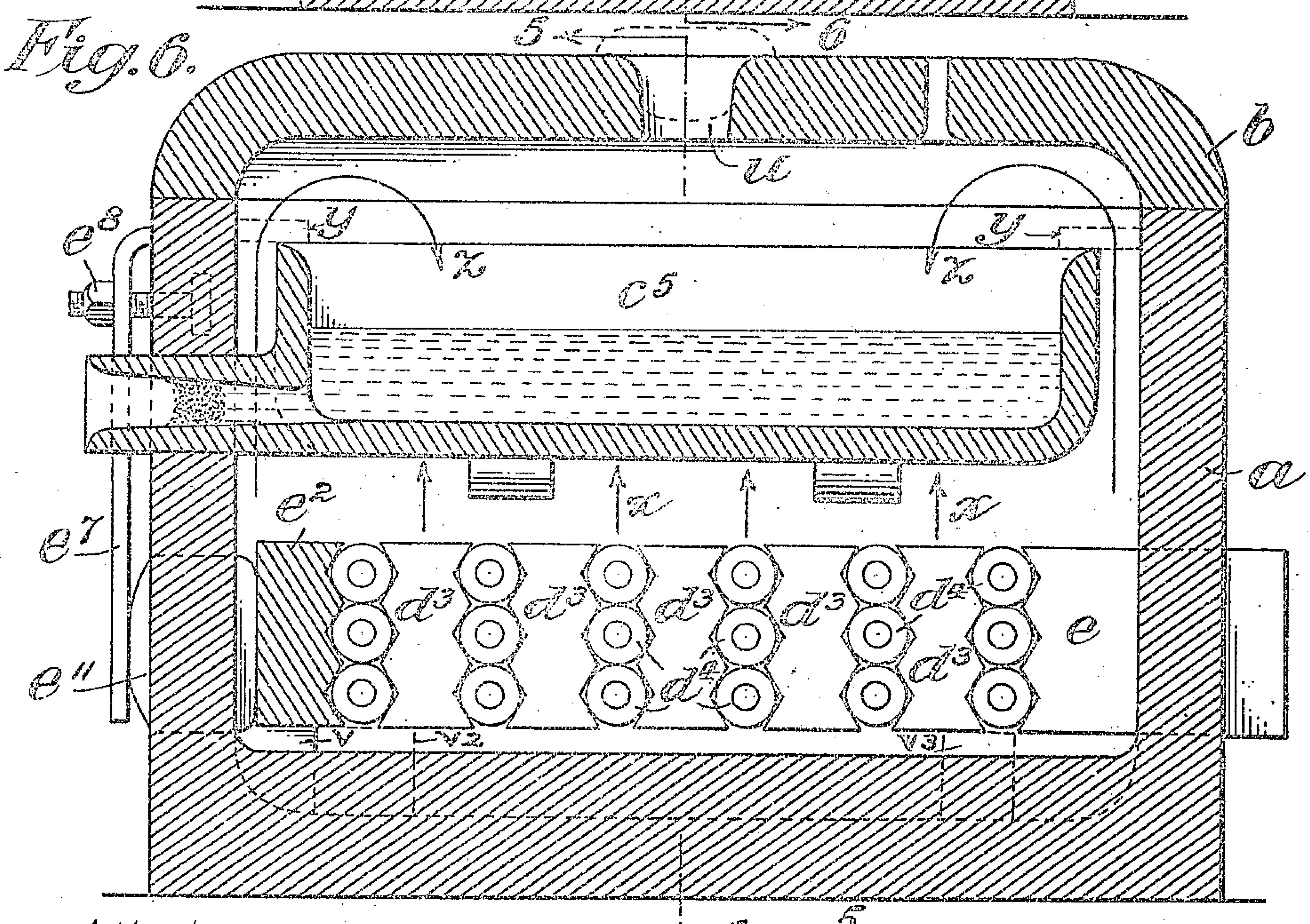


Fig. 6.



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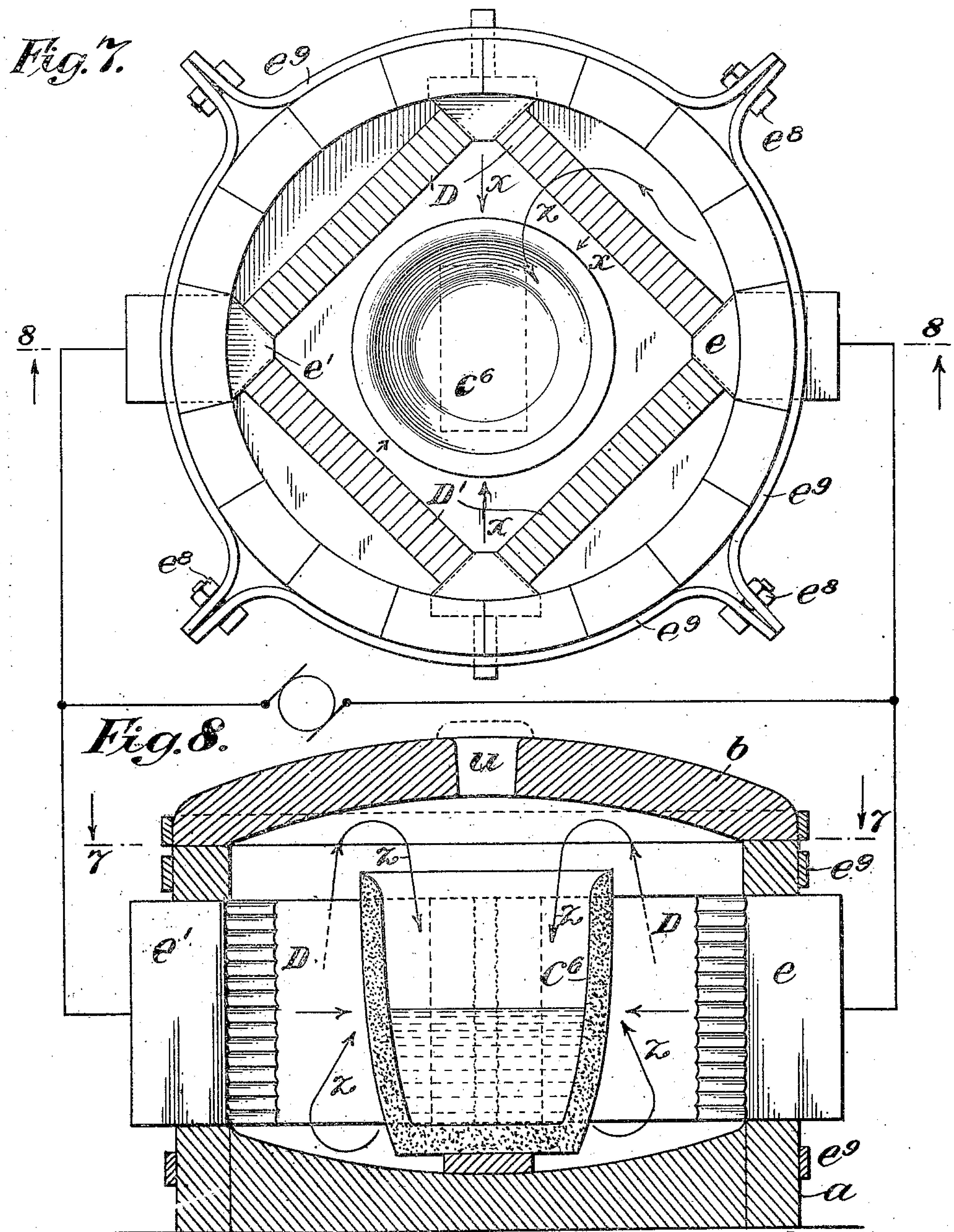
5 SHEETS—SHEET 4.



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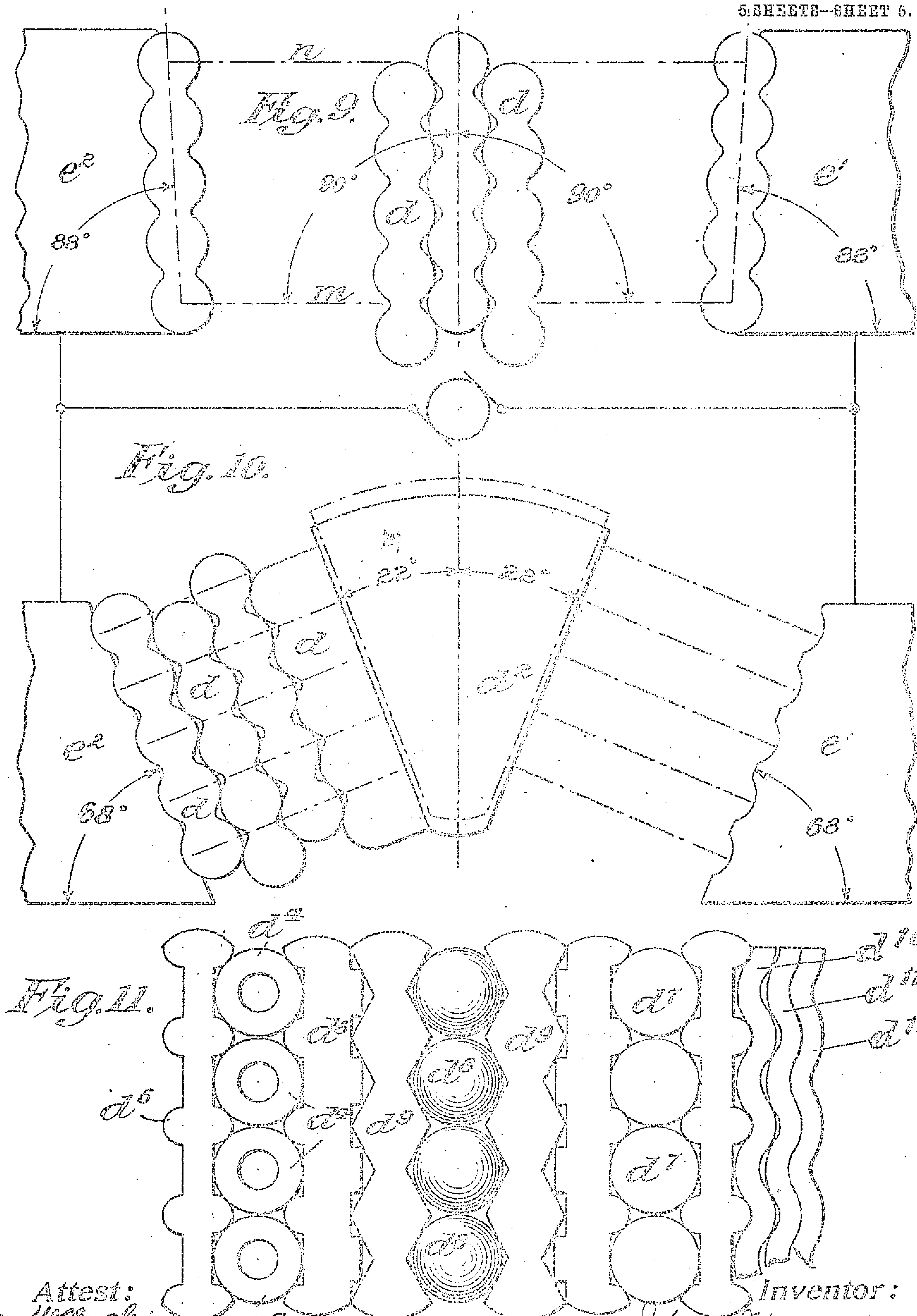
5 SHEETS—SHEET 5.



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UNITED STATES PATENT OFFICE.

JOHN THOMSON, OF NEW YORK, N. Y., ASSIGNOR TO IMBERT PROCESS COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

ELECTRIC FURNACE.

.50,879. Specification of Letters Patent. Patented Mar. 1, 1910.

Application filed September 1, 1909. Serial No. 515,698.

To all whom it may concern:

Be it known that I, JOHN THOMSON, a citizen of the United States, and a resident of the borough of Manhattan, of the city of New York, in the county and State of New York, have invented certain new and useful Improvements in Electric Furnaces, of which the following is a specification, reference being had to the accompanying drawings, forming a part hereof.

This invention relates particularly to improvements in resisters of electric furnaces and to their arrangement and disposal in the furnace chamber with a view to most effectually realizing the widest range of adaptability and the highest thermal efficiency.

One of the principal objects of the invention is to provide a resister, which, while being composed of a plurality of elements, is self supporting; that is one which does not require any extraneous means of support between the terminals, whereby the resister may be entirely free from or out of contact with all parts of the refractory and, in fact, suspended in space within the furnace chamber.

Another object of the invention is to provide a resister which may have its resistivity increased or decreased in different zones whereby to correspondingly change the current density within itself; which shall be capable of being formed by the established methods of manufacture; which shall be readily applicable to various types of furnace and to which the furnace and its heating chamber are conformable in a manner to derive both the maximum of temperature and the highest rate of delivery, or volume, of heat-units in a given time from a given amount of energy.

In accordance with the present improvements, the foregoing is realized by forming the resister, preferably of carbon, from a plurality of parts constructed and arranged to interlock one with the other, or one or more with others, and also to interlock with or be sustained by the terminals, in such manner that the resister is in free space and may be built either above, or below, or at the sides of a heating chamber; and furthermore, the coördinative construction of the furnace chamber is such that the delivery of the heat waves from all portions of the exposed surfaces of the resister is realized in useful effect upon the charge with the minimum of dynamic loss.

In the drawings: Figure 1 is a plan view of a furnace embodying the invention, with the cover removed. Fig. 2 is a longitudinal central section, the plane of the section being indicated by the line 2—2 in Fig. 1. Figs. 3 and 4 are transverse central sections, left and right, respectively, the plane of the sections being indicated by the line 3—4 in Figs. 1 and 2. Fig. 5 is a transverse central section and Fig. 6 is a longitudinal central section of a furnace showing modifications. Fig. 7 is a plan view and Fig. 8 is a vertical central section of a furnace showing other modifications. Fig. 9 is an enlarged detail view of the resister sections and the terminals, to better illustrate the application thereof, as shown in the preceding figures. Fig. 10 is an enlarged detail view of a resister applied in a modified manner, and Fig. 11 is a diagrammatic detail indicating some of the various forms of construction of elements which may be employed to build the resister.

Referring first to Figs. 1–4 inclusive and to Figs. 9 and 10, one embodiment of the invention will first be described in connection with the particular type of furnace shown in these figures. Here, the main body a of the furnace is provided with a removable cover b containing an opening u for charging or for visually inspecting the interior of the furnace, and the resister is a compound one having two sections D and D′, which are connected up in series, confined between the terminals e and e' at one end and the connector-piece e^2 at the other end.

Each section of the resister will be seen to consists of a plurality of grooved plates d laid transversely thereof and the opposing faces of which are so disposed as to prevent a staggered arrangement of the whole; and in the figures under present consideration, each resister element may be likened to a series of round rods laid together lengthwise but having rounded or neck-like joints along the intersections, thus presenting the form of a fluted plate. Manifestly, when such plates are laid together, with the rounds of one plate in the hollows of another the contacts will be in lines, and when a series of such plates are set between terminals, or a terminal and a connector, having corresponding flutings, as shown, and held against displacement endwise, the several parts are interlocked and the resister as a whole is self-sustaining, its weight and end-thrust being taken wholly by the said terminals. As comparatively little end-pressure is necessary to maintain the lines of contact along all of the convolutions, it will now be apparent that with such a keyed structure a wide range of electrical contact resistance may be obtained and that, being independent of position for its support, it can be built in various forms and applied to many types of furnaces. Thus, in Figs. 1 to 4, the resister is shown suspended in clear space above the bath; in Figs. 5 and 6 the resister is suspended below the retort e^5, while in Figs. 7 and 8, the resister is suspended within a circular furnace casing, in four vertical sections, forming a hollow square within which a crucible, as e^6, may be set. In this instance the convolutions of the resister plates would be cross-wise of the plates instead of lengthwise. But while the described arrangement of having the resister suspended by the terminals is regarded as the preferable this is not an indispensable feature and in fact there may be circumstances where the said suspension might equally well be upon the furnace walls direct. Thus, the refractories e, e', Figs. 1 to 6, shown in full lines, which act as the primary supports for the terminals, and as secondary supports for the resister, simply require to be extended inwardly, as shown by the dotted outlines e^2, e^3, Figs 2 and 6, when the resister would be primarily supported at each end thereby; and in this wise the terminals may be arranged to be removed without interfering with the resister.

As has already been pointed out in another application for Letters Patent filed May 13, 1909, Serial No. 495,585, "in order to maintain a practically constant pressure upon the carbon. . . which is essential to the control of the electro-thermacy", the end-pressure required to maintain the interlock of the fluted plates is produced through the intervention of suitably mounted springs e^7, Figs. 1, 2 and 6, actuated by adjusting screws e^8, or in the instance of Figs. 7 and 8 by yielding steel bands e^9 acting resiliently against the brick-work. In this wise, the exact amount of pressure can readily be applied and also such an extent of resiliency that the expansion or contraction of the resister can take place without sensibly changing its density. When a compound resister is used, connected in series, two screw-actuated springs are preferred, as shown in Fig. 1, whose outer thrust is taken by the bar e^{10} which contains the adjusting screws. In this instance each spring is located to impart its thrust through a sliding refractory e^{11} impinging against the connector e^2 along the central axis of each section of the resister. Now, by placing slidable carbon rods e^{12} capable of being impinged when desired against the connector and a volt-meter, or meters, as e^{13}, connected by a shunt circuit between these rods and the main circuit, it can be ascertained at once and at any time if the rate of generation of energy in both sections of the resister is the same, and if not the resistance of the said sections can be made the same by proper manipulation of the spring tension. Without some convenient means of this kind the rate of generation of energy in one section might be much greater than in the other and the endurance of the whole would be that of the overloaded member.

Another advantageous feature of this interlocking resister system is that any side of a resister may readily be given greater compression than the opposite side, thereby correspondingly increasing the current density and the temperature. Again, when a resister is disposed along a horizontal plane, with just sufficient end-pressure to make contacts between the flutings, its upper portion, due to its weight, will be under compression while its lower portion will be in tension, tending like an arch to separate. An exactly neutral condition, or an excess, can readily be effected by the simple expedient shown in Fig. 9, wherein the faces of the terminals are slightly beveled so that when the terminals approach each other horizontally, the pressure will be greater, or more intense, along the lower line m than the upper n. In practice the actual amount of the difference in spacing between the top and bottom of each plate is ordinarily very slight, say from .002 to .005 inch; and may be gaged with the utmost exactness by the angle given to the terminals.

It will be observed in Fig. 2 that the terminals and the connector are wider than the main portion of the resister and that resister plates d' are provided to connect therewith whose widths are approximately equal to that of the said terminals and connector; the object and advantage of this being to obtain the largest possible area of contact and thereby deliver the current into the resister with the least possible drop in voltage from the line connection.

A construction of the resister is shown in Fig. 10 in which the interlocked plates are stacked at a considerable angle to the horizontal, 22 degrees, as denoted in the drawing. This involves the use of a key-section d^2 but in this wise the terminals may be rigidly confined as the key will rise or fall to compensate for expansion or contraction. The pressure upon the resister plates will be that due to gravity and the use of such a structure is correspondingly limited. But the electrical effectiveness of this form would not be impaired in that, unlike an arch, the lineal length of the resister elements, above and below, are equal, the lineal difference being entirely compensated in the key, which would ordinarily be of pure graphite; and consequently the variation in its resistance through top or bottom would be inappreciable.

Because of its strength, rigidity and ease of manufacture, the fluted resister plate, with staggered interlock, is regarded as the preferable form; but, as will now be shown, various modifications thereof can be made, whereby to meet any or all practical requirements. Thus, in Figs. 5 and 6, the resister is composed of plates d^3 having V-grooves and between the said grooves separate tubes, as d^4 are interposed. Here each tube acts as a key and yields four lines of pressure contact between each pair of plates. This combination possesses the obvious advantage of having an exceedingly large area of radiating surface. In the various modifications illustrated in Fig. 11, the tubes d^4 are shown as interlocking shallow square-shaped grooved plates d^5 and d^6 in a manner whereby six lines of pressure contact are shown for each tube; round rods d^7 are here shown, substituting the tubes; balls, d^8 may take the place of either and corrugated plates d^{10}, d^{11}, d^{12} may be employed, of uniform thickness, where the combination of d^{10} and d^{11} will obtain line contacts. Finally, should the requirement arise of obtaining an interlocked resister of the lowest possible resistivity, this may be realized by combining the two similarly V-grooved plates d^9, or the corrugated plates d^{11} and d^{12} as in these instances the area and intimacy of contact would be greater than that of flat plates of corresponding face dimensions.

It may be pointed out with respect to the arrangement of parts shown in Fig. 6 that this type of furnace readily lends itself to metallurgical operations where an oxidizing atmosphere is required, or where the gases given off by the charge would act detrimentally on the carbon resister. Thus, by simply closing the side spaces at the top, as by thin plates of recrystallized silicon carbid or the like, shown in dotted lines y, the resister would then be effectively contained in a chamber distinct and separate from that of the charge.

When a compound resister is employed, in seri and arranged after the manner shown in Figs. 1, 2, 3 and 4, it is preferable to use a connector made of Acheson graphite; but the leading-out terminals are preferably of amorphous carbon. The advantage is in the higher electrical and thermal conductibility of the graphite, inside of the furnace, and the lower thermal conductibility of the carbons to the exterior of the furnace. At normal temperature the electrical resistance of pure graphite is about four times less than amorphous carbon, for like sections; but at high temperatures the difference is considerably less. Still, the difference, even at the best, is not negligible when thousands of amperes are to be delivered to the resister. This objection is largely overcome by making the inner portions of the terminals, where they are in contact with the resister, as from r to s, of graphite, and the outer portions, as from s to p, of carbon. This can be accomplished by graphitizing only that portion of the terminals which are to lie inside of the furnace, or by suitably jointing two blocks, one of graphite and the other of carbon.

It will be perceived that if the register plates are under an equal degree of contact between their various lines of impingement—a condition which the construction already described can readily obtain and indefinitely continue—that all parts of its surface will similarly radiate heat; and also that the longitudinal spaces along the line-contacts of the flutings afford an exceedingly effective egress for the heat from every portion of the incandescent mass. To realize the utmost efficiency of this condition is the complementary feature of the design, and consists in forming the inner walls of the heating chamber so as to present a surface of incidence which shall be less or more than a right angle to the emitted heat of the resister, thus rendering the incipient energy less effective to impart heat to the furnace ll and more effective to increase the temperature of the charge. Therefore, in Figs. 2, 3, 4, 5, 6 and 8, where the arrows x indicate heat waves radiating directly from the resister and the arrows z indirect or refracted waves, the impingement of the heat upon the bath, retort or crucible is generally shown as in direct lines, the most effective possible for the contemplated purpose; while the surrounding and overtopping walls are appropriately curved to deflect the direct heat waves received from the various surfaces of the resister and cause them to continue their movement, although with lessened intensity, downwardly or upwardly toward the bath, retort or crucible. And the consequence of this construction, which is entirely feasible to realize in practice, is a material increase in thermal efficiency and endurance of the refractories.

From the foregoing, it will be understood how the invention may be embodied in various types of furnaces. In the several constructions illustrated herein, the same reference letters have been used to refer to corresponding parts, so that a detailed description in the case of each of the furnaces specifically alluded to has been unnecessary. Moreover, it may be noted here that in all of the illustrations of the present case, the resister has been shown in compound form with its sections connected up in series. In such instances, the connector-piece between any two sections is, mechanically considered at least, the equivalent of a terminal and should be so understood in reading the claims.

It only remains to be stated that the interlocking plate resister may be used, retaining many of the advantages that have been pointed out in the foregoing, by being supported along its sides, either continuously or at one or more locations, or at one or both sides. For instance, such an arrangement would be the preferable when very light line-contacts are desirable.

I claim as my invention:

1. A resister for an electric furnace comprising a plurality of interlocking resistance elements.

2. A resister for an electric furnace comprising a plurality of interlocking resistance plates.

3. A resister for an electric furnace comprising a plurality of fluted plates.

4. A resister for an electric furnace comprising a plurality of interlocking carbon plates.

5. A resister for an electric furnace comprising a plurality of grooved plates arranged to interlock with each other.

6. An electric furnace having a resister comprising a plurality of elements disposed in a direct line between the terminals and supported entirely free of the refractory.

7. In an electric furnace, in combination with the terminals, a resister having a plurality of elements suspended from and in a direct line between the terminals and self sustaining so as not to require any extraneous means of support other than the terminals.

8. An electric furnace having a resister composed of separable interlocking resistance plates arranged transversely thereof.

9. An electric furnace having a resister composed of separable grooved plates arranged transversely thereof, the said resister being supported wholly from its ends.

10. An electric furnace having a resister comprising a plurality of interlocking resistance elements and terminals at each end thereof acting to maintain the interlocking of and thereby to support the elements.

11. An electric furnace having a resister comprising a plurality of interlocking resistance plates mounted face to face and means to support the resister by maintaining a thrust lengthwise of the same.

12. An electric furnace having a resister comprising a plurality of grooved plates mounted face to face and terminals at each end of the resister adapted to exert a thrust to keep the plates interlocked with each other.

13. An electric furnace having a resister composed of separable resistance parts interlocked between themselves and the terminals.

14. An electric furnace having a compound resister adapted to be connected in parallel or in series and composed of separable parts interlocked between themselves, the terminals and the connector.

15. An electric furnace having an interlocked resister engaged by the terminals and suspended thereby in a direct line.

16. In an electric furnace, a resister composed of grooved plates held together by the terminals.

17. In an electric furnace, a resister composed of grooved plates, assembled in staggered relation and held together by the terminals.

18. In an electric furnace, a resister composed of grooved plates, and means disposed in the grooves to interlock the said plates, all being held together by the terminals.

19. In an electric furnace, a plurality of interlocking resistance elements, and terminals having their faces adapted to engage and interlock with the resister.

20. In an electric furnace, a compound resister consisting of interlocking carbon elements, terminals, and a connector, said terminals and connector having their faces adapted to engage and interlock with the resister.

21. In an electric furnace, a plurality of interlocking resistance elements constituting the resister, and terminals whose faces are wider than the main portion of the said resister.

22. In an electric furnace, an interlocking resister and terminals by and between which the resister is arranged to be self-sustaining in a direct line, the said terminals having the planes of their faces disposed to impart either uniform pressure or an excess of pressure at one or the other sides of the neutral axis of said resister.

23. An electric furnace having a resister composed of interlocking parts, terminals therefor and resilient or reactive means to clamp the terminals.

24. An electric furnace having a resister composed of interlocking parts mounted in a plurality of sections between electrical connections, the end pressure on each section being separately adjustable.

25. An electric furnace having an interlocking resister mounted in a plurality of sections between terminals, and a movable electrode or electrodes for connecting each of said sections in a shunt circuit whereby to separately measure its resistivity under actual working conditions.

26. An electric furnace having a resister mounted therein the inner surface or surfaces of the furnace being irregularly curved

or sloped so that the angle of refraction therefrom shall be less or more than a right angle to the line of impingement of the emitted heat waves.

27. An electric furnace having a resister mounted therein to heat the charge or its container by direct radiation from a portion thereof, the inner surface or surfaces of the furnace being formed with irregular curves to refract the radiated heat from the other portions of the resister in directions different from that of the lines of impact.

28. An electric furnace having a resister composed of a plurality of self-supporting elements, and terminals between which the elements are confined, one of the terminals being freely slidable to vary the distance between both terminals.

29. An electric furnace having a resister composed of a plurality of grooved plates, terminals between which the plates are confined, a sliding refractory bearing against one terminal, and means to adjust the refractory for the purpose set forth.

30. An electric furnace having a resister comprising a plurality of elements disposed between the terminals and supported entirely free of the refractory, and yielding means to retain one of the terminals.

31. In an electric furnace, in combination with the terminals, a resister comprising a plurality of elements disposed between the terminals and supported wholly thereby, and means to permit one of the terminals to have a limited range of movement to compensate for the expansion and contraction of the resister elements due to thermal changes.

32. An electric furnace having terminal supports extending under the resister.

33. An electric furnace having refractories to support the terminals, said refractories being extended underneath the ends of the resister to support the same.

34. In an electric furnace a resister having a plurality of interlocked members and adapted to be supported wholly from its ends, terminals therefor and extended terminal supports.

This specification signed and witnessed this 31st day of August, A. D., 1909.

JOHN THOMSON.

Signed in the presence of—
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G. McGRANN.