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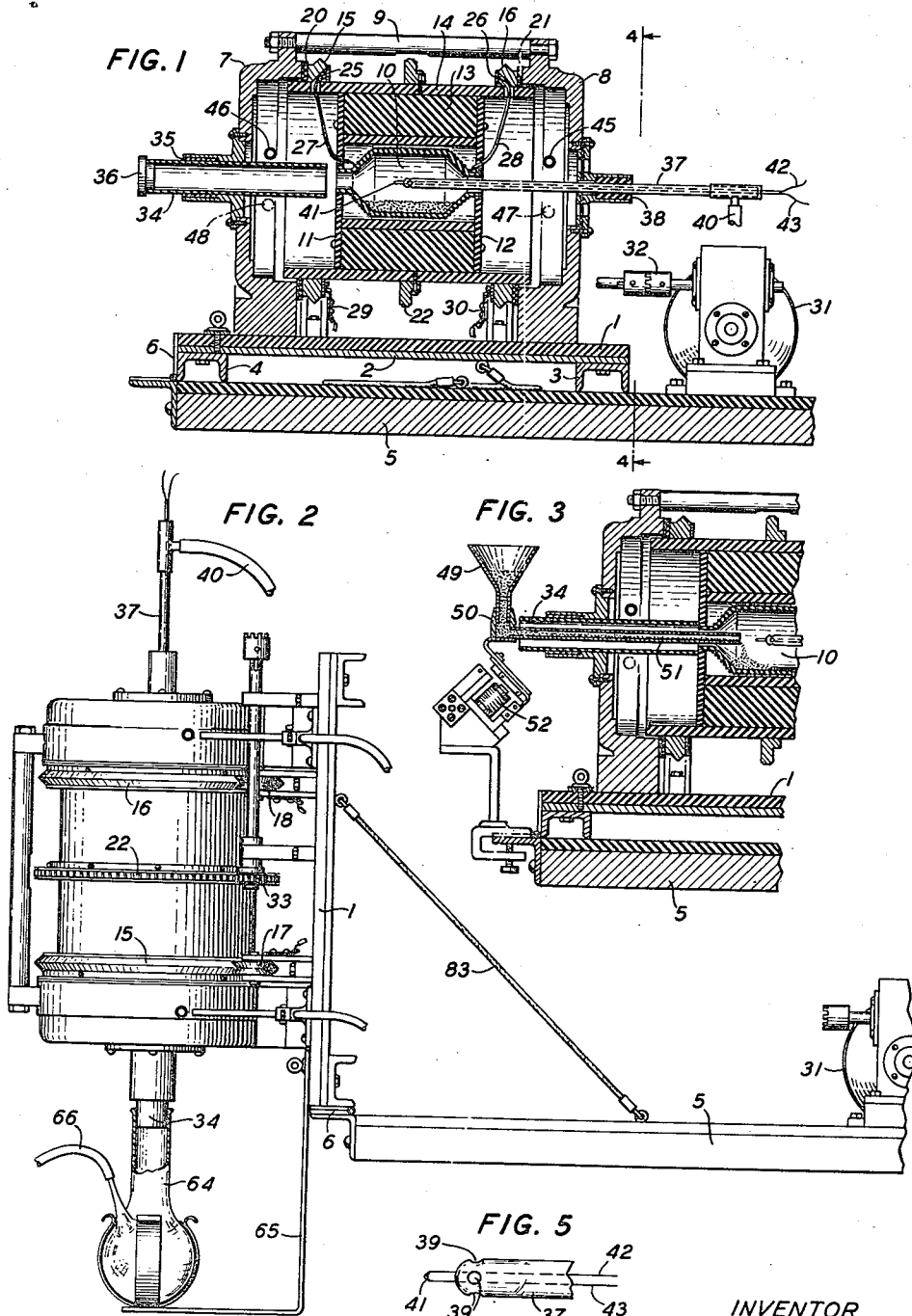
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2,161,950

DEPOSITION FURNACE

Filed May 27, 1936

2 Sheets-Sheet 1



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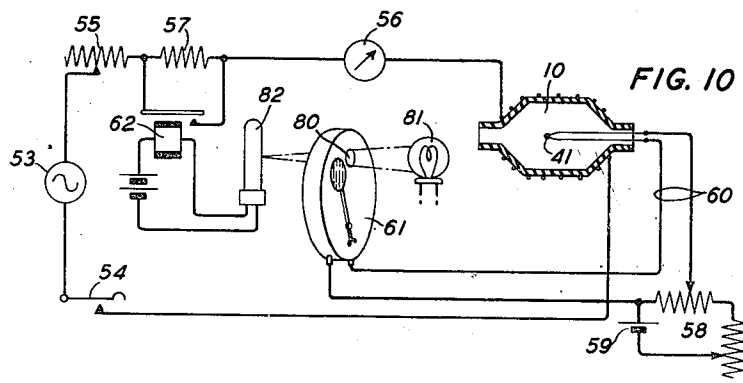
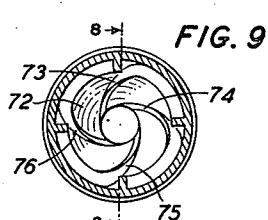
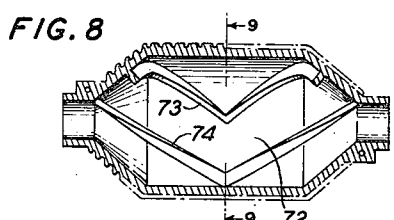
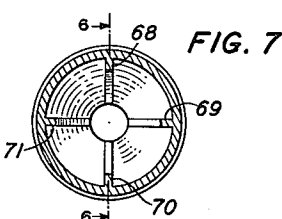
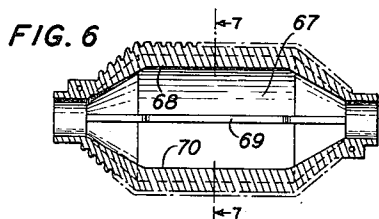
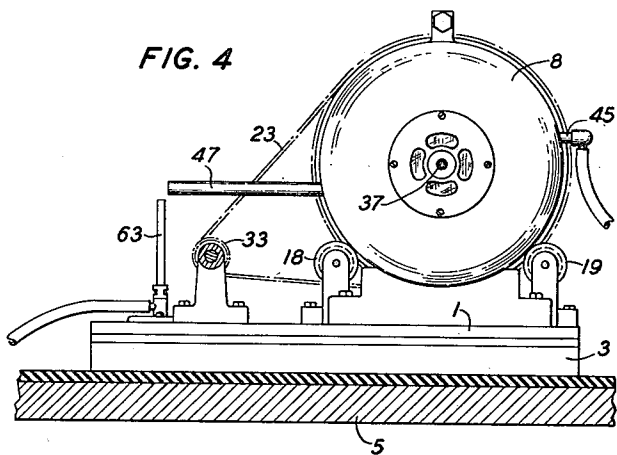
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DEPOSITION FURNACE

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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DEPOSITION FURNACE

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Application May 27, 1936, Serial No. 82,035

9 Claims, (Cl. 91-18)

This invention relates to coating and depositing and particularly to apparatus for the production of carbon deposits.

The objects of the invention are to produce deposits and coatings having a higher degree of uniformity than those obtainable heretofore; to increase the yield of the depositing apparatus; to safeguard the deposited material from oxidation or other harmful effects; and otherwise to improve apparatus of this character.

In the past it has been proposed to produce resistance-varying material for microphones by depositing thin coatings of carbon on base particles of some suitable substance, such as quartz. In the patent to Goucher and Christensen 1,973,703 of September 18, 1934, which discloses an apparatus for producing microphonic material in this manner, the base particles are placed in a heating chamber and subjected under a relatively high temperature to a carbon-yielding gas. Also it has been proposed to construct resistors for use in electrical systems by depositing thin coatings of carbon on the surface of small cylindrical elements of some suitable material, such as porcelain.

According to the present invention these carbon-deposited materials are produced by means of a deposition furnace having a number of improved features which contribute to simplify and expedite the process of producing carbon coatings and to secure greater homogeneity in the structure of these depositions.

One of these features is a rotatable cylindrical heating chamber having tapered or conically-shaped ends with a heating coil wound about the external surface of the chamber and so disposed thereon that the turns of the coil surround the tapered portions as well as the cylindrical portion of said chamber. By giving the chamber this shape and by disposing the heating coil thereon in this manner, energy is applied to substantially all surfaces of the chamber, and relatively large amounts of energy are applied to those parts, namely, the ends, where the heat losses are greatest. This results in a more uniform temperature throughout the interior of the chamber. Moreover, the combined cylindrical and tapered shape tends to maintain the charge, which is constantly agitated by the rotation of the chamber, within the central portion of the chamber where the uniformity of temperature is highest. Also, the tapered ends serve to guide the waste products out of the exit openings during the process, preventing them from accumulating within the chamber and contaminating

the deposition. The tapered configuration of the chamber also greatly facilitates the dumping of the charge without making it necessary to remove the chamber from the furnace.

Another feature is a heating chamber having ribs on the internal surfaces for the purpose of promoting the tumbling action of the material under treatment. By properly shaping these ribs, the material within the chamber may be made to circulate between the ends and the center of the chamber as the latter rotates, thus subjecting all particles within the chamber to the same average treatment and resulting in a greater uniformity of coated particles.

Another feature is an arrangement for administering the carbon-yielding gas into the chamber in which an intake pipe extends through an opening in one end of the chamber and along the axis of rotation of the chamber. The end of the pipe within the chamber is sealed, and openings are provided in the side walls of the pipe. With this arrangement of gas inlet the gas enters the heating chamber at the center, flowing in a direction at right angles to the axis of the chamber. This produces a turbulence of the gas in the coating chamber and causes the nature of the gas, which is progressively altered with time due to its chemical decomposition to be more uniform in all parts of the chamber, thereby causing the deposition of the carbon to be more uniform in all parts of the chamber.

A further feature is an arrangement whereby the charge may be removed from the chamber immediately that the deposition process is completed, and without exposing it to the oxidizing influence of the atmosphere while it is cooling. This is accomplished by means of a slidable conveying tube which projects through a packed opening in the end of the furnace wall, and which is in alignment with the opening in one end of the heating chamber. While the deposition process is in progress, the outer end of said tube is sealed. When the charge is ready to dump, the conveying tube is unsealed, a receiving bottle is passed on over its outer end, and the tube is advanced into the furnace until its inner end registers closely with the opening in the chamber. The furnace is then lifted about a hinge to a vertical position, permitting the contents of the chamber to fall through the opening therein and into the receiving bottle. The bottle is removed and corked, and the furnace is now ready for the next charge.

These and other features of the invention will be more fully described in the following de-

tailed specification, which should be considered in connection with the accompanying drawings, in which:

Fig. 1 is a side view, partly in section, of a deposition furnace incorporating some of the features of this invention;

Fig. 2 is a side view illustrating the furnace when tilted to its dumping position;

Fig. 3 is a partial view of the furnace showing the filling conveyor in position;

Fig. 4 is an end view of the furnace;

Fig. 5 is a detail of the gas supply tube;

Figs. 6 and 7 are views of a modified form of the heating chamber;

Figs. 8 and 9 are views of a further modified form of the heating chamber; and

Fig. 10 is a schematic diagram of the electrical system for controlling the heating of the furnace.

Referring now to the drawings, a description will be given of the detailed construction of the furnace. As seen particularly in Figs. 1 to 4, inclusive, the furnace structure is mounted upon a base comprising a plate 1, preferably of some insulating material such as slate, and a plate 2 of any suitable material. The plates 1 and 2 are secured to each other and to the channel iron supports 3 and 4. The furnace base thus formed is mounted in any suitable location, as on the surface of a bench or table 5. The channel iron 4 is fixed in proximity to the edge of the bench 5 by means of a hinge 6. This attachment permits the entire structure to be rotated or tilted to the position illustrated in Fig. 2.

The furnace proper is provided with two end members 7 and 8 which are cast or otherwise formed from any suitable material and are securely fastened by bolts or machine screws to the supporting plate 1. The end members 7 and 8 are in the shape of shallow, hollow cylinders closed at one end, and they serve together with the other parts of the structure to provide the closed interior chamber of the furnace. After being bolted to the base plate 1, and with all other parts in place, the end members 7 and 8 are held securely in position by means of the adjustable tie rod 9.

Located between the end members 7 and 8 is the heating chamber assembly. The heating chamber 10, which is located at the center of the assembly, is made of any suitable material capable of withstanding high temperatures and has a combined cylindrical and conical shape. The intermediate portion of the chamber 10 is cylindrical in shape, and the two ends are tapered for the purpose of giving the interior of the chamber the desired shape and also for the purpose of reducing the openings in the ends of the chamber. The external surfaces, including the cylindrical and conical portions, are grooved, and a heating coil is disposed within these grooves to heat the interior of the chamber. The heating chamber 10 is supported by circular plates 11 and 12, which are secured in turn to a hollow cylindrical member 13 of insulating material. The assembly thus formed of the chamber 10, the plates 11 and 12 and the cylindrical insulating member 13 is located and secured within a cylindrical casing 14. The plates 11 and 12, the member 13 and the casing 14 may be of any material having suitable heat-resisting and insulating characteristics.

The heating chamber assembly above described, including the casing 14 and the other parts secured therewith, is designed to rotate with respect to the end members 7 and 8 of the

furnace. For this purpose the casing 14 is equipped with two annular tracks 15 and 16 located near the respective ends of the casing. These tracks have a V-shaped surface for engaging four rollers mounted on the base-plate 1. Three of these, rollers 17, 18 and 19, are shown in the drawings. Packing rings 20 and 21 of suitable material are located between the tracks 15 and 16, respectively, and the adjacent surfaces of the stationary end members 7 and 8. These rings maintain a sufficiently tight joint between the rotatable and the stationary parts of the furnace. The rotatable cylinder 14 is also provided with a sprocket ring 22 through which the heating chamber assembly is driven. The inner faces of the V-shaped tracks 15 and 16 are provided with conducting commutator rings 25 and 26, respectively. The heating coil, which surrounds the external surface of the heating chamber 10 is connected by way of lead wires 27 and 28 to these commutator rings. Near the bottom of the furnace and mounted on the base-plate 1 are two brushes 29 and 30 which bear on the commutator rings 25 and 26 to supply the heating current to the coil wound about the heating chamber 10.

A driving motor 31, mounted conveniently on the bench 5, is connected through a coupling 32 to a driving gear wheel 33. The gear wheel 33 is joined to the rotatable heating chamber assembly by means of the chain 23 and the sprocket wheel 22. The purpose of this driving mechanism is to rotate the heating chamber 10 at a desired speed during a heat run to maintain the charge within the chamber in a continuous state of agitation.

The end member 7 is equipped with a tube 34 slidably fitted therein by means of a packing element 35. This tube serves as an entrance for admitting a charge to the heating chamber 10 and also as an exit for dumping the charge after treatment. The outer end of the tube 34 is sealed with a plug 36.

The opposite end member 8 is provided with a small cylindrical opening for admitting the gas supply tube 37. The tube 37 is also slidably with respect to the end member 8 and is tightly held in position by the packing 38. The tube 37 projects through the opening in the end member 8 and thence through the reduced opening in the end of the chamber 10 and into the interior of said chamber. As seen in the enlarged view in Fig. 5, the supply tube 37 is sealed at its inner end and is provided with lateral orifices 39 near the sealed end. The supply tube 37 is connected by way of a pipe 40 to any suitable tank or other source of supply of deposition gas, such as methane. The tube 37 also serves to support a thermocouple 41 within the chamber 10 and as a container of the electrical conductors 42 and 43 leading to the thermocouple.

The furnace is also provided with two intake pipes 45 and 46 and two outlet pipes 47 and 48 for supplying a stream of some suitable gas to the furnace for cleansing the interior and for delivering the waste products of the heating chamber from the interior of the furnace.

It is believed that the purposes of this furnace, the functions it performs, and the detailed construction of those parts that have not already been described will be better understood by proceeding with an explanation of the operation. Assume for this purpose that it is desired to deposit a layer of carbon on the external surfaces of a finely divided material such as that used

in microphones. The comminuted material is placed in the funnel-shaped container 49, the small end of which projects into the vibratory base 50. The tube 51, which communicates with the interior of the vibratory base 50, is then inserted through the entrance tube 34, through the reduced opening in the end of the chamber 10 to the interior of the chamber. The electromagnet 52 is then operated repeatedly by a suitable interrupting circuit to produce a vibratory movement of the base 50. The vibration of this base member 50 is such that it causes the material within the container 49 to advance through the horizontal tube 51 and into the interior of the heating chamber 10. When a sufficient charge has been administered to the chamber 10, the charge device is withdrawn, the slidable tube 34 is pulled outwardly so that it does not obstruct the free passage of gases to and from the opening in the heating chamber 10. Also the outer end of the tube 34 is sealed by plug 36. The gas supply tube 40 is adjusted so that the openings 39 are located at substantially the center of the cylindrical portion of the chamber 10.

Current from the source 53, Fig. 10, is now applied to the heating coil wound about the heating chamber 10. To energize the heating coil a suitable switch 54 is closed and the rheostat 55 is given the required adjustment. The circuit for the heating current may be traced from the lower pole of the generator 53 through the switch 54, thence through the successive turns of the heating coil of the chamber 10, through an indicating meter 56, resistance 57 or contacts of relay 62, rheostat 55 to the other pole of the generator 53. The potentiometer 58 is adjusted so that the potential difference produced by the battery 59 across the control circuit 60 is in opposition to that produced in the thermocouple 41 and of such a magnitude that it is just equal to the potential difference that will be produced by the thermocouple at the desired temperature within the chamber 10. As long as the temperature of the thermocouple is below the desired value, current flows in the circuit 60 in such a direction that the needle of the galvanometer 61 is deflected away from the aperture 80. This permits light from source 81 to shine through aperture 80 and excite the photoelectric cell 82, causing the relay 62 to operate. Relay 62 short-circuits the resistance 57, permitting current of full intensity to flow through the heating winding.

In the meantime the electric motor 31 is set in operation, and the heating chamber assembly is driven at the required speed. As the heating chamber 10 revolves, the charge therein is agitated so as to expose all surfaces of the particles to the carbon depositing gas. The depositing gas, which may be methane or other suitable gas, flows from the pipe 40 and the supply tube 37. As it encounters the end of the tube 37, it is forced to undergo a change of ninety degrees in its direction of movement in order to emerge through the lateral orifices 39. The gas, therefore, enters the chamber 10 at right angles to the axis of the chamber which produces a state of turbulence with the result that the gas distributes itself more uniformly throughout all parts of the chamber. The high temperature within the chamber causes the deposition of carbon on the surfaces of the material, producing a hard uniform coating of substantially pure carbon. While the deposition process is taking place the interior of the furnace is kept relatively free from the by-products of the process by sweeping out

the furnace constantly with some inert gas, such as nitrogen. The nitrogen gas flows in through the supply pipes 45 and 46 and, together with the by-products of the deposition process, out through the exit pipes 47 and 48. Bunsen burners 63 are located near the openings of the exit pipes 47 and 48 to completely burn the combustible gases that may emerge therefrom to prevent contamination of the surrounding atmosphere. The tapered shape of the chamber 10 serves to maintain the charge near the central portion thereof and also expedites the movement of the waste products out through the openings in the ends of the chamber. As these decomposition products emerge from the openings in the ends of the chamber 10, they are swept by the flowing nitrogen gas out through the exit pipes 47 and 48. Thus the interior of the decomposition chamber and furnace is maintained free of contaminating products that might have an injurious effect upon the coating that is being deposited upon the surface of the material within the chamber.

If the temperature within the chamber rises beyond the desired value, the potential produced by the thermocouple 41 becomes sufficient to oppose the potential across the circuit 60, resulting in the movement of the needle of the galvanometer 61 over the aperture 80. This shuts off the light and causes the release of relay 62. Relay 62 on releasing removes the short circuit from resistance 57, and the heating current in the coil is immediately reduced. In this manner the temperature within the chamber is held within close limits and at the desired values.

When the deposition process has been completed, the charge can be immediately withdrawn from the furnace without waiting for the chamber to cool. To dump the furnace, the plug 36 is withdrawn, and a receptacle 64 is placed on over the outer end of the slidable tube 34. The receptacle 64 is held in place by the spring support 65 which is attached in a suitable manner to the base-plate 1 as illustrated in Fig. 2. The tube 34 is then advanced into the furnace until the inner end registers closely with the opening in the end of the chamber 10. Next the motor 31 is disconnected from the furnace by means of the adjustable coupling 32. Finally the entire structure is rotated about the hinge 6 into a vertical position where it is held as seen in Fig. 2 by a cord or chain 83. As the furnace approaches the vertical position, the charge within the chamber 10, guided by the tapered surface of the chamber, passes out through the opening, through the tube 34 and into the container 64. Thus the charge is removed immediately and without exposing it to the atmosphere. The container 64 may now be removed and sealed, and if necessary any suitable gas may be passed into the container by way of a tube 66 while the charge is cooling. The furnace although at a high temperature is immediately ready for a new charge.

A brief description will now be given of the modified forms of the heating chamber illustrated in Figs. 6 to 9, inclusive. The chamber 67 shown in Figs. 6 and 7 is substantially the same in shape as chamber 10 and differs therefrom primarily in the provision of internal ribs 68, 69, 70 and 71. These ribs project from the internal cylindrical surface of the chamber 67 and inhibit the tendency for the mass of particles to merely slide on the smooth walls of the coating chamber and thus serve to cause a greater tumbling or agitation of the comminuted material under-

going the deposition treatment. It is sometimes desirable to deposit carbon on refractory cylinders, discs or other shapes, which are then used as resistors or electrodes. With a smooth interior such as illustrated in the chamber 10, these pieces tend to slide with the movement of the chamber and thus do not present all sides equally to the reacting gases. With the internal ribs shown in the modification of Figs. 6 and 7 a greater degree of tumbling is secured.

The other modification of the heating chamber shown in Figs. 8 and 9 differs from that of Figs. 6 and 7 in the shape of the internal ribs. The chamber 12 of Figs. 8 and 9 is provided with four ribs 13, 14, 15 and 16, each of which starts from the ends of the chamber and follows a curved course along the interior surface meeting in a point at the center of the cylindrical portion of the chamber. The V or herring-bone shape of these ribs causes the material within the chamber to undergo the desired tumbling action and also results in a lateral circulation of the material between the ends and the center of the chamber, thus securing more uniform conditions for the coating of all surfaces.

What is claimed is:

1. The combination in a deposition furnace for treating divided material of a rotatable enclosed heating chamber having raised ribs formed on the internal surfaces thereof for tumbling said material and so arranged with respect to the axis of rotation of the chamber as to cause the material to move in both directions with respect to the central portion of the chamber.
2. The combination in a furnace for the deposition of carbon on the surface of a base material of a housing, a horizontally-disposed cylindrically-shaped heating chamber mounted within said housing having openings in the ends thereof and having its side walls tapered toward said openings, means for introducing a charge of said material into the chamber through one of said openings, means for delivering a carbon-yielding substance into the interior of said chamber, means for rotating said chamber about its horizontal axis, and pivotal means for permitting the tilting of the furnace to bring the heating chamber into an upright position for dumping the charge out of one of said openings.
3. The combination in deposition apparatus of a rotatable chamber having an opening therein and a feed pipe having a sealed end which projects into said chamber and having lateral outlets near said sealed end for delivering a fluid into the chamber.
4. The combination in a deposition furnace of a rotatable heating chamber having an opening therein and a gas feed pipe having a sealed end which projects through said opening to a central point within the chamber and having holes in the side walls near said sealed end for delivering gas

into the interior of said chamber in such a manner that turbulence is caused within said chamber.

5. The combination in a furnace of a rotatable chamber having an opening in the end thereof, a housing member for enclosing said chamber and having an opening therein, a conveying tube projecting through the opening in said housing member and into registration with the opening in said chamber, and pivotal means for enabling the displacement of the furnace to permit the contents of the chamber to move out of the opening therein and through said conveying tube.

6. The combination in a furnace of a rotatable chamber having an opening in the end thereof, a casing member for said chamber having an opening therein, a tube slidably fitting into the opening in said casing to bring its inner end into registration with the opening in said chamber, a receptacle fitting the outer end of said tube and serving to seal the furnace from the outer atmosphere, and means for permitting the furnace and receptacle to be moved as a unit to dump the contents of the chamber into said receptacle.

7. The combination in a furnace of a rotatable chamber having an opening in the end thereof, a housing member for enclosing said chamber and having an opening therein, a receptacle removably inserted through the opening in said housing and into proximity to the opening in said chamber, and pivotal means for enabling the displacement of the furnace to permit the contents of the chamber to fall out into said receptacle.

8. The combination in an electric furnace of a base plate, a housing comprising two stationary end members mounted on said plate and a rotatable cylindrical casing interconnecting said end members, rollers mounted on said plate and supporting said casing for rotation, a heating chamber mounted within said casing for rotation therewith and having openings in the opposite ends thereof, said end members being cup-shaped to form enclosed spaces within said housing on either end of the heat chamber, means for charging and discharging the heating chamber through one of its openings, means for supplying gas to the heating chamber through its other opening, and exit pipes leading from the enclosed spaces for conducting the waste products out of the furnace.

9. The combination in a furnace for treating material of a cylindrically-shaped heating chamber having openings therein and having its end portions tapered toward said openings, a coil wound about the cylinder portion and the tapered end portions of said chamber for heating the interior of said chamber, means for rotating said chamber and integral ribs formed on the interior surfaces of said heating chamber for causing the material undergoing treatment to move with the chamber through a portion of its revolution and then to fall to the bottom of the rotating chamber.

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