

[54] **FURNACE CARRIER AND HANDLING SYSTEM**

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[63] Continuation of Ser. No. 101,036, Dec. 23, 1970, abandoned.

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263/48

[51] Int. Cl. **F27b 9/14**

[58] Field of Search **263/6 R, 41, 48,**
263/47, 52; 198/213

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[57] **ABSTRACT**

In an impurity treatment chamber, such as a gas diffusion furnace or the like, of a type having means for passing gases into and out of a chamber for treating semiconductor elements disposed therein, a carrier is movable longitudinally thereof and adapted to support semiconductor elements within the chamber. An elongated screw mounted for rotation within the chamber adjacent to the bottom thereof cooperates with a follower portion formed on the carrier for engaging the threads of the screw for positive movement of the carrier in response to rotation of the screw. Motive means rotate the screw so as to positively drive the carrier between advanced and retracted positions within the chamber and to oscillate the carrier within the chamber over a short distance so as to preclude adhesion or sticking of the parts of the system which would otherwise make difficult the withdrawal of the carrier from the chamber.

7 Claims, 8 Drawing Figures

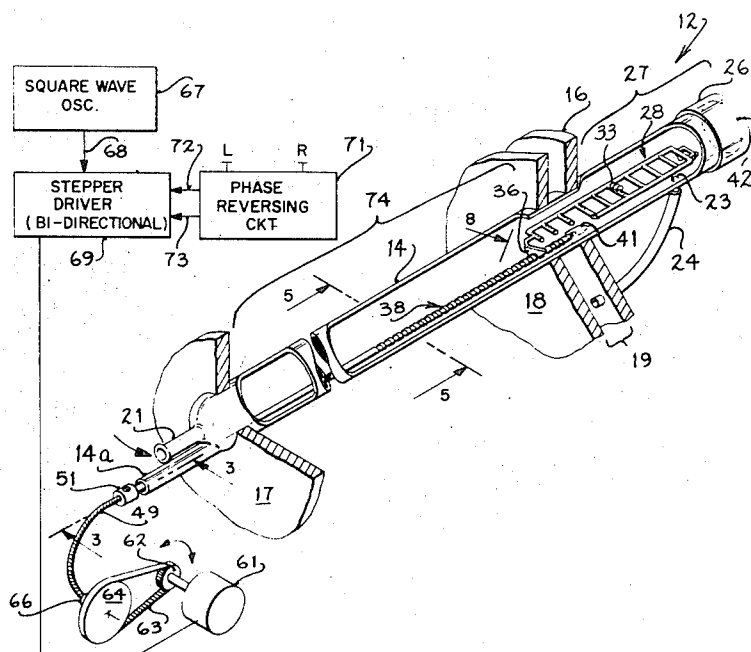


FIG 1

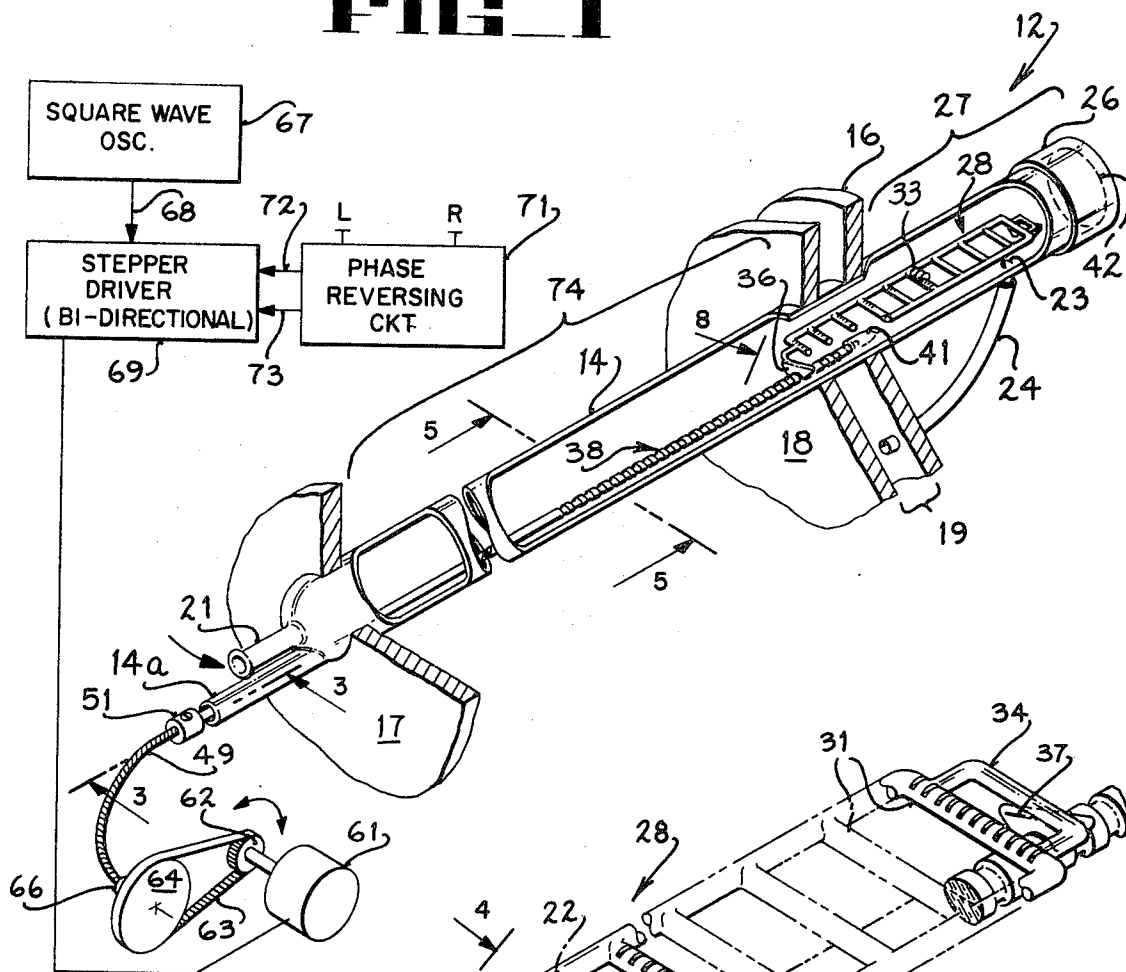


FIG 2

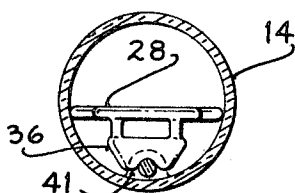
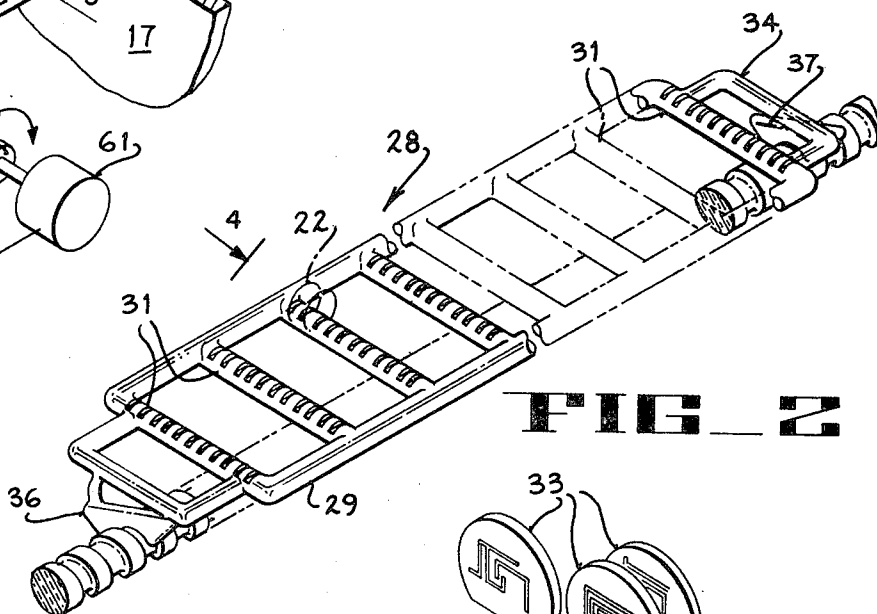


FIG 5

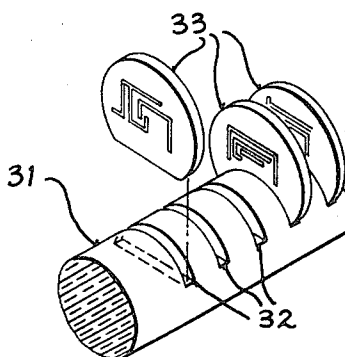


FIG 4

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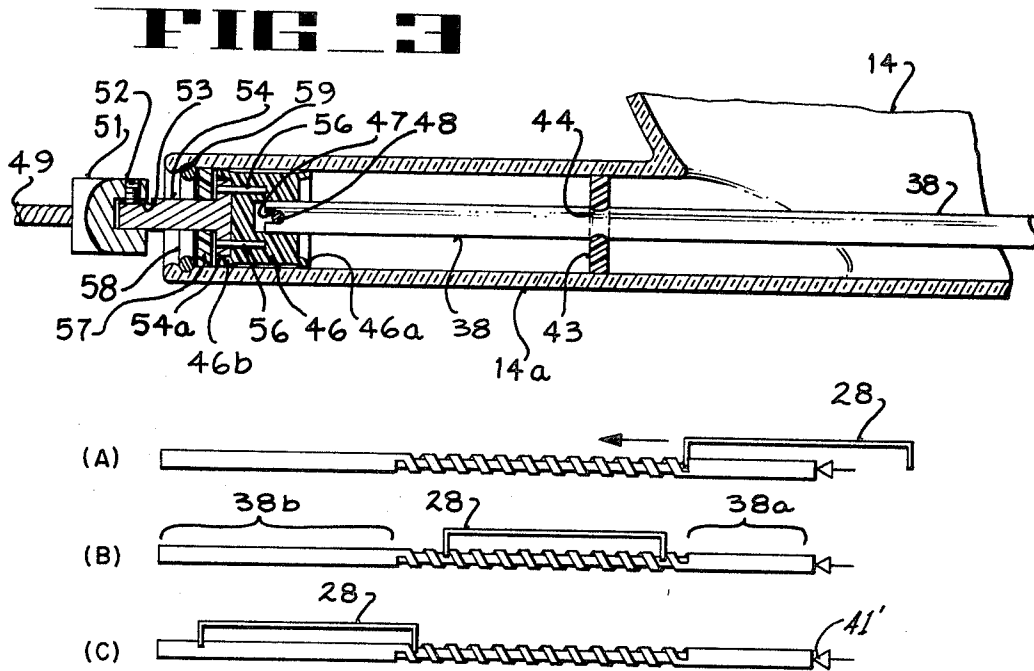


FIG 6

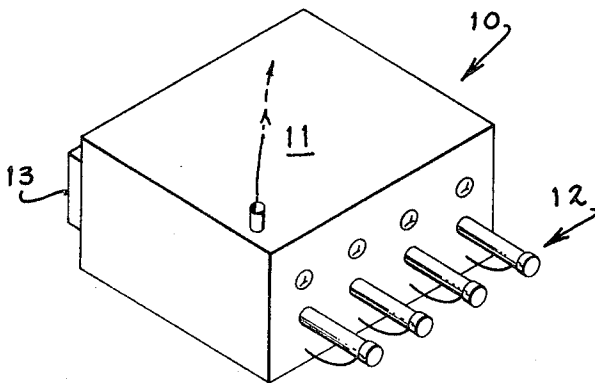


FIG 8

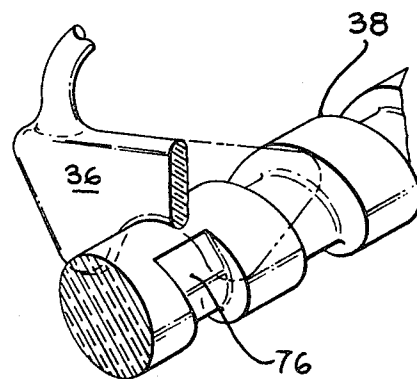


FIG 7

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FURNACE CARRIER AND HANDLING SYSTEM

This is a continuation of application Ser. No. 101,036 filed Dec. 23, 1970, now abandoned.

BACKGROUND OF THE INVENTION

This invention pertains to impurity treatment apparatus, for example, of the type used in treating semiconductor elements, such as integrated circuits and the like by gas deposition, gas diffusion, epitaxial growth of semiconductor materials, etc., as conducted in a furnace or reactor chamber.

In a typical diffusion furnace, for example, an elongated, hollow chamber, preferably of quartz material, is disposed in the heating zone of the furnace or reactor. Semiconductor or other elements to be treated may be moved into and out of the heating zone by means of an elongated carrier or "boat" movable by manipulation applied from an access opening of the chamber.

In operation, the chamber may be sealed at the access opening and gas, such as boron, phosphorous, arsenic, antimony, or others, for treating the semiconductor material is passed into and out of the chamber while the semiconductor elements are exposed to the gas. After such exposure, the carrier is drawn out of the heating zone and into a cooling zone outside the furnace but within the chamber. Ultimately, the carrier is removed from the chamber entirely to retrieve the treated semiconductor elements.

As has been experienced, movement of the carrier along the surface of the tubular chamber frequently is rendered difficult, if not impossible, by adhesion of the carrier to the chamber as a result of bonding deposits of the treatment gases and otherwise, such as by flaking of an uncured chamber.

SUMMARY OF THE INVENTION AND OBJECTS

In general, there is provided a furnace for preparing semiconductor elements in exposure to gases comprising an elongated chamber or tube carried by the furnace to receive the elements via an end thereof. Means forming a carrier to support a number of the semiconductor elements therefrom in the chamber moves longitudinally of the chamber. An elongated screw element is mounted for rotation within the chamber and adjacent the bottom thereof to cooperate with means formed on the carrier for engaging the threads of the screw for positive driving movement of the carrier in response to rotation of the screw in each of two opposite directions so as to advance the carrier between advanced and retracted positions within the carrier. According to a preferred embodiment, means have further been provided for oscillating the rotation of the screw to continuously move the carrier back and forth in the chamber over a relatively short distance whereby the parts of the apparatus will be kept from sticking or adhering together.

In general, it is an object of the invention to provide an improved means for handling a carrier within a gas treatment chamber so as to prevent adhesion of the parts therebetween.

It is another object of the invention to provide an improved semiconductor element carrier for use within a gas treatment chamber.

It is yet another object of the invention to provide means for positively and readily moving a carrier of the kind described between advanced and retracted posi-

tions within a gas diffusion tube and to oscillate the longitudinal movement of the carrier within the tube during periods of treatment.

The foregoing and other objects of the invention will become more readily evident from the following detailed description of a preferred embodiment when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view with portions broken away of an improved system according to the invention and including schematic block diagram controls for operating same;

FIG. 2 is an enlarged detail view in perspective schematically showing an improved carrier unit according to the invention;

FIG. 3 is a side elevation section view taken in the region 3-3 of FIG. 1;

FIG. 4 is an enlarged detail view of an element-supporting portion of the carrier shown in FIG. 2 and taken in the region of 4-4 thereof;

FIG. 5 is a transverse section view in enlarged detail taken along the line 5-5 of FIG. 1;

FIG. 6 is a diagrammatic representation showing three stages in the sequence of operation of the apparatus shown in FIG. 1;

FIG. 7 is an enlarged detail view of a terminal convolution of the lead screw shown in the apparatus in FIG. 1;

FIG. 8 is a perspective view of the exterior of a diffusion furnace construction utilizing the apparatus shown in FIG. 1.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

In general, as shown in FIG. 8, a diffusion furnace 10 includes a heating chamber 11 and a number of diffusion tube assemblies 12 disposed to extend through the heating chamber 11. At the rear of furnace 10, a control cabinet 13 houses controls and apparatus for operating the diffusion tube assembly 12 as shown in greater detail in FIG. 1 and FIG. 3.

Tube assembly 12 comprises an elongated, generally cylindrical, tubular chamber 14 of heat resistant, pure material, such as quartz, whereby high temperatures can be created within the confines of furnace 10 without generating impurities to contaminate the elements being treated. Tube assembly 12 is disposed to extend outwardly of the front and rear walls 16, 17 respectively which are constructed of suitable material, such as stainless steel or the like. Immediately behind and spaced from front wall 16, a secondary wall 18, also of stainless steel, serves to provide a flue 19 into which gases exhausting from within chamber 14 can be drawn.

Thus, means have been provided for passing gas into and out of chamber 14 as by means of the elongated flow passage connection 21 for admitting gas, such as boron, for diffusion treatment of the elements 33 therein while a flow passage 23 discharges gas into flue 19 via the gas connection 24.

The outer end of chamber 14 is normally covered by a cylindrical closure element 26 which serves to seal the end of chamber 14 and thereby prevent introduction of contamination by gases or otherwise into the interior of chamber 14.

The protruding end of chamber 14 provides a cooling zone 27 into which elements 33 can be withdrawn while supported on a moving elongated carrier 28, as shown more particularly in FIG. 2. Carrier 28 is constructed of heat resistant material, such as quartz, so as to preclude emission of contaminants during treatment of elements 33.

Carrier 28 includes elongated, parallel side portions 29 for engaging and riding upon the sloping inner surface portions of chamber 14 (FIG. 5). By virtue of the fact that the cross-section of chamber 14 is cylindrical in shape, and that the side portions 29 resting upon the interior surface of chamber 14 lie in a common plane, carrier 28 will be supported to ride in a substantially horizontal plane.

Carrier 28 further includes element-supporting portions disposed between side portions 29, such as the transversely extending members 31.

Each member 31 is formed with a number of laterally spaced slots 32, having a relatively flat bottom thereto, for receiving a semiconductor wafer element 33 of generally circular configuration but formed with a chord segment portion removed so as to fit snugly upon the flat bottom of the slot 32. The plane of elements 33 are oriented, accordingly, in the direction of the passage of gas through the interior of chamber 14 so as not to create turbulent flow in the gas as it passes thereacross.

Carrier 28 is further prepared with a retrieving handle 34 located at the "outer" end of carrier 28 (when it is positioned within chamber 14) so that by means of a hook or other device carrier 28 can be engaged and withdrawn from within the cooling zone 27 of chamber 14.

Finally, each end of carrier 28 includes screw follower means in the form of an arcuate planar element 36, 37 disposed at an angle to the direction of travel of carrier 28.

Thus, an elongated lead screw element 38 also formed of quartz is disposed in chamber 14 adjacent the bottom thereof and mounted for rotation in a stationary position aligned to engage the thread-engaging elements 36, 37 so as to positively drive carrier 28 back and forth within chamber 14.

Thus, lead screw 38 includes a threaded portion flanked by elongated unthreaded portions 38a, 38b (FIG. 6). Lead screw 38 is journaled at its right hand end as viewed in FIG. 1 simply by urging its conical tip into a conically-shaped depression formed in a stationary journal block 41 also of quartz. Journal block 41 is formed as a portion of the interior of chamber 14 at a distance removed from the access opening 42 of chamber 14 whereby carrier 28 will be advanced by lead screw 38 outwardly into zone 27.

The other end of lead screw 38 is supported for rotation by means of the annular Teflon support bushings 43 (FIG. 3) carried about the left end of lead screw element 38 captured in a groove 44 formed therearound. Lead screw element 38 is rotated by a drive connection as now to be described with respect to FIG. 3.

A resilient generally cylindrical rotary seal 46, formed with outwardly biased rims 46a, 46b, rotates within the interior surface of chamber extension portion 14a to maintain a seal therewith. The end of lead screw element 38 fits into a drilled hole formed axially of seal 46 and by means of a notch 47 and Rulon pin 48 extending transversely through the body of seal 46 forms a positive drive connection between the rotating

seal 46 and the shaft portion of lead screw element 38.

Means for rotating seal 46 comprises a flexible drive cable 49 carrying a standard attaching head 51 whereby a set screw 52 can be tightened down against the flat 53 formed on the outer end of a drive shaft 54. Drive shaft 54 is formed with a flange portion 54a through which drive pins 56 serve to couple drive shaft 54 with seal 46.

Drive shaft 54 is supported by means of an annular stainless steel retaining ring 57 and an annularly shaped lock spring 58 lodged in a groove formed about the interior of the end of chamber extension portion 14a.

Accordingly, by rotation of cable 49, lead screw element 38 can be made to rotate in one direction or the other as desired and, accordingly, means have been provided for rotating lead screw element 38 in each of two opposite directions in a stepwise mode of operation.

Thus, a four-phase or other suitable stepping motor 61 is coupled by a pinion 62 and a positive displacement drive belt 63 to drive a bull gear 64 about its axis of rotation. At its axis of rotation, there has been attached a head 66 of a type comparable to head 51 and in this manner rotation of lead screw 38 is obtained.

The system as disclosed in FIG. 1 provides a means for oscillating the rotation of lead screw 38 to continuously cycle carrier 28 back and forth within chamber 14 over a relatively short distance only sufficient to keep the parts of the apparatus from sticking.

Accordingly, a square wave generator or oscillator 67 of conventional construction feeds a train of pulses at a selected rate along line 68 into a stepper/driver circuit 69 operatively coupled electrically to activate stepping motor 61. A phase-reversing circuit 71 provides one or the other of two outputs 72, 73 by suitable means, such as the bi-stable states of a series of flip-flops whereby, with a four-phase operated stepping motor 61, for example, the phases can be activated in a forward or reverse sequence simply by sequencing the flip-flop elements in conventional style to start from one direction or the other.

Further, phase-reversing circuit 71 automatically reverses the sequence of signals appearing on lines 72, 73 after relatively short numbers of pulses have been provided on these lines whereby stepping motor 61 will normally oscillate between forward and reverse modes of operation to oscillate the rotation of lead screw 38.

In addition, as shown in FIG. 1 schematically, push-buttons labeled "L" and "R" have been provided in conventional style to establish and hold one or the other of the two output conditions on lines 72, 73 for driving motor 61 in one or the other of its two directions.

In operation (FIG. 6), carrier 28, pre-loaded with a number of semiconductor wafer elements 33 located in slots 32, is disposed into chamber 14 with thread-follower element 36 positioned to pass over journal block 41, the unthreaded portion 38a, and into engagement with the first of threads of lead screw 38. Subsequently, closure 26 is applied to the access opening 42 for sealing the outer end of tube assembly 12. Depressing push-button "L" of phase-reversing circuit 71 serves to maintain a predetermined state on line 72 or 73 so as to cause stepping motor 61 to advance carrier 28 leftwardly into the heating zone 74 within furnace 10. Ultimately, thread-follower element 36 will reach the left end of the threaded portion of lead screw 38

and continue out onto the unthreaded portion 38b by virtue of the face that by this time thread-follower element 37 will have engaged the threaded portion of lead screw element 38 and be driving carrier 28.

Ultimately, as thread-follower element 37 reaches the leftmost convolution of the threaded portion of lead screw 38, carrier 28 will be arrested by the last remaining convolution or thread and come to a stop while leaving thread-follower element 37 in threaded engagement with the threaded portion of lead screw 38.

Thus, the terminal convolutions of the threaded portion of lead screw 38 at each end thereof has been formed to arrest and retain a follower 36, 37 so as to prevent carrier 28 from becoming disengaged in the furnace or at the right hand end. Thus, the terminal convolutions include an abrupt termination 76 thereof whereby driving engagement between the screw convolutions and screw-follower elements 36, 37 will be terminated before carrier 28 advances beyond the end of the threaded portion of lead screw element 38.

Accordingly, by driving carrier 28 from either end, only a limited portion of lead screw element 38 is required to be formed with a thread. This is advantageous since the formation of threads around a quartz rod is a relatively expensive undertaking but is required under the circumstances in order to obtain a quartz construction within the diffusion tube.

Reverse feeding of carrier 28 operates in the same manner whereby the terminal convolution on the right hand end of the threaded portion of screw 38 will fail to disengage element 36 driving the end of carrier 28 and, accordingly, carrier 28 is never "out of reach" of the threaded portion of lead screw 38, while carrier 28 can be positively positioned substantially beyond either end of the threaded portion.

As thus described, it will be readily evident that there has been provided an improved impurity treatment furnace characterized by an improved gas treatment chamber assembly whereby the semiconductor carrier or "boat" is positively driven between advanced and retracted positions within the assembly and while within the heating zone 74 will be oscillated continuously longitudinally back and forth within a relatively short distance so as to preclude bonding or adherence of carrier 28 to the interior of chamber 14 or sticking of the various parts of the rotationally driven lead screw assembly.

I claim:

1. In a treatment furnace for preparing semiconductor elements in exposure to gases and having an elongated chamber carried by the furnace to receive said elements via one end thereof, said one end protruding from a wall of the furnace, means for passing gases into and out of said chamber for treatment of said elements, means forming a carrier to support a number of said elements therefrom for movement in said chamber, an elongated screw mounted for rotation within, and adjacent to the bottom of, said chamber, means formed on said carrier for engaging the threads of said screw for positive movement of said carrier in response to rotation of said screw, and motive means for rotating said screw to positively drive said carrier between advanced and retracted positions within said chamber.

2. In a treatment furnace having an elongated chamber for preparing semiconductor elements, a carrier

within the chamber for supporting said elements for treatment, an elongated screw mounted for rotation within said chamber, means disposed at each end of said carrier for engaging said screw in positive driving relation to advance and retract said carrier in response to rotation of said screw, means for passing gas into and out of said chamber for treatment of said elements, and means for rotating said screw in each of two opposite directions to drive said carrier.

3. In a furnace according to claim 2 wherein the last named means further includes means for oscillating the rotation of said screw to continuously cycle said carrier to move back and forth in said chamber over a relatively short distance sufficient to keep the parts of the apparatus from sticking.

4. In an impurity treatment chamber of a type having means for passing gases into and out of same, a carrier movable longitudinally thereof and adapted to support semiconductor elements in said chamber, said carrier including side portions for engaging the inner surface of said chamber and supporting said carrier in a substantially horizontal plane, element-supporting portions carried between said side portions, thread-engaging means carried from the ends of said carrier, and an elongated lead screw element disposed in said chamber and mounted for rotation in position aligned to engage said thread-engaging means to positively drive said carrier back and forth within said chamber.

5. In a chamber according to claim 4 wherein said lead screw element includes unthreaded elongated end portions at each end and a threaded portion therebetween, said threaded portion having a follower-arresting convolution at each end serving to preclude unscrewing the terminal one of said thread-engaging means thereby retaining said carrier threadedly engaged thereon at both ends of its travel along said lead screw element.

6. A carrier for supporting elements for treatment within an impurity treatment chamber, said carrier comprising a pair of spaced apart side portions adapted to ride upon the inner surface of the chamber, means between said side portions for supporting a number of semiconductor elements to be treated, and thread-follower means disposed from the last named means in position for engaging an elongated threaded element mounted for rotation within the chamber.

7. In a treatment furnace having an elongated chamber for preparing semiconductor elements, a carrier within the chamber for supporting said elements for treatment, an elongate drive element in said chamber, means disposed at each end of said carrier for engaging said drive element in positive driving relation to advance and retract said carrier in response to driving of said elongate element, means for passing gas into and out of said chamber for treatment of said semiconductor elements, and means for driving said drive element in each of two opposite directions to drive said carrier, the last named means further including means for oscillating the movement of said drive element to continuously cycle said carrier to move back and forth in said chamber over a relatively short distance sufficient to keep the parts of the apparatus from sticking while maintaining said carrier substantially at a predetermined station in said chamber during said oscillating movement.

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