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Redan

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[54] **DIFFUSION FURNACE LOADER**

[75] Inventor: **Joseph Redan,** Parsippany, N.J.

[73] Assignee: **Simmonds Precision Products, Inc.,** Tarrytown, N.Y.

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[52] **U.S. Cl.** .....**214/34,** 254/DIG. 6, 263/6 R

[51] **Int. Cl.** **F27b 9/26**

[58] **Field of Search** ...214/23, 26, 34, 18 R; 263/6 R; 254/DIG. 6; 219/10.69, 10.71

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Primary Examiner—Robert G. Sheridan

Attorney—Edwin E. Greigg

[57] **ABSTRACT**

A furnace-loading mechanism for use with a diffusion furnace, the components thereof facilitating the entry and withdrawal of a wafer-bearing quartz boat member relative to a furnace through an articulated chain link construction which is capable of storage in a horizontal plane on the loader.

9 Claims, 5 Drawing Figures

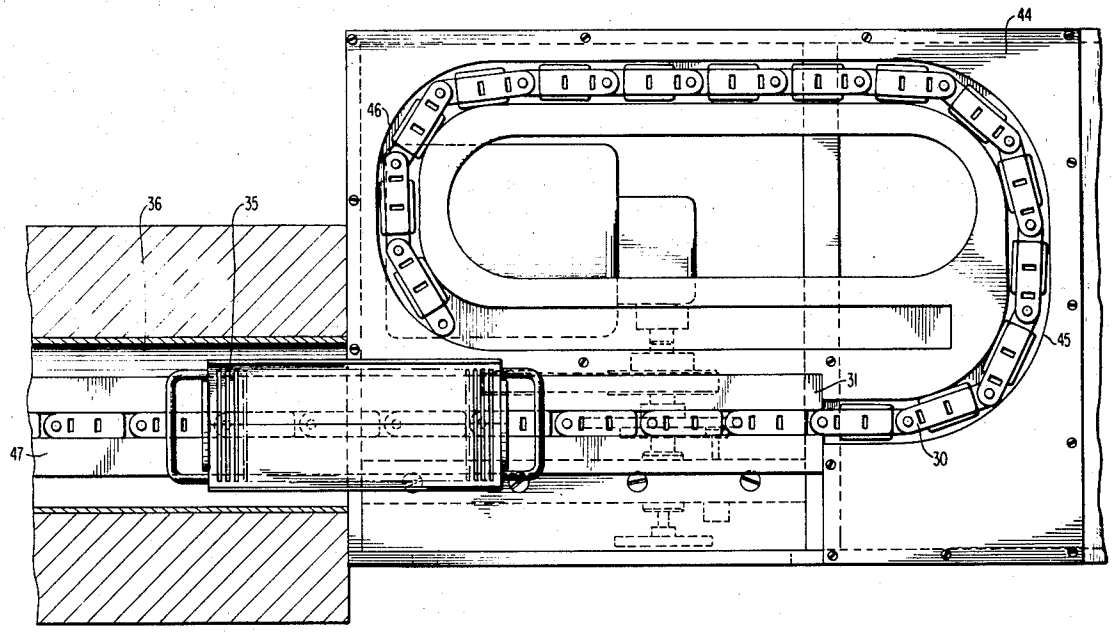


FIG1

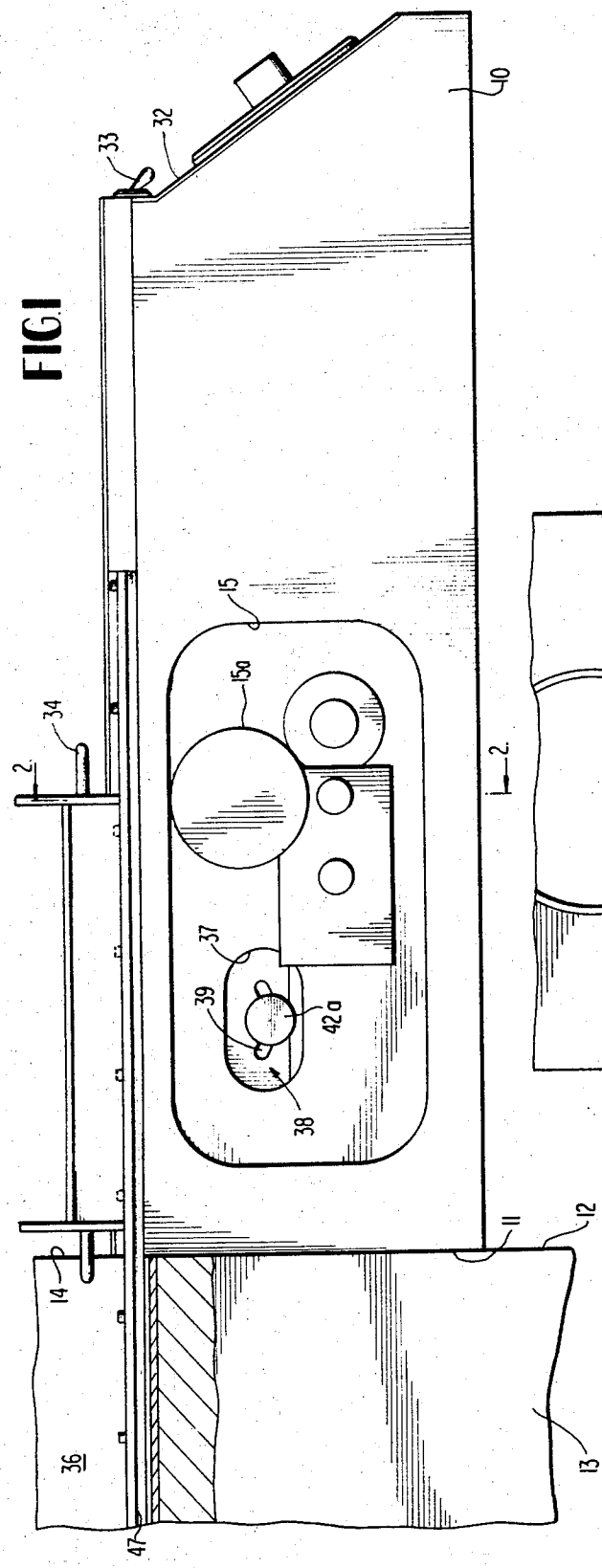
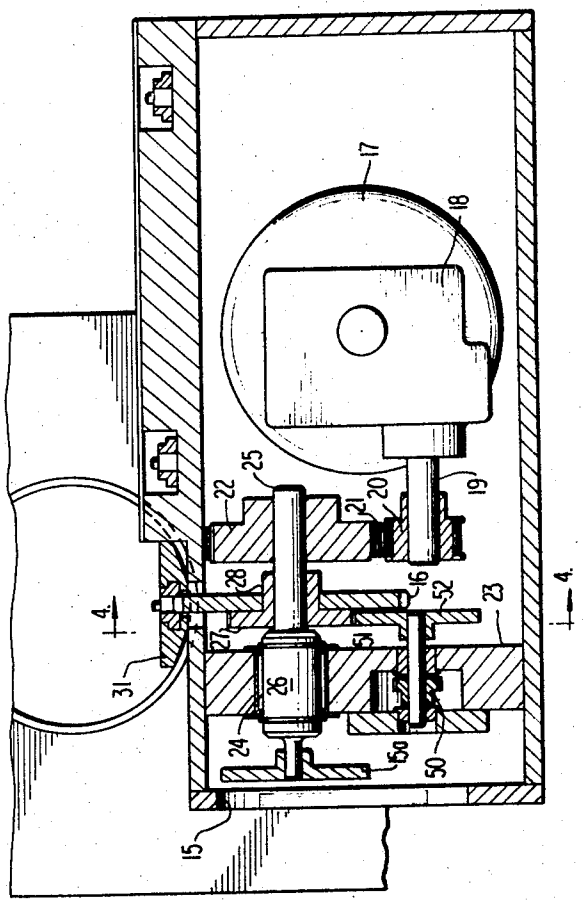


FIG2



INVENTOR
JOSEPH REDAN

BY Edwin L. Greigg

ATTORNEY

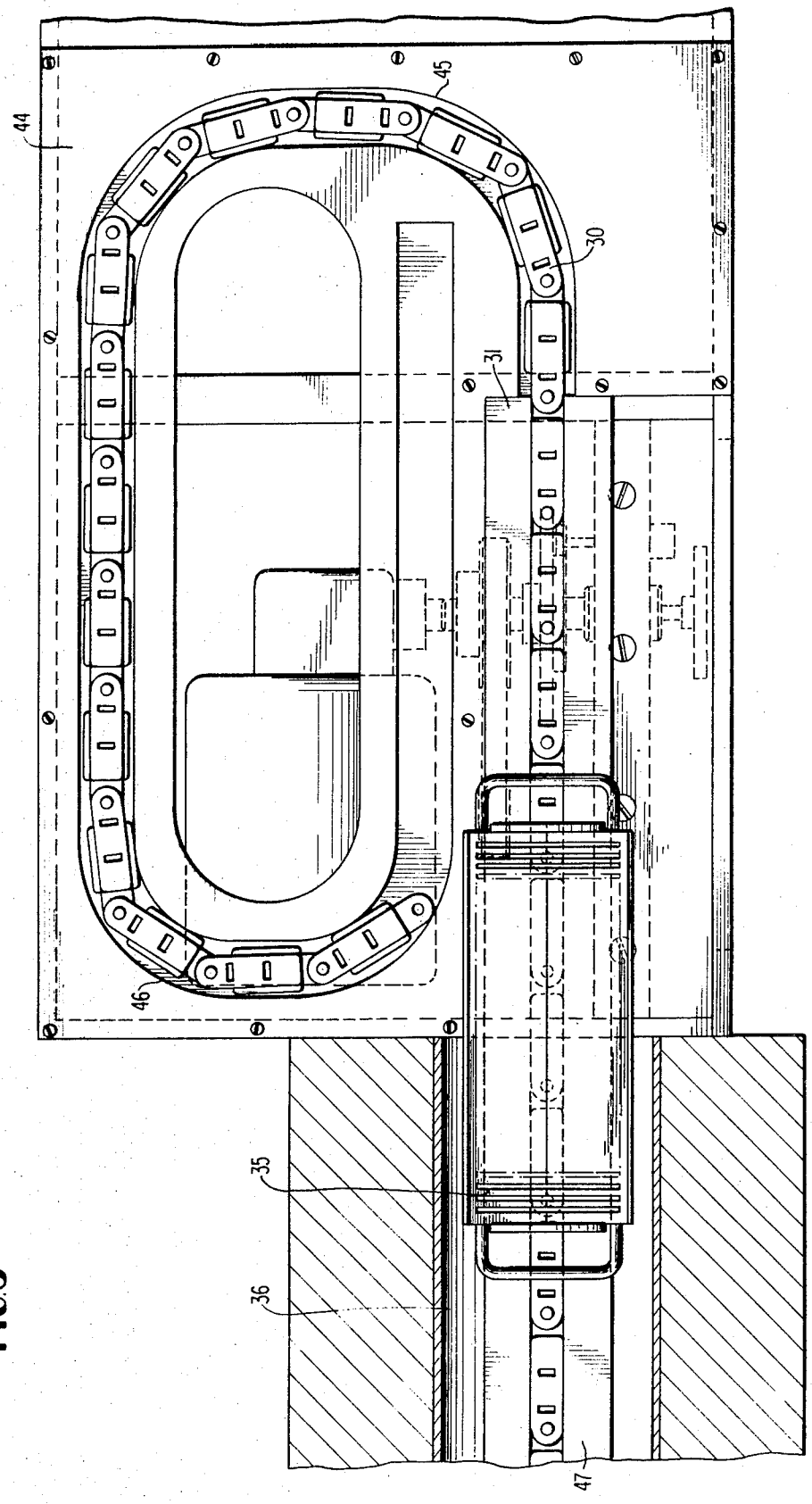


FIG3

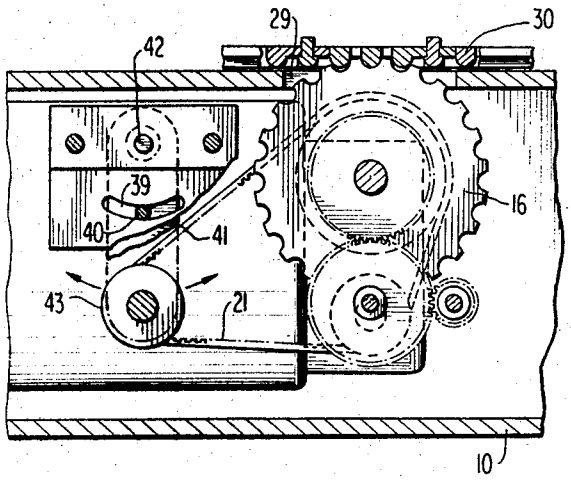
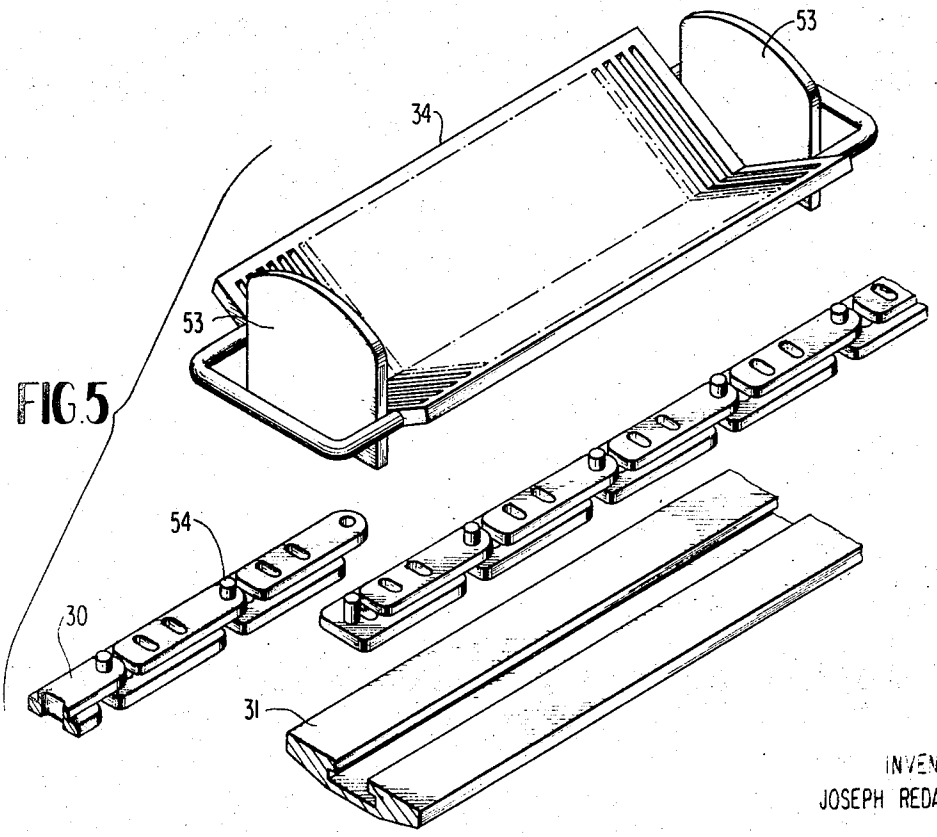


FIG.4

FIG.5



INVENTOR
JOSEPH REDAN

DIFFUSION FURNACE LOADER

This invention relates to an improved furnace loading mechanism to more expeditiously achieve completely automatically the function of positioning a batch of semiconductor wafers into the furnace temperature flat zone and the withdrawal at a controlled rate at the completion of the diffusion process.

Basically, the process consists of heating the semiconductor to be diffused to a high temperature in a furnace containing the vapors of the impurity to be diffused into the semiconductor.

BACKGROUND OF THE INVENTION

Transistor technology is now well known as the fundamental of transistor construction. In 1948 Bell Laboratories created the point contact transistor and principally because it proved to be unstable, it tended to oscillate.

Progress of this earlier type of transistor led to the development of the grown junction transistor which began with the melt of purified material into which a "seed" or what is known as a small single crystal of the semiconductor material, was lowered. Later because the grown junction transistor had a number of serious deficiencies, the alloy junction transistor, with germanium as the semiconductor, came into existence and has proved to be a very successful design. However, continued experimentation developed the fact the silicon was more suitable for high-powered semiconductors than germanium, the principal reason being that it could be used at much higher temperatures and, moreover, because processing techniques yielded more economical devices. As a natural consequence of the development of the semiconductor devices, there came into existence diffusion furnaces, this type of furnace having thermal energy which causes charge carriers, i.e. electrons and holes, to diffuse from one side at the p-n junction to the other side thereof. The law of diffusion states that the diffusion species will flow from the region of high concentration (the vapor) to the region of low concentration (the semiconductor).

To those skilled in this art it is well known that carefully prepared semiconductor materials have a crystal structure which is called a lattice. The outer or valence electrons of individual atoms are tightly bound to the electrons of adjacent atoms in electron-pair bonds. As a consequence, in order to separate electron-pair bonds and provide free electrons for electrical conduction, one may add small amounts of other elements having a different atomic structure to the semiconductor. It is well known that these infinitesimal amounts of elements, called "impurities," can be controlled and modified and that in order to accomplish this, the resultant device, which is denoted as a "wafer," is positioned upon a quartz boat or carrier member, and thereafter introduced into the diffusion furnace.

There are two types of diffusion-current furnaces, one type is open at each end and the boat containing the wafers to be treated to change their atomic structure is transversed through the furnace on the boat on an endless chain, or the boat containing the wafers may be inserted into the furnace by means of a quartz pedal which is manually operated by a workman. The other type of furnace is open only at one end and heretofore it has been customary to insert the boat or carrier member bearing the wafers into the furnace or retract it therefrom by the operator's quartz pedal.

OBJECTS AND ADVANTAGES OF THE INVENTION

Accordingly, this invention relates to improvements in furnace loading devices, particularly for use with diffusion furnaces.

Another object of the invention is to provide a self-contained housing which includes all the necessary controls to fully automate the subjection of the silicon wafers to the diffusion current of the furnace.

Still another object of the invention is to provide the housing with a circuitous trackway which acts as a guide means for a multiplicity of articulated link members which advance the wafer-bearing boat into and retract it from the furnace.

Yet another object of the invention is to provide a series of interconnected articulated link members which are adapted to be actuated by a power-driven sprocket member with the links being so designed as to also form a means by which the wafer boat is moved into and out of the furnace.

A still further object of the invention is to provide manually operable means for controlling the articulated link members and the wafer upon electrical power failure.

These and other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 discloses a side elevational view of the furnace loader with a portion of the trackway extending into the furnace;

FIG. 2 is a cross-sectional view on line 2—2 of FIG. 1;

FIG. 3 is a top plan view of the furnace loader and the wafer boat with the drive elements for the boat shown schematically;

FIG. 4 is a cross-sectional view on line 4—4 of FIG. 2; and

FIG. 5 is a perspective view showing the drive chain, boat and trackway in exploded form to better disclose their details.

DESCRIPTION OF THE EMBODIMENT

Turning now to FIG. 1, there is shown the left side of the furnace loader housing **10** with its rear wall **11** secured to and in abutted relation with the front wall **12** of the diffusion furnace **13**, the entrance of which is denoted at **14**.

There is also well shown in this particular view an enlarged aperture **15** provided in the left side wall of the housing **10**, this opening providing for access not only to the knurled wheel **15***a* for manual drive of the sprocket wheel **16**, all of which will be explained in greater detail hereinafter, but also for driving adjustment of the potentiometer, the necessity for which will be apparent to those skilled in the art.

Referring at this time to FIG. 2 there is clearly shown therein the drive motor **17**, a gear reduction unit **18** associated therewith, and a shaft **19** extending therefrom, the terminus of which includes a minor pulley **20** securely fastened thereto in any suitable manner. Adjacent thereto and in driving relation with the minor pulley **20** through an endless belt means **21** is a major pulley **22**.

A perpendicularly extending plurally apertured partition 23 includes means defining an opening denoted 24 and through which the shaft 25 provided at one end with the pulley 22 and at its opposite end with the knurled drive means 15a is arranged to extend. As shown in FIG. 2, the shaft 25 includes a bearing means 26 for purposes that will be apparent.

Substantially medially of the partition 23 and the pulley 22 there is secured to the shaft 25, a gear member 27 which is provided with a collar means 28 and on which the sprocket member 16 is securely arranged, as shown. It will be observed that the shaft 25 is so positioned relative to an opening in the top wall (FIG. 4) of the cabinet 10 that the teeth of the sprocket will extend up through the trackway 31 and circumscribe an arcuate path therethrough and thereby gain access to and drive the multiple chain link members 30 which are slidably confined on the trackway 31.

Referring at this time again to FIG. 1, there is generally denoted on the front wall 32 of housing 10 several of the control members including an on-and-off switch 33, a gauge for indicating the position of the boat 34 relative to the furnace chamber 36 and one of several other switches which, when operated by a skilled workman, will compensate for the rate of control of treatment of the wafers 35 carried by the boat 34, as well as their preheat and dwell time within the furnace chamber.

The partition 23 (see FIGS. 1 and 4) is provided with an aperture 37 which is covered by an arcuately slotted plate member 38, the slot 39 thereof being arranged to receive a shaft 40, one end of which is affixed to a plate element 41 pivoted as at 42 to the wall of the housing with the opposite threaded end of the shaft 40 adapted to receive a knurled knob 42*a* whereby the idler pulley 43 carried by plate 41 can be swung in one direction to tension the belt 21, and in the opposite direction for releasing tension thereon. In view of the foregoing, it will be apparent that by first loosening the knob 42 relative to the shaft 40, whereupon the front wall of the knob (not shown) is disengaged from contact with plate 38, the pivotal plate 41 can be moved to one side so the belt can be suitably tensioned and then the knob 42 once again turned down sufficiently in order that its front wall will be brought into tight frictional engagement with the plate 38.

It will be apparent that in the event of electrical power failure, such as the well-known "blackouts" that have occurred extensively in recent years on the East Coast of the United States, that the operator of the furnace loader will be able to withdraw the boat 34 from the furnace chamber manually by merely loosening the knurled knob 42 and releasing the tension from the drive belt so that the knob 15*a* carried at the end of the sprocket bearing shaft can be rotated to drive the sprocket in the desired direction.

Turning now to FIG. 3 of the drawings, there is shown a top plate element 44 which is securely fastened to the housing 10 and is provided with a guideway 45 having a reentrant bend portion 46 so that the interconnected chain link members 30 can be fully retracted from the furnace chamber in a horizontal plane and stored on the top of the housing, as shown. The trackway 31 is securely mounted on the top wall of the housing and includes a terminal portion 47 that extends substantially the length of the furnace chamber 36. Thus, the chain links can be extended fully into the furnace (approximately 4 ft.) and entirely retracted therefrom so as to lie on the top of plate 44.

In FIG. 2 the rotary element 50 carried on shaft 51 and which is driven through gear means 52 that, in turn, is drivably associated with the sprocket is adapted to drive a shaft on which is mounted a contact arm of a potentiometer, the position of the arm being arranged to determine the resistance in the circuit with the latter elements enumerated not being illustrated.

Referring at this time to FIG. 4, there is shown a schematic view of the left side wall of the housing 10 clearly illustrating the driven sprocket 16, the teeth of which are shown extending up through the trackway and into engagement with the chain link members 30.

The exploded schematic view in FIG. 5 shows the quartz boat 34 which includes upright end walls 53—53 with lifting handles being shown extending therefrom, the latter facilitating positioning the boat on the links 30. The boat 34 can be provided with converging sliding walls, as shown, or the wafer-receiving slotted surface may be merely concave, the boat member not forming any part of this invention. The lower surface of the boat 34 is provided with depressions (see FIG. 1) which receive the upstanding pins 54 of the interconnected chain links 30.

SUMMARY

TYPICAL OPERATING CYCLE

A typical operating cycle consists of the operator preselecting one of two types of operating modes:

a. Run mode, which will drive the boat first to the dwell (if selected) and then to the diffusion zone.

b. Oscillate mode; selection of this mode of drive imposes an oscillation on the drive causing the boat to move plus or minus 2 inches at both the dwell (if selected) and diffusion zone.

Step 1: Turn selector to set up position. Load boat

Step 2: Select boat position in furnace by turning selector potentiometer to position desired.

Step 3: Turn rate control to desired time one, two or three minutes for full stroke.

Step 4: Turn preheat dwell timer potentiometer to select length of time desired.

Step 5: Turn preheat position potentiometer to select desired dwell position in furnace.

Ref. At this time the operator has completed the set up and needs only turn selector knob to run mode.

Step 6: Turn selector to run mode.

That which is claimed is:

1. A furnace-loading mechanism comprising a laterally flexible and longitudinally rigid, elongated means for moving a wafer-bearing boat member for advancement into or retraction from the furnace and a support means for said moving means, said support means comprising a housing containing a power driving means for the moving means, said support means also including a guideway for the moving means, said guideway being positioned in a horizontal plane on a top surface of said housing, said guideway first extending away from said furnace, curving laterally and then extending towards said furnace for compact storage of the moving means when retracted form the furnace and

said guideway having an opening through which a portion of said driving means extends for driving said moving means.

2. A furnace-loading mechanism as claimed in claim 1, wherein said driving means includes a control means adapted to advance the wafer-bearing boat to a preheat position within the furnace and thereafter automatically advance it to its dwell position therein.

3. A furnace-loading mechanism as claimed in claim 1, comprising manually operated means engaging said moving means for driving said moving means when the power means is not used.

4. A furnace-loading mechanism as claimed in claim 3, wherein both the power drive and the manually operated means are drivingly connected to a means for controlling the resistance of a potentiometer.

5. A furnace-loading mechanism as claimed in claim 1, wherein the driving means includes a motor and a gear train between said motor and said moving means, and a movable idler means in the gear train for interrupting power transmission between said motor and said moving means.

6. A furnace loading mechanism as claimed in claim 1, wherein the guideway has a portion extending into the furnace.

7. A furnace loading mechanism as claimed in claim 1, wherein said moving means includes articulated link members, a plurality of said link members having means interengaging with means on said boat member.

8. A furnace-loading mechanism comprising a conveyor adapted to move a wafer-bearing boat member for advancement into or retraction from the furnace and a conveyor support means including a driving means for the conveyor, said conveyor support means also including a horizontally positioned guideway for the conveyor having a reentrant bend for compact storage of the conveyor when retracted from the furnace, said conveyor including articulated link members, each link member further including a detent means which is complemental to means carried by an adjacent link member, said detent means arranged to cooperate with means on said boat member to advance the same into and retract it from the furnace.

9. A furnace-loading mechanism comprising a conveyor adapted to move a wafer-bearing boat member for advancement into or retraction from the furnace and a conveyor support means including a driving means for the conveyor, said conveyor support means also including a horizontally positioned guideway for the conveyor having a reentrant bend for compact storage of the conveyor when retracted from the furnace, said driving means including an electric motor drivingly connected to a sprocket means for driving said conveyor and a manually operated means also drivingly connected to said sprocket for driving the conveyor upon failure of the motor to operate.

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