April 7, 1964 K. J. HINTENBERGER 3,128,326

ELECTRICALLY HEATED VACUUM FURNACE

Filed Feb. 28, 1961 3 Sheets-Sheet 1

Fig. 1

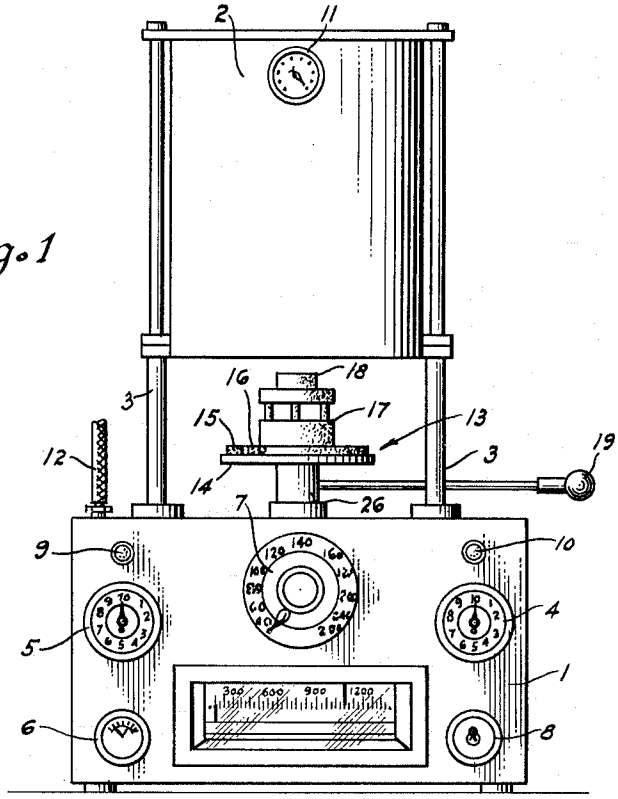
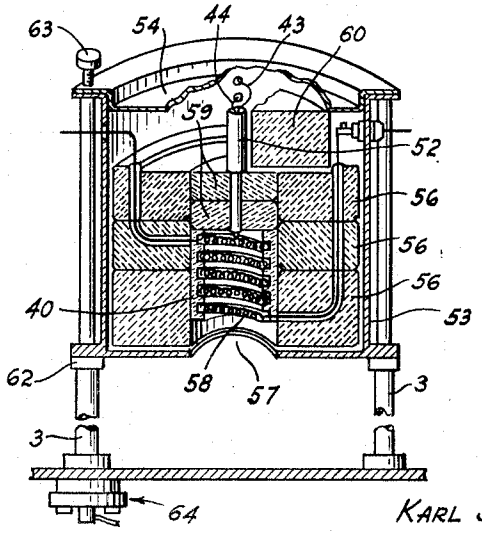


Fig. 4



INVENTOR
KARL JOSEF HINTENBERGER

BY

ATTORNEY

April 7, 1964 K. J. HINTENBERGER 3,128,326

ELECTRICALLY HEATED VACUUM FURNACE

Filed Feb. 28, 1961 3 Sheets-Sheet 2

Fig. 3

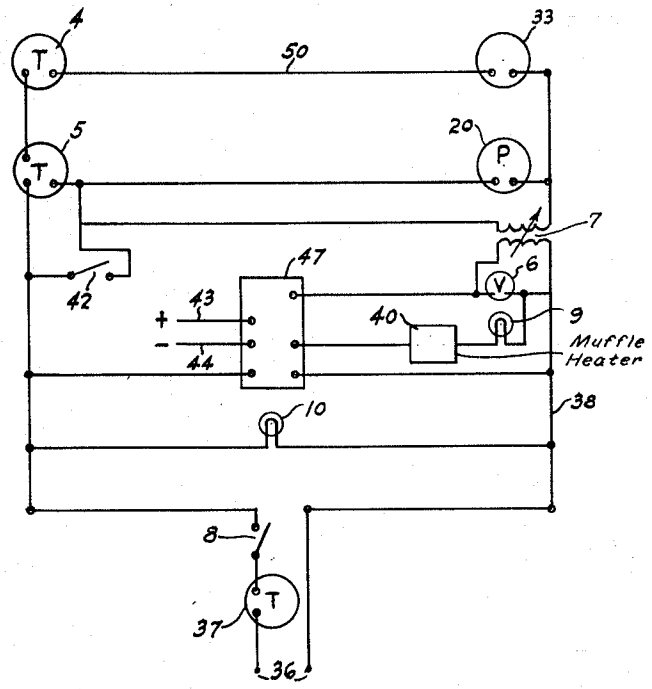
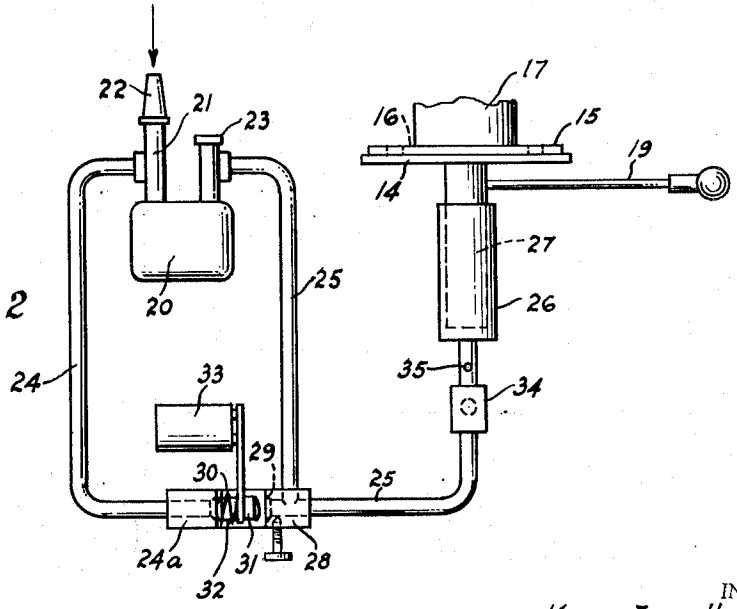


Fig. 2



INVENTOR
KARL JOSEF HINTENBERGER

BY

ATTORNEY

April 7, 1964 K. J. HINTENBERGER 3,128,326

ELECTRICALLY HEATED VACUUM FURNACE

Filed Feb. 28, 1961 3 Sheets-Sheet 3

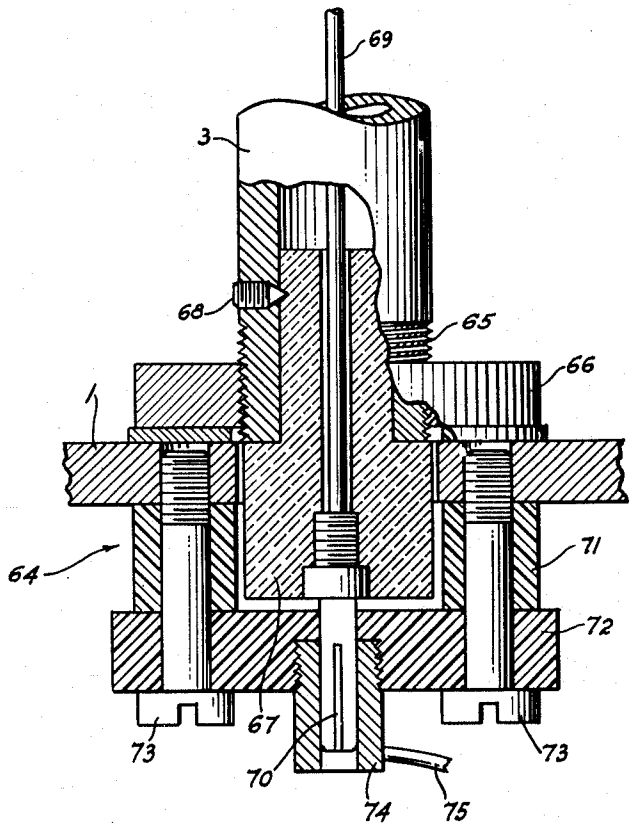


Fig. 5

INVENTOR
KARL JOSEF HINTENBERGER

BY

ATTORNEY

United States Patent Office 3,128,326 Patented Apr. 7, 1964

3,128,326

ELECTRICALLY HEATED VACUUM FURNACE

Karl Josef Hintenberger, Hochstrasse 39, Frankfurt am Main, Germany

Filed Feb. 28, 1961, Ser. No. 92,370
5 Claims. (Cl. 13—31)

This invention relates to an improved electrically heated vacuum furnace used particularly in denture ceramics, for instance, to bake, fire and glaze artificial teeth, crowns, and the like, and generally, where the items to be processed in the furnace are made of ceramics and are fused, or dried, at reduced atmospheric pressure in a chamber accommodating the heater muffle.

More specifically, the invention relates to assemblies comprising an instrument case and a furnace mounted thereon, where the instrument case contains a vacuum pump and driving means for the same as well as switching and control devices for all power-consuming units while the furnace comprises a vacuum chamber mounted in spaced relationship to and above the chest-like instrument case, the furnace chamber being connected by a conduit or pipe to a vacuum pump. The furnace comprises a vertically extending inverted cup-shaped chamber heat-insulated or shielded at the sides and the top, but open in the lower face which is nearest the instrument case. A charge elevator also is supported by the instrument case for vertical movement toward and from the top so that the furnace charge placed on a horizontal table of the elevator is moved from a loading position into the furnace, the table also having means to seal the furnace aperture.

Vacuum furnaces of the type above described have several advantages over those where the charge is inserted into the furnace from the top or from one side, these being, (1) the loss caused by heat radiation is reduced due to the fact that the furnace top has no aperture at its top side, and (2) the operator is not discomforted by the heat radiated from the furnace charging opening.

Another advantage of the type of vacuum furnace comprising the invention is that the charges placed within the furnace chamber always move identical short distances and in a uniform, smooth manner, resulting in uniform products, the homogeneity being enhanced as a result of the elimination of the conventional necessity of removing and inserting, by tweezers, shielding bricks and heat insulators into and from the furnace, respectively.

It is an object of this invention to provide an improved vacuum furnace in which the operations are automatically controlled and especially the manual work is simplified over that required in conventional porcelain firing furnaces so as to eliminate human errors and irregularities resulting from manual handling, as well as faulty operation particularly under conditions where a substantial series of successive firings are required.

Another object of this invention is to eliminate some of the control functions previously required to be performed by human operators, thus simplifying the mode of operation, reducing manual work to a minimum and providing greater convenience and reliability.

Still another object of this invention is to provide electrical circuits and electrical devices adapted to provide proper timing and control of individual operations.

A further object of this invention is to provide cooperative functioning of the vacuum and pressure ends of the vacuum pump by means of electrical and pneumatic mechanism so as to conveniently and automatically control and perform mechanical operations.

Another object of this invention is to provide a vacuum furnace with adjustable means to control the various mechanical, electrical and pneumatic means which may

be regulated and interrelated without interference or impedance.

Details of the foregoing objects, and others, are set forth in the following specification and are illustrated in the accompanying drawings forming a part thereof.

In the drawings:

FIG. 1 is a front elevation of a vacuum furnace according to the present invention and showing the elevating apparatus in its lowered position, prior to being elevated.

FIG. 2 is a schematic side elevation of a control system according to the invention for moving the elevating apparatus up and down by means of the vacuum and pressure produced by the vacuum pump of the device.

FIG. 3 is a circuit diagram of the instruments and controls of the preferred embodiment of the invention.

FIG. 4 is a vertical sectional view, partially in perspective, of the furnace and especially showing details of the insulated firing chamber, including the columns upon which the furnace is supported and details of the connection between the furnace and the instrument casing, and

FIG. 5 is a fragmentary vertical elevation, partially sectioned, showing details of the detachable connection between the columns carrying the furnace and the instrument casing, on a larger scale than in FIG. 4.

Referring to FIG. 1, there is shown a supporting base comprising a housing or case **1** containing the instruments, and a furnace **2**. The furnace **2** has an internal firing or baking chamber, which is an inverted cup, supported on columns **3** a predetermined distance above case **1**. The front side of case **1** contains the dials of the various switching and control units, such as the operating handles and dials of two timing switches **4** and **5**, a voltmeter **6**, a transformer **7**, a toggle type main switch **8**, which is manually operated, by which the entire circuit is controlled, and two pilot lamps **9** and **10**. The furnace is provided with a vacuum gage **11**. Hose **12** is connected, at one end, to a vacuum pump **20**, see FIG. 2, arranged inside of the instrument casing, and, at its other end, to a control valve, not shown, mounted at the rear of the furnace **2**.

The elevating apparatus **13** is supported by casing **1** and consists of a pneumatic cylinder **26** and piston **27**, and table **14** connected to the upper end of piston **27**, said table also serving to hermetically close the opening in the bottom of the furnace chamber. For this purpose, a seal **15** of silicone rubber is arranged on the perimeter of table **14**. Concentrically arranged on the table **14** within seal **15** is an asbestos washer **16** which abuts against the rim of the opening in the furnace. A cylindrical charge carrier base **17**, which carries three columns supporting an upper disc portion, is mounted coaxially on the table **14**. This charge carrier base **17** is formed of ceramic material such as fire clay. A charge carrier **18** is provided which may consist of a bowl and supporting members, if desired. A charge to be fired is placed within the carrier **18** and may, for example, consist of a ceramic artificial tooth or crown.

To perform the firing process according to the present invention, the elevating apparatus **13** is operated to elevate table **14** by means of pneumatic piston **27**, after the charge has been inserted into the carrier **18**. Although this movement may be manually performed by a suitable handle rod **19**, the invention contemplates preferably that the piston **27** be moved automatically by means of air pressure from the pressure side of the vacuum pump **20**. Cylinder **26**, as shown in FIG. 2, communicates at its bottom with a pipe in which a ball check valve **34** is mounted below the bottom of the cylinder, and a vent hole **35** is formed in said pipe between the cylinder and the ball check valve, said vent hole having a diameter substantially smaller than that of the pipe. Said pipe is connected by means of another pipe **25** to the pressure

side of the vacuum pump 20 and has a valve block 28 connected therein which is provided with an opening having a valve seat 29. Similarly, the suction pipe 24 connected to the suction side of the vacuum pump 20 leading to the furnace has a valve block 24*a* having an opening also provided with a valve seat. Both valve blocks 24*a* and 29 are closed or opened by electrical means provided for that purpose, to be described.

Referring now to FIG. 2, the vacuum pump 20 is shown having a suction pipe 21 provided with a hose, connector 22 to which the hose 12 shown in FIG. 1 is connected. Furthermore, a connecting nipple 23 is provided at the pressure side of the pump. Air pressure line 25 is connected to the connector 23 at the pressure side of the pump 20 and leads to the hollow cylinder 26 in which piston 27 is closely slidable for moving the lifting apparatus. A double headed valve member 31 is movable reciprocably in a guide member 30 between valve seat 24*a* which controls flow to suction line 24 and valve seat 29 which controls flow to pressure line 25. Movement of valve member 31 into seat 24*a* is caused by means of a retracting spring 32. Upon energization of an electrical relay 33, described hereinbelow, the double-seat valve member 31 is moved away from valve seat 24*a*, against the action of the retracting spring 32, and is pressed against the valve seat 29 of the valve block 28.

The arrangement which has been described above is used to produce the following results relative to the firing furnace comprising the invention. When the vacuum pump of the system is started, preferably after the furnace 2 has been heated to firing temperature, the double head valve 31 is moved against the valve seat 29 of the valve block 28 through energization of relay 33, whereby the vacuum pipe 24 is opened to atmosphere, and air under pressure from nipple 23 is transmitted through line 25, through ball check valve 34, thereby elevating the ball of said valve and acting on the piston 27 to elevate it and the table 14 toward the entrance opening in the lower end of the furnace 2. In this manner it is possible, smoothly, and without jamming, to move the charge carrier together with the charge into the baking chamber, in a highly improved manner over previously used manual insertion.

Upon de-energization of the relay 33, spring 32 retracts the double seat valve to its normal seat position against seat 24*a*, whereby the vent line of the vacuum pipe is closed and vacuum is produced in the interior of the furnace 2 to draw table 14 tightly against the furnace opening, since the vacuum rapidly increases to accomplish this. Although pressure line 25 is opened by the aforementioned shifting of valve member 32, table 14 will not drop quickly in any event, prior to the action of the vacuum, because of the limited air discharge through small vent hole 35 and the action of ball check valve 34 which is in its seat under such conditions. Relay 33 which can for example be of the electromagnet type, may be replaced by any other suitable mechanism to reverse the double headed valve member 31. It is also possible to use other types of electrically controlled devices, such as slide valves, to alternately close and open the valves in the valve blocks 24*a* and 29.

Reversal of the double headed valve member 31 can be further improved by a time switch, such as a timing apparatus connected in conventional manner to a suitable electric switch, the time switch being connected in series with the circuit which supplies current to the motor of the vacuum pump and to other components, if necessary, and being adapted to reverse the movement of the double headed valve member rather than by using the above mentioned relay or other electric switch. As the circuit of the motor for the vacuum pump, to which other devices such as the furnace heating elements and its controls are connected, is closed by actuating a main switch 8 which is provided on the instrument casing and is connected to a suitable circuit of a source of electrical energy, through the means of an electric plug 36 as shown in FIG. 3, for example, and the timing switch 4 has been set for a desired period of vacuum firing time, produces a desired degree of vacuum in the furnace, the relay 33 will be energized by timing switch 4 to connect pressure pipe 25 to cylinder 26 and thereby cause the elevating apparatus to move table 14 upwards. Such vacuum atmosphere in furnace 2 is maintained until the expiration of the time as set by the timing switch 4, whereupon the circuit to the vacuum pump motor is interrupted, so that the vacuum pump is stopped, and the elevating apparatus gradually will be lowered as the air from cylinder bleeds through hole 35, as described.

The foregoing description refers to the time switch 4 in the circuit of the vacuum pump and the other aforementioned units by which the circuit thereto is closed at the instant the time switch is closed and interrupted after a predetermined period of time. Further advantages result from the inclusion of a second timing switch 5 which is connected in series with this first timing switch, the contacts of the second timing switch being arranged so that a circuit leading from said second timing switch and through the control relay 33 is opened at the instant when the switch starts to run, and is closed upon termination of the running time of the switch. Relay 41 is arranged to reverse the double headed valve member 31 in the manner described above, as will be seen from FIG. 3 of the drawings.

In FIG. 3, there is also illustrated an electric plug 36 which is on a flexible electric cord extending from the instrument casing 1 and is connected in the circuit with main switch 8 mounted on the instrument casing and also with a time delay timer switch 37 conveniently mounted on case 1. The main switch 8 serves to close the main circuit 38 which controls the operation of the motor of the vacuum pump 20, and the muffle heater 40 within the furnace 2 for heating the chamber thereof, and another relay 41 which functions as a temperature-sensitive switch of conventional type and is adapted to interrupt the current supply to the furnace heater 40 automatically upon the chamber reaching a pre-selected maximum temperature. To achieve such interruption of the current, a pyrometer 52 is mounted in the furnace chamber and is connected in the heater circuit. The pyrometer is connected to the relay 41 by leads 43 and 44 shown in FIG. 3.

The variable transformer 7 serves to infinitely vary the heater voltage and is provided with scale divisions which are identical with those on voltmeter 6. Excessive or under voltages are compensated for by transformer 7. Pilot lamp 9 of a certain color serves to indicate that the circuit to the furnace heater 40 is ON, as controlled by the action of the relay 41. Another pilot lamp 10 of a different color indicates that the circuit of the entire system is energized.

The contacts of timing switch 5 are arranged so that circuit 38 as well as conduit 50, which is connected within said circuit between timing switch 4 and relay 33 (see FIG. 2), will be closed when timing switch 5 starts to run. After expiration of a predetermined running time, time switch 5 interrupts the entire circuit 38. The contacts of the second time switch 4 are so arranged that conduit 50, which is connected with relay 33, will be interrupted when the switch 4 starts to run, and will be closed again after expiration of a predetermined running time for which time switch 4 is set.

This circuit arrangement permits the device to operate as follows: When the furnace has been put into operation by closing switch 8 and has been suitably heated by the heater 40, and the charge has been placed on the charge carrier table 14 of the lifting apparatus, time switch 5 is set for the total desired heating time for furnace 2. Since the device, as described above, provides for automatic control of the entire process commencing from the insertion of the charge until the re-

moval of the finished material, and also including in the time cycle control of the operation time and duration of the vacuum atmosphere within the furnace, followed by restoration of atmospheric pressure during the remaining firing period, the second time switch **4** is preset for a given time interval to control the vacuum firing period duration.

Under the foregoing circumstances, the circuit for heating the furnace chamber **2** includes the variable transformer **7** and the motor for the vacuum pump **20** is started directly upon closing timer switch **5**. Relay **41** has a rocking mercury switch which is ready to operate. By starting pump **20**, the valve seat **29** of valve block **28** of the pressure line **25** is maintained closed by the double headed valve member **31** as long as time switch **4** is not actuated. Piston **27** now moves upward to elevate the charge into the furnace. Upon time switch **4** closing, pressure line **25** is opened by movement of valve member **31** away from seat **29**. However, the elevating apparatus remains in its upper position, since it is held in place by the suction action of the vacuum within the furnace chamber. Upon expiration of the predetermined running time of switch **4**, the circuit leading from this timing switch to relay **33** is again closed so that the lifting apparatus will remain in its upper position because of the application of pressure to piston **27**. By reversing the double headed valve member **31**, the furnace is opened to atmospheric air, whereby the further firing is accomplished under atmospheric pressure until expiration of the running time of timing switch **5**, whereupon the current supply to the vacuum pump is interrupted. The lifting apparatus then slowly lowers and permits the removal of the baked charge.

A bypassing switch **42** serves to bridge the timing switch **5** past one of its poles when the furnace is to be heated up to a predetermined temperature. By this bridging arrangement, it also is possible to dispense with the automatic interruption of the heating circuit. In such case, which is of practical importance in performing several successive firings, the muffle remains constantly heated, it being controlled only by the relay **41**.

The invention also permits firing under atmospheric pressure alone, without including vacuum, by using only time switch **5**, whereby the pump **20** and the relay **33** are energized so that the elevating apparatus raises table **14**. Upon expiration of the running time of time switch **5**, both the pump and the relay are de-energized, thus causing the table **14** to move downward.

For accomplishing the entire baking process under vacuum it will be necessary first to activate timing switch **5** and shortly afterwards, switch **4**. Both switches must be set for the same period of elapsed time under such circumstances. However, provision should be made that time switch **4** is actuated a little earlier than switch **5** so that relay **33** will reverse when intended and, hence, insure elevation of the table **14**. This small time differential is necessary, since, if time switch **5** should open earlier, the valve controlled by relay **33** would remain closed against its seat.

FIG. 4 and the enlarged partial view of FIG. 5 illustrate how the space between the instrument case **1** and the furnace can be easily adjusted to set the proper stroke length for piston **27** which is very important relative to automatic control of the elevating apparatus to insure that the table **14** may positively engage the rim of the furnace opening. FIG. 4 also illustrates certain details of the design of the furnace **2**. The metal casing **53** of furnace **2** is open at its upper end and is closed by a cover which is partly broken away in the illustration. Heat-insulating bricks **56** are arranged in such manner that the heater **40** is held in place therein within helical grooves which are disposed at a certain distance from the bottom entrance opening of the firing chamber **57**.

A tube projecting from the pyrometer extends through an opening in the bricks **59** which line the firing chamber **57**. The circuit leads **43** and **44** of the pyrometer **52** are connected to the relay **41** (FIG. 3), as described hereinbefore. A cap brick **60**, which is shown partly broken away, is formed of ceramic insulating material and surrounds the bricks **59** through which the pyrometer extends. The casing **53** has a bottom flange which is secured to columns **3** upon which collars **62** are mounted. Cover **54** of the casing is securely connected to an upper flange of the casing by knurled cap nuts **63** which engage the upper threaded ends of upper extensions on the columns **3** which extend through openings in the flange and the cover **54**.

The lower ends of the columns **3** preferably are inserted into guide means **64** (FIG. 4) in the instrument case **1** and are provided with threaded end portions **65** (FIG. 5) having supporting nuts **66** thereon. By adjusting the nuts, columns **3** can be adjusted vertically relative to nuts **66** and the guide means **64** in general.

The columns **3**, or at least one of them, should preferably be hollow in order to receive electric leads **69** for connection of electrically energized items in the furnace **2** with the controls in the instrument case **1**. For this purpose, the columns **3** are preferably of the plug-type so that the entire furnace can be easily removed from the instrument casing. These plug-type columns have moreover the advantage that, when the furnace is placed upon the instrument case, the electrical connection is made automatically also. For this purpose, the lower open ends of the columns **3** are provided with insulators **67** which are locked in the columns by set screws **68**. Moreover, the leads **69** extending through the columns are provided with split, elastic metallic plugs **70**. The cover of the instrument case also contains guide members for the insulators, each guide member consisting of an insulating ring **71** secured to the cover from below, and a bottom portion **72** of the same insulating material, both parts of which are secured to the cover by screws **73**. A metal bushing **74** in the bottom plate **72** serves to connect conduit **75**, comprising part of circuit **38**, with conduit **69** within the column.

I claim:

1. An electrically heated vacuum furnace particularly for fusing dental ceramics and comprising in combination, a base housing, an inverted cup-shaped furnace chamber supported above said base with the entrance facing said base, a vacuum pump connected by conduit means to the interior of said furnace chamber, the sides and the top of the furnace chamber being insulated for heat retention, a charge elevator movable in opposite vertical directions above said base housing toward and from the entrance in the bottom of the furnace chamber and provided at its upper end with a charge carrying horizontal table adapted to fit against the entrance of the furnace vessel to seal the entrance opening tightly when the table is lifted into engagement with the said aperture, the lower end of said charge elevator having a piston slidably movable within a vertical cylinder for movement in opposite directions, an air conduit connected to the lower end of the said cylinder, a ball check valve mounted on said conduit, said conduit having between this valve and the said cylinder a bleeder hole of a diameter substantially less than that of said conduit, the other end of said air conduit being connected to the pressure side of the said vacuum pump, a conduit extending from said air conduit to receive air under pressure therefrom and having a valve seat at the outer end thereof, another branch conduit extending from said vacuum conduit interconnecting the vacuum pump and the said furnace vessel and having a valve seat at the free end thereof, and valve means operable relative to said valve seats successively first to close said valve seat in said first-mentioned branch conduit to cause air pressure to raise said piston and charge-carrying table against said entrance of said furnace to close it and said valve means then being movable to close said valve seat in said second mentioned branch

conduit to close said vacuum conduit to said furnace chamber to maintain said table against said furnace entrance while said air pressure is released from said piston.

2. The furnace according to claim 1 further including a solenoid connected to said valve means and operable to actuate the same to close said air pressure conduit, and spring means connected to said valve means to move it to close said vacuum conduit.

3. The furnace according to claim 1 further characterized by said valve means comprising a valve member reciprocable in opposite directions between said valve seats, means to reciprocate said valve member in the sequence aforesaid, and timer means operable automatically to control the interval between such reciprocating movements of said valve member first to close the furnace and next to apply vacuum to the furnace.

4. The furnace according to claim 3 further including electric heating means for said furnace, circuit means to connect the same to a source of current, and a second timer switch connected in said circuit in series with said

timer switch for said valve member, said second timer switch being operable to control the period of time the furnace is heated.

5. The furnace according to claim 4 further including an electric motor to drive said pump and said motor being connected in the circuit of said electric heating means for said furnace and controlled by the timer thereof, whereby when said heating means is shut off by said timer therefor said pump will stop and permit said charge-carrying table to descend by the dispelling of air from said cylinder thereof through said bleeder hole in said air pressure conduit.

References Cited in the file of this patent

UNITED STATES PATENTS

1,617,359	Westberg	Feb. 15, 1927
1,678,875	Rohn	July 31, 1928
1,994,917	McGregor	Mar. 19, 1935
2,966,537	Witucki et al.	Dec. 27, 1960
3,075,263	Juckniess et al.	Jan. 29, 1963