PATENT SPECIFICATION (11) 1 585 458

(21) Application No 17893/76 (22) Filed 1 May 1976 (19)

(23) Complete Specification filed 18 April 1977

(44) Complete Specification published 4 March 1981

(51) INT. CL.³ F27D 11/02 H05B 3/66

(52) Index at acceptance

F4B 104 35F6 35G FX

H5H 111 112 130 151 179 199 200 231 232 254 BF1

1 585 458

(54) IMPROVEMENTS IN OR RELATING TO FURNACE MUFFLES AND FURNACES COMPRISING SUCH MUFFLES

(71) I, ALBERT GEORGE DOCX, a British Subject of 70 Ellesmere Road, Altrincham, Cheshire, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to furnace muffles and furnaces comprising such muffles.

A variety of muffle furnaces are available which are designed for the firing of ceramic work pieces such as are required for example for dental applications. Ceramic work pieces must be heated gradually in accordance with a predetermined heating programme from a relatively low temperature to a relatively high baking temperature if satisfactory results are to be obtained. The known furnaces generally comprise a muffle adapted to be maintained at a high temperature and a transport mechanism for transporting work pieces into the muffle at a controlled slow speed. The speed at which the transport mechanism moves relative to the muffle controls the pre-heating programme.

The transport mechanisms employed, which have to achieve slow speed substantially vibration free movement are costly both in terms of production and maintenance, and in addition the transport mechanisms increase the size of the furnace to an undesirable extent. Furthermore, as work pieces are advanced by the transport mechanism towards the muffle they initially receive radiant heat from the muffle on only one side. The resulting non-uniform heating is not desirable.

Furnaces incorporating transport mechanisms have been used as it has not been though possible to achieve the desired heating programme satisfactorily simply by placing a work piece in a muffle and controlling the temperature within the muffle by controlling the energy supplied. The primary reason for this is that it has been conventional practice to manufacture muffles with a solid refractory support base possessing a high heat storage capacity and a general structure which is designed to maintain the muffle at a substantially constant high temperature. As a result, once a furnace has been heated, it takes a considerable time for it to cool down to a sufficiently low temperature as to enable a ceramic work piece firing sequence to be initiated. The furnace is of course inoperative during the cooling period which greatly reduces its productive capacity.

Furthermore, the rapid cyclical heating and cooling of muffle furnaces over a temperature range of in excess of 1000°C as required in dental furnaces has been found in the past to result in the rapid destruction of the muffles. It is for this reason that commercially available muffle furnaces have incorporated complex transport mechanisms.

It is an object of the present invention to obviate or mitigate the above problems by providing a furnace muffle which can withstand rapid heating and cooling.

According to the present invention, there is provided a furnace muffle comprising a hollow cylindrical ceramic fibrous support member, an open helical channel defined on the inside of said support member, a helical coiled heating element loosley disposed in said channel, and a plurality of strips of ceramic fibrous material cemented across the openings of said channel for retaining said heating element therein.

Preferably the open channel in which the heating element is disposed is defined by adjacent turns of a coil of ceramic fibrous material secured inside a tubular body of ceramic fibrous material. Alternatively, the open channel may be cut in the inner face of a tubular body of ceramic fibrous material.

The strips of ceramic fibrous material are preferably arranged diagonally to the open channel.

The invention also provides a furnace comprising a muffle of the above type, the furnace further comprising a closure member adapted to close an opening in the furnace through which opening workpiece may be directly introduced into the muffle, means for energising the heating element, to heat the muffle, and means for controlling the rate at which the muffle is heated, the closure member and opening being arranged at the top of the muffle so as to ensure the rapid cooling of the muffle subsequent to removal of the closure member from the opening.

Preferably the muffle is located so as to define an open topped cup into which workpices may be lowered through the opening.

The closure member may comprise a thermally insulating disc pivotally mounted and movable so as to close the open top of the muffle.

Means are advantageously provided to prevent energisation of the element when the furnace is opened by removal of the closure member from the opening.

Preferably the closure member is adapted to seal the muffle so as to enable evacuation of the muffle for example by a vacuum pump.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a part sectional front view of an embodiment of the present invention;

Fig. 2 is a perspective cut-away view of a muffle incorporated in the embodiment of Fig. 1;

Fig. 3 is a side view of the embodiment of Fig. 1;

Fig. 4 is a graph illustrating the variations of the temperature in the muffle during the operation of the illustrated embodiment; and

Fig. 5 is a block diagram illustrating a heating programme controller suitable for controlling the embodiment of Fig. 1.

Referring to Fig. 1, the illustrated furnace comprises a casing 1 of sheet steel defining a circular aperture in which a spun aluminium container 2 is located. The container 2 has a lip 3 which overlaps the edge of the aperture in the casing 1 and a resilient ring 4 resting on the casing. The lip 3 is pressed against the ring 4 by the action of a nut and bolt assembly 5 secured to the container 2 and to the bottom of the casing 1. A series of apertures 6 are provided in the casing around the container 2 and in the bottom of the casing around the nut and bolt assembly 5. A connector 7 enables a vacuum pump (not shown to be used to evacuate the container 2. The casing 1 is supported on legs 8 to enable air to circulate beneath the casing 1 to the lower apertures 6.

A pad 9 of a ceramic fibrous material is supported within the container 2 on legs 10 so as to define an air-space 11. A cylinder 12 of ceramic fibrous material rests on the pad 9 and a muffle 13 is located on the pad 9 inside the cylinder 12. As may be more clearly seen from Fig. 2, the muffle 13 comprises a tubular body 14 of ceramic fibrous material within which a strip 15 of generally rectangular section is wound in a helical path. A channel 16 is defined between adjacent turns of the strip 15 and a coiled heating element 17 is located within this channel. The ends of the element 17 are connected to conductors which extend through the muffle wall and project from its outer cylindrical surface, as shown in Fig. 2. Further strips 18 of ceramic fibrous material are secured by cement across the top of the channel 16 so as to retain the heating element 17 in position. The strips 18 are arranged to cross the channel 16 at an angle such that adjacent windings of the coiled heating element are inclined thereto. This prevents the strips 18 sliding between adjacent windings of the heating element. The strips 18 are secured in position by a cement formed of chopped ceramic fibres and a liquid rigidiser. The liquid rigidiser is a liquid binder such as TRITON HARDNER (Registerd Trade Mark), a high purity water based colloidal silical solution containing traces of sodium silicate and chloride ions. TRITON HARDNER is marketed by Morganite Ceramic Fibres Limited.

As an alternative to defining the channel 16 between adjacent turns of the strips 15, the channel can be cut from a tubular body having a small thickness equal to the sum of the thicknesses of the body 14 and strip 15 of Fig. 1.

A closure member in the form of a lid 19 is supported by a pivot 20 on the casing 1. The lid 19 comprises a stainless steel cap 21 supporting a thermally insulating body 22 of ceramic fibrous material. An O-ring 23 is arranged around the edge of the lid 19 so that when the lid is closed an air-tight seal is formed between the O-ring and the lid 19 and the O-ring and the lip 3 of the container 2.

The lid 19 is counter-balanced by a spring 24, and may be held in a closed position against the action of the spring 24 by a latch 25 supported by a pivot mounted on the casing 1. The latch 25 may be moved manually or by a solenoid 26. When the lid 19 is closed, the latch 25 automatically engages. When the latch 25 is released either manually or by the solenoid 26 the spring 24 raises the lid 19 to the position shown in Fig. 3 in which the spring 24 is in an "over-centre" position relative to the pivot 20.

In use, workpieces that are to be fired are placed on a support (not shown) and the support is placed in the muffle. The pad 9 (Fig. 1) at the bottom of the muffle supports a pin 27. The pin 27 is adapted to engage in a bore in the workpiece support to ensure that the support is correctly oriented with respect to the muffle. After the support has been positioned in the muffle, the lid 19 is closed and a heating sequence may be initiated. The body 22 of the lid 19 supports a convex dome 28, and the pad 9 supports a convex dome 29. The domes 28, 29 ensure that the workpiece support is located centrally within the muffle and receives reflected energy from the heating element substantially uniformly.

When a heating sequence has been completed, the lid 19 is raised. As the muffle is now fully open to the atmosphere it cools rapidly, the cooling being enhanced by air flow in the direction of the arrows in Fig. 1 from the lower to the upper apertures 6 in the casing 1. Although the heating element 17 is only resting in the muffle wall, it is adequately restrained from drift with a minimum amount of physical contact by the ceramic fibre strips. This allows free radiation of heat without "hot spots" developing and thus enhances rapid cooling. The structure of the muffle and its surrounding insulation is such that the heat capacity of the furnace is relatively low and therefore the energy which has to be dissipated to cool the muffle is also relatively low.

Referring now to Fig. 4, a graph (not to scale) is shown which illustrates a particular heating sequence which may be obtained with the illustrated furnace when controlled by electronic apparatus such as will be generally described hereinafter with reference to Fig. 5.

Starting from ambient temperature T_1 the furnace is heated to a ttmperature T_2 at time t_1. Workpieces are then located within the muffle and the lid 19 is closed. No further heating occurs until time t_2. This enables the workpieces and support to come to equilibrium with the furnace. The furnace is then steadily heated to temperature T_3 at time t_3 to dry and pre-heat the workpieces. The air in the space 11 ensures that any dyes or starches gassed off from the workpieces can be absorbed despite the fact that the furnace is sealed. At time t_3, the pump (not shown) is started, evacuating the container 2, and the heating is continued at a different steady rate until temperature T_4 is recahed at time t_4. At time t_4 a solenoid valve (not shown) connected in the line from the connector 7 breaks the vaccum. The temperature T_4 is then maintained until time t_5 when the solenoid 26 is energised to release the lid 19 which swings open automatically. Opening of the lid 19 automatically de-energises the heating element and rapid cooling takes place. When the temperature T_2 is reached at time t_6, fresh workpieces can be located in the furnace and a fresh sequence started.

Referring now to Fig. 5, the control of the sequence will now be described starting from time t_1 as indicated in Fig. 4.

A heating sequence is manually programmed by adjusting time selectors 30, 31 and 32 to set periods (t_3-t_2), (t_4-t_3) and (t_5-t_4) respectively and adjusting temperature selectors 33 and 34 to set temperatures T_3 and T_4 respectively. Workpieces are then placed in the furnace, and the lide is closed.

Closure of the lid sends a signal from a lid switch 35 to a delay unit 36 and a muffle heater inhibitor 37, the latter subsequently enabling energisation of the heating coil by a muffle heater 38. After a predetermined period such as one minute determined by the delay unit 36, a signal is applied to a sequence controller and programme temperature calculator 39 which receives inputs from selectors 30 to 34 and from a clock 40.

The controller and calculator 39 provides a signal indicative of the desired programme temperature as determined by selectors 30 to 34, the signal varying with time in a manner apparent from Fig. 4. The desired programme temperature signal is applied to a temperature controller 41 which also receives a signal indicative of actual muffle temperature from a muffle temperature sensor 42. The unit 41 controls the muffle heater 38 so as to cause the actual muffle temperature to follow the programmed temperature. A temperature difference indicator 43 also receives the two signals applied to the controller 41 so that any differences between the actual and programmed temperatures can be monitored.

The controller 39 provides outputs to a vacuum pump 44, and to latch release and vacuum release circuits 45, 46. The pump is turned on and off at times t_3 and t_4 respectively, and the latch and vacuum release circuits are operated at times t_5 and t_4 respectively. Release of the latch opens the furnace lid causing the inhibitor 37 to prevent further energisation of the muffle heater. A further cycle may be commenced after the furnace has cooled to temperature T_2 at time t_6.

It will be appreciated that the ability to adjust temperatures T_3 and T_4 and intervals (t_3-t_2), (t_4-t_3) and (t_5-t_4) electronically gives a wide range of possible firing programmes.

The above described control arrangement is advantageously mounted within the casing 1.

It will be appreciated that alternative control arrangements to that described with reference to Fig. 5 could be provided.

A ceramic fibrous material suitable for the manufacture of the described muffle is marketed by Morganite Ceramic Fibres Limited under the trade name TRITON KAOWOOL (Registered Trade Mark).

WHAT I CLAIM IS:—

1. A furnace muffle comprising a hollow cylindrical ceramic fibrous support mem-

ber, an open helical channel defined on the inside of said support member, a helical coiled heating element loosely disposed in said channel, and a plurality of strips of ceramic fibrous material cemented across the openings of said channel for retaining said heating element therein.

2. A furnace muffle according to claim 1, wherein the open channel in which the heating element is disposed is defined by adjacent turns of a coil of ceramic fibrous material secured inside a tubular body of ceramic fibrous material.

3. A furnace muffle according to claim 1, wherein the open channel in which the heating element is disposed is cut in the inner face of a tubular body of ceramic fibrous material.

4. A furnace muffle according to claim 1, 2 or 3, wherein the strips of ceramic fibrous material are arranged diagonally with respect to the open channel.

5. A furnace comprising a furnace muffle according to any preceding claim, a closure member adapted to close an opening in the furnace through which opening workpieces may be directly introduced into the muffle, means for energising the heating element, to heat the muffle, and means for controlling the rate at which the muffle is heated, the closure member and opening being arranged at the top of the muffle so as to ensure the rapid cooling of the muffle subsequent to removal of the closure member from the opening.

6. A furnace according to claim 5, wherein the muffle is located so as to define an open topped cup into which workpieces may be lowered through the opening.

7. A furnace according to claim 6, wherein the closure member comprises a thermally insulating disc pivotally mounted and movable so as to close the open top of the muffle.

8. A furnace according to claim 5, 6 or 7, comprising means for preventing the energisation of the heating element when the furnace is opened by removal of the closure member from the opening.

9. A furnace according to claim 5, 6, 7 or 8, wherein the closure member is adapted to seal the muffle so as to enable its evacuation.

10. A furnace muffle substantially as hereinbefore described with reference to the accompanying drawings.

11. A furnace comprising a furnace muffle according to any one of claims 1 to 4 and substantially as hereinbefore described with reference to the accompanying drawings.

MARKS & CLERK,
7th Floor,
Scottish Life House,
Bridge Street,
Manchester M3 3DP.
Agents for the Applicant.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1981
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY.
from which copies may be obtained.

1585458 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

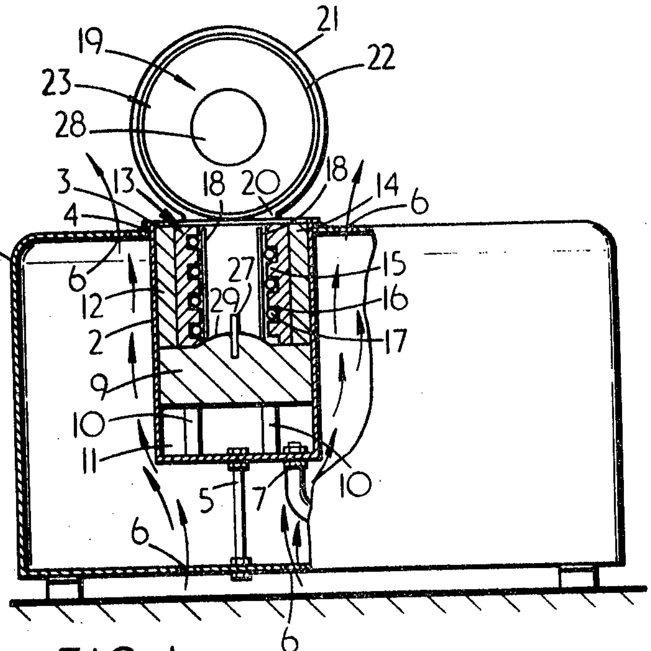

FIG. 1

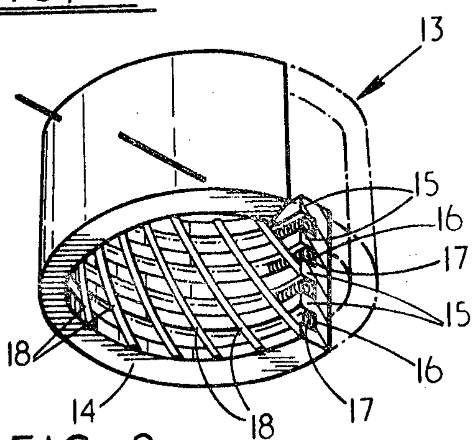

FIG. 2

1585458 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

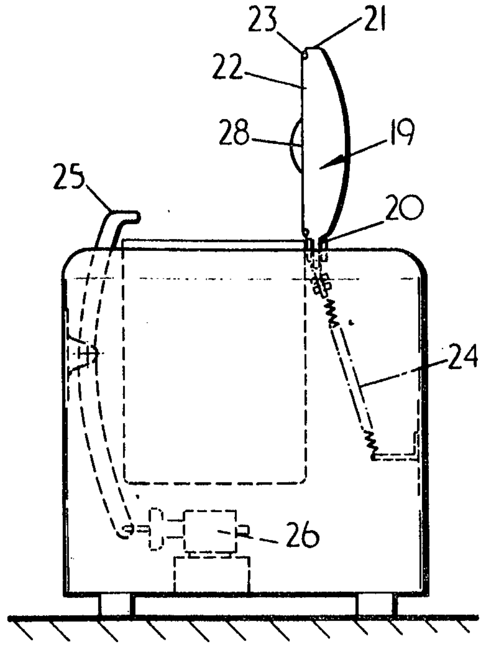

FIG. 3

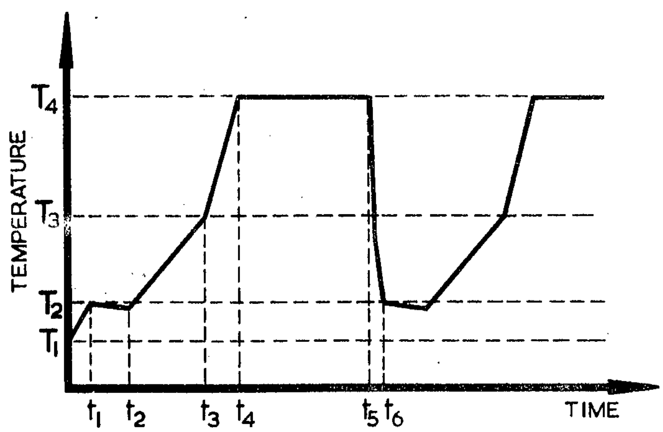

FIG. 4

1585458 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

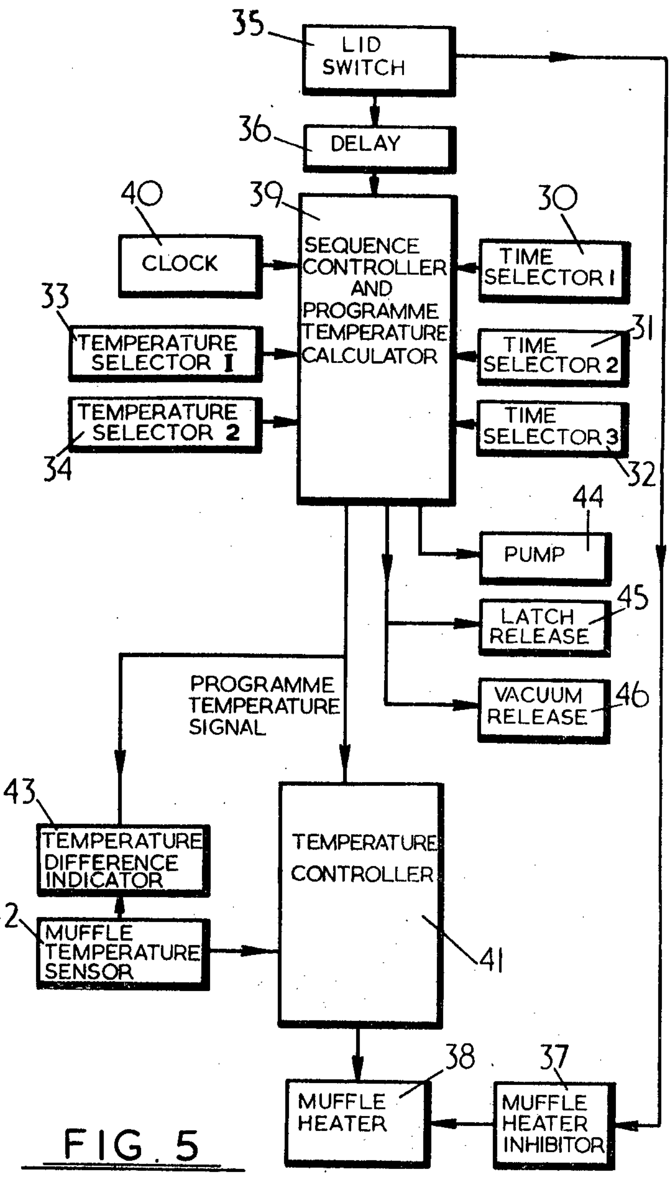

FIG. 5