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AUTOMATIC HOT PRESSING OF PLATES

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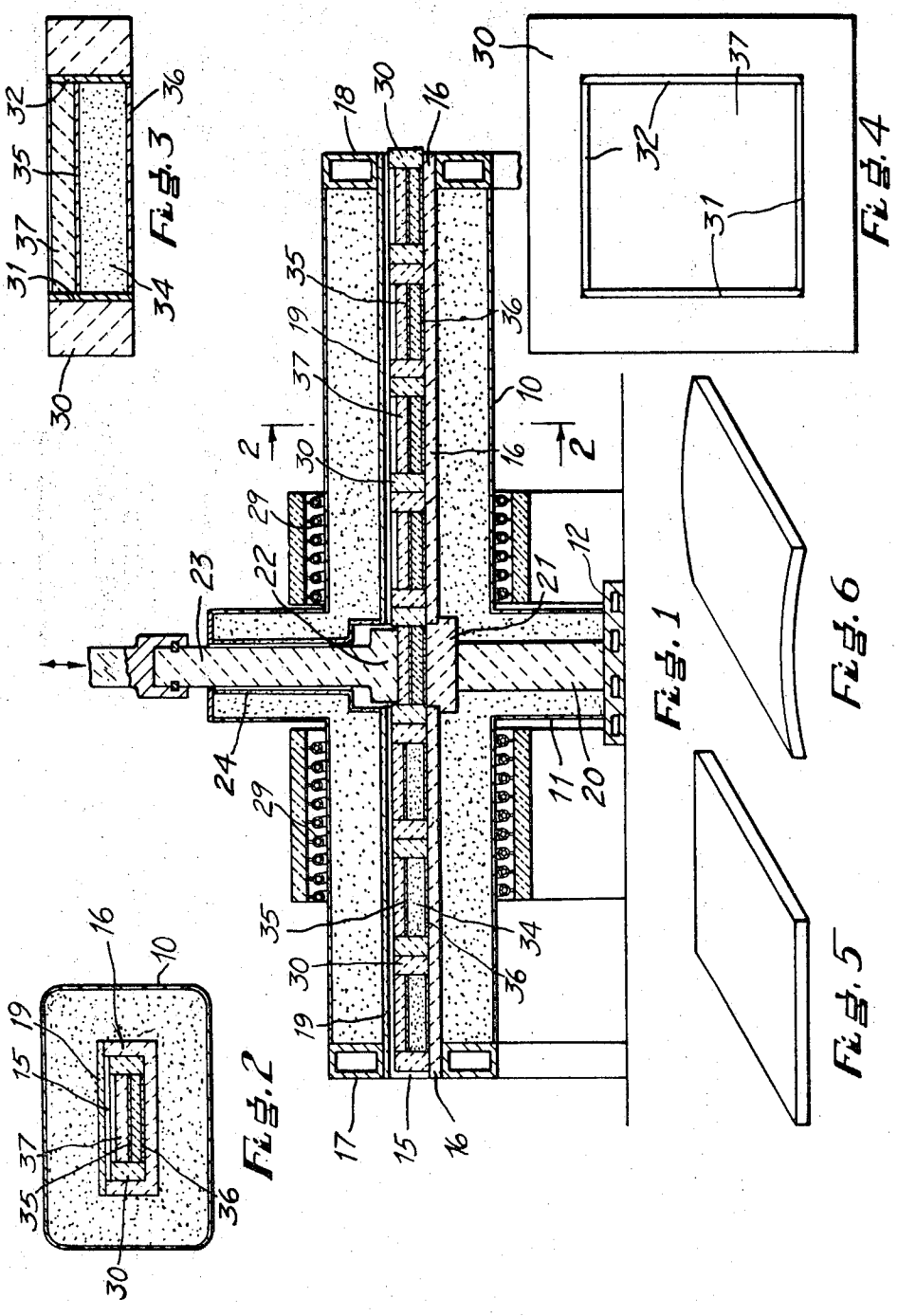


Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

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AUTOMATIC HOT PRESSING OF PLATES

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U.S. Cl. 25—142 2 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for hot pressing refractory powders in a mold to produce thin plates wherein the apparatus has a preheating zone in a furnace, a hot pressing zone and pressing means adapted to engage the mold across its wider dimension to simultaneously apply pressure and flow heat into the product being molded.

This is a division of application Ser. No. 475,940, filed July 30, 1965, which has matured into Pat. 3,440,312 issued on Apr. 22, 1969.

This invention relates to the molding of relatively thin refractory plates and more particularly to a hot pressing equipment for the manufacture of thin boron carbide and other plates.

It is an object of this invention to provide an improved apparatus for making thin refractory plates including the use of new mold equipment and pressing procedure.

Typical of the plates such as produced by the apparatus and process herein disclosed, are 4 x 4 inches, 6 x 6 inches, and 8 x 8 inches square plates varying in thickness from 0.25 to 0.6 inch in thickness. This invention has particular application to what is referred to as thin plates. By "thin" is meant plates having a maximum dimension to thickness ratio of from about 4 to 1 to about 60 to 1.

Whereas in the past it has been the practice to form a number of hot pressed units in a single pressing operation, each unit being disposed within a single chamber in a multiple mold structure, or in other instances molding elongated single objects confined within a chamber by applying end pressure to the object, I have conceived a procedure for hot pressing flat relatively thin masses having top and bottom faces and thin side faces, of refractory powder by confining the powder in a mold. The confined mass of powder is individually heated and pressed across the top and bottom faces while confining the thin side faces in the mold. In following this procedure it is possible to preheat the powder rapidly across a thin section of the mold and thereafter subject the powder to a relatively quick hot pressing action while continuing the heat and confining the powder in the mold. The main pressing forces are produced across the refractory body from the top and bottom faces, both faces being backed up by pressing means engaging evenly across the entire face. The pressing means disposed in contact with the faces produces pressure directly through the thin section and, since there is very little hydraulic flow in the body mass, very little sidewise pressure is produced against the relatively thin sides of the mold. Because of this pressing action produced across the top and bottom faces of the thin section, a rather thin mold device may be used to sustain the side faces of the plate as the pressing action proceeds. The performance of this pressing procedure within the thin wall or "picture frame" type mold makes it possible to complete the hot pressing of individual thin refractory plates in a much faster time than has heretofore been thought possible with much less apparent wear on the mold structure.

The invention will be understood more fully from the detailed description which follows wherein FIG. 1 is a sectional side elevation of a furnace structure in which my process may be performed. FIG. 2 is a sectional view taken on line 2—2 of FIG. 1. FIG. 3 is a detailed sectional side view of a mold for pressing refractory plates. FIG. 4 is a top plan view of a mold such as is shown in FIG. 3. FIG. 5 is a perspective of a flat plate such as may be produced in following my invention and FIG. 6 shows a curved plate such as may be produced.

In following my invention, I preferably provide a furnace construction or heating and pressing device as shown in FIG. 1. This furnace construction is moreover less diagrammatically shown but includes a suitable supporting casing **10** mounted on a pedestal **11** preferably insulated from the floor by water cooled platten **12**. The casing **10** is somewhat enlarged and may be filled with any suitable insulating material **13** such as lampblack insulation.

Extending horizontally through the elongated casing **10** is a passage **15** formed by supporting U-shaped graphite troughs **16** within the casing **10**. The troughs **16** are provided with graphite tops **19**.

At opposite ends of the horizontal passageway, the troughs **16** and tops **19** forming the passage may be sealed against the casing **10** by water cooled glands **17** at the inlet and **18** at the outlet. Within the casing **10** and approximately centrally disposed thereof is a pedestal **20** preferably formed of silicon carbide which supports a pressing platform **21**. The upper surface of the platform **21** is maintained in generally horizontal alignment with the floor of the passage **15** over which the hot pressing molds move. Vertically above the platform **21** is a pressing head **22** that is carried at the lower end of a push rod **23** that is also preferably formed of silicon carbide. A suitable guiding bearing arrangement **24** is provided for surrounding the push rod and if necessary insulation may be provided between the bearing **24** and an extension of casing **10** to permit the push rod to pass vertically upwardly to the top of the casing to be actuated by any suitable power means such as a hydraulic press.

Any conventional heating means may be used to produce heat within the passage **15**. Electrical resistor bars suitably placed adjacent the passageway could be provided, however, in my preferred construction I use induction heating means **29** disposed both on the inlet and on the outlet side of the pressing station as best shown in FIG. 1. The induction heating coils disposed on the inlet side of the pressing station are designed to introduce relatively more heat to the product being hot pressed to effect pre-heating of the powder. The heating by means of the induction heating coils disposed on the outlet side of the passage and past the pressing station is provided to control the cooling cycle after completion of the hot pressing operation.

In the use of my hot pressing apparatus, relatively thin plates are produced by passing the material to be hot pressed flatwise through passage **15** to accomplish the heating and pressing operation. In the normal hot pressing operation powder is pressed in a mold and is contained within the mold while pressure and heat are applied. I provide a mold such as is shown in FIGS. 3 and 4 for producing a flat plate such as is disclosed in FIG. 5. It will be noted that such a mold takes the form of a "picture frame" in that it is formed of thin walls **30** preferably of graphite to define an opening **31**. In performing my process, the inner walls of the mold are provided with a suitable liner **32** of graphite, which may be provided wth a release coating, which receives powder **34** to be pressed. Suitable top and bottom plates **35** and **36** of graphite are situated above and below the powder that is evenly distributed throughout the mold and a top plate **37** also of graphite is then placed over the plate **35**.

The filled molds are inserted in the inlet on the left hand end of the hot pressing device disclosed in FIG. 1 and are intermittently fed forwardly through the passage **15** until they arrive at the hot pressing position near the center of the furnace. As the mold and powder charge move forward in a stepwise fashion the powder held within the mold is pre-heated to the temperature required to complete the hot pressing action. The inlet passage and heater construction **29** are co-ordinated with the stepwise movement of the molds such that sufficient heat is introduced to the powder to bring it up to hot pressing temperature. The mold and powder are then moved into position on the hot pressing platform **21** and the push rod **23** and pressing head **22** are driven downwardly to engage the top plate **37** which forms a pressing plate to transmit the force from the push rod to distribute it evenly over the entire mass of heated powder contained within the mold. It will be noted that as long as the hot pressing station is surrounded by the heating means **29** both on the inlet and exit sides, heat will continue to flow into the mold and powder charge while the pressing action continues.

The preferred design of the furnace as in the disclosed design is such that essentially all of the heat flow to the molding powder is through plates **35**, **36** and **37**, and the molding powder reaches its hot pressing (maximum) temperature just as it passes into the hot pressing zone of the furnace. In the hot pressing zone the heat flow is just sufficient to maintain the powder at the optimum designed temperature.

After pressing action has been continued for a sufficient time period, the push rod **23** is retracted and the mold assembly together with the hot pressed plate is moved stepwise from the pressing station toward the exit end of the furnace while the next succeeding mold moves into position at the pressing station.

The completed plate then is cooled under controlled conditions as it moves toward the exit of the furnace and after being completely cooled upon removal from the furnace, is stripped from the mold.

It is to be understood that the inlet passage and exit passage associated with the hot pressing station may be made as long or as short as desired. The length is controlled by the heat input and cooling cycle considered appropriate for the particular product being hot pressed.

As an example of one type of product which can be made in following this invention, a boroncarbide powder is prepared having boron present in an amount from 76% to 78% (by weight), carbon present in an amount of from 21% to 23% and with 0.2% iron, the ingredients of the powder having a particle size of the order of 10 microns as measured on a Micromerograph. A powder having this composition may be placed in a mold **30** and pre-heated to a temperature of 2,220° C. plus or minus 10° C. The mold and powder are heated to this temperature as they move through the inlet end of the furnace and obtain this temperature by the time the mold is placed in position on the hot press platform **21**. The pushrod **23** is then driven against the hot press plate positioned over the powder to produce a pressure of about 1,000 pounds per square inch over the entire surface of the powder charge within the mold This pressure is maintained for a period of five minutes while the temperature of the powder is maintained in the range of 2,220° C. It will be found that the boron carbide molding powder of this composition can be almost fully densified to at least 2.3 grams per cubic centimeter and usually approaches the theoretical density of 2.51 grams per cubic centimeter. The hot pressed plate produced by this operation is then slowly cooled as it moves to the exit end of the furnace and after the mold is removed from the furnace, the mold and contents are allowed to cool to room temperature whereupon the hot pressed boron carbide plate may be stripped from the mold. Plates produced in this fashion have been found to have

the hardness of boron carbide which is 2800 on the $Knoop_{100}$ scale and a compressive strength in the order of 400,000 pounds per square inch. Such plates may be used for mold linings, wear plates or for other purposes. Because of the strength and lightness of such plates, the boron carbide hot pressed thin structures are useful in any structural members where high strength and light weight are of importance.

As another example of the molding of boron carbide plates a powder as described above is filled into the picture frame mold such as is shown in either FIGS. 3 or 4 and passed through a furnace to be pre-heated to a temperature of 2,200° C. plus or minus 10° C. The mold and heated powder when positioned on the hot press platform **21** is pressed by driving the push rod **23** and pressing head **22** against the hot press plate **37** with sufficent force to produce 2,000 pounds per square inch pressure approximately over the entire surface of the mass of powder. Such a pressure for a time period of approximately three minutes accomplishes the production of a plate having the same characteristics as the plate described in the previous example.

If curved plates are to be formed, it is apparent that the bottom plate **36** is shaped to provide an incompressible filler having the desired curvature. The upper plate **35** and hot press plate **37** is likewise shaped to engage the powder charge **34** from above to bear against the upper surface of the powder to shape the final hot press plate as desired.

It is apparent that other powder compositions formulated either from boron carbide or other compositions could be used. Various release agents could be used on the sidewalls of the mold and other well-known hot pressing techniques may be applied.

Because of the operation of the disclosed process, in which the mold and its contents are subjected to high temperature for a minimum period of time, it is possible to employ release agents on the interior of the mold and on the powder contacting surfaces of plates **35** and **36** Suitable release agents are: a flake graphite slurry in a Carbowax (Union Carbide), methylene chloride vehicle; graphite paper (Dow Chemical Company); Grafoil (National Carbon); and cardboard.

Other refractory powder compositions, 10 micron particle size, which can be molded in the disclosed furnace are:

	Approximate, ° C.	Pressure, p.s.i.
Alumina	1,700	1–2,000
Bauxite	1,300	1–2,000
Titanium carbide	2,000	1–2,000
Titanium diboride	2,000	1–2,000
Zirconium diboride	2,000	1–2,000

In view of the relatively high processing temperatures required for boron carbide, the disclosed process is of particular application to fabrication of boron carbide plates.

The use of a simple mold with thin self-supported side walls and the pressing of a single layer in a mold at one time, in the apparatus disclosed, result in a uniform heating with no localized hot spots. Lower overall temperature and pressures may be employed than in prior art apparatus and more uniform and reproducible products result. Furthermore, the times and temperatures employed in the present apparatus permit the use of mold release coatings or layers, not previously practicable at the times, temperatures, and pressures required for producing boron carbide articles.

Further due to the introduction of heat to the powder mass distributed in a very thin layer, it is possible to flow heat into the powder mass quite rapidly. The heated mass of powder which has been quickly brought to the hot pressing temperature may be quickly pressed to complete the necessary densification, thus saving wear and tear

on the molds and producing maximum uniformity from piece to piece.

I claim:

1. Apparatus for making relatively thin hot pressed refractory plates from molding powder by hot-pressing said powder at temperatures exceeding 2,000° C. comprising a furnace including an elongated chamber having a constant cross-section to receive molds containing said powder serially, said molds having a shape in cross-section to substantially fill said chamber, said chamber including an inlet preheating zone adapted to hold a plurality of molds that contain said powder to be molded disposed therein in a thin layer, said mold formed from thin self-supporting side walls and thin top and bottom graphite members, a cooling zone adapted to hold a plurality of molds containing said hot pressed refractory plates, a hot-pressing zone to receive the molds between the inlet zone and the cooling zone, means to feed said molds through said apparatus, said hot-pressing zone having a pressure applying ram and an opposed anvil to apply pressure to said top and bottom carbon members and across the thin dimension of the thin layer of molding powder contained in the cavity of the mold and disposed between said top and bottom carbon members, said furnace having a heat source so arranged that the heat flow into the powder in the molds is essentially through the top and bottom plate into the thin layers of molding powder while the molds are being fed through the inlet zone and means to energize said heat source to maintain a temperature such that the contents of molds are each heated to their respective hot pressing temperature at the end of said inlet zone.

2. Apparatus of claim 1 wherein said top and bottom graphite members have a curved pressing face to produce hot pressed plate having a complementary curved shape.

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