

# PATENT SPECIFICATION

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## DRAWINGS ATTACHED

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## (54) METHOD OF MOULDING POWDERED OR GRANULAR MATERIAL

(71) We, THE CARBORUNDUM COMPANY LIMITED, a British Company, of Trafford Park Road, Trafford Park, Manchester 17, Lancashire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to the moulding of powdered or granular material in the field of metallurgy, ceramics, plastics and composites and also to equipment for carrying out said moulding.

In the field of metallurgy, ceramics, plastics and composites, many methods of fabricating articles are used but this invention is solely concerned with the moulding, under pressure, of powdered or granular materials.

In particular the invention is concerned with an improved method of moulding shapes which are not normally made from powdered material. For example, shapes with a deep recess are commonly produced in the case of metals, by deep drawing using suitable dies and high pressures; in the case of ceramic articles such shapes are commonly slipcast; in the case of plastics the normal method is injection moulding.

For the sake of convenience of explanation reference will be made hereinafter mainly to the ceramic art.

Tablets, tiles, bricks and similar flat shapes are not difficult to produce from a suitable raw mix in powder or granular form usually though not always moistened with a little liquid and sometimes with the addition of temporary binder. However, in the ceramic industry when the article to be moulded has a relatively deep recess such as a cup or deeply recessed dish or when the article required is relatively thin or has a particular configuration, such as a plate or saucer for tableware, moulding is usually carried out using either a slip casting or plastic clay body technique.

The difficulties of using a conventional steel

mould for moulding recessed articles from a powdered ceramic mix, commonly called dust pressing, are firstly that of maintaining a uniform distribution of the mix prior to and during moulding, and secondly that of achieving uniform pressure. Consequently, dust pressed recessed or other non-flat shapes have uneven density and suffer from distortion, cracks or breakage during moulding, stripping or subsequent kiln firing.

It is known that although dust pressed fabrication of flatware, by which is meant plates and saucers, is not normal practice, research is in progress on that subject based on multi-station presses using steel moulds. Any such solution to the problem, however, could not be applied to deeply recessed shapes.

According to one aspect of the present invention, there is provided a method of moulding a shaped article from a powdered or granular mix, comprising the steps of dispensing measured quantities of said mix in spaced relationship on a rubber, as herein defined, sheet, moving said sheet so as to bring one of said measured quantities of mix over the lower die of a mould, bringing together said lower die and a co-operating upper die of the mould so as to form a shaped article from said mix in the mould under pressure, separating the dies, and removing the moulded article by moving the sheet so as to bring another measured quantity of said mix into position over the lower die of the mould for a subsequent moulding operation.

According to a further aspect of the present invention, there is provided apparatus for moulding shaped articles from a powdered or granular mix, comprising a mould defining a moulding position, said mould comprising a lower die and a co-operating upper die movable towards and away from each other, a rubber, as herein defined, sheet movable in a path passing between said upper and lower dies, means for dispensing measured quantities of the mix on to the sheet at spaced inter-

vals, and means for automatically moving the sheet so as to convey the measured quantities of the mix in turn to the moulding position and to hold the sheet stationary during the moulding operation.

For the purpose of this invention the term "rubber" means, as used above and hereinafter, a natural or synthetic elastomeric material.

On release of pressure and retraction of the male die the rubber sheet relaxes to its original horizontal position and the moulded article is left supported thereon. Although developed particularly for deeply recessed articles the invention is not limited thereto.

The success of the method depends on such details as suitable raw mix and preparation thereof, accurate distribution of the mix, control of the rubber sheet so that there is no sag immediately prior to pressing; thickness and elasticity of the rubber and die design.

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

Fig. 1 is a sectional view of a moulding station in an apparatus for moulding shaped articles according to the present invention with the mould shown in an open position.

Fig. 2 is a simplified sectional view on a larger scale of the mould shown in Fig. 1 in a closed position.

Fig. 3 is a side view showing an alternative construction of belt,

Fig. 4 is a sectional view of a mix distribution station in a modified form of apparatus for moulding shaped articles also according to the present invention,

Fig. 5 is a sectional view of a moulding station in the apparatus of Fig. 4 and

Fig. 6 is a simplified sectional view on a larger scale of the mould shown in Fig. 5 in a closed position.

Referring now to Figs. 1 and 2, the apparatus, which is automated, is used to produce once-fired, glazed earthenware rectangular dishes 17×11 cm, 2.8 cm deep, with a wall thickness of 0.25 cm. Each dish weighs 110 gm. The sides of the dish incline outwards at an angle of 30° to the vertical.

An earthenware mix is prepared by conventional blunging and filter pressing followed by de-flocculation and addition of water to form a high solids content (70% solids) slip which is spray dried to a moisture content of 7%—8% and a granule size of 250 microns and finer. The mix is metered out from a hopper (not shown) fitted with an adjustable gate (also not shown) which closes and opens as a belt 1 travels thereunder to provide five uniform layers 2 (only one shown) of mix 25×18 cm and 0.6 cm thick, spaced at 25 cm intervals across the width of the belt 1 which is 140 cm wide, 4 mm thick and is formed of

synthetic rubber having a 30—35 Shore durometer hardness on the A scale.

The belt 1 moves 55 cm, stops for 11 seconds, then moves forward another 55 cm, this cycle being continually repeated. When the belt 1 stops five layers of mix are in the correct moulding position over five female dies 3 (only one shown). These female dies 3 each have 6 vent holes, (only four shown) one in each corner and two in the base. One of the holes, 4a, in the base is used to supply low pressure air which effectively prevents sag of the rubber belt 1 when in the stationary position and carrying a layer 2 of mix immediately prior to pressing. The other vent holes 4 allow the air to escape and provide more effective control of the air pressure. Furthermore these vent holes 4 prevent compression of air under the rubber belt 1 during pressing. In addition, they allow air to re-enter after release of pressure which assists the natural relaxation of the rubber belt 1 to its horizontal position.

The moulding cycle starts when the belt 1 stops with the automatic introduction of low pressure air, followed by descent of co-operating male dies 5 (only one shown) which are silicone lubricated. As the male dies 5 descend they are each preceded by a spring-loaded clamping bar assembly 6 which firmly holds the rubber belt 1 along rectangular contours 32×25 cm surrounding each of the five layers 2 of mix. This ensures that virtually all rubber belt movement during moulding is confined to the five areas of 32×25 cm which are trapped by the clamping bar assemblies 6.

When the male dies 5 descend the rubber belt 1 and mix 2 is deformed to the shape of the cavity defined by the co-operating dies 5 and 3 (See Fig. 2). The mix which eventually forms the side walls of the dishes does not fall or falls only to a limited non-critical extent as portions of the rubber belt 1 is forced to an inclined position since the male die 5 effectively traps the layer 2 of mix between itself and the rubber belt 1 before such fall can take place.

A particular feature of the design of the male die 5 is a curved nip 7 (Fig. 2) which forms the rim of the dish and forms a seal, adjacent to the rim, between the male die 5 and the rubber belt 1 prior to application of full pressure. This has the added advantage of leaving a very thin moulding flash to be removed in the subsequent towing operation.

Up to the point where the male die 5 has descended so as to trap all the mix, very little pressure has been transmitted to the mix but from this point onwards the desired pressure is quickly achieved and is extremely uniform on all parts of the mix. The pressure used is 300 Kg/cm<sup>2</sup> held for 1 second. The uniformity of pressure is due to the isostatic effect of the rubber. In normal isostatic moulding, fluid pressure is applied to an elastomeric

envelope or surface so as to exert even pressure over the whole area thereof. In our method virtually the same effect is achieved without the expensive complications of fluid pressure on the rubber.

After forming the dishes, pressure is released and the male dies are retracted. The moulded dishes release from the male dies aided by the silicone lubricant. The rubber belt 1 relaxes to the horizontal position aided by the air passing through the vent holes 4 and 4a in the female die 3, as aforementioned and the dishes remain supported on the rubber belt 1.

The whole pressing cycle is 11 seconds, after which the rubber belt 1 moves forward carrying the moulding dishes and taking five more layers of mix to their moulding stations.

As moulded dishes reach the end of the rubber belt 1 they are taken by transfer conveyors through the stages of automatic drying, towing, glazing, drying and firing to final inspection.

The whole production unit is controlled by the use of time switches, limit switches and motorised valves according to known automation techniques to bring the measured quantities of said mix in turn to the moulding stations.

Several modifications and refinements come within the scope of the invention. For example, there is a problem with thin-walled sharp cornered articles. In such cases (see Fig. 3) we use a thin rubber sheet 8 on top of the main conveyor rubber belt 1 and if necessary a lubricant 9 such as talc, between the two sheets 1 and 8.

With sharp cornered articles rubber relaxation on release of moulding pressure applies a stress to the underside of the article causing cracks in the vicinity of the corners. The use of the second thin rubber sheet 8 overcomes this problem.

Other modifications relating to the conveyor belt include the use of several individual belts passing through a multi-cavity moulding unit instead of one wide belt.

A major feature of the method described above is the slightly granular texture produced by the rubber on the underside of the moulded article. This may be modified for aesthetic reasons by using specially patterned belts, e.g. woven or embossed designs or any desired configuration, provided only that it does not interfere with required pressing characteristics. The same effect may be achieved by using individual patterned rubbers placed on a plain conveyor belt or placed in recesses in a conveyor belt.

In the case of articles of non-uniform thickness a non-uniform layer of mix may be provided either by using shaped rubbers or by using a thin belt over a vacuum forming unit which holds the rubber on to its surface by vacuum. The said forming unit may be designed for one specific shape (as in the case

of suction box 13 Figure 4) or the unit may be constructed so that any desired portion of the unit may be raised or lowered thus temporarily causing a projection or a recess in the rubber. A layer of mix is then distributed over the rubber which layer will be non-uniform in thickness in the manner desired. The vacuum is released when the rubber assumes its normal flat position. The rubber carrying the mix in the desired non-uniform disposition passes forward for moulding.

In a further modification of the present invention, finished articles having recesses and/or projections can be obtained by moulding an initial uniform layer but one in which a greater or lesser mass of material is located at spaced locations in accordance with any desired pattern. The recesses and/or projections are formed at these locations in a subsequent moulding operation.

In order to obtain these areas of greater mass, a former of a given pattern is employed to compress the material in accordance with that pattern and the recesses formed thereby are filled with additional powdered or granular material to again provide a layer of uniform thickness. The same effect can be obtained by initially providing a thicker layer than necessary, compressing portions of the layer by means of a patterned former and subsequently removing the uncompressed material down to the level of the compressed portions to once again provide a layer of uniform thickness having spaced denser portions.

For conventional flatware such as plates and saucers the granulated surface created by the rubber would in many cases not be desirable. More often a smooth finish is required, which may be obtained by machining the underside of the article.

As an alternative to machining to obtain a smooth finish, articles may be moulded with a smooth finish by employing the apparatus shown in Figs. 4 to 6, and using an elastomeric sheet having a thickness which is not greater than the granular size of the mix and preferably a lesser thickness and by holding the sheet in tension to avoid creasing during the process steps of mix deposition and moulding. Referring now to Figs. 4 to 6, a bone china mix is prepared by blunging, filter pressing, deflocculating with the addition of water to form a 70% solids content slip which is then spray dried to a moisture content of 7-8% and a granular size of 250 microns and finer. The granular mix is distributed by a shuttle box (not shown) on to a tensioned, smooth surfaced 100 micron thick polyvinyl chloride sheet 10 for the production of a 18 cm. diameter plate. The shuttle box provides a uniform layer 11 of mix on a flat surface. In the case of our plate we want extra mix for a foot 12 (the annular rim on the under side of the plate, Fig. 6).

Accordingly we provide a suction box 13,

Fig. 4, with an annular recess 14 at the mix distribution station vacuum is applied through small holes 15 in the suction box to pull the PVC sheet 10 into the recess.

5 Mix delivered by the shuttle box therefore forms a uniform layer except for the greater depth at the annular recess 14. Release of vacuum plus slight low pressure air to break the seal between the suction box 13 and the  
10 PVC sheet 10 allows the PVC sheet 10 to straighten out and transfer the annulus of extra mix to the upper side of the layer of mix to form an annulus 16 on the upper surface of the layer 11 of mix. The PVC sheet 10 moves  
15 over a table 17 to the moulding station where it is supported over a mould cavity 18 by being held in tension and by low pressure air fed into the cavity.

Pressing occurs as described with reference  
20 to Figure 1 and 2 except that there is no isostatic effect with the very thin sheet 10. Faster production rates are obtained by the use of vacuum applied to the cavity 18 at the moment male die 5 touches the mix in its  
25 downward travel. We prefer to use vacuum applied through a connection 19 in this way and to actuate a vacuum valve by an adjustable control fitted to the upper press platen 20. The connection 19 also serves to enable  
30 the low pressure air to enter the cavity 18.

The nip design 7 in Fig. 2 is modified to a flat area 21 (See Fig. 6) for use with very thin conveyor belts.

35 The plates produced were found to be as smooth as the steel mould surface and were biscuit fired, glazed and gloss fired in the normal way without the need for any further smoothing operation on the underside, i.e. the side in contact with the PVC sheet.

40 Articles made according to this invention in metal would undergo normal sintering processes, plastics would be heat cured as required and composites would undergo whatever heat treatment was appropriate to their composition.

#### 45 WHAT WE CLAIM IS:—

1. A method of moulding a shaped article from a powdered or granular mix, comprising the steps of dispensing measured quantities of  
50 said mix in spaced relationship on a rubber, as herein defined, sheet, moving said sheet so as to bring one of said measured quantities of mix over the lower die of a mould, bringing together said lower die and a co-operating  
55 upper die of the mould so as to form a shaped article from said mix in the mould under pressure, separating the dies, and removing the moulded article by moving the sheet so as to bring another measured quantity of said mix  
60 into position over the lower die of the mould for a subsequent moulding operation.

2. A method as claimed in claim 1, including the step of supporting the rubber sheet to prevent sag thereof whilst the dies are being  
65 brought together.

3. A method as claimed in claim 2, wherein the rubber sheet is supported by means of fluid pressure on the underside thereof.

4. A method as claimed in any preceding claim, including the step of clamping the parts  
70 of the rubber sheet surrounding the mix prior to applying the pressure to the mix.

5. A method as claimed in any preceding claim, wherein the rubber sheet is nipped  
75 between the dies prior to the application of full pressure.

6. A method as claimed in any preceding claim, wherein an additional rubber sheet which is thinner than the first rubber sheet is  
80 provided on top of the first rubber sheet.

7. A method as claimed in claim 6, wherein a lubricant is provided between the two rubber sheets.

8. A method as claimed in any preceding claim, wherein a rubber sheet patterned in relief is employed to impart a relief pattern  
85 to the moulded article.

9. A method as claimed in any preceding claim, wherein the rubber sheet is held over a vacuum forming unit so as to configure the rubber sheet prior to distributing the layer  
90 of mix on the sheet.

10. A method as claimed in any one of claims 1 to 5, wherein the rubber sheet has a thickness which is not greater than the granular  
95 size of the mix.

11. A method as claimed in claim 10, wherein the rubber sheet is held in tension to avoid creasing whilst the dies are brought together.

12. A method of moulding a shaped article  
100 substantially as hereinbefore described with reference to Figs. 1 and 2, or Figs. 1, 2 and 3 or Figs. 4 to 6 of the accompanying drawings.

13. Apparatus for moulding shaped articles  
105 from a powdered or granular mix, comprising a mould defining a moulding position, said mould comprising a lower die and a co-operating upper die movable towards and away from each other, a rubber, as herein defined,  
110 sheet movable in a path passing between said upper and lower dies, means for dispensing measured quantities of the mix on to the sheet at spaced intervals and means for automatically moving the sheet so as to convey the  
115 measured quantities of the mix in turn to the moulding position and to hold the sheet stationary during the moulding operation.

14. Apparatus as claimed in claim 13, wherein more than one mould is provided.  
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15. Apparatus as claimed in claim 13 or 14 wherein more than one rubber sheet is provided.

16. Apparatus as claimed in claim 13, 14 or 15 wherein the upper die is a male die and  
125 a lower die is a female die.

17. Apparatus as claimed in claim 16, wherein the lower die is provided with a conduit to enable a pressure fluid to be supplied

Fig. 4, with an annular recess 14 at the mix distribution station vacuum is applied through small holes 15 in the suction box to pull the PVC sheet 10 into the recess.

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55 upper die of the mould so as to form a shaped article from said mix in the mould under pressure, separating the dies, and removing the moulded article by moving the sheet so as to bring another measured quantity of said mix into position over the lower die of the mould  
60 for a subsequent moulding operation.

2. A method as claimed in claim 1, including the step of supporting the rubber sheet to prevent sag thereof whilst the dies are being  
65 brought together.

3. A method as claimed in claim 2, wherein the rubber sheet is supported by means of fluid pressure on the underside thereof.

4. A method as claimed in any preceding claim, including the step of clamping the parts  
70 of the rubber sheet surrounding the mix prior to applying the pressure to the mix.

5. A method as claimed in any preceding claim, wherein the rubber sheet is nipped between the dies prior to the application of  
75 full pressure.

6. A method as claimed in any preceding claim, wherein an additional rubber sheet which is thinner than the first rubber sheet is provided on top of the first rubber sheet.  
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7. A method as claimed in claim 6, wherein a lubricant is provided between the two rubber sheets.

8. A method as claimed in any preceding claim, wherein a rubber sheet patterned in relief is employed to impart a relief pattern to the moulded article.  
85

9. A method as claimed in any preceding claim, wherein the rubber sheet is held over a vacuum forming unit so as to configure the rubber sheet prior to distributing the layer of mix on the sheet.  
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10. A method as claimed in any one of claims 1 to 5, wherein the rubber sheet has a thickness which is not greater than the granular size of the mix.  
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11. A method as claimed in claim 10, wherein the rubber sheet is held in tension to avoid creasing whilst the dies are brought together.

12. A method of moulding a shaped article  
100 substantially as hereinbefore described with reference to Figs. 1 and 2, or Figs. 1, 2 and 3 or Figs. 4 to 6 of the accompanying drawings.

13. Apparatus for moulding shaped articles  
105 from a powdered or granular mix, comprising a mould defining a moulding position, said mould comprising a lower die and a co-operating upper die movable towards and away from each other, a rubber, as herein defined, sheet movable in a path passing between said upper and lower dies, means for dispensing measured quantities of the mix on to the sheet at spaced intervals and means for automatically moving the sheet so as to convey the measured quantities of the mix in turn to the moulding position and to hold the sheet stationary during the moulding operation.  
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14. Apparatus as claimed in claim 13, wherein more than one mould is provided.  
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15. Apparatus as claimed in claim 13 or 14 wherein more than one rubber sheet is provided.  
120

16. Apparatus as claimed in claim 13, 14 or 15 wherein the upper die is a male die and a lower die is a female die.  
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17. Apparatus as claimed in claim 16, wherein the lower die is provided with a conduit to enable a pressure fluid to be supplied



\* C L N S \*

to the underside of the sheet to prevent sag thereof.

- 5 18. Apparatus as claimed in claim 16 or 17 wherein apertures are provided in the lower die to allow air to escape therefrom as the upper and lower dies are brought together.

19. Apparatus as claimed in claim 16 wherein means are provided for enabling the lower die to be evacuated.

- 10 20. Apparatus as claimed in claim 16, 17, 18 or 19 wherein means are provided for clamping the portions of the rubber sheet around the die while the two dies are being brought together.

- 15 21. Apparatus as claimed in any one of claims 16 to 20 wherein the upper die is provided with a projection therearound, said projection being arranged to nip the rubber sheet between the dies prior to application of full  
20 moulding pressure.

22. Apparatus as claimed in any preceding claim, wherein an additional rubber sheet is provided over the or each rubber sheet, said additional sheet being thinner than said rubber sheet belt.

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23. Apparatus as claimed in any one of claims 13 to 22 wherein a vacuum forming unit is provided under the or each rubber sheet opposite the mix distributing means.

24. Apparatus for moulding shaped articles, substantially as hereinbefore described with reference to Figs. 1 and 2, or Figs. 1, 2 and 3, or Figs. 4 to 6 of the accompanying drawings.

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