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(54) **Reinforced articles of sanitaryware**

(57) A method of forming an article of sanitaryware from a shaped thermoplastic shell and a curable backing composition, preferably of foamed polyurethane, wherein a metal structure is included in the curable backing to provide a heat sink for heat generated in the curing process, and optionally rigidising reinforcement for the article, the curing process being carried out in a closed mould. The process avoids the distortion of the thermoplastic shell which occurs when using curable compositions having exothermic curing reactions, particularly when the thermoplastic shell has been formed from sheet having a thickness of less than 5 mm.

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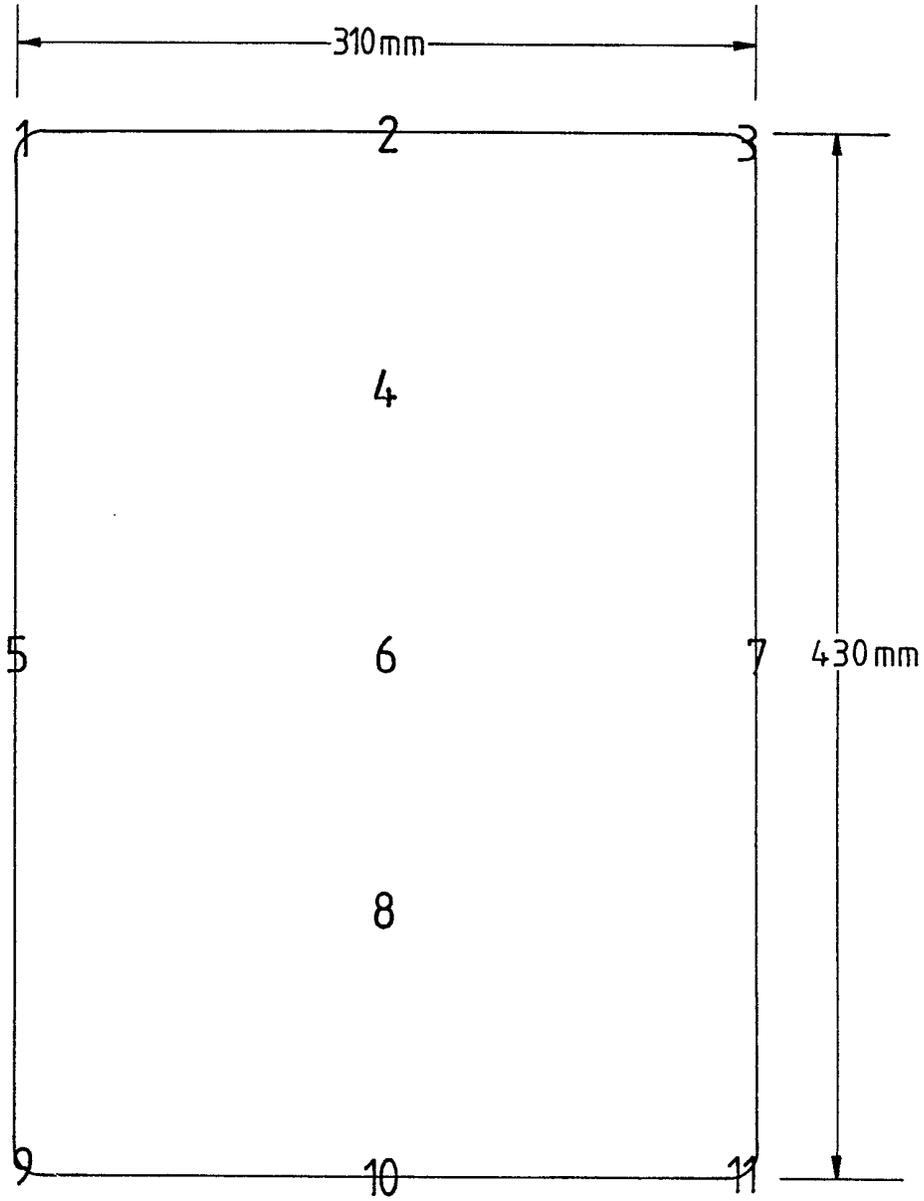


FIG. 1.

## SPECIFICATION

## Reinforced articles of sanitaryware

5 This invention relates to articles of sanitaryware having a thermoplastics sheet show surface and a reinforced backing to provide increased impact strength and rigidity. 5

Articles of sanitaryware, particularly baths and shower trays have been available for many years in the form of a composite consisting of a thermoplastics shell which has been reinforced on the underside or back surface with a glass-fibre composition, usually glass fibres in a curable, thermosetting matrix.

10 The various methods of producing such articles are reviewed in *Plastics World*, July 1977, pages 56-58. 10  
This article describes the so-called open moulding and closed moulding processes. In the former the reinforcement is applied as a glass mat which is subsequently impregnated with a curable resin by spraying or brushing or alternatively a mixture of the curable resin and chopped glass fibres are sprayed on to the underside of the plastics shell. In the closed moulding process a thermoplastics shell, conforming to 15  
the shape of a mould formed from matching male and female moulds, is placed in the mould and a curable, reinforcing composition is injected under pressure into the mould on the underside of the shell and subsequently cured. Variations on this process are described in the article. Generally, polyester resins have been used to provide the matrix of the reinforcing composition. More recently other materials have been considered for providing the reinforcement. In particular attention has turned to providing 20  
suitable reinforcement using the available polyurethane compositions. Polyurethanes have been widely used to rigidify articles of sanitaryware, particularly shower trays by injecting a polyurethane foam in the cavity between the shaped plastics shell and the base on which it is supported. A recent article in "Cannon News" 1983/1984 (a machinery supplier's newsletter from the Cannon Co.) describes the use of polyurethane foams in a closed moulding process to reinforce the underside of a bath. 20

25 In order to provide the most economical process of producing such reinforced articles it is advantageous to minimise the thickness of the plastics sheet employed. The major property of the sheet which makes it so suitable for use in this application is the high quality surface finish obtainable on plastics sheets, particularly acrylic sheets based essentially on poly(methyl methacrylate). Thus relatively thin sheets can be employed providing they are sufficiently well reinforced on the underside of shaped sheet. 25  
30 Significant thinning of the sheet occurs during the thermoforming of the shaped shell over those parts of the sheet that are stretched so that the minimum thickness of sheet which can be tolerated (before shaping) is of the order of 2 to 4 mm. Such sheet has been widely used for many years in processes which utilise polyester resin/glass fibre reinforcement. It has now been found that processes which use an adequate layer of foamed polyurethane to provide acceptable reinforcement tend to give rise to unacceptable articles when sheet of such thickness is employed. This deficiency is shown up as distortion or 35  
creasing of the sheet surface of the article of sanitaryware in those areas where thinning of the sheet is greatest as a result of the thermoforming operation. Thus distortion can be visually apparent, particularly in the corners of the shaped shell. This problem appears to arise as a result of the reaction exotherm occurring when the polyurethane reinforcement cures. 35

40 Whilst this problem can be overcome by using thicker sheet a more economically attractive solution is desirable. The present invention provides such a solution. 40

According to the invention there is provided a method of forming an article of sanitaryware comprising providing a mould cavity consisting of male and female mould halves, the cavity of the mould being of dimensions to accommodate a shaped thermoplastics shell to be reinforced together with sufficient of a 45  
curable reinforcing material to provide a backing layer on the shell, placing in the cavity in contact with the male mould a thermoplastics shell having a shape corresponding to the surface of the male half of the mould together with a metallic structure located between the surface of the female mould and the underside of the shaping, the metallic structure being present to a sufficient extent to provide an effective heat sink for heat generated when the curable material cures, introducing a curable composition into 50  
the cavity to envelop the metallic structure and curing the curable composition before removing the article from the mould. 50

It has been found that the presence of a metallic structure in the curing process results in articles of good surface quality, even in those areas which are susceptible to distortion in the absence of the metal structure.

55 In addition to avoiding the processing problem of sheet distortion the presence of the metal structure may make a significant contribution to other properties of the article such as rigidity. Thus a particularly valuable facet of the invention is that whereas it is normally necessary to attach a reinforcing board to the underside of the bath or within the reinforcing backing to confer adequate rigidity this can be dispensed with in the present invention. The use of the method provides an improved article of sanitary- 60  
ware comprising a laminate of a thermoplastics shell layer, providing a show surface of the article, and a backing layer of a cured reinforcing material containing a metallic component embedded in the backing material which provides increased rigidity at least over the base area of the article of sanitaryware. 60

As indicated, the thickness of the sheet used to provide the show surface should be less than 5 mm (before the sheet is thermoformed into a shell) when it is desired to minimise costs. The thickness of the 65  
cured, reinforcing backing layer should be greater than the thickness of the thermoplastic sheet particu- 65

larly in those areas where thinning of the sheet has occurred as a result of shaping. Preferably the backing layer should have a thickness of at least 3 mm. It is preferred that the backing layer is formed of foamed, curable material such as a foamed polyurethane so that a substantial thickness of backing material, that is up to 20 mm or more, can be present without making the article excessively heavy or expensive. The density of the foam that can be used will be controlled by the degree of reinforcement required of the backing layer. When the curable backing is a polyurethane or polyisocyanurate composition the foam density is preferably within the range 100 to 800 kg/m<sup>3</sup>, desirably 300 to 600 kg/m<sup>3</sup>, although higher and lower densities can be used.

Although the presence of additional metal reinforcement can reduce the sheet distortion problem by enabling a lower foam density to be employed than in the absence of the metal reinforcement, thereby reducing the heat arising from the curing process other problems tend to be introduced as the foam density is reduced. In particular, the risk of delamination increases. The major benefit of the invention arises from the fact that the presence of the metal structure allows high foam density to be achieved without sheet distortion. As previously indicated it is believed that this results from the metal structures acting as a heat sink and reducing the temperature rise in the curing composition and the consequent temperature rise in the thermoplastics shell.

The actual disposition of the metal structure within the curable composition is not excessively critical. Thus it is not necessary to ensure that metal is present in close proximity to the thinnest areas of the shell, that is on the corner portions. Neither is it necessary to ensure that the metal structure is in close proximity to any other portion of the shell. Providing that the metal structure is positioned so that it is distributed in the base area of the backing distortion of the sheet can be substantially avoided. A convenient method of providing such a distribution is by using a metal structure in the form of a grid of metal rods of appropriate dimensions and spacing. The grid is most conveniently made up for each individual shape of article by assembling rods in parallel alignment using plastic strips to provide the cross members of the grid, the strips being provided with clips to receive and secure the rods.

Surprising, it has been found that the finished shaped article shows no impression or shadow of such a grid when viewed from the show surface side even though it is located close to the thermoplastic shell.

Alternatively, a simple metal frame conforming to the dimensions of the base of the bath may be used to insure that the effective heat sink is provided in proximity to the thinnest portions of the thermoplastic shell. Yet again the heat sink may be provided by plate members located near the corners of the shell. It is not essential that the metallic structure is totally encapsulated within the curable or cured composition, providing that there is sufficient of the metal structure present to provide a heat sink effective to reduce distortion of the acrylic shell to an acceptable level. It may be advantageous to construct the moulding means so that a part of the metal structure extends outside the cavity containing the curable composition. Such extensions can provide supports for the article, such as legs to position the article on a desired surface, or a means for attaching supports for the article. Even when the metal structure is totally encapsulated it may be provided with means, such as screw threaded bores, for receiving fixtures such as supports. It may be necessary to clear the bore of cured material before attaching the supports.

To effective heat sink may also take the form of metallic bodies dispersed in the curable composition. These metallic bodies may be metallic flakes, metallic fibres or particles of a size that can be dispersed in the curable composition. The concentration of such particulate material is preferably greater than 5% by weight of the curable composition. These metallic bodies will be essentially uniformly distributed in the reinforced backing, apart from the non-uniformity introduced by sedimentation of the particles, rather than being localised as in the case of rods or plates. In the process of the invention using such metal filled curable composition, the metal structure is introduced into the mould cavity simultaneously with the curable material to provide a totally enveloped metallic reinforcing component.

The curable materials used for the reinforcing backing include the widely available polyurethane and polyisocyanurate compositions known to provide high density rigid foams. The compositions may be either unfilled or may contain particulate fillers or short fibrous fillers other than the particulate metal fillers described above, such as short glass fibres, to confer additional reinforcement on the backing.

Other means of reinforcing the backing, such as the inclusion of glass fibre mats or long fibre strands in the backing layer, may be employed. Although generally unnecessary, if the metal structure used provides adequate reinforcement, they can provide additional useful reinforcement in those circumstances where the use of the metal structure has overcome the shell distortion problem in the curing process but has not provided adequate reinforcement for the article when in use.

When a polyurethane is used to provide the curable material for the backing it is particularly useful to provide an interlayer of a polyester conventionally used for reinforcing sanitaryware because improved bonding may therefore be obtained. For example, the thermoplastics shell may be provided with a backing of curable polyester composition, optionally in the presence of glass fibre reinforcement in mat or long strand form, which composition is cured prior to placing the shell in the mould and applying further reinforcement in the form of a curable polyurethane composition together with the metal structure. The polyester based interlayer provides good resistance to delamination by bonding effectively to both the thermoplastic shell, particularly an acrylic shell and the polyurethane based backing.

The method of forming such reinforced shaped articles employs a closed mould to contain the shell to be reinforced, the metal structure and the curable backing material. The curable composition is pumped

into the mould using proprietary metering units so that mixing of the reactive ingredients of the composition occurs prior to introduction of the mixture into the mould.

In order to achieve good results it has been found advisable to make provision for certain additional features. Thus it is a marked advantage to provide means for cooling the male portion of the mould on which the shell rests. This is most easily achieved by providing the mould with pipework through which water can be circulated. In the same context it is highly desirable to ensure that the shape of the shell, which has been thermoformed on a mould of shape corresponding to the male mould half, conforms as closely as possible to the shape of the male mould half.

The invention is now described with reference to the following examples.

#### 10 *Comparative Example A*

A sheet of poly(methyl methacrylate) of thickness 3.2 mm and dimensions 800 mm × 570 mm was shaped into an acrylic shell having a base area approximately 430 mm × 210 mm. The depth of draw was 220 mm resulting in the base having a thickness of about 1 mm with the corner portions being reduced to about 0.75 mm. The underside of the shell was cleaned with solvent before the shell was assembled in a matched epoxy male and female mould assembly, the shape of the male mould conforming closely to that of the shell so that the shell closely contacted the male mould. The moulds were provided with internal water circulation to provide some temperature control. The mould cavity was nominally 10 mm in thickness. In order to measure the maximum extent of the temperature rise during the curing process 'Thermax' thermometer strips ('Thermax' is a registered Trade Mark) were attached to the show surface of the shell over the base area, before the shell was placed in the mould. 'Thermax' strips were also placed in corresponding positions on the male mould surface. The temperature of the male mould was set at 25°C and the female mould at 40°C. A mixture of 'Daltolac' K1328 and 'Suprasec' VM30 in the weight ratio 100:118, containing 5 parts by weight of 'Arcton' 11 blowing agent (based on D K1328) was mixed using a Cannon H40 metering unit and injected into the mould as backing for the acrylic shell. ('Daltolac', 'Suprasec' and 'Arcton' are Registered Trade Marks of Imperial Chemical Industries PLC). After ten minutes the article was removed from the mould. The polyurethane was firmly bonded to the acrylic shell. The density of the foam backing produced was 440 kg/cm<sup>3</sup>. Examination of the show surface of the article showed that the surface was of unacceptable quality because distortion of the shell had occurred during the curing process in the corners of the article where the sides met the base.

The temperatures recorded on the Thermax strips are given with respect to the diagram in Figure 1 which records the approximate positions of the strips on the base of the acrylic shell. Figure 1 shows the positions of the strips on the show surface of the base of the shell, there being eleven strips positioned at each corner (1, 3, 9 and 11), at the mid point of each side edge and end edge (5, 7 and 2, 10 respectively), mid-way between positions 5 and 7 (position 6) and three strips spaced equally between strips 2 and 10 (4, 6 and 8). At the corners and edges the strips were placed at the curved surfaces where the base meets the walls of the shell. The highest temperatures reached in positions 1 to 11 by the acrylic shell during foaming was:

1	60°C	4	46°C	7	54°C	10	65°C
2	65°C	5	54°C	8	54°C	11	60°C
3	60°C	6	46°C	9	60°C		

The higher temperatures of the corner and edge areas (positions 1, 2, 3 and 9, 10, 11) are due to heat transfer from both the base and adjacent vertical face to the same position. The temperatures obtained on the face of the male mould during the reaction were:

1	54°C	4	46°C	7	54°C	10	54°C
2	54°C	5	54°C	8	49°C	11	54°C
3	54°C	6	46°C	9	54°C		

Again the temperature rise was higher in the corner and edge areas of the base.

#### *EXAMPLE 1*

The procedure of Comparative Example A was repeated except in that the mould was assembled with a grid of 2 mm diameter steel wire in the space on the underside of the acrylic shell. The grid was made up of parallel lengths of the wire clipped 7 mm apart using two plastic strips spaced about 25 cm apart. The strips were provided with clips to retain the rods in position. The wires ran the length of the long axis of the base of the shell and were bent to overlap the corners on the ends of the base by about 3 cm. Using the procedure described in Example 1 the space behind the shell was filled with the curable composition thereby embedding the metal grid. The temperature profiles recorded in the same positions as in Comparative Example A were:

	1	54°C	
	2	49°C	
	3	54°C	
	4	43°C	
5	5	49°C	5
	6	43°C	
	7	54°C	
	8	46°C	
	9	54°C	
10	10	49°C	10
	11	60°C	

The temperatures registered on the male mould were:

15	1	49°C	6	43°C	11	54°C	15
	2	46°C	7	46°C			
	3	54°C	8	46°C			
	4	43°C	9	54°C			
	5	49°C	10	49°C			

20 The inner surface of the shaping showed a high gloss acrylic surface free from the distortion observed in Comparative Example A. The density of the foam (not containing metal) was 460 kg/m<sup>3</sup>.  
 25 The metal heat sink reduced the temperature significantly and to a level below that which allowed distortion of the "Perspex" shell. In addition no shadow of the iron work was visible when the acrylic top surface was viewed. This is particularly surprising as slight distortions often occur on stretched acrylic surfaces when different temperatures occur over a sharp boundary.

#### CLAIMS

- 30 1. A method of forming an article of sanitaryware comprising providing a mould cavity consisting of male and female mould halves, the cavity of the mould being of dimensions to accommodate a shaped thermoplastics shell to be reinforced together with sufficient of a curable reinforcing material to provide a backing layer on the shell, placing in the cavity in contact with the male mould a thermoplastics shell having a shape corresponding to the surface of the male half of the mould together with a metallic structure located between the surface of the female mould and the underside of the shaping, the metallic structure being present to a sufficient extent to provide an effective heat sink for heat generated when the curable material cures, introducing a curable composition into the cavity to envelop the metallic structure and curing the curable composition before removing the article from the mould.
- 35 2. A method according to claim 1 wherein the metallic structure comprises a grid of metal rods.
- 40 3. A method according to claim 2 wherein the grid of metal rods is formed from a plurality of metal rods held in parallel alignment with each other by means of plastic strip cross members provided with clips to receive and secure the rods.
4. A method according to any one of the preceding claims in which a means provided with a screw threaded bore suitable for receiving external support means for the article of sanitaryware is included in the curable composition.
- 45 5. A method according to any one of the preceding claims in which reinforcing means other than the metallic structure are included in the curable composition.
6. An article of sanitaryware comprising a laminate of a thermoplastics shell layer, providing a show surface of the article, and a backing layer of a cured reinforcing material containing a metallic component embedded in the backing material which provides increased rigidity at least over the base area of the article of sanitaryware.
- 50 7. An article according to claim 6 in which the shell has been formed from a sheet having a thickness of less than 5 mm.
8. An article according to either of claims 6 or 7 in which the cured reinforcing material is obtained from a foamed, curable material.
- 55 9. An article according to claim 8 in which the cured material is a polyurethane or polyisocyanurate composition.
10. An article according to claim 9 in which the cured material is a foam having a density between 100 and 800 kg/m<sup>3</sup>.
- 60 11. An article according to claim 10 in which the foam is a rigid foam.
12. An article according to any one of claims 6 to 11 in which the cured material backing has a thickness of at least 5 mm.