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COMPLETE SPECIFICATION

Improvements in and relating to method and apparatus for making Building Units, for example Panels or Slabs of Gypsum Plaster or other Mouldable Material

We, STANLEY HOWARD FLOWER, JOHN PARSONS and NORMAN GREENLEES WEIR LOUDON, all British subjects, and BELLROCK GYPSUM INDUSTRIES LIMITED, British Company, all of the Company's address at 41, London Street, Chertsey, in the County of Surrey, 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 methods and apparatus for manufacturing panel units or slabs (hereinafter called panels) of gypsum plaster or other mouldable building material (hereinafter called plaster) of the type comprising a continuous facing sheet (hereinafter referred to as a facing) homogeneous in one with cell-forming walls extending therefrom the cells being disposed at right angles to the facing.

The aim of the present invention is to provide an improved method and apparatus adapted to simplify and expedite the manufacture of panels units of the above type, the invention being calculated to lend itself to the mass production of units suitable for building constructions, including walling, partitioning, flooring or roofing work.

The present invention is in respect of subject matter divided from our concurrent Patent Specification No. 2907 of 1952 (Serial No. 748,693) directed to a double faced cellular panel and to a method and apparatus for producing such with one facing moulded in one with cell forming walls and the other face mechanically bonded to the cell walls by keying formations thereon.

The invention consists in a method comprising moulding cellular walling in one with a facing by the use of a series or assemblage of rubber or other flexible and deformable hollow plugs of an external shape which is the counterpart of that of the intended cells and disposed in spaced relationship to one another over the panel area to cell wall moulding clearances, the moulding operation being performed by immersing the plugs in a contained body of plaster sufficient to form the facing and rise into said clearances to mould the cell walls, and after the setting of the plaster contracting the plugs to facilitate their withdrawal.

The invention also includes apparatus comprising a facing-mould table for containing the body of plaster having displaceable side walls or flaps, a series of rubber or like deformable plugs for moulding cell walling in one with the facing layer of plaster, a vertically movable framing or support(s) on which the plugs are mounted in spaced relation, means for immersing the plugs in plaster to form the whole of the cell walling for a panel simultaneously with the facing, and means for contracting the plugs for their withdrawal from the moulded plaster after it has set.

Each plug is hollow and of appropriate form in plan for the moulding of the interior of a cell of chosen shape, which for economic reasons is preferably hexagonal (or a component of a hexagon) such that the moulded cells lie in relation to one another in a honeycomb pattern. The plugs may be prisms; it is, however, preferred that the walls thereof should taper externally from the base, or in other words the plug is a steep frustum or a truncated pyramid having an apertured base and a truncation surface parallel to the base, the base corners or other selected part such as the truncation surface, preferably being more readily deformable than the plug walling. Although other cross-sectional shapes, such as rectangular, triangular, polygonal, circular or ~~over~~ oval, may be employed for the cells and plugs, the invention will hereinafter be more particularly described with reference to a basically

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hexagonal form.

The deformation of each plug for facilitating their extraction or release from the plaster, is effected by the inward retraction of the section of the plug walling preferably by decreasing the internal hydraulic (i.e. gaseous or liquid) pressure exerted within the hollow plug.

According to one mode, contraction of the plugs is effected by placing the hollow interior of each plug in communication with a source of vacuum such that the walls or facets of the plug are retracted or rendered concave such as to create clearance between the plug walling and the moulded cell walling.

In order to support the plug facets during the moulding process against the pressure of the plaster, and also to render the truncation surface convex to ensure the expulsion of air from beneath the truncation region during moulding, gas, air or liquid is preferably introduced at a suitable pressure into the plug before or as the plug is immersed in the plaster, the pressure being thereafter released.

Although it is no part of the present invention it will be appreciated that a second facing may be moulded to the rims of the cell walling by inverting the single faced unit and immersing the ends of the cells in plaster supported on a second facing-mould or table. In other words the present invention, resulting in a single facing having cell walls projecting integrally therefrom, may be employed as a preliminary step in moulding a double faced panel. The moulding of a second facing onto the rims of the cell walling to provide a double faced panel is described in our concurrent patent specification No. 2907 of 1952.

In the accompanying drawings which illustrate a suitable mode of carrying the invention into effect:—

Figures 1 and 2 are respectively a plan, and a section of a hexagonal rubber cell-forming plug employed for carrying the invention into effect.

Figure 3 is a plan of a half hexagonal plug for moulding certain of the cells at the side of a panel.

Figure 4 is a plan view of a fragmentary cell suitable for use in moulding the end cells of panels.

Figure 5 is a plan view of an assembly of plugs in a framework unit for moulding the panel facing and cell-forming walling simultaneously and in one with one another.

Figure 6 is a view of the plug assemblage and framework in which a portion at the left hand side of the drawing is shown in outside elevation and the remainder is shown in longitudinal section as taken on the line 6—6 of Figure 5. In this figure the plugs are shown as in position on a mould table for moulding the facing and cell walls but with the plaster omitted.

Figure 7 is a transverse section as taken on the line 7—7 of Figure 5 but with plaster shown in position.

The sections in Figures 6 and 7 are as for the assemblage of plugs in the plan (Figure 5) but with plugs of different axial extent, Figure 6 showing plugs suitable for shallow panels while Figure 7 illustrates plugs for thicker panels i.e. panels in which deeper cells may be moulded.

Figure 8 is an isometric view of a mould table suitable for use in moulding the facing and cell-forming walls and edges or margins of a panel.

Describing in detail a panel unit made according to the invention, a facing *a* of plaster is moulded in one and simultaneously with hexagonal cell walling *b*, (see Figure 7). The cells of the main area of the panel are full hexagons moulded by plugs A Figure 1 while those at the ends of the panel are fragmentary hexagons formed by plugs A^2 such as shown in Figure 4. At the sides of the panel full hexagonal cells A alternative with half hexagonal cells formed by plugs A^1 as seen in Figure 3. The cell walling at the ends and side edges of the panel merge into and are bounded by peripheral or edge walling *c*. The cell walls taper steeply from the bottom of the cells towards the rim thereof.

The panels are preferably moulded in lengths suitable for room height to extend from floor to ceiling and for such purpose sets may be moulded in 8 ft., 9 ft., or 10 ft. lengths. If units are to be used in bonded horizontal courses the dimension will be chosen for convenient handling and erection. The width of the panels is conveniently 2 ft. although it will be obvious that panels may be made in other chosen widths, and it may be desirable to mould panels of a width equal to the full length of a wall or partition or some fraction (such as a half) of such length. Panels may also be moulded which include gaps or openings for windows, doors and the like.

In carrying the invention into effect according to one mode described, by way of example, for the manufacture of gypsum plaster panel units with cells of regular hexagonal shape extending therefrom at right-angles a series of moulded rubber plugs A (Figures 1 and 2) are provided for assembly in a framework having the general reference B (Figures 5, 6 and 7) for use (as hereinafter described) in conjunction with a facing-mould table C (shown in perspective in Fig. 8) for forming the facing in monolithic integrity with the cell forming walls.

Each plug A for the main area of the panel unit is moulded of a sufficiently pliable rubber to enable it to be deformed or distorted by suitable differences of air pressure internally applied. The shape of the plug is that of a steep frustum or truncated pyramid having a regular hexagonal base and is in cup-like form

to afford a hollow interior 1, the truncation surface 2 being the bottom of the cup whilst a rim 3 thereof is flanged to receive a base closure plate 4 secured to the rubber in an airtight manner. The facet walls 5 of the plug may be made sufficiently stout to withstand the pressure of the plaster when the plug is immersed therein without the assistance of air at superatmospheric pressure introduced into the interior of the plug but it is preferred to use a slight supporting air pressure.

The facets 5 of the pyramid are moulded in one with the truncation surface 2 which may be made somewhat thinner or thicker than the facet walls of the plug. The relative dimensioning of the thickness of the facets and the truncation surface will depend on the relative areas exposed to the air pressure, as it is the intention that when air pressure is employed before or during the immersion of the plug it shall have a preferential effect on the truncation surface so as to cause it to become convex in order to drive out air which might otherwise be trapped beneath the truncation surface, when such contacts with the plaster.

The grooving shown at 5*a* and 5*b*, 5*c* and 5*d* (Figures 2 and 3 and in Figures 6 and 7) is described in our concurrent Patent Specification No. 2907 of 1952, for moulding keying formations on the cell forming walling and comes into use in making a double faced panel according to said specification. Similarly the ribs or projections 7 are described in the above specification for moulding air communication apertures in the cell walling, which come into use during the moulding of the second facing of a double faced panel.

According to one suitable mode of closing the base of the pyramid, it may have a shoulder 3*a* (Figure 2) adjoining the neck flange 3 to receive the rim of the closure plate 4, the neck being sealed to the plate adhesively, by bonding or by pressure exerted mechanically as by a metal contractible strap 3*b* of known type. Alternatively, the base may be provided with a closure surface or member in any appropriate manner. Each closure is provided with a pair of rods 8, tapped into holes in the plate 4, adapted to form suspensory supports for the plugs in a framework described below. These rods are tubular having bores 8*a* so that they may be employed as air ducts as well as securing means, for which latter purpose they are provided with screw-threaded portions 8*b* but for convenience in making suspensory adjustments of the plugs in the framework, it may be preferred to provide separate air ducts which may in the form of a pipe or pipes communicating with the plug interior thrugh the base closure. In either case the rods or pipes serve as conduits for varying the air pressure within the plug by supplying air under pressure and for evacuating the interior of the plug.

Although it is preferred to make the cell-forming plugs of rubber, they may be formed of a synthetic composition such as neoprene or other pliable and resilient resin, and the side flaps (described hereinafter) of the mould table may be lined with a material such as polyvinyl chloride, or polythene, to prevent sticking and avoid the application of grease or the like.

The rubber or other composition of which the plugs are mainly composed may be reinforced or lined with canvas or other fabric in a manner which will not interfere with their deformation or collapsing in the described manner.

Plugs having the above characteristics are mounted in the framework described below for the main area of the units but for the sides of the units and at both ends special plugs which are half or a fragment of a hexagon are provided. For example, for the longer sides of the panel unit plugs A' (as shown in Figure 3) of half hexagon shape are employed. Each of such plugs has the division taking place across the diagonal between corner and corner while the fractional plugs A" (see Figure 4) for the ends of a panel may be divided by a line at right-angles to a pair of parallel facets. These fractional plugs otherwise have the same general characteristics as the full hexagon plugs and the same reference numerals are applied to corresponding parts.

The plugs may be made in any suitable size, a convenient width being 5¼ inches taken between parallel facets at the truncation end and 5⅝ inches at the base of the pyramidal form, affording a suitably small angle of taper. The axial length of a plug may be somewhat more than 2 inches, 3 inches, 4 inches or in some cases 6 inches (or other suitable chosen dimensions) according to the thickness of the units to be moulded. It will be appreciated that if a universal plug is to be provided for moulding panels of different thicknesses, a certain limitation will exist owing to the fact that if very long plugs are used, the cell walling at its base will have to be thicker than is desirable to ensure an adequate thickness of plaster at the outer end or rim of the tapering cell walling.

The plugs are disposed in spaced relation to one another such as to leave an adequate clearance between the exterior periphery thereof at their bases when in the moulding position for moulding the rims of the cell walling of suitable thickness. The taper form of each plug causes the walling of each cell to be moulded of corresponding taper decreasing in thickness towards the outer end or rim of the cells of the element formed in the moulding operation, resulting in the facing and open-ended cells.

The appropriate number of plugs A, A', A" for moulding a panel are assembled and mounted on a plate or in the spider or framework B comprising stout bars 9 (Figures 5, 6 and 7) disposed transversely of the length of

the panel to be moulded, welded to longitudinal angle bars 10 and 10*a*. The plugs A are hung from the bars 9 and the plugs A^1 from short extensions 9*a* welded to the bars 9. The longitudinals 10 also support vertically depending members, such as channels 11, carrying hinged guide members 12 adapted to serve for registering with the sides or flaps of a first mould table. Similar vertical channels 11 are mounted at the ends of the framework and each vertical channel (see Figure 6) also serves as a mounting for an adjustable foot 11*a* which acts as a stop bearing upon a ledge on the sides of the mould table (described below) to limit the depth to which the plugs are immersed in the plaster according to the thickness of panel being moulded. This foot is vertically slidable in the channel and is secured by a bolted connection 11*b* affording facility for vertical adjustment.

The guide members comprise a pair of depending plates 12 pivoted at 12*a* (see Figure 7) and having a pair of transverse rollers 12*b* for engaging the outer portion of the adjacent flaps of the mould table. A pair of bell-crank levers 15 pivoted at 15*a* and terminating in cam noses 15*b* are connected together by bars 15*c*. In the position shown in the drawing the cams 15*b* thrust the rollers 12*b* into the engaging position while when the levers are turned downward through 90 , the plates 12 are free to move away from the engaging position. The side and end vertical channels 11 themselves may be adjustably bolted in position and in the latter case the bolts pass through a packing block 11*c*.

The framework end members, such as angle irons 13, are connected to the ends of the longitudinals 10, and the irons 13 are coupled to small subsidiary frames 14 for convenience in mounting the fragmentary plugs A^2 or for making up panels of a different length. The longitudinal members 10 are connectible to lifting mechanism or hoists (not shown) by hooks which are attached through holes 10*b*, for raising and allowing the plug framework to be lowered for immersion of the plugs in the plaster of the mould table. The vertically controlling mechanism or hoists for the plug framework may be mounted on carriages traversable on rails for displacing for the frame work and plugs as a whole horizontally in mutually perpendicular or other directions for the purpose of positioning the plugs over the mould table.

The plugs are connected together pneumatically in any suitable manner to afford the equal and simultaneous distribution of the air pressure effects which are applied through a header pipe 16 extending longitudinally over the flange of the central angle iron 10*a* (Figure 7) and attached thereto at intervals by clips 17. The header is alternatively connectible by suitable three-way valve means to a source of compressed air and a source of evacuation (not shown in the drawings). The tubular rods 8 of the plugs have connected to them flexible pipes 18 of rubber or the like which connect a rod 8 of one plug with a rod 8 of an adjacent plug. For convenience in distributing the pneumatic pressure the plugs may be served in groups by flexible connections 18*a* from the header 16. In the plan view in Figure 5 the arrows at the right hand side of the figure indicate a suitable intercommunicating grouping which includes some of the full hexagonal and fragmentary hexagonal plugs A, A^1, A^2.

The mould table C (see Figures 6, 7 and 8) with which the frame plugs co-operate to form the cell walling in one with the facing and marginal walls or edges for a panel, comprises a bottom plate 19 of suitable rigidity or made rigid by the addition of reinforcement, or the bottom plate 19 may be of composite form comprising a pair of plates united by webs 19*a* as seen in Figure 7. The side and end margins of this plate or table have hingedly secured thereto flaps 20, the hinging at 20*a* being convenient for displacing them outwardly to release the unit at the completion of the moulding operation. The form of the hinges adjacent the pivotal axis affords stop means to limit the outward and inward hinging movement of the flaps, stops for the inward position being adapted to ensure the vertical disposal of the flaps in the moulding position. Each flap is formed with a projecting ledge 20*b* which serves as an abutment for contact with the feet 11*a* of the vertical side and end channels 11 on the plug assembly framework B (see, for example, Figure 7). The mating corners of the flaps may be mitred and rebated to secure a plaster-tight joint and the flaps at their corners are secured by tightening clamps or clips 21 of any suitable kind.

The inward sides of the flaps are provided with broad ribs or like forms 20*c* extending horizontally for moulding grooves in the outer edges or margins of the panel unit and this ribbing may be contoured to mould a channel extending into a deeper channel in the central zone of said edges. This ribbing and the corresponding moulded channels are for the purpose of forming elongated continuous cavities when moulded units are placed edge to edge for building purposes, in order that plaster or cement grouting may be poured into the cavities formed by the mated vertical channels.

The ribbing or internal surface of the side flaps may be made interchangeable, or side flaps themselves may be interchangeable for moulding different thicknesses of panel or changing the peripheral configuration of the edges of such element or unit. According to one mode of providing for interchangeablility the hinge formation may be such that the hinging knuckles may be readily detached or the hinge pin withdrawn. Alternatively, separate mould tables may be made for the differ-

ent thicknesses of panels to be moulded or for the different forms of contour required for the margins or edges of the panels.

The plate surface area of the mould table may be plain or formed with ornamental relief or intaglio forms or with supplemental ribbing or grooving in order to form the facing with keying elements to which a Portland cement or quick-setting cement or composition of harder or different characteristics from that of the plaster may be moulded in order to render the units suitable for the outer walls of buildings or for other purposes.

During the moulding operations high frequency or other vibrations may be imparted to the mould table or to the plug supporting framework B, and it is preferred to employ a rectilinear vibration or one confined to a plane parallel to the facing.

In moulding a panel the process of moulding the cell walling in conjunction with the facing is as follows:—

The plugs A, A^1, A^2 assembled and secured in the framework B (Figures 11, 12, 13) are moved to the correct vertical position over mould table C for the first moulding operation. When once the plugs have been mounted in the framework at the correct vertical height for a unit of pedetermined dimensions they remain fixed but in order to accommodate any irregularities in the flow or displacement of the plaster owing to differences in the moulding action of the plugs, certain of the plugs may be readjusted to accommodate such variations.

The facing-mould table C with the marginal flaps 20 in position is charged with plaster which is sufficiently liquid to enable it to rise in the clearances between the plugs when they are immersed in the plaster, the quantity of plaster being predetermined such that the plaster will rise to the edge of the flaps.

Compressed air is admitted to all the plugs under sufficient pressure laterally to support the facets of the plugs against the pressure of the plaster and cause the truncation surface 2 thereof to become slightly outwardly dished or convex.

The plug framework B is then lowered, being guided by the rollered plates 12 which are locked by depressing the cam levers 15, until the truncation surface of the plugs touches the plaster level, after which the plugs are allowed to sink into the plaster under gravity action (or under applied pressure) while vibration is applied to the mould to facilitate the flow and displacement of the plaster and to avoid the occlusion of air. Instead of initially introducing compressed air, it may be admitted as the plugs are about to or after they contact the plaster. The plugs sink by gravity action into the plaster until the feet 11*a* of the vertical channels 11 rest upon the ledges 20*b* of the mould flaps 20 and further downward movement is arrested.

The mould table C is appropriate for moulding a shallow panel while in Figure 7 the mould table C is appropriate for moulding thicker panels, (such as a panel about 4 inches thick).

A period is then allowed for the plaster to set, after which the compressed air is released, enabling the convex truncation surfaces of the plugs to retract or tend to retract to their normal position. Upon the escape of compressed air, connection is made with the evacuating source and the air pressure within the cells is reduced to about 6 inches mercury pressure for example, that is to say to an extent which will render the facets of the plugs to be drawn inwards and assume a concave form, thereby releasing the moulding contact of the facets with the plaster and allowing the plugs to be withdrawn by lifting the framework B, such withdrawal taking place clear of the internal surface of the plaster walling defining the cell cavities, leaving the facing with upwardly projecting cell walls lying on the mould table.

Panel units as above described may be used, in addition to the uses already mentioned, for lining interior walls of buildings, or a pair of such elements may be positioned with the open cells towards one another and utilised as shuttering for use with cement or for receiving other filling.

In the above described mode of carrying the invention into effect, full hexagon plugs have been described for the main cells and the use of half or fractional cells for the marginal or corner portions. It is to be understood that all the cells may, if desired, be moulded in half hexagonal (or other fractional) forms by the use of plugs of corresponding shape, each half plug having its diagonal (or radial) spaced from the complementary plugs such that the unit is provided with rectilinear aligned cell walls arranged either lengthwise or transversely of the unit or with the cell walls disposed according to a predetermined pattern.

The plaster employed for the moulding operation may be used plain or mingled with reinforcing vegetable or mineral fibres of a length such as will not interfere with the flow of the plaster and, if desired, foamed plaster may be employed for the cell walling and facing; also for certain purposes it may be suitable to charge the cells when formed with foamed plaster, instead of leaving them hollow.

Furthermore, reinforcement for the facing may be provided in the form of embedded wires or net by laying such in the facing plaster on the mould table in the appropriate position. Similarly open mesh vegetable fabric may be introduced into the facing as reinforcement.

What we claim is:—

1. A method of making a panel of the

ent thicknesses of panels to be moulded or for the different forms of contour required for the margins or edges of the panels.

The plate surface area of the mould table may be plain or formed with ornamental relief or intaglio forms or with supplemental ribbing or grooving in order to form the facing with keying elements to which a Portland cement or quick-setting cement or composition of harder or different characteristics from that of the plaster may be moulded in order to render the units suitable for the outer walls of buildings or for other purposes.

During the moulding operations high frequency or other vibrations may be imparted to the mould table or to the plug supporting framework B, and it is preferred to employ a rectilinear vibration or one confined to a plane parallel to the facing.

In moulding a panel the process of moulding the cell walling in conjunction with the facing is as follows:—

The plugs A, A', A² assembled and secured in the framework B (Figures 11, 12, 13) are moved to the correct vertical position over mould table C for the first moulding operation. When once the plugs have been mounted in the framework at the correct vertical height for a unit of pedetermined dimensions they remain fixed but in order to accommodate any irregularities in the flow or displacement of the plaster owing to differences in the moulding action of the plugs, certain of the plugs may be readjusted to accommodate such variations.

The facing-mould table C with the marginal flaps 20 in position is charged with plaster which is sufficiently liquid to enable it to rise in the clearances between the plugs when they are immersed in the plaster, the quantity of plaster being predetermined such that the plaster will rise to the edge of the flaps.

Compressed air is admitted to all the plugs under sufficient pressure laterally to support the facets of the plugs against the pressure of the plaster and cause the truncation surface 2 thereof to become slightly outwardly dished or convex.

The plug framework B is then lowered, being guided by the rollered plates 12 which are locked by depressing the cam levers 15, until the truncation surface of the plugs touches the plaster level, after which the plugs are allowed to sink into the plaster under gravity action (or under applied pressure) while vibration is applied to the mould to facilitate the flow and displacement of the plaster and to avoid the occlusion of air. Instead of initially introducing compressed air, it may be admitted as the plugs are about to or after they contact the plaster. The plugs sink by gravity action into the plaster until the feet 11a of the vertical channels 11 rest upon the ledges 20b of the mould flaps 20 and further downward movement is arrested.

The mould table C is appropriate for moulding a shallow panel while in Figure 7 the mould table C is appropriate for moulding thicker panels, (such as a panel about 4 inches thick).

A period is then allowed for the plaster to set, after which the compressed air is released, enabling the convex truncation surfaces of the plugs to retract or tend to retract to their normal position. Upon the escape of compressed air, connection is made with the evacuating source and the air pressure within the cells is reduced to about 6 inches mercury pressure for example, that is to say to an extent which will render the facets of the plugs to be drawn inwards and assume a concave form, thereby releasing the moulding contact of the facets with the plaster and allowing the plugs to be withdrawn by lifting the framework B, such withdrawal taking place clear of the internal surface of the plaster walling defining the cell cavities, leaving the facing with upwardly projecting cell walls lying on the mould table.

Panel units as above described may be used, in addition to the uses already mentioned, for lining interior walls of buildings, or a pair of such elements may be positioned with the open cells towards one another and utilised as shuttering for use with cement or for receiving other filling.

In the above described mode of carrying the invention into effect, full hexagon plugs have been described for the main cells and the use of half or fractional cells for the marginal or corner portions. It is to be understood that all the cells may, if desired, be moulded in half hexagonal (or other fractional) forms by the use of plugs of corresponding shape, each half plug having its diagonal (or radial) spaced from the complementary plugs such that the unit is provided with rectilinear aligned cell walls arranged either lengthwise or transversely of the unit or with the cell walls disposed according to a predetermined pattern.

The plaster employed for the moulding operation may be used plain or mingled with reinforcing vegetable or mineral fibres of a length such as will not interfere with the flow of the plaster and, if desired, foamed plaster may be employed for the cell walling and facing; also for certain purposes it may be suitable to charge the cells when formed with foamed plaster, instead of leaving them hollow.

Furthermore, reinforcement for the facing may be provided in the form of embedded wires or net by laying such in the facing plaster on the mould table in the appropriate position. Similarly open mesh vegetable fabric may be introduced into the facing as reinforcement.

What we claim is:—

1. A method of making a panel of the

type described comprising moulding the facing of the panel in one and simultaneously with cell-forming walls projecting therefrom, by immersing in a previously laid contained body of plaster, sufficient in quantity for the facing and cell forming walls, an assemblage of hollow deformable rubber or like plugs, disposed in spaced relationship to provide cell-forming wall clearances into which the plaster rises, allowing the plaster to set, contracting the plugs to free them from the moulded plaster and withdrawing the assemblage of plugs.

2. A method as claimed in Claim 1 wherein boundary edges for the panel are moulded simultaneously with the cell forming walls, by the plaster rising against panel edge moulding means.

3. A method as claimed in Claim 1 or 2, characterised in this that the step of contracting the plugs is effected by placing such in communication with an evacuating source.

4. A method as claimed in Claim 1, 2 or 3 characterised in this that before or during the immersion of the plugs in the contained plaster, hydraulic pressure is admitted to the interior of the plugs to afford support to the plug walling against the pressure of the plaster and preferably also to expel air which might be trapped in the cells under the plugs, the application of hydraulic pressure being followed by releasing the said pressure and the placing of the plugs in communication with an evacuating source to contract the plugs preparatory to their withdrawal.

5. Apparatus for carrying out the method claimed in any of the Claims 3 or 4 comprising a framework, a series of hollow deformable rubber or like plugs, preferably of hexagonal frustum form, assembled and supported in said framework in spaced relationship to afford cell wall forming clearances, means for containing plaster for the immersion of the plugs therein and means associated with the hollow plugs and with an evacuating source or with a source of superatmospheric pressure and subsequently with an evacuating source for causing their inward contraction preparatory to their withdrawal from the plaster after it has set sufficiently or for subjecting them firstly to superatmospheric pressure and subsequently to subatmospheric pressure.

6. Apparatus as claimed in Claim 5 wherein the means for containing the plaster for the immersion of the plugs comprises a mould table having a plate area, and, at the margins of said area, displaceable flaps for moulding edge margins upon the panel.

7. Apparatus as claimed in Claim 5 or 6, and wherein guide members supported in depending relationship from said framework are provided and adapted to co-operate with the means for containing the plaster.

8. Apparatus as claimed in Claim 5 wherein vertically adjustable stop means are provided in depending relationship with said framework and adapted to contact with abutment means on the said means for containing the plaster to determine the depth of immersion of the plugs and thickness of the facing.

9. Apparatus as claimed in Claim 5 wherein the means associated with the hollow plugs comprise tubular connections between the plug interiors and header piping connectable to the evacuating source or to a source of superatmospheric pressure and subsequently with the evacuating source.

10. Apparatus as claimed in Claim 9 wherein each plug has a pair of tubular connections and said connections are arranged to establish hydraulic communication between the various plugs such that the pressure throughout the series of plugs may be varied substantially simultaneously and equally as pressure changes take place in the header piping.

11. Apparatus as claimed in Claim 9 or 10 wherein groups of plugs are hydraulically coupled together in pairs by their tubular connections.

12. Apparatus as claimed in Claims 5 to 11 wherein plugs are tapered and of an axial length for moulding a range of thicknesses of panel (from, say, 2 inches to 6 inches).

13. A plaster panel moulded according to the method claimed in any of the claims 1 to 4.

14. Apparatus for moulding a panel of the type indicated with the facing of the panel moulded in one and simultaneously with cell forming walls projecting therefrom, substantially as described with reference to the accompanying drawings.

MARKS & CLERK

PROVISIONAL SPECIFICATION

Improvements in and relating to method and apparatus for making Building Units, for example Panels or Slabs of Gypsum Plaster or other Mouldable Material

W, STANLEY HOWARD FLOWER, JOHN PARSONS and NORMAN GREENLEES WEIR LOUDON, all British subjects and BELLROCK GYPSUM INDUSTRIES LIMITED, British Company, all of the Company's address at 41, London Street, Chertsey in the County of Surrey, do hereby declare this invention to be described in the following statement:—

This invention relates to building units and to methods and apparatus for manufacturing

such units, as for example: panels or slabs of gypsum plaster or other mouldable composition (hereinafter called plaster) with or without fibrous or other reinforcement, and comprising an internal cellular structure (the cells of which may be hexagonal) formed with a facing sheet (hereinafter called a facing) on one side in a plane at right-angles to the axes of the cells.

The aim of the present invention is to provide an improved method and apparatus adapted to simplify and expedite the manufacture of units of the above character, the invention being calculated to lend itself to the mass production of units suitable for building constructions, including walling, partitioning, flooring or roofing work, which are capable of being combined with members adapted to increase the load carrying capacity.

The invention consists in moulding a cellular core or structure in one with a facing by the use of a series of rubber or other flexible and deformable plugs of counterpart shape to that of the intended cells and disposed in spaced relationship to one another to constitute the cell walling, the moulding operation being performed by immersing the plugs in plaster to force the plaster into the spaces between the plugs.

The invention also comprises a facing mould table having displaceable side walls, a series of rubber or like distortable core forming plugs for moulding cell walling in one with the said facing, a movable framing or support(s) on which the plugs are mountable in spaced relation, means for immersing the plugs in plaster of the facing-mould to form the whole of the cell walling for a unit simultaneously and in one with the facing, and means for distorting or collapsing the plugs for their withdrawal from the plaster after setting.

Each plug is hollow and of appropriate form in plan for the moulding of the interior of a cell of chosen shape, which for economical reasons is preferably hexagonal (or a component of a hexagon) such that the moulded cells lie in relation to one another in honeycomb pattern. The plugs may be prisms or the walling thereof may taper externally from the base, or in other words the plug may be a steep truncated pyramid having a closing base and a truncation surface, the base corners or other selected parts preferably being more readily deformable than the plug walling or other part. Although other cross-sectional shapes, such as rectangular, triangular, polygonal, circular or oval, may be employed for the cells and plugs, the invention will hereinafter be more particularly described with reference to a basically hexagonal form.

The deformation or distortion of each plug for facilitating their extraction or release from the plaster, is effected by retraction of the cross-section of the plug walling by altering internal gaseous or liquid pressure exerted on the plug.

Deformation of the plugs is effected by placing the hollow interior of each plug in communication with a source of vacuum such that the walls or facets of the plug are rendered concave for the purpose of freeing such from the cell walling when moulded. In order to support the plug facets during the moulding process against the pressure of the plaster, and also to render the truncation surface convex to ensure the expulsion of air from beneath the truncation region during moulding, gas, air or liquid at superatmospheric pressure is preferably introduced into the plug before or as the plug is immersed in the plaster.

The method according to the invention for moulding the element or unit consists in charging a facing-mould with plaster after the erection of the side walls, lowering the plug spider to immerse the plugs to the desired depth into the plaster with the said plugs under air pressure to cause the plaster to rise between the plugs to form the cell walling integrally with the facing, releasing the air pressure after the plaster has set and applying a vacuum or reduced air pressure to the plugs to cause the plug facets to become concave and withdrawing the plugs by raising the frame and releasing the unit by freeing the side walls of the mould.

In carrying the invention into effect according to one mode described, by way of example, for manufacture of gypsum plaster panel units (suitable for walling purposes), a series of rubber plugs are moulded for use in conjunction with a mould table having displaceable side walls for forming a facing in monolithic integrity with the cell forming walls.

Each plug for the main area of the unit is moulded of a sufficiently pliable rubber to enable it to be deformed or distorted by suitable differences of air pressure internally applied. The shape of the plug is that of a steep truncated pyramid having a regular hexagonal base and is in cup-like form, the truncation surface being the bottom of the cup whilst the rim thereof is flanged or channeled to receive a base closure plate secured to the rubber in an airtight manner. The facets of the plug are sufficiently stout to withstand the pressure of the plaster when the plug is immersed therein with or without the assistance of air at superatmospheric pressure introduced into the interior of the plug. The facets of the pyramid are moulded in one with the truncation surface which may be made, if desired, somewhat thinner than the facet walls of the plug or be made with a slightly convex exterior surface, in either case the intention being that when air pressure is employed before or during the immersion of the plug in plaster, the truncation surface will become convex or increase its convexity in order to drive out air which might otherwise be trapped beneath the truncation sur

face, when such contacts with the plaster.

According to one suitable mode of closing the base of the pyramid, it may be provided with a short circular neck portion which is inwardly channelled or flanged to receive a correspondingly shaped closure plate, the neck being sealed to the plate adhesively or by pressure exerted by a metal contractible strap of known type. Alternatively, the base may be provided with a closure surface or member in an appropriate manner. Each of the closures is provided with a pair of rods adapted to form suspensory supports for the plugs in a framework or spider described below. These rods may be tubular or semi-tubular to decrease their weight. Tubular rods may be employed as air ducts but for convenience in making adjustments of the plugs, it is preferred to provide separate air ducts which may be in the form of a pipe or pipes traversing the base closure of each plug, through which the air pressure within the plug may be varied by supplying compressed air or evacuating the interior of the plug.

Plugs having the above characteristics are provided for the main area of the units but for the sides of the units and at one or both ends special plugs which are half or a fragment of a hexagon are provided, when it is not desired to form the unit with a whole number of complete hexagonal cells. For example, for the longer sides of the panel unit plugs of half hexagon shape are employed, the division taking place across diagonals between corner and corner while the fractional plugs at the end or ends of a panel may be divided by a line at right-angles to a pair of parallel facets. These fractional plugs otherwise have the same characreristics and accessories as the full hexagon plugs.

The panels are preferably moulded in lengths suitable for room height to extend from floor to ceiling and for such purpose sets may be moulded in 8 ft., 9 ft., or 10 ft. lengths. If units are to be used in bonded horizontal courses the dimension will be chosen for convenient handling and erection. The width of the panels is conveniently 2 ft. although it will be obvious that panels may be made in other chosen widths, if desired.

The plugs may be made in any suitable size, a convenient size being $5\frac{1}{4}$ inches taken between parallel facets at the truncation end and $5\frac{5}{8}$ inches at the base of the pyramidal form. The axial length of a plug may be 2 inches, 3 inches or 4 inches, or other chosen dimensions, according to the thickness of the units to be moulded. It will be appreciated that if a universal plug is to be provided for moulding panels of different thicknesses, a certain limitation will exist owing to the fact that if very long plugs are used the cell walling at its base will have to be thicker than is desirable, while ensuring an adequate thickness of plaster at the outer end or rim of the cell walling.

The plugs are disposed in spaced relation to one another such as to leave an adequate clearance between the exterior periphery of the plugs at their base when in moulding position for moulding the outer edge of the cell walling of suitable thickness, for example in the region of $\frac{1}{2}$-inch. The taper form of each plug causes the walling of each cell to to be moulded of corresponding taper decreasing in thickness towards the outer end of the cells of the element formed in the first moulding operation, resulting in one facing and open-ended cells.

The spider for supporting the plugs comprise stout bars disposed transversely of the length of the panel to be moulded, mounted in longitudinal channel members having depending, preferably hinged, flaps or sides adapted to register with the side walling of a mould table described below. The transverse panel end members such as angle irons, are connected to the ends of the said longitudinal channels to which are coupled hinged end flaps to register with the end walling of the said mould table. The longitudinal members may be mounted on lifting mechanism or hoists for raising and allowing the plugs to be lowered for immersion in the plaster of the mould table, or lifting means may be separate members attached to the spider. The vertically controlling mechanism for the spider, may be mounted on carriages traversable on rails for displacing the spider and plugs as a whole horizontally in mutually perpendicular or other directions for the purpose of positioning the plugs over the mould table and moving such away.

In place of a spider or framework, a flat plate may be employed for mounting the plugs, the underside of which may be operated as a stop or moulding limit for the upper edge of the cells.

The air pipes of selected pairs of plugs are connected together in series for the equal distribution of the air pressure effects and the terminal piping of each row of plugs is connected to a header which is alternatively connectible by suitable three-way valve means to a source of compressed air and a source of evacuation. Alternatively, the air connections are disposed in any suitable manner in order to distribute the air pressure effect equally and simultaneously to all plugs for moulding a unit, and any arrangements are provided for ensuring that the pressure, having regard to the shape of the plugs operates, substantially equally in each plug whether of full or fractional form.

The mould table comprises a bottom plate of suitable rigidity or made rigid by the addition of reinforcement. The margins of this plate or table have hingedly secured thereto flaps, the hinged arrangement being convenient for displacing them outwardly to

release the unit at the appropriate stage in the formation thereof. Stop means are provided for the flaps to limit their outward and inward hinging movement, stops for the latter position being adapted to ensure the vertical disposal for the moulding position. The inward sides of the flaps are provided with broad ribs or like forms extending horizontally for moulding grooves in the outer edges or margins of the unit and this ribbing may be contoured to mould a channel extending into a deeper channel in the central zone of the edges. This ribbing and the corresponding moulded channels are for the purpose of forming elongated continuous cavities when moulded units are placed edge to edge for building purposes, in order that plaster or cement grouting may be poured into the vertical channels and extend along the horizontal channelling between a unit and flooring or base supports or between one unit and the next below it in the case of horizontally bonded units.

The ribbing or internal surface of the side flaps may be made interchangeable, or interchangeable side walling flaps may be provided for moulding different thicknesses of the element or unit or changing the peripheral configuration or edges of such element or unit. According to one mode of providing for interchangeability the hinge formation may be such that the hinging knuckles may be readily detached or the hinged pin withdrawn.

Suitable means may be provided on the side flaps for ensuring the registration of the depending portions of the plug spider. For example, means may be provided which form a groove or clearance for the reception of the edges of the spider flaps, the bottom of the groove serving as a downward limit for the descent of the plugs into the moulding plaster.

The vertical position of the plugs with respect to their supporting bars is determined by adjustable means associated with the suspension rods. For example, the rods may be screwthreaded and secured by nuts in any adjusted position with respect to the bars. These adjustments when made will be standard for the predetermined unit to be moulded but may be varied when using universal plugs for different thicknesses of unit. Certain of the plugs (for standard sets of plugs) may be adjusted for accommodation purposes as explained hereinafter.

The process of moulding the cell walling in conjunction with the facing is as follows:—

The plugs are adjusted in the selected spider to the correct vertical position for moulding an element comprising the cell walling, including the peripheral walling of the element and a facing of the chosen thickness.

The facing-mould with the marginal walling is charged with plaster which is sufficiently liquid to enable it to rise in the plug clearances when the plugs are immersed in the plaster, the quantity of plaster being predetermined such that the plaster will rise to the edge of the mould walling.

Compressed air is admitted to all the plugs and sufficient pressure laterally to support the facets of the plugs against the pressure of the plaster and cause the truncation surface thereof to become slightly dished or convex.

The plug spider is then lowered until the truncation surface of the plugs touches the plaster level, after which the plugs are allowed to sink into the plaster under gravity action while vibration is applied to the mould to facilitate the flow and displacement of the plaster and to avoid the occlusion of air. Instead of initially introducing compressed air, it may be admitted as the plugs are about to contact the plaster. The plugs sink by gravity action (or under applied pressure) into the plaster until the edge of the side flaps of the spider rest upon the mould walling and further downward movement is arrested.

A period is then allowed for the plaster to set, after which the compressed air is released enabling the convex truncation surfaces of the plugs to retract to their normal position. Upon the escape of compressed air, connection is made with the evacuating source and the air pressure within the cells is reduced to an extent which will render the facets of the plugs to be drawn inwards and assume a concave form, thereby releasing the moulding contact of the facets with the plaster and allowing the plugs to be withdrawn by lifting the spider, such withdrawal taking place clear of the internal surface of the plaster walling defining the cell cavities.

When once the plugs have been adjusted to the correct vertical height for a unit of predetermined dimensions they remain fixed but in order to accommodate any irregularities in the flow or displacement of the plaster owing to the differences in the moulding action of the plugs, certain of the plugs may be readjusted from time to time to accommodate such variations.

The plate surface area of the facing-mould may be plain or formed with ornamental relief or intaglio forms or with ribbing or grooving in order to form keying elements to which a Portland cement or quick-setting cement or composition of harder or different characteristics from that of the plaster may be moulded in order to render the units suitable for the outer walls of buildings or for other purposes. The flaps of the facing-mould at its corners may be mitred, rebated or otherwise formed for the purpose of preventing leakage of plaster.

In the above described mode of carrying the invention into effect, full hexagon plugs have been described for the main cells and the use of half or fractional cells for the marginal or corner portions. It is to be understood that all the cells may, if desired, be moulded in half

hexagonal form by the use of plugs of corresponding shape, each half plug having its diagonal face or walling spaced from the complementary plug such that the unit is provided with rectilinear aligned walls arranged either lengthwise or transversely of the unit.

The plaster employed for the moulding operation may be used plain or reinforced or mingled with vegetable or mineral fibres of a length such as will not interfere with the flow of the plaster and, if desired, foamed plaster may be employed for the cell walling and the facing; also for certain purposes it may be suitable to charge the cells when formed with foamed plaster, instead of leaving them hollow.

Although it is preferred to make the cell-forming plugs of rubber, they may be formed of a synthetic composition such as neoprene or other pliable and resilient resin, and the side walling of the facing-mould may be lined with a material such as polyvinyl chloride or polythene, to prevent sticking and avoid the application of grease or the like.

The rubber or other composition of which the plugs are mainly composed may be reinforced or lined with ~~canvas~~ Canvas or other fabric in a manner which will not interfere with their deformation or collapsing in the described manner.

During the moulding operation high frequency or other vibrations may be imparted to the plug supported framework, or to the mould table, or both. and it is preferred to employ a rectilinear vibration or vibration confined to one plane.

The moulded element comprising a facing, open-ended cells and marginal walling, may be useful for lining interior walls of buildings, or a pair of such elements may be positioned with the open cells towards one another and utilised as ~~shutting~~ Shuttering for use with cement or for receiving other filling.

Reinforcement for the facing may be provided in the form of embedded wires or net by laying such in the facing plaster in the appropriate position.

In the edging walls holes or slots may be provided so that they are transversely and/or longitudinally aligned for the purpose of locating bolts or set screws through metal inserts embedded in the edging of one unit with a screwthreaded insert or nut member on another unit.

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