Nov. 21, 1944. J. A. BRUND 2,363,226

METHODS OF MAKING WALL PLATES AND THE LIKE

Filed Dec. 21, 1943

FIG. 6.

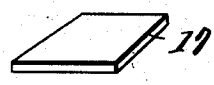


FIG. 7.

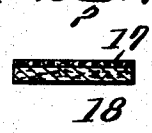


FIG. 8.

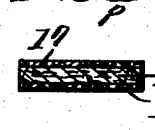


FIG. 9.

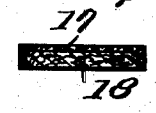


FIG. 10.

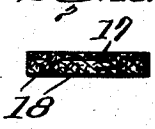


FIG. 11.

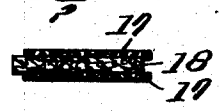


FIG. 12.

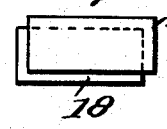


FIG. 13.

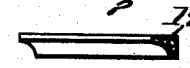


FIG. 14.

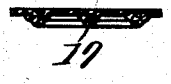


FIG. 15.

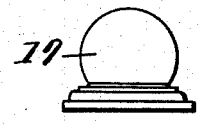


FIG. 1.

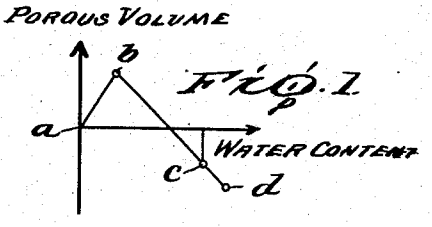


FIG. 2.

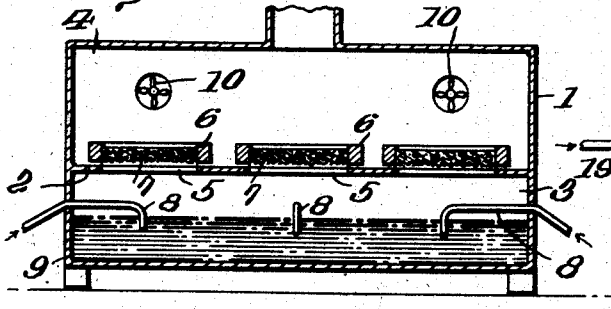


FIG. 4.

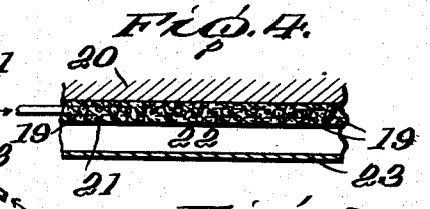


FIG. 5.

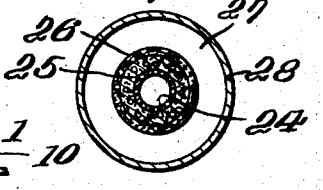
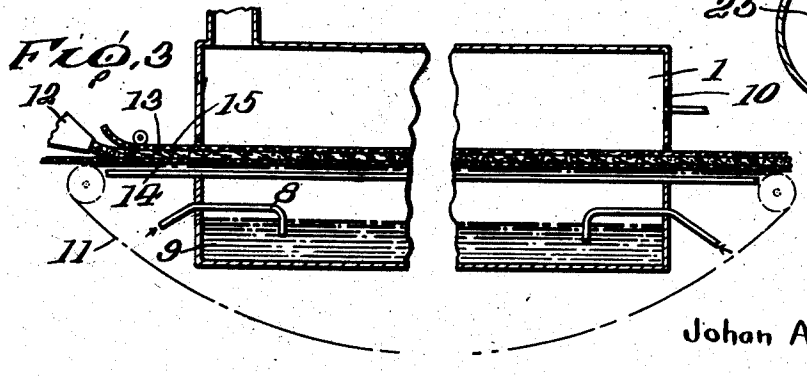


FIG. 3.



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Patented Nov. 21, 1944

2,363,226

UNITED STATES PATENT OFFICE

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METHODS OF MAKING WALL PLATES AND THE LIKE

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Application December 21, 1943, Serial No. 515,158
In Sweden January 8, 1943

19 Claims. (Cl. 25—155)

This invention relates to the manufacture of flame protective tiles, wall panelling plates, wall lining plates, insulating plates, wall decorating and ceiling plates, cornices, pieces of sculpture, wall finishing coats, ceiling coats and various other articles and structures that are made, wholly or in part, of a plaster or mortar hardening on drying. More particularly the invention relates to the manufacture of such articles or structures when made, wholly or in part, of a plaster or mortar containing a substance, such as quicklime, or hydrated lime, magnesia or the like, that is capable of chemical reaction with carbon dioxide, or carbonic acid, to form a carbonate practically insoluble in water.

One object of the invention is to provide a method for using lime plaster or mortar with success for the manufacture of such articles and structure as are otherwise usually made of gypsum plaster. That lime plaster or mortar could hitherto not be used with success for the manufacture of the articles and structures in question, was substantially due to the fact that lime plaster or mortar would take too long a time to set or harden and would not attain the necessary, or desirable, strength.

A further object of the invention is to provide a method for obtaining a relatively quick hardening and a relatively high strength of lime and like plasters and mortars when used in, or for, the manufacture of articles and structures of such various kinds as hereinbefore referred to by way of example.

The above and other objects of the invention will become apparent from the following description and the accompanying drawing in which—

Fig. 1 is a diagram illustrating the relation between porous volume and water content of a lime plaster or mortar.

Fig. 2 is a diagrammatic sectional view of a carbonic acid hardening chamber for carrying out the method of the invention according to one form thereof.

Fig. 3 is a diagrammatic sectional view of a carbonic acid hardening chamber for carrying out the method of the invention according to a second form thereof.

Fig. 4 is a sectional view of a wall or ceiling coat of lime plaster, and illustrates a form of the invention for carbonic acid hardening of such a coat.

Fig. 5 is a sectional view of a pillar having a coat of lime plaster, and illustrates a form of the invention for carbonic acid hardening of said coat.

Figs. 6 to 15 illustrate, by way of example, various articles or structures that can preferably be made, wholly or in part, of lime or like plaster or mortar when carbonic acid hardening the latter according to the method of this invention. Fig. 6 is a perspective view of a flame protective tile, Figs. 7, 8, 9, 10 and 11 are sectional views of different forms of insulating or wall panelling plates having on one side or both sides a flame protective coat of lime or like plaster or mortar. Fig. 12 is a plan view of the plate shown in Fig. 11. Fig. 13 is a perspective view of a cornice. Fig. 14 is a sectional view of a decorating or ceiling plate. Fig. 15 is an elevation of a piece of sculpture.

It is well known that the setting or hardening of lime plasters and mortars in the air is caused, to a certain degree at least, by the formation of calcium carbonate in the plaster or mortar by chemical reaction of the calcium hydrate therein with carbonic acid having its origin in the carbon dioxide in the air. This chemical reaction, however, is but slow on account of the small carbon dioxide content of the air. To expedite the reaction it has been proposed to produce and maintain an atmosphere of a higher carbon dioxide content in the surroundings of the plaster or mortar during the setting or hardening thereof. But even if the hardening process could be expedited to a certain degree in this way, it still required a considerable length of time and, furthermore, no appreciable increase, but often a decrease, of the resulting strength of the plaster or mortar was obtained in this way.

The lack hitherto of a quick method for carbonic acid hardening of lime plaster and mortar to a high degree of strength is obviously due to the fact that those skilled in the art had no exact knowledge of the chemical and physical conditions of the process causing the hardening. It might be mentioned by way of example that the exact amount of water necessary for the process was not known. In certain technical literature it has even been stated that a generally valid lime water ratio (kg. water per kg. lime) cannot be ascertained precisely. Only little was known of the effect of surplus water, or water formed during the reaction, or of the elimination of such water in the course of the process. To solve these problems it is necessary to give up the old idea that lime in a plaster or mortar can without further ado give a crystallized cal-

cium carbonate with the carbon dioxide contained in the surrounding air or atmosphere. This is not the case, for in reality a number of conditions must be fulfilled for obtaining a complete crystallization of calcium carbonate throughout the whole mass of plaster or mortar. The first condition is that the plaster or mortar shall have such a water content from the very beginning that both the lime and the carbon dioxide may dissolve in the water so that the formation of carbonate may take place by exchange of ions according to the following formula:

$$Ca^{\cdot\cdot}+2OH'+2H'+CO_3''=CaCO_3+2H_2O$$

The necessary, or optimal, quantity of water for the reaction is not to be seen from the quantitative equation of this formula. The necessary, or optimal, quantity of water for the reaction must therefore be ascertained in another way, for which the following rules may serve as a guide. As indicated in the diagram in Fig. 1 of the drawing, with an increasing addition of water to the mortar the porous volume thereof increases from an original value *a* to a maximum value *b* and thereafter decreases again to a value *d* at which value, when the mortar is packed to the desired degree, water begins to trickle out through the surface of the mortar. Generally the value *d* is considerably lower than the value *a*. The greater the porous volume is, the smaller the contact between the particles in the mortar is. If the quantity of water is less than that corresponding to the value *b*, the formation of carbonate crystals is but weak, the crystals thus formed not being able to grow or develop to a substantial size or come into substantial contact with one another, partly on account of the quantity of water being rather small, partly on account of the contact between the particles, which favours the crystallization, at the same time being relatively small. If, on the other hand, the quantity of water is greater than that corresponding to the value *d*, part of the added water will ooze out through the surface of the mortar. This surplus water contains lime, and as long as this water has not evaporated, it retards the crystallization because it obstructs the water in the mortar, including that water arising from the reaction, from escaping to the surface and evaporating. As the crystallization conditions thus also become less favourable, if the quantity of water exceeds that value corresponding to *d*, the quantity of water should obviously be such as corresponds to a value lying between *b* and *d*. But as a substantial contact between the particles in the mortar is favourable for the crystallization, such contact ought to be as great as possible without entailing the risk of water trickling out through the surface of the mortar. Hence the optimal quantity of water ought to be such as to correspond to a value which like that shown by way of example in Fig. 1 and designated with *c*, is in the neighbourhood of the value *d*. Not all conditions, however, for the formation of carbonate and for the crystallization thereof are fulfilled by the elimination, or evaporation, of water from the surface of the mortar, even though a suitable content of water is thereby obtained in the mortar. When water evaporates from the surface of the mortar the lime contained in such water will form on the surface of the mortar a crust of calcium carbonate which prevents or retards the penetration, or absorption, of carbon dioxide into the mortar and encloses the water in the interior of the mortar. It is therefore especially important to prevent the formation of such a crust. In accordance with the invention this is obtained by letting the mortar, whilst setting or hardening, form a diaphragm between two spaces, and by maintaining in the one of these spaces a moist atmosphere containing, and preferably rich in, carbon dioxide, and in the other space an atmosphere of sufficiently low relative humidity to cause evaporation of water from the mortar on that side or surface thereof exposed to this last mentioned atmosphere. As the atmosphere containing, and preferably rich in, carbon dioxide is maintained in a moisture charged condition, little or no evaporation of water takes place on that side or surface of the mortar exposed to this atmosphere and, therefore, in spite of the carbon dioxide content of this atmosphere being relatively high, no crust is formed on the surface of the mortar exposed to this atmosphere, and so the continued penetration, or absorption, of carbon dioxide into the mortar and solution in the water contained therein will not be obstructed. The carbon dioxide dissolving in the water in the mortar diffuses through the latter towards the evaporating side, and because the evaporation of the water from the mortar on this side thereof does not interfere with the penetration, or absorption, of carbon dioxide into the mortar through the other side thereof, the evaporation of the water from the mortar on the evaporating side may be regulated in such a way that a complete conversion of the lime content in the mortar to a well crystallized calcium carbonate of limespar type is secured, with the result that the mortar attains an unusually high strength. In this way the hardening of lime plaster or mortar in any thicknesses usual, or desirable, in such various articles and structures as herein referred to, can be carried out in a sufficiently short time and with the aid of sufficiently simple means to make the herein described method of production advantageous both technically and economically.

So that the invention may be clearly understood some simple forms of means for carrying it into effect are illustrated more or less diagrammatically in Figs. 2 to 5 on the drawing.

According to the form shown in Fig. 2 the carbonic acid hardening process is carried out in a chamber **1** provided with a horizontal partition **2** dividing the chamber into a lower compartment or space **3** and an upper compartment or space **4**. The partition **2** is provided with apertures **5** and supports moulds **6** having bottoms **7** that are foraminous or otherwise permeable to carbon dioxide and, for instance, consist of wire or screening, perforated sheet metal, fibrous material, cloth or the like. The moulds **6** are placed with their permeable bottoms **7** over the apertures **5** in the partition **2**. The bottom portion of the lower space **3** serves as a water container. Supply conduits **8** for carbon dioxide or gases containing, and preferably rich in, carbon dioxide, e. g., combustion gases, debouch under the surface of the water **9**. When pure carbon dioxide is supplied, it may be taken from a high pressure container therefor through a pressure reducing valve, and when combustion gases or the like are supplied, they may be propagated by means of a fan or the like. The upper space **4** is adapted to be ventilated in a suitable way, by means of fans **10** for fanning air through it, for example, the air being heated or its relative humidity regulated, as required, in any other suitable manner. Lime plaster or mortar whose

water content has been suitably adjusted in accordance with the invention, is cast, or otherwise placed and shaped as desired, in the moulds 6 and allowed to remain in these moulds during the hardening process. In carrying out this process a moist atmosphere containing, and preferably rich in, carbon dioxide is produced and maintained in the space 3 by introducing carbon dioxide, or gases containing carbon dioxide, into this space through the water 9, so that the carbon dioxide or gases bubble up through the water and thus become charged with moisture. Water is evaporated from that surface of the mortar facing space 4, and the evaporation is regulated in a manner suitable for the hardening process by means of regulating the ventilation of this space, through which ventilation the evaporated water is eliminated. During the hardening process preferably a certain, though small, difference in pressure is maintained between the atmospheres in the spaces on either side of the diaphragm formed by the mortar, and in such a way that the pressure of the moisture charged atmosphere rich in carbon dioxide is predominant. This difference in pressure promotes the penetration, or absorption, of the carbon dioxide into the lime mortar and to the passing of the carbonic acid and moisture through the lime mortar from the carbon dioxide supply side towards the water evaporating side.

According to the illustrative form of the invention just described the hardening process is carried out discontinuously, which may be preferable, when it is a question of the hardening of a piece of sculpture or like articles of more or less irregular shape and size and moulded in lime plaster or mortar. In the case of mass production of flame protective or panelling plates or tiles and the like of regular form and size it is preferable to carry out the production, including the hardening, continuously, which, as far as the hardening is concerned, can be achieved in a simple manner by letting the permeable support carrying the lime mortar during the hardening run on an endless conveyer through the hardening chamber. For this purpose moulds used for the casting of the plates and having bottoms permeable to the carbon dioxide may be provided, or placed, on an endless conveyer running through the hardening chamber.

As illustrated in Fig. 3 the permeable support for the lime plaster or mortar during the hardening may also consist of an endless permeable conveyer 11 running through the hardening chamber 1, the lime plaster or mortar being applied, e. g., pressed out through a nozzle 12, in the form of a layer 13 onto this conveyer before, or on, entering the hardening chamber. In this way a continuous lime plate may be produced which is continuously removed from the supporting conveyer on, or after, its exit from the hardening chamber. This continuous plate may afterwards be divided into pieces of any desired size, but such division can of course also be performed before the hardening, if desired. The conveyer 12 may consist of metal wire netting (like a paper machine net) or of fine metal netting or of cloth.

As a lime mortar support permeable to the carbon dioxide during the hardening process, it is also possible to use a layer, for instance in the form of a plate or sheet, of fibrous material of such a nature that the lime mortar during the setting or hardening adheres to this fibrous layer. When casting lime mortar in a mould in which it remains during the hardening, the bottom of the mould may by way of example consist of a fibrous board or sheet which during the setting or hardening of the mortar adheres or binds to the latter. When using moulds of the kind shown in Fig. 2, a fibrous plate or sheet may be laid on the bottom 7 of the mould before filling the lime plaster or mortar into the mould. When applying the lime plaster or mortar in a continuous layer onto a support running through the hardening chamber, this support may consist of fibrous material. When using an endless conveyer as shown in Fig. 3, a fibrous plate or sheet 14 may be continuously introduced between the endless conveyer 11 and the lime mortar 13 in applying the latter onto the conveyer. It is also possible to provide a fibrous plate or sheet, for instance as shown at 15 in Fig. 3, on the upper side of, and in such contact with, the lime mortar to be set or hardened that the mortar whilst setting or hardening adheres or binds to this plate or sheet, through which, when it is on the evaporating side of the mortar, the elimination or evaporation of the water from the mortar during the hardening takes place. Thus composite panelling plates or the like of hardened lime mortar having a reinforcing or insulating layer or the like of fibrous material on one side or both sides may be produced. Plates, panels or the like may of course be manufactured with an inner reinforcement of any nature, or with an inner insulating layer of fibrous or porous nature. In order to strengthen the adherence or bond obtained between the fibrous material and the lime or like plaster or mortar during the hardening of the latter, the fibrous material may be soaked with lime milk or the like before bringing it in contact with the plaster or mortar to be hardened. This method of strengthening the adherence or bond is generally applicable to the production of composite articles or structures of a fibrous material and a plaster or mortar comprising a binding agent, such as burnt lime or slaked lime, hardening under the influence of carbon dioxide. In all such cases the fibrous material may be soaked with a solution, or suspension, of such binding agent and then be allowed to dry more or less before the fibrous material and the plaster or mortar are brought into contact with one another to form the desired article or structure which is then subjected to the herein described hardening process. If and when drying the soaked fibrous material before the application of the plaster or mortar thereto, care should be taken to avoid the formation of a crust on the surface of the soaked fibrous material. The binding agent absorbed by the fibrous material will form roots therein, so to say, which during the hardening process bind to the plaster or mortar in contact with the fibrous material. Figs. 6 to 15 show various panelling and insulating plates and other articles that can preferably be manufactured in accordance with the method of this invention, and in these figures the reference numeral 17 denotes hardened lime or like plaster or mortar, whilst the reference numeral 18 denotes fibrous or like porous material.

The support carrying the plaster or mortar whilst hardening need not necessarily be horizontal, but can even be vertical and may consist of a reinforcement or revetment or the like. In this case the space in which the moisture charged atmosphere rich in carbonic acid is

maintained during the hardening, may consist of an interior hollow space in the reinforcement or revetment which, for the purposes in question, may consist of a revetment mat or the like of thin pipes into which the moist carbon dioxide atmosphere is introduced, said pipes being perforated for permitting the passage of the carbon dioxide to the mortar. By means of such a modification of the method it may be used even for hardening a finishing layer of lime plaster or mortar on a wall, ceiling or the like. As illustrated in Fig. 4 a mat or the like of thin revetment pipes 19 is fixed to a wall 20 for holding a coat 21 of lime plaster or mortar, the pipes being provided with the perforations on that side facing the wall so that a choking of the holes is prevented when the lime plaster or mortar is applied. The regulated evaporation of water from the lime plaster or mortar during the hardening process takes place on the outer surface of the coat 21 by means of fanning and heating of the air there. To facilitate this fanning and heating, or for making same more effective, a limited space 22 may be provided adjacent the surface of the lime mortar by erecting a provisional wall 23 of tarpaulin, wood fibre plates or the like at a suitable distance from the said surface.

According to the form of the invention illustrated in Fig. 5, a pillar or the like is made by providing a perforated metal tube 24 with an outer layer 25 of fibrous material, and with a coat 26 of lime plaster or mortar on said fibrous material, the said coat being hardened by introducing moist gases rich in carbon dioxide into the tube 24, whilst evaporating water from the outer side of the coat by fanning air, heated as requested, through a space 27 formed between the coat 26 and a provisional wall 28.

It is to be understood that the term plaster or mortar used hereinbefore and in the appended claims is to cover not only all plastic masses hardening under the influences of carbon dioxide (CO_2), e. g., plasters or mortars comprising burnt lime or slaked lime or magnesia or the like, but also mixtures thereof with inorganic or organic fillers, such as sand, saw-dust, hair, fibre, etc.

What I claim and desire to secure by Letters Patent is:

1. In the manufacture of wall plates, wall coats and other articles and structures that are made, wholly or in part, of a plaster or mortar hardening on drying, the herein described method which comprises using a plaster or mortar hardening under the influences of carbon dioxide, and hardening said plaster or mortar by subjecting it on different sides to a moist atmosphere containing carbon dioxide, and an atmosphere of sufficiently low relative humidity to cause evaporation of water from the plaster or mortar on that side thereof subjected to this last-mentioned atmosphere.

2. In the manufacture of wall plates, wall coats and other articles and structures that are made, wholly or in part, of a plaster or mortar hardening on drying, the herein described method which comprises using a lime plaster or mortar, and hardening said plaster or mortar by maintaining on different sides thereof a moist atmosphere containing carbon dioxide, and an atmosphere of sufficiently low relative humidity to cause evaporation of water from that side of the plaster or mortar exposed to this last-mentioned atmosphere.

3. In the manufacture of wall plates, wall coats and other articles and structures that are made, wholly or in part, of a plaster or mortar hardening on drying, the herein described method which comprises using a plaster or mortar hardening under the influence of carbon dioxide, moulding said plaster or mortar, maintaining in separate spaces a moist atmosphere containing carbon dioxide and an atmosphere of a relatively low relative humidity, and hardening the moulded plaster or mortar by letting same form a diaphragm between said spaces.

4. In the manufacture of wall plates, wall coats and other articles and structures, the herein described method which comprises moulding a plaster or mortar hardening under the influence of carbon dioxide, causing the moulded plaster or mortar to form a diaphragm between two spaces, charging one of said spaces with a moist atmosphere containing carbon dioxide, bringing about an atmosphere of such reduced humidity in the other space as to cause an evaporation of water from the surface of the diaphragm exposed to this last-mentioned atmosphere, and maintaining these different atmospheric conditions in the spaces on opposite surfaces of the intermediate diaphragm until the plaster or mortar has set and hardened.

5. The method of producing articles and structures of a plaster or mortar hardening under the influence of carbon dioxide, which comprises shaping the plaster or mortar into a desired form and, in so doing, arranging it as a diaphragm between two spaces, passing carbon dioxide to one of said spaces, charging the carbon dioxide with moisture during the passage thereof to the said space, bringing about an atmosphere of such reduced humidity in the other of said spaces as to cause an evaporation of water from the surface of the diaphragm facing this last-mentioned space, and maintaining said different atmospheres in the spaces on opposite surfaces of the intermediate diaphragm until the plaster or mortar has set and hardened.

6. The method of producing articles and structures of a plaster or mortar hardening under the influence of carbon dioxide, which comprises shaping the plaster or mortar into a desired form, letting the shaped plaster or mortar form a diaphragm between separate spaces, introducing moist gases containing carbon dioxide into one of said spaces, and ventilating air of such reduced humidity through the other of said spaces as to cause an evaporation of water from the surface of the diaphragm facing this last-mentioned space.

7. The method of producing articles and structures of a plaster or mortar hardening under the influence of carbon dioxide, which comprises shaping the plaster or mortar into a desired form and then hardening it by letting it act as a diaphragm between two spaces and by maintaining in one of said spaces an atmosphere charged with moisture and rich in carbon dioxide, and in the other of said spaces such atmospheric conditions as to cause an evaporation of water from the surface of the diaphragm exposed to these atmospheric conditions, a somewhat higher pressure being maintained in the first-mentioned than in the last-mentioned of said spaces.

8. The herein described method which comprises moulding an article or structure of a plaster or mortar hardening under the influence of carbon dioxide and then hardening it by subjecting it on one of its sides to heated drying air, while simultaneously supplying carbon dioxide in a

moist state to another side of the article or structure.

9. The herein described method which comprises shaping a plaster or mortar hardening under the influence of carbon dioxide into a desired form and then hardening it by passing it through a chamber on supporting means permeable to carbon dioxide and, in so doing, letting the plaster or mortar form a diaphragm dividing said chamber into two spaces, charging one of said spaces with a moist atmosphere containing carbon dioxide, and ventilating the other of said spaces for evaporating water from the surface of the structure facing the last-mentioned space.

10. The herein described method which comprises moulding an article of a plaster or mortar hardening under the influence of carbon dioxide, by depositing the plaster or mortar into a mould with a bottom permeable to carbon dioxide, arranging the mould containing the deposited plaster or mortar in such a manner that the plaster or mortar forms a diaphragm between two spaces, charging one of said spaces with moist carbon dioxide, and ventilating the other of said spaces for evaporating water from the plaster or mortar in the last said space.

11. The herein described method which comprises depositing a layer of a plaster or mortar hardening under the influence of carbon dioxide on a foraminous endless band continuously running through a chamber and dividing said chamber into two spaces, charging one of said spaces with a moist atmosphere containing carbon dioxide, and ventilating the other of said spaces for evaporating water from the surface of the mortar in the last said space.

12. The method of producing a composite article or structure of a fibrous material and a plaster or mortar hardening under the influence of carbon dioxide, which comprises depositing a layer of such plaster or mortar associated with a fibrous material onto a foraminous endless conveyer continuously running through a chamber and dividing said chamber into two spaces, charging one of said spaces with a moist atmosphere containing carbon dioxide, ventilating the other of said spaces for evaporating water from the plaster or mortar, and discharging the said plaster or mortar and associated fibrous material from said conveyer.

13. The herein described method which comprises coating a permeable fibrous board or sheet on one side with plaster or mortar hardening under the influence of carbon dioxide, and then hardening the plaster or mortar by subjecting the coated board or sheet on one side to a moist atmosphere containing carbon dioxide, while simultaneously evaporating water from the other side of the coated board or sheet.

14. The herein described method which comprises coating a permeable fibrous plate or sheet on both sides with a plaster or mortar hardening under the influence of carbon dioxide, and then hardening the plaster or mortar by subjecting the coated plate or sheet on one side to a moist atmosphere rich in carbon dioxide, while simultaneously evaporating water from the other side of the coated plate or sheet.

15. The herein described method which comprises applying a plaster or mortar hardening under the influence of carbon dioxide as a coat to a revetment made of thin perforated hollow members erected in the proximity of a wall or ceiling, introducing a moist gaseous medium comprising carbon dioxide into said hollow members, and heating and circulating the air adjacent the outer surface of the said coat.

16. The herein described method which comprises providing a wall or the like with a revetment of hollow unilaterally foraminated members with their foramina facing the wall, applying a coat of a plaster or mortar hardening under the influence of carbon dioxide onto said revetment, and supplying a moist gaseous medium comprising carbon dioxide to said coat through said hollow foraminated members, whilst drying said coat through evaporation of water from the outer surface thereof.

17. The method as claimed in claim 16, which comprises erecting a provisional wall at a short distance in front of the applied coat, and circulating heated air through the space between the coat and the said provisional wall to promote, and to afford an opportunity to regulate, the evaporation of water from the outer surface of the coat.

18. The method claimed in claim 1, in which the plaster or mortar to be used is given a water content approaching that at which water begins to trickle out through the surface of the plaster or mortar when packing same to the desired degree.

19. The method of producing a composite article or structure of a fibrous material and a plaster or mortar comprising a binding agent hardening under the influence of carbon dioxide, which comprises soaking the fibrous material with a solution of such a binding agent, then applying said plaster or mortar and said soaked fibrous material in contact with one another for forming the desired composite article or structure, and finally hardening said plaster or mortar, while in contact with said fibrous material, by subjecting the article or structure formed on one side to a moist gaseous medium containing carbon dioxide, and on another side to a gaseous medium of relatively low relative humidity for evaporating water from the article or structure on last said side thereof.

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