(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 607 625 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **93121160.1**

(51) Int. Cl.[5]: **B27K 3/08**

(22) Date of filing: **31.12.93**

(30) Priority: **19.01.93 JP 23752/93**

(43) Date of publication of application:
27.07.94 Bulletin 94/30

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB IT LI LU NL SE

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(54) Method of and apparatus for injecting treating liquid into wood and porous inorganic material.

(57) Disclosed is a method of injecting treating liquid into wood material and porous inorganic material comprising the steps of:

an initial pressure-applying step in which the material to be treated is subjected to a predetermined pressure which does not cause deformation and maintained at said pressure for a predetermined period of time;

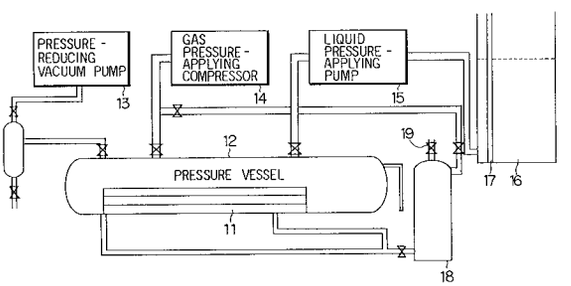
a preliminary pressure-applying step in which after the material is maintained at said pressure for the predetermined time, the pressure thereon is increased in steps, while in each stage of pressure application the material to be treated is subjected to a particular pressure for a predetermined length of time; and

a treating-liquid injecting step in which the treating liquid is injected into said material to be treated at a predetermined treating-liquid injecting pressure.

Disclosed is also a method of removing and reducing the pressure from a high pressure back to atmospheric pressure, without destroying the material.

Accordingly, the treating liquid can be thoroughly injected to its interior, without deforming the raw material.

Fig.7



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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method of and apparatus for injecting treating liquid such as resin into wood material and stone material. More particularly, the present invention relates to a method of injecting a treating liquid which gives the wood material high rot resistance, insect resistance, ant resistance, mold resistance, flame resistance, dimensional stability, and increased strength, and which gives the stone material increased acid resistance. The present invention also relates to a method of destroying ray parenchyma cell walls and aspirated pit-pairs. Description of the Related Arts

Hitherto, various methods have been used for injecting treating liquids into the wood material for making it highly flame resistant, rot resistant and insect resistant, and for giving it high dimensional stability and increased strength.

The treating liquids have been injected into the wood material by applying thereupon pressure right up to a specified pressure in a short time while maintaining that pressure for a long period of time. In this case, though depending on the kind of wood material used, the injection of the treating liquid has been generally carried out at a pressure not more than 15 kg/cm2 because injection carried out above this pressure causes the wood material to deform such as to warp, bend, or to become thinner.

In recent years, deterioration of buildings made of stone material caused by acid rain has become a problem in Europe. Various measures have been taken to protect the stone material from acid rain, such as applying the treating liquid to the stone material, and taking advantage of the properties of the stone material itself, such as the property of marble to neutralize acid water which comes in contact with its surface.

The wood material generally has many groups of cells as shown in Fig. 8. Between each cell is a structure consisting of a wall pit-pair 1 scattered about forming wall pit 2 as shown in Fig. 8. At the center of the wall hole 2 is a hyperplastic portion, called a torus 3. The torus 3 is surrounded by a thin mesh-like pattern (margo). In the wood material having this kind of structure, in the process of processing the wood material into heart wood and the like, the wall pit wall is drawn toward one of the pit openings, so that the torus 3 blocks the pit opening. The wood material in this condition is said to have an aspirated pit-pair. When the wood material has an aspirated pit-pair, the torus 3 blocks the pit 2. The wall pit 2 in the heart wood as well as those in the sap wood are also blocked by the torus 3. For this reason, in order to spread the treating liquid throughout the wood material, it is necessary to destroy the torus 3 which blocks the pit opening of an aspirated pit-pair, or to destroy the cell wall itself, so that the treating liquid can permeate into adjacent cells.

In order to destroy the torus 3 to those at the center of the material, an applied pressure of 30 kg/cm2 has been required using the conventional treating-liquid injecting methods. However, as described above the material has been deformed at an applied pressure of 15 kg/cm2 or more. As a result, it has been necessary to carry out the injection at a low pressure which does not cause deformation of the material. Consequently, there has not been enough pressure to destroy the torus 3 adequately and inject sufficient treating liquid into the interior of the wood material.

On the other hand, particularly for broadleaf trees, pressure is applied to the wood material to a predetermined pressure. For this reason, impurities such as tylose get clogged in the vessels, making it extremely difficult to inject the treating liquid to the central portion of the material.

In addition, the stone material has been only protected at the surface because the treating liquid has only been applied to the surface thereof, and because of the nature of the stone material itself. As the stone material was exposed to acid rain over a long period of time, its acid resistance decreased, so that the measures taken against the acid rain became ineffective. As a result, the acid rain permeated to the interior, and the stone material was eaten away from the interior, resulting in a powdered interior and the like.

SUMMARY OF THE INVENTION

The present invention is intended to overcome the above-described problems and has as its object the provision of a method of and an apparatus for injecting a treating liquid into wood material and porous inorganic material so that the treating liquid spreads throughout the interior thereof, without deforming the wood material, stone material, and other materials to be treated. The present invention has as another object the provision of a method of destroying ray parenchyma cell walls and aspirated pit-pairs.

The above objects are accomplished by the method of injecting the treating liquid into the wood material and the porous inorganic material related to the present invention which is a method of injecting treating liquids such as resin into the wood material. The method comprises the following steps: An initial pressure-applying step in which the pressure is applied to the material to be treated to a predetermined pressure which does not cause

deformation thereof, with the pressure maintained for a predetermined time; a preliminary pressure-applying step in which after the material has been maintained for the predetermined time, the pressure on the material is increased in steps until the final stage of pressure application, while in each pressure-applying stage the material to be treated is maintained at a particular pressure for a predetermined time; and a treating-liquid injecting step in which the treating liquid is injected into the material to be treated at a predetermined treating liquid injecting pressure.

The treating liquid injecting method is preferably used for injecting treating liquids such as resin into conifers. The method comprises the following steps: A pressure-reducing step in which the pressure on the material to be treated is reduced for removing the gas therein; an initial pressure-applying step in which a low pressure is applied to the material to be treated, which does not cause deformation, while the pressure is maintained for a predetermined time; a preliminary pressure-applying step in which after the material has been maintained at that pressure for the predetermined time, the pressure on the material is increased in steps until the final stage of pressure application, while in each pressure-applying stage the pressure on the material to be treated is increased, with the pressure maintained for a predetermined time; and a treating-liquid injecting step in which the treating liquid is injected into the material to be treated at a predetermined treating-liquid injecting pressure.

The treating-liquid injecting method is also a method for injecting treating liquids such as resin into broadleaf trees. The method can comprise the following steps: A pressure-reducing step in which the pressure on the material to be treated is reduced for a longer period of time than it is for the conifers for removing the gas therein; an initial pressure-applying step in which a low pressure is applied to the broadleaf trees, which does not cause deformation, with the pressure maintained for a longer period of time than it is for the conifers; a preliminary pressure-applying step in which after the material has been maintained at that pressure for the determined time, the pressure on the material is increased in steps up to the final stage of pressure application, while in each pressure-applying stage the material to be treated is maintained at a particular pressure for a predetermined time; and a treating-liquid injecting step in which the treating liquid is injected at a predetermined treating-liquid injecting pressure.

The treating-liquid injecting method can further be a method for injecting treating liquids such as resin into stone material. The method can comprise the following steps: A pressure-reducing step in which the pressure on the stone material is reduced for a longer period of time than it is for the wood material for removing the gas therein; an initial pressure-applying step in which a low pressure is applied to the material to be treated which does not cause deformation, with the pressure maintained for a longer period of time than it is for the wood material; a preliminary pressure-applying step in which after the material has been maintained at that pressure for the predetermined time, the pressure is applied to the material to be treated until the final stage of pressure application; and a treating-liquid injecting step in which the treating liquid is injected into the material to be treated at a predetermined treating-liquid injecting pressure.

According to the method of injecting treating liquid related to the present invention, varying the pressure-reducing time or pressure-applying time, or pressure-applying conditions in accordance with the type of material treated and its interior structure, is effective in injecting treating liquids into the raw wood materials up to the heart wood, which was very difficult using the conventional methods, and in injecting treating liquid sufficiently to the central portion of the stone material, which injection itself was not carried out using the conventional methods.

Accordingly, the wood material has greatly increased rot resistance, insect resistance, ant resistance, and mold resistance, increasing the life of the wood. In addition, injecting a treating liquid, having no possibility of leaking, to the central portion prevents cracking from occurring for a long period of time, allowing a high dimensional stability to be obtained. Further, using a flame-resistant treating liquid therewith injects the treating liquid thoroughly to the central portion, so that the wood material treated by the present method has high flame resistance and dimensional stability, allowing it to be used in a variety of applications. Moreover, the increased life of the wood material helps stop the unplanned cutting of tropical forests, a problem in recent years, thereby making the method extremely useful from the viewpoint of forest protection.

The stone material can also be protected from damage caused by acid rain, so that its properties are not deteriorated. The outside walls of buildings can be protected from destruction caused by acid rain, a serious problem in regions, such as Europe, which have many buildings built of stone material. In other words, according to the present invention it will not be necessary to prohibit the use of marble and other stone materials for the outside walls of buildings. The invention not only prevents damages to the stone materials from occurring, but also is very useful for preserving a nation's culture and for environmental protection.

The present invention also provides an apparatus for injecting treating liquid into the wood material and porous inorganic material. The apparatus comprises a pressure vessel for storaging and sealing the material to be treated, a liquid pressure-applying vessel for applying pressure to the above-described pressure vessel using the treating liquid, a pressure-removing tank connected to the above-described pressure vessel, to which tank is applied pressure equal to that in the pressure vessel, and a pressure-removing valve connected to the pressure-removing tank which opens and closes to gradually remove the pressure in the pressure vessel through the pressure-removing tank.

The apparatus prevents air expansion from breaking the material while pressure is being removed, allowing the treating liquid to be injected into the central portion of the material.

The present invention further provides a method for destroying ray parenchyma cell walls and aspirated pit-pais. The method comprises the following steps: A pressure-reducing step in which the gas in the material to be treated is removed by reducing the pressure thereof; an initial pressure-applying step in which the pressure is applied to the material to be treated to a predetermined pressure which does not cause deformation, with the pressure maintained for a predetermined time; and a preliminary pressure-applying step in which after the material has been maintained at that pressure for the predetermined time, the pressure is increased in steps up to the final stage of pressure application, while in each pressure-applying step the material to be treated is maintained at a particular pressure a predetermined period of time.

Accordingly, it is possible to destroy the toruses in the wood material to those at the central portion thereof, so that the present method can be used to inject the treating liquid to the central portion of the material.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates graphs showing the reduction and application of pressure when the treating-liquid injecting method of the present invention is applied to conifers;

Fig. 2 illustrates graphs showing the reduction and application of pressure when the treating-liquid injecting method of the present invention is applied to broadleaf trees;

Fig. 3 illustrates graphs showing the reduction and application of pressure when the treating-liquid injecting method of the present invention is applied to stone materials;

Fig. 4 illustrates the internal structure of the conifer;

Fig. 5 illustrates the internal structure of the conifer;

Fig. 6 is a cross section illustrating the condition of the wood material after it has been treated with the treating-liquid injecting method of the present invention, and that after it has been treated with a conventional treating-liquid injecting method;

Fig. 7 is a block diagram illustrating the arrangement of the treating apparatus for implementing the method of the present invention;

Fig. 8 is an enlarged sectional perspective view illustrating the structure of the wood material; and

Fig. 9 is a cross section of the wall pits between the wood material structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiment of the treating-liquid injecting method of the present invention will be described with reference to the drawings.

Fig. 1 shows graphs showing the reduction and application of pressure in the first embodiment of the present invention when the method is used to inject the treating liquid into the conifer. Figs. 4 and 5 each illustrate the structure of the conifers. Fig. 6 compares the conditions of the wood material after it has been treated using the treating-liquid injecting method of the present invention, and after it has been treated using a conventional treating-liquid injecting method. Fig. 7 is a block diagram showing the arrangement of the apparatus used for implementing the present method.

The conifers generally have the structures shown in Figs. 4 and 5. For this reason, it is necessary to destroy the ray parenchyma cell walls and aspirated pit-pairs to inject the treating liquid to the central portion. In the present method, the pressure is gradually applied from a low pressure to the material to be treated, so that the pressure difference between the internal and external portions of the wood material is maintained, which pressure difference is large enough to destroy the torus 3, but not too large to deform the wood material. Each torus 3 is then gradually destroyed to those at the central portion, allowing the injected treating liquid to permeate sufficiently to the internal portion of the wood material.

First, the ray parenchyma cell walls at the outermost portion and the aspirated pit-pais are destroyed, and then the pressure in the tracheid 21a is made equal with the external pressure. The pressure in the tracheid 21b, 21c, and the like is made equal with the external pressure as each torus is successively destroyed to those in the heart wood. In this case, the pressure is transmit-

ted through very narrow gaps or small holes. Accordingly, it is necessary to increase the pressure for higher efficiency, but a sudden increase in pressure causes the material to become thinner and become deformed. Consequently, in the present invention the pressure is increased successively in steps so as not to thin and deform the material.

In the pressure-reducing step of the present invention, a treating material 11 is stored and sealed in a pressure vessel 12 comprising the apparatus illustrated in Fig. 7. Then as shown in Fig. 1, the pressure of the material is temporarily reduced to 760 mmHg by a pressure-reducing vacuum pump 13, with the material maintained at this pressure for about 20 minutes, in order to remove as much air from the material as possible. The next step is the pressure-applying step. In the initial pressure-applying step, pressure is applied on the material to 2 kg/cm2 by a gas pressure-applying compressor 14. In this case, each portion of the material in the pressure vessel 12 is subjected to the same pressure in accordance with Pascal's law. The material is maintained at this pressure for about 20 minutes. A pressure of 2 kg/cm2 is large enough to destroy each torus 3 and the like. As a result, although when the material is maintained at this pressure not all of the ray parenchyma cell walls and aspirated pit-pairs are destroyed, a portion of them are destroyed, allowing pressure to be transmitted to the central portion. At this relatively low pressure of 2 kg/cm2, the wood material itself is not deformed.

The next step is the preliminary pressure-applying step. As shown in Fig. 1, the pressure is increased stepwise from a pressure of 2 kg/cm2 of the initial pressure-applying step until the final stage of pressure application. In the present embodiment, the pressure is increased to 8 kg/cm2, 15 kg/cm2, and 25 kg/cm2.

First, the pressure is increased to 8 kg/cm2. Since a pressure of 2 kg/cm2 has been applied in the initial pressure-applying step, there is a relative pressure difference of 6 kg/cm2 between the internal and external portions of the wood material at the time when the pressure is increased to 8 kg/cm2. Though depending on the type of wood material, the torus 3 is usually destroyed when a pressure of 2 to 5 kg/cm2 is applied to it. Accordingly, in the first stage of the preliminary pressure-applying step, a greater number of aspirated pit-pais, mainly those near the outer portion of the wood material, are destroyed. The material is again maintained at 8 kg/cm2 for about 10 minutes. For this reason, in the same way as it is described above, the pressure is transmitted through destroyed ray parenchyma cell walls and aspirated pit-pais, allowing the wood material to be subjected to a pressure of 8 kg/cm2 to its inner portion.

In the preliminary pressure-applying step, the pressure is further increased when appropriate while in each pressure-applying stage the material is maintained at a particular pressure for a certain period of time. That is, in the present step pressure is further applied to the wood material to 15 kg/cm2 for 10 minutes and to 25 kg/cm2 for 20 minutes until the final stage of pressure application. The relative pressure difference which occurs between the internal and external portions of the wood material in each stage successively destroys the ray parenchyma cell walls and the aspirated pit-pairs.

As described above, wood materials are usually deformed when a pressure of 15 kg/cm2 is applied thereto. The materials are, however, deformed due to shock arising from a pressure difference which is caused by a sudden application of pressure from no pressure to 15 kg/cm2. Accordingly, if the pressure is applied in steps to the wood material as it is in the present invention, the wood material is not easily deformed even when the final pressure applied thereto exceeds 15 kg/cm2.

In the present invention, in each stage pressure is applied for a predetermined time so that the internal portion of the wood material is subjected to the pressure of a particular pressure-applying stage. Therefore, even if, for example, a pressure of 25 kg/cm2 is applied, the pressure increase during pressure application is merely the relative pressure difference between the internal and external portions of the wood material. That is, the pressure which the wood material experiences is merely 10 kg/cm2 (25 kg/cm2 minus the previous applied pressure of 15 kg/cm2), causing no deformation.

Accordingly, according to the present invention the preliminary pressure-applying steps carried out stepwise allows the aspirated pit-pairs and the like to be destroyed to those at the internal portion of the wood material, without deforming the wood material itself.

In each pressure stage, it is preferable that for the first few pressure application stages of up to about 15 kg/cm2 the material is maintained at a particular pressure for a relatively long period of time of 10 minutes or more, while the length of time can be shortened thereafter.

The pressure and pressure difference for each stage, and the length of time the material is maintained at a certain pressure are naturally set at different values in accordance with the type and dimensions of the wood material. For example, the pressure difference is made large when a large pressure is required to destroy the torus 3, and the material is maintained at a certain pressure for a

longer period of time when time is required to equalize the pressure to the inner portion of the wood material.

The preliminary pressure-applying step is followed by the treating-liquid injecting step. In the treating-liquid injecting step, the treating liquid is injected into the material to be treated with a liquid pressure-applying pump 15 and allowed to spread throughout the material under a certain pressure. In this case, the gas of the material remaining in the tracheid 21 is introduced into the injected treating liquid under applied pressure in accordance with Henry's law.

The material can be treated at the same pressure as the final applied pressure in the preliminary pressure-applying step, or can be treated at a different pressure. In the present method, the preliminary pressure-applying step allows the treating liquid to easily permeate to the internal portion of the wood material because the ray parenchyma cell walls and the aspirated pit-pairs to those in the internal portion have already been destroyed. Therefore, the material can be treated at a pressure lower than the conventional treating-liquid injecting pressures.

After injecting the treating liquid under applied pressure, it is necessary to remove the pressure from the pressure-applied material. In this case, a sudden removal of the pressure causes a rapid expansion of the gas introduced into the treating liquid in accordance with Henry's law, so that the material itself may be destroyed. For this reason, in the present embodiment a pressure-removing tank 18 is particularly installed in the treating apparatus, to which tank is previously applied pressure to eliminate pressure differences with that in the pressure vessel 12. From the pressure-removing tank 18, the pressure is gradually removed via the pressure-removing valve 19, allowing the gas dissolved in the treating liquid to escape first. The gas dissolved in the treating liquid, which has a low molecular weight, flows out of the material first, so that the treating liquid accumulates in the internal portion of the material.

The condition of the wood material treated using the treating-liquid injecting method of the present embodiment, and That treated using a conventional treating-liquid injecting method are shown in Fig. 6 for comparison. A water-soluble dye was injected using the present method and a conventional method, and then each treated wood material was cut for comparison (Japanese cedar and radiator pine heartwood having a water content of 55% and measuring 20 x 20 x 100 cm were used). As is apparent from Fig. 6, the wood material treated by a conventional method only permits a small amount of treating liquid to enter from the cut end face, and almost no treating liquid is injected from the other faces. On the other hand, according to the present method the treating liquid is injected from any direction, from the cross-grain, straight-grain, and the like. That is, according to the present method the ray parenchyma cell walls and the aspirated pit-pairs in the material are destroyed for injecting the treating liquid, so that the treating liquid is consistently injected not only into the material's surface but to its central portion, thereby posing no problems when heartwood is used as the material to be treated. The present embodiment comprises the steps of a preliminary pressure-applying step using gas followed by the injection of the treating liquid, in which the aspirated pit-pairs and the like are first destroyed, but it may comprise a step in which the treating liquid is injected directly in steps under applied pressure. In this case, the treating liquid is injected by storing the treating material 11 in the pressure vessel 12 and filling up the vessel with the treating liquid, and then applying pressure. The injection amount is adjusted by the pressure, and checked with a liquid-pressure level gage 17 installed in a liquid tank 16.

Usable liquids to be injected include vegetable oil and mineral oil emulsified and made water-soluble by cationic surfactants to which are mixed antiseptics, insecticides, ant killer substances, and mold retarders. The treating liquids to be injected, which are cationic, combine ionically with the anionic wood material to prevent leakage from the wood material, making them suitable treating liquids. Compared to water-soluble glycols used as treating liquids, these treating liquids prevent leakages from occurring and have better dimensional stability and the like over a longer period of time. In addition, emulsifying them by non-ionic and anionic surfactants and adding antiseptics thereto allow the same effects to be obtained. Further, since in the present method the treating liquid can be injected to the central portion of the wood material, a treated material having a higher flame resistance than the conventional treated materials can be obtained by the injection of flame retarders.

A second embodiment of the treating-liquid injecting method related to the present invention will be hereunder described. The second embodiment is a method for injecting the treating liquid into broadleaf trees. Fig. 2 illustrates graphs showing the reduction and application of pressure during the treatment.

Unlike the aforementioned conifers, broadleaf trees usually have vessels which pass water. Therefore, it may seem that these vessels can be used to easily inject the treating liquid. However, these vessels actually contain a large amount of impurities such as tylose. Accordingly, applying

pressure all at once causes the impurities to get clogged in the vessels, preventing injection of the treating liquid. For this reason, the present embodiment is intended to transmit equal pressure to the central portion of the material and to inject the treating liquid thereto by applying a relatively low pressure which does not cause the impurities to get clogged in the vessels over a long period of time.

The present method sets the pressure-reducing time at 60 minutes which is longer than that set for the conifers as shown in Fig. 2, in view of the the fact that the broadleaf trees contain more elements in their vessels compared to the conifers, which makes it necessary to minimize the extent of vessel clogging occurring during pressure application by removing as much gas in the vessel as possible.

Even in the following pressure-applying step, a relatively low pressure of about 1.5 kg/cm2 is applied, so that the clogging in the vessels does not occur. The pressure-applying time is set at 30 minutes, which is longer than it is for the conifers (refer to Fig. 2). Accordingly, the vessels can be set at a certain pressure, without being hampered by vessel clogging. After a low pressure is applied for a long period of time, the pressure is applied in steps at 7 kg/cm2 for 10 minutes, 30 kg/cm2 for 30 minutes, and so on. In this case, the pressure on the broadleaf trees can be increased in a fewer number of steps than for the conifers, since they have a larger number of vessel elements. After the treating liquid has been injected, the pressure is gradually removed using the pressure-removing valve 19 as described above.

The same results as those of the conifers were obtained (Japanese oak and beech heartwood having a water content of 60% and measuring 20 x 20 x 100 were used.).

Fig. 3 illustrates graphs showing the reduction and application of pressure during material treatment in the third embodiment of the treating-liquid injecting method related to the present invention. The present embodiment is a method for injecting the treating liquid into porous inorganic materials such as stone material. In the present method, the time for reducing the pressure and the time for applying low pressure are made long. After the pressure is reduced and low pressure is applied, the pressure is increased at once to a high pressure, which allows injection of the treating liquid to the internal portion of the stone material.

Porous inorganic materials such as marble contain a large quantity of gas in their interior due to their structure. Accordingly, in the present method sufficient pressure-reducing time is taken so that the gas in the interior can be sufficiently removed. In this case, it is desirable that the pressure-reducing time is longer than it is for the aforementioned broadleaf trees, about 120 minutes.

Stone materials also contain a large amount of fine impurities or fine powder in their interior. Accordingly, in order to prevent clogging by these entities from occurring, a relatively low pressure of about 5 kg/cm2 is applied for a longer period of time than for the wood material, for example for about 60 minutes. This allows the material's interior to be at a certain pressure as is the case for the broadleaf trees. In the present embodiment, after low pressure is applied for a long period of time, unlike in the case of the wood material a high pressure of 30 kg/cm2 is applied at once, because the stone material is not easily deformed by pressure application. Then, the treating liquid is injected under applied pressure.

The pressure may also be applied by using a liquid pump and directly applying pressure by the treating liquid, in addition to using a compressor to apply preliminary pressure with gas and then injecting the treating liquid under pressure. On the other hand, after injecting the treating liquid under high pressure, the pressure-removing valve 19 is used to gradually remove the pressure as described above.

Accordingly, according to the methods of the present invention, the treating liquid is injected to the central portion of the material. A piece of 2 x 40 x 80 cm-marble (made in Italy) used as stone material was injected with a water-soluble dye and then cut. It was found that the marble was uniformly dyed to its central portion, thereby verifying that the injected treating liquid does reach the material's central portion.

In the present method, using, for example, a Toa Kagaku's "Alone Water Shut" (trade name) whose major component is silane monomer further increases the treated stone material's resistance to acid rain. That is, the silane monomer in the base material chemically combines with silanol and forms a layer highly effective in preventing water absorption, thereby protecting the stone material from damage caused by acid rain and the like. In addition, since the hair net pits in the stone material, particularly the marble, are not embedded, the stone material can be treated by taking advantage of its characteristics, without deteriorating the respiratory action of the marble.

Claims

1. A method of injecting treating liquids such as resin into wood material and porous inorganic material comprising the steps of:

   a) a pressure-reducing step in which gas in said material to be treated is removed by reducing the pressure thereon,

b) an initial pressure-applying step in which said material to be treated is subjected to a predetermined pressure which does not cause deformation and maintained at said pressure for a predetermined period of time,
c) a preliminary pressure-applying step in which after the material is maintained at said pressure for the predetermined period, the pressure thereon is increased in steps until the final stage of pressure application, while in each pressure-applying stage the material is subjected to a particular pressure for a predetermined length of time, and
d) a treating-liquid injecting step in which the treating liquid is injected into said material to be treated at a predetermined treating-liquid injecting pressure.

2. A method for injecting treating liquids such as resin into conifers comprising the steps of:
a) a pressure-reducing step in which gas is removed from said material to be treated by reducing the pressure thereon,
b) an initial pressure-applying step in which said material to be treated is subjected to a low pressure which does not cause deformation and maintained at said pressure for a predetermined period of time,
c) a preliminary pressure-applying step in which after the material is maintained at said pressure for the predetermined period, the pressure thereon is increased in steps until the final stage of pressure application, while in each stage the material to be treated is subjected to a particular pressure for a predetermined period of time, and
d) a treating-liquid injecting step in which the treating liquid is injected into said material to be treated at a predetermined treating-liquid injecting pressure.

3. A method of injecting treating liquid such as resin into broadleaf tree material comprising the steps of:
a) a pressure-reducing step in which gas in said material to be treated is removed by reducing the pressure thereon for a longer period of time than it is for the conifer materials,
b) an initial pressure-applying step in which said material to be treated is subjected to a low pressure which does not cause deformation and maintained at said pressure for a longer period of time than it is for the conifer materials,
c) a preliminary pressure-applying step in which after the material is maintained at said pressure for the predetermined time, the pressure thereon is increased in steps until the final stage of pressure application, while in each pressure-applying stage the material to be treated is subjected to a particular pressure for a predetermined length of time, and
d) a treating-liquid injecting step in which the treating liquid is injected into said material to be treated at a predetermined treating-liquid injecting pressure.

4. A method for injecting treating liquids such as resin into stone material comprising the steps of:
a) a pressure-reducing step in which gas in said material to be treated is removed by decreasing the pressure thereon for a longer period of time than it is for the wood material,
b) an initial pressure-applying step in which said material to be treated is subjected to a low pressure which does not cause deformation and maintained at said pressure for a longer period of time than is the case for the wood material,
c) a preliminary pressure-applying step in which after the material is maintained at the aforementioned pressure, the pressure is applied on said material to be treated until the final stage of pressure application, and
d) a treating-liquid injecting step in which the treating liquid is injected into said material to be treated at a predetermined treating-liquid injecting pressure.

5. An apparatus for injecting treating liquid into wood material and porous inorganic material comprising:
a pressure vessel for storing and sealing said material to be treated therein;
a pressure-reducing device for reducing the pressure on said pressure vessel;
a pressure-applying device for applying pressure to said pressure vessel;
a liquid pressure-applying device for injecting the treating liquid into said pressure vessel under applied pressure;
a pressure-removing tank connected to said pressure vessel, whose pressure is previously equalized by gas with that in said pressure vessel; and
a pressure-removing valve connected to said pressure-removing tank, which opens and closes, to gradually remove the pressure on said pressure vessel through said pressure-removing tank.

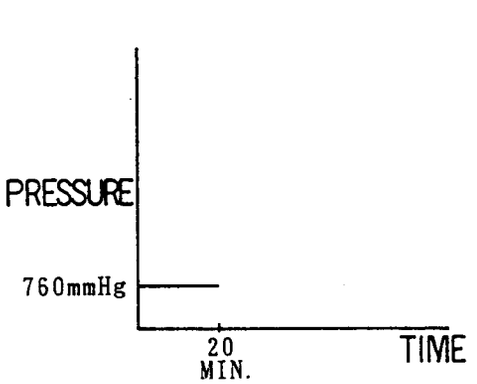
6. A method of destroying the ray parenchyma cell walls and aspirated pit-pairs of the wood material comprising the steps of:

a) a pressure-reducing step in which gas in said material to be treated is removed by decreasing the pressure thereon,

b) an initial pressure-applying step in which the material to be treated is subjected to a predetermined pressure which does not cause deformation and maintained at said pressure for a predetermined period of time, and

c) a preliminary pressure-applying step in which after the material is maintained at said pressure for the predetermined time, the pressure thereon is increased in steps, while in each pressure-applying stage the material to be treated is subjected to a particular pressure for a predetermined length of time.

Fig.1



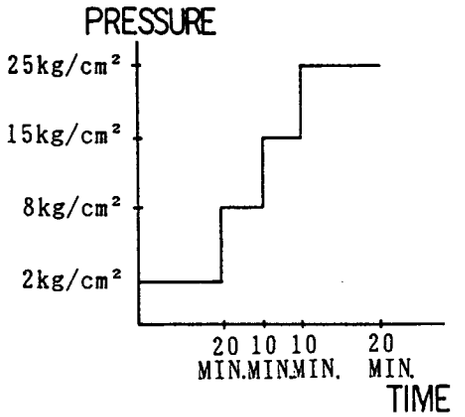
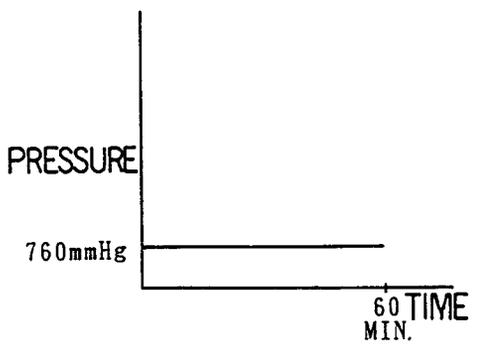


Fig.2



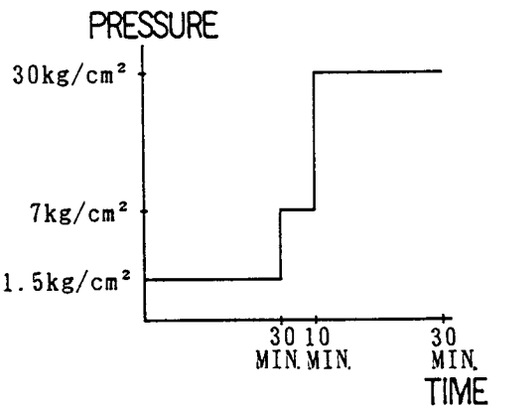
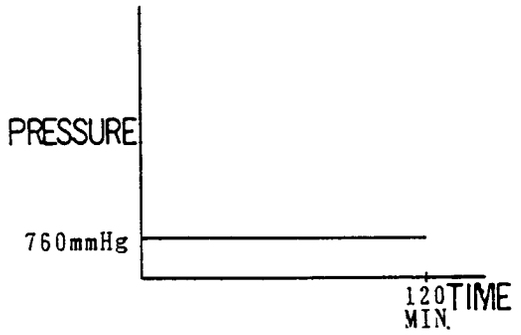


Fig.3



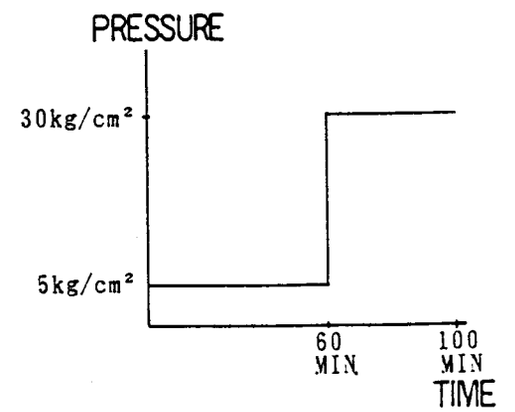


Fig.4

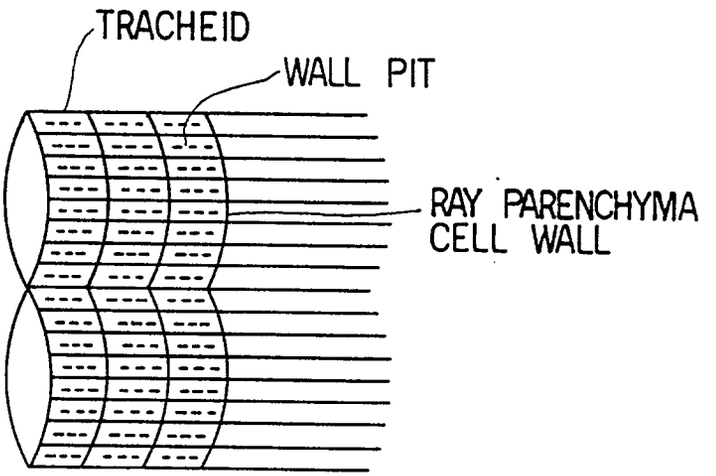


Fig.5

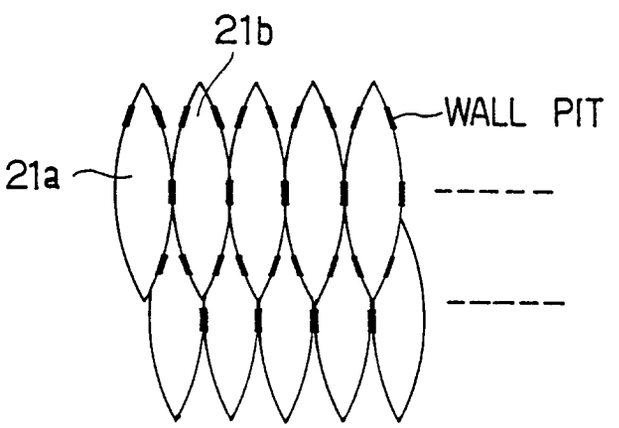


Fig.6

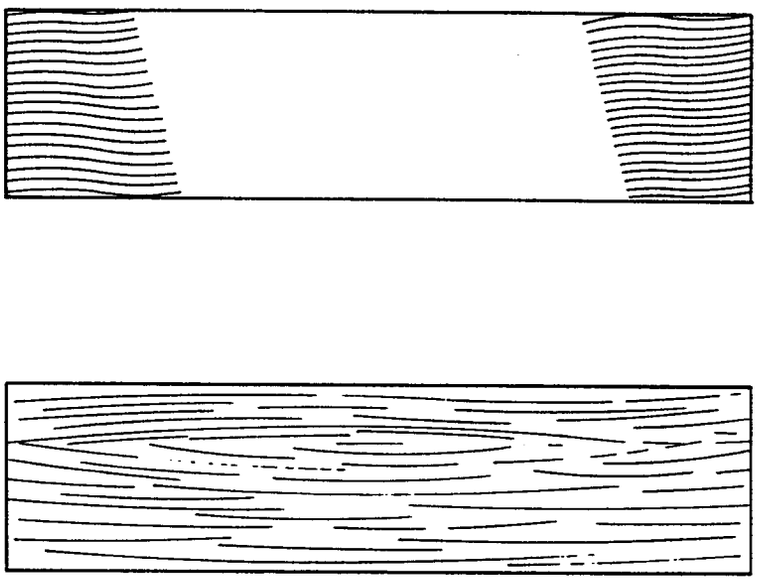


Fig.7

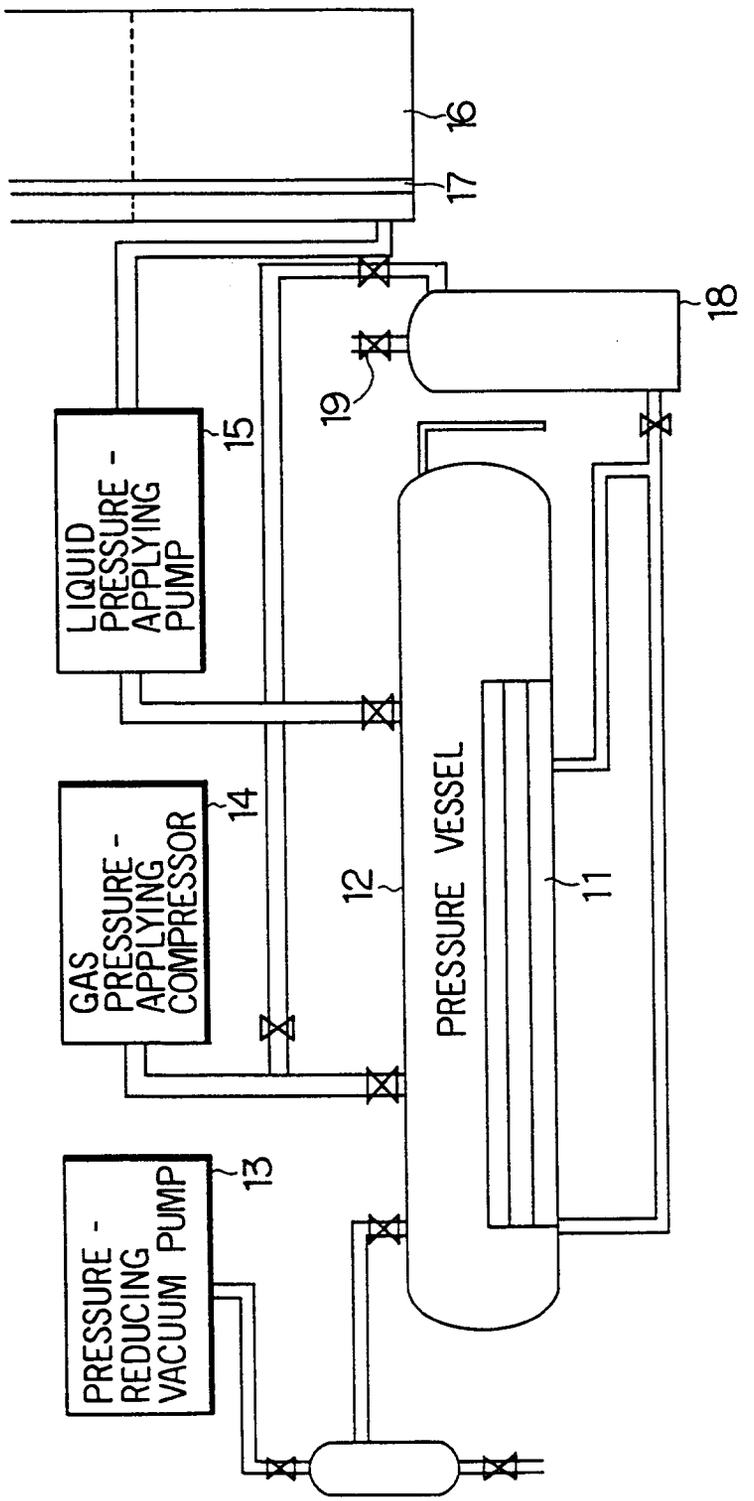

16
17
18
19
15
LIQUID PRESSURE - APPLYING PUMP
14
GAS PRESSURE - APPLYING COMPRESSOR
12
PRESSURE VESSEL
11
13
PRESSURE - REDUCING VACUUM PUMP

Fig.8

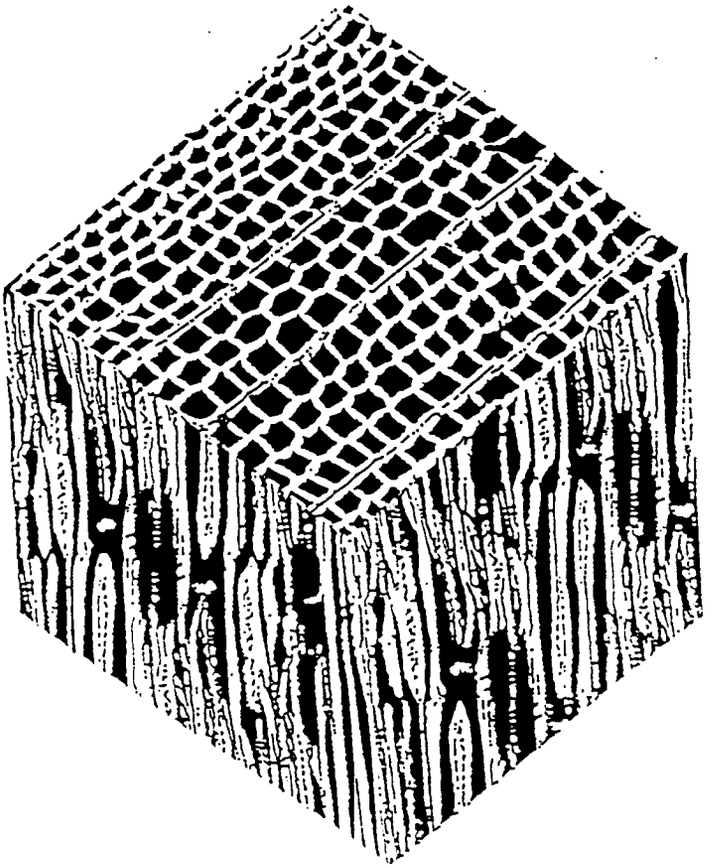
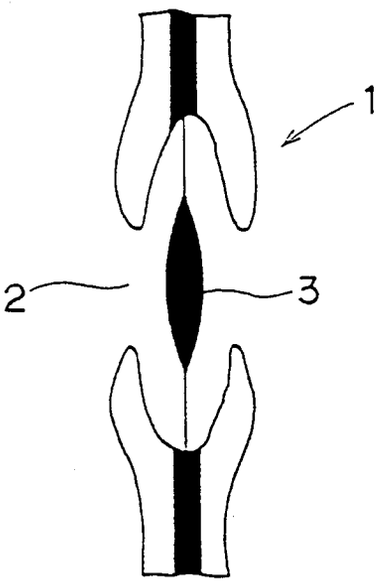


Fig.9



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 12 1160

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	GB-A-1 602 577 (H.D.HECKERT) * page 1, line 72 - line 104 * * page 2, line 55 - line 81 *	1-6	B27K3/08
A	WO-A-85 03474 (ROSENLUND)		
A	GB-A-2 021 952 (PROTIM INTERNATIONAL LTD)		

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

B27K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 March 1994	Dalkafouki, A

CATEGORY OF CITED DOCUMENTS

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