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(71) Applicant: **POL.I.CON.ENGINEERING S.r.L.**
Via Monte delle Gioie 1
I-00199 Rome(IT)

(72) Inventor: **Portoghesi, Franco**
Via Livio Andronico 75
I-00136 Rome(IT)
Inventor: **Spezzano, Paolo**
Via Gaetano Donizetti 7
I-00198 Rome(IT)

(74) Representative: **Banchetti, Marina et al**
c/o Ing. Barzanò & Zanardo Roma S.p.A.
Via Piemonte, 26
I-00187 Roma (IT)

(54) Apparatus and method for the protective treatment of concrete works.

(57) An apparatus for the protective treatment of concrete works employing the polymer impregnated concrete (P.I.C.) technology, said apparatus comprising an air-tight housing (2) which is preferably thermally insulated, and defines a chamber (3) between itself and the concrete work portion (1) to be treated, a device for feeding hot air into said chamber (3) for drying said concrete work portion (1), a device for spraying a liquid polymerizable compound onto said concrete work portion (1), and a device for delivering saturated steam onto the same after impregnation, for thermopolymerizing the monomer; the corresponding method for the protective treatment of concrete works, for employment either on first construction or within the frame of restoration works.

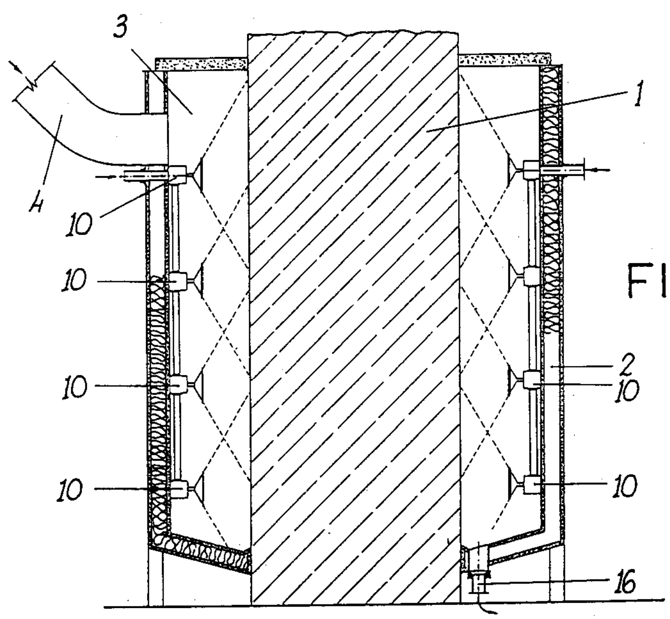

FIG. 1

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This invention relates to an apparatus for the protective treatment of concrete works as well as to the method for employing the same. More specifically, this invention relates to an apparatus particularly suitable for applying the P.I.C. (polymer impregnated concrete) productive technology to concrete works already installed, either on first construction or within the frame of restoration works.

As is well known, the cement mix or concrete, which is at present the most employed building material, is made of stone aggregates of various sizes which are held together by a hydrated cement paste matrix. Such cement paste is obtained by the interaction of cement, which consists essentially of calcium silicates, with water. The resulting hydrated products progressively set in time.

The main reasons for the large employment of concrete in the field of building, where it is generally employed together with iron in all kinds of works, are to be found in its relatively low cost, in its good mechanical strength and in its capability of being shaped so as to take practically any desired shape. The high porosity of such material, as well as the intrinsically inhomogeneous nature therof when it is set, however, result in a number of phenomena that negatively affect its durability, and finally cause the iron reinforcements enclosed within such material to deteriorate.

Internal differential size changes, which result from shrinkage and swelling of the material, give rise to potentially dangerous cracks, while the high water permeability and the connected high absorption power cause the material to suffer from the action of ice and of aggressive agents. Said agents penetrate the material down to the iron reinforcement, causing the oxidation of the metal.

Various traditional techniques are known for restoring concrete works and for strengthening reinforced concrete structures. Said techniques generally require a remarkable waste of labour, of materials, as well as of time, and they do not always solve the problem in an efficient and durable way, or they can give objectonable results from the aesthetic standpoint.

Examples of such restoration interventions are those which are carried out on vertical reinforced concrete members, when the aggregate is merely integrated, generally for repairing cracks or damages of limited extent. The surfaces to be treated are prepared by removing the crumbly parts therefrom while any cracks present are suitably widened and deepened, then a thin layer of an epoxide adhesive is applied on said cracks. The cracks are then filled with a fine cementitious mixture while the adhesive is fresh.

Further examples of interventions of such kind are those which are carried out on reinforced concrete pillars, with the addition not only of further amounts of concrete, but also of iron. More particularly, in the case of circular cross-section pillars, a further cylindric reinforcement can be provided, after suitable cleaning of the surfaces, around the original pillar. In this case a cylindric mould is arranged around the pillar, and the concrete is casted between the original pillar and the new mould.

In the case of rectangular cross-section pillars whose size cannot be altered, the strengthening operation can be carried out through the application of angle bars, with the interposition of a layer of epoxide adhesive and very fine siliceous sand. Obviously, the surface of the original pillar must be previously cleaned. When the member in question is remarkably damaged and it is possible to increase the size of its cross section, it is preferable to weld a stirrup or a metallic net on the angle bars applied as mentioned above, said angle bars being optionally reinforced with transverse metallic plates. The pillar is then coated with a layer of fine cementitious mixture.

In order to overcome the problem of the progressive degradation of concrete works and to improve their mechanical strength, a protective technology for concrete has been widely investigated and experimented in the two past decades. Said protective technology is based on the impregnation of the material, after its setting, with a polymerizable organic product. Once said product has penetrated the material, it is caused to polymerize in situ thermocatalytically. The cement mix so impregnated with organic polymers, which is known as P.I.C. (polymer impregnated concrete), is only one of the products that can be obtained by applying polymeric materials in the specific field of concrete (the other ones being the composite materials in which the polymer is added directly to the cement mix, either in addition to cement or in substitution therefor), but the P.I.C. is certainly the most developed one of said products, and it has become commonly employed in some specific fields.

A major one of such fields is the protection of reinforced concrete road bridges, where the conventional plastoelastomeric sheaths are being increasingly replaced by reinforced concrete plates fully impregnated with polymer for water-proofing.

It is well known that road structures, especially in cold climates, undergo a rapid degradation of the water-proofing layers of conventional type, due to sudden temperature changes and to the use of anti-ice salts. Such degradation results in the degradation of reinforcement iron as well, and in the formation of damages and cracks throughout the structure.

The steps of the new waterproofing intervention are the following:

- removing the protection layers of the floor slab

- cleaning the concrete by means of high-pressure water jets
- providing a new mould on the already existing slab, and subsequently casting concrete
- applying an impregnated concrete plate of 5 cm thickness, which is fastened by means of an adhesive mortar of resin type
- remaking the road carpet by conventional methods.

Interventions of the kind mentioned above are also possible for the protection of tunnels and dam facings, as well as of pipes, with the adoption of prefabricated members of fully impregnated concrete for the coating.

The presence of a polymer in the concrete, so as to fill up the pores of the latter, remarkably increases the mechanical properties, improves the adhesion of the cement matrix to the stone filler and, above all, remarkably reduces water absorption by the concrete works, thus making them waterproof, and protecting them both against the action of ice and against penetration of aggressive agents.

The general technology of P.I.C. production comprises a number of operations starting from the formed and set concrete works:

a) Drying the works, such operation having the object of removing the free water present within the pores of the material, so allowing the subsequent monomer penetration. The operation is carried out by heating the concrete works up to a maximum temperature in the range between 105 and 180 °C, at prefixed values of heating rate and duration of the operation.

b) Possible removal of gases through vacuum treatment, such operation having the object of removing the air left behind within the pores.

c) Impregnation of the concrete works with the organic monomer, said impregnation being obtained by contacting the dried concrete with the monomer, possibly under pressure. The organic products usually employed to that aim are the polymerizable vinyl compounds, specially methyl methacrylate, and also acrylonitryle, styrene, vinyl acetate, or mixtures thereof. A polymerization initiator and optionally a crosslinking agent are added to the mixture. It is evident that the spreading rate of the monomer through the pores of the mix depends also on the viscosity of the former, and that a partial impregnation can be obtained, i.e. an impregnation limited to a portion of the concrete work, by suitably choosing the duration of the impregnation step. A further factor of remarkable importance is the vapour pressure of the monomer, which determines the amount of product losses through evaporation once the product itself has penetrated the concrete work, during the next heating step, before polymerization is complete.

d) In situ thermocatalytic polymerization, obtained by heating the impregnated work and due to the presence of the initiating agent. The polymerization temperature is in the range between 60 °C and 100 °C depending on the monomer employed. In order to avoid the mentioned problem of monomer losses by evaporation, the heating is not performed in air as in the above drying step a), but hot water generally is employed, by putting it directly in contact with the work itself.

In the above case of production of fully impregnated prefabricated members the process described above gives no particular difficulties in application, because it is applied to a work not in situ. The plates of dried mix are impregnated with methyl methacrylate by dipping them directly into a suitable tank, and then they are subjected to the polymerization step by dipping them into a hot water bath.

However, when trying to apply the P.I.C. production technology to concrete works already installed, both for protection purposes on new works and for the purpose of restoring damaged works, remarkable practical problems are met with.

An attempt at solving such problems has been made in the U.S. in the case of horizontal surfaces, by proposing a procedure in which the cement mix is dried by means of a thermo-insulating coating, in which a hot air flow is circulated. Then a layer of dry sand is spread all over the dried surface, and the sand layer is soaked with the polymerizable compound. The whole material is covered with a polyethylene sheet to reduce monomer losses by evaporation, and said sheet is lifted from time to time for adding further monomer. Finally, the monomer is polymerized by employing hot air, by means of the same heating apparatus as that employed in the first step. It is evident from the foregoing that said final operation causes first the evaporation of the monomer and its polymerization inside the sand layer, and only later on it causes the desired polymerization to occur within the cement mix. This results in an unacceptable waste of product and in a very strong discomfort to the workers, and it also gives rise to the need for removing, in the end, the solidified sand crust bound to the polymer which is formed on the work.

Another technology which has been suggested to overcome the above drawbacks is that disclosed in the Italian patent No. 1.145.292, filed on 14th October, 1980. Said patent discloses an apparatus for protective treatment of cement mix through impregnation, said apparatus being adapted for employment on installed works.

The apparatus comprises a board for heating the surface of the element to be treated (the drying step), said board comprising a heat radiant plate connected to a hot air circulation system, for circulating hot air through the gap between the surface of the element and the surface of the heat radiant plate, parallel thereto. Said apparatus also comprises a feeding system for feeding the liquid polymerizable compound (the impregnation step) within the same gap, thus completely filling said gap with the monomer, and a system that feeds hot water (the polymerization step) into the same gap, so as to fill it up. As a result of its own structure, the apparatus disclosed above is only suitable for treating portions of horizontal plane surfaces or surfaces of very limited slope, and it is potentially applicable only to the protective treatment of road bridges and of concrete floors.

Accordingly, this invention proposes an apparatus for the protective treatment of concrete works, which apparatus can be also employed for treating already installed works, and can be applied on building elements of any shape and on surfaces at any slope, even vertical surfaces.

To that end, there is proposed to employ a housing whose shape is such as to enclose within itself a portion of the work to be treated, with an air-tight chamber between said housing and said portion of work, for instance a length of a pillar, and to carry out the drying operation by causing hot air to flow within said chamber.

For the monomer impregnation a new spray system is adopted by which, instead of contacting the work with a liquid monomer mass, the monomer is sprayed onto the concrete surface so creating on the same a thin liquid coating which is partially absorbed by capillarity, and partially collected at the bottom of the chamber, for being recycled to the spraying devices.

Moreover, according to this invention, the heat polymerization step is carried out by introducing saturated steam into the chamber, and the condensate is collected and discharged from the bottom of said chamber.

Accordingly, this invention specifically provides an apparatus for the protective treatment of concrete works, said apparatus comprising an air-tight housing which defines a chamber between itself and the portion of concrete work to be treated, a device for feeding hot air into the said chamber for the drying operation, a device for spraying a liquid polymerizable compound onto said portion of concrete work, for impregnating the same, and a device for feeding saturated steam onto the impregnated portion of concrete work for thermopolymerization of the monomer.

Preferably, the said housing is made of a thermally insulated envelope, and its size and shape are such as to leave a gap of about 10 cm between the housing itself and the work to be treated.

According to a preferred embodiment of this invention, the device for spraying the polymerizable compound comprises: -) spray nozzles arranged inside the chamber and so placed as to hit with their jets the surface of said concrete work portion; -) a reservoir for the polymerizable compound; -) a recirculation pump; -) a set of tubular feeding ducts connected to said spray nozzles; -) one or more tubular return ducts connected to the bottom of the chamber; -) a tubular duct having an iterception valve that connects the reservoir to the duct circuit.

The device for feeding saturated steam preferably employs the same spray nozzles employed for spraying the polymerizable compound, as well as the same set of tubular ducts for feeding the nozzles, and in addition it comprises a boiler for producing steam, and a tubular duct having an interception valve connecting the boiler to said set of tubular feeding ducts.

The device for feeding hot air for the drying operation preferably comprises: -) a fan for sucking air from the outside; -) a heat generator with a burner; -) a duct for feeding hot air into the said chamber; -) an air return duct from said chamber; -) a fan connected with its sucking side to said return duct and with its delivery side to said heat generator.

This invention futher provides a method for the protective treatment of concrete works, said method comprising the operations of:

-) positioning an air-tight housing on the concrete work portion to be treated, said housing being preferably thermally insulated, and defining a chamber between itself and the surface of said portion of concrete work;

-) feeding hot air into the said chamber for drying said concrete work portion;

-) spraying a polymerizable compound onto said concrete work portion for impregnating the same with said polymerizable compound;

-) feeding saturated steam onto said impregnated concrete work portion for thermopolymerizing said polymerizable compound.

Preferably, the drying operation is carried out at a temperature of 110-120 °C, and the heating operation is such as to result in a heating rate not higher than 15-20 °C/hour. Such preferred values are lower than those most usually employed (130-150 °C with a maximum temperature increase of 30-40 °C/hour), because it is considered important to avoid, especially in the case of surface treatments, excessively high thermal gradients in the concrete layer to be dried. Not only the temperature should rise gradually in time, but also the temperature gradient towards the contiguous layers should not be too high. This results in reducing the danger of crack formation in the treated concrete.

It has been found experimentally that by applying the new spray system in the way disclosed above the penetration of the monomer into the concrete work is practically equal to the penetration obtained whith the full immersion system. It has been also found that the leading impregnation edge proceeds uniformly and compactly in both cases, thus confirming the possibility of application of the procedure according to this invention, with particular advantage in those cases in which only a surface impregnation is required for the protective treatment.

This invention will be disclosed in the following just for illustrative and not for limitative purposes, with reference to a specific embodiment thereof. Said embodiment is illustrated in the figures of the enclosed drawings, wherein:

Figure 1 shows a vertical cross-sectional view of a concrete work subjected to the treatment according to the present invention, together with a portion of the relevant apparatus;

Figure 2 shows a horizontal cross-sectional view of the same concrete work shown in Figure 2;

Figure 3 is a front view of a second portion of said apparatus;

Figure 4 is a plan view of the same portion of the appparatus shown in Figure 3;

Figure 5 is a front view of a third portion of the same apparatus; and

Figure 6 is a plan view of the same part of the apparatus shown in Figure 5.

The three sections of the apparatus which are illustrated partly as cross-sectional views and partly as front views in Figures 1, 3 and 5 represent a specific embodiment of this invention, as applied to a square cross-section pillar 1. The housing 2 around the pillar 1 (see Figure 1) is made of a thermally insulated metal sheet, which encircles the pillar 1 fully up to a given height. Figure 1 shows the apparatus as applied to the pillar length that rests on the ground, but it is well evident that the housing 2 can also be shifted upwards gradually so as to treat, if necessary, further portions of the concrete work.

The housing 2 is of such a shape as to create around the pillar 1 an air-tight chamber 3. In different embodiments, the housing 2 could take various different geometric configurations according to the shape of the concrete work to be treated.

As a first step of the treatment, after having installed the housing 2 and the remainder of the apparatus, hot air is conveyed to chamber 3 (the drying step). The hot air enters the chamber 3 through the pipe 4 and goes out through the pipe 5 (shown in Figure 2), and is produced by the section of apparatus shown in Figures 3 and 4. In said section a fan 6 sucks air from the outside, said air is then heated in the methane or L.P.G. burner 7, which is provided with adjustment and control devices 8. The hot air is made to circulate by the fan 9, which pushes it into the chamber 3 (Figures 1 and 2) through the pipe 4, and sucks air from said chamber 3 through the pipe 5.

The impregnation step is carried out by the spray nozzles 10 (Figures 1 and 2), which are arranged inside the chamber 3 in such a way that their jets (shown by dashed lines) hit the whole surface of the concrete work to be treated. The spray nozzles 10 are connected to a sytem for the circulation and distribution of the monomer, said system being shown partly in Figure 2 and partly in Figures 5 and 6: the monomer contained in the tank 11, once the interception valve 12 is open, is pushed by the action of the pump 13 through the pipe 14 and then to the manifold 15, that distributes said monomer to all spray nozzles 10. The monomer not absorbed is collected at the bottom of the chamber 3 and flows through the hole 16 into the return pipe 17 (Figures 5 and 6), from which it is sucked by the pump 13.

In the last step of the treatment of the concrete work (the polymerization), saturated steam is introduced into the chamber 3, again through the spray nozzles 10. Steam is produced in the boiler 18 (Figures 5 and 6) and is introduced into the same pipes provided for the monomer feeding, by opening the valve 19 (after the valve 12 has been duly closed).

The P.I.C. technology and its application by means of the method according to this invention have been widely investigated, in particular with the aid of an experimental apparatus operating on the same principle as the apparatus disclosed previously.

In applying the method of this invention, the drying step has been carried out at 110 °C, and during the whole step the behaviour of the temperature of the concrete work has been detected. In particular, the temperature has been detected in the heated zone, at 3 and 10 cm below the surface, and in the zone not heated, outside the housing 2, about 10 cm away from the hot zone and at the same depths. It has been possible to show that, during the whole drying step, the temperature in the zone not heated never went above 70 °C, a value that does not impair the properties of concrete and the structural properties of the pillar itself.

After application of the whole procedure according to this invention, samples of the concrete work were obtained by carrying out core borings both in the treated and in the untreated zone, for comparison purposes.
The penetration depth of the polymer, in the experimental case investigated, turned out to be 40 mm, and the determination of polymer concentration in three subsequent layers of 15 mm thickness starting from the outer surface gave the following results:

first 15 mm layer	3.6 %
second 15 mm layer	3.0 %
third 15 mm layer	0.7 %

As it is evident, the average polymer concentration in the impregnated layer is not lower than 30 % by weight, if one keeps into account the fact that the third layer contains a part (of about 5 mm) which is not impregnated.

The porosity to mercury is remarkably lowered by the treatment, as it goes from a value of 11.7 % by volume in the untreated concrete samples to a value of about 3.4 % by volume in the impregnated layer, while the compression strength increases by about 50 %, going from an average value of 538 kg/cm in the untreated layer up to an average value of 760 kg/cm in the impregnated layer.

Accordingly, it is evident that the protective treatment according to this invention, through the realization of a compact and waterproof P.I.C. surface layer, remarkably improves the properties of the concrete work. This is further proved by the chlorides penetration test, as well as by the ice-resistance test and by the carbonation test illustrated below.

The ice resistance was determined according to the RILEM CDC standards (second edition), by subjecting concrete to freezing/thawing cycles in the presence of anti-ice salts, and the test gave the results shown in the following Table I:

TABLE I

Ice resistance

Freezing/thawing cycles according to the RILEM CDC standards, II edition

Weight loss per unit surface (mg/mm2)

Cycles No.	Untreated sample	Surface treated sample
20	0.3	absent
30	0.4	"
35	0.5	"
40	0.7	"
50	0.9	trace amounts

As is well known, carbonation of cement mixes, by lowering the initial value of the passivation pH of the irons of the concrete work, facilitates the attack of said irons in the presecence of oxygen. On the contrary, chlorides exert their aggressive action directly on the reinforcement, even at high alkalinity values of the thin liquid layer which the concrete is soaked with, and the strength of such effect increases when the pH value of such liquid drops.

The results of the chloride penetration test carried out according to the UNI standard both on an untreated sample and on the surface impregnated sample are summarized in the following Table II. According to said standard, the samples were sectioned at the various times and the penetration of Cl ions into the concrete work in contact with the aggressive solution was determined chromatographycally.

TABLE II

Chloride penetration

Test according to the UNI 7928 standard

Penetration measured as mm after contact with a 0.27 M $CaCl_2$ solution

Untreated sample	Surface treated sample
after 24 hr, mm 50	n.d.
after 66 hr, mm 91	"
after 120 hr, n.d.	absent

The amount of the chlorides present within subsequent layers of 10 mm thickness was also determined, starting from the contact surface between the concrete work and the test solution.
The results so obtained are shown in the following table.

TABLE III

Chloride penetration

Quantitative determination layer by layer

mg of Cl/kg of concrete

Layers of 10 mm thickness	Untreated sample (66 hours)	Impregnated sample (120 hours)
1st	1,412	105
2nd	750	53
3rd	668	53
4th	344	43
5th	275	62
6th	76 (unaffected value).	67

It is to be observed that the Cl ion concentrations found in the various layers of the impregnated samples are equal to those previously existing in the concrete employed, i.e. they correspond to Cl ions already contained in the binding agent, in the aggregates and in water employed. The difference between such amounts and those which are caused by the chloride penetration into the untreated concrete work is remarkable.

The carbonation test was carried out on a core sample obtained from a surface impregnated zone, after 30 days of exposure in C02 environment. After exposure, the core sample was split vertically and the inside surfaces were treated with phenolphtalein.

As is well known, after treatment with phenolphtalein, the uncarbonated zones at high pH values are red, whereas the carbonated zones, having a pH value lower than that of color change of the indicator, are clear, exactly of the same color as the untreated concrete.

The visual examination of the core sample split and treated as disclosed above put into evidence an upper zone of 40-45 mm, fully red, corresponding to the protected surface zone, and a lower zone, corresponding to the untreated concrete work, in which the material is cololess down to an average depth of 15 mm from the surface (corresponding to the carbonated material), and is red-colored just in the central core.

This experimental result also shows the possibility of obtaining, by means of the treatment according to the present invention, the creation of P.I.C. protective layers which are practically waterproof and not attackable. These layers insulate the concrete work from the outer environment, thus remarkably delaying degradation of the same.

Claims

1. An apparatus for the protective treatment of concrete works, said apparatus comprising a housing (2) which defines an air-tight chamber (3) between the housing (2) and the concrete work portion (1) to be treated, a device for feeding hot air into said chamber (3) for drying said concrete work portion (1), a device for spraying a liquid polymerizable compound onto said concrete work portion (1) for impregnating the same with said liquid polymerizable compound, and a device for feeding saturated steam onto said impregnated concrete work portion (1) for thermopolymerizing said liquid polymerizable com-

pound.

2. An apparatus according to claim 1, wherein said housing (2) is thermally insulated.

3. An apparatus according to claims 1 or 2, wherein said device for spraying the liquid polymerizable compound comprises:
   - spray nozzles (10) arranged inside said chamber (3) and so placed as to hit with their jets the surface of said concrete work portion (1)
   - a reservoir (11) for the polymerizable compound
   - a recirculation pump (13)
   - a set of tubular feeding ducts (14,15) connected to said spray nozzles (10)
   - one or more tubular return ducts connected to the bottom of said chamber (3)
   - a tubular duct having an interception valve (12) that connects said reservoir (1) to the duct circuit.

4. An apparatus according to claim 3, wherein said device for feeding saturated steam has some members in common with said device for spraying the polymerizable compound, and comprises:
   - the same spray nozzles (10)
   - a boiler (18) for producing steam
   - the same set of tubular feeding ducts (14,15)
   - a tubular duct having an interception valve (19) connecting said boiler (18) to said set of tubular feeding ducts (14,15).

5. An apparatus according to any one of claims 1-3, wherein said device for feeding hot air into said chamber (3) comprises:
   - a fan (6) for sucking air from the outside
   - a heat generator (7,8) with a burner
   - a duct (4) for feeding hot air into said chamber (3)
   - an air return duct (5) from said chamber (3)
   - a fan (9) connected with its sucking side to said return duct (5) and with its delivery side to said heat generator (7,8).

6. A method for the protective treatment of concrete works, comprising the operations of
   - positioning an air-tight housing (2) on the concrete work portion (1) to be treated, said housing (2) being preferably thermally insulated, and defining a chamber (3) between itself and the surface of said concrete work portion (1)
   - feeding hot air into said chamber (3) for drying said concrete work portion (1)
   - spraying a liquid polymerizable compound onto said concrete work portion (1) for impregnating the same with said liquid polymerizable compound
   - feeding saturated steam onto said impregnated concrete work portion (1) for thermopolymerizing said polymerizable compound.

7. A method according to claim 6, wherein said housing (2) is thermally insulated.

8. A method according to any one of claims 7-8, wherein said drying operation is carried out at a temperature of 110-120 °C.

9. A method according to any one of claims 6-8, wherein said drying operation is carried out with a heating rate not higher than 15-20 °C/hr.

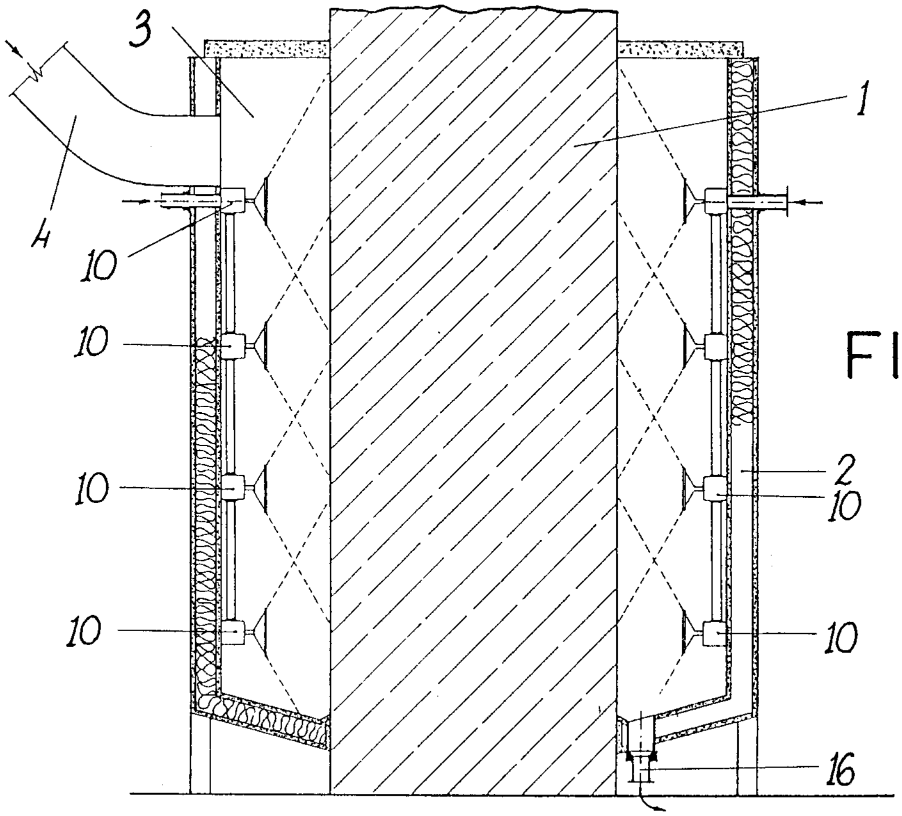

FIG. 1

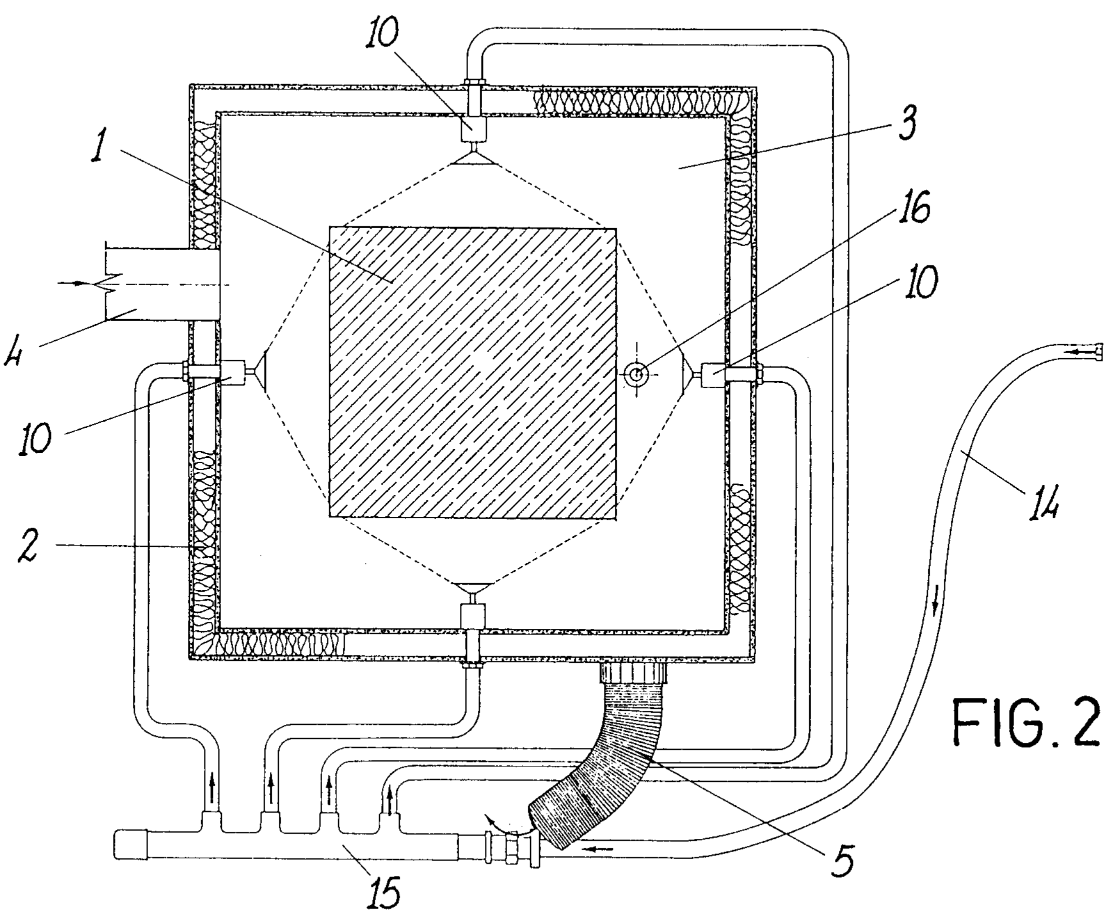

FIG. 2

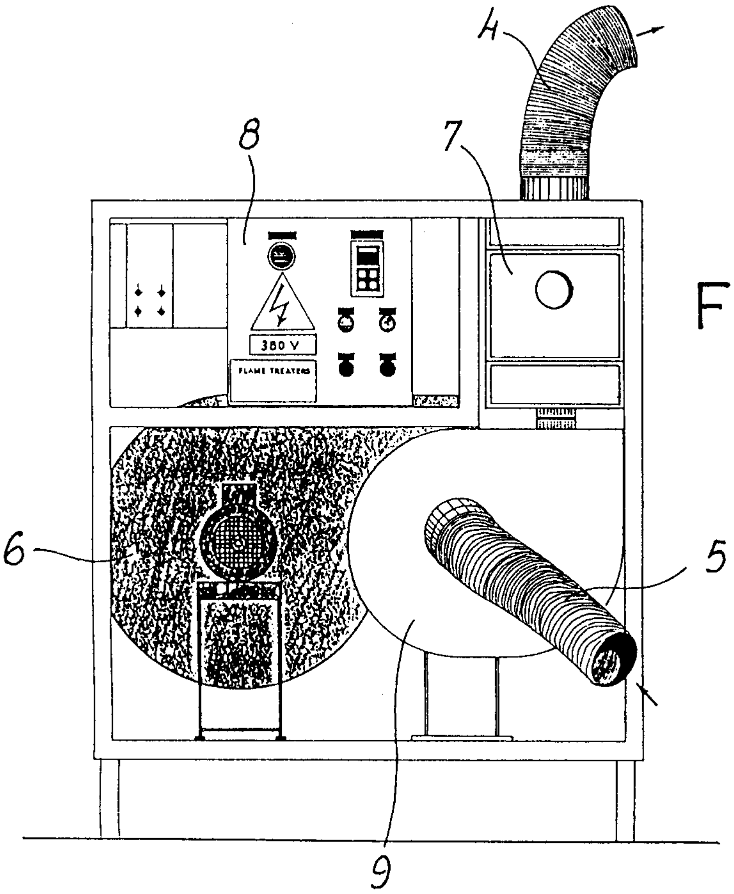

FIG. 3

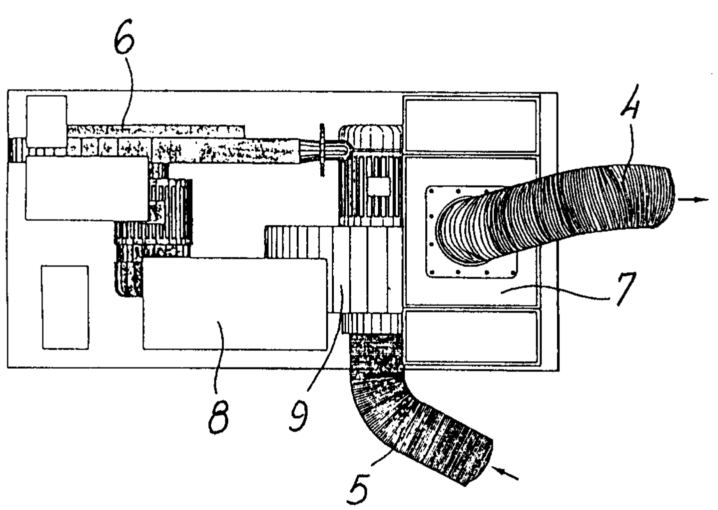

FIG. 4

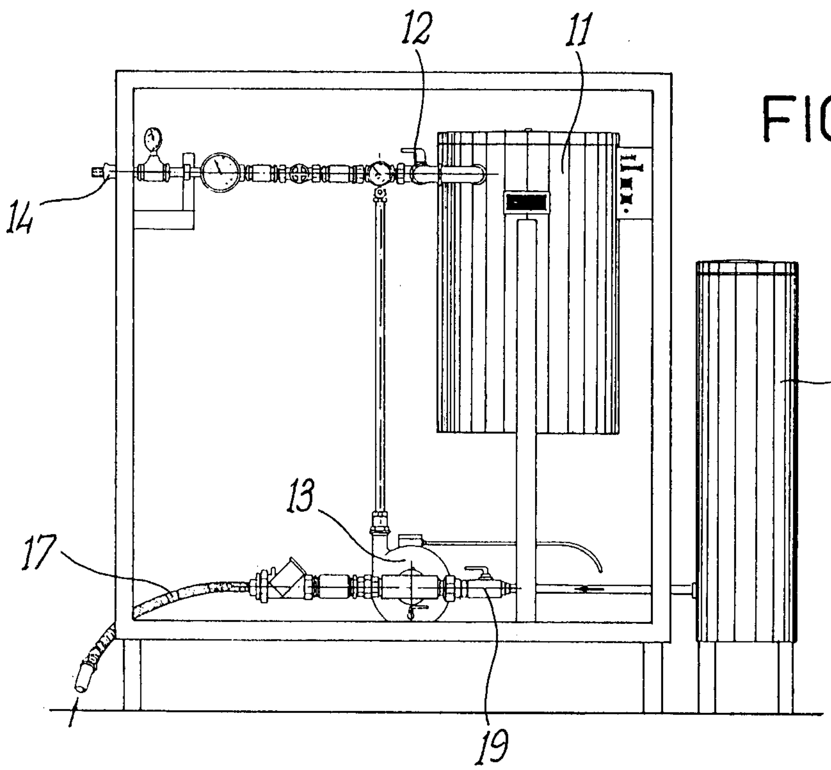

FIG. 5

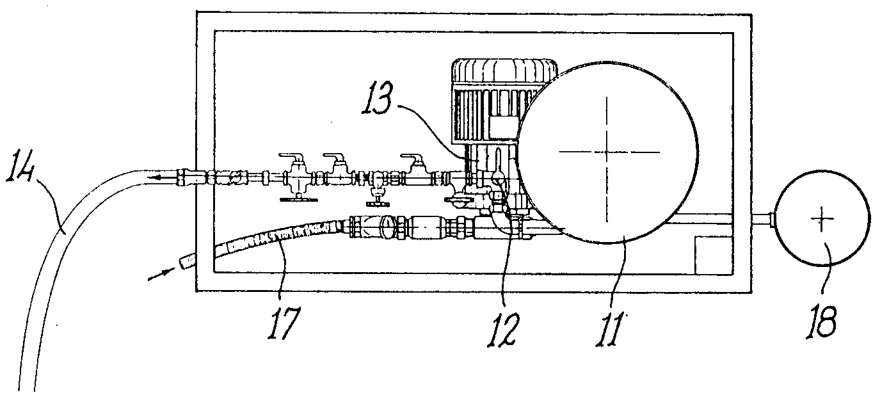

FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 83 0176

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)
Y	EP-A-0 036 397 (MAZZANOBILE)	1,2,3,6,7	E04G23/02
A	* page 17, line 11 - page 23; claims; figures *	4,5	
D,Y	GB-A-2 085 325 (ITALCEMENTI-FABRICHE RIUNITE CEMENTO) * the whole document *	1,2,3,6,7	
A	CH-A-569 677 (WIHR)		
A	CH-A-632 036 (IMCHEMIE)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

E04G
E01C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	04 DECEMBER 1992	VIJVERMAN W.C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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