

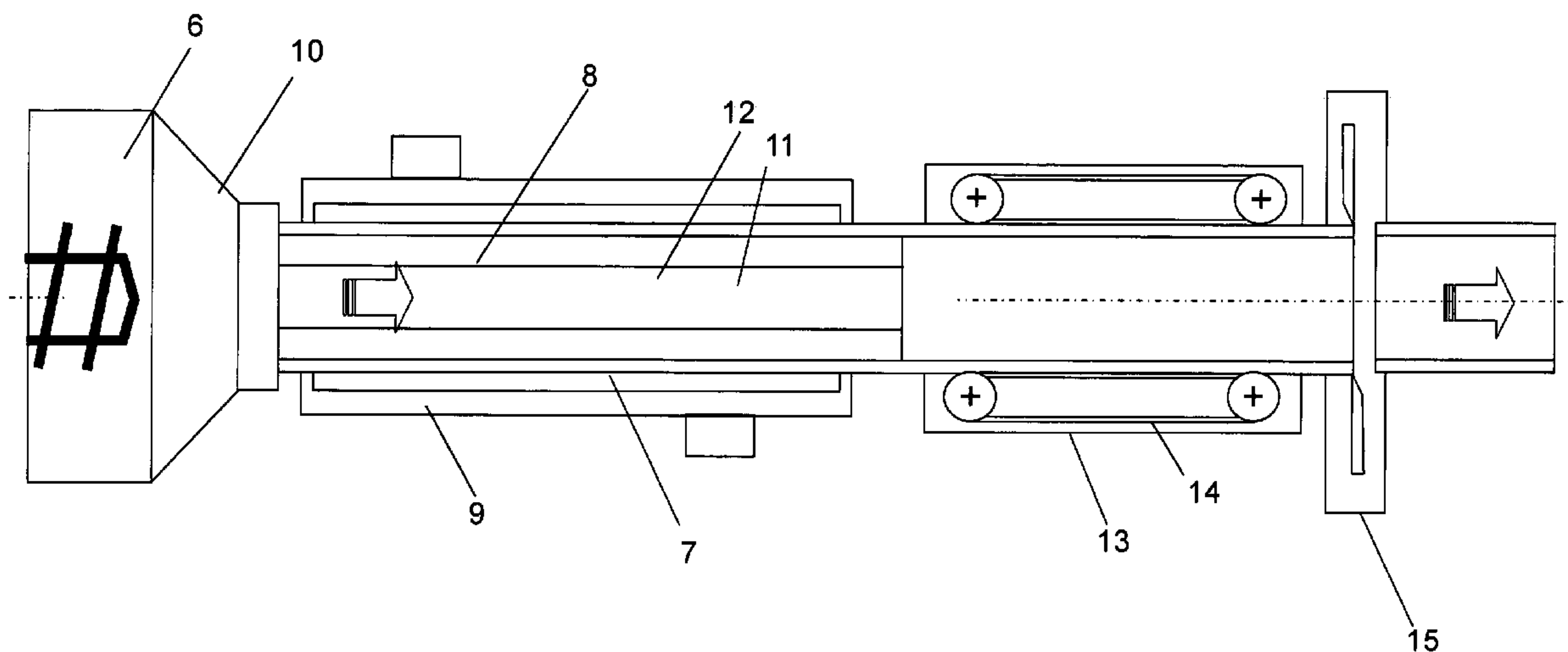


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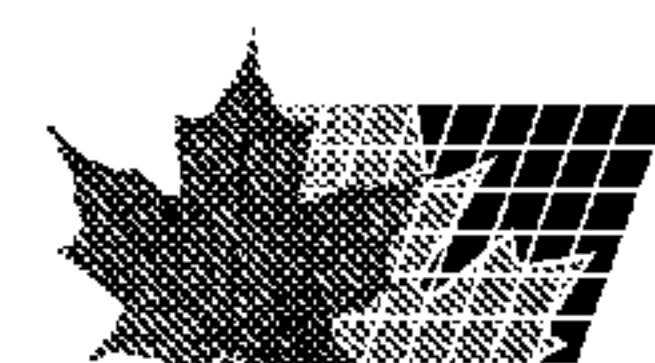
(54) Titre : PROCEDE DE PRODUCTION ET DE CONSERVATION DE LA FORME D'UN PRODUIT EXTRUDE
CONSTITUE D'UN MATERIAU CIMENTAIRE

(54) Title: PROCESS FOR THE PRODUCTION AND FORM PRESERVATION OF AN EXTRUDED PRODUCT MADE OF
CEMENTITIOUS MATERIAL



(57) Abrégé/Abstract:

The present invention relates to a process for the production and form preservation of an end-product made of cementitious material comprising a rapid stiffening phase of the neo-extruded end-product made of cementitious material by irradiation of the neo-extruded end-product with microwaves.



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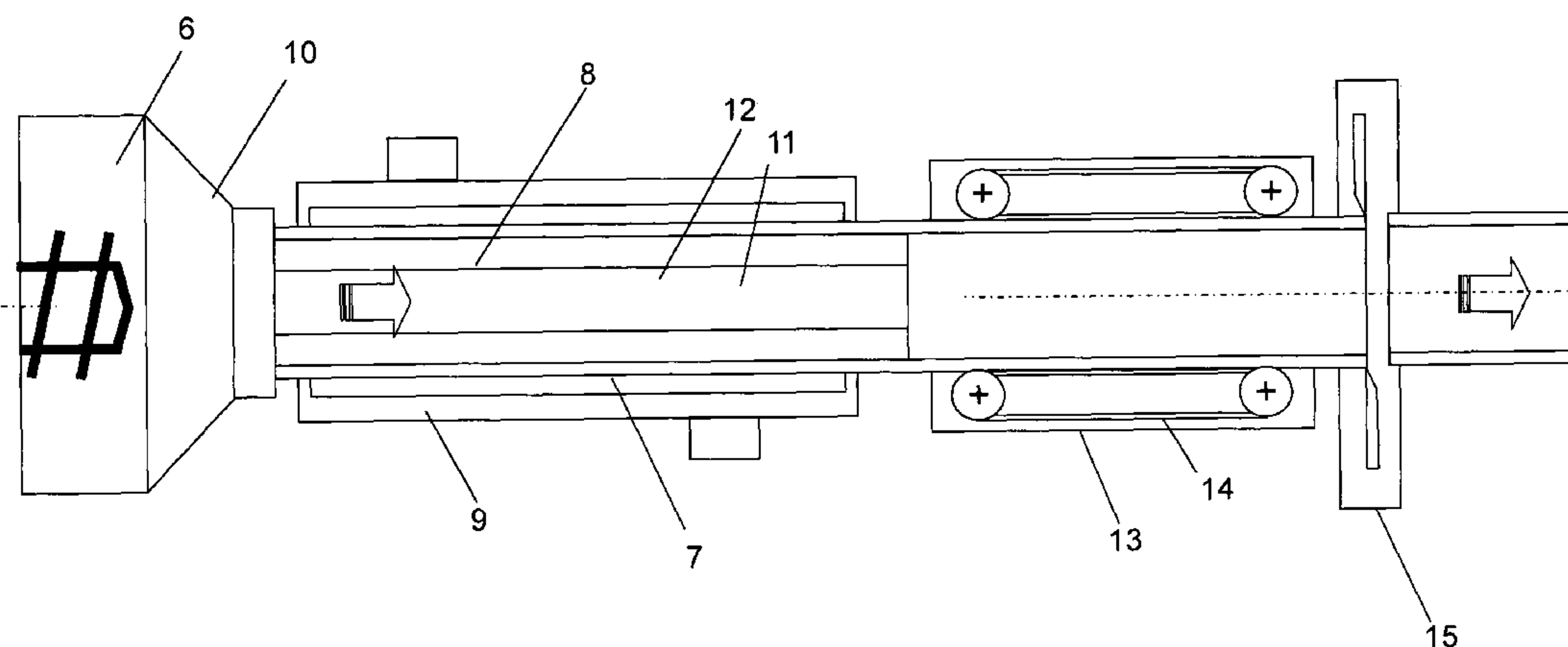
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(54) **Title:** PROCESS FOR THE PRODUCTION AND FORM PRESERVATION OF AN EXTRUDED PRODUCT MADE OF CEMENTITIOUS MATERIAL



(57) **Abstract:** The present invention relates to a process for the production and form preservation of an end-product made of cementitious material comprising a rapid stiffening phase of the neo-extruded end-product made of cementitious material by irradiation of the neo-extruded end-product with microwaves.

WO 2007/065668 A1

PROCESS FOR THE PRODUCTION AND FORM PRESERVATION OF AN
EXTRUDED PRODUCT MADE OF CEMENTITIOUS MATERIAL

The present invention relates to a process for the
5 production and form preservation of an extruded product
made of cementitious material.

The present invention relates to the field of
extrusion processes of end-products made of
cementitious material of any hollow form, for example,
10 tubular, box-shaped with or without internal
partitions.

In particular, the present invention relates to a
process for the production by extrusion of piping made
of fibre-cement with a circular section and fine
15 thickness.

Furthermore, the present invention allows the
production of cementitious products, for applications
in the building and industrial sector such as for
example permanent formworks for pillars, channels and
20 chimney flues, etc..

In the transportation of drinking water,
irrigations and wastewater, various types of products
or ducts are normally used, made of different kinds of
materials such as: cementitious materials, plastic
25 materials, concrete, ceramic stoneware and iron.

For these applications, the typical end-products used have a tubular form and are made of cementitious materials such as concrete reinforced with fibres, reinforced concrete, asbestos-cement and fibre-cement
5 without asbestos.

Alternatively plastic materials are used such as polyvinylchloride (PVC), polyethylene (PE), polypropylene (PP) and glass-resin.

As far as the form of the end-products is
10 concerned, those most commonly used, with a circular section, have found an increasingly wider market.

Cementitious end-products having different shapes are also available on the market, such as for example, tubular footrest or flat bottom pipes, elliptic or
15 ovoidal pipes, rectangular end-products, or pipes with other sections specifically designed for favouring the maximum fluid flow in their interior.

In the case of pipes having a circular section, the diameters available can vary and are divided
20 according to the various types of use.

Another important construction characteristic of cementitious end-products and in particular pipes consists in their thickness; those having a so-called "fine thickness", typically have a vacuum percentage of

the section higher than 60%. A typical example is represented by pipes made of fibre-cement.

With respect to processes for the production of piping made of cementitious material, these have been
5 known from the beginning of the last century.

In 1910, W.R. Hume described, in Australian patent 4843/2622, a process for the production of reinforced concrete pipes by means of centrifugation exploiting the centrifugal force. A cylindrical mould with a
10 horizontal axis charged with concrete was rotated at a high velocity, with the removal of the excess water until a compact material was obtained. The so-called "Hume pipes" are still produced, still exploiting the technique based on centrifugation, optionally using
15 reinforced concrete with steel fibres, or other compositions.

Another production technique used in the past is that called "Rotopress" or "Giropress" whereby pipes were produced in vertical, by a rotating mandrel which
20 packed the concrete having a consistency of the humid earth type in an axial direction.

This system has now been substituted by other production technologies such as, for example, the vibrocompression technology, in which dry concrete is
25 again used.

In this case, the pipe produced in vertical is immediately removed from the mould and sent to the curing phase.

With the type of production technologies so-far
5 cited, pipes having relatively high thicknesses are obtained, which comply with the European regulation EN 1916 (reinforced concrete, non-reinforced concrete, concrete reinforced with steel fibres).

In addition to concrete pipes, pipes made of
10 fibre-cement having a fine thickness are also known, mainly produced by means of the so-called Mazza process (deriving from the Hatschek technology). In this case, the material used par excellence, was asbestos-cement, recently substituted for environmental reasons by so-
15 called fibre-cement. In the Mazza/Hatschek process, cementitious compositions are used, containing cement, process fibres and reinforcing fibres (both synthetic and natural) and other secondary additives. The products obtained have high mechanical characteristics,
20 they are extremely compact and have low thicknesses.

More recently, the use of the extrusion technology has been proposed, widely used for plastic materials, metals, ceramics, ceramic stoneware and bricks, and also for cementitious materials. The extrusion can be
25 effected with batch or intermittent plug/cylinder

systems ("plug extrusion", or "capillary extrusion"),
or with continuous screw/cylinder systems. With the
exception of ceramic stoneware, in all the other cases
the extrusion is carried out horizontally. In the case
5 of ceramic stoneware, in fact, thanks to the high
thicknesses of the pipes in relation to their length
(normally two metres), there is a rigidity in the fresh
state of the pipes which does not cause deformation or
distortion.

10 As far as the extrusion of cementitious materials
is concerned, the known art refers to extruders having
two consecutive screws, intervalled by a vacuum chamber
to facilitate the pressurized extrusion of pastes.
These are extruder models normally used in the brick
15 industry.

Extrudable cementitious compositions for the
production of pipes made of cementitious materials are
described in US patents 3,857,715 issued in 1974 in the
name of C.W. Humphrey, and 5,047,086 issued in 1991 in
20 the name of K. Hayakawa et al.

The US patent 5,658,624 of 1997 in the name of
Anderson et al. describes compositions and methods for
producing a variety of articles based on extrudable
hydraulic cement.

US patent 5,891,374 of 1999 of Shah et al., which describes the extrusion of reinforced-fibre products, is also known.

US patent 6,309,570 of Fellabaum et al. describes
5 a vacuum system for improving the extrusion of cementitious products, without referring however to tubular products.

The extrusion of a reinforced-fibre with a pseudoductile behaviour for the production of low-
10 thickness pipes, is also known from international patent application WO 2005/050079. This international patent application makes reference to a particular extrusion technique previously described in US patent 6,398,998 B1 which does not exploit the screw system
15 for the extrusion phase, but a water suction method from a liquid reinforced-fibre cementitious formulation, introduced under pressure into a kind of coaxial cylinder. After the water extraction, the material is formed at a high pressure, obtaining pipes
20 having a particularly fine thickness with extremely valid mechanical properties, above all in terms of ductility and flexural and crushing strength.

The US patent application 2004/0075185 Al di Dugat et al. which relates to a plug moulding system of a
25 high performance cementitious material for producing

sewage pipes with a medium-high thickness, is also known. The technology described is also known by the name of Tetris or Evolit*.

The technologies for the production of pipes made of cementitious material however are not without processing drawbacks.

One of the main problems which arise in production techniques by extrusion of hollow cement-based pipes, is represented by maintaining the circular form (or geometry) at the outlet of the die.

Cementitious materials produced by extrusion have the problem at the outlet of the die of maintaining their form as, due to their weight and low thickness, they bend over themselves and, in the case of pipes, they lose their circular shape.

The lower the thickness of the extruded profile and with high vacuum percentages of the end-product the more significant this technical problem becomes. The "vacuum percentage" refers to the percentage ratio between the empty surface and the full surface of the end-product. The greater this percentage, especially in the presence of large dimensional end-products, the more critical the problem of maintaining the form becomes.

* trade-mark

The problem of preserving the form for fibre-cement pipes having a low thickness is further increased by the high market demand for this type of fine piping. A greater vacuum percentage of the pipe section does in fact correspond, with the same nominal diameter, to a greater lightness of the pipe and consequently a lower cost per linear metre of the end-product.

Under normal extrusion process conditions, however, the fine thickness of the pipe can cause a loss in its circularity which, on the other hand, must be guaranteed in the hardened product to allow its final acceptability. In the field of the invention, this characteristic is also defined as the "green strength" of the extruded product, also known as "form stability". This concept is widely described in US patent 5,658,624, mentioned above with reference to the extrusion of pipes.

The possibility of obtaining an adequate green strength of the extruded product is typically related to various composition or process parameters, such as: compactness of the solid components; the low water/solid ratio of the paste also correlated with the mechanical resistance of the material; the extrusion pressure; the possibility of using a heated die; the

possibility of using chemical compounds capable of being thermally activated to harden the outgoing material.

It should also be noted that the problem relating to the difficulty of preserving the form does not even allow tubular or box-shaped end-products having an adequate length (at least 2.5 metres) to be obtained.

A further development of the above patent is represented by the process described in US patent 5,545,297 in which a complicated mechanical system for continuous filament winding is introduced downstream of the die, for obtaining pipes with a high resistance and low thicknesses. The winding system also allows more rigid pipes to be obtained which preserve their circular form. The system described however is somewhat complex and expensive and does not adequately solve the problem.

Another document which refers to maintaining the circular form of extruded pipes consists of international patent application WO 2005/050079 A1 in the name of Rocla Pty Ltd. This describes the production of fibre-cement pipes having a low thickness, by means of a particular dewatering extrusion process which comprises eliminating the water from the material during extrusion. The level of the

final water/binder ratio is in the order of 0.20, congruent with what is indicated in literature, for obtaining adequate mechanical resistance and therefore, in this case, high performance pipes with a low
5 thickness.

Not even in this case however is the problem of maintaining the form and in particular the circularity after extrusion satisfactorily solved, as in the description it is stated that a substantially constant
10 section of pipe length, not necessarily circular, is accepted.

In the current state of the art, the technical problem of the bending of fibre-cement pipes and more generally hollow end-products with other geometries at
15 the outlet of the extrusion die, which occurs as a result of their weight and fine thickness, has consequently remained unsolved.

One of the objectives of the present invention therefore consists in providing a process for the
20 production of hollow extruded products made of cementitious material which allows to maintain substantially the form of the end-product immediately after the extrusion phase.

A further objective of the present invention
25 consists in providing a process for the production of

5 piping made of cementitious material having a circular section which allows to maintain substantially the form of the end-product immediately after the extrusion phase.

5 Another objective of the present invention consists in providing a process which allows the production of piping made of fibre-cement with a fine thickness which stably preserves its circular form after extrusion.

10 According to an aspect of the invention, there is provided a process for a production and a form preservation of a neo-extruded end-product made of a cementitious material comprising a rapid hardening phase of the neo-extruded end-product made of the cementitious material, characterized in that said rapid
15 hardening phase comprises an irradiation phase of the neo-extruded end-product with microwaves in order to stiffen said neo-extruded end-product so that a form of said neo-extruded end-product is preserved, followed by a final curing phase to complete a hydration of the neo-extruded end-product, said irradiation phase taking
20 place by a passage of the neo-extruded end-product in a microwave oven with a power ranging from 0.1 to 60 KW, said neo-extruded end-product being moved at a rate ranging from 0.5 to 5 metres/minute by means of an external pulling system.

 According to another aspect of the invention, there is provided a process for a production of an end-product made of a cementitious material, the process comprising:

- a mixing phase of a cement-based mixture with water to give a wet cement-based powder;

- a homogenization phase of said wet cement-based powder in a pasting machine to form a cement-based paste suitable for extrusion;

5 - an extrusion phase of said cement-based paste in an extruder to provide a cement-based end-product;

10 - an irradiation phase of the neo-extruded cement-based end-product with microwaves in a microwave oven having a power ranging from 0.1 to 60 KW to stiffen said neo-extruded cement-based end-product so that a form of said neo-extruded cement-based end-product is preserved and to accelerate a hydration of the cementitious material, said neo-extruded cement-based end-product being moved at a rate ranging from 0.5 to 5 metres/minute by means of an external pulling system;

15 - a curing phase after said irradiation phase to complete the hydration of the neo-extruded cement-based end-product;

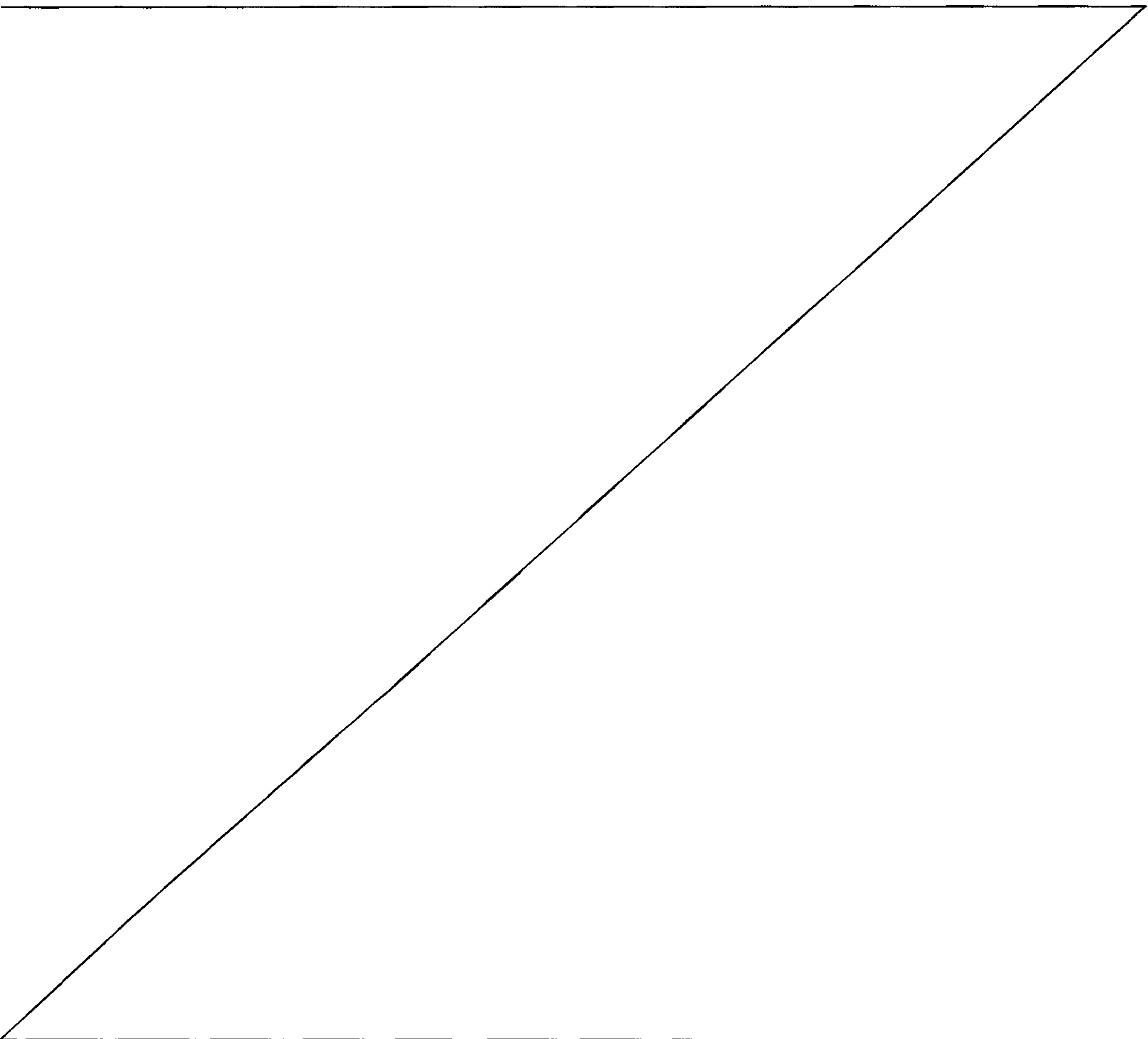
- a cutting phase of said neo-extruded cement-based end-product.

20 A further aspect of the present invention consists in providing a method for preserving, at the outlet of the die, the circular form of the fibre-cement piping produced by extrusion.

In view of the above objectives, according to a first aspect of the invention, a process is provided for the production of piping made of cementitious material having a circular section, as described herein.

Further accessory characteristics of the process of the invention are also indicated herein.

According to a first aspect of the invention a process is provided for the production and form
5 preservation of a neo-extruded end-product made of cementitious material wherein the neo-extruded end-



product is subjected to treatment with microwaves which causes its rapid stiffening allowing its form to be preserved.

"Neo-extruded" end-product refers to the product
5 continuously leaving the die of the extruder without having undergone any cutting phase and therefore still in contact with the extruder die.

"Stiffening" as referred to in the present invention, does not coincide with the final curing
10 phase of the material during which it hardens.

"Hardening" refers to the completion of the hydration process of the cement-based materials reaching the final performances required.

"Stiffening" according to the present invention
15 gives the neo-extruded end-product the physical consistency of lack of ductility and mobility of the material mass, due to the release of water.

The process of the invention is particularly used in the production and form preservation of cementitious
20 end-products having a circular geometry. The end-products with a circular geometry tend to collapse immediately after the extrusion phase and consequently lose their circular form.

An embodiment of the invention envisages the use
25 of a tunnel oven which, installed downstream of the

extrusion die, allows the continuous treatment of the neo-extruded end-product causing its stiffening and allowing the form provided by extrusion to be maintained.

5 According to an embodiment, in the process of the invention the extruded product continues to move, after leaving the extruder die, on a mandrel which guarantees the low friction slipping of the neo-extruded product.

10 The process of the invention allows the form of the neo-extruded product to be maintained by irradiation with microwaves which causes an acceleration of the hydration reactions of the cement. This effect prevents deformation of the end-product in the period immediately after extrusion.

15 The use of microwaves is known for the treatment of non-extruded cementitious materials, in order to accelerate the hardening process (US 4,338,138). In this case, the use of microwaves is described for completing the curing of cementitious materials,
20 already partially cured by means of conventional methods (wet, vapour methods and with autoclaving).

US patent 5,245,149 of Pinna and Lai (1993) describes a process which consists in the treatment with microwaves of concrete products in a static
25 chamber, in order to accelerate their forming and

hardening process.

Another patent which describes the use of microwaves relates to the rapid forming of panels produced by the pouring of cement-based pastes (US
5 6,572,811 of W.C. Heirich (2003)).

In the present invention, "treatment with microwaves" refers to the use of electromagnetic waves generally having a frequency ranging from 300 to 300,000 MHz of the electromagnetic spectrum, which
10 correspond to wavelengths varying from 1 to 1000 mm. From a practical point of view, there are only certain frequencies allowed for industrial use. These are called "ISM frequencies" (Industrial, Scientific and Medical) which correspond to the wavelengths indicated
15 in the following Table:

Table 1

frequency, MHz	Wave-length, cm
915	32.8
2450	12.2
5800	5.2
24120	1.2

The frequency of 2450 MHz is that most commonly used, whereas in some industrial processes the
25 frequency of 915 MHz. is also used. The majority of

microwaves are produced by means of wave generators called magnetron.

In some cases, other types of wave generator have been used, called "klystron" or "gyrotron". In any
5 case, the latter two types are only used for very high frequency microwaves (corresponding to wavelengths of less than a centimeter). For higher frequencies (5800 and 24120 MHz) they have so far only been used in extremely rare cases as they are very expensive.

10 The treatment of cement-based materials with microwaves according to the present invention differ from the known art in that it is applied to hollow neo-extruded products and also because the application is carried out on line in relation to the stiffening phase
15 of the material.

The on-line treatment with microwaves according to an aspect of the invention, can be applied to the extrusion of all geometries of end-products made of cementitious material, to accelerate the production
20 process, especially in cases in which there can be problems relating to form maintenance at the die outlet, such as for example, panels, draw-pieces of various sections, tubular elements.

The capacity of maintaining the form of the neo-
25 extruded product is also particularly appreciated in

the production of tubular cement-based end-products as their application in various sectors is restricted by the preservation of the circular geometry.

The process of the invention is therefore particularly suitable for the production, by means of extrusion, of pipes having a circular geometry and fine thickness, typically having a vacuum percentage of the section higher than 60%, preferably higher than 70%. A higher vacuum percentage corresponds, with the same nominal diameter, to a greater lightness of the pipe which, for a same malt in fibre-cement composition, in turn corresponds to a lower cost per linear meter of product, as indicated in Table 2 below.

Table 2

		THICKNESS (mm)							
		10	12	14	16	18	20	24	28
Nominal diameter mm	150	78%	74%	71%	\	\	\	\	\
	200	83%	80%	77%	74%	72%	70%	\	\
	250	\	\	81%	79%	76%	74%	70%	67%
	300	\	\	\	82%	80%	78%	74%	71%
	400	\	\	\	\	\	83%	80%	77%

The fine thickness referred to in this case is, for the same internal diameter (called "nominal" for fibre-

cement piping), lower than that of a pipe made of reinforced or non-reinforced concrete, of the traditional type, or ceramic stoneware.

This value is very close to that of pipes made of
5 asbestos-cement, no longer in use, which however, on an average, have mechanical performances still higher than those made of fibre-cement without asbestos.

The process of the invention typically allows an end-product having a circular section to be obtained,
10 such as pipes, joints and accessories for gravity systems according to the regulation UNI EN 588-1 and for discharge systems for buildings in accordance with the regulation UNI EN 12763.

The pipes having a circular section obtained with
15 the process of the invention are used in numerous applications sectors, for example in discharge systems, such as sewage disposal, or in drainage systems, and also in pressurized applications or in other types of liquid or gas channelling, at atmospheric operating
20 pressure or slightly higher (for example chimney flues), or as permanent formworks, for the construction of circular pillars or other cylindrical and hollow elements for the building industry.

The end-products obtained with the process of the
25 invention are typically based on cementitious material

or fibre-cement, the latter term comprising cement-based materials containing reinforcing fibres of the natural or synthetic type.

In the process of the invention, the dimensioning
5 of the microwave system suitable for obtaining the stiffening of the end-product and also the moving system, is typically effected according to operating requirements.

Advantageously, the use in the process of a tunnel
10 microwave oven allows the controlled heating of the extruded product so as to make it sufficiently rigid in line with the extrusion process.

The neo-extruded product can be typically moved either by the thrust of the extruder or by means of an
15 external pulling or haulage system, as occurs for example in the extrusion of piping made of plastic material. The pulling system is followed by a cutting system of the piping, which, according to an embodiment, is sent to the final curing section.

20 The characteristics and advantages of an embodiment of the process according to the present invention will appear more evident from the following illustrative and non-limiting description, referring to the enclosed schematic drawings, in which:

25 figure 1 illustrates an embodiment of the

extrusion phase and treatment with microwaves of an end-product having a circular section made of cementitious material according to the invention;

figure 2 is a schematic representation of the form
5 preservation process of an end-product made of cementitious material by means of microwaves according to the invention;

figure 3 illustrates three sections of pipe cut after treatment with microwaves at increasing power
10 values.

With reference to figure 1, this schematically illustrates the preliminary phases of an embodiment of the process of the invention. In a preliminary phase, a mixer 1 is fed with:

- 15 - a solid cement-based component, which typically comprises one or more components selected from cement, sand, aggregates, fillers of a mineral or pozzolanic origin, various types of fibres such as polymeric, glass, carbon fibres and viscosizing additives, stored
20 in a series of hoppers 2, preferably of the gravimetric type,
- water , stored in a hopper for liquids 3,
 - additives, conveniently fluidizing agents stored in a separate hopper 4.

The components in solid phase are dosed and then mixed in the mixer 1, conveniently of the intensive type, for a time preferably ranging from 1 to 5 minutes, in relation to the characteristics of the mixer and outside temperature until a homogeneous mixture is obtained. The liquid components, comprising water, are then added, and the mixing is prolonged for a time typically ranging from 1 to 5 minutes again in relation to the characteristics of the mixer and outside temperature.

At the end of the mixing phase the mixture can be in different semi-solid forms varying from wet powder to small pellets or in the form of a paste. The system thus obtained is preferably collected in an intermediate collection box, before being sent by transporting means to a pasting machine or homogenizing mixer 5.

According to an embodiment, the semi-fluid system obtained in the form of a paste is collected in a box and sent on belts for feeding an extruder 6. The extruder is preferably of the twin-screw type in series, for example of the type produced by the company Haendle. The twin-screw extruder is equipped for example with two screws arranged orthogonally with respect to each other, of which the second screw 6b,

which is horizontal, typically having a diameter of 350 mm, is suitable for compacting the material also a high pressures. Said extruder is particularly suitable for high viscosity materials and which produce considerable friction as cementitious materials. The first screw, 6a, which is vertical, is used for the loading of the material, the second horizontally 6b for the actual drawing phase and, in correspondence with the draw-plate, a typical maximum internal pressure of 50 bars can be reached, preferably about 40 bars; between the two areas, there is a chamber for creating a vacuum in order to obtain the maximum compacting of the material for a good surface finishing of the end-product.

The extrusion phase is preferably effected under controlled temperature conditions, typically below room temperature, by means of a cooling system, to ensure a good processability of the pastes thus slowing down the hydration kinetics of the cement.

Under these conditions (diameter of the second screw 350 mm) it is possible for example to extrude pipes having an internal diameter, for pipes made of fibre-cement called nominal diameter (ND) according to UNI EN 588-1 and UNI EN 12763 ranging from 150 mm to 350 mm, a thickness ranging from 10 to 22 mm and a length varying from 1 to 5 metres.

Typically, the pipe 7 leaving the extrusion die continues to move on a mould or mandrel 8, conveniently fixed onto the inner buffer of the extruder die passing through a tunnel microwave oven 9.

5 The oven 9 is described in detail in figure 2.

With reference to figure 2, the cementitious end-product, coming from a die 10 of a specific extruder 6 which is in the form of a piping having a circular section, is subjected to a rapid stiffening phase by
10 irradiation with microwaves.

For this purpose, the neo-extruded product 7 is passed onto a mandrel 8 and irradiated with microwaves generated by an appropriate source, such as for example a microwave oven 9 in the form of a tunnel.

15 The applied power of the microwave oven according to an aspect of the present invention varies from 0.1 to 60 KW, referring to a frequency of 2450 MHz. Upon changing the reference frequency to 915 MHz, the applied power decreases as the greater the penetration
20 capacity of the microwaves, the greater is the efficacy of the heating.

The mandrel 8, in particular, comprises an internal metal core 11 which guarantees the correct mechanical rigidity, and an outer coating 12 made of
25 plastic material transparent to microwaves, typically

polypropylene or polytetrafluoroethylene (Teflon). The materials forming the coating 12 must also be capable of facilitating the sliding of the pipe during the stiffening phase inside the oven 9.

5 The mandrel 8 must have an outer diameter lower than the internal diameter of the extruded pipe to avoid friction phenomena during the sliding phase. In particular, the outer diameter of the mandrel 8 has lower dimensions ranging from 0.5 to 5% with respect to
10 the internal diameter of the pipe, more preferably lower than 1-2%.

 The neo-extruded cementitious end-product 7 moves between the various process phases thanks to the cooperation between the thrust of the extruder and that
15 generated by a specific external pulling system 13.

 According to an advantageous aspect of the present invention, the neo-extruded end-product is moved from the system 13 at a rate ranging from 0.5 - 5 metres/minute, preferably from 0.7-3 metres/minute,
20 even more preferably 1 metre/minute.

 The pulling system 13, as can be seen in figure 2, is situated downstream of the microwave oven and consists of a series of conveyor belts 14 in a number and with dimensions in relation to the diameter of the
25 neo-extruded piping, positioned in contact on two sides

with the cementitious end-product.

Downstream of the pulling system 13, the neo-extruded cementitious end-product is cut by means of a suitable system 15 obtaining pipes having a length
5 varying in relation to the final specifications of the end-product.

Once the desired length has been reached, the neo-extruded pipe is cut and sent to a final curing cycle for example by treatment with water at room temperature
10 or heated, or for treatment in static climatic chambers and/or in tunnels on line with controlled temperature (maximum 50°C) and humidity conditions. The pipe is subsequently sent to the final storage phase.

The following examples are provided for purely
15 illustrative purposes of the present invention and should not be considered as limiting its protection scope, as indicated in the enclosed claims.

Example 1

Piping made of fibre-reinforced cementitious
20 material with a low thickness was obtained by extrusion and subsequent microwave treatment of the piping in the fresh state, so that it can be sent to the subsequent curing phase.

A fibre-reinforced cementitious formulation is
25 used for the production of a piping having a nominal

diameter DN 200 (internal diameter 200 mm, thickness 11 mm) .

The extrusion is effected using a Haendle extruder model E56a/40 at whose end a die with an annular
5 section is assembled. The pipe made of cementitious material is extruded at an advance rate of 1 metre/minute and, once it has left the die, it continues to move on a coaxial tubular core made of a mixed material, internally of metal (steel), externally
10 coated with plastic transparent to microwaves (polypropylene) with an outer diameter 2% lower than the internal diameter of the cement pipe. The core is wedge-fixed to the internal buffer of the die. Considering the volume mass in the fresh state (about
15 2300 kg/m³) and the extrusion rate (1 metre/minute), the mass flow-rate of the product is equal to about 16 kg/minute.

In order to effect the microwave treatment of the pipe with the above dimensions, a total power of 36 KW
20 was installed.

For this purpose, applicators of the "horn" type are installed on the tunnel in a suitable position (alternatively, applicators of the irradiating slot type can be installed) which irradiate their energy on
25 an annular section corresponding to that of the neo-

extruded pipe, thus optimizing the energy necessary for the hardening. The magnetrons used for the production of energy with microwaves are thermo-regulated with a cooling system. The total length of the tunnel - where
5 the treatment takes place - is 750 mm. The whole system is designed so that there is no dispersion of microwaves outside, for the safety of the operators. In particular, the tunnel is produced with a final area which absorbs and provides protection from the possible
10 leakage of microwaves. The microwave treatment allows a controlled heating of the mass, in temperature and section, thanks to its action on the free water present. Hot and humid air circulation can also be effected in the tunnel to allow a more homogeneous
15 treatment on the surface.

At the end of the microwave tunnel, the internal core sustaining the pipe, which at this point is hardened, also terminates.

The extruded piping moves both as a result of the
20 thrust of the extruder and also due to the presence of a haulage system which is installed downstream of the microwave system, which advances with a synchronized rate with respect to the extrusion rate, so as not to create tears, slits or undulations in the product; the
25 haulage system can be appropriately designed so as to

operate in depression, in order to maintain the circular form of the pipe and can also be suitably thermo-regulated.

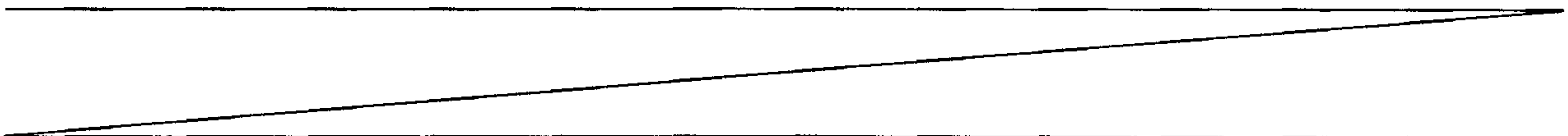
After the haulage system, the pipe is subjected to cutting and then sent to the subsequent curing section, which can be effected with a hot humid air or vapour system or with autoclaving.

Following the microwave treatment, an adequate stiffening of the material was verified with a calculated energy consumption equal to about 1 kW per 0.66 kg/minute of product (corresponding to about 24 kW absorbed for the extrusion rate equal to 1 metre/minute). A water mass loss equal to 1% by weight was estimated without the formation of any defects (slits and breakages).

Figure 3, shows, from right to left, three sections of pipe (16, 17 and 18) cut immediately after being treated with microwaves at increasing treatment powers: nr. 1 corresponding to about 8 KW of absorbed energy, nr. 2 corresponding to about 16 kW of absorbed power, nr. 3 corresponding to 24 kW of absorbed energy.

Example 2

A test was carried out substantially following the same conditions as Example 1, but with a test rate equal to 2 metres/minute. 2 microwave tunnel modules



were used for an overall length of 1500 mm for a total installed power of 72 KW.

In this case, the absolute absorbed power, necessary for obtaining the adequate stiffening of the end-product, proved to be about 48 kW.

Example 3

Another test was carried out on neo-extruded chimney flues having a box-shaped section (outer side 20 mm and thickness 10 mm). In particular, a microwave oven equipped with a hot air generation system was used for the stiffening. In particular the power was distributed as 20% of power generated with microwaves and 80% of energy generated with hot air. In this way, equivalent results were obtained, in terms of stiffening of the end-product, significantly reducing the installed electric power required for the microwaves. By using, as in Example 1, the extrusion rate of 1 metre/minute, a microwave consumption of 5 KW and of hot air of about 20 KW, was calculated.

WHAT IS CLAIMED IS:

1. A process for a production and a form preservation of a neo-extruded end-product made of a cementitious material comprising a rapid hardening phase of the neo-extruded end-product made of the cementitious material, characterized in that said rapid hardening phase comprises an irradiation phase of the neo-extruded end-product with microwaves in order to stiffen said neo-extruded end-product so that a form of said neo-extruded end-product is preserved, followed by a final curing phase to complete a hydration of the neo-extruded end-product, said irradiation phase taking place by a passage of the neo-extruded end-product in a microwave oven with a power ranging from 0.1 to 60 KW, said neo-extruded end-product being moved at a rate ranging from 0.5 to 5 metres/minute by means of an external pulling system.

2. The process according to claim 1, characterized in that at least a portion of said neo-extruded end-product is passed on a mandrel and irradiated with microwaves.

3. The process according to claim 1 or 2, characterized in that said irradiation phase of the neo-extruded end-product is effected inside a tunnel-shaped microwave oven through which said neo-extruded end-product passes.

4. The process according to any one of claims 1 to 3, characterized in that said irradiation phase is effected with microwaves with a power ranging from 3 to 36 KW.

5. The process according to claim 4, characterized in that said irradiation phase is effected with microwaves at a frequency of 2450 MHz.

6. The process according to any one of claims 1 to 5, characterized in that said rate ranges from 1 to 2 metres/minute.

7. The process according to claim 6, characterized in that the external pulling system comprises a series of sliding rolls.

8. The process according to any one of claims 1 to 7, characterized in that said neo-extruded end-product is a piping having a circular section.

9. The process according to claim 8, characterized in that said piping having the circular section is equipped with a vacuum percentage of the section higher than 60%.

10. The process according to claim 9, characterized in that said vacuum percentage of the section is higher than 70%.

11. The process according to any one of claims 1 to 10, characterized in that said neo-extruded end-product is made of fibre-cement.

12. The process according to any one of claims 1 to 11, characterized in that said process also comprises a cutting phase of the neo-extruded end-product.

13. A process for a production of an end-product made of a cementitious material, the process comprising:

- a mixing phase of a cement-based mixture with water to give a wet cement-based powder;
- a homogenization phase of said wet cement-based powder in a pasting machine to form a cement-based paste suitable for extrusion;

- an extrusion phase of said cement-based paste in an extruder to provide a neo-extruded cement-based end-product;
- an irradiation phase of the neo-extruded cement-based end-product with microwaves in a microwave oven having a power ranging from 0.1 to 60 KW to stiffen said neo-extruded cement-based end-product so that a form of said neo-extruded cement based end-product is preserved and to accelerate a hydration of the cementitious material, said neo-extruded cement-based end-product being moved at a rate ranging from 0.5 to 5 metres/minute by means of an external pulling system;
- a curing phase after said irradiation phase to complete the hydration of the neo-extruded cement-based end-product;
- a cutting phase of said neo-extruded cement-based end-product.

14. The process according to claim 13, characterized in that said neo-extruded cement-based end-product is a piping made of a cementitious material.

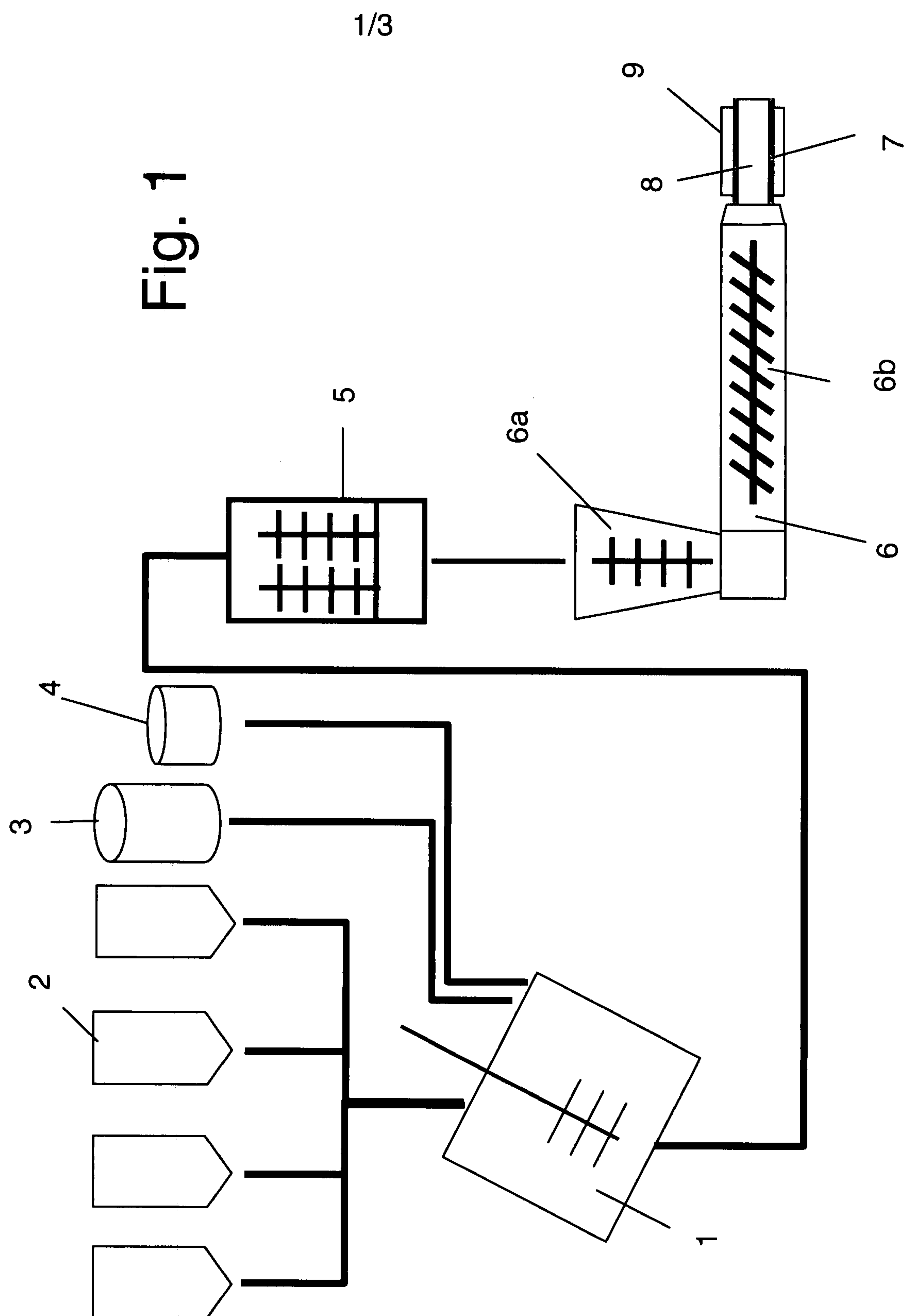
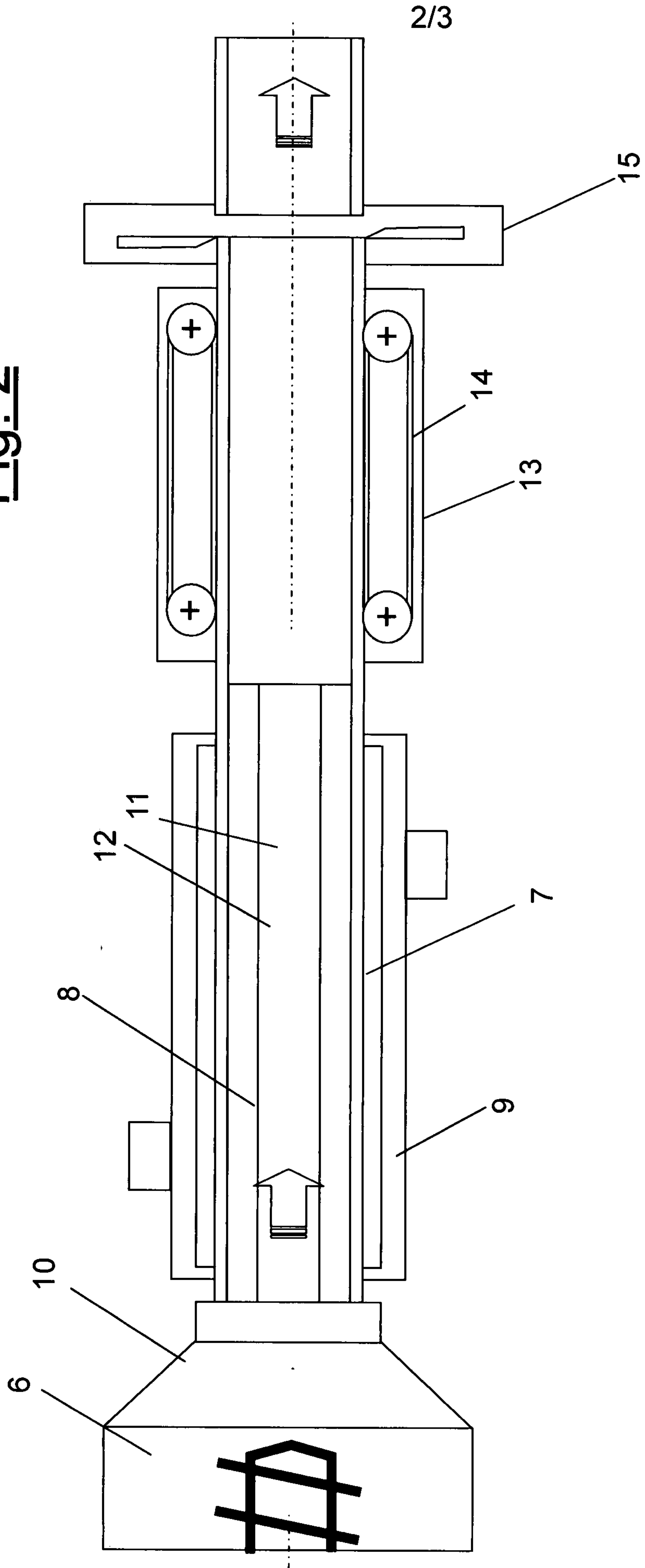


Fig. 2



3/3

