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(71) Applicant: **ART CERAMICHE S.r.l.**
Strada Statale 16 chilometro 308
I-60027 OSIMO Province of Ancona(IT)

(72) Inventor: **Galeone, Giulio**
Via San Mauro, 2
I-20055 Renate Province of Milano(IT)

(74) Representative: **de Pasquale, Carlo**
Via Carlo Ravizza 53
I-20149 Milano(IT)

(54) **Process and equipment for quick drying of ceramics.**

(57) Process for reducing strongly the drying time of ceramics, even of considerable weight, consisting in effecting drying in a single room in three stages, the first by supplying heat to a static or slightly ventilated ambient at room temperature; the second by placing the dryer under a vacuum of about 380 Torr so as to cause highly turbulent air to be introduced in the ambient; the third stopping air inlet and increasing vacuum up to about 45 Torr; or as a variant, carrying out drying in two separate rooms and in two stages: the first by supplying heat to a heated and highly ventilated ambient at room pressure; the second in an ambient where a vacuum of about 60-45 Torr is created.

Means for carrying out the process according to the first system, consisting in putting the interior of a static drying oven of known type in communication with one or more vacuum pumps, and arranging inside the oven along its walls, at intervals, a set of pipes provided along their length with a set of injection nozzles oriented on said pipes, in such a way that those of a pipe are blowing opposite to those of the pipes arranged in front and aside said pipe, respectively, so as to create a strong turbulence, said pipes being connected through manifolds with the external environment from which air is sucked only by vacuum produced in the oven.

Means for carrying out the process according to the variant, consisting in placing the material firstly in a tunnel of known type, inside which there are, for each group of materials, means blowing hot air in the form of a blade and means for moving back and forth the blowing means in respect of the group of products to be dried, or the groups of products in respect of the blowing means, for the time required to the stage in which to drying of the products corresponds also a material shrinkage, and then a second tunnel provided with heat radiating walls and with the interior communicating with one or more vacuum pumps so as to effect final drying without shrinkage.

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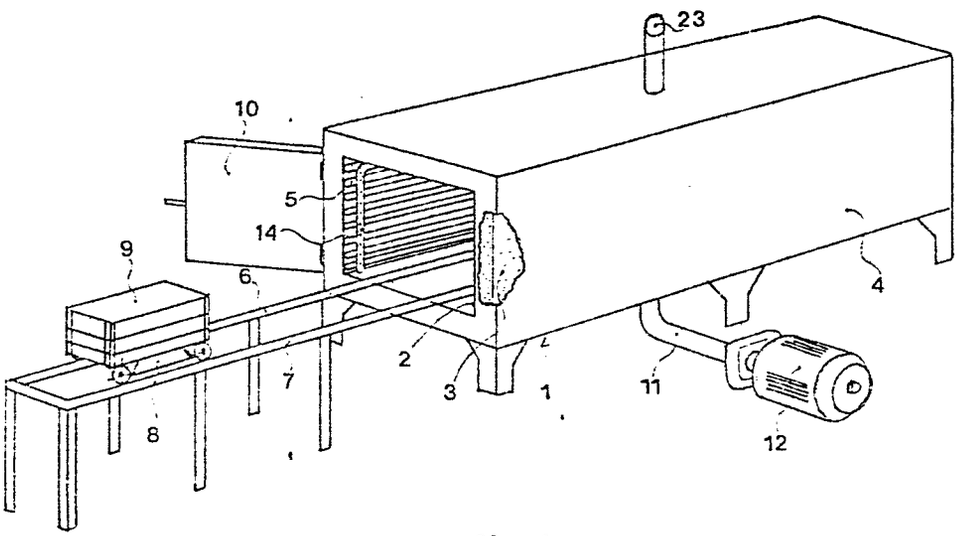

fig.1

"PROCESS AND EQUIPMENT FOR QUICK DRYING OF CERAMICS"

Dryers for ceramics of the static type under air stream are known, or of the type where the pieces to be dried are placed in an oven, the walls of which are surrounded by heat radiating surfaces, fed with electric current or heated liquid. It is also known the difficulty of drying ceramics of a certain size in a short time.

It is further known that drying of ceramics occurs in two discrete stages, the first in which the piece still contains a considerable amount of water and to moisture removal corresponds a shrink and therefore a motion of the mass proportionate to the decrease of water contents, and the second in which there is only a moisture decrease until the predetermined degree of drying is reached.

It is also known that in the known dryers, the drying times are very long (minimum time up to now achieved is 24 hours), even if some measures were taken, such as to put under light vacuum the drying chamber in order to accelerate water evaporation from the products.

With the system according to the present invention it is possible to greatly reduce drying time of the most complex ceramic products, such as for instance the sanitary fixtures, in the sense that tests carried out showed that it is possible to dry sanitary articles of a weight of 20 kg each and with a humidity of 16%, reducing it to a 1%

contents in 2-3 hours without formation of cracks or faults in the article.

Furthermore the process of the present invention allows to match the physical condition of the material during the various stages of drying (drying together with shrinkage or drying alone).

The process according to the present invention consists in causing evaporation of water to be removed from the pieces by placing them in a heated ambient in presence of hot air adapted to reach all the most concealed recesses of the materials to be dried and then by placing the ambient under a rather high vacuum.

The process provides for two possible solutions:

the first consists of three sequential stages, namely:

First stage: heating of the piece introduced in a static or slightly ventilated room, at a pressure equal to that of the externalenvironment. The internal room tends to become steam saturated and therefore it occurs a heating in a nearly saturated ambient and with limited evaporation, this lasting almost up to the end of the shrinkage phase.

Second stage: ambient is put under vacuum at about 380 Torr (500 millibars) and at the same time inlet of ambient air is effected through a device adapted to cause inside the oven a motion of highly turbulent air, so that the temperature of the material to be processed is kept above that of water evaporation under the above mentioned conditions.

Third stage: air inlet is shut off and vacuum increased up to a pressure of about 45 Torr (60 millibars).

Air may be preheated or it is heated through the supply ducts which are arranged inside the drying oven. Air motion is automatically caused by the high pressure differential between internal room and external environment. Duration and use of each

stage depends from the shape of the article, the type of material and humidity contents with which the article enters the dryer.

For instance the first stage is particularly suitable for the most difficult pieces to be dried, which must be shrunk, but it may be dispensed with in case it is not indispensable, either for the shape of the article, or when the humidity contents of the piece at its entrance in the oven is already lower than that causing the contemporaneous shrinkage in the particular article and material involved.

The second stage, which is the most efficient, is that allowing to decrease strongly the drying time because of the high turbulence caused by the inlet device where air reaches a speed close to the sound velocity, so that even the most recessed zones of the article are touched and dangerous zones of concentrated drying are avoided.

The third stage allows to complete quickly the drying cycle because of the increased vacuum, so as to remove even the last spots of residual humidity.

To sum up, in the first stages at ambient pressure one obtains drying with shinkage, firstly by heat and high ventilation and then by heat and turbulent high ventilation so as to reach all the parts of the pieces to be dried, this being obtained by putting the drying tunnel under light vacuum, while in the third stage one obtains residual drying without shrinkage in a high vacuum ambient.

The second solution is particularly suitable for plants having a high output, combining in a single operation the first two stages at ambient pressure and employing two separate rooms, namely:

First stage: blowing air at a certain speed into the tunnel operating at ambient pressure, this being not obtained by putting the tunnel under vacuum (which required structures of considerable strength), but by hitting the various groups of pieces to be dried wih several hot air blades blown from the outside and by causing said air blades

to be moved back and forth in respect of the pieces, which can be carried out either keeping the air jets stationary and moving the pieces back and forth in respect of the air blades, or giving the alternative motion to the nozzles generating the air blades. In this way the drying stage with shrinkage is obtained in the first tunnel in about one hour.

Second stage: The pieces are transferred to a second tunnel provided with heat radiating walls where a rather high vacuum is obtained, of about 60-45 Torr.

As a non limiting example only, there are now described two embodiments of two plants made for carrying out the process of the invention, according to the two above mentioned systems, illustrated in the sheets of accompanying drawings, in which:

Fig. 1 is a perspective view of an oven according to the first solution of the process;

Fig. 2 is a diagram of the pipes delivering air to the oven in order to give the required turbulence; and

Fig. 3 is perspective view, partially broken to show the interior, of the two tunnels according to the second solution of the process.

With reference now to Fig. 1, the reference numeral 1 is a dryer for ceramic material of known type as to form and shape, substantially comprising a metal inner structure 2 with parallelepipedal section in the form of a tunnel, externally covered by an insulating shell 3 enclosed by a protective envelope 4. Along the inner walls of the tunnel structure 2 there is a set of radiating panels 5 of electric type or fed with diathermic oil, so as to give the heat required for evaporation of water contained in the ceramic products to be dried. The dryer is also provided in its lower part with rails 6 and 7 on which trolleys 8 are running, on which the pieces 9 to be dried are placed, as well as with a door 10 which is closed once the dryer is loaded, and the foregoing is

the known prior art structure.

In order to carry out the process of the invention, in a suitable wall of the drying oven a pipe 11 is inserted, in communication at one end with the interior of the oven and connected at the other end with a vacuum pump 12.

Even more than one pump may be provided for a better distribution of suction in the oven, or for better commensuration of suction or vacuum level to the type of material to be processed, so as to avoid use of a too large apparatus when a smaller vacuum and/or suction is required.

Furthermore, always in order to carry out the process according to the invention, inside the oven, as shown in Fig. 2, at intervals depending upon the size and shape of the pieces to be dried, there is a set of vertical pipes 13, 14, 15, 16, 17, 18 provided along their height with a set of injection nozzles 19, but oriented in such a way that each set of nozzles is arranged opposite to the sets of nozzles arranged in front of it or aside it. This particular arrangement is such that in operation the air jets cause a strong turbulence around the material introduced in the oven, reaching every recessed portion thereof.

The vertical pipes 13, 16, 18 are connected at their upper end with the longitudinal manifold 20 and the pipes 14, 15, 17 with the longitudinal manifold 21, said manifold being in turn connected each other by a single cross pipe 22 which sucks air from atmosphere through the upright pipe 23.

Sucked air may be preheated, if necessary, but it is generally sufficient the heating obtained by the simple passage in the pipes delivering it inside the oven.

According to the characteristics and the wet condition of the material entering the dryer, one of the three stages, and generally the first one, may be dispensed with.

An embodiment of a plant made for carrying out the variant of the process

according to the invention is now being described always as a non limiting example only.

With reference now to Fig. 3, the plant consists of two indipendent elements 101 and 201 arranged in series. In the element 101 the first stage of quick drying with shinkage takes place, and in the element 201 occurs the second stage of final drying without shrinkage.

The element 101 is substantially a dryer for ceramic materials of known type as to shape and form, essentially comprising an internal metal structure 102 of parallelepipedal section in the form of a tunnel, externally covered with an insulating shell 103 enclosed in a protective envelope 104. Inside the tunnel, at a distance approximately equal to the length of the material carrying trolleys, all around the internal perimeter of the tunnel there are blowing pipes 105, 105' etc. provided with nozzles adapted to produce a laminar blow.

The dryer is also provided in its lower part with rails 106, 107 on which trolleys 108 are running, on which the pieces 109 to be dried are placed. The tunnel is closed at its ends by moving lamellar elements 110, adapted to allow passage therethrough of the trolleys with the material and at the same time a certain air sealing.

All the blowing pipes are connected to one or more manifolds 111 in turn connected to one or more fans 112 adapted to suck hot air from a suitable source and to supply it to the blowing pipes 105, 105'.

In order to obtain a quick drying without cracks of the products introduced in the oven during this first stage in which to the evaporation of water contained in the products corresponds also a material shrinkage, the relative position between blowing pipes and material to be dried does not remain stationary, but on the contrary an alternative motion is imparted either to the blowing pipes or to the trolleys during the

whole drying time which takes place in the short term of about one hour, the motion having a width equal to the distance between two blowing pipes in order to sweep with the blown air the material to be dried. The device for effecting the alternative motion is not shown in the drawings, but there are several devices of different mechanical, pneumatic or hydraulic type which are well known to a man skilled in the art.

The element 201 is also substantially a drying oven for ceramic materials of known type as to shape and form, essentially comprising an internal metal structure 202 of parallelepipedal section in the form of a tunnel, externally covered by an insulating shell 203 enclosed in a protective envelope 204. Along the inner walls of the tunnel structure there is a set of radiating panels 205 of electric type or heated with diathermic oil, so as to produce the heat required for evaporation of water contained in the ceramic products to be dried.

The dryer is also provided in its lower part with rails 106 and 107 on which run the trolley 108 carrying the pieces 109 to be dried and with the doors 206 and 207 which are closed once the dryer is loaded. The foregoing is a known structure of the prior art.

In order to carry out the second stage of the variant of the process, in a suitable wall of the drying oven there is inserted a pipe 208 communicating at one end with the oven interior and at the other end with a vacuum pump 209.

Even more than one pump may be provided for a better distribution of suction in the oven, or for better commensuration of suction or vacuum level to the type of material to be processed, so as to avoid use of a too large apparatus when a smaller vacuum and/or suction is required.

Furthermore, always in order to carry out the process according to the invention, inside the oven, as shown in Fig. 2, at intervals depending upon the size and shape of

the pieces to be dried, there is a set of vertical pipes 13, 14, 15, 16, 17, 18 provided along their height with a set of injection nozzles 19, but oriented in such a way that each set of nozzles is arranged opposite to the sets of nozzles arranged in front of it or aside it. This particular arrangement is such that in operation the air jets cause a strong turbulence around the material introduced in the oven, reaching every recessed portion thereof.

This particular arrangement is such, that during operation of the system,the trolleys are transferred to the second drying oven 201, after completion of the first stage in the first element 101.

Air-tight doors 206 and 207 are closed, the heating device 205 and the vacuum pump 209 are actuated and at the same time additional trolleys are introduced in the first dryer 101. When the drying operation lasting about two hours is completed, the pump is stopped, doors are open and the oven is unloaded so as to be ready for a new operative cycle.

In view of the speed with which in the dryers according to the present invention the complete drying of the pieces occurs, although they are drying plants of the static type, they were designed in the form of a tunnel, i.e. provided with doors at each end of the oven, so that the wet materials enter from one door at one end and go out from a second door at the other end of the tunnel, in order to create an almost continuous flow of material, and to allow in this way to insert the dryer of the present invention in a continuous production line.

It is to be understood that the foregoing embodiments were described only for a non limiting illustrative purpose, so that many variations may be devised to put into practice the proposed solutions of the system of the invention.

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CLAIMS

1) Process for quick drying of ceramics in static ovens, characterized by the fact that drying is carried out by placing the pieces to be dried in a heated ambient under vacuum and in presence of highly turbulent air following three stages: the first consisting in their heating in a static or slightly ventilated room at a constant pressure equal to the ambient pressure; the second stage in putting the room under a vacuum of about 380 Torr and delivering air to the room through a device causing a high turbulence in the room; and the third stage in increasing the vacuum up to a pressure of about 45 Torr.

2) Process according to a Claim 1, characterized by the fact that one of the three stages may be eliminated according to the characteristics and conditions of the material to be dried.

3) Process according to Claims 1 and 2, characterized by the fact that drying may be carried out as a variant by putting the pieces to be dried, first in a heated and highly ventilated room at ambient pressure and subsequently in a room where a vacuum of about 60-45 Torr was produced.

4) Device for carrying out the process according to Claim 1, characterized by the fact that to a static oven of known type one or more vacuum pumps (12) and means to blow air inside the oven are applied, said blowing occurring at high velocity and exclusively as a consequence of the vacuum made inside the oven, the air blowing nozzles being arranged in such a way to cause a turbulent motion of said air inside the oven.

5) Air blowing means according to Claim 4, characterized by the fact of comprising a set of vertical pipes (13, 14, 15, 16, 17, 18) arranged inside the oven and distributed along the longitudinal walls of the oven at a suitable distance and provided along their

extension with a set of injection nozzles (19), said nozzles being arranged on said pipes in such a way that the nozzles of a given pipe blow oppositely (in a direction swung at 90°) in respect of the pipes arranged in front and aside it respectively, so as to create inside the oven a very high turbulence, each set of pipes arranged on one side of the oven being connected at the upper end with a horizontal pipe or manifold (20, 21), and the two horizontal pipes may possibly but not necessarily be connected to each other by a pipe (22) from which a suction pipe (23) may lead outside the oven in order to suck ambient air.

6) Plant for carrying out the process according to Claim 2, characterized by the fact of comprising two elements (101, 102) arranged in series, substantially consisting of two tunnel structures like those of the known static drying ovens for ceramics, but open at both ends, wherein in order to carry out the process according to Claim 1, the pieces (109) are placed on trolleys (108) running on rails (106, 107).

7) Element (101) according to Claim 6, characterized by the fact that inside it, at a distance approximately equal to the distance between centers of two trolleys and all around the inner perimeter of the oven, are arranged blowing pipes (105, 105' etc.) provided with nozzles (107) adapted to produce a laminar flow and at the ends with lamellar doors (110) adapted to allow with their displacement entrance of pieces and to form a certain partial sealing dam for the air blown inside the oven.

8) Element (101) according to Claim 7, characterized by the fact that a fan (112) supplies through the manifold (111) pressurized air to the nozzles (107) of the blowing pipes (105), said air being preheated with known means arranged outside the oven.

9) Element (101) according to Claims 7 and 8, characterized by the fact that during the whole time during which the drying stage occurs, either the blowing pipes or the trolleys are effecting an alternative back and forth motion of a width equal to the

distance between centers of the blowing pipes, said motion being actuated with known mechanical, pneumatic, hydraulic systems and the like.

10) Element (210) according to Claim 6, characterized by the fact that all around the internal walls there are radiating panels (205) of the electric type or fed by diathermic oil, and the dryer is provided at its ends with sealingly closed doors (206, 207).

11) Element (201) according to Claim 10, characterized by the fact that in a tunnel wall there is inserted a pipe (208) communicating at one end with the oven interior and connected at the other end to a vacuum pump (209).

12) Quick drying plant acording to one or more of Claim 3 to 11, characterized by the fact that they are designed in the form of tunnels, with entrance and exit doors so as to carry out and intermittent but unidirectional flow of material, so as to allow that the plant may be inserted in a continuous production line.

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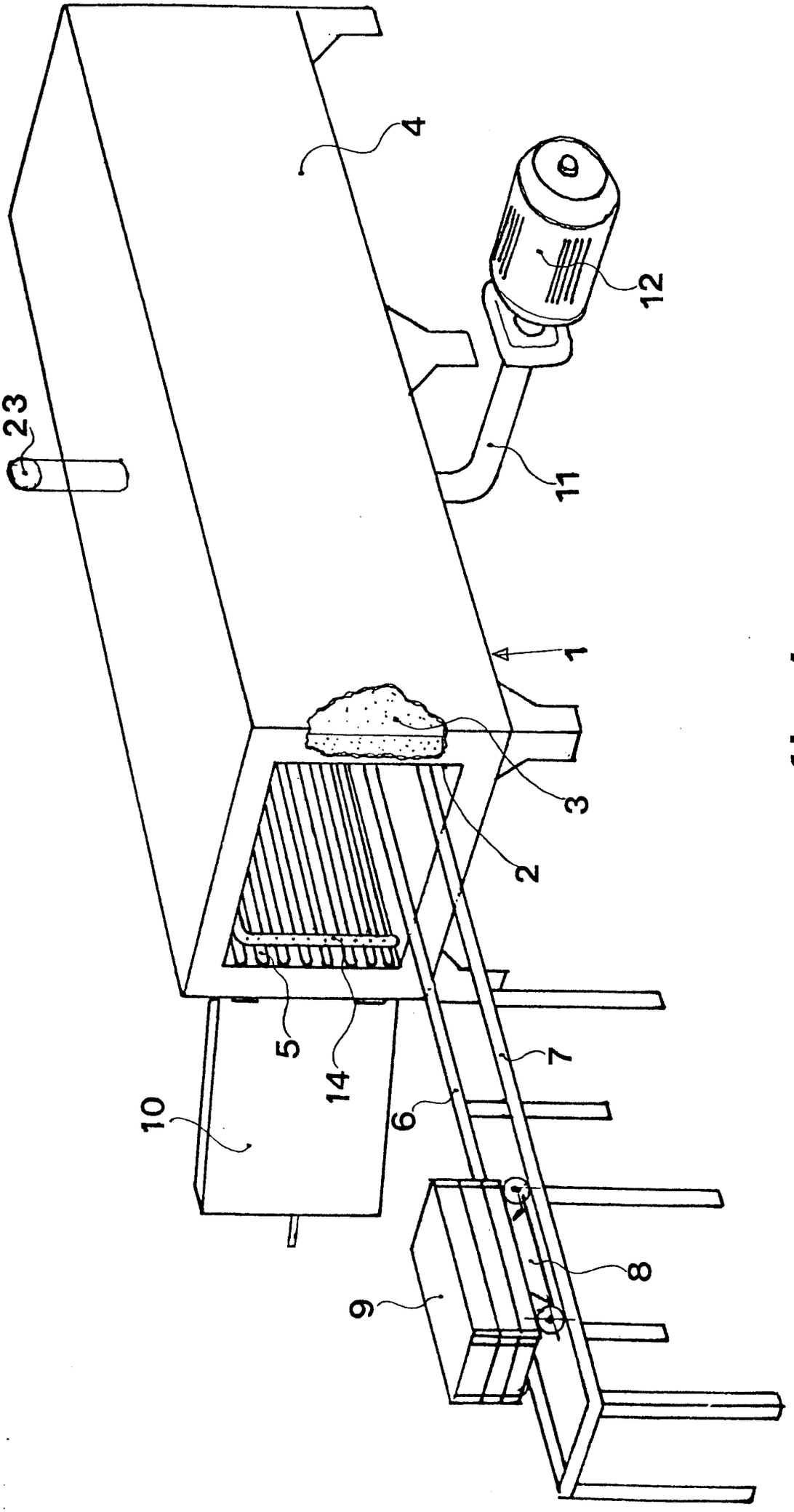

fig.1

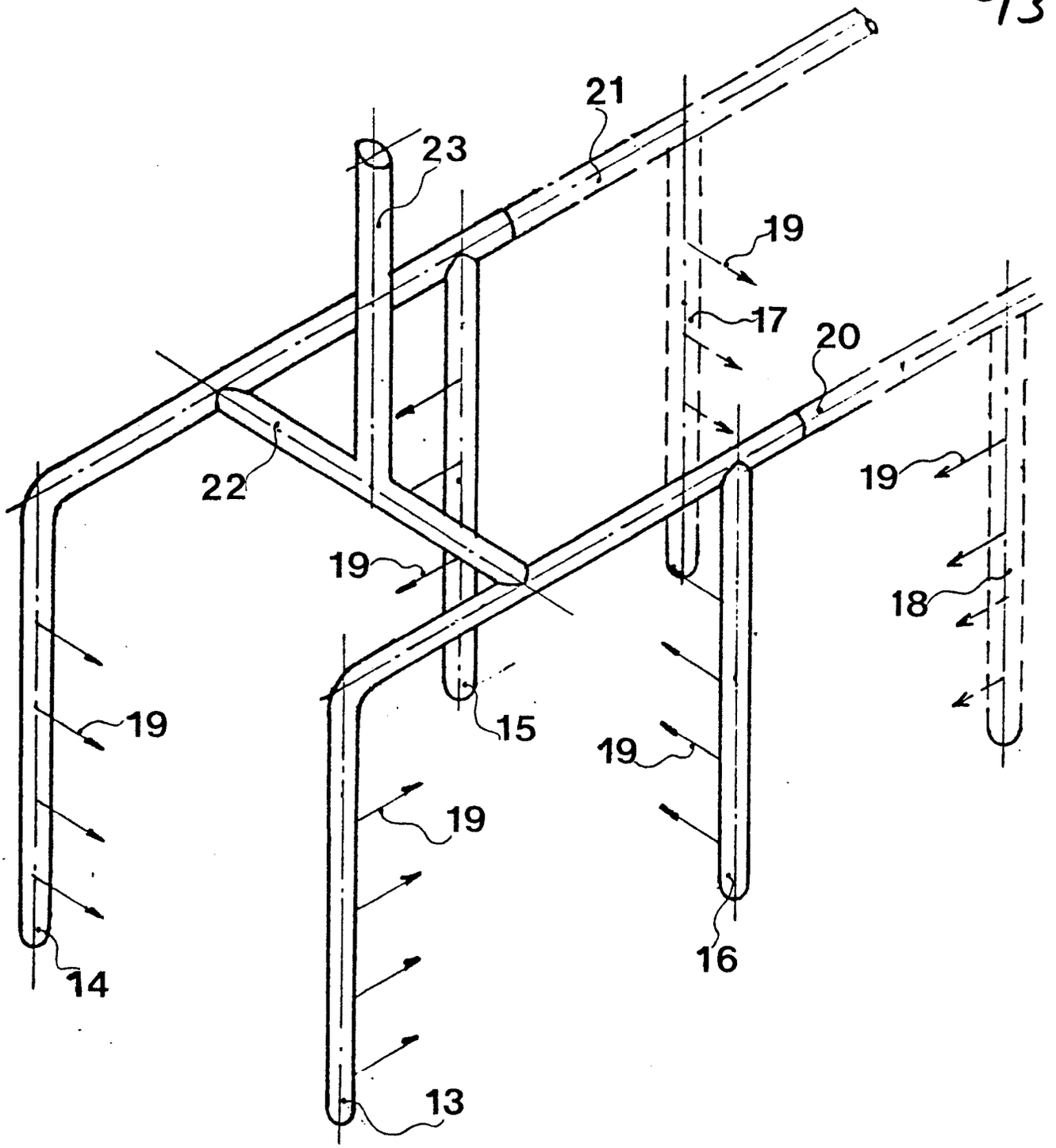

fig. 2

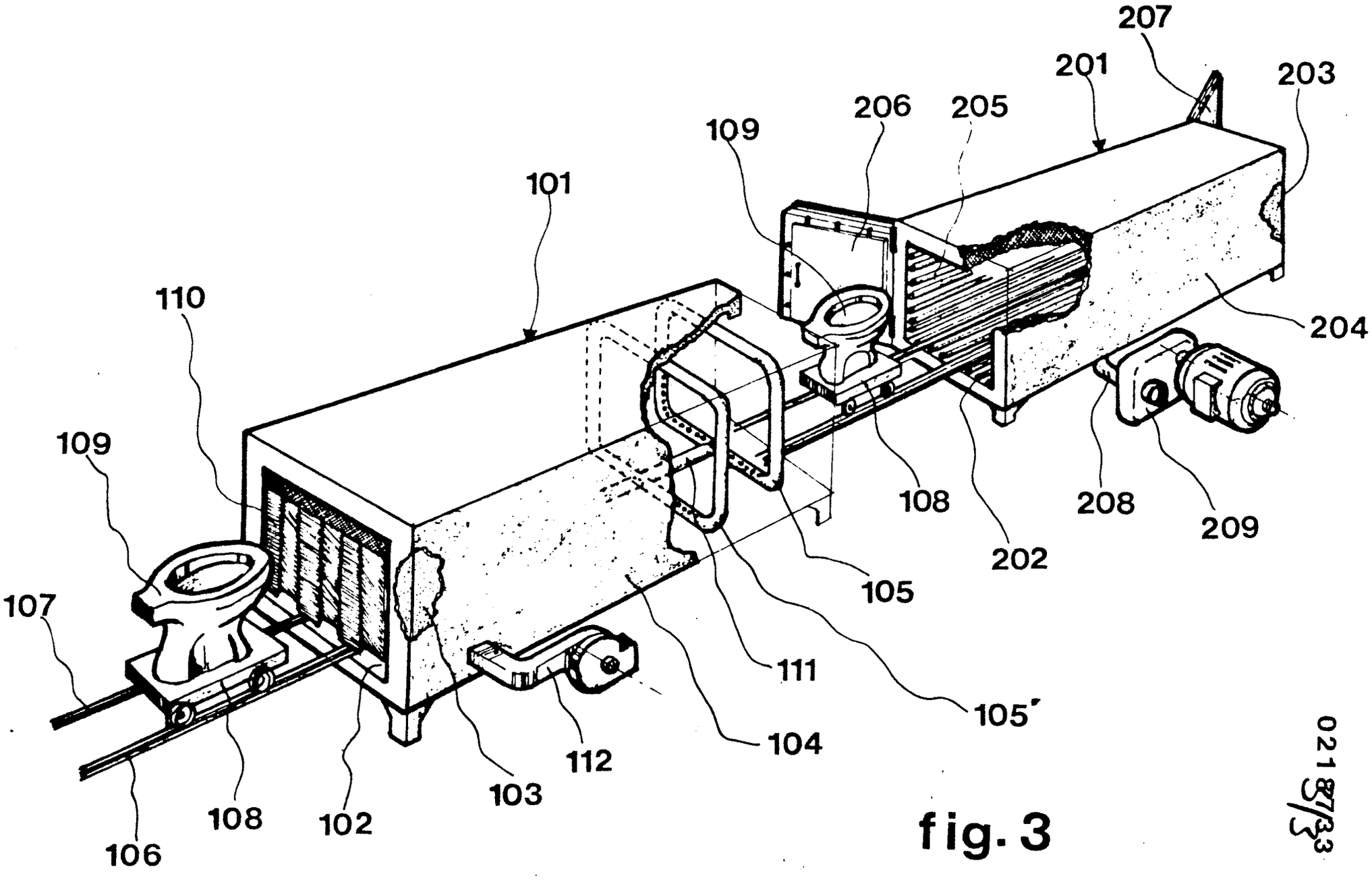
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fig. 3