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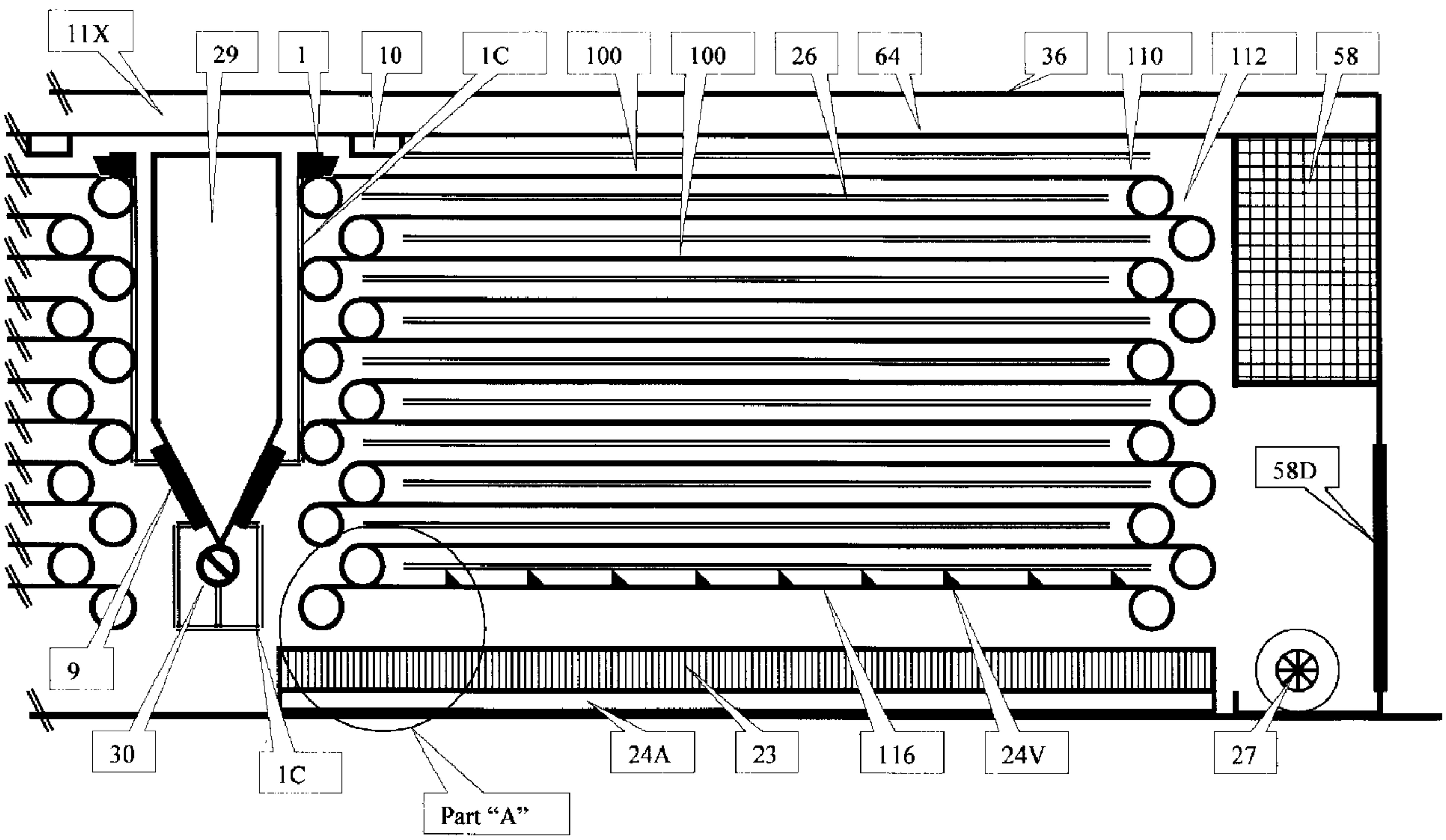
(54) Titre : SYSTEME DE TRAITEMENT DES DECHETS DE LARVES D'INSECTES
(54) Title: SYSTEM FOR PROCESSING WASTE USING INSECT LARVAE

SYSTEM FOR PROCESSING SUBSTRATE – Longitudinal Crosscut

Single Column Processing Block – Modified Conveyer Belt



(57) Abrégé/Abstract:
The present invention is a system for processing organic waste using insect larvae, which has the advantage of being able to process large quantities of organic fecal waste material. The system includes a plurality of substantially flat Reaction Vessels stacked one on top of the other in parallel arrangement to form a processing block. Each of the Reaction Vessels in the Processing Block 11 are dimensioned and configured to contain a quantity of organic waste, each Reaction Vessel having front and back edges and parallel side edges, the Reaction Vessels each being separated from the Reaction Vessel above by an Air Space, the

(57) Abrégé(suite)/Abstract(continued):
Processing Block being contained in a Plant Enclosure having side walls. At least one of the side walls of the Plant Enclosure positioned adjacent the Processing Block such that the side wall is adjacent one of the side edges of the Reaction Vessels, said wall, herein called Plenum Wall 65, having a plurality of openings which open to the Air Spaces, the openings positioned on the plenum walls such that openings are immediately adjacent Air Spaces. The system further includes an air circulation system for circulating purified and adjusted air through each of the Air Spaces by passing air through each of the openings in the plenum wall. The system also includes a larvae collector positioned below the block of Reaction Vessels for collecting the larvae, which fall of the edged of the Reaction Vessels. The system also includes a feeder system for loading raw organic waste onto the Reaction Vessels, and a discharge system for removing processed organic waste from the Reaction Vessels.

ABSTRACT

The present invention is a system for processing organic waste using insect larvae, which has the advantage of being able to process large quantities of organic fecal waste material. The system includes a plurality of substantially flat Reaction Vessels stacked one on top of the other in parallel arrangement to form a processing block. Each of the Reaction Vessels in the Processing Block 11 are dimensioned and configured to contain a quantity of organic waste, each Reaction Vessel having front and back edges and parallel side edges, the Reaction Vessels each being separated from the Reaction Vessel above by an Air Space, the Processing Block being contained in a Plant Enclosure having side walls. At least one of the side walls of the Plant Enclosure positioned adjacent the Processing Block such that the side wall is adjacent one of the side edges of the Reaction Vessels, said wall, herein called Plenum Wall 65, having a plurality of openings which open to the Air Spaces, the openings positioned on the plenum walls such that openings are immediately adjacent Air Spaces. The system further includes an air circulation system for circulating purified and adjusted air through each of the Air Spaces by passing air through each of the openings in the plenum wall. The system also includes a larvae collector positioned below the block of Reaction Vessels for collecting the larvae, which fall of the edged of the Reaction Vessels. The system also includes a feeder system for loading raw organic waste onto the Reaction Vessels, and a discharge system for removing processed organic waste from the Reaction Vessels.

PATENT APPLICATION

Title: System for Processing Waste Using Insect Larvae

Inventor: Ivan Milin

TITLE: System for Processing Waste Using Insect Larvae

FIELD OF THE INVENTION

The invention relates generally to processes for processing organic waste.

BACKGROUND OF THE INVENTION

As long as life existed, recycling was the way to balance the life cycle on this planet. We currently have the technology to recycle most of our waste, but most recycling technologies are not profitable and are therefore not likely to be implemented. In particular, the large scale processing and recycling of animal, bird and human feces, which is generated in enormous amounts on huge industrialized bird and animal farms, and in our own cities, is extremely problematic. The goal of this invention was to design equipment and plant layout for total recycling of animal, poultry and human feces, which would be sufficiently profitable, that it would make feces wanted commodity, instead of being major environmental pollutants. The desired plant would mimic Mother Nature and produce organic fertilizer and protein-rich animal feed with no waste at all and without using any artificial chemical compounds in the process.

For hundreds of millions of years, flies have been depositing their larvae onto animal feces and in the process of feeding, the larvae where transforming the feces into the best natural, organic fertilizer known. The bi-product of the larvae is the best fertilizer because for hundreds of millions of years, plants of this planet relied on exactly that kind of fertilizer for their growth and development, and in their fight for survival, they have adopted their metabolism to use exactly that kind of fertilizer. The same way, larvae themselves are the best natural source of protein and fat for animals and birds.

Beside some laboratory and pilot-plant experiments, there are a few known attempts, to design equipment and plant layout, which would use larvae of flies to process animal and bird feces. The attempts where somewhat successful in obtaining organic fertilizers and protein rich mass of larvae, but up till now, this technology was not used much because of sever technological problems encountered during production and due to a lack of profitability of the plants. Up till now, a few different systems are being tested in this field. In one system, flies are simply allowed to deposit larvae on the pile of feces placed in a pit and mature larvae were collected as they try to migrate out of the pile, to start the process of pupating. Approximately 12% of feces where transformed to fertilizer and the rest of feces simply degraded anaerobic, releasing large amounts of ammonia, formaldehyde and other highly polluting gasses into the atmosphere. A huge infestation of flies tormented the neighborhoods and leakage from the pile polluted soil and underground water.

In other system, feces (herein called "Substrate") are deposited directly onto a conveyer belt, seeded with larvae of flies and the belt itself is used as a Processing Vessel. System, which uses trays as a Processing Vessels, was also tested. Trays with substrate are moved on conveyer belts through the process for several days, until substrate is transformed into organic fertilizer.

Using conveyer belts as a Processing Vessel has many difficulties. One of the difficulties is that older larvae would migrate into the territory of younger larvae and compete with the younger larvae for the food, causing a food shortage for younger larvae, which would stay underdeveloped. On the other side, where older larvae migrated from, the substrate is left with not enough larvae to finish the process, so some substrate remained unprocessed. Also, a thick crust of dried out substrate, formed on the top of the processed material, could not be processed by larvae. The thick crust also prevents poisonous decomposition gasses from leaving the substrate. Removing the crust with scrapers was a very messy and costly procedure.

Another problem with the use of conveyor belts is that at the end of the process, when most of the substrate is transformed into organic fertilizer, mature larvae instinctively start to migrate out of the substrate and if they start migration along the conveyer belt, they would never be able to reach the end and come out of substrate. Only larvae that started migration across the belt would find the end of substrate and come out of it. Also, conveyer belt systems, as used now, are very bulky, very messy, and require huge facilities but offers very low productivity (capacity per occupied area). The high cost of energy makes it very costly to maintain large facilities, especially in this industry, where the cost of heating and ventilation makes up a large portion of operating expenses.

Some improvements are made by placing 3 conveyer belts one on top other and using each level as a Processing Vessel for one-day production. In such a system, two sets of 3 conveyer belts are used to finish the process of conversion. These triple conveyer belt systems solved the problem of older larvae migrating to the substrate of younger larvae, because in these triple conveyer belt systems all the larvae on one level are of the same age.

In triple conveyer belt systems, the conveyer belts are moved once a day, dumping their substrate onto the belts below them. After several days, the substrate is converted into organic fertilizer and could go to further processing and packaging.

Multilevel conveyer belt systems created new problems. As they are now, conveyers are very messy and it is very difficult to contain and control the substrate when it is dropping 60 to 70cm from one conveyer to other. The falling distance could not be lowered, because every conveyer is placed within the tunnel along which the warm air is blown to take away decomposing gasses and maintain the suitable temperature for larvae growth.

The moving tray system is similar to the conveyer belt system but instead of loading the substrate onto a belt, the substrate is loaded into a plurality of trays and the trays are placed onto the conveyer belt. In this system, older larvae could not migrate to the trays with younger larvae but they also could not get out of the substrate after the process is finished. Also, this design does not lend itself to a multi-layer or stacked design, so the process is much bulkier and less productive.

Static, non-moving trays have also been suggested for use with this technology. Unfortunately, filling, emptying, cleaning and handling large amounts of trays is very difficult and costly, for any system using standard trays.

Furthermore, static tray systems also do not use the natural instinct of larvae to migrate out of the finished product. The formation of dry crust was not solved in tray system as well.

As a result of everything, tray systems, as they are now, are very costly, and problematic and acceptable only for small laboratory operations.

None of the above processes utilize an efficient and economical solution for heating and ventilation of processing facilities, which represent a good portion of operating expenses. Also, because of the nature of the processed material, good ventilation system is needed for obvious reasons

Preheating of substrate was also not solved efficiently in any of the prior existing processes. Small quantity of substrate could be preheated in a few hours with the use of heaters placed on the outside surfaces of a substrate Receiving tank, but for a larger amount of substrate in colder climates, heating from the outside of the tank could take days to reach the suitable working temperature. High temperatures could not be used to speed up the heating process, because mixing in large tanks could never be good enough to prevent burning of substrate on the heated surfaces. The smell of burned substrate would definitely be unacceptable.

Also, every time the new, cold substrate is dumped into the Receiving tank with mixer, the whole substrate would cool down and production would have to wait until all the substrate is slowly heated to the optimal temperature for larvae growth. There are other problems associated with mixing the substrate within the large Receiving Tanks, which where not solved in the previous art.

Mechanically, anything could be done, but if any unused substrate is left in the tank and it is mixed with freshly arrived substrate, some portion of that old substrate would remain in the tank for a very long time. Since degradation of substrate is increased by time, the remaining amount of old substrate would degrade rapidly, releasing ammonia, formaldehyde and other toxic and unpleasantly smelling gases. The unused portion of the old substrate might linger in a large tank for months and degradation and smell would be worse and worse every day. Beside the bad smell, degradation products from decomposing feces are also toxic to the larvae.

Given the numerous drawbacks of the prior art systems of substrate processing, improved systems are desirable. The improved system would overcome the problems of low productivity, poor and expensive heating & ventilation, inefficient mixing and heating of substrate, improve larvae/substrate separation and others. All of the improvements would lead to sufficient profitability and thus, acceptance of this technology by the industry.

SUMMARY OF THE INVENTION

The present invention is a system for processing organic waste using insect larvae. The system includes a plurality of substantially flat reaction vessels stacked one on top of the other, to form a processing block, each of the reaction vessels in the processing block being dimensioned and configured to contain a quantity of organic waste, each reaction vessel having front and back ends and substantially parallel side edges, the reaction vessels each being separated from the reaction vessel above by an air space, the processing block being contained in a plant enclosure having side walls. At least one of the side walls of the plant enclosure is positioned adjacent the processing block such that the side wall is adjacent one of the side edges of the reaction vessels. The side wall has a plurality of openings, which communicate with the air spaces. The openings are positioned on the side wall such that the openings are immediately adjacent the air spaces. The system further includes an air circulation system for circulating air through the air spaces by passing air through the openings in the side wall and a feeder system for loading raw organic waste onto the reaction vessels. The system also includes a discharge system for removing finished products from the reaction vessels.

With the foregoing in view, and other advantages as will become apparent to those skilled in the art to which this invention relates as this specification proceeds, the invention is herein described by reference to the accompanying drawings forming a part hereof, which includes a description of the preferred typical embodiment of the principles of the present invention.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic top view of a system for processing substrate according to the present invention showing the various components of the system arranged in a rectangular arrangement.

Figure 2 is side view from the center of the system shown in figure 1, showing the stacked arrangement of processing vessels (modified conveyer belts), in a single column processing block.

Figure 3 is an expanded view of part A of figure 2 and shows the end portion of a pair of bottom conveyors during the substrate transfer, with a side view of the guide, scraper, water spray, unloading plows and heating elements.

Figure 4 is a cross sectional view of a portion of figure 2 showing the relationship of the stacked reaction vessels (conveyors) to the larvae collecting system, both enclosures and ventilation slots.

Figure 5 is a top schematic view of a system for processing substrate according to the present invention showing a multitude of production sections 11A, around the substrate receiving tank 29.

Figure 6 is a schematic side view of the Receiving Tank 29 with feeder system of the present invention.

Figure 7 is side view of an alternate embodiment of the present invention wherein the reaction vessels comprise flat plates in a multi column processing block.

Figure 8 is top view of the Guide 15 portion of the present invention.

Figure 9 is a front view of the Guide 15 portion of the present invention.

Figure 10 is a cross sectional view of loading ends of belts during the operation of depositing and transferring substrate, with a side view of Perforator 6D.

Figure 11 is a cross-sectional view of the Mixer-Homogenizer portion of the invention, of the present invention.

Figure 12 is a cross-sectional view of a Depositor 1 portion of the present invention.

In the drawings like characters of reference indicate corresponding parts in the different figures.

DETAILED DESCRIPTION OF THE INVENTION

Referring firstly to figure 1 and 2, a system (or plant) for treating substrate with fly larvae made in accordance with the present invention, is shown generally as item 99, and consists of one or more independent Production Sections 11A coupled to mutual Substrate Receiving Tank 29 in the middle. The production sections 11A are each placed on one side of the mutual substrate Receiving tank 29 and consists of one or more Processing Blocks 11, plus finishing and air treating equipment placed on the periphery of the plant, opposite of Receiving tank 29. Processing Blocks 11 each consist of a plurality of substantially flat processing vessels (or trays) arranged in parallel stacks one above the other, in a rows containing one or more stacks adjacent to each other. Preferably, the processing vessels each consists of a modified conveyer belt, 100, which are stacked as a single column, in a staggered arrangement on the top of each other such that the unloading end 110 on one belt would be immediately above the loading end 112 of the belt placed below it. Each Processing Block includes a substrate depositor 1 and Larvae Seeder 10, which are positioned above the Loading End 112 of the Topmost Belt 114. Larvae Seeder 10 is a device configured to deposit predetermined amount of live fly larvae on the organic substrate as the topmost belt 114 passes underneath it.

From the Receiving Tank 29, the substrate is pumped by the Pump 30, through the Substrate Mixer-Homogenizer 2, which is located within the Warming Mantle 9, to the Depositor 1. Distributing Pipes 1C split and deliver the mixed and preheated substrate to depositors of different Processing Blocks 11.

Referring now to figure 4, at the end of the processing cycle, mature larvae instinctively start to leave the Substrate Piles 200 in order to start transformation into pupae. For the purpose of collecting migrating larvae, a Seesaw Collector 23 is placed below the lowest belt. Migrating larvae would fall onto the Seesaw Collector 23 and would slide down to the Larvae Collecting Container 23B. The bottom modified conveyer belt 116 is equipped with a multitude of Plows 24V, which are dimensioned and configured to plow the processed Substrate Pile 202 off the sides of the last belt 116, and spread it uniformly over the whole length of the Seesaw Collector 23, which is now turned to slope towards Fertilizer Collector 24A. From the Seesaw Collector 23, processed substrate (fertilizer) would slip to a Fertilizer Collector 24A, equipped with system of transporters. Transporters deliver the fertilizer to the Sieving Station 58 (see figure 1&2) which is positioned on the end of Production Section 11A, opposite Receiving Tank 29.

Referring back to figure 1 and 2, sieving station 58 is a series of sieves, which removes larger material from the finished fertilizer and separate fertilizer within numbers of desired grain sizes. The lower portion of the Sieving Station 58 contains the Entrance Door 58D to the Production Section 11A and Ventilation Fan 27 (Fig. 2&7). Air Treating Unit 28 is placed beside the Sieving Station and it is connected to the pressure side of the Ventilation Fan 27 (Fig. 2&7). Drying Station 68 is placed on the other side of Sieving Station 58, on the end of Processing block 11. The Drying Station 68 receives fertilizer from the Sieving Station 58 and dries it by a warm airflow. After the fertilizer is dried, it goes to further processing and packaging.

Referring again to figure 4, the entire plant is completely enclosed within a Plant Enclosure 64, creating Interior Space 11S, which is in turn further enclosed within the Exterior (high pressure) Enclosure 36, creating Exterior Space 11X, (see figure 1 and 4). Ventilation Fan 27 is configured to draw air from inside of the Plant Enclosure 64 (interior space 11S) and push the air through the Air Treating Unit 28 into the Exterior Space 11X of the Exterior Enclosure 36, thereby creating negative pressure within interior space of Plant Enclosure 64 and positive pressure within the exterior space of Secondary Exterior Enclosure 36. Plant Enclosure 64 forms a Plenum Wall 65 adjacent belts 100 and having a plurality of horizontal ventilation slots 26 which are strategically located on the plenum wall 65 immediately adjacent the Air Space 206 between adjacent reaction vessels, just where the deposited substrate pile 200 is (Fig. 4). As the air pressure within the plant enclosure 64 is lowered, purified and conditioned air is sucked from the outside of Plant Enclosure 64, through Slots 26 and into air space 206 where the substrate and larvae are located. The temperature, humidity and impurities of the air contained within exterior enclosure 36 are maintained at optimal levels for larvae growth.

Referring now to figure 6, when the organic waste to be processed is deposited into the Receiving tank 29, it becomes a “Substrate”. The Substrate Receiving Tank 29 is preferably placed inside the plant enclosure (see item 64 of figure 1 and 2), between production sections 11A. The bottom of the Receiving Tank 29 is “V” shaped, with a Pump 30 connected to the narrow bottom. Referring now to figures 6 and 12, to avoid mixing and heating of the substrate within the large Receiving tanks, a small but efficient Static Mixer-Homogenizer 2 is dimensioned and configured to be enclosed within the Warming Mantle 9, creating a very efficient Heat Exchange Unit 9H. The pump (item 30 of figure 6) pushes the substrate trough the piping system and mixer-homogenizer 2, which is designed to break the structure into a homogenous mass.

A Warming Mantle 9 is preferably mounted on the Receiving Tank 29. Warming mantle 9 is a double walled structure, where in which warm water circulates, thereby preheating the substrate within the Static Mixer-Homogenizer 2.

Referring now to figure 12, after the substrate is heated to the needed temperature, the distributing pipes 1C will distribute the substrate to the Substrate Depositors 1. Depositor 1 is positioned above loading end of the Topmost Belt 114. Depositor 1 consists of Distributing Chamber 1D and Shaped Opening 1N. The preheated substrate is pumped by Pump 30, through Distributing Pipes 1C, into the Distribution Chamber 1D where it gets distributed evenly through the chamber The substrate passes trough the Isosceles trapezoid Shaped Opening 1N, where the substrate gets shaped and deposited onto the moving Belt below. After the substrate has bin deposited along the whole length of the belt, the belt would stop moving and the depositor would stop depositing. The cross-sectional profile of the deposited substrate is shaped as an isosceles trapezoid with the edges of the substrate being spaced from the edges of the belt.

In order to create ventilation canals and holes within the deposited or transferred substrate, Perforator 6D, with circular pins or discs (Fig. 8, 9,10 and 13) is mounted on an axis just above the surface of the substrate as the substrate is being deposited or transferred on the loading side of the belt (Fig. 10). As the substrate moves, perforator's pins are caused to rotate and create a plurality of holes or canals within the substrate.

Referring now to figure 3, prior art methods suggest separate "rollers" to spread and distribute fallen substrate evenly after it falls from an upper belt to a lower belt. In this innovation, a special roller is not needed because the upper Roller 47D does the spreading and distributing after the substrate falls down from it to a lower belt (Fig. 3). By placing the Belts so close to each other, the height of the fall of substrate is reduced substantially and it is much easier to control the falling substrate and keep the area clean. The distance between two modified conveyer belts could actually be reduced to the thickness of the substrate itself (Fig. 3)

Referring now to figures 3, 8 and 9, to minimize offsetting of the Belts, and to prevent spillage of substrate during transfer to the lower belt, a specially designed Guide 15 is placed around the unloading Roller of the top belt. The bottom of the Guide 15 is position on the receiving belt thereby preventing the spillage of the substrate and keeping the substrate from getting too close to the side edges of the belt. Two prolonged “Shaping Arms” 15A, push the excess substrate away from the edges of the belt and at the same time, shape the edges of the transferred substrate to have downwardly sloped sides 5A, towards the side edges of the belt (Fig. 9).

To improve the contact between the bottom edge of the shaping arms 15A and the receiving belt, Belt Holders 13A (Fig. 9) are shortened to make room for installation of flat Supporting Plates 47H below the belt, under the bottom edges of the Shaping Arms 15A. The shaping arms 15A could also be used to hold the Perforator Axis 6X with circular pins or disks.

Referring back to figure 3, Belt Cleaning Scraper 14 is provided to improve the discharge of substrate material from one belt onto another and to clean the surface off the belt. Belt Support 13 is placed below belt 100 as close as possible to the top portion of the belt, and at a position on the belt immediately adjacent Roller 47D. Belt Support 13 is positioned such that lower portion of belt 100 is lifted immediately adjacent to Roller 47D, and has the effect of forcing the bottom of belt 100 upward. By forcing the bottom of the belt upwards, a perfect place is created for belt cleaning scraper 14. Cleaning scraper is placed behind and adjacent to the unloading Roller 47D, between the bottom of the unloading roller

47D and the belt support 13 (Fig. 3), so that the Belt will be cleaned after it distributes and spreads the fallen substrate. In prior art, the scraper was placed in front of the unloading roller, which contributed to the substrate being pushed further from the roller, thereby requiring the receiving (lower) conveyer belt to be offset more to prevent spillage. Offsetting creates unproductive space, which decreases productivity. Also, spreading and distributing of fallen substrate, by Roller of unloading belt, would not be practical if cleaning scraper would not be placed after the spreading and distributing point.

Referring now to figure 4, the larvae collection system will now be discussed in greater detail. Close to the end of the processing cycle, mature larvae instinctively start to leave the substrate in order to start transformation into pupae. Migrating larvae will fall of the side edges of the belt into a Seesaw Collector 23, which is placed underneath the last belt. The larvae normally start their instinctive migration in all directions and the one migrating along the length of the belt would not be able to reach the end of the substrate. To encourage larvae to migrate across the substrate rather than along it, heating element 4 is placed along the middle of the belt, preferably below the upper belt of the last in the series (see item 4 on figure 3), to raise the temperature along the middle of the belt. The only way for larvae to escape the heat would be to migrate across the substrate.

From the Seesaw Collector 23, larvae would slide down to the Larvae Collecting Container 23B. If the space is limited and Seesaw Collector 23 could not be tilted enough, a vibrator device 23V could be installed onto the Seesaw Collector 23 to help fertilizer and larvae slip down the Collector's slope.

After the substrate is processed on the modified conveyer belts, larvae would convert the substrate into fertilizer and migrate out of it. To remove finished fertilizer from the last belt, and distribute it evenly along the Seesaw Collector 23, a multitude of Unloading Plows 24V are placed just above the substrate. Plows 24V are lowered down to the belt surface, just before the belt starts to move. As the belt moves, fertilizer is plowed from the belt onto the Seesaw Collector 23. Without the Unloading Plows, fertilizer would be dumped all on one spot below the unloading end of the last belt. From the Seesaw Collector 23, fertilizer would slide down to the Fertilizer Container 24A. Fertilizer Container is equipped with screw transporter, which would take it for further processing through the Sieving, Drying and other processing stations.

Referring back to figure 1, the Production Sections 11A as discussed thus far are placed on both sides of the Receiving Tank; however, for smaller capacities, the plant could be built on only one side of the Receiving Tank and with only one Processing Block 11. Alternatively, as illustrated in figure 5, for very large capacities, the tank could be designed to have six or more sides and production sections could be build on each side of the tank.

The present invention has many advantages over the prior art. Since the heating and ventilation of large and bulky facilities is very costly and represents a large portion of expenditure in this technology, the biggest challenge of this innovation was to compress the processing aria as much as possible and yet have sufficient and uniform flow of properly conditioned and purified air across the Reaction Vessels, for optimal development and living conditions of fly larvae. In the previous art, heating and ventilation was achieved by blowing heated air along relatively large tunnels in which the conveyer belt was placed. As a result, the beginning of the tunnel was vented vigorously with the substrate drying up more then needed, making it impossible for larvae to process it, while the opposite end of the tunnel was poorly ventilated with air already saturated with decomposition gasses and moisture from the rest of the tunnel. To achieve the proper ventilation on the opposite end of the tunnel, unreasonably large amounts of warm air had to be blown along the tunnel. According to the prior art, it was necessary to maintain a distance of between 60cm to 70cm between the substrate and the ceiling of a tunnel for proper ventilation, what made the whole system very bulky. A large amount of energy was used that way and most of it was vented to the atmosphere.

For the reasons stated above, in the present invention, ventilation is done “sideways”, across the belts or across the rows of processing vessels, thereby eliminating all of the problems mentioned above. Furthermore, in the previous art, the large space needed for proper ventilation created other problems as well. During the transfer of substrate to the lower belt, substrate would have to fall from the height of the tunnel (at least 60cm), which made the operation very messy and difficult to control. Indeed, everything in the previous art suggests a huge expenditure of energy, large processing facilities and great difficulty in containing falling substrate and larvae from one level to other. Furthermore, the previous art did not take appropriate measures to heat and mix the substrate in large quantities.

In this invention the working space is compressed to the bare minimum. The space between deposited substrate and the upper modified conveyer belt has been completely eliminated. The Roller of the upper modified conveyer belt is actually touching the surface of the substrate on the lower belt and it is used to spread and distribute substrate across the lower belt during the transfer operation. There is no room at all between the substrate and the Roller of the belt above it (Fig. 3).

To create additional room for ventilation, the lower belt of the conveyer was lifted as much as possible by the small Belt Supports creating relatively thin Air Space 206, slightly smaller then the radius of the Roller (Fig. 3). For the ventilation to be efficient in a narrow space like that, a uniform airflow, across the substrate has to be achieved for the entire length of the deposited substrate. The relatively inexpensive solution was achieved by enclosing the entire plant within the Plant Enclosure 64, making sure that, at least one side edge of the belts with deposited substrate, are adjacent to one side wall of the enclosure. Further more, Ventilation Slots 26 are provided along the walls of Plant Enclosure 64 just adjacent the Air Spaces 206 (Fig. 4 and 3). To create a sufficient, uniform and precise air flow through the ventilation slots 26 in the wall, a Ventilation Fan 27 was placed within the plant enclosure 64, which is adapted to suck air from the plant and push it through an Air Treating Unit 28 outside of the plant. The fan creates a partial vacuum within the plant enclosure, which sucks the air from surroundings of the plant, trough the ventilation slots 26 and create the needed uniform airflow over the substrate. This very simple solution has many advantages over traditional ventilation systems. An important economic advantage is that expensive installation of ventilation ducts are not needed at all. Also, to achieve so precise and uniform delivery of air at so many places, ductwork would have to be very intricate and numerous, requiring much extra space. In a ducted system, the Ventilation Fan would have to spend extra power to overcome the pressure-drop created by intricate and long ductworks and the cost would be unacceptable.

Beside economic advantages, there are other advantages worth mentioning. The partial vacuum, created within the plant interior, would suck toxic decomposition gasses (ammonia, formaldehyde, and others) out of the substrate, creating better environment for larvae growth. Lowered amounts of toxic decomposition gasses within the substrate would allow larvae to feed deeper within the substrate, which means the thickness of substrate could be increased, which would increase the productivity of the plant and make it more profitable.

To make the air flow more efficient and to prevent warm and conditioned air to simply be vented to the atmosphere, a secondary Exterior Enclosure 36 was provided around the Plant Enclosure 64 (Fig. 1, 2, 4 and 7). The Ventilation Fan 27 can now push the air through the Air Treating Unit 28 to the Exterior Enclosure 36 and create the positive air pressure in the space between two enclosures (Exterior Space). With positive pressure on the outside of the plant and the negative pressure inside the plant, the sufficient airflow through the Ventilation Slots 26 could be achieved with much less power. This ventilation system would work if pressures between the inside and outside of the plant would be reversed, but some of the advantages mentioned above would be lost.

By circulating the air between the two enclosures, very little heat and moisture would be lost to the atmosphere. Besides removing the toxic by-products of decomposition of substrate, not much has to be done to condition the recycling air.

Since the distance between the reaction vessels in this invention is so small, transferring substrate from upper to lower belt does not represent a big problem. To assure cleanliness during the transfer and proper shaping of the transferred substrate, a specially configured Guide 15 with Shaping Arms 15A (Fig. 3, 8 and 9) was placed around the unloading end of the belts.

Properly shaping the deposited substrate is important to prevent falling of the substrate from edges of the belt. Depositor 1 was also designed with features to properly shape the deposited substrate.

To improve the venting of toxic decomposition gasses from the deposited substrate, a specially designed Perforator with circular pins 6D was implemented after the deposition and transfer of substrate (Fig. 10).

Water spray 3 was placed above the unloading end of the belts (Fig. 3) to soften the dry crust during the transferring of substrate, so larvae would be able to consume the crust as well.

To avoid heating and mixing the substrate within large Receiving tanks, a small but efficient Static Mixer-Homogenizer 2 was placed within the piping system 1C (Fig. 6&12). If needed, Mixer-Homogenizer could be easily adapted to preheat the substrate during the mixing operation. For that purpose, Mixer-Homogenizer is placed within the Warming Mantle 9 (Fig. 6&12), creating an efficient heat exchanger. The source of heat in Warming Mantle 9 is preferably circulating warm water.

Furthermore, to encourage mature larvae to migrate towards the edges of the belt, Heating Elements 4 were placed along the middle of the belt. Heating elements 4 would raise the temperature of the middle of the substrate to the uncomfortable level for the larvae and encourage them to migrate towards the edges, instead of migrating along the belt.

Finally, to prevent the last belt from dumping all the fertilizer on one spot, below the unloading end, a plurality of Plows 24V are placed above the processed substrate (Fig. 3 and 4), which would drop down to the surface of the belt when belt starts unloading and uniformly plow the fertilizer over the side edges of the belt.

A specific embodiment of the present invention has been disclosed; however, several variations of the disclosed embodiment could be envisioned as within the scope of this invention. It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims.

Therefore, what is claimed is:

1. A system for processing organic waste using insect larvae comprising: a plurality of substantially flat reaction vessels stacked one on top of the other in a substantially parallel arrangement to form a processing block, each of the reaction vessels in the processing block being dimensioned and configured to contain a quantity of organic waste, each reaction vessel having front and back ends and side edges, the reaction vessels each being separated from the reaction vessel above by an air space, the processing block being contained in a plant enclosure having side walls; at least one of the side walls of the plant enclosure positioned adjacent the processing block such that the side wall is adjacent one of the side edges of the reaction vessels, said wall having a plurality of openings which communicate with the air spaces, the openings positioned on the side wall such that the openings are adjacent the air spaces; an air circulation system for circulating air through the air spaces by passing air through the openings in the side wall; a feeder system for loading raw organic waste onto the reaction vessels, and a discharge system for removing finished products from the reaction vessels.

2. The system of claim 1 further comprising an exterior enclosure having an exterior space, the exterior enclosure being adjacent the side wall of the

plant enclosure, and wherein the air circulation system includes an air blower communicating with the air spaces for creating an air pressure difference between the air spaces and the exterior space sufficient to flow air between the air spaces and the exterior space.

3. The system of claim 2 wherein the plant enclosure has an interior space communicating with the air spaces and wherein the air blower communicates with the interior space.

4. The system of claim 3 wherein the air blower also communicates with the exterior space.

5. The system of claim 4 wherein the air blower is adapted and configured to lower the air pressure in the air spaces relative to the exterior space.

6. The system of claim 1 wherein the air circulation system is adapted and configured to lower the air pressure in the air spaces relative to the air surrounding the plant enclosure.

7. The system of claim 2 wherein the air circulation system further comprises an air treatment device for optimizing the air for processing needs.

8. The system of claim 1 wherein the reaction vessels comprise an elongated belt.

9. The system of claim 8 wherein elongated belt comprises an elongated continuous flexible web suspended between a pair of rollers, the belt having a lower portion and an upper portion, the upper portion of the belt acting as the reaction vessel, the lower portion of the belt being elevated towards the upper portion by a pair of belt supports positioned adjacent the rollers.

10. The system of claim 1 wherein the feeder system comprises a receiving tank for storing a quantity of organic waste, a depositor for depositing the organic waste onto the reaction vessels, a moving device for moving the organic waste from the receiving tank to the depositor.

11. The system of claim 10 wherein the feeder system further includes a substrate mixer-homogenizer between the receiving tank and the depositor, the substrate mixer-homogenizer being adapted and configured to substantially mix and homogenize the organic waste.

12. The system of claim 11 wherein the mixer-homogenizer comprises a static mixer.

13. The system of claim 9 wherein the belts further comprise a belt scraper dimensioned and configured to bear against the belt at a position on the belt between a bottom of the unloading roller and a belt support.

14. The system of claim 8 further comprising a water sprayer for spraying water onto the substrate on the belt.

15. The system of claim 9 wherein each of the belts have a loading end and an unloading end, the belts being oriented such that the unloading end of one belt is above the loading end of the belt immediately below, the ends of the belts being positioned such that the substrate unloaded from one belt fall on to the loading end of the belt immediately below, and further comprising a guide mounted adjacent to the unloading end of the belts for guiding the falling substrate onto the loading end of the belt immediately below.

16. The system of claim 15 wherein the guide has shaping arms which force the falling substrate towards the center of the belt immediately below.

17 The system of claim 1 further comprising a heating element mounted adjacent the middle of at least one of the reaction vessels, the heating element adapted and configured to heat the substrate adjacent the

heating element to a temperature sufficient to cause the larvae to move away from the heating element.

18. The system of claim 11 further comprising a water inlet placed in front of the substrate mixer-homogenizer for injecting water into the substrate.

19. The system of claim 11 further comprising a heater positioned in such way to heat the substrate within the substrate feeder system, between the receiving tank and the depositor for heating the substrate before depositing.

20. The system of claim 1 wherein the discharge system comprises a larvae collector, being a substantially flat member tilted so as to guide the falling finished products towards a collecting container.

21. The system of claim 1 wherein the discharge system comprises a larvae collector being a substantially flat member which is pivotally movable between a first position wherein the collector guides the falling larvae towards a larvae collecting container and a second position wherein the flat member guides processed substrate towards a second position.

22. The system of claim 8 wherein the discharge system comprises a series of plows, movably mounted above the lowermost belt and movable between

a raised position wherein the plows are above the substrate and a lowered position wherein the plows are forced into the substrate.

23. The system of claim 15 wherein the roller of the unloading end of the belt is separated from the upper portion of the belt immediately below by a distance, the distance being selected such that the roller of the unloading end of the belt as a spreader to uniformly spread out the substrate deposited on the lower belt to a desired thickness.

24. The system of claim 1 further comprising a perforator for creating a series of venting perforations in the substrate on the reaction vessels.

Fig.1

SYSTEM FOR PROCESSING SUBSTRATE (99) – Top View – Modified Coveyer Belt

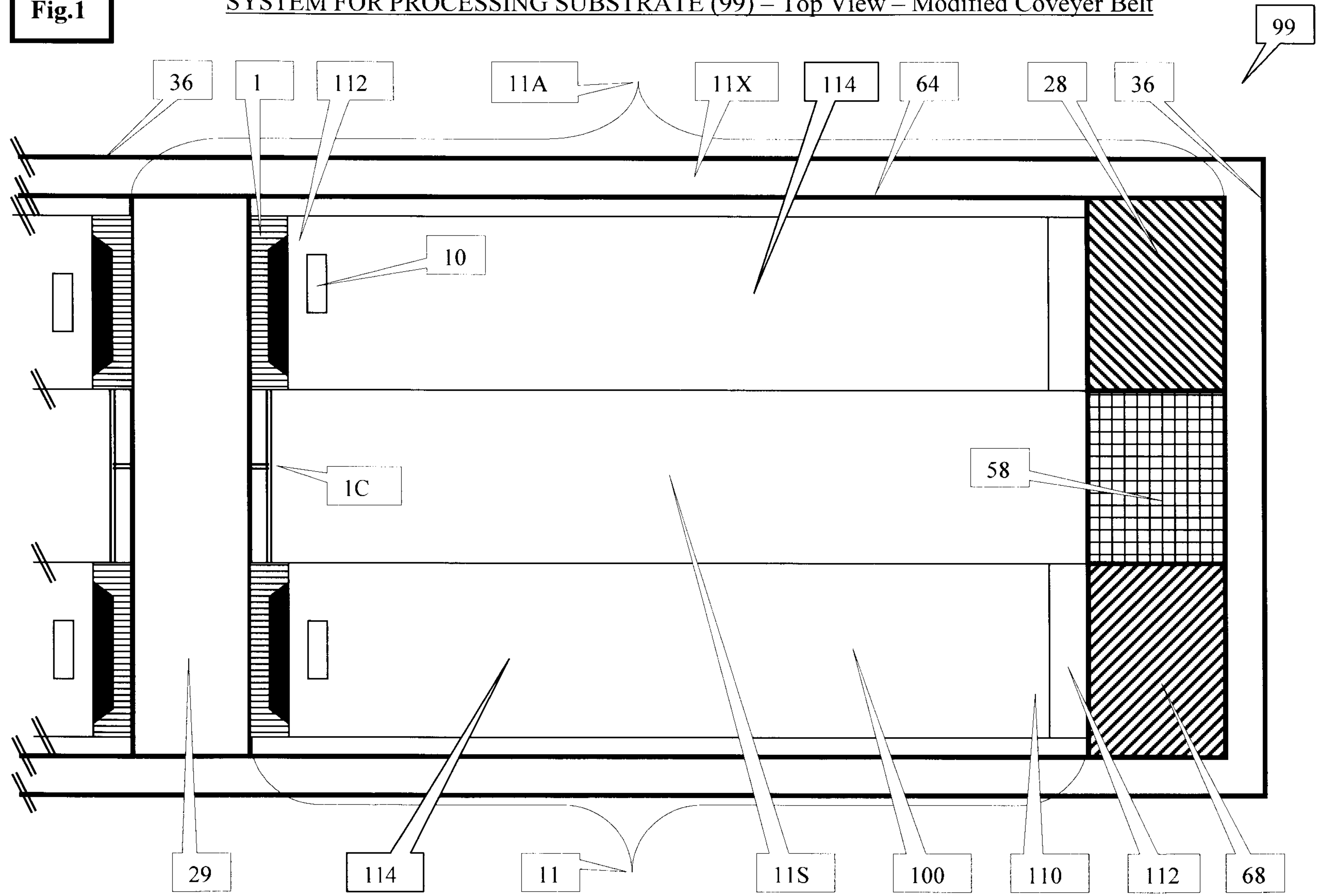
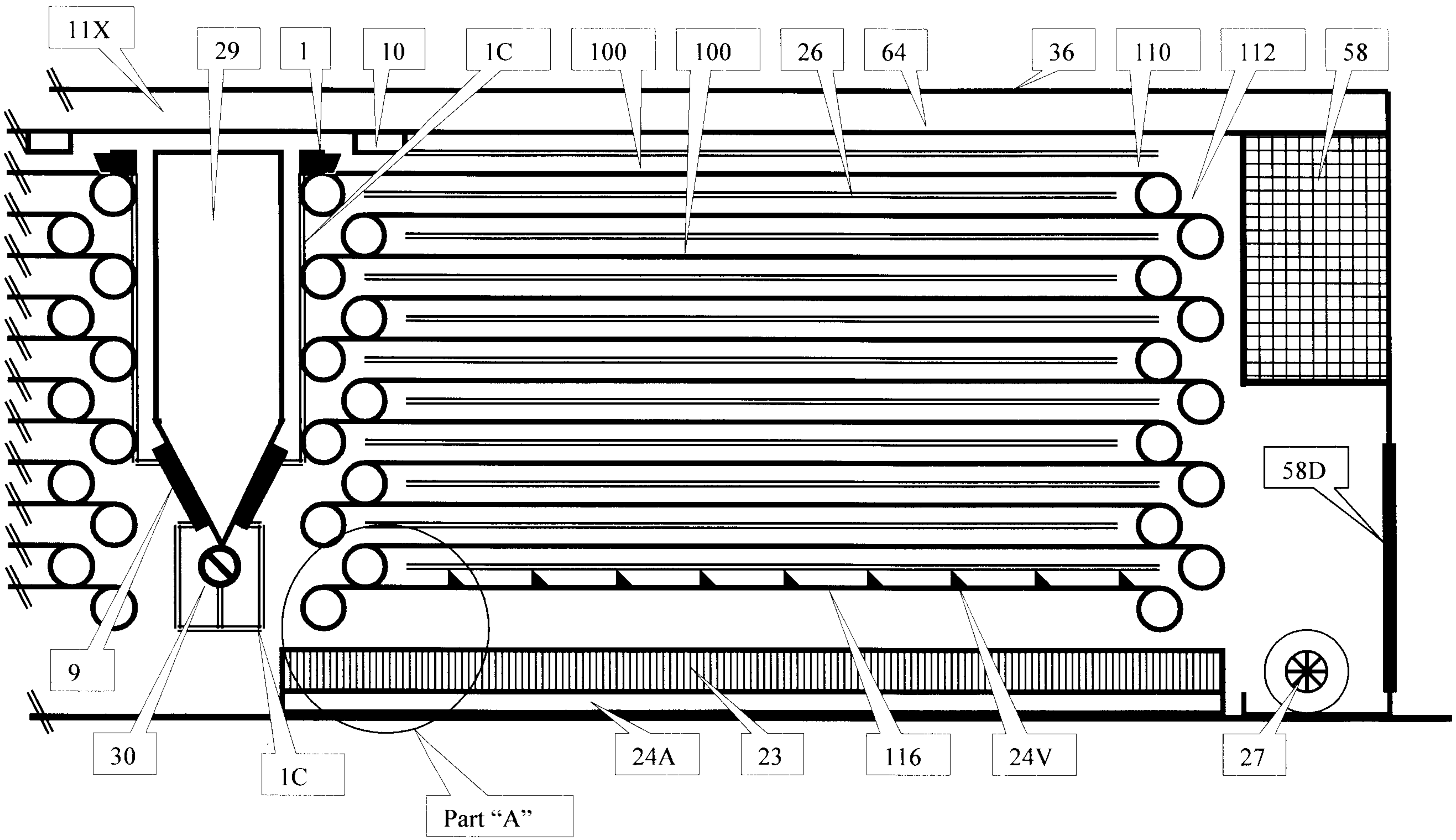


Fig. 2

SYSTEM FOR PROCESSING SUBSTRATE – Longitudinal Crosscut

Single Column Processing Block – Modified Conveyer Belt



PART "A" - TRANSFERING SUBSTRATE TO THE LAST BELT – Side View

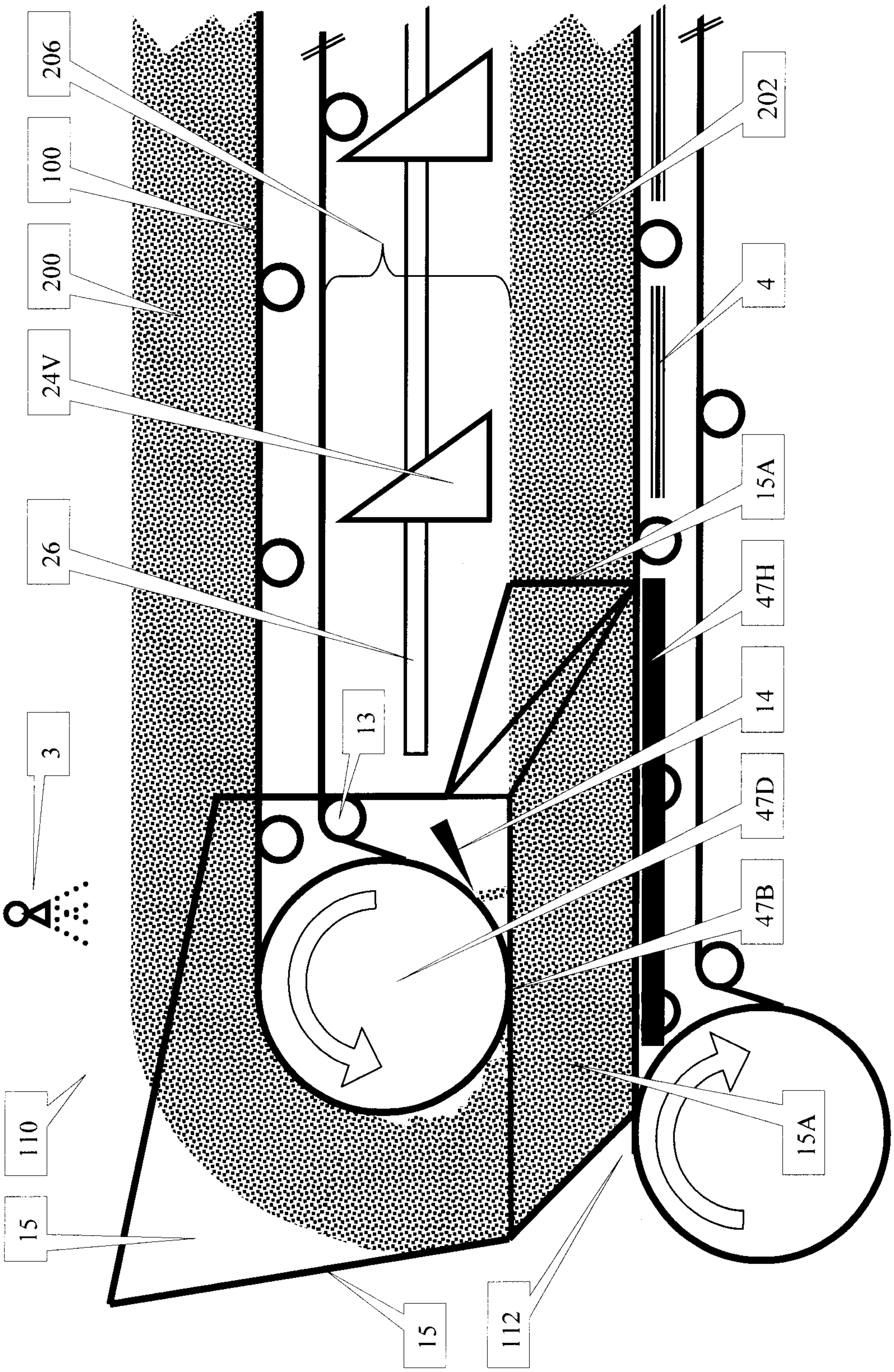


Fig. 3

Fig. 4

PROCESSING BLOCK – Front view

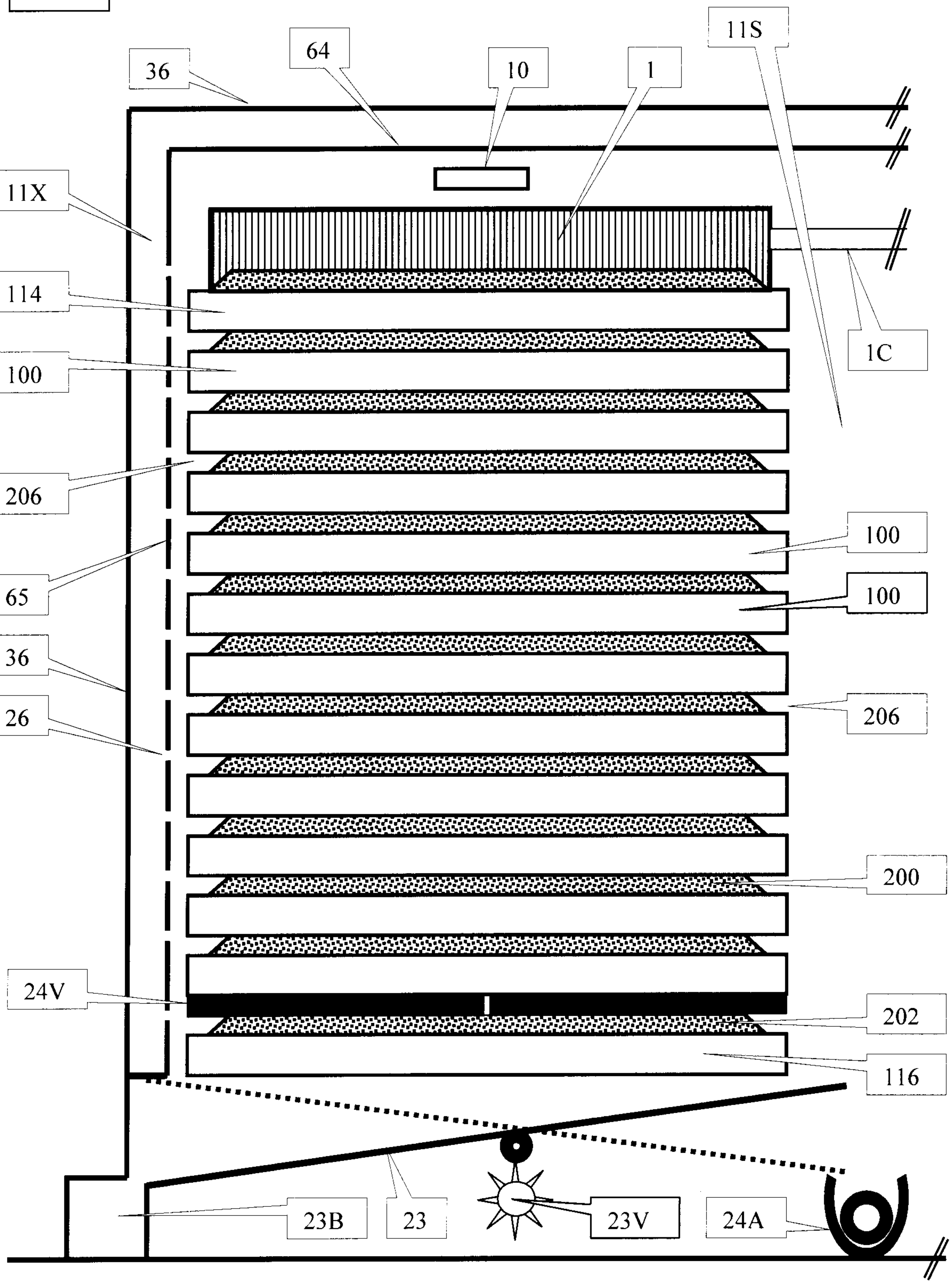


Fig. 5 **PLANT WITH MULTIPLE PRODUCTION SECTIONS**– Top View

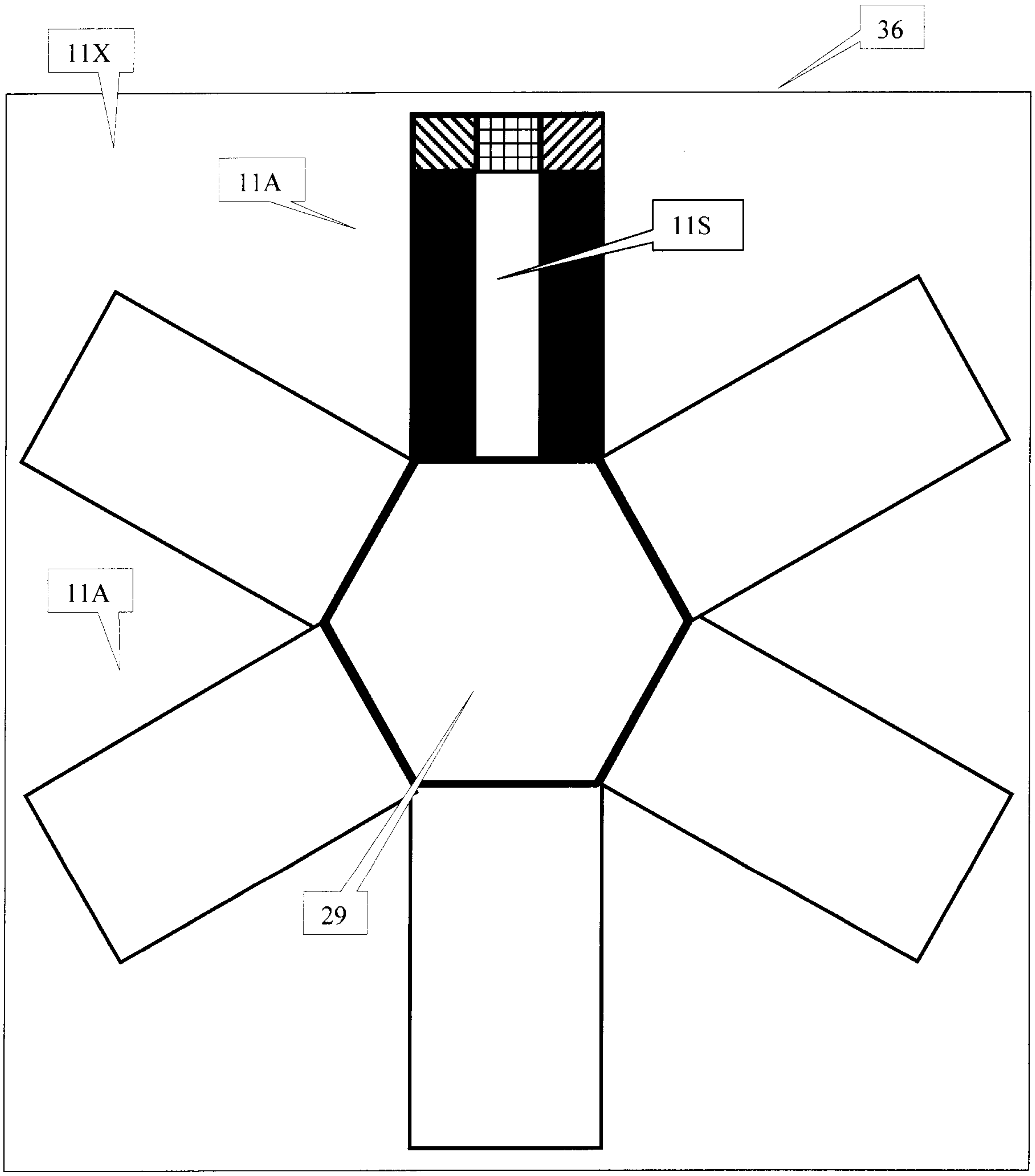


Fig. 6

SUBSTRATE RECEIVING TANK WITH FEEDER SYSTEM

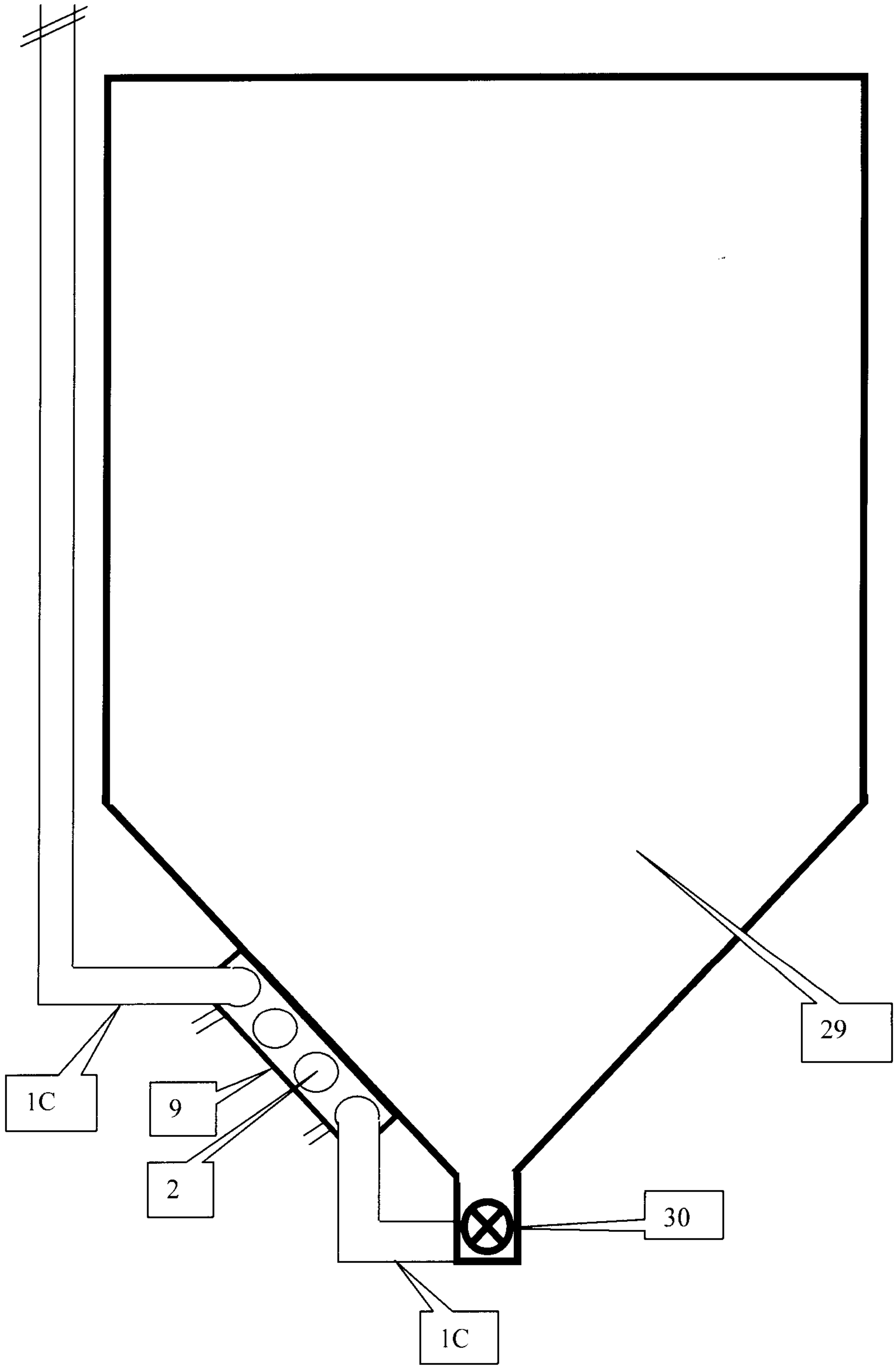


Fig. 7

MULTI COLUMN PROCESING BLOCK - Flat Reaction Plates

Longitudinal Crosscut

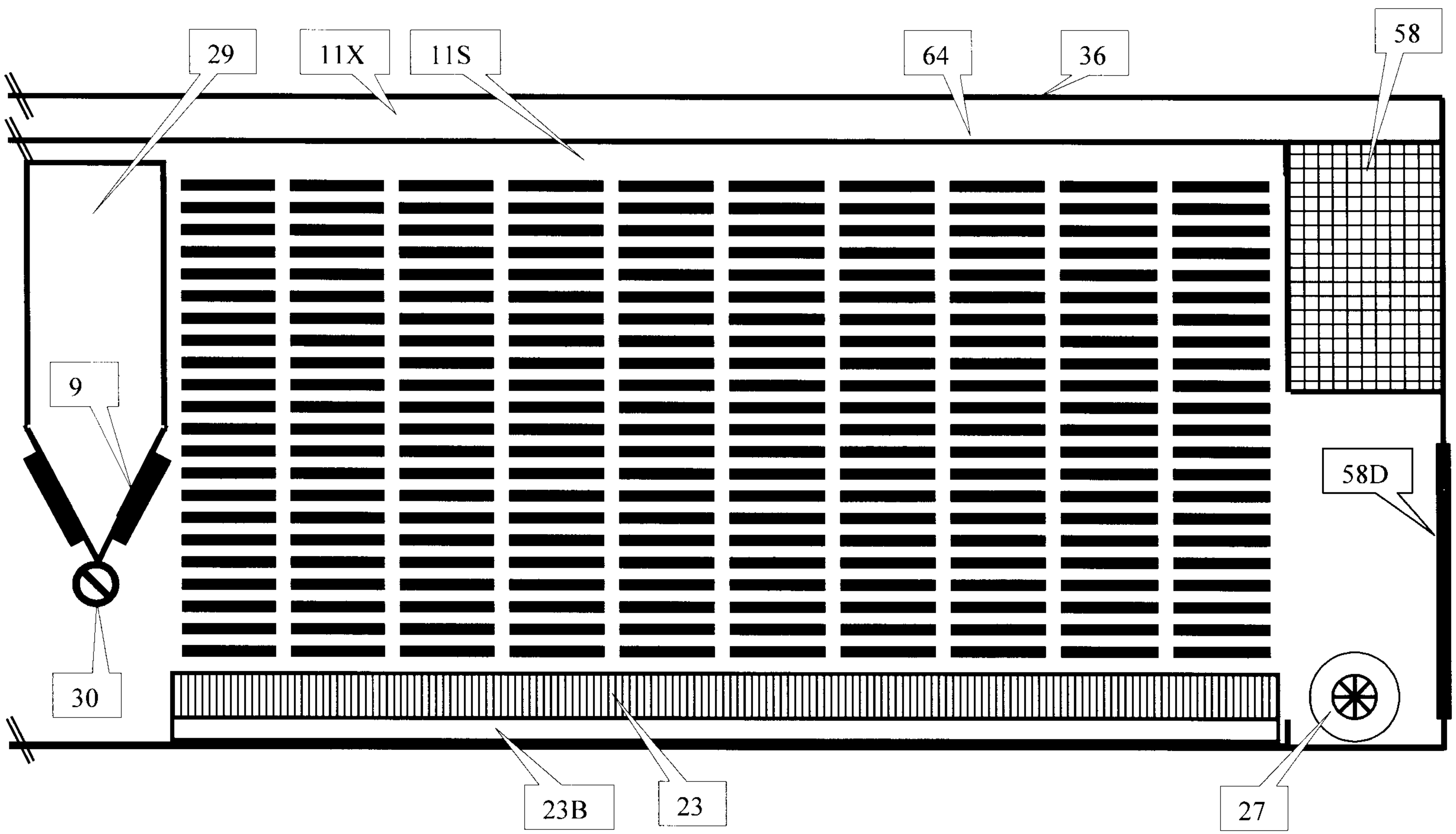


Fig. 8

GUIDE PLATE WITH SHAPING ARMS

Top View

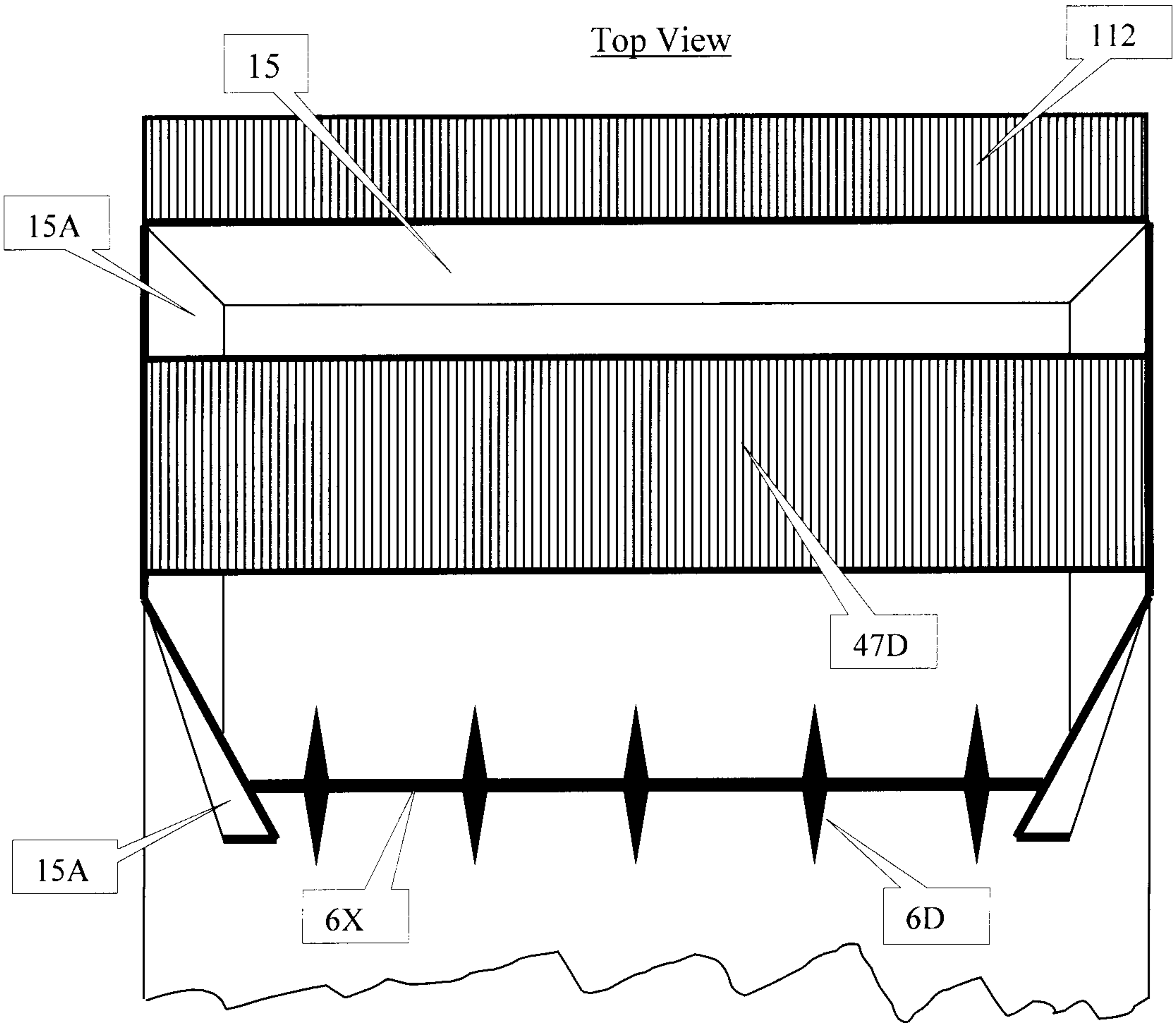


Fig. 9

Front View

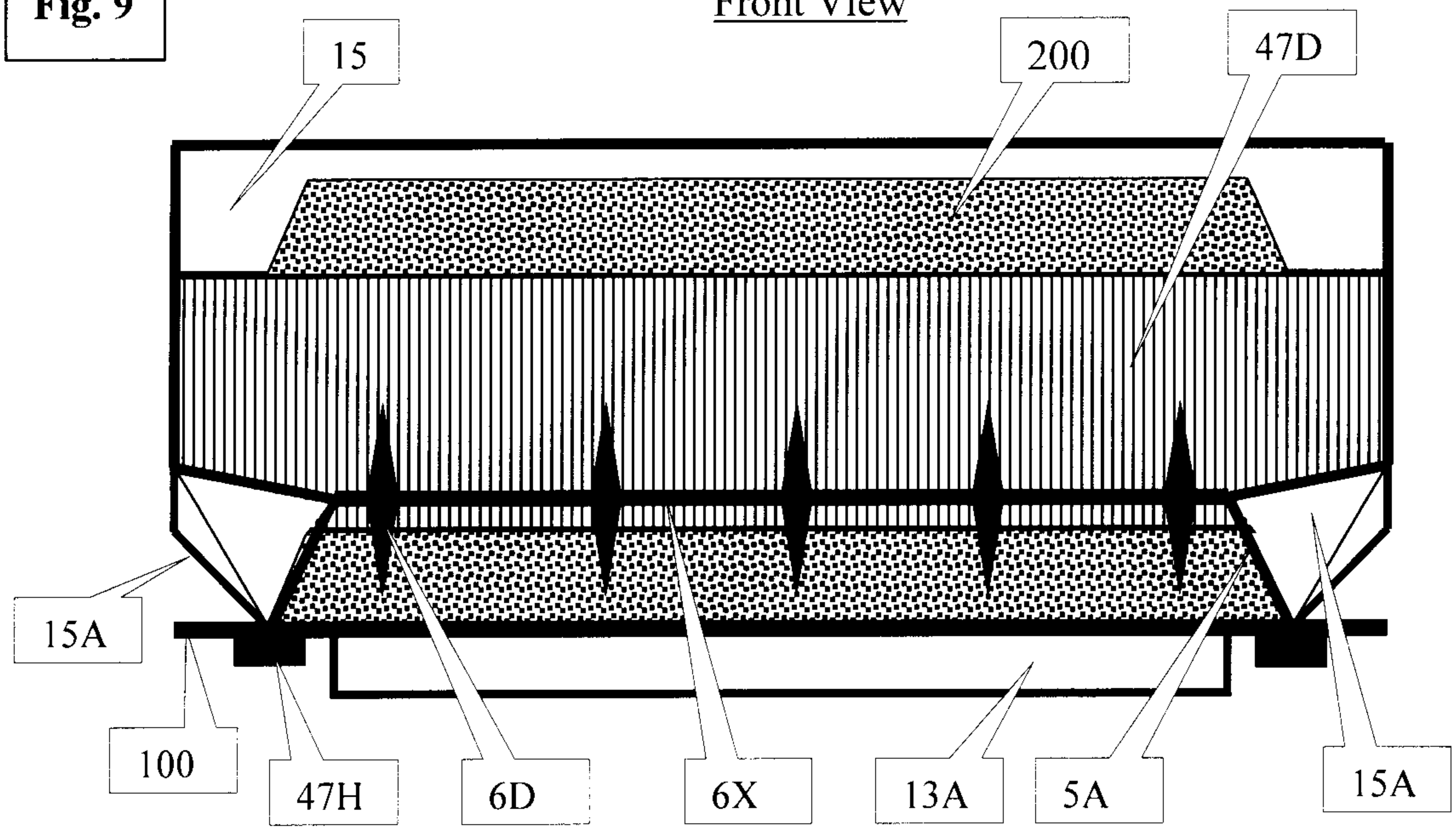
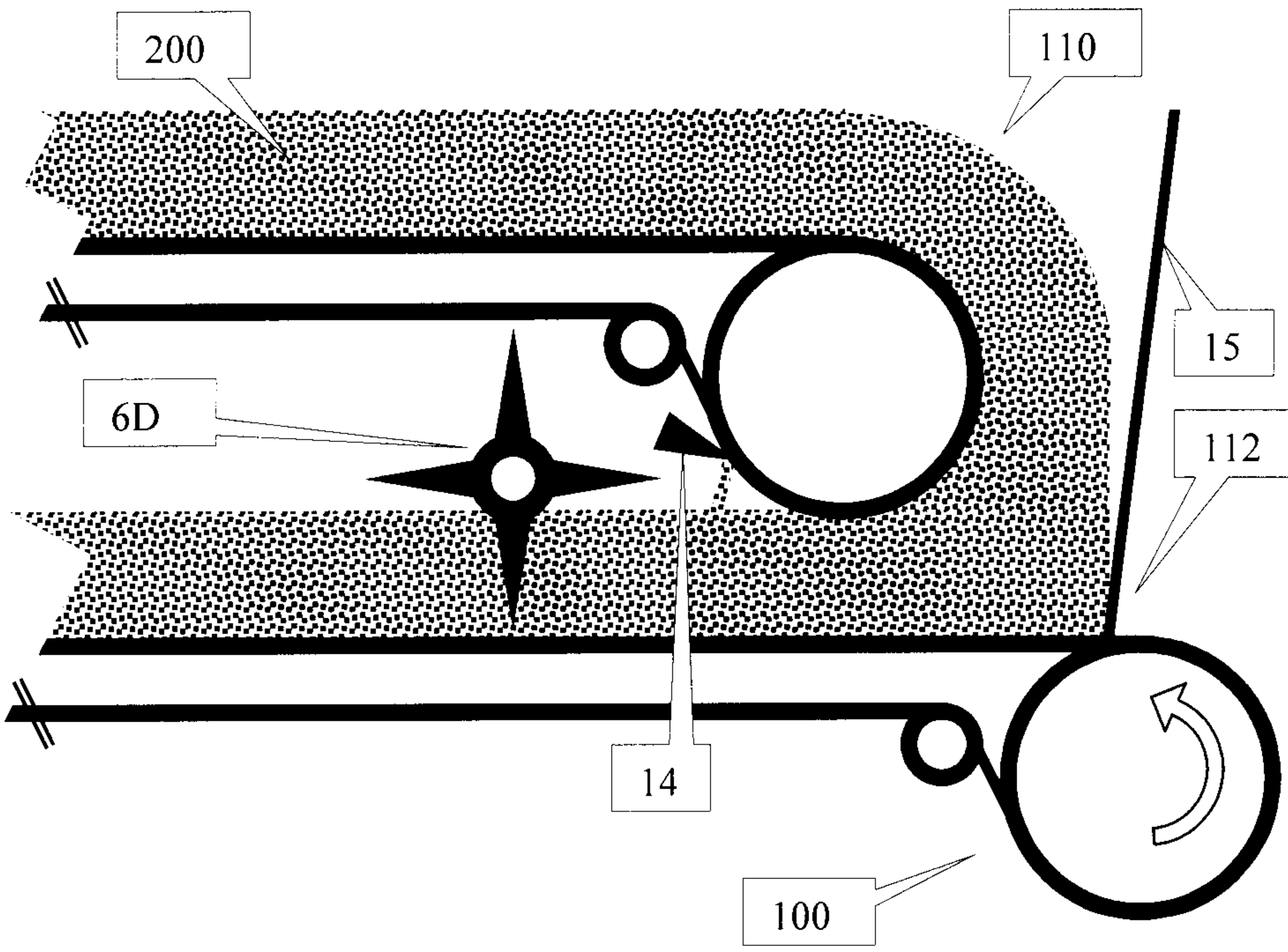


Fig. 10

PERFORATOR

Transfering



Depositing

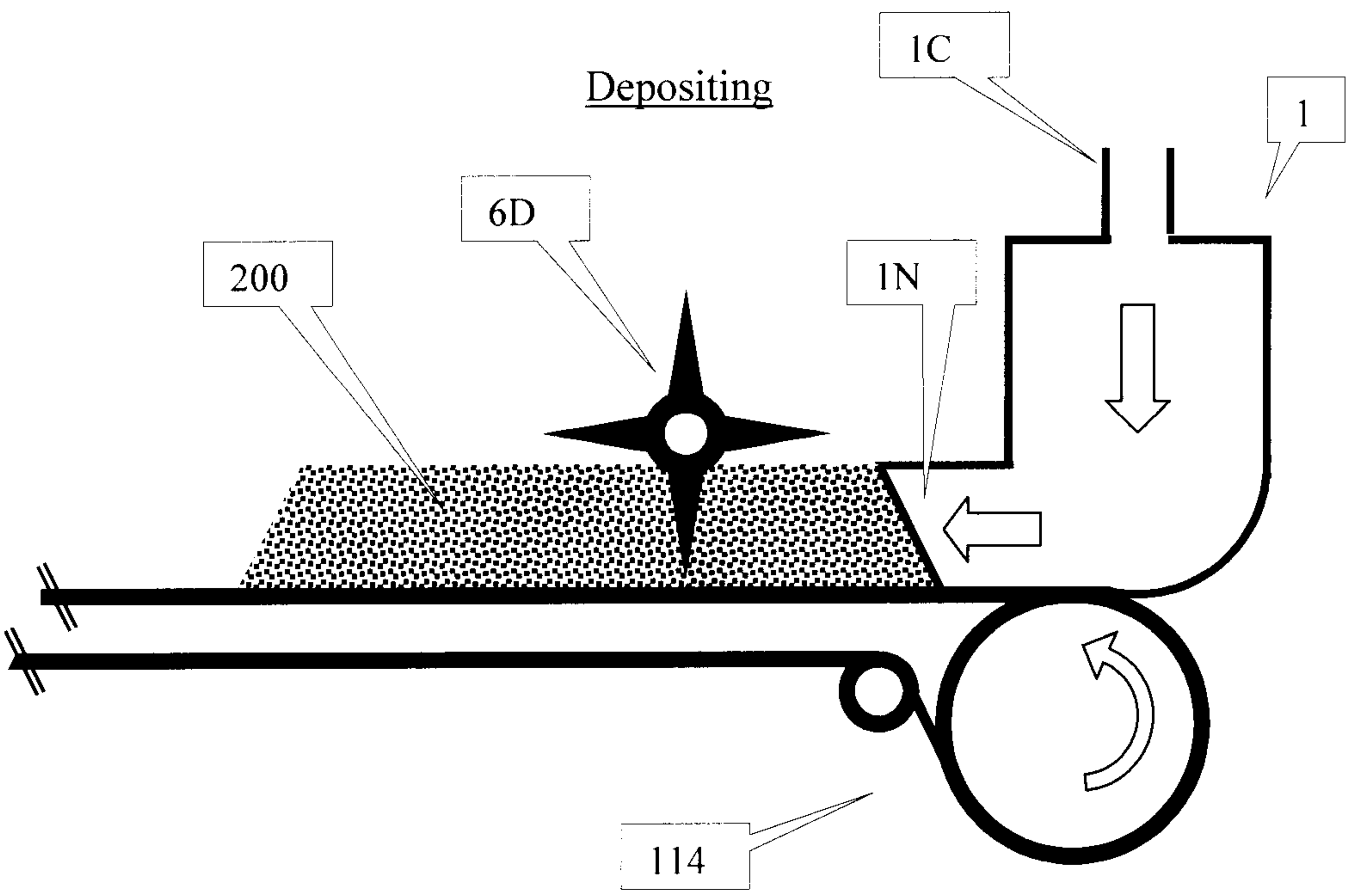
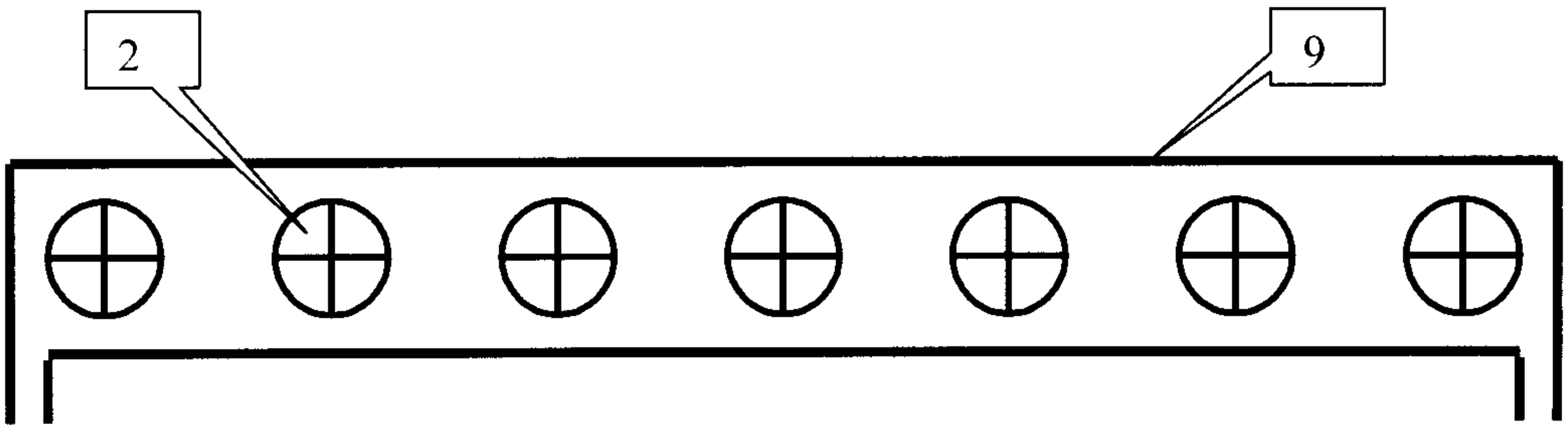
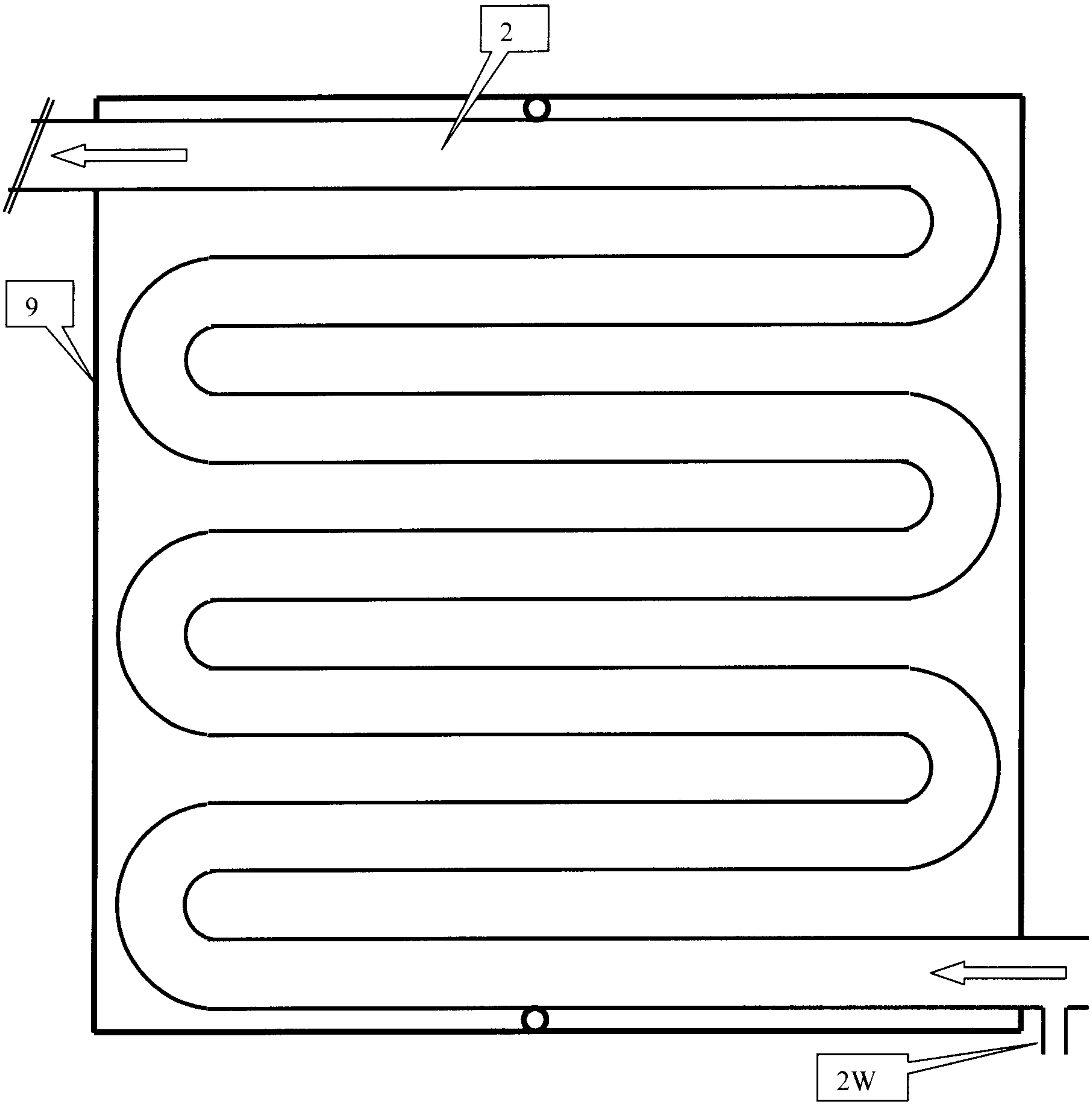


Fig. 11

HEAT EXCHANGE UNIT (9H) - Crosscuts





DEPOSITOR (1)

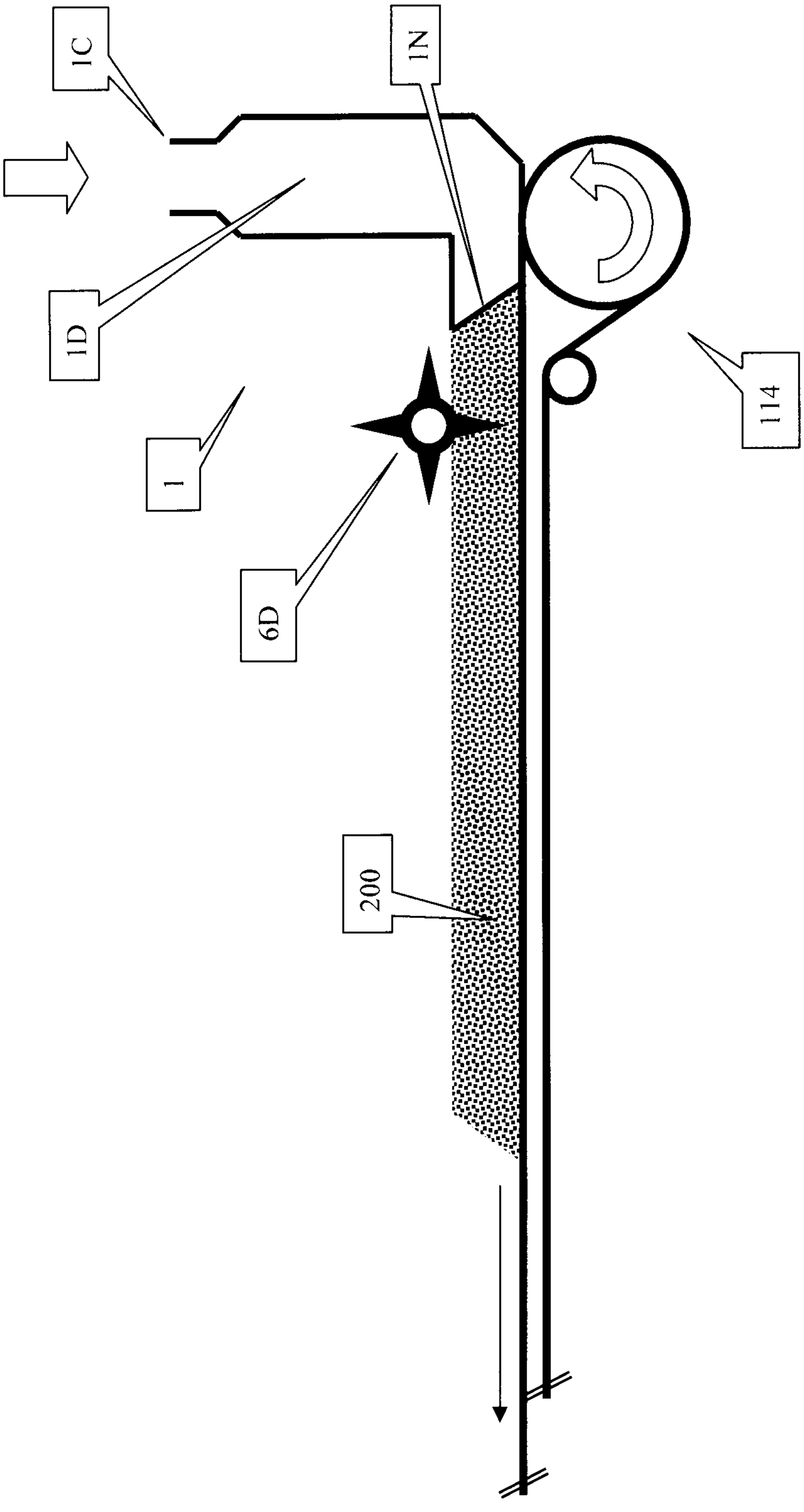


Fig. 12

SYSTEM FOR PROCESSING SUBSTRATE – Longitudinal Crosscut

Single Column Processing Block – Modified Conveyer Belt