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(54) **Apparatus and method for providing recesses in a surface of a concrete element**

(57) Method for providing recesses in a surface of a concrete element (60), comprising the steps of cutting unhardened concrete to be removed, from the surface of an unhardened concrete element (60) by means of cutting elements (112,113,141-143), in a tooling direction substantially parallel to the surface of the concrete element (60), discharging the unhardened concrete cut from the concrete element, and grinding the unhardened concrete cut from the concrete element. The tooling apparatus comprises a frame (10) supported by wheels (20) driven by a mechanism (21) above the surface of the concrete element (60). The cutting apparatus (80) is characterized by cutting tools (112,113,141-143) for cutting the recesses, a discharge member (27,160) for discharging the unhardened concrete cut from the element (60), a grinding element and a mixer for mixing the unhardened concrete with water.

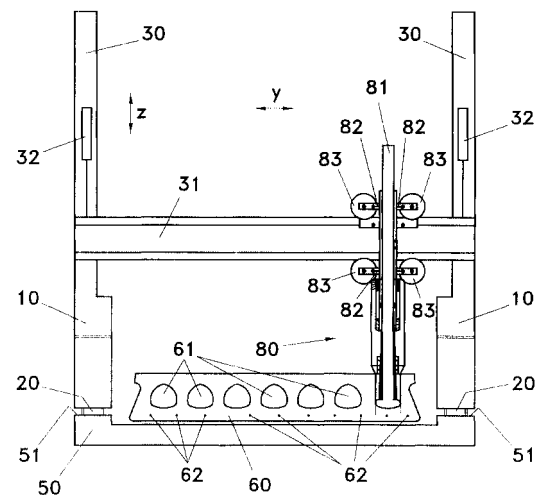


FIG. 2

Description

[0001] The invention relates to a method and an apparatus for providing recesses in a surface of a concrete element.

[0002] Such method is, for instance, used for providing slots in hollow-core slabs formed from concrete which have not yet hardened, as known from applicant's non-prepublished Dutch patent application 1013136. Such hollow-core slabs are used for forming a floor field in a house, wherein electricity, discharge or water lines can be accommodated in the slots provided during the manufacturing process. In this method, it is advantageous that the provision of an additional layer on the floor surface in which the lines are usually fitted, is avoided. The fitting of lines in such layer is time-consuming and causes the level of the floor surface on a story to vary, which is disadvantageous in the case of reconstructions and reuse of the floor.

[0003] A problem involved in providing slots in unhardened concrete during the manufacture is the realization of a slot at the surface of the hollow-core slab without disturbing the areas adjoining the slot, and the realization of a well-defined slot having regular, smooth walls. Disturbing the surrounding areas could cause the strength of the hollow-core slab to decrease unacceptably. Irregular walls of the slot present problems during the laying and passing-through of lines and lead to voltage concentrations under a load, which may cause the strength of the hollow-core slab to decrease.

[0004] The object of the invention is to provide a method wherein a slot can be provided in a surface of an unhardened concrete element without disturbing the other areas of the concrete element and wherein a regular, smooth wall surface of the slot is obtained.

[0005] To this end, according to the invention, a method of the above-described type is characterized by the steps of cutting unhardened concrete to be removed, from the surface of an unhardened concrete element by means of cutting elements, in a tooling direction substantially parallel to the surface of the concrete element, discharging the unhardened concrete cut from the concrete element, and cutting with cutting elements provided with two spaced-apart cutters at the front, each cutter being connected to a sidewall which extends rearwards in a tooling direction.

[0006] Also, according to the invention, an apparatus of the above-mentioned type is characterized by a cutting tool for cutting from the concrete element unhardened concrete to be removed, in a tooling direction substantially parallel to the concrete surface, a discharge member for discharging the unhardened concrete cut from the concrete element, the cutting tool comprising at least one fixed cutting edge which, in a tooling direction, is located in front of the cutting tool.

[0007] By cutting a slot in the concrete surface to be tooled and discharging the cut-out pieces of concrete, a well-defined slot with regular walls is obtained without

disturbing the unhardened concrete surrounding the slot. As a result, after hardening of the concrete, a concrete element is obtained.

[0008] The invention is also embodied in a tooling apparatus having a cutting apparatus according to the invention, and displacing means connected to the cutting apparatus for displacing the cutting apparatus relative to a concrete element to be tooled.

[0009] French patent specification 1,416,393 discloses an apparatus for tooling a cellular concrete poured into a mold, comprising a shaft having blades whereby concrete is scraped off and displaced to a mixer. From the mixer, the concrete scrapings are discharged.

[0010] The invention will be further specified on the basis of a detailed description of an exemplary embodiment of the invention, with reference to the drawing. In this drawing:

Fig. 1 is a side elevation of a tooling apparatus according to the invention,

Fig. 2 is a front view of the tooling apparatus of Fig. 1, with the posterior parts left out,

Fig. 3 is a side elevation, partly in section, of a portion of the tooling apparatus of Fig. 1,

Fig. 4 is a side elevation, partly in section, of a cutting apparatus according to the invention,

Fig. 5 is a top plan view of the cutting apparatus of Fig. 4,

Fig. 6 shows a control system according to the invention, and

Fig. 7 is another exemplary embodiment of a cutting apparatus according to the invention.

[0011] Figs. 1, 2 and 3 show a tooling apparatus 1 according to the invention. The tooling apparatus 1 comprises a frame 10 supported by wheels 20 driven by a drive mechanism 21. By means of the wheels, the drive mechanism 21 can move the apparatus 1 in the direction indicated by X. Disposed on the frame 1 is a tank 22, mobile over the frame by means of wheels and comprising extraction means 27 for extracting cement. Also disposed on the frame is a water tank 23, having a water pump, not shown, for pumping water from the tank 23. Located behind the tanks 22 and 23 is a second tank 24 likewise arranged for extracting cement.

[0012] At the front of the tooling apparatus 1, there are arranged two columns 30 interconnected by means of a cross girder 31. On the cross girder 31, a cutting apparatus 80 is mounted. The cutting apparatus 80 is provided with an elongated frame part 81 connected, by means of supports 82, to four guide wheels 83. The guide wheels 83 are arranged for rotation relative to the supports 82 and engage the cross girder 31. The wheels 83 are connected to a drive mechanism 88 (Fig. 3) capable of displacing the cutting apparatus 80 via the guide wheels 83 along the cross girder 31 in a direction indicated by the arrow Y. The cross girder 31 is further connected to a drive mechanism 32 arranged for dis-

placing the cross girder 31, and accordingly the cutting apparatus 80, in a direction indicated by the arrow Z.

[0013] Mounted on the frame part 81 is an electromotor 84 comprising a driven shaft with a number of pulleys 85. By means of a number of endless belts 86, the pulleys 85 are connected to pulleys 87. The pulleys 87 are rotatable relative to the frame part 81 and are connected to a cutter head 140 so as to be restrained from rotation. The cutter head 140 is bearing-mounted for rotation relative to the frame part 81, so that via the belt drive mechanism 85, 86 and the pulley 87, the motor 84 can rotate the cutter head 140.

[0014] Figs. 4 and 5 show a lowermost portion of the cutting apparatus 80 in more detail. A substantially rectangular top plate 100 is provided with two opposite openings 121 and 122 wherein connecting means, not shown, engage, which connecting means project upwards and are connected to the frame part 81. Adjacent one end thereof, the top plate 100 is provided with a discharge opening 101 and at its opposite end, it is provided with an opening 102 extending to the edge of the top plate 100. Mounted below the top plate 100 is a sidewall 110, consisting of a plate bent so as to be U-shaped. As a result, the sidewall 110 has a rounding 111 and two ends 112 and 113. The rounding 111 of the sidewall 110 is located adjacent the discharge opening 101, and the two ends 112, 113 are located adjacent the opposite edge of the top plate 100. The ends 112, 113 are provided with respective cutting edges.

[0015] The top plate 100 and the sidewall 110 bound a tooling space, a front side of which is provided with an entrance 130 bounded by the cutting edges 112 and 113. The thus formed tray 135 has two parallel sidewalls; the invention is not limited hereto, and if so desired, the sidewalls can also be designed so as to converge from the opening.

[0016] Preferably, the tray 135 is rotatably connected to the frame part 81, so that the tray can rotate relative to the cross girder 31. Preferably, for this purpose, the tray 135 comprises rotation means. The effect thus achieved is that the tray can follow changes in direction more effectively.

[0017] Located above the top plate 100 is a cutter head 10, provided with three cutter blades 141, 142, 143 which project into the tooling space via the opening 102. By means of a drive mechanism, the cutter head 140 can rotate in the direction indicated by the arrows B, thereby displacing the cutter heads 141-143, rotating in the direction B. Preferably, the cutter blades 141-143 are fitted on the cutter head 140 so as to be changeable.

[0018] Located concentrically in the cutter head 140 is a water supply 150, comprising two water supply pipes 151 and 152, each terminating in a spray nozzle 153 located in the space between the cutter blades 141-143. The supply pipe 152 opens into three outlets 154 located at the same level and positioned at an angle relative to each other. The supply pipe 151 opens into two outlets 155 and 156 located above the outlets 154.

The spray nozzle 153 is rotatable relative to the top plate 100. The pipes 151 and 152 are connected to the pipe 26, which pipe is connected to the water tank 23.

[0019] In a structural variant according to the invention not shown, the sidewall 110 is provided with a bottom plate along its side remote from the top plate 100. The edge of the bottom plate located adjacent the ends of the sidewall is provided with a cutting edge. If so desired, the connecting means projecting upwards from the bottom plate 100 can be left out. In this case, the bottom is connected to the bottom side of the spray nozzle, so that the tray is rotatably connected to the cutting apparatus.

[0020] Via the opening 101, a discharge pipe 160 is introduced into the tooling space, of which discharge pipe a suction opening 161 is located adjacent the cutter blades 141-143.

[0021] The tooling apparatus 1 further comprises a control system 200 shown in Fig. 6, connected to the drive mechanisms 21, 32 and 88, and to the water supply means 22, the discharge means 27 and the electromotor 84. The control system 200 is arranged for controlling the tooling apparatus 1.

[0022] An application of the invention will hereinafter be specified on the basis of a practical example. Reference is made to Fig. 2. In a suitable and known manner, a hollow-core slab 60 is formed on a path 50. In this example, the hollow-core slab 60 is provided with a number of channels 61 extending lengthwise of the hollow-core slab, and with prestressed reinforcement 62 oriented lengthwise of the hollow-core slab 60. The hollow-core slab 60 is formed from so-called dry-poured cement, i.e. cement having a relatively low water content. By means of a vibrating operation, the cement of the hollow-core slab 60 has already been compacted, but has not yet hardened. This condition is also referred to as "green" concrete. In this condition, the consistency of the hollow-core slab 60 is such that the hollow-core slab 60 does have self-supporting capacity, but is not capable of supporting greater loads. In course of time, the cement hardens into concrete, whereupon the hollow-core slab 60 has obtained the strength needed for use. For a detailed description of the geometry of the hollow-core slab 60, reference is made to applicant's non-prepublished Dutch patent application 1013136.

[0023] The path 50 on which the hollow-core slab 60 lies is provided with raised longitudinal edges 51 on which the wheels 20 of the apparatus 1 are placed. The control system 200 is arranged for moving the cutting apparatus 80 in the directions X, Y and Z by operating the drive mechanisms 21, 32, 88, and accordingly moving the cutting apparatus 80 along a predetermined path relative to the hollow-core slab 60. Thus, a tooling direction is defined along which the cutting apparatus 80 is guided, which direction is indicated in the drawing by an arrow A (Fig. 5).

[0024] By means of the drive mechanism 32, the cutting apparatus 80 is moved to such a height that the

opening 130 relative to the hollow-core slab 60 is located at the level of the recess to be formed in the hollow-core slab 60.

[0025] During the displacement of the cutting apparatus 80, the cutting edges 112 and 113 cut into the unhardened concrete of the hollow-core slab 60, thus defining the shape of the walls of the recess to be formed. The lower side of the cutter blades defines the bottom of the recess. Through the displacement in the tooling direction A, the cut, unhardened concrete ends up downstream in the tooling area of the cutter blades 141-143 rotated by the control system 200. Through the rotation of the cutter blades 141-143, the unhardened concrete is reduced and ground into small cement particles through the cutting operation of the cutter blades. By adding mechanical energy to the unhardened concrete, the cement becomes slightly fluid again.

[0026] When the unhardened cement is being ground into small particles, water is fed by the control system 200 and via the pipes 26, 151 and 152, from the tank 23 and via the outlets 154-155 to the area surrounded by the cutter blades 141-143. Through rotation of the cutter blades 141-143, the water thus supplied is formed, with the ground cement particles, into a liquid mass of cement, cement particles and water.

[0027] The liquid mass formed is pumped downstream, via the extraction means 27, through the extraction opening 161 and the pipes 160 and 25, to the concrete tank 23. Thus, the unhardened concrete cut from the concrete surface of the hollow-core slab is discharged and the intended recess in the concrete surface is formed through displacement of the cutting apparatus 80 along the predetermined path.

[0028] Because the tray 135 is mounted for rotation relative to the frame part 80, the opening 130 of the tray can rotate during changes of direction in order to follow the path.

[0029] Since the opening 130 provided with cutting edges 112, 113 cuts the shape of the slot to be formed in the top portion of the hollow-core slab, it is achieved that the removal of the concrete, and accordingly the formation of the slot, can take place in a fast and accurate manner, to obtain a smooth and regular wall of the slot.

[0030] Although in this example, cutting edges are used for cutting the slot in the unhardened concrete, the invention is not limited hereto; the invention also provides other apparatus for cutting a slot in the unhardened concrete, such as, for instance, a wire frame, a water cutting apparatus, and multiple cutting blades.

[0031] Because the walls, located behind the cutting edges, of respectively the sidewall and the bottom slide along the slot formed, a smooth finishing of the slot is realized.

[0032] Since the tooling space where the grinding of the unhardened concrete and the mixing of the water take place, is closed off from the other parts of the hollow-core slab by the walls, the risk of slot-adjoining parts

being disturbed is reduced considerably.

[0033] Although in this example, a cutter is used for grinding the cut concrete, the invention is not limited hereto; the invention also provides other apparatus for grinding concrete, such as, for instance, rotating cutter blades, a rotating propeller or screw. In particular, the invention provides an embodiment wherein, by means of supplying a mixture of water and air downstream of the cutting apparatus, the cement to be removed is broken open and the mixture thus formed is extracted.

[0034] Although in this example, the cut concrete is ground before being discharged, the invention is not limited hereto; the invention also provides that the cut concrete is discharged without grinding, such as, for instance, through extraction or a discharge belt.

[0035] Fig. 7 shows a structural variant according to the invention. As to the design of the cutter 140, the spray nozzle 153 and extraction 160, the cutting apparatus 300 shown in Fig. 7 is identical to the design of the first example; the identical parts are designated by identical reference numerals and for the sake of brevity, for a description hereof, reference is made to the foregoing.

[0036] The top plate 100' of the cutting apparatus 300 corresponds to the top plate 100 of the first example, but is not provided with sidewalls. The top plate 100' is preferably mounted for rotation relative to the frame part 81.

[0037] The use of the cutting apparatus 300 corresponds to that of the first example. However, whereas in the first example the cutting of the concrete takes place through a leading cutting apparatus in the form of the cutting edges 112 and 113, the cutting of the concrete according to this exemplary embodiment takes place by means of the cutter blades 141, 142. Because a leading cutting apparatus can be left out, the apparatus 300 is easy to manufacture and has an improved maneuverability during the cutting of the concrete, without affecting the quality of the slot formed.

[0038] The invention is in no way limited to the use with prestressed hollow-core slabs, mentioned by way of example. The invention may also be used for providing recesses in other concrete parts manufactured from dry-poured cement, such as, for instance, wall and facade elements.

Claims

1. A method for providing recesses in a surface of a concrete element, comprising

cutting unhardened concrete to be removed, from the surface of an unhardened concrete element by means of cutting elements, in a tooling direction substantially parallel to the surface of the concrete element, and discharging the unhardened concrete cut from the concrete element, **characterized by cut-**

ting with cutting elements provided with two spaced-apart cutters at the front, each cutter being connected to a sidewall which extends rearwards in a tooling direction.

2. A method according to claim 1, **characterized by** grinding the unhardened concrete cut from the concrete element.

3. A method according to claim 1 or 2, **characterized by**

supplying water adjacent the cutting elements, and
mixing the unhardened concrete cut from the concrete element with water.

4. A method according to any one of the preceding claims, **characterized by** extracting the unhardened concrete cut from the concrete element.

5. A method according to any one of the preceding claims, **characterized by** cutting the unhardened concrete to be removed, with a cutting tool.

6. A method according to claim 5, **characterized by** grinding the unhardened concrete cut from the concrete element with a grinding apparatus which, in the tooling direction, is located behind the cutting tool.

7. A method according to claim 5 or 6, **characterized by** discharging the unhardened concrete cut from the concrete element by means of a discharge apparatus which, in the tooling direction, is located behind the cutting tool.

8. A method according to any one of the preceding claims, **characterized by** milling the unhardened concrete to be removed.

9. A method according to any one of claims 3-8, **characterized by** supplying water to the unhardened concrete to be removed during the grinding of the unhardened concrete to be removed.

10. A cutting apparatus for providing recesses in a surface of an unhardened concrete element, having

a cutting tool for cutting from the concrete element unhardened concrete to be removed, in a tooling direction parallel to the concrete surface, and

a discharge member for discharging the unhardened concrete cut from the concrete element, **characterized in that** the cutting tool comprises at least one fixed cutting edge, located in front of the cutting tool in a tooling di-

rection.

11. A cutting apparatus according to claim 10, **characterized in that** the at least one fixed cutting edge is connected to a wall extending rearwards in a tooling direction.

12. A cutting apparatus according to claim 11, **characterized in that** the wall at least partially defines a tooling area.

13. A cutting apparatus according to any one of claims 10-12, **characterized in that** the cutting tool comprises, at its front side, two spaced-apart cutters, each cutter being connected to a sidewall which, in a tooling direction, extends rearwards.

14. A cutting apparatus according to claim 13, **characterized in that** the sidewalls are connected to a bottom comprising a foremost cutting edge.

15. A cutting apparatus according to any one of claims 12-14, **characterized in that** the grinding member is located in the tooling area.

16. A cutting apparatus according to any one of claims 10-15, **characterized by** a grinding member, located behind the cutting tool in a tooling direction, arranged for grinding unhardened concrete cut from the concrete element.

17. A cutting apparatus according to any one of claims 10-16, **characterized by** a mixing member, located behind the cutting tool in a tooling direction, comprising a water supply, arranged for mixing unhardened concrete cut from the concrete element, with water.

18. A cutting apparatus according to any one of claims 10-17, **characterized by** an extraction member, located behind the cutting tool in a tooling direction, for extracting unhardened concrete cut from the concrete element.

19. A cutting apparatus according to claims 10-18, **characterized in that** the cutting tool comprises a milling cutter.

20. A cutting apparatus according to claim 19, **characterized in that** the grinding member is formed by the milling cutter.

21. A cutting apparatus according to any one of claims 10-20, **characterized in that** the cutting tool comprises a water cutting member.

22. A tooling apparatus for providing recesses in a surface of an unhardened concrete element, **charac-**

terized by a cutting apparatus according to one of claims 10-21, and displacing means connected to the cutting apparatus for displacing the cutting apparatus relative to a concrete element to be tooled.

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23. A tooling apparatus according to claim 22, **characterized by** an extraction apparatus connected to the cutting apparatus.

24. A tooling apparatus according to claim 22 or 23, **characterized by** a control system connected to the displacing means, arranged for controlling the cutting apparatus along a defined path.

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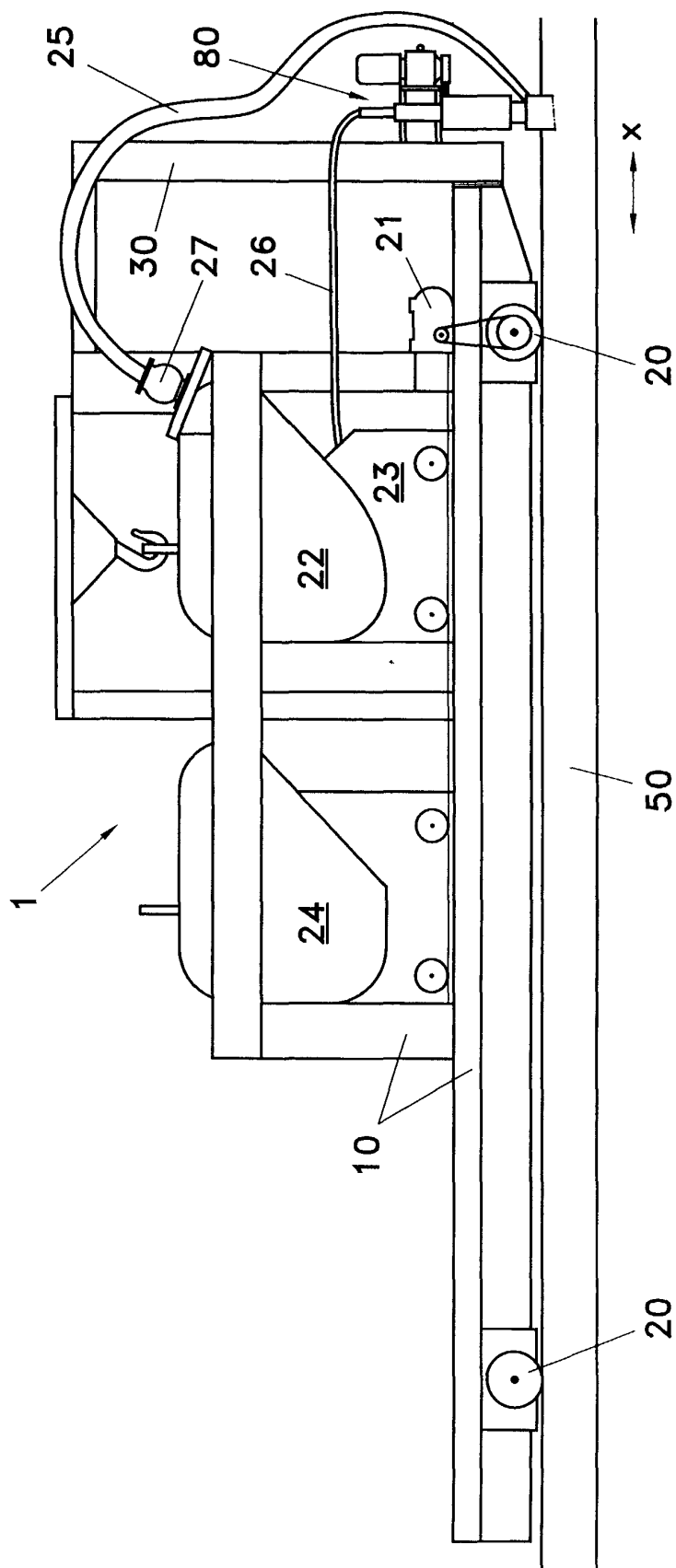


FIG. 1

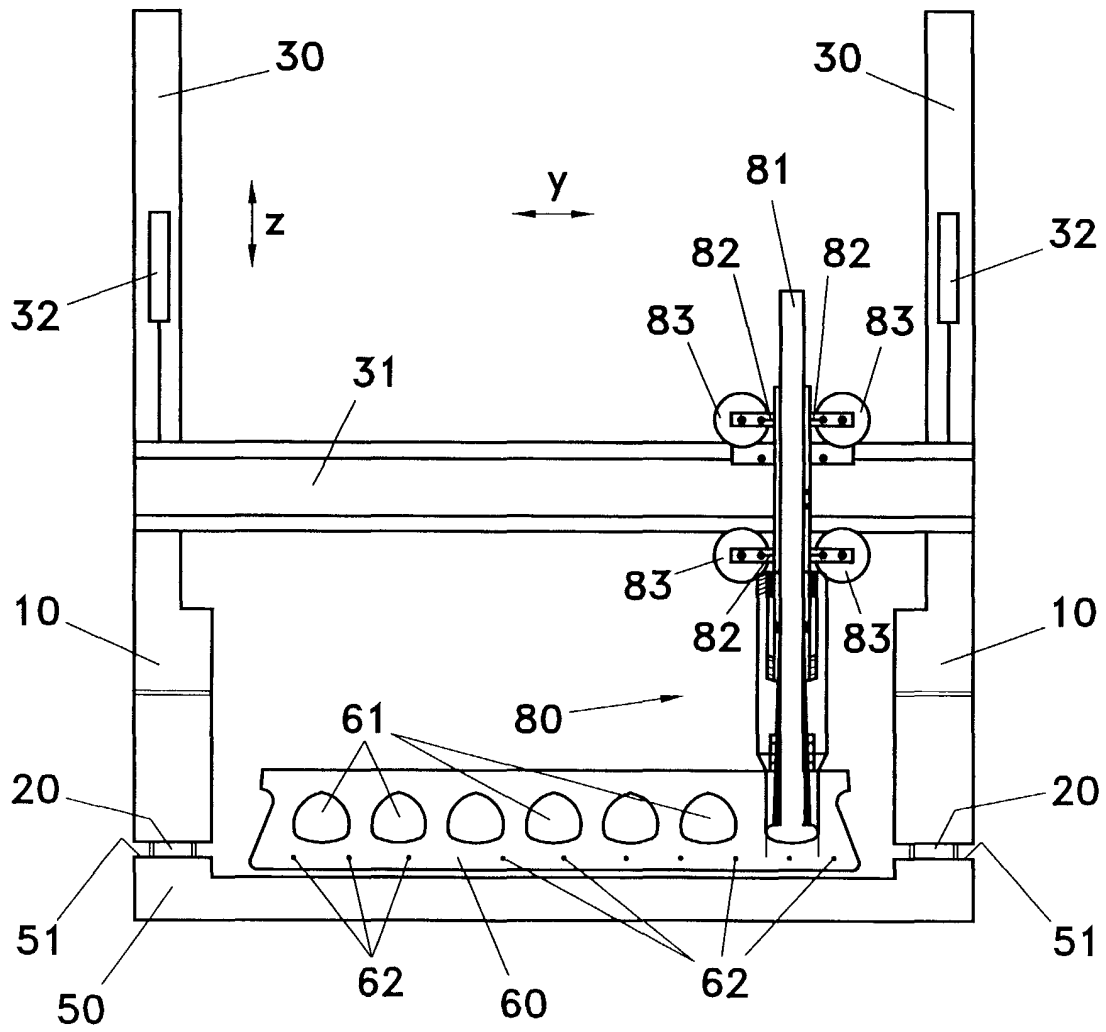
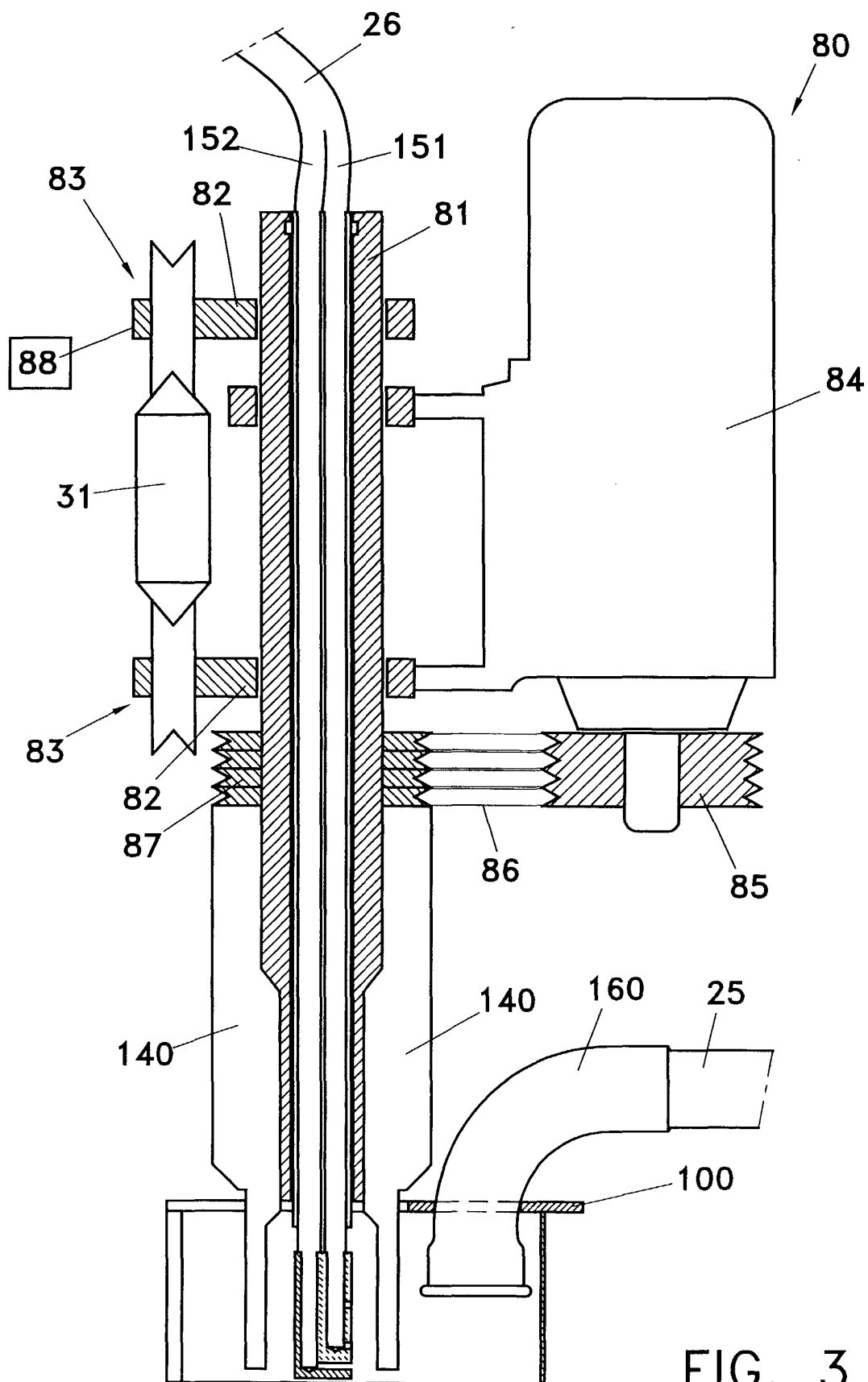
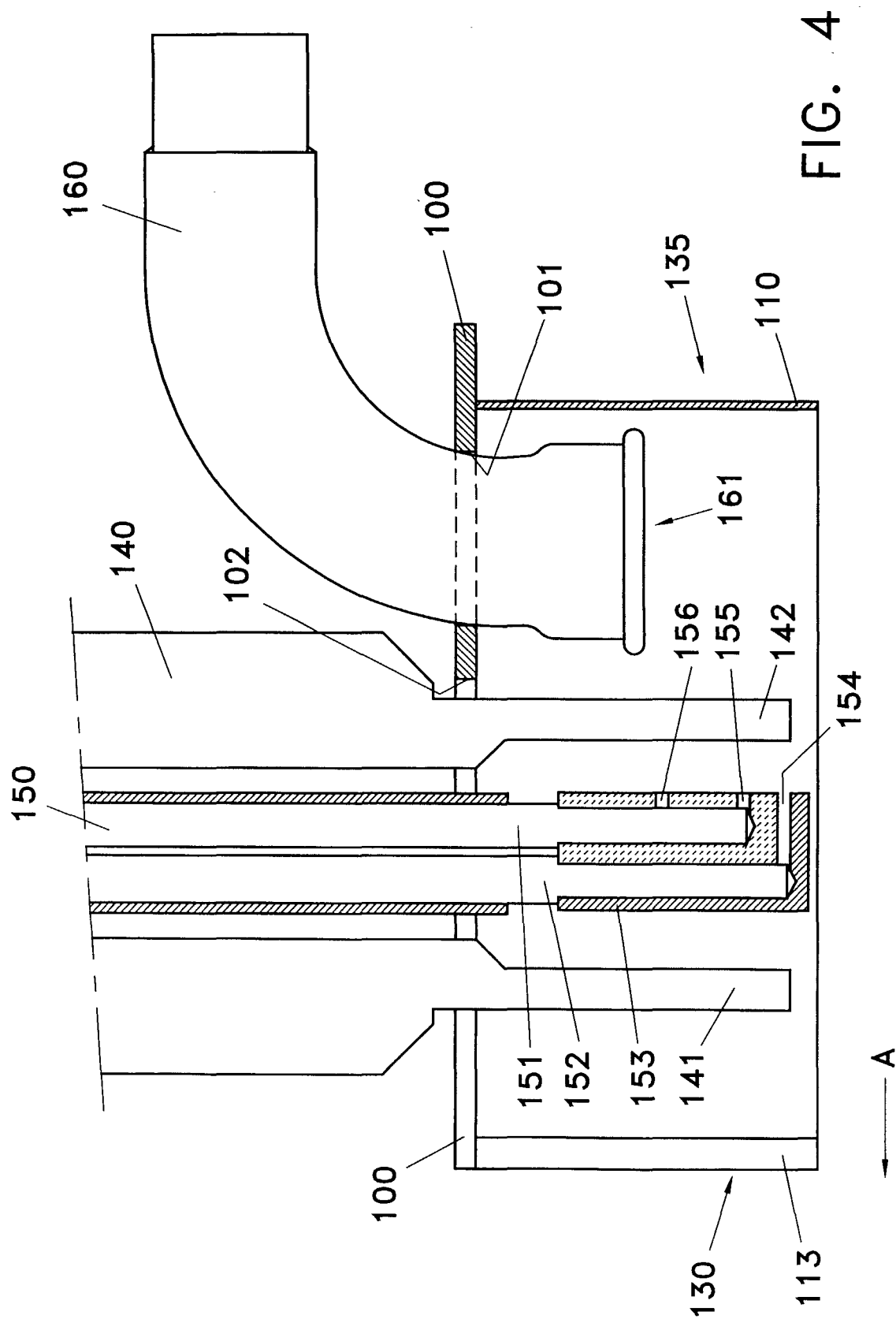


FIG. 2





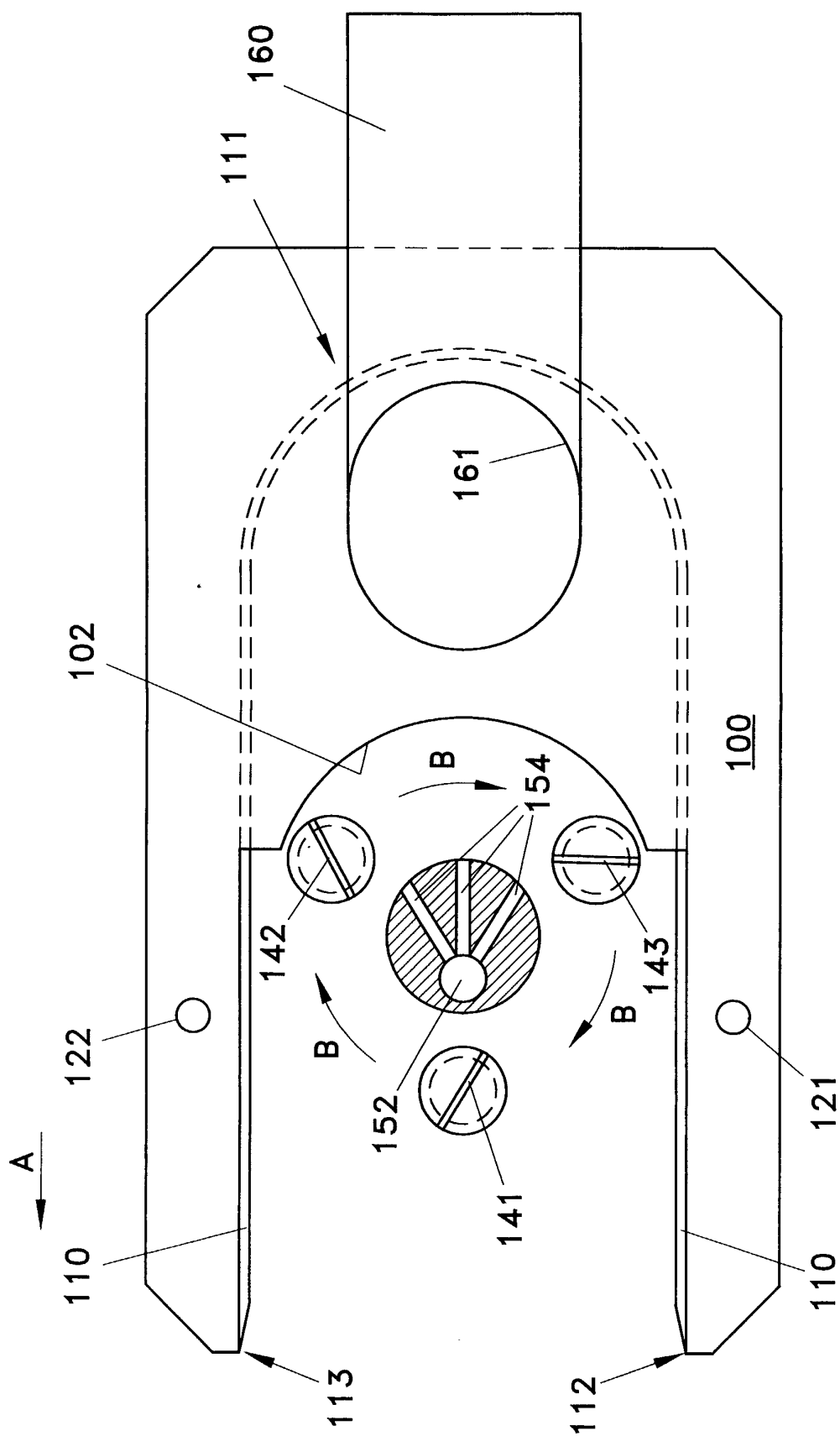


FIG. 5

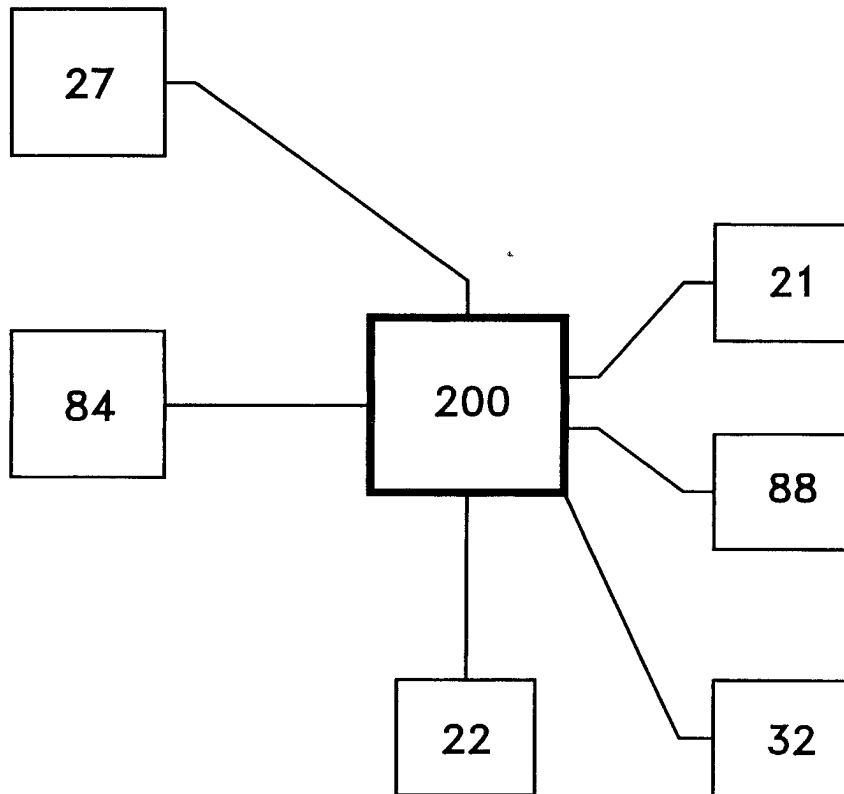


FIG. 6

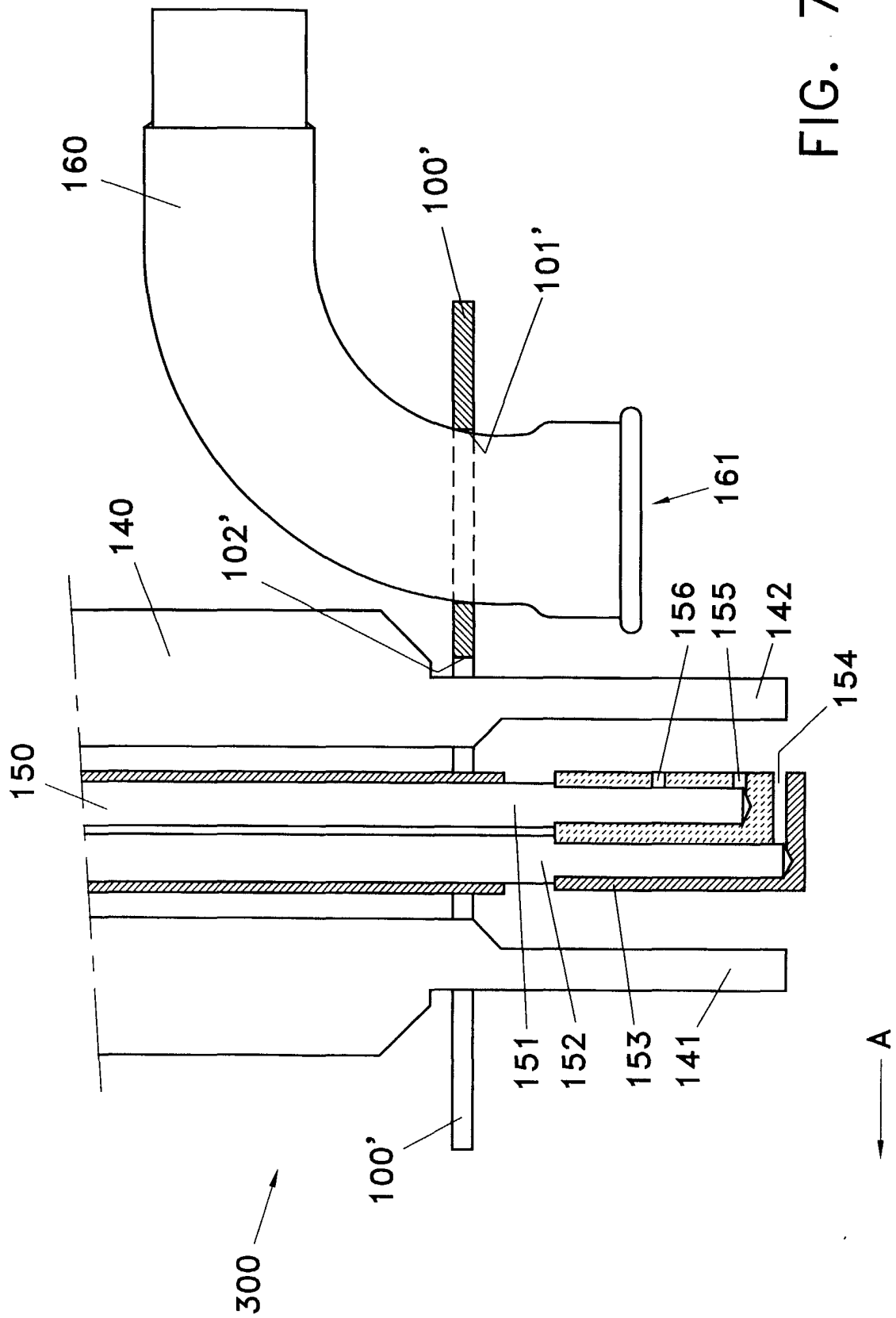


FIG. 7



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 00 20 4076

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 31 July 2001	Examiner Gourier, P
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 00 20 4076

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