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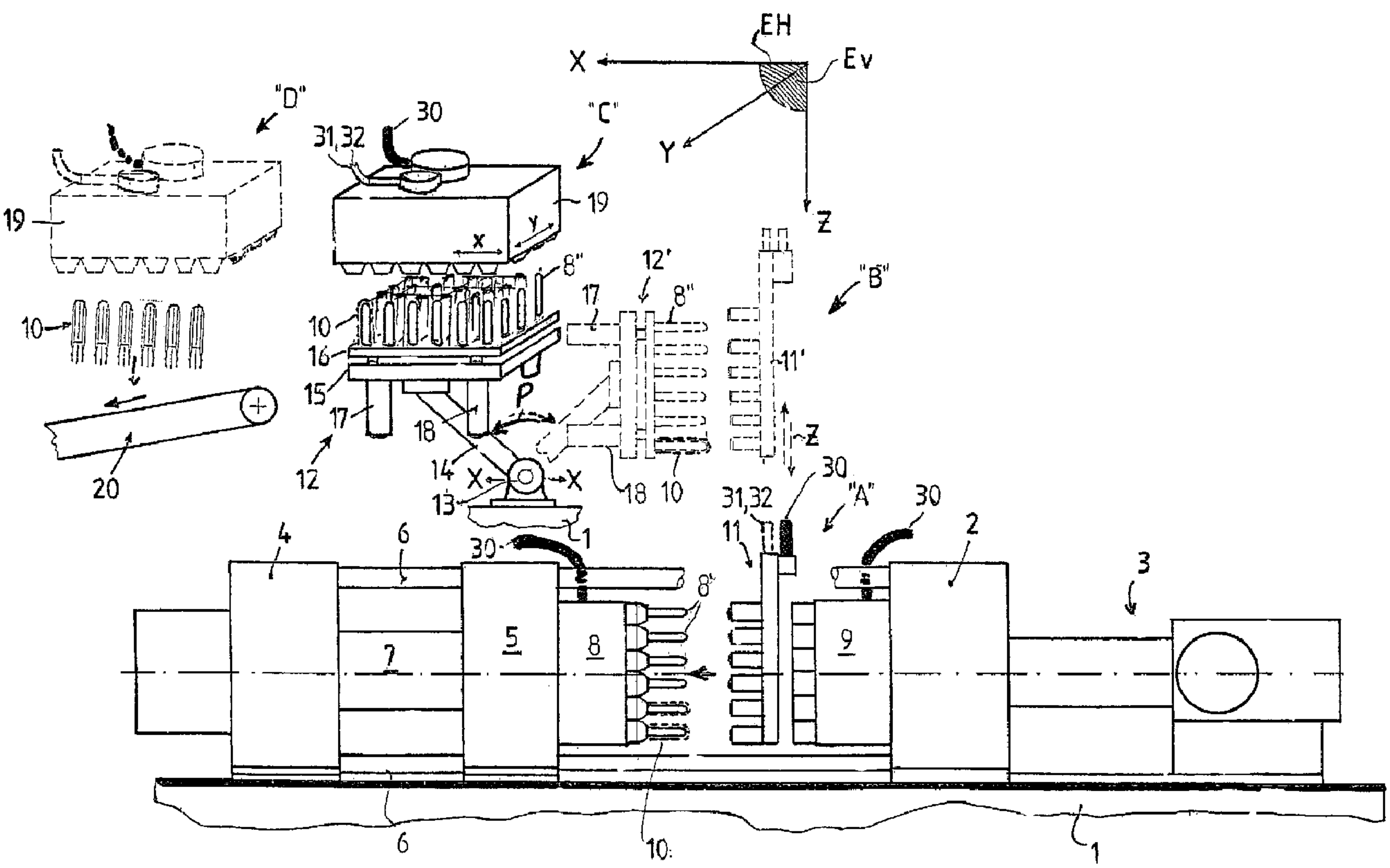
(54) Titre : DISPOSITIF DESTINE A LA REALISATION DISCONTINUE DE PREFORMES
(54) Title: DEVICE FOR PRODUCING PREFORMS IN BATCH QUANTITIES



(57) **Abrégé/Abstract**:
The invention relates to the production of preforms (10) for PET bottles in batch quantities. According to the invention, the mould nests are arranged in the injection moulds in a specific manner, thereby increasing the number of cooling positions in an after cooler (19, 40). The inventive device is provided with controllable/adjustable movement means for the two coordinates (x, y; y, z) of the transfer plane of the after cooler (19, 40), enabling the after cooler (19, 40) to be cyclically positioned with respectively free cooling positions in the fixed arrangement of moulded objects (10) in the moulds, whereby a maximum density of cooling positions

(57) Abrégé(suite)/Abstract(continued):
can be obtained in said after cooler (19, 40) . The invention enables four times more cooling positions to be obtained, especially when arranged in a staggered manner, in comparison with the number of mould nests in said mould, in addition to allowing the number of mould nests to be increased to 144 and more.

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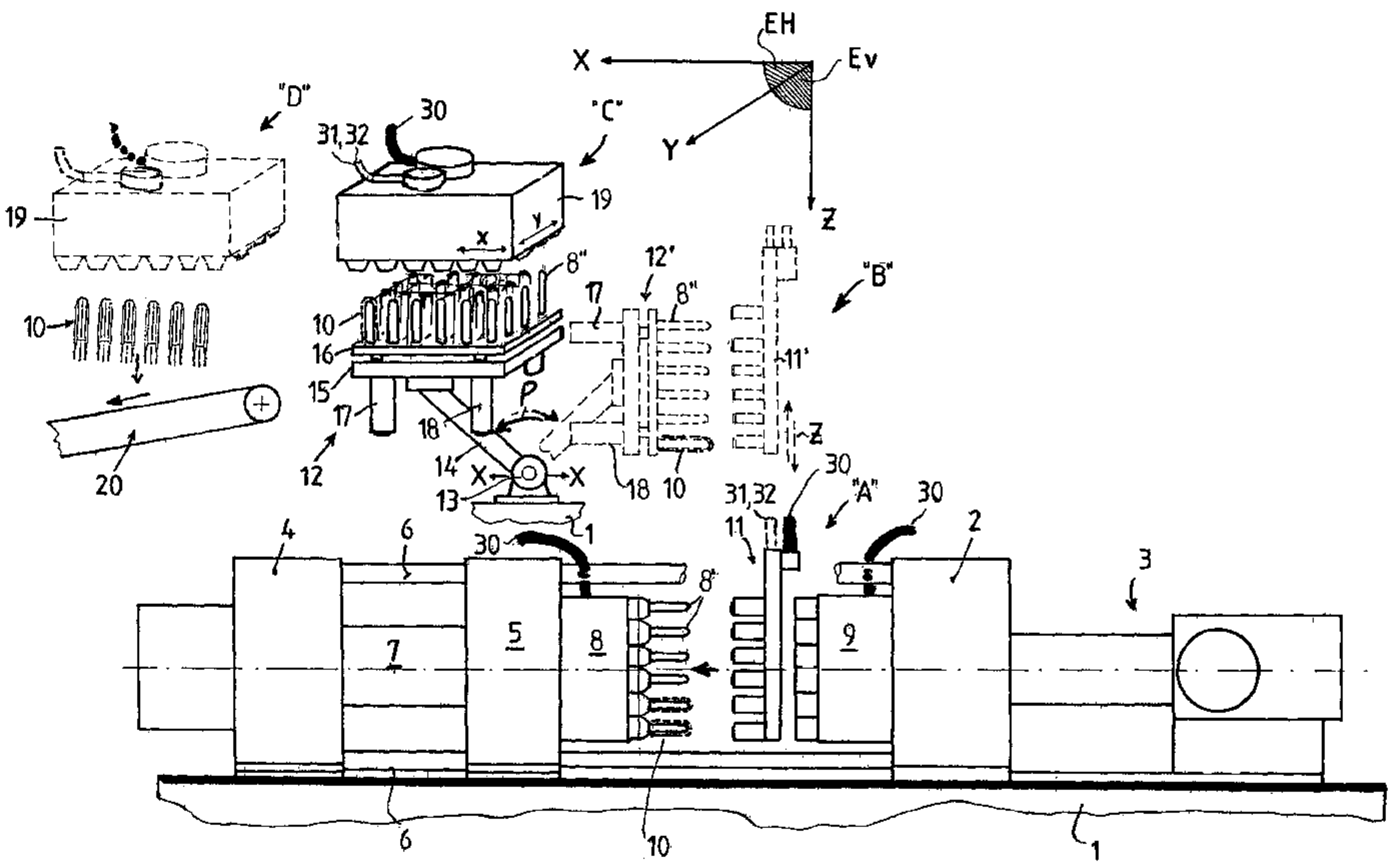
(54) Title: DEVICE FOR PRODUCING PREFORMS IN BATCH QUANTITIES

(54) Bezeichnung: VORRICHTUNG FÜR DAS CHARGENWEISE HERSTELLEN VON PREFORMEN



(57) Abstract: The invention relates to the production of preforms (10) for PET bottles in batch quantities. According to the invention, the mould nests are arranged in the injection moulds in a specific manner, thereby increasing the number of cooling positions in an after cooler (19, 40). The inventive device is provided with controllable/adjustable movement means for the two coordinates (x, y; y, z) of the transfer plane of the after cooler (19, 40), enabling the after cooler (19, 40) to be cyclically positioned with respectively free cooling positions in the fixed arrangement of moulded objects (10) in the moulds, whereby a maximum density of cooling positions can be obtained in said after cooler (19, 40) . The invention enables four times more cooling positions to be obtained, especially when arranged in a staggered manner, in comparison with the number of mould nests in said mould, in addition to allowing the number of mould nests to be increased to 144 and more.

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[Fortsetzung auf der nächsten Seite]

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(57) Zusammenfassung: Die neue Erfindung schlägt für das chargenweise Herstellen von Preformen (10) für PET-Flaschen eine Lösung vor, gemäss der bei entsprechender Anordnung der Formnester in den Spritzformen die Anzahl der Kühlpositionen in einem Nachkühler (19, 40) erhöht werden kann. Die neue Vorrichtung weist für die zwei Koordinaten (x, y; y, z) der Übernahmeebene des Nachkühlers (19, 40) steuer-/regelbare Bewegungsmittel auf, über welche der Nachkühler (19, 40) mit je freien Kühlpositionen zyklisch in die in den Formen festgelegte Anordnung der Spritzteile (10) derart positionierbar ist, dass im Nachkühler (19, 40) die maximal mögliche Dichte der Kühlpositionen erreichbar ist. Die neue Lösung erlaubt insbesondere bei versetzter Anordnung das Vierfache an Kühlpositionen im Verhältnis zu der Anzahl Formnester in der Form, ferner eine Steigerung der Zahl der Formnester auf 144 und mehr.

DEVICE FOR PRODUCING PREFORMS IN BATCH QUANTITIES

Technical field

The invention relates to a device for the production of sleeve-shaped objects, particularly preforms for PET bottles, which are removed from their moulds after injection and transferred to an after cooler to assume a dimensionally stable storage condition, whereby all objects injected into a mould per cycle are simultaneously removed from the moulds and transferred to free positions in an after cooler, which has a transfer plane capacity, which corresponds to a multitude of the objects produced per cycle.

When producing preforms with relatively thick walls, the cooling or cooling time is an important and deciding factor of the cycle time. The main cooling takes place in the mould halves. Both halves are water-cooled intensively during casting in order to decrease the temperature inside the mould from approx. 280° to around 70° to 80°C, at least inside the marginal layers. 2/3 of the cooling is achieved through the core, 1/3 through external cooling of the corresponding injection moulds. In the outer layers of the moulded objects, a so-called glass temperature of approx. 140°C is obtained very quickly. The actual casting until the removal of the hot moulded objects could be shortened to approx. 13 to 15 seconds without compromising the quality of the semi-rigid moulded objects. The outside of the moulded objects must be rigid enough to be handled by the relatively high forces exerted by the ejection means and to be removed from the moulds without deformation or damage. The physical-type intensive water cooling inside the halves of the injection mould occurs from the outside in with an immense delay in time due to the enormous wall thickness. This means that the 70° to 80° C are not uniformly achieved across the entire cross-section, resulting in a quick re-heating from the inside out (note the material's cross-section) once the intensive cooling is interrupted. The so-called after cooling is very important for two reasons: Firstly, any shape-related changes as well as surface damage like pressure marks etc. are to be avoided until the dimensionally stable storage condition has been reached; and secondly, it must be avoided that the cool-down in higher temperature ranges is too slow leading to re-heating, which could cause harmful formations of crystals in certain places. The aim is a uniform amorphous condition inside the material of the mould. The surface of the moulded objects must not be sticky because adhesion damage may result at the contact points of the thousands of objects that are loosely poured into relatively large boxes or bunches. Even with slight re-heating, a finished moulded object cannot exceed a surface temperature of 40°C. After cooling takes longer than the main cooling in the injection mould. A big handling problem results because, for example, 96 preforms are simultaneously injected into the mould. The moulded objects with insides still being soft may only be held and moved in appropriate transfer moulds. Different solutions are used in practice.

Prior art

The main objective of DE 38 86 076 was a device for the production of hollow plastic items by means of injection moulding, which results in a possible short cycle with prolonged after cooling of the hollow items. The issue is solved by using an enlarged after cooler, which retrieves the preforms from the open tool by moving into the respective transfer positions. The capacity of the after cooler was increased by providing a transfer plane with a multitude of objects in comparison to the maximum number of objects in the mould. Like a chessboard, the after cooler has a number of rows, which, in groups, hold the result of an injection cycle. Using two or three parallel groups, the corresponding amount of two or three cycles can be held and cooled simultaneously. The groups are staggered in regular fashion, enabling the use of the free positions or cooling positions, respectively, of the after cooler by inserting the first, second or third position. In relation to an injection cycle, each group stays at least for twice as long in the after cooler before being ejected. This solution has been used successfully in practice.

US-PS 5 855 932 furthers the idea of DE 38 86 076. Depending on the position, which the after cooler assumes in relation to the grouping of the mould nests and to the free positions in the after cooler, one of the three differently arranged sensors must be activated. For safety reasons, the after cooler moves with a fork-like guide onto a carriage bolt.

EP 0 686 081 suggests an entirely different solution to increase the after cooling time for an injection cycle. It provides for two or more completely independent and movable after coolers, each having the capacity of the mould. Both after coolers are synchronous insofar as they alternately extend into and retract from the open mould in identical fashion to pick up one batch of preforms from the opened mould halves. Both after coolers are suitably positioned on either side of the injection machine for the duration of the actual cooling time. After cooling is accomplished alternately in two separate coolers. Compared to the two concepts mentioned above, the solution provided by EP 0 686 081 is disadvantageous insofar as it requires extra installations, especially if more than two after coolers are required, e.g. for tripling the after cooling time.

The new invention had the task of finding a solution, that provides for an increased number of cooling positions in the transfer plane of the after cooler, if possible in staggered rows, with given arrangements of the moulded objects in the mould.

Disclosure of the invention

The inventive solution provides for a device with controllable/adjustable movement means for two coordinates of the transfer plane of the after cooler, enabling the after cooler to be cyclically positioned with respectively free cooling positions in the fixed arrangement of moulded objects in the moulds, whereby a maximum density of cooling positions can be obtained especially in chessboard-like or staggered row layouts.

Furthermore, the new solution suggests a freely controllable extension into an arrangement, which is determined by the moulds, that is only possible through free movement in two spatial axes or coordinates, respectively. DE 38 86 076 and US-PS 5 855 932 are solely based on linear shifting of the after cooler and on a movement towards several variable stops. The movement towards a stop or a respective switch point is disadvantageous if a large body must be moved in two spatial directions or to various positions either simultaneously or in short succession. With the new invention, the movement means can be combined for the furthest destination of the travelling after cooler and the movement towards an exact position to obtain a movement that can be optimized for both coordinates, which is a main concern of robotics, especially if a rather large mass like the after cooler must be moved quickly and precisely.

The new invention provides for a series of particularly advantageous configurations as stated in Claims 2 to 14.

The capacity of the after cooler corresponds at least to the triple or quadruple amount of objects produced in an injection cycle. A quadruple capacity is particularly preferred for larger moulds with 96, 144 or more mould nests. The quadruple capacity is especially advantageous for objects with thick walls, because with triple capacity, the required after cooling time is often a little bit too short in relation to the main cooling inside the mould. The controllable movement means are advantageously equipped with program memories as well as program-controlled/adjusted servomotors for each of the two spatial axes.

The result provides for two solutions for controlling/adjusting the displacement: The first solution provides for position signals for the displaced object directly from the AC servomotor control unit via respective sensors. The second solution provides for a position signal obtained directly via the displaced object and the respective control/adjustment of the movement.

According to a first configuration of the new invention, the transfer plane of a machine is vertically arranged with the horizontal mould opening movement and the after cooler itself is designed as a removal robot with movement means. This configuration is based on the known state of the art according to e.g. DE 38 86 076 or US 5 855 932. Partial automation can already be observed at this point. By moving the after cooler for the removal in only one coordinate, further extension is very limited.

Another important configuration is the after cooler being designed as a replacement module with adaptation points for quick and exact re-attachment of another replacement module. Mainly two problems of any mould-maker are addressed: Economic solutions are either achieved through even bigger preforms with larger division distances or by smaller preforms with smaller distances and considerably more mould nests. The adaptation of the after cooler as a replacement module features a range of new possibilities, whereby existing moulds or after coolers can be utilized even further. While the moulds are being changed, the after cooler can be exchanged as well to provide for a production with new moulds and no delay at the highest possible stage of automation. It is preferred to have a device with computer and memory means for programmatic saving of all movements in such a way that the production can be ready for operation by selecting the right program following the exchange of a mould and after cooler.

It is important for the new solution that every interim position can be obtained in both coordinates according to the arrangement of the mould nests. These positions can be obtained with an accuracy of millimetres or tenths of millimetres, respectively.

The second configuration is based on WO00/24562. It provides for a horizontal transfer plane for the after cooler. The movement control of WO00/24562 is also based on the concept "movement towards variable stops". The after cooler performs a big transfer movement between preform holding and preform ejection. It can be transversally shifted to select groups. Regarding the level of automatisation, WO00/24562 is like DE 38 86 076. According to the second configuration of the new invention, the transfer of the objects from the injection moulds and their transfer to the after cooler is provided by robotics integrated in the control/adjustment device. Preferably, these separate robotics are provided in two pieces as a removal unit and a transfer gripper, whereby the removal unit provides for a controlled/adjustable movement axis, preferably in vertical direction, and the transfer gripper provides for controlled/adjustable movement axes, i.e. one horizontal axis as well as a rotary axis.

According to another particularly advantageous configuration, the removal units as well as the transfer gripper have interchangeable holding module plates with adaptation points for quick and exact re-attachment of another replacement module. This measure provides for an unexpectedly high flexibility with respect to handling, especially for the making of moulds. The achieved flexibility does not only provide for the existing tooling distance, but also for any future development. The movement axes of the after cooler and/or the removal unit and/or the transfer gripper are provided as controllable AC servo-axes, which can be controlled/adjusted via central programs. The controllable/adjustable movement means of the removal units and/or the transfer gripper and/or the after cooler preferably provide for at least one overhead belt drive and/or an overhead rack and pinion drive.

Brief description of the invention

The following is a detailed description of the invention by means of design examples.

Figure 1 depicts the central functional elements of an injection-moulding machine with after an cooling system;

Figure 2 depicts an after cooler with robot-like control/adjustment means in two coordinates;

Figure 3 depicts the enlarged drive and overhead drive means for the after cooler;

Figures 4 & 5 show an example of a staggered arrangement of the cooling sleeves inside the after cooler, with Fig. 5 being a selective enlargement of Fig. 4; and

Figure 6 depicts a control scheme for several axes.

Manners and configuration of the invention

Fig. 1 shows a complete injection moulding machine for preforms with a machine bed 1, which supports a stationary mould mounting plate 2 and an injection unit 3. A support plate 4 and a flexible mould mounting plate 5 are supported in an axially shiftable manner on the machine bed 1. The two stationary plates 2 and 4 are connected to each other through four poles 6 and guided through a flexible mould mounting plate 5. A drive unit 7 is located between the support plate 4 and the flexible mould mounting plate 5 to generate the closing pressure. The stationary mould mounting plate 2 and the flexible mould mounting plate 5 each carry half a mould 8 or 9 with a number of cavities for producing a corresponding number of sleeve-shaped moulded objects. The moulds 8' are provided as arbours to which the sleeve-shaped moulded objects 10 stick once the mould halves 8 and 9 have been opened. At this time, the moulded objects 10 have already assumed a semi-solidified state and are indicated with a broken line. Fig. 1 shows the same moulded objects 10 at the top left in their final cooled-down state after they have been ejected from the after cooler 19. The upper poles 6 are broken for better representation of the details between the opened halves of the mould. As per solution shown in Fig. 1, the four most important handling stages for moulded objects following the completion of the casting are:

"A" is the removal of the moulded objects or preforms 10 from the two mould halves. The semi-solidified objects are removed by a retracted removal unit 11 (position "A"), which is located in the space between the open mould halves and lifted to position "B" (holding unit 11' in Fig. 1);

"B" is the transfer position of the removal unit 11 with the preforms 10 at a transfer gripper 12;

"C" is the transfer of the preforms 10 from the transfer gripper 12 to an after cooler 19; and

"D" is the ejection of the cooled and dimensionally stabilized preforms from the after cooler 19.

Figure 1 shows snapshots of the four main handling steps. In position "B", the moulded objects 10, which are vertically stacked on top of each other, are taken by the transfer gripper 12 or 12', respectively, to assume a standing position by swinging the transfer unit in the direction of the arrow P (phase "C"). The transfer gripper 12 is comprised of a mounting arm 14, which rotates around an axis 13, carrying a mounting plate 15 with a parallel carrier plate 16 for centre arbours 8". The carrier plate 16 can be extended parallel to the mounting plate 15, providing for the sleeve-shaped moulded objects 10 to be removed from the removal unit 11 in position "B" and, once rotated to position "C", to be pushed into the after cooler 19 located above. The transfer takes place by extending the distance between the mounting plate 15 and the carrier plate 16. The semi-solidified moulded objects 10 are completely cooled in the after cooler 19 and, once the after cooler 19 has moved into position "D", are ejected onto a conveyor belt 20. The reference symbol 30 indicates the water cooler with its feed and return lines, respectively, which are identified by arrows and are assumed to be common knowledge. The reference symbol 31/32 indicates the air side, whereby 31 indicates the blow or compressed air supply, respectively, and 32 indicates the vacuum or air extraction, respectively.

In Fig. 1, the horizontal plane is identified with EH and the vertical plane is identified with EV. The horizontal plane EH is defined by the coordinates X and Y, and the vertical plane is defined by the coordinates Y and Z. Coordinate Z is vertical and the X-axis is transversal to it. The movement of the individual units or the automatisation, respectively, is only indicated schematically through arrows. The main objective of the new solution is to increase the density of the positions of the preforms for after cooling. An important partial objective is the optimisation with respect to handling of various dense mould arrangements inside the after cooler. Fig. 1 shows a possible basic schematic, which, according to the new solution, can be configured to different variations:

- The transfer gripper 12 performs a swivelling movement and a linear movement in the X coordinate. The transfer gripper 12 can also be configured with a controlled movement in the Y coordinate. It is possible to exactly position the preforms located on the mounting arbours of the transfer gripper in X direction by means of a corresponding controlled/adjusted movement, because the transfer gripper performs a controlled movement in the X coordinate already. In this case, the transfer of the preforms to the after cooler 19 is performed by moving the after cooler 19 in X direction to a fixed position, and the transfer gripper is placed into the desired position in Y direction in a controlled/adjusted movement.

- Regarding the preferred configuration, the movement means for the after cooler 19 can be controlled/adjusted for the two coordinates X and Y to obtain the exact positioning for the transfer of the preforms, with the transfer gripper 12 being moved to a stationary transfer position.

Fig. 2 shows the after cooling concept as a compact design. Regarding the injection machine, the solution can correspond to Fig. 1, i.e., the same components are identified using the same reference symbols. An after cooler 40 with a number of cooling sleeves 41 has a vertical transfer plane, i.e., a plane within the coordinates Y and Z. In the position shown, both mould halves 8 and 9 are open and the after cooler 40 can move into the free space 42 between the mould halves. The after cooler 40 has a total of three movement axes, one horizontal movement axis in the Y coordinate, one vertical movement axis in the Z coordinate and one rotary axis 43. The rotary axis 43 is used for the ejection of the completely cooled preforms onto the conveyor belt 20. However, this will not be discussed in detail. The rotary axis is located opposite to the baseplate 44, which is part of the movement means for the vertical movement or the vertical drive 45. The vertical drive 45 can slide and is attached to a baseplate 46 of a horizontal drive 47.

Fig. 3 shows both drives on a bigger scale. The frame 48, to which the entire horizontal drive 47 is mounted, is indicated in Fig. 3 only. The horizontal drive has an AC servomotor 49 with vertical axis. The driven axis of the servomotor 49 drives a cogged V-belt 51, which moves the baseplate 46 via a transmission wheel 50. Due to its support, the baseplate 46 can be moved reciprocatingly via four sliding elements 52 on two parallel guideways 53. The baseplate 46 has a baseplate component 46', which points straight upward and to which the vertical drive 45 is anchored. The vertical drive 45 also has an AC servomotor 60 with horizontal axis. It drives a cogged V-belt 62, which assures the vertical movement of the after cooler 40 by means of the baseplate 44 via a transmission wheel 61. Two guideways 63 are anchored in the baseplate 46, 46'. The baseplate 44 is moved on sliding elements 64 along the guideways 63. The sliding elements 64 and 42, respectively, may have a recirculating ball guide for guiding without play and friction.

The after cooler as per Fig. 4 and 5 has several parallel rows 1, 2, 3, 4. The depicted example has 12 cooling sleeves 70 each per vertical row for holding one preform 10 each. With respect to the mould spacing ratios, the cooling sleeves 70 can be arranged much closer together. Therefore, this suggestion does not only include several parallel rows but also a staggering of rows as shown in Fig. 4 and 5 with the measurements x or y, respectively. This means that the cooling tubes with the number 1 indicate the first cast cycle, the cooling tubes with the number 2 indicate the second cast cycle, etc. If, according to the example with four parallel rows, all rows with No. 3 are full, the rows with No. 1 will be prepared, as described, for ejection onto the conveyor belt 20. The remainder is conducted accordingly during the entire production time. As per example, the entire after cooling time is about three to four times the casting time. The cooling chambers 71 for the water cooling must be optimally arranged so the water cooling has a uniform and optimum effect for all cooling tubes. On the other hand, the air pressure or vacuum ratios in the after cooler must be controllable by rows in order to be able to simultaneously activate all rows 1 or 2 at a given point in time.

Fig. 6 shows an advantageous basic schematic, which represents the main functional elements for the control/adjustment of several axes. A machine computer 80 with a computer data memory 81 is connected to several axes via a bus or a sensor/actor bus 82, each with controllers 84 and one drive computer 85. Each controller 84 has its own velocity control (V control) and a power control (I control), which governs the torque and the field control (φ control) and is connected to an axis or the corresponding motor M1, M2 or M3, respectively. The sensor/actor bus 82 can also be connected to necessary signal or control connections of the machine, like sensors, auxiliary motors, etc. Direct velocity processing for all control tasks is done by the machine's computer 80 using desired values, limit values or a corresponding formula that is uploaded from the computer data memory 81 for every task. In addition to the accuracy of the displacement control, it is important that the acceleration and delay functions are optimally controlled. Visualisation takes place in a command device 88 of the machine control or of the machine's computer 80, respectively.

Fig. 6 shows three axes as per example. Regarding the control philosophy mentioned, any number of other axes could be controlled/adjusted and coordinated. The movement sequences can be optimized in every respect. This applies to start and stop, but especially velocities and delays with respect to velocity and displacement. Other machine functions like the injection process and the mould closure can be performed with the same, uniform control or adjustment philosophy, respectively, to facilitate the control of the entire process and to allow for a very high flexibility with high quality results. The most critical stages or areas of the process can now also be performed with a production sequence of unprecedented stability and reproducibility within a very short overall cycle time. Especially advantageous is the combination of multi-variable control and multi-axis drive. According to another configuration, it is further possible to integrate a velocity actuator signal to be sent to the control electronics (drive with integrated velocity and position control) as a displacement actuator signal (possibly as displacement signals).

Patent Claims

1. A device for the production of sleeve-shaped objects, particularly preforms for PET bottles, which are removed from the moulds after injection and transferred to an after cooler configured as a removal robot to assume a dimensionally stable storage condition, whereby all objects injected in a mould per cycle are simultaneously removed from the moulds and transferred to free positions in the after cooler, which has a capacity in a transfer plane that corresponds to a multitude of the objects produced per cycle, and is characterized as follows:

the removal robot has divided cooling positions in staggered rows for increased density of the objects to be cooled, whereby the device has controllable/adjustable movement means for two coordinates of the transfer plane of the removal robot, enabling the removal robot to be cyclically positioned with respectively free cooling positions in the fixed arrangement of moulded objects in the moulds, whereby a maximum density of cooling positions can be obtained in the removal robot.

2. A device as per Claim 1 providing for the capacity of the removal robot to correspond to at least triple the amount of objects produced in one injection cycle.

3. A device as per Claim 1 or 2 providing for controllable movement means with program memory and program controlled/adjustable servomotors with internal position measuring means for handling of the moulded objects for each of the coordinates, or external position measuring means and position control/adjustment means allocated to the coordinates for position control/adjustment of the movement means.

4. A device as per Claim 1 or 2 providing for the removal robot to be configured as a replacement module with adaptation points for quick and exact re-attachment of another replacement module.

5. A device as per Claim 4 providing for computer and memory means for programmatic saving of all movements to enable a ready production by selecting a right program after exchanging the mould and after cooler.

6. A device as per Claim 1 providing for the movement axes of the removal robot to be controllable servo-axes to be controlled/adjusted via central programs.

7. A device as per Claims 1 to 6 providing for a displacement adjustment/control, which obtains the position signals for the moved object via corresponding sensors directly from an AC servomotor control or via the moved object, and the movement to be controlled/adjusted accordingly.

8. A device as per Claim 1 providing for the controllable/adjustable movement means of the after cooler to have at least one overhead belt drive or an overhead rack and pinion drive.

9. A device as per Claim 1 providing for the injection mould to be configured for 96, 144 or more objects per injection cycle.

10. A device as per Claim 9 providing for the removal robot to be divided into four groups with staggered rows.

11. A device as per Claim 1 providing for the transfer plane for the preform to be vertical to the direction of the movement of the mould.

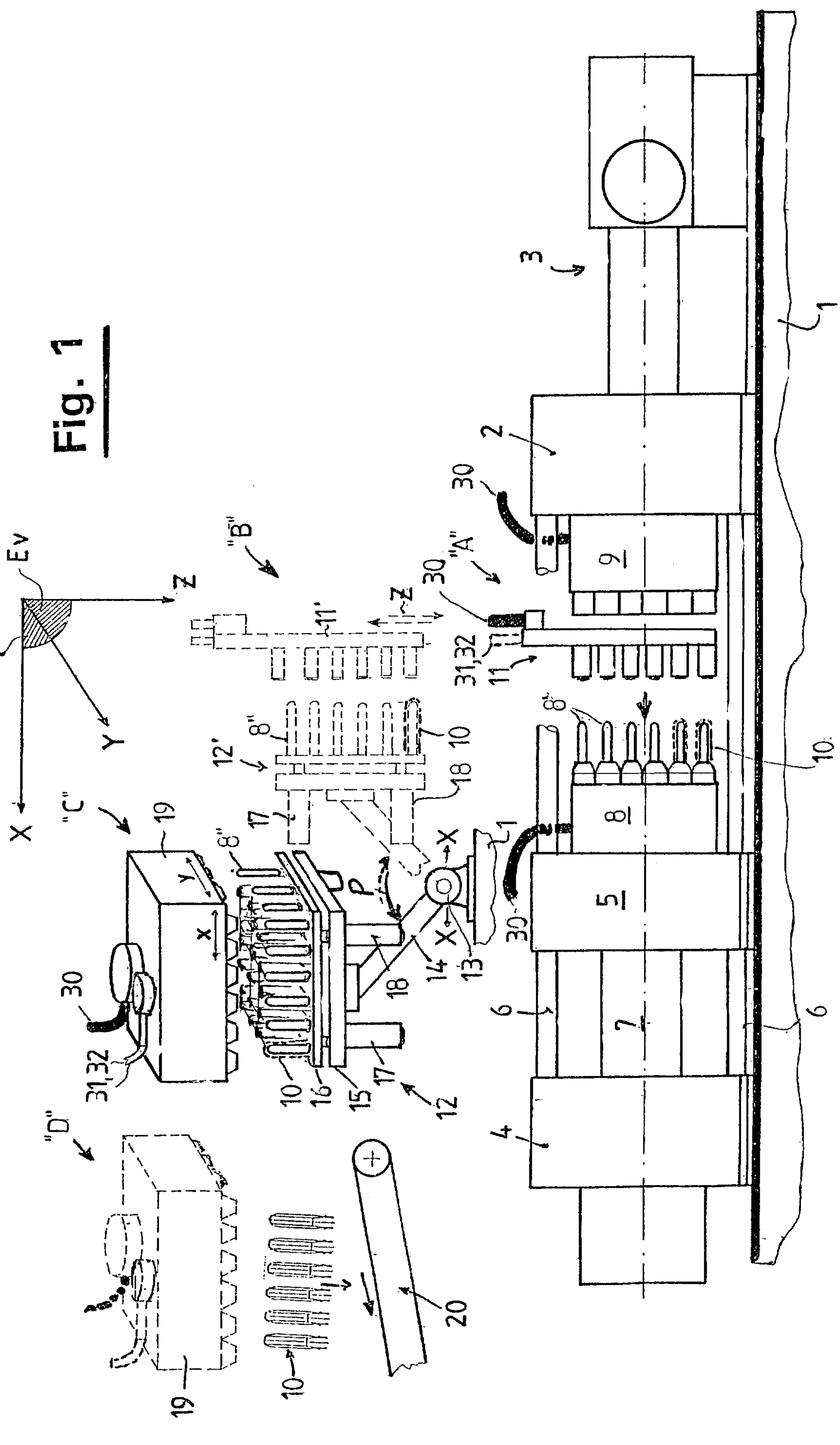

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Fig. 1

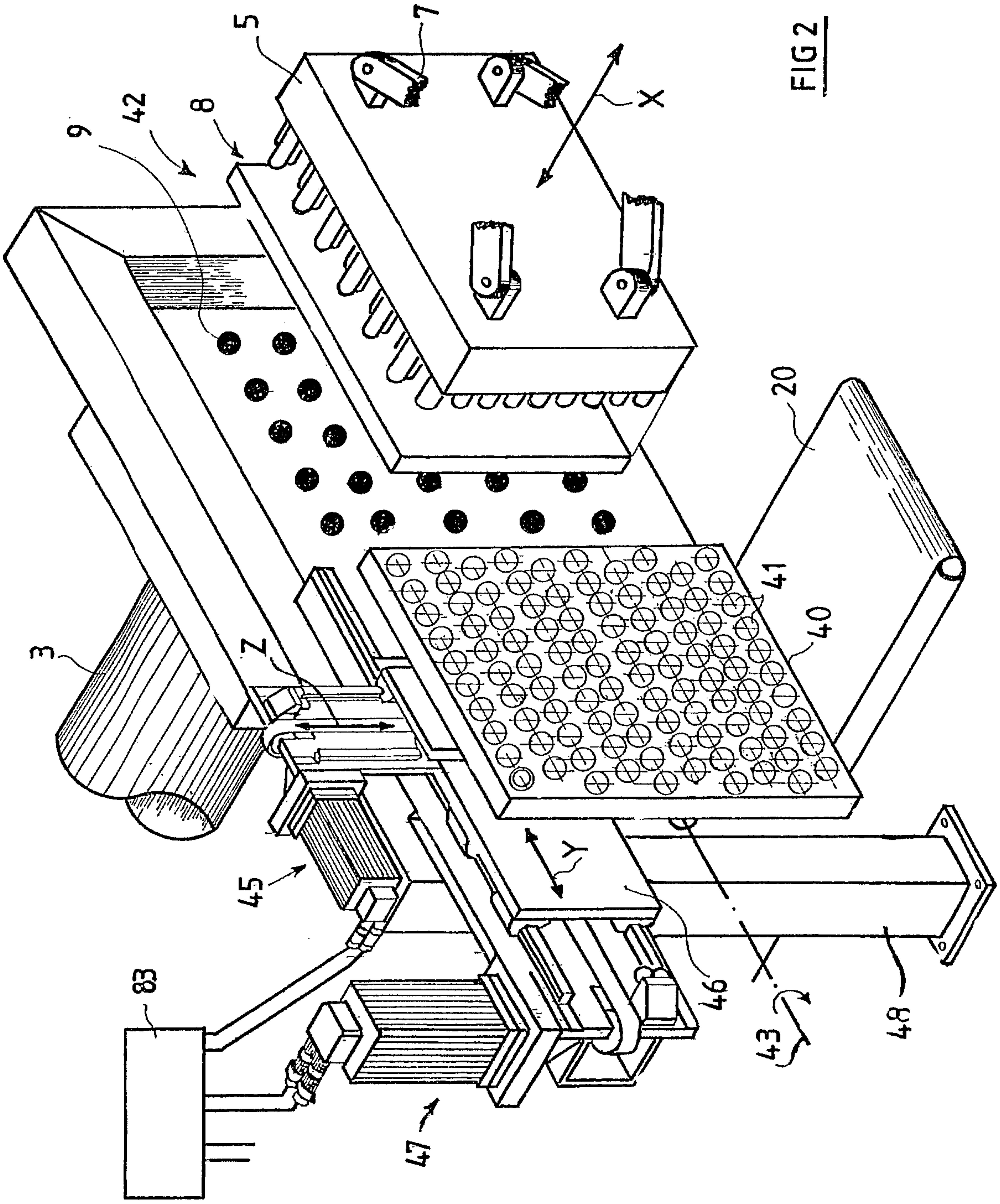


FIG 2

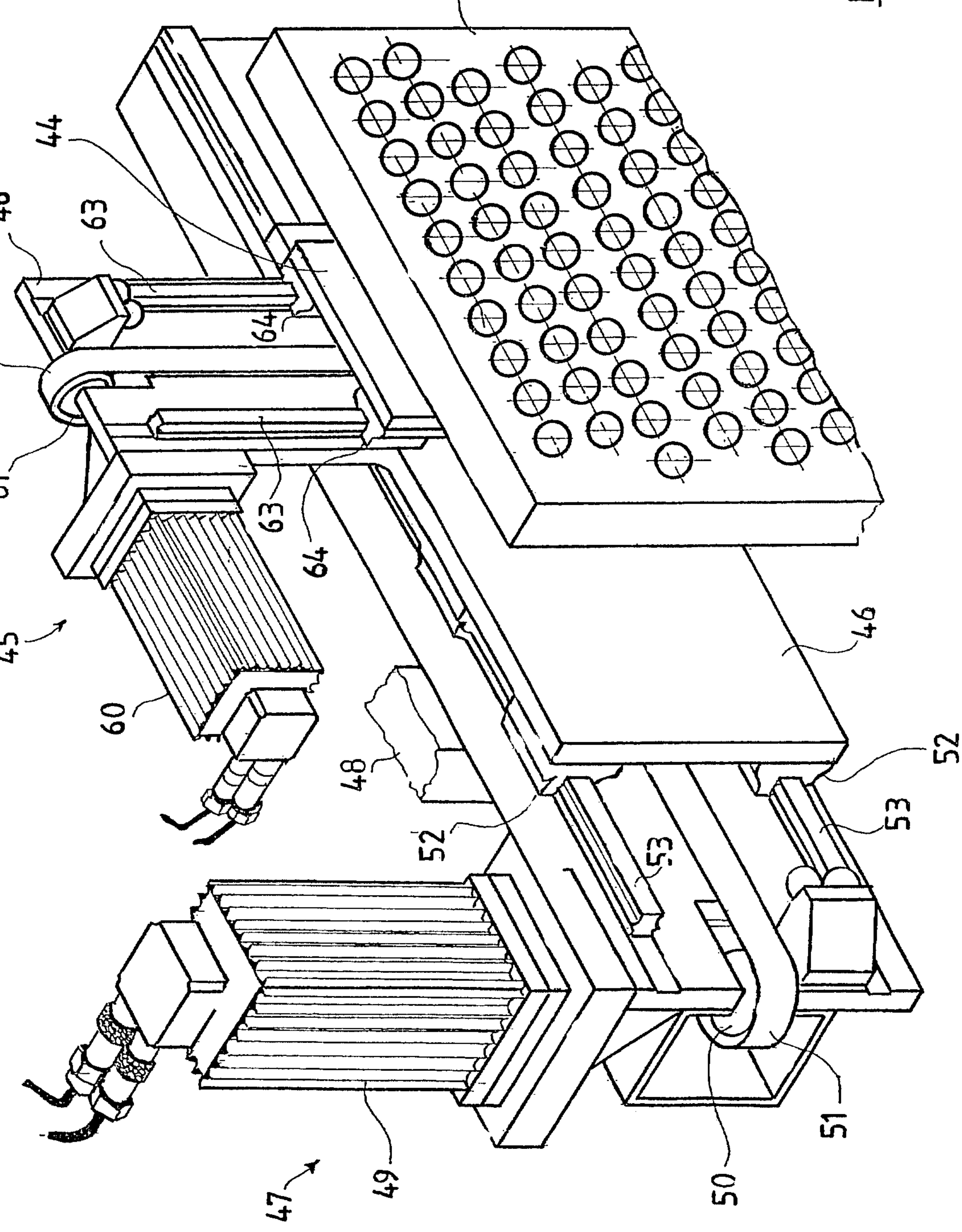


FIG 3

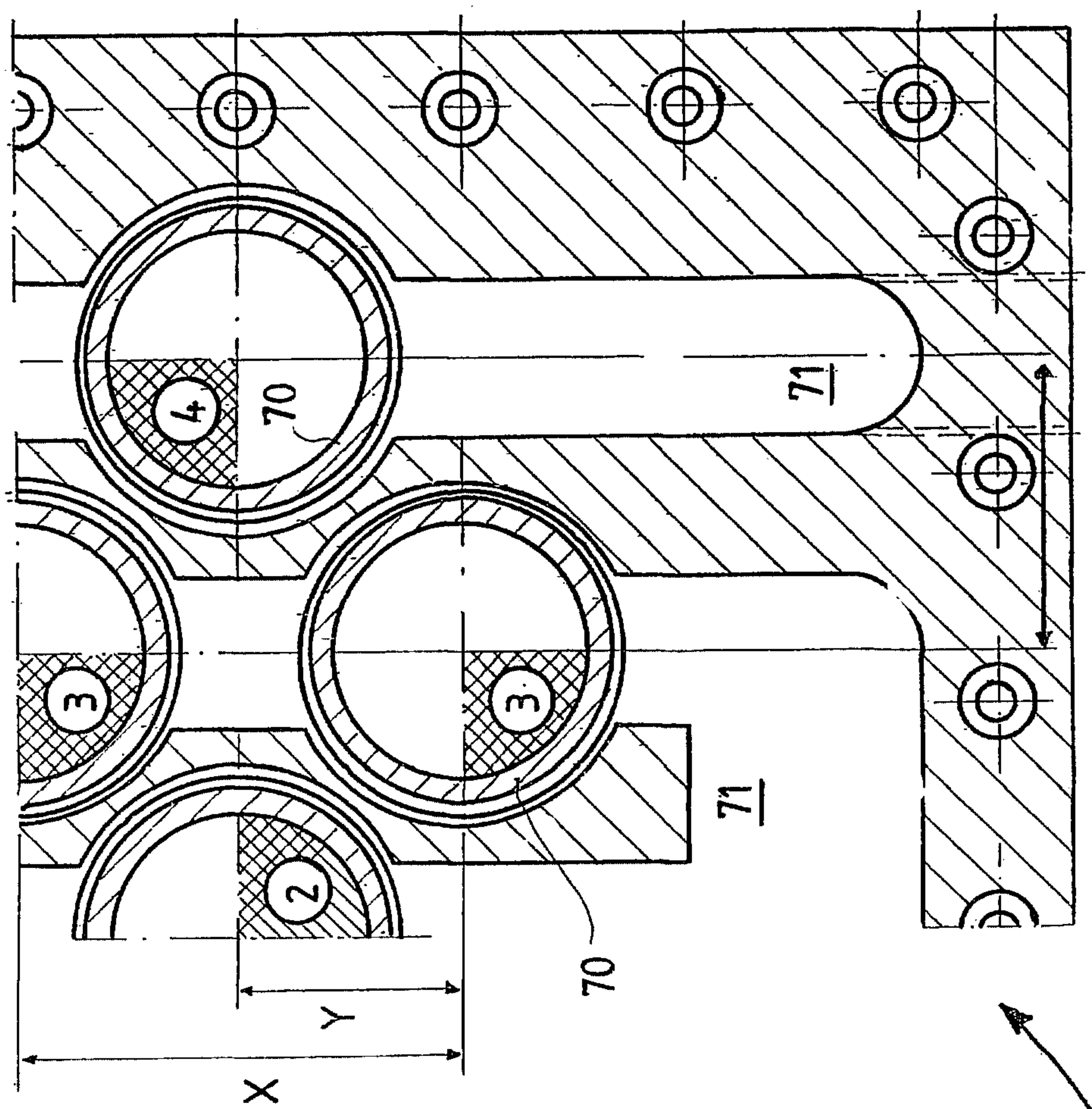


FIG 5

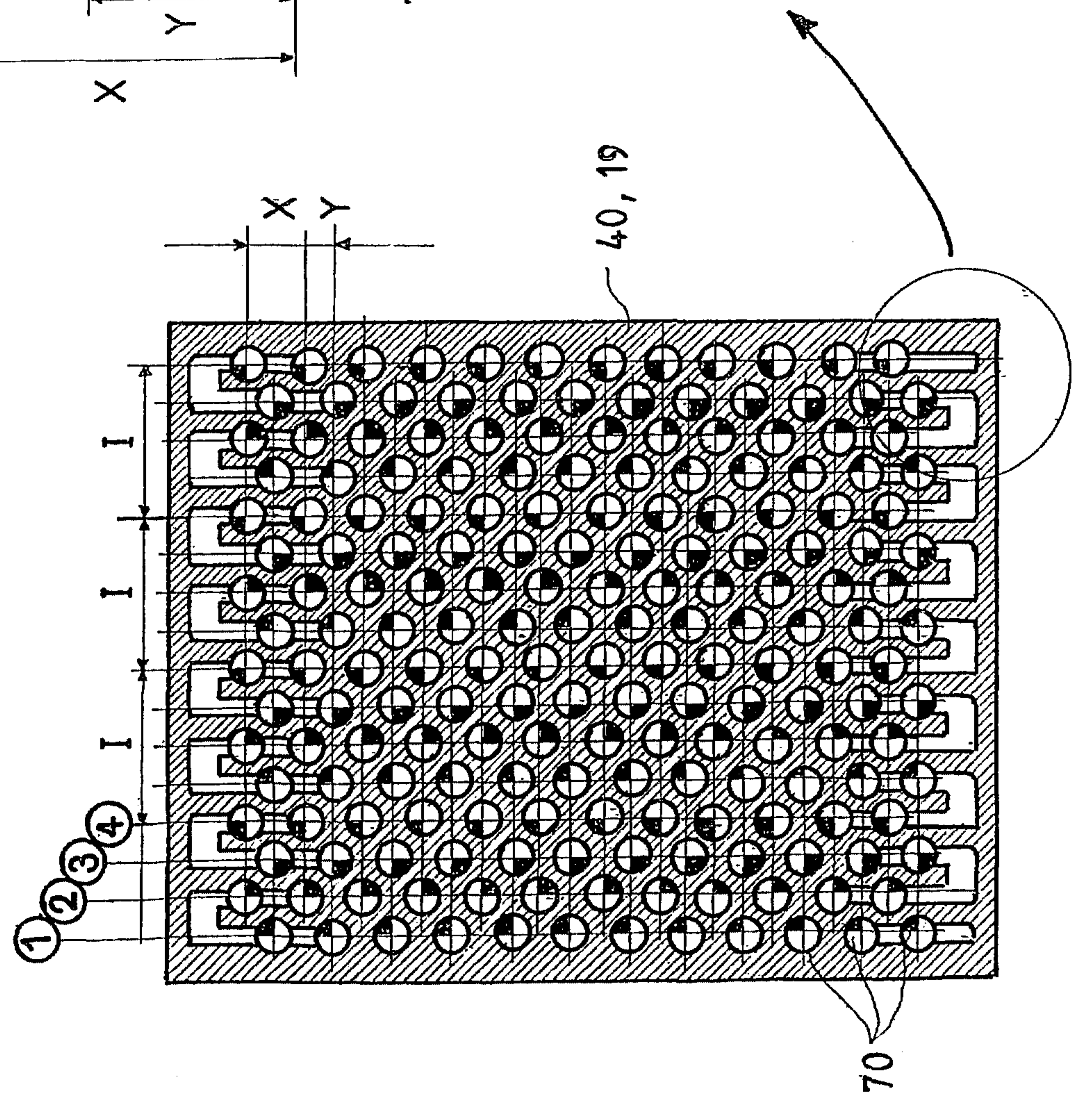
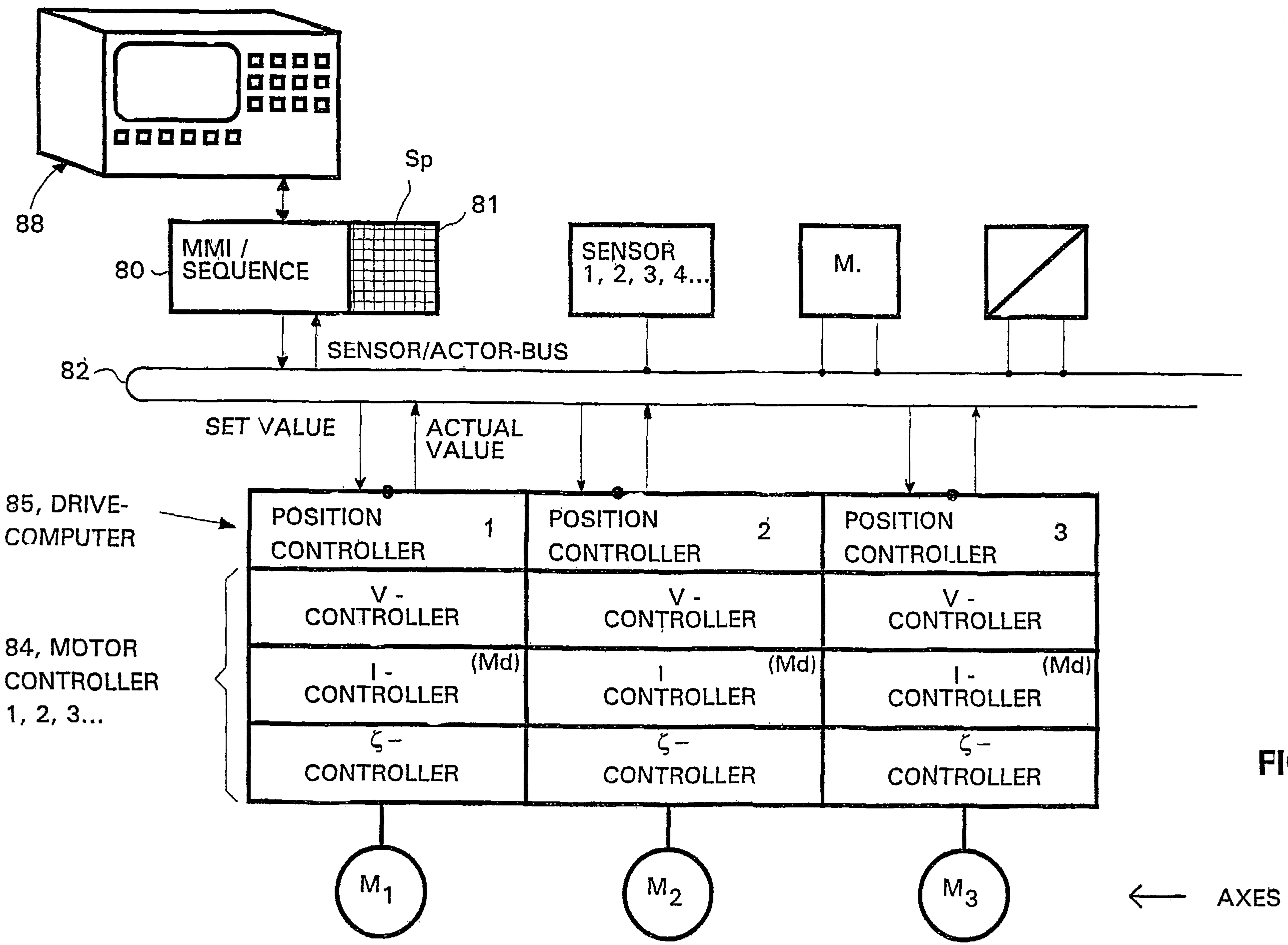


FIG 4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COMPUTER
POSITION
CONTROLLER
1
POSITION
CONTROLLER
2
POSITION
CONTROLLER
3
V -
CONTROLLER
84, MOTOR
CONTROLLER
1, 2, 3...
(Md)
I -
CONTROLLER
ζ –
CONTROLLER
M_1
M_2
M_3
AXES

FIG 6

EH
X
Ev
Y
Z
"D"
30
"C"
31,32
19
19
x
y
8"
12'
"B"
17
8"
10
10
16
11'
15
P
17
18
Z
12
14
X
X
18
10
30
20
13
31,32
"A"
30
1
4
6
30
11
2
3
8'
5
7
8
9
6
10
1