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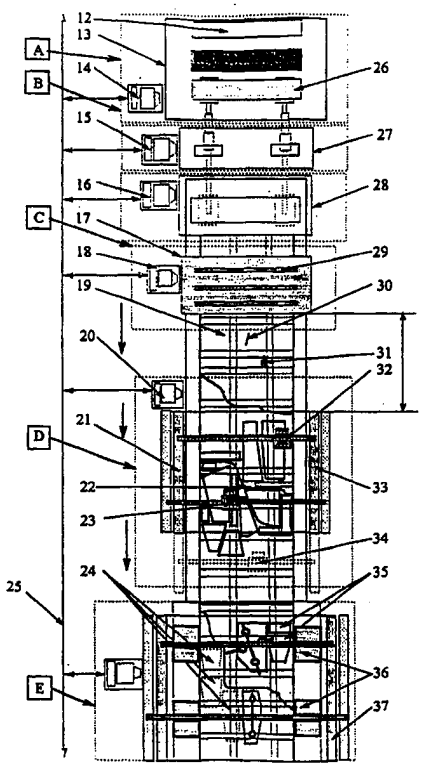
(54) Title: METHOD AND APPARATUS FOR AUTOMATICALLY LAYING, CUTTING AND REMOVING, ON AND FROM A CONTINUOUSLY MOVING CONVEYOR

(57) Abstract

A method for automatically cutting products, composed of a plurality of elementary pieces, such as items of clothing in general, shoes, leather goods, sofa upholstery and any other similar product, including the steps of: acquiring all the geometric characteristics and defectiveness characteristics of the material to be cut and storing all the above–described characteristics in an electronic memory so that they can be sent or retrieved automatically in real time for subsequent processing; optimizing the shapes to be cut in the material acquired in the previous step in a fully automatic manner and taking simultaneously into account all the characteristics of the acquired material and all the characteristics and rules according to which the elements that constitute the product must be cut and then assembled; removing (E), on said conveyor, said pieces cut in the previous step and managing them in single–product mode or as a pack; and sending, by computerized control system which controls the entire synchronization of the preceding steps in real time all the information concerning the correct operation of the entire production sequence.



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METHOD AND APPARATUS FOR AUTOMATICALLY LAYING, CUTTING AND REMOVING, ON AND FROM A CONTINUOUSLY MOVING CONVEYOR

Technical Field

The present invention relates to a fully automatic method and apparatus for cutting products composed of a plurality of basic elements (items of clothing, shoes, sofa upholstery, etcetera) which are fully or partially made of a material which can be laid on a moving surface and can be cut continuously without any external manual intervention on a conveyor which is moving continuously and at a variable speed.

Background Art

Machines that cut the fabric in a layer set and in single layers are currently known in the specific field of the cutting of items of clothing. These two methods, which are the current state of the art, require a layout study which cannot be performed on the actual fabric being acquired; accordingly, they do not take into account the characteristics of the fabric, such as stripes, checked patterns, flowers etcetera or flaws found during the actual cutting of the fabric.

Also in the specific case of single-layer cutting, the fabric is cut in "windows", where each window corresponds to a layout determined beforehand by optimization systems without taking into account the actual characteristics of the fabric that will be cut. In all these systems, the cutting logic system is practically the same, except for the fact that in the case of a layer set a plurality of

layers are cut simultaneously, while in the case of the single layer the layering system is removed, eliminating this step but maintaining the entire logic system of the production system both upstream and downstream.

Disclosure of the Invention

The aim of the present invention is to revolutionize and fully automate, in all its parts, the laying, cutting and the cut part removal system for items of clothing and for products made entirely or partially of a material which can be laid on a moving surface to be cut, by providing a method and an apparatus which allow to cut any number of products, particularly items of clothing, continuously and automatically, attempting to minimize and ultimately eliminate all manual interventions.

This aim and other objects which will be described hereinafter are achieved by a method for automatically cutting products, composed of a plurality of elementary pieces, such as items of clothing in general, shoes, leather goods, sofa upholstery and any other similar product, comprising the steps of:

a) accommodating, in an automatic store, materials to be cut in a predefined sequence;

b) removing the materials to be cut from the store and sending them to a depositing system on a continuously-moving variable-speed conveyor;

c) automatically depositing the material to be cut in a single layer on a conveyor which moves continuously and at a variable speed;

d) acquiring all the geometric characteristics and defectiveness characteristics of the material to be cut and

storing all the above-described characteristics in an electronic memory so that they can be sent or retrieved automatically in real time for subsequent processing;

e) cutting said material on the conveyor which moves continuously and at a variable speed when the system reports that the number of pieces to be cut of that product has been reached and that the remaining material must be rolled up again and returned to the store to be replaced with another material for cutting a different product;

f) optimizing the shapes to be cut in the material acquired in the previous step in a fully automatic manner and taking simultaneously into account all the characteristics of the acquired material and all the characteristics and rules according to which the elements that constitute the product must be cut and then assembled;

g) removing, on said conveyor, said pieces cut in the previous step and managing them in single-product mode or as a pack; and

h) sending, by computerized control system which controls the entire synchronization of the preceding steps, in real time all the information concerning the correct operation of the entire production sequence.

The above-described method and the related apparatus entail considerable advantages in the cutting sequence and specifically allow the following improvements:

1) Manual or automatic layout and optimization of the pieces to be cut on screen on an ideal fabric is eliminated, since the layout is generated when the fabric is to be cut, taking exactly into account all the characteristics of the fabric, acquired by the sensing

system, at cutting time.

2) All the checks for fabric flaws, which had to be conducted before placing the rolls in the store, are no longer required.

3) Production becomes highly flexible, since at any moment the system can decide to halt production, roll up the fabric being cut, automatically remove from the store a new fabric to be cut, lay and cut a number "n" of more urgent items, roll up the fabric of the urgent items, take up again the old fabric that was being cut and continue the temporarily halted production without any manual intervention. All this can be done without requiring any predefined layout and in real time, under the supervision of a management program (MAIN+SLAVE).

4) Fabric waste can be optimized better than in the current state of the art. When a fault is detected during fabric laying, current technology in fact allows to obviate this problem as shown in figure 1. The fabric is moved back and laying resumes from the last complete shape affected by the flaw. In this manner, however, extra item pieces are obtained which are unusable and therefore a portion of fabric is wasted over its entire width. With the present invention, instead, since the shapes are arranged on the fabric acquired by the fabric sensing system, the exact location of the flaws is known and it is therefore possible to arrange the shapes in the best possible manner, avoiding said flaw as shown in figure 2, achieving a better result in terms of waste caused by fabric flaws.

5) The system for automatically removing the pieces allows to supply production sequences according to

conventional production methods, i.e., a production line, or to supply production islands, where items are produced at a single station in a fully automatic manner depending on the required production.

Brief Description of the Drawings

Further characteristics and advantages of the apparatus according to the present invention will become apparent by accurately examining the system according to a preferred but not exclusive embodiment thereof, illustrated only by way of non-limitative example, for manufacturing items of clothing, with the aid of the accompanying drawings, wherein:

figure 1 illustrates the current state of the art in the management of fabric flaws;

figure 2 illustrates the innovative method according to the present invention for handling fabric flaws;

figure 3 is a general top view of the machine, illustrating all the above-described steps;

figure 4 is a view of the system for storing the fabrics for managing the store according to the logic mode that provides for sequential searching and management of the rolls of fabric;

figure 5 is a view of a fabric storage system for managing the store according to the logic mode that provides for random (parallel) searching and management of the rolls of fabric;

figure 6 is a view of an acquisition system for checking the exact linearity of the fabric during the unrolling of said fabric on the part of the automatic unrolling unit and the corresponding checking of the

correct linearity of the laying of the fabric;

figure 7 is a side view of the fabric unrolling/roll-up unit in the configuration in which it is associated with the sliding table on which the fabric is made to advance;

figure 8 is a view of an arrangement of the optical sensors for the linear sensing of the fabric and for storing said sensing in memory in the form of consecutive lines at the resolution required for the kind of fabric being acquired;

figure 9 is a view of a possible arrangement of the video cameras for the optical sensing of all the flaws and the color and geometric characteristics of the fabric;

figure 10 is a view of a twin-head cutting system which allows to achieve speeds that allow to cut any item of clothing conveniently in single-layer mode;

figure 11 is a side view of said twin-head cutting table, illustrating the suction chamber and the moving table for continuous cutting;

figure 12 is a view of the automatic system for removing cut pieces continuously to pack them in single-item mode or in a pack according to the production requirements of the company;

figure 13 is a diagram of the cutting head with a linear motor to be applied to the cutting table to obtain a high cutting performance from said table;

figure 14 is a diagram of the continuous variable-speed conveyor system for managing the movement of the fabric during the various steps of the cutting system;

figure 15 is a view of the system for loading and unloading the store towards the system for

unrolling/rolling up the fabric on the moving conveyor and viceversa;

figure 16 is a view of a method for performing the continuous single-layer cutting of materials that are not inherently rigid and whose cutting requires perfect knowledge of their geometric, chromatic and defectiveness characteristics and all the other necessary characteristics in real time;

figure 17 is a view of the connection among the various parts of the apparatus according to the present invention with the CED system and the CAD system of the company.

Ways of carrying out the Invention

With reference to figure 3, the system is composed of an automatic fabric storage system A, which is controlled by a computer which communicates with the overall management system MAIN. The store contains rolls of fabric 39, 42 which the system must remove in order to meet the demands of the production management system CED. The store, which has a limited number of rolls of fabric, communicates automatically with the general fabric store, from which it removes the rolls that it needs for current production. Said store can be configured sequentially (figure 4) or in parallel mode (figure 5). In the sequential mode (figure 4), the system is slower because in order to select the chosen fabric 39 it is necessary to scroll through all the rolls of fabric up to the chosen one Pa. If many items are manufactured using the same fabric, this system can still be effective, since the time required by the system to cut all the fabric is sufficient to allow a fresh roll of

fabric to be present when it is required at the end of the current process. In the parallel mode, the system is instead very fast in any condition, even if a single item must be cut from each roll of fabric. The fabric access time of the parallel system is always the same, regardless of the position of the fabric inside the magazine i, j. In this method, the rolls of fabric are arranged in vertical columns, numbered 0 to N, which can move up or down. This movement allows to select the column from which the fabric roll is removed and place it in the upper position and to place all the other columns in the lower position. In this way, the fabric roll removal system can access, inside the store, only the fabric rolls that correspond to the elevated column. In this way, by means of a removal arm 46, it is possible to directly access the chosen roll without interfering with all the other rolls.

This method allows to access any roll of any other column in the same manner, by selecting the column from which the roll is to be removed and placing it in the upper position while placing all the other columns into the lower position.

The roll of fabric is removed by the movable arm 108 and by rotating about its fulcrum 109 it is moved into the position 110 which allows it to be deposited in the fabric unrolling/roll-up unit 112 in the position 111, from which the roll can begin to be unrolled onto the continuously moving conveyor which has a variable controlled speed 103. Said moving conveyor is composed of three separate moving conveyors 103, 104, 105, all of which operate synchronously with each other except for the conveyor 103, which can be

operated separately if the fabric is to be rolled up after a production run has ended.

The conveyor 103 is the one that takes up the fabric and stabilizes it with respect to the conveyance table by means of the control photocells 50, 51 with the aid of the unrolling/roll-up unit 49 which, being able to move transversely in both directions with respect to the fabric advancement direction, allows to correct the small variations that might occur during laying and are caused merely by the strength characteristics of the fabric to be laid. Said unrolling/roll-up unit, by means of control and tensioning pulleys 54, 55, 56, 57, allows to keep the fabric under tension without deforming it, leaving the fibers that compose the fabric free from tension, and to send the fabric to the conveyor 58, 59 with a perfectly uniform speed.

Once the fabric has been deposited onto the moving conveyor 103, 104, 105, which always moves continuously but at a variable speed caused by the different characteristics of the fabric and by the dimensions of the parts to be cut and ultimately by the perimetric characteristics of the pieces to be cut, the system conveys the fabric to the system for sensing the characteristics of the fabric (figure 8), which is composed of a set of linear video cameras 65 arranged so as to have a plurality of lightings 63, 62, 67 of the same line of fabric 66. Actually, the video cameras 65 are arranged along three sensing lines, depending on the type of lighting applied to the fabric, and specifically in the vertical case 63, in the parallel oblique case 62, and in the perpendicular oblique case 67.

Comparison of these three or more sensing operations, if necessary, produces a highly precise indication, with an almost zero probability of error, of all the characteristics of the fabric and of its flaws, i.e., the characteristics that do not match the average description of said fabric.

The sensing operations do not occur with a single video camera but by aligning three video cameras (figure 9), wherein each video camera 68 senses a line a fabric over a length, termed sensing cone 70, which is equal to the need to achieve the chosen precision both in the fabric advancement direction and transversely thereto, which in the specific case can vary between 0.1 mm and 0.25 mm. The alignment of the video cameras 68 produces an overlap in the work areas of the resulting images, which must be filtered so as to eliminate this interference region by means of computational algorithms which allow to obtain a uniform image over the entire width of the fabric. Said line image is stored in the memory of the system in order to have a sequence of lines which is sufficient to perform a color analysis of the fabric. Depending on the sensed colors, which correspond to the different lightings performed, it is possible to obtain, by comparison, indications related to the geometry of the fabric and to any flaws that might be present internally.

Once the image has been acquired, highly sophisticated computational algorithms process said continuous image of the fabric in real time, in the period during which the acquired fabric passes from the acquisition step to the cutting step, i.e., in the region between the steps C and D

in figure 3, in order to obtain a geometrically described image thereof. Said geometric image, which is the result of said processing, indicates the pattern of the fabric, provides information as to its periodic repetition, reports any flaws and their location 73, 78, reports whether there are stripes or checked patterns and, if so, whether the stripe remains unchanged along the fabric or changes shape, together with all the other information required for its complete management.

Once the characteristics of the fabric have been defined, again in real time, their description is passed to a very fast and complex computing system which is capable of handling, in real time, the depositing and optimization of the pieces to be cut, taking into account all the information concerning the fabric acquired in the previous step. Optimization is performed so as to comply with the characteristics of the item to be cut; all the parameters concerning the characteristics of the item are supplied by a model creation system CAD, to which the layout optimization system is connected in real time. The system must be connected not only to the system CAD but also to the system CED in order to receive in real time the number of items of that model to be produced, so as to lay them out along the entire length of the acquired fabric. All these operations are performed while the fabric is moving on the moving conveyor during the step between the acquisition of the fabric and the cutting system. The space between these two steps is constant and is a fixed parameter of the machine, while the time required to pass from one step to the next is variable and depends on the

speed at which the conveyor is made to advance, so that if the fabric to be acquired or the item to be laid out is very complex, the system is capable of slowing the system in a fully automatic manner, so as to reach the cutting step exactly in time for the end of the computing of the optimum layout.

After the step for optimizing the pieces to be cut, the fabric arrives, again with a continuous cycle, at the cutting system (figure 10, figure 11), composed of a plurality of cutting heads 76 which are limited to two 82, 84 in the specific case for the sake of simplicity; each head operates on the entire cutting table asynchronously, and the heads are controlled by a computing system which optimizes the cutting path of both heads according to the path to be covered for each cutting head. In this manner, the two cutting heads never collide and can both work on the same piece to be cut if necessary. Cutting is performed while the fabric is moving and the cutting heads work so as to take into account the advancement speed of the fabric on the moving conveyor, following the variations thereof caused by the preceding steps.

The cutting system is composed of a suction system 83, which forces the layer of fabric to remain rested on the cutting table 80, which is composed of self-regenerating material or of a material which allows the blade 99 to penetrate to a thickness of no more than 4 millimeters. The suction table 83 operates exclusively on the moving conveyor, so that the fabric continues to adhere perfectly during the cutting step. The cutting heads are equipped with a blade-type cutting system which can be of the

conventional type or a linear motor (figure 13), capable of producing very high cutting frequencies and with a very short vertical path of the cutting blade 99, measuring 1 or 2 millimeters. The two cutting heads work on the same cutting table and travel either on two separate sliders 75 or on the same slider, depending on whether movement occurs on the beam that supports the cutting heads (same slider) or is generated by a transmission generated at the level of the sliders by means of a belt drive or other equivalent mechanisms (two separate sliders).

Once piece cutting 74, 77 of the item to be produced has been completed, the cut fabric is sent to the system for removing said pieces (figure 12), so that said pieces are packaged to move on to the subsequent assembly step. Said packing system can operate in two modes which are controlled by a program that allows to collect the pieces in single-item mode or as a pack.

In the first case, all the pieces that compose an item are removed 89 by a removal system capable of adapting to the various geometries of the pieces 92, 93 and are deposited in a suitable container 88 which runs to the sides of the removal system and with the same speed as the moving conveyor, so that each container contains a complete item. When all the pieces that compose an item have been deposited into the container, an automatic packing system binds together all the pieces that compose the item, so that it can be handled as a single unit and sent automatically to the subsequent processes.

CLAIMS

1. A method for automatically cutting products, composed of a plurality of elementary pieces, such as items of clothing in general, shoes, leather goods, sofa upholstery and any other similar product, comprising the steps of:

a) accommodating, in an automatic store, materials to be cut in a predefined sequence;

b) removing the materials to be cut from the store and sending them to a depositing system on a continuously-moving variable-speed conveyor;

c) automatically depositing the material to be cut in a single layer on a conveyor which moves continuously and at a variable speed;

d) acquiring all the geometric characteristics and defectiveness characteristics of the material to be cut and storing all the above-described characteristics in an electronic memory so that they can be sent or retrieved automatically in real time for subsequent processing;

e) cutting said material on the conveyor which moves continuously and at a variable speed when the system reports that the number of pieces to be cut of that product has been reached and that the remaining material must be rolled up again and returned to the store to be replaced with another material for cutting a different product;

f) optimizing the shapes to be cut in the material acquired in the previous step in a fully automatic manner and taking simultaneously into account all the characteristics of the acquired material and all the

characteristics and rules according to which the elements that constitute the product must be cut and then assembled;

g) removing, on said conveyor, said pieces cut in the previous step and managing them in single-product mode or as a pack; and

h) sending, by computerized control system which controls the entire synchronization of the preceding steps, in real time all the information concerning the correct operation of the entire production sequence.

2. An apparatus for automatically laying, cutting and removing, on and from a continuously moving conveyor, components of a product made of a material that can be laid on said conveyor, comprising:

a) a high-speed automatic magazine for rolls of fabric, of the sequential or parallel type, for the management of rolls of fabric to be used for production, which are removed automatically or manually from a central store;

b) an automatic device for removing the fabrics from the central store and for sending them to a fabric unrolling/roll-up unit and viceversa when the fabric must be rolled up and stored from the unrolling/roll-up unit to the store;

c) a device for rolling up and unrolling the fabric on said conveyor, said device unrolling and rolling up the fabric continuously on the conveyor, which moves at a variable speed, according to cutting requirements and according to the complexity of the items to be cut, and is capable, when production ends, of rolling it up and optionally labeling it automatically in order to also have

the remaining fabric, expressed in meters, even in writing on the roll;

d) an automatic device for acquiring the fabric that moves on the conveyor at a variable speed, capable of acquiring all the characteristics of the fabric in a fully automatic manner during the continuous laying of the fabric on the conveyor;

e) an automatic layout device which arranges, in a fully automatic manner, all the items to be cut, on one or more rolls of fabric;

f) a device for automatically cutting on said conveyor, with two or more cutting heads;

g) a device for automatically removing the cut pieces continuously on said conveyor, composed of one or more piece removal modules;

h) a slave device for control of the production line while the fabric moves continuously and at a variable speed, connected to a main processing system, said slave device sending in real time the status of the system to a remote data acquisition and management system; and

i) a main system, capable, on the basis of the information received from the various management centers, of deciding in a fully automatic manner which production must be performed, complying with the characteristics of the company and with its production requirements.

3. A method according to claim 1, characterized in that materials in roll form are rolled up if the production to be executed does not use up said roll over its entire length.

4. An apparatus according to claim 2, characterized in

that it comprises a computerized system for interfacing the production system and the outside world of the company, capable of receiving all the graphic data and management data and of sending them to the production system in a fully automatic manner.

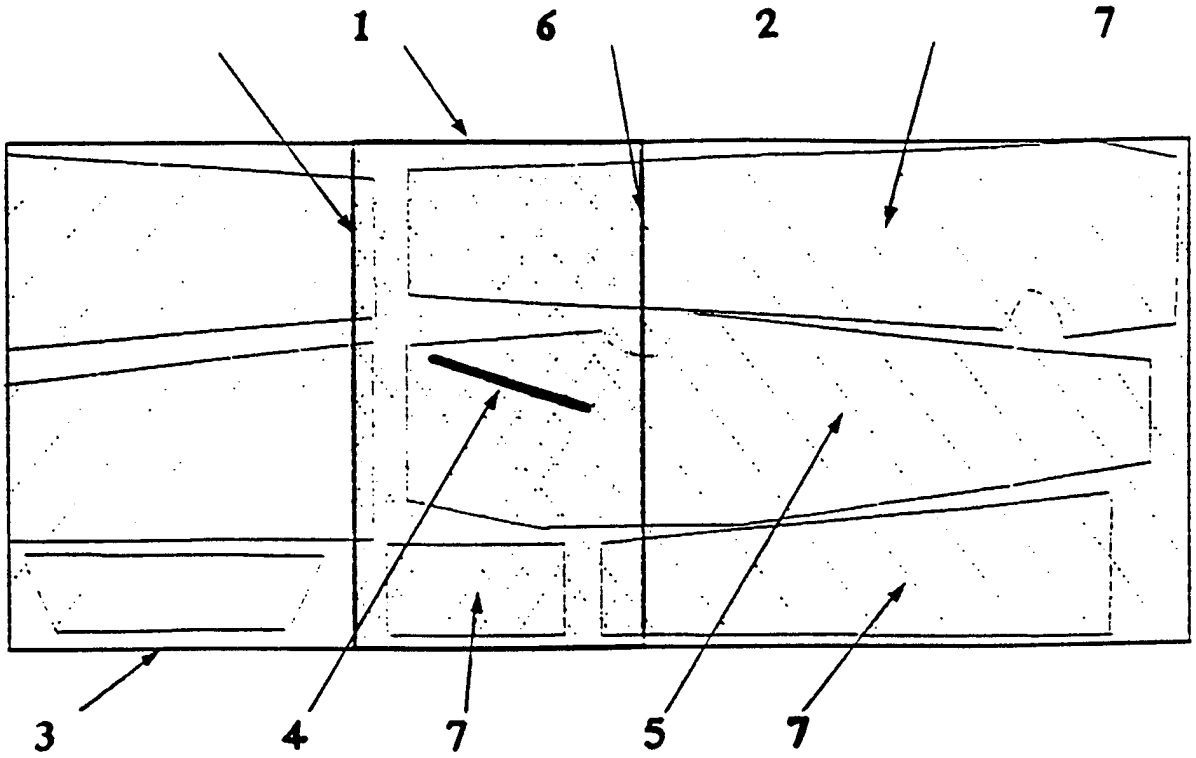

Fig. 1

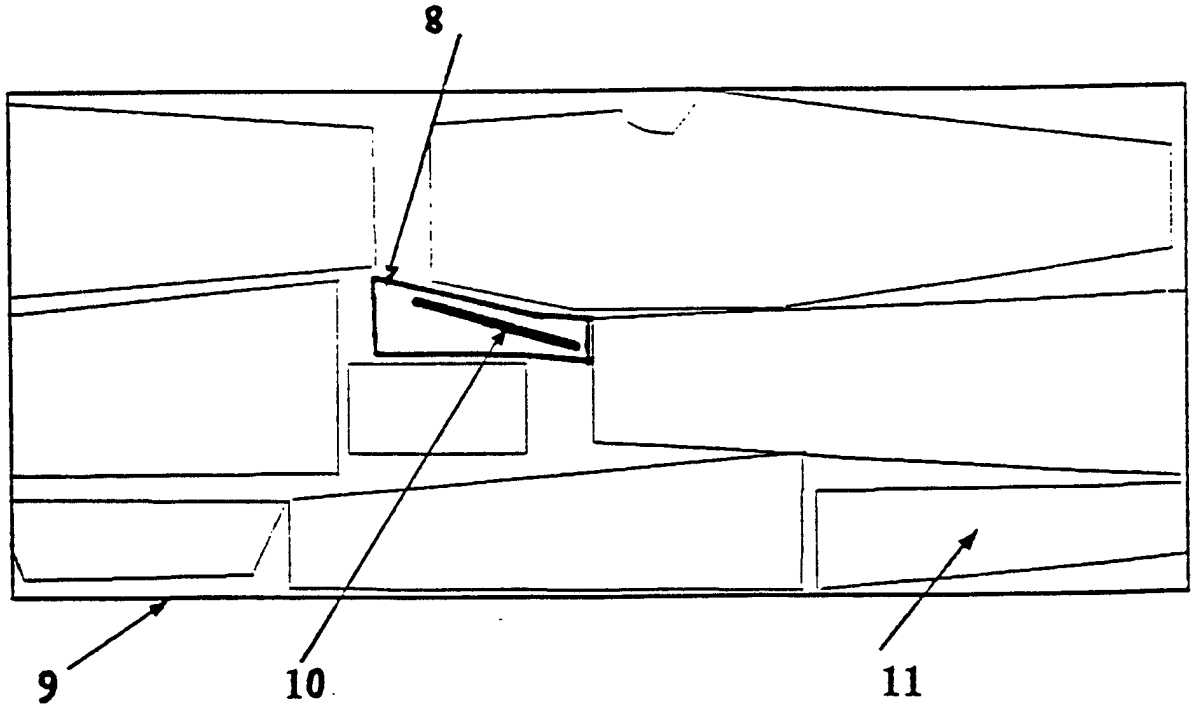

Fig. 2

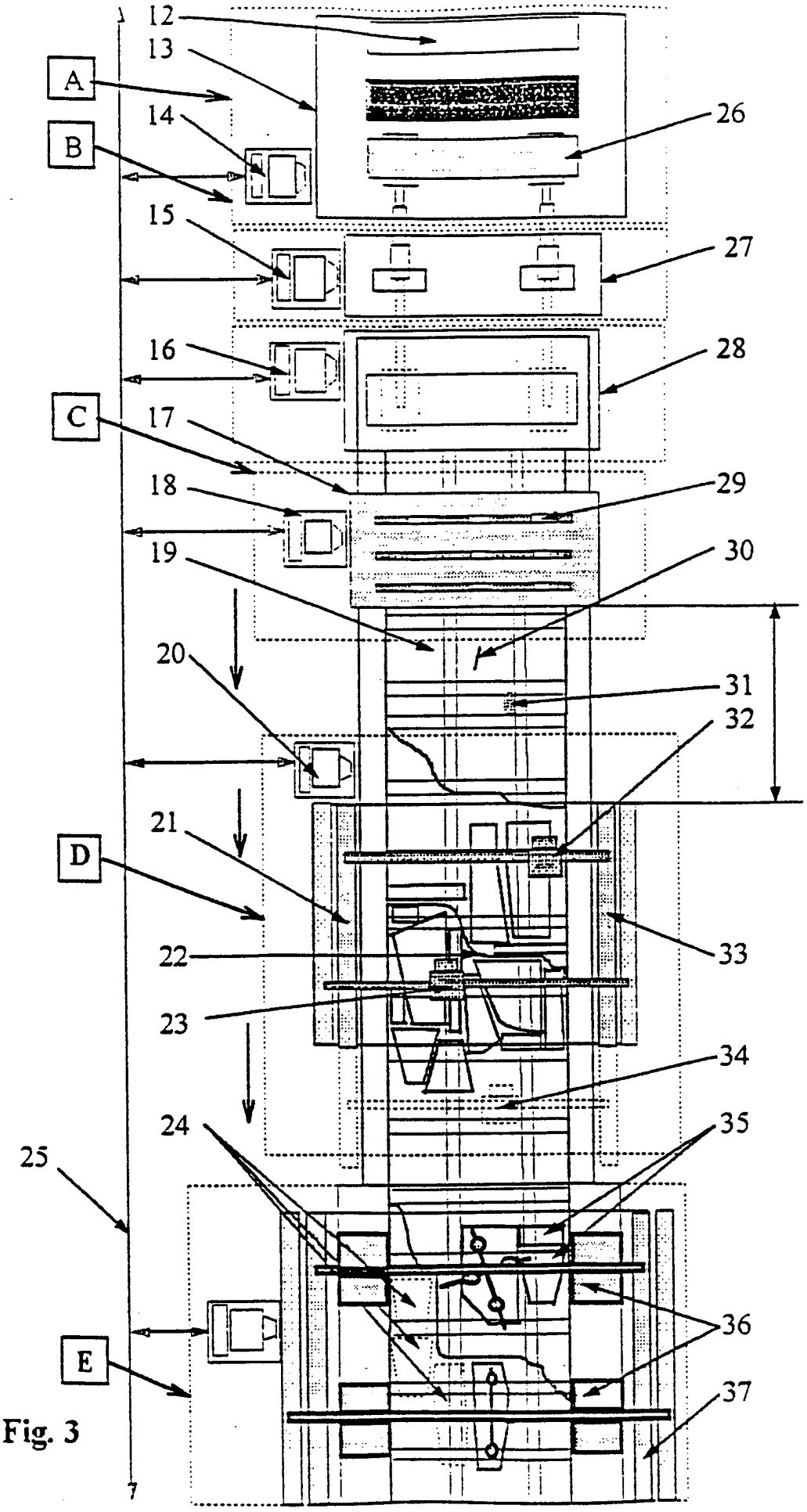
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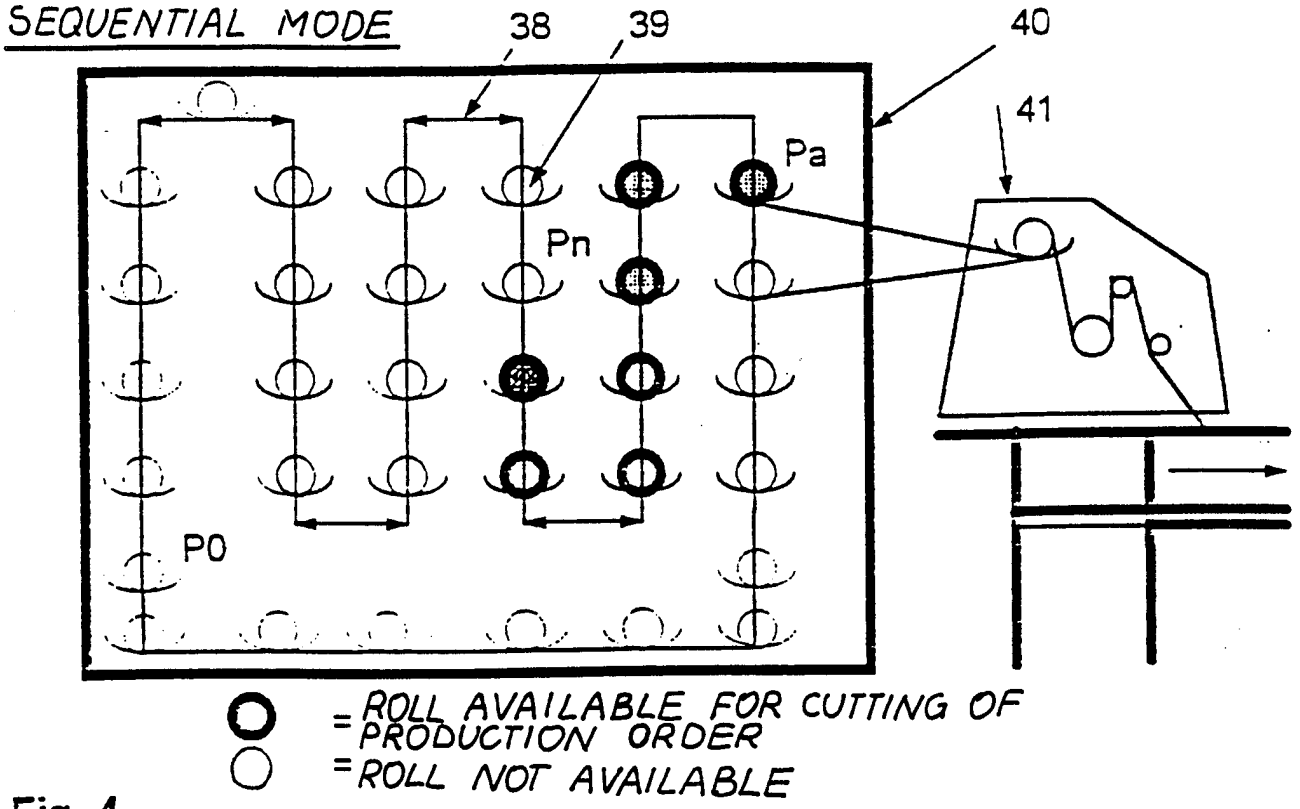
Fig. 3


SEQUENTIAL MODE
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= ROLL NOT AVAILABLE

Fig. 4

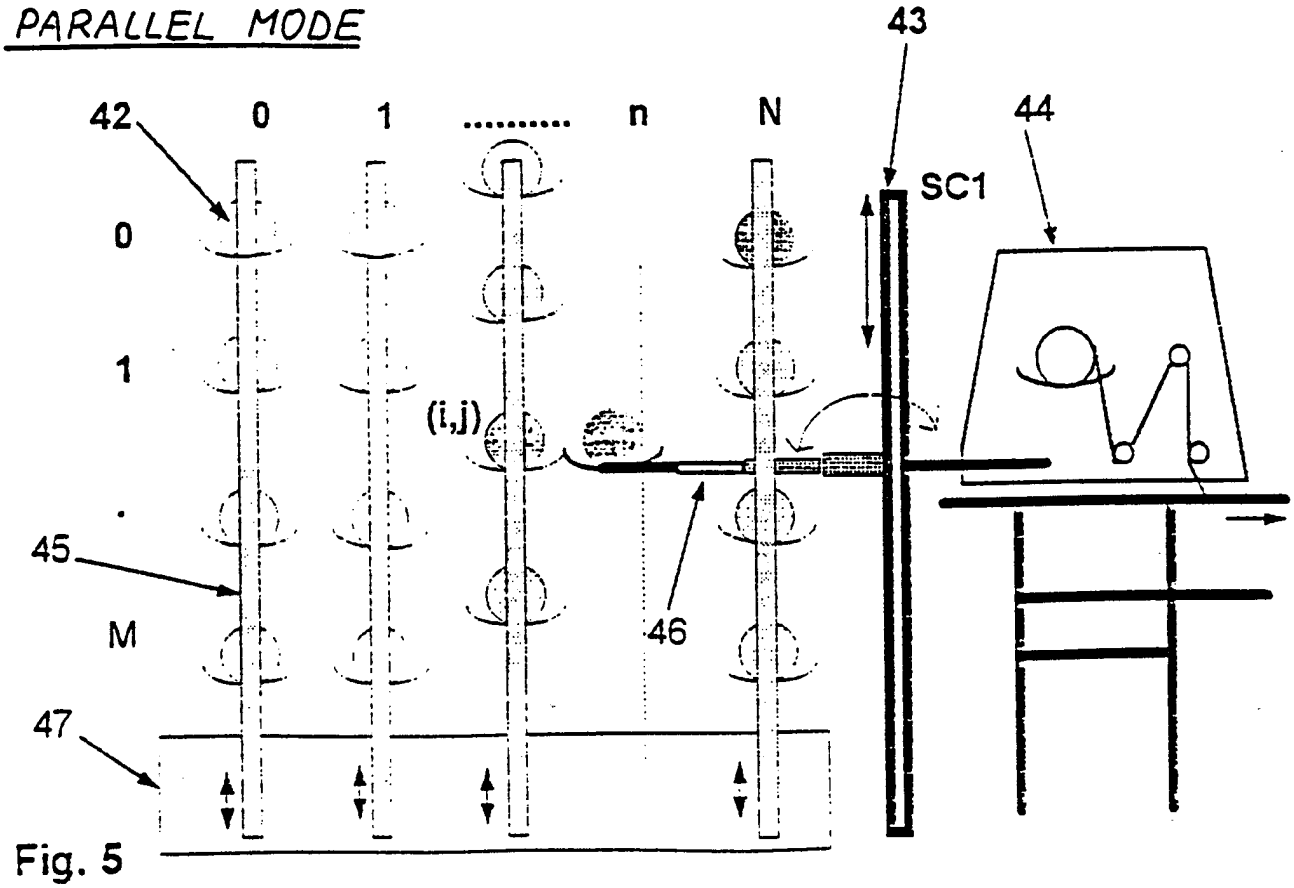
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Fig. 5

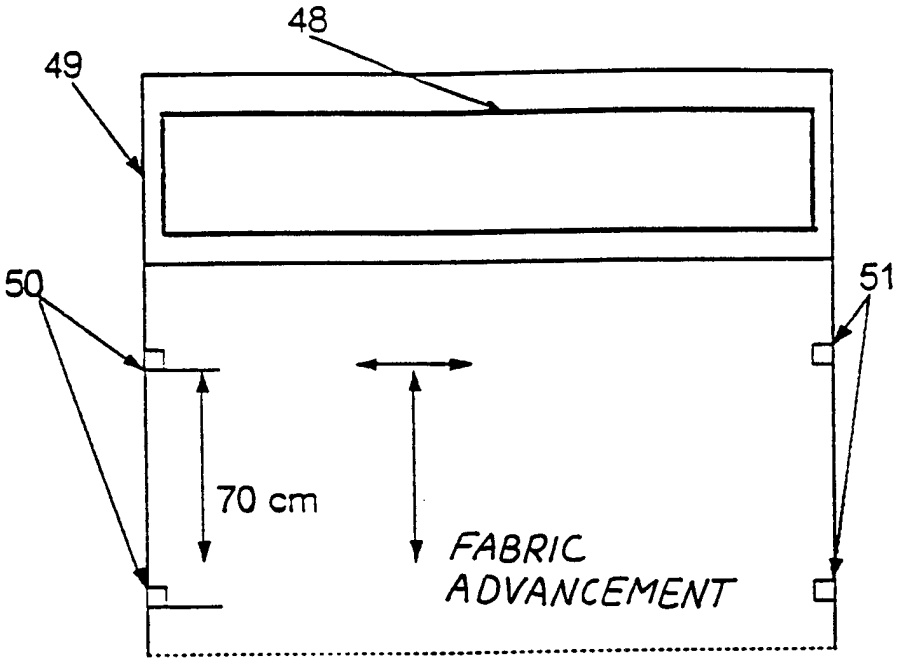
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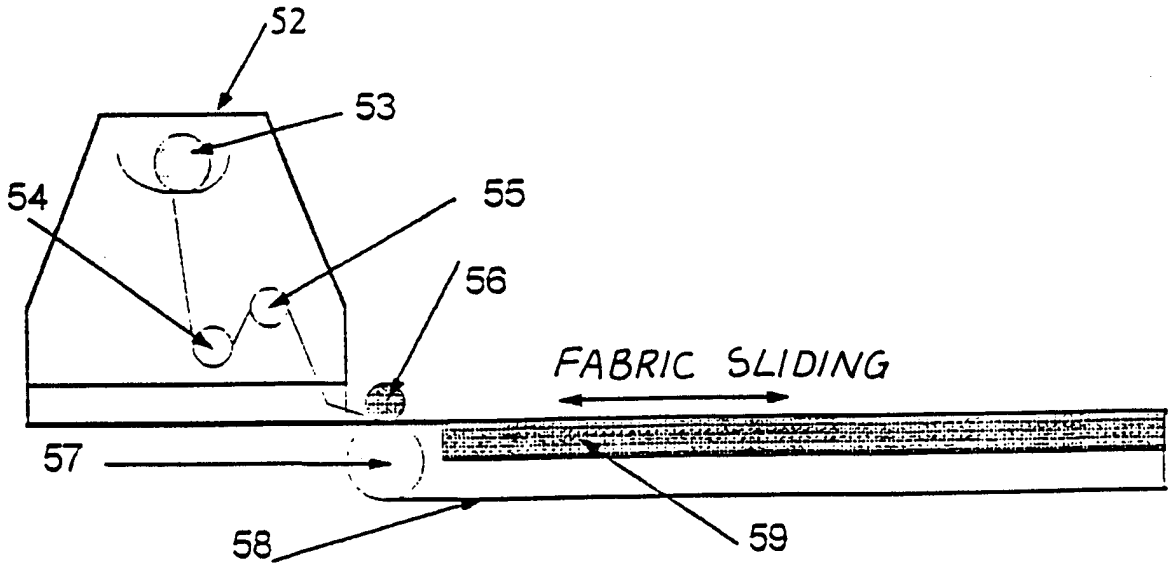
Fig. 6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FABRIC SLIDING
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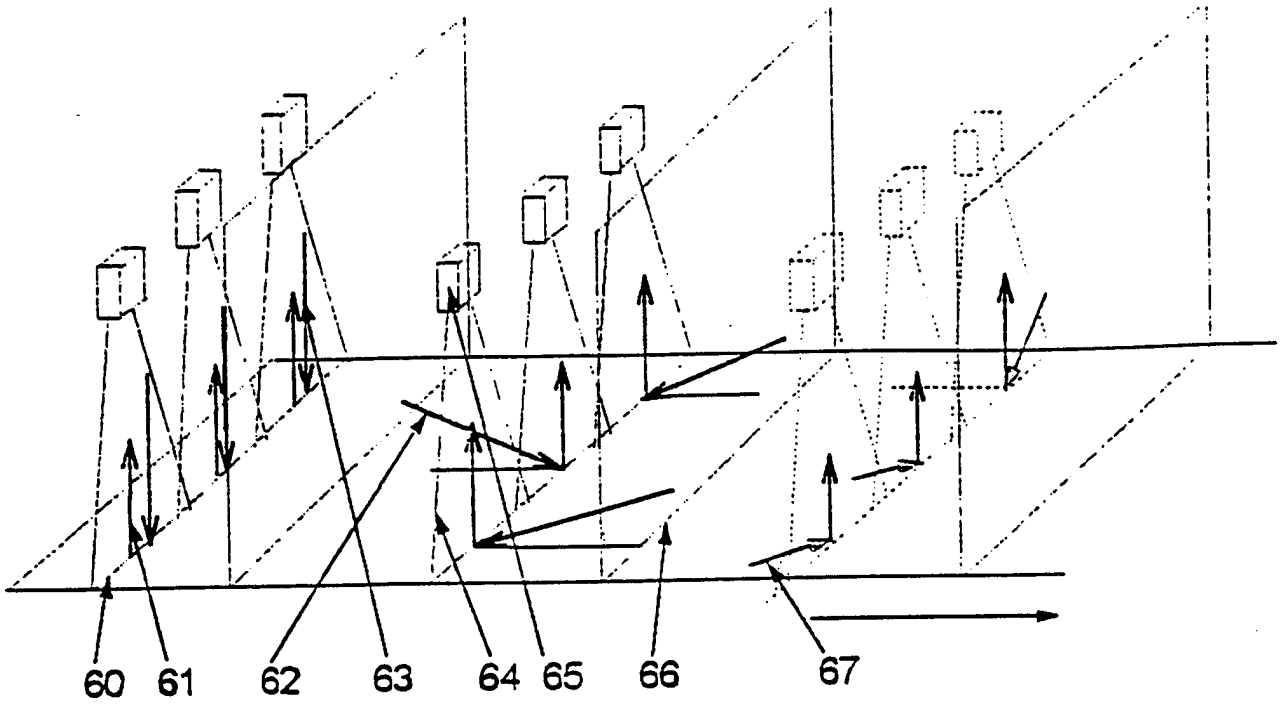
Fig. 7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67

Fig. 8

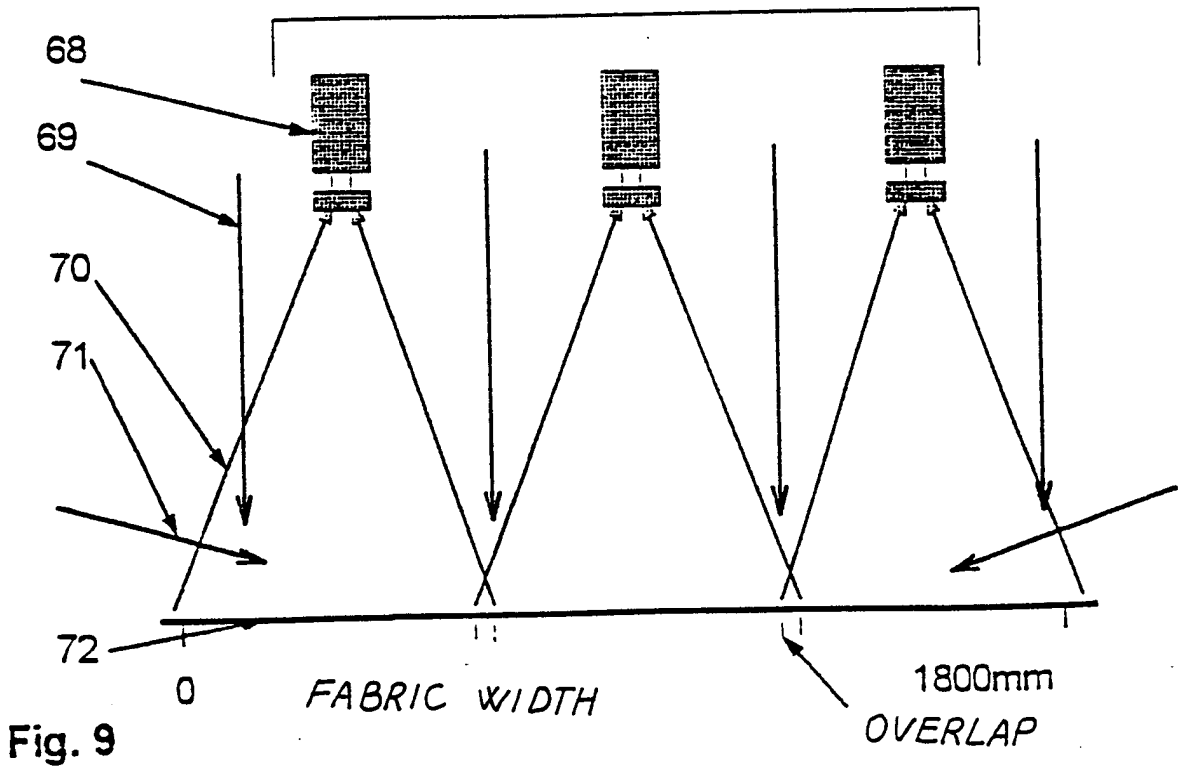
68
69
70
71
72
0
FABRIC WIDTH
1800mm
OVERLAP

Fig. 9

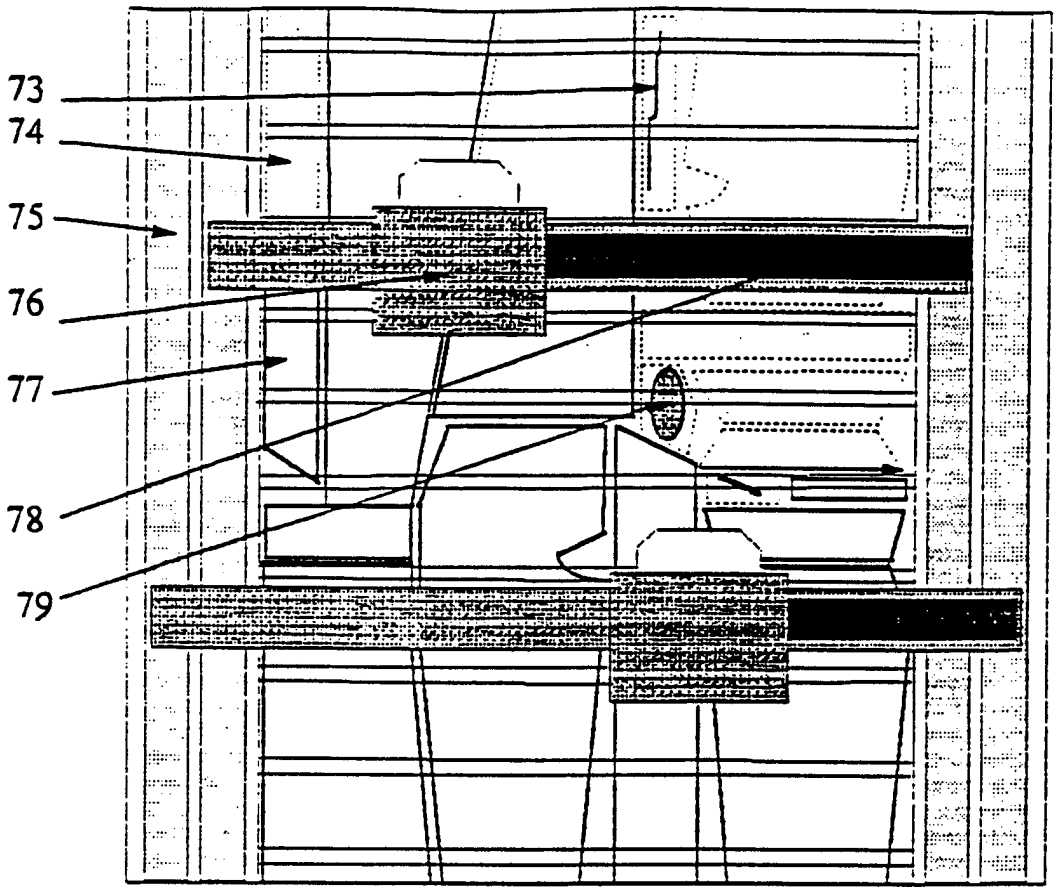

Fig. 10

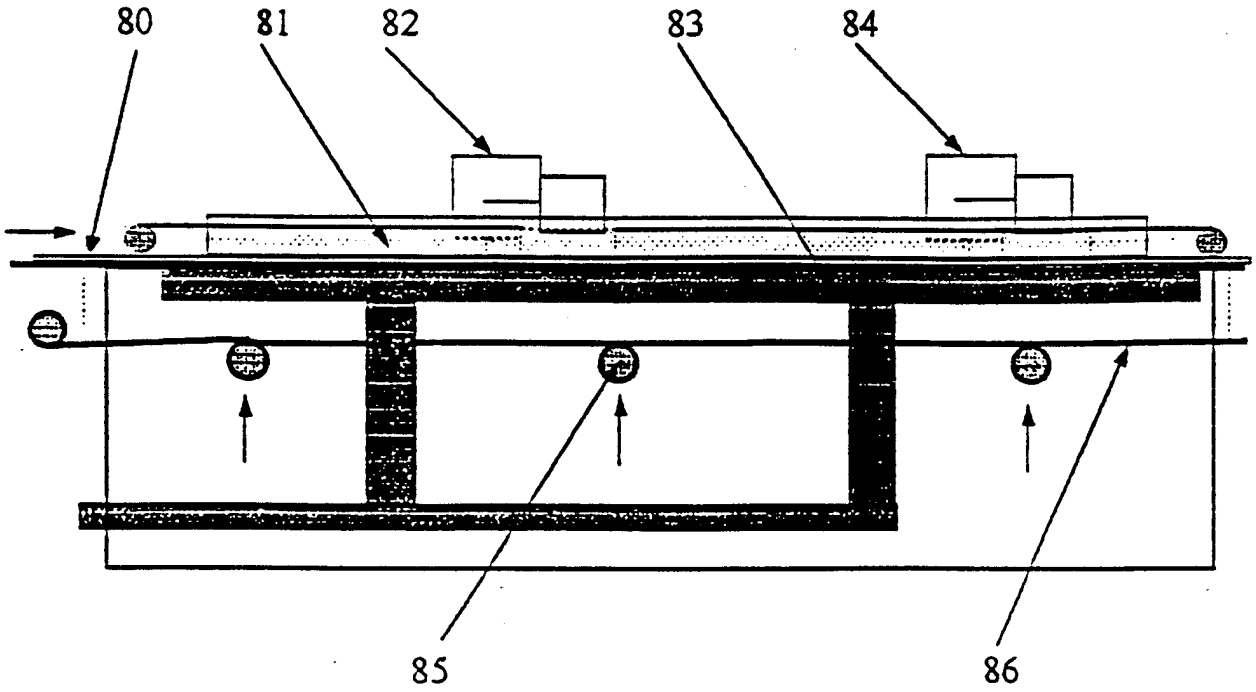

Fig. 11

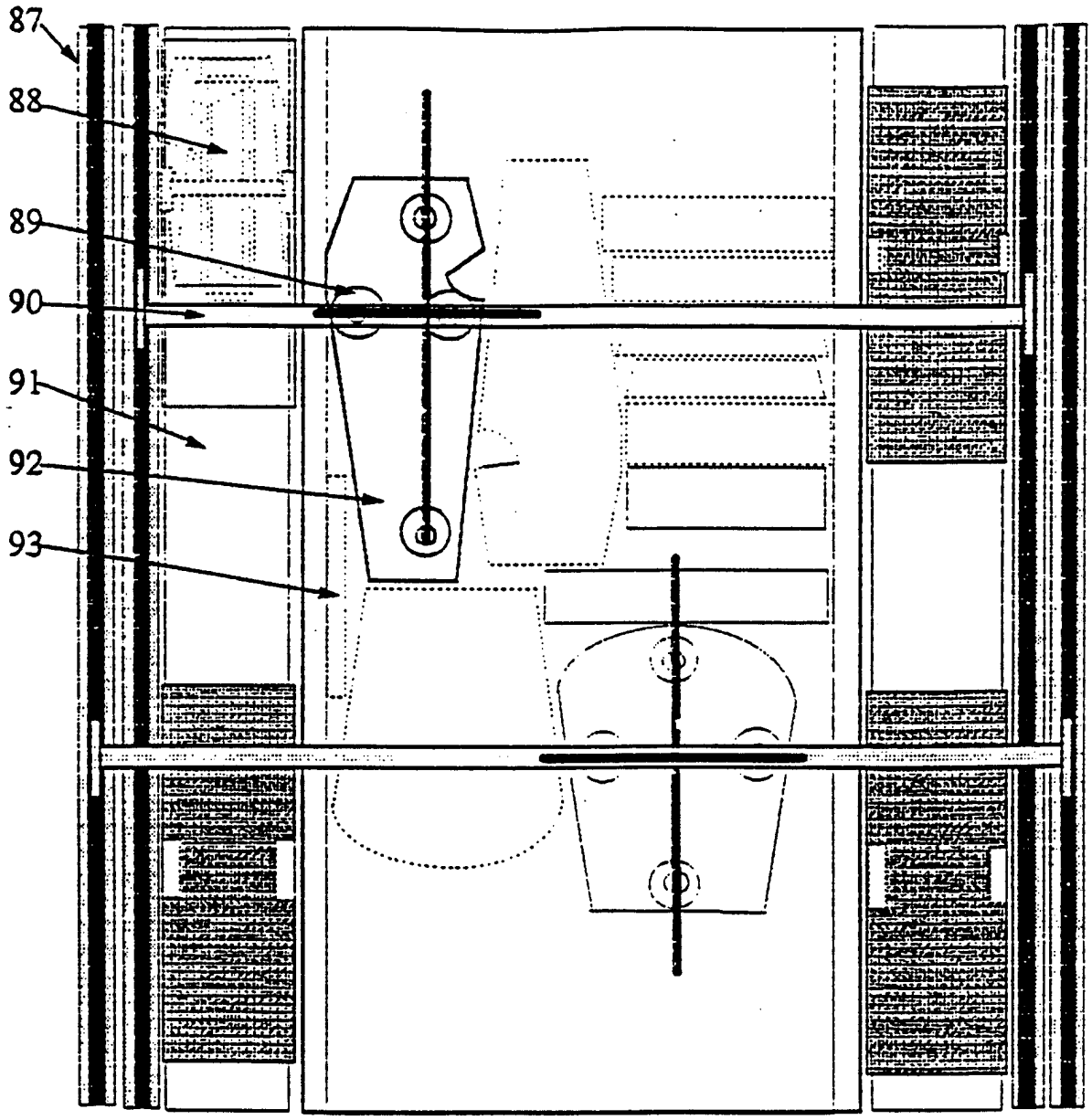

Fig. 12

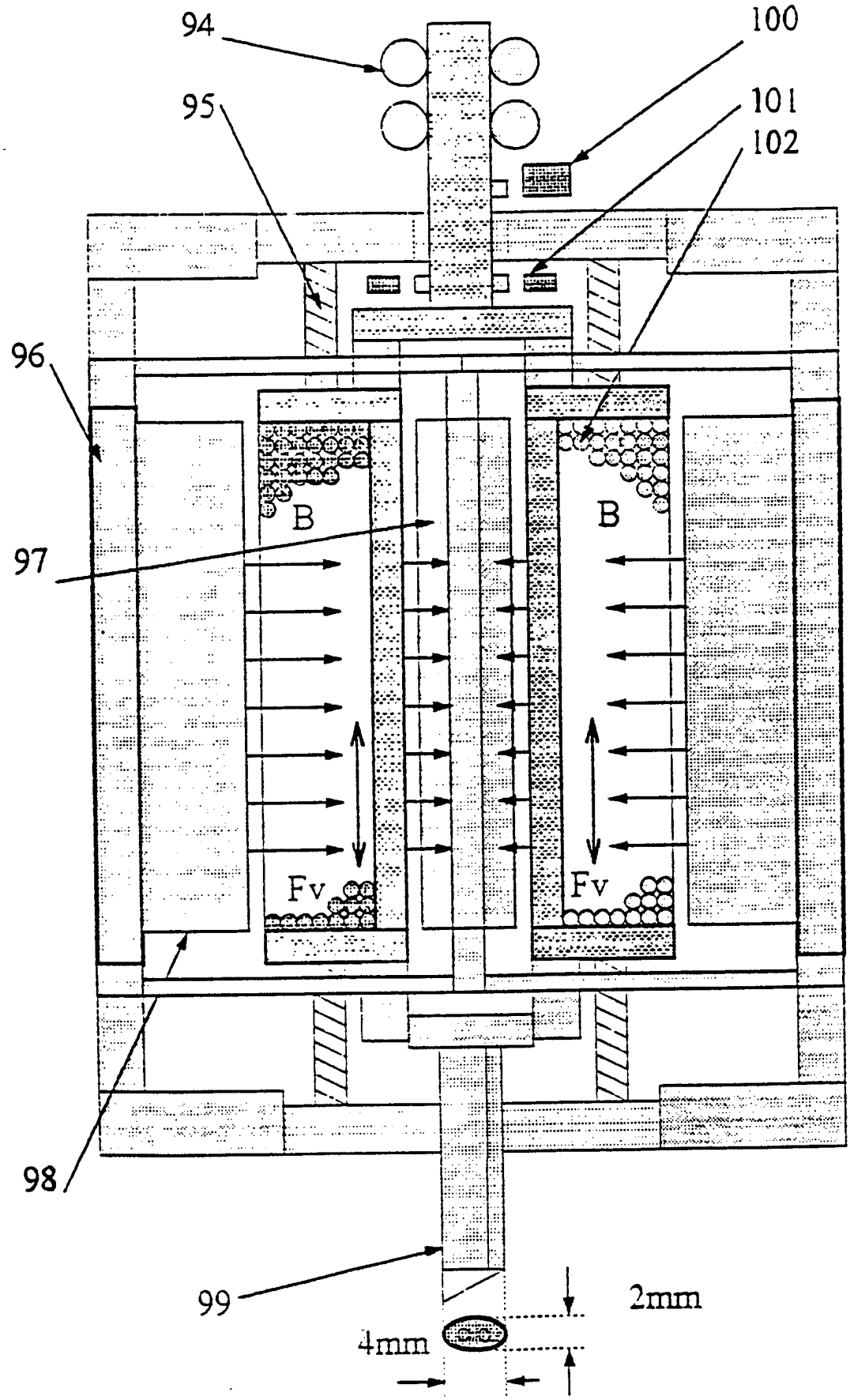

Fig. 13

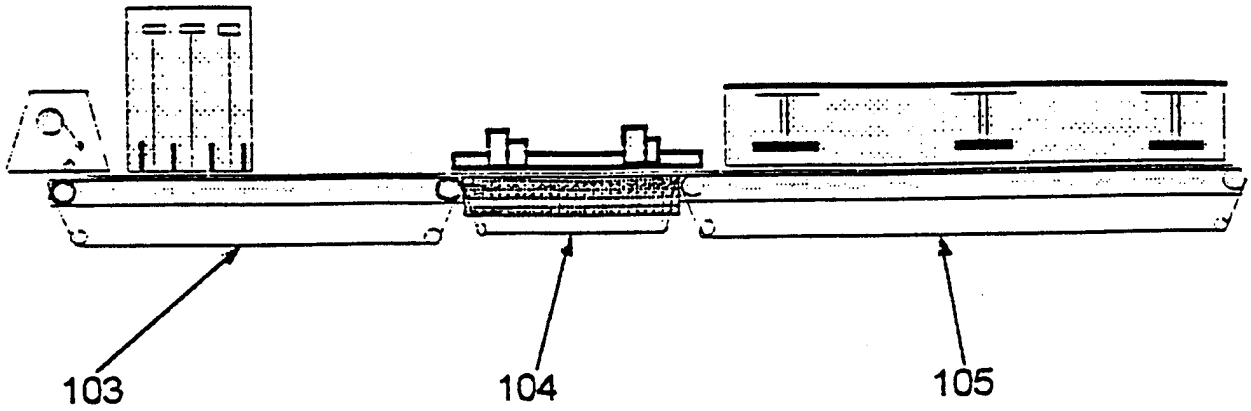

Fig. 14

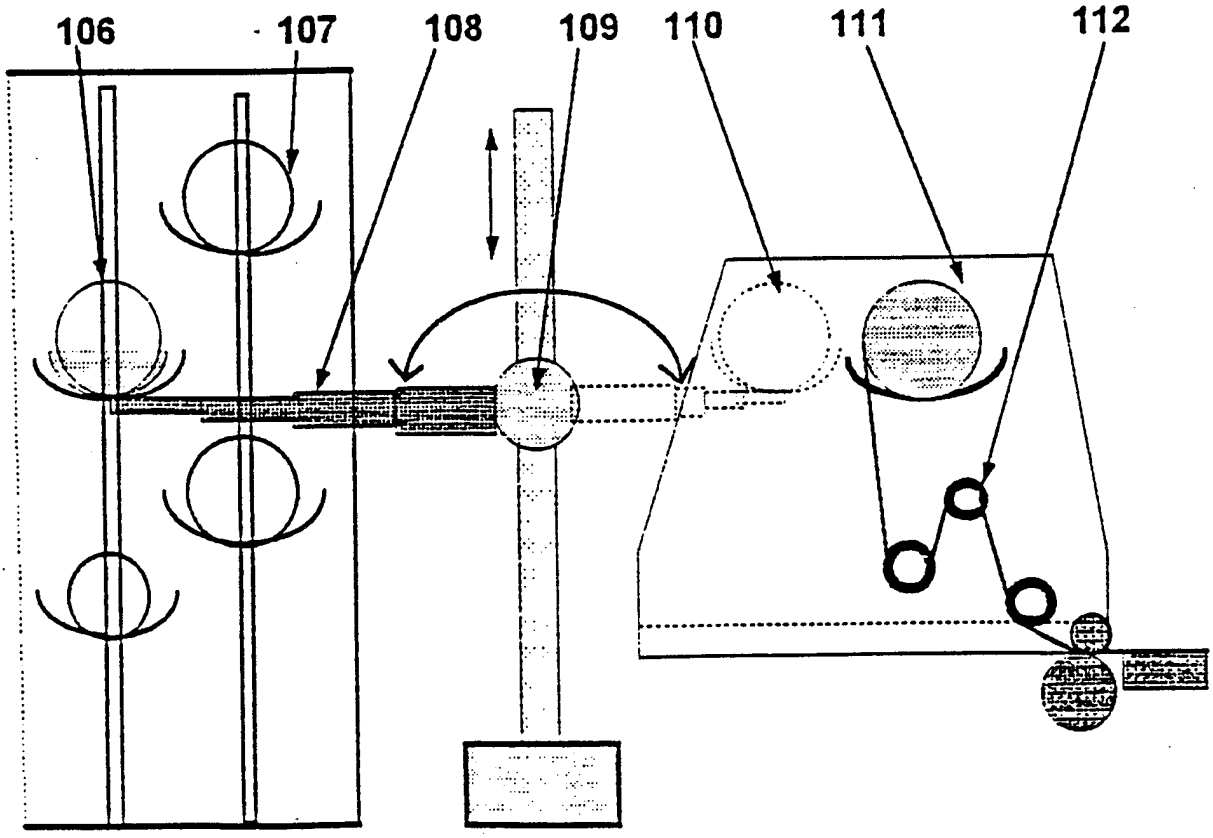

Fig. 15

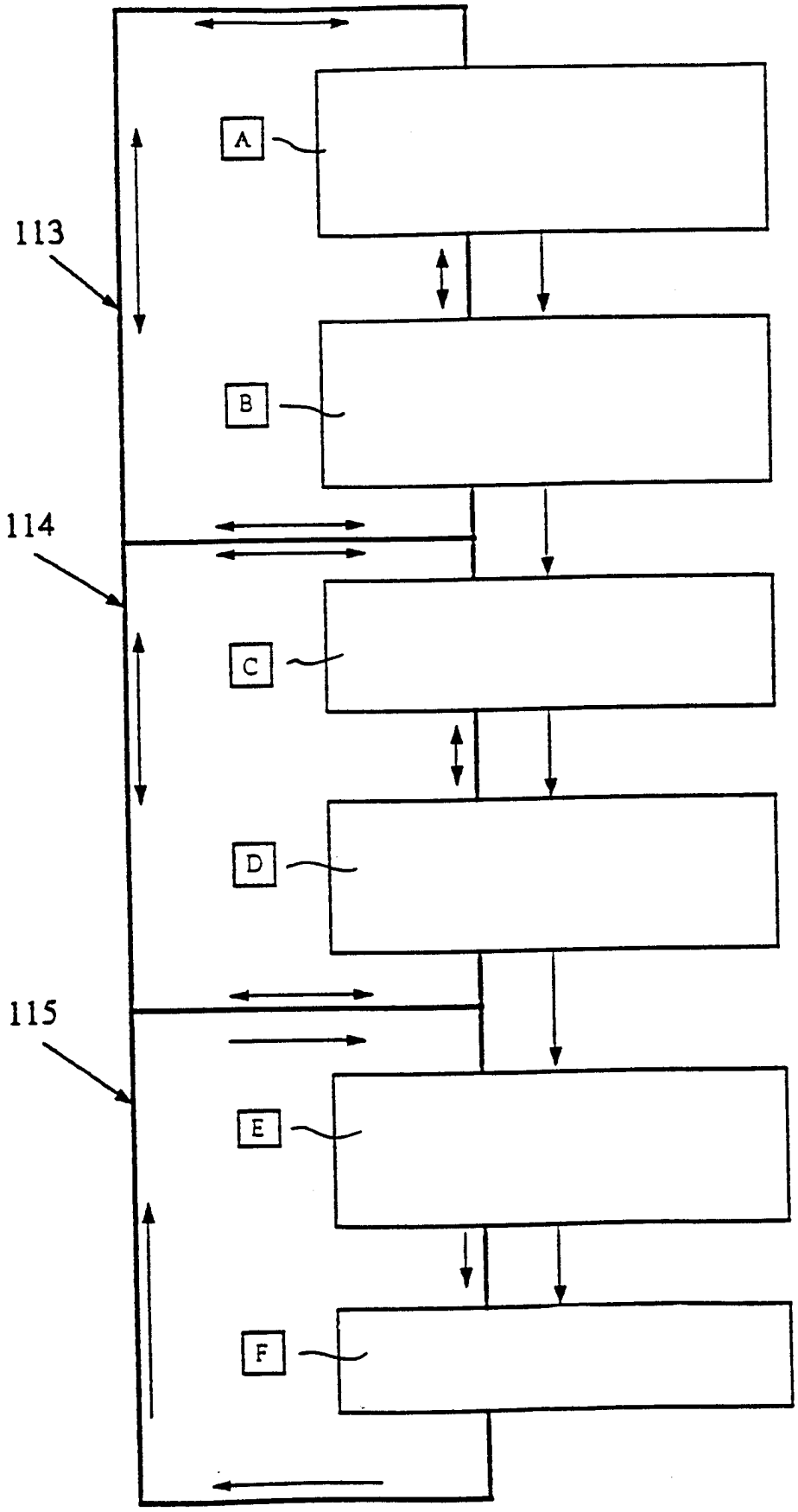

Fig. 16

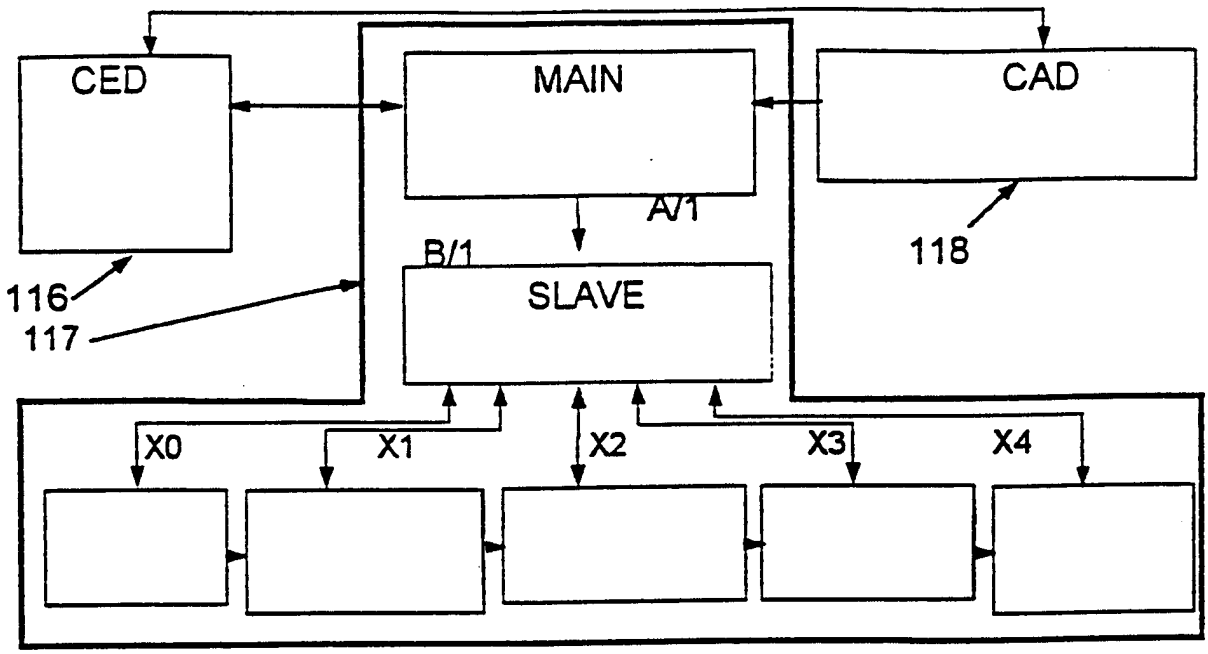

FIG. 17

INTERNATIONAL SEARCH REPORT

Inte. onal Application No
PCT/EP 98/00534

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B26F1/38 B26D5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B26F B26D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 419 820 A (STUMPF GUENTER O) 13 December 1983 see column 2, line 48 - line 60; figure 1	1-4
Y	US 5 258 917 A (BRUDER WOLFGANG ET AL) 2 November 1993 see column 1, line 54 - column 2, line 23 see column 2, line 42 - line 44 see column 3, line 49 - column 4, line 5 see column 7, line 24 - line 31	1-4
Y	US 5 172 326 A (HOLSHOUSER THOMAS E ET AL) 15 December 1992 see column 5, line 45 - line 62	1-4
A	EP 0 387 371 A (MERZ WOLF DIETER) 19 September 1990 see claim 1	1

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

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Date of the actual completion of the international search	Date of mailing of the international search report
18 May 1998	04/06/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Huggins, J

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INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/EP 98/00534

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	VERNAY: "DECOUPE DE COSTUMES: LASER ET TEMPS REEL" MESURES REGULATION AUTOMATISME, vol. 52, no. 14, 23 November 1987, page 37, 39/40, 42 XP002046913	4

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte: ɔnal Application No
PCT/EP 98/00534

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4419820 A	13-12-83	NONE	
US 5258917 A	02-11-93	DE 4012462 A	24-10-91
		ES 2037582 B	16-01-94
		FR 2661193 A	25-10-91
		IT 1245714 B	14-10-94
		JP 4225100 A	14-08-92
US 5172326 A	15-12-92	NONE	
EP 0387371 A	19-09-90	DE 58908110 D	01-09-94