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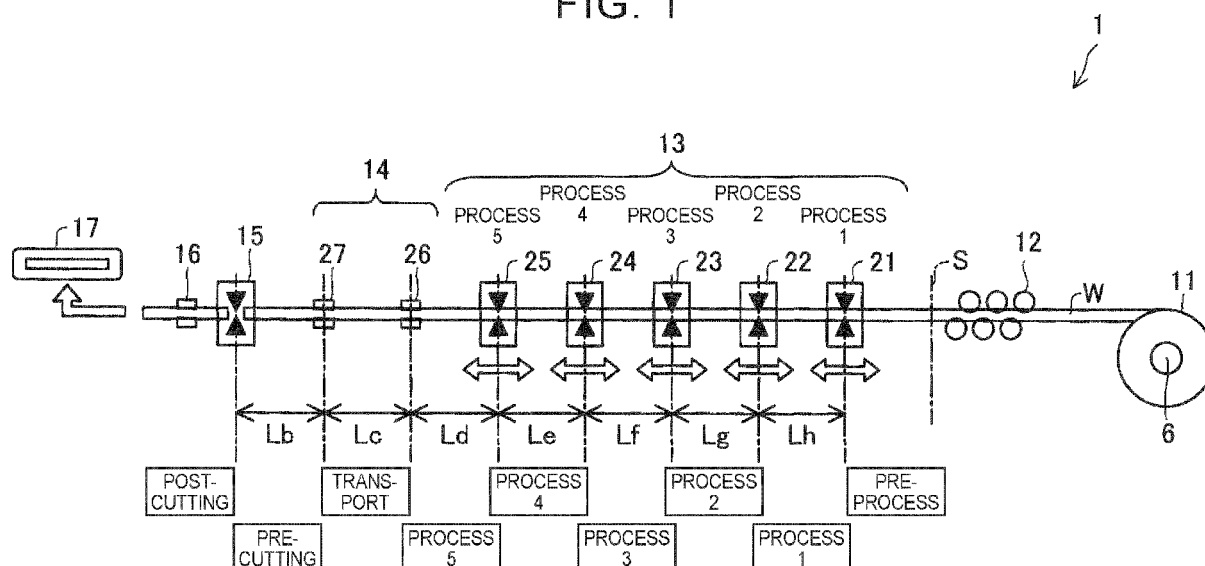
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(54) **LINEAR MATERIAL MANUFACTURING APPARATUS**

(57) A linear material manufacturing apparatus (1; 2; 3; 4) includes an unwinding device (11), a processing device (21, 22, 23, 24, 25) configured to move between positions along a transport direction in each of transport cycles, a transport device (26, 27) configured to move between positions along the transport direction in each

of the transport cycles, a cutting device (15) fixed at a predetermined position, and a control device (30) configured to control positions of a plurality of the processing devices (21, 22, 23, 24, 25) and the transport device (26, 27) in each of the transport cycles.

FIG. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present disclosure relates to a linear material manufacturing apparatus.

2. Description of Related Art

[0002] There is known a winding (enameled wire) having an insulation coating formed on the surface of a conductor made of a metal wire. Windings are widely used as coils for various electric devices. Examples of the electric devices using coils include a reactor and an on-board motor.

[0003] For example, in a coil manufacturing apparatus described in Japanese Unexamined Patent Application Publication No. 2016-46863 (JP 2016-46863 A), a winding is bent into a predetermined coil shape while being fed, wound into a spiral shape, and cut at the terminal end of a coil, thereby manufacturing the coil. A high-efficiency motor includes segment coils. The segment coil is made of one coil material (also referred to as "linear material") before bending. When manufacturing the coil material, for example, a part of an insulation-coated rectangular wire is subjected to a coating stripping process multiple times while being fed by a feeding device. At a place to which the insulation-coated rectangular wire is fed, the insulation-coated rectangular wire is cut to a necessary length. Various coil materials having different lengths are needed for one product.

SUMMARY OF THE INVENTION

[0004] In the manufacturing apparatus described above, however, a plurality of processing devices for processing the winding is generally fixed. To manufacture a plurality of types of linear materials having different lengths in this case, it is necessary to first manufacture a plurality of first type linear materials, then change the positions of the processing devices and the cutting position, and then manufacture second type linear materials having different lengths from those of the first type linear materials. Therefore, the manufacturing process is complicated when manufacturing the linear materials having different lengths. Equipment needs to be temporarily stopped when switching the linear material to be manufactured. Therefore, the linear materials having different lengths cannot be manufactured with high productivity in accordance with planned sequence.

[0005] The present disclosure can be realized in the following aspects.

(1) According to one aspect of the present disclosure, a linear material manufacturing apparatus is provided. The linear material manufacturing apparatus is configured to manufacture a plurality of types of linear materials having different lengths in accordance with planned sequence by feeding a wound wire in a transport direction in each of transport cycles, processing the wire, and cutting the wire at a place to which the wire is transported. The linear material manufacturing apparatus includes: an unwinding device configured to feed the wire in the transport direction; a processing device configured to process the wire, and move between positions along the transport direction in each of the transport cycles; a transport device configured to transport the wire in the transport direction in each of the transport cycles, provided on a downstream side of the processing device in the transport direction, and configured to move between positions along the transport direction in each of the transport cycles; a cutting device fixed at a predetermined position, and configured to cut the wire processed by a plurality of the processing devices; and a control device configured to calculate, in each of the transport cycles, positions of the processing devices and the transport device in each of the transport cycles by using pieces of information on the lengths of the linear materials, and control the positions of the processing devices and the transport device in each of the transport cycles. According to the linear material manufacturing apparatus of this aspect, the control device calculates, in each of the transport cycles, the positions of the processing devices and the transport device in each of the transport cycles by using the pieces of information on the lengths of the linear materials, and controls the positions in each of the transport cycles. Therefore, the linear materials having different lengths can continuously be produced in accordance with the planned sequence by sequentially feeding the wound wire in the transport direction by the unwinding device and cutting the processed wire by the cutting device. That is, the productivity can be improved.

(2) In the above aspect, the control device may be configured to, when calculating a position of a calculation target device that is any one of the processing devices and the transport device whose position is to be calculated in each of the transport cycles, calculate the position of the calculation target device by summing the lengths of the linear materials interposed between the cutting device and the calculation target device. According to the linear material manufacturing apparatus of this aspect, the position of the calculation target device can easily be calculated by

summing pieces of wire type information of the linear materials interposed between the cutting device and the calculation target device.

(3) In the above aspect, the control device may be configured to, in a plurality of data storage boxes provided in association with a plurality of steps including a pre-process step that precedes a process to be performed by the processing device and is expected to proceed to the processing device, a process step to be performed by the processing device, and a transport step to be performed by the transport device, store pieces of wire length related information related to the lengths of the linear materials serving as processing targets in the respective steps. The control device may be configured to calculate the position of the calculation target device by using the stored wire length related information. The control device may be configured to, every time the transport cycle is finished, execute a transfer process for transferring the pieces of wire length related information stored in the data storage boxes set for the transport cycle to the data storage boxes set for the next transport cycle. The control device may be configured to, when executing the transfer process, transfer the pieces of wire length related information stored in the data storage boxes associated with the respective steps in the transport cycle to the data storage boxes associated with steps subsequent to the respective steps in the next transport cycle. The control device may be configured to, in the next transport cycle, calculate the position of the calculation target device in the next transport cycle by using the wire length related information transferred to the data storage box. According to the linear material manufacturing apparatus of this aspect, the control device stores the pieces of wire length related information related to the lengths of the linear materials serving as the processing targets in the respective steps in the data storage boxes provided in association with the respective steps. Through the transfer process executed every time the transport cycle is finished, the pieces of wire length related information stored in the data storage boxes associated with the respective steps in the transport cycle are transferred to the data storage boxes associated with steps subsequent to the respective steps in the next transport cycle. By using the transferred wire length related information in the next transport cycle, the position of the calculation target device can be calculated easily.

(4) In the above aspect, the linear material manufacturing apparatus may include a plurality of the processing devices. The processing devices may be configured to perform a plurality of the process steps on the wire. According to the linear material manufacturing apparatus of this aspect, it is possible to perform the plurality of process steps on the wire by the plurality of processing devices. Therefore, the linear material manufacturing apparatus can manufacture linear materials that need a plurality of processes before cutting.

(5) In the above aspect, the wire may include a mark indicating a defective portion. The linear material manufacturing apparatus may further include a detection unit configured to detect the defective portion between the unwinding device and a first processing device that is the processing device closest to the unwinding device. The control device may be configured to, when the detection unit detects a leading end of the mark in the transport direction, calculate a distance from the first processing device to the leading end in each of the transport cycles. The control device may be configured to, when the calculated distance is smaller than the length of the linear material in the pre-process step by comparing the distance with the wire length related information stored in the data storage box associated with the pre-process step, interpose discard wire type information indicating a wire type to be discarded as the wire length related information in the data storage box associated with the pre-process step. According to the linear material manufacturing apparatus of this aspect, the detection unit detects the mark indicating the defective portion of the wire. The control device calculates the distance from the first processing device to the leading end of the mark, and compares the distance with the wire type information stored in the data storage box associated with the pre-process step. When the distance is smaller than the length indicated by the wire type information in the pre-process step, the discard wire type information is interposed. By performing the process based on the detection of the leading end of the mark, it is possible to interpose the discard wire type information during the production in accordance with the planned sequence.

(6) In the above aspect, the control device may be configured to, when the detection unit detects a terminal end of the mark in the transport direction and the terminal end is transported downstream in the transport direction with respect to the first processing device, store the wire length related information in accordance with the planned sequence in the data storage box associated with the pre-process step to cause the linear material to be subsequently processed by the first processing device in accordance with the planned sequence. According to the linear material manufacturing apparatus of this aspect, it is possible to return to the wire type information in accordance with the planned sequence by performing the process based on the detection of the terminal end of the mark. By performing the processes based on the detection of the mark leading end and the mark terminal end, it is possible to minimize the amount of a non-defective portion in the discarded winding without stopping the equipment. The discarded portion can be minimized.

(7) In the above aspect, the wire may be an insulation-coated copper wire having a rectangular cross section and serving as a material for a segment coil. The processing device may be a stripping device configured to strip an insulation coating. According to the linear material manufacturing apparatus of this aspect, the linear materials can efficiently be manufactured in accordance with the planned sequence by stripping the insulation coating and cutting

the insulation-coated copper wire having the rectangular cross section and serving as the material for the segment coil.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:

FIG. 1 is a schematic diagram showing an overall schematic configuration of a linear material manufacturing apparatus according to a first embodiment of the present disclosure;

FIG. 2 is a control block diagram showing a system configuration of the linear material manufacturing apparatus;

FIG. 3 is a flowchart showing a processing procedure of a linear material manufacturing method to be executed by a control device;

FIG. 4 is a table showing a storage form of wire type information to be read for each step in each transport cycle;

FIG. 5 is a schematic diagram showing an overall schematic configuration of a linear material manufacturing apparatus according to a second embodiment of the present disclosure;

FIG. 6 is a schematic diagram showing the overall schematic configuration of the linear material manufacturing apparatus according to the second embodiment of the present disclosure;

FIG. 7 is a flowchart showing a processing procedure of mark leading end detection to be executed by a control device;

FIG. 8 is a table showing a storage form of wire type information to be read for each step in each transport cycle;

FIG. 9 is a flowchart showing a processing procedure of mark terminal end detection to be executed by the control device;

FIG. 10 is a table showing a storage form of wire type information to be read for each step in each transport cycle;

FIG. 11 is a schematic diagram showing an overall schematic configuration of a linear material manufacturing apparatus according to a third embodiment of the present disclosure;

FIG. 12 is a flowchart showing a processing procedure of a linear material manufacturing method to be executed by a control device;

FIG. 13 is a table showing a storage form of wire type information to be read for each step in each transport cycle;

FIG. 14 is a schematic diagram showing an overall schematic configuration of a linear material manufacturing apparatus according to a fourth embodiment of the present disclosure;

FIG. 15 is a table showing a storage form of wire type information to be read for each step in each transport cycle; and

FIG. 16 is a table showing a storage form of wire type information to be read for each step in each transport cycle.

DETAILED DESCRIPTION OF EMBODIMENTS

A. First Embodiment:

A1. Overall Configuration of Linear Material Manufacturing Apparatus 1:

[0007] FIG. 1 is a schematic diagram showing an overall schematic configuration of a linear material manufacturing apparatus 1 according to an embodiment of the present disclosure. As shown in FIG. 1, the linear material manufacturing apparatus 1 includes an unwinding device 11, a straightening device 12, a processing unit 13, a transport unit 14, a cutting device 15, a loading device 16, a stocker 17, and a control device 30 (see FIG. 2).

[0008] The linear material manufacturing apparatus 1 of the first embodiment feeds a rectangular copper wire W wound around a drum 6 (hereinafter also simply referred to as "rectangular wire W") by predetermined amounts, performs a plurality of stripping processes, and cuts the wire into predetermined lengths, thereby manufacturing a plurality of types of linear materials having different lengths as materials for segment coils. The rectangular wire W is an insulation-coated copper wire having a rectangular cross section and corresponds to a "wire". Segment coils are used, for example, in high-efficiency motors serving as drive motors of vehicles. Coils for high-efficiency motors are produced by assembling segment coils in accordance with planned sequence.

[0009] The rectangular copper wire W serving as a material for a segment coil is manufactured by stretching and softening a fed wire rod into a conductor, and then forming an insulation coating on the surface of the conductor. The rectangular copper wire W is disposed in the unwinding device 11 while being wound around the drum 6. The rectangular copper wire W wound around the drum 6 is hereinafter simply referred to as "winding".

[0010] The unwinding device 11 feeds the winding in a transport direction from the drum 6 around which the winding is wound. The straightening device 12 corrects a curl of the winding. The processing unit 13 is a device that strips the insulation coating of the winding, and includes a first processing device 21, a second processing device 22, a third processing device 23, a fourth processing device 24, and a fifth processing device 25.

[0011] Examples of the processing devices 21 to 25 include a stripping device unit including a punch, a die, and a servomotor serving as a drive device (not shown). A cutting edge is provided at the tip of the punch, and a receiving edge is provided at the die. For example, an eccentric cam is driven to rotate by the drive of the servomotor, and the punch can perform movement relative to the die, such as vertical movement, along with the rotational motion of the eccentric cam. The punch is driven toward the rectangular wire W whose posture is maintained, and the cutting edge stamps a predetermined portion of the rectangular wire W, thereby stripping the insulation coating of the predetermined portion. Necessary stripping processes (process 1 to process 5) are sequentially performed by the processing devices 21 to 25.

[0012] In the present embodiment, the rear end of an arbitrary (n-1)th linear material and the front end of an n-th linear material are processed by one stripping device unit. After the process 1 to the process 5 on the rectangular wire W, the center of the processed portion is cut by the cutting device 15 to obtain a linear material.

[0013] The processes 1 to 5 by the processing devices 21 to 25 specifically correspond to, for example, stripping of the upper and lower surfaces and the right and left surfaces of the predetermined portion of the rectangular wire W, and chamfering of the corners of the stripped portion. In the present embodiment, the five processing devices 21 to 25 are provided, but the number of installed processing devices is not limited to five and is set as appropriate depending on products because the required steps and the number of steps vary depending on products.

[0014] The transport unit 14 is a device that sequentially transports the rectangular wire W to the next processing device. The transport unit 14 includes a first transport device 26 and a second transport device 27. Each of the transport devices 26 and 27 includes a chuck mechanism capable of chucking the rectangular wire W, and can perform an operation of transporting the rectangular wire W chucked by the chuck mechanism in the transport direction and a return operation for returning to the chucking position. The transport devices 26 and 27 alternately perform the operations of chucking and transporting the rectangular wire W. That is, when the rectangular wire W is chucked and sent in the transport direction by the chuck mechanism of one transport device, the chuck mechanism of the other transport device to which the rectangular wire W is transported is open. The front and rear of the transport devices 26 and 27 are switched in turn to alternately transport the rectangular wire W.

[0015] The processing devices 21 to 25 and the transport devices 26 and 27 are self-advancing devices, and can move, in each transport cycle of the rectangular wire W, to positions along a transport line in the transport direction in which the rectangular wire W extends. Examples of a drive mechanism for self-advancing each device include a rack-and-pinion mechanism to be driven by a servomotor and a linear actuator mechanism including an electromagnet. The control device 30 calculates positions of the processing devices 21 to 25 and the transport devices 26 and 27 in each transport cycle and control movement to the calculated positions. Details of the calculation of the calculated positions and the control on the devices to the calculated positions will be described later in a linear material manufacturing method below.

[0016] The cutting device 15 cuts the rectangular wire W processed by the processing devices 21 to 25 into predetermined product lengths. The cutting device 15 is, for example, a cutter, and cuts off the rectangular wire W from the winding. Unlike the processing devices 21 to 25 and the transport devices 26 and 27, the cutting device 15 is fixed at a predetermined position. The loading device 16 loads the rectangular wires W cut by the cutting device 15 into the stocker 17. The stocker 17 temporarily stores the cut rectangular wires W before transferring them to the next bending step. The stocker 17 includes a plurality of stages associated with bending stations (not shown) to be transported after the stripping and cutting. The rectangular wires W cut by the cutting device 15 are sorted and loaded on the stages of the stocker 17 by the loading device 16 as appropriate.

A2. System Configuration of Linear Material Manufacturing Apparatus 1:

[0017] FIG. 2 is a control block diagram showing a system configuration of the linear material manufacturing apparatus 1. As shown in FIG. 2, the control device 30 of the linear material manufacturing apparatus 1 is connected to communicate with a processing mechanism unit 40 including various processing mechanisms described above (unwinding device 11, straightening device 12, processing devices 21 to 25, transport devices 26 and 27, cutting device 15, loading device 16, and stocker 17). The control device 30 includes a central processing unit (CPU) 31 and a storage unit 32. The control device 30 is a microcomputer including a read only memory (ROM), a random access memory (RAM), and input/output ports (not shown), and controls the entire linear material manufacturing apparatus 1. The control device 30 is connected to a production management system 50. For example, the control device 30 receives, as an instruction from the production management system 50, the order of models of vehicles to be produced and to be equipped with motors using linear materials.

[0018] The CPU 31 functions as an operation control unit 33, a wire type information transmission/reception unit 34, a position calculation unit 35, and a processing unit 36 by loading various programs stored in the storage unit 32. The operation control unit 33 controls movement and operation of the processing mechanism unit 40. The wire type information transmission/reception unit 34 transmits and receives wire type information. The "wire type information" is an example

of "wire length related information" related to the length of a linear material to be processed, and includes information on the length of the linear material. The position calculation unit 35 calculates positions of the processing devices 21 to 25 and the transport devices 26 and 27 in each transport cycle. For example, the processing unit 36 executes, as described later, various arithmetic processes and various determination processes associated with results of the arithmetic processes.

A3. Linear Material Manufacturing Method by Linear Material Manufacturing Apparatus 1:

[0019] FIG. 3 is a flowchart showing a processing procedure of the linear material manufacturing method to be executed by the control device 30 of the linear material manufacturing apparatus 1 detailed above. As shown in FIG. 3, the linear material manufacturing method includes a wire type information reading step (S10), a position calculating step (S20), a product workpiece loading step (S30), a stripping step (S40), a cutting step (S50), and a wire type information transferring step (S60). The flow in the flowchart shown in FIG. 3 is executed in each transport cycle. In the example of the present embodiment, eight product workpieces A, B, C, D, E, F, G, and H having different lengths are manufactured in the order of the product workpieces A to H in accordance with planned sequence. The product workpieces A to H are linear materials serving as materials for segment coils constituting motors for vehicles of any models.

[0020] In the wire type information reading step (S10), pieces of wire type information of products to be handled by the processing devices 21 to 25 and the transport devices 26 and 27 are read from data storage boxes Db (hereinafter simply referred to as "storage boxes Db") by the wire type information transmission/reception unit 34. FIG. 4 is a table T1 showing a storage form of the wire type information to be read for each step in each transport cycle. The wire type information is read and assigned in the data storage box Db associated with each step in each transport cycle. As shown in FIG. 4, the storage box Db associated with each step stores the wire type information of any one of the products to be manufactured in accordance with the planned sequence.

[0021] The storage boxes Db are provided in association with steps of "pre-process", "process 1", "process 2", "process 3", "process 4", "process 5", "transport", "pre-cutting", and "post-cutting". These steps are sequentially executed in the transport direction. The "pre-process" step is a step preceding the process by the first processing device 21 and expected to proceed to the processing device 21. The storage box Db of "pre-process" is associated with an area from an imaginary boundary line S (see FIG. 1) between the unwinding device 11 and the first processing device 21 to the first processing device 21, and stores data for preparing in advance wire type information to be subsequently transferred to the first processing device 21.

[0022] The storage box Db of "process 1" stores wire type information of a product to be processed by the first processing device 21 in the corresponding cycle. The storage box Db of "process 2" stores wire type information of a product to be processed by the second processing device 22 in the corresponding cycle. The storage box Db of "process 3" stores wire type information of a product to be processed by the third processing device 23 in the corresponding cycle. The storage box Db of "process 4" stores wire type information of a product to be processed by the fourth processing device 24 in the corresponding cycle. The storage box Db of "process 5" stores wire type information of a product to be processed by the fifth processing device 25 in the corresponding cycle.

[0023] The storage box Db of "transport" stores wire type information of a product to be transported in a transport step by the transport unit 14 in the corresponding cycle. A "pre-cutting" step is a step in which a linear material is positioned to be cut in the next transport cycle. The storage box Db of "pre-cutting" is associated with an area from the transport unit 14 to the cutting device 15, and stores data to be subsequently transferred to the cutting device 15. The "post-cutting" step is a step of transferring a cut linear material to the stocker 17. The storage box Db of "post-cutting" is associated with an area from the cutting device 15 to the stocker 17 in the corresponding cycle, and stores information on a product cut off from the winding. The information in the storage box Db of "post-cutting" is wire type information of a product workpiece (any of A to G) subjected to stripping and cutting by the linear material manufacturing apparatus 1.

[0024] In the position calculating step (S20), the positions of the processing devices 21 to 25 and the transport devices 26 and 27 are calculated by the position calculation unit 35. Specifically, the positions of the processing devices 21 to 25 and the transport devices 26 and 27 during a cycle n are calculated by summing pieces of wire type information of linear materials interposed up to a calculation target device with respect to the position of the fixed cutting device 15. Although the linear materials are not separated apart before cutting, the linear materials can be regarded as being connected together. It can be said that the connected linear materials are interposed between the cutting device 15 and the calculation target device.

[0025] The wire type information of the product workpiece A is represented by La. The wire type information of the product workpiece B is represented by Lb. The wire type information of the product workpiece C is represented by Lc. The wire type information of the product workpiece D is represented by Ld. The wire type information of the product workpiece E is represented by Le. The wire type information of the product workpiece F is represented by Lf. The wire type information of the product workpiece G is represented by Lg. The wire type information of the product workpiece H is represented by Lh. The "wire type information of product workpiece" is hereinafter also simply referred to as "wire

type length". The processing devices 21 to 25 and the transport devices 26 and 27 corresponds to the "calculation target devices". Specifically, the positions of the processing devices 21 to 25 and the transport devices 26 and 27 during the cycle n are calculated by using the following expressions.

- 5 Position of second transport device 27: $L7 = Lb$
 Position of first transport device 26: $L6 = Lb + Lc$
 Position of fifth processing device 25: $L5 = Lb + Lc + Ld$
 Position of fourth processing device 24: $L4 = Lb + Lc + Ld + Le$
 Position of third processing device 23: $L3 = Lb + Lc + Ld + Le + Lf$
 10 Position of second processing device 22: $L2 = Lb + Lc + Ld + Le + Lf + Lg$
 Position of first processing device 21: $L1 = Lb + Lc + Ld + Le + Lf + Lg + Lh$

15 **[0026]** In the product workpiece loading step (S30), the cut workpieces A to H are loaded into the stocker 17 by the loading device 16. The position calculating step (S20) and the product workpiece loading step (S30) are executed in parallel substantially simultaneously.

[0027] In the stripping step (S40), predetermined processes are executed by the processing devices 21 to 25 moved to the positions calculated in S20. In the cutting step (S50), the cutting device 15 cuts the rectangular wire W off from the winding. The stripping step (S40) and the cutting step (S50) are executed in parallel substantially simultaneously. In the wire type information transferring step (S60), the wire type information transmission/reception unit 34 transfers
 20 the pieces of wire type information of the target products in the current transport cycle to the next steps. In the table T1 of FIG. 4, each oblique arrow represents the transfer of the wire type information to the next step. The wire type information transferring step (S60) corresponds to a transfer process. With the above, the processing routine is terminated.

[0028] Through the above processes, as shown in FIG. 4, the product workpiece A is completed in the cycle n, the product workpiece B is completed in a cycle n+1, and the product workpiece C is completed in a cycle n+2. Similarly,
 25 the products are manufactured in order of the product workpieces D, E, F, G, ... in accordance with the planned sequence in the individual transport cycles.

Effects

30 **[0029]** According to the linear material manufacturing apparatus 1 and the linear material manufacturing method of the first embodiment, the positions of the processing devices 21 to 25 and the transport devices 26 and 27 are calculated in the position calculating step (S20) based on the pieces of wire type information read in the wire type information reading step (S10). Then, the processes by the processing unit 13 and the transport by the transport unit 14 are executed at the positions associated with the cycle (for example, the cycle n). Each time the processes and the transport are
 35 completed, the pieces of wire type information are transferred to the next steps in S60. In the next transport cycle (for example, the cycle n+1), the pieces of wire type information are read (S 10) and the positions of the processing devices 21 to 25 and the transport devices 26 and 27 are calculated again.

[0030] By repeating the above processes, the product workpieces A to H having different lengths can be produced continuously in accordance with the planned sequence. The various product workpieces manufactured by the linear
 40 material manufacturing apparatus 1 are then bent and welded in a state in which the product workpieces are arranged in order. For example, when manufacturing a plurality of product workpieces A and then manufacturing a plurality of product workpieces B, it has been necessary to rearrange the products to send them to the subsequent steps as described above. In this respect, according to the first embodiment, the product workpieces A to H having different lengths are manufactured in accordance with the planned sequence. Therefore, the rearrangement work is unnecessary and the
 45 efficiency is secured.

B. Second Embodiment:

B 1. Overall Configuration:

50 **[0031]** Next, a second embodiment of the present disclosure will be described with reference to FIGS. 5 to 10. In the second embodiment and each of the following embodiments, the overall configuration of a linear material manufacturing apparatus 2 and the schematic configuration of a control device 30 (FIG. 2) are substantially the same as those in the first embodiment. Therefore, substantially the same parts are denoted by the same reference signs, and description thereof is omitted. FIGS. 5 and 6 are schematic diagrams showing the overall schematic configuration of the linear
 55 material manufacturing apparatus 2 according to the second embodiment of the present disclosure. The linear material manufacturing apparatus 2 of the second embodiment differs from the linear material manufacturing apparatus 1 of the first embodiment in that a mark detection sensor 28 for detecting a defect mark 41 is further provided.

[0032] The winding (rectangular wire W) used in the second embodiment has the defect mark 41 indicating a defective portion. The defect mark 41 is attached in advance to the defective portion of the winding. Examples of the defective portion include a pinhole and swelling or peeling of a coating. The defect mark 41 is colored, in a marking step, over several millimeters around the defective portion of the winding that is detected in a defect inspection step.

[0033] Examples of the method for inspecting a defective portion of the insulation coating in the case of swelling or peeling include a method of detecting the defective portion by capturing an image of the surface of the winding with a charge-coupled device (CCD) camera or the like and processing the captured image with an image processing device, and a method of detecting the defective portion by measuring the thickness of the insulation coating on the surface of the winding with a laser displacement meter. The pinhole can be detected, for example, by measuring insulation resistance with a withstand voltage tester

[0034] (spark tester). In the marking step, for example, an inkjet printer is used to mark the defective portion in black.

[0035] The mark detection sensor 28 is provided between the unwinding device 11 and the straightening device 12. The mark detection sensor 28 is a color sensor in the present embodiment, and reads the defect mark 41 attached in advance to the winding. The mark detection sensor 28 corresponds to a "detection unit".

[0036] FIG. 5 shows a state when a leading end 42 of the defect mark 41 is detected. FIG. 6 shows a state when a terminal end 43 of the defect mark 41 is detected. As the time "when detected", FIGS. 5 and 6 show a state when the defect mark 41 is detected during transport of the winding and the transport cycle in which the mark 41 is detected is terminated and stopped, instead of the moment when the mark detection sensor 28 described later detects the defect mark 41 during transport of the winding.

[0037] In the second embodiment, the mark detection sensor 28 detects the leading end 42 and the terminal end 43 of the defect mark 41 while the same control as in the first embodiment (flowchart shown in FIG. 3) is executed. Since the portion with the defect mark 41 cannot be included in the product, information indicating a discard wire type is assigned to the corresponding portion of the winding including the defect mark 41 in the second embodiment. Portions that follow the corresponding portion of the winding including the defect mark 41 and can be manufactured into products are continuously manufactured by restoring the wire type information in accordance with the planned sequence. That is, the processes are skipped for the portion of the winding with the defect mark 41, and a minimum necessary portion of the winding is discarded. Details will be described below with reference to a flowchart as well.

B2. Detection of Mark Leading End 42:

[0038] FIG. 7 is a flowchart showing a processing procedure of the mark leading end detection to be executed by the control device 30 of the linear material manufacturing apparatus 2 of the second embodiment. The mark leading end detection is executed simultaneously with the start of transport. As shown in FIG. 7, the processing unit 36 determines in S 101 whether the leading end 42 of the defect mark 41 is detected by the mark detection sensor 28. When the leading end 42 of the defect mark 41 is not detected (S101: NO), the process returns and this control routine is repeated.

[0039] When the leading end 42 of the defect mark 41 is detected (S101: YES), the process proceeds to S102, and the processing unit 36 calculates a distance L from the first processing device 21 (process 1) to the leading end 42 of the mark 41. In S103, the processing unit 36 determines whether the calculated distance L is smaller than the length of a product workpiece in the pre-process step. When the distance L is equal to or smaller than the length of the product workpiece in the pre-process step (S103: YES), the processing proceeds to S104, and a discard wire type Z is interposed in the storage box Db of the pre-process. When the distance L is larger than the length of the product workpiece in the pre-process step in S103 (S103: NO), the process returns to S102, and the process of calculating the distance L is repeated.

[0040] FIG. 8 is a table T21 showing a storage form of the wire type information to be read for each step in each transport cycle, including a cycle in which the mark leading end 42 is detected. In this example, eight types of product workpieces A to H are manufactured in accordance with the planned sequence, the mark leading end 42 is detected in the cycle n, and then the mark leading end 42 reaches the pre-process step in four cycles. As shown in FIG. 8, in a cycle n+4, the data to be stored in the storage box Db of the pre-process should be "E", but the discard wire type Z is interposed. This is because the defect mark 41 reaches the first processing device 21 in the next cycle "n+5".

[0041] In this manner, the distance L is always calculated, and the discard wire type Z that is discard information is stored when the length of the product workpiece to be processed subsequently cannot be secured due to the defect mark 41. The discard wire type Z is interposed until the mark terminal end 43 passes, that is, reaches the first processing device 21.

Method for Calculating Distance L from First Processing Device 21 (Process 1) to Mark Leading End 42

[0042] Next, a method for calculating the distance L from the first processing device 21 (process 1) to the mark leading end 42 will be described. The mark leading end 42 is detected during transport of the rectangular wire W. Assuming

that ΔL represents a movement amount from the moment of detection to the end of the transport in the transport cycle involving the detection, a distance L_n from the first processing device 21 to the mark leading end 42 at the end of the cycle n in which the mark is detected is represented as follows.

$$L_n = LS - L1 - \Delta L$$

($L1$: distance from the cutting device 15 to the first processing device 21)

[0043] The symbol "LS" (see FIG. 5) is a distance from the cutting device 15 to the mark detection sensor 28 and is a fixed value.

[0044] The transport distance of the rectangular wire W in each cycle is a wire type length to be cut in the post-cutting step in the next transport cycle. That is, a wire type length in the pre-cutting step in the previous transport cycle is the transport distance. Assuming that $L1$ represents the wire type length before cutting, a distance L_{n+1} of the mark leading end 42 from the first processing device 21 in the next cycle is represented as follows.

$$L_{n+1} = L_n - L1 = LS - L1 - \Delta L - L1$$

[0045] When the length of each wire type is represented by a lower case letter of the wire type (e.g., L_a), the wire type in the pre-cutting step in the cycle n is "B" based on the table T21 (FIG. 8). Therefore, the following expression is established.

$$L_{n+1} = LS - L1 - \Delta L - L1 = LS - L1 - \Delta L - L_b$$

[0046] This value is compared with the wire type length (represented by L_0) in the pre-process step.

$$L_{n+1} = L_n - L1 - L1 = LS - L1 - \Delta L - L_b > L_0 = L_a$$

[0047] The comparison in the above expression corresponds to the process of S103. This is repeated in each cycle, and the mark leading end 42 has reached the pre-process step when the distance L from the first processing device 21 to the mark leading end 42 is smaller than the wire type length L_0 in the pre-process step, that is, when $L < L_0$. At this time, the planned sequence wire type information in the pre-process step is replaced with the discard wire type.

B3. Detection of Mark Terminal End 43:

[0048] Next, detection of the mark terminal end 43 will be described. FIG. 9 is a flowchart showing a processing procedure of the detection of the mark terminal end 43 to be executed by the control device 30 of the linear material manufacturing apparatus 2 of the second embodiment. The flow in the flowchart shown in FIG. 9 is executed after the mark leading end 42 is detected in the flowchart shown in FIG. 7. As shown in FIG. 9, the processing unit 36 determines in S111 whether the terminal end 43 of the defect mark 41 is detected by the mark detection sensor 28. When the terminal end 43 of the defect mark 41 is not detected (S 111: NO), the process is terminated.

[0049] When the mark terminal end 43 is detected (S111: YES), the process proceeds to S112, and the processing unit 36 calculates a distance L' from the first processing device 21 (process 1) to the mark terminal end 43. In S113, the processing unit 36 determines whether the calculated distance L' is smaller than zero. When the distance L' is smaller than zero (S113 : YES), the process proceeds to S114, and the wire type information in accordance with the planned sequence is stored in the storage box Db of the pre-process. That is, the discard wire type Z is returned to the original wire type information in accordance with the planned sequence. When the distance L' is equal to or larger than zero in S113 (S113: NO), the process returns to S112, and the process of calculating the distance L' is repeated.

[0050] FIG. 10 is a table T22 showing a storage form of the wire type information to be read in the storage box Db of each step in each transport cycle, including a cycle in which the mark terminal end 43 is detected. In this example, eight types of product workpieces A to H are manufactured in accordance with the planned sequence, the mark terminal end 43 is detected in a cycle m , and then the mark terminal end 43 reaches the pre-process step in four cycles. The number of discards is two. As shown in FIG. 10, during a cycle $m+4$, the wire type information "E" in accordance with the planned sequence is stored in the storage box Db of the pre-process in place of the "discard wire type Z ". This is because the mark terminal end 43 has reached the process 1 in the cycle " $m+4$ " and the product workpieces can be manufactured from the next cycle.

Method for Calculating Distance L' from First Processing Device 21 (Process 1) to Mark Terminal End 43

[0051] Next, a method for calculating the distance L' (see FIG. 6) from the first processing device 21 (process 1) to the mark terminal end 43 will be described. The terminal end 43 of the defect mark 41 is detected during transport of the rectangular wire W. Assuming that $\Delta L'$ represents a movement amount from the moment of detection to the end of the transport in the transport cycle involving the detection, a distance L'm from the first processing device 21 to the mark terminal end 43 at the end of the cycle m in which the mark is detected is represented as follows.

$$L'm = LS - L1 - \Delta L'$$

[0052] The transport distance of the rectangular wire W in each transport cycle is a wire type length to be cut in the post-cutting step in the next transport cycle. That is, the transport distance is a wire type length in the pre-cutting step in the previous transport cycle. Assuming that L'I represents the wire type length before cutting, a distance L'm+1 from the first processing device 21 to the mark terminal end 43 in the next transport cycle is represented as follows.

$$L'm+1 = L'm - L'I = LS - L1 - \Delta L' - L'I$$

[0053] When the length of each wire type is represented by a lower case letter of the wire type (e.g., La), the wire type in the pre-cutting step is "D" based on the table T22 (FIG. 10). Therefore, the following expression is established.

$$L'm+1 = LS - L1 - \Delta L' - L'I = LS - L1 - \Delta L' - Ld$$

[0054] A check is made as to whether this value is smaller than zero.

$$L'm+1 = L'm - L'I = LS - L1 - \Delta L' - Ld < 0?$$

[0055] The comparison in the above expression corresponds to the process of S113. This is repeated in each cycle. When the distance L' from the first processing device 21 to the mark terminal end 43 is smaller than zero (when $L' < 0$), the mark terminal end 43 has reached the process 1. At this time, the discard wire type information in the pre-process step is returned to the planned sequence wire type information. That is, in the processes described above, when the terminal end 43 is detected by the mark detection sensor 28 and transported downstream in the transport direction with respect to the first processing device 21 (S113: YES), the wire length related information in accordance with the planned sequence is stored in the data storage box associated with the pre-process step so that the linear material to be processed subsequently in the first processing device 21 follows the planned sequence.

Effects

[0056] The second embodiment attains effects similar to those in the first embodiment. By performing the process based on the detection of the mark leading end 42 as detailed above, it is possible to interpose the discard wire type information during the production in accordance with the planned sequence. By performing the process based on the detection of the mark terminal end 43, it is possible to return to the wire type information in accordance with the planned sequence. Therefore, by performing the processes based on the detection of the mark leading end 42 and the mark terminal end 43, it is possible to minimize the amount of a non-defective portion in the discarded rectangular wire W without stopping the equipment. The discarded portion can be minimized.

C. Third Embodiment:

[0057] Next, a third embodiment of the present disclosure will be described with reference to FIGS. 11 to 13. FIG. 11 is a schematic diagram showing an overall schematic configuration of a linear material manufacturing apparatus 3 according to the third embodiment of the present disclosure. The linear material manufacturing apparatus 3 differs from the linear material manufacturing apparatus 2 of the second embodiment in that a discard chute 18 is further provided to automatically discard the discard wire type Z. The other configurations are the same. The discard chute 18 is disposed

on a downstream side of the cutting device 15 in the transport direction, and stores a cut material corresponding to the discard wire type Z.

[0058] FIG. 12 is a flowchart showing a processing procedure of a linear material manufacturing method to be executed by a control device 30 of the linear material manufacturing apparatus 3. The difference from the flowchart shown in FIG. 3 is that processing steps S11 and S12 are added after S10. The other processes are the same. In the third embodiment, before the product workpiece loading step (S30) by the loading device 16, the processing unit 36 determines in S11 whether the wire type of the cut workpiece is the discard wire type Z. Information on the discard wire type has been transferred to the previous step similarly to the above embodiment.

[0059] When the wire type of the workpiece is the discard wire type Z (S11: YES), the process proceeds to S12, and the cut workpiece is discharged by the loading device 16 to the discard chute 18 instead of the stocker 17. When the wire type of the cut workpiece is not the discard wire type Z (S11: NO), the process proceeds to S30, and the cut workpiece is loaded into the stocker 17 by the loading device 16.

[0060] FIG. 13 is a table T3 showing a storage form of the wire type information to be read for each step in each transport cycle. In the example shown in FIG. 13, eight types of product workpieces A to H are manufactured in accordance with the planned sequence, and discard workpieces reach the post-cutting step during the cycle n and the cycle n+1. The number of discards is two.

[0061] In the example shown in the table T3 of FIG. 13, the discard workpieces are in the post-cutting step in the cycle n and the cycle n+1. Therefore, the loading device 16 discharges the discard workpieces to the discard chute 18. From the cycle n+2, the product workpieces (planned sequence wire types) are sent again to the post-cutting step. Therefore, the loading device 16 starts loading the product workpieces into the stocker 17.

Effects

[0062] The third embodiment attains effects similar to those in the first embodiment. Since the loading device 16 discharges the discard workpiece to the discard chute 18 based on the discard wire type information, the discard workpiece can automatically be discharged out of the apparatus. This eliminates the need to take out the discard workpiece involving the stop of the equipment. Thus, it is possible to improve the productivity by improving the operation of the equipment.

D. Fourth Embodiment:

[0063] Next, a fourth embodiment of the present disclosure will be described with reference to FIGS. 14 and 15. FIG. 14 is a schematic diagram showing an overall schematic configuration of a linear material manufacturing apparatus 4 according to the fourth embodiment of the present disclosure. The linear material manufacturing apparatus 4 differs from the linear material manufacturing apparatus 3 of the third embodiment in that the mark detection sensor 28 also functions as a terminal end detection sensor for detecting a terminal end 44 of the winding. The other configurations are the same. The terminal end detection sensor detects the terminal end 44 that is the end of turns of the winding. In the third embodiment, when the terminal end 44 of the winding is detected by the terminal end detection sensor, products are manufactured until the remaining length reaches a limit length at which the winding can be discharged by the loading device 16 as a discard workpiece, and the terminal end copper wire is automatically discarded without stopping the equipment. Details will be described below.

[0064] FIG. 15 is a table T4 showing a storage form of the wire type information to be read for each step in each transport cycle. In the table T4, a discard wire type is represented by Z', a terminal end discard wire type is represented by Z'', and no wire type (after passage of the terminal end) is represented by N. To pick up and discard into the discard chute 18 by the loading device 16, it is necessary to secure a minimum length from the terminal end 44 of the winding to perform this operation. A discard wire type that is the rearmost portion including the terminal end 44 is the "terminal end discard wire type Z"". The discard wire type preceding the terminal end discard wire type Z" is the "discard wire type Z"". In the example shown in FIG. 15, eight types of product workpieces A to H are manufactured in accordance with the planned sequence, and the discard workpiece (discard wire type Z') at the terminal end 44 reaches the pre-process step during the cycle n and reaches the post-cutting step during the cycle m.

Method for Calculating Distance L" from First Processing Device 21 (Process 1) to Winding Terminal End 44

[0065] Next, a method for calculating a distance L" (see FIG. 14) from the first processing device 21 (process 1) to the winding terminal end 44 will be described. The winding terminal end 44 is detected during transport of the rectangular wire W. Assuming that ΔL represents a movement amount from the moment of detection to the end of the transport in the transport cycle involving the detection, a distance L"k from the first processing device 21 to the terminal end 44 at the end of a cycle k in which the terminal end 44 is detected is represented as follows.

$$L''k = L''S - L1 - \Delta L''$$

[0066] The symbol "L"S" is a distance from the cutting device 15 to the terminal end detection sensor and is a fixed value.

[0067] Since the transport distance of the rectangular wire W in each cycle is a wire type length cut in the post-cutting step in the next transport cycle, the transport distance is a wire type length in the pre-cutting step in the previous transport cycle. Assuming that L"I" represents the wire type length before cutting, a distance L''_{k+1} from the first processing device 21 to the winding terminal end 44 in the next transport cycle is represented as follows.

$$L''_{k+1} = L''k - L''I = L''S - L1 - \Delta L'' - L''I$$

[0068] Assuming that a final workpiece length is represented by L"E" to securely discharge the winding terminal end 44, it is necessary to set a variable length for the discard workpiece immediately before the final workpiece. Since the shortest length of a workpiece can be produced by the equipment is LZ, a total discard length L"Z" at the terminal end 44 needs to satisfy the following condition.

$$2 \times LZ + L"E \geq L"Z > LZ + L"E$$

[0069] That is, the timing of change from the planned sequence wire type to the discard wire type can be known by checking, in each cycle, whether the distance L" from the first processing device 21 to the winding terminal end 44 satisfies the above condition. When determination is made in the pre-process step based on the timing of transfer of the wire type information (see the flowchart shown in FIG. 12), the following expression is established. $2 \times LZ + L"E \geq L'' - L0 > LZ + L"E$ (L0: wire type length in pre-process step) ... Condition (1)

[0070] At this time, a wire length L'Z' of the discard wire type "Z'" (discard workpiece immediately before the final workpiece) is represented as follows.

$$L'Z' = L'' - L0 - L"E$$

[0071] At the timing when the above condition (1) is satisfied, the wire type information in the pre-process step may be changed to the discard wire type "Z'". Assuming that the discard wire type has reached the pre-process step in the cycle n as shown in the table T4, the following condition is satisfied at the end of a cycle n-1.

$2 \times LZ + L"E \geq L''_{n-1} - La > LZ + L"E$ (La: wire type A in pre-process step)

[0072] At this time, the wire length L'Z' of the discard wire type "Z'" is represented by $L'Z' = L'' - La - L"E$.

[0073] In the next cycle (cycle n+1), the terminal end discard wire type "Z'" that is the final workpiece is stored in the pre-process step, and the process is executed at the wire length L"E. Since there is no rectangular wire W to be supplied from the next cycle onwards, no wire type "N" is stored and the operation is stopped. In this manner, the information on the discard wire type "Z'", the terminal end discard wire type "Z'", and the no wire type "N" are stored, and the loading device 16 automatically discharges the discard workpiece at the terminal end 44 when the discard wire type reaches the post-cutting step.

Effects

[0074] The fourth embodiment attains effects similar to those in the first embodiment. It is possible to produce the product workpieces up to the vicinity of the winding terminal end 44 fed from the bobbin. Thus, it is possible to improve the yield of the winding and eliminate the need for work involving the stop of the equipment, thereby improving the productivity and the operating rate.

E. Other Embodiments

E1

[0075] In the above embodiments, the product workpieces A to H are manufactured as the materials for a motor to be mounted on a certain vehicle. By setting the pieces of wire type information, it is possible to continuously manufacture product workpieces as materials for a different motor to be mounted on a different vehicle in succession to the production of the product workpieces A to H. That is, by setting the pieces of wire type information, it is possible to continuously

perform the manufacturing without stopping the equipment, thereby achieving so-called mixed flow production in which motors for a plurality of vehicle models are manufactured in a mixed manner.

[0076] A specific example will be described with reference to FIG. 16. FIG. 16 is a table T5 showing a storage form of the wire type information to be read for each step in each transport cycle. In the form shown in FIG. 16, the product workpieces A to H serving as materials for a product P1 and product workpieces A' to H' serving as materials for a product P2 are manufactured alternately. FIG. 16 shows an example of pieces of wire type information when the products are switched. The products P1 and P2 can be manufactured from the same winding. As shown in FIG. 16, the product P1 starts to be switched to the product P2 in the cycle n. The wire types of the product P2 gradually fill the equipment as the cycle proceeds. In a cycle m+2, the wire types are switched to the wire types of the product P2 in all the steps. Thus, the switching is completed. The stop of the equipment is not necessary during this period. The automatic switching can similarly be made and the mixed flow production can be achieved in a case of switching of the product P2 to the product P1 or in a case of any other product that can be manufactured from the same winding.

E2

[0077] In the above embodiments, the transport unit 14 includes the two transport devices 26 and 27, but may include one transport device. The operation of one transport device to chuck and transport the rectangular wire W, release the rectangular wire W, and return to the next chucking position may be repeated.

E3

[0078] In the above embodiments, the processing unit 13 includes the processing devices 21 to 25, but may include one processing device.

E4

[0079] In the fourth embodiment, the mark detection sensor 28 functions also as the terminal end detection sensor for detecting the terminal end 44 of the winding, but the terminal end detection sensor may be provided separately from the mark detection sensor 28.

E5

[0080] In the above embodiments, the rectangular wire W serving as the wire is the insulation-coated copper wire serving as the linear material for the segment coil of the vehicle motor, but the wire is not limited to this. The processing devices 21 to 25 are the stripping devices that strip the insulation coating, but may perform other processes.

[0081] The present disclosure is not limited to each of the above embodiments, and can be realized by various configurations without departing from the spirit thereof. For example, the technical features in each embodiment corresponding to the technical features in each aspect described in "SUMMARY OF THE INVENTION" can be replaced or combined as appropriate in order to solve some or all of the above issues or achieve some or all of the above effects. When the technical features are not described as being essential herein, these features can be deleted as appropriate.

Claims

1. A linear material manufacturing apparatus (1; 2; 3; 4) configured to manufacture a plurality of types of linear materials having different lengths in accordance with planned sequence by feeding a wound wire in a transport direction in each of transport cycles, processing the wire, and cutting the wire at a place to which the wire is transported, the linear material manufacturing apparatus (1; 2; 3; 4) comprising:

an unwinding device (11) configured to feed the wire in the transport direction;
a processing device (21, 22, 23, 24, 25) configured to process the wire, and move between positions along the transport direction in each of the transport cycles;
a transport device (26, 27) configured to transport the wire in the transport direction in each of the transport cycles, provided on a downstream side of the processing device (21, 22, 23, 24, 25) in the transport direction, and configured to move between positions along the transport direction in each of the transport cycles;
a cutting device (15) fixed at a predetermined position, and configured to cut the wire processed by a plurality of the processing devices (21, 22, 23, 24, 25); and
a control device (30) configured to calculate, in each of the transport cycles, positions of the processing devices

(21, 22, 23, 24, 25) and the transport device (26, 27) in each of the transport cycles by using pieces of information on the lengths of the linear materials, and control the positions of the processing devices (21, 22, 23, 24, 25) and the transport device (26, 27) in each of the transport cycles.

2. The linear material manufacturing apparatus (1; 2; 3; 4) according to claim 1, wherein the control device (30) is configured to, when calculating a position of a calculation target device that is any one of the processing devices (21, 22, 23, 24, 25) and the transport device (26, 27) whose position is to be calculated in each of the transport cycles, calculate the position of the calculation target device by summing the lengths of the linear materials interposed between the cutting device (15) and the calculation target device.

3. The linear material manufacturing apparatus (1; 2; 3; 4) according to claim 2, wherein:

the control device (30) is configured to, in a plurality of data storage boxes (Db) provided in association with a plurality of steps including a pre-process step that precedes a process to be performed by the processing device (21, 22, 23, 24, 25) and is expected to proceed to the processing device (21, 22, 23, 24, 25), a process step to be performed by the processing device (21, 22, 23, 24, 25), and a transport step to be performed by the transport device (26, 27), store pieces of wire length related information related to the lengths of the linear materials serving as processing targets in the respective steps;

the control device (30) is configured to calculate the position of the calculation target device by using the stored wire length related information;

the control device (30) is configured to, every time the transport cycle is finished, execute a transfer process for transferring the pieces of wire length related information stored in the data storage boxes (Db) set for the transport cycle to the data storage boxes (Db) set for the next transport cycle;

the control device (30) is configured to, when executing the transfer process, transfer the pieces of wire length related information stored in the data storage boxes (Db) associated with the respective steps in the transport cycle to the data storage boxes (Db) associated with steps subsequent to the respective steps in the next transport cycle; and

the control device (30) is configured to, in the next transport cycle, calculate the position of the calculation target device in the next transport cycle by using the wire length related information transferred to the data storage box (Db).

4. The linear material manufacturing apparatus (1; 2; 3; 4) according to claim 3, wherein the linear material manufacturing apparatus (1; 2; 3; 4) includes a plurality of the processing devices (21, 22, 23, 24, 25), and the processing devices (21, 22, 23, 24, 25) are configured to perform a plurality of the process steps on the wire.

5. The linear material manufacturing apparatus (2) according to claim 3 or 4, further comprising

a detection unit (28) configured to detect a defective portion between the unwinding device (11) and a first processing device (21) that is the processing device (21, 22, 23, 24, 25) closest to the unwinding device (11), wherein

the wire includes a mark (41) indicating the defective portion, and
the control device (30) is configured to:

when the detection unit (28) detects a leading end (42) of the mark (41) in the transport direction, calculate a distance from the first processing device (21) to the leading end in each of the transport cycles; and
when the distance is smaller than the length of the linear material in the pre-process step by comparing the distance with the wire length related information stored in the data storage box (Db) associated with the pre-process step, interpose discard wire type information indicating a wire type to be discarded as the wire length related information in the data storage box associated with the pre-process step.

6. The linear material manufacturing apparatus (2) according to claim 5, wherein

the control device (30) is configured to,

when the detection unit (28) detects a terminal end (43) of the mark (41) in the transport direction and the terminal end (43) is transported downstream in the transport direction with respect to the first processing device (21),

store the wire length related information in accordance with the planned sequence in the data storage box (Db) associated with the pre-process step to cause the linear material to be subsequently processed by the first

processing device (21) in accordance with the planned sequence.

7. The linear material manufacturing apparatus (1; 2; 3; 4) according to any one of claims 1 to 4, wherein:

5 the wire is an insulation-coated copper wire having a rectangular cross section and serving as a material for a
segment coil; and
the processing device (21, 22, 23, 24, 25) is a stripping device configured to strip an insulation coating.

10

15

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25

30

35

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55

FIG. 1

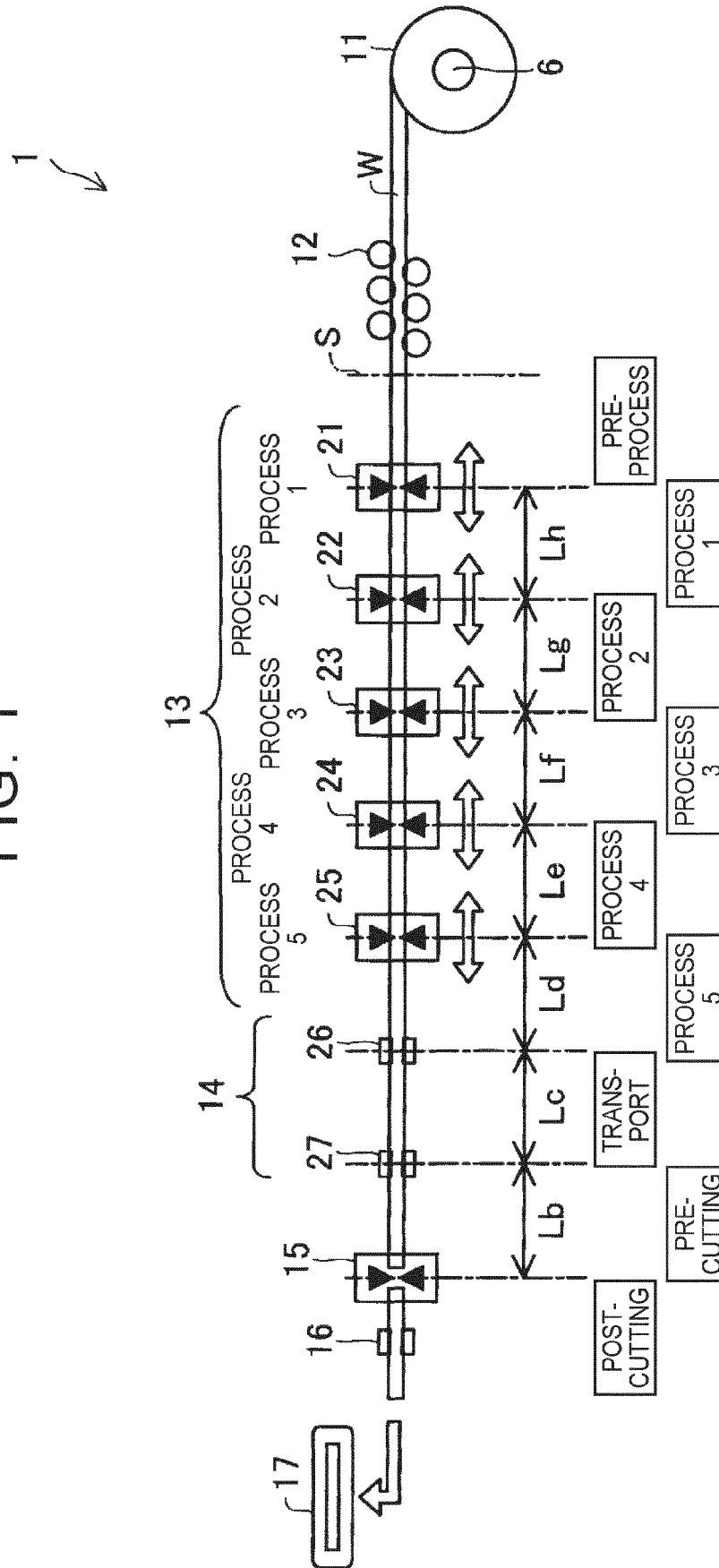


FIG. 2

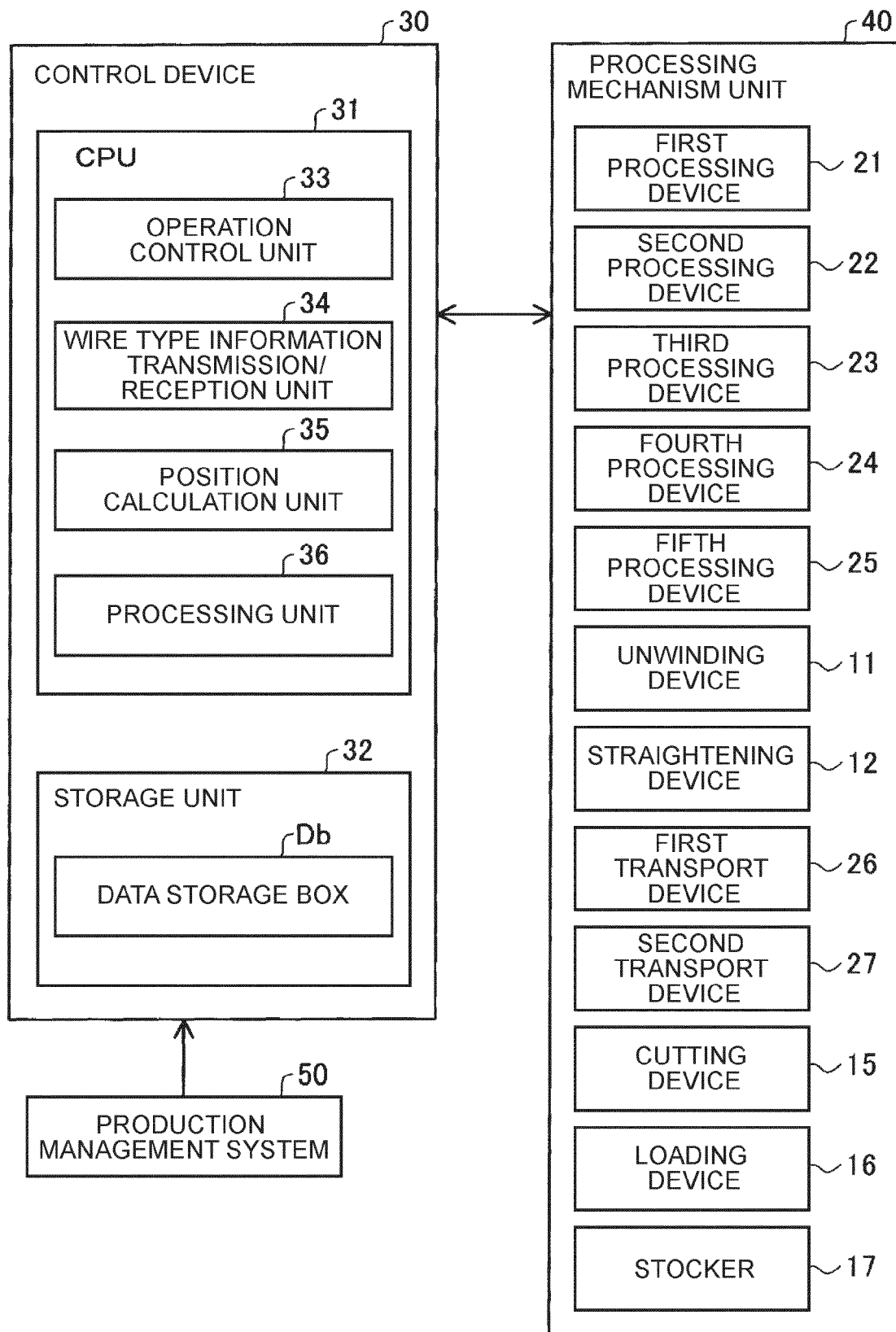


FIG. 3

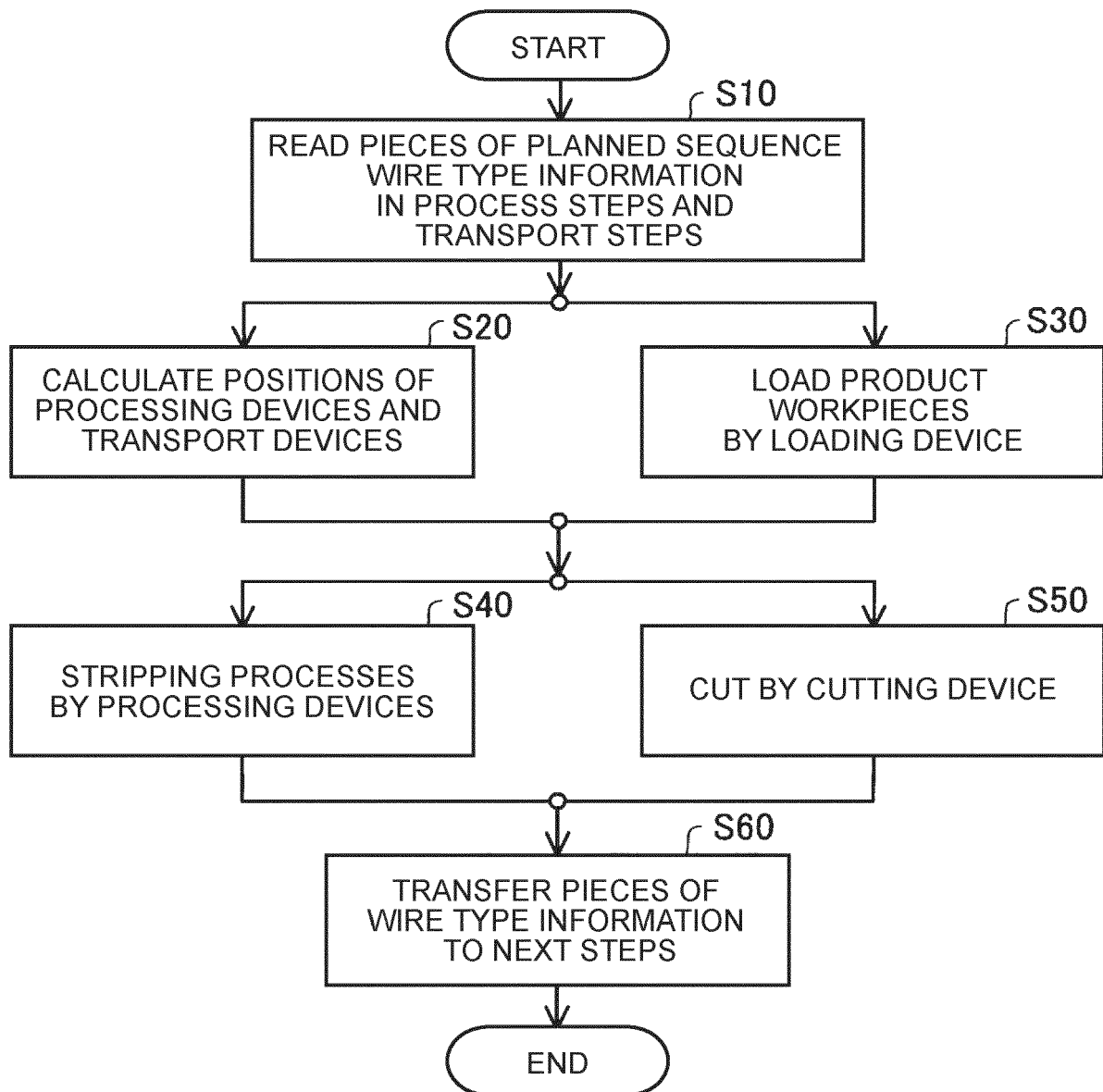


FIG. 4

T1 ↘

[STEP NAME]	POST-CUTTING	PRE-CUTTING	TRANSPORT	PROCESS ₅	PROCESS ₄	PROCESS ₃	PROCESS ₂	PROCESS ₁	PRE-PROCESS
CYCLE n	A	B	C	D	E	F	G	H	I
CYCLE n+1	B	C	D	E	F	G	H	I	J
CYCLE n+2	C	D	E	F	G	H	I	J	K
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

Db Db

FIG. 5

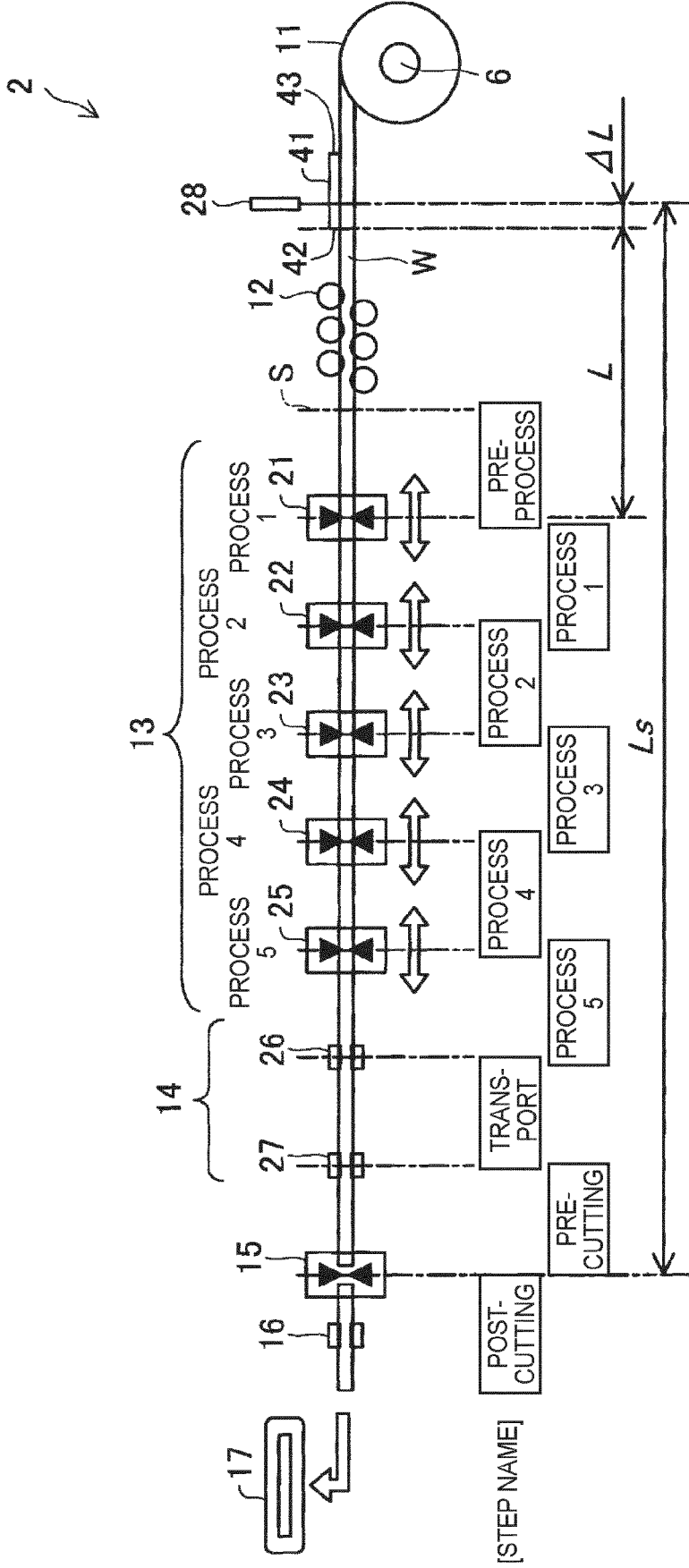


FIG. 6

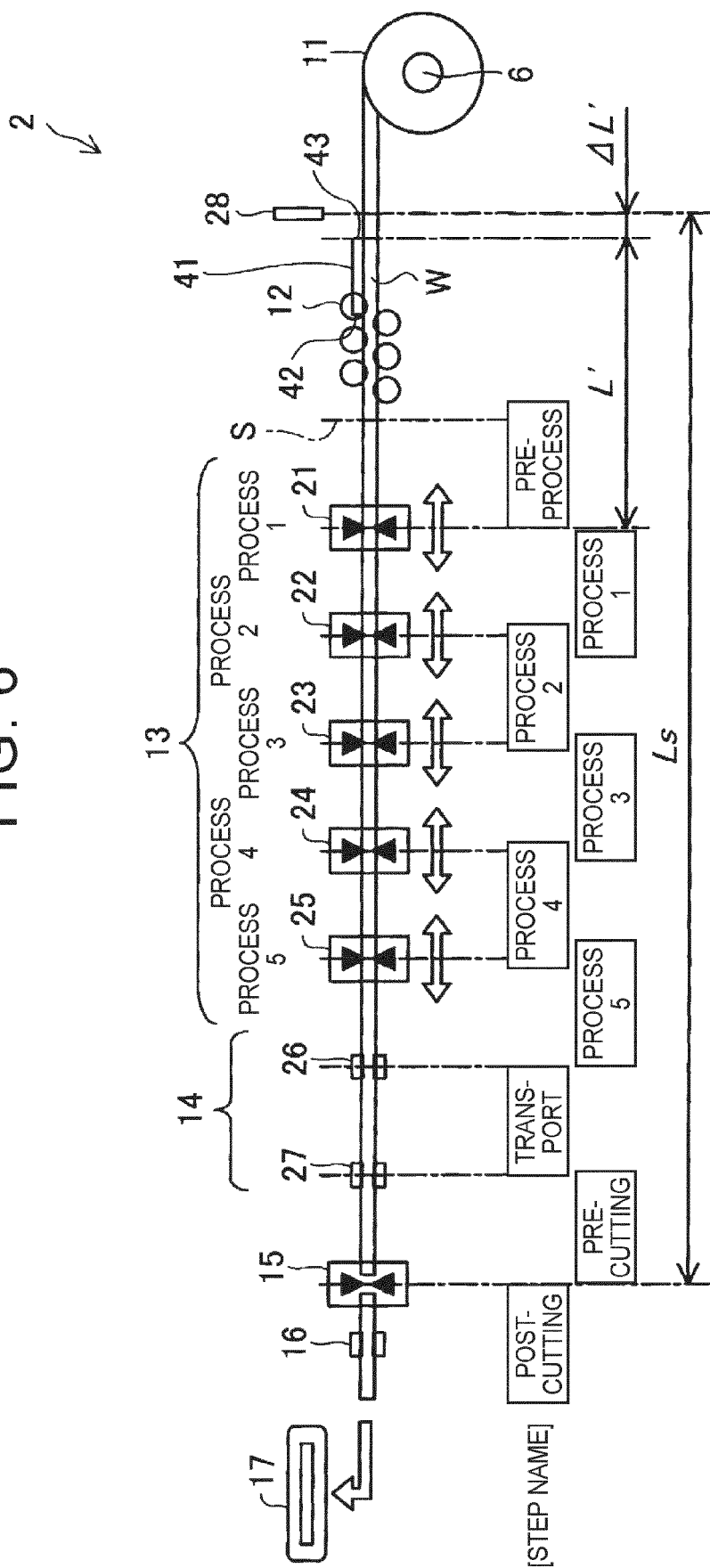


FIG. 7

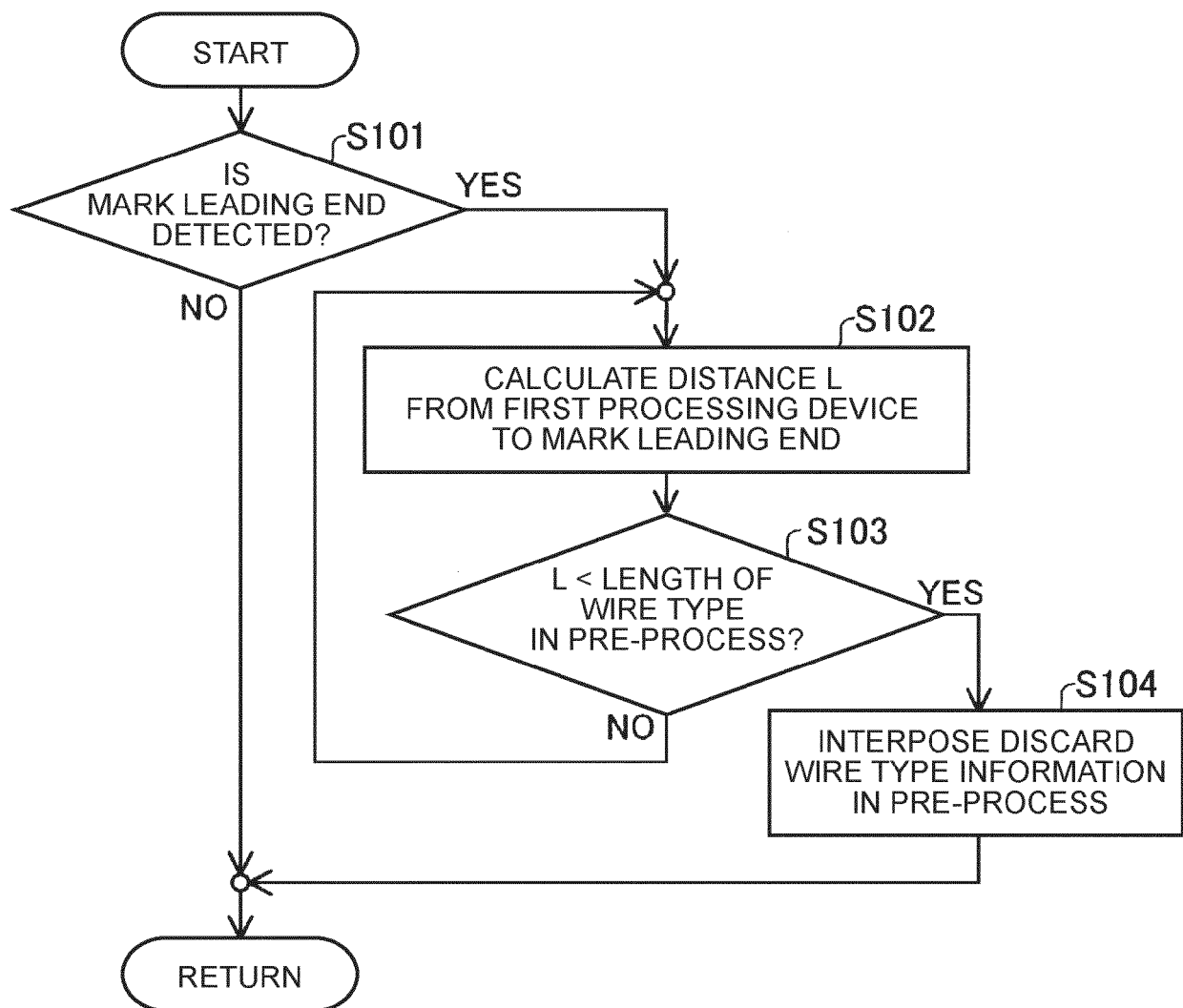


FIG. 8

T21

CYCLE	POST-CUTTING	PRE-CUTTING	TRANSPORT	PROCESS ₅	PROCESS ₄	PROCESS ₃	PROCESS ₂	PROCESS ₁	PRE-PROCESS
n	A	B	C	D	E	F	G	H	A
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
n+3	D	E	F	G	H	A	B	C	D
n+4	E	F	G	H	A	B	C	D	E→Z
n+5	F	G	H	A	B	C	D	Z	Z
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

MARK LEADING END IS DETECTED

Db

MARK REACHES PRE-PROCESS STEP

FIG. 9

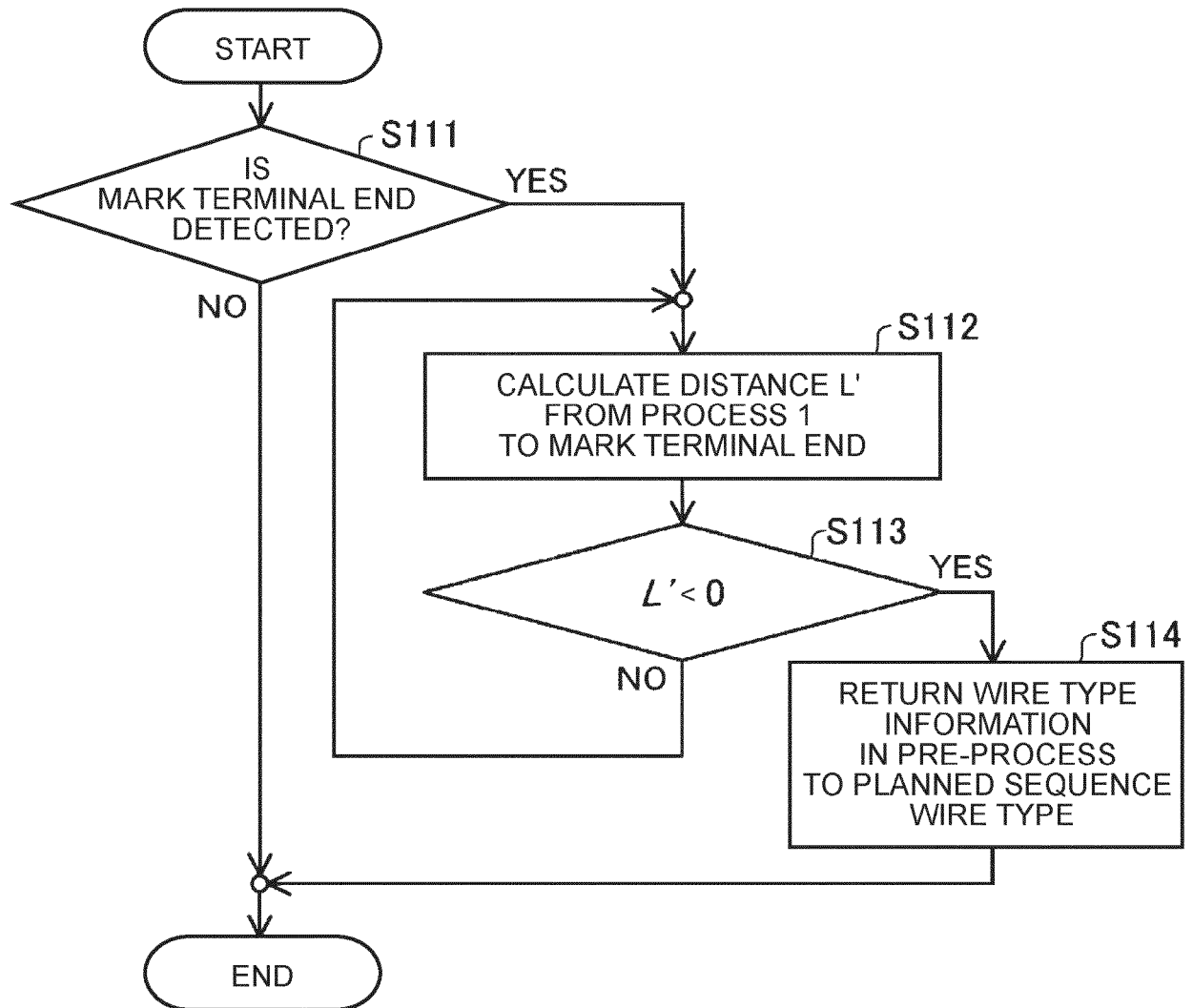


FIG. 10

T22

CYCLE	POST-CUTTING	PRE-CUTTING	TRANSPORT	PROCESS ₅	PROCESS ₄	PROCESS ₃	PROCESS ₂	PROCESS ₁	PRE-PROCESS
m	C	D	E	F	G	H	A	B	C
:	:	:	:	:	:	:	:	:	:
m+3	F	G	H	A	B	C	D	Z	Z
m+4	G	H	A	B	C	D	Z	Z	Z→E
m+5	H	A	B	C	D	Z	Z	E	F
:	:	:	:	:	:	:	:	:	:

MARK TERMINAL END IS DETECTED

←

Db

MARK TERMINAL END REACHES PROCESS 1

←

FIG. 11

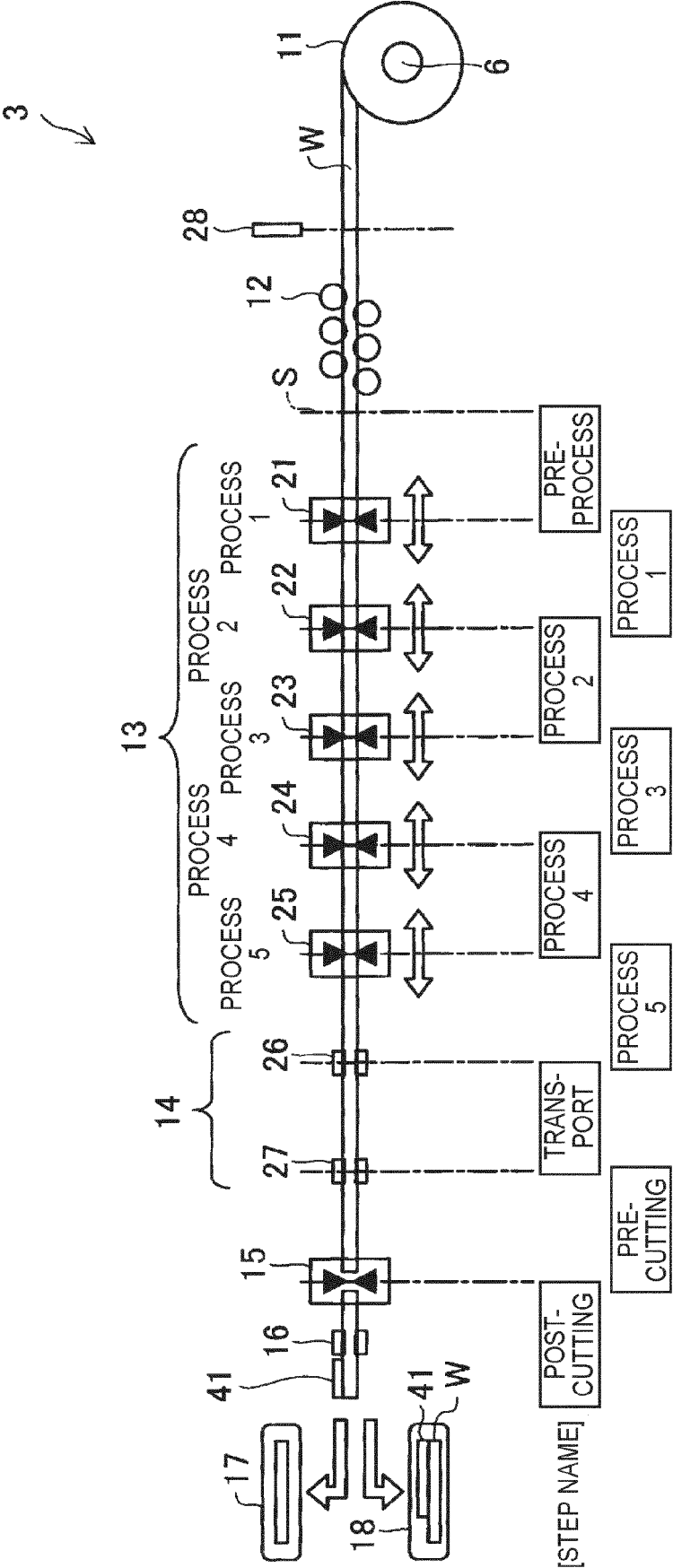


FIG. 12

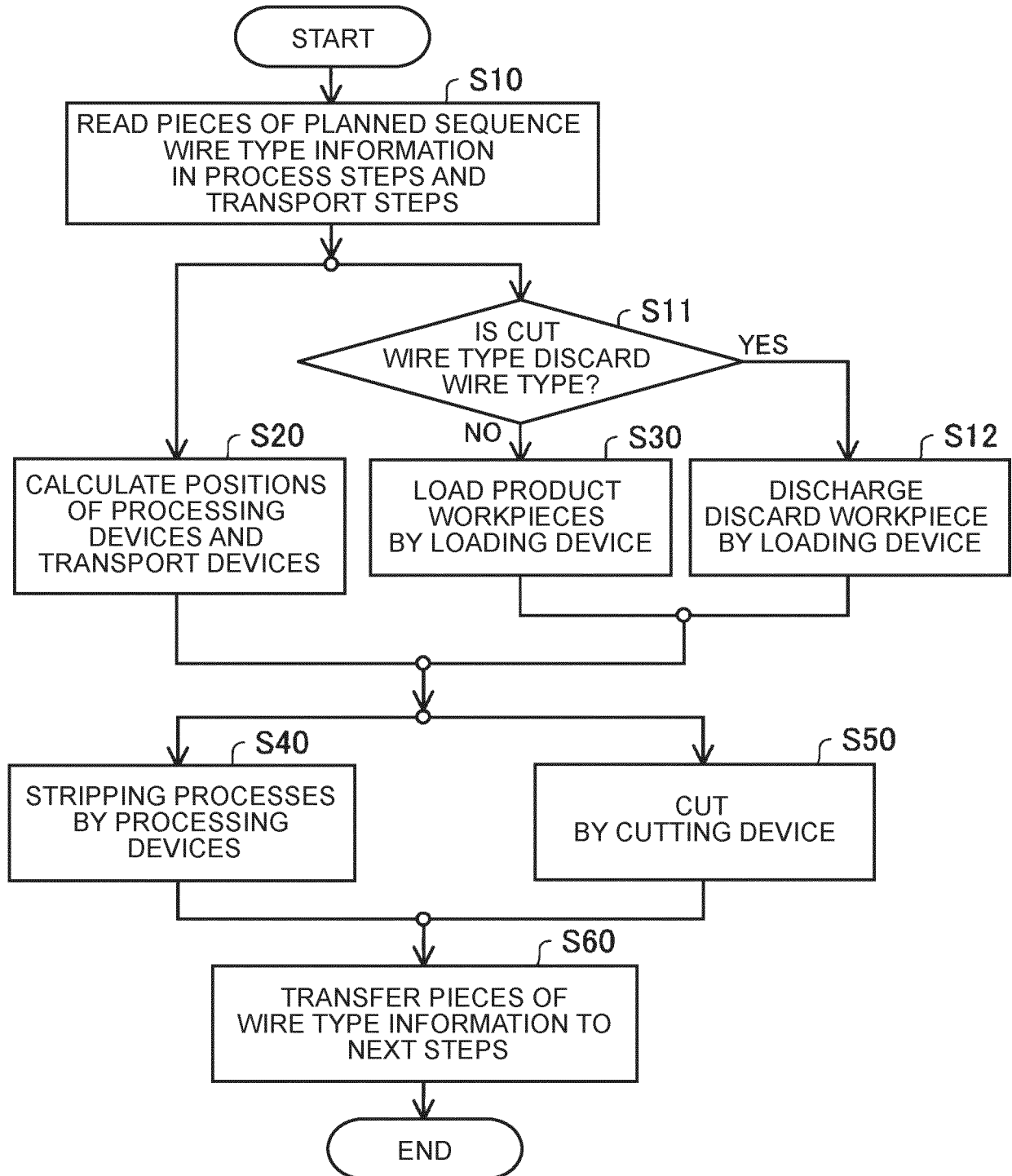


FIG. 13

T3

CYCLE	POST-CUTTING	PRE-CUTTING	TRANSPORT	PROCESS 5	PROCESS 4	PROCESS 3	PROCESS 2	PROCESS 1	PRE-PROCESS	POST-CUTTING STEP: PLANNED SEQUENCE WIRE TYPE WORKPIECES (PRODUCT WORKPIECES) ARE LOADED INTO STOCKER	POST-CUTTING STEP: DISCARD WIRE TYPE WORKPIECES (DISCARD WORKPIECES) ARE DISCHARGED TO DISCARD CHUTE	POST-CUTTING STEP: PLANNED SEQUENCE WIRE TYPE WORKPIECES (PRODUCT WORKPIECES) ARE LOADED INTO STOCKER
n-2	A	B	Z	Z	C	D	E	F	G			
n-1	B	Z	Z	C	D	E	F	G	H			
n	Z	Z	C	D	E	F	G	H	A			
n+1	Z	C	D	E	F	G	H	A	B			
n+2	C	D	E	F	G	H	A	B	C			
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	Db		

14. G. F.

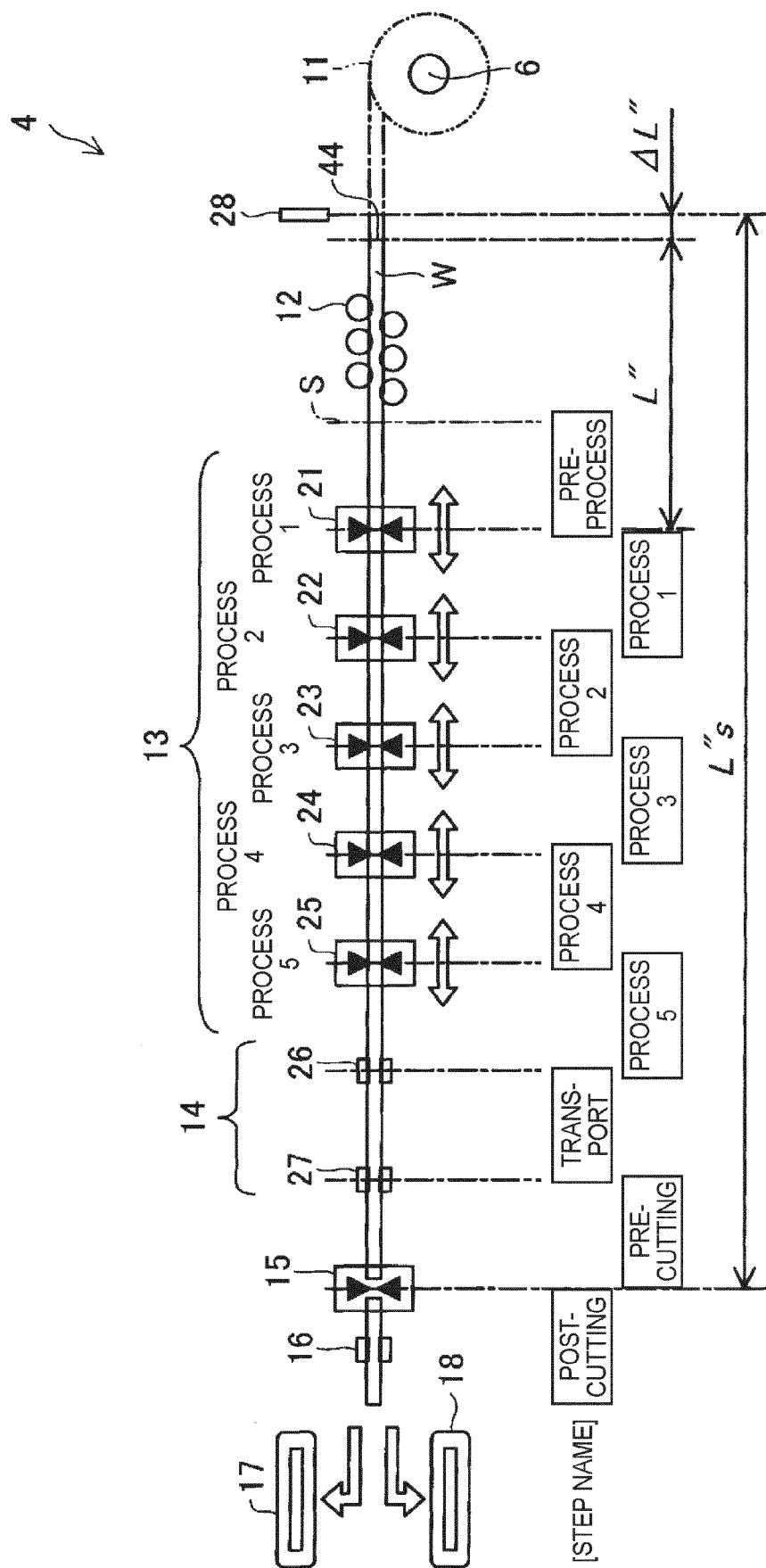


FIG. 15

T4

CYCLE	POST-CUTTING	PRE-CUTTING	TRANSPORT	PROCESS ₅	PROCESS ₄	PROCESS ₃	PROCESS ₂	PROCESS ₁	PRE-PROCESS
n-1	A	B	C	D	E	F	G	H	A
n	B	C	D	E	F	G	H	A	B→Z'
n+1	C	D	E	F	G	H	A	Z'	Z''
n+2	D	E	F	G	H	A	Z'	Z''	N
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
m-1	A	Z'	Z''	N	N	N	N	N	N
m	Z'	Z''	N	N	N	N	N	N	N
m+1	Z''	N	N	N	N	N	N	N	N
m+2	N	N	N	N	N	N	N	N	N

Db

FIG. 16

T5

CYCLE	POST-CUTTING	PRE-CUTTING	TRANSPORT	PROCESS 5	PROCESS 4	PROCESS 3	PROCESS 2	PROCESS 1	PRE-PROCESS
n	A	B	C	D	E	F	G	H	A'
n+1	B	C	D	E	F	G	H	A'	B'
n+2	C	D	E	F	G	H	A'	B'	C'
n+3	D	E	F	G	H	A'	B'	C'	D'
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
m	G	H	A'	B'	C'	D'	E'	F'	G'
m+1	H	A'	B'	C'	D'	E'	F'	G'	H'
m+2	A'	B'	C'	D'	E'	F'	G'	H'	A'
m+3	B'	C'	D'	E'	F'	G'	H'	A'	B'

PRODUCT P1

PRODUCT P2

Db



EUROPEAN SEARCH REPORT

Application Number

EP 23 17 3995

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			H01F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 8 November 2023	Examiner Subke, Kai-Olaf
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