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(54) Modular packing assembly

(57) A cigarette packing system comprises a plurality of reconfigurable modules (100). Each module includes tooling for performing a section of the packaging process. Product is transferred between modules by robots (110) mounted on the modules and controlled from individual modules. Interface protocols between modules control transfers between modules. The product may be transferred with or without a carrier between modules. The modules may be reconfigured for a different assembly process and modules added or removed. Process specific tooling maybe changed. Reconfigurable modules reduces the time and cost of changing to a different packaging process.

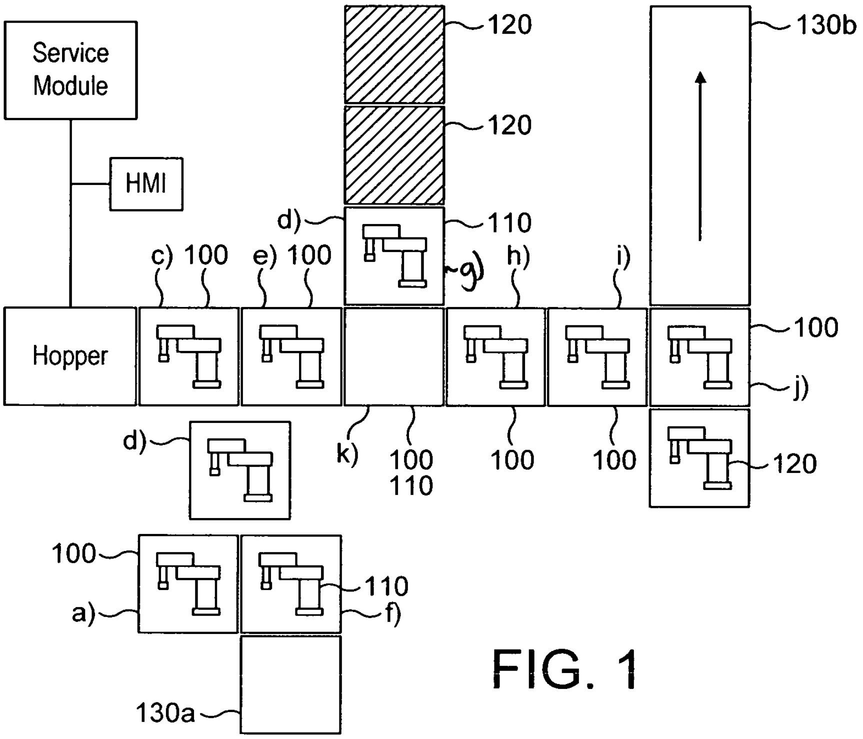

FIG. 1

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Description

[0001] This invention relations to modular machines for packing goods. It is particularly related to modular machines that require reconfiguration from time-to-time as product packing requirements change.

[0002] In the tobacco industry, normally finished cigarettes are delivered to a packing machine where they are formed into collations and packaging formed around the collation. A number of different types of packaging may be applied, for example, a hard pack or a soft pack. The packaging process is complex and involves a number of steps performed sequentially. This may include card handling, scoring, cutting, folding and gluing, embossing, foil handling, cellophane wrapping and gluing.

[0003] A packing machine is a very heavy investment for a manufacturer. However, high manufacturing speeds and long packaging runs make packaging lines economic.

[0004] The efficient and economic manufacture of limited quantities of cigarette packs, e.g. some thousands of packs, may be a challenge. For example, where a novel pack shape or cigarette collation is to be tested it is uneconomic to install a dedicated packing line for that design as, if the design is not pursued further, the line will become redundant. Accordingly, small quantities of cigarette packs tend to be assembled, at least partially, by hand. It would be valuable to be able to run much larger tests, e.g. tests involving some millions of packs.

[0005] Although it is possible to make relatively low volume packing machines which can be reconfigured to different packaging designs, the reconfiguration process is itself very slow and very expensive.

[0006] It is the aim of the present invention to address the problems discussed above and to provide an approach to packing lines that facilitates reconfiguration for different packaging requirements.

[0007] Broadly, the invention resides in the provision and use of a packing system comprising a plurality of modules. The modules may be reconfigured and modules added or subtracted for different packaging assemblies. Articles are generally moved between modules by robots under the control of module controllers. Each module has its own controller. The term articles refers either to the articles to be packaged or those articles and a part or all of the packaging which is formed around the articles in the packaging process.

[0008] More specifically, there is provided a packing system for packaging articles in a pack, comprising a plurality of interconnected modules, each module comprising tooling for performing a part of the packaging process, and at least some of the modules comprising a robot for moving articles between modules.

[0009] Preferably at least one of the modules comprises a robot for performing a packing process.

[0010] Embodiments of the invention have the advantage that relatively low capacity packing system may be provided that can be reconfigured quickly and at low cost compared with prior art packing lines or machines. A system embodying the invention made be reconfigured from one cigarette packing configuration to another in a couple of weeks. This is significantly better than is possible in any prior art system in which reconfiguration, to the extent that it is possible at all, will take several months. Even then, the term reconfiguration is not entirely appropriate as the reconfigured system is largely a rebuilt system. There is a very large cost saving associated with the ability to reuse modules and to switch the packs being made by the system very quickly.

[0011] This ease of reconfigurability makes it practical and economic to produce test runs in the order of millions of packs rather than the thousands produced using manual packaging at present.

[0012] Preferably, the robots perform some of the packing processes and move either articles or articles and article carriers between modules. The articles moved may either be the actual articles to be packaged, partially or fully packaged artilces or an element of the packaging.

[0013] In a preferred embodiment of the invention, the packaging is formed around the articles to be packaged. This contrast with prior art arrangements in which the packaging is formed, or partially formed apart from the articles to be packaged. Forming the packaging around the articles is advantageous as it assists the ease of reconfigurability of the packing system. Thus, the same approach may be taken, for example, with a pack formed from hard plastic end caps and a wrapper as is taken for a more complex cardboard blank pack. The cardboard pack is not preformed but is formed around the articles.

[0014] Preferably, the robots may be SCARA, Cartesian or anthropomorphic robots. The robots may have a number of degrees of freedom allowing movement in X, Y and Z axes and possible also rotational degrees of freedom. Although all these degrees of freedom may not be needed in a given packaging operation, the robots are part of a reconfigurable system and the provision of a large number of degrees of freedom increases the configurability of the modules for other packaging operations.

[0015] Preferably, a number of different module types are provided. Flexible modules may include a robot and include a base plate onto which process specific tooling is mounted. Where a robot is included, the robot actuator head may also include process specific tooling. Reel feed modules provide for reel fed materials such as wrapping, foil, and labelling to be introduced into the process, and blank delivery modules allow for blanks such as card blanks to be delivered into the system. Any of these modules may include a robot. Some or all of the module types may be included in a given configuration.

[0016] Preferably, each module includes a module controller for controlling module sensors and actuators. Preferably, where present, the module controller also controls the module robot. This approach to control increases the flexibility of the modular approach. For example, where the movements of a robot have to be changed for a new process, it is a relatively simple matter to reprogram that robot to define its movements and actions with respect to adjacent modules.

[0017] The control system of each module preferably interfaces with the control system of adjacent modules, allowing transfer of goods between modules to be controlled by the modules themselves and not by an overall system controller. This again increases flexibility.

[0018] Preferably, a module has a set of stations, or positions to which articles, which might be on a carrier, can be moved for transfer to an adjacent module. Interface software controls movement between the module processes and the bays occupied by both carriers with articles and returning empty carriers. Preferably, both the control systems of adjacent modules are involved in a transfer between modules.

[0019] Preferably, control system software handles movement between modules by use of a product state indicator, indicating the presence or absence of articles, an access request state, indicating a request to access product by a module when the product state indicates that product is present, and an access granted state indicating that the robot for one module has access to the articles to pick the articles or to a carrier to place articles. This control approach avoids clashes between robots of adjacent modules.

[0020] The reconfigurable modular packaging system embodying the invention is particularly suitable for packing rod shaped articles such as cigarettes but may be used for packaging other articles.

[0021] The invention also provides a set of reconfigurable modules for forming a packing system configuration, the modules being interconnected and each having removable tooling for performing a part of the packaging process, at least a plurality of the modules including a robot for transfer of articles between modules, each module having a module controller for controlling the part of the packaging process performed by the module and for coordinating transfer of articles between the module and adjacent modules. The modules may also perform some of the packing processes.

[0022] Embodiments of the invention will now be described, by way of example only, and with reference to the accompanying drawings, in which:

Figure 1 is a representation of the packing system configuration as a series of modules;

Figure 2 shows a side view of a pair of modules each including a robot, which is used in the process of figure 1;

Figures 3a) and 3b) show the mechanical interface between modules, illustrating how product is passed between modules;

Figures 4a) and 4b) are similar views to figures 3a) and 3b) for a double product transfer;

Figure 5 illustrates connectivity between 3 adjacent modules;

Figure 6 illustrates the connectivity between 6 adjacent modules;

Figure 7 illustrates the interface sequence for a picking operation;

Figure 8 illustrates the interface sequence for a placing operation;

Figure 9 illustrates the picking operation for a 2:1 module interface;

Figure 10 illustrates the overall control architecture for all the modules; and

Figure 11 shows an alternative module configuration for a different pack design.

[0023] The packing system configuration represented in figure 1 is an exemplary configuration used to illustrate the reconfigurable modular nature of embodiments of the present invention. The packing system is intended for packaging of cigarettes or other rod shaped articles but the invention is not limited to packaging of this type of article and extends to other types of article, such as foodstuffs including confectionery products, writing instruments such as coloured pencils or crayons or other rod-shaped articles.

[0024] Similarly, the invention is not limited to any particular packing system configuration. Indeed, the invention permits the reconfiguration of modules to enable different types of packaging to be made, for different types of articles.

[0025] The configuration represented in figure 1 is intended to package cigarette collations in a pack that has rigid plastic end caps and a metalised web wrapped over the cigarettes and over depending flanges of the end caps. The web is sealed and air is evacuated from the pack and replaced by nitrogen to preserve product freshness. The details of the various stages of the product are not germane to the present invention but it is helpful to discuss each part of the process at a high level.

[0026] The process is provided by a number of modules, with product and carriers being moved between carriers by servo controlled robots using pneumatics to control handling. The robots may include Cartesian, SCARA and Anthropomorphic robots. After describing the process of figure 1 in detail, the interface between the modules, both mechanical and software will be described to be understood how a modular packaging process can operate. Finally, an alternative configuration will be discussed to illustrate how the modules may readily be re-configured for a different packaging at greatly reduced cost and time.

[0027] The choice of robot will depend on the requirements of the situation in which they are to be used. Cartesian, SCARA and anthropomorphic robots are preferred. SCARA (Selective Compliance Articulated Robot Arm) robots usually have four degrees of freedom and have two primary links that swing in a horizontal plane with a quill type Z-axis at the end of the arm that provides vertical motion and angular rotation (Theta) in the horizontal plane. Cartesian robots are typically modular, consisting of a series of linear slides that can be chosen for length and payload and are mounted to be orthogonal to each other. Z-Theta units are available, allowing a four axis (X, Y, Z, Theta) robot to be built with a similar functionality to a SCARA robot. Cartesian robots can be configured so that the rotation axis is horizontal. Cartesian robots are generally considered to be simpler to control in cartesian space. Anthropomorphic robots, specifically vertically articulated anthropomorphic arms normally have five or six axes. Typically in a five axis arm, a first axis is rotation about the vertical; the second, third and fourth axes are rotation about the horizontal with the axes parallel to each other and offset by the link length between axes; and the fifth axis is a roll axis orthogonal to the fourth axis. In a six axis arm, axes one two and three are the same as the five axis example. The fourth axis is orthogonal to the third, normally along the link axis; the fifth axis is orthogonal to the third axis and the sixth axis is a roll axis which is orthogonal to the fifth axis. Vertically articulated anthropomorphic arms have a large operating envelope particularly in the Z direction. Six axis arms give control of position and orientation of objects in space leading to great flexibility.

[0028] Finished cigarettes are delivered to the packing system and held in the hopper. In one preferred embodiment, four parallel hoppers are used, each of which has a parallel hopper vane chute for presenting cigarettes individually to a collation mandrel. Cigarettes are transferred to the collation mandrel by a single push rod. A push rod is provided for each hopper and the four push rods are preferably linked by a bar enabling them to be activated together although they could be driven independently. The mandrel has a plurality of through holes arranged to define the shape of the collation to be packaged. The push rods push the cigarettes one-by-one into these through holes to fill the mandrels. The push rods reciprocate along the Z axis and do not move with respect to the hoppers in the X,Y planes. Instead the mandrels are moved in the X,Y planes by a servo controlled robot to position themselves correctly for receipt of cigarettes.

[0029] Once filled, the mandrels are moved downwards in the Y plane at which point the collations are transferred from the mandrels to shaped pockets. Within the shaped pockets the cigarettes are no longer spaced from one another and are ready to have the packaging formed around them. Transfer to the shaped pockets is achieved via a set of parallel push rods for each mandrel. These push rod sets are linked by a bar and also reciprocate in the Z axis. The rods are arranged to match the shape of the collation in the mandrels so that, on reciprocation, the rods are received in the through holes of the mandrels, pushing the cigarettes through the mandrels into the pocket. The servo controlled robot ensures that the position of the filled mandrel is accurately registered to the sets of push rods to ensure that the push rods are correctly received in the mandrel holes. Once emptied, the mandrels are returned to a position proximate the single push rods to receive, one-by-one, the next cigarette collations.

[0030] The filled shaped pockets are now transferred to a rigid end cap case filling station. This requires the filled pockets to be lifted by a servo robot and moved to another module.

[0031] The cases comprise a pair of rigid end caps each of which has a dependent skirt that in position, extends over a portion of the length of the cigarettes. One of the end caps includes a flip top lid for removal of cigarettes from the pack by the user. To ensure that the contents of the pack remain fresh, a foil is applied to the opening beneath the flip top lid which is automatically opened on the rigid end cap case unload and lid seal turntable. The foil is removed by the user when opening the pack.

[0032] The rigid end caps are delivered by a tray delivery system and are uploaded from the tray by a robot picker and delivered to a turntable. During this delivery process, the top end caps, having a flip top lid are delivered to a testing station to test for the presence of a flip top lid on the cap and then the robot picker orientates the flip top lids correctly for presentation to the turntable. Bottom end caps are delivered straight to the station on the turntable. The rotation of the turntable presents the top end caps to a lid foil application module. A further servo robot on this module places a lid foil, previously picked by the robot from a magazine, onto the top end cap. The rotation of the turntable places the top end caps and lid foil at a sealing station where the lid foil is joined onto the top end cap.

[0033] A servo robot on the rigid end cap case transfer module picks the top and bottom end caps off the turntable and presents them to the rigid end cap case fill module. At this module, the cigarette collation and the end caps are manipulated so that the cigarettes are inserted into the end caps. From there, a further servo robot moves the collation and end cap assembly to a rigid end cap case assembly module. This module interacts with the web fold and seal module, which provides the rigid end cap case assembly module with a mandrel around which is formed a foil wrap.

[0034] The web is provided from a web roll and transported via an assembly of tensioning rollers to a web preparation and cutting station. The web preparation and cutting station ensures that the web is cut to the correct length required for the pack and then delivered in front of the web fold and seal module. The web fold and seal module, using a servo robot, presents a mandrel to the web at the exit for the web preparation module. The web is gripped to the side of the mandrel and then the mandrel and web is moved through a folding unit. This motion may be either servo robot controlled or pneumatically actuated. The web is folded around the mandrel and then sealed along its length to form a sleeve. Sealing may be achieved either by gluing or heating. Preferably the web is formed of a metalised plastics material and any convenient method of sealing may be used.

[0035] From the web folding station, the mandrel having a sealed web sleeve around it is transported, again by a servo robot, to the rigid end cap case assembly module, where the mandrel and sleeve are aligned with the collation and end cap partial assembly. The sleeve is then slid over the assembly. The pack is now complete but not airtight. A robot picker moves the completed assembly to a web sealing station which seals the ends of the sleeve against the rigid ends of the pack. Again any convenient type of sealing may be used although heat sealing is presently preferred. The sealed pack is them passed by a further servo robot to a nitrogen charge and sealing station. At this station air in the pack is evacuated through a small hole in the bottom end cap and replaced with nitrogen. Some other inert gas could be used. The hole is then sealed by heating and melting the surrounding plastic. The finished product now includes gas under pressure which will be released with an audible sound when the consumer opens the package, thereby assuring the consumer of the freshness of the product.

[0036] The sealed packs are then passed to a labelling station where promotional labelling may be attached and finally to a date stamp station and to an offloading station (not shown).

[0037] In the process described, many operations are performed which will be common to any type of cigarette pack assembly and filling and some are performed which are particular to the product pack being produced. Prior art packaging machines have built all these functions into a single machine with drives and controls passing along the length of the machine. The embodiment of the present invention divides the entire process into a series of discrete modules. Each module performs a particular function and goods may be passed from module to module by using servo controlled robots which pick the goods off one module and transfer them to another module. The modules may include turntable modules such as the unloading module, which, as well as performing a function in the assembly process, in this case sealing the lid foil to the top cap, also functions to move goods, in this case end caps, to positions where they maybe picked up by robots and delivered to other modules. The nature of goods that can be transported between modules varies. Thus, for example, the collation pockets are transferred from the module containing the hoppers and the collation mandrels. These pockets are transferred, filled with cigarettes, to the rigid end cap case fill module and returned empty to the hopper and collation mandrel module. The web sleeve mandrel is transferred between the rigid end cap case assembly module and the web preparation and folding modules.

[0038] A modular representation of the system is shown in figure 1. The system is made up of the hopper and two types of module: flexible modules 100 which may be used with or without robots 110; and reel feed material modules 120 which may also be used with or without robots. In figure 1 the flexible modules are indicated as open boxes and the reel fed materials by hatched boxes.

[0039] Thus, in figure 1, the two flexible module 100 that include robots correspond to a module a) responsible for attaching lid foils to the rigid end cap lids, and a module b) responsible for attaching promotional materials. The two reel feed modules 120 without robots correspond to the web delivery and web preparation stations. The unshaded boxes 130a) and 130b) correspond to the rigid end cap delivery chute and the end of the process, respectively.

[0040] The remaining modules comprise flexible modules c) to j) having robots and a flexible module k) having no robot. Module 100 k) is the module which assembles the rigid end cap case receiving the sleeve wrapped around a mandrel from module g) and the assembled collation and rigid end cap case from module e). Module h) passes the assembled pack on to module i) which evacuates air and charges the pack with nitrogen. Module j) is a date code and offload module.

[0041] Module c) is responsible for transferring the collation mandrels from the hopper module to the rigid end cap case fill module d), and module f) is responsible for receiving the end caps, checking their orientation and distributing them to the lid foil application module and rigid end cap case filing module.

[0042] Thus, the packaging process uses a number of robots arranged on modules, the modules being linked together to form a re-configurable arrangement of independent modules. It will be appreciated that each module carries process specific tooling and than many modules also have a SCARA, Cartesian or other robot for moving product between modules. The robot may also have process specific tooling. Control of the module is handled by the module's own controller under the overall control of a system controller, and neighbouring modules communicate with each other, exchanging handshaking protocols to ensure correct transfer of product between module processes. The product may be then formed or partially formed goods, or a combination of those goods and carriers.

[0043] On reconfiguration, the process specific tooling has to be changed but the modules can be reconfigured in any desired manner. The operations performed by the robots will differ, and reprogramming will be required. However, the manner in which modules interact remains unchanged.

[0044] Thus, the packing system comprises a plurality of modules. These modules may be arranged and re-arranged in different configurations. Each module can function on its own and the system software breaks the control functionality into routines. One of the important aspects of such an approach is to define the interfaces between modules. The control interfaces reflect the mechanical interfaces which may change from configuration to configuration. In the example described, turntables were used to avoid robots crossing into each others space.

[0045] Figure 2 shows an illustrative and schematic connection between two modules 60, 62. Each module comprises a base frame 64 within which is housed an electrical and control system 66. The modules are independent of one another and are subject to an overall system controller. However, the operation of each module is controlled by the module itself. A base plate 68 is mounted on the base frame. For convenience, the base plates are arranged at a common height to assist transfer of product from module to module. A robot 70 is mounted on each base plate and is responsible for handling the product, or product on a carrier such as the collation pockets, and for transferring the product or product and carrier between modules in the manner to be described.

[0046] Not all modules include robots. For example, the rigid end cap case assembly module in figure 1 is a module that interfaces with three other modules each of which have robots that move product and carriers to and from the rigid end cap case assembly module. The latter module does not need a robot itself.

[0047] The modules each carry a sub-plate 72 on which is mounted actuation and pack specific tooling 74 and the robots will also each carry similar actuation and pack specific tooling depending on the task they are to perform. The modules are connected together for control 76, safety 78, power 80 and pneumatics 82.

[0048] In order to be able to handle all possible arrangements of modules, the following mechanical interfaces between modules need to be defined;

Single transfer mechanical interface, in which a single product is transferred;
Double transfer mechanical interface;
Quad transfer mechanical interface.

[0049] An example of the single transfer mechanical interface is shown in figure 3. In this transfer, a single product and/or carrier is picked up and moved from one module to another. There are two basic variants. In the first variant, a carrier and a product are passed forwards and the empty carrier is passed back. An example of this variant is the transfer of the filled shaped pocket from the hopper module to the rigid end cap case filling module in the configuration of figure 1. The second variant is where only the product is passed forward. Here there is no carrier. An example of this is the completed pack after application of the sleeve which is transferred to the web sealing station from the rigid end cap case assembly station. From the point of view of the interface, the second variant may be viewed as a subject of the first variant.

[0050] Thus, referring to figure 3, there is shown the steps in the transfer of a carrier and a product from a first module M to a second module N. Figure 3a) shows the steps that occur at module M and figure 3b) shows the steps that occur at Module N. The empty box represents an empty position; a filled box represents the carrier, for example a mandrel, or a pocket; and a hatched box represents the product. The interface uses two bays which are positions at which the product and/or carrier can be positioned.

[0051] Initially, the carrier is at bay 2 and bay 1 is empty. The module M then completes its transaction by (i) putting the carrier and product in bay 1 (arrow 1 in fig 3a); (ii) moving to bay 2 (arrow 2) and then (iii) picking up the product. The robot picks up the empty carrier from bay 2 and removes the carrier back to its process (arrow 3). The position is now as shown in figure 3 (b) with the carrier and product in bay 1 and an empty slot at bay 2. Module N then completes its transaction in three steps: (i) Module N puts the carrier at bay 2 (arrow 1 in fig 3b) - Note this is a carrier from module N and not the carrier from module M; (ii) the carrier is then moved to bay 1 (arrow 2); whereupon (iii) the product is placed on the carrier and both are picked up by Module N for its process (arrow 3).

[0052] In both cases, the product and/or carrier are picked up by robots under the control of the individual modules.

[0053] The double transfer mechanism interface is an extension of the single transfer interface of figure 3 and is shown in figure 4. In this transfer, a pair of products are picked up and moved, at the same time, from one module to another. As with the single transfer interface there are two basic variants. First, a carrier and product are carried forwards and an empty carrier passed down. Second, only the product is passed forward. Again, the second variant is a subset of the first. The manner in which this is handled is shown in figure 4. As well as showing the sequence of movements, the configuration allows for the possibility that a product in a product pair might be faulty and marked for rejection.

[0054] Thus, referring to figure 4, two products are shown in place of a carrier at Module M and are to be moved, one-by-one, by Module N. Two bays are provided for each of the product/carrier pairs, shown as bay 1a and 1b, 2a and 2b. At the start, the carrier is at bay 2 and bay 1 is empty. Module M completes it double transaction by putting the carrier and product at bays 1 a and 1b, moving to bay 2. and then picking up the products. The robots pick the carries from bays 2a and 2b and take them back to the process. These carriers are empty.

[0055] Module N then completes the sequential transactions. First, a carrier is placed from process to bay B1 (arrow 1 in figure 3b). Then, the robot is moved to bay A1 (arrow 2) and the robot picks up the carrier and its product and returns it to the module to carry out its process (arrow 3). The module then completes its second transaction putting the carrier of bay B2 using the robot (arrow 4); moving the robot to bay A2; (arrow 5); and then picking up the carrier and product with the robot and moving them back to the Module N to perform its process.

[0056] It is possible that one or both of the products could be rejected due to a detected fault. In that case, where both products are rejected by Module M, Module N simply misses a cycle. Where only one product is rejected by Module M, there will be an empty carrier, so Module N only performs the transfer process once.

[0057] Figures 5 and 6 show various typical interconnectivities between modules. In these firgures, I/F refers to Interface. The software controlling a module has to support the mechanical interface. In the previous examples, we have considered the transfer of goods with or without a carrier from one module to an adjacent module. However, there may be more than one input interface to a module and more than one output. As the interfaces are generic, any module must be able to cope with the greatest number of inputs and outputs. In practice, modules may be four sided in plan. They comprise a work surface onto which components are mounted. The work surface is mounted on top of a cabinet which houses control and electrical circuitry for the module. From a practical point of view it is only feasible for a module to interface with three other modules to allow one side of the module to be used to gain access to the cabinet. At a minimum it must be possible to open the cabinet door.

[0058] Figure 5 shows a module N with two in-feeds, one out-feed and a supervisory interface. This requires a total of four interfaces.

[0059] In figure 6, Module S has two mainstream in-feeds from twin track and one side feed. Thus, Module S has three in-feeds, module M has two out-feeds and every module has a supervisory interface. It will be noted that the arrangement in figure 5 breaks the physical requirement to use all four module faces. Thus, it is prudent for the module interface structure to be designed for three infeed streams, two outfeed stream and one interface to the supervisory system.

[0060] Figure 7 illustrates the basic handshake for a pick between two modules. A module having a second side input merely replicates this interface. In figure 7, three states are shown: "product present"; "access request"; and "access granted". The product state is vacant until Module M presents the product. The state then switches to high indicating product present to request a product pick. The access request state then goes high, requesting a lockout by Module N and the access granted state goes high, granting that lockout by Module M. The product is then picked. On completion, Module N sets the product state back to vacant, the access request goes low to release access by Module N and the access granted state is cleared in response.

[0061] Figure 8 shows a similar handshake for product placing. The same three states: product, local access request and local access granted are present, however, the product state can move through four levels: vacant, RPC (Remote Procedure Call - a generic mechanism that allows a module to invoke an action by an adjacent module) request, RPC granted and aged product. An aged product is one which is allowed to cool or glue allowed to set for a period of time, the ageing time.

[0062] Initially, the product state is vacant. A local access request by Module M causes the Local Access Request state to go high, requesting a lockout. The Local Access Granted state then goes high granting the lockout to Module M. A product is then placed by Module N, changing the product state from "vacant" to "request RPC", when Module N sees the "request RPC"; and executes the RPC, for example activating the lock, and sets the product state to RPC completed. Now, robot M can release while ageing starts. Module M sees the "RPC completed" status and sets "Access request" low to release access by Module N. The "Access granted" state is then cleared in response. In parallel with the local access request and granted signals going low, the interface sees "RPC completed" and after an ageing time sets the product state to "Aged Product".

[0063] Figure 9 shows the interface for a module that communicates with two other modules M and N. Product from M goes high to request a pick from M and waveforms a) -g) represent respectively: a) the product state between modules M to P; b) the product state between modules N to P; c) the locking state between modules P to M; d) the locking state between modules P to N; e) the locked state between modules P to N; f) the locked state between modules N to P; and g) the picking of product by module P from M.

[0064] Product waveform a) will go low until Module M presents product. Product waveform a) will then go high to request a pick from Module M and locking waveform c) will go high requesting a lockout by Module P. The locking waveform e) goes high to grant lockout by module M to P and in parallel, the product waveform from N (b)) goes high as product becomes available. This is ignored by Module P which is already negotiating with module M. The picking waveform g) then goes high to indicate picking by Module P and picking and locking (waveform c) go low to indicate that product has been picked by Module P. Module P now sees product from N and sets locking waveforms d) high requesting lockout. The process then repeats for the negotiation between modules P and N. If both modules try and lock simultaneously, an arbitration algorithm is used. This might simply always select Module N. The losing module will see the product single go low and reset its interface awaiting the next product.

[0065] Multi-position interfaces are derived in the same manner as described above with the addition of the bay concept described with respect to the mechanism interface. When asking for access, the interface routines can either specify a specific bay or have bay = 0 to return any free bay number, for a place operation, or any occupied bay number, for a pick operation to indicate which position can be used. If an interface cannot specify a valid bay number, the number returned is zero indicating that the request cannot be satisfied.

[0066] Figure 10 shows the overall architecture of the software for a modular packing system embodying the invention. Although as described, each module is self controlled and interacts with neighbouring modules as described, the entire system is controlled by a system controller. The movement of product and carriers from module to module is preferably performed by robots, for example as provided by Adept Technologies Inc. At least some of the modules include an Adept ^{TM} robot controller under the control of a central controller which is responsible for coordination functions.

[0067] Thus, a packaging process may be implemented by a number of individual modules each of which can be configured to perform a function and to interact with adjacent modules in the manner discussed. The modules may be reconfigured, and additional modules added, or modules renowned to adapt to different packaging techniques.

[0068] Figure 11 shows one example of module reconfiguration. Many others are possible. Figure 11 illustrates how the modules of figure 1 can be reconfigured to form a packaging process for a very different pack type, here a cardboard pack. The figure 11 process is more complex, requiring more modules. However, it can be formed by rearrangement of the figure 1 modules including their robots, together with the addition of further modules. This approach contrasts with conventional packaging which uses gears, belts, shafts, cams, linkages and belts to produce high speed, high reliability systems. The present approach handles product using pneumatics, robots and under the control of servo motors to enable a highly flexible, configurable and programmable approach to the construction of packaging processes which is ideal for low volume production.

[0069] The hopper can be the same as that used in the figure 1 embodiment and cigarettes are transferred to collation pockets via collation mandrels. The configurations of the holes in the mandrels, and the shape of the collation pocket may be different form that of the figure 1 embodiment. However, this is easily handled by adjusting the programming of the robot controlling the mandrel position. The system is controlled from the same service module and HMI as the figure 1 embodiment.

[0070] Thus, in figure 11, there are illustrated flexible modules 200 eleven of which include Cartesian, SCARA, or Anthropomorphic robots a) to k). Two sets of reel feed modules 220 are provided, one of which includes a Cartesian, SCARA, or Anthropomorphic robot. In addition three blank delivery modules 230 are provided for delivering card or plastic blanks into the process and hot or cold gluing stations are provided at three of the flexible robot modules.

[0071] The flexible module having robot a) corresponds to the module that transfers the filled pockets from the hopper to the rigid end cap case fill module in figure 1. Flexible module 200 including robot b) is a foil wrapping station at which foil delivered from foil delivery modules is wrapped around the collation. At a blank feeder module, an inner face is delivered and handled by robots d) and c) where the frame is glued and passed on to a module housing robot e). Top and body blank feeders are arranged on either side of this module supplying blanks via robots f) and g). At the module housing robot g), tabs and the inner lids on the top blank are glued using a hot glue unit and at the centre module a Z plane fold is made in the blank assembly. The partially folded blank is passed to the module housing robot h) where end tucks, side folds and a final seal using a cold glue applicator are made and at a further station the packs are passed to a tax stamp applicator. Robot I) module handles application of a date code to the pack and also drying of the pack prior to wrapping. The pack is then passed to robot j) which interfaces with a cellophane wrapper and tear tape applicator station and handles wrapping of the pack. Finally, robot k) is responsible for controlling and heating of the wrapped pack prior to final dispensing of finished packs down an end chute.

[0072] From the foregoing description it will be understood that whatever the packing configuration chosen, the pack is formed around the articles. The articles may first, if required, be formed into a desired collation although the necessity of this step will depend on the nature of the articles being packed. The forming of the pack around the articles occurs no matter what type of pack is being made. Thus, in the figure 11 embodiment, cardboard blanks are used. These are not preformed into packs either wholly or partially but are formed *in situ* around the articles. This approach to pack formation makes reconfigurability of the packing system more easy to attain. The same approach of forming the pack around the article is taken regardless of the nature of the pack.

[0073] It will also be appreciated that embodiments of the invention vastly speed up the change from one pack assembly to another, making low capacity production feasible. By forming packs around the articles, and using reconfigurable modules, a system may be switched from producing one pack to another in a matter of weeks rather than months, vastly reducing the associated cost.

[0074] It will be appreciated that the two configurations of modules described in figures 1, and 11 are only two examples of possible configurations. The invention is not limited to these or any other configurations but resides in the reconfigurability of the modules to form a desired packaging process. The invention is limited only by the scope of the following claims.

Claims

1. A packing system for packaging articles in a pack, comprising a plurality of interconnected modules, each module comprising tooling for performing a part of the packaging process, and at least some of the modules comprising a robot for moving articles between modules.

2. A packing system according to claim 1, wherein the robots move articles and article carriers between modules.

3. A packing system according to claim 1 or 2, wherein at least one of the modules comprises a robot for performing a packing process.

4. A packing system according to claim 1,2 or 3, wherein the robots are Cartesian, SCARA or Anthropomorphic robots.

5. A packing system according to claim 1, 2, 3 or 4, wherein the modules include at least one module for delivering reel-fed materials.

6. A packing system according to any preceding claim, wherein the modules include at least one module for delivering packaging blanks.

7. A packing system according to any preceding claim wherein at least one of the modules includes a gluing station for gluing packages.

8. A packing system according to any preceding claim, wherein each module includes a module controller for controlling the module tooling.

9. A packing system according to claim 8, wherein the control system of modules includes robot controllers for controlling movements of the robots.

10. A packing system according to claim 8 or 9 wherein the control system of each module comprises interface software for interfacing with the control system of adjacent modules to move articles between modules.

11. A packing system according to claim 10, wherein the control system of a first module includes software for moving articles to bays between the first module and a second module and the second module control system includes software for picking the articles from the bay or placing articles in the bay.

12. A packing system according to claim 10, wherein the articles to be packaged are mounted on a carrier and the articles and the carrier are moved to the bays at the first module and moved from the bays at the second module.

13. A packing system according to claim 11 or 12, comprising first and second bays, wherein the product is placed at the first bay from a first module process, moved to the second bay under the control of the first module control system, moved back to the first bay and transferred to the second module process.

14. A packing system according to any of claims 11 to 13, wherein the software for moving articles between modules includes a article state, an access request and an access granted, wherein the access request and granted states enables lockout to be established between adjacent modules.

15. A packing system according to any of claims 11 to 14, wherein interfaces are defined between each module and all adjacent modules to define the movement of articles therebetween.

16. A packing system according to any preceding claim, wherein the modules are reconfigurable.

17. A packing system according to any preceding claim, wherein the articles to be packaged are rod-shaped articles.

18. A packing system according to any preceding claim, wherein the articles to be packaged are cigarettes.

19. A packing system according to any preceding claim, comprising a system controller for providing coordinating control of the modules.

20. A packing system according to any preceding claim, wherein the pack is formed around the articles.

21. A packing system according to claim 20, wherin the articles are first formed into a collation and the pack is formed around the collation.

22. A set of reconfigurable modules for forming a packing system, the modules being interconnected and each having removable tooling for performing a part of the packing process, at least some of the modules including a robot for transfer of articles between modules, each module having a module controller for controlling the part of the packaging process performed by the module and for coordinating transfer of articles between the module and adjacent modules.

23. A set of reconfigurable modules according to claim 22, wherein at least one of the modules comprises a robot which performs a packing process.

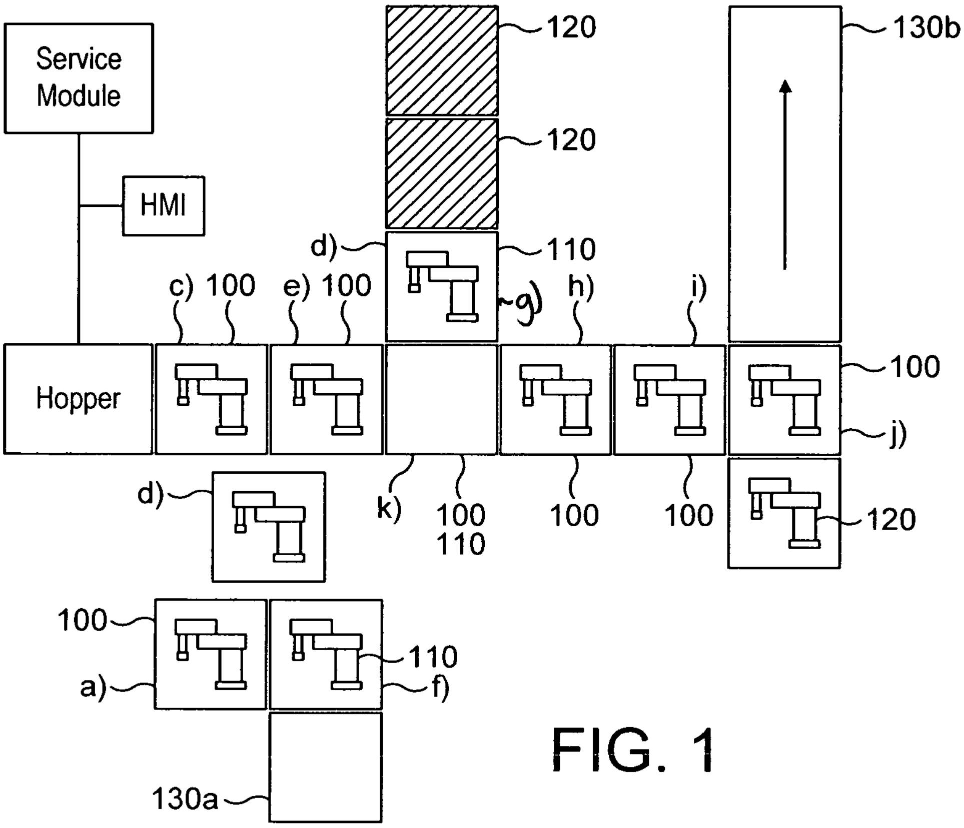
Service Module
HMI
Hopper
120
120
130b
d)
110
c) 100
e) 100
g)
h)
i)
100
j)
d)
k)
100
110
100
100
120
100
a)
110
f)
130a

FIG. 1

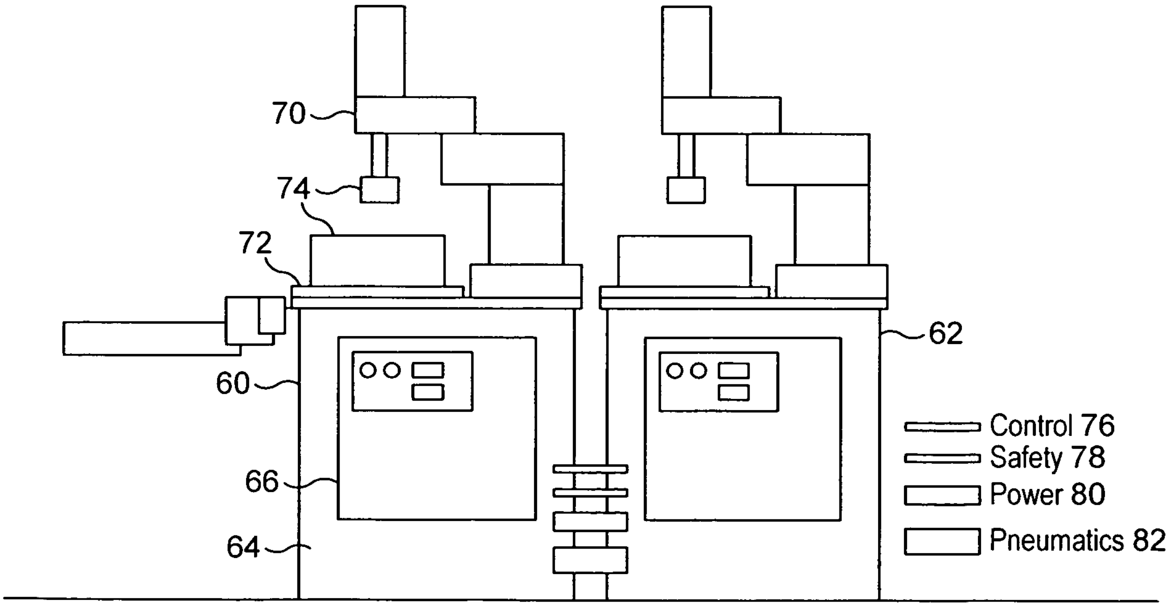
70
74
72
60
66
64
62
Control 76
Safety 78
Power 80
Pneumatics 82

FIG. 2

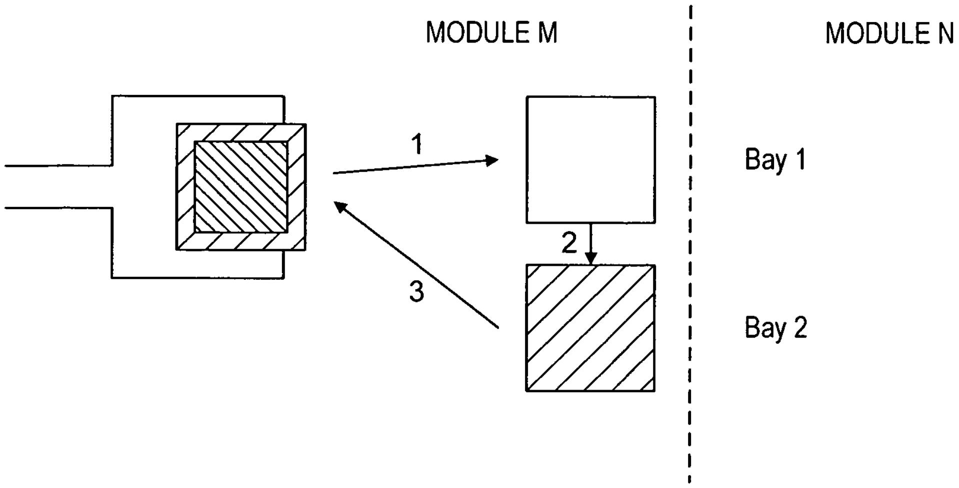
MODULE M
MODULE N
1
2
3
Bay 1
Bay 2

FIG. 3a

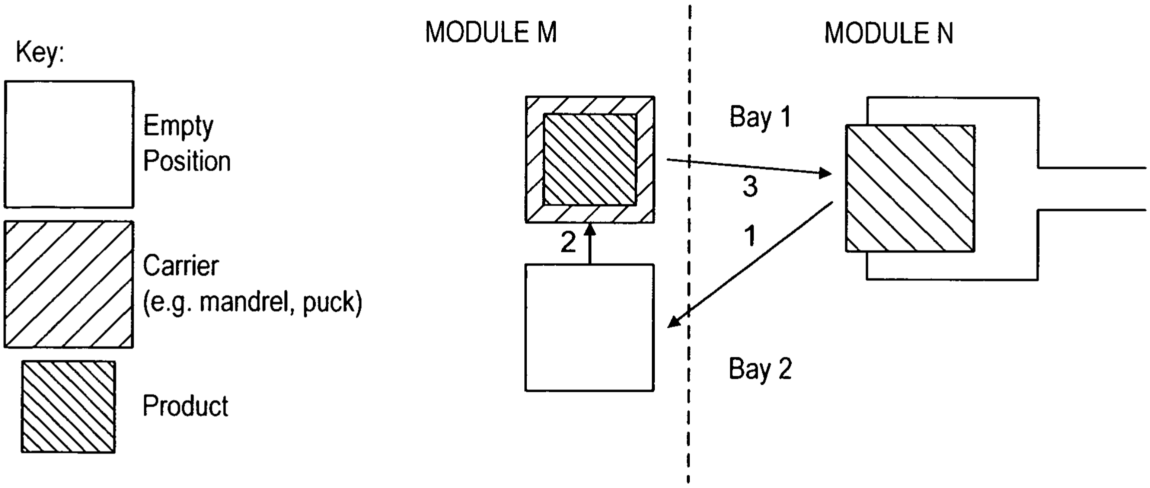
Key:
Empty Position
Carrier (e.g. mandrel, puck)
Product
MODULE M
MODULE N
Bay 1
Bay 2
1
2
3

FIG. 3b

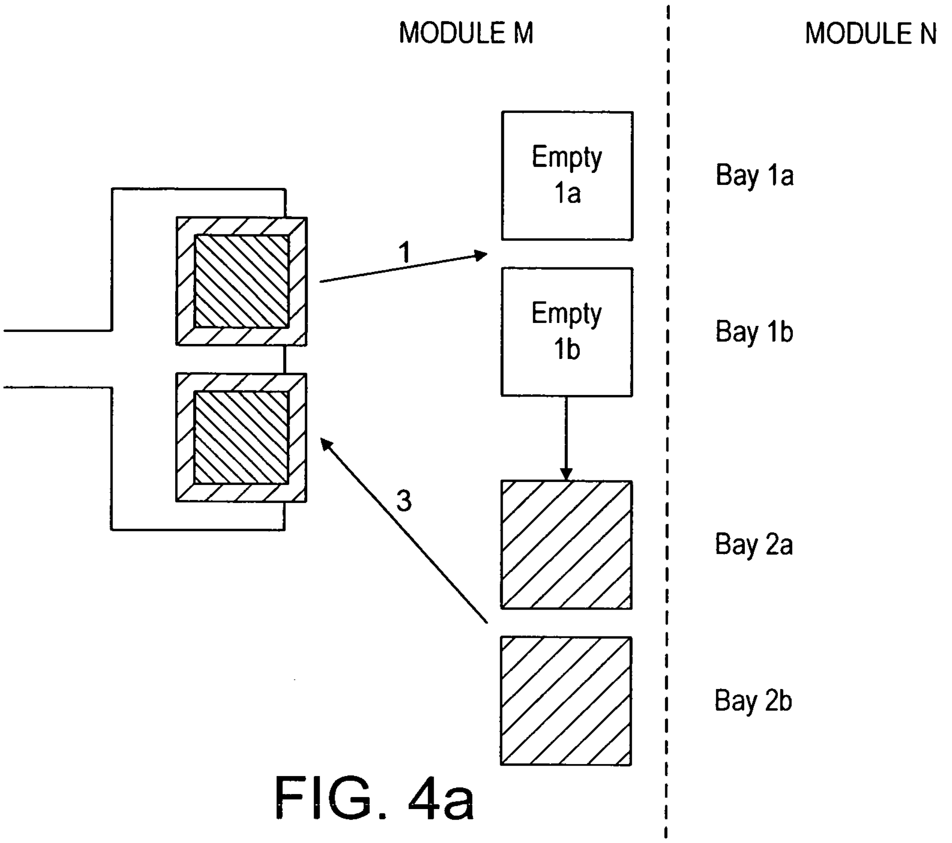
MODULE M
MODULE N
Empty
1a
Empty
1b
1
3
Bay 1a
Bay 1b
Bay 2a
Bay 2b

FIG. 4a

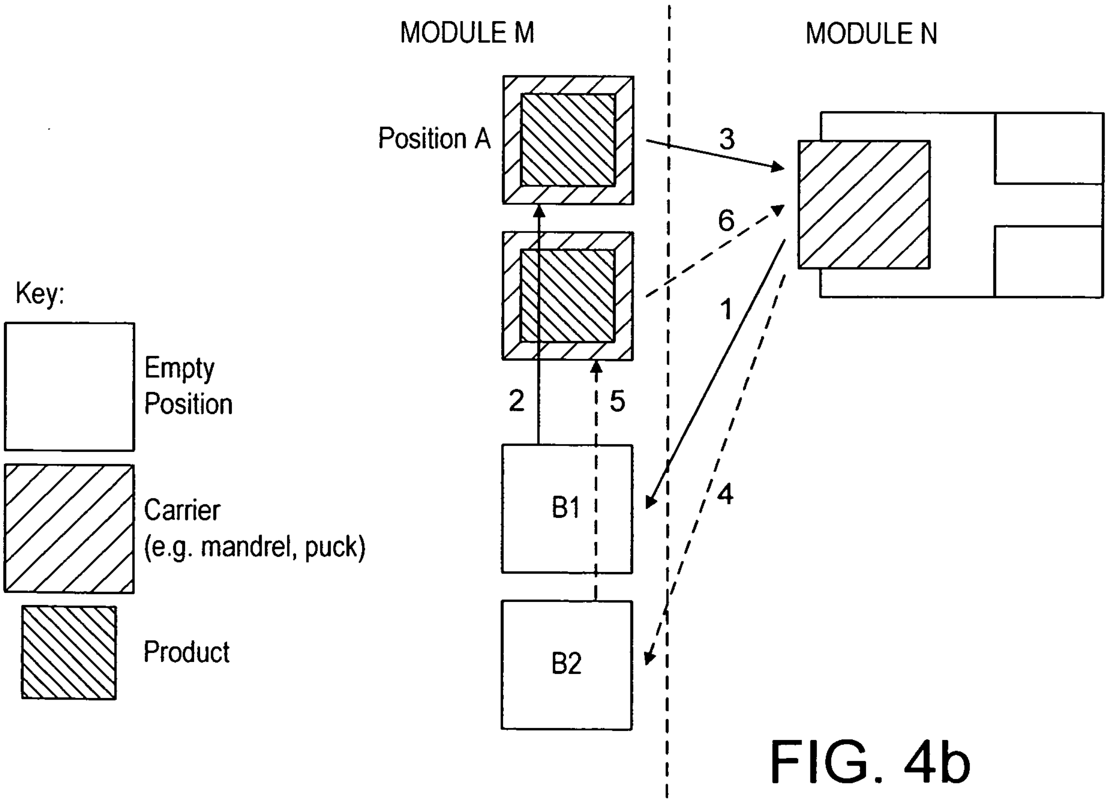
MODULE M
MODULE N
Position A
3
6
1
2
5
4
B1
B2
Key:
Empty Position
Carrier (e.g. mandrel, puck)
Product

FIG. 4b

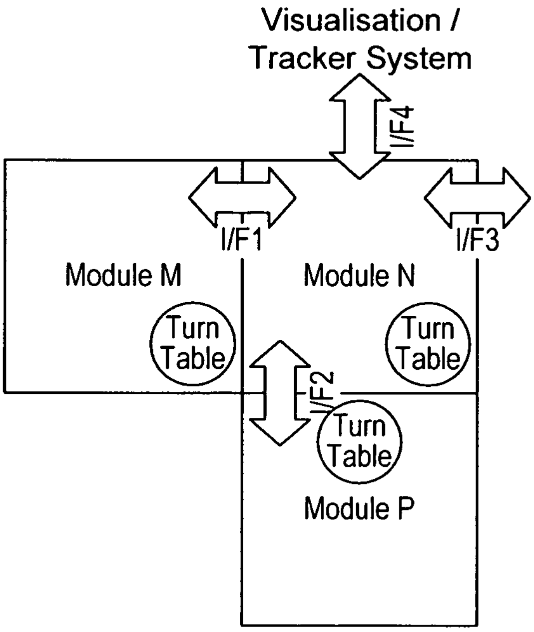
Visualisation / Tracker System
I/F4
I/F1
I/F3
Module M
Module N
Turn Table
Turn Table
I/F2
Turn Table
Module P

FIG. 5

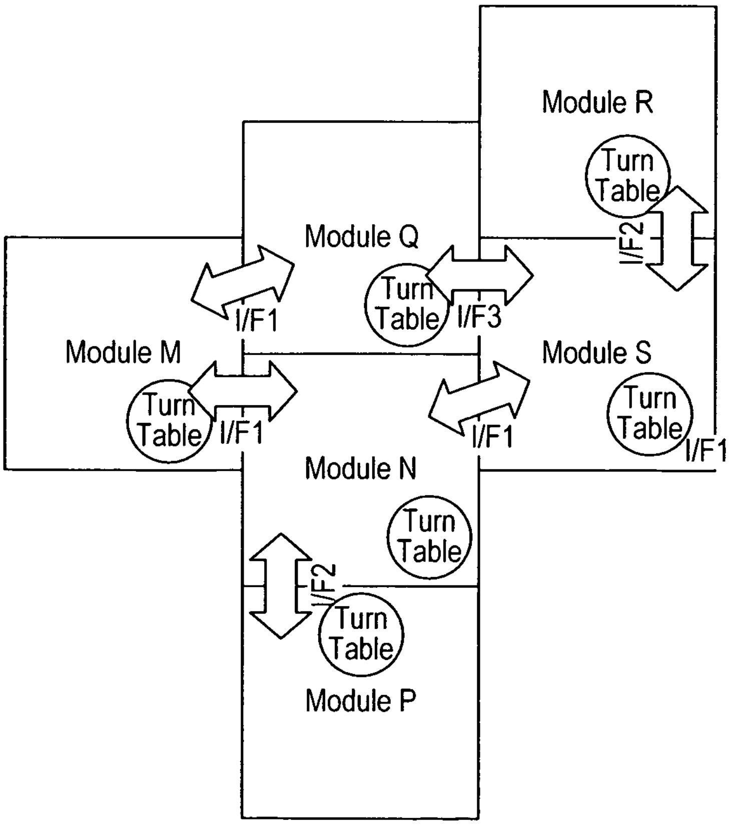
Module R
Turn Table
Module Q
I/F2
I/F1
Turn Table
I/F3
Module M
Module S
Turn Table
I/F1
I/F1
Turn Table
I/F1
Module N
Turn Table
I/F2
Turn Table
Module P

FIG. 6

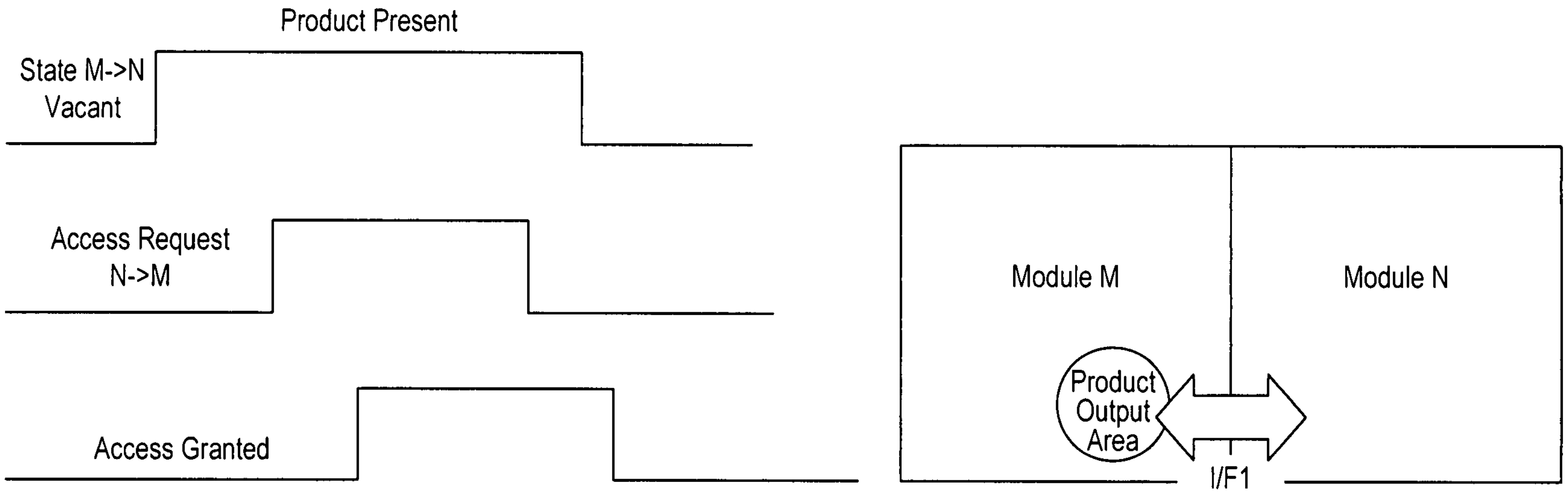
Product Present
State M->N
Vacant
Access Request
N->M
Access Granted
Module M
Module N
Product
Output
Area
I/F1

FIG. 7

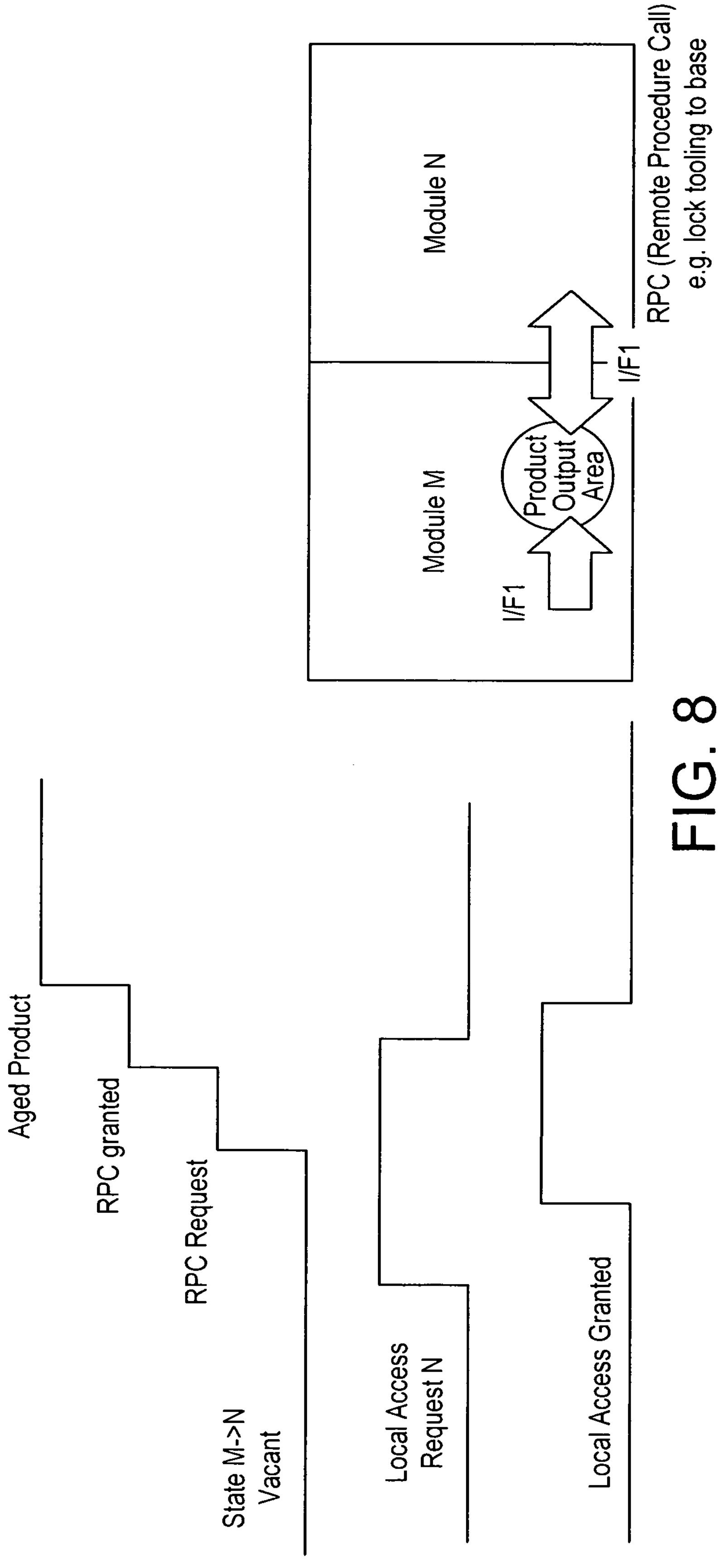
Aged Product
RPC granted
RPC Request
State M->N
Vacant
Local Access
Request N
Local Access Granted
Module M
Module N
Product
Output
Area
I/F1
I/F1
RPC (Remote Procedure Call)
e.g. lock tooling to base

FIG. 8

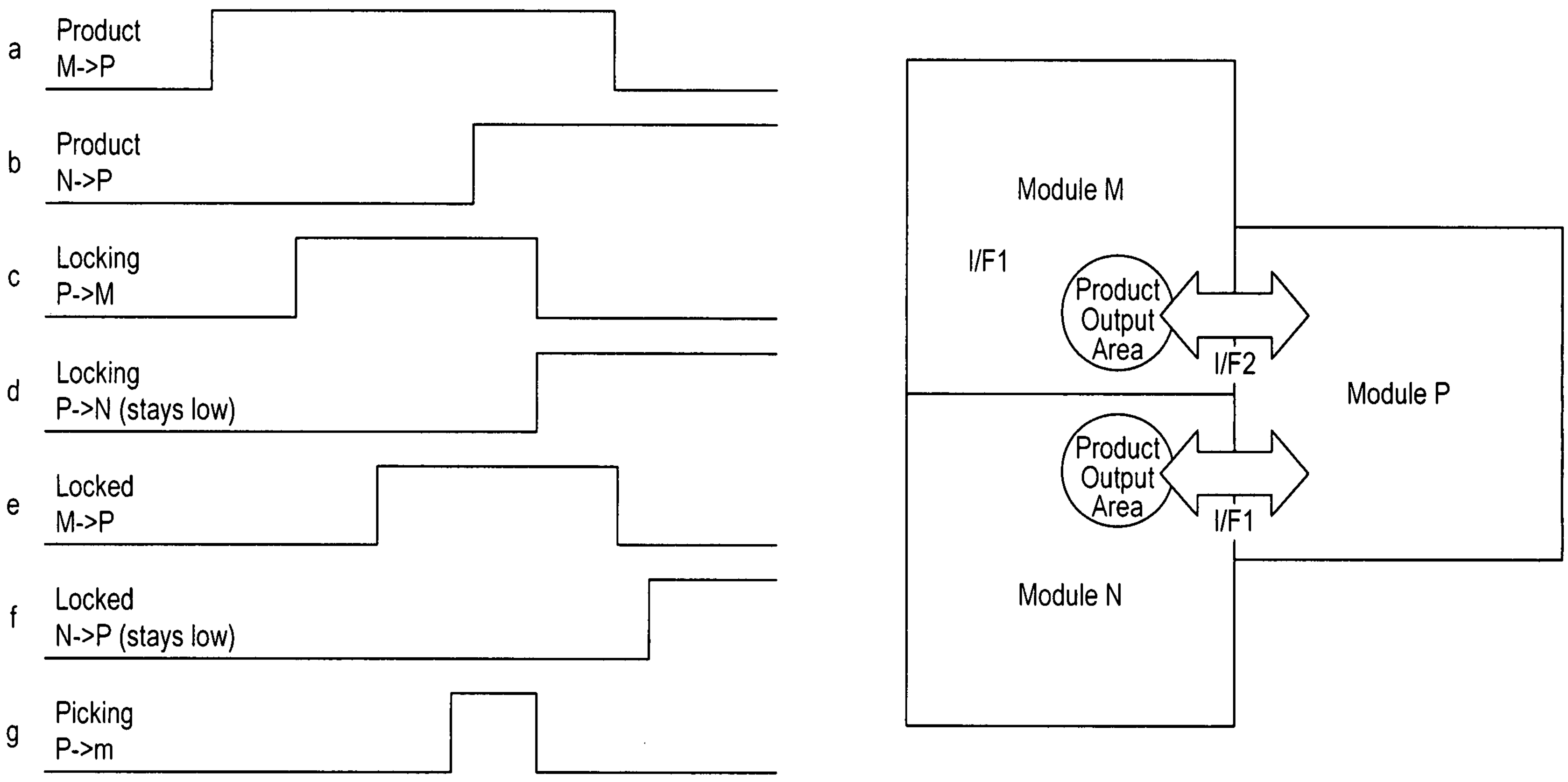
a
Product
M->P
b
Product
N->P
c
Locking
P->M
d
Locking
P->N (stays low)
e
Locked
M->P
f
Locked
N->P (stays low)
g
Picking
P->m
Module M
I/F1
Product
Output
Area
I/F2
Module P
Product
Output
Area
I/F1
Module N

FIG. 9

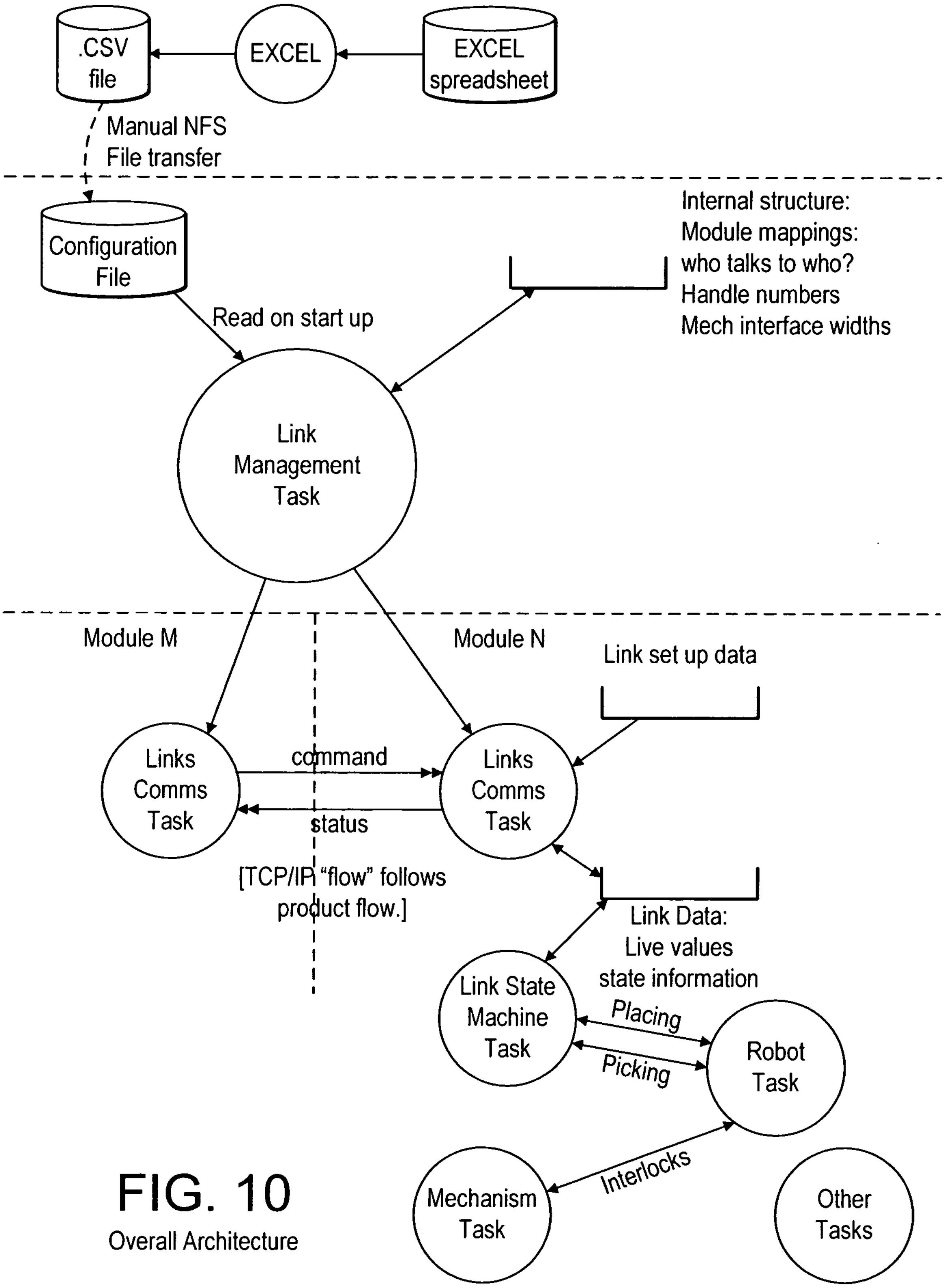

FIG. 10

Overall Architecture

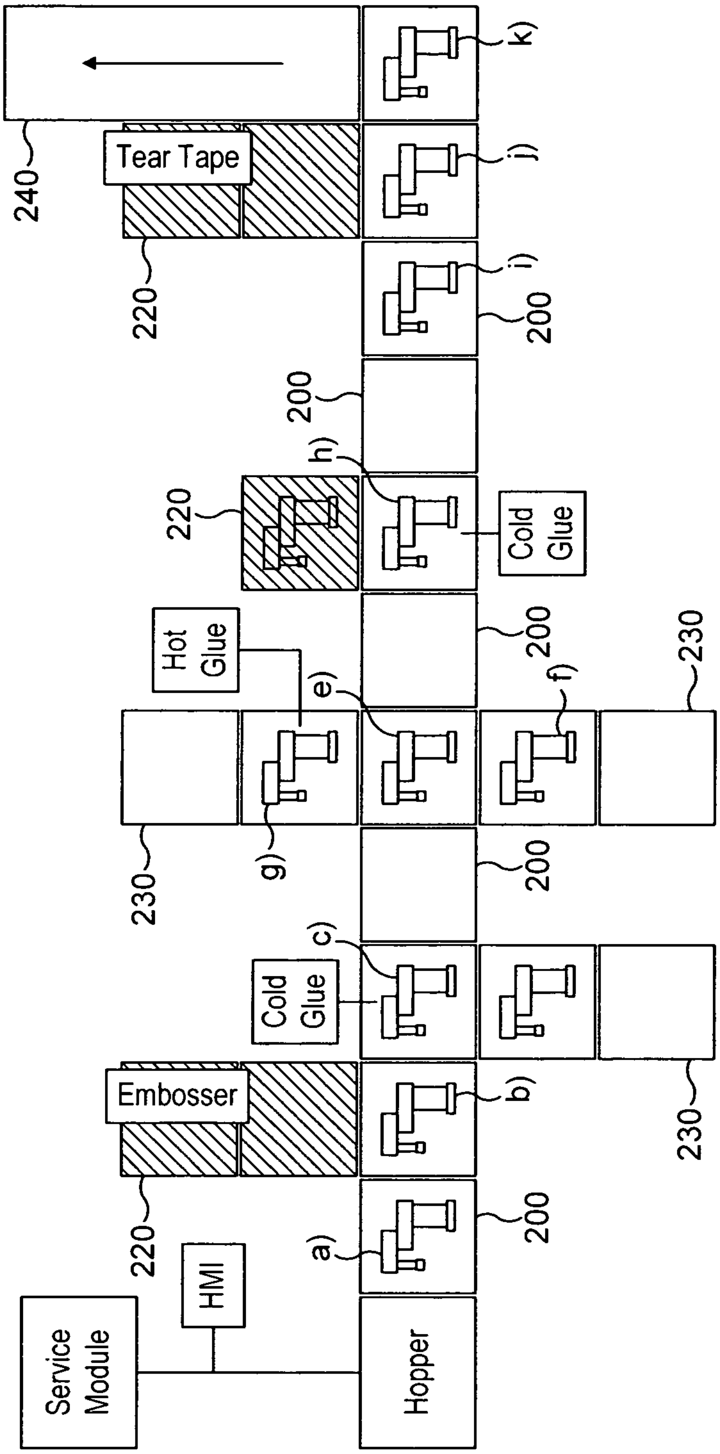
Service Module
HMI
Hopper
220
Embosser
a)
200
b)
230
Cold Glue
c)
200
230
g)
Hot Glue
e)
f)
200
230
220
h)
Cold Glue
200
220
Tear Tape
240
i)
200
j)
k)

FIG. 11