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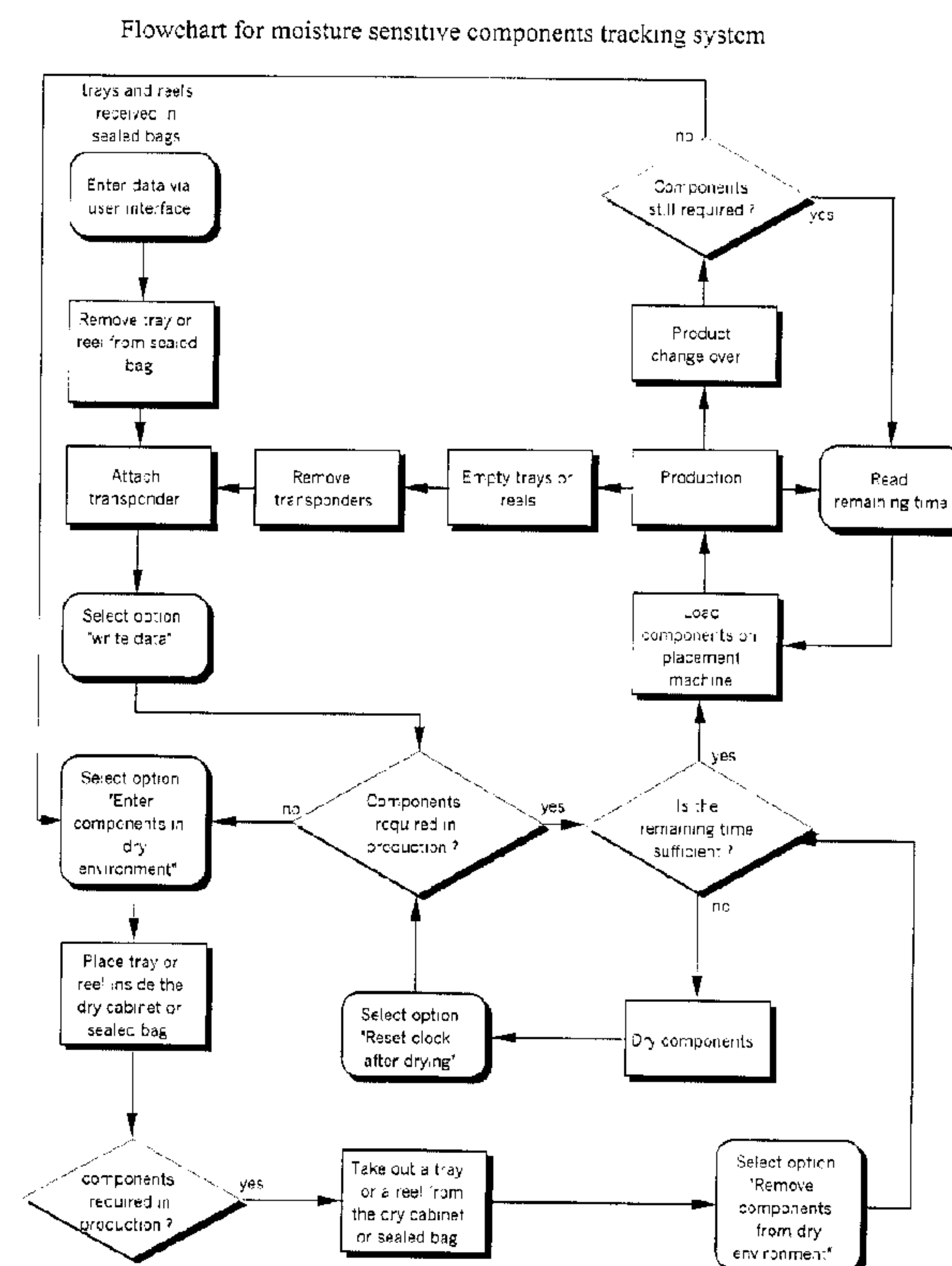
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(54) Titre : SYSTEME AUTOMATISE DE CONTROLE DE LA PRODUCTION

(54) Title: AUTOMATED MANUFACTURING CONTROL SYSTEM



(57) **Abrégé/Abstract:**

An automated manufacturing control system greatly reduces the human interaction relative to the data transfer, physical verification and process control associated with the movement of electronic components in a PCB assembling plant. This is achieved by the use of data carriers, which are attached to the packaging, e.g. trays, reels and tubes. These data carriers can store all the relevant material and production data required by the various elements of the manufacturing system. Various readers, integrated with controllers and application software, are located at strategic points of the production area, including production equipment and storage areas, to enable automatic data transfer and physical verification that the right material is at the right place at the right time.



Abstract**AUTOMATED MANUFACTURING CONTROL SYSTEM**

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This is achieved by the use of data carriers, which are attached to the packaging, e.g. trays, reels and tubes. These data carriers can store all the relevant material and production data required by the various elements of the manufacturing system. Various readers, integrated with controllers and application software, are located at strategic points of the production area, including production equipment and storage areas, to enable automatic data transfer and physical verification that the right material is at the right place at the right time.

AUTOMATED MANUFACTURING CONTROL SYSTEM

Field of the invention

The present invention relates to PCB assembly plants using surface mount technology.

Background of the invention

In a PCB assembly plant, there is a large number of electronic components, which must be assembled on a PCB with the use of automated production machines of various kinds, following a number of pre-determined specifications and processes. These activities must be performed for multiple products, each one having a unique combination of materials and corresponding tooling and machine programs. In general the complexity and risk of errors is directly proportional to the quantity of different products that must be produced on a given assembly line and the resulting production changeovers.

In most of these environments a human operator is the central element responsible to interface with the various other elements of the manufacturing system, including the movement of the material, the proper operation of the equipment, the process control and the data transfer between the various elements.

Manual data transfer

In a manufacturing environment, each time that a human is required to perform a given task represents an opportunity for error. This is a growing concern since the quantity and complexity of human interactions tend to

increase with the increasing complexity of the products being manufactured and the associated manufacturing systems.

The type of information that is associated with electronic components and their packaging generally falls within one of the following categories :

Identification data : Manufacturer, Part Number or Model, Lot Number, etc.

Physical data : dimensions, quantity, temperature rating, etc.

Process data : Process step, history, status, time, process parameters, expiration date, etc.

This data needs to be read, verified, modified, stored into a system or a machine at multiple stages of the production process. This is normally done through the intervention of an operator. In the simplest case, the data will be read visually and written on a piece of paper or entered in a computer system, with the use of a keyboard.

Auto ID Technology

In order to ease the burden for the operator and to reduce the risk of human errors, there exist a number of Automatic Identification (Auto ID) techniques that are used at various stages of a PCB assembly. These systems, such as barcode, RFID, Optical Character Recognition, are often used to provide a simple identification of an object and their primary benefit in this case is to reduce the time and possible errors associated with the manual entry of this information.

Barcode Technology

One general inconvenient of using barcode labels to identify electronic products is the fact that their installation and removal can generate static electricity, which can damage sensitive electronic devices. In addition, a sufficiently large flat area is required to apply a barcode label. This is often restrictive in the world of electronics packaging due to the ongoing trend toward smaller and denser products. Finally all barcode readers require direct line-of-sight with the barcode label. This can be a major restriction toward complete automation of the reading operation.

RFID Technology

In addition to barcode labels, which have now become fairly common on many standard materials and containers, some manufacturing systems take advantage of the greater capabilities associated with the use of Radio Frequency Identification (RFID) technology. A typical RFID system is always made up of two components: the transponder, which is located on the object to be identified and the interrogator or reader, which, depending upon design and the technology used, may be a read or write/read device (in this text – in accordance with common usage – the data capture device is always referred to as the reader, regardless of whether it can only read data or it is also capable of writing).

The RFID technology offers multiple benefits when compared to other alternatives such as barcode. Some of the key benefits from the perspective of factory automation include the greater flexibility in packaging, greater and more flexible read-range and larger data storage capability.

Another very significant benefit of RFID technology is related to the read and write capability (as opposed to read only). In addition to recording the identity of the object, it is also possible to track its current state (e.g. processing level, quality data), and the past and future (desired end state) of the object.

There are two possible methods of controlling a system based upon object data: central and decentral control. In the first method, all elements of the system must be connected, through a network or other means, with a common database in a central computer. In this case, a unique identification number can be stored on a RFID transponder to access all of the relevant data stored in the database.

In the second method, the use of readable and writable data carriers opens up the possibility of controlling a system locally, i.e. completely independently of the central process computer. Material and data flow become interlinked. In a manufacturing environment this is very significant since it may be impractical to have all machines and manufacturing systems connected to a single network and central database. This is especially true when a manufacturing process is made up of multiple production steps which may be performed in separate autonomous plants.

Tooling Identification

In the field of electronics manufacturing, a transponder is integrated in a component feeder which is used to feed electronic components to an automatic placement machine. Details of this prior art can be found in patent US5713125. The benefits and shortcomings of this method can be found hereinbelow in the section "Feeder Set-up Validation".

Carrier Identification

There exist other applications and prior art relative to the use of RFID technology to identify temporary production carriers. In one application, a transponder is inserted in a magazine that carries wafers through multiple operations (ref. WO0002236). In this case, the identification data is relative to the main product being manufactured. In a different application, transponders are inserted in a pallet, which carries material between various processing stations. Other relevant prior art is described in DE19745228.

These applications are limited to a single type of carrier and they offer a limited range of applications and a limited interaction with external systems.

General disadvantages of existing systems

A number of independent Auto ID based systems are commonly used in a PCB assembly environment and the actual shortcomings of each system will be reviewed in detail in the following section. The major drawback of these methods however is the fact that they have not been designed from a complete integrated systems approach which means that they cannot address all of the data transfer applications of a given material and associated carrier during its complete life cycle. At the same time, many systems are not designed to enable complete automation of the data transfer and verification of the physical location of the material.

In the current electronics manufacturing environment, there are many Auto ID applications using traditional barcode based identification for

which the infrastructure and industry standards are well developed. There are also a few isolated RFID applications but these systems tend to be costly and difficult to implement due to the lack of standardization. As such, it appears critical that any investment in RFID technology must be leveraged by enabling multiple applications with the same transponders and readers, and a higher level of automation than is possible with barcode technology.

Example : Identification of trays and reels containing electronic components

Depending on the relative size and cost of each type of components, they may be individually marked during their manufacturing process (fig. 2). However in general the electronic components are tracked by batch number and physically they are managed by individual reels, trays or stacks of trays.

The reels and trays are standard containers which are used as a packaging and shipping container as well as a convenient mean to feed components to an automated placement machine.

It is a common practice for the manufacturers of electronic components to apply a barcode label to the reel which contains the electronic components (figs.3a and 3b). The data, which is normally found on the barcode labels, includes the part number (supplier and/or customer), batch number and quantity of the components on the reel. One common problem in this case is the fact that there is no recognized standard barcode label to identify reels of components. In order to simplify and standardize the information format for the operators, some card assembly

locations apply their own labels to each reel of component prior to releasing them to the production area.

The standard IC trays, by virtue of their physical characteristics, do not lend themselves well to traditional barcode identification. Their standard outline does not offer a flat surface of sufficient size to apply a typical barcode label (fig. 4a). In cases like this, the identification data is usually not attached directly to the container. For example, the part number and batch number can be written on a separate element such as a bag, sheet of paper, edge of a shelf, etc. The obvious disadvantage of this method is that it is easy for the operators to misplace or mix-up a tray during normal handling and to lose the association between the data and the material.

The following section describes specific applications where the manufacturing systems require proper identification and process control associated with the reels and trays of components.

Tracking of moisture sensitive components

There exists a great variety of electronic components that are made up of plastic or organic materials which tend to absorb ambient moisture in a manufacturing environment. Because of the high temperatures experienced during solder reflow of the components on the printed circuit boards, these components can suffer internal damage in the form of cracks and delamination if they are allowed to absorb too much moisture prior to the actual reflow cycle. This problem has been well documented and there are some industry standards that specify the proper shipping, storage and handling procedures for moisture sensitive electronic components.

The standard procedure dictates that the moisture-sensitive components, which are typically packaged in trays or reels, must be placed by the manufacturer inside of sealed dry bags with desiccants and humidity indicators. The bag seal date must be indicated on the label because there is a maximum specified shelf life for storage of the components in the dry bags (fig. 4c). The user of these components, which is located at the card assembly plant must verify that the expiration date has not been exceeded prior to opening the package.

Once these bags are opened at the card assembly locations, there is a pre-determined number of hours or days to which the components can be exposed to ambient air prior to placement and reflow. The maximum exposure time varies for each component and this data is also found on a label which is located on the dry bag.

In a typical production environment, the actual number of hours and days of exposure must be tracked manually for each individual tray and reel of moisture sensitive components. This information can be recorded on labels applied to the reels or protective bags or it can be logged on separate sheets of paper.

There exist provisions in the standard to account for storage time in a dry environment. This means that the clock of the total exposure time can be suspended while the product is maintained in a dry cabinet for example but the cumulative time must be tracked once the parts are returned to production.

This manual tracking process is very cumbersome and not very reliable which results in considerable inefficiencies. Furthermore, due to the high

risk of human errors, the quality and reliability of the manufactured PCBs is not completely assured.

Another common concern relative to moisture-sensitive components is the risk associated with the rework procedure. Whenever components have been over-exposed, the standard recommends that they be dried at a given temperature for a given period of time. There are normally two options available: a first drying process at room temperature and a faster process at high temperature. A problem can arise whenever the plastic carrier cannot stand the higher temperature. If the operator is not aware of this limitation, he may use the wrong temperature which will result in melting the carrier with the components and a significant waste of valuable material.

Feeder Set-up Validation

On a typical placement machine, multiple reels of electronic components must be installed on feeders and these feeders must be loaded at the proper location on a placement machine (figs. 8a and 8b). Since many components have the same physical packaging, but different electrical values, it is easy for an operator to load the wrong reel or the wrong feeder at the wrong location and the placement machine may not be able to detect the error. In this case, multiple PCBs can be assembled with the wrong components. In order to avoid this kind of error, it is often required that a different operator performs a second verification that the proper parts are loaded at the proper location. This verification process takes valuable operator and machine time and it is not completely error-free.

In order to reduce the above concerns, there exist versions of automated verification systems that are aimed at reducing this risk of human errors.

These systems are not available for every type of machine and they tend to be proprietary to each model of equipment. The vast majority of these systems require the operator to use a manual barcode reader to scan the part number data located on the barcode label on the reel of each component. This must be done at a specific point in time during the process of loading the reels on the feeders or the feeders on the machine.

Depending on the exact characteristics of the placement machine and associated feeders, this validation process may or may not need to be repeated each time that the feeders are loaded or removed from the machine. If the feeders themselves are equipped with a memory, the material data can be temporarily kept on the feeder and automatically recognized by the machine when the feeders are re-loaded. The major disadvantage of all these systems is that the process must be repeated every time that the reels are removed from the feeders. These considerations are mostly significant in a high-mix production environment where reels of components must be frequently removed and re-loaded from the placement machine. Furthermore, there exists no method to do this verification with some of the other types of carriers which do not have any automatic identification, such as trays and tubes.

Partial tray information

A typical placement machine normally picks and places components, using a placement head carrying one or more spindles fitted with vacuum nozzles. This head usually picks components directly from the trays located in a specific feeder and in a specific sequence, for example starting with the top row up moving down and by column from left to right. The placement machine normally starts with a full tray and it will remember the pick position of the last component that was picked from a

specific tray. This information is normally kept in the memory of the machine until there is a power shutdown or whenever a tray is removed from the machine.

In a production environment, it is very rare that a tray or a stack of trays will contain the exact number of components required for a given production batch. Hence, every time that a product change-over is performed, there is a significant number of partial trays that are removed from the machine to be kept in temporary storage. In order to insure a "first in, first out" material usage and to avoid the multiplication of partial trays, they are normally the first ones to be re-loaded in the placement machine for the next production run that requires this specific part number. Since the placement machine cannot recognize whether a partial tray or a full tray has been loaded, the operator must enter this data through the user interface of the placement machine. The operator must look at the partial tray and indicate exactly which pockets are empty and consequently where the machine will start picking. This step must be repeated for each partial tray that is loaded in the machine which consumes valuable operator and machine time during product change-over. In addition, there is a risk that the operator will forget to enter the data or enter wrong data in the placement machine. This can result in further production down-time and even damaging fragile and expensive components.

Component traceability and real-time inventory on a placement machine

In addition to the part number data located on the barcode labels of the reels, some placement machines can also use additional information, such as lot or batch number and quantity. In one example, the lot number is read from the label at the same time as the part number and this data is

used to keep a history file containing full traceability of which lot of component was used to build which lot of PCB. This information can be required due to the critical nature of the product being manufactured, such as military or medical devices.

In a similar system, the quantity of the components is also read from the barcode label at the same time as the part number and this information is kept in a local memory in the feeder or in a central database in the machine. This data can be updated as the machine is picking and placing components from that specific feeder. Some systems offer the possibility of re-printing a new barcode label with the revised quantity when the reels are removed from the feeder.

Once again, there exists no such system for components that are packaged in other types of carriers without automatic identification, such as trays and tubes.

Inventory and physical location of material in production

In the process of PCB assembly, it is common to have hundreds of different electronic components that must be assembled on a single PCB. Often, a critical production run cannot be started because of only one missing type of component. In some cases it is possible that there exists another reel or tray of components somewhere on the production floor but it cannot be quickly located.

In a typical manufacturing plant, the inventory control system can identify whether a specific lot of material has been released from the stockroom to the production area but this does not provide a sufficient level of detail to

quickly and efficiently locate the said material or to find out the remaining quantity.

In some cases, the control systems that are associated with the placement equipment can provide reports of the exact types and quantities of components that are located on a specific placement machine. However, this information is lost as soon as the reels and trays are removed from the machine (or when the reels are removed from the feeders if they have a local memory). In addition it is not possible to obtain a rapid and accurate inventory of the trays and reels that are stored in various boxes, shelves, carts, cabinets or other temporary storage areas on the production line.

In addition, in order to perform this type of physical inventory, it is required that each reel be handled by an operator. The reels are normally stored side-by-side and they must be pulled from their storage location to enable the labels to be visually seen or to provide the required line-of-sight for the barcode reader. Because of the nature of a reel, it is not possible either to determine the remaining quantity of components without unwinding the tape.

There also exist some handling difficulties specific to the trays. In most cases, the components are held within their respective pockets by the bottom of the next tray which is stacked on top of it. This means that there is normally an empty tray on top of each stack that is used as a protective cover. This cover tray may prevent the operator from seeing how many parts are left on the first tray which is often partially filled. If there are no top trays, then the parts can easily be dislodged from their pockets through normal handling and cause damage to the sensitive component leads.

The above considerations can lead to a significant waste of time for employees trying to locate material, to potentially damaging components, and to a resulting production downtime and subsequent delivery problems.

Inter-plant information transfer (fig. 7)

In general, the electronic components and/or its packaging have to be transferred from one facility to another for subsequent processing. In this case it becomes even more difficult to transfer and share product and process information through a central network.

Semiconductor Packaging Plant to Card Assembly Plant

The semiconductor packaging plant is often referred to as the first level of electronics packaging. This level of production normally starts with complete wafers received from the wafer manufacturing plant. The end product is a batch or lot of complete electronic components, which is properly packaged in reels or trays and ready to be assembled on a printed circuit board (PCB). The information required by the next level of assembly, which is the card assembly plant, is located on one or more labels which may be applied directly on the reel or on the protective bags and boxes.

Some of the information on these labels is available in a barcode format, which typically includes, but is not limited to : supplier ID, part number (supplier and customer), lot number, quantity. Additional data is sometimes printed on the label only in a text format, for example JEDEC moisture sensitivity level, maximum exposure time, packaging date and time, etc.

Tray Manufacturer to Semiconductor Packaging Plant

In this application, the tray manufacturer is the company that makes the plastic injection-moulded container. There are many basic parameters associated with each tray that can be required by the semiconductor packaging plant.

In many cases, the basic information data relative to the tray itself is embossed in the plastic moulding. This can include the name or logo of the manufacturer, the part number or model description, the engineering change or revision number, the batch number or date of manufacture (e.g. Month/Year), the maximum temperature rating, etc.

It is important to note that during the later steps of the semiconductor packaging process, the tray can be used as a component carrier. In this case, and prior to final packaging, the operators must verify that they are using the proper type of tray. If the wrong tray is used, this can result in damage to the electronic components during later shipment and processing. This can cause mechanical damage to sensitive component leads.

Another common issue relates to high temperature processing such as drying moisture sensitive components prior to final packaging in sealed dry bags. This operation can be done at a temperature of 125°C and the operator must ensure that the tray is rated for this temperature. Otherwise the tray will melt and damage the components that it contains.

Recycling of trays and reels

It is common practice for the card assembly plants to collect all of the empty containers and to send them to a recycling company. This will typically consist of large boxes full of mixed trays and reels of various types and models. The recycling company will start by sorting the trays, according to the manufacturer, part number or model description, EC#, etc. The trays and reels will also be inspected and cleaned before being resold to the original manufacturer or directly to a semiconductor packaging plant.

Design and assembly data

In addition to the identification elements of the materials required during normal production, there is a large quantity of design data required for the initial set-up of the various production systems and machines. This data is normally stored in each machine program database for later use.

In most cases, the components will be placed and/or removed from the tray by automatic machines. In order to create the initial machine program, some physical dimensions data must be measured precisely on the tray, for example the respective location of each pocket of the tray. This information can be transferred directly from the tray manufacturer to the user via a detailed mechanical drawing and a technician or programmer must enter this data in the machine.

In the case of electronic components, it is very common for the placement machines to use sophisticated vision systems to verify that the proper type of component is being placed, to inspect its critical dimensions, and to perform a best fit alignment based on actual physical dimensions. In

many cases, this data must be obtained by measuring individual components or it may be available from a detailed mechanical drawing supplied by the component manufacturer. In both cases a technician or programmer must input all of the required elements of information for each new component or product.

Summary of the invention

The present invention relates to a system which greatly reduces the level of interaction required from an operator relative to the data exchange, physical verification and process control associated with the movement of electronic components in a PCB assembly plant.

This is achieved by the use of data carriers which are attached to the component's packaging, including reels, trays and tubes. These data carriers can store all the relevant material and production data required by the various elements of the manufacturing system. Various readers, integrated with controllers and application software, are located at strategic points of the production area, including production equipment and storage areas, to enable automatic data transfer and physical verification that the right material is at the right place at the right time.

Brief Description of the drawings

Having thus generally described the nature of the invention, reference will now be made to the accompanying drawings, showing by way of illustration a preferred embodiment thereof, and in which:

Fig. 1a shows a Printed Circuit Board (PCB);

Fig. 2 shows an electronic components and identification;

Fig. 3a shows a ape and reel packaging;
Fig. 3b shows a reel identification and packaging;
Fig. 4a shows a tray;
Fig. 4b shows a tray identification and packaging;
Fig. 4c shows moisture sensitive labels for sealed bags and shipping boxes;
Fig. 5 shows tubes and cassettes;
Fig. 6 shows a material flow in a card assembly plant;
Fig. 7 shows a material flow inter-plant;
Fig. 8a shows a placement machine;
Fig. 8b shows a tape feeder for a placement machine;
Fig. 9a shows a clip for a tray;
Fig. 9b shows a clip for a reel; and
Fig. 10 shows a flowchart for moisture sensitive components tracking system.

Description of the preferred embodiments

The invention will now be described with reference to its application with the assembly of printed circuit boards.

In general, the present invention relates to a material data communication system which is part of a production control system. The material data communication system includes data capture devices, control modules, power supplies, communication hardware and software to transfer the captured data. In this instance, the data capture devices employ radio frequency identification (RFID) tracking technology for capturing data from passive data-carrying devices which are attached to the production material.

Components of the control system

1. The transponder, which is attached to the packaging of the electronic components (tray, reel, tube, cassette)
2. The readers, which are located at strategic points of the manufacturing system
3. The controllers which process the data acquired by the readers

Definition of transponder

The transponder, which represents the actual data-carrying device of an RFID system, normally consists of a coupling element and an electronic microchip. When the transponder, which does not usually possess its own voltage supply (battery), is not within the interrogation zone of a reader, it is totally passive. The transponder is only activated when it is within the interrogation zone of a reader. The power required to activate the transponder is supplied to the transponder through the coupling unit (contact-less) as is the timing pulse and data.

The transponder also includes a protective packaging for the electronic device and associated coupling element (antenna), and a mechanical structure to facilitate its attachment to the object to be identified. The attachment method can be temporary or permanent, based on the most practical and cost-effective solution for each application.

Definition of reader

The interrogator or reader, depending upon design and the technology used, may be a read or write/read device. A reader typically contains a radio frequency module (transmitter and receiver), a control unit and a

coupling element to the transponder. In addition, many readers are fitted with an additional interface (parallel or serial communication) to enable them to forward the data received to another system (PC, robot control system, etc.).

The coupling element (antenna) must be optimized for each application in accordance with the basic requirements of the specific RFID technology (frequency), in order to provide an adequate read range in combination with the transponder. In some applications, many transponders can be at the same time in the range of a reader and the system must be designed with the appropriate anti-collision software.

Definition of controller

A controller is the system that receives and processes the data acquired by the reader. In the simplest form, the controller can be integrated with the reader in a portable hand-held unit and this can be used only to display information contained on a transponder. This portable unit can be fully autonomous or it can be connected, continuously or punctually, to a host computer through a docking station, radio-frequency communication or other means.

The controller can be a fixed stand-alone system integrated with a reader into a conveyor, production machine or storage area. In this case, the controller contains a CPU and application software to accomplish a given function including reading or writing information on a transponder. The controller can also be a central host computer which is used for enterprise data management or dedicated to a specific function such as statistical process control.

Due to the nature of a PCB assembly plant, a typical application may include multiple controllers, with a combination of stand-alone and centralized software controls.

Semi-Automatic R/W operation

Depending on the nature of the application, it may be preferable to use a semi-automatic reader. The semi-automatic designation means that the system requires the intervention of an operator to perform the read/write cycle. This intervention can simply consist of bringing one or more objects with a transponder in the field of a specific reader or to bring a portable reader close to one or more specific transponders. The operator intervention can only consist of starting a specific read/write cycle by pushing a button or selecting a proper software command from a PC user interface.

Fully Automatic R/W operation

A fully automatic read/write operation implies that no human intervention is required. This is applicable when a reader is integrated, for example, in a conveyor or automated machine. The read/write cycle may be continuous or it can be triggered by appropriate sensors and software or other automatic control systems.

Modular System Architecture

In order to maximize the potential benefits of an investment in a system based on this invention, it is preferable that it can handle many different applications.

The typical data structure would be different for each type of packaging and transponder. For a given type, it would be very beneficial to have a single data structure that can accommodate all potential applications, closed-loop and inter-plant. In this context, it must be recognized that the same packaging may be used in more than one environment and that some data elements might be common to multiple steps while others may be required only for individual applications.

1st example : Transponders on reels and trays

Given the existing infrastructure of barcode identification and the relatively high unit cost of a typical transponder, the present invention is based on the use of a temporary clip, with different designs adapted to each format of packaging. In this case, the transponders are used in a closed loop cycle during the PCB assembly process. For this reason, the benefits of the system must be more important than the additional cost associated with the attachment and removal of the transponders, including the initial data entry. Any application would become even more advantageous if the card assembly plant can receive the reels and trays from its suppliers with the transponders already attached thereto and with the data already present in the proper format.

Figs. 9a and 9b illustrate a proposed method to attach the transponders temporarily to the reels and trays, using spring metal clips containing read/write RFID transponders.

In this application it is important that the shape and location of the transponders do not affect the normal handling, storage and use of the reels and trays during production.

The transponder for reels must not interfere with most common tape feeders of automated placement equipment. The transponder for trays must allow the trays to be stacked and it must not interfere with most common tray feeders of automated placement equipment.

Data structure : transponder attached to a tray with electronic components

Tray Identification :

Manufacturer

Part number

Revision or Engineering change number

Date code

Component Identification :

Manufacturer

Manufacturer part number

Customer part number

Date code or lot number

Quantity

Partial tray 1st row

Partial tray 1st column

Process Data :

JEDEC level

Maximum exposure time

Current exposure time

Status flag (inside dry environment or normal production floor)

Attachment of the clips for trays and reels

In this application, the clips are first attached to reels and trays when the latter are unpackaged, i.e. before being released to the manufacturing area. If the trays are always handled in stacks, and given that the placement machine is always starting to pick from the top tray of a stack, it is possible to attach only one transponder to the bottom tray of each stack. This reduces the number of transponders to attach and the associated handling of the trays.

Transfer of Identification Data

After the transponders have been attached, the information to be entered on the transponders is normally taken from the labels located on the bags or the box containing the reels and trays. This data is either scanned with a standard barcode reader, entered manually or both, and it is transferred to the transponder. This can be achieved with the use of a set-up station, equipped with a reader, personal computer and application software. This information typically includes the part number, date code and quantity and it can be used for multiple applications, including, but not limited to the following:

Material Identification

The first benefit from this is the ability to clearly identify the content of any particular tray, anywhere on the production floor. A portable reader of RFID tags can be used to display the PN (i.e. Part Number), the LN (i.e. Lot Number) and the Qty (i.e. Quantity) associated with each

transponder. This was not previously possible due to the absence of material identification on a standard plastic tray.

Moisture sensitive components tracking system (fig. 10)

For components that are categorized to be moisture-sensitive, the bags containing the components in trays or reels are typically opened only when the material is required in production. In this case, the standard level of sensitivity and the maximum exposure time in hours or days are also clearly indicated on the bag or box containing the reels or trays. This information is transferred on the transponders at the same time as the material identification, along with a record of the time and date relative to the opening and the maximum exposure limit. Additional information relative to the carriers themselves, such as temperature rating, can be read directly from the carriers and written on the transponders at the same time.

The same set-up station is used to record material movement in and out of a controlled dry air environment. The software takes into account the fact that the clock of total exposed time is suspended when the moisture-sensitive components are properly stored. A manual portable reader is used to verify the remaining exposure time of each individual tray and reel on the production floor. This verification can be done during a new set-up or at specified intervals of time (once per shift).

A further refinement of this system would take into account the ambient temperature and humidity measured by sensors on the production floor and would adjust the expiration date and time accordingly.

Whenever components reach their exposure limit, provided that this information is written on the transponder, the system can verify whether the carrier is capable to withstand the higher drying temperature and prevent an operator from using a high temperature process with a low temperature tray.

Integration to dry cabinet, drying oven and placement machine

For the previous application, a higher level of automation can be achieved by integrating readers and a suitable controller in the dry storage areas, drying oven and in the placement machine.

This integration can be done at different levels. In the simplest form, it can consist of a stand-alone controller with a dedicated reader and application software, located in close proximity to the dry cabinet, drying oven or placement machine. In this case, the operator needs to scan the transponders by bringing the trays or reels in proximity to the reader, within the range of the antenna, each time that the material is moved in or out.

Depending on the application the software may be used simply to update the information in a database or on the transponder. For example, when reels and trays are scanned before being placed inside a dry storage area, the status flag is switched to “inside dry environment”. Whenever the same trays and reels are scanned after being taken out of the dry storage area, the expiration date and time are recalculated based on a pre-determined set of rules, and reset on the transponder. At the same time the status flag is switched back to “in normal production environment”. The status flag is used to make sure that the operator did not forget to scan the transponders when the material was entered or removed from dry storage.

According to the needs of each specific application, the interface with the operator may consist of a simple set of visual or audible signs to indicate a “good read” or to indicate a process alarm. It may also include a complete display and keyboard. In this application, a display could, for example, indicate the remaining exposure time each time that the material is removed from dry storage.

In the case of a production equipment which possess its own controller or CPU, the reader/controllers may also be directly connected to the equipment, using a standard (RS-232, SECS/GEM) or custom communication hardware and software interface. This would enable automatic data transfer and potentially request actions from the production machine, such as the activation of an interlock or the generation of error messages. The highest level of integration consists of installing a reader directly inside the machine envelope and to use the controller and software of the actual production machine to perform the appropriate process control.

By integrating antennas at strategic locations, it is possible to transfer the necessary data and update the information on the transponders with no operator intervention, thereby improving the efficiency of the operations and reducing the risk of errors. The following examples demonstrate practical solutions relative to the control of moisture-sensitive components.

On a placement machine, before a reel or tray of moisture-sensitive parts exceed the specified time limit, a pre-alarm can be generated to advise the operator to take appropriate action. If the material is expired, the system

can also engage an interlock to prevent the placement of the components by the machine.

On a dry storage area, such as a dry cabinet, a reader and associated controller can be integrated to automatically register the material moving in and out of the cabinet and to update the expiration date and time and status flag on the transponders accordingly.

On a drying oven, a reader and associated controller can be integrated to automatically register the material being dried and to reset the expiration date once the drying cycle is completed. In addition, it can also prevent use of the oven if the container (tray or reel) is not compatible with the set temperature.

Feeder Set-up Validation

A further development of the integration to a placement equipment includes a feeder set-up validation. In this application, the transfer of the part number information from the transponder on a reel can be made faster and in a more automated manner than with a traditional barcode label. This can be done through the use of a dedicated set-up station or hand-held reader, whichever is more practical for the specific machine. This application can also be extended to components in trays, which is not possible with prior methods.

A further refinement of this application consists of integrating readers directly onto the placement machine thereby enabling complete automation of the verification process.

Update of Remaining Quantity

Another benefit from this new approach is to allow the update of the remaining quantity directly on the transponder on the reels, even when they are removed from the feeders, without having to manually write the revised quantity on a label or to reprint a new barcode label. This also enables a similar application for components in trays which is not possible with prior methods. Ultimately, the readers can be fully integrated in the placement equipment such that no local memory is required on the feeders and no manual scanning operation is required from the operator.

Partial tray information

This is a further development from the present invention relative to the integration with a placement machine. Every time that a partial tray needs to be removed from the machine, the information relative to the last component picked is first transferred to the transponder attached to the tray. This data can be recorded with a row number and column number for example. Then, the tray can be stored temporarily and the partial tray information is uploaded to the placement machine during the next set-up. This system reduces significantly the operator intervention, which reduces the set-up time and potential damage to components.

Traceability

Yet another further development is to transfer the lot number or batch number information associated with each reel to enable complete traceability of the components used to assemble a specific batch or serial

number of PCB. Once again, this is also true for components in trays, and this is not possible with prior methods.

Real-time inventory control and physical location of material in WIP

The information on each transponder can also enable real time inventory control of the raw material on the production floor. As described in the previous placement machine integration, the exact quantity and location of each reel and tray of components loaded on every machine is already available locally. The next step consists of integrating readers at other material storage locations, which mainly consist of various shelves, cabinets and carts. This can be achieved in many different configurations, by increasing the number of readers based on the level of resolution that is required and the overall cost of the system. At one extreme, the transponders can be scanned with a hand-held reader when they enter a given section of the manufacturing floor. Another option is to integrate one reader for each storage unit, each shelf, each section of each shelf, etc. In order to reduce the cost of the overall system, many antennas can be multiplexed through a single read/write card controller. The integration of all the individual elements in a single network allows for centralised real-time inventory control.

A storage area can include additional features to simplify the interface with the operator. For example LEDs can be located at each individual storage area to indicate the location where the material needs to be placed or removed. A more sophisticated system can include a series of digital displays to show information relative to the material in a given storage area.

One of the obvious benefits of this system includes the ability to rapidly locate any specific reel or tray of components.

Inter-plant information transfer (fig. 7)

The above applications can be further enhanced by using the same transponders between various manufacturing locations in the supply chain.

In this case, the transponders can still be attached temporarily but it may be more practical to attach them permanently. This can be done through the use of a clip, similar in shape to the temporary clip, but using a more rigid material and which might require a tool to install. Another alternative is to insert the transponder directly inside the object, during the initial fabrication process, e.g. plastic moulding or a subsequent operation, such as drilling a hole in the carrier.

In the context of an inter-plant application it becomes critical that all the elements are designed to be compatible with each other and to accommodate the various requirements from each different application. This means that the transponders, readers and associated software must be designed as a complete system. The common elements of an inter-plant system are the transponder technology and its communication and data structure.

Semiconductor Packaging Plant to Card Assembly Plant

From the perspective of the card assembly plant, it would be very beneficial to receive, from their component suppliers, the trays and reels already equipped with transponders containing the information required,

such as part number, lot number, quantity, JEDEC moisture sensitivity level, packaging date and time, etc. In this case, all the relevant data can be used to automate the receiving of the components and initiate the proper applications.

Carrier Manufacturer to Semiconductor Packaging Plant

In one embodiment of the present invention, all the data relative to the manufacture of the tray is written directly on the transponder at some point in the manufacturing process. This information may include the following : manufacturer, part number, EC#, description, physical dimensions, maximum temperature rating, etc.. This information can be read by an operator, using a hand-held reader, to insure that the proper tray is being used for the proper product in a given process.

At the same time, the transponder can be used to store information relative to the components that it contains, including identification data, process data, physical data, etc. From a different perspective, similar applications and benefits can be derived during the component manufacturing process as was described in the card assembly process.

A further refinement of this invention consists of integrating readers in the automated equipment that handles the trays at various operations.

Recycling of trays and reels

The recycling company can greatly benefit from the presence of a transponder on the trays to be recycled. This allows a rapid and accurate recognition and classification of any tray such that it can be sorted out

more efficiently. This identification method can eventually enable higher levels of automation and reduce errors in the sorting process.

Before returning the trays to the original manufacturer or directly to a semiconductor packaging plant, the recycling company can verify that the proper information is indicated on the transponder attached to the tray and it can remove any additional data that was associated with the previous usage.

For example, the information to be left on the transponder might include the same data that was provided by the original tray manufacturer, as described earlier. It may also contain information relative to the recycling process, such as the recycling company, the number of recycling loops, etc. However, it might be desirable to remove other data that is no longer relevant such as the data relative to the electronic components that it originally contained.

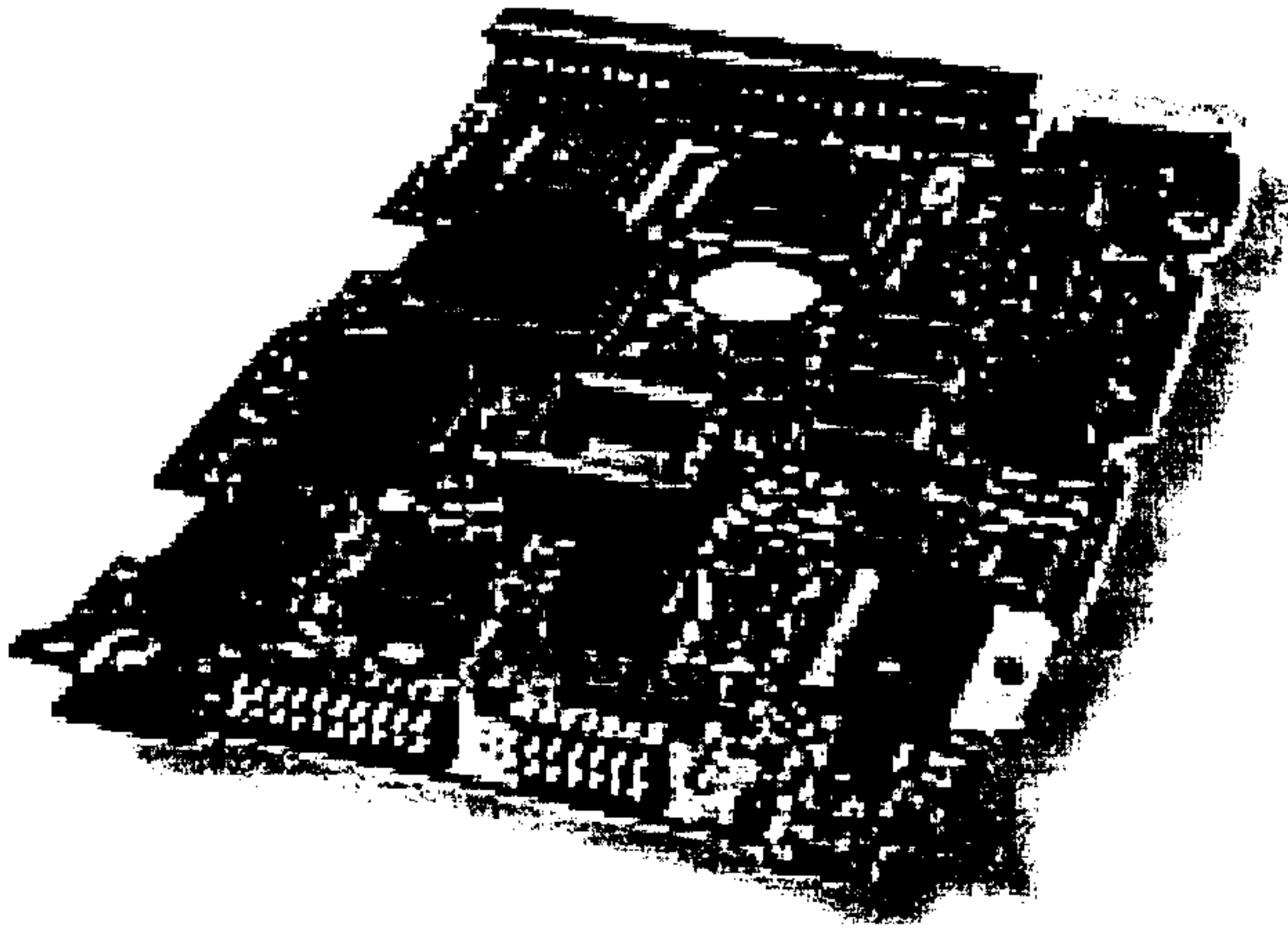
Design and assembly data

Provided that there is a sufficiently large memory available on the transponder, the containers can also be used to automatically transfer the basic data required for the initial set-up of the production equipment.

Whenever a new component is loaded on a placement machine this allows the automatic transfer of the required information such that the machine can program itself without human intervention. This can include all physical dimensions relative to a shipping tray, including the data relative to the matrix of rows and columns. It can also include the data relative to the components themselves, including package type, number of leads, lead length, etc.

Another alternative consists of using the basic material identification (manufacturer, part number) to access an external database which contains the required design data in a format that can be uploaded to the production machine. This database can be maintained by the tray and component manufacturers and it can be accessed through the internet.

Fig 1a : Printed Circuit Board (PCB)



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Fig.2 : Electronic components and identification

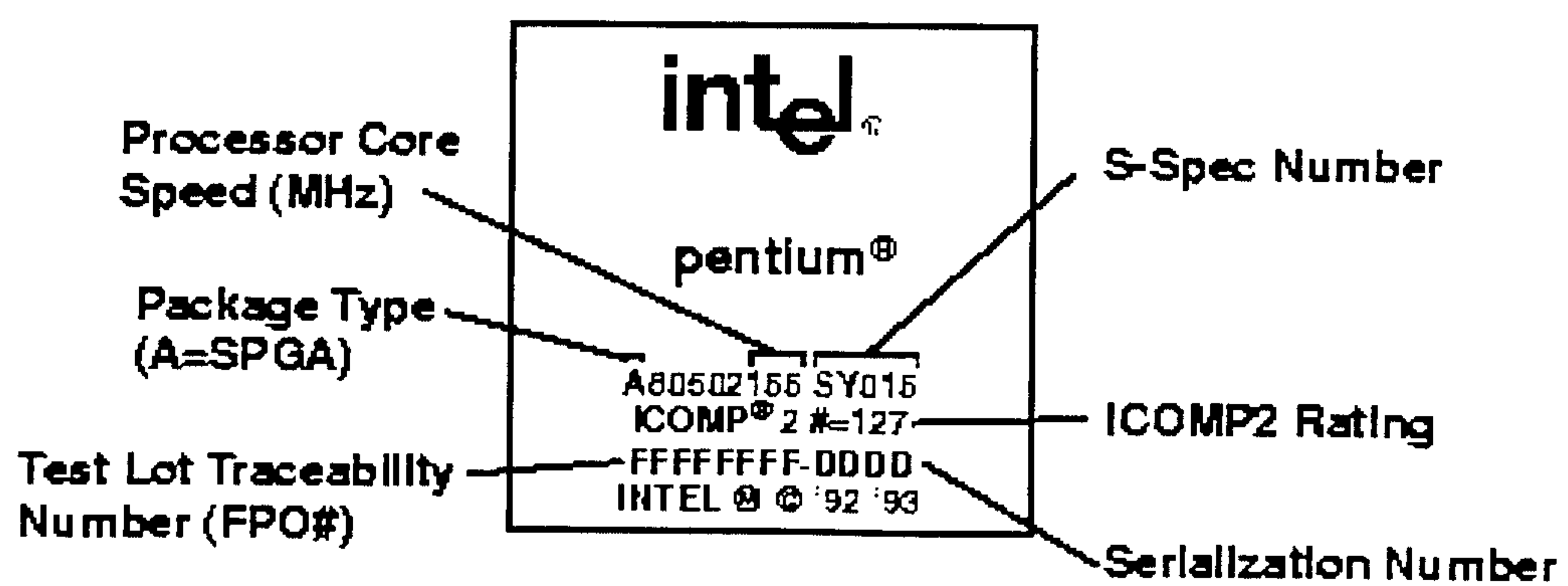
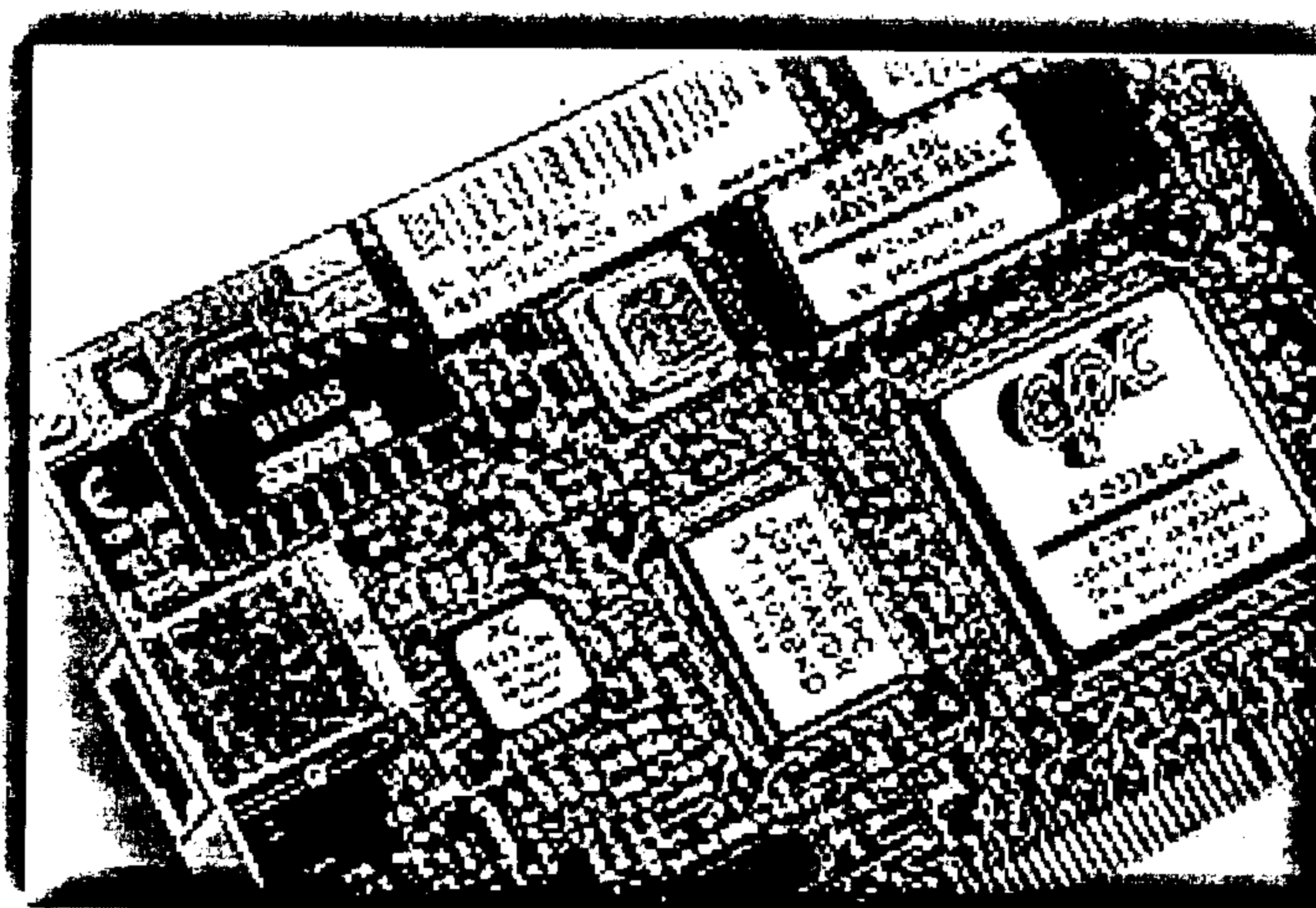


Fig.3a : Tape & Reel packaging

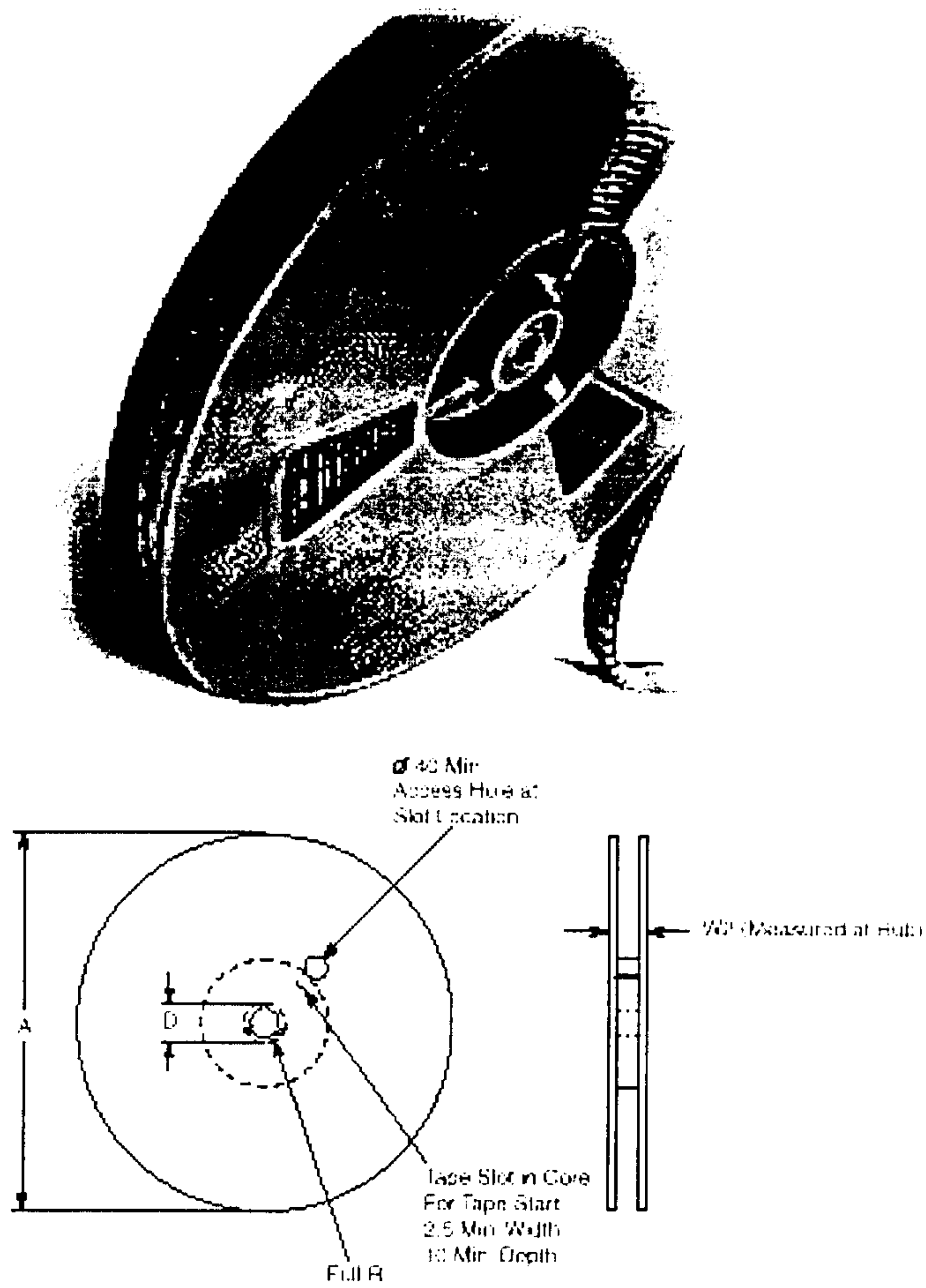


Fig.3b : Reel identification and packaging

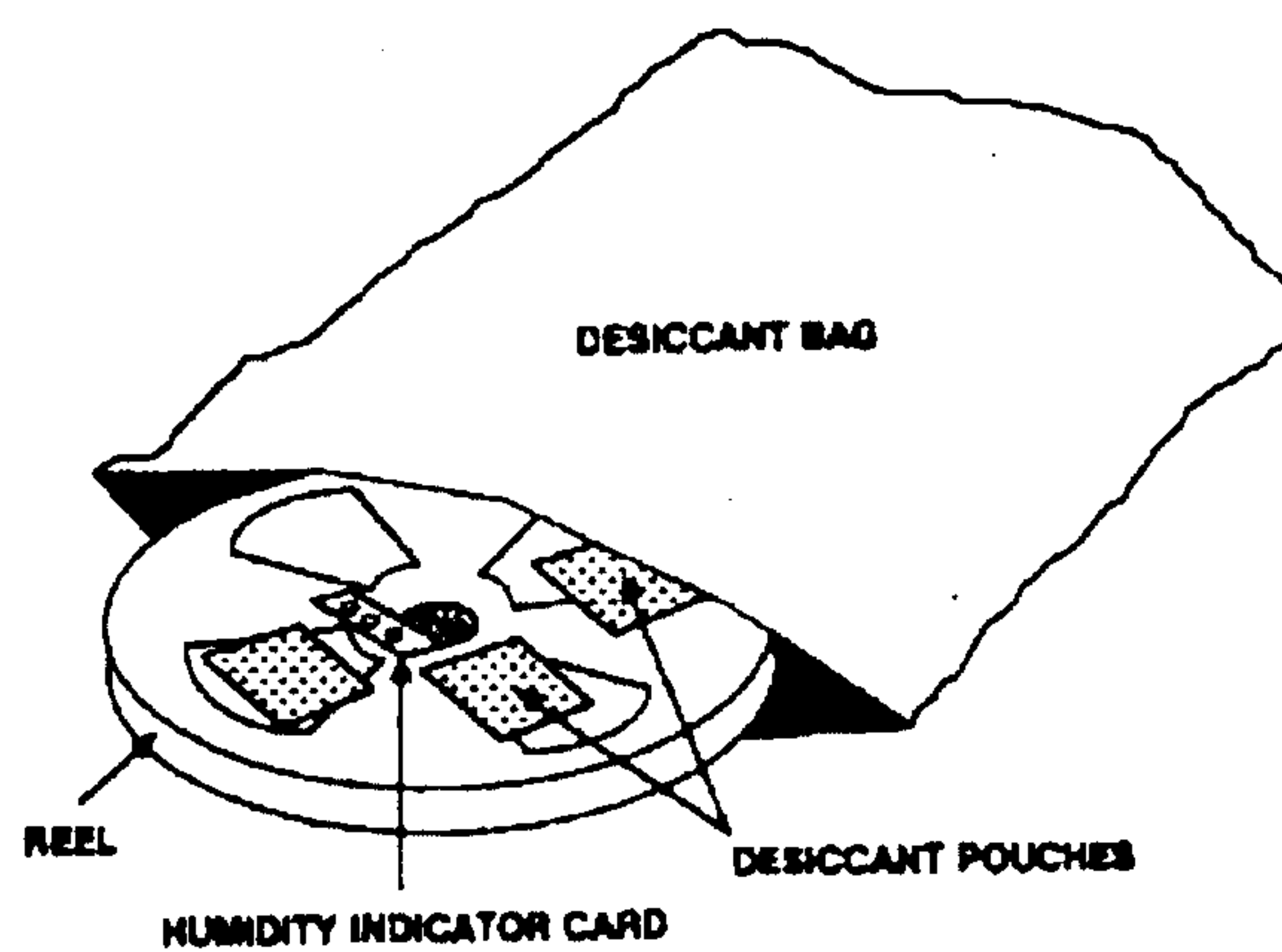


Fig.4b : Tray packaging

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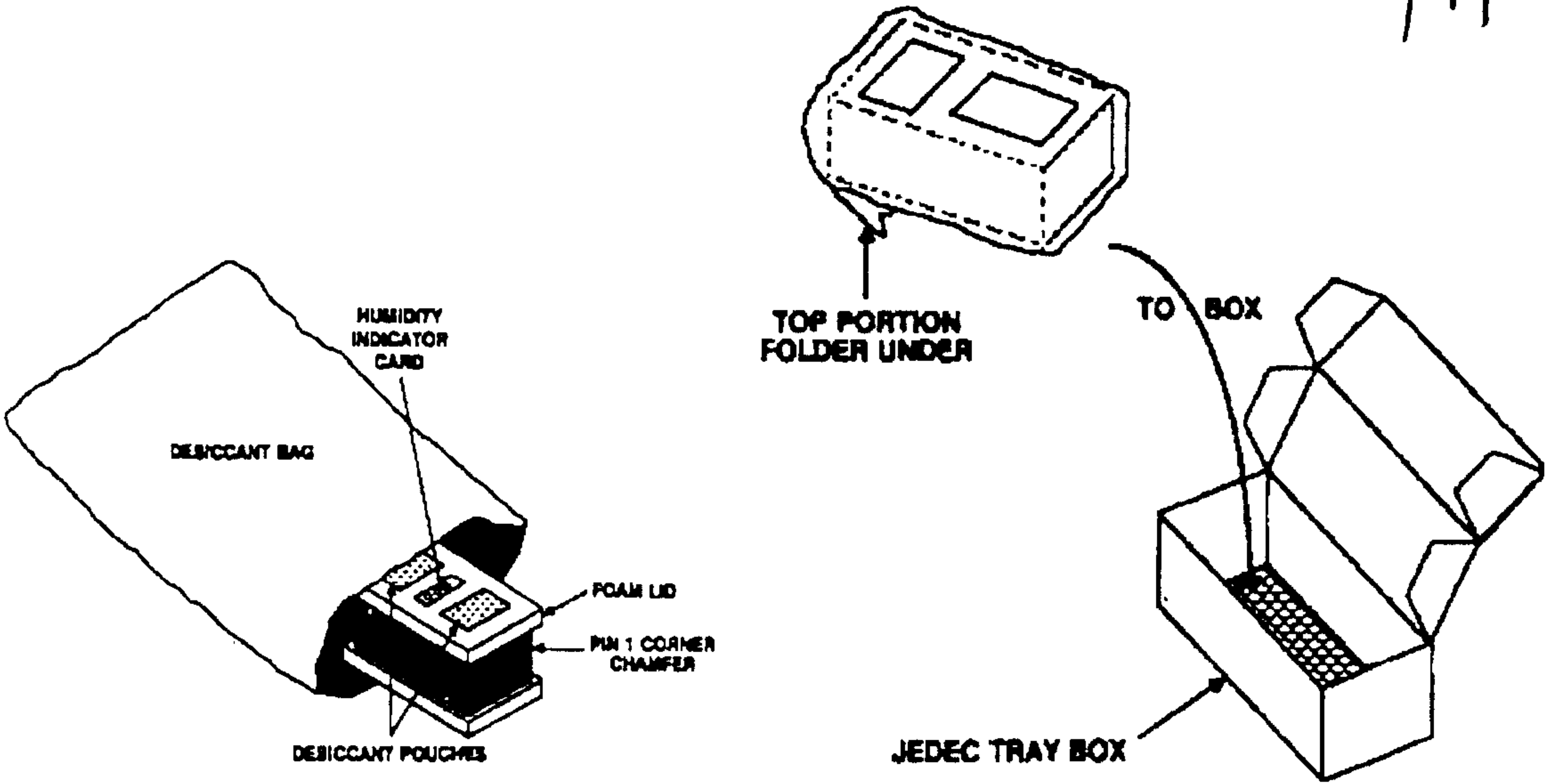


Fig. 4c : Moisture Sensitive labels for sealed bags and shipping boxes

(P) CUST PROD:		(HB) BOX ID: RW001104	
(V) SUPPLIER: 04195			
		(M):	(C):
(IP) IPN: G28F8M0R3T120		OF	
		LEVEL 2 - HOURS 1 YR	
(S) SPEC: STD		BAG SEAL DATE: 08AUG97	
(IT) LOT: T1234567	(Q) QTY: 2000	(9D) DATE: 9732	
(IT) LOT:	(Q) QTY:	(9D) DATE:	

ASSEMBLED IN PUCH IPINEX



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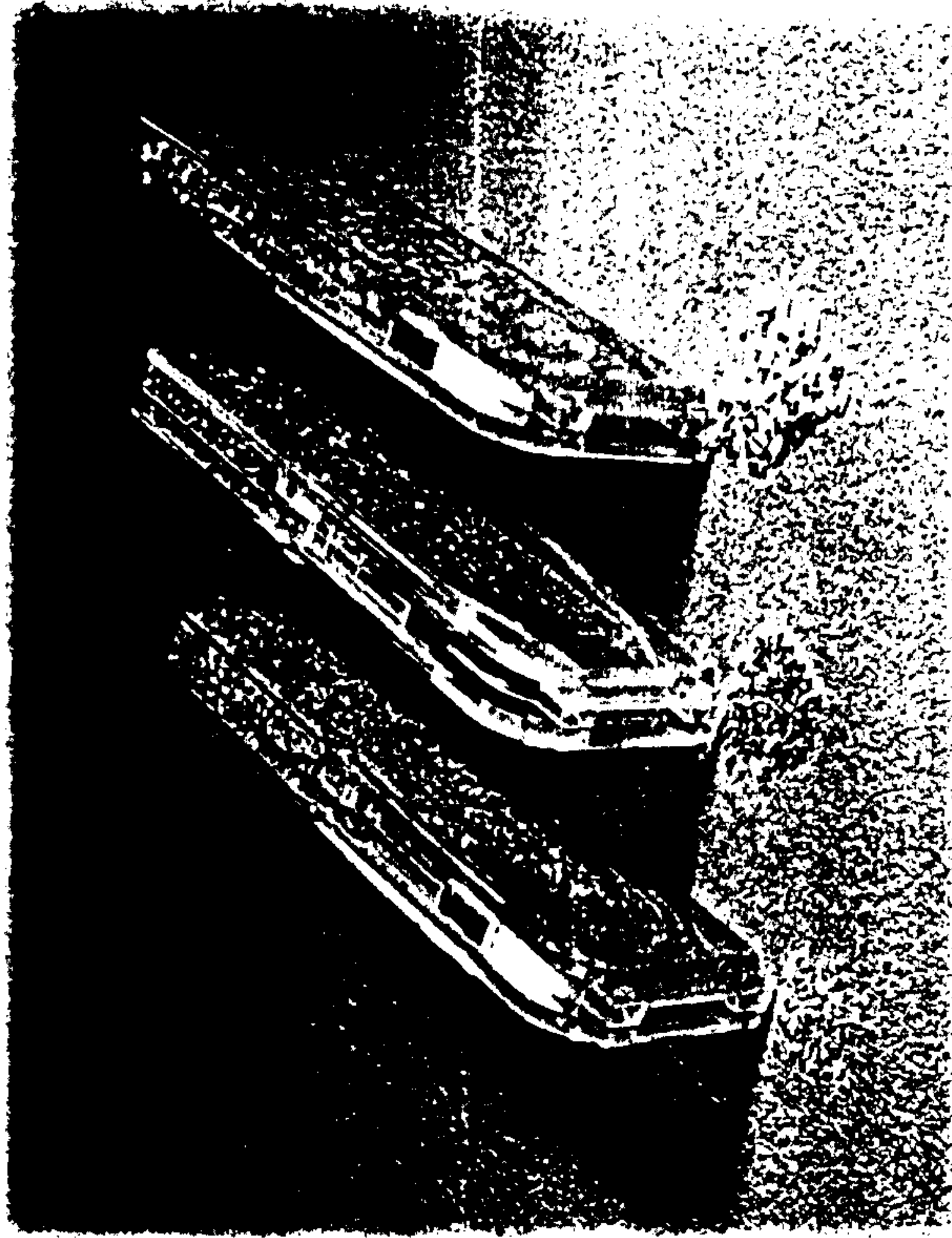
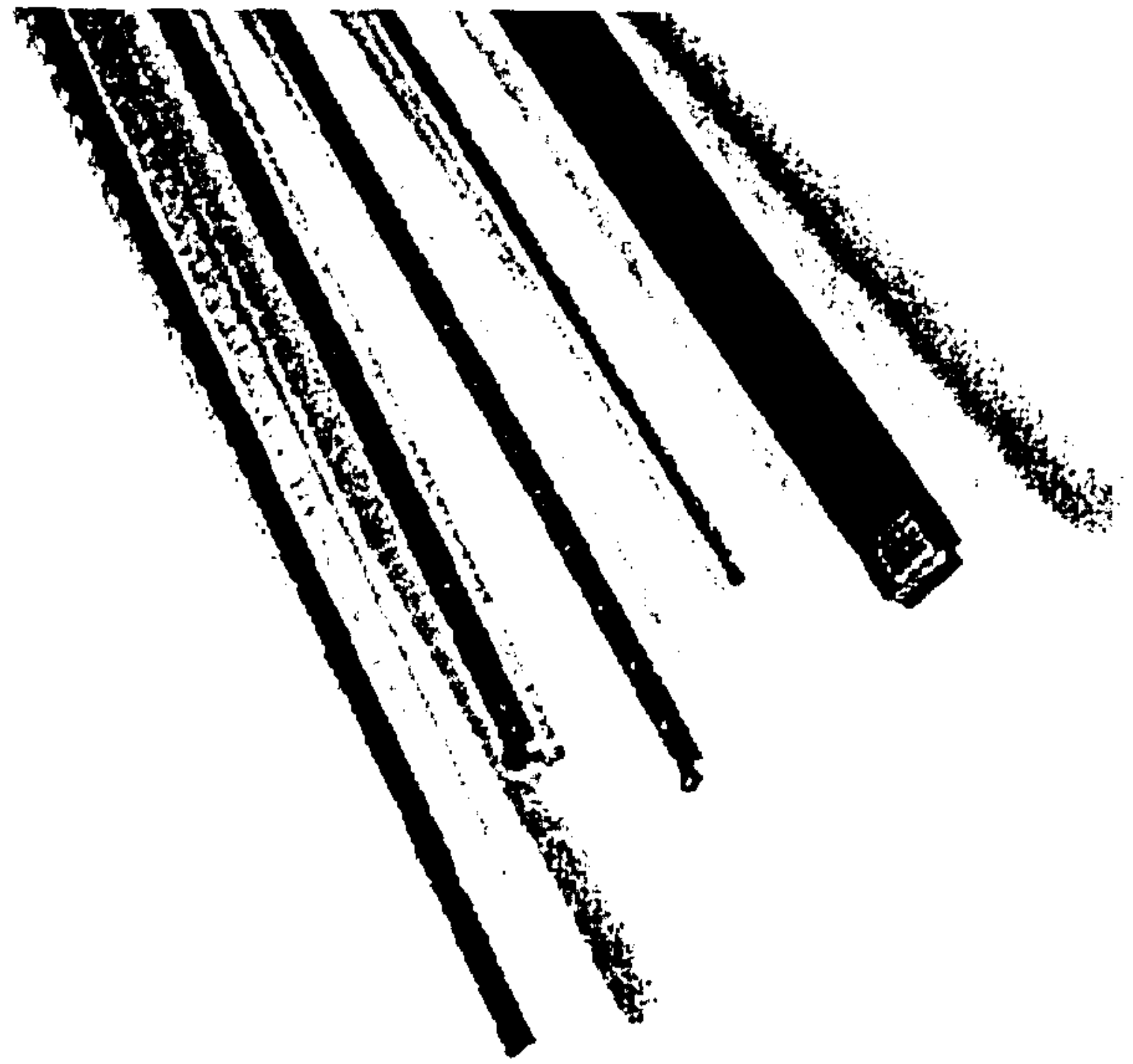


Fig.5 : Tube, cassette



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Fig.6 : Material flow in a card assembly plant

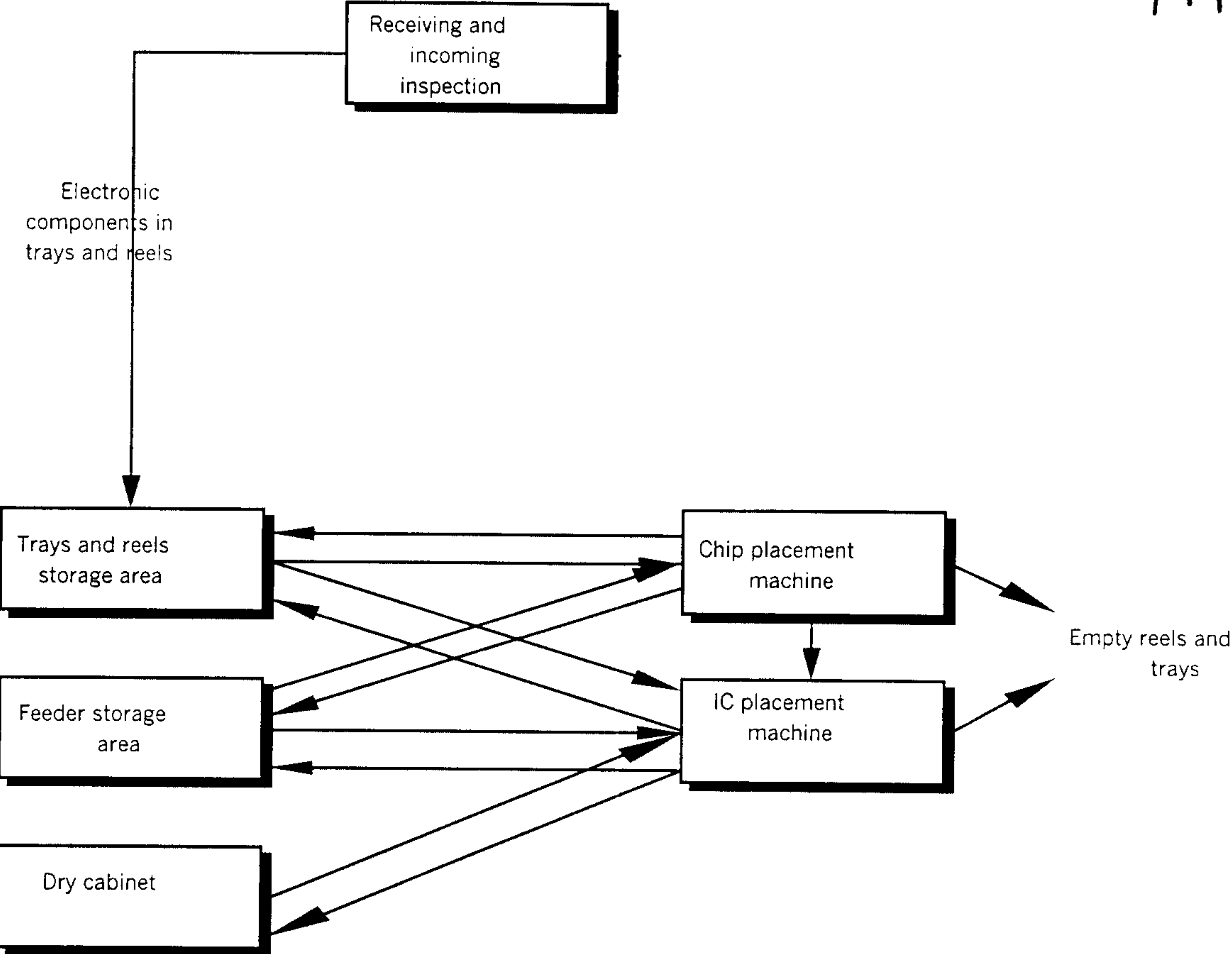
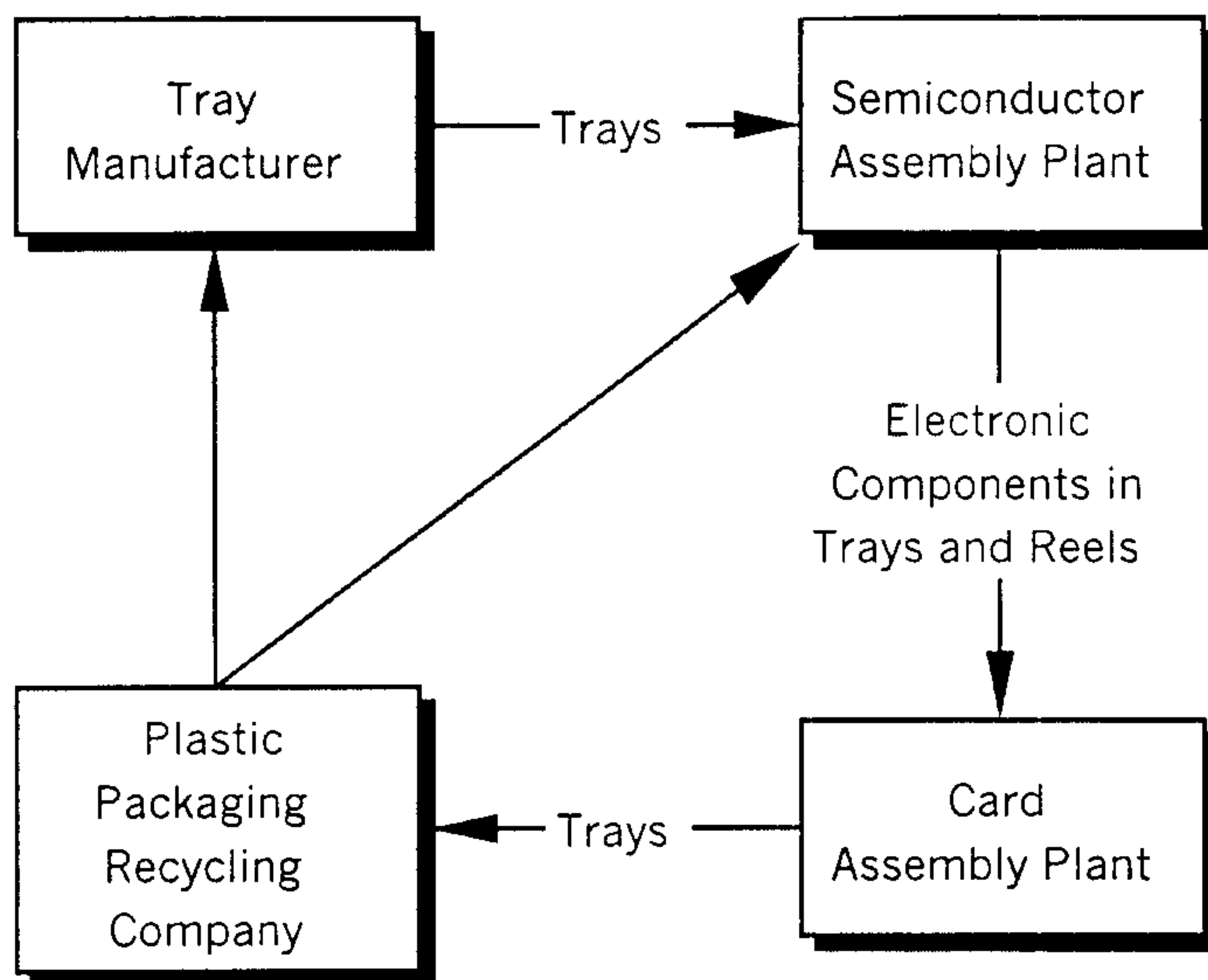


Fig.7 : Material flow inter-plant

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Fig.8a : Placement machine

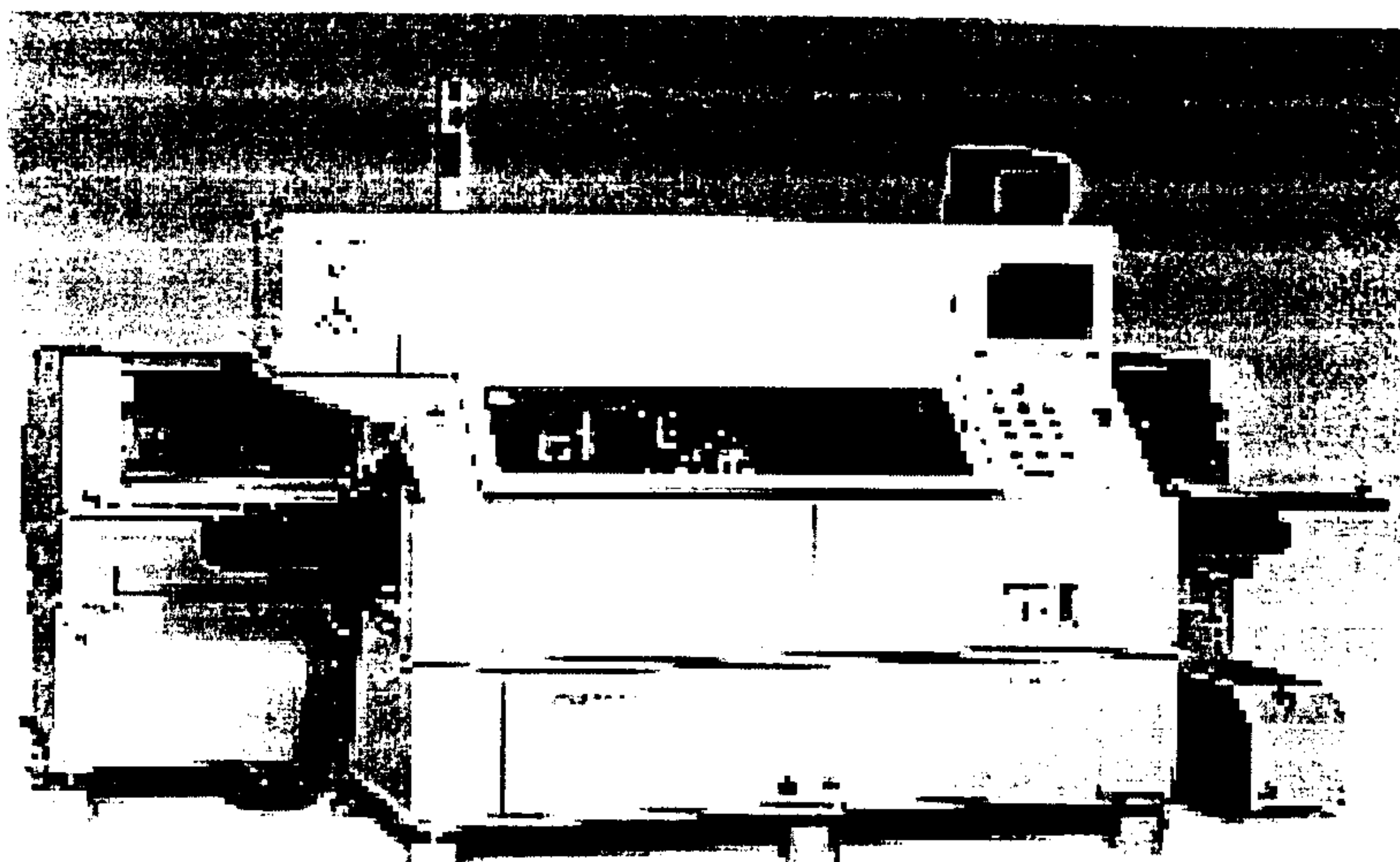
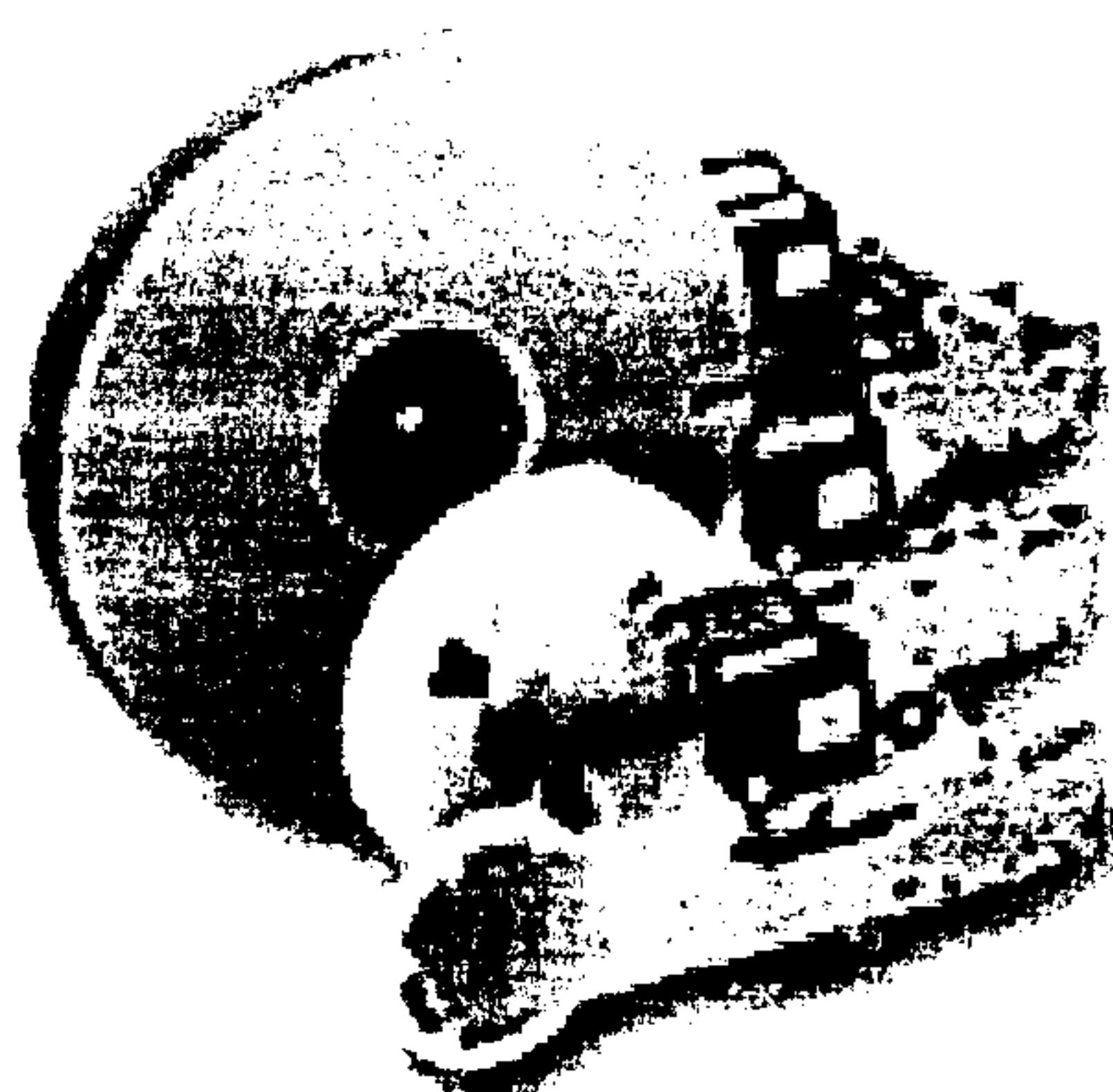
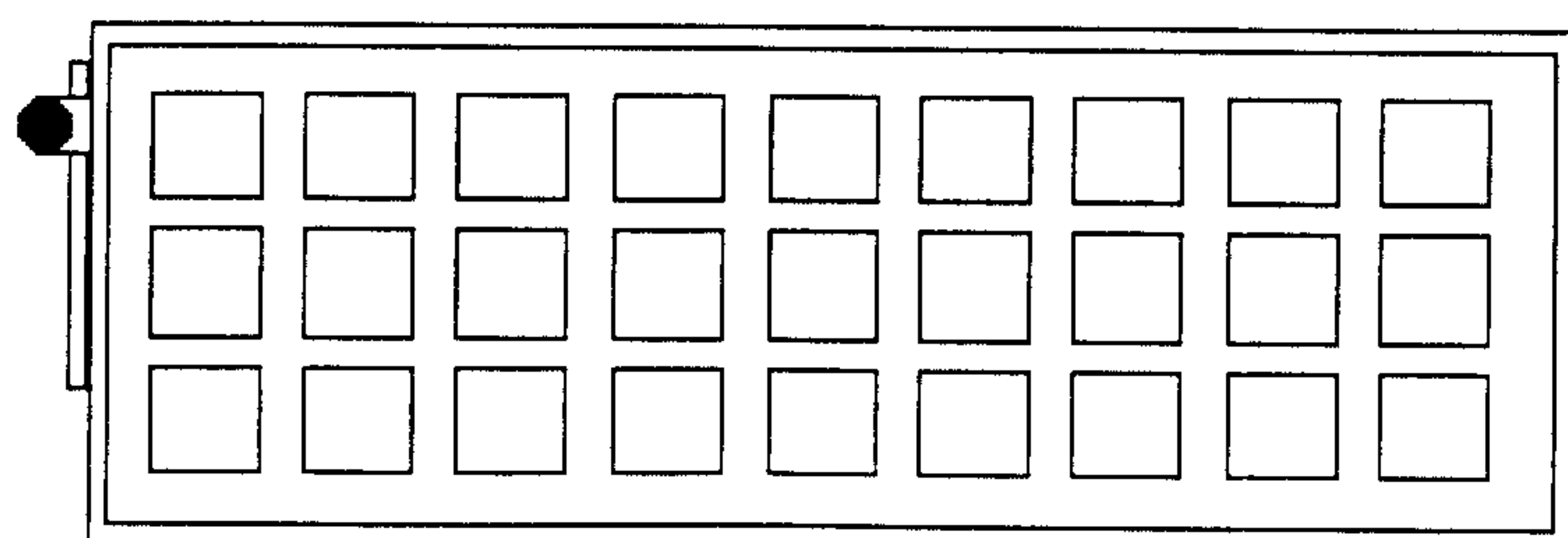


Fig.8b : Tape feeder for placement machine



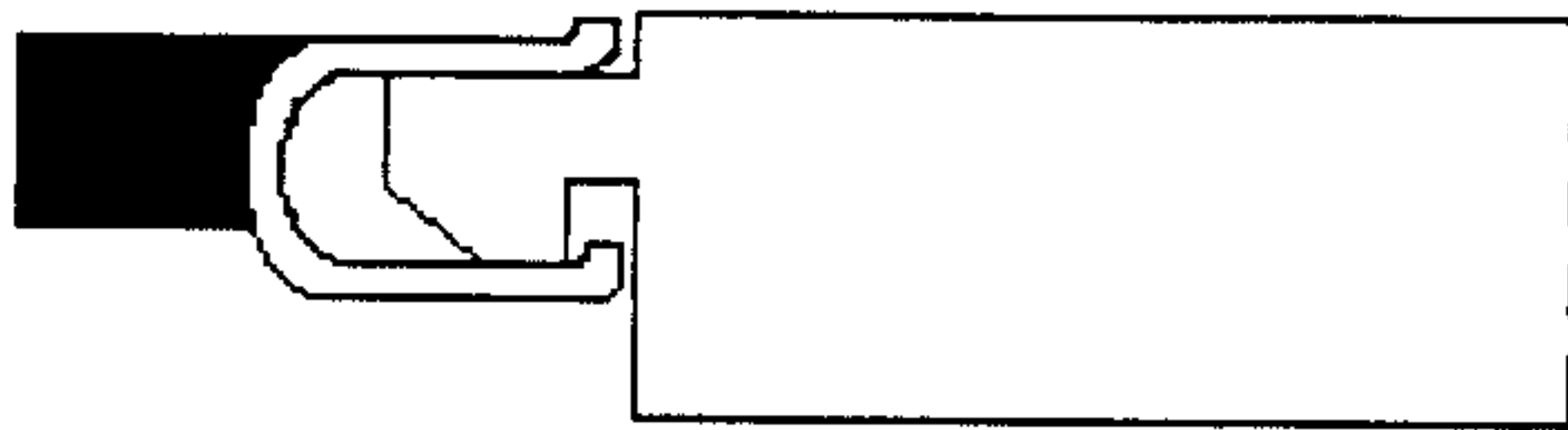
TAPE FEEDERS

Fig.9a : Clip for tray



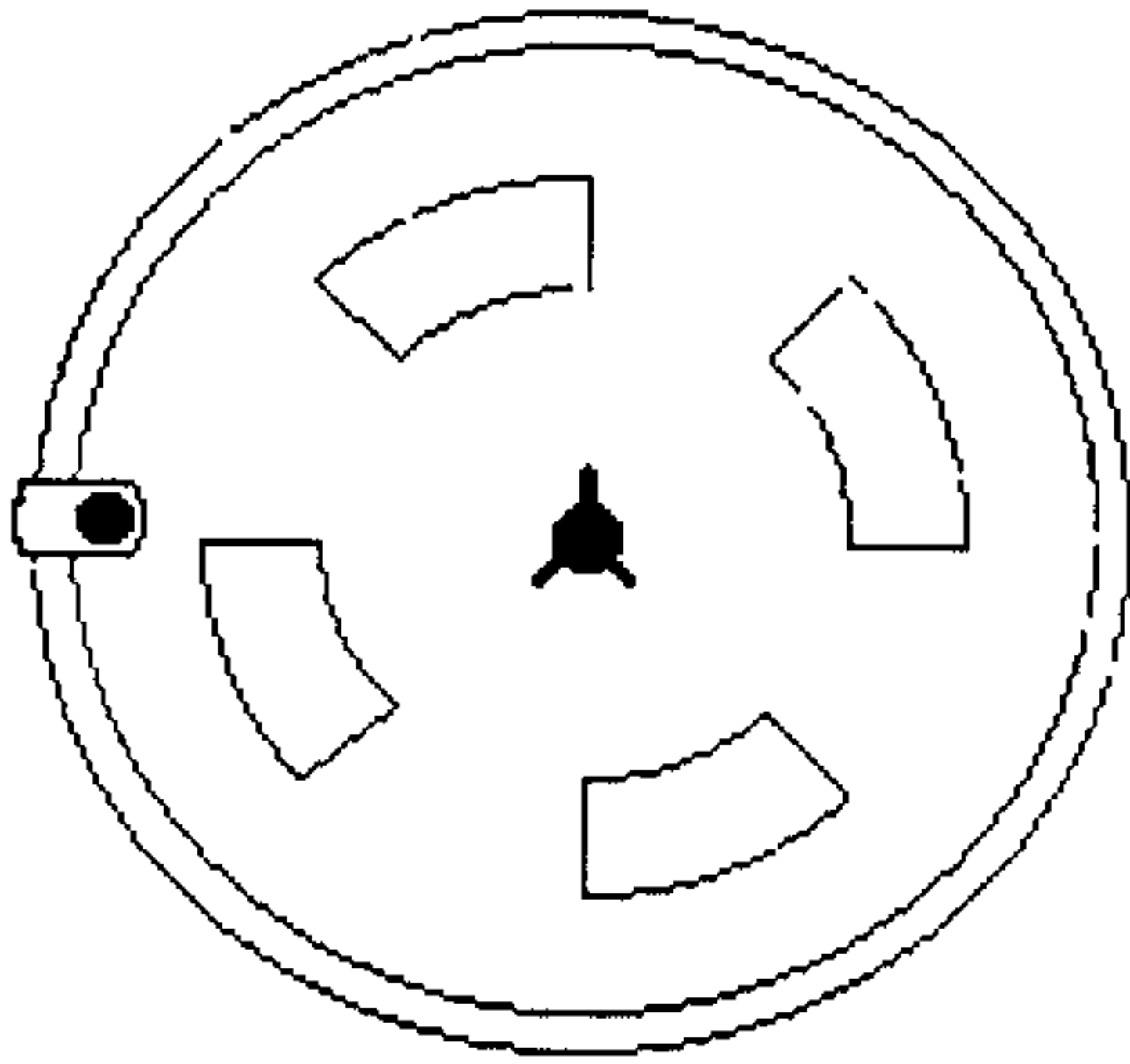
Top view

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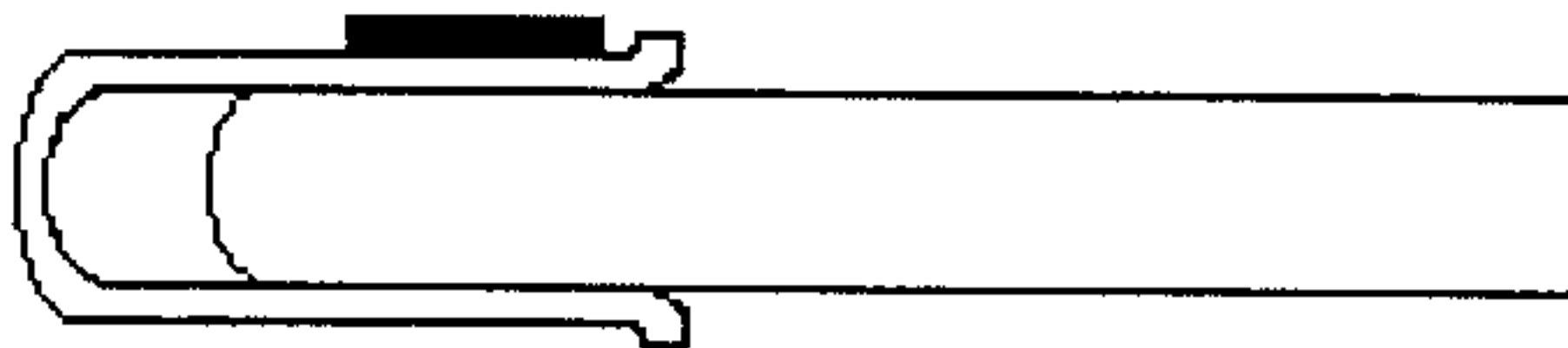


X-section, side view, enlarged

Fig.9b : Clip for reel

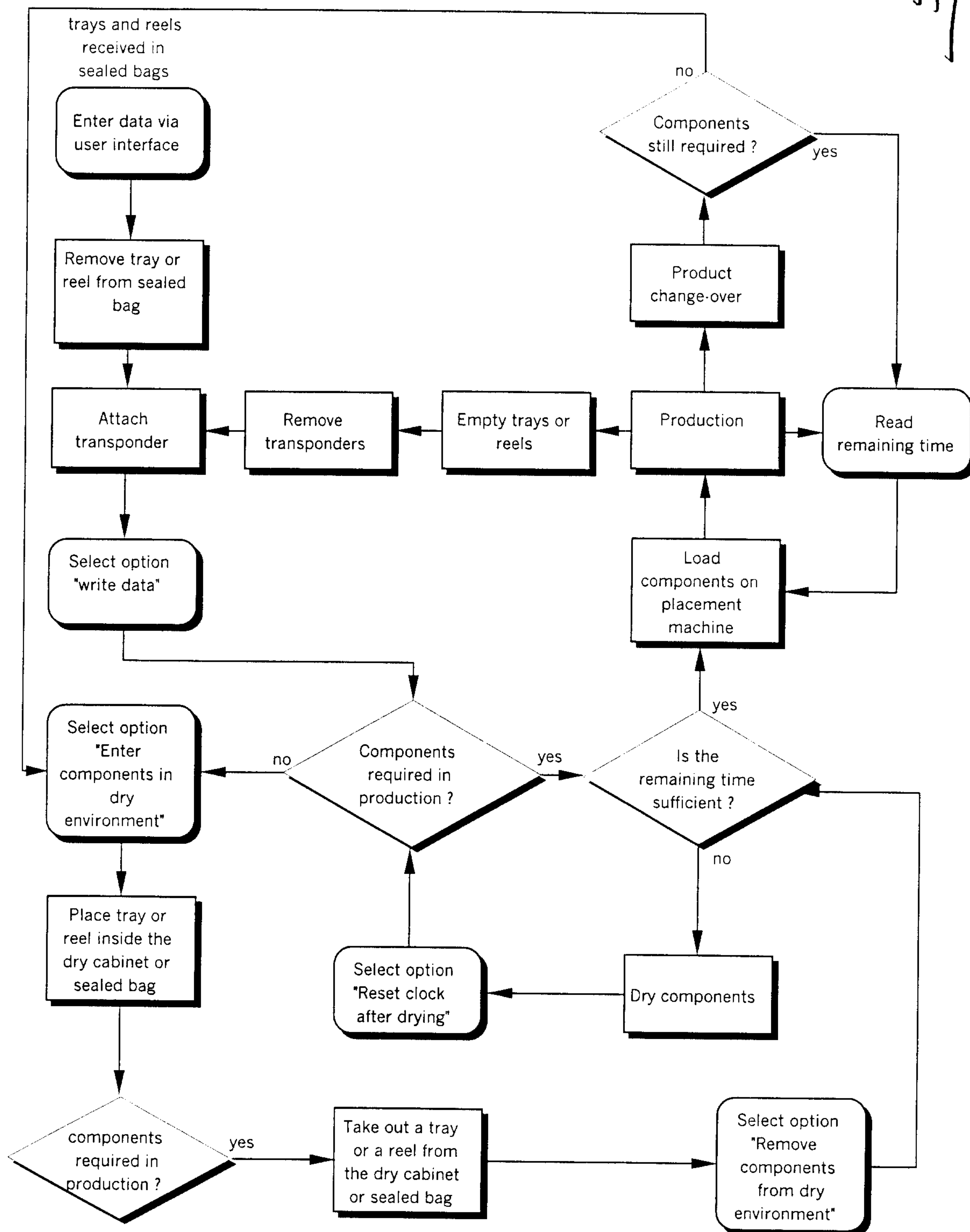


Top view



Side view, enlarged

Fig.10 : Flowchart for moisture sensitive components tracking system



Flowchart for moisture sensitive components tracking system

