# Automation of Magnetic Hard Disk Production Lines

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## 1. Introduction

In industry, the main aim of production line automation is to reduce the workforce. However in the magnetic hard disk (hereinafter referred to as the disk) industry, the aim is to improve quality and to enhance stability of the disk through a cleaner working environment as well as to reduce the workforce.

The surface area of the disk per bit ($0.8 \times 0.07$ μm at present) and the size of particles and defects under consideration are decreasing year by year as the storage capacity of disks increases. To cope with this, automation of the disk production line can prevent damage to the disk caused by manual transfer and can prevent dust from adhering to the disk in the case of a clean transfer.

Ever-increasing demand for higher-quality disk, however, cannot be satisfied only by automation of the disk production line, resulting in the necessity of an automated transfer system integrated with clean room design.

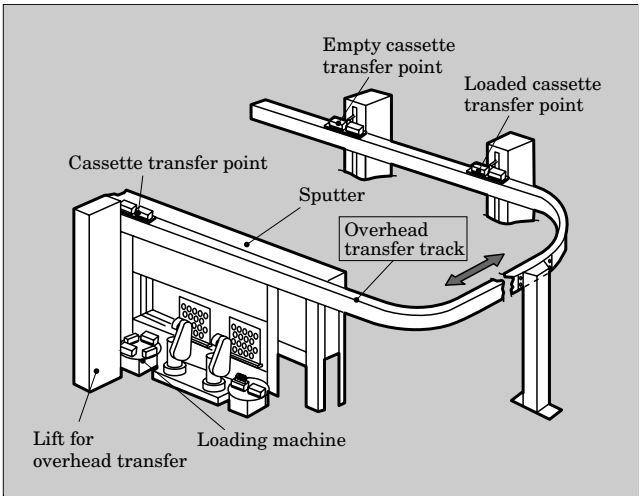
Since an automated transfer system equipped with a cleaning function for a disk production line is highly specialized, there are very few dedicated systems compared with other industries. Thus, transfer systems for this purpose have mainly been developed jointly with transfer system manufacturers based on their existing systems.

This paper describes examples of the introduction of an automated transfer system into an existing production line, replacing a previous manual transfer system, and introduction into a newly built production line. Also described is an example of an automated transfer system as a total system for integrating clean room design to meet the requirements of a cleaner work environment.

## 2. Introduction of an Automated Transfer System into an Existing Production Line

Figure 1 shows a schematic diagram of an automated transfer system introduced between processes where disk cassettes have traditionally been manually transferred. This automated transfer system aims to improve cleanliness of the disk.

Fig.1 Schematic diagram of an automated transfer system




### 2.1 Space savings in the clean room

Automated transfer systems within a single process or between several processes require a rather large amount of space in a clean room for installation. Especially when installed on the floor, such a system can obstruct passage and reduce workspace, resulting in increased cost of the clean room.

As for the introduction of an automated transfer system into an existing production line, it is difficult to secure space for its installation. Thus, we designed an overhead-transfer system that saves space by utilizing the space near the clean room ceiling.

Consequently, the space under the transfer system could be used for the existing passage and workspace. This has enabled the introduction of a clean transfer system without requiring expansion of the clean room.

### 2.2 Purification due to the overhead-transfer system

Since the transfer system was installed close to the ceiling, the clean area directly underneath the fan filter unit has become a transfer route for disk cassettes. This separates the disk from the workers, a source of particles.

Automation can also reduce the quantity of goods-in-process between operations and the time during which disk is left exposed.

The above measures were implemented to realize clean media transfer that prevents particles from adhering to the disk.

### 2.3 Considerations regarding the automation of an existing line

In the above example of the automation of an existing line, the transfer system could not be suspended from the ceiling of the clean room due to insufficient strength, but was instead supported by standalone posts and by using existing facilities. However, the locations of supporting posts and the transfer route were restricted to secure space for the existing production line.

In this manner, installation of the automated transfer system in the clean room was subjected to various constraints due to the construction of the clean room and the facilities layout.

Thus, it has become important to design an integrated production line and clean room that incorporates the concept of an automated transfer system in the early stages of the clean room design.

Based on this overhead transfer system, we have developed subsequent automated transfer systems.

## 3. Introduction of an Automated Transfer System into a New Production Line

### 3.1 Selection of a transfer system in accordance with its uses

Figure 2 shows a schematic diagram of an overhead automated transfer system introduced between processes of a new production line. The system, jointly developed in collaboration with a transfer system manufacturer, is based on the overhead disk cassette transfer system that has been introduced into existing production lines.

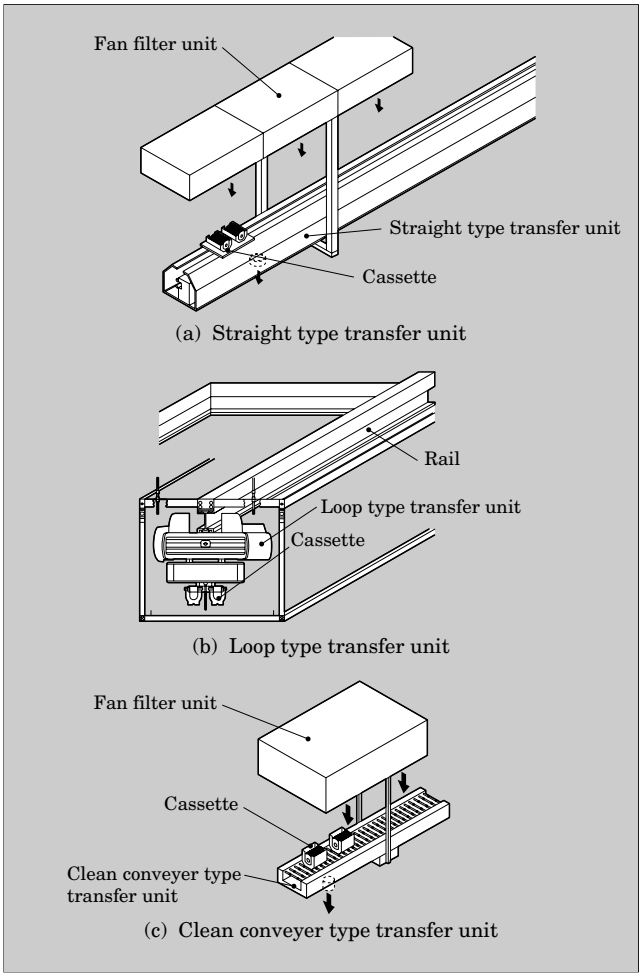
(1) Straight type transfer system (linear transfer system)
Applicable to a high-class clean area where transfer distance is short, buffers between processes are not required, and high transfer speed is required

(2) Loop type transfer system (track feed system)
Applicable to a middle- or low-class clean area where multiple input and output devices are installed to transfer multiple transfer cassettes

(3) Clean conveyer type transfer system
Applicable to a high- or middle-class clean area where a buffer function for disk cassettes is required between processes

An automated transfer system that complies with high quality requirements was realized by choosing from among the above-mentioned systems according to the use and operating environment of the transfer system.

Fig.2 Schematic diagram of an overhead automated transfer system introduced in a new production line




### 3.2 Automated production line integrated with clean room design

In the introduction of a transfer system, the design and installation of the transfer system along with the design of the clean room take into consideration, from the outset, the required transfer area, attachment of hanging bolts to the ceiling, ceiling strength, arrangement within the clean room and air flow in the clean room due to cover mounting.

Consequently, an automated transfer system can be introduced smoothly without impairing the function of a clean room and resulting in reduced installation cost.

After the installation, minor changes such as alterations of floor openings and the addition of covers were performed to improve the cleanliness in the room based on the results of investigation and analysis of particles and airflow in the clean room.

If even higher quality is required, it is necessary to design a clean room and automated transfer systems between processes as a total system, including the placement of peripheral equipment of the transfer system and clean room construction.

Fig.3 Schematic diagram of a total system

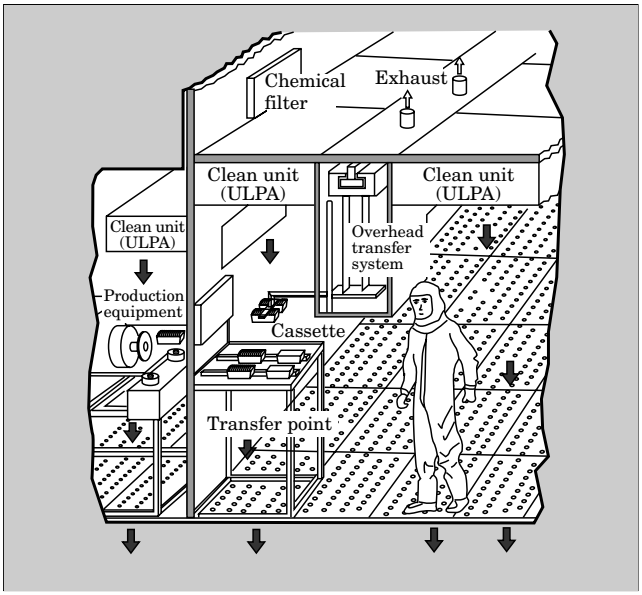
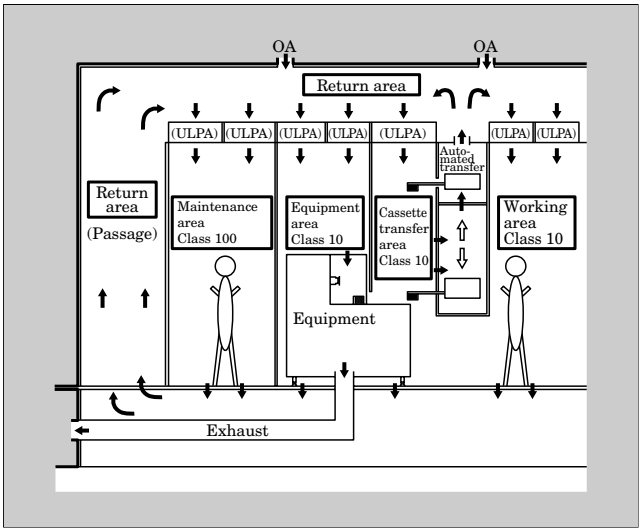



Fig.4 Schematic diagram of area separation




## 4. Design as a Total System

To cope with higher quality requirements for the disk, an example of an automated transfer system introduced between processes will be described.

Figure 3 shows a schematic diagram of the total system.

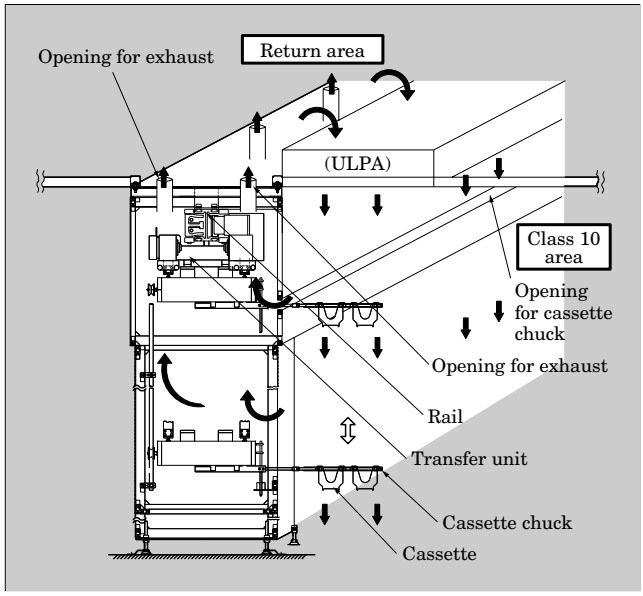
### 4.1 Area separation

In designing an automated transfer system, areas in and between processes were separated from each other in accordance with the required cleanliness.

Due to economical and technical limitations, it is impossible to make dust source free of the system. Therefore, disk cassette transfer routes, facilities installation areas, and maintenance and working areas were completely separated to isolate the disk and dust sources. In addition, no shielding materials were used over the disk cassette transfer routes in order to secure a laminar flow of air. Figure 4 shows a schematic diagram of the area separation.

Thus, dust sources and the disk were completely isolated in the clean room to create a clean environment that maintained the required cleanliness in each area even if there was dust from human bodies and facilities.

Fig.5 Schematic diagram of low cost clean transfer system




### 4.2 Development of a transfer system for improving cleanliness

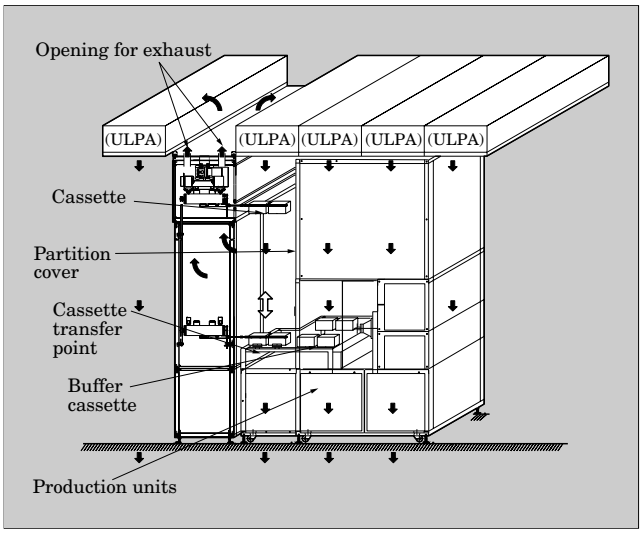
Traditionally, transfer systems in areas requiring a high level of cleanliness were not popular because of their high cost.

By improving the track feed system (the loop type transfer system mentioned above) and integrating it with a clean room, Fuji Electric has developed a low-cost clean transfer system which can be used in an ultra high-class clean area. Previously, track feed systems could only be applied to medium- and low-class clean areas. Figure 5 shows a schematic diagram of the newly developed low-cost clean transfer system.

In the previous type of transfer systems, disk cassette chucks were provided under the transfer system body. In the new system, the chucks were removed from the system and placed outside the body cover to separate them from dust sources. In addition, to provide a clean power supply system to the transfer system body, an induction type feed system (non-contact type) was developed to replace the brush type feed system (contact type) because the latter emits a relatively large amount of dust.

The transfer system was developed as part of the total system, integrating a clean room design around the transfer system.

Fig.6 Configuration of an automated transfer system and peripheral equipment




### 4.3 Improvement of exhaust routes

The exhaust of air from facilities and dust sources is important in maintaining cleanliness of the clean room. The exhaust of a large amount air required for automated transfer systems within a single process or between several processes also requires a large amount of intake air, resulting in increased cost.

Realizing that exhaust air does not contain hazardous gases but only particles, Fuji Electric has developed a system that, utilizing pressure differences in the clean room to reduce the amount of intake air, directly exhausts dust sources to a return area and then removes particles from the exhaust. Figure 5 shows a schematic diagram of a low cost clean transfer system.

More specifically, exhaust pipes are attached to the top of the main body of the transfer system that is installed close to the ceiling. Usually these pipes are connected to exhaust ducts, but instead they pass exhaust air to the return area. In addition, since disk cassette chucks are provided outside the cover, slits are needed. An exhaust system was constructed to allow the exhaust air to be drawn into and to flow inside the cover and to directly return to the return area utilizing the pressure in the clean room.

Since media cassettes are transferred in an area outside the cover, which is installed immediately below clean units (ULPA) where a laminar flow of air flows, the clean transfer of disk was realized.

This type of transfer system was employed in other ceiling transfer systems [items (1) and (3) of section 3.1 above].

The driving unit of the transfer system was placed below disk cassettes and shielded with covers to separate it from the cassettes. The covers were provided with openings so that the exhaust air would directly return to the return area.

These measures can reduce costs in the exhaust system of an automated transfer system.

### 4.4 Configuration of peripheral equipment

Figure 6 shows the configuration of an automated transfer system and peripheral equipment that, as a total system, aim at improving cleanliness.

As a total system, measures for improving cleanliness were implemented for production facilities as well as for the automated transfer system. Particular attention was paid to the cassette transfer points of the automated transfer system, areas where cassettes and the disk passed, and their surrounding areas.

As higher quality products are required, special attention must be paid to the residence period between processes, and thus the buffer function was improved.

#### 4.4.1 Areas where cassettes and the disk pass

To secure a laminar flow of air from the ceiling, measures where implemented in the facility at areas where cassettes and the disk passed.

Partition covers are attached to the ceiling to separate areas for cassettes and the disk from the areas for facilities. Disk cassettes were placed on a framework construction to allow the laminar flow of air to and under the floor bottom.

Since cassettes and the disk are placed on transfer units at the transfer points, and robots for chucking are operated from the side, there are no shielding materials over the cassettes and the disk while they travel, preventing clean-air flow turbulence and securing a laminar flow of air.

#### 4.4.2 Buffer function of cassettes

To cope with higher quality requirements for the disk, the residence period between processes should be shortened to reduce the quantity of adhered particles and ion contamination. In some cases, there are limitations on the residence period for products between processes. An automated transfer system was designed taking into consideration not only tact time but also the residence period of disk cassettes.

In addition, a buffer function for disk cassettes is required for short time stoppage of the facilities. The number of buffer cassettes is designated in the production specifications for each unit, taking into consideration the number of units in each process, unit reliability and tact time at the time of total system design.

Buffer areas for disk cassettes were constructed in the same manner as cassette transfer points to secure a laminar flow of air from the ceiling. Utilizing the advantage of an overhead transfer system, the buffer function was incorporated into the design of overhead transfer routes.

Specifically, an area for receiving disk cassettes was secured on the overhead transfer routes. Although that area is not normally used, during operation of the production line it provides functions to remove and buffer all of the disk cassettes from the

previous process in the event of a short stop of the production line when disk cassettes being transferred to the next process.

Since disk cassettes are buffered directly below the overhead clean units, they are shielded from other dust sources, and particles are prevented from adhering to the disk cassettes even if the buffer time is short.

## 5. Conclusion

In order to construct automated transfer systems within a single process or between several processes, it is necessary to design as a total system all facilities including the transfer systems, clean room and each area.

Cost and technical limitations in improving cleanliness can be overcome by total system design, leading to a substantial cost reduction.

As the drive toward lower cost has intensified much faster than expected, cost reduction of the production line and transfer systems has become imperative. On the other hand, total automation of the production line is required to meet the demands of higher quality disk.

To satisfy these mutually contradictory requirements, it is necessary to shorten the residence period to prevent contamination, to reduce the quantity of goods in process and simplify production management, to reduce the cost of the transfer system and to save space, and as a result, to provide a production line with a minimized transfer system.

Minimization of the transfer system can be realized by connecting processes, eliminating distances between several processes, and improving the reliability of facilities.

Fuji Electric will continue to develop total systems in which the transfer function is incorporated into production facilities, beginning from the early stage of production specification determination.