SEGMENT AUTO CARRIER SYSTEM FOR SHIELD WORKS

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ABSTRACT

This paper proposes the integrated system in which the segments may be automatically conveyed from the shaft to the erector positioned at the rear of the shield machine.

Procedures of the system are summarized as follows:

1) Segments are automatically loaded into the battery-operated carriages by the segment-stock-rack device located on the ground. The carriages are controlled through the optic fiber communication system by the central control unit on the ground.
2) Carriages loaded with segments are carried down to the shield machine level through the shaft by the elevator.
3) Segment-lifting-device placed at the rear of the shield machine automatically receives the segments from the carriages.
4) Segments are conveyed from the Segment-lifting-device to the erector for the installment by the radio-controlled trolly hoist.

1. Introduction

Demand for the shield works has steadily increased as the technology to creste the linear-shaped underground space such as the roads, railroads and life lines. However,some serious may be present in the shield works such as the shortage of the labor of advanced age of the experienced workers. Therefore,the research has been developed to introduce the automatization and robotization into the shield works and its final goal is the unmanned shield works. Until now,it is not common that the materials such as segments are automatically conveyed according to the excavation process except for the case of the automatization in shield machine operation and robotization in installation of the segments.

This paper demonstrates the practical use of the automatization in conveying the segments from the stock yard to the erector at the rear of the shield machine.

2. Automatic Segment Carrier System

2-1 Components

Proposed system consists of the following components:

1) Central Control Unit
2) Automatic Segment-stock-rack Device
3) Battery-operated Carriage for Segment
4) Elevator
5) Segment-lifting Device
6) Optical Fiber Communication System

2-2 Central Control Unit

Central control unit is placed on the ground and it controls the stock of the segments and operation of the carriage and elevator.

In the unit,followings are equipped:

1) Monitor which shows the position of the elevator,kind and position of the segments placed in the stock-rack device, condition of the carriage and other components
2) Graphic panel which shows the position of the carriage
3) Monitor connected to the TV cameras placed along the path for conveying segments

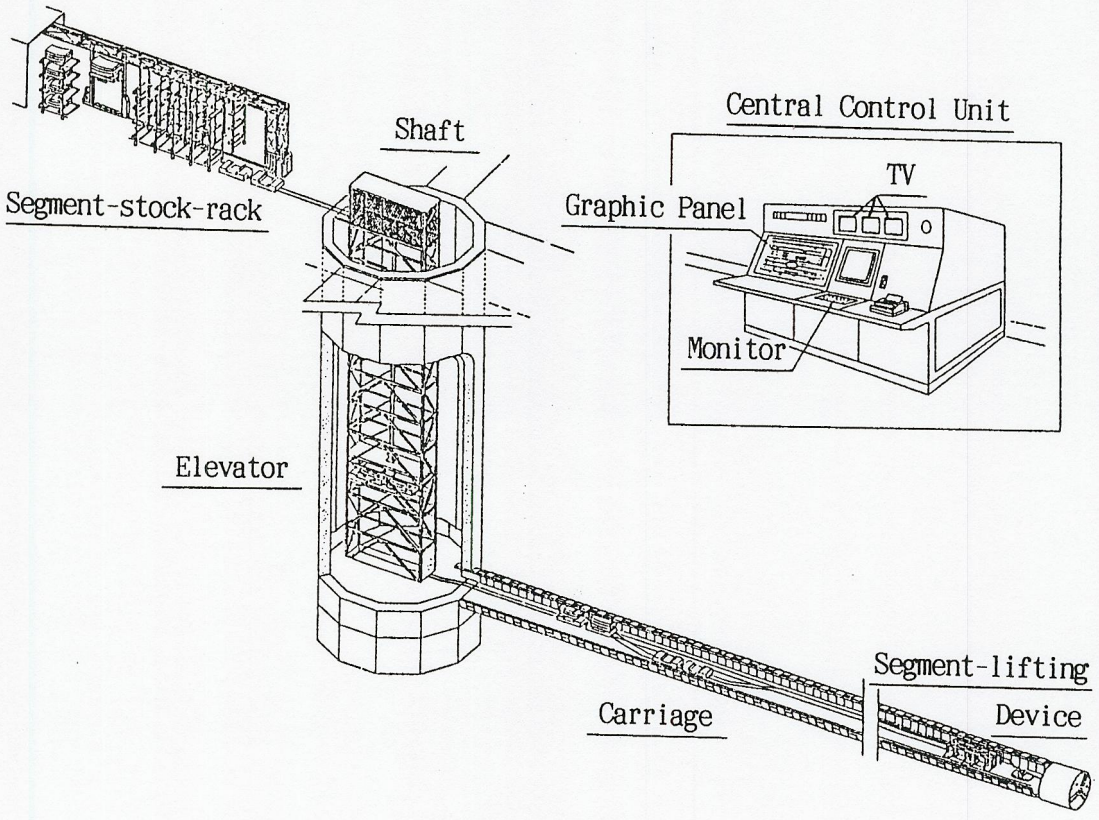

Fig-1 Concept of the System

2-3 Segment-stock-rack

RC segments are used here and one ring is formed by the six pieces of segment,that is,three A-segments,two B-segments and one K-segment. There are four kinds of segments and they are standard segment,taper segment and segments to adjust the directions (for rightward and leftward).

Three accumulated A-segments,and two accumulated B and one K-segment are treated as one unit,respectively in being brought to the site. Therefore,there are totally eight kinds of units of segments and segment-stock-rack has been equipped to store them.

Some processes have depended upon the man power such as:

1) stick the waterproofing tapes to the segments
2) loading of the segments to the traverser and conveying to the stock-rack
3) input of the kind of the segments brought in

However,followings are automatically operated:

1) prosess to receive the units on the traverser and place onto the rack
2) prosess to load the specified unit onto the carriage

Furthermore,followings are monitored in the central control unit and printed out:

1) Condition and number of the stocked segments for each kind of units
2) Records of the time on bring-in and take-out of the segments
3) Cycle-time for bring-in and take-out of the segments
4) Amount of work done for every day
5) Cumulative amount of the carriages of bring-in and take-out

Stock-rack is arranged in nine rows horizontally and in four stories vertically in both sides of the lifting device and therefore, 36 rings can be accomodated at maximum.

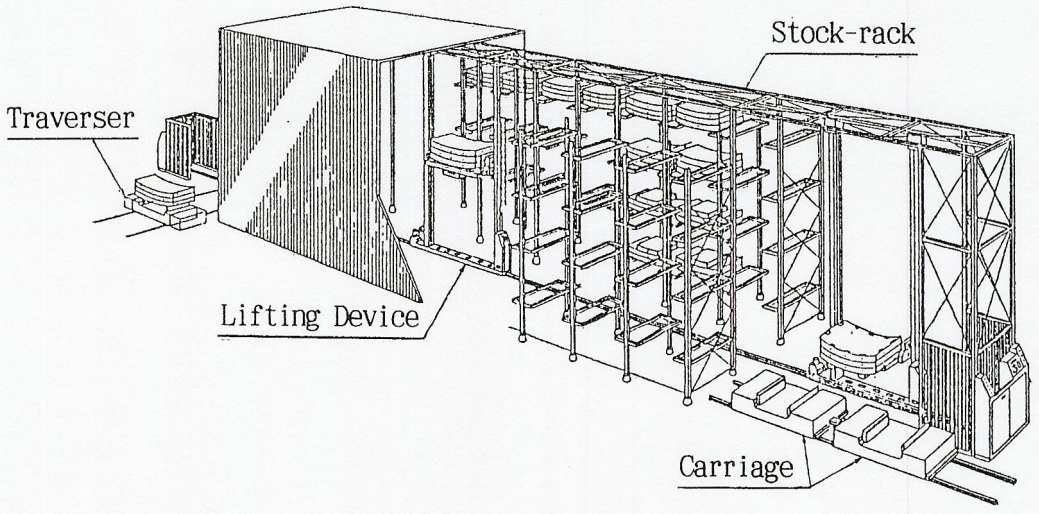

Fig-2 Segment-stock-rack

2-4 Battery-operated Carriage

Battery-operated carriage are primary component of the system and play an important role in conveying the segments from the ground to the segment-lifting device at the rear of the shield machine by way of the shaft. Segments corresponding to one ring are loaded in the two 3-ton carriages as shown in Photo-1. Two groups of the carriages receive the orders of Start or Stop,Forward or Backward,and Accelerate or Decceleraate from the central control unit through optical fiber communication system and also controled to run without bothering each other.

Their speed can be switched to 6.0km/h,3.6km/h,2.0km/h and 0.6km/h.

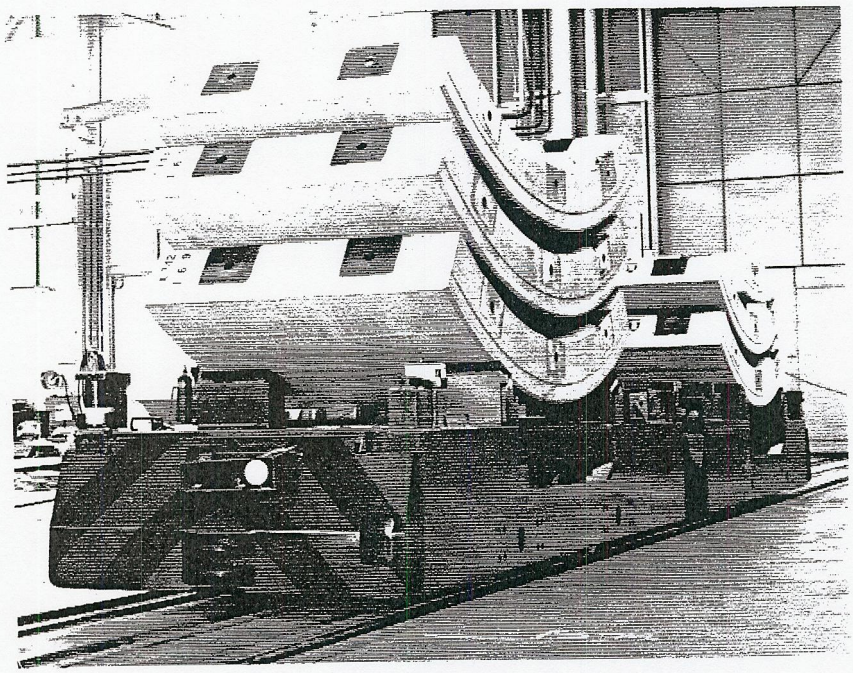

Photo-1 Carriage

Carriage are equipped following safety devices:

1) Indication light for automatic operation
2) Warning alarm for start
3) Warning alarm for moving
4) Warning alarm for emergency
5) Button for emergency stop
6) Sensor for avoiding collision
7) Safety bumper
8) Sensor to catch the unstable movement of the load

Once the battery is charged,the carriage can run about 4 round trips of 2-km-long path on the rail. The amount of the remaining battery may be automatically checked and the carriage move into the specified route to charge or change of the battery on the ground. The carriage is designed to carry not only segments but also general materials. It can also be connected to the passenger's car under the automatic operation.

2-5 Automatic Elevator

Previously,crane was used to convey the segments from the top of the shaft to the bottom. However,deep shaft may cause the several problems such as erroneous communication or insufficient ability of the crane. In this system,the carriages loaded with the segments go up and down by the elevator under the efficient operation by the central control unit so that wasting time of the carriages does not occur.

Floor of the elevator is equipped with the lock for stopping the carriage wheel which is out of control during going up and down. At the right position for stop of the elevator,the fixing device is designed to keep the stability for the carriage to go in and out.

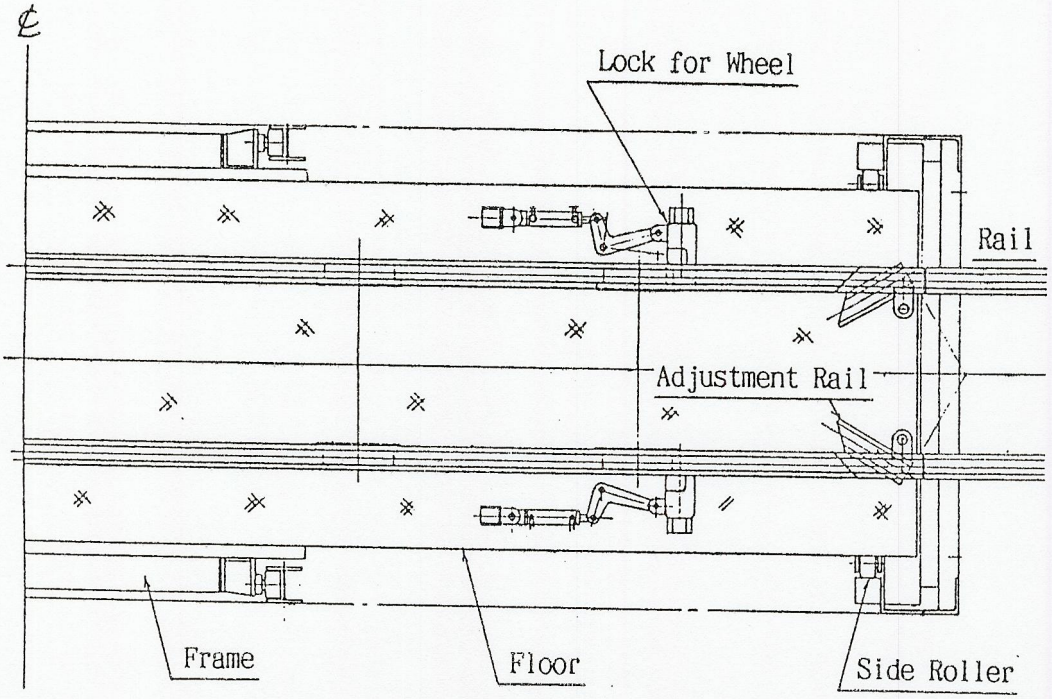

Fig-3 Plan of floor of the Elevator

2-6 Segment-lifting Device

This device has a function to receive the segments from the carriage and hand them to the erector. It consists of the forklift to receive the segments on the carriage and trolley-hoist to carry the every piece to the erector as shown in Photos-2 and 3.

Forklift is designed to lift up the segments from the carriage stopped at the specified position due to the signal from the forklift and move the carriage backwards to lift it down to the working range of the trolley hoist. Trolley hoist can grab the segment and rotate within 90 degrees. Those procedures may be performed by the radio control accounting for the safety of the workers in the narrow space.

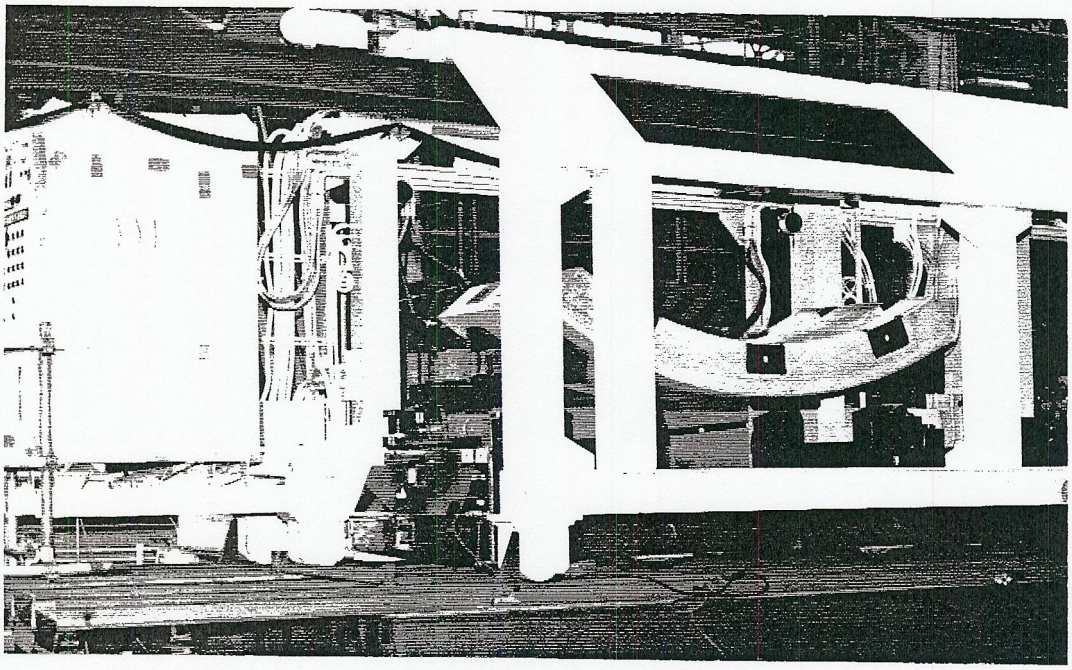

Photo-2 Segment-lifting Device

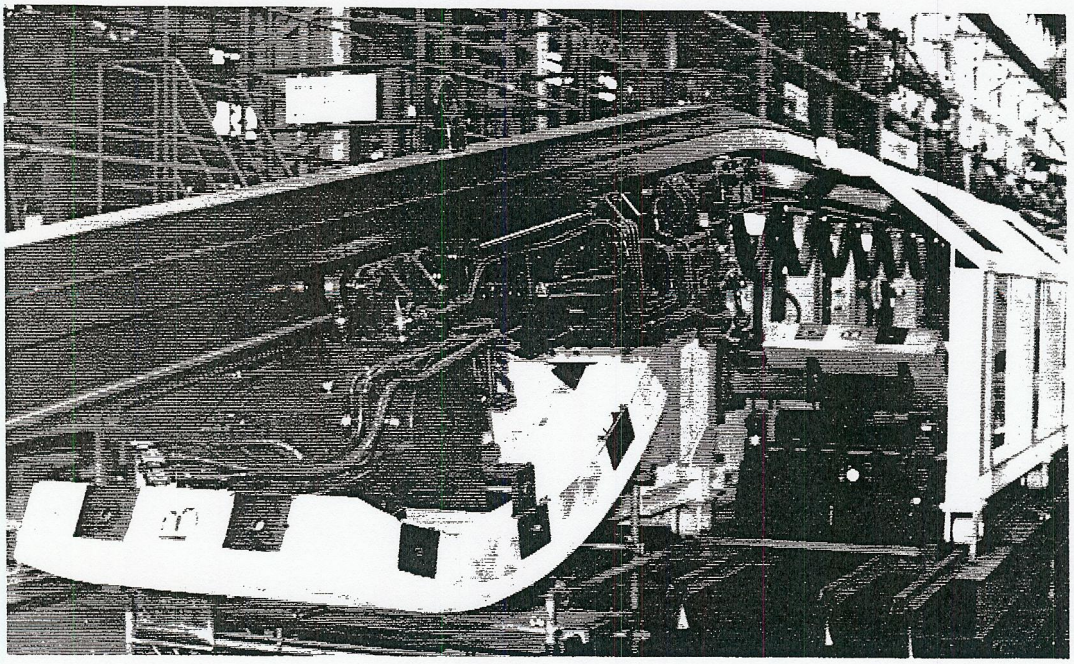

Photo-3 Segment-lifting Device

3. Method of Control

3-1 Control of Bring-in and Take-out of Segments in Stock-rack

The flow of this procedure is indicated in Fig-4.
The segments are stored in the order from the lowest rack to the upper one and older segments are arrenged to be taken out first.

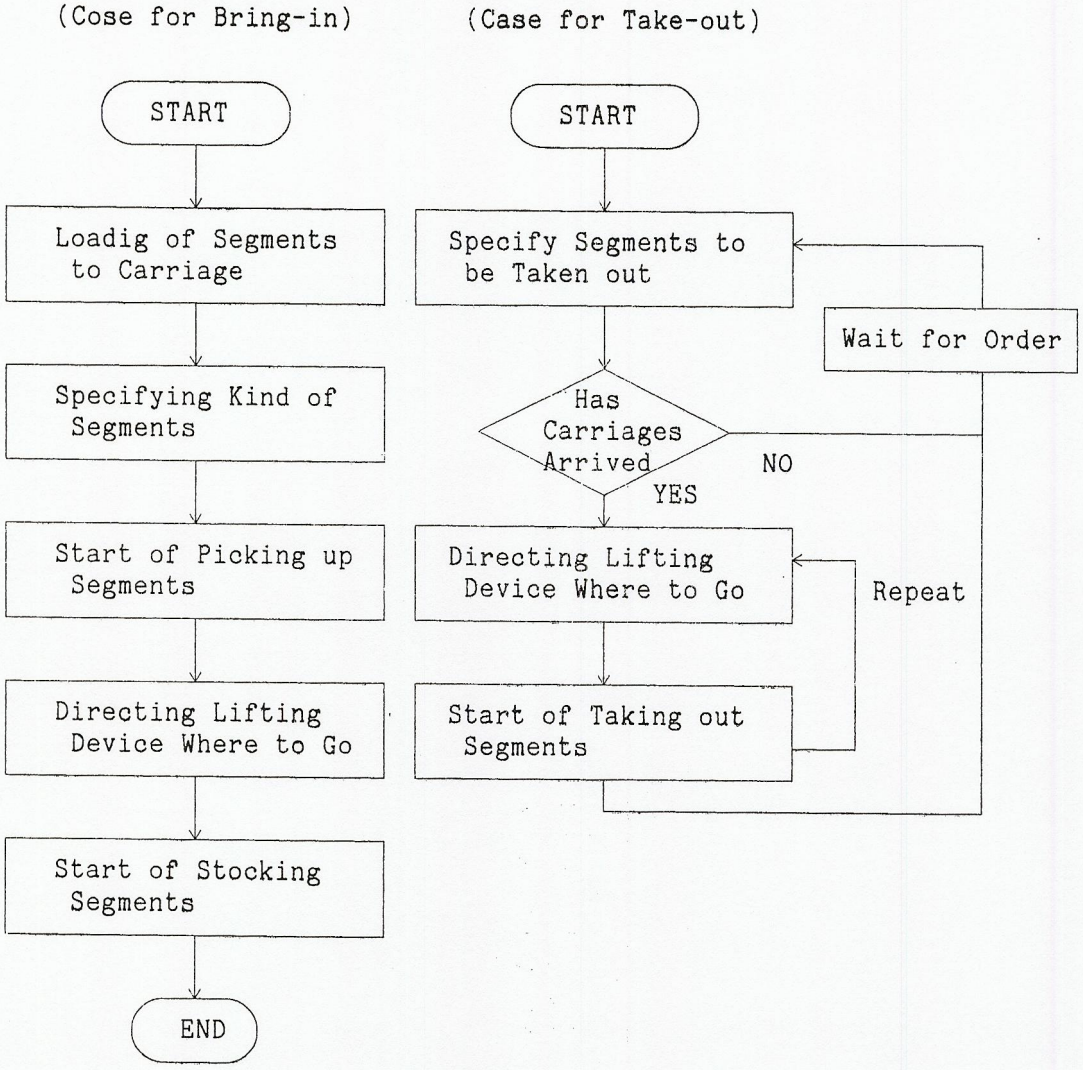

Fig-4 Flow of Procedures in Stock-rack

3-2 Control of stocked Segments

Fig-5(next page) shows a sample of monitor of Central Control Unit.

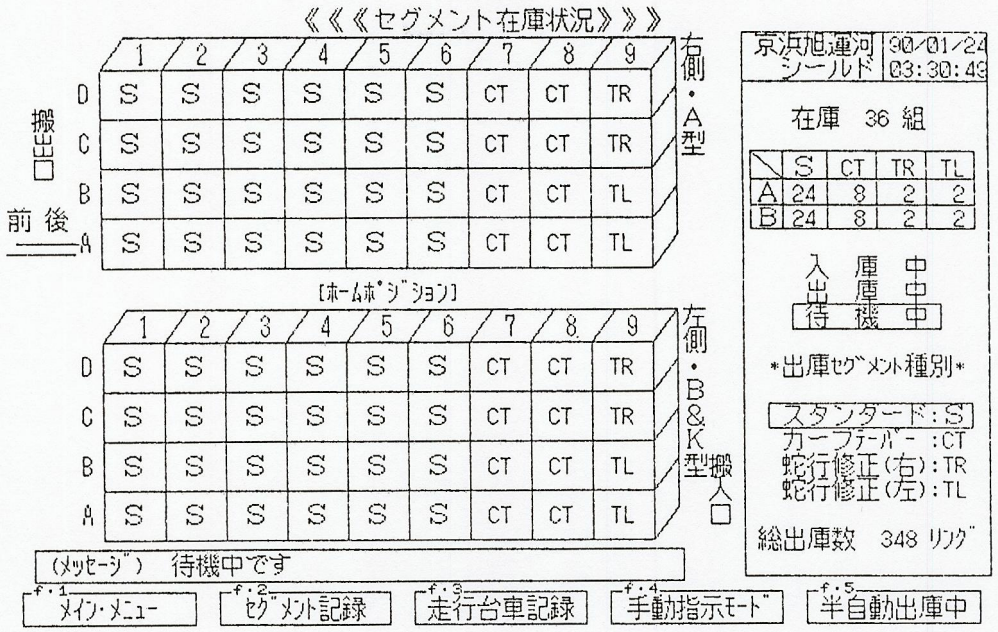

Fig-5 A Sample of the Monitor

3-3 Control of Operation of Carriage

First,central control unit transmits the signal to the optical control device through optical fiber communication cable.

Next,carriage receives such signal via device and runs.

Optical control device are installed along the carriage path if necessary and adress simlar to the phone-number is allocated to each device. Adress and carriage number in addition to data are included in the optical signal from the central control unit and they are transmitted from the specified control device to the specified carriage. Furthermore,carriage which receives the signal transmits the answering signal to the central control unit to confirm the order for the sake of the safe and reliable operation.

4. Conclusion and Summary

This system is now in operation in Keihin-unga Shield Works since November of 1989.(The outer diameter of the segment is 3.2m and tunnel-length is 1980m.) With the purpose of the automatic conveyance of the segments for the long distance,the system has been developed for practical use.

As the result,loading and unloading processes of the segments,which were previously done by the man,have became completely automatic and accordingly,safety has largely improved.

This technology will play a very important role for the efficient operation as shield works become more longer and deeper in the future. Further improvements may be attempted based upon the results at this site.