NEW STANDARDIZED RESIDENTIAL ELEVATORS

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ABSTRACT

Mitsubishi has developed and put on the market a new standardized residential VVVF controlled elevator that can offer reliability and stillness and shorten term of installation work by making the best use of state-of-the-art microelectronics technology and carrying out a drastic change in its structure. This paper describes the prominent features and the structure of this elevator.

1 FEATURES & STRUCTURE

Figure 1 shows the overall structure of the new standardized residential elevator. The rated load of this elevator is 450Kg and 600Kg, and its speed is 45m/min. and 60m/min. Mounting of the largely miniaturized control device at the upper part of the traction machine and guiding the counterweight with one rail make this elevator much different from the conventional one. The following are the main items newly developed and improved this time.
(1) Compact control panel
(2) New type rail for counterweight
(3) New type car
(4) Large digital indicator for car

1.1 Compact Control Panel

The basic construction of the VVVF control circuit is almost the same as that of the former VVVF elevator, however, it has been miniaturized to 1/5 of the former one (in volume) employing the new techniques described below, further, improvement in reliability has been achieved. Figure 2 shows appearance of the control panel mounted over the traction machine.
(1) Regenerative power control VVVF
In the elevator motor drive, braking torque must be controlled when the elevator car decelerates and runs at a constant speed in the condition of a traction motor driven by a heavier car or a counterweight. For the voltage source type VVVF motor drive, regenerative braking method is usually employed. But, this method

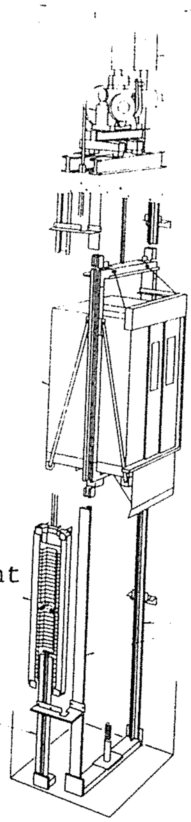


FIGURE 1 Overall structure

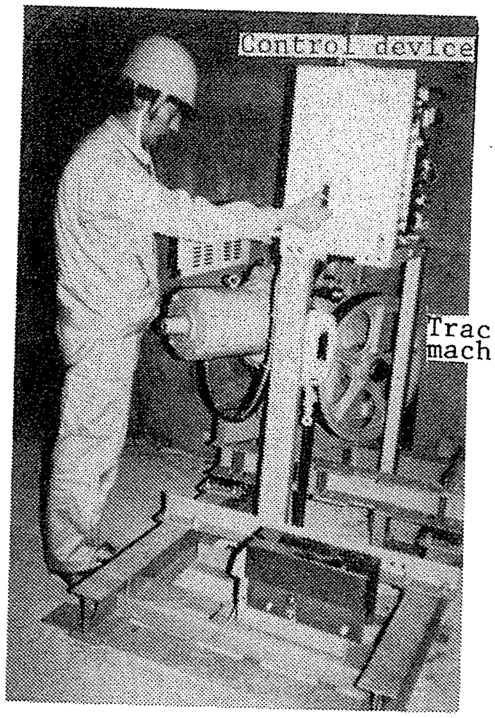
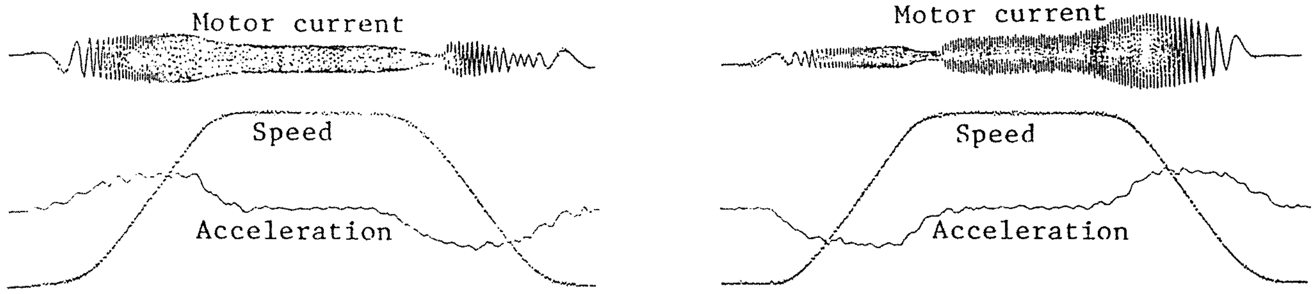


FIGURE 2 Control device

requires the regenerative power dealing equipment such as braking resistors which consume regenerative power or reversible converter which returns regenerative power to the power source.
We developed the new braking method "critical braking method" which controls the braking torque with keeping the motor slip constant at a critical value. This method can consume the regenerative power just in the motor windings without any extra power supply or power back. By adopting this system, the braking resistor is no longer necessary, and miniaturization of the control panel has been realized and reliability has been improved.
Figure 3 shows operation characteristics when this system is introduced.
(2) Development of custom LSI
We have developed and adopted custom LSI that was requisite for an interface circuit with the microprocessor and integrated processing functions peculiar to elevators. As a result, a speed feedback signal processing circuit, which was conventionally composed of about 50 general logical elements, has been attained with only one custom LSI ship. Thanks to this circuit, the control device has been further miniaturized and reliability has been improved. Also, adoption of the custom LSI has made wiring among elements unnecessary and increased operation speed and noise tolerance.
(3) Utilization of low power logical elements
High-speed CMOS (Complementary Metal Oxide Semiconductor), which consumes less power than the conventional LSTTL (Low power Schottky Transistor Transistor Logic), has achieved lower power consumption



(a) Rated load upward operation (b) Rated load downward operation

FIGURE 3 Operation characteristics

of the logic circuit. By adopting this element, power capacity for the logic circuit inside the control device has been reduced to 1/4 or less than the conventional one, and low heat emission in the device has been effectuated. Furthermore, this element has ameliorated tolerance to noise and ambient temperature.
As described above, heat emission, the obstacle to miniaturization of the control device, has now been cleared up by the development of the regenerative power control VVVF "critical braking method", realizing high densification of printed circuit boards by the best use of the most advanced microelectronics technology. This technology has also brought unification of the greatly miniaturized control device and the traction machine and made the layout of the machine room equipment and wiring between them in the machine room easy.
On unifying the control device and the traction machine, antiresonance design was carried out by modal analysis using FFT (Fast Fourier Transformation) device. And, rubber of low dynamic spring constant and high damping performance has been selected as a vibrationproof rubber in order to improve vibrationproof characteristic. In addition, higher chopping frequency of the inverter has reduced electromagnetic vibration and noise that the motor produces. As mentioned above, vibration transmitted from the traction machine or the motor to buildings has been reduced and further stillness in rooms near the machne room has been obtained.

1.2 New Type Rail for Counterweight

Shown in Figure 4 are the plans of the hoistways for a standardized passenger elevator and a standardized residential elevator respectively. Compared with a standardized passenger elevator, a standardized residential elevator has a larger depth as indicated in Figure 4 to make conveyance of furniture of tenants easy. The two side opening sliding door has been introduced to save opening and closing space. With such features of a residential elevator taken into consideration, we have developed a new system which can guide the counterweight with only one rail.

(1) Configuration and layout

The section configuration of this rail is illustrated in Figure 5. It has a π-shaped section configuration that offers sufficient torsional rigidity and bending rigidity. Plate thickness is 4.5mm and weight is 11kg/m.

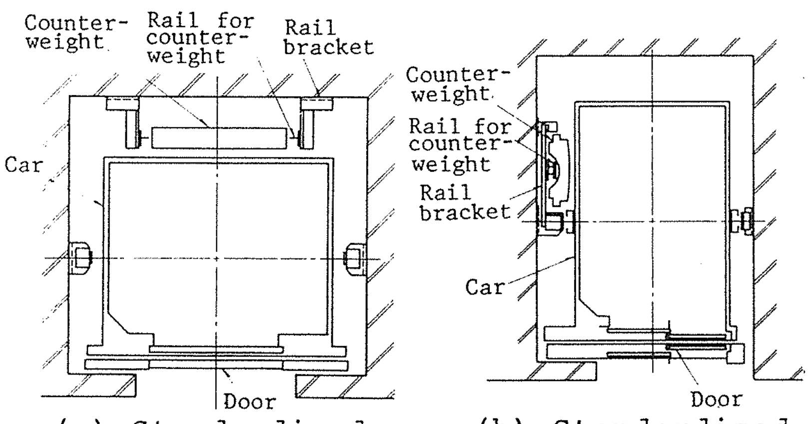
Figure 6 shows the configuration of the counterweight. The rail bracket for the car extends to support this new type counterweight rail. Utilizing one rail for counterweight and common use of the rail bracket of the car and the counterweight have reduced the period of installation work.

(2) Working method

This rail is formed by roll forming and has possessed satisfying accuracy by the use of a material of high elongation rate and improvement in forming technique. The material, of which elongation rate was improved by adjusting such constituents as carbon, manganese and sulfur and which was controlled so as to restrain content of debris, was selected. Spring back in end parts of formed products has been reduced largely and forming accuracy has been increased by both improvement in the roll forming machine and applying compressed stress to 180° bent portions.

(3) Confirmation of safety

Safety of this rail when an earthquake happened was confirmed in vibration test utilizing actual rail as well as stress and deformation against static load identified by calculation and experiment. In Figure 7, the test scene is shown. First, natural frequency and damping coefficient of the rail-counterweight system was examined by applying sine-wave sweep frequency vibrations in two



(a) Standardized passenger elevator

(b) Standardized residential elevator

FIGURE 4 Plan of hoistway

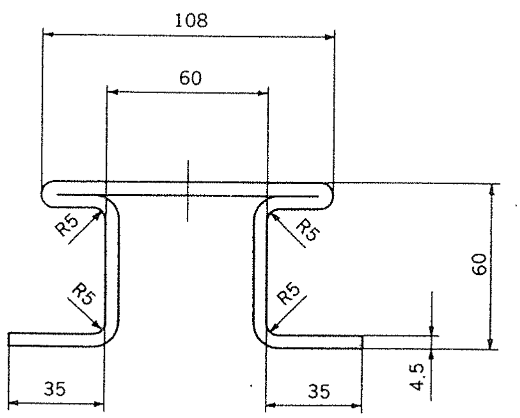


FIGURE 5 Section configuration of rail

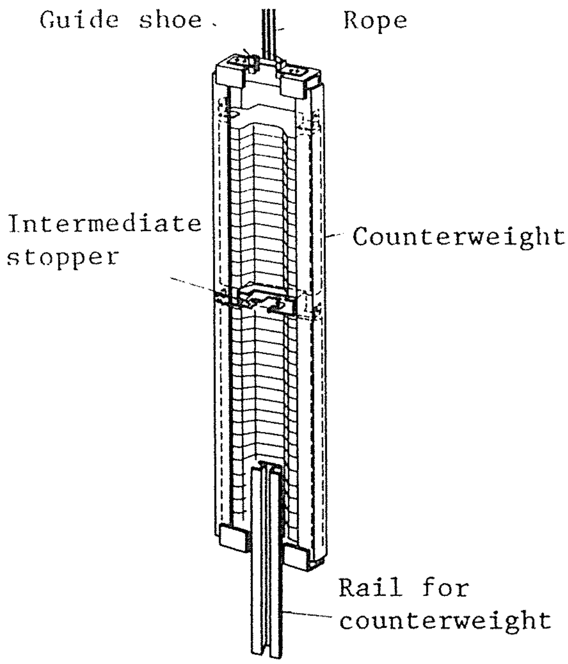


FIGURE 6 Counterweight

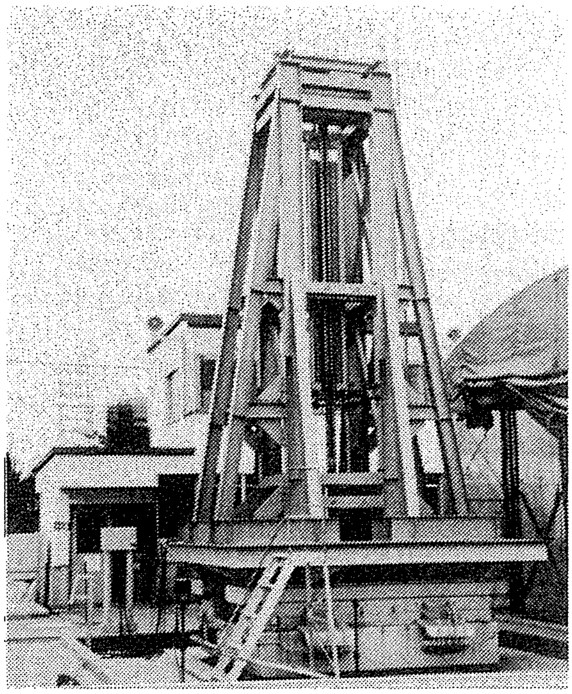


FIGURE 7 Scene of vibration test of rail

horizontal directions. Next, actions of the rail during earthquakes were checked by giving vibrations of waveforms which were recorded during actual earthquakes. Three types of representative earthquake waveforms - El Centro, Taft and Miyagioki earthquakes - were adopted. As a result, it was found that natural frequency and damping coefficient of this rail-counterweight system was not much different from those of the conventional ones, and stress and displacement of the rail when earthquakes occurred were within the allowable range. The test results are shown in Figure 8. Table 1 shows the test results when acceleration of the counterweight was 0.6G (G: gravitational acceleration), disclosing satisfactory safety of the rail. The value 0.6G is horizontal seismic scale for design of elevators installed in buildings of 60m or lower in height.

1.3 New Type Car

To an elevator, miniaturization and lightness of car apparatus are important for reduction in load working on buildings and energy saving. Reduction in weight by 15% has been achieved in this elevator by miniaturizing such apparatus as the cardoor operator, the safety device and the car frame and by employing lightweight materials.

(1) Cardoor operator

In the new type cardoor operator, timing belts have been employed to the speed reducing mechanism of the driving motor and the driving part for doors in order to prevent slip on the belt part and make door opening and closing performance better. And, thanks to miniaturization of both the pulley and the door driving machine, weight has been decreased by 30%. Furthermore, adoption of the optical switch for the door position detecting unit has realized improvement in reliability and longer service life.

(2) Gradual safety

Vibration direction / Vibration waveform	X direction			Y direction	
	Max. rail stress (kg/cm^2)	Max. rail displacement (mm)		Max. rail stress (kg/cm^2)	Max. rail displacement (mm)
		X direction	Y direction		
El Centro	170	0.8	1.8	150	1.6
Taft	210	0.9	2.1	180	1.6
Miyagioki	100	1.5	2.4	130	1.5

Note: Counterweight acceleration 0.6G, rail bracket span 2.5m

TABLE 1 Vibration test results

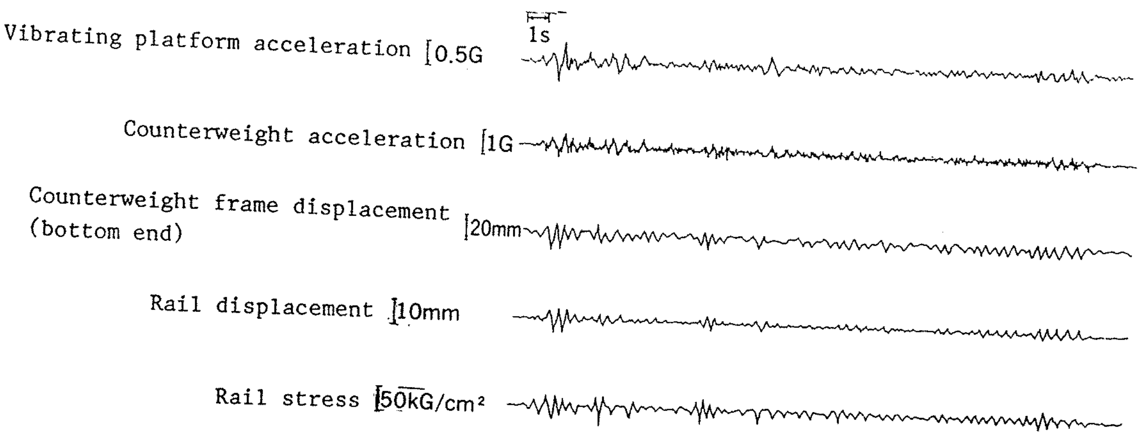


FIGURE 8 Vibration test results

The gradual safety is a safety device that supports the rail with the wedge type shoe to decelerate and stop the car when the lowering speed of the car exceeds the specified value. Besides the improvement in friction characteristic by using hardened steel of special shape for the shoe, reduction in weight by 40% compared with the conventional one has been attained by improving the mechanism. Figure 9 shows the measuring results of the braking characteristics of the gradual safety.

(3) Car frame

For this car frame, a high-strength steel (rolled plate for automobiles: SAPH 45) has been employed and the structure of the frame has been ameliorated, resulting in reduction in weight by about 20%. And, modal analysis of the car using this car frame made resonance frequency and vibration mode clear. By antiresonance of each member and the most appropriate use of the vibration isolation rubber, vibration of the car has been decreased. In Figure 10, the results of modal analysis is shown.

1.4 Large Digital Indicator

This elevator has been equipped with a large, high-brightness orange LED digital indicator. The upper part of the car operating panel is the mounting place of the indicator as well as the direction lamp and the operating lamp. By this arrangement, the indicating position has been fixed even in multiple floor service and recognizability has been increased with the enlargement of the indicator. As the indicator of 16-segment type is used, numbers, English letters and combinations of them can be displayed. Maneuverability has been further improved by such ways as illuminating the indicator just before the stop to let passengers know the arrival at the destination floor beforehand.

The transmission line for destination floor button signals has served as the line for indication signals sent from the control device. This system has made the special transmission line for indication letters and signals unnecessary and accomplished shortening of period of installation work and improvement in reliability.

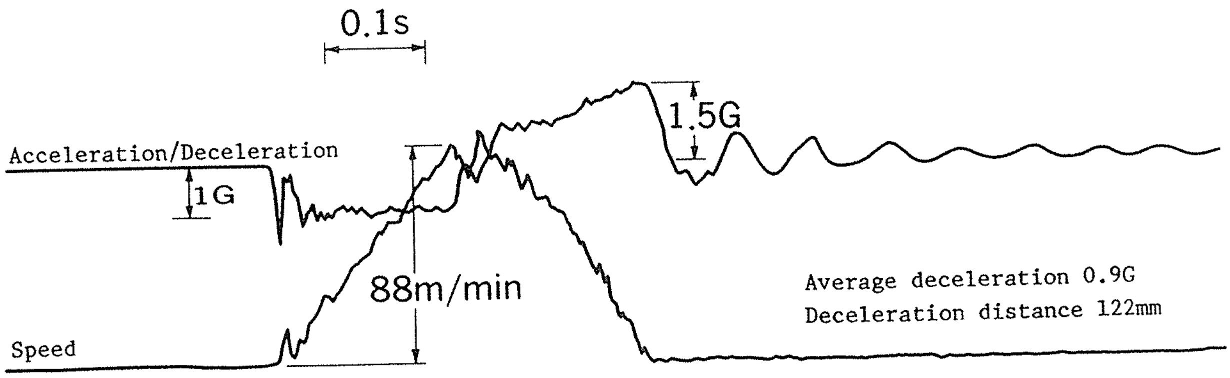
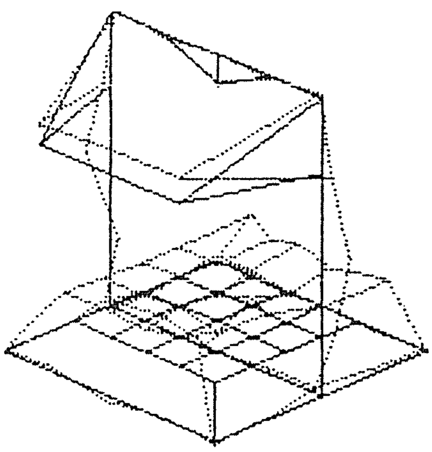
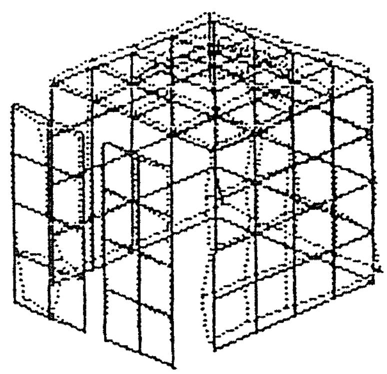


FIGURE 9 Braking characteristics of safety device



(a) Car frame and car platform

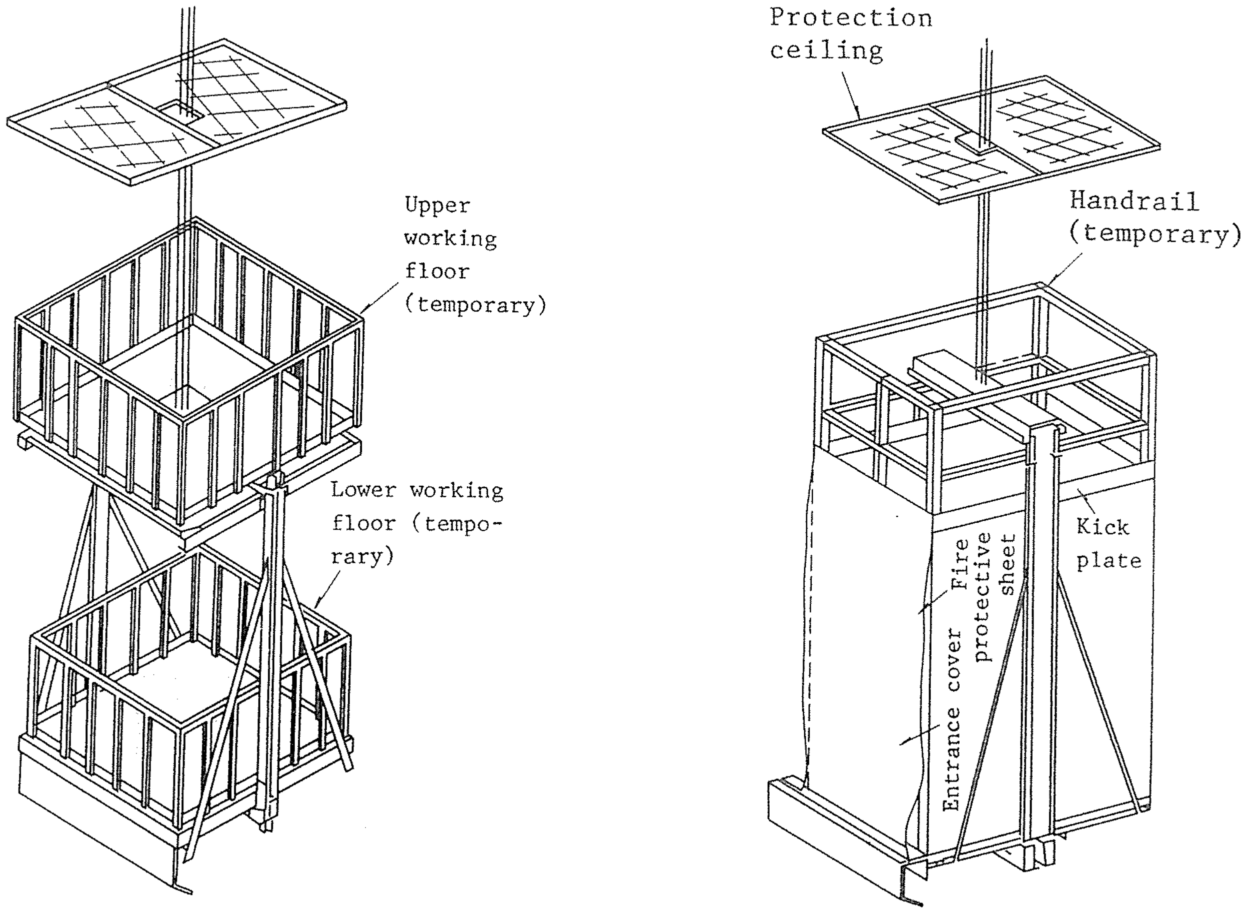


(b) Car enclosure

FIGURE 10 Measuring results of vibration mode

2 INSTALLATION METHOD

Construction period of buildings has been shortened owing to progress in construction method. In view of this circumstance, improvement in installation method for this elevator has been made with the development of products, so that the term of installation work has been reduced by 15%.
In case of conventional installation method, as shown in Figure 11, work inside the hoistway was carried out with temporary working floors provided at the top and the bottom of the car frame, then, the car closure was fabricated after completing work in the hoistway and removing the floors. But, the installation method has been changed so as to utilize the ceiling of the car enclosure as a working floor as illustrated in Figure 11 (b), resulting in shorter work time.
In addition to such structural improvements in the product as unification of the control device and the traction machine and utilization of one rail for the counterweight, shortening of mounting period required for the above apparatus has been realized.



(a) Conventional method (b) New method

FIGURE 11 Working floor for installation