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A New Running Test Facility for the Study of Flight Dynamics

By

Akira AZUMA, Bunji TOMITA, Matsusaburo IUCHI,
Masahiko ISHII*, Akira NOGUCHI*
and Tsukasa KOJIMA*

Summary: This is the first part of a report for "A New Running Test Facility for the Study of Flight Dynamics". The facility may be used to evaluate the aerodynamic and/or flight dynamic characteristics of a model of aircraft or, specifically, V/STOL aircraft loaded on a carriage which can move on a track by the maximum speed of ten meters per second. If the model is fixed on the moving carriage low speed aerodynamic characteristics of the model may be obtained by using the internal balance systems installed in the model with similar treatment as well known in the wind tunnel excepting that the model is running instead of flowing the air. If the model is supported on "A New Free Flight System"**, which can be carried on the carriage, as to be able to fly the model freely for specified directions in any given degrees of freedom, then the flight dynamic characteristics of the model may be evaluated by analyzing the data of the model trajectory which are recorded during the test run.

The present report includes the detailed description of the design philosophy, simple explanation of the structural outline and arrangement of the equipments, and the test results for the mechanical performance of the facility.

INTRODUCTION

Although the wind tunnel test has provided a lot of usable informations on the aerodynamic and flight dynamic characteristics of a model, there must be a some limit in its performance. For example, in usual wind tunnel very low speed operation, such as less than five meters per second, does not necessarily work well as in ordinary used velocity range and also a correct measurement of the wind velocity must be difficult with usual anemometer, such as pitot static tube, since the dynamic pressure is too low to detect the fluid column change. Furthermore, the wind-tunnel-boundary correction due to the development of the boundary layer along the wall adds the difficulty for either test procedure or analysis of the results.

The above described shortcomings in the low speed aerodynamics will, however, be overcome if the model is run with a specified speed in still air confined in a large building.

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* Uraga Heavy Industry Co., Ltd., Uraga, Yokosuka

** The detailed explanation on "A New Free Flight System" will be reported on the subsequent paper.

So far we concern low speed operation the total cost for the construction of a new running test facility must be lower than that of the wind tunnel having same test-sectional area.

In addition, by using the running test facility the flight dynamic simulation will also be attained with a dynamically similar model supported on the free flight system which is loaded on the carriage. It is further preferable that if the model is clamped on the system each component of the aerodynamic forces and moments can be detected by internal balance units in the system.

We have known that such facility has already been constructed in Flight Mechanics Laboratories at Princeton University [*1*] and felt the necessity for the construction of a facility in Japan. In the fiscal year of 1967, the V/STOL committee headed by Professor Itiro Tani, which had been organized in the Institute of Space and Aeronautical Science, University of Tokyo, since 1964 for the systematic research to the fundamental analysis and development of V/STOL aircrafts, had planned to build a new running test facility for the study of flight dynamics, specifically for V/STOL aircraft, in the campus of the Institute. (See Fig. 1)

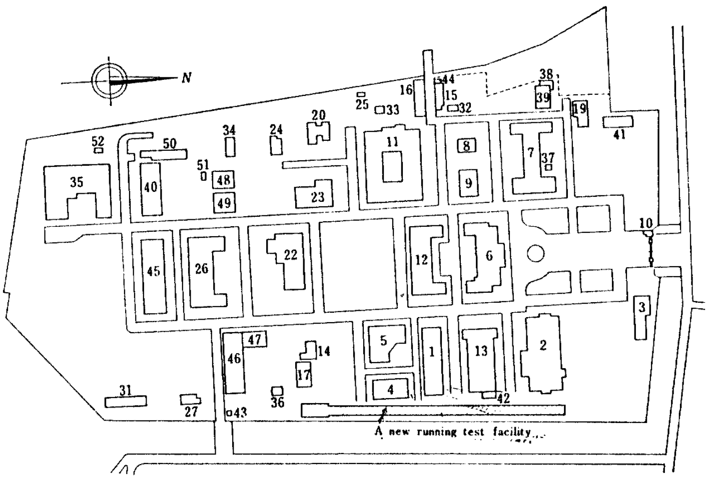


FIG. 1. Location of the new running test facility in the campus of The Institute.

The Committee for the Construction of the New Running Test Facility had been formed for this purpose, the members of which were Prof. H. Asada, Prof. K. Ikeda, Prof. I. Tani, Prof. S. Fukui, Prof. M. Okada, Prof. K. Hatta, Prof. R. Kawamura, Prof. H. Tanaka, Prof. B. Tomita and Prof. A. Azuma in the Institute. The committee had proceeded the construction with the grateful assistance of the consulting members, Prof. H. Maeda, Kyoto University, Prof. S. Otsuka, Nagoya University, Prof. K. Washizu, Prof. S. Motora and Prof. T. Tagori, Faculty of Engineering, University of Tokyo, and Prof. T. Shoda and Prof. G. Miki, The Institute of Industrial Science, University of Tokyo.

The construction of the facility was ordered to the Uraga Heavy Industry Company Ltd. in which the Machinery Design Department had responsibility for this project. The following companies cooperated to the construction of the facility:

Kyoei Kogyo Co., Ltd. for the construction of pit and building, Furukawa Denki Kogyo Co., Ltd. for the electric collecting apparatus, and Meidensha Co., Ltd. for the power and control system.

The total cost of the facility except the Free Flight System was about $250,000.

A general description on the New Running Test Facility willl be reported with Japanese in the Bulletin of the Institute of Space and Aeronautical Science, University of Tokyo, Vol. 5, No. 2(A), 256 (1969) under the name of the Committee for the Construction of the New Running Test Facility.

Building for Sheltering the Atmosphere Disturbance

The test area must completely be enclosed in a building to prevent disturbing air currents and to provide weather protection.

Except economical consideration, the cross sectional area of the building may preferably be as large as possible since the cross sectional dimensions determine the maximum size of a model which can be tested in the facility. The width and the height of the building restrain not only the lateral and vertical motions of the model but also the strength of induced velocity produced by lifting means of the model.

The length of the building is solely determined by the length of a track which is, as described later, a function primarily of the model speed and the test duration of free flight during the experiments.

Thus, the over all dimensions of the building have been decided to fulfil the minimum requirements and given in Table 1 and Fig. 2.

Table 1.

Item	meters	feet
length	200	655
width*	6.0	20
height from the ground level from the base of pit	 5.5 8.0	 18 26

The test area must be kept calm as much as possible to avoid undesirable air currents. Except a part of starting end the building is shielded by a ply of corrugated steel sheets and a ply of porous wooden plates and also has a sprinkler on the roof for every ten meters to cool the top of the building so that the convection due to the temperature gradient is inconspicuous. The part of the starting end of the building was reclaimed from an old warehouse so that this part was not insulated with wooden plate.

* Only a part of the starting end of the building has ten meters width and thirty meters length.

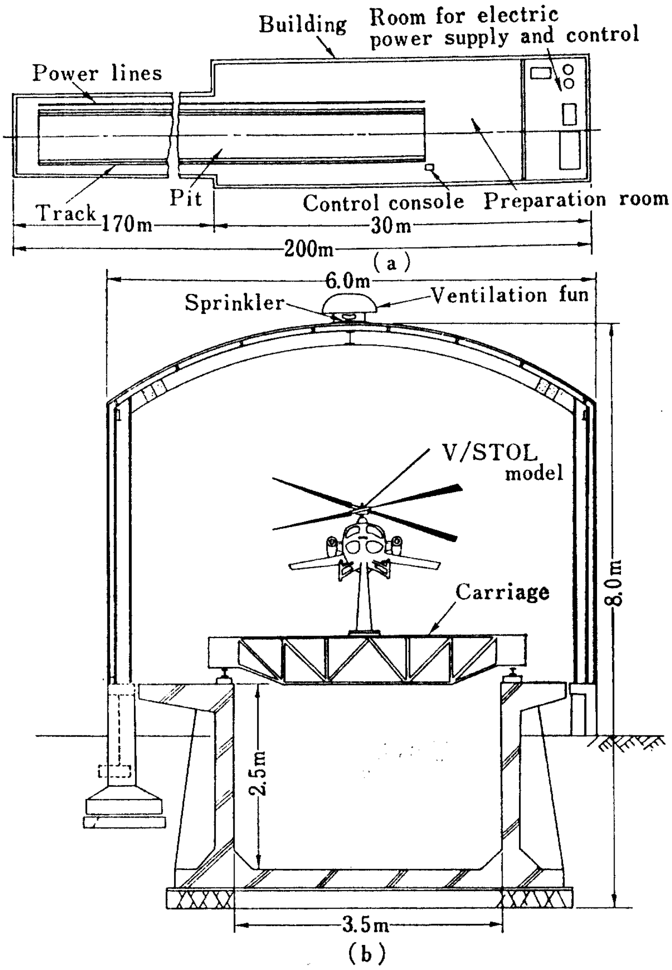


FIG. 2. Building.

There are equipped with seven fans on the roofs and seven filters on the side walls for ventilation (flow volume is 95 $m^3/min \times 7$) inside of the building. Any other special temperature control systems are not employed.

PIT FOR THE ESCAPE OF DOWNWASH

As shown in Fig. 2b, a pit is constructed with ferro-concrete and is separated from the footing of the building. The dimension of the pit is described in Table 2. Ledges of opposite sides of the pit are utilized to fix two rails for running of the

TABLE 2.

Item	meters	feet
length	185	610
width	3.5	11.5
depth	2.5	8.5

carriage. The channel section of the pit is used to escape the downwash from the lifting means of the model and also can be used to test, for example, ditching of the model if water is stored in the channel.

There are graduated on the bottom of the pit for every five meters with number plates so that the pilot of the carriage can read the distance from either side of the track even on board during running test.

TRACK

The track can be used to support and guide a carriage with commanded speed, acceleration and deceleration while the carriage must be free from the vibration due to the mechanical contact between wheels and rails.

The track consists of two series of steel rails spaced three and half meters (3.5 m), rail chairs and stoppers at both ends of the track as shown in Fig. 3 and 4. We decided to adopt two parallel rails instead of a mono-rail since the strong requirements for a large carrying capacity with satisfactory structural rigidity and strength of the carriage.

FIG. 3. Track.

It is natural to use the strong rails as much as possible, but from only the financial reason the rails are machined and ground from the so called 30 kg-rail which means weight to unit meter. Since the smoothness in the surface finishing of the rails and their joints which are welded except on the top surface and the accuracy in following a straight line determine the amplitude of undesired disturbance to the motion of the carriage or model, the work and the maintenance of the rails must carefully be kept to an acceptable level throughout a wide range of temperature conditions and ground conditions.

The vertical acceleration of a wheel is proportional to both a curvature of the rail deflection and a square of horizontal speed of the carriage. The rail chairs which support the rails adjustably are arranged to minimize the curvature, instead of deflection, of the rail caused by a load from the weight of moving carriage and the inevitable malalignment in the setting up the rails. In order to reduce the deflection, hence the rail curvature, due to the moving load it is surely necessary to shorten a rail span or a distance between adjacent chairs. However, to reduce the rail curvature due to the irregular setting, which will be considered to have lower limit about $\pm 5/100$ mm for the present state of art, the said distance should preferably be large. Therefore, the distance between adjacent chairs must be decided to compromise the above two effects on the rail deflections caused by moving load and the irregular setting of the rail chairs.

The total weight of the loaded carriage is assumed to be about four tons, hence one of four wheels of the carriage is assigned to support one ton. Two loaded wheels, which are separated each other by wheelbase, move on the rail with the maximum speed of ten meters per second (10 m/s). The wheelbase is decided to have two and half times the rail span so as to reduce the acceleration at a center of the wheelbase. The deflection due to the above moving loads is calculated by simple beam theory.

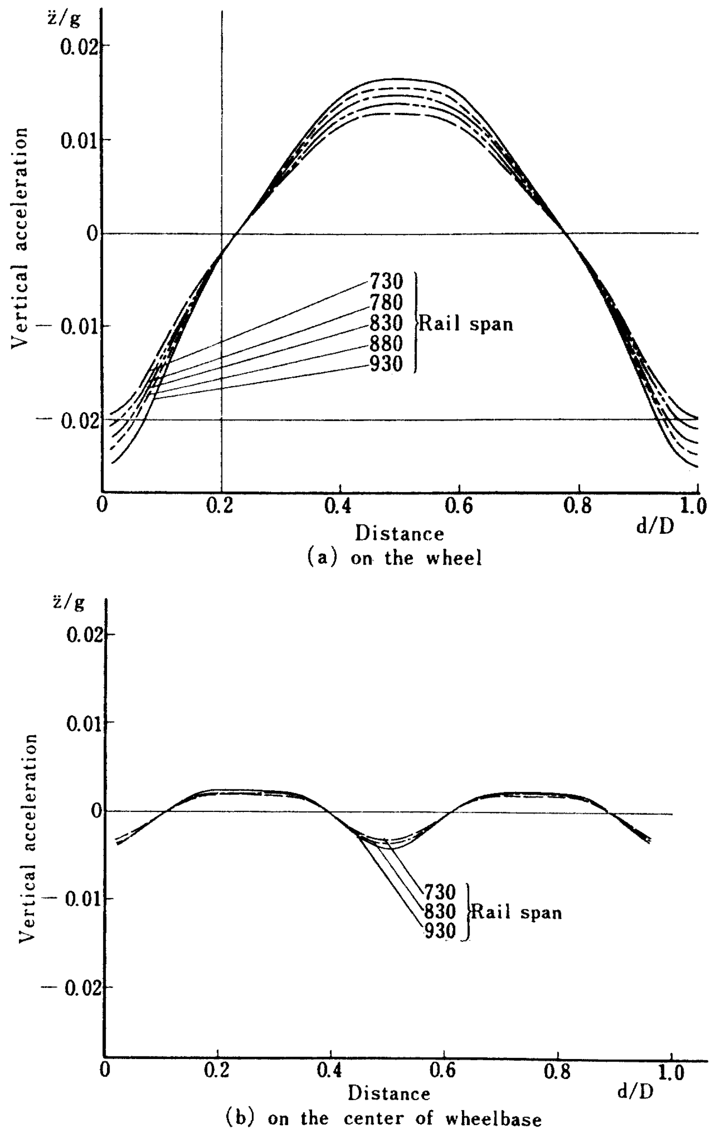
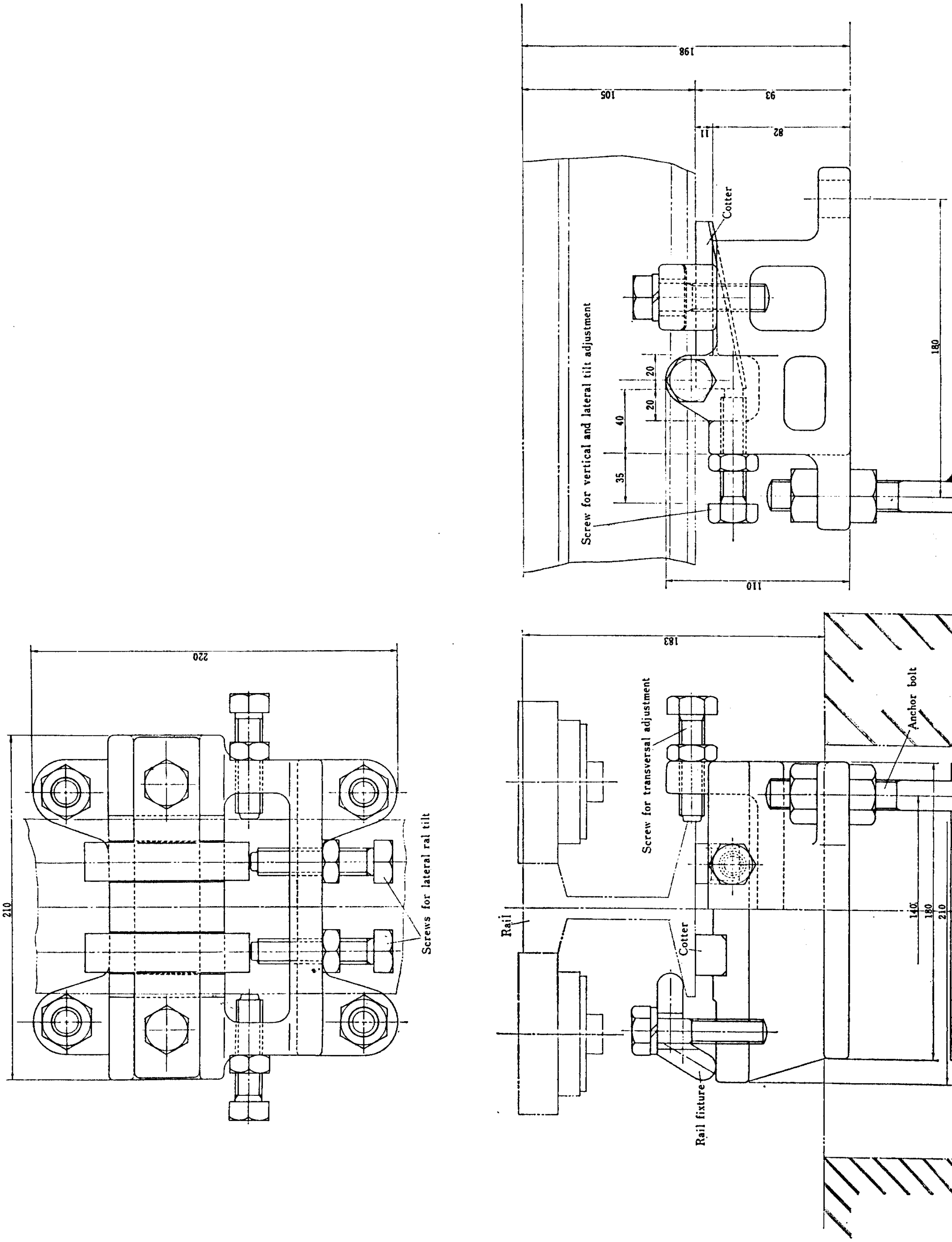


FIG. 5. Vertical acceleration caused by moving load.

Fig. 5a and b show the vertical accelerations on the wheel and the center of wheelbase respectively caused by a series of two loaded wheels moving with ten meters per second. The acceleration is expressed by "g" or nondimensionalized


198
105
93
11
82
Cotter
Screw for vertical and lateral tilt adjustment
20
20
40
35
180
110
183
220
Screw for transversal adjustment
Anchor bolt
Screws for lateral ral tilt
210
Rail
Cotter
Rail fixture
140
180
210

Screws for lateral ral tilt

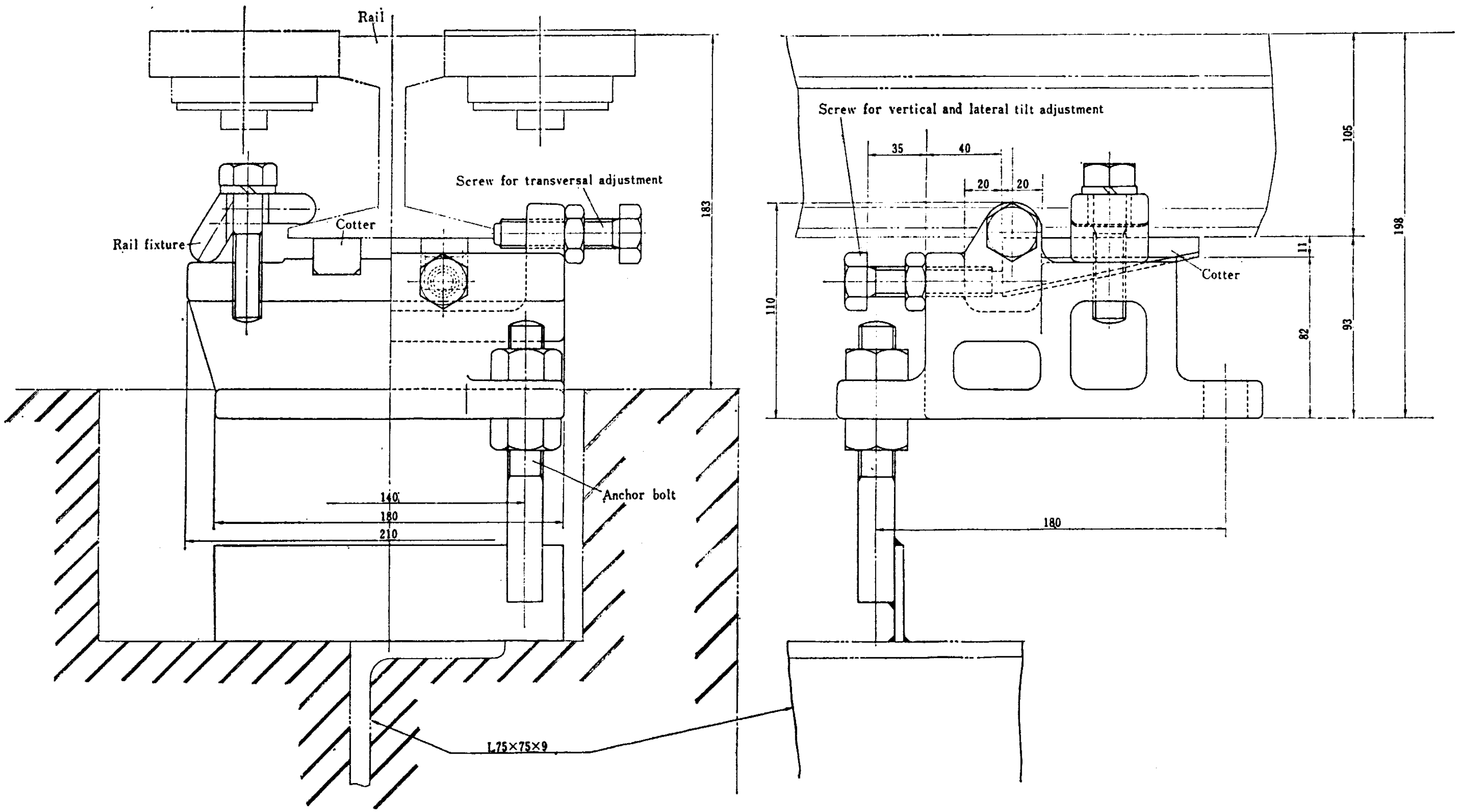


FIG. 4. Chair.

with "g" and shown as a function of distance, d, from the one of chairs, normalized by the rail span, D, or the distance between two adjacent chairs.

It will be observed that the vertical acceleration along the rail span is appreciably reduced from a point on the wheel to another point on the center of wheelbase. This acceleration reduction is caused by taking the wheelbase two and half times of the rail span whereby the vertical accelerations on front and rear wheels are mutually canceled at the center of wheelbase.

In calculation of the acceleration the rail span is varied from 730 to 930 mm and the result is shown as a parameter in the figures. It will be notified that as the rail span increases the maximum acceleration is increased for both cases of Fig. 5a and b.

The accuracy of the rail setting is, however, considered statistically from the past experimental data obtained from the other facilities having similar construction. As previously described, the chair is capable to adjust vertical and transversal positions

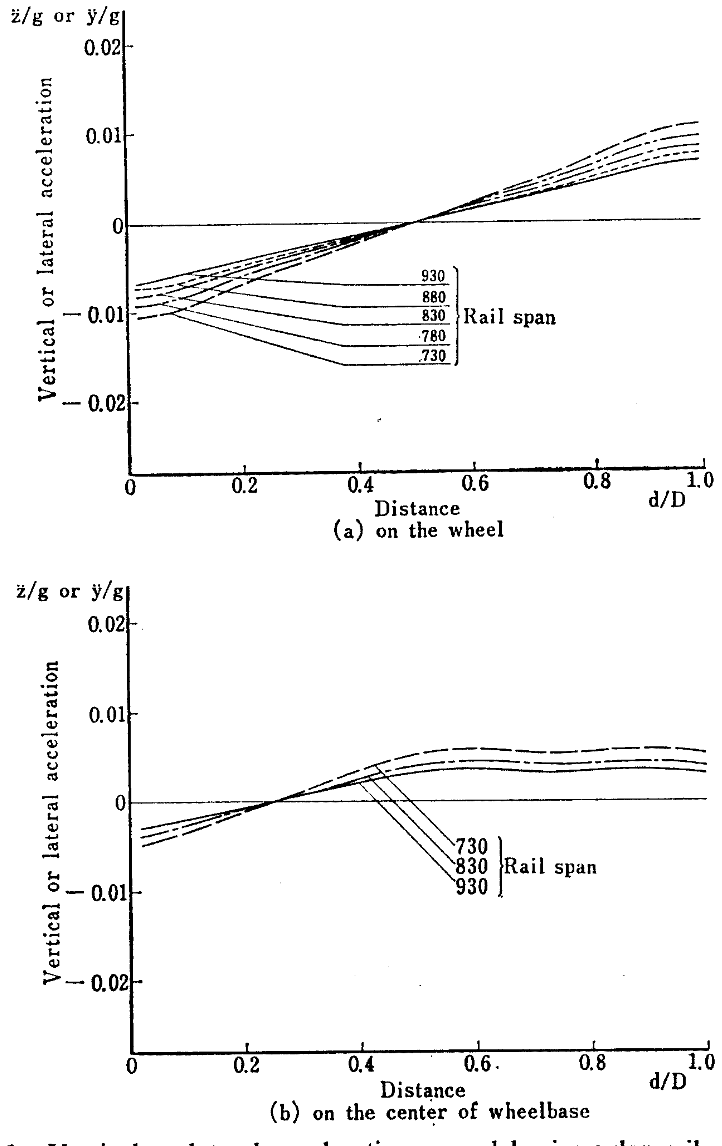


FIG. 6. Vertical or lateral acceleration caused by irregular rail setting.

and lateral tilt of the rail. Such adjustment is done to keep the rail within a given setting accuracy by driving or loosening each corresponding screw as shown in Fig. 4.

The most severe case for either vertical or lateral acceleration must be obtained from the assumption that the subsequent rail chairs are zigzagged with the amplitude of 5/100 mm. Inspection rule for rail setting was defined as to keep any inspection point on the rail surface seated on the chair to be within ±5/100 mm and at least the subsequent inspection points on the chair to be within ±2/100 mm along a straight line for lateral direction which is defined by a piano steel line stretched between two marked points fixed at the opposite sides of the track and a horizontal line for vertical direction which is defined by water level in a channel located alongside of each rail.

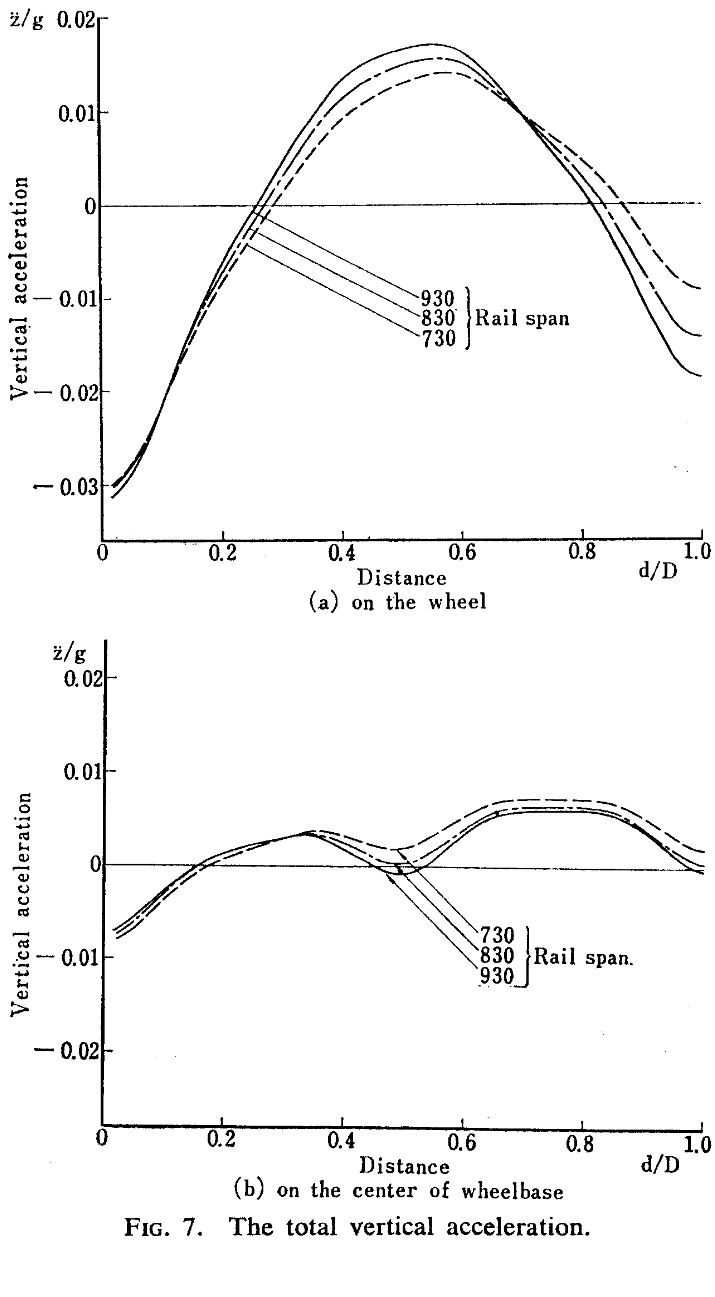


FIG. 7. The total vertical acceleration.

It was also assumed that the rail on the rail chair was clamped at a point on the center of chair as a pin so that the rail deflection was calculated for a series of zig-zagged pin joints.

From the above assumed deflection due to the irregular rail setting the vertical or lateral accelerations* on the wheel and the center of a wheelbase are calculated respectively as shown in Fig. 6 similar to Fig. 5. It will be apparent that the acceleration is weakened for the center of wheelbase and the maximum acceleration is observed for small rail span.

The total vertical accelerations on the wheel and the center of wheelbase are obtained by summing up the above two acceleration components as shown in Fig. 7. It is interesting to say that for the total acceleration on the wheel the maximum values are observed at the center of rail span as shown in Fig. 7a while the maximum values of the total acceleration on the center of wheelbase are observed near the one of chairs as shown in Fig. 7b. In the all above calculations the higher harmonics more than about 50 cps are omitted since such high frequency modes are not practical for the present analysis**.

It will be appreciated from the Fig. 7b that the maximum vertical acceleration on the center of wheelbase*** is really within ±1/100 g for all different rail spans.

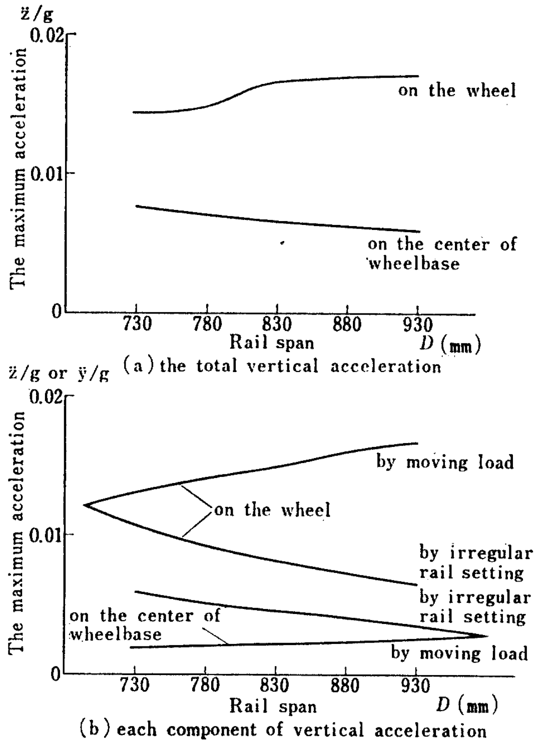


FIG. 8. The maximum acceleration.

* The lateral acceleration is similarly treated since the guide rollers are attached on only one side of carriage as described later.

** This is equivalent to cancel the terms more than $n=5$ in the Fourier expansion of the rail deflection, $z=\sum_{n=0}^{5} a_n \cos(2\pi nd/D)$ for loading or $z=\sum_{n=0}^{5} a_n \cos(\pi nd/D)$ for irregular setting.

*** As described in Fig. 21, the acceleration measurement was performed on the center of the middle part of the H-frame instead of the center of the wheelbase.

Fig. 8 shows the maximum vertical accelerations on the wheel and on the center of wheelbase as a function of rail span. There was no appreciable difference among several rail spans calculated tentatively so that the actual rail span was decided by $D=0.830$ m.

The chairs are staggered along two rails. For the lateral motion two units of guide rollers are attached on the opposite ends of one side of the carriage and pinch one rail which is recognized as a standard rail for rail setting at opposite side. The chairs are alternatively arranged to be opposite each cotter-surface for the vertical adjustment so that the longitudinal force caused by mechanical brake which is operated to grip the rail in emergency stop is withstood by opposite cotter-surfaces of the paired chair for either direction.

Four stoppers are rigidly fixed at the opposite terminal ends of both sides of the pit and can absorb the kinetic energy of the carriage if the carriage fail to stop accidentally at the terminal ends of the rails.

As shown in Fig. 9 the stopper consists of a lod having a head at one end and a piston at opposite end, inner cylinder in which the piston can reciprocate, outer cylinder, air chamber and a body for supporting the above systems.

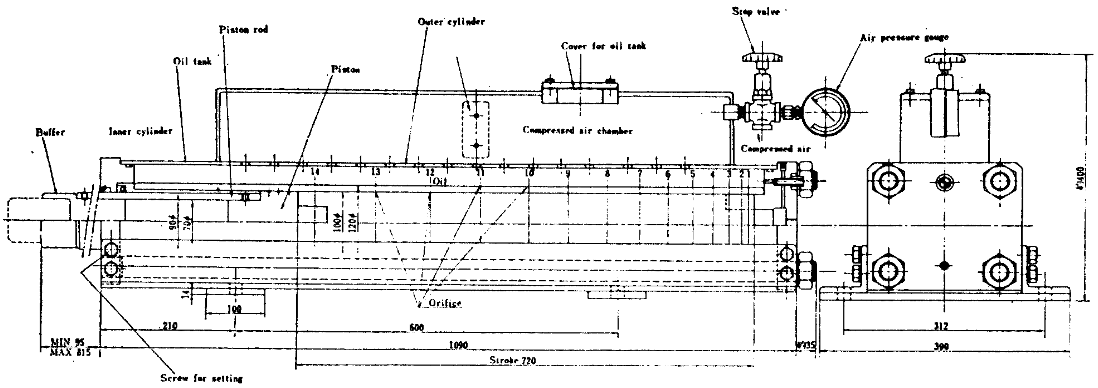


FIG. 9. Stopper.

When the head is impacted by the carriage the piston advances in the inner cylinder and pushes out oil which is filled up in the inner cylinder to the outer cylinder through orifices provided on the inner cylinder. The jet of the oil spurted through the orifices generates damping action for the piston motion. Because of long stroke of the piston motion (0.720 m) the rod is restored to an original extended position by compressed air which is accumulated in the air chamber with 1.5~2.0 kg/cm^2 absolute pressure.

The maximum deceleration of the carriage obtained with this stopper is about 0.3 g.

CARRIAGE

The carriage consists of a main frame, four wheels, four guide rollers, four sets of driving system, two sets of braking system, a control panel, two speed-detecting means and an electric collecting apparatus, and its empty weight is about 3.6 ton.

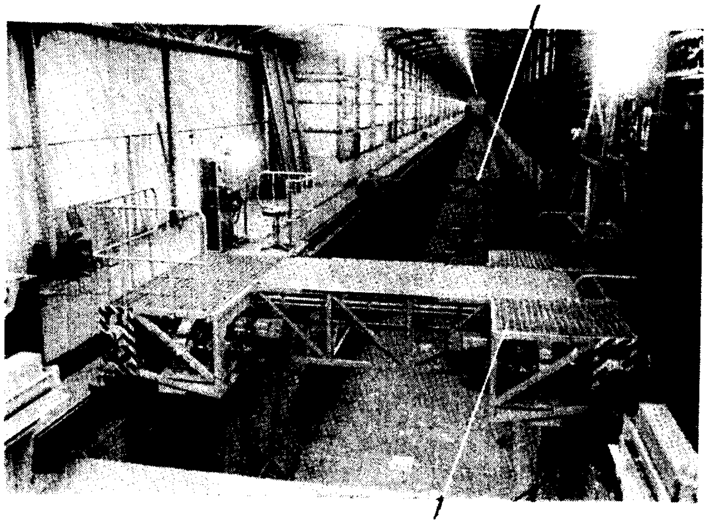


FIG. 10. Main carriage and subcarriage.

The main frame is constructed with welded steel tubes having rectangular cross section. As shown in Fig. 10 and 11 a planform of the main frame is a H-shaped configuration, or H-frame, and a middle part of the H-frame can be used to support the model or the free flight system. A pair of laterally spaced branch section or longitudinal leg of the H-frame is utilized to install the other apparatus and equipments.

The frame was designed to have enough rigidity in the fully loaded condition so that the natural frequencies of the frame were 20.5 cps for bending and the 37 cps for torsion.

The upper surface of the frame is, if necessary, covered with grating plates for safety of the operator.

Two of four wheels are disposed in lengthwise spaced positions in each side of laterally spaced branch section of the H-frame and driven by respective driving motor coupled to the axle of the wheel through a reduction gear with 29:182 gear ratio.

The wheels were machined very carefully and finished with grinder after hardening in order to get smooth contact with the rail surface. The diameter is 0.47746 m so that the advance distance is 1.500 m per one revolution.

Two pairs of guide rollers are installed to the opposite ends of one longitudinal leg of the H-frame to nip a rail between the rollers so that the carriage is constrained for lateral motion.

The driving system includes four 14 KW D.C. motors, two tachometer dynamos, four reduction gears and four wheels.

Each motor has exactly same performance individually. The motor speed is varied from 0 to ±2,500 rpm by changing the armature voltage from 0 to ±200 V respectively while desired torque is obtained independently of motor speed. Two motors of each side of the H-frame are mutually connected in series and two pairs

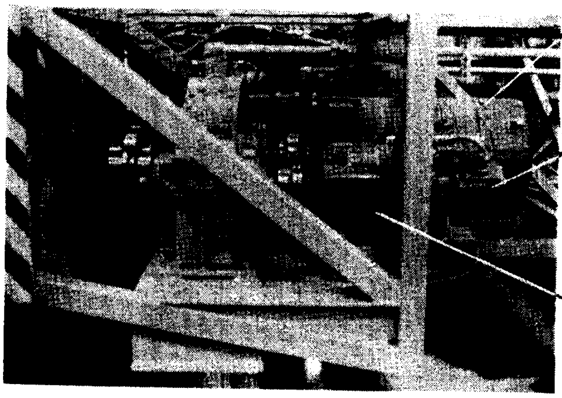


FIG. 13. Dinamo.

of motor in both sides are connected in parallel so that the homogeneous driving will be obtained. (See Fig. 12)

The two tachometer dynamos, which are separately mounted on the respective motor of both sides of H-frame as shown in Fig. 13, are electrically connected in series and can be used to pick up the motor speed for indication and to feedback for regulation. The output is 10 watts and the voltage range is 0 to ±125 volts.

As readily seen from Fig. 12, the carriage can, normally, be stopped by two ways and two braking systems are installed for this purpose.

When an operator, who can control the carriage motion either on board or on the ground, wants to stop the carriage at any desired position on the track he may push a stop button which is located on the control panel of the carriage or on the control console on the ground. Then the carriage is stopped by actuating the driving motor as a braking apparatus with regenerative control so that the deceleration of the carriage is arbitrary regulated with presetting a deceleration dial on the control console within a range from 0 to 0.14 g.

If the carriage approaches to one end of the track without any stopping operation a limit switch, which is located on the appropriate position of either side near the opposite terminal ends of the track as shown in Fig. 14, is magnetically actuated by a metal plate extended from the carriage. Then respective four pairs of braking shoes on each side of the H-frame are actuated to hold both sides of each rail by spring action and stop the carriage. In this case the deceleration will come up to about 0.4 g for dried condition so that the operator on board must be careful for sudden stop of the carriage.

In normal operating condition, the braking shoes are retracted by hydraulic apparatus which is operated with hydraulic pressure (50~140 kg/cm^2) accumulated in three accumulators connected in parallel and supplied with a gear pump and a 0.75 KW A.C. motor.

In emergency such that either the electric power line is accidentally disconnected or the operator turns a change over switch on the control panel to be braked or pushes an emergency stop button on the control console, the above braking mechanism actuated by spring will be operated and the carriage will immediately be stopped.

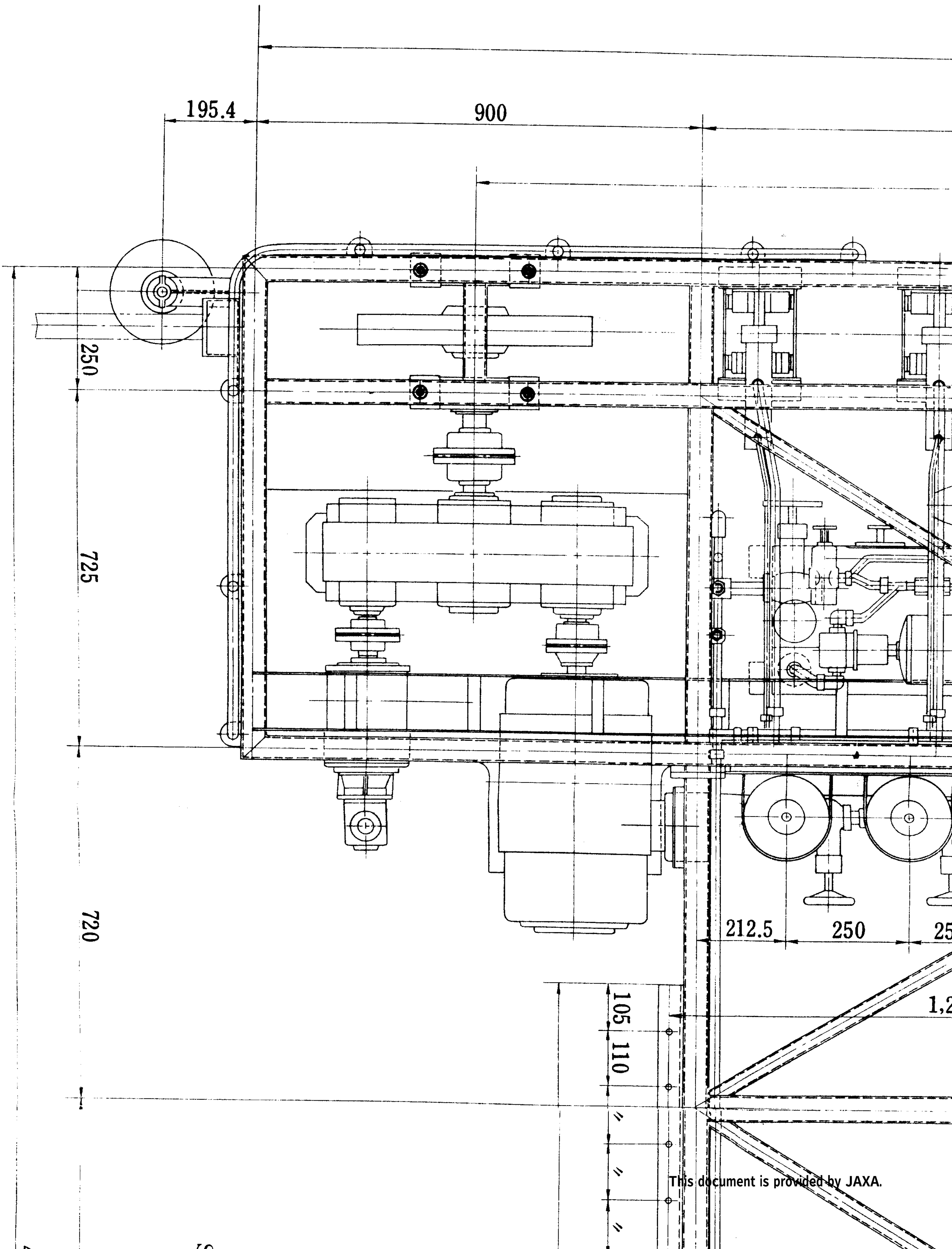
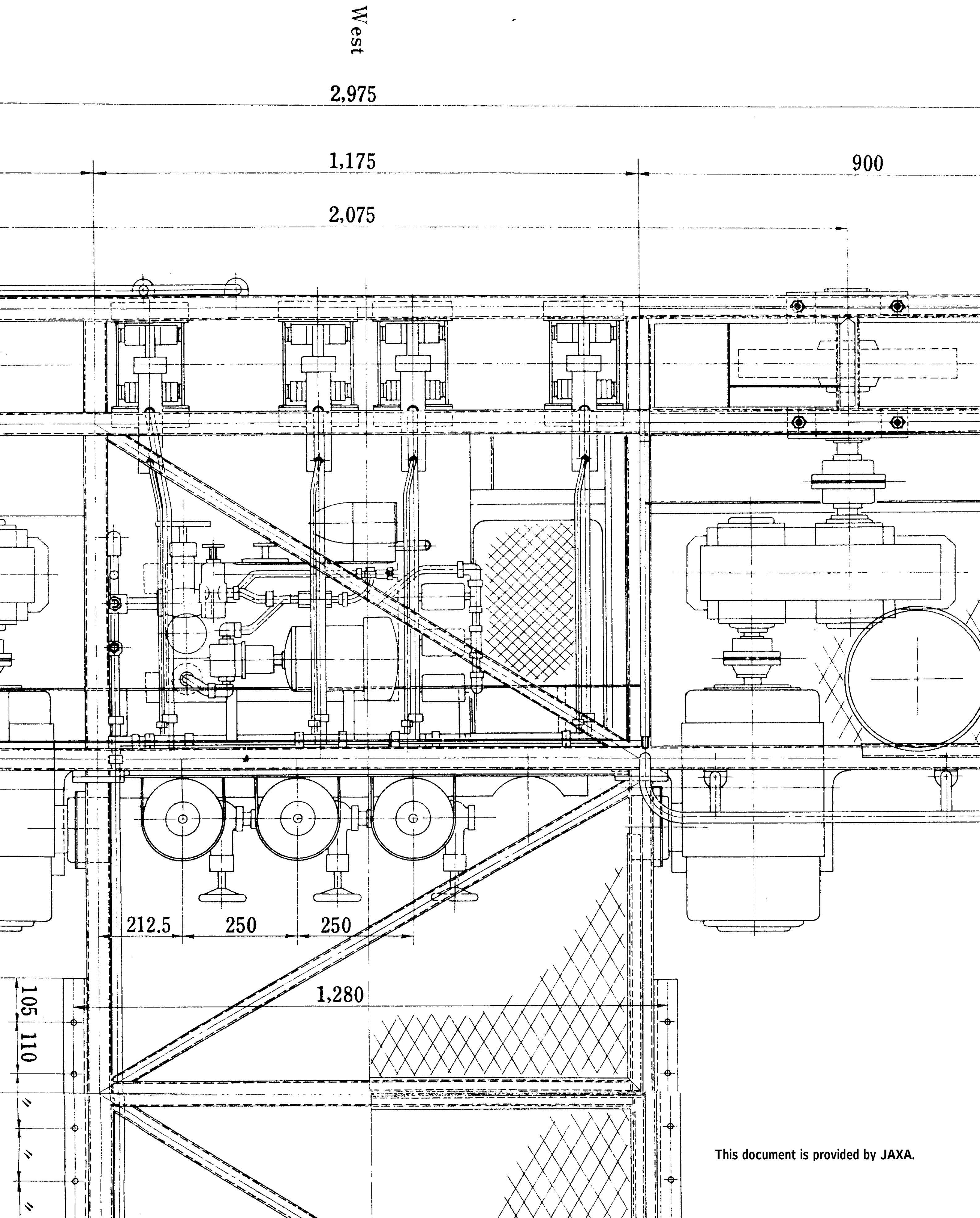


Fig. 11. (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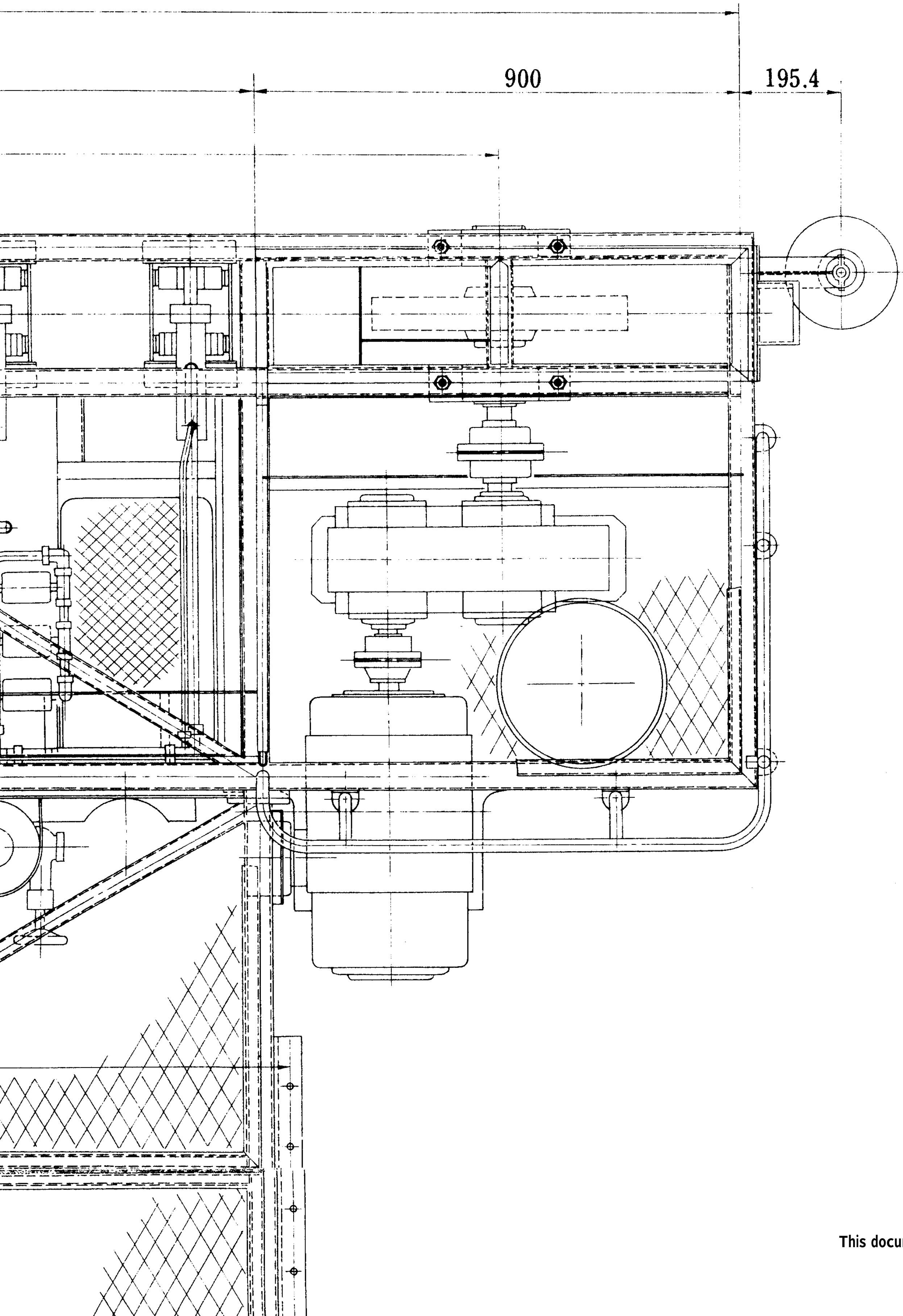
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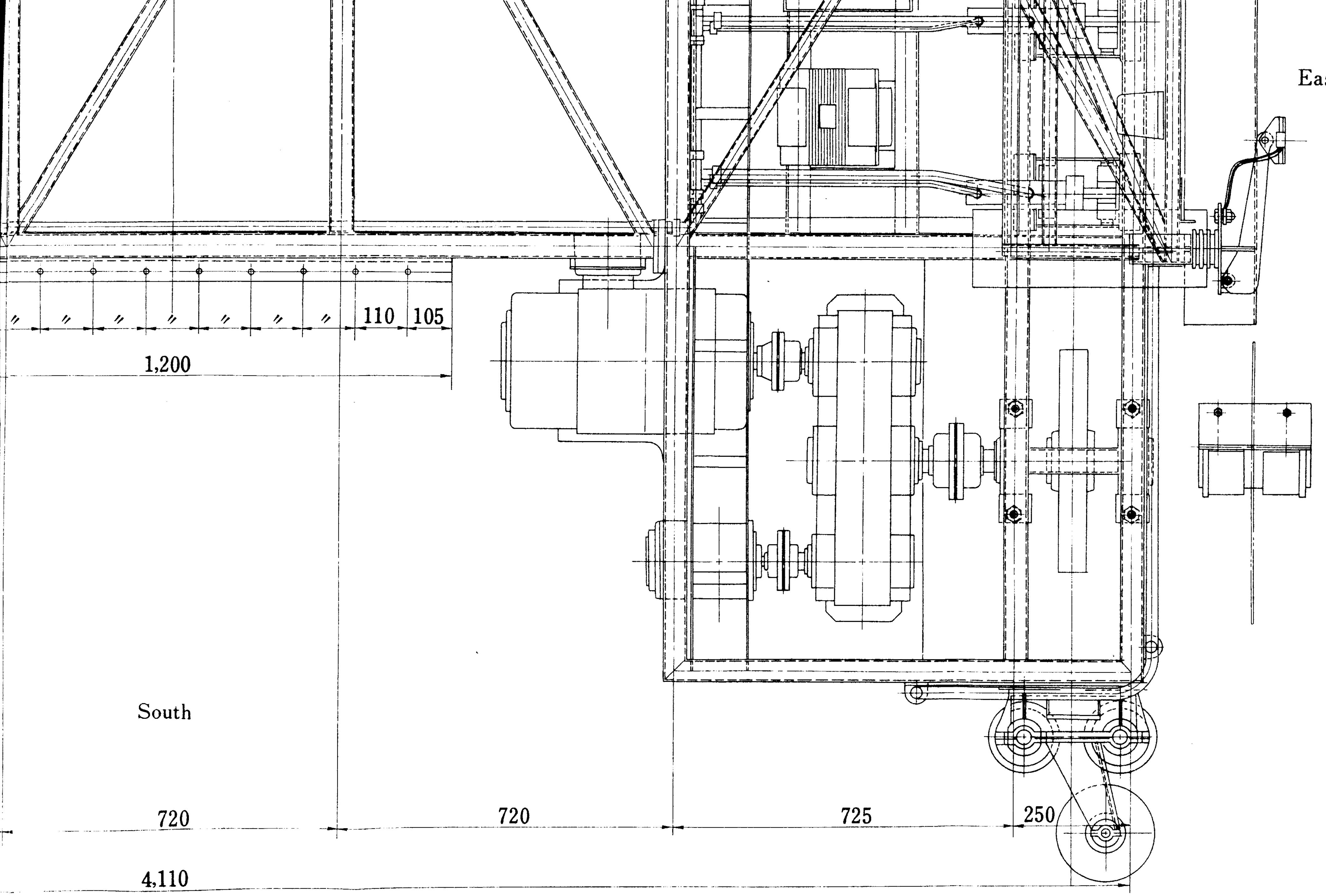
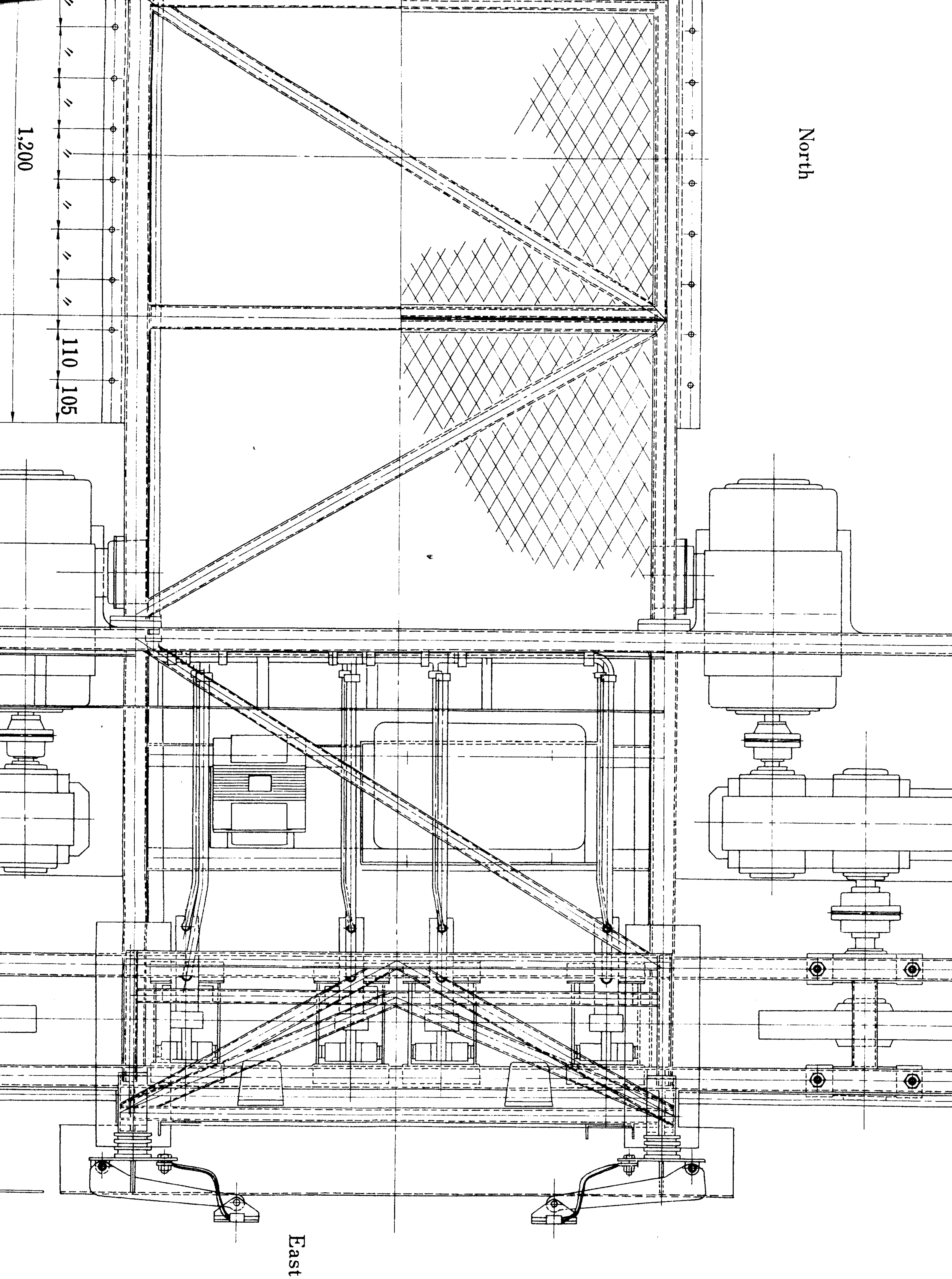


Fig. 11. (a). Main carriage.



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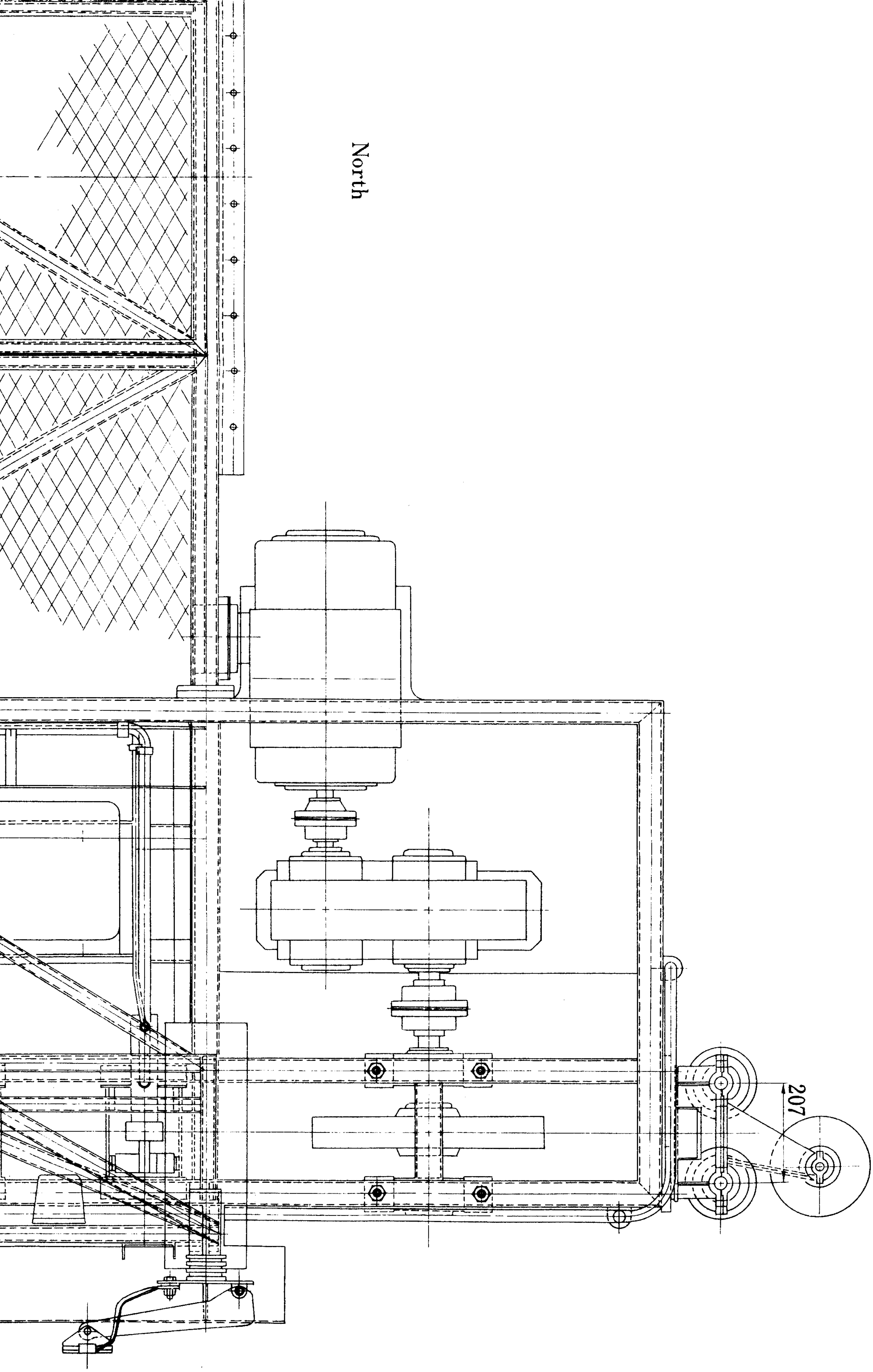
North
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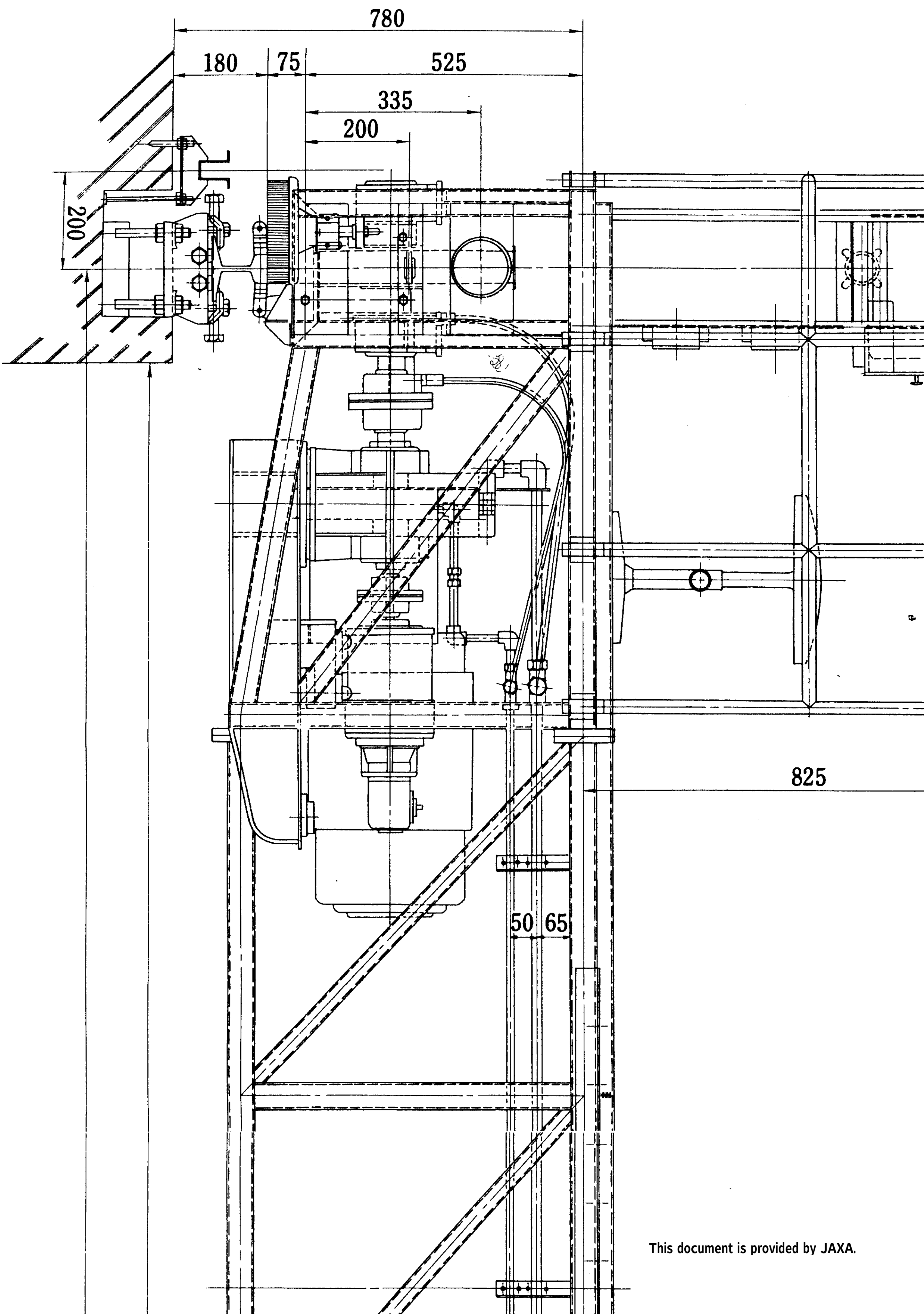
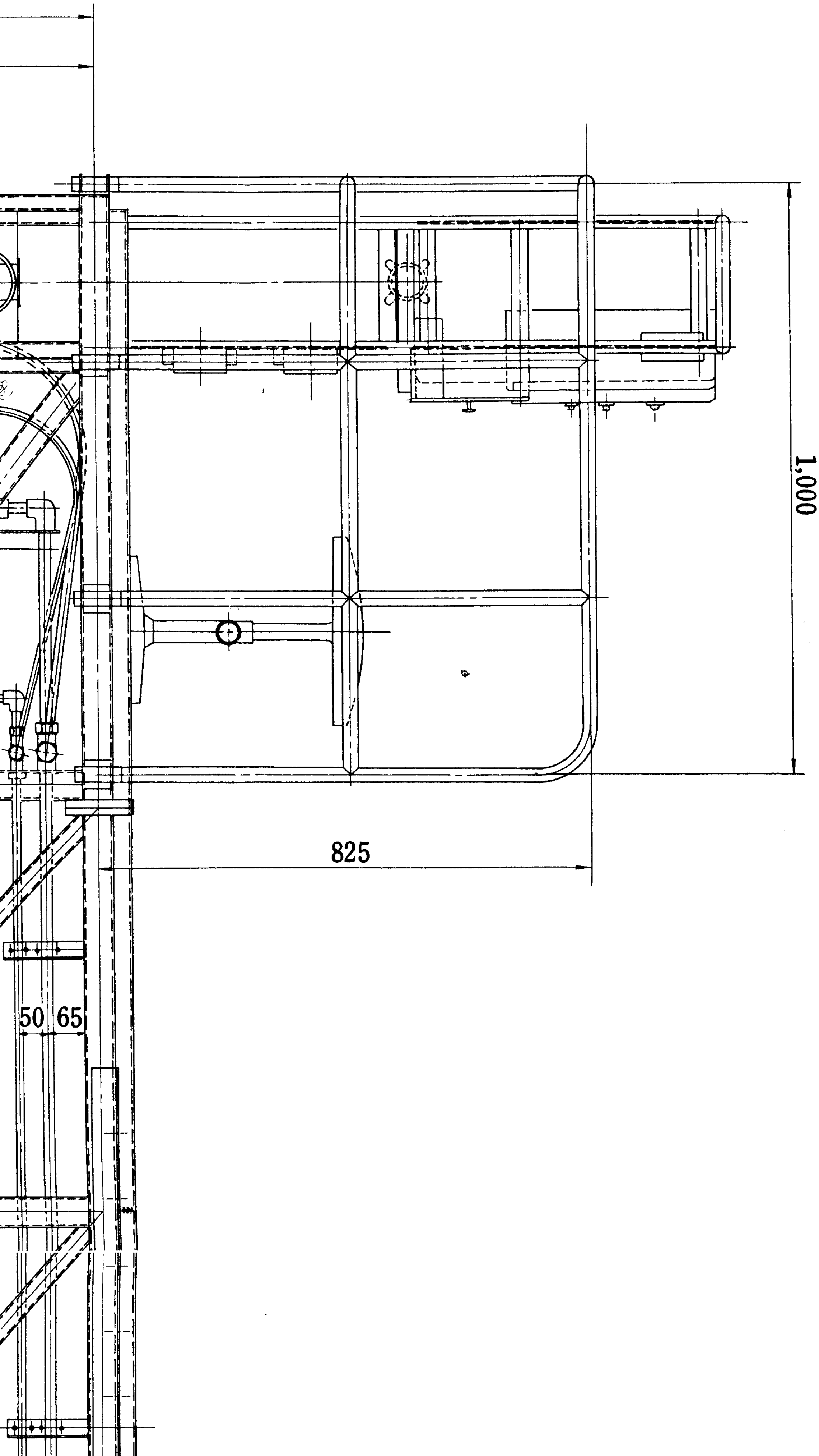


Fig. 11.



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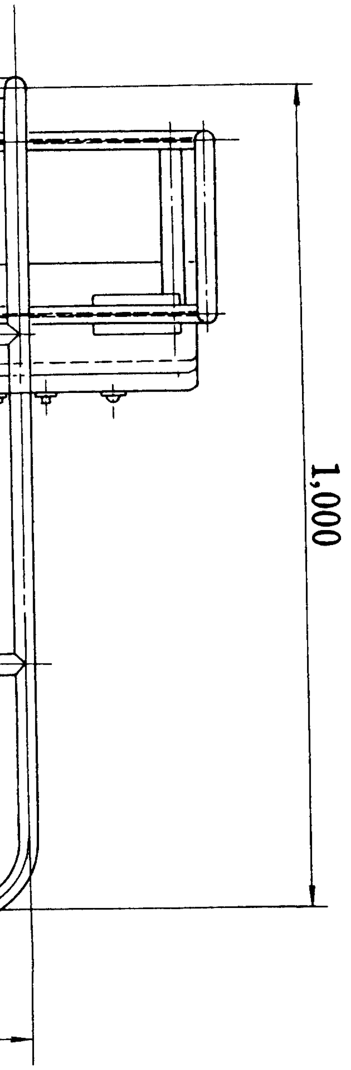
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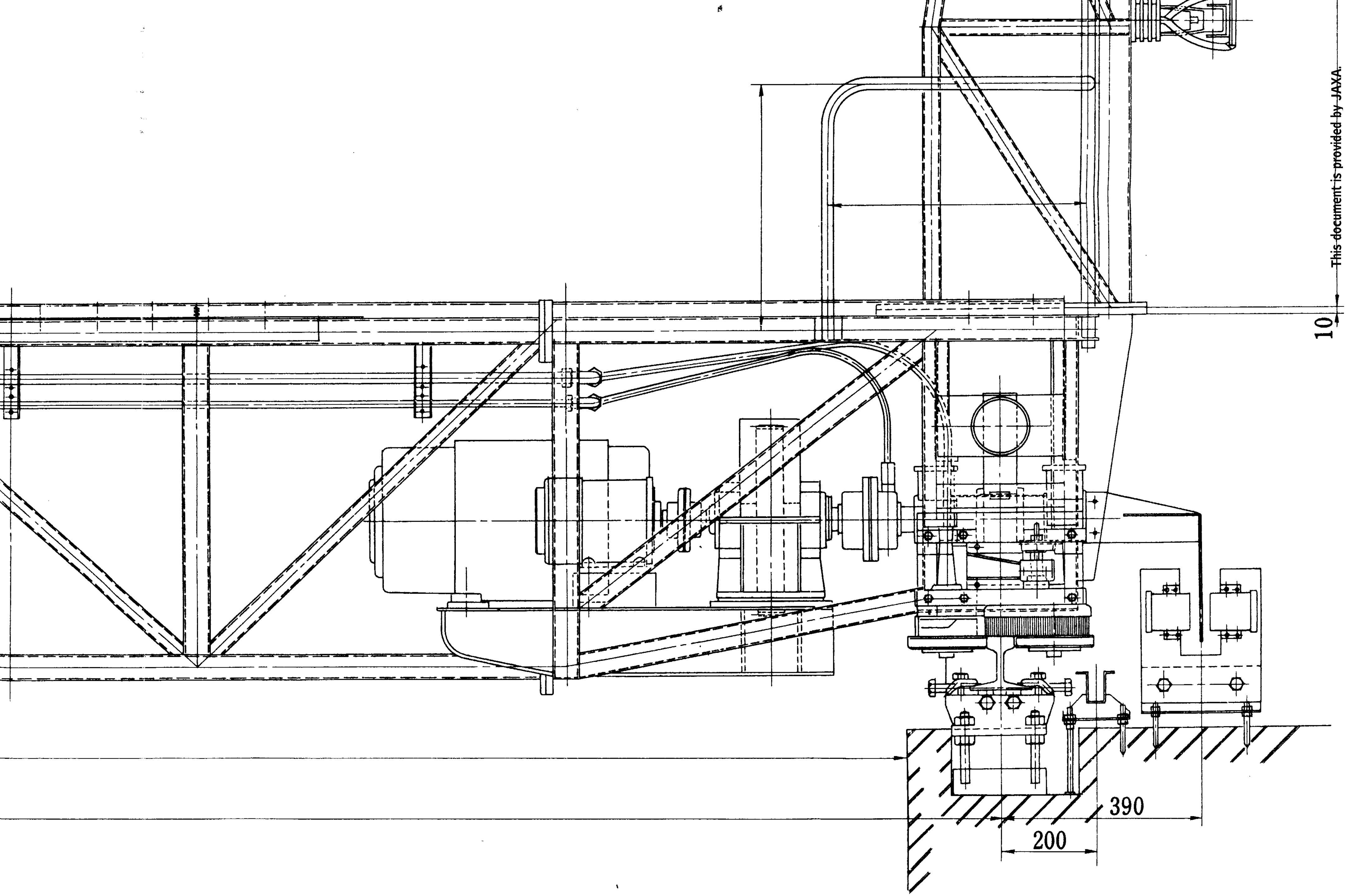
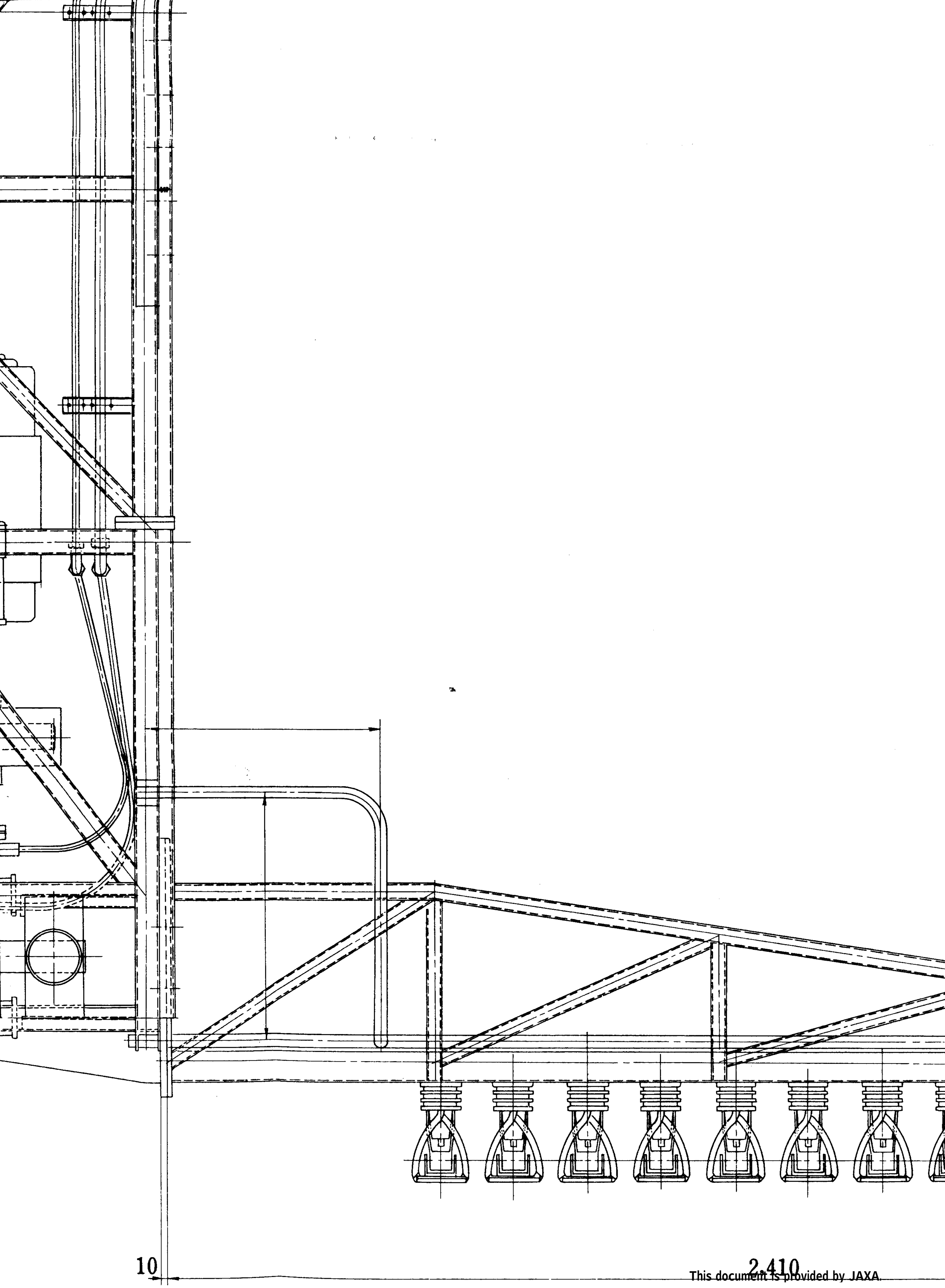


G. 11. (b). Main carriage.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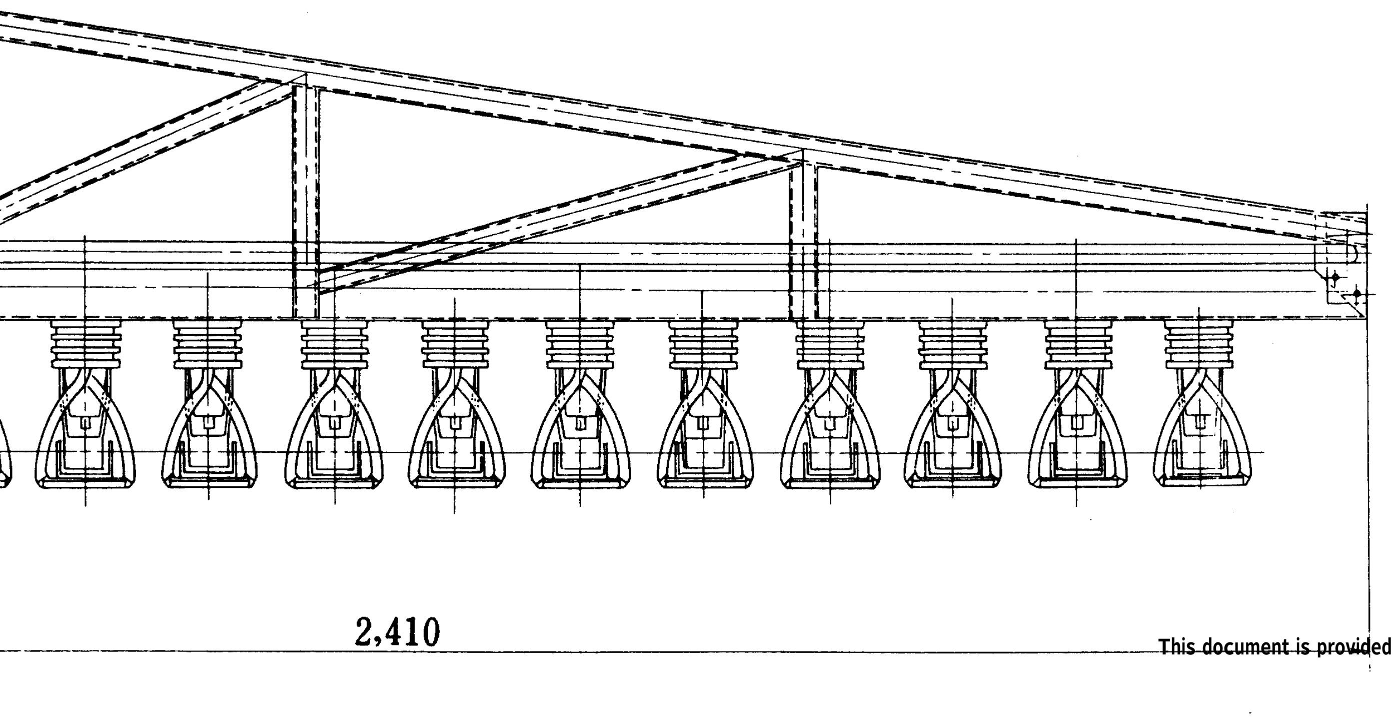
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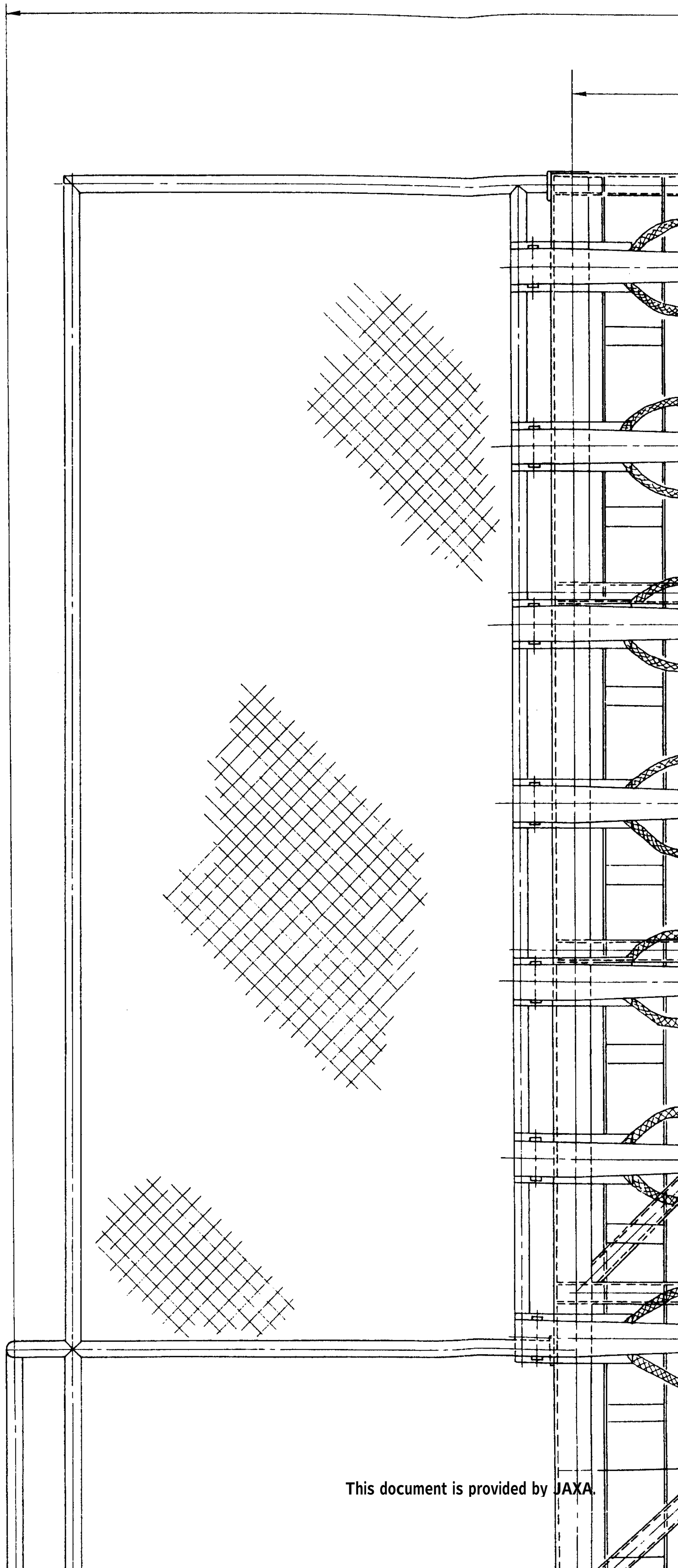

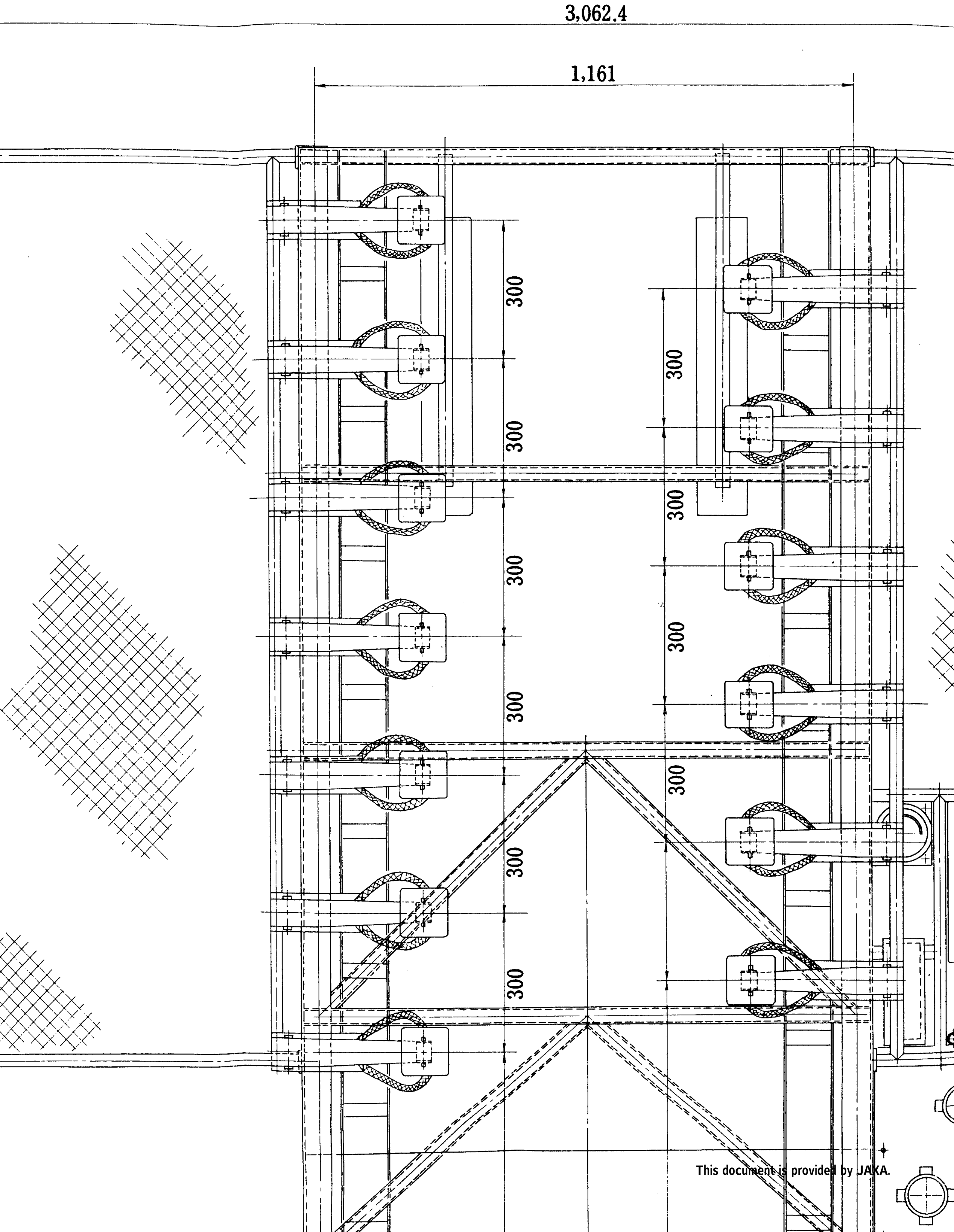
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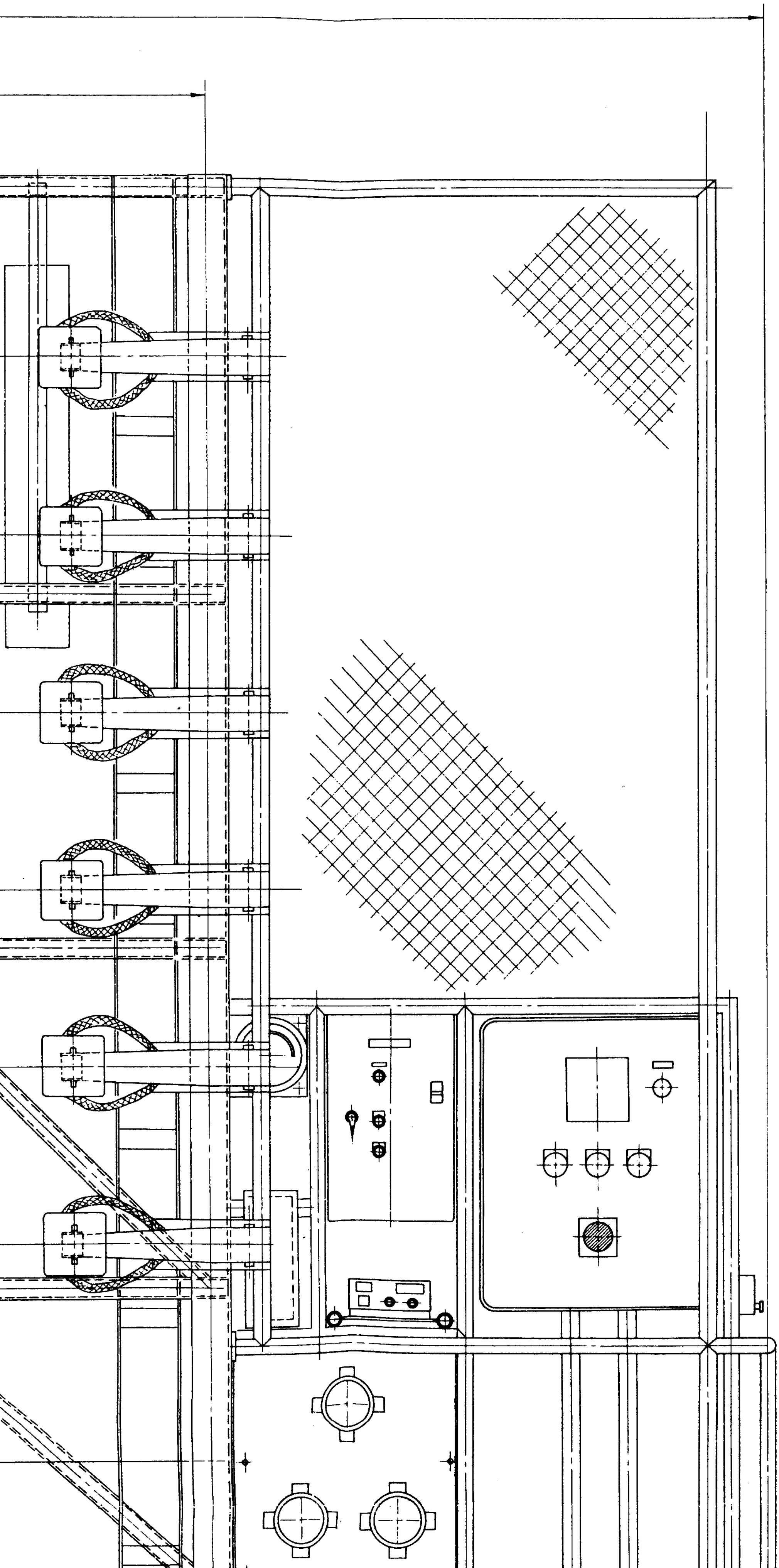

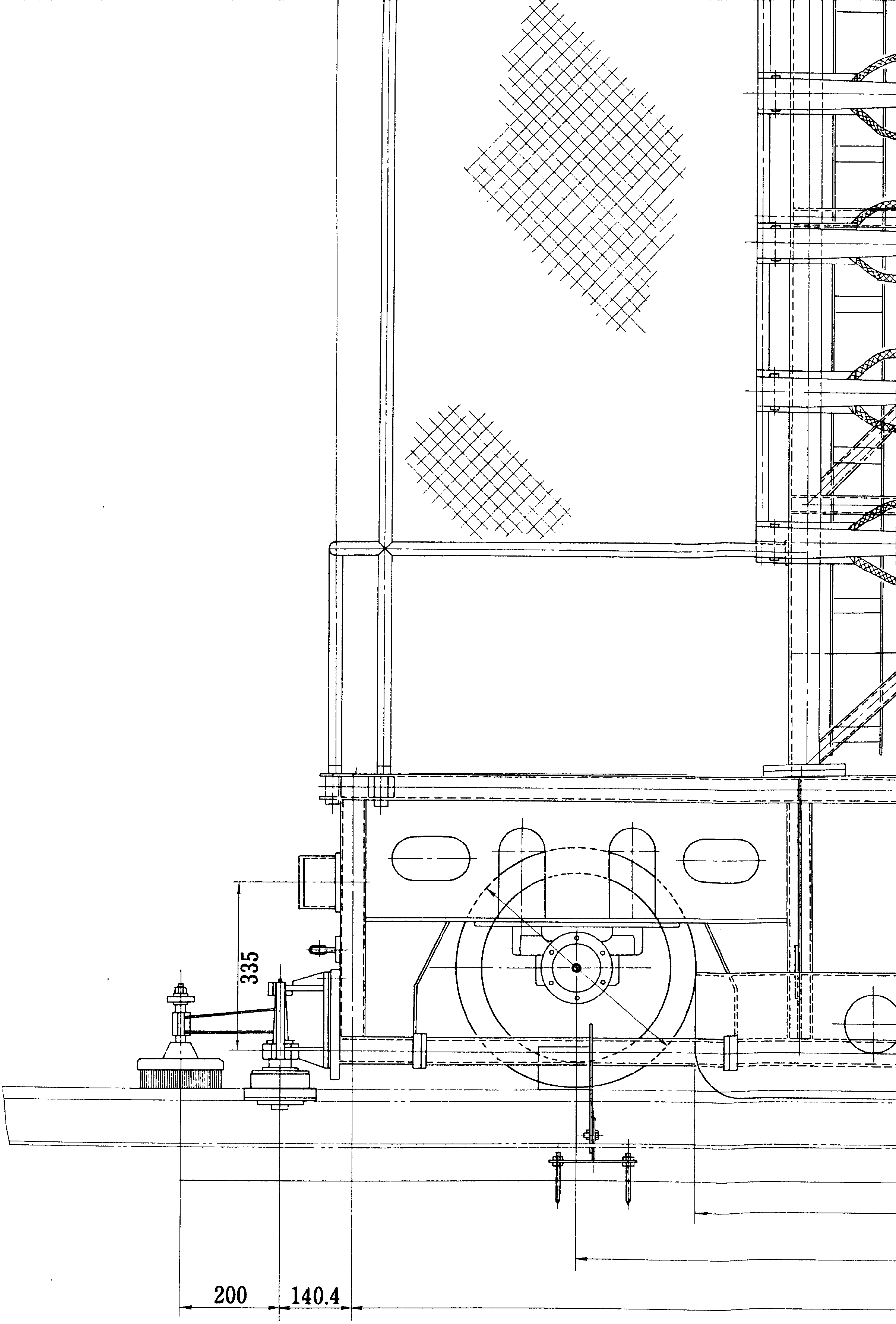
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200
140.4

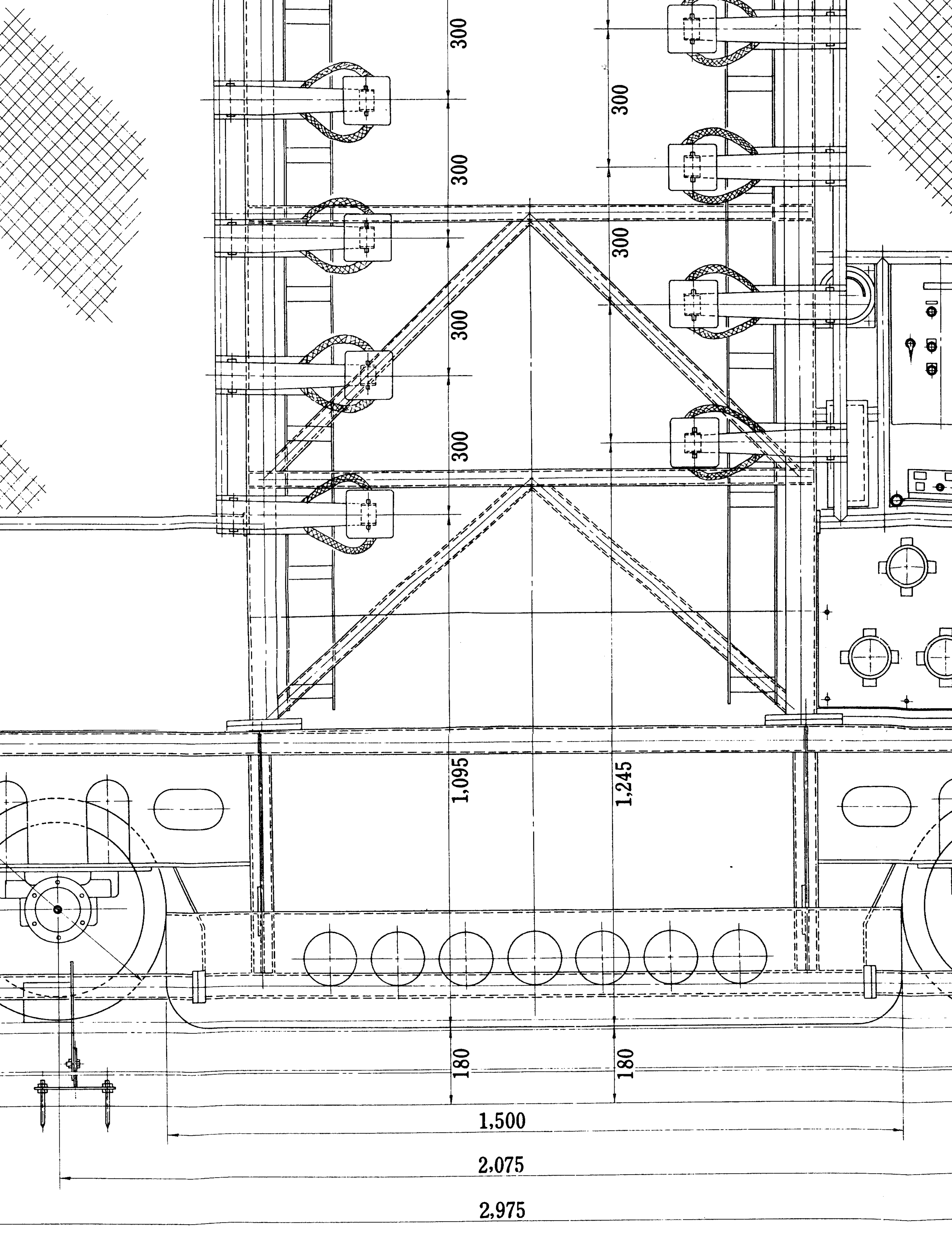
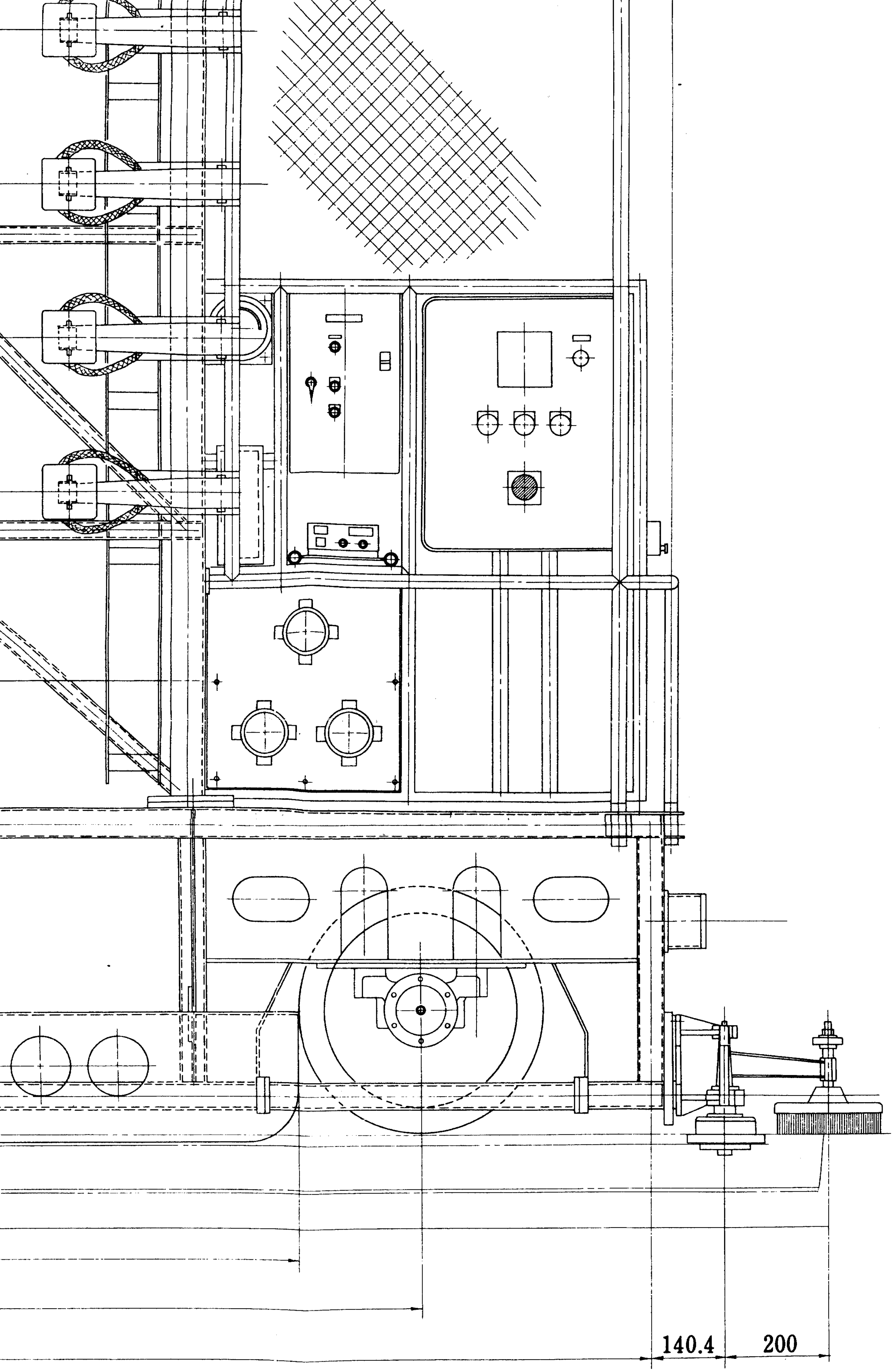


FIG. 11. (c). Main carriage.


140.4
200

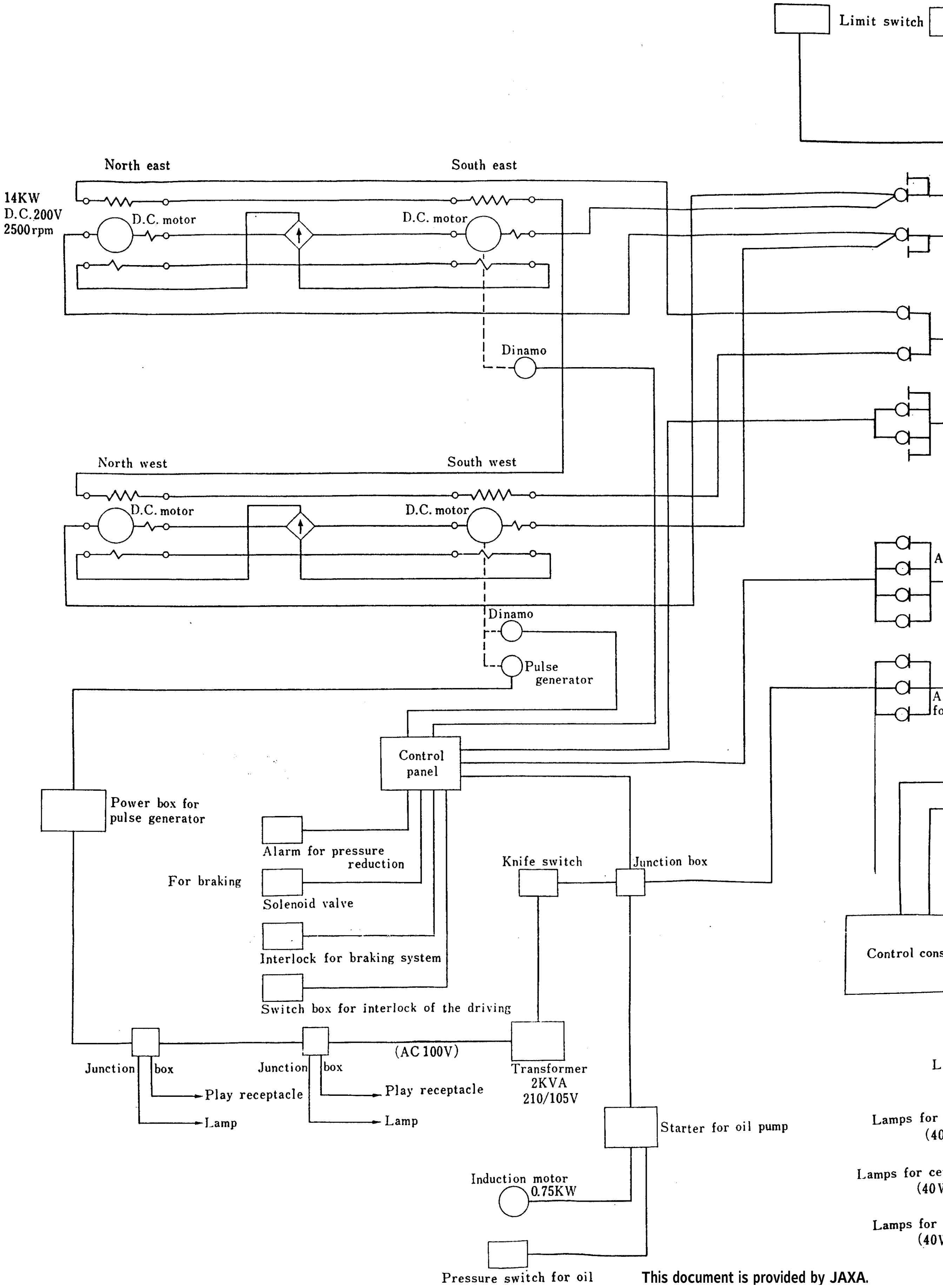


FIG. 12. Block dia

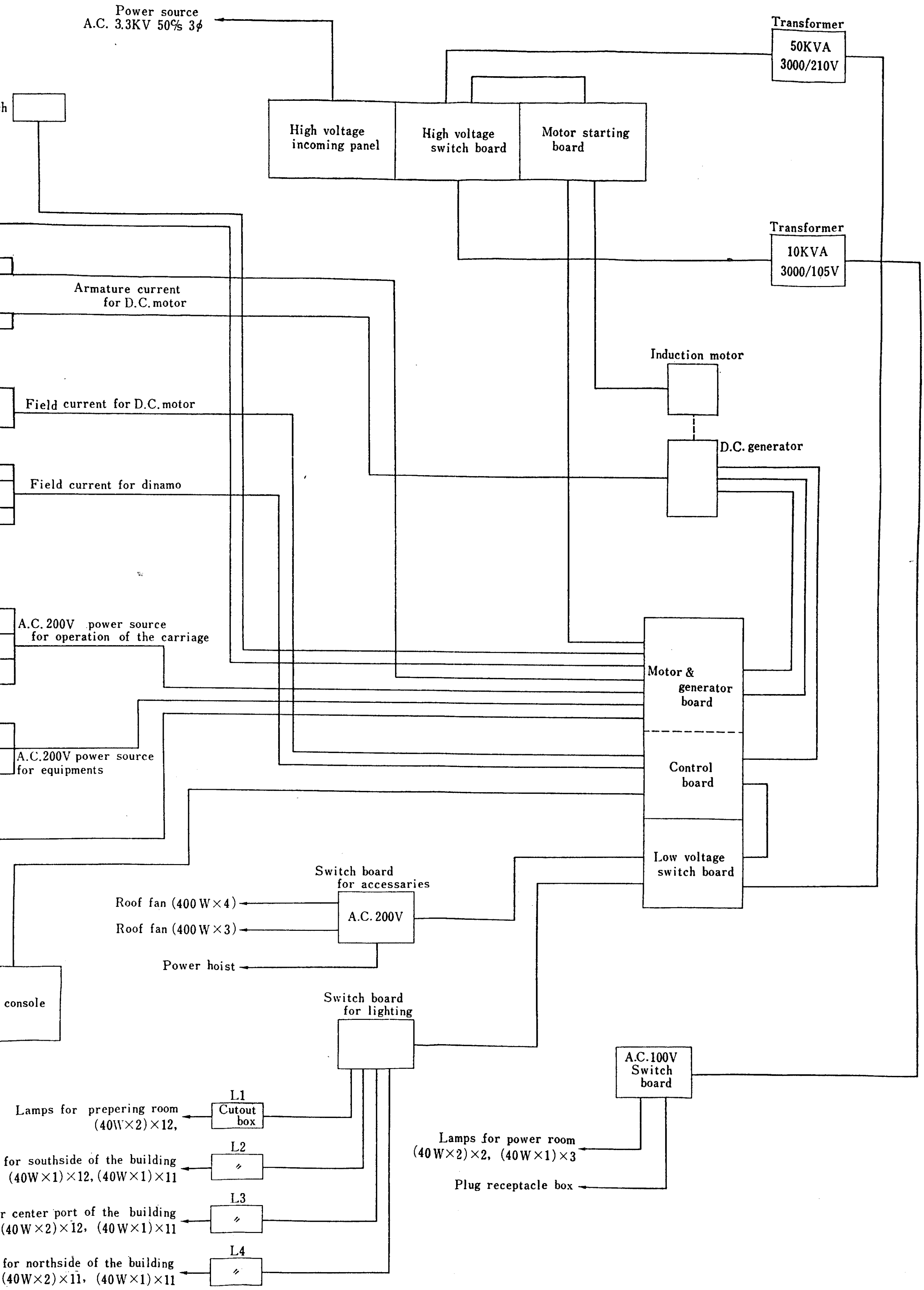


diagram for operation.

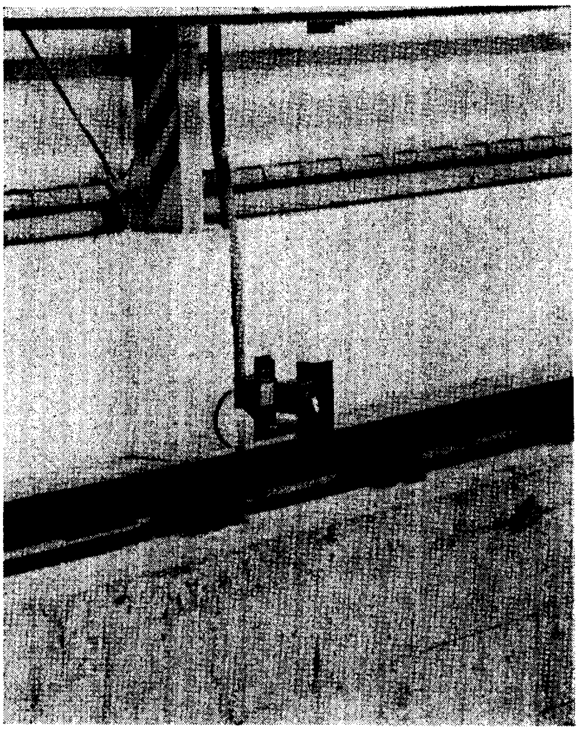
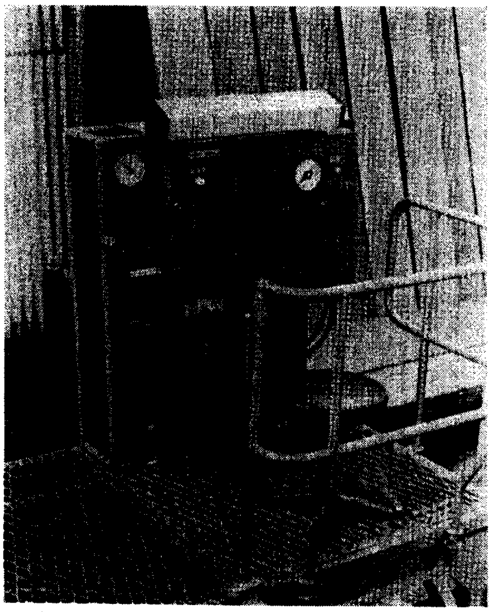
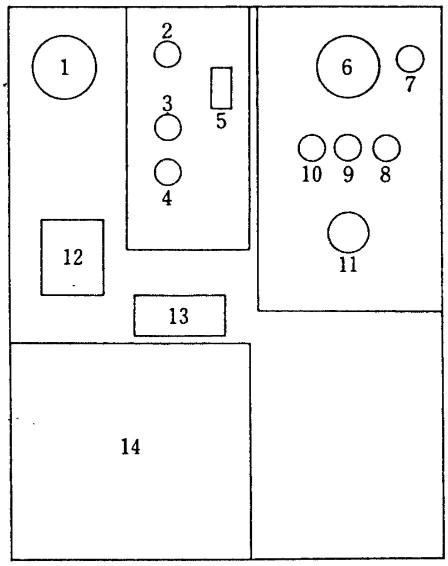


FIG. 14. Limit switch.





1. Oil pressure gauge
2. Pilot lamp for oil pump
3. Button for oil pump ON
4. Button for oil pump OFF
5. Main switch for oil pump
6. Speedometer
7. Pilot lamp informing ready for operation
8. Start button for southbound
9. Stop button
10. Start button for northbound
11. Alarm bell
12. Three-ways-change over switch
13. Power source for pulse generator
14. Branch plug for AC 100 V

FIG. 15. Control panel on the carriage.

The control panel is located at one end of longitudinal leg of the H-frame as shown in Fig. 15 and watched by an operator sitting on a chair fixed on the floor of the longitudinal leg.

On the control panel there are an oil pressure gauge, two pilot lamps for oil pump and operation, two buttons for oil pump on and off, a main switch for oil pump, two start buttons for south- and north-bounds, a stop button, speedometer, an alarm bell and a three-ways-change over switch for normal drive, non drive and non drive on mechanical braked condition. Beside the panel there is a switch for lighting on the carriage. It is possible to drive the carriage by the operator on board as well as on the ground when the change over switch is set to normal drive. The change over switch can also be used for emergency stop, when the carriage is running, by setting it to non drive on mechanical braked condition.

The carriage speed is detected by the before described two tachometer dynamos as well as a photo-electrical transducer installed on the one of two dynamos. The output of two dynamos connected in series is sent to the speedometer on the panel and the control system for feedback. While the transducer generates 60 pulses per one revolution of the motor and these pulses having the height of 1.5~4.5 volts may be sent to another speedometer through a digital-analogue transducer or a digital counter which will be installed in future in order to get more acculate speed measurement.

All electric powers for the driving, regulating, lighting and measuring systems are obtained through the collecting apparatus from a generator and A.C. 200 volts switch board in electric power room.

The collecting apparatus on the carriage comprises fifteen copper shoes installed on the individual pantographs as shown in Fig. 16. Thirteen shoes contact with respective thirteen power lines and, as shown in Table 3, the additional two shoes

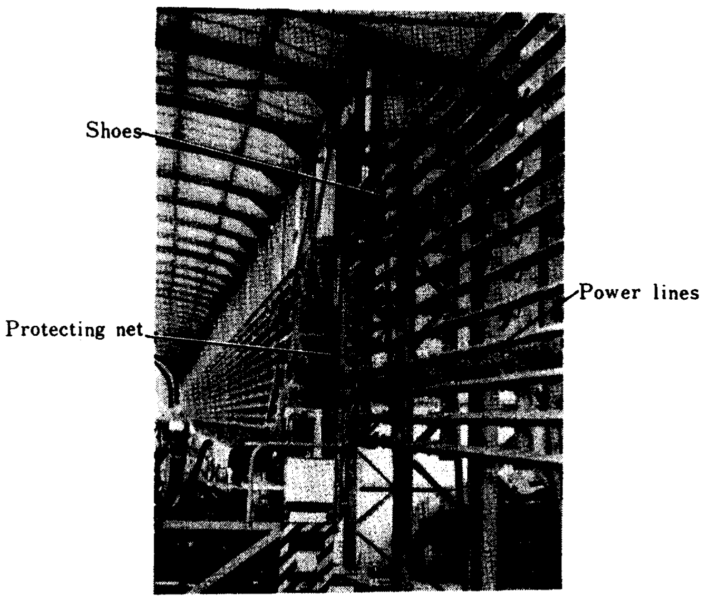


FIG. 16. Shoes and power lines.

are assigned to respective two power lines for a dynamo current in order to prevent undesirable interruption of the current which is used as a feedback signal for the speed regulation of the main motor. The pantographs are staggeringly attached through spring means to a vertical frame which is fixed on the longitudinal leg located in the opposite side of the control panel. The vertical frame is sheltered by a plastic-covered-steel net for safety.

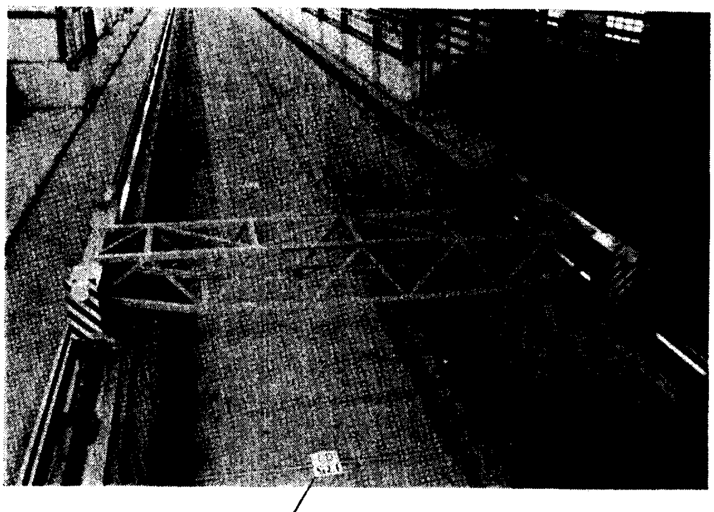
The assignment for fifteen shoes and thirteen power lines are given in Table 3.

TABLE 3.

No. of shoes	No. of power lines	Available voltage	Application
1,3,5	1,3,5	AC 3 200 Volts	For equipments (including a 100 Volts step down transformer)
2,4,6,8	2,4,6,8	AC 2 200 Volts	For operation of the carriage
7,9	7,9	DC 100 Volts	For field current of main motor
10,12	10,12	DC 0 440 Volts	For armature current of main motor
11,13,11a,13a	11,13	DC 250 Volts	For dynamo current

SUBCARRIAGE

A subcarriage can be used not only to carry a small testing model but also to inspect the gauge of track. Hence, as shown in Fig. 17 the subcarriage has a simple frame construction welded with steel tubes having rectangular cross section like the main frame and has four small wheels without driving system and four guide rollers. The unloaded weight is about 0.3 ton.



Number plate for travelling distance

FIG. 17. Subcarriage.

If the subcarriage is utilized to test the small model the carriage is pushed by the main carriage.

While, if the subcarriage is utilized for inspection of gauge a gauge measuring instrument must be installed to the frame and the carriage is pushed by hand.

POWER SOURCES

A prime source of driving motors is obtained from a D.C. generator driven by an induction motor which is supplied by A.C. 3ϕ 3,000 volts power source from a high voltage switch board through an incoming panel and controlled through a starting board which has a disconnecting switch, magnetic contactors with over current trip, a starting transformer, a control switch for start and stop, a current meter and a pilot lamp.

The output of the induction motor is 80 KW in normal 1,450 rpm operation and the maximum output of the D.C. generator is 73 KW. The voltage of the D.C. generator can be varied from 0 to $\pm$440 volts.

The output of the generator is introduced to a control board for driving system through a low voltage switch board. The control board has a non-fuse breaker for A.C. source, an air circuit breaker with over current trip, a magnetic contactor, relaies for control and over speed or over current, two exciters for the D.C. motor field with constant current control system and the D.C. generator field with automatic speed control and current limiting system, a current meter and a pilot lamp, in which the source of control and field currents are obtained from A.C. 220 volts via switch board.

The above described apparatuses are all set up in the electric power room. (See Fig. 18)

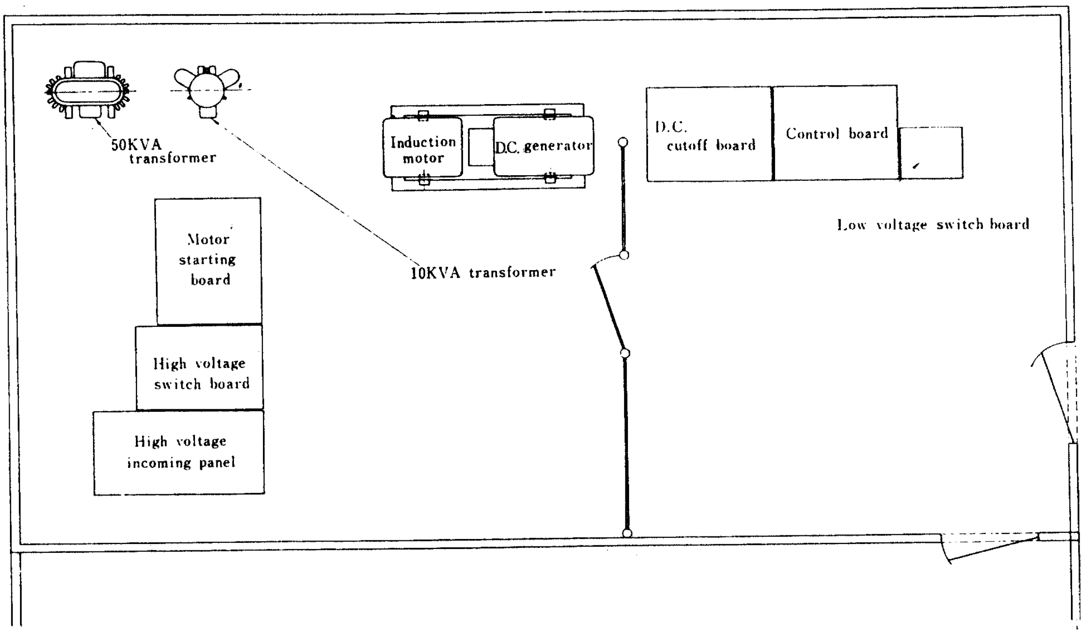
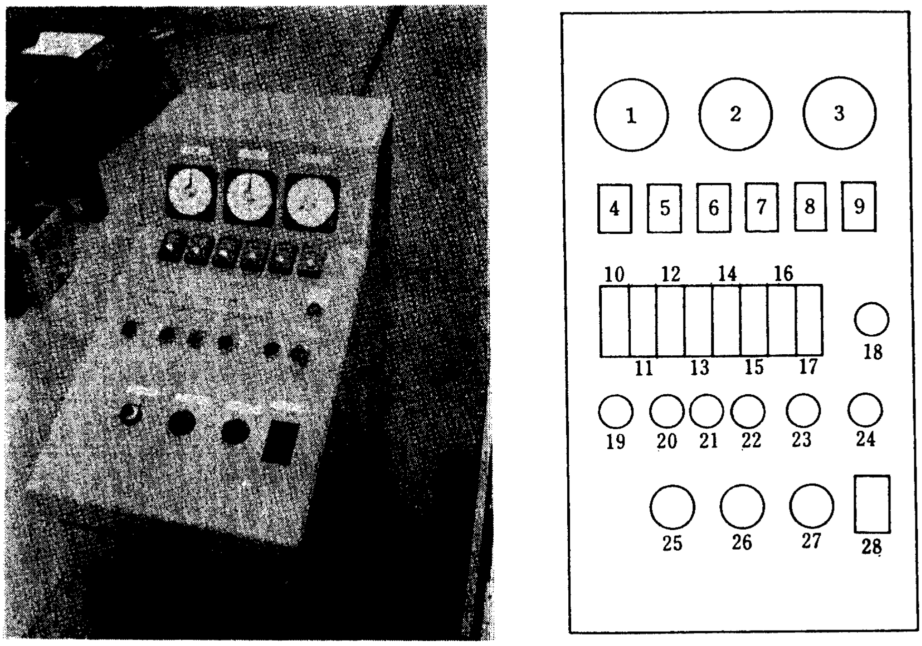


FIG. 18. Power room.

As heretofore described, the carriage motion is controlled by the operator through either control panel on board or control console on the ground. The control console is located at the end of track alongside the one of rail so that the operator can watch the carriage motion for full travelling.

The control console includes a key switch, three presetting dials for speed, acceleration and deceleration, five buttons for preparation of drive, north- and south-bounds, stop and emergency stop, pilot lamps, fault indicators and an alarm bell for driving and emergency, a voltmeter and a current meter for D.C. main current and a speedometer. (See Fig. 19) Before driving the carriage the operator has



1. Voltmeter for D. C. main circuit
2. Current meter for D. C. main circuit
3. Speedometer
4. Emergency lamp for motor-generator
5. Emergency lamp for over current of D. C. main current
6. Emergency lamp for no-fuse-braker
7. Emergency lamp for over speed
8. Emergency lamp for field-current loss
9. Emergency lamp for dinamo-current
10. Pilot lamp for operation
11. Pilot lamp for ready to start
12. Pilot lamp for southbound
13. Pilot lamp for stop
14. Pilot lamp for northbound
15. Pilot lamp for mechanical brake
16. Pilot lamp for limit switch
17. Spare
18. Switch button for emergency stop
19. Switch button for alarm bell
20. Switch button for southbound drive
21. Stop button
22. Switch button for northbound drive
23. Switch button for ready to start
24. Key switch
25. Speed setting dial
26. Acceleration setting dial
27. Deceleration setting dial
28. Reset switch for bell

FIG. 19. Control console.

to preset a desired acceleration and a deceleration by percentage and a desired speed by m/sec through the above dials on the control console, then he may start the carriage by pushing respective button. If he wants to stop the carriage any desired position he may push the stop button.

As shown in Table 3 the electric powers required by the carriage are all distributed to thirteen power lines which are made of pure copper and rigidly stretched along respective steel frames from end to end of the track so that the copper shoes of the collecting apparatus can keep smooth contact with the power lines. (See Fig. 16)

Performance and Test Results

As heretofore described, the carriage can move with specified acceleration, speed and deceleration. The maximum acceleration and deceleration with regenerative motor brake were 0.11 g and 0.14 g respectively for dried condition and 0.05 g for humid or oil-film coated condition. The operator can select any desired acceleration and deceleration by the above maximum values by presetting the respective dials on the control console within ±5% accuracy of the maximum value.

The maximum allowable speed is 10.0 m/sec. The operator can also select any desired speed between 0.025 m/sec and 10.0 m/sec with the accuracy of

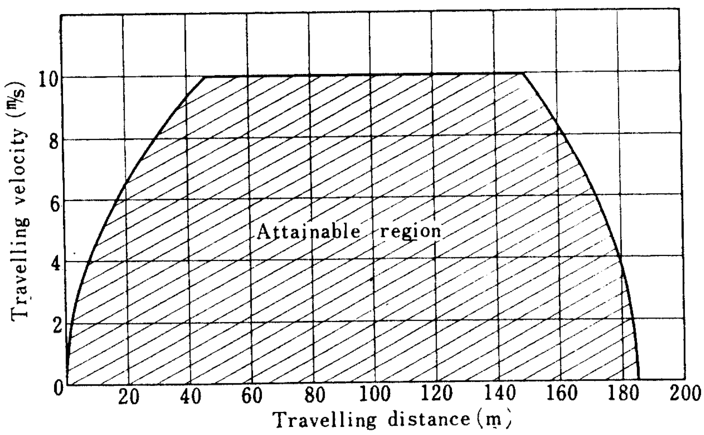


FIG. 20. Velocity-range profile.

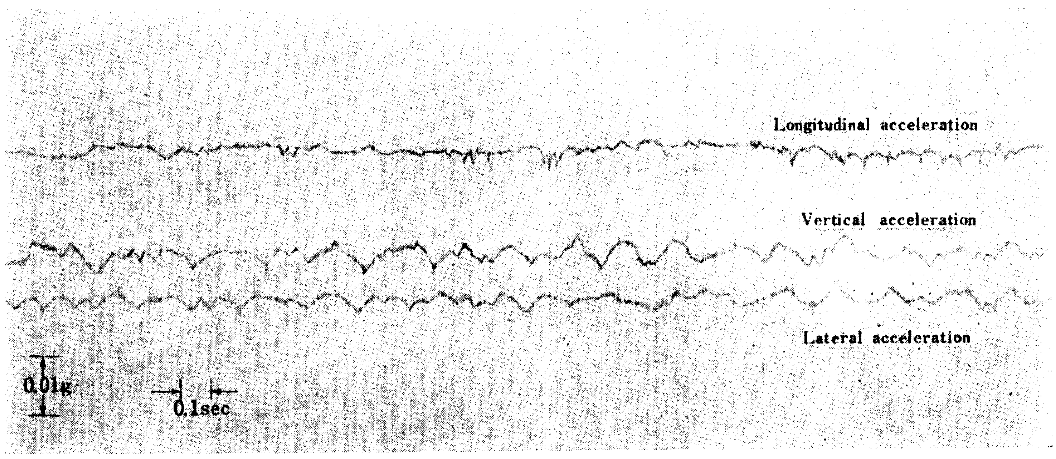


FIG. 21. An example of the variation of accelerations during 10 m/sec running test. (The sensors of the acceleration are installed on the center of the middle part of the H-frame)

0.05 m/sec by dial setting on the control console. The traveling distance, in dried condition, being able to advance with a given constant speed is given in Fig. 20 as a hatched region.

In emergency stop the deceleration came up about 0.4 g by spring actuated brake shoes.

The maximum accelerations for longitudinal, lateral and vertical directions in constant speed traveling were within 1/100 g. An example of the test results obtained for the maximum speed traveling is shown in Fig. 21.

Air turbulence in a test range was kept so small that it was almost impossible to detect the air current by the smoke test.

CONCLUSION

A new running test facility for the study of flight dynamics has been built in the campus of the Institute of Space and Aeronautical Science, University of Tokyo.

The new test facility may not be so large to get satisfactory quantitative data for aero and flight dynamics of the model airplane or V/STOL plane but the facility having high performance with low vibration level has been constructed in its own way. The maximum longitudinal, lateral and vertical accelerations were restrained within 1/100 g in the maximum travelling speed of 10 m/sec.

It was also observed from the smoke test that air turbulence in a test range was kept sufficiently small.

Department of Aerodynamics
Institute of Space and Aeronautical Science
University of Tokyo, Tokyo
March 2, 1969

REFERENCES

[1] E. Martinez: A New Facility of the Study of Aircraft Dynamics, Rep. No. 532, Department of Aeronautical Engineering, Princeton Univ., July 1961.