

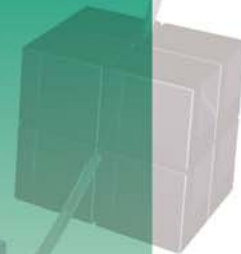
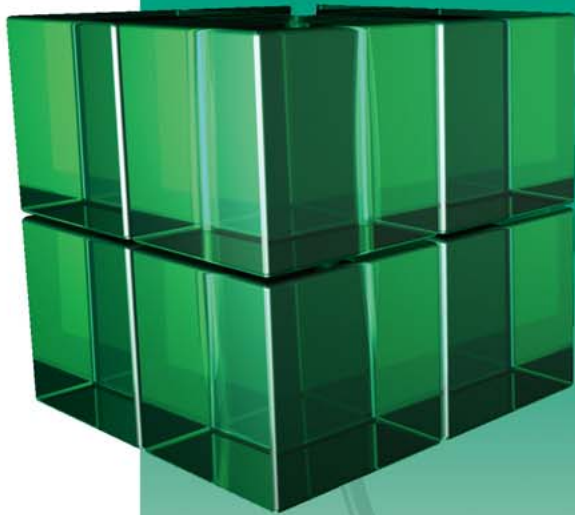
HITACHI TECHNOLOGY

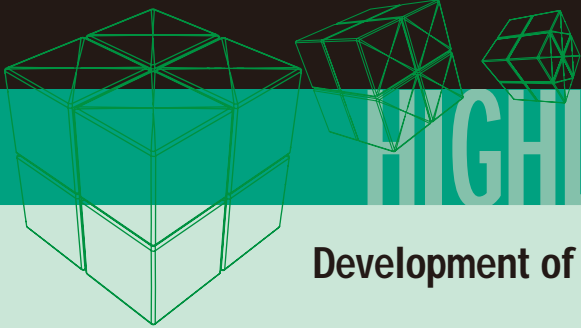
2007-2008

# Industrial Infrastructure Business

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Industrial Systems  
Steel and Chemical Plants  
Automotive Systems  
Biotechnology and Scientific Instruments  
Semiconductor Manufacturing  
and Inspection Equipment





## Development of BAS Hybrid System Delivered for GM Corporation

Given the growing public awareness about environmental issues, the hybrid car that combines a gasoline (or diesel) engine with an electric motor is the subject of greater attention because it improves energy efficiency and helps reduce environmental impact. Based on its accumulated experience with motors and inverters, the Hitachi Group is working to develop technologies associated with hybrid cars. Hitachi has developed and commercialized a new system in order to apply its achievements thus far, and this system is now installed in a hybrid car built by General Motors Corporation (GM).



Michinori Shiga (left), Manager, 1st Business Development Dept., Business Development Div., Automotive System Group; Daisaku Morinaga (middle), Chief Project Leader, 1st Development Dept., Motor Business Div., Motor Power Systems Div.; Kazuaki Takano (right), Chief Project Leader, Inverter Design Dept., Electronic Device Design Div., Electronic Control Systems Div., Automotive System Group (at time of interview)

### What is the BAS Hybrid System?

Hybrid cars are categorized as several types, depending on differences in voltages and mechanisms. The BAS (belt alternator starter) hybrid car of General Motors Corp. in the U.S. is equipped with a secondary 36-V battery and categorized as a mild hybrid car due to the relatively easy replacement with an existing gasoline engine car. The BAS hybrid is a system that connects the engine and electric motor with a belt so that the motor serves as both a generator and starter. This system has been installed in the Saturn VUE Green Line Hybrid that was released for sale in North America in fall 2006. With the BAS hybrid, energy efficiency has been improved by about 20% compared to a gasoline engine car according to GM. Hitachi specifically developed a motor called the MGU (motor generator unit) equipped with a generator function and an inverter designated PEB (power electronics box) to control



Hybrid system structure of Saturn VUE Green Line Hybrid

the MGU. The subject of development included not only the hardware but also a system including control software built into the inverter.

### What are the Features of the Motor and Inverter?

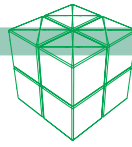
The mass of the motor is about 60% of that of other generally-used products and offers an equivalent or superior torque property to that of other products despite its compact size. In addition, a motor exerts constant torque in both low and high revolution ranges. The BAS hybrid reduces fuel consumption not only by eliminating idling when the car makes a stop and assisting the start of motor-driven movement, but also assists in rapid acceleration and steady motor-driven driving performance. These are all noteworthy features of this motor. Regarding the generation function, the motor can generate up to 5 kW of electric power made possible by our long accumulated experience with alternators.

The inverter also controls the motor as well as other components that require voltage conversion because, although the MGU generates 36 V of voltage, typical vehicle components are designed for 12 V. Therefore, the inverter features a built-in DC/DC (direct current/direct current) converter function. One key feature here is that the inverter retains its compact size. The inverter's power module generates a large amount of heat and thus requires cooling. Cooling water for the engine is utilized to accommodate this heat-generating effect, but a proprietary cooling device is not installed due to its structural complexity and the resultant increase in cost.

An onboard system is needed to retain high reliability even in severe environments subject to drastic changes in temperature. More than one year of the three-year development period was devoted to improving the reliability of the inverter through durability testing in terms of temperature and resistance to water and vibration.

### What is the Future of Hybrids?

The full-scale mass production of the hybrid system required a new technology not possessed by the automotive system group. Therefore, such resources as personnel and technologies were combined from various fields within the group to accomplish the development. It may be said that the product symbolizes a culmination of collective efforts by the Hitachi Group. Based on this experience, our current goals include responding to the planned expansion of car types for consumers, as well as launching the high-voltage hybrid system known as strong hybrid. In response to greater awareness of environmental issues, hybrid cars are expected to occupy a major share of the auto market in the future. We will continue focusing our efforts on improving the performance of such key components as the motor, inverter, and battery in order to promote the proliferation of hybrid cars.



## 24-kV Vacuum-insulated Switchgear

Hitachi has developed a switchgear using safe and eco-friendly vacuum insulation instead of SF<sub>6</sub> (sulfur hexafluoride) gas. Vacuum insulation is a technology for which Hitachi has long accumulated know-how. The product was developed as a next-generation

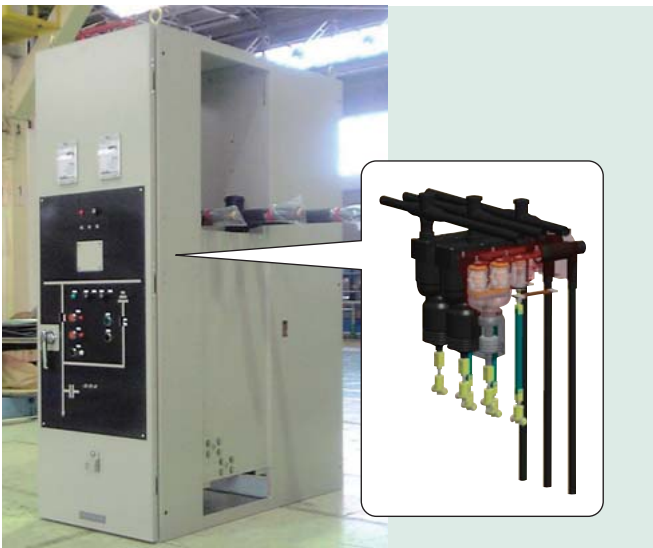
switchgear to replace GIS (gas insulated switchgear). It is applicable to many medium voltage substations by using designs conforming to IEC (International Electrotechnical Commission) 62271-200 and other international standards. Should an internal breakdown occur, the product poses no risk of exploding due to gas expansion, and thus ensures safety. Moreover, there is no need for gas leakage control during maintenance. Vacuum insulation also offers exceptional insulation performance, resulting in more compact equipment design and improved economic efficiency. Maintenance requirements for the grease-less electromagnetic operation device, which enjoys a proven track record of more than four years, have also been simplified.

[Main specifications]

- (1) Rated voltage: 24 kV; rated normal current: 800/1,250 A
- (2) Rated short duration power frequency withstand voltage: 50 kV; rated short time withstand current: 25 kA (3S)

[Main features]

- (1) An internal fault in the vacuum chamber does not cause hazardous pressure rise.
- (2) The vacuum design switchgear is free from the risk of greenhouse gas leakage.
- (3) The Hitachi's grease-free electromagnetic actuator achieves the stable operation over 10,000 times without periodical lubrication.
- (4) The high insulation performance of vacuum makes the switchgear compact and lightweight.



External view of 24-kV vacuum-insulated switchgear

## Medium Power New Type UPS Series

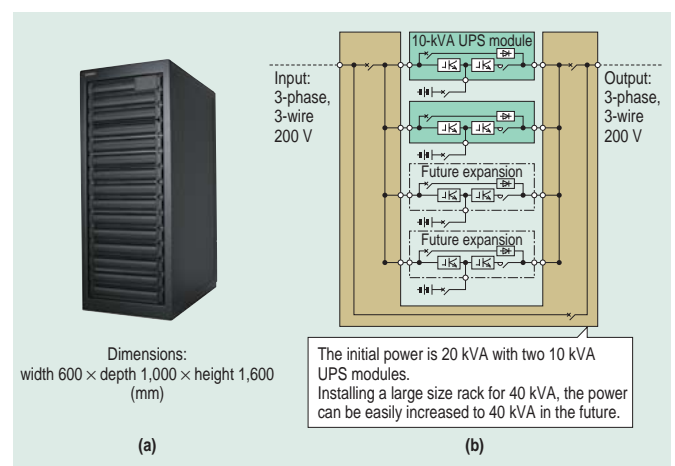
Hitachi developed a medium-power new type UPS (uninterruptible power system) series. Hitachi frequently receive requests, such as minimizing initial investments, from customers who are considering installing UPSs, integrating plural UPSs into a single UPS to reduce maintenance costs, or automating control of the power supply to their server. The new UPS series meets each of these demands.

[Main features]

- (1) UPS module: 3-phase, 3-wire, apparent power: 10 kVA
- (2) By connecting UPS modules in parallel, users can easily increase the system power from 10 kVA to 40 kVA. This feature enables users to commence the operation at a small power and thus reduce the initial investment.
- (3) Users can control servers with a network (e.g. system shutdown before powering off the UPS in the event of a long-term power failure).
- (4) The UPS is configured in a rack, and this matches the server room.

This series is going to be expanded to line up single phase UPSs

and to offer power supply solutions to meet customers' individual needs.

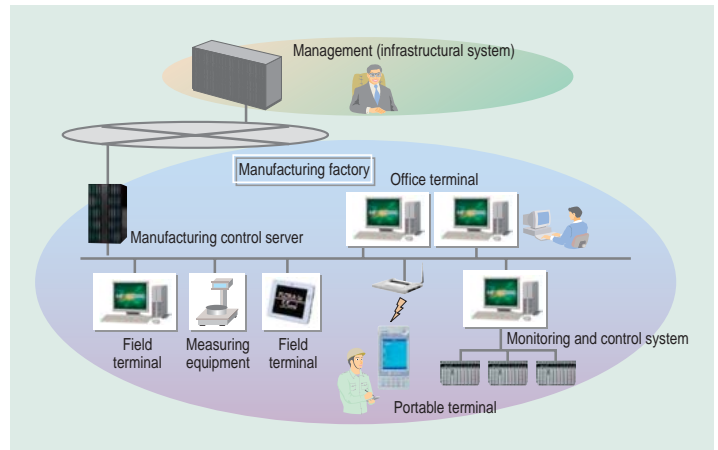


Appearance of 20-kVA UPS (a) and example of 40-kVA UPS configuration (b)

## Hitachi's Comprehensive Manufacturing Control System

One recent requirement for the MES (manufacturing execution system) is the ability to flexibly meet changing user needs based on a good understanding of operation practices on the factory shop floor. To adapt to such situations, Hitachi has released its comprehensive manufacturing control system, an MES package featuring the architecture modeled on the ecological system and its fundamental source – cells – that continues responding to changes and evolving.

This control system consistently manages all processes ranging from the assignment of manufacturing instructions to final output of all manufacturing results in a manufacturing process on the factory shop floor based on production schedule data received from the infrastructural system. One particular feature of the system is the enhanced linkage of the assist function for shop floor work and functions for plant monitoring and control, and thus offers a factory environment where humans and systems are fused together.



Typical configuration of Hitachi's comprehensive manufacturing control system

## High-voltage Direct Inverter for High-voltage Synchronous Motor



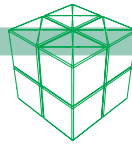
2,000-kVA, high-voltage direct inverter

Hitachi has developed an inverter control system for driving high-voltage motors with less maintenance, and at low cost. The new system uses no speed or position sensors and has robustness to changes in the motor parameters.

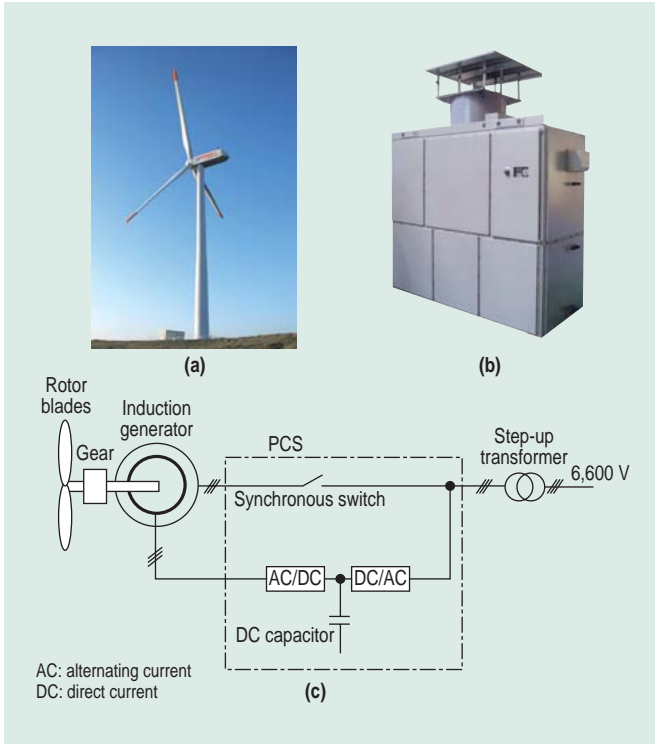
Hitachi has commercialized this control system by applying it to a high-voltage direct inverter that drives high-voltage, large-capacity motors efficiently with variable speeds without using an output transformer.

[Main features]

- (1) This high-voltage direct inverter outputs voltage waveform similar to a sine wave, and is therefore applicable to existing motors.
- (2) Control to inhibit reverse run at startup has been developed to enable stable startup by estimating the motor's magnetic pole positions without using speed or position sensors.
- (3) Control to recover power at restart enables stable operation in regions where power supply is unstable during an instantaneous drop in voltage.



## PCS for 2,000-kW Wind Turbine System



Hitachi developed a PCS (power conditioning system) for a wind turbine system, located in Kamisu City, Ibaraki Prefecture, Japan, and it was installed in December 2005. This PCS-controlled wind turbine system is the world's first practical down-wind machine in the 2,000-kW range with blades on the lee side of the tower.

Fuji Heavy Industries Ltd. manufactured the wind turbine, which has blades 80 m in diameter.

Hitachi's originally developed generator is mounted in the nacelle, and the PCS is set in the tower bottom.

This wind turbine was specifically designed to operate with high reliability even under the severe conditions found in Japan, typhoon winds, lightning surges, heat and humidity, and mountainous and hilly terrain.

The high-performance generator-drive technologies are based on practical power priority control. The down-wind system generates stable power even when the rotor speed fluctuates due to changes in wind velocity.

[Features of the PCS]

- (1) Antifreeze liquid cooling system enables compact and dust-proof power cabinet.
- (2) Remote monitoring system minimizes down-time.

Appearance of wind turbine (a) and PCS (b), and overview of wind power generation system (c)

## High Performance Inverter — SJ700 Series

The high performance SJ700 Series inverter that accommodates all applications requiring high torque runs powerfully with a starting torque of 200% or more, and offers superior control performance and user-friendliness over conventional models.

[Main features]

- (1) Powerful drive at a high starting torque (200% at 0.3 Hz)
- (2) Inverter control by built-in programming function
- (3) Achieves higher internal calculation speed as much as three times faster than that of conventional models. It also inhibits over-current and overvoltage effectively, and thereby increases trip-less performance.
- (4) Uses long lifetime components for the cooling fan and DC bus capacitor, achieving design lifetime of 10 years. It also incorporates lifetime warning function (using a monitor and warning signals).
- (5) EMC (electromagnetic compatibility) filter integrated as standard
- (6) Complies with the RoHS (Restriction of Hazardous

Substances).

- (7) Hitachi original PWM (pulse width modulation) control system (patent registered in Japan, USA and Korea) to inhibit micro-surge voltage (Hitachi Industrial Equipment Systems Co., Ltd.)



Three-phase 400-V class 15-kW SJ700-150HFF

## High Speed, Large-capacity CPU Module for Programmable Logic Controllers

Hitachi has commercialized the EHV-CPU128, a new model incorporating an industry leading basic commands processing speed of 20 ns and an Ethernet\* port as standard equipment. It meets large-capacity requirements by incorporating a ladder program memory of 128 ksteps. Three types (64, 32, and 16 ksteps) are offered.

[Main features]

(1) High speed

Achieves a basic command processing speed of 20 ns.

(2) Larger program memory

Achieves a user program memory of 128 ksteps to enable programming with leeway.

(3) Comment storage area

Comment memory is set in an area separate from ladder program memory.

(4) Improved communication ports

Incorporates not only a serial port but also an Ethernet communication port and a USB (universal serial bus) port as standard equipment.

(5) Segmented LED (light emitting diode) as standard equipment  
Incorporates a segment LED as standard equipment for displaying error codes.

(6) Program sheet structure

Uses a sheet structure that enables the creation of ladder programs for each unit to be controlled. Special-purpose programming software called Control Editor is also being simultaneously marketed (sold separately).

(Hitachi Industrial Equipment Systems Co., Ltd.)

\* See "Trademarks" on page 86.



EHV-CPU equipped with modules (a) and EHV-CPU (b)

## Oil Free Rotary Screw Compressors for the U.S. Market

Hitachi Industrial Equipment Systems Co., Ltd. (HIES) has proudly decided to re-enter the U.S. market with its high-reliability and proven-performance air compressors. HIES has completed comprehensive development of DSP series (Oil Free Rotary Screw Compressor series) from 15 kW to 90 kW. The series have fixed speed control and variable speed control, taking advantage of high performance and reliability of HIES' inverter drives.

To meet the market requirements, the U.S. model DSP series have UL (Underwriters Laboratories) approved starter panels, the high efficiency motors required by the U.S. law and safety devices. For the UL panels, HIES Shimizu Works has been approved as an UL panel shop so HIES can make the UL panels. Various functions, including control methods such as Oil Mist Remover, lead/lag control and Instantaneous Power Interruption restart are standard functions for the U.S. models, whereas those functions are optional in other markets.

The DSP series aftermarket services are distributed through the

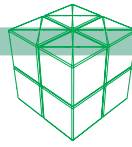
local operation center and warehouse in Charlotte, North Carolina.

(Hitachi Industrial Equipment Systems Co., Ltd.)

(Local stocking started January 2007)



Hitachi oil free rotary screw compressor



## Industrial High-speed Ink Jet Printer: PXR-H

Hitachi has added the PXR-H high-speed printer to its lineup of industrial ink jet printers that print the expiration dates for consumption and use, lot number, control number, and other details in various fields of manufacturing. A printing head has been exclusively developed for high-speed printers to improve the frequency of preparing printing particles and the technology for controlling particle flight, and thus realized a printing speed among the fastest in the world (1.4 times that of conventional models, 150 m/min at two-line printing). Moreover, the ink viscosity is controlled to ensure operating stability, coupled with eco-friendly management as per the EU's RoHS (restriction of hazardous substances) Directive.

(Hitachi Industrial Equipment Systems Co., Ltd.)



Industrial high-speed ink jet printer PXR-H

## Laser Drilling Machine with High Productivity

The production of PWBs (printed wiring boards), particularly build-up boards, flexible substrates, and package boards, is

increasing; therefore, the productivity of the laser drilling machine used in manufacturing PWBs needs to be increased. To meet this demand, a new CO<sub>2</sub> laser-drilling machine was developed and was found to have 5 to 10% higher productivity than a conventional machine when manufacturing PWBs.

[Main features]

(1) To accelerate the scanning beam, a new water-cooled moving-magnet galvanometer scanner that has a coil on the stator side was developed. A maximum scanning frequency of 2.2 kHz was achieved (the previous maximum was 2.0 kHz).

(2) Comprehensive integrated virtual prototyping of the structure, electromagnetic field, and control mechanism enabled a rigid galvanometer scanner, including support structure, to be produced that has high-precision beam positioning.

(3) The new digital servo control system implements advanced control algorithms, offers stable and precise beam positioning, and provides a user-friendly interface.

(Hitachi Via Mechanics, Ltd.)



Laser drilling machine with 2.2-kHz scanners

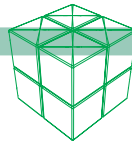
## Commercial Air Conditioners with “DC Inverter UTOPIA IVX” Series Outdoor Unit and Four-way Cassette Dehumidifier Type Indoor Unit

The “DC Inverter UTOPIA IVX” series is an outdoor air conditioner unit used in commercial applications, such as stores and offices. Features of this series include a horizontal-blowing system and not the current upward-blowing system—this is a first for large commercial-use air conditioners (22.8 to 33.5 kW). The heat exchanger uses copper heat transfer tubes with a diameter of 7 mm, which is thinner than the current 9.53 mm. Also, to optimize the heat transfer efficiency, the dimensions and the angle of slits of the aluminum fins were reexamined. Furthermore, a high-efficiency compressor, featuring asymmetry scroll teeth and a DC (direct current) inverter motor, greatly improved the efficiency and enabled an industry-leading energy savings. In the case of a unit with a heating capacity of 28.0 kW, for example, the average energy consumption efficiency of heating and cooling functions is 3.85. The outdoor unit weighs 168 kg (25% lighter than the current type) and is the smallest and lightest in the industry. In addition, the optimized heat exchanger successfully lowers the ventilation resis-

tance and reduces the noise level to the lowest in the industry. The four-way cassette dehumidifier is a ceiling cassette indoor unit with a four-way blowing system. The system features a “pleasant dehumidification” function to make the room more comfortable, which is the original purpose of air conditioners. When the current indoor units are used for dehumidification during the rainy season, users must reduce the airflow in the cooling mode to avoid having cold direct air on them. As a result, the blowing temperature of the air conditioner drops. This problem was solved by adding a reheater in part of the heat exchanger. The blowing air after dehumidification is heated by refrigerant heat, and the cold air is controlled, thus improving comfort for the users. Moreover, this indoor unit can be connected to multi-split system air conditioners for buildings in which multiple indoor units are individually operated and controlled. This industry-first design ensures a pleasant and comfortable office environment. (Hitachi Appliances, Inc.)



“DC inverter UTOPIA IVX” series outdoor unit (140 type) (a), four-way cassette type indoor unit (b), and multi-split system air conditioner for buildings; outdoor unit (280 type) (c)



## ZAXIS-3 Series Hydraulic Excavators

As infrastructure construction plans have been increasing all throughout the world, so too has the demand for hydraulic excavators.

Hitachi Construction Machinery Co., Ltd. focuses on the whole world, and its goal is to develop machines of the highest level of quality. Worldwide concerns for the environment must be seriously considered by manufactures when developing machines. For example, Tier 3 emission regulations started to take effect from 2006 in Europe, North America, and Japan, and regulations for noise levels started to take effect in Europe. Safety issues are also strongly focused on by Hitachi, and the cab frame structure that protects the operator in case the hydraulic excavator rolls has been examined for new regulations.

Hitachi came up with the concept "Where Quality Meets Ability." The launch of the ZAXIS-3 series (ZX200-3, ZX240-3, ZX270-3, and ZX330-3) in the market made Hitachi realize that "Evolution of Basic Performance" is required in every aspect of the hydraulic

excavator development. Such aspects include improved productivity, less fuel consumption, increased respect for environment and safety, and increased information technology.

[Main features]

(1) Improved productivity and low fuel consumption

Installing the latest diesel engine and a newly developed hydraulic system enabled boost productivity and provided better fuel efficiency.

(2) Environment measures

A highly efficient diesel engine, whose emission complies with the latest exhaust regulations enforced in Europe, North America, and Japan was installed. Moreover, the new model complies with European noise regulations, reduces the engine noise level by 5 dB and reduces the fan noise level with less air resistance. Both noise levels were compared using other conventional machines.

(3) Safety measures

Cab strength has been significantly improved, and a cab frame structure that protects the operator in case of rolling was developed.

The machine is also equipped with a rear view camera so that the operator can see what is behind the machine. This feature will reduce blind spots and increase safety.

(4) Embedded information technology

The operator can take hold of the machine with a standard equipped multi function monitor that requires a password to start the engine. Also, the location of machine is constantly monitored by a GPS (global positioning system). This system prevents theft and vandalism. The operator can take hold of the location of the machine and obtain maintenance records by using a standard equipped controller and a data transmission apparatus. This data can be transmitted over the Internet and can be viewed at a remote location or a customer's office.

(5) Color and design reflects Hitachi brand image, high reliability and quality.

Hitachi machines reflect their high quality production, enforced safety, and reliability. The machine's design is cutting edge and impressive.

(6) Winner of the 2007 IF design award.

(Hitachi Construction Machinery Co., Ltd.)



ZAXIS-3 series ZX200-3 hydraulic excavator

## Boiler Feedwater Pump Units for Zouxian Power Plant in China

Four boiler feedwater pump units have been delivered to the 7th and 8th equipment sections of the Huadian Power International Corporation Ltd.'s Zouxian Power Plant in the Shandong Province of China. The total list of products delivered within 13 months from the date of contract is as follows:

- (1) Four turbine driven boiler feedwater pumps
  - (2) Two motor driven boiler feedwater pumps
  - (3) Six booster pumps for boiler feedwater pumps
  - (4) Motors, hydraulic couplings, high-pressure valves, and others
- The latest high-performance hydraulic model was used in these boiler feedwater pumps, and the performance of all pumps was factory tested and verified. Installation work is currently in progress, and the plant is scheduled to start operation in 2007 after test runs.

Power plant construction in China has become a boom industry in response to the rapid increase demand for power: In particular, the

Zouxian Power Plant is attracting attention from various fields as one of the first 1,000-MW-class power plants in China. (Hitachi Plant Technologies, Ltd.)



| Specifications            |                         |
|---------------------------|-------------------------|
| Inlet and outlet diameter | 400 × 450 mm            |
| Inlet flow rate           | 1,981 m <sup>3</sup> /h |
| Pump total head           | 3,621 m                 |
| Feedwater temp.           | 186.3°C                 |
| Speed of rotation         | 5,200 min <sup>-1</sup> |
| Driver                    | 20,600 kW               |

Appearance and specifications of turbine driven boiler feedwater pump

## Large-capacity IGBT Drive System for Hot-rolling Mill

Hitachi has commercialized a large-capacity IGBT (insulated gate bipolar transistor) drive system suited for the hot-rolling mill used in steelmaking.

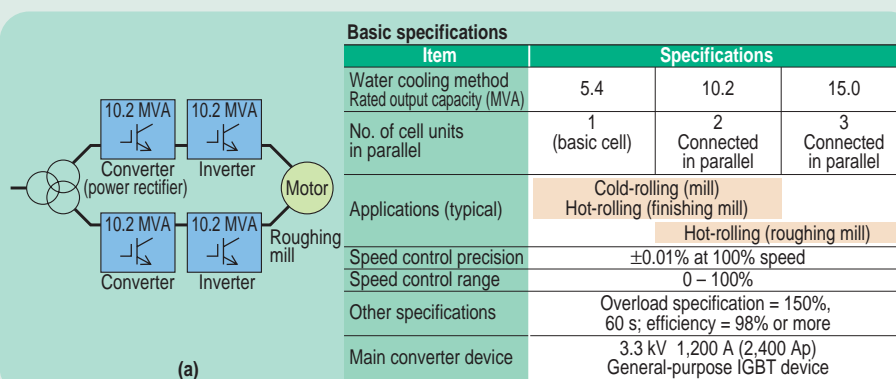
Hot-rolling mill requires a large torque at low speed. Consequently, there is only a limited range of application for conventional IGBT systems in terms of capacity. This system incorporates device serialization technology to increase the main circuit voltage for greater system capacity. In so doing, Hitachi has realized a maximum capacity of 15 MVA for a single unit to enable IGBT system application to hot-rolling mill.

[Main features]

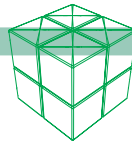
- (1) Uses a general-purpose IGBT device.
- (2) Adopts device serialization technology to increase the main circuit voltage and cell unit capacity.
- (3) Increases the capacity by connecting cell units in parallel.

The use of cell units allows inverter capacity suited for each motor to be selected, and thereby facilitates maintenance and the standardization of spare parts.

(Date for marketing: December 2006)



Typical example (water cooled system) of hot-rolling (roughing-mill), and basic specifications (a) and appearance (b) of the IGBT drive system



# Hot-rolling Equipment Control System Delivered to China's Zhangjiagang Pohang Stainless Steel Co., Ltd.

The Steckel hot-rolling equipment control system delivered by Hitachi to China's Zhangjiagang Pohang Stainless Steel Co., Ltd. has begun steady operation in commercial production. This system was built by a Chinese joint venture established by POSCO (Pohang Iron & Steel Company) of South Korea as a production site in China for coils made of hot-rolled stainless steel. Given the growing demand for steel strips, the system helped launch production only 18 months after the start of construction work by taking advantage of similar control systems.

The system uses model prediction control based on a process computer for the functions of controlling strip thickness, strip width, temperature, and other qualities, and thereby precisely estimates the status of equipment and rolled materials to improve the accuracy of control references. Moreover, the system serves as a high-speed controller that integrates strip thickness control and oil pressure reduction control. This reduces the transmission time and other time delay factors between both controls and increases the

response in strip thickness control to improve strip thickness accuracy by about 10% compared to conventional systems. Hitachi has also newly developed a PDA (process data analysis) system for storing operation data for long periods and at short samplings in an attempt to alleviate user workload in terms of maintenance after plant startup.



(a)



(b)

Central operation room (a) and a scene of rolling at a coarse mill (b)

# Advanced Pickling Line and Tandem Cold-rolling Mill Electromechanical Equipment Delivered to China's Wuhan Iron and Steel Company Limited

The advanced pickling line and tandem cold-rolling mill electromechanical equipment delivered by Hitachi to China's Wuhan Iron and Steel Company Limited in Hubei Province have begun steady commercial operation.

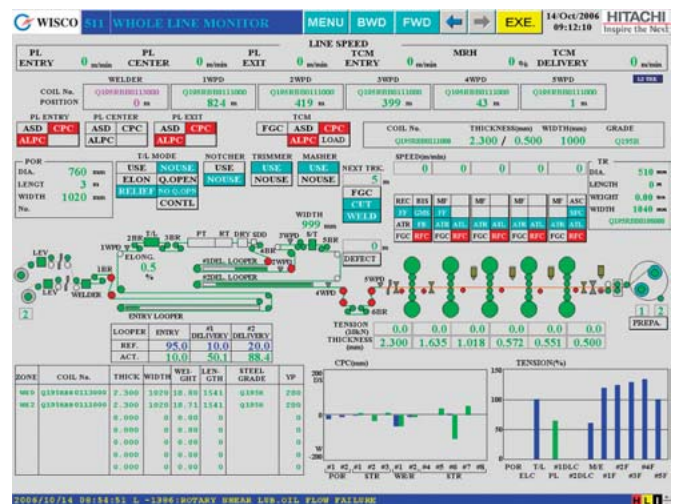
This rolling equipment produces the electromagnetic steel sheets necessary for efficient transformers, motors, and other energy-saving equipment. It adopts a high-response IGBT (insulated gate bipolar transistor) drive and the latest strip thickness and shape control to produce sheets as thin as 0.35 mm with high-precision quality.

Electromagnetic steel sheets require a particularly high yield. Hitachi has therefore combined the system with a six-high UC (universal crown) mill, which is advantageous in producing such steel sheets, to achieve such high yield through optimal work roll and intermediate roll shift/bender control.

Hitachi has also adopted an open network incorporating MODBUS and DeviceNet\* for compatibility with interfaces of other makes.

(Startup date for commercial operation: November 2006)

\* See "Trademarks" on page 86.

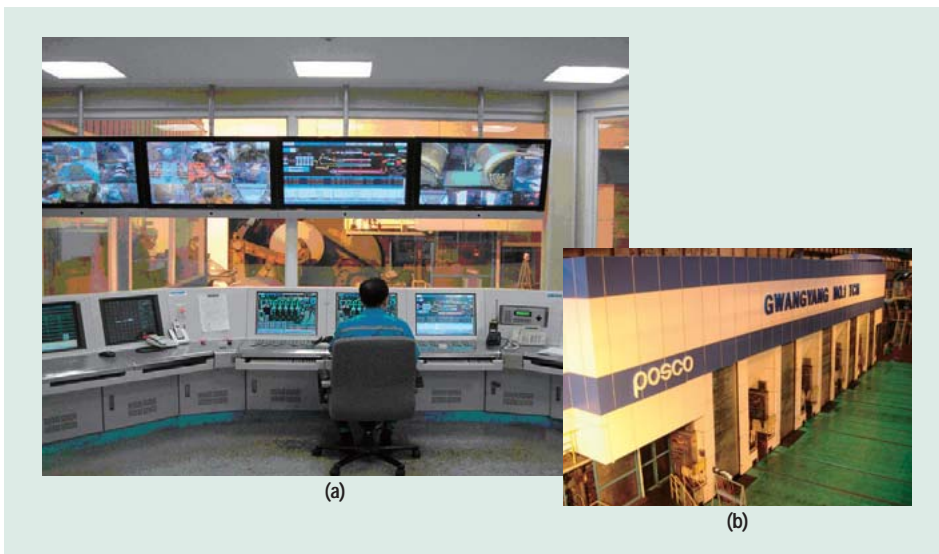


Typical overall monitoring screen for pickling continuous cold-rolling equipment

## Renewal of Continuous Cold-rolling Electrical Equipment Delivered to South Korea's POSCO

Hitachi previously delivered a K1C (Gwangyang No.1 Cold Mill) electrical control system to POSCO's Gwangyang works in South Korea. The equipment based on that system began commercial operation in June 2006 and has since been running steadily. The project involved completely renewing the pickling equipment by adding a 6Hi UC (universal crown) mill to the rolling equipment

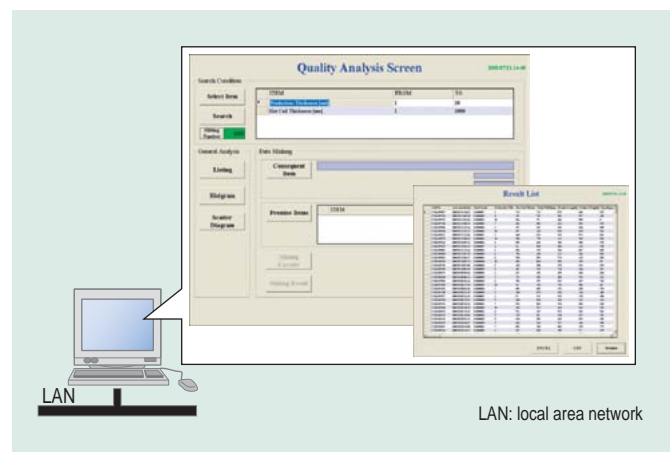
for increased productivity, and conducting other remodeling operations for the pickling continuous cold tandem rolling mill. The motors for the main and auxiliary equipment, control system, and other electrical equipment were also completely renewed. Hitachi combined a high-performance and multi-functional large-capacity IGBT (insulated gate bipolar transistor) drive, high-response oil pressure reduction control system, and strip thickness control based on optimal control theory to ensure strip thickness quality with a deviation of  $\pm 0.4\%$  or less over the entire length of strips. Hitachi also applied a new shape control technology that properly controls the WR/IMR (work roll/intermediate roll) bender and multi-spot cooling, and thus succeeded in increasing the shape precision of hard-to-roll materials. This cold-rolling equipment incorporates the essence of all related leading-edge technologies to produce highly tensile automotive strips, for which recent demand continues to grow.



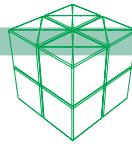
Operation room (a) showing one-person operation, and K1C rolling equipment (b)

## Hitachi Commercialized a System for Facility and Steel Quality Diagnoses

Hitachi has commercialized a compact diagnosis system that performs facility and quality diagnoses in steel plants from a single PC (personal computer). The system creates a database of collected data divided into facilities-related data and quality-related data for managing the operation status and operation history of equipment, and setting the replacement timing for consumable equipment. Hitachi also provided a quality analysis function based on various statistical execution regarding data on steel strip thickness, shape, and other qualities. Users can also use the data mining function that automatically searches for operating conditions where poor quality coils are readily produced, and thus improve operation and help to tune up the control system.



Typical screen of a compact diagnosis system showing data mining in progress



## High Pressure Fuel Control System for Gasoline Direct-injection Engines

**Engine control unit (injector, pump drive integrated)**

- New custom IC (injector, pump drive)
- Modularizing of power and voltage converter circuit (no less than 70 V)

Peak current  
Holding current  
Optimization of injector drive

Fuel piping system  
Injector  
Fuel pressure sensor  
High pressure fuel pump  
Six cylinder compliance

Reduction in fuel pressure pulsation in fuel rail  
Pressure ratio  
Crank angle

Proposal of various spray patterns

IC: integrated circuit

Overview of high-pressure fuel control system for gasoline direct-injection engine

Hitachi provides a high-pressure fuel control system, and this system is the key for achieving a gasoline direct-injection engine required to address environmental concerns (CO<sub>2</sub> reduction).

[Main features]

(1) A high-pressure fuel control system contains an injector, a high-pressure fuel pump and a controller, all of which contain integrated drive IC chips.

(2) A wide ranging fuel flow rate is possible that can be optimized by controlling the drive based on injector characteristics. Fuel pressure control is also possible by adapting to driving conditions, which address future requirements for engines (turbo charge, alcohol fuel).

(3) A pump configuration and fuel rail that minimizes fuel pressure pulsation in fuel rail, and a high-speed feedback control mechanism that uses fuel pressure sensors to precisely control the fuel injection volume

(4) The proposed optimized fuel spray system is compliant with different combustion concepts and chambers based on Hitachi's own simulation technology of turbulent flow and in-cylinder mixture.

An entirely optimized fuel control system (hardware, and control) can provide increased engine performance.

## Motor Generator Unit and Power Electronics Box for BAS Hybrid Systems

Hitachi has developed the MGU (motor generator unit) and the PEB (power electronics box) for GM (General Motors Corporation)'s BAS (belt alternator starter) hybrid system to meet the needs of global environmental conservation. The BAS system has idle stop/start, electric power assist to engine and regenerative braking functions. As a result, about a 20% improvement in fuel economy is achieved (estimation by GM). The MGUs and PEBs have the following features.

[MGU]

- (1) Permanent magnet enhanced Lundell machine
- (2) Motor assist and electrical generation functions
- (3) Peak motoring power of 4 kW and peak generating power of 5 kW

- (4) Idle stop/start, electric power assist to engine, regenerative braking, and electrically motored creep functions

[PEB]

- (1) Small size by implementing both inverter and DC/DC converter functions into single unit
- (2) AC of 5 kW at 36 V and DC of 1.6 kW at 12 V

PEB

GM Saturn VUE Green Line

12-volt battery and accessories  
Engine control module  
Power electronics

Advanced nickel metal hybrid battery pack  
Regenerative braking  
Electric motor generator

MGU

GM Saturn VUE Green Line vehicle (center), and equipped MGU (bottom) and PEB (top)

## New Mono-tube Type Shock Absorber

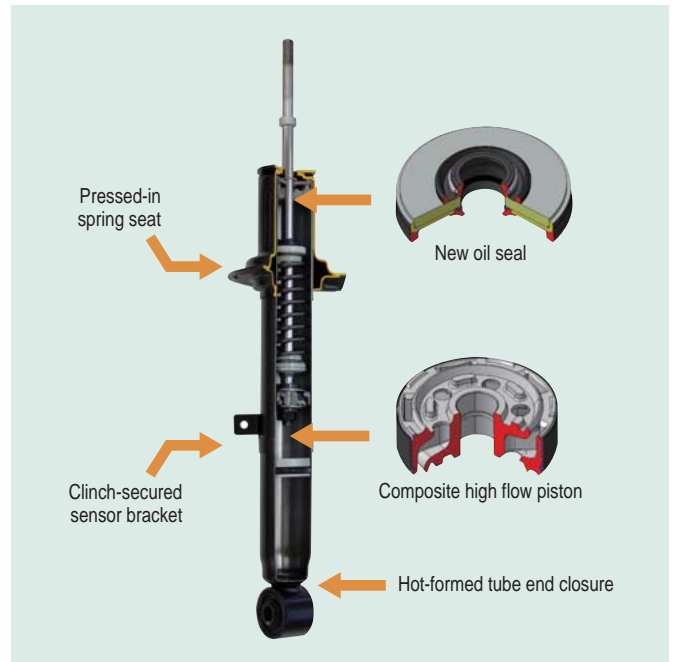
Simultaneous developments in the design process, processing methods, and the equipment used in manufacturing have resulted in the successful launch of new-generation mono-tube type shock absorbers. Main features are as follows.

(1) The structure of the seal portion has been completely redesigned. In addition, the bracket and the spring seat have been designed to be secured onto a shock absorber without the need for welding so as to improve reliability. The piston valve, where the damping force is generated, uses a specially designed composite type high flow piston. The new valve design provides damping characteristics that enhance the ride comfort and handling of a vehicle to the highest order.

(2) Clinching, pressing-in and hot-forming methods have replaced the welding operations. Also, a unique process has been developed for this product in which the assembly is pressurized to increase the internal gas pressure in the automated assembling machine.

(3) A designated assembly line has been constructed for this new mono-tube shock absorber to create this newly developed design and process. The new assembly line is installed in an independent room with several part cleaning devices to avoid contaminating products.

The first application of this new mono-tube shock absorber is the IS series by Lexus, and more products are planned for the future.



Mono-tube shock absorber using new design, processing methods and equipment

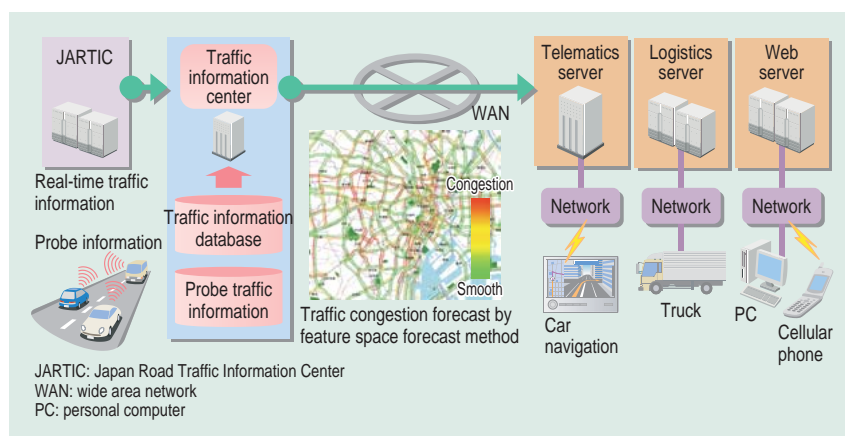
## Traffic Information Solution

The need for comprehensive traffic information has greatly increased as people become more reliant on cars. Many users expect services to provide advanced traffic information over a much wider coverage area and more accurate and up-to-date traveling times. Such features are not supported by conventional services. Hitachi

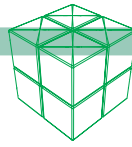
developed a traffic information center and integrated its traffic information technique, which has been thoroughly investigated and developed, to provide information to car navigation systems using the telematics center.

Core techniques used to provide traffic information are (1) “feature space forecast method”—the method enables highly accurate forecasts by using statistical methods that take various past conditions into account, such as the days of week or continuous public holidays, stored in the traffic database, (2) the probe car technique which increases the traffic congestion forecasting accuracy by estimating traffic conditions of road in service, and (3) the complementary technique which estimates missing traffic information when no such information is provided.

Hitachi is expanding the area of traffic information solution using the core techniques for various fields, such as logistics planning, displaying traffic conditions on PC/cellular phone, supporting travel plan and so on.

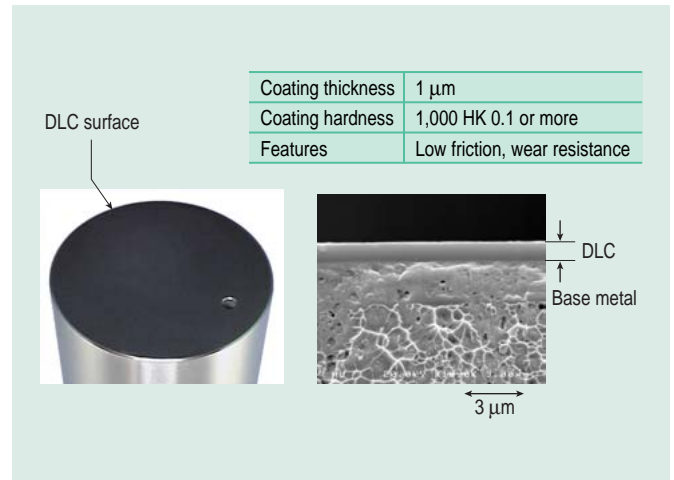


Outline of traffic information solution



## Hydrogen-free DLC Coating Valve Lifter

The rising cost of gasoline in recent years has made it ever more necessary to improve the fuel economy of motor vehicles. In such an environment, Hitachi has developed a valve lifter that features a hydrogen-free DLC (diamond-like carbon) coating. Low friction with superior conformity to the engine oil has been achieved using this coating. As a result, the fuel economy related to low friction in engine valve train systems has been improved. Many hurdles remain to develop a coating with good adhesion to a base metal based on existing coating technology. Hitachi has produced a highly reliable coating through the development of lapping and special washing technologies prior to the treatment.



Outline of hydrogen-free DLC coating valve lifter

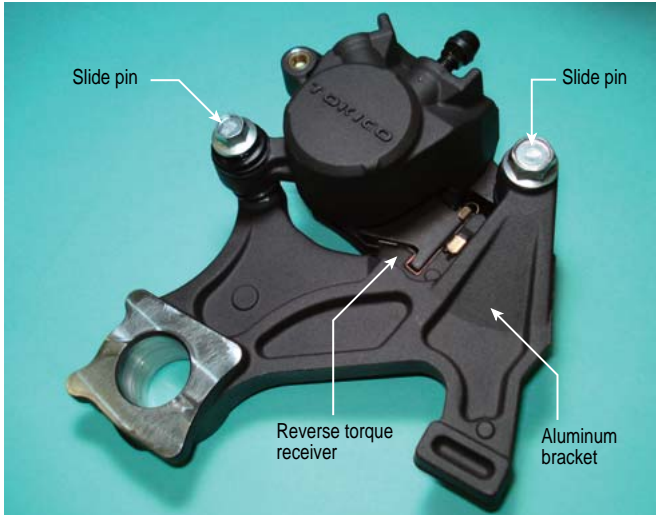
## Variable-displacement Power Steering Pump



Variable-displacement power steering pump

In response to global warming prevention and steps to reduce carbon dioxide levels, the demand for energy conservation has constantly increased. Developing an EPS (electronic power steering) system for luxury cars is difficult, and advanced technology is required to conserve energy in an HPS (hydraulic power steering) system without degrading exterior steering feeling. Hitachi developed the variable displacement pump to achieve and satisfy this strong requirement. This pump is used to not only enhance the steering feeling, but also to reduce the torque consumption by adjusting the displacement based on the flow required from the power steering system. Therefore, a cooling pipe can be eliminated because of reduced heat generation due to more efficient process being used. As a result, this will reduce cost. Hitachi has been improving quietness and plans to expand this technique to other vehicle categories.

## Integrated Sliding Type Caliper Incorporated with an Aluminum Bracket for Two-wheeler's Rear



External view of new sliding type caliper integrated into an aluminum bracket for two-wheeler's rear

Hitachi has developed a new sliding (floating) type caliper that is incorporated into an aluminum bracket for two-wheeler's rear. This device reduces thumping vibrations associated with a high-powered motorcycle engine and is lightweight.

[Main characteristics]

(1) Major improvements in reducing vibration by changing the slide pins with a caliper housing and using a latch brake pad method

(2) Improved caliper housing slide elasticity by adding a constitution to provide a greater reverse torque

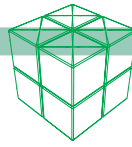
Future work involves marketing this new caliper to other models.

## Global Standard HDD Navigation System

A new global standard navigation system that has manufacturer-installed options, including an HDD (hard disk drive) was developed. The model for the Japanese market has high functionality and better viewing, and is a more user-friendly navigation system than previous models. The key features of this system are a high-definition WVGA (wide video graphics array) liquid-crystal display monitor and the latest navigation technology. The system provides a substantially reduced route calculation time, suitable route guidance with departure date and avoidance of anticipated congestion based on past statistical traffic information, a 3-dimension graphic display, and a function that automatically selects a track depending on the situation. (Xanavi Informatics Corporation)



Global standard HDD navigation system



## F-7000 Fluorescence Spectrophotometer Allows High Sensitivity and High Throughput Studies

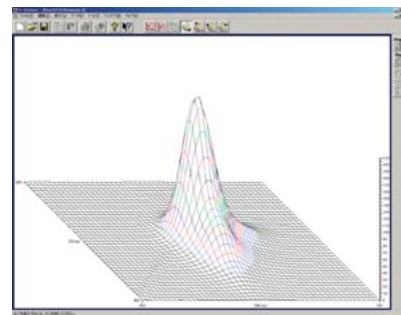
Demands for high sensitivity, small sample volume, and automatic measurements of multi-samples have increased as a result of advances in biotechnology. Also, increased demands for measurements exist that require sophisticated technology, such as intracellular calcium measurements. The F-7000 fluorescence spectrophotometer was released to meet these demands. This spectrophotometer has a greatly improved sensitivity (2.5 times greater when compared to the previous model) and high throughput. The detection limit of fluorescence by using the F-7000 spectrophotometer is ten times better than that of the previous model. The F-7000 spectrophotometer has a scan speed twice that of the old model and



F-7000 fluorescence spectrophotometer

enables 3-dimensional fluorescence spectra to be measured, which is useful for qualitative analysis of unknown samples, in 75% of the time as the old model. The negative environmental impact of the F-7000 spectrophotometer has been reduced. The F-7000 spectrophotometer is compact (about 66% in volume) and lighter (about 70%) as compared to the previous model.

Furthermore, the micro titer plate accessory is added as an option. This accessory is used to automate small sample volume measurements. Moreover, this accessory can be used as an auto sampler and it enables easy automation of spectra measurements. F-7000 spec-



Example of 3-dimensional fluorescence spectrum

trophotometer is expected to be used in new fields, such as those that estimate intermolecular distance by using FRET (fluorescence resonance energy transfer) techniques.

(Hitachi High-Technologies Corporation)

## Scanning Electron Microscope for Samples up to 300 mm in Diameter

SEMs (scanning electron microscopes) are used to observe the surface microstructures of substances in various applications ranging from research and development to quality control in wide-ranging industries. Recent years have witnessed a particularly high rate of rising demand for speedily observing the microstructures of large samples on a nondestructive basis in the steel and automotive industries, as well as in other fields.

To meet these demands, Hitachi has marketed the SEM S-3700N that can handle samples up to 300 mm in diameter and 110-mm in thickness.

[Main features]

(1) The product can handle samples up to 300 mm in diameter. It also incorporates a large analysis sample chamber capable of being simultaneously equipped with such analytic devices as EDX (energy dispersive X-ray spectrometry), WDX (wavelength dispersive X-ray spectrometry), and EBSP (electron backscattering pattern).

(2) The product incorporates a large, five-axis motor drive stage that enables the observation and EDX analysis of samples up to 110-mm thickness.

(3) The product incorporates as standard equipment a low-vacuum function effective in the unprocessed observation of insulator samples.

(4) The product incorporates a turbo molecular pump to save electricity and space (reduced by about 56% and 27% from Hitachi's conventional models, respectively).

(Hitachi High-Technologies Corporation)



Scanning electron microscope S-3700N compatible with large samples

## Model HD-2300A STEM with Improved Automatic Adjustment Functions

To enable more user-friendly operations, a new STEM (scanning transmission electron microscope) HD-2300A was equipped with improved automatic adjustment functions. The automatic focus alignment function, which has already obtained a good reputation with customers, was improved. More user-friendly functions, such as simultaneous acquisition and display of STEM images and high acceleration voltage SEM (scanning electron microscope) images, were achieved by utilizing a high-resolution observation mode that does not require any re-adjustment from low magnification. These are additional user-friendly functions to support user operation.

[Main characteristics]

- (1) Three automatic alignment functions
  - (a) secondary electron alignment, (b) stigma alignment, and (c) bright area centering
- (2) Automatic image adjustment
  - (a) auto focus, (b) auto stigma, and (c) auto brightness and contrast
- (3) Highly accurate dimensional measurement  
Achieved  $\pm 3\%$  magnification accuracy by using newly developed

magnification correction function.  
(Hitachi High-Technologies Corporation)



Model HD-2300A STEM

## Spherical Aberration Corrected STEM HD-2700

In collaboration with CEOS GmbH in Germany, Hitachi High-Technologies Corporation has commercialized a new HD-2700 STEM (scanning transmission electron microscope) that is equipped with a spherical aberration corrector.

Hitachi's HD series STEM is used to not only analyze the surface and the inner fine structure of materials, but also to analyze chemicals for nanotechnology-based applications by using EDX (energy dispersive X-ray spectrometer) and EELS (electron energy loss spectrometer). (Both spectrometers are optional.)

Spherical aberration, which limits the performance of electron microscopes, was corrected resulting in higher resolution observation and higher sensitivity analysis than standard models (approximately 1.5 times higher resolution and 10 times higher probe current than the standard model).

In addition, a common sample handling system for the HD-2700 and Hitachi's FIB-2100 focused ion beam system ["Hitachi Microsampling" (JP patent: 2774884, US patent: 5270552)], enables continuous specimen sampling, observation, and analysis when high analysis-throughput is used.

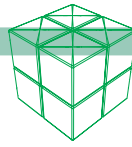
The graphical user interface installed is similar to that of an SEM (scanning electron microscope) and various automatic adjustment systems are included to make the microscope more user-friendly. In addition, the microscope contains an anti-contamination device and highly-stable electron optics suitable for nano-region analysis.

Spherical aberration correction is a promising technology that will be commonly used in electron microscope from now on. These technical advantages are achieved by mounting a spherical aberration corrector on a dedicated STEM—a world first.

(Hitachi High-Technologies Corporation)



Spherical aberration corrected STEM HD-2700



## Large Glass Substrate Exposure System for 8th Generation Products

A large glass substrate exposure system was developed to massproduce 8th generation color filters. The LCD (liquid crystal display) panel has revolutionized the displays for personal computers, and screen sizes have been enlarged. Enlarging the LCD panels has resulted in enlargement of the mother glass and the development of mother glass with a size of 2.2 m–2.5 m, which is called the 8th generation. By combining an industry first XY step exposure system, which was adopted in 5th generation products, and a double chuck system, Hitachi was able to create a low cost system that has a high throughput. In addition, 8-micron resolution was achieved by using an original photo mask bending correction mechanism and an original optical non-contact gap control mechanism.  
(Hitachi High-Technologies Corporation)



Large glass substrate exposure system for 8th generation products

## CG4000, a High-resolution FEB CD-measurement SEM for Next-generation Devices



CG4000 high-resolution FEB length meter for next-generation devices

Hitachi has developed a new FEB (field emission beam) CD (critical dimension)-measurement SEM CG4000 with high resolution and reproducibility as a device designed for next-generation DRAM (dynamic random access memory) and half-pitch 57-nm devices and later.

Hitachi has enhanced the hardware and software even further for this particular device, achieving higher speed, resolution, and reproducibility. In so doing, the company has significantly increased productivity.

[Main features]

(1) High resolution

A new electron optical system is used to achieve a maximum resolution of 1.8 nm (with an accelerating voltage of 800 V).

(2) High reproducibility

The hardware and software have been enhanced to achieve length-measuring reproducibility of 0.3 nm (3 $\sigma$ ) (using Hitachi standard wafers as samples).

(3) Higher environmental resistance

(Hitachi High-Technologies Corporation)

## Next-generation Inline Defect Review SEM

As the dimensions of semiconductor device continue to decrease and wafer size becomes larger, it is difficult to identify killer defects from a large number of defects and to classify them fast so that collected data are effectively sorted and fed back to the process control and yield enhancement in a timely manner. Such circumstances have increased demand for a high-speed defect review SEM (scanning electron microscope) for in-line use capabilities. To meet such demand, Hitachi has developed a high-resolution DR-SEM (RS Series) capable of inspecting devices of 45-nm (half-pitch) nodes and beyond.

[Main features]

- (1) New electron optics with high-accuracy and high-resolution ADR (automatic defect review).
  - (2) High-speed non-patterned wafer ADR.
  - (3) User-friendly high accuracy ADC (automatic defect classification).
  - (4) Automatic X-ray elemental analysis (energy dispersive X-ray spectrometer) (option)
  - (5) Process monitoring function (option)
- (Hitachi High-Technologies Corporation)



New inline defect review SEM

## Single-wafer Integrated High-*k* Gate Stack Processing Tool



Single wafer integrated high-*k* gate stack processing tool

Hitachi Kokusai Electric Inc. has developed a single-wafer integrated high-*k* (high dielectric constant) gate stack processing tool that allows the various required processes in series. High-*k* films are expected to replace the currently used silicon dioxide films in the next-generation high-performance logic devices. As a result, they will become a very widely used device in the near future. The high-*k* films formed by using Hitachi developed tool provide high-*k* quality thin films with exceptionally low levels of impurities. Hitachi has participated in the MIRAI-PJ (Millennium Research for Advanced Information Technology Project) and SELETE (Semiconductor Leading Edge Technologies) program and been jointly evaluating and developing a wide range of process technologies and their applications.

[Main features]

- (1) Sequential processing for high-*k* gate stack formation
  - (2) Very low levels of impurities within deposited films
  - (3) Excellent thickness uniformity and very low particle size by using a unique gas supply system and simple reactor design
- (Hitachi Kokusai Electric Inc.)