Featured Articles

Development of Room Air Conditioners

—Adding Multi-monitoring System to Environmentally Conscious Features—

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OVERVIEW: There is a demand for further energy savings and electricity conservation in room air conditioners, which consume a large amount of electrical energy in the home. The stainless/clean room air conditioners that was released in FY2014 features unique energy-saving technology along with a multi-monitoring system that provides comfort through the use of an "imaging camera", a "thermal imaging camera", and a "near-infrared camera". This system detects not only surrounding temperature and the positions of people, but also the positions and shapes of furniture and the layout of the room, and identify airflow paths. The system blows warm air toward the feet when heating, and circulates cool air to cool the entire room when cooling, using fine-tuned control over the direction of air to achieve comfortable air conditioning all year round.

INTRODUCTION

AS concerns mount over global warming and the cost of electricity rises, the need for products with excellent energy-saving performance continues to grow. The "annual performance factor" (APF)[(1)] is an index used to represent a room air conditioner's energy-saving performance. Many companies are developing room air conditioners with higher APF values each year by improving basic technologies such as compressors, heat exchangers, fans, and the inverter circuits used to drive motors.

According to surveys, however, in addition to consumer complaints such as "my electricity bill is too high," there are also many complaints that "it doesn't warm my feet" when heating, and "it doesn't cool the whole room" when cooling (see Fig. 1).

To respond to these needs and complaints, and to save electricity while improving comfort at the same time, Hitachi developed the "Imaging camera", making it the first time a visible light camera was used as a sensor in an air conditioner. This technology, which detects the movements of people within a living space to achieve comfortable electricity-saving control

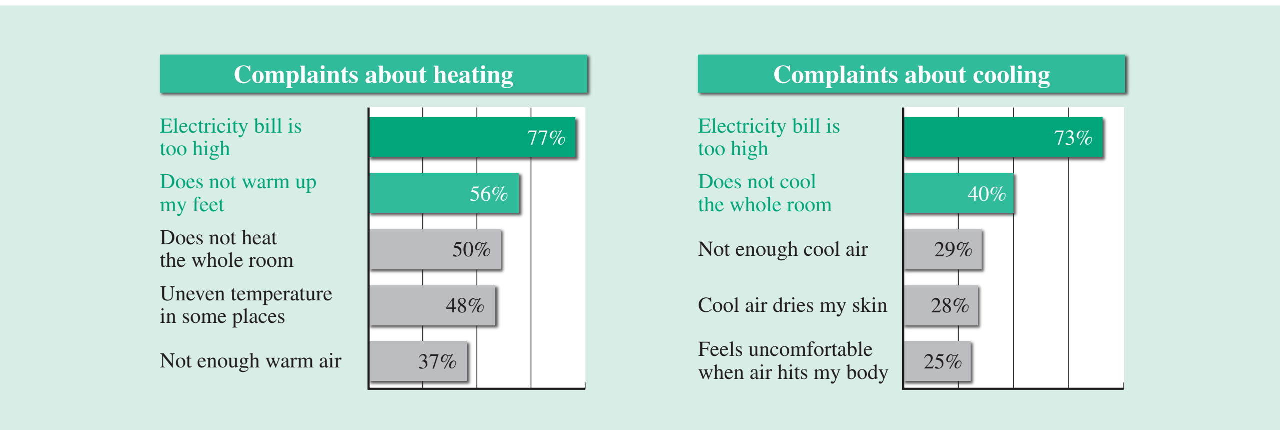

Fig. 1—Complaints about Room Air Conditioners (Hitachi Survey from May 2014: n=515).
Along with "my electricity bill is too high," complaints included "it doesn't warm my feet" for heating, and "it doesn't cool the whole room" for cooling.

Fig. 2—Room Air Conditioner (X-series) Released in FY2014.
This model included the multi-monitoring system and a three way front flap. Comfortable air conditioning is achieved by finding airflow paths.

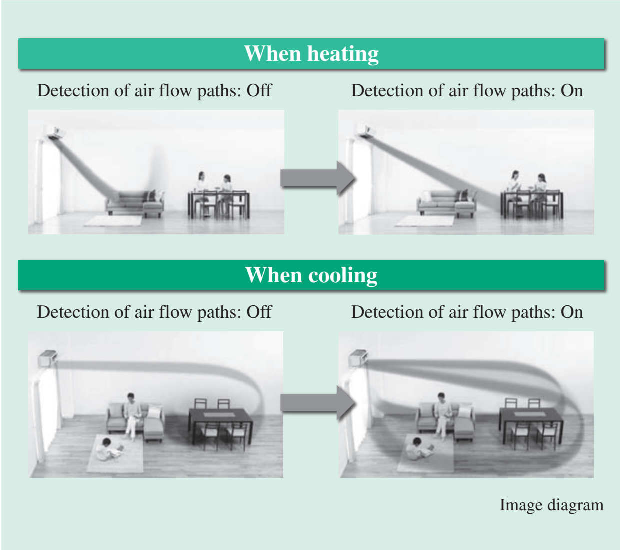

Fig. 3—Improved Handling of Airflow Blocked by Furniture.
Comfortable air conditioning is achieved by controlling the airflow based on consideration of the shapes and positions of furniture.

that suits the situation, was adopted for use in high-end models released in FY2012.

Furthermore, in FY2013 a thermal imaging camera using a thermopile was included in addition to the imaging camera, and a monitoring system with these cameras could detect the temperature around people and achieve electricity-saving functionality that was more accurate and comfortable.

For the product released in FY2014, the multi-monitoring system was developed even further based on the premise of energy-saving performance with a goal of providing comfort that would resonate with consumers. This article describes an airflow control function that utilizes the sensing technology of the stainless/Clean Room Air Conditioners released in FY2014, and technology that improves energy-saving performance (see Fig. 2).

COMFORT TECHNOLOGY BASED ON MONITORING WITH CAMERA

Room air conditioners are frequently used in the home, and living room/dining room/kitchen (LDK) floor plans with living rooms where large models are installed are the norm for homes. Family members gather together in the living rooms of such homes, which depending on the time period, are characterized by a wide variety of situations. Unlike other rooms, living rooms have sofas and dining tables, and in Hitachi's surveys, consumers have complained that "when heating the room, the sofa or the dining table blocks the airflow, preventing the warm air from reaching my feet," or that "when cooling the room, the whole room is not cooled, and the temperature is uneven."

Detection Technology of Monitoring System

The monitoring system includes an imaging camera that looks at the number of people in the room, their activity levels, and positions, as well as factors such as distance and layout of the room,(2) and a thermal imaging camera that looks at the temperatures around people in the room. By more closely examining the states of both people and the living room, this system achieves a higher level of comfort in air conditioning while precisely responding to a wide range of situations.

Furthermore, by focusing on the aforementioned challenges that are unique to the living room, Hitachi considered methods for achieving the important goal of ensuring that air currents find paths to reach people even when there is furniture in the way (see Fig. 3). Near-infrared images are utilized to detect the positions and shapes of furniture. This technology has been developed to improve comfort and to contribute to electricity conservation with the one button for all operation*.

Multi-monitoring System

With a camera mounted in the center of the indoor unit, and only when near-infrared images are acquired in front of the central imaging camera, a filter that is transparent to near-infrared wavelengths is moved by

* This automatic electricity-saving function maintains an even, comfortable temperature based on the number and positions of people, the surrounding temperature, the amount of activity, and the amount of sunlight.

a shutter system to cause the camera to function as a near-infrared camera. A near-infrared light-emitting diode (LED) is used to provide the illumination necessary to acquire near-infrared images.

Processes such as noise removal, edge detection, and area segmentation are applied to the acquired near-infrared images to detect candidate pieces of furniture. The furniture characteristics (shape, size, etc.) are then used to narrow down these furniture candidates. The lengths of furniture legs and the areas of open space are computed to determine whether airflow can pass through them, in order to identify furniture that blocks air and furniture that does not (see Fig. 4).

Airflow Control Using Three Way Front Flaps

To control the airflow emitted from the indoor unit so that the airflow paths identified by the method outlined above can be used, the front one of the two vertical flaps of the previous products were split further into three for the newly developed three way front flap (see Fig. 5). This enables the fine-tuned control of the air direction toward the airflow paths, the blowing of airflow toward the feet when heating, and the circulation of cool air in such a way that the formation of stagnant region is inhibited when cooling, thereby achieving comfortable air conditioning.

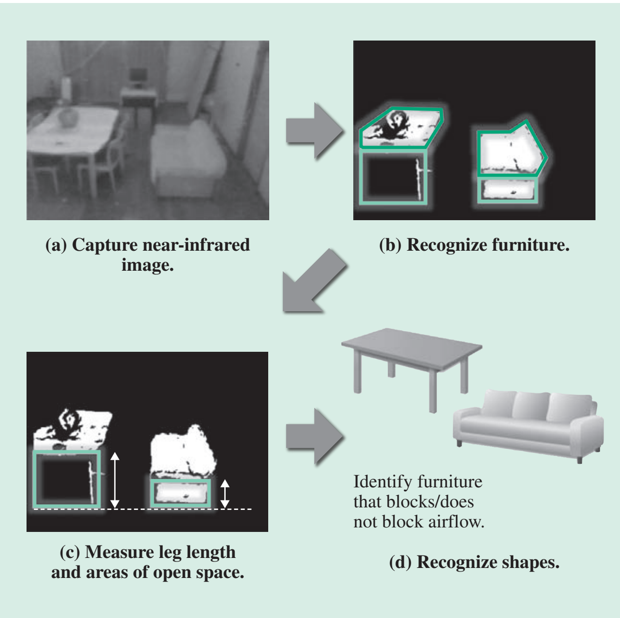

Fig. 4—Furniture Detection Using Near-infrared Images and Image Processing.
Edge processing and pattern recognition are used to detect the characteristics (shapes) of furniture, and furniture that airflow can pass through is differentiated from furniture that blocks airflow.

Furthermore, foot detection technology was developed using visible light images to detect feet regardless of their temperature or state (regardless of whether slippers, thick socks, or other clothes are worn; see the left side of Fig. 6).

Based on the above information, airflow paths are identified as shown in Fig. 6 (right) for directing airflow toward the feet when heating. Airflow paths that can circulate throughout the room without being blocked by furniture are also identified when cooling (see Fig. 7).

IMPROVING ENERGY-SAVING PERFORMANCE

High-efficiency Scroll Compressor

Preventing leaks in the seals between adjacent compression chambers is important when it comes to improving the efficiency of scroll compressors. The

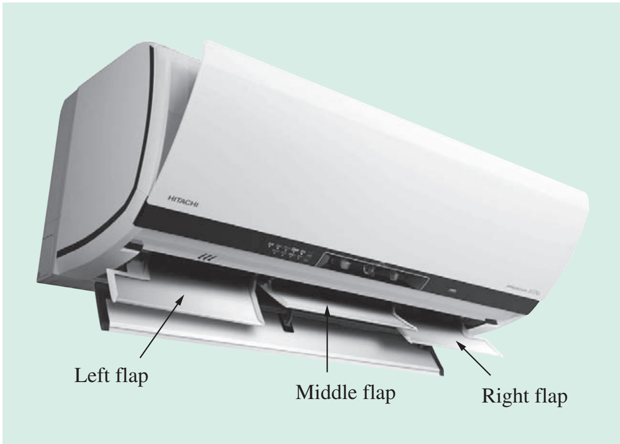

Fig. 5—Three Way Front Flaps.
The three way front flaps move independently to provide fine-tuned control of air direction.

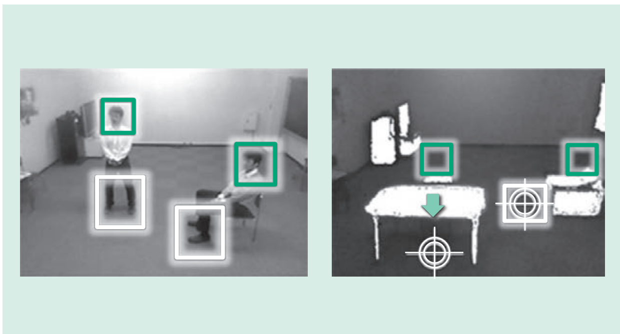

Fig. 6—Foot Detection (Left) and Identification of Airflow Paths when Heating (Right).
The imaging camera detects feet, and the near-infrared camera function identifies airflow paths.

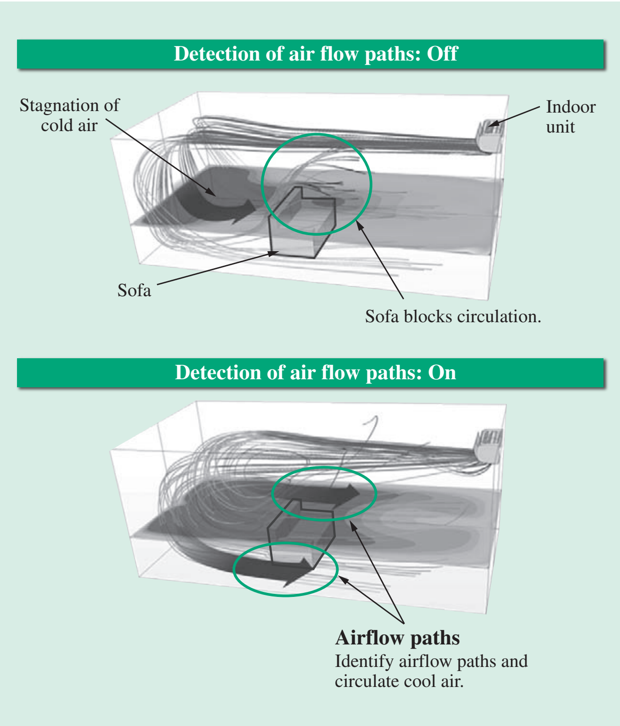

Fig. 7—Detection of Airflow Paths when Cooling.
The system detects a sofa that blocks airflow and controls the flow efficiently.

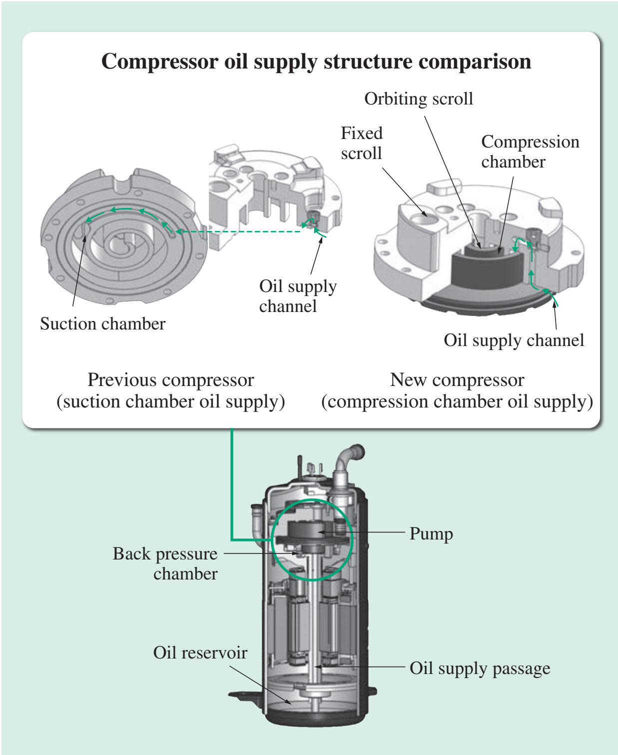

Fig. 8—High-efficiency Scroll Compressor.
Efficiency was improved by revising the oil supply structure.

R32 refrigerant that is used has a small molecular size, and tends to pass through gaps easily. For this reason, previously oil was supplied from the oil reservoir at the bottom of the compressor through an oil supply passage inside the shaft, after which it was fed through the back pressure chamber (used to force the orbiting scroll on the fixed scroll) into the suction chamber. Although this method was an effective means of preventing leaks, it also caused loss due to heating of refrigerant in the suction chamber, and tended to increase mechanical loss as oil became jammed between the fixed scroll and the orbiting scroll when large quantities of oil were inserted into the pump. This is why Hitachi used a new structure to supply oil to the compression chamber that can inhibit increases in leakage loss while also reducing both heat and mechanical loss, thereby improving the APF value (see Fig. 8).

Indoor Unit

To improve the cross-flow fan's efficiency while reducing blowing power, the outer diameter of the fan blades was widened from the previous diameter of 115 mm to 118 mm. When the fan diameter is widened to improve its efficiency, ensuring blowing stability becomes an issue. This is why Hitachi's development focused on both improvements in the cross-flow fan blades and nose configuration as well as reductions in flow resistance.

In other words, the previous 30 blades arranged around the circumference were increased to 32 in order to ensure stability when blowing, and the blades were reduced to 91% of the previous thickness in order to secure the pitch between the thinner blades, thereby preventing an increase in friction loss. The front nose configuration was also optimized to increase blowing stability by stabilizing the circular vortex that occurs near the front nose of the cross-flow fan, and to prevent reverse flows from occurring in the gap between both edges and the front nose of the fan (see Fig. 9).

Outdoor Unit

Like those in the indoor units, the propeller fan, the passage, and the heat exchanger in the outdoor unit were also numerically analyzed with the goal of reducing blowing power and effectively utilizing the heat exchanger.

The propeller fan was expanded by 5% to improve efficiency, and the center of the trailing edge, where the flow concentrates, was cut into a V shape to inhibit flow separation and improve fan efficiency (see Fig. 10).

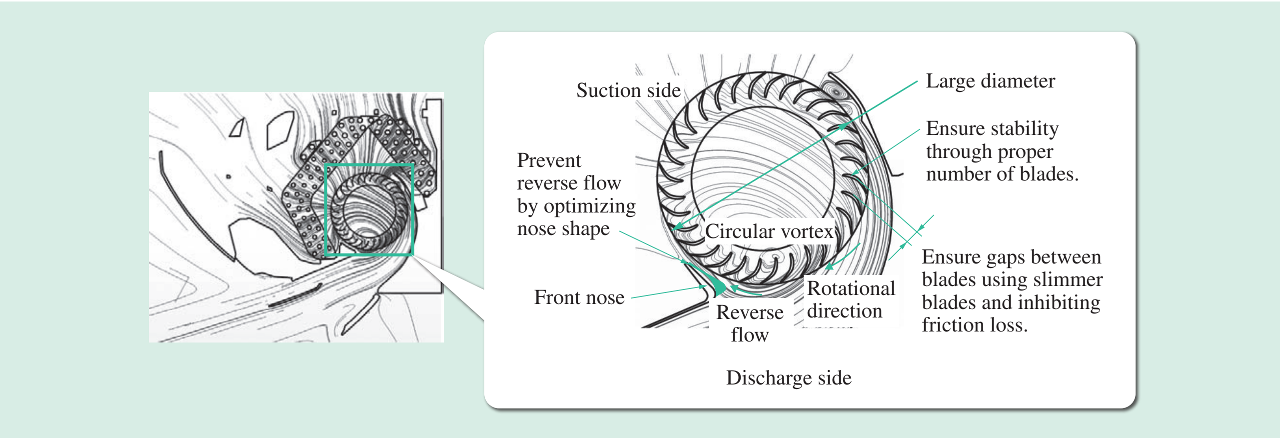

Fig. 9—Indoor Unit Blowing System.
Numerical simulations were used to optimize the shape and part layout to improve efficiency.

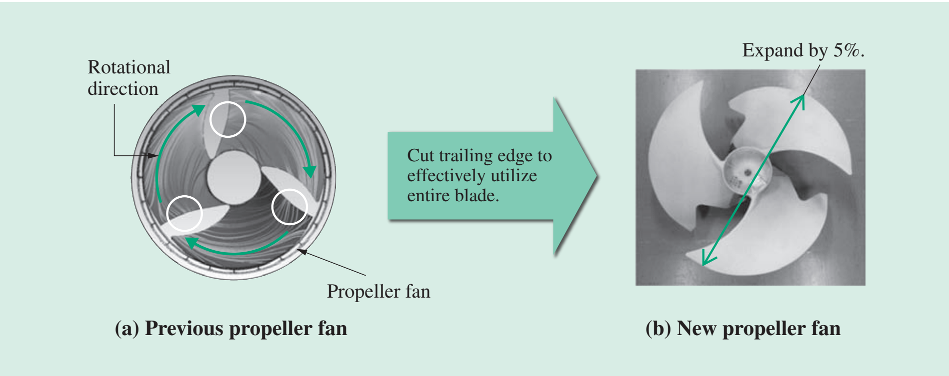

Fig. 10—Outdoor Unit Propeller Fan for Outdoor Unit.
The diameter of the fan was expanded, and the blade shape was optimized through numerical simulations.

CONCLUSIONS

Although each of the energy-saving basic technologies described above provides only a tiny effect when estimated separately, by continuously focusing on technological development, Hitachi has steadily improved energy-saving and electricity-conservation performance on an annual basis. Saving energy in room air conditioners, which consume much of the power used in the home, is a universal consumer need, as is environmental consciousness in products. Hitachi will continue mobilizing all of its technological prowess in developing room air conditioners.

With respect to electricity-saving functions that also pursue comfort, Hitachi has put forth a variety of solutions to match changing consumer lifestyles along with advances in sensing devices. Hitachi will continue its development efforts while remaining constantly aware of the new value consumers seek.

REFERENCES

(1) Japanese Industrial Standards: JIS-C9612, Room air conditioners.

(2) Y. Komatsu et al., “Layout Detection Technology for Air Conditioners,” Information Processing Society of Japan 76th National Convention (Mar. 2014) in Japanese.

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