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TELEROBOTIC "BUCKET TRUCK"

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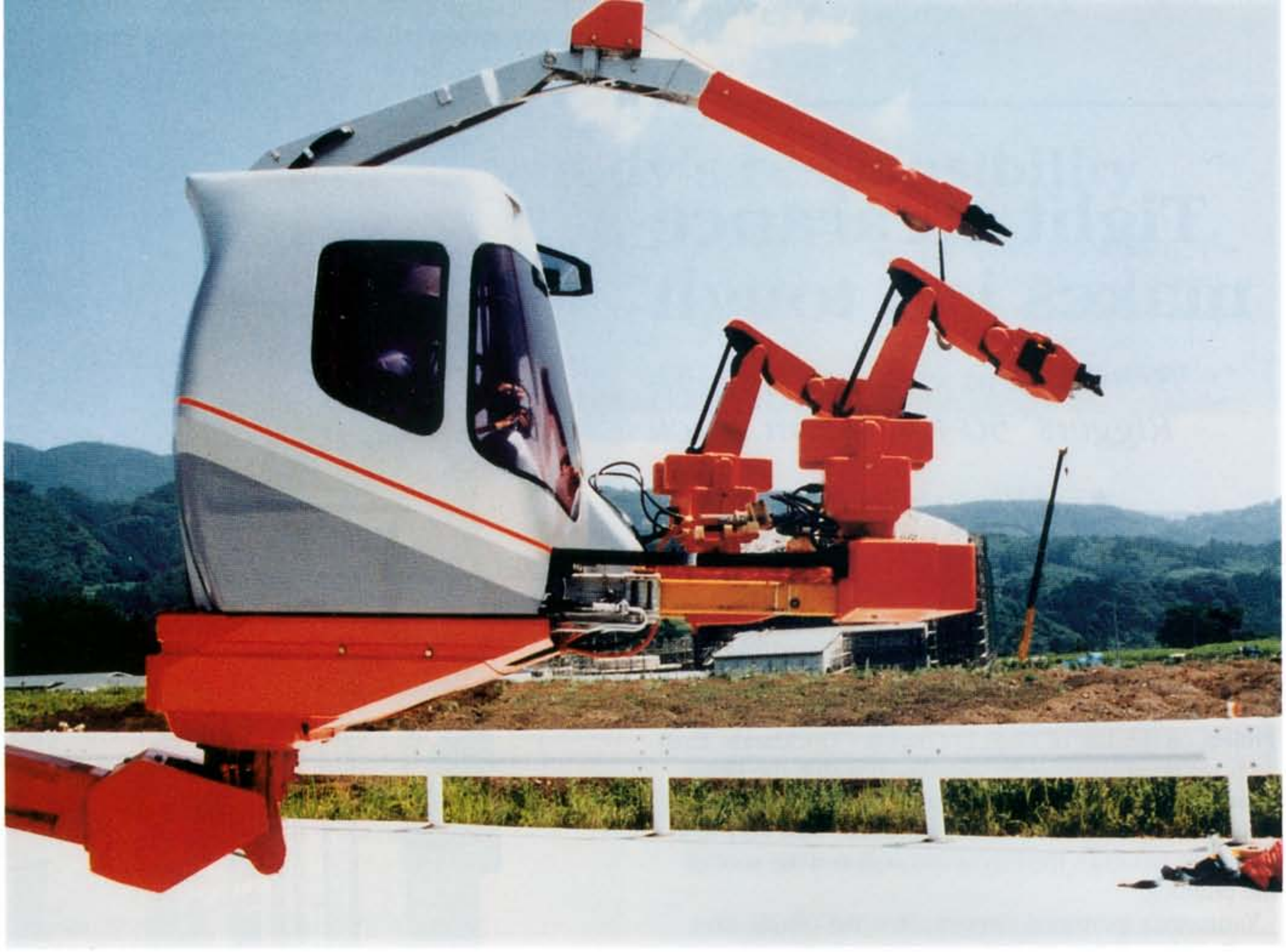


A lineman in a weatherproof cabin can make power line repairs with insulated telerobotic arms.

Reach out and touch...robotically

Japanese company develops telerobotic 'bucket truck'

By Ron Koehler

Two squarish, orange robotic arms that look like something straight out of science fiction steady a power line switch as it is lowered onto the cross arm of a pole.

Inside an air-conditioned cabin at the end of an insulated boom a few feet away, a lineman operating the robotic arms gets ready to bolt the three-phase switch to the crossarm, splice its six wires to the power lines and complete the other steps in the installation. He'll do the whole job in about 45 minutes, without ever having to get up from his comfortable seat in the operator's cabin.

This demonstration of the prototype of a futuristic power utility truck developed by a Japanese manufacturer took place last summer at ESMO '90, an international conference and exhibition for the electric utility industry that was held in Toronto, Canada. The truck will be manufactured for the Japanese domestic utility market by Aichi Sharyo Co. Ltd., one of the largest manufacturers of aerial lifts and special purpose vehicles for Japan's electric utility industry. It uses a sophisticated robotic arm manipulator system developed by Kraft Telerobotics Inc., Overland Park, Kan.

"It's the bucket truck of the future," says Steve Harbur, director of product development for Kraft Telerobotics. "It's a state-of-the-art, fully operational system, and it's absolutely revolutionary. It won't replace power company linemen, but it gives them a new, safer tool to work with."

The prototype developed by Aichi Sharyo is intended for use on Japan's 6,600 volt residential distribution lines. The insulated manipulator arms, which have gripper hands to hold tools and perform other tasks, are mounted on an insulated, extendable platform which is part of the base of the molded operator's cabin made of an insulating plastic material. The arms are 51 inches long, but additional reach can be gained by extending

the platform which serves as a tool storage area. The arms can be assisted in their work by an articulated boom winch mounted on top of the cabin. The winch, which has a lift capacity of 330 pounds, can be used to raise objects attached by an assistant on the ground so they can be positioned and installed by the manipulator arms.

According to Harbur, the telescoping boom on the Japanese truck has a maximum reach of about 45 feet. The operator in the cabin atop the boom has full control of the extension and positioning of the boom through a fiber optic system, and fiber optics are also used to control the hydraulically operated manipulator arms. The entire system is insulated to withstand voltages several times greater than 6,600 volts. This insulation protection allows the machine to work on "hot" lines.

Harbur says the Japanese designed the cabin to be comfortable so the operator-lineman can do whatever power line work is necessary in any kind of weather.

"They'll be able to use their older and more experienced linemen, no matter how bad the weather is," Harbur says. "They can work during a cold downpour at night and still stay dry and comfortable. There's no need anymore to 'lose' older linemen because of environmental conditions."

Harbur says the system will also attract apprentice linemen who will be eager to learn how to use the sophisticated manipulators. The training of this new breed of linemen in the use of the manipulators should be fairly simple because the force feedback manipulator system developed by Kraft Telerobotics is an intuitive system that allows the operator to use hand, wrist, arm and shoulder movements he already knows, and the force feedback feature allows the operator to "feel" what is being felt by the manipulator arms as they do their work. For instance, if the gripper hand at the end of the arm is pressed against a solid object, the operator can feel how much resistance there is and can react accordingly.

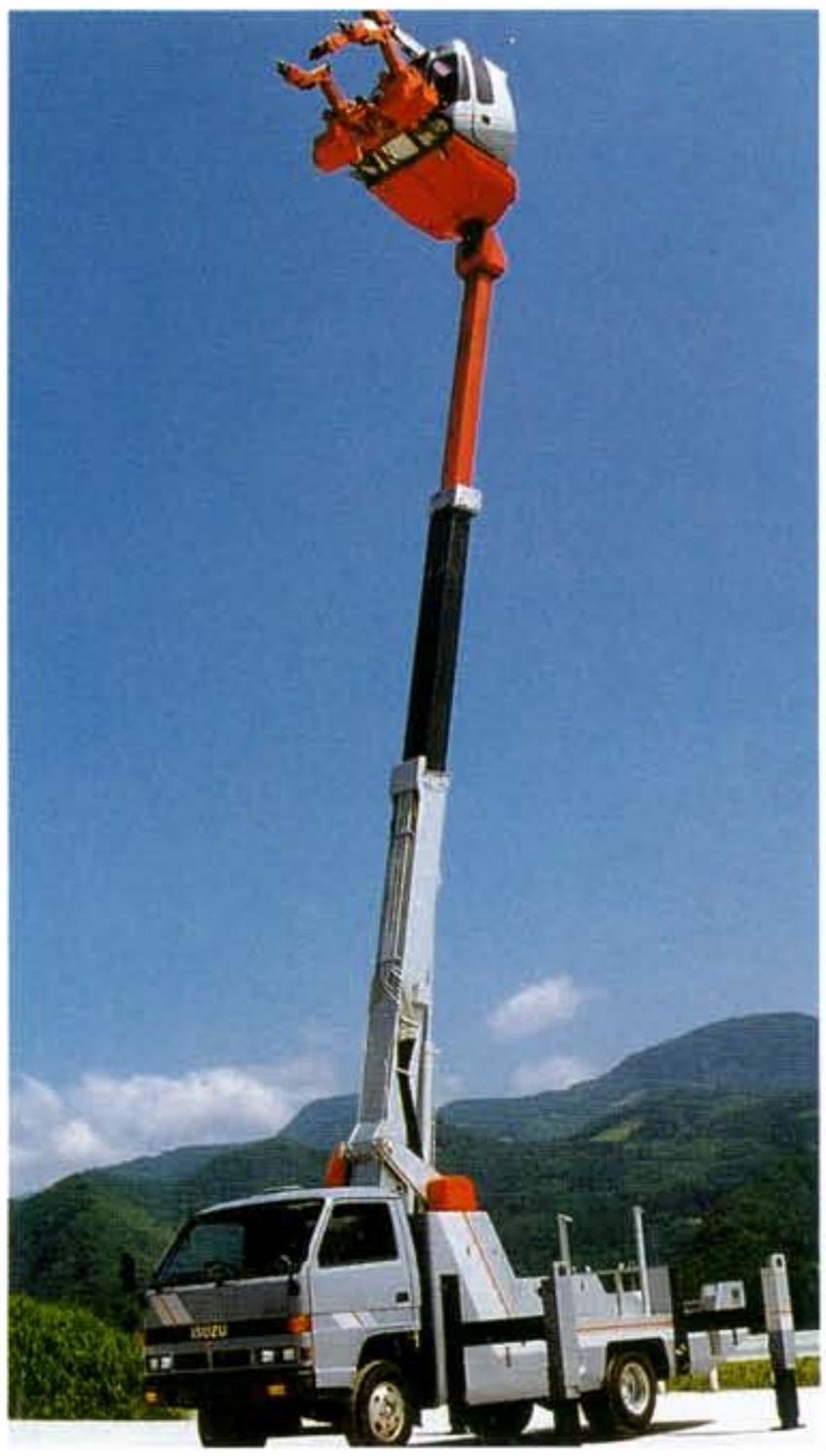
Brett Kraft, president of Kraft Telerobotics, explains that force feedback is not a new idea—it's been used for years in the nuclear power industry—but these systems were primarily mechanical, not electrical.

"This is not just a manipulator," Kraft says, as he operates a demonstration model of the system that has been licensed for production in Japan by Aichi Sharyo. "The key to it is force feedback. That's very important."

Holding a pistol-grip controller in his right hand, Kraft sits in a pedestal chair and watches as the manipulator arm duplicates every move he makes with his hand, wrist, arm, and shoulder. This arm, which is not covered with plastic insulation, is slender and graceful-looking. As it twists and turns and bends, it resembles the long neck of a black water bird ready to grasp something in its opened beak. It looks alive, and it looks suspiciously intelligent.

Kraft moves the manipulator arm toward a small nail resting in a drilled hole on a plywood board several feet away, activates the gripper hand at the end of the arm, takes the nail out of the hole, moves it around in the air for a moment like a magician waving a silk scarf, then replaces it in the hole. The force feedback feature of the system has enabled him to sense the location of the nail hole with the tip of the nail, allowing him to replace the nail precisely in the hole.

"If you can move your arms, you can operate one of these manipulators," Harbur says, as Kraft continues the demonstration. "And it's field proven. It's not just a laboratory project."



Fully extended, the telescoping boom has a reach of about 45 feet.

Harbur explains that Kraft's remote manipulator system has been used extensively by the offshore gas and petroleum industry in remote-controlled minisubs that inspect and maintain the underwater structures of oil drilling platforms.

"Undersea work is a very hostile environment for any kind of machine," Harbur says. "Our manipulators are built to withstand that kind of environment."

The system works so well under water it is being used to recover millions of dollars worth of gold coins from the wreckage of a steamship that sunk off the coast of South Carolina during a hurricane about 150 years ago. The manipulator arms, mounted on a remote-controlled minisub, can reach out and pick up the gold coins laying on the ocean floor 8,000 feet below the surface.

Kraft's force reflecting controllers will also be used as part of NASA's flight telerobotic servicer (FTS) program, which is now in the development stages. The end result of FTS will be what Harbur describes as a "robot astronaut" which will be used for assembly, maintenance and inspection in unpressurized areas of the space shuttle and a planned U.S. space station. NASA researchers are now using Kraft technology to evaluate some of the capabilities of state-of-the-art manipulators.

The designers and machinists at Kraft's production

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plant in Overland Park are also working on the prototype of a remotely-operated, track-mounted excavator and material handling system called "Haz-Trak." This machine, which will use a large-scale version of Kraft's manipulator system to operate a backhoe shovel, is being designed for removal of contaminated soil. The designers at Kraft Telerobotics believe it could easily become the backhoe of the future because they believe it is much easier to operate than a regular backhoe, plus it can quickly be taught to perform almost any digging task automatically.

"For example," Harbur says, "we could use it to dig the hole for a swimming pool. While we were digging that hole, the machine would memorize every move the operator makes. That information would be stored in a bubble memory unit. Then we could take the excavator to your backyard and have it automatically dig the same hole for your swimming pool."

The force feedback feature of the system also allows the operator of the excavator to "feel" buried objects such as water, sewer and natural gas lines so digging can be stopped before the lines are cut.

Kraft's manipulator technology will also be used in a power line service truck now under development by Hydro-Quebec, one of the largest power companies in North America. Harbur says Hydro-Quebec's service truck is expected to have some of the same features and capabilities as the truck developed in Japan.

According to Harbur, U.S. power companies are taking a "wait and see" attitude regarding the type of service truck that will soon be used extensively in Japan and Canada. None of the U.S. companies has made a firm commitment with Kraft to develop a truck that uses manipulator technology, although Kraft is willing to license that technology to large U.S. manufacturers and other manufacturers throughout the world.

"What we need is to have a few big companies recognize the value of our manipulator system so they can be produced in quantity for all kinds of different applications," Harbur says. "Right now, our manipulators are being produced in small quantities, so they're fairly expensive, but if you can build them in quantity they become very cost effective. The larger the market opportunity, the cheaper things become."

Harbur estimates that the first-run models of the Japanese and Canadian service trucks will cost about $150,000 each, including the cost of the truck, the boom, the operator's cabin, and the manipulator system. That cost should come down, though, if the units can be produced in quantity.

"The possibilities for this manipulator system are endless," Harbur says. "There are probably uses for it that we haven't even dreamed of yet. It's revolutionary, and there's nothing else like it in the world.

"It's the future...now."

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