



ROBOT OF ROBOTS

This unusually fast and accurate mechanism, designed to control calculating machines in complex engineering problems, has many possible applications, including the automatic steering of aircraft and ships, automatic control of industrial processes, and the accurate guiding of astronomical telescopes. It was developed by Dr. H. L. Hazen who is shown watching it in operation.

PHYSICS

Machine Boss for Machines Invented By Engineers

Robot Designed to Control Calculating Machines Working Complex Problems May Also Direct Airplanes and Ships

A MACHINE that bosses another machine with unusual alertness, speed and accuracy, has been developed in the Massachusetts Institute of Technology's electrical engineering laboratory.

This new "servo-mechanism," as this robot is called, substitutes for human skill in operating calculating machines used in research. It consists of a combination of specially designed motors, photoelectric cells, vacuum tube amplifiers and other mechanical devices, and it follows an ink line drawn on paper like a dog with his nose to a trail.

Although built for research use, application of this M. I. T. servo-mechanism to automatic steering and stabilization of airplanes and ships, to gun control, to automatic control of industrial processes and other uses are foreseen. Robots are already doing the helmsman's work on large ships but they operate on a different principle.

So quick is the new servo-mechanism that it completes its control operation within one-twentieth of a second. In-

stead of nervously oscillating back and forth and achieving its purpose by periodically overrunning and underrunning its mark like some robots, the new servo-mechanism by delicate mechanism goes just far enough and does not need constantly to correct itself.

Electric Eye Follows Line

The invention of the new device was suggested by Dr. Vannevar Bush, M. I. T. vice-president, and it was developed by Dr. H. L. Hazen and other members of the staff.

In its present form the new servo-mechanism consists of a vacuum-tube amplifier, a small specially designed electric motor driven by the amplifier, and a mechanical torque amplifier. In its application to an engineering calculating machine, the servo-mechanism is required to make a pointer follow the line of a curve drawn on a sheet of paper. The device quickly and accurately follows the rambling path of ink which in the calculating machine represents part of a complex engineering problem.

On one side of the line to be followed, the paper is darkened with a black ink which reflects very little light. On the other side of the line, is clean white paper which reflects most of the light falling upon it. The pointer which is to follow the line consists of an open slit in an otherwise dead black sheet of metal through which the curve can be seen by a photoelectric cell or "electric eye." This slit, and the paper under it, is brightly illuminated by a small electric flashlight lamp.

The electric circuit is so adjusted that if the photo-cell receives too much light the motor will drive the slit toward the black part of the paper, while if it sees too much black, the slit is driven toward the white part. When the paper seen by the photo-cell is half black and half white the motor has no current through it and does not turn. Thus the center of the slit is always kept on the boundary between the black and white portions of the paper.

To prevent the slit from traveling too far, suitable "damping" or braking is provided, which stops the motor just as the slit has reached the correct position. It is very important to design a servo-mechanism with just the correct amount of this "damping."

In the motor lies the secret of the rapid action. The moving parts of this motor have very little weight, the iron which usually rotates having been made stationary. As a result, this motor can start and stop with great rapidity and takes but little current. For example, if the current from an ordinary radio receiver tube is suddenly connected to the motor it reaches nearly the normal speed of 500 revolutions per minute in about one-fiftieth of a second, having turned during this time about one-eighth of a revolution.

Among the numerous possible applications of the new servo device, one of the most interesting is the automatic steering of ships or aircraft by direct reading of the magnetic compass.

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The Front Cover

The photographer very likely took a more beautiful picture than he thought he would when, flying low over the Canadian Pacific's *Empress of Australia*, he snapped the photograph that adorns the front cover of this week's SCIENCE NEWS LETTER. The vessel has a gross tonnage of 21,850 tons and her displacement is 32,800 tons.