ENGINEERING-MATHEMATICS

# Mathematical Machine

**New mathematics of future engineering expected from mechanical brain now released from war work; works on non-linear problems.**

**See Front Cover**

➤ THE mathematics that the engineers of the future are likely to use is expected to come out of the research to be done with the new electronic differential analyzer of the Massachusetts Institute of Technology which has been released from war to peacetime work. The machine is shown on the cover of this SCIENCE NEWS LETTER.

This new mathematical robot, with 2,000 electronic tubes, several thousand relays, 150 motors and nearly 200 miles of wire in its mechanical "brain", has worked on the development of radar theory, computing range tables for the U. S. Navy guns and other war tasks.

Now it is to be used on an equally important job. It is free to turn to the task for which it was designed—creating the groundwork for the mathematics of the future.

The mathematics currently used in physics and engineering applications has been devoted to the solution of what mathematicians call "linear" problems, but it has become increasingly evident that the usefulness of these methods has been almost exhausted. They will still constitute the major body of information in handling routine problems.

But the new problems in physics, electrical engineering, aerodynamics, and similar fields seem to be primarily non-linear. Leading mathematicians admit that their principal handicap in handling such problems is that they just don't know enough about the nature of solutions to these problems to make intelligent guesses as to what they are like. From the mathematician's point of view, the major contribution of the differential analyzer and similar computing machines will be to provide the "horse-work" to build up an immense number of detailed numerical solutions to non-linear problems so that the form or shape of the general solutions will become intuitively familiar.

To solve new problems, a mathematician must develop a feel for what the solution will be like. The computing machines of the future must provide a skeleton outline of the new mathematics as a framework for the mathematician to construct theories which the physicist and the engineer require.

Scientific announcement of the differential analyzer has just been made in the Journal of the Franklin Institute in a joint paper by Dr. Vannevar Bush, formerly vice-president of the Massachusetts Institute of Technology, and now president of the Carnegie Institution of Washington and director of the Office of Scientific Research and Development, and Dr. Samuel H. Caldwell, director of the Institute's Center of Analysis.

The original differential analyzer, designed by Dr. Bush and his associates and built in 1931, was entirely a mechanical machine, and the solution of problems required manual setting of gears and other connections. In the new machine these settings and connections are automatically accomplished by electrical "couplings," an instantaneous process controlled by punched paper tapes. For ordinary operations the huge machine requires only one operator. The symbols of the mathematician representing the problems for which a solution is desired are translated into a "language" which the machine understands. This "language," a code punched on a paper tape, is transmitted to the machine which automatically selects the various units required for the process of computation.

Unlike conventional types of calculating machines which operate on numbers, the new differential analyzer deals with problems involving rates of change among variable quantities. The solution of a differential equation is not just a number; it is a numerical history of the concurrent instantaneous values of two or more variables. These solutions may be produced either graphically or numerically, or in both forms. A graphical solution consists of a curve drawn automatically by the machine, showing the relation between any two variables appearing in the differential equation. A numerical solution consists of a printed table of the corresponding values of the variables at any convenient intervals.

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*LOTS OF WIRE!—A behind the scene view of the complex wiring in the new electro-mechanical differential analyzer. The machine contains 200 miles of wire, 2,000 electronic tubes, several thousand relays, and about 150 motors.*

ELECTRONICS

## Television in Full Color Will Soon Be on the Air

➤ TELEVISION pictures in full color will soon be on the air from a new installation in the Chrysler building in New York. It will be an experimental color television transmitter station to conduct propagation tests both local and long-distance. The installation follows the relatively recent successful sending of pictures in full color, not only within a laboratory, but from one building here to another several blocks away where they were received with full clarity.

Full color television employs radio waves of the new ultra high frequencies, according to Paul W. Kesten, executive vice-president of the Columbia Broadcasting System, who was probably the first to announce the successful transmission of television in color through the air. "Transmitting power of less than 1/10 the present power requirements of low frequency television transmitters," Dr. Peter C. Goldmark, television engineer of the same company, declares, will satisfactorily cover an area like New York.

Describing the color-television tests recently before the Federal Communications Commission in Washington, Dr. Goldmark pointed out that by means of an inexpensive directional antenna and the use of the high-frequency television bands, "ghost free" reception was possible for the first time in the history of television. "Ghosts" in television are similar to echoes in radio and appear as shadows on the television screen.

The manufacture of receiving and transmission equipment for color television is already in progress. The General Electric Company has taken the CBS receiver developments and will turn them into commercial products. The first are scheduled to be completed by the end of January, 1946. The studio equipment developed by CBS technicians is now being manufactured by the Westinghouse Electric Corporation.

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ELECTRONICS

# Located Nazi Submarines

➤ THE STORY of the development of sono-radio buoys, that located Nazi submarines under the waters of the Atlantic and guided Allied destroyers to the spot for the kill, can now be told.

Visual and radar sighting served well as long as the enemy U-boats stayed on the surface but were of no value when the subs remained under water. The sono-radio buoy gave the airplane ears to hear, locate, and to follow a submerged U-boat.

The warned airplane could itself attack or call destroyers to the spot.

By relaying subsurface noises to the plane, the sono-radio buoy also made it possible to know the outcome of the attack. Sometimes the propeller beat of the U-boat as it fled the scene could be heard. Sometimes ominous break-up noises followed by silence testified to the death of the sub.

The sono-radio buoy, according to Dr. John T. Tate of the National Defense Research Committee, was a development of Division 6 of that committee, carried out under contract with Columbia University, Division of War Research, at the U. S. Navy Underwater Sound Laboratory at New London, Conn.

"The sono-radio buoy," Dr. Tate states, "was not a flash of genius springing from the brow of an inventor. Rather it was one of the results of purposefully bringing a group of trusted scientists and engineers into intimate and continuing contact with the progress and problems of U-boat warfare as it developed in the Atlantic."

The idea of the sono-radio buoy was not new, he said, but was taken from a heavy moored type of buoy, developed by the Naval Research Laboratory, for use in harbor protection where cable-connected hydrophones were not practical. But the adaptation to use a device of this sort from airplanes in U-boat warfare was new.

The problem was to develop a sono-radio buoy light enough to be carried in quantities by airplanes, cheap enough to be expendable, and rugged enough to withstand the shock of water entry. In addition it had to have battery-power sufficient for several hours' life, and adequate acoustic and radio range.

The floating sono-radio buoy picks up the sounds of a submerged U-boat by hydrophones which change the sound waves in the water into small electrical voltages which are amplified and converted into radio waves in the transmitter part of the buoy. Airplanes carried receivers tuned to the same frequency of the buoy transmitters.

Operators easily learned to distinguish between natural underwater sounds and foreign underwater noises. After locating an underwater craft and flashing word back to the destroyer base, the plane hovered over the spot and, by dropping additional buoys, followed the U-boat along its course.

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CHEMISTRY

## More Efficient Method For Extracting Magnesium

➤ MORE efficient, hence cheaper, extraction of magnesium from sea water is promised through a newly patented method developed by two chemists employed by the Dow Chemical Company at Midland, Mich., Dr. John J. Grebe and Dr. William C. Bauman. They have assigned to their employing corporation rights in their patent, No. 2,387,898.

Although the application is new, the principle involved has been used for a long time in water-softening systems, in which the undesired minerals are seized and held fast by what is known as a base exchange agent, such as sodium aluminum silicate. Such a base exchange agent is used in the Grebe-Bauman method for extracting the magnesium from the sea water. When the concentration in the base exchange bed has become high enough, the magnesium is dislodged by passing through what is essentially concentrated sea water—a 15% solution of sodium chloride. Partial evaporation of this brings down the common salt in solid crystals; the magnesium chloride flows out, still in solution, and may then be finally evaporated down and the magnesium extracted electrolytically.

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*Copper sulfate* is used to dull or deepen the shade of dyed leather.

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