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Instrumentation—Revolution in Industry, Science, and Warfare

DURING the last century, man's muscular burdens have been partly transferred to machines. Now, instruments are at hand for automatic supervision and control of these machines and manufacturing processes. The vigorous growth of this field of instrumentation is accelerating revolutionary changes in industry, science, and warfare. The extent to which these developments have progressed was impressively shown at the First International Instrument Congress and Exposition held by the Instrument Society of America in Philadelphia last month (reported elsewhere in this issue).

Notable among the exhibits were the increasing number of devices for automatically representing the results of measurement in numerical form or as recorded signals in code (as on magnetic tape) for further use in automatic computation or control. The handling of measurement information in numerical (digital) form permits a considerable decrease in errors associated with the transmission, conversion, display, or utilization of measurement data. Further, as more instrument systems are designed to utilize digital techniques, simplification and standardization of components will be possible. This in turn will augment reliability and simplify maintenance and replacement when necessary.

Automatic control of *continuous* production processes, such as oil refining, is well advanced, although far from complete. The extension and adaptation of automatic controls to the "unit" processes—the handling, manufacture, or treatment of discrete items—has already led to talk of the "automatic factory." Although economic factors and the shortage of instrument engineers limit this trend, the implications for increased productivity are profound.

Measurements and, therefore, instruments are fundamental to exploration of the physical world. Science progresses by the four steps of *cerebration, instrumentation, manipulation,* and *interpretation.* Every addition to the already wide repertory of scientific instruments contributes proportionally to the general advance of science. The interdependence of various branches of science is nowhere more evident than in the fruitful adaptation of the same instrument in quite different fields. For example, a simple bar magnet pushed through a coil of wire, for measuring the impact velocity in testing the resistance of ship structures to explosions, was adapted recently as a ballistocardiograph. More accurate measurements of heart activity are now possible, and a vigorous impetus has been given to research in this field of physiology.

For centuries, man has waged warfare by the process of *launching* destruction at his enemies—throwing stones, hurling spears, shooting arrows, aiming guns, or dropping bombs—but with the advent of automatic instrumentation, it becomes possible to *guide* destruction to the enemy. The probability of a hit in any one operation is thus enormously increased.

The guidance concept combines automatic detection—for example, radar, sonar, infrared—with automatic piloting and has led to homing torpedoes, guided missiles, and perhaps other weapons not disclosed. In these developments, military instrumentation has given much, and received more, from scientific and industrial instrumentation.

The spectacular destructiveness of atomic bombs has tended to overshadow the real significance of the guidance concept. Only through the successful and early achievement of complete and reliable means for automatically detecting and *intercepting* enemy ships, aircraft, or guided missiles may we hope, temporarily, to deter atomic aggression. Perhaps in this way, civilization can gain the time required to perfect the art of peaceful relations.

All scientists, engineers, warriors, and the informed public need to become better acquainted with *instrumentation* with respect to its effects on their own work and lives and its vast potential for increasing the military security and the productive capacity of the world.

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