SCIENCE



# New Tools for Research

THE common concern that links all the experimental sciences is their dependence on the measuring process. Although the instruments for making measurements—the tools of research—are based on the discoveries of physics and the designs of engineering, they are adapted, refined, and applied by all the sciences. Instrumentation is the common denominator of the sciences—the common thread of physics that ties them together.

Perhaps the most striking aspect of the newer developments in instrumentation is their universal usefulness. The same basic measurement, and therefore the same instrument, is frequently of interest in a number of sciences. Consider, for instance, the sciences that are applying the unique analytical capabilities of the mass spectrometer which, in some new designs, can now analyze solids and liquids, as well as gases. Many problems common in all fields have more direct bearing on the choice of instrumentation than either the application of the measurement or the thing being measured. The most fundamental influence of all is the existence in the general measurement process of many elements or steps that are common not only to all sciences but to all instruments and are quite independent of the particular quality, quantity, condition, and factors to be measured. The primary detector, transducer, or pickup often gives an output signal of an electrical nature that may be translated into variations in pneumatic pressure, sound or light intensity, mechanical displacement, changes in color, or other output. The signal once obtained may undergo the further steps of transmission, amplification, indication, recording, controlling, reduction, and analysis. Somewhere along the way it may be converted from analog to digital representation by quantization. Once the *transducer* takes the signal, the later steps in the measurement process have lost any real dependence on the original quantity or thing being measured.

Many significant advances have recently been made. The excitation possibilities of $\alpha$-, $\beta$-, $\gamma$-, and x-rays have been recently augmented by quantitative use of neutron beams, modulated by composition or structure of materials. The transmission of large quantities of data at high speed has developed a specialized field of information handling, and radio telemetry is being rapidly perfected for military purposes. The same techniques make possible the rapid transmission of all sorts of measurements in biological and physiological experiments on human or animal subjects while they go freely about their accustomed routine.

The amplification of signals for measurement purposes has always used the same type of amplification that is used in radio. Within the past few years the development of the transistor and new principles applied on the traveling-wave tube give promise of radical improvements in amplifying devices. The development of the saturable reactor or magnetic amplifier points to other possibilities for increasing by several orders of magnitude the faintest signals.

Within the past year a number of generally applicable analog-to-digital converters have been announced, some of them capable of sampling 50,000 times per second, with an accuracy of 1 part in 64. Another type records with accuracy of 1 part per thousand at a sampling rate of about 500 per second. Steady progress has been made in recording data. Writing speeds on cathode-ray oscilloscopes approach the speed of light, and successive photographs have been taken at rates of a million times per second. Facsimile recording and xerography both promise to handle large amounts of information rapidly and cheaply. Provision for automatic control may be built into any instrument where a signal is present that can be measured and compared with a desired value.

The use of high-speed computers—both digital and analog—in the automatic evaluation and analysis of data while it is being taken offers significant possibilities in automatic guidance and control. These advances in the science of measurement, rapidly assimilated by all other sciences, will accelerate their progress.

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