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Scanning the issues

A Great Age. Some observers believe that we are now entering upon a Great Age of Biology, and that the remainder of this century will be predominantly spent doing for biology (or, more broadly speaking, for the life sciences) what the previous age has done for the physical sciences. Accordingly, each new advance, each new tool or weapon that technology now places in the hands of the biologists, is to be watched with more general interest than the still-narrow, specialized journals would seem to warrant.

A foreshadowing of the development of computer techniques in biology appears in a paper by E. M. Glaser and H. van der Loos. It describes a semiautomatic computer–microscope that can be used in quantitative neuroanatomical studies. Quantitative microscopic studies of individual neurons of the central nervous system, especially of the elaborate dendritic and axonal patterns [see Fig. 1(A)], have in the past been done painstakingly and with great difficulty using conventional microscope instrumentation. This new instrument, which simplifies and speeds the gathering of such data, integrates sensing transducers and an analog computer with the mechanical stage of a light microscope for measuring microdistances.

The instrument functions as a unit under the control of the investigator examining the histologic preparations. It is capable of measuring accurately distances in all three coordinate axes. Measurement of the length of dendrite branches is performed by means of a chord approximation. Computation is carried out by conventional electronic analog techniques. Chord distances are computed according to the Pythagorean theorem. The initial coordinates of the chord are held in capacitor hold-circuits. Input to the computer section is through linear-motion transducers, fixed to the stage of the microscope along the three coordinate axes. There are two output devices, a digital printer that prints on tape the distance measurements and a plotting board on which is drawn a two-dimensional projection (in the plane of section) of the neuron. Figure 1(B) shows a computer–microscope drawing of a basal dendrite system compared with the photomicrograph in Fig. 1(A).

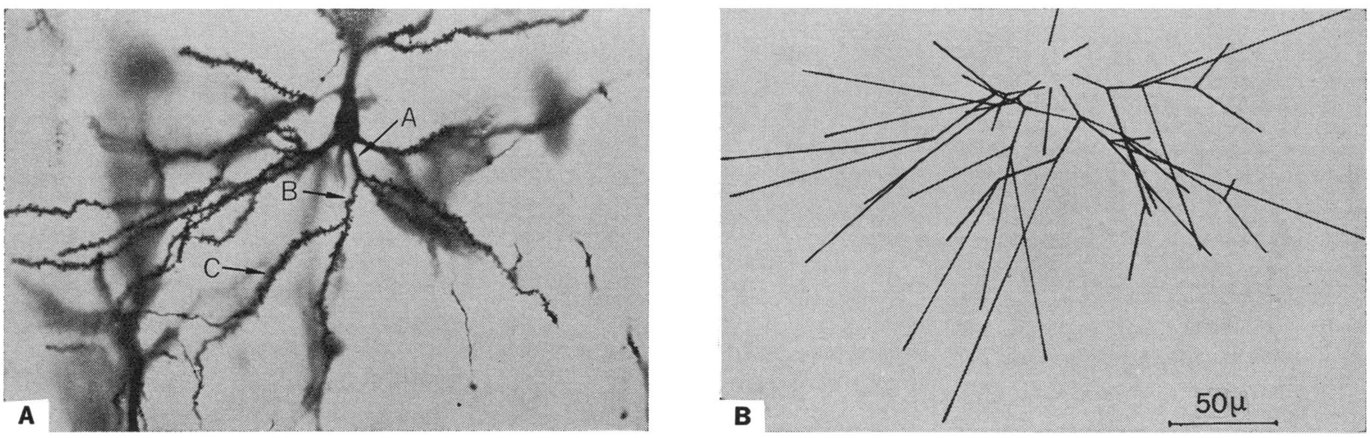
Distances measured range roughly from 3 to 100 μ, and the accuracy of the measurement is ± 1 μ or ± 9 per cent, whichever is greater. Analysis times are reduced from the approximately 24 hours required by camera lucida techniques and hand calculation to 30 minutes with this new instrument. (E. M. Glaser and H. van der Loos, "A Semi-Automatic Computer–Microscope for the Analysis of Neuronal Morphology," *IEEE Trans. on Bio-Medical Engineering*, January 1965.)

Automatic Control. Three papers are singled out for attention in the latest issue of the TRANSACTIONS ON AUTOMATIC CONTROL; two deal with questions of applications and the third with components.

"On the Use of Optimization Theory for Practical Control System Design," by W. L. Nelson, is concerned with more effective utilization of optimal control theory for the development and the evaluation of practical system designs. The traditional approach to control system design, which evolved mainly from feedback amplifier theory and linear circuit analysis techniques, has become inadequate for solving newer problems such as have arisen in the fields of industrial process control and space vehicle guidance and control. In consequence, there has been developed a more general theory, which emphasizes the theory of optimal control.

However, the powerful advantages that result from the modern, more realistic models of control systems often lead to complex optimization and synthesis problems, which in many cases necessitate the use of computers. Nelson's paper, in effect a bridge between optimal control theory and its

Fig. 1. Photomicrograph (A) compared with computer–microscope drawing (B) of the same basal dendrite system.



application, examines the persistent question raised by practical control engineers with regard to optimal control theory, namely: "What good is it?"

This question had previously been put to information theory by communication engineers, and the answer, it is said, is similar in both cases. While the theory seldom, if ever, provides a direct synthesis of practical system design, it does indicate the *form* of the control or communication strategy to be used, and it also provides information on the ideal system performance bounds, against which the performance of practical system designs can be evaluated. This point of view is explored in Nelson's paper, and its usefulness is illustrated in a familiar design example, the satellite attitude control problem. Computer-aided design methods for evolving practical feedback designs are also outlined.

An unusual class of control problems closely related to the problem of space rendezvous is the main concern of "Analysis of Pulse-Width Modulation with a Variable Transport Lag in a Rendezvous Radar," by G. S. Axelby. In this paper, the author develops the solution to a control problem inherent in the actual design of rendezvous radar equipment, which is to measure the range between two solid-state transmitters, widely separated in space, by equating their simultaneously transmitted pulse widths to each other and to the transmission time between them. As shown, the problem is difficult to solve using a continuous data model, but a discrete data analysis results in an interpretation of the system operation as the interaction of a fast-phase lock loop and a slow-range track loop. The analysis also results in an optimum system design for a given pulse repetition frequency and a desired degree of system stability. Although the analysis was made for an unusual interrogator–transponder radar, the author points out that this type of control might be used in other applications.

The third paper deals with an unconventional type of gyroscope that has been the object of much attention in the past half-dozen years, namely, the vibratory gyroscope, which is man's version of the halteres of certain insects such as the common housefly. It has been found that insects use their club-shaped halteres as vibrating flight instruments, but thus far, theirs have been rather more accurate than the ones men have built.

Vibratory gyroscopes sense angular motion through vibratory torques induced by Coriolis effects. The advantages and difficulties of obtaining precise angular rate measurements with a gyro that uses a vibrating tuning fork type of instrument are discussed by R. W. Bush and G. C. Newton, Jr., in "Reduction of Errors in Vibratory Gyroscopes by Double Modulation." Although, theoretically, these gyros should provide high accuracy, the actual accuracies achieved in practice have been relatively poor because of the practical difficulty in preventing cross-coupling between the forces required to accelerate the mass elements and those required to overcome losses in the vibrating motion. It is shown theoretically and proved experimentally that this difficulty may be largely overcome by oscillating the gyro about one of its rate-insensitive axes to produce a modulated signal that can be separated electronically so as to discriminate between the desired rate signal and the undesired nonacceleration-dependent cross-coupling and to exclude the latter. Thus, this technique appears to have great promise in producing a long-life low-power gyroscope with an accuracy comparable to a conventional rotating-wheel instrument. (*IEEE Trans. on Automatic Control*, October 1964.)

Radical New Technique. Integrated circuits available for the past few years have used methods of isolating individual active and passive components from each other in a manner that has not proved wholly satisfactory. A radical new technique for the fabrication of integrated circuits, which completely changes microelectronic design, and which provides for almost total isolation, has been developed. The fabrication technique may well play an important role in the development of integrated circuits in the future.

In place of the back-biased *pn* junctions usually used for isolation of devices in a substrate, a dielectric is substituted whose properties are such that almost total isolation is achieved with no increase in area. Leakage currents are reduced by several orders of magnitude to around 10^{-10} amperes/cm^2, stray capacitances to around 10^{-5} pF/μ^2, parasitic *npnp* and *pnpn* action is eliminated, and breakdown voltage is increased up to 1000 volts.

Great flexibility in the design of components is achieved through the ability to place highly conductive "wells" where needed to obtain the benefits of epitaxial techniques, and through being able to use devices with higher breakdown voltages.

The technique makes practically all circuit configurations possible, and greatly enhances the possibilities for fabrication of *npn* and *pnp* transistors in the same substrate. Some details on circuits fabricated by this technique are given, such as digital circuits with propagation delay times of 3 nanoseconds and a video amplifier with a gain-bandwidth product of over 700 Mc/s. (D. A. Maxwell, R. H. Beeson, and D. F. Allison, "The Minimization of Parasitics in Integrated Circuits by Dielectric Isolation," *IEEE Trans. on Electron Devices*, January 1965.)

Some Elegant Results. The January TRANSACTIONS ON MILITARY ELECTRONICS is a special issue, the first to be devoted to radar/sonar problems. Although most of the contributions in the issue come from the radar community, all except one have some relevance to sonar as well.

One paper, in particular, treats a problem of considerable interest, the degradation of radar systems due to imperfect coherence, which can be introduced by such factors as oscillator drift, dispersive propagation, and inexact phasing of antenna arrays. With an imperfectly phased antenna, a pattern degradation occurs. Similarly, phase errors limit the performance of pulse compression systems. Specifically, if one considers a phase error across the illumination function of an antenna, the resulting beam is displaced in angle and the beam is broadened. For random phase errors the major analytical difficulty rests in obtaining results that depict the extent of each of these effects. The paper in question, which is said to contain the most elegant closed-form results available on such problems, provides simple formulas for the rms shift in antenna pattern and rms beam broadening. The results are applied to the radar ambiguity function.

The general results have a broad scope of applications, and here the spreading of the ambiguity function in time and frequency in the presence of time phase errors and dispersion (frequency phase errors) is described with particular attention to linear FM pulses. Finally, some observations are made about quadratic phase errors, signal-to-noise performance, and mean-square point-target response. (W. M. Brown and C. J. Palermo, "Effects of Phase Errors on Resolution," *IEEE Trans. on Military Electronics*, January 1965.)