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Electronics in Medical Research

By VICTOR W. BOLIE

Due to modern achievements in science, and increasing public support, medical research in the United States is gaining a strong foothold, particularly in the areas of cancer and heart disease. Medical research work demands the best available efforts from many different fields of science. Chemistry has and will continue to play a dominant role. Only in recent years, however, has the science of electronics emerged to a place of major significance. The measurement of biological functions by means of extremely sensitive electronic methods presents a vast new horizon otherwise unattainable in the search for medical knowledge.

Medical research now being conducted at the University of Southern California, under the auspices of the U. S. C. Medical School, the U. S. Public Health Service, the American Cancer Society, the American Heart Association, and others, was demonstrated on a field trip sponsored by WESCON (Western Electronics Show and Convention) during its annual August meeting. The writer attended the field trip as a member of the Professional Group on Medical Electronics, a section of the Institute of Radio Engineers. The experiments and equipments described by the U. S. C. Medical Research Staff were observed with a high degree of interest by over a hundred IRE members who attended the trip to the laboratory.

Electrical experiments with anaesthetized animals were being conducted in connection with studies of heart and lung functions. Possible results might be an "electronic resuscitator" for treating drowning-victims, an "electronic defibrillator" for treating cases of electric shock, and an "electronic pacemaker" for treating cases of cardiac arrest without requiring heart massage. Several equipments of preliminary design were shown.

Biological tissue repair in magnetic fields was being studied with an experimental apparatus designed around a magnetron magnet from a discarded radar set. A test-tube containing a tissue culture undergoing repair growth was periodically passed through the magnetic field. The contents of this tube were then compared with those of another which was kept out of the field. It was found that repairing growth of tissue is greatly disrupted in the presence of a steady magnetic field of strong intensity. Results of this experiment provide information on the electric currents generated in growing tissue.

Also shown were two electron microscopes—one large stationary model and one small portable model. The electron microscope is a device in which a thin specimen is placed in an evacuated chamber

and bombarded with particles from an electron gun. Electrons passing through the specimen are magnetically focused before they strike a luminescent screen, producing a greatly enlarged image of the specimen. The electron microscope is capable of magnifying images of objects far smaller than those which can be seen with any optical device, thus permitting more detailed views of intricate cell structure.

An x-ray diffraction camera uniquely demonstrated the feminine touch in experimental design. An ordinary pressure cooker was used as a vacuum chamber in which the photographic film was mounted opposite a powdered specimen glued over a small hole in the side of the vessel. The sample was bombarded with 50 kilovolt x-rays focused on the hole from a copper target located in a small pipe attached to the outer surface of the vacuum chamber at the site of the hole. The feeble scattering of x-rays by some biological samples require a 7-day film exposure to obtain a diffraction pattern. These diffraction patterns are used to determine the geometric orientation of atoms and molecules in complex biological substances such as the amino acids and proteins. The x-ray diffraction camera is currently being used in an arteriosclerosis research project to study the complexes of calcium and other metal-ions which form in the aorta walls during hardening of the arteries.

In the isotope laboratory was a thick-walled vault, for storing radioactive materials, a specially ventilated test bench, and other protective equipment. Geiger counters and scintillation transducers were being used to measure the emission of activated chemicals and to trace the course of radioactive elements in metabolic reactions. A certain type of thyroid cancer shows promise of treatment with a radioactive isotope of iodine. Phosphorous is known to exist in somewhat greater concentration in neoplastic tissue than in normal tissue, so that localized tumors can frequently be detected by tracing the biological course of the radioactive P32 phosphorous isotope. The success of this technique has been demonstrated in many cases of brain tumors, where both external and internal scintillation detectors have been used. The persistent, high-intensity emission of radioactive cobalt allows the design of a radiation therapy instrument which is considerably better, in many respects, than the conventional x-ray machine. The cobalt emission beam is focused by placing the activated sample in a thickwalled lead housing having equally thick shutters. All radiation from the sample except that passing through the adjustable shutter aperture is absorbed in the walls of the housing, thus giving a narrow beam of highly intense radiation. The beam is focused in any direction by remotely positioning the heavy housing and its supporting yoke with the aid of conventional servomechanisms.

In a stomach-ulcer research project, an interesting experiment

was under way at the time of the laboratory tour. A young man of commendable fortitude was busy interpreting data being recorded on a multichannel oscillograph. One of the recorder inputs was a pH meter having a pair of leads extending to a tiny glass electrode which the fellow had swallowed. Among other things he was regularly swallowing ordinary anti-acid pills and observing the resulting acid neutralization as a function of time. A single dose of three pills brought the stomach pH from 3.2 up to 5.4 for several minutes, which afterward decreased slowly backward to normal. His description of the experiment was periodically interrupted by the need to swallow the electrode down in position. He announced that he had learned to sleep with the apparatus in operation, and hoped to study the correlation between stomach acidity with dreams and nightmares.

Other laboratory equipment showed the broad scope of the U.S.C. medical research program. In lung cancer studies, a prism spectrophotometer of the self recording type was being used to record the transmission spectra of suspected carcinogenic agents such as smog and tobacco smoke. In kidney research, an automatic recorder with strain-gauge pressure transducer inputs was being used in animal experiments to study the correlation between intracellular kidney fluid pressure and renal blood flow. In albumin and lipoprotein studies, a 70,000 rpm air-driven ultracentrifuge was being used to observe densities and sedimentation rates of complex biological substances from flash photographs of samples being spun at high speed. In respiratory studies, an electronic mass spectrometer of the RF linear accelerator type was being used to observe the relative proportions of the various gases in inhaled and exhaled air. In heart research, multichannel oscilloscopes were being used to observe Lissajous figures produced by normal and abnormal cardiac potentials. Magnetic tape recordings of signals picked up with tiny catheter microphones inserted in the blood vessels of the heart have shown ultrasonic frequencies up to 50 kc, believed due to cavitation. In bacteriology, a broadband ultrasonic transducer having a solenoid core of iron particles suspended in oil has been used with 0-1 mc voltage sources to find resonant frequencies at which certain bacteria explode when irradiated with powers of less than a half watt. In blood circulation studies, an adjustable-parameter electric analog of an artery has been constructed to simulate the elasticity and flow-resistance of normal and abnormal vessels. A special capacitance meter has been constructed to detect abnormal growths in the bladder. In tissue studies, a self-recording elastometer has been constructed to measure the elasticity and hysteresis of various tissue samples.

Most of the instruments used in medical research experiments show the influence of modern advances in electronic measurement

methods. The string galvanometer and smoked paper recorder have been made obsolete by the electric transducer, amplifier, and power-driven recorder. Out of the medical research come new techniques for the prevention and cure of human diseases. It is safe to predict that many of these new techniques will employ electronic instruments for monitoring, diagnosis, or treatment.

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