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RADIO AND ELECTRICAL ENGINEERING DIVISION

REVIEW OF TECHNICAL PAPERS PRESENTED AT THE FIFTH CONFERENCE ON ELECTRONIC INSTRUMENTATION AND NUCLEONICS IN MEDICINE

NEW YORK CITY, NOVEMBER 24-25, 1952

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OTTAWA

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INTRODUCTION

The Fifth Conference on Electronic Instrumentation and Nucleonics in Medicine was held at the Hotel New Yorker, in New York City, on November 24th and 25th, 1952. It was attended by a group of from 80 to 90 representatives of research centers, hospitals, and nuclear energy laboratories. About half the papers presented were on electronic instrumentation in diagnosis and treatment in medicine; the others dealt with methods of photo detection of nuclear radiation, and deep therapy radiation techniques.

The writer was primarily interested in the reports of instrumentation for clinical treatment or diagnosis, and precedence is given in this review to a discussion of these papers. Some of the reports on nucleonics are not reviewed, since the subject matter is not of direct application in our work. Several papers dealt with photoelectric detection techniques for measurement of radiation, and four of these reports are mentioned briefly.

Unfortunately it was impossible to reproduce many of the graphs and tables presented with the papers. In most instances the lectures were conducted in darkness for viewing slides, and the recording of notes therefore was quite difficult. A camera for photographing the projected slides would have been most useful.

The quality of some of the papers fell short of the standard set at the fourth convention, held a year ago. This can possibly be attributed to a last minute advancement of the conference date, to avoid conflict with an IRE convention to be held early in 1953. However, there were a few excellent papers, provocative in their approach, and of considerable interest and application in electromedical projects undertaken in our laboratories.

REVIEW OF PAPERS

"Heating of Fat-Muscle Layers by Electromagnetic and Ultrasonic Diathermy", by Herman P. Schwan, Kam Li, and Edwin L. Carstensen, Graduate School of Medicine and Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pennsylvania.

Comparative tests were made to assess the relative merit of electromagnetic and ultrasonic therapy in heating body tissue. For the electromagnetic irradiation, tissue samples were heated using a transmission line in the frequency range from 200 to 1000 megacycles per second. Values of dielectric constant over this range, and also at 3000 megacycles per second were obtained for fatty tissues and muscle, and are shown in Table I.

TABLE I

Dielectric Constant (ε) of Fatty and Muscular Tissues

f(mc/sec.)	100	300	1000	3000
Muscle	74.0	60.0	54.0	45.0
Horse Fat	8.0	7.1	4.4	3.3
Pork Fat	5.2	4.6	3.4	-

An ultrasonic applicator was used for the ultrasound tests over a range from 0.5 to 10 megacycles per second. For absorption in tissues of high water content, electromagnetic radiation at about 50 megacycles per second is comparable with ultrasound of 1 megacycles per second. However, the presence of fatty tissues presents a complex reflection coefficient at the fat-muscle interface. Standing-wave patterns exist in subcutaneous fat if its thickness and the applied frequency are high enough. These standing-wave patterns exert great influence on the ratio of heat in fat to muscle in the case of electromagnetic radiation, but contribute little to the heat distribution with ultrasound. The author concludes that frequencies below 1000 megacycles per second should be used for electromagnetic heating of deep body tissues, and that the effect of such diathermy should be comparable with that of ultrasonic therapy in the 1 megacycle per second region.

* * *

"The Elements of Electrocardiographic Theory", by Ernest Frank, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pennsylvania.

This paper presented a very general outline of the fundamentals of electrocardiography. The standard lead connections were discussed and the P, QRS, and T Waves associated with the cardiac activity from which they arise.

The principles of vector cardiography were stated, based on a conception of the heart as a homogeneous spherical conducting model containing a current dipole at its center. The author discussed some of the obvious errors arising from such an over-simplification. The concept and use of the heart vector was outlined and methods of portraying heart vector functions were explained.

This paper will be published in "Electrical Engineering".

* * *

"Evaluation of Factors Affecting Accuracy of Oscillographic Recording Systems", by Arthur Miller, Sanborn Company, Cambridge, Mass.

Since the accuracy of an oscillographic recording system is dependent upon the proportionality between the input signal and the resulting deflection, consideration must be given to factors affecting this proportionality in equipment used for medical diagnosis, if complete interpretation is to be obtained.

The author outlined methods of analysing fidelity of oscillographic response and presented circuits for simplified checking of linearity in "step" and "constant increment" d-c systems and in carrier systems.

Complex wave forms recorded by oscillographs are not sinusoidal, nor do they contain wave fronts of infinite steepness. Yet it is customary to test oscillograph performance with sinusoidal or square waves. Direct correlation between distortion and sine or square wave response is difficult to achieve. The use of triangular pulses for testing electrocardiographs was suggested as offering a more satisfactory reference than either sinusoidal or square wave forms.

In a brief discussion of damping of moving coil recorders, the author concluded that optimum performance results with a 71 per cent critically damped movement.

* * *

"The Technique of Recording Blood Pressures with Intravascular Miniature Manometers", by O.H. Gauer, M.D., Aero Medical Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio.

This paper was one of the most informative of those presented at the Conference, and is of particular interest since we have developed a similar manometer, based on the work reported by Wetterer in 1943.*

The manometer developed in the Aero Medical Laboratory uses a differential transformer pickup on the distal end of a heart catheter. The pickup probe is about one-eighth inch in diameter, and one-half inch in length. The elastic membrane used by Wetterer as a pressure diaphragm has been replaced by a berrylium copper disc which actuates an armature within the transformer coils.

The catheter used by Gauer has the four Formax lead wires to the probe wound about its hollow core. The probe is attached to the end of the core — and this is the most difficult problem encountered. The outer covering is then applied to the catheter core, extending part way over the pickup probe. Such a technique is a distinct improvement, as it leaves the hollow core free for back-pressure calibration of the transducer.

Pressure sensitivity gives artifact-free indication of pressures as low as 1 cm of water. The optimum sensitivity is obtained with an armature about 50 per cent longer than one chamber of the differential transformer. An armature of 3.8 mm length has almost twice the sensitivity of a 2.5 mm slug. The armature is reduced to 0.6 mm diameter to give as much coil volume as possible, as such proportion has been found to increase the sensitivity.

To permit withdrawal of blood samples in the region of the pressure measurement, a double-lumen catheter has been used. This feature has been suggested to us as being of extreme value in medical diagnosis, and it was interesting to note that it has been achieved with small increase in the catheter diameter.

The amplifier of the Gauer manometer uses a carrier frequency in the range from 2 to 10 kilocycles per second. Circuitry is similar to that of the NRC instrument.

* * *

*"A New-Manometric Probe With Electrical Transmission", by E. Wetterer, Zeitschrift fuer Biologie, 101, 332-350, 1943, (Translated by Dorothy J. Wright, NRC, May, 1950).

"A Photomultiplier Tube Signal Converter for Low-Level, Wide-band Applications" by Douglas A. Kohl, B.E.E., University of Minnesota, Minneapolis, Minnesota.

A photomultiplier tube is used for measurement of low-level light signals by applying two low-frequency signals to the tube, so that the tube acts as a signal converter as well as an electron multiplier. The inter-electrode capacities of photomultiplier tubes are such that it is impossible to vary the gain in accordance with a carrier frequency directly and maintain suitable signal-to-noise ratios. Therefore the two frequencies are applied, the difference frequency being amplified in normal superheterodyne manner. As a result, the gain can be controlled as a function of the two input frequencies and a band-pass of several kilocycles can be obtained.

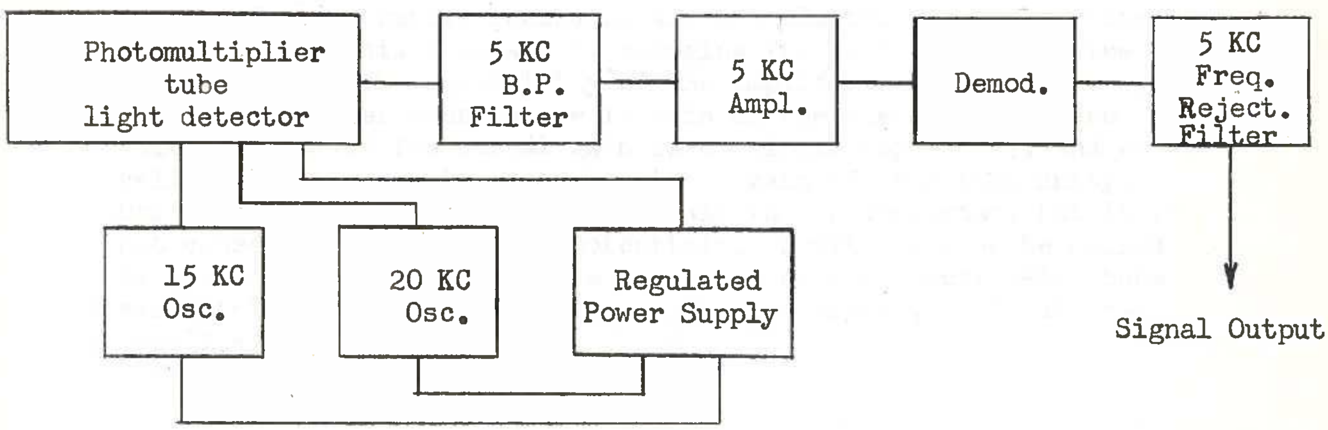


FIGURE 1

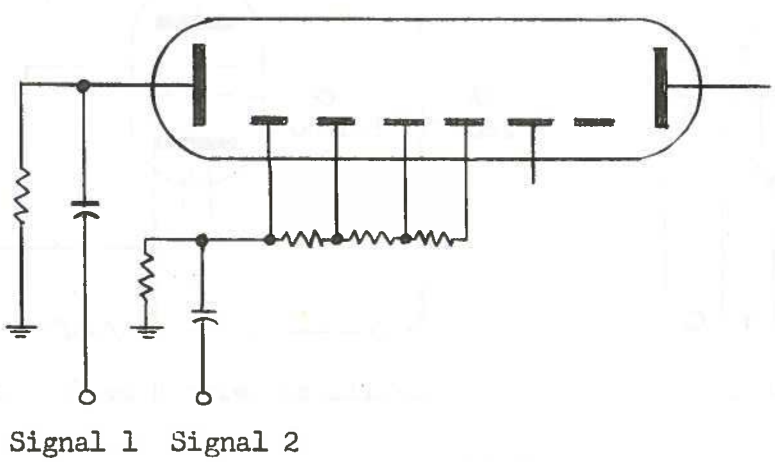


FIGURE 2

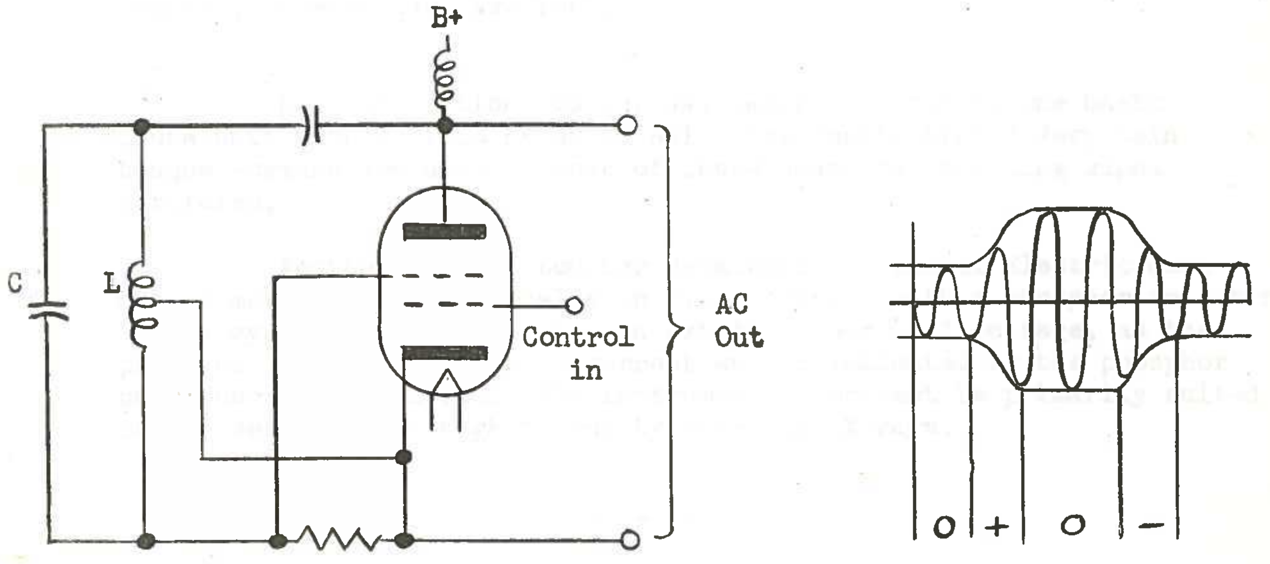
Figure 1 is a block diagram of the circuitry involved. Figure 2 indicates the manner of connection of the low-frequency inputs to the photomultiplier tube. Input frequencies of 15 and 20 kc/sec. were chosen, giving a 5-kc bandpass.

* * *

"An Oscillator-Electrometer" by T.A. Rich and J.E. Bigelow, General Engineering Laboratory, General Electric Company, Schenectady, New York.

A low current d-c amplifier has been made, in which the amplitude of an oscillator is controlled by an electrometer tube. The oscillator serves as a converter of d-c to a-c at any frequency up to about one megacycle per second.

The unique feature of the circuit is the function of the electrometer. The amplitude of oscillation is very sensitive to the amount of regenerative feedback, and the electrometer tube controls the amount of this feedback by changing its gain with the value of signal input. The sensitivity of the amplifier is directly proportional to the per cent change in gain of the electrometer tube per volt of signal. The actual gain is of little importance, and excellent performance is possible with a gain of less than unity. Drift may be caused by changes in gain in the converter, but it is not caused by shifts of d-c potentials. Drift may also be caused by changes in the grid-cathode potential of the electrometer tube since this "contact-potential" acts like a signal, as in all d-c amplifiers.



(a) Controlled Hartley Oscillator

(b) Output waveform

FIGURE 3

Figure 3 shows the oscillator, a simple Hartley circuit with a control grid operated by the electrometer tube. A high a-c gain can be obtained with few tubes. A transformer and rectifier produce an easily filtered d-c output, which can be fed back to the input to give the necessary speed and stability for electrometer applications.

* * *

"Trends in Detection and Measurement of Radioisotopes for Medical Purposes", by J.W. Hitch, Advisory Field Service Branch Isotopes Division, United States Atomic Energy Commission, Oak Ridge, Tennessee.

This paper reviewed the various types of radiation detectors in common use and discussed some of the types of instruments that are still in the development stage. Scintillation counters have replaced Geiger-Müller and proportional counters, because of their fast resolving time and relatively high efficiency. With proper selection of primary detector phosphors the scintillation counter can be adapted as a β-ray or γ-ray detector in addition to its common use for alpha particle detection. The high-gain low-noise feature of photomultiplier tubes produces a sizeable output from this type of detector. The relative sensitivities of Geiger-Müller and scintillation counters is controversial at the present time.

* * *

"Instrumentation Employing Phosphors as the Primary Detector", by W.W. Schultz and R.A. Dewes, General Electric Laboratory, General Electric Company, Schenectady, New York.

A scintillation counter was described, having one basic probe unit with various heads to suit the application. Very thin opaque screens are used on some of these heads for counting alpha particles.

Another type of counter developed by General Electric uses one or more photovoltaic cells in close contact with a phosphor detector. Such a system does not require an external source of voltage, as the photovoltaic cells deliver a current when illuminated by the phosphor under nuclear radiation. The instrument at present is primarily suited to the detection of high intensity gamma and X-rays.

* * *

"Light Collection and Transmission in Photoelectric Detection Devices", by Z.L. Collins and E.L. Webb, Westinghouse Electric Corporation, X-Ray Division, Engineering Department, Baltimore 3, Maryland.

This was a brief discussion, more concerned with the optical problems of scintillation counters than the electrical features. Methods were described for increasing the output of the scintillation counter phosphor by using reflectors. Mirror reflectors are frequently used, but are considered to give less output than diffusing reflectors placed to distribute the light reaching the photomultiplier tube from the phosphor.

In the case of photometers, counters, and X-ray phototimers, where the problem is to get the maximum light into a phototube from an extended area source, the use of diffusing reflectors is recommended. The problem is compared with that encountered in the illuminating engineer's 4π photometer.