President, Dr. Gordon H. Ball, University of California at Los Angeles.
Vice-president, Dr. Herbert W. Graham, Mills College.
Secretary-Treasurer, Dr. Denis L. Fox, Scripps Institution of Oceanography.
Members of the Executive Committee: Dr. Ira L. Wiggins, Stanford University; Dr. H. L. Mason, University of California.

D. L. Fox,
Secretary

REPORTS

REPORT TO CONGRESS OF THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

"SCIENTIFIC research is the most fundamental activity of the Government in connection with the development of America's potential strength in the air," Congress was told on January 13 in the report of the National Advisory Committee for Aeronautics, transmitted by President Roosevelt. It was submitted to him by Dr. Vannevar Bush, president of the Carnegie Institution of Washington, chairman of the committee.

This quotation from the report and the following further quotations have been selected and sent to SCIENCE by Science Service, Washington, D. C.

"No matter how greatly production facilities may be increased, no matter how many pilots may be trained, unless the aircraft that are built for action are at least equal in performance to those of any possible enemy, the whole effort will be largely wasted," the report continues.

Importance of such research has been recognized, for, it is stated:

"The Army and Navy have maintained the closest contact with the committee's laboratories and have taken the fullest advantage of the committee's facilities in the solution of their pressing problems. The Army Air Corps has appointed at the committee's laboratory at Langley Field a liaison officer, and the Navy's liaison officer, having headquarters in Washington, visits Langley Field at regular and frequent intervals.

"The committee has two major research laboratories, one at Langley Field, Va., known as the Langley Memorial Aeronautical Laboratory, and the others at Moffett Field, Calif., known as the Ames Aeronautical Laboratory. The flight research laboratory was the first unit of the Ames Laboratory to get into operation. Other units will be placed in operation as rapidly as their construction is completed.

"Both the Langley Memorial Aeronautical Laboratory and the Ames Aeronautical Laboratory are devoted chiefly to aerodynamics, although the committee has at Langley Field a structures research laboratory, a hydrodynamics research laboratory and a small engine research laboratory. To remedy the deficiency in engine research facilities the Congress by act approved June 26, 1940, authorized the construction of a third major research station for the committee which is to be an aircraft-engine-research laboratory. The site finally selected by the committee under authority of that act is adjoining the municipal airport at Cleveland, Ohio, and the committee is proceeding with its construction. The details of this action are set forth in Part II of this report.

"The committee highly appreciates the support of the President and the Congress in providing these two additional research stations during the past two years. They were indispensable to strengthen research and to accelerate aeronautical progress in the United States. They will prove of great value to the national defense, and it is confidently predicted that their economic value to the nation will more than offset their cost."

Many of the researches are necessarily secret, for, the report states:

"The committee has found it necessary in the national interests to withhold from public distribution the detailed results of its researches. Therefore, until world conditions change, this and succeeding Annual Reports will deal only in general terms with the results accomplished."

Higher speed planes, with greatly increased armor and armament, are viewed as the outstanding trend produced by the European war. Special studies to meet the requirements are being made.

"The demand for increased speed has resulted in the need for much greater horsepower," the report continues. "Whereas pursuit airplanes of a year ago were equipped with engines of 1,000 horsepower, they are now being designed with single engines of 2,000 horsepower. The trends toward increased speed and higher ceiling, toward larger and heavier engines, toward increased armor and armament, necessitate larger and much heavier types of airplanes. This condition has established a definite trend toward higher wing loadings.

"Because of the higher flying speeds demanded by the Army and Navy, the committee has given special study to the important subject of compressibility shock encountered at high speeds. With the speeds now attainable, it is essential that care be taken to design all parts of the airplane structure so as to prevent velocities approaching the speed of sound from occurring at any point. The 500-mile-per-hour wind tunnel at the Committee's Langley Field laboratory has proved of great value in the study of this problem."

Despite war needs, commercial aviation should not be neglected. The committee believes, it says, "that commercial aviation will prove of ever-increasing importance to the United States in promoting international trade and good will, especially in the Western Hemisphere. When the present wars have ended, aviation will have an opportunity to prove its real value to civilization in shortening the distances between nations and in facilitating international trade and commerce. When that day comes, the extension of world trade routes of the air will bring some compensation for the awful destruction wrought and to be wrought by military aviation before peace again prevails."

SPECIAL ARTICLES

LOCALIZATION OF LITHIUM IN TUMOR TISSUE AS A BASIS FOR SLOW NEUTRON THERAPY[1]

THE destructive action of x-rays and fast neutrons on living tissue is known to be due to the action of energetic electrons resulting from the absorption of the x-rays, and of recoil nuclei, especially hydrogen nuclei, which have been projected by neutron impact. The biological action in either case is a result of energy absorption by the tissue from the high-energy, charged particles. With either x-rays or fast neutrons, however, the destructive action occurs throughout the irradiated tissue, and no satisfactory method has been found for localizing the damage, in the case of cancer therapy, to the tumor zone. Very often skin damage sets an upper limit to the dose which can be delivered through the skin to underlying tissue.

Since the passage of slow neutrons through body tissue is not accompanied by the production of energetic recoil protons, there should be little or no resulting damage from this cause. However, if these slow neutrons be introduced into a zone which has been perfused with certain chemical elements such as boron or lithium, or their compounds, nuclear capture reactions will occur which release very energetic particles, and result in the local destruction of tissue.

The foregoing considerations suggest an investigation of the applicability of neutron-boron or neutron-lithium techniques to the localized treatment of tumors. The method would be based on the introduction of boron or lithium compounds into the tumor region and the subsequent irradiation of this region with slow neutrons. The neutron capture reactions would then result in localized damage to the tumor.

Zahl, Cooper and Dunning[2] injected growing mouse sarcomas with various forms of slow neutron-capturing materials. When the whole animal whose tumor was so injected was irradiated with slow neutrons, a significant increase in tumor regression was observed which presumably resulted from the nuclear disintegration products of the capture process.

In connection with this work, however, it was pointed out that the method of direct hypodermic injection of slow neutron-capturing materials into the tumorous area does not seem clinically feasible. The authors suggested that for any future employment of the boron-slow neutron process in tumor therapy, some device other than simple hypodermic injection should be developed for localizing either boron or lithium, or related materials, in malignant tissue.

The possibility of selective localization in malignant tissue of slow neutron-capturing materials through the medium of intravenous injection was suggested by the work of Ludford,[3] Duran-Reynals[4] and others who observed that certain acid dyes, when introduced into the blood stream, would accumulate in greater concentration in tumor tissue than in normal tissue. Since most of such localizing dyes are sodium salts of the azo-sulfonic acid complex, it was hoped that by substituting lithium atoms for the sodium atoms which are normally present in the dye-salt molecule, the dye molecule would act as a vehicle for localizing lithium in the malignant tissue.

Lithium salts[5] of Pontamine Sky Blue 6B, Trypan Blue and carminic acid were prepared and injected intravenously both into mice bearing spontaneous mammary tumors and mice bearing implanted tumors of the Sarcoma 180 strain. After suitable periods following intravenous injection of the dyes, animals were sacrificed and tumor and other tissues removed and analyzed spectroscopically for lithium content.

Since the purpose in capturing the slow neutrons is to make available the nuclear reaction energy for cellular destruction, it is of interest to compare the amounts of energy made available by the addition of boron and lithium to the tissue in various concen-

[1] We wish to express our appreciation to Dr. C. P. Rhoads and Dr. G. Failla for courtesies extended us at Memorial Hospital, and to Professor J. R. Dunning, of Columbia University. Grateful acknowledgment is made to Lucius N. Littauer, who generously supported certain portions of this work.

[2] Paul A. Zahl, Franklin S. Cooper and J. R. Dunning, *Proc. Nat. Acad. Sci.*, 26: 589–598, 1940. Similar *in vitro* work has been reported by P. G. Kruger, *Proc. Nat. Acad. Sci.*, 26: 181–192, 1940.

[3] R. J. Ludford, *Proc. Roy. Soc.* (London). Series B., 104: 493–511, 1929.

[4] F. Duran-Reynals, *Amer. Jour. Cancer*, 35: 98–107, 1939.

[5] Grateful acknowledgment is made to the Dyestuffs Division of the E. I. du Pont de Nemours and Company and to the National Aniline and Chemical Company for the preparation of the lithium salts of their dyes.