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OCTOBER 1, 1946, TO FEBRUARY 29, 1948

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INTRODUCTION

As has been the custom for many years, the California Institute of Technology presents herewith the annual list of publications of the members of its staff. This list has naturally grown longer as the research work at the Institute has expanded over the last 25 years. It is now evident that this record of publications constitutes more than simply a list of titles, but is a condensed report of progress on a vast amount of research now under way at the Institute.

To bring out this "report of progress" feature more clearly, the listings have been rearranged in this edition and an introductory summary by the chairman of each division has been prepared. These summaries, it is hoped, will be a general guide to those interested in an over-all picture of the research activities now in progress at the California Institute.

Though it would be misleading to judge the research activity of any division by the number of published papers, it is nevertheless impressive to note the large volume of work represented by the publications of the Divisions of Biology and of Chemistry and Chemical Engineering. It is particularly important to note how much of the work of these two divisions is so closely related, to such an extent that it can be said that a large share of the effort of the two divisions is now being devoted to the combined field of "Chemical-Biology" or "Molecular Biology." This field is without a doubt one of the most exciting in all of modern science and the dynamic groups working so intimately together at the California Institute have assumed a place of national leadership in exploring this field. The excellence of the work of these groups has commanded generous financial support, particularly from such foundations as the Rockefeller Foundation, the National Foundation for Infantile Paralysis, the American Cancer Society and many others. The generous support of these foundations has in turn greatly accelerated, improved and extended the research program.

The research activity in the field of Aeronautics, including the work of the Guggenheim Aeronautics Laboratory, the Southern California Cooperative Wind Tunnel and the Jet Propulsion Laboratory, has also expanded greatly in recent years and continues on the high plane of excellence on which it started when the Guggenheim Laboratory was organized 20 years ago. It would be hard to exaggerate the influence which this basic research in an important field has had on the development of the aircraft industry in the United States and particularly in Southern California. Radical new developments in both military and commercial aircraft are now taking place and important studies in supersonic speeds and with jet propulsion now going on at the Institute will,

as they have in the past, play a basic role in forwarding this development.

The activities in Civil and Mechanical Engineering are represented by a smaller list of publications but they are of basic importance in these critical fields. The developments in these fields are of such great importance and the demand for trained men so great that it is urgently necessary that the Institute expand its facilities and personnel in these areas as soon as practicable.

The fact that the Southwest is a region of intense geological interest is reflected in the activities of the Division of Geological Sciences. Problems of earthquakes, of mineral and oil deposits, make these studies of great practical importance. At the same time the important palentological deposits of the area have provided rich material for the study of the early evolution of certain mammals.

A long list of important publications in the fields of Physics, Astronomy, Mathematics and Electrical Engineering reflects the continued strength of these fields at the Institute which began with the arrival of Dr. R. A. Millikan in 1921. The California Institute has always, since that time, held a leading place in the country in its research in nuclear physics and cosmic rays. The important work in Astrophysics and Cosmology which has gone forward in the past will be greatly expanded as the 200-inch Hale Telescope and the 48-inch Schmidt Telescope of the Palomar Observatory come into operation during the coming year. The cooperative plan of operation between Palomar and Mount Wilson essentially adds the entire scientific staff of Mount Wilson to the California Institute research staff and future publications in this field will be under the joint auspices of the Institute and of Mount Wilson.

Taken as a whole, this compilation of scholarly work completed constitutes an impressive record in which the Institute can take pride. But it is also a stimulating challenge to continue and expand its work in many critical areas.

L. A. DuBRIDGE, *President.*

July 7, 1948

PUBLICATIONS OF THE STAFF

OCTOBER 1, 1946, TO FEBRUARY 29, 1948

Note: Books or articles of multiple authorship are listed under the name of the first author. A name-index of all authors, pages 44 to 46, can be consulted for the publications of individuals.

Requests for reprints should be addressed to the division, department, laboratory or section under which the publication is listed. Where a division or laboratory serially numbers the contributions of its staff members, these numbers appear in parentheses immediately after the title, and may be used for brevity in requesting reprints.

DIVISION OF BIOLOGY

William G. Kerckhoff Laboratories of the Biological Sciences

PUBLICATIONS of the staff members of the Division of Biology for the year 1947-1948 cover a wide range of subject matter. Among them are reports of work in the fields of plant and animal biochemistry, bioorganic chemistry, plant and animal physiology, genetics, chemical genetics, embryology, cytology, neurophysiology, psychobiology, immunogenetics, marine biology and others.

Three examples will serve to illustrate how basic work in biological fields often has far-reaching implications.

The work of Emerson and Zalokar on sulfonamide-requiring strains of the red bread mold Neurospora has contributed in a significant way to our understanding of the biological action of these widely used drugs. All too often in medical practice such knowledge is lacking.

The demonstration by Mitchell, Nyc, and collaborators, that the amino acid tryptophane is converted to the vitamin niacin through kynurenine and 3-hydroxyanthranilic acid as intermediates clarifies several heretofore puzzling relations in the dietary deficiency disease pellagra. This is another of an increasing list of instances in which it is evident that protoplasmic metabolism is very much alike wherever it is found—whether in bread mold or in man.

In making clear the conditions under which liver homogenates synthesize hippuric acid, Borsook and Dubnoff have made an important contribution to an understanding of peptide linkage formation. The manner in which this type of union between amino acid components of

proteins is brought about is a part of the large and key biological problem of the mechanism of protein synthesis.

Additions to our knowledge of living systems usually come in small increments. It is the hope of the authors of the papers listed below that each of them represents a step in the forward direction.

G. W. BEADLE, *Chairman.*

ALLES, GORDON A., CHARLES H. ELLIS, G. A. FEIGEN AND MILDRED A. REDEMANN.

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The Physiology and Biochemistry of Rubber Formation in Plants, *Bot. Rev.,* 13, 10, 543-596 (1947).

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Methionine Formation by Transmethylation in Vitro, *J. Biol. Chem.*, 169, 2, 247-258 (1947).
On the Role of the Oxidation in the Methylation of Guanidoacetic Acid, *J. Biol. Chem.*, 171, 1, 363-375 (1947).
Ornithine-catalyzed Urea Formation in Liver Homogenate, *J. Biol. Chem.*, 169, 2, 461-462 (1947).
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Plant Growth under controlled Conditions. VIII. Growth and Fruiting of the Chili pepper (Capsicum Annuum), *Am. J. Bot.*, 34, 8, 393-401 (1947).

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The Enzymatic Conversion of Tryptophan to Auxin by Spinach Leaves, *Arch. Biochem.*, 13, 1, 131-144 (1947).
WRIGHT, ERNEST B.
The Effects of Asphyxiation and Narcosis on Peripheral Nerve Polarization and Conduction, *Am. J. Physiol.*, 148, 1, 174-184 (1947).
ZALOKAR, MARKO.
The p-Aminobenzoic Acid Requirement of the "Sulfonamide-requiring" Mutant Strain of Neurospora, *Proc. Nat. Acad. Sci.*, 34, 32-36 (1948).

DIVISION OF CHEMISTRY AND CHEMICAL ENGINEERING

Gates and Crellin Laboratories of Chemistry

PUBLICATIONS of the staff of the Division of Chemistry and Chemical Engineering for this period report progress in a wide variety of investigations in the fields of physical chemistry, inorganic chemistry, organic chemistry, and chemical engineering.

New results in the fields of protein chemistry and immunochemistry are presented by Pauling, Niemann, Campbell, and their collaborators. Recent advances in the techniques of chromatography and in their applications to the study of natural products are described by Zechmeister. Contributions to the chemistry of antimalarials are reported by Koepfli and his coworkers.

Structural studies of molecules and of organic and inorganic crystals by the techniques of electron and x-ray diffraction are reported by Schomaker, Sturdivant, and other workers in the field of structural chemistry. Pauling describes a new theory of the metallic bond which promises to clarify many obscure points in the structure of metals. Badger and coworkers describe the molecular properties of nitrocellulose and discuss new optical techniques of general importance in high polymer chemistry.

Sage and Lacey report new results and describe new techniques in their studies of phase equilibria in hydrocarbon systems. Preliminary studies on heat transfer in turbulent gas streams are also presented.

J. G. KIRKWOOD, *Acting Chairman.*

BENNETT, EDWARD L., CLARK W. GOULD, JR., ERNEST H. SWIFT, AND CARL NIEMANN.
Systematic Qualitative Tests for Certain Acidic Elements in Organic Compounds, (1117), *Analyt. Chem.*, 19, 1035-1039 (1947).

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Molecular Properties of Nitrocellulose. II. Studies of Molecular Heterogeneity, (1077), *J. Phys. & Coll. Chem.*, 51, 574-579 (1947).

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"Multiple Condensed Phases from Crude Oils—2: Greeley Field," (1039), 42-50 of *Fundamental Research on Occurrence and Recovery of Petroleum,* 1944-45, American Petroleum Institute, New York, N. Y.

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Temperature Gradients in Turbulent Gas Streams. Preliminary Studies, (1050), *Chem. Eng. Progress,* 43, 135-142 (1947).

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DIVISION OF CIVIL AND MECHANICAL ENGINEERING AND AERONAUTICS

PUBLICATIONS of members of the Division of Civil and Mechanical Engineering and Aeronautics for the period covered by this bulletin reflect the continued strong interest of the Division in the broad subjects of fluid mechanics, structures, and materials. These publications also focus attention on the growing interest in problems of fluid dynamics, such as the studies in the shock phenomena of transonic flow, hydrodynamics of water entry, and structural vibrations of aerodynamic bodies.

The aerodynamic studies reported here range in scope from fine details of boundary layer phenomena to thermodynamic problems of large-scale atmospheric circulation. The hydrodynamic investigations cover problems of steady flow, as well as those of dynamic flow. Basic to all of these studies has been the instrumentation, which has been the subject of several of the publications listed.

Investigations in static and dynamic properties of materials are reported here, as well as applications to structures. Porous metals in particular are of interest because of the indicated application to new cooling techniques. The dynamic properties of materials which are reported are part of an extended study in this subject and have led to reports which indicate continuing interest in these problems, particularly those of elastic and plastic strain propagation. Closely associated with the dynamic behavior of structures is the analysis of strong motion earthquakes, a study of considerable interest to structural engineers and which is a continuing one at the Institute.

Some of the papers listed represent wartime publications reported in this listing for the first time as the result of the removal of security classification.

F. C. LINDVALL, *Chairman.*

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Daniel Guggenheim Aeronautical Laboratory

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INDUSTRIAL DESIGN SECTION

DURING the war years and immediately thereafter, a major part of the Industrial Design Section's efforts were devoted to a reorganization of the information needed to enable product design to reflect more accurately the then available materials and processes. To this end, the Section's war-time research and publications show design adjusted to the use of refractory earths and other non-critical basic materials.

The post-war readjustment period in Industrial Design is characterized by re-evaluation of the basic elements in the light of current technological advances and economic conditions. The designer of mass-produced items today must be trained in engineering, sales management, and finance, as well as in the arts traditionally associated with design. The approach used by Mr. Welch in his articles is representative of the type of industrial design which today finds the greatest acceptance in industry—that is, planning for the future by the use of product and market research, and designing in terms of engineering materials and processes unknown to the past generation.

J. P. YOUTZ, *Administrative Assistant in Charge.*

WELCH, DAVID F.
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DIVISION OF THE GEOLOGICAL SCIENCES

Balch Graduate School of the Geological Sciences; Charles Arms and Seeley W. Mudd Laboratories of the Geological Sciences; Seismological Laboratory

AMONG the research contributions by staff members and students in the Division of the Geological Sciences are investigations of earthquake phenomena, propagation of elastic waves in the earth's crust, studies in geomorphology and paleontology, river floods and mineral deposits of economic value.

It has been found by C. Y. Fu that the usual way of treating energy propagation through the earth by means of the ray picture may lead to incorrect results. This has led to a new theory more in conformity with the facts.

Study has been made by B. Gutenberg of the records obtained from the atomic bomb test, and not only have travel times been obtained of elastic waves through the earth from New Mexico to California, but information is also available regarding the propagation of sound waves through the atmosphere. The travel times calculated from earthquake records are confirmed. Gutenberg has likewise summarized the method employed to locate hurricanes by the use of microseismic records that were obtained from the experimental stations of the U. S. Navy Department.

The waves through the earth which resulted from the Bikini test and were recorded on a number of Pacific Coast Benioff vertical seismographs were used by Gutenberg and C. F. Richter to check the travel times of elastic waves through the earth, calculated from earthquakes, and the agreement between the two was found to be close. These two authors have also published a summary of research conducted at the Seismological Laboratory during 1946.

Richter published the results of a microseismic study of an earthquake known to have occurred along a fault previously studied in detail in the field by J. P. Buwalda.

R. P. Sharp of the Division staff, lately appointed associate editor of the Journal of Geology, reports in this journal on a new interpretation as to the origin of a certain formation found in the Big Horn Mountains, Wyoming, regarded for the past forty years as representing a glacial deposit.

R. H. Jahns is responsible for the most exhaustive study of pegmatite deposits yet published. It represents the first of a series to be published by the U. S. Geological Survey. The contribution demonstrates a systematic distribution of commercially desirable minerals in pegmatites. In a paper published by the U.S.G.S., Division of Water Resources, Jahns

attempts to determine the periodicity of extraordinary floods in the Connecticut Valley by study of flood sedimentation and the recording of the detailed Quaternary history of the Connecticut River.

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DIVISION OF THE HUMANITIES

THE publications listed below reflect some of the varied interests and activities of the members of the Division. Professor Gilbert's articles present some of the results of work carried on during the war, when he was on loan, part- or full-time, to the War Production Board and the Army Air Forces. As is the case with many other members of the Faculty, some of his work must still remain unreported because of security restrictions.

Professor Paul's book on the first twenty-five years of gold-mining in California was fortunately published in time for the centennial of the discovery of gold in the state. It is the first part of an extensive investigation of the growth and development of California as a part of the Union during the second half of the nineteenth century.

Dr. Stern's articles indicate that he is primarily a philosopher, though his appointment at the Institute is as Lecturer in French and German.

* Not available for distribution.
† Not previously reported.

Of particular interest at present is his critical analysis of Existentialism, a theory which is currently attracting a good deal of attention.

Professor Stanton's article is an appreciation of the late Professor Laing's service to the Institute during the years 1921-1946.

The work of the Industrial Relations Section, since it represents a closely unified program of activity, is listed separately below.

C. K. JUDY, *Chairman.*

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INDUSTRIAL RELATIONS SECTION

THE Industrial Relations Section has issued a variety of publications designed for two purposes: (1) to interpret to as large a group as possible some of the problems and some of the solutions of problems of industrial relations, and (2) to present the results of original research.

Since the problems of industrial relations affect all industries including manufacturing, service, and even government itself, the Section has felt a responsibility to explain the problems of industrial relations and some of the proposed solutions to as many groups as possible. Some of the many addresses by the director were published for still wider distribution among such diverse groups as the alumni of the California Institute, the producers of butadiene, and employers in the apparel industry.

The Section recognizes the need for developing and training the staffs of the personnel and industrial relations departments. As part of this activity the Section has started a series of publications outlining some of the "Current Problems of Personnel Management" and providing selected reading lists to aid in further study of these problems by individuals.

The Section has not confined its activities to personnel departments alone. It has realized that every supervisor has to perform a great variety of personnel functions. The Section has made available a carefully annotated list of thirty-two books for supervisors and has compiled for the same books a composite index in tabular form. This new technique makes it relatively easy for supervisors to find solutions for specific problems and for training directors to develop appropriate courses within individual companies.

One of the most pressing problems of management in the post-war period has been the problem of maintaining discipline. The Section encouraged the preparation of a study of the experience of General Motors Corporation by H. W. Anderson, Vice President in Charge, Personnel Staff of General Motors. Mr. Anderson's analysis was presented at a special dinner and his paper was published by the Section. As a supplement to this analysis of the experience of one company, Francis Odell prepared an analysis of "Disciplinary Clauses in Union Contracts."

In the area of research the Section inaugurated a survey of personnel practices among industries in Los Angeles County. The first study, which was published early in 1948, pioneered in the use of new techniques in the preparation and analysis of questionnaires. The response to the improved questionnaire was so satisfactory that for the first time in any community it has been possible to analyze personnel practices in terms of specific industries as well as in terms of the community as a whole. The Section plans to amplify such material and keep it up to

date, and by so doing, make available a great deal of information needed in the formulation of sound policies either by companies or through collective bargaining.

ROBERT D. GRAY, *Director.*

Note: Of the publications listed below, Bulletin No. 14 is for sale at $2.50 per copy. Single copies of Circulars No. 10, 11, 12, 13, 14, 15 are available for free distribution; quantity prices will be quoted on request.

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DIVISION OF PHYSICS, ASTRONOMY, MATHEMATICS AND ELECTRICAL ENGINEERING

ASTRONOMY *and Physics.* While the members of the Physics Staff at the Institute have for the most part resumed their prewar activities, this is not yet fully evident from their publications. Nevertheless the following list does indicate in a general way, in spite of serious gaps, the range of investigations underway in physics and astrophysics.

Thus important cosmic-ray and mesotron studies, fundamental work on the energy levels in the nuclei of the light elements, and the systematic search of the sky with the Schmidt telescopes on Palomar Mountain have been resumed. Moreover, the gamma-ray spectrometer described in one of the papers listed below has been put to use and promises to provide an important new precision tool for the attack on nuclear disintegration processes.

As indicated also in the list of publications that follows, intensive work on many different types of theoretical problems is being carried on and somewhat scattered investigations of various problems of the solid state and low-temperature physics are under way, as well as experiments on the production of artificial meteors from shaped charges.

Other important investigations actually in progress, but not yet published, include experimental work in electronics, in spectroscopy, on the separation of isotopes and a new precision determination of e/m, and theoretical work on the absorption of sound in fogs, on cosmic-ray showers, and on astronomical applications of physics.

Mathematics. In the past the main lines of mathematical research and publication at the Institute have been algebra and the theory of numbers, abstract spaces and general analysis, and the special functions of mathematical physics. That these lines are still being intensively followed is indicated in the following list of publications but not that new work is also underway in modern analysis, theory of differential equations, mathematical statistics, lattice theory, etc., as is actually the case.

Electrical Engineering. As indicated in part only in the list of publications that follows, the Electrical Engineering staff and students at the Institute are engaged in research work in the following fields: high voltage dielectric studies (particularly dielectric recovery), instrumentation for rockets, airplanes and missiles, television techniques, the use of electronic circuits in cosmic-ray work, noise sources in radio (including solar noises), frequency modulation phenomena (particularly multipath distortion), the physics of microwaves as related to dielectric

constants, conductivity and permeability, microwave propagation and its contribution to meteorology, phase conversion of electric currents, basic studies of missile control systems, airplane stability and landing shock, building vibration analyses, and temperature distribution and heat flow in liquids.

E. C. WATSON, *Chairman.*

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JET PROPULSION LABORATORY OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY

THE prime function of the Jet Propulsion Laboratory is the evaluation of propulsion systems for the armed services rather than the development and fabrication of specified jet propulsion equipment. For this reason publications of the staff members cover a very wide range of subject matter related to the field of jet propulsion.

During the year 1947-48 a total of 127 reports were published and distributed to various Government agencies, educational institutions, and industrial organizations. The distribution of these reports is generally made according to the Army-Navy distribution lists, and approximately 195 copies of each report are so distributed.

The following representative list indicates the type of problems with which the Laboratory is concerned and on which reports have been published:

1. Thermodynamics and kinetics of combustion.
2. Physical and chemical properties of liquid and solid propellants.
3. Theoretical and experimental studies of the performance of both liquid and solid propellants.
4. Development of porous metals for use in the cooling of rocket-motor chambers and the study of flow of gases through porous media.
5. The investigation of ceramic materials for rocket motors.
6. Fluid mechanics and chemistry of air-fuel combustion.
7. Basic as well as applied studies on heat transfer with surface boiling, and sweat cooling with porous metals.
8. Supersonic aerodynamics as applied to guided missiles.
9. The effect of rocket motor geometry on performance.

A fairly large portion of the work at the Jet Propulsion Laboratory is still of a classified nature; only the unclassified reports are listed below.

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