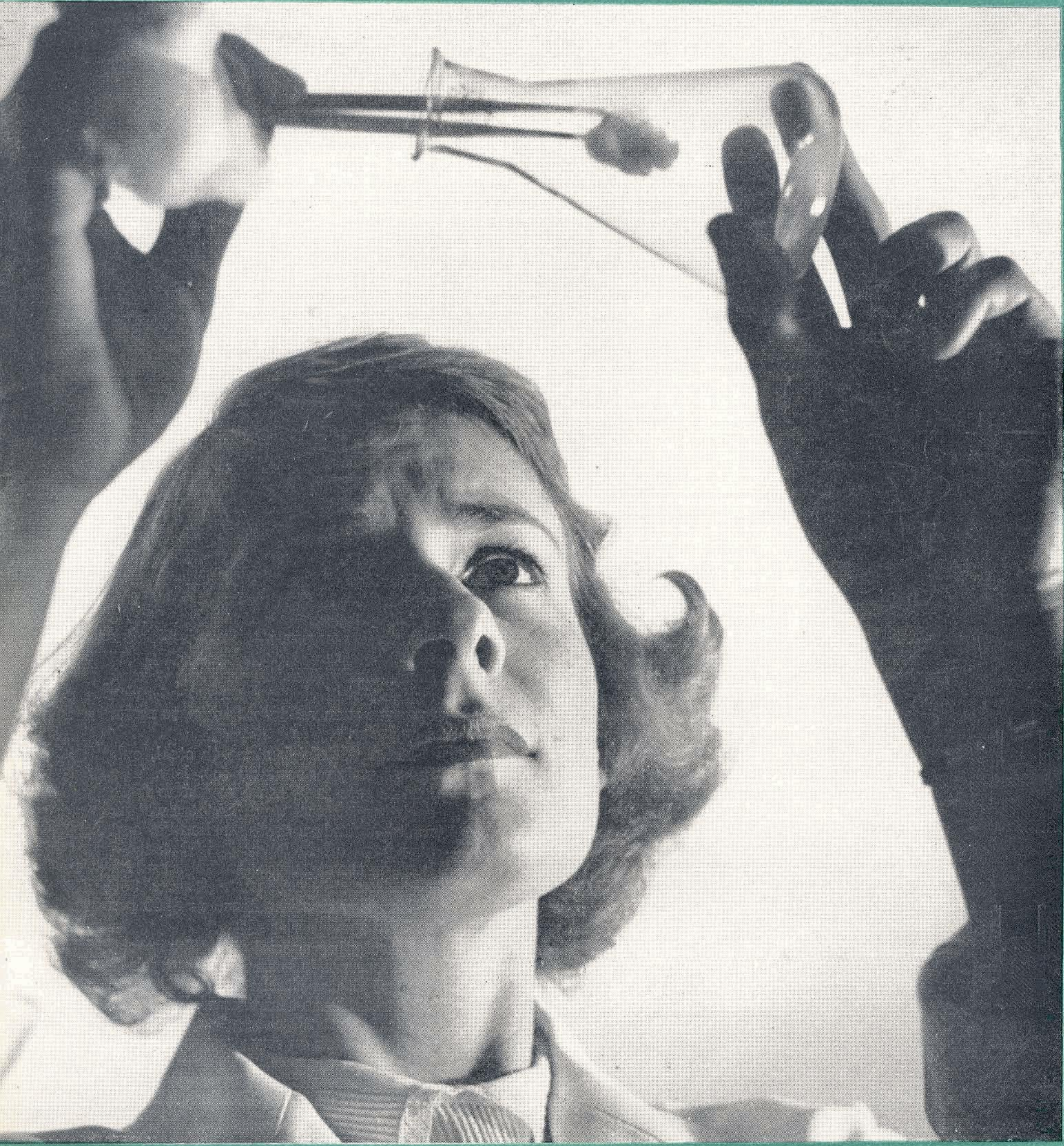
ENGINEERING | AND | SCIENCE

MARCH/1953



Plant Hormones . . . page 16

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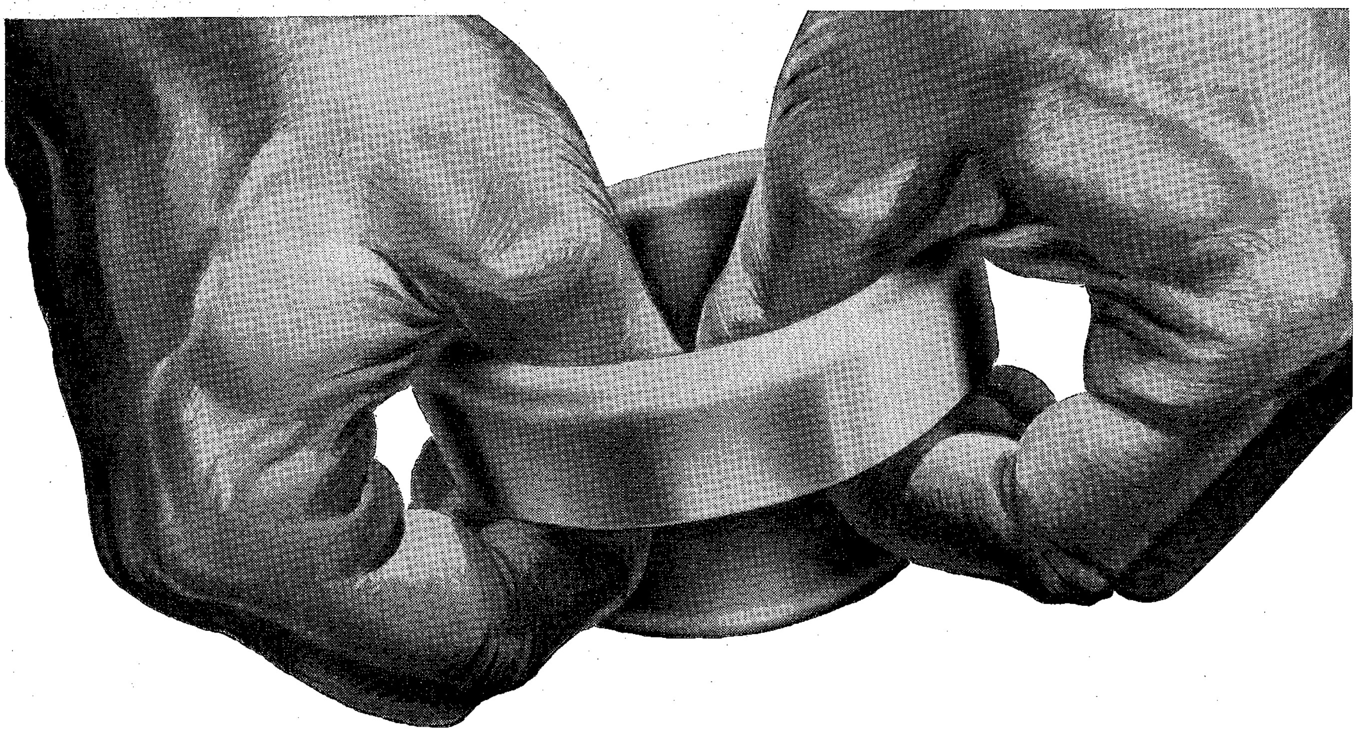
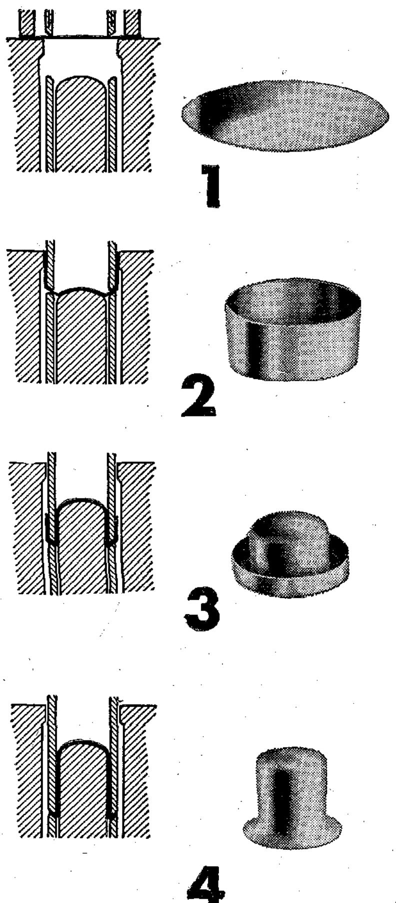


How to turn a high strength steel cup **inside out, cold**



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ENGINEERING AND SCIENCE

IN THIS ISSUE

The girl on the cover this month is—or rather, was—Marjorie Hand, research assistant in biology. She's inspecting a fragment of stem tissue which has been grown in a synthetic nutrient medium, with the aid of various plant growth substances. "Plant Hormones," on page 15 of this issue, describes some recent progress in this field of research at Caltech.

The article has been written by James Bonner, Professor of Biology. It might, however, just as easily have been done by either of the two other men working with Bonner in this field: D. Harold McRae, Biology Graduate Student, and Robert J. Foster, Research Fellow in Chemistry. This trio is responsible for most of the research described in the article. "Plant Hormones" has been adapted from a talk given by Dr. Bonner before the Harvey Society, October 23, 1952.

To get back to Miss Hand, however: first of all, she's Mrs. Von Abrams now; secondly, she's left Caltech. This notice is inserted here to warn our avid readers that they'll only be wasting their time by wandering in and out of all the labs in Kerckhoff.

"Liberal Education in Our Engineering Colleges" by Earnest C. Watson, Dean of the Faculty at Caltech, was originally presented as a talk before the Phi Beta Kappa Society in Pasadena, on February 13. The article on page 11 of this issue is an abbreviated version of that talk—but just as provocative in print as it was on the platform.

PICTURE CREDITS

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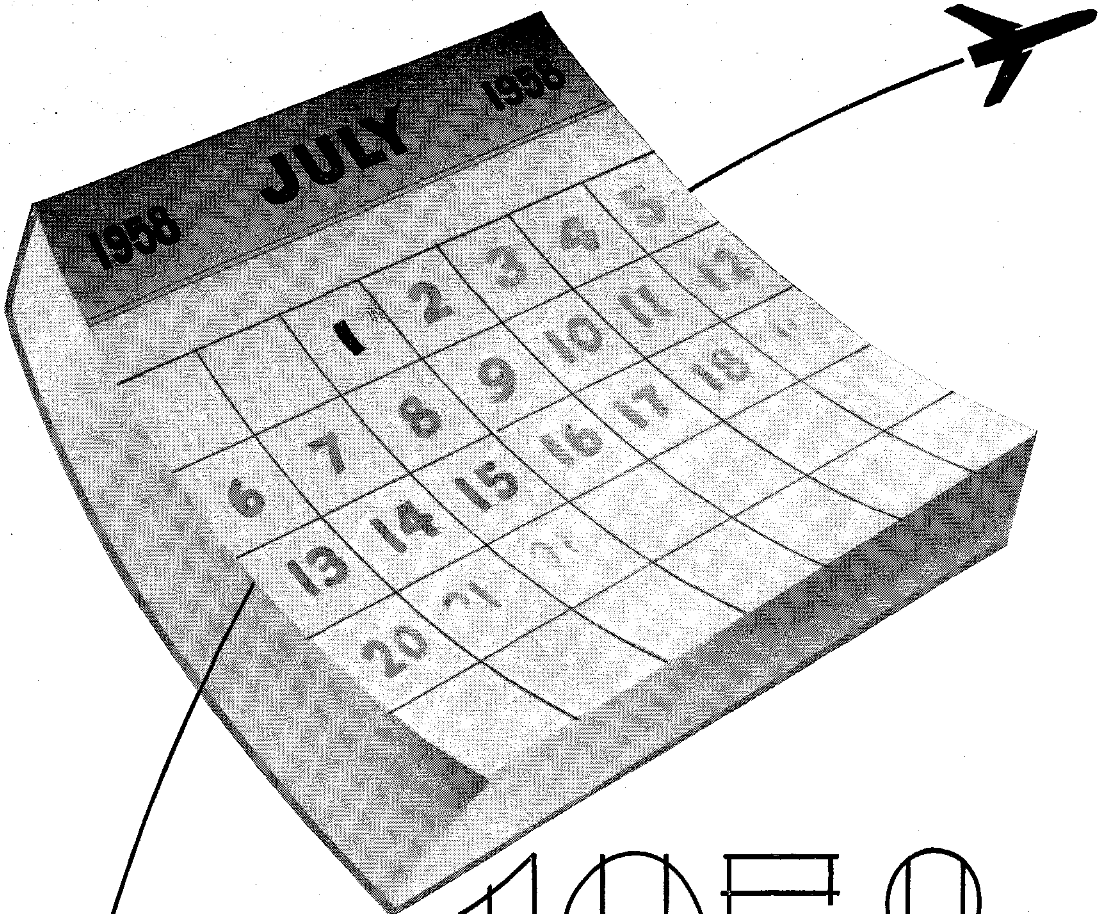

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BOOKS

HARWELL: THE BRITISH ATOMIC ENERGY RESEARCH ESTABLISHMENT

Prepared under the direction of Sir John Cockcroft, Director, Harwell
Philosophical Library, N. Y. $3.75

Reviewed by John G. Teasdale
Research Fellow in Physics

THIS REPORT on the atomic energy research in the United Kingdom is a description of the progress of a scientific endeavor, rather than that of the development of a military weapon. It lacks, then, the vividly recounted military-scientific decisions characteristic of the Smyth Report. The general advances in the field of atomic energy are amply illustrated in the remarkable progress of the Harwell establishment. The magnitude of the administrative as well as the technological problems in setting up such an establishment is made clear to the reader. The social and political implications are left to his imagination.

The book contains an account of the establishing of Harwell in 1946 and of the subsequent progress. The major fields of research and technology undertaken at Harwell are described in detail, together with an indication of those related fields of technology which seem best handled by private industry rather than by a laboratory of fundamental research. The progress of reactor design and construction at Harwell is reported, together with the results and the future plans for fundamental research. The program of particle acceleration and associated research is also reported. The production and use of isotopes (radioactive and stable) are briefly discussed.

In addition to the programs of fundamental research, the associated technological problems which arise in such fields as chemistry, metallurgy, and medicine are described. Such typical problems as health protection for employees and disposal of waste products are also treated.

The reader will also find here an excellent description of the theory and design of such tools of research as the nuclear reactor, impulse accelerator, van de Graaff generator, cyclotron, betatron, synchrotron, and linear accelerator. In a general manner, many of the detection and monitoring tools of nuclear physics are described as well.

The book is, then, more than a history of an administrative effort; it is a progress report describing techniques and results. It succeeds in bringing to its reader an appreciation of the magnitude and ramifications of non-military atomic research by recounting the success at Harwell.

MESONS—A SUMMARY OF EXPERIMENTAL FACTS

by Alan M. Thorndike
McGraw-Hill, New York $5.50

Reviewed by Robert F. Christy
Professor of Theoretical Physics

THE CAREFUL READER of this book will indeed find a reasonably complete summary of experimental information available on mesons. It is complete in the sense that most of the relevant work is mentioned and referred to and some of the more

CONTINUED ON PAGE 6

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easily digested results are briefly quoted. It does not attempt a detailed discussion of very many items in the imposing list of references.

The diversity of the experimental material on mesons demands some guiding principle in the organization of the book. The author has chosen an essentially logical or didactic type of organization. Thus Chapter 1 provides the original evidence for the existence of mesons in cosmic rays and Yukawa's ideas on nuclear forces. Chapter 2 reviews the data on the properties of the cosmic-ray (mu) mesons such as mass, charge and spin. Chapter 3 discusses new types of mesons, pi and others. The discussion of the heavier particles is of course already out of date.

As far as the pi meson is concerned, only a small part of the findings (mass by grain counting) of the basic experiment in its discovery is given in Chapter 3 since the other findings can be logically included in later chapters. Chapter 4 discusses some of the fundamental experiments on artificial production of mesons, gives the mass of the pi meson, and describes the discovery of the pi-zero meson.

In Chapter 5 are collected data and experiments on meson decay. Here are the mu lifetime, its change for negative charge and larger Z, and its decay scheme. The decay experiments on the pi mesons include the range of mu mesons from pi decay and the mass of the pi, the decay scheme, and lifetime, and the decay of pi-zero mesons.

Chapter 6 covers the interaction of mesons with matter—both electromagnetic and nuclear. The Z^4 law of the capture of mu mesons is here brought out for the first time. Experiments on the star production of pi mesons and the capture of pi mesons in hydrogen are discussed.

The remaining chapters, 7 and 8, deal with the production of and experiments on mesons in cosmic rays. The subject matter here is of great diversity and is still only poorly digested.

The arrangement of the book, as outlined above, permits fairly ready access to the material as a reference source and it is probable that the book will find its greatest use as a reference on meson experiments, particularly as a guide to the literature.

The organization of the material has, however, also brought with it some very serious disadvantages. The fact that the original and striking experiments on pi-mu decay, for example, are dissected into three parts in as many chapters, prevents any appreciation or understanding of the work and leaves only a dry collection of apparently unrelated facts, devoid of interest to the reader. Nuclear capture of mu mesons has received similar treatment with the same result: what was an exciting and important discovery is presented, not only without interest, but also in such a way that an understanding of the interrelation of various types of experimental results is apt to be missed.

The book also suffers from the almost total lack of theoretical discussion and argument. Even although no complete or adequate theory of mesons exists, there are many points —such as meson spin and the selection rules in meson capture in hydrogen—where a little theory is very illuminating and can very materially help to tie together what is otherwise, as it is in this book, an undigested collection of facts.

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AUSTIN BUSH, inspecting stuffing box assembly on boiler feed pump.

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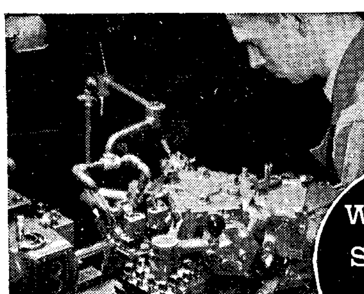

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LIBERAL EDUCATION

in Our Engineering Colleges

By EARNEST C. WATSON

MANY OF YOU probably consider my subject, "Liberal Education in Our Engineering Colleges," as paradoxical. Not so long ago, this would have been the case, but that time has passed, or is rapidly passing. In fact I propose here to expound and defend the thesis that many of our engineering schools today are providing a better liberal education than are some of our so-called liberal arts colleges and universities. I know that this is not universally true, but I think I can convince you that it is more often true than is generally realized. But even if I do fail in establishing this thesis, I can at least point up, in a rather striking manner, the changes that are taking place in our better engineering and scientific schools.

Please do not misunderstand me. This will not be an attack upon the liberal arts colleges. On the contrary, I firmly believe that the liberal arts colleges are a vital part of the system of higher education in this country and should be supported and strengthened in every possible way. But I also believe that they should be willing to profit by the experience which the engineering colleges have had, and are having, in resisting pressures which produce over-specialization; for, unfortunately, the liberal arts colleges, it seems to me, are experiencing—and in some cases yielding to—similar pressures at the present time. I should like to begin by quoting from a brochure issued recently by one of our best known engineering colleges:

"There may never have been a time, really, when the specialist was not a mainspring of society. But even if there has ever been such a time, now long gone, we live today in an age in which the specialist has become indispensable. We live in an age when the amount a man must know about his specialty is truly formidable.

"These circumstances have generated many fears about the education of specialists. It is well known that they are among the most intelligent and the most influential members of our society. We sometimes fear lest, in the necessary pursuit of their specialization, they shall not have time to develop a sense of proportion about the whole society of which, after all, even the noblest specialism is but a small part. Although developing a sense of proportion has to happen within the individual and over a considerable time, we suspect that the nature of his education may have something to do with his interest in developing such a sense.

"If the specialist does not develop this sense, those who worry about him and about society have two antipodal apprehensions. One is that the specialist, concentrating on his specialty, will let the rest of the world go by with the Pharisaical plea that it is 'out of his field.'

"The opposite fear is that the specialist may charge into difficult problems, confident in his skill in his own field, transposing that real skill to a fancied wisdom in another, and behave, as Ortega y Gasset suggests, with all the petulance of one learned in his own special line.

"No one in his senses would try to improve the situation by diminishing the skills of the specialists, by trying to turn back the clock. This could lead only to social disaster. Indeed, we actually need more specialists and better ones—they must know more about their specialty in the future, not less.

"On the other hand, it also appears that specialists will on the whole continue to exercise increasing influence on affairs outside their specialty. And this is the basic reason why those who are engaged in educating specialists in America are so concerned about the liberal education of the specialists."*

This is a problem which worries every educator who is concerned with the training of men for the professions. American engineering schools are, however, particularly concerned because of their realization that engineers and scientists are playing, and will continue to play, an increasingly important role in national and international affairs. They are key men, perhaps *the* key men of modern civilization.

This concern began developing about thirty years ago when some of our leading engineers, themselves graduates of engineering schools, pointed out that our engineering graduates, while well-trained technically, did not have the general background to assume the larger administrative positions that were opening up because of this country's rapid industrial development. They realized that in general engineers had not engaged in great policy-making experiments, but had remained essentially hired men without voice in ultimate policy or planning. And so these leading engineers began sending their own sons to liberal arts colleges for a few years before letting them enter engineering school.

This is certainly one possible solution to the problem, and it is still the procedure that is followed by the medical profession. However, some engineers and scientists, and in particular the great physical chemist, Arthur Amos Noyes, felt that it was not the best solution.

Science is for young men

Dr. Noyes pointed out that elementary science, since it is closely allied with keen boyhood interests, is absorbed better in the early years. Moreover, he was impressed by the interesting fact that many of the greatest scientific discoveries have been made by young men in their early twenties, and he clearly sensed what has now been well established by numerous vocational aptitude tests that vocational interests have definitely crystallized, in the case of over two-thirds of the population, before they are 19 years of age. As a result, he felt very strongly that students should begin their scientific studies early, before their interests and enthusiasms are diverted, and should not postpone getting into a creative scientific and engineering atmosphere until their graduate years. He also realized that cultural interests, on the other hand, usually awaken late and should be approached with a mature mind.

As a result, at the California Institute of Technology, although it is in many ways primarily a graduate school, able students have for the past thirty years been taken directly from the high school, while their enthusiasm for science or engineering is at its height, and have been immersed in a creative and research atmosphere where, right from the start, they have been allowed to study intensively the fundamentals that underlie all the scientific and engineering fields. At the same time, however, *and this I wish to emphasize*, they are required to devote a minimum of a quarter of their time to work in history and government, literature, economics, philosophy, psychology and the like—not for two years, but for four years; and even for five, if they go on for the master's degree.

These humanistic studies are not of the survey type, which are so likely to be superficial. Instead, they try to provide each student with as deep a knowledge as possible of a few intellectual disciplines, in which the ways of thinking are likely to be quite different from those in science and engineering. They, therefore, serve to enlarge the student's mental horizon beyond the limits of his immediate professional interest and thus better qualify him to realize his opportunities and fulfill his responsibilities as a citizen and member of society.

Humanities at Caltech

And the men who teach these humanistic studies are coming to be as distinguished in their own fields as are those who teach the scientific and engineering disciplines; in short, as distinguished as any in the nation. This we are accomplishing, even though we do not offer graduate work in these fields, partly because we have the Huntington Library as a close neighbor; but more especially because we are paying fair salaries and are allowing time for creative and scholarly work by requiring only relatively light teaching loads. Also the necessary funds for research are provided, as well as leaves of absence with full pay when facilities for the desired scholarly work are not available here.

Moreover, all members of the humanities staff at Caltech have to be good teachers as well as competent scholars for, whether they like it or not, they are forced by the fact that they are teaching at an engineering school to think both deeply and continually about why they are teaching what they are, and how they can improve their offerings both as to content and manner of presentation. In the liberal arts colleges, on the other hand, the liberal arts courses are taken for granted and do not have to be well taught. The instructor at Caltech, however, is being asked continually by his students, "Why should I be required to take this course?" and frequently by his colleagues, "Why should valuable time be taken from the professional courses I am teaching to provide for the sort of thing you do?" As a result, he discovers a new perspective in his teaching. He finds he has a mission and that this mission is closely related to that of his colleagues in other areas.

But you may well ask what the effect has been upon the professional success of our engineering graduates of our emphasis upon the humanities and the basic sciences at the expense of the traditional engineering applications. When we first introduced this program, our engineering staff all believed that our students would have to go on for a fifth year largely devoted to the applications in order to compete successfully with the graduates of other engineering schools. It was soon demonstrated, however, by their actual performance

* Bulletin of the Massachusetts Institute of Technology

that in the long run they did at least as well in industry as the graduates of these other engineering schools and that they almost without exception performed better in graduate work. We are now convinced that thorough basic training and greater breadth of background more than compensates for any lack of knowledge of the immediate applications. This provides a strong argument against the validity of the claims that more and more of the student's time must be devoted to work in his field of specialization if he is to be adequately prepared for graduate work.

But even so, the liberal education of our students is not left entirely in the hands of the humanities staff, for physics, chemistry, and even mathematics are generally recognized as liberal arts and in the hands of master teachers make a very real contribution to liberal as well as to special education. And I am sure that even our professional and graduate courses, when properly taught, add much to the moral and ethical character as well as to the technical competence of our students. It seems to me also, as Dean Dennes of the University of California has recently argued, that such basic notions as value, purpose, law, meaning, evidence, etc. are better taught as a part of our regular courses than in special courses artificially designed for the purpose.

Outside the curriculum

Finally, we are not neglecting that factor in the education of an undergraduate which lies outside the formal curriculum. The Institute encourages a reasonable participation in student activities of a social, literary or artistic nature, such as student publications, debating, dramatics, and music; and all undergraduates are required to take regular exercise, preferably in the form of intercollegiate or intramural sports. In fact, California Institute students not only engage in student activities, athletics, and social affairs, but they engage in them *more*, on the average, than do other college students.

The Caltech undergraduate can (and does) take part in a wide range of campus activities, including an efficient student government organization, and an honor system that really works. He can (and does) engage in religious activities arranged and sponsored by his own Y. M. C. A. He can (and does) have access to a comprehensive library of recorded music which he listens to in a comfortable lounge. (This facility is, in fact, in use on an average of 14 hours a day.) He can (and does) sing and play good music under a trained leader, and hear concerts by leading string quartets, instrumentalists, vocalists, and symphony orchestras. He can (and does) attend extra-curricular lectures on music theory and appreciation. He can (and does) participate in Saturday classes in art under an experienced teacher. He can (and does) attend lectures by authorities in varied fields. He can (and does) make good use of a Public Affairs Room where magazines, newspapers, government documents and educational material from all over the world are received regularly by air mail. And, believe it or not, Caltech students, entirely on their own initiative, have started publishing a literary magazine.

So, in short, every effort is made to carry on a well-rounded, well-integrated program which will not only give the student sound training in his professional field but will also develop character, wisdom, taste, ideals, breadth of view, general culture, a sense of values and physical well-being, as well as intellectual power.

Specialization and general education

But you say, isn't this just what the liberal arts college is set up to do and actually does better than an engineering school can do? Admittedly, I have too little first-hand information to appraise fairly the general education programs of the liberal arts colleges. I have, however, observed what is probably a better than average sampling of the graduates of our liberal arts colleges among the students who come to the California Institute for graduate work, and frankly I am not always happy with what I see. In many, if not the majority of cases, these liberal arts graduates are more highly specialized than our Caltech graduates and have actually had less work outside their field of specialization than have our own students. Moreover, the liberal education they have had has mostly been concentrated in their first two years of college, when they were still too immature to derive much benefit from it. As a result, in order to satisfy our requirements for the master's degree, they have, much against their will, to make up undergraduate prerequisites—not in science and engineering, but in the humanities.

Liberal education and liberal arts

I have also examined the curricula offered by a number of liberal arts colleges, and when I have had the opportunity I have spot-checked the program cards of randomly selected students. My findings may not be typical but for what they are worth, they are as follows:

(1) The amount of time which a liberal arts student is required to spend outside his field of specialization is no greater than in an engineering school. Many so-called liberal arts institutions grant the B.A. and M.A. degree on programs of study that include less than 20% of humanistic courses, and I know of Bachelors of Arts whose total studies in the humanities consist of a course in English composition and a course in citizenship.

(2) Students in liberal arts colleges are in general encouraged to complete their general education requirements during the first two years.

(3) The subjects allowed for satisfying the general education requirements are often either so diverse as practically to defeat the purpose of providing the basic core of a liberal education or are survey courses that do not require of the student any deep digging outside his field of specialization.

(4) The demand of specialization and the desire to

prepare students adequately for graduate work have caused the introductory courses, not only in the sciences but also in the humanistic and social fields, to become steps in the ladder of professional advancement rather than the introduction to liberal disciplines. Thus many of their values for a liberal education have been lost.

What all this adds up to is that while a student probably can obtain a liberal education in a liberal arts college, he often fails so to do, particularly if he is interested in going on for graduate work. As Oliver C. Carmichael, President of the Carnegie Foundation for the Advancement of Teaching, wrote recently, "the liberal arts college has to some extent lost its identity and its position as a dominant element in higher education. It has become more a service agency teaching the tools of learning, introducing the student to the broad fields of knowledge through elementary or watered-down survey courses, providing pre-professional courses for medicine, law, the ministry, nursing, etc., and preparing students for the graduate school through a kind of specialized training in some field, styled his major. The broad liberalizing program in terms of which the college is usually described simply does not exist in many institutions called colleges of arts and sciences."

It would be exceedingly interesting if objective tests could be conducted on a nationwide scale to evaluate the results of the various and sundry general education programs that are under way in many of our colleges and universities. To the best of my knowledge such tests have not yet been conducted. Nevertheless, I should like to cite the results of two types of test which are available. These results, it seems to me, shed some light upon the major question of how good a job of liberal education the engineering colleges are doing. More particularly, they refute the charge which is so often made that the engineering student has no interests beyond mechanical gadgets and only a rudimentary sense of values.

Some test results

You might expect engineering students to score well on the College Entrance Board mathematics aptitude tests—and of course they do. But would you expect that more than 75% of Caltech students do better than the national average on the verbal aptitude test? And does it surprise you that on a nation-wide test of college sophomores, taken by 11,700 students in 128 predominantly liberal arts colleges, Caltech students topped the lists by a considerable margin?

The facts are these: In the spring of 1952, Caltech participated in the National College Sophomore Testing Program. The tests, which were designed to measure objectively the students' abilities and interests in major areas of college study, were of three types: (1) an English Test, covering *Mechanics of Expression, Effectiveness of Expression* and *Reading Comprehension;* (2) a General Culture Test, including *History and Social Studies, Literature, Science, Fine Arts,* and *Mathematics;* and (3) a Contemporary Affairs Test, indicating current interest in and information about ***Public Affairs, Science and Medicine,*** and ***Literature and Arts.***

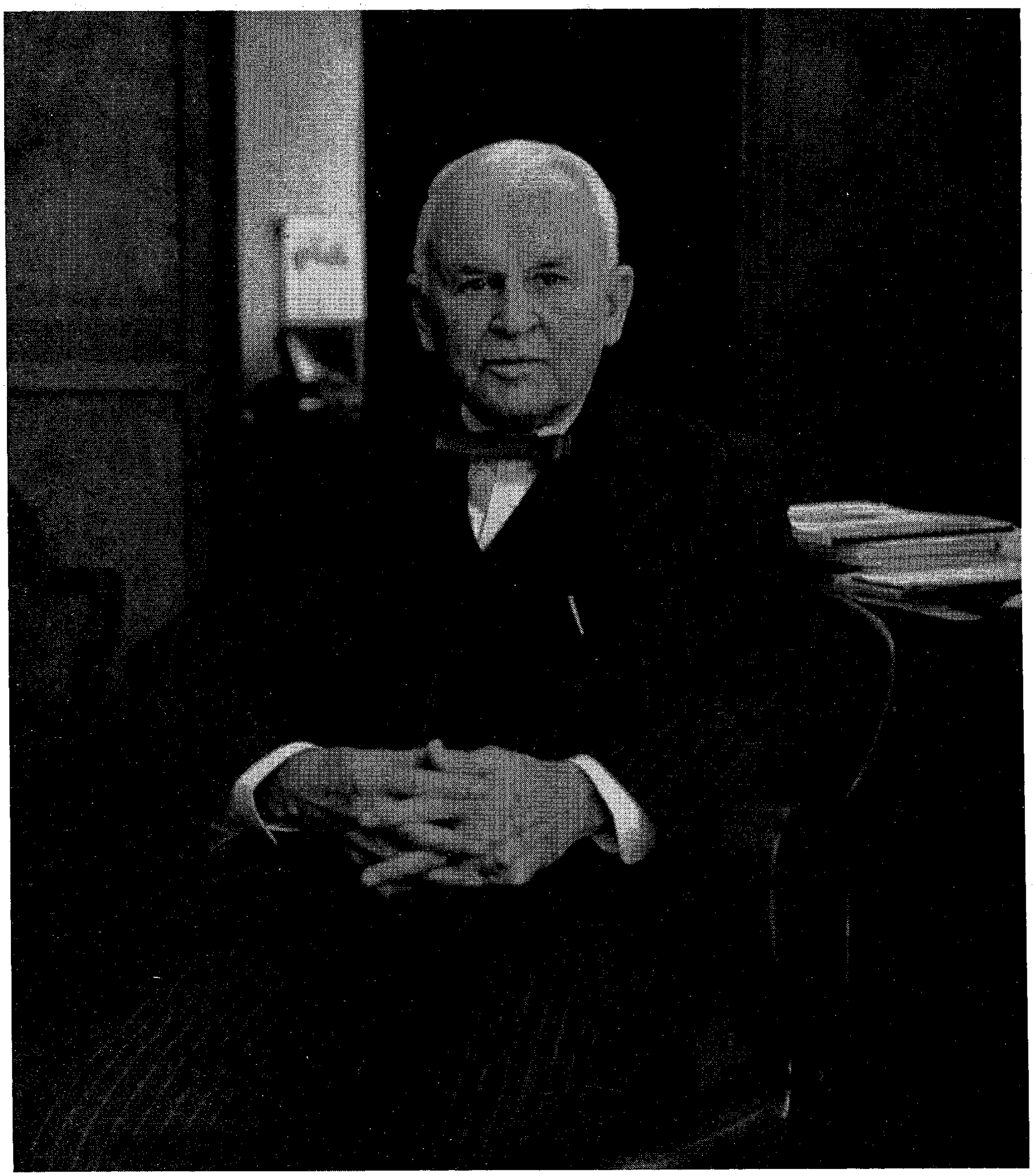
When the scores of the 128 participating colleges were ranked, Caltech stood third in the English Test with a score of 66.3. A women's liberal art college was first with a score of 67.1 and a coeducational liberal arts college second with a score of 66.6. In the General Culture Test and the Contemporary Affairs Test, Caltech students were way ahead of the rest. On General Culture Caltech scored 203, with the second college scoring 161.9, the third college 160. On Contemporary Affairs Caltech scored 67.9, the second college 54.8, the third college 53.8.

The liberally-educated man

A recent committee report by members of the faculties of Andover, Exeter, Lawrenceville, Harvard, Princeton, and Yale, entitled *General Education in School and College,* characterizes "the liberally-educated man" as follows:

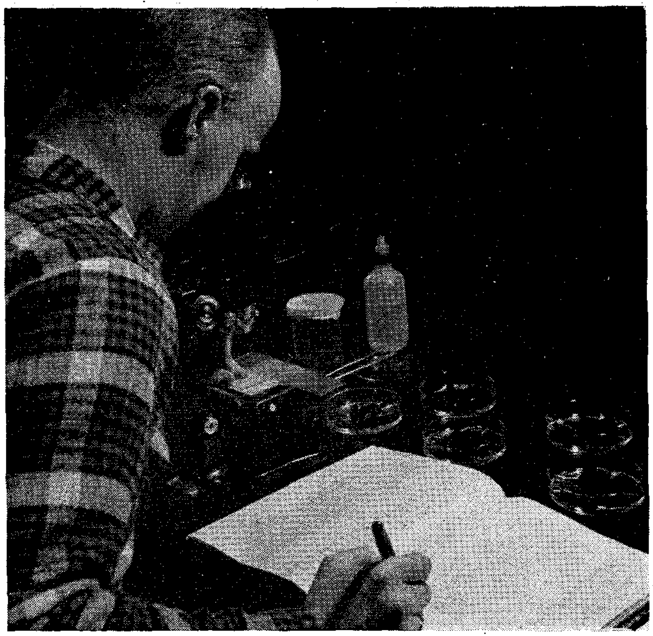
"The liberally-educated man is articulate, both in speech and writing. He has a feel for language, a respect for clarity and directness of expression, and a knowledge of some language other than his own. He is at home in the world of quantity, number and measurement. He thinks rationally, logically, objectively, and knows the difference between fact and opinion. When the occasion demands, however, his thought is imaginative and creative rather than logical. He is perceptive, sensitive to form and affected by beauty. His mind is flexible and adaptable, curious and independent. He knows a good deal about the world of nature and the world of man, about the culture of which he is a part, but he is never merely 'well-informed.' He can use what he knows, with judgment and discrimination. He thinks of his business or profession, his family life, and his avocations as parts of a larger whole, parts of a purpose which he has made his own. Whether making a professional or a personal decision, he acts with maturity, balance, and perspective, which comes ultimately from his knowledge of other persons, other problems, other times and places. He has convictions, which are reasoned, although he cannot always prove them. He is tolerant about the beliefs of others because he respects sincerity and is not afraid of ideas. He has values, and he can communicate them to others not only by word but by example. His personal standards are high; nothing short of excellence will satisfy him. But service to his society or to his God, not personal satisfaction alone, is the purpose of his excelling. Above all, the liberally-educated man is never a type. He is always a unique person, vivid in his distinction from other similarly educated persons, while sharing with them the traits we have mentioned."

This is, I believe, the type of man that our better engineering schools, as well as our liberal arts colleges, are trying to produce. It is absolutely essential that our specialists be such liberally-educated men if our democratic society is to survive.



R. A. MILLIKAN . . . A Birthday Portrait

On March 22 Robert A. Millikan celebrates his 85th birthday—though it's a safe bet that the celebration won't begin until after he has put in a full day's work in his office. Officially retired in 1945, after serving for 25 years as Chairman of the Institute's Executive Council, he is still active as Vice-President of the Caltech Board of Trustees, and Chairman of the Board of the Huntington Library.



Measuring chemically-induced elongation of plant sections

PLANT HORMONES

By JAMES BONNER

Basic studies on plant hormones have resulted in the development of a new science — the science of the chemical control of plant growth

THROUGH BASIC WORK on the plant growth hormones, the concept has become available to us that particular substances may be applied to the plant to accomplish particular useful purposes—to make the leaves drop off, to make the fruit stay on, to induce flowering, to inhibit flowering, and even to kill undesired plants.

The different chemicals which are used for the supervision of these varied aspects of plant development are also without exception substances whose biological effectiveness is based upon structural similarity to one or another of the native plant growth hormones. Since a great many substances have been investigated or screened as to ability to evoke this or that plant growth response, we have today what is almost a pharmacology of plants.

It is, of course, well known that the growth of the plant depends upon the process of photosynthesis by which the carbon dioxide of the air is transformed into the manifold materials of which a plant is made. The growth of the plant is dependent, too, on the water and on the varied mineral constituents of the soil which are ordinarily taken up by the root and incorporated into plant materials.

As photosynthesis, mineral uptake, and the chemical transformations of metabolism proceed, the plant increases in size and in mass, and, in due course, proceeds from the vegetative state to a reproductive one. The total increment of plant which occurs as a result of synthetic reactions must be apportioned between the several organs, the roots, leaves, stems, and, ultimately, the flowers and fruits.

It is the harmonious integration of the development of the several plant organs and tissues in space and in time which appears to be the primary function of the plant hormones. Each of these materials is produced in a particular organ in minute amounts, and is then transported to other organs where it brings about a specific effect on growth. It is through the growth hormones that the individual parts of the plant interact with one another and mutually regulate one another's growth.

That the growth of the root is dependent upon specific chemical substances which are normally supplied by the aerial organs can be shown simply and elegantly by the cultivation of the excised tips of roots. If we remove a tip a few mm. long from a growing root and place this in an appropriate nutrient solution the tip will grow into a whole root. If the nutrient solution has been correctly selected, the excised root will, in fact, grow in length as rapidly as it would have done had it remained attached to the intact plant.

We may now ask ourselves what chemical substances must be added to the nutrient solution used for the culture of excised roots in order to bring about continued root growth. One knows *a priori* that an appropriate nutrient solution must contain a carbohydrate, which may be used by the root tissue as a respiratory substrate, and which may serve as a source of building blocks for the synthesis by the root of the many substances of which roots are made.

The nutrient solution must also contain the inorganic nutrients which plants require for their growth. A nutrient solution containing only mineral salts and sucrose, however, is inadequate for the cultivation of excised roots. An excised root tip of flax, for example, cultivated in such a nutrient, ceases its growth in a few days or a few transfers. In order to cause excised flax roots to grow at the normal rate, it is necessary to add a small amount of thiamine to the nutrient solution. All of the species of excised roots which have been studied up to the present time require thiamine and, in general, one or both of the vitamins pyridoxine and niacin, in order to continue growth as isolated roots.

It is possible by simple plant physiological experiments to show that these three vitamins of the B complex are produced in mature green leaves, primarily in the light. They are then transported from the leaf, through the stem to the root. Since roots cannot produce these vitamins, and since these materials are required for root growth, thiamine, pyridoxine, and niacin constitute root growth hormones.

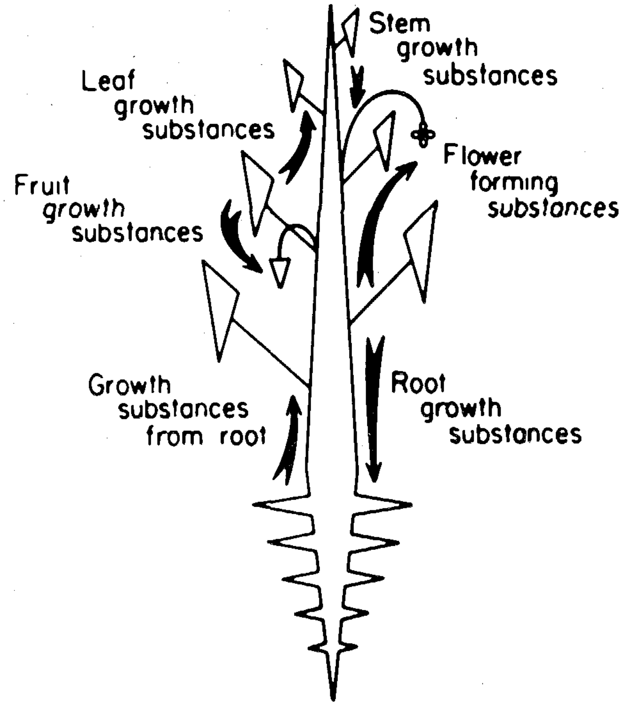
Other types of growth hormones

The same basic kind of experiment used for the demonstration of the presence in the plant of root growth hormones may be used for the demonstration of the existence of other types of growth hormones as well. Thus, we know of leaf growth hormones, stem growth hormones, fruit growth hormones, and hormones for the initiation of flowering.

We must then visualize the growing plant as containing many currents of transport of a variety of growth regulating substances. The mature leaves produce the vitamins of the B complex which are transported to and used in the regulation of root growth. The same leaves produce the leaf growth factors such as adenine, as well as the hormones which regulate flower initiation and reproductive development—hormones which are possibly protein in nature.

Still other factors produced in the roots are required for the growth of the aerial parts. And to this array of known or suspected correlational carriers we will doubtless add, in the future, further hormones whose existence is not even suspected today.

A major portion of our knowledge of plant growth substances has been derived from the study of one particular group of materials, known collectively as the auxins. This term is a physiological one, and the auxin concept is physiological rather than chemical. An auxin is a substance produced in the apical bud and young leaves of the plant and transported from this point to the growing region of the stem, where it is used in the support of stem elongation.

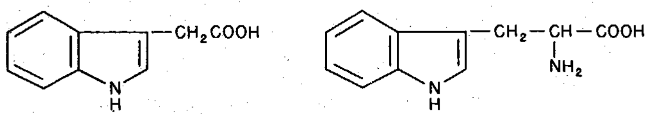


Within the plant are varied currents of hormone flow.

It can be simply demonstrated that special chemical substances have to do with the regulation of stem elongation. If we excise sections from the growing region of, say, a seedling oat plant, and place the sections in a nutrient solution containing only sugar and mineral salts, they grow but little. However, if we add a small amount of indole acetic acid (IAA) to the nutrient solution, the rate of growth of the sections is greatly increased, and may in fact achieve or surpass the rate normally attained in the plant.

That IAA is a naturally occurring plant material has been shown by isolation from a variety of plant products. It is produced in the apical bud and young leaves and transported downward through the stem and thus satisfies the requirements of the auxin concept. IAA is in fact the best known and perhaps the most important of the stem growth regulating substances produced by and used by the plant.

Although the relation of IAA, and of auxins generally, to plant growth was first appreciated in relation to stem elongation, we know today that the functions of this hormone are actually manifold. IAA appears to act as a master hormone, inciting cells or tissues to activities of the most varied kinds. Among the terminal manifestations of auxin-induced activity are growth in length (stems), suppression of growth in length (roots), induction of cell division in the cambium, in callus and in tumors, inhibition of leaf and fruit fall, production of adventitious roots, and finally the production or nonproduction of other and more specific hormones which are in turn responsible for further responses, such as the initiation of reproductive activity.



Indole-3-acetic acid   Tryptophan

Indole acetic acid is related to—and derived from—the amino acid tryptophan.

It is precisely because of the wealth of different responses which can be brought about by appropriate auxin application that plant hormone therapy has assumed such agricultural significance today and this therapy is in turn largely based on our knowledge of auxin physiology.

Auxins: native and synthetic

IAA, as is shown above, consists of an indole nucleus to which an acetate side chain is appended at position 3. It is thus related in structure to the amino acid tryptophan, and is in fact synthesized in the plant from trytophan by a series of reactions mediated by an enzyme system which is found in apical buds and other centers which possess the ability to generate the hormone.

Approximately 15 years ago it became known through the work of Haagen-Smit and Went that IAA is not alone in its ability to regulate the stem growth of plants. Certain related chemical substances, not necessarily naturally occuring, were found to be able to duplicate the effects of IAA in causing the elongation of excised sections of stems of oat coleoptiles. Naphthalene acetic acid is not a naturally occurring plant material. It is a chemical substance which is able to simulate the effects of a plant hormone, although it is not itself a plant hormone. In the years since 1935 a very great number of compounds have been tested for their ability to replace IAA in the induction of plant growth responses. So much study has been put into this matter that at present our knowledge of the relation of chemical structure to biological activity among the auxins is one of the best documented studies of this nature. Let us therefore see what new insight into auxin physiology these intensive chemical studies have given us.

The conclusions which we draw from the study of the activity or non-activity of a great many different substances may be summarized in the empirical rules that a compound, in order to manifest auxin activity, must possess the following minimum qualifications: (1) A ring system containing at least one double bond; (2) A side chain ending in a carboxyl group; (3) Ability to assume a certain configuration in which the carboxyl group is suitably arranged relative to the ring system.

It has recently become possible to define more closely the role of the cyclic unsaturated nucleus in relation to auxin activity and from this to learn more concerning the biochemistry of auxin action.

Muir, Hansch and Gallup (1949) of Pomona College have shown that a compound, to be active as an auxin, must possess in its cyclic nucleus a substitutable hydrogen or other group of a minimum critical reactivity. This reactive position is in general either of the two positions ortho to the carboxyl group containing side-chain. This is shown by the example below. The ortho reactivity of phenoxyacetic acid is increased by halogen substitution in the 2 and 4 positions and 2,4-D is active as an auxin. Blocking of both ortho positions renders the molecule inactive.

It appears, then, that a molecule, to be an auxin, must possess not only a carboxyl group but also a cyclic nucleus with an ortho group of some critical reactivity. These two functional groups must further be capable of assuming some suitably spatial relationship with one another. All of our present knowledge of structure and activity among the auxins appears to be qualitatively encompassed by this generalization.

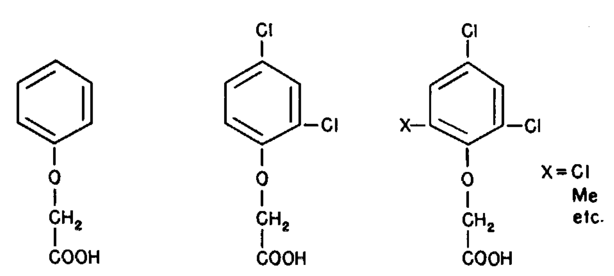
Two-point attachment

The fact that auxins act at low concentrations suggests at once that they may perform their work in promoting growth by acting as prosthetic groups of an enzyme or enzymes; that in short they may be bound to protein in the plant.

It has long been known that auxin is in fact bound to protein within the plant and that auxin thus bound may be again released by proteolytic hydrolysis. This suggests that the carboxyl group of the auxin molecule may be involved in the binding, perhaps through the formation of peptide-like linkages. That the ortho group is also involved in chemical reaction within the plant, and that this is also related to binding, is indicated by both chemical and kinetic studies.

We may suggest, therefore, as a tentative working hypothesis, not only that the auxin molecule possesses two reactive functional groups, but that the molecule, in carrying out its growth-promoting task, reacts with and binds to two suitable receptor sites within the plant.

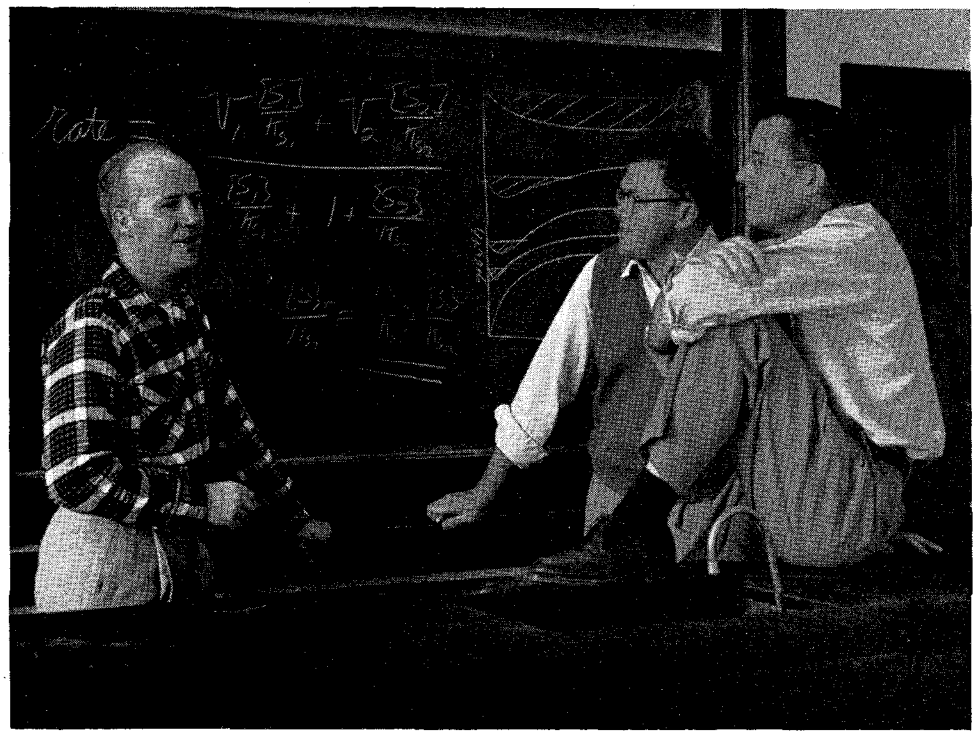
This concept—the two-point attachment concept—has served as a fruitful basis for, and is strongly supported



Phenoxyacetic acid (POA) INACTIVE   2,4-Dichloro POA (2,4-D) ACTIVE   2,4-Dichloro 6-X POA INACTIVE

Growth substance activity can either be increased or decreased by the proper ring substitution.

D. Harold McRae, Robert J. Foster, and James Bonner—Caltech co-workers on the chemical control of plant growth. The equation they're discussing here describes plant growth rate for cases in which two growth substances are simultaneously applied.

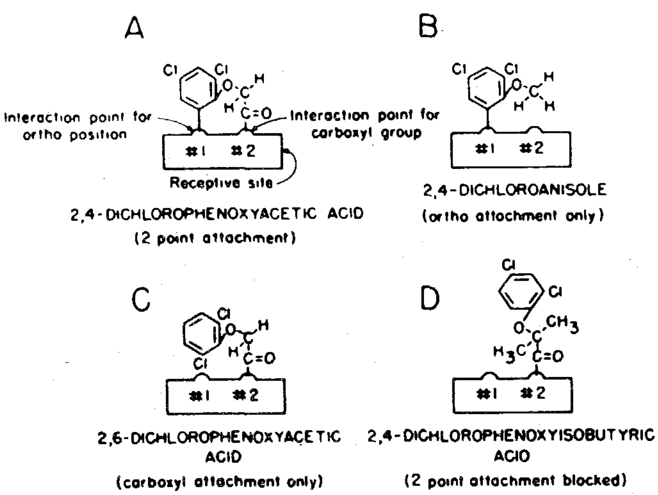


by, further experimentation, particularly in the way of auxin antagonists.

Inhibition of growth

The extensive studies of D. H. McRae have shown not only that an active auxin is normally bound to the plant receptor entity through its two reactive groups, but that in addition a substance capable of combining with but one site of the receptor entity and incapable of consummating two-point attachment is thereby an antiauxin—an inhibitor of auxin action. Examples of antiauxins and the way in which they act to block receptor molecules are shown below.

The effect of auxins in promoting plant growth, like the effects of so many biologically active substances, is a twofold one. Although auxins promote plant growth over a wide range of relatively low concentrations (10^{-8}-10^{-5}M), *at still higher concentrations the same substances become inhibitory.* Thus, if we plot growth rate against concentration of added auxin we find that the hyperbolic relationship of growth rate to auxin concentration obtains up to a concentration of roughly 10^{-5}M. At this concentration, growth rate passes through a maximum and dies away to 0 as the concentration is still further increased.

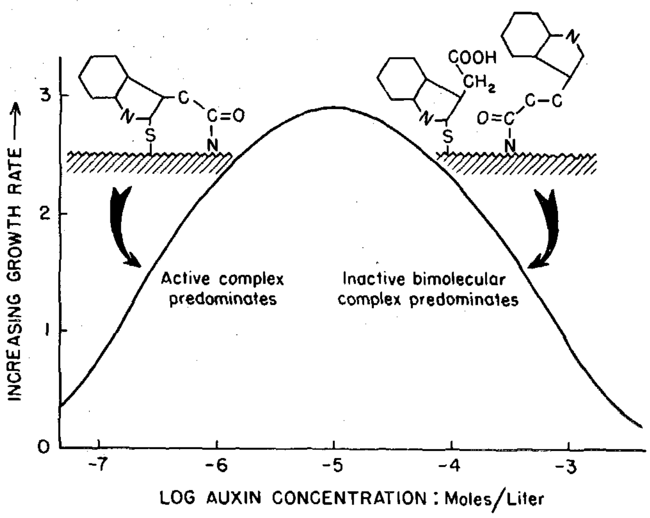


Growth substances are active by consummating two-point attachment. Molecules which can make only single-point attachment are growth inhibitors.

That auxins in high and unphysiological concentrations elicit growth inhibitions of this type has been known for many years. This effect now assumes new interest and importance, since it can be shown that such a dual growth response is a natural and indeed an inescapable consequence of the two-point attachment by which the auxin molecule is bound to the receptor entity within the plant.

Auxin-induced growth inhibition appears to be nothing more than the kinetic expression of two-point attachment. Let us consider the sequence of events which leads to the formation of the active auxin-receptor complex. A molecule of auxin, IAA for example, approaches the receptor entity and combines with it through one of its two functional groups. After a suitable period of twisting it adjusts itself in such a manner as to be able to consummate its second point of attachment through its second functional group.

Now let us consider the sequence of events at higher auxin concentrations. At some sufficiently high concentration the probability will become appreciable that two molecules will simultaneously approach the receptor entity and will simultaneously combine with it. In this instance, one auxin molecule will necessarily become attached through its carboxyl group while the other must attach through its reactive ortho position. Each molecule will therefore prevent the other from consummating the two-point attachment which, as we have seen, is essential to the manifestation of auxin activity. The bimolecular auxin-receptor complex is therefore inactive in promoting growth, and to the extent that such bimolecular auxin-receptor complex formation occurs, growth rate will be depressed, as is summarized in the chart at the right.



The inhibition of plant growth by auxin at high concentrations is due to bimolecular complex formation.

Conclusion

It is a matter for some intellectual satisfaction that the structural demands for auxin activity can be resolved into three simple and inclusive requirements; namely, (a) a requirement for a carboxyl group, (b) a requirement for a critically reactive ortho group, and (c) a requirement for a specific spatial relationship between these two. These three requirements must, as we have seen, all have their basis in the nature of the binding of the auxin molecule to its receptor entity within the plant. In any case we are now in a position to predict with some assurance the activity or inactivity of further compounds. In any future search for new materials with auxin activity, the past approach of empirical and indiscriminate screening might well be replaced by an approach based on thoughtful consideration of the structures involved.

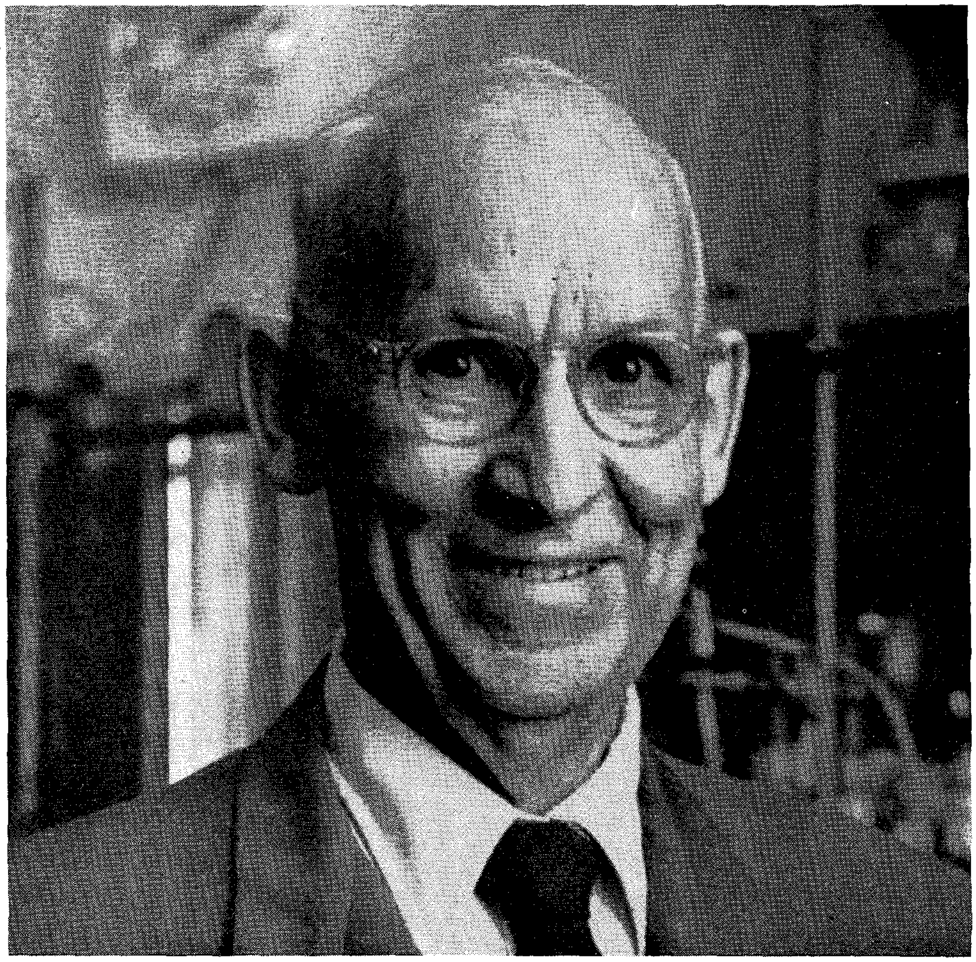
Of more importance to physiology, however, is the insight which the two-point attachment concept has given us into the structural requirements for antiauxin activity. An antiauxin is, it appears, merely a prospective auxin in which one of the three above requirements is not fulfilled. Through applications of this knowledge a number of highly effective antiauxins have already been made available and it is already apparent that these materials may fill a host of agricultural needs. A hormone is by its very nature normally contained in the living creature, and the kinds of responses which may be elicited in this creature by the application of further hormones are necessarily limited. The antiauxins now offer us the opportunity to practice a chemotherapy of plants which is the obverse of that which we practice with 2,4-D.

Finally, the two-point attachment concept of auxin action has provided us with new insight into the nature of the deleterious effects of high auxin concentrations. This, in turn, has illuminated the question of why it is that a synthetic growth substance such as 2,4-D, which behaves as an auxin at low concentrations, is nevertheless so extremely deleterious as to be herbicidal at higher concentrations.

IAA itself cannot ordinarily be used to kill normal green plants, since most such plant tissues are equipped with an enzymatic system for the removal of IAA in excess of a concentration which is well below those which give complete growth suppression. This safety mechanism does not work with such non-native materials as 2,4-D, which are then free to accumulate in plant tissues in concentrations which appropriately reflect those applied. It is characteristic of the 2,4-D concentrations which are used for herbicidal purposes that they are far into the range at which bimolecular complex formation must be expected to predominate. Herbicidal activity of an auxin may therefore be nothing more than an extreme expression and ultimate consequence of the two-point attachment principle.

We have seen that, in the plant, communication of information as between the separate and varied organs and tissues is mediated by a complex system of appropriate chemical materials. Integration, control and synchronization of the plant's activities are established and maintained by a whole series of hormones, each of which bears from its point of origin to other receptor points an appropriate signal and evokes appropriate responses. Only when we view the plant as a whole can we perceive the wonderful and complete autotrophism of these organisms, their ability to transform such simple materials as carbon dioxide, water, light energy, and a few mineral elements into the complex array of organic substances which constitute living matter. The individual organs and tissues of the plant are appreciably less autotrophic than is the whole, and are each dependent upon other organs and tissues for particular and specific chemical substances. Thus, in a sense, the plant makes use of slight variations in its autotrophism to assure the harmonious development of its several parts.

The fact that plant growth and development is so firmly based on hormonal relationships gives us a corresponding opportunity to control and modify the course of plant development by the artificial application of chemical substances which are either identical with, synthetic substitutes for, or antagonists of the native hormones.



HOWARD J. LUCAS

Professor of Organic Chemistry at Caltech for nearly 40 years, he's achieved real success in his favorite field of research — the synthesis of chemists

At the American Chemical Society's National Meeting in Los Angeles this month Howard J. Lucas, Caltech Professor of Organic Chemistry, will receive the 1953 Scientific Apparatus Makers Award in Chemical Education.

This $1,000 award goes each year to a man who has made "outstanding contributions to chemical education considered in its broadest meaning, including the training of professional chemists; the dissemination of reliable information about chemistry to prospective chemists, to members of the profession, to students in other fields, and to the general public; and the integration of chemistry into our educational system."

As anyone can see, it takes quite a man to qualify for this award—and yet the qualifications, when applied to Howard Lucas, sound like a straightforward description of his life's work.

Professor Lucas has been in charge of the undergraduate courses in organic chemistry at Caltech for 38 years, and it is a gauge of his success as a teacher that a good many of his former students are today outstanding organic chemists themselves. At a gathering of professional chemists such as the ACS meeting in Los Angeles this month, Professor Lucas is likely to run into something like 200 of his old students.

For the past quarter of a century Professor Lucas has been identified with the field of modern organic chemistry. He was one of the first chemists to recognize the value of electronic interpretations of chemical data, and he has made numerous contributions to the understanding of the electronic structure of organic molecules.

In 1935 he established the pattern for all modern elementary textbooks in organic chemistry when he published the first text in the field which related organic chemistry to modern chemical theory. More recently, he collaborated with Dr. David Pressman, one of his former students who is now head of the Immunochemistry section of the Sloan-Kettering Institute for Cancer Research, on "Principles and Practice in Organic Chemistry," a book which has already become a standard work in the field. He's also published more than 85 papers. Many of these, too, have been collaborations with students.

Biography of a chemist

Howard Lucas was born on March 7, 1885, in Marietta, Ohio. His grandfather was a steamboat pilot on the Ohio River, his father one of the first telegraph operators in the country. Howard went to high school in Columbus, Ohio, then entered Ohio State University, where he developed an immediate interest in chemistry. By his senior year he was working as an assistant in the freshman chemistry lab, getting his first crack at teaching —and liking it. As a graduate assistant in organic chemistry, he decided to make a career of teaching in that field. After he got his M. A. at Ohio State in 1908 he spent a year in research at the University of Chicago, then took a position as assistant chemist with the Chicago laboratories of the U. S. Department of Agriculture.

The Chicago laboratories, at that time, were busy developing standards of purity for all kinds of food products, and getting evidence against violators of the Pure Food Law. A good deal of Howard's work involved the analysis of commercial food preparation and tests for adulterants, and his experience led, in 1912, to his spending a year as a chemist for the government of Puerto Rico.

In 1913 he came to California to find a teaching job, and joined the staff of the predecessor of Caltech, the Throop College of Technology. He was one of three chemistry instructors for a student body of 55 or 60 then. Today, he's got the longest service record of anyone in the Caltech chemistry department—and one of the longest of the whole Caltech faculty.

He has served, at various times, on the Institute's Registration Committee, Student Relations Committee, Faculty Board, and Industrial Relations Committee. In 1941-42 he was Resident Associate of Fleming House.

Like most noted teachers, Howard has a few classic classroom idiosyncrasies. The most prominent of these is an aversion to sneezers. When, in the course of a routine lecture in Ch 41, a student callously allows a sneeze to run its full course, from the first faint tingle in the nose to the final cataclysmic blatt, Professor Lucas' reaction is as immediate as it is predictable. Barely pausing in his flight across the room to shout a few dire imprecations at the spent but happy sneezer, he flings open the window and takes several heady draughts of fresh air before returning to the subject of his lecture.

Inevitably, of course, sneezing often reaches epidemic proportions in Ch 41.

Consulting

For a number of years (1932-40) Howard was a consultant for the Kelco Company of San Diego, manufacturers of sodium alginate. He helped to develop the use of this compound in such food products as chocolate milk, ice cream, and salad dressing. As a result, sodium alginate has largely displaced gelatine in these and other food products.

During World War II he was an official investigator for the National Defense Research Committee of the Office of Scientific Research and Development at Caltech, working on hard protective coatings for optical plastics.

He's been a member of the American Chemical Society since 1907, the year he was graduated from college. He served as chairman of the Southern California Section of the ACS in 1931-32. He is also a member of the American Association for the Advancement of Science, Sigma Xi, and Phi Beta Kappa.

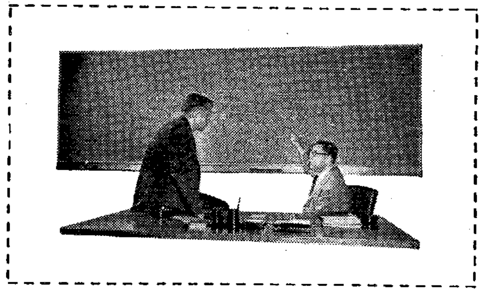
A bachelor, Howard used to be an avid mountain-climber and camper. He's tapered off on this outdoor activity in recent years, however—though he's compensated to some extent by sharpening up his bridge-playing.

Chief field of endeavor

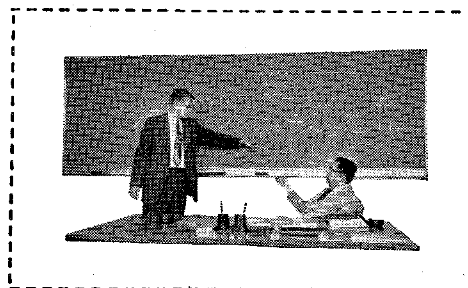
His chief interest, though—now, as always—is his students. His real field of endeavor, as he explains it, is the synthesis of chemists from the raw material of Caltech undergraduates. The award he is receiving from the American Chemical Society this month is one indication of how well this synthesis works.

It is fitting that this tribute comes at a time when Howard Lucas is turning over his Caltech classes in organic chemistry to a new man (p. 28), in preparation for his own retirement. It's an impressive addition to the many tributes Howard has received in his long career. Of all these tributes, though, probably the simplest and soundest was paid him by one of his colleagues.

"Of all chemists," he said, "the one most easy to get along with. Of all scientists who would be justified in having a little intellectual pride or snobbery, none ever has less."



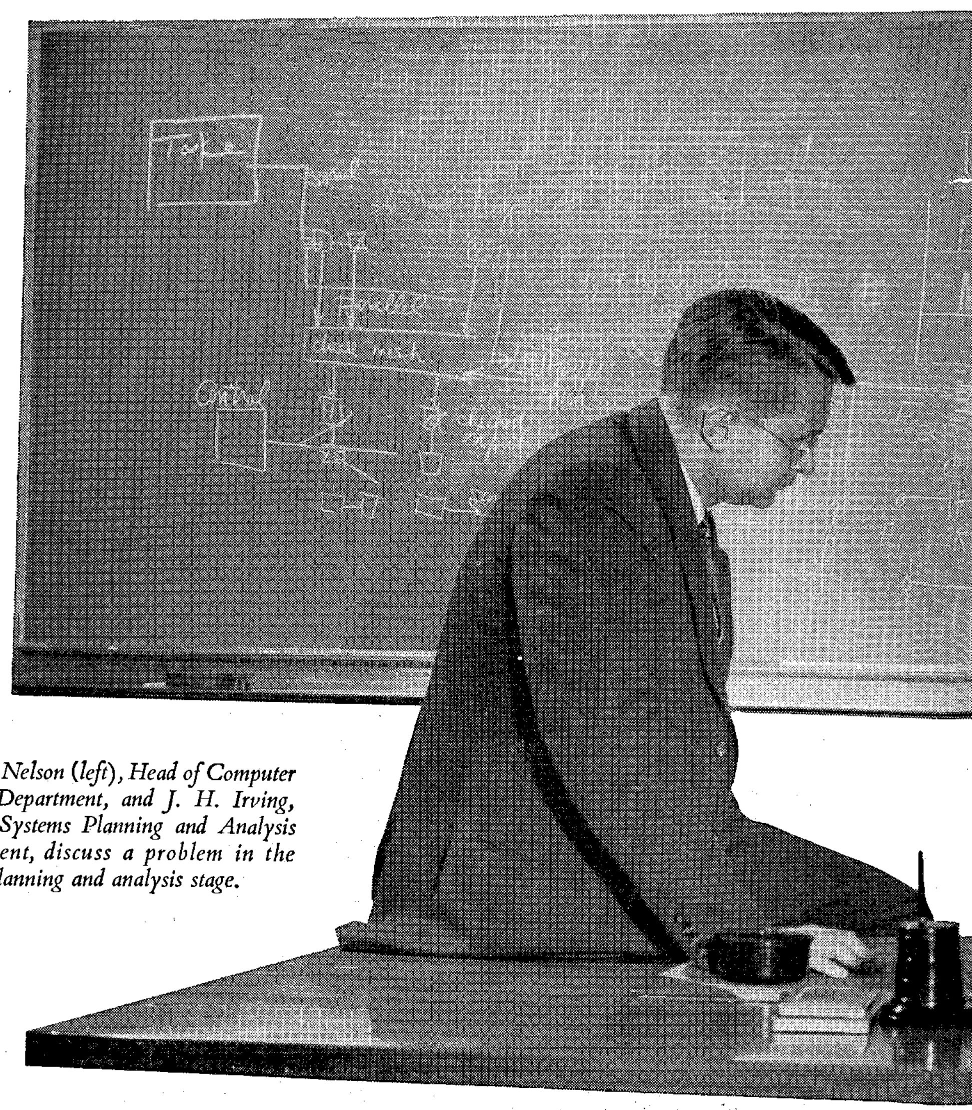
PLANNING THE RIGHT ANSWERS



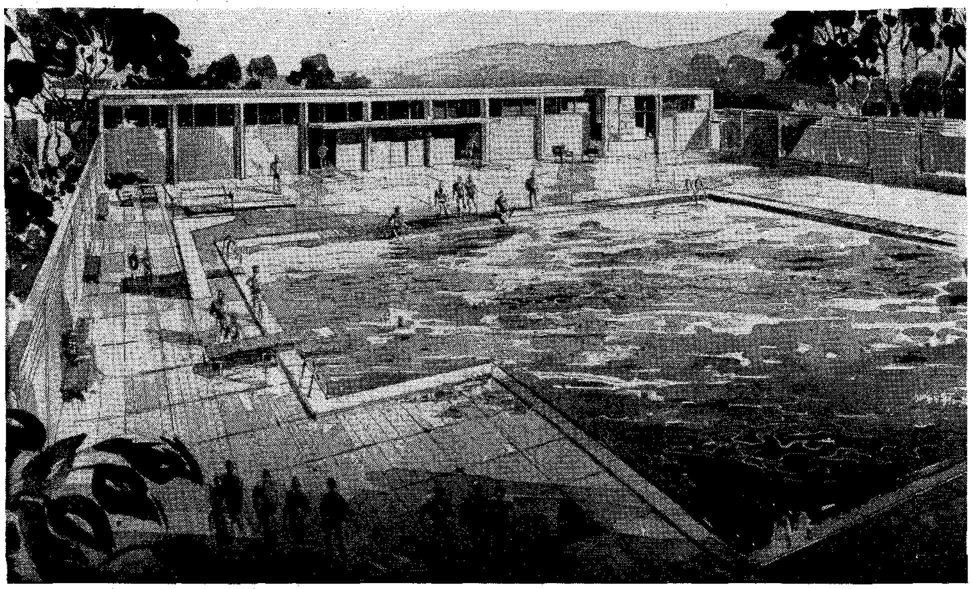
The complexity of modern air defense—extreme aircraft speeds, highly complex weapons, new combat strategies, the advanced state of today's technology—poses serious problems for the scientist and engineer.

One significant solution lies in the extensive use of airborne automatic equipment, including electronic digital computers, to augment or replace the human element in aircraft control.

At Hughes Research and Development Laboratories



Dr. E. C. Nelson (left), Head of Computer Systems Department, and J. H. Irving, Head of Systems Planning and Analysis Department, discuss a problem in the systems planning and analysis stage.



THE MONTH AT CALTECH

Pool and Gym

WITHIN THE MONTH, plans were announced for construction of both a swimming pool and a gymnasium at the Institute.

The pool came first. As contributions to the Alumni Fund approached the $150,000 goal, the Caltech Alumni Association announced contruction details of the new Alumni Swimming Pool. It will be located at the south end of the parking lot in Tournament Park. It will be L-shaped, covering 3,870 square feet. The adjacent locker rooms will cover 4,000 square feet and will include dressing rooms, showers and other facilities.

The pool will be built in the shape of an "L" to make it more versatile than the usual rectangular pool. It will provide a relatively shallow, six-lane, 75-foot-long racing section in the long leg of the "L"—or a deeper, 40-by-50 foot water polo area by utilization of the short leg of the "L". Suitable placement of surface floats will make it possible to conduct diving competition and four-lane racing simultaneously. When either six-lane racing or water polo is in progress, the remainder of the pool will be available for swimming practice. The pool will be heated and lighted for night swimming.

About 20 feet of concrete deck will surround the pool. An 8½-foot windbreak will shelter three sides. The dressing room structure will enclose the fourth side. The Institute's consulting architects, Pereira & Luckman, Los Angeles, are supervising the design.

Less than a week after the news of the new pool came the announcement that funds made available through a bequest of the late Scott Brown had been allocated by action of the Board of Trustees to the construction of a gymnasium in Tournament Park.

Mr. Brown, a lawyer and a resident of Pasadena, left a trust fund of approximately $400,000 to the Institute, directing that it be used in whatever way the trustees decided. Because of the long-felt need for an athletic center the trustees voted to use the Brown funds for this purpose.

Since this money has become available rather suddenly, it will now be necessary to begin the long talked-of expansion plan for a gym-swimming pool combination. Architects are already preparing working drawings. These will go out for bids in several months, and we can probably look forward to the completion of the athletic center in the spring or summer of 1954. However, all efforts will be made to advance the construction schedule.

Mr. Brown, in whose memory the gymnasium will be named, had been active in Pasadena civic and philanthropic affairs for two decades before his death last June 14. He was honored in 1938 with the Arthur Noble

CONTINUED ON PAGE 28

Award as the city's outstanding citizen. In the preceding year he received an award from Pasadena Post No. 13 of the American Legion for distinguished civic service. A graduate of the University of Chicago, he practiced law in that city and came to Pasadena as a permanent resident in the early 1930's. He was a former general counsel of the Studebaker Corporation and vice president of the Illinois Power and Light Company and of the Illinois Traction Company.

Mr. Brown had been a member of the California Institute Associates since 1931 and a director of the organization from 1940 until his death. He also was associated in Pasadena with the Community Chest and was a member of the Valley Hunt Club, Annandale Golf Club and the Twilight Club, of which he had at one time been President.

New Trustees

THE BOARD OF TRUSTEES of the Institute elected two new members last month: Dr. Arnold O. Beckman, president of Beckman Instruments, Inc., and Mr. Charles Stone Jones, president of the Richfield Oil Company.

Dr. Beckman, a California Institute Associate since 1948, is the first Caltech alumnus to be elected a trustee. President of Beckman Instruments, Inc., its Berkeley Scientific Division and the Helipot Corporation, a subsidiary, he is also president of Arnold O. Beckman, Inc., scientific instrument manufacturing company.

His major professional interest has been the development of scientific and industrial instruments, particularly in the field of chemical analysis. During the war he did research on instruments for detecting war gases, and for the detection and measurement of radioactivity.

Dr. Beckman has been consultant to the Los Angeles County Air Pollution Control District since its formation in 1948. He is also chairman of the scientific committee of the Los Angeles Chamber of Commerce, and a member of the board of governors of the San Gabriel Valley Council of the Boy Scouts of America.

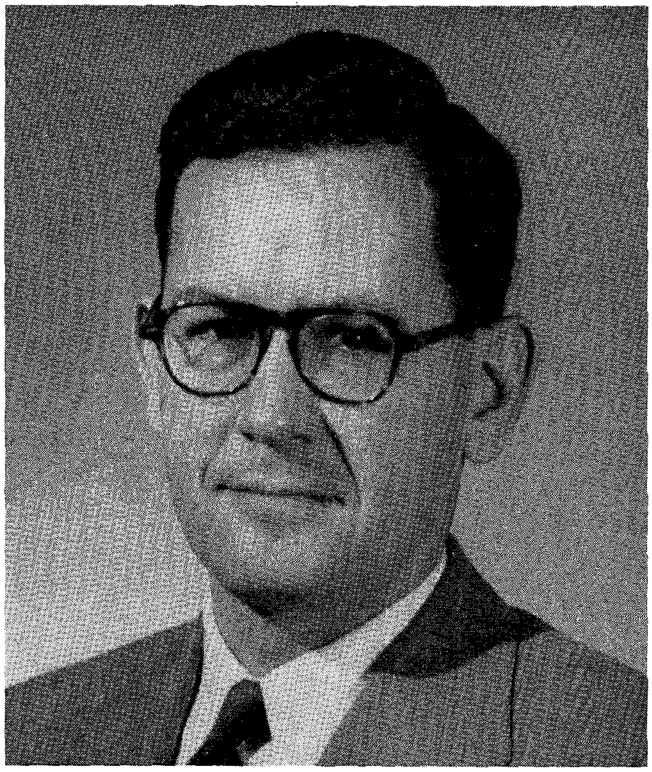
A native of Cullom, Illinois, Dr. Beckman graduated from the University of Illinois in 1922. After receiving his Ph.D. from Caltech in 1928, he became instructor in chemistry here and was promoted to assistant professor in 1929.

He left Caltech in 1940 to go into business for himself, manufacturing scientific instruments. Beckman Instruments, Inc., is now a member of the Institute Industrial Associates. President of the Instrument Society of America last year, Dr. Beckman has been a councilor of the American Chemical Society for the past decade. He is also a member of the Electrochemical Society, Faraday Society of England, and Sigma Xi, honorary research fraternity.

Mr. Jones has long been prominent in both the oil industry and civic affairs. He entered the oil business in Texas, his native state, and later became president of the Rio Grande Oil Company of California. He has been president of the Richfield Oil Company since its reorganization in 1937. The Richfield Oil Company is a member of the Institute Industrial Associates.

A member of the California Institute Associates for more than ten years, Mr. Jones has been president of the group for the past two years. Community beautification is one of his deep interests and he recently supported an ordinance banning advertising on freeways. He was one of the founders and first president of the Los Angeles Men's Garden Club, an organization that works to beautify the area.

Mr. Jones is a director of the American Petroleum Institute and the Western Oil and Gas Association. He also is a member of the California Club, Hunt and Fish Club, Bohemian Club and the Flintridge Riding Club.



John D. Roberts, Professor of Organic Chemistry

Organic Chemistry Professor

DR. JOHN D. ROBERTS, 34, Associate Professor of Organic Chemistry at the Massachusetts Institute of Technology, has been appointed Professor of Organic Chemistry at Caltech. He joins the staff about July 1.

Dr. Roberts is a John Simon Guggenheim Memorial Fellow for 1952-53. On a year's leave of absence from M.I.T. he has been conducting research at Caltech since last September on the theory of the structure of organic compounds. He leaves this month on a 10-week trip to England, France and Switzerland to continue his research.

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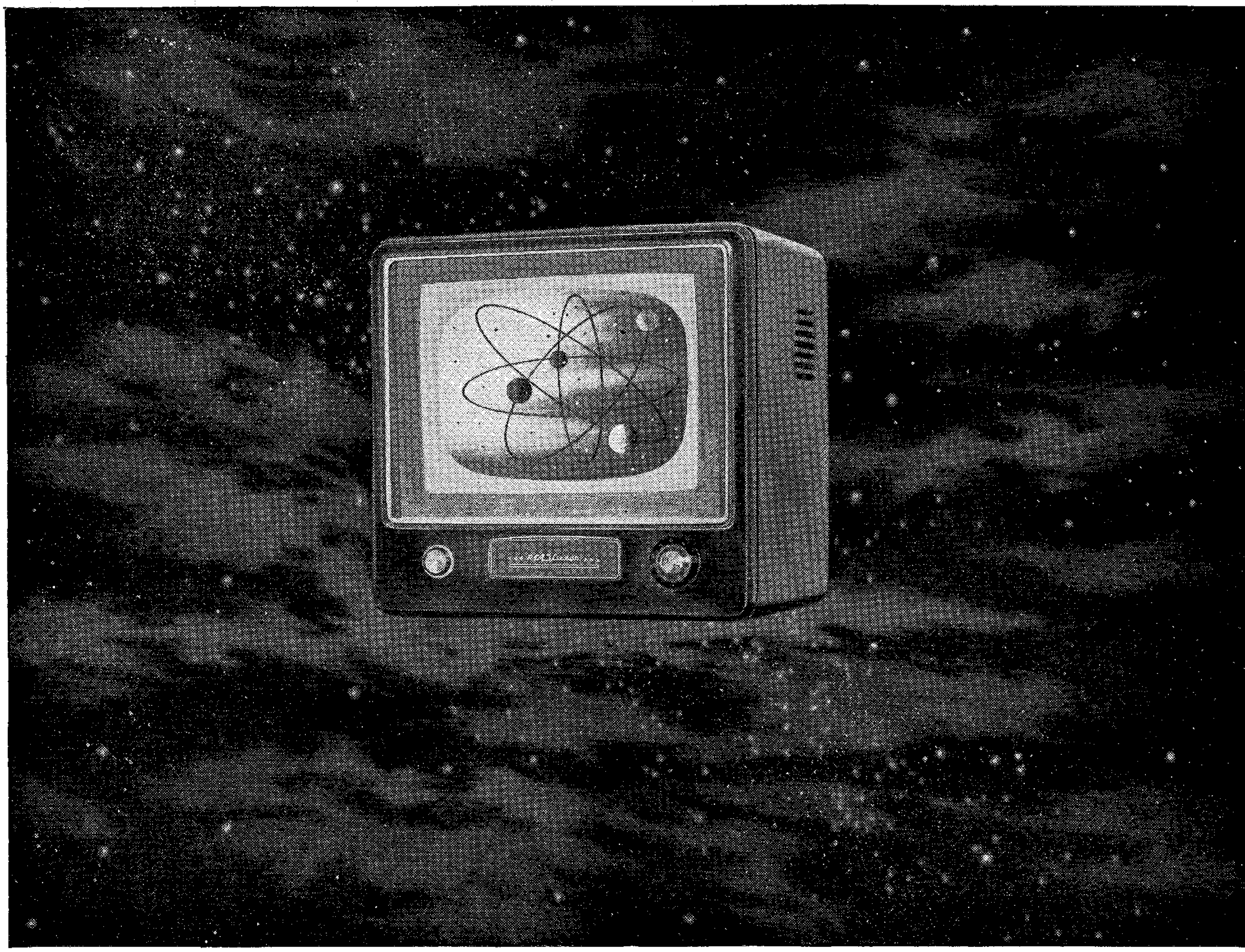


Basic research and engineering advances make RCA Victor's 1953 TV receivers the finest you can buy.

Professor Roberts will teach the undergraduate course in organic chemistry at Caltech, conducted for 38 years by Professor Howard Lucas, who will devote his time to research after this year. Both scientists are physical organic chemists, interested in the mechanisms of organic chemical reactions.

A native Californian, Dr. Roberts graduated from Los Angeles High School in 1936. He was graduated from U.C.L.A. in 1941 and received his Ph.D. there in 1944. In 1945 he went to Harvard as a National Research Fellow and Instructor in Chemistry. He joined the M.I.T. staff in 1947.

He has conducted research in organic chemistry since 1940. His present investigations include radio-active tracer research, studies on small-ring organic compounds and research in theoretical organic chemistry. Since 1949 he has been a consultant for the DuPont Company and for the Oak Ridge National Laboratory.

Caltech and the ACS

President DuBridge is due to speak on "Science and Government" at the opening general session of the 123rd National Meeting of the American Chemical Society, to be held in Los Angeles March 15-19.

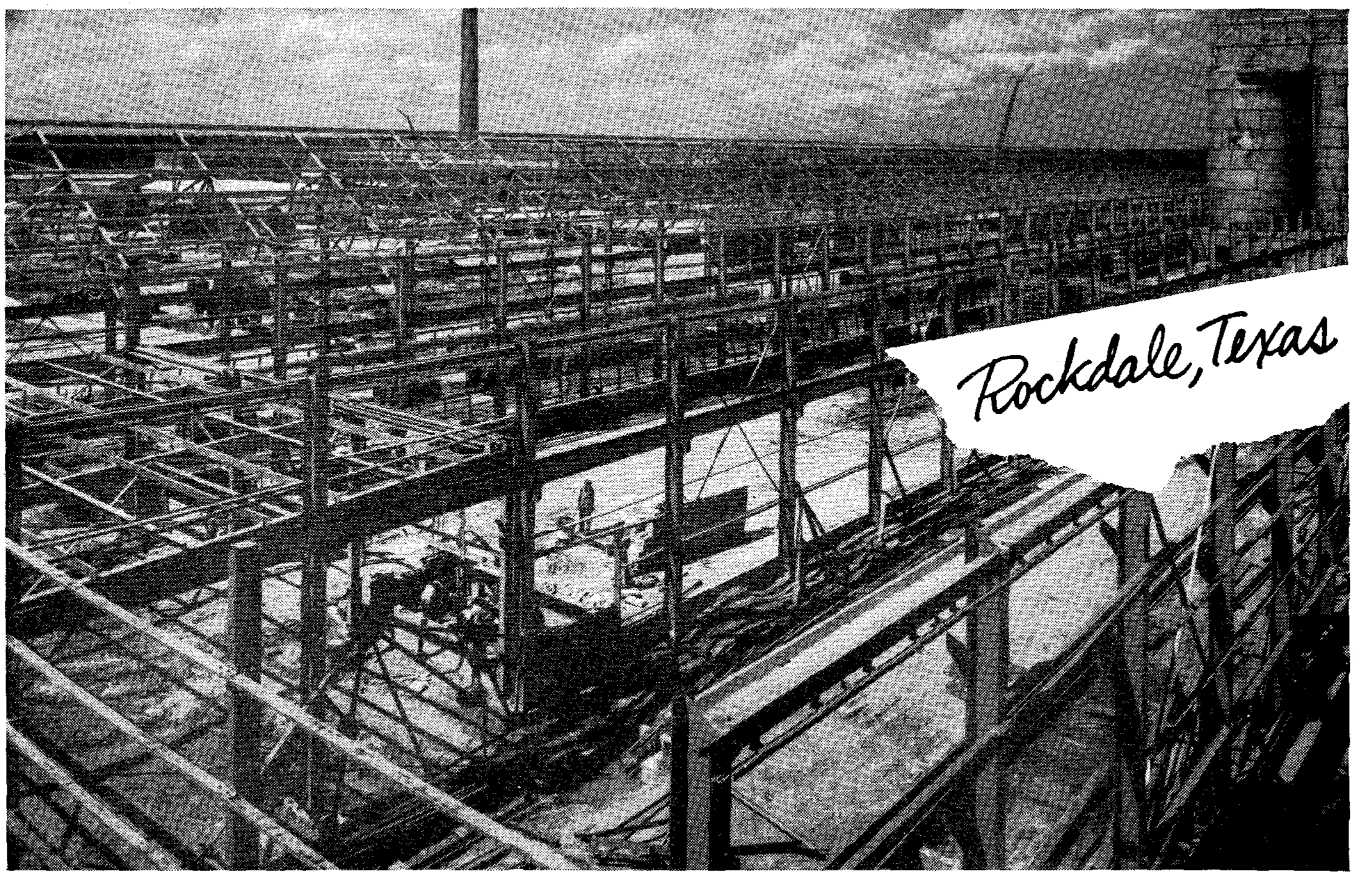
Dr. DuBridge will address ACS members in the Pacific Ballroom of the Hotel Statler on the night of March 16. His talk will follow presentation of special ACS awards — among them the Scientific Apparatus Makers $1,000 Award in Chemical Education to Dr. Howard J. Lucas, Caltech Professor of Organic Chemistry (see page 21).

Among other Caltech staff members participating in the ACS meeting will be Professor Linus Pauling, Chairman of the Division of Chemistry and Chemical Engineering, who will address a joint meeting of three ACS divisions on "Configuration of Polypeptide Chains in Proteins," at 10 a.m. March 17.

Recent research developments at Caltech will be presented in more than a dozen papers, given at various symposia by Caltech staff members including Drs. Lucas, Pauling, Gordon A. Alles, Harrison Brown, A. J. Haagen-Smit, Henry Dan Piper, Ernest H. Swift and L. Zechmeister.

Dr. Frank F. Grout, Visiting Professor of Geology at Caltech, will be honored with a 50-year ACS membership certificate. Professor-Emeritus of Geology and Mineralogy at the University of Minnesota, Dr. Grout has been a consultant to the U. S. Geological Survey since 1945.

A luncheon for alumni of Caltech will be held at 12:15 on March 16 in the New York Room of the Statler Hotel, and an open house will be held for ACS visitors at Caltech March 17 from 2 to 5 p.m., when various research facilities and laboratories will be open for their inspection.



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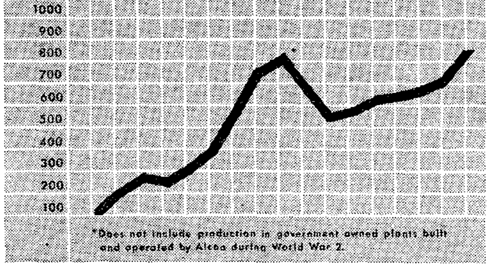

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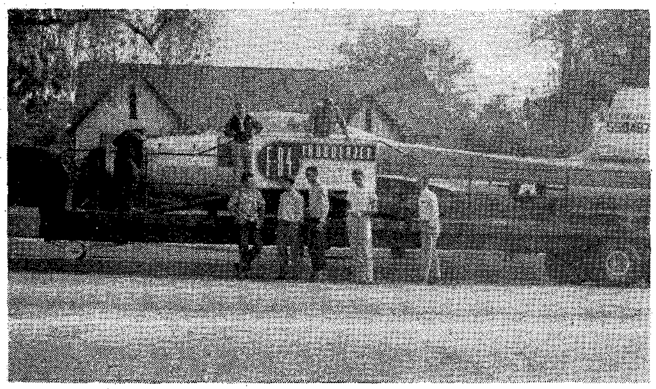


Missing Thunderjet, safely landed on Allen Avenue

WINGLESS FLIGHT

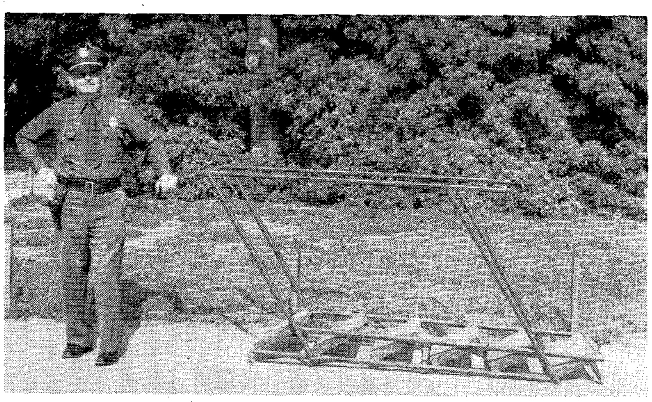
"NEVER A DULL MOMENT," said Dean Strong, when he was informed that a group of students had spirited several tons of wingless F-84 jet fighter, complete with truck and trailer, from the campus—and deposited same at the door of Col. Small's home in Altadena. Despite the general approval of the student body, however—who rated the prank one of Tech's biggest and best—the FBI chose to take a very dim view of the proceedings.

The Air Force Cadet Recruiting Service had brought the jet along as window dressing for its visit to the Caltech campus. The first indication of greater things to come was the disappearance, in broad daylight, of the plane's $1200 plastic canopy. Then a group began to take measurements and "case the joint" to determine the feasibility of moving the entire plane to some other part of the campus. The plot snowballed, and the conspirators were soon determined to deliver the jet to the Oxy campus—until they remembered that Oxy was not in session. By the evening of February 3 an agreeable—even inspired—alternative plot had been hatched; the plane would be delivered to the home of the commanding officer of the Caltech AFROTC.

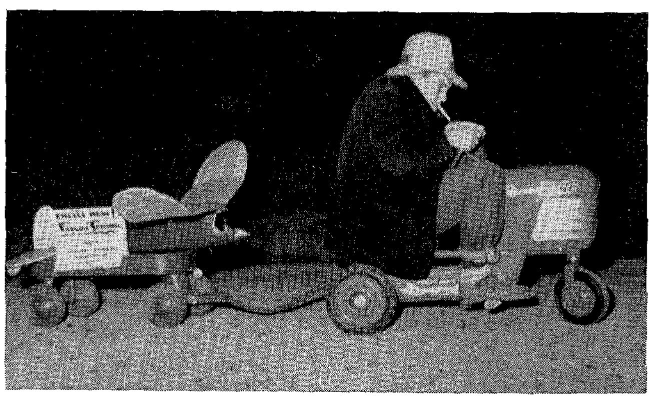
The operation got into high gear sometime around midnight when certain individuals thought they had the tractor hooked up to the 65-foot trailer bearing the plane, and set off in a cloud of enthusiasm. With a resounding crash the trailer fell off and everyone scattered. Regaining courage—some three hours later—the adventurers returned with a fork lift, and this time successfully coupled the trailer and drove away. Unfortunately, the trailer brakes were still on, and part of the tail of the plane was ripped off on a tree. Otherwise, the journey to Altadena was uneventful.

The plane's new resting place was duly noted, in the morning, by Col. Small, a large part of the public, the press—and the FBI. Because government property was involved—and damaged government property, at that—the FBI was ready to step in and make one of its traditionally thorough investigations. However, the Deans eventually worked out an agreeable compromise with the authorities. The students will now pay for the damages to the Air Force equipment and to the Buildings and Grounds fork lift. All told, this is a little matter (sob!) of $1100.

—*Jim Crosby '54*

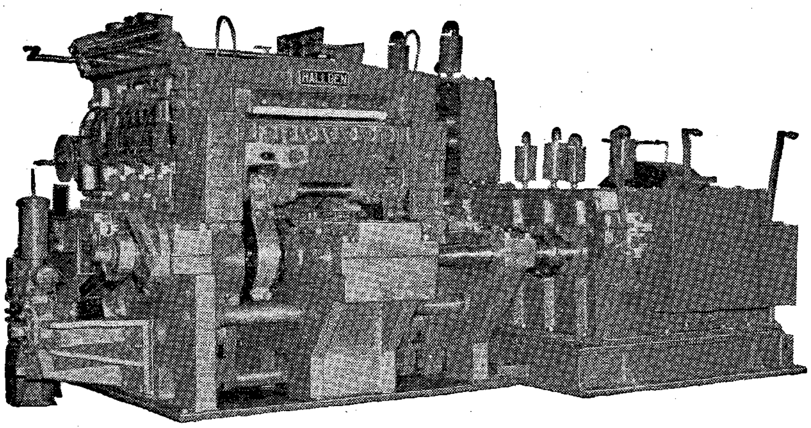


Police Officer Newton grimly guards remaining evidence



Ricketts Rowdy re-enacts the crime

Another page for YOUR BEARING NOTEBOOK

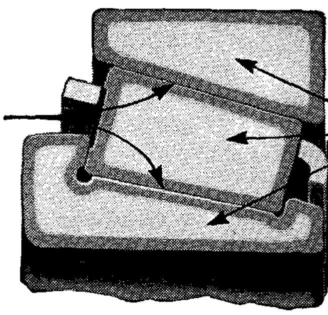


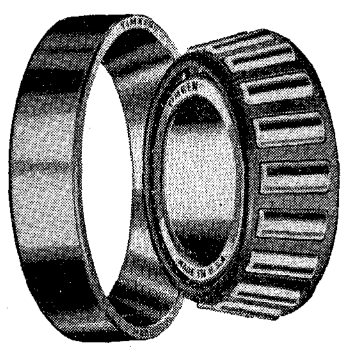
Guillotine shear cuts cost of cutting steel

To carry the terrific shock loads imposed on pinions and gears in *this flying shear*, engineers mount them on Timken® tapered roller bearings. Maintenance and repair costs are cut, costly breakdowns prevented, accuracy insured. Because of their tapered construction, Timken bearings take radial and thrust loads in any combination. They minimize friction, reduce wear — normally last the life of the machine.

Why TIMKEN® bearings can take the toughest loads

In Timken bearings, the load is carried on a line of contact between the rollers and races instead of being concentrated at a single point. Made of Timken fine alloy steel, the rolls and races are case-carburized to give a hard, wear-resistant surface with a tough core to withstand shock.





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ALUMNI NEWS

New Board Members

THE BOARD OF DIRECTORS of the Alumni Association met as a nominating committee on February 17, 1953, in accordance with Section 3.04 of the bylaws. Five vacancies will occur on the Board at the end of the current fiscal year, one vacancy to be filled from the present Board and four members to be elected by the Association. The present members of the Board and the years in which their terms of office expire follow:

F. H. Felberg '42........1954	H. N. Marsh '22........1953
G. P. Foster '40..........1953	A. A. Ray '35............1954
F. M. Greenhalgh '41..1954	K. F. Russell '29........1954
K. E. Kingman '29......1953	J. E. Sherborne '44....1953
R. W. Stenzel '21..........1953	

The four members of the Association nominated by the Directors are:

W. E. Baier '23	Douglas G. Kingman '28
R. R. Bennett '45	C. Vernon Newton '34

Section 3.04 of the bylaws provides that the membership may make additional nominations by petition, signed by at least ten (10) regular members in good standing, provided the petition is received by the Secretary not later than April 15. If further nominations are not received by April 15, the Secretary casts a unanimous ballot for the members nominated by the Board. Otherwise a letter ballot is required.

Statements about the nominees of the Directors are presented in this issue of *Engineering and Science*.

—*Donald S. Clark, Secretary*

The Nominees

WILLARD E. BAIER received his B.S. in chemical engineering in 1923, and immediately following graduation became a research chemist for the California Fruit Growers Exchange. In 1927 he became Plant Superintendent of The Exchange Orange Products Company, and from 1929 to date has been Manager of the Research Department of the California Fruit Growers Exchange—now Sunkist Growers, Ontario, with a branch at Corona, Calif. His field covers citrus products and their uses, agricultural and food chemistry, fundamental chemistry, and pharmaceutical chemistry. He is a member of the American Chemical Society, the American Pharmaceutical Association, the Institute of Food Technologists and Sigma Xi. His son, Rodger, graduated from Caltech last June.

ROBERT R. BENNETT received his B.S. in electrical engineering in 1945. After a tour of duty in the Navy he returned to the Institute to obtain an M.S. in 1947 and a Ph.D. in 1949, both in E.E. Following graduation he joined the technical staff of the Hughes Research and Development Laboratories, where he is presently concerned with simulation and theoretical studies in connection with Hughes' guided missile program. He is also a consultant to the Air Force Advisory Board on Simulation. Bob served on the Alumni Seminar Committee in 1950.

DOUGLAS G. KINGMAN received his B.S. in engineering in 1928 and his M.S. in mechanical engineering in 1929. Immediately upon receiving his degree he started work for the General Petroleum Corporation and, with the exception of a year and a half during 1931-32, has been with them ever since. Starting as a technical clerk in the production engineering office, he advanced to the post of Division Superintendent in the San Joaquin Valley in 1944. In May 1952 he was transferred to Los Angeles as Assistant Manager of Joint Venture Operations. Since the first of the year he has been Manager of this division.

C. V. NEWTON received his B.S. in mechanical engineering in 1934. His first job was with the Union Oil Company of California, as mechanical engineer in the pipeline department at San Luis Obispo. From 1940 to 1941 he held the position of mechanical engineer in the metallurgy department at the Los Angeles works of the Aluminum Company of America. Then, for seven years, he was Superintendent of the Kinney Aluminum Company. In 1948 he joined the staff of the California Walnut Growers Association as Production Manager; all warehousing, packaging and engineering activities are under his supervision. Last year he was Chairman of the Program Committee for the Annual Alumni Seminar Day; this year he is Seminar Chairman.

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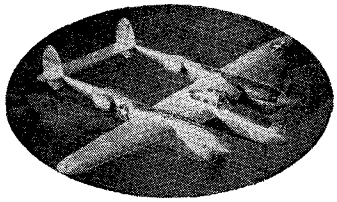
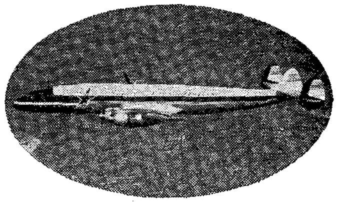


The P-38 Lightning – first 400 mile per hour fighter-interceptor, the "fork-tailed Devil" that helped win World War II.

This Plane is making History



The Super Constellation – larger, faster, more powerful; the plane that bridges the gap between modern air transport and commercial jet transport.

This Plane will make History

This plane – which exists only in the brain of an engineer like yourself – is one reason there's a better future for you at Lockheed. For Lockheed will always need engineers with ideas, engineers with imagination, engineers who build the planes that make history.

PERSONALS

1912

John D. Merrifield has seen his business, the manufacture of automatic weighing machines, grow from a back porch operation into a business that ships scales to all parts of the world, according to a feature article about him in the Denver *Post.* John built his first scale in 1938, when he was still employed at the American Crystal Sugar plant, and it worked so well that the company asked him to build more. Today the J. D. Merrifield & Son Corporation has a fine plant for the manufacture of automotive scales, employs an average of ten men for work in the shop, and a staff of six to care for the office work. Much of the work is custom work, and manufacturers all over the world who have problems in packaging—especially the automatic weighing of materials to be packaged—send them to John in Rocky Ford, Colo.

1918

Frank Capra is back in the news again, as witness this quote from a syndicated Hollywood column by Herb Stein:

"Easily television's biggest grab from motion pictures to date is the Frank Capra snatch to meg 13 videfilms for AT&T. Capra's being earmarked for the celestial subjects is understandable in view of the work he's done secretly with Caltech scientists the past few years—and ducking any number of important assignments to complete the job."

1923

George N. Ramseyer has been appointed manager of operations for General Petroleum's Marketing Department. He has been assistant division manager of operations since 1949.

1929

Richard M. Sutton, Ph.D., Professor of Physics at Haverford College, received the Oersted Medal of the American Association of Physics Teachers at presentation ceremonies at Harvard University recently. The award—the highest that fellow professors can confer—cited him as an outstanding professor and as the author of the first book dealing with the demonstration of experiments in physics.

L. Reed Brantley, M.S., Ph.D. '30, head of the Chemistry Department at Occidental College, will be chairman of the 123rd Annual Meeting of the American Chemical Society, to be held in Los Angeles March 15-19.

1933

L. Jackson Laslett obtained leave of absence from Iowa State College from June, 1952 to September, 1953, to serve as head of the Nuclear Physics Branch of the Office of Naval Research in Washington, D. C. He finds the work in the ONR affords him an opportunity to be of some service to both the government and to physics, while providing the added stimulation of contacts with many practicing research physicists. The Lasletts are living in Silver Spring, Maryland, and have three children—one boy and two girls.

F. R. Hunter is still Professor and Head of the Department of Physiology at Florida State University. The Hunters have two boys and one girl, aged 13, 10, and 6 respectively, still live in the new house they built in the summer of 1950, and generally enjoy life in Florida very much.

Henry Suhr, after graduation from Tech, spent 19 years with the American Potash and Chemical Company at Trona, and became Assistant Director of Research. About a year ago he accepted a three-year contract as Director of Research and Development in Chile with this large producer of potassium nitrate. His major problem at this time is the solar evaporation of residual brine from the nitrate process and the economic recovery of various by-products. The Suhrs have a fourteen-year-old daughter, who expects to enter Santiago College soon.

1934

Louis Stevenson has been working in the electrical group of the Guided Missile Project of Boeing Airplane Company in Seattle since July, 1952.

1936

Fred Stitt, Ph.D., who is in charge of the physical chemical section of the Western Regional Research Lab of the U. S. Department of Agriculture in Albany, Calif., is now on loan to the Department of Defense and is working with the Weapons Systems Evaluation Group in the Pentagon.

E. V. Watts was named Assistant to the Director, Production Department, in the General Petroleum Corporation. He has been superintendent of the production department's Southern division since 1949.

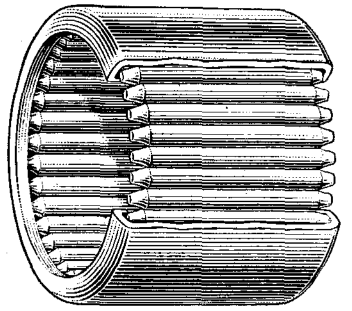
Frank W. Davis has been appointed to the staff of R. C. Sebold, vice president-engineering for Consolidated Vultee Aircraft Corporation. Frank was formerly assistant chief engineer for research and development in the company's San Diego Division. He was a Marine Corps pilot

CONTINUED ON PAGE 38

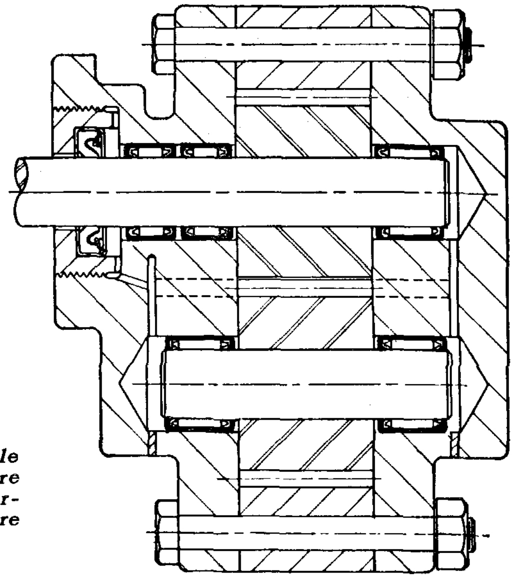
The Torrington Needle Bearing

proper housing design is essential to proper performance

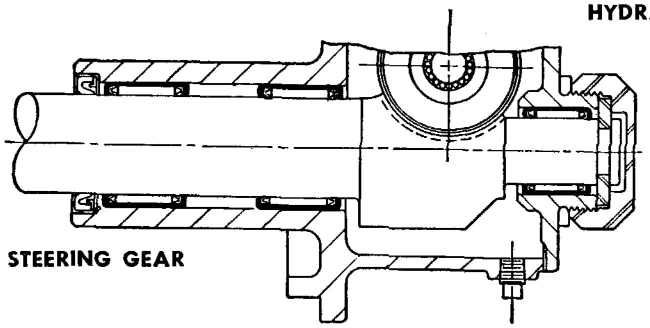
The Torrington Needle Bearing offers many design and operational advantages for a great variety of products and equipment. For example, a Needle Bearing has greater rated radial load capacity in relation to its outside diameter than any other type of anti-friction bearing. It is extremely light in weight. And it is easy to install and lubricate.



Needle Bearings require simple housings. If the housing bores are held to proper size, accurate operation and high radial capacity are assured.



HYDRAULIC PUMP



STEERING GEAR

Housing Maintains Bearing Roundness

The housing is an essential part of the Needle Bearing assembly. Care should be taken to provide a straight, round housing bore to the recommended tolerances.

The thin, surface-hardened outer shell of the Needle Bearing acts as the outer race surface as well as a retainer for the rolls. This shell assumes the shape of the housing into which it is pressed. Consequently, the housing bore should be round, and the housing so designed that it will carry the radial load imposed on the bearing without distortion.

Housing Material Determines Bore Size

The specified housing bore dimensions for any given material should be maintained in order to give the proper running clearance between the needle rollers and the shaft, and to assure sufficient press fit to locate the bearing firmly.

When designing housings of materials that are soft or of low tensile strength, allowance should be made for the plastic flow of the material when the bearing is pressed into place. Bore dimensions in such cases should be less than standard. Needle Bearings can be pressed directly into phenolic or rubber compounds, although metal inserts are recommended.

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before joining Convair's Vultee Field Division in Downey, Calif. in 1940 as an engineering test pilot. In 1947 he joined the San Diego Division engineering staff. Frank, his wife, and three children live in La Jolla.

Robert H. Marsh has recently been promoted by Raytheon Manufacturing Company to assistant chief engineer at their new South Lowell, Mass. plant, where he will be in charge of mechanical and production engineering. Last October the Marshes bought a new home in Lexington.

Jack Paller and his wife announced the arrival of a second son, Gary Norman, on February 8. The Pallers are living in Los Angeles.

Hugh F. Colvin has been promoted to Vice-President and Treasurer of the Consolidated Engineering Corporation, Pasadena. One of Hugh's first big jobs will be to coordinate the activities of Consolidated's recent acquisition, the Consolidated Vacuum Corporation of Rochester, New York, with those of the parent company in Pasadena. After receiving his M.B.A. from Harvard in 1939 Hugh was associated with the Wilshire Oil Company and later with Union Oil Co. During the war years he also found time to teach a course in industrial management at Caltech. The Colvins and their four children live in Sierra Madre.

1937

Harry H. Carrick, Jr., M.S. '39, formerly assistant to the superintendent of the southern division of the General Petroleum Corporation, Los Angeles, is now production superintendent.

Charles A. Van Dusen, Ex., was ordered to General Ridgway's top U. S. Joint Staff—United States European Command—as a member of the Policies Branch, on December 22, 1952. He and his wife, Evelyn, his son, Derek Lawrence, and English "Nanny" are now all in Germany. Chuck was promoted to Commander in 1949 and was sent to London in June of '51 in connection with North Atlantic Treaty Planning. He made a courier trip back to Washington in October, when he married Evelyn Dagmir Ott, originally from Tallinn, Estonia. His son was born the following October in Cambridge, England, and was named after his uncle, *Laurence William Van Dusen* '39. The Van Dusens plan to be in Germany, or Europe at least, until this June. Any Tech contemporaries passing through Frankfurt are invited to call. (Home phone: Frankfurt Civilian 58730, Office, Frankfurt Military 7884. Or, he can be tracked down in room 126 of the I. G. Farben Building.)

Elburt F. Osborn, Ph.D., has been named dean of the School of Mineral Industries at the Pennsylvania State College. Elburt, who joined the Penn State faculty in 1946 as professor of geochemistry and head of the department of earth sciences, was named associate dean of the school last April. The Osborns have two children; James, 10, and Ian, 6.

Walter S. White, M.S., is with the U. S. Geological Survey, studying Michigan's copper deposits. The Whites' second child, Sarah Jameson, was born April 19, 1951.

William D. Yale, M.S. '38, has been promoted to assistant division manager of the gas division of the producing department of The Texas Company. Bill started with The Texas Company in June, 1938, in the refining department in New York.

1938

Major General Donald L. Putt, M.S., is Vice Commander of the Air Research and Development Command of the U. S. Air Force in Baltimore, Md.

Cdr. Richard B. Forward recently graduated from the Navy's General Line School in Monterey, Calif. His next assignment will be for duty under the Air Force Commander of the Pacific Fleet at San Diego.

J. Kneeland Nunan, M.S., was recently elected Executive Vice-President and member of the Board of Directors of the Consolidated Vacuum Corporation of Rochester, New York He will replace *Hugh F. Colvin* '36. Prior to joining Consolidated Engineering, Nunan was employed by Howard Hughes in various administrative positions. Before that he served for five years as General Manager of the Motion Picture Department of the Ansco Division of General Aniline and Film Corp.

1940

James E. LuValle, Ph.D., formerly a research associate at Eastman Kodak, is now project director with Technical Operators, Inc., in Arlington, Mass. He's directing a project on fundamental photographic theory under the sponsorship of the chem-

CONTINUED ON PAGE 42

"Allis-Chalmers Graduate Training Course Helped me Continue my Studies,"

says ROBERT D. BAIRD, Ph. D.

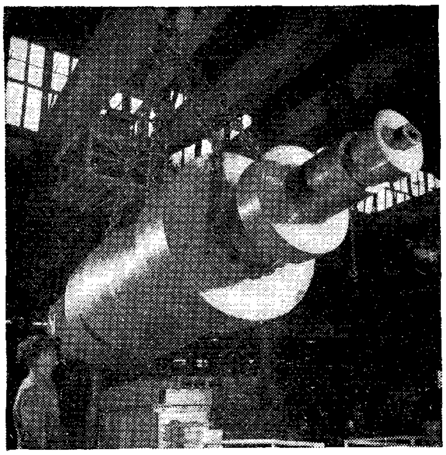
University of Illinois, B. S.—1942 • University of Wisconsin, M. S.—1949
University of Wisconsin, Ph. D.—1951
and now a member of Engineering Calculations Group

"I'VE ALWAYS been interested in the *basic* problems of engineering. But when I got out of school, I needed additional courses to do the things that interested me. More mathematics—more mechanics were required. Since joining Allis-Chalmers, these gaps have been filled."

Variety of Experience

"I became interested in the Allis-Chalmers Graduate Training Course during a plant tour in my Senior year. As I watched men building steam turbines, electric motors, transformers, pumps, rotary kilns, crushers, and many other products, I was impressed by the variety of experiences to be obtained at A-C. It looked to me like a cross-section of heavy industry. When I found that GTC students choose the departments they work in, as well as the type of work, I decided to join Allis-Chalmers.

"As a GTC student, I was given every opportunity to work in many departments. However, the basic problems involving aerodynamics, mechanics and elasticity appealed to me and I chose to work primarily on blowers and steam turbines."



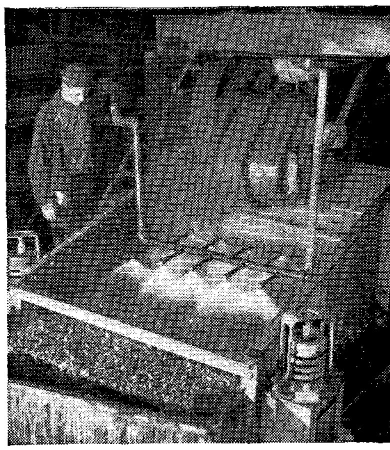
Rough-machined turbine spindle for 120,000-kw steam turbine. Calculating torsional stress and critical speed on shafts like these is part of Baird's job.

Aided by Experts

"Since joining A-C, I have had the opportunity to work with the company's leading consultants, and was encouraged to attend evening courses at the University of Wisconsin, in Milwaukee, which led to a Master's degree.

"In 1949 the company awarded me a graduate fellowship for 12 months' residence study at the University of Wisconsin and I got my Doctor's degree in Mechanics.

"So you see, whether you want to do basic engineering or be a sales engineer, designer, production or research engineer, Allis-Chalmers Graduate Training Course offers a wonderful opportunity."



Vibrating screens by Allis-Chalmers are found throughout the world, wherever coal and ore are mined and rock is quarried.

Facts Graduates Should Know About Allis-Chalmers Graduate Training Course

1. It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

2. The course offers a maximum of 24 months' training.

3. The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

4. He may choose the kind of power, processing, or specialized equipment with which he will work, such as: steam or hydraulic turbo-generators, circuit breakers, unit substations, transformers, motors, control, pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

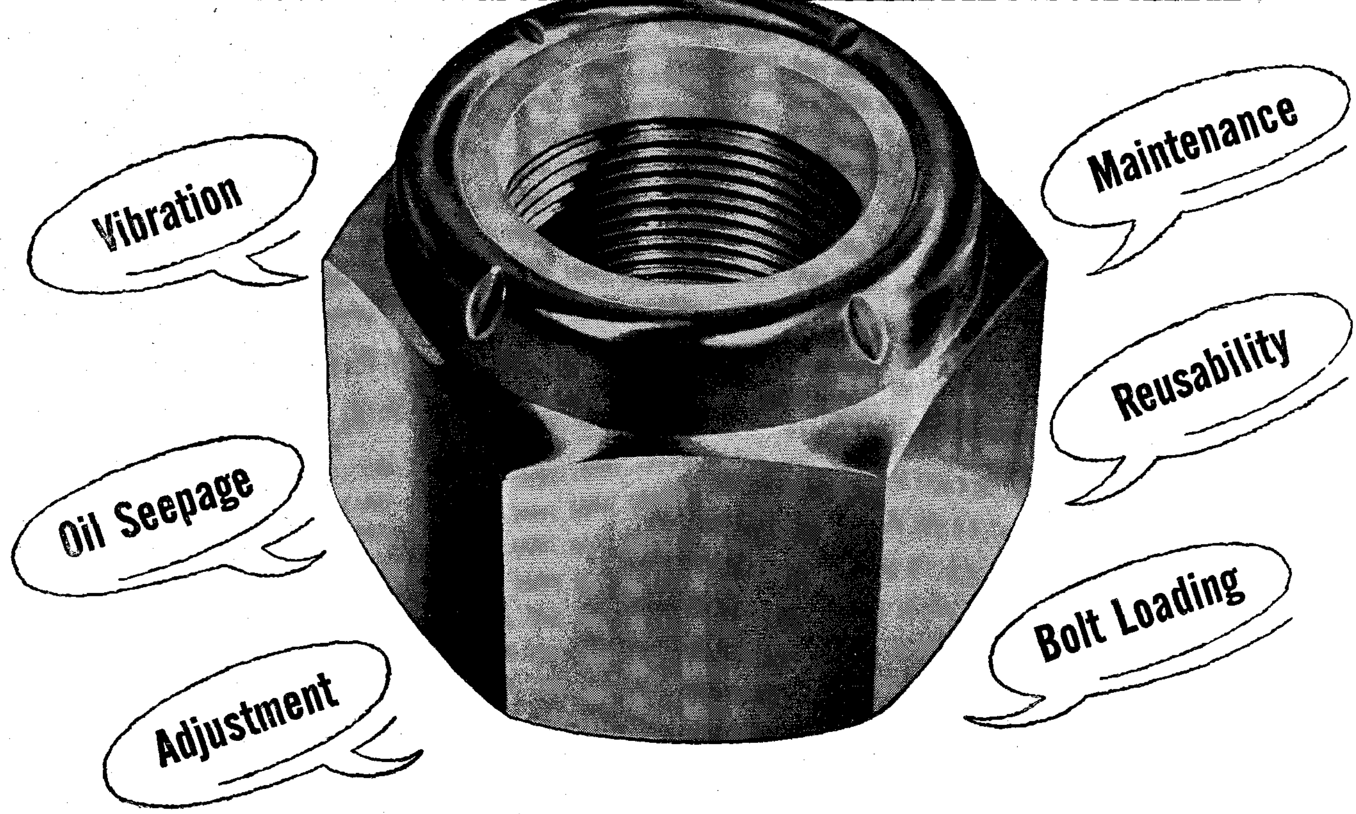
5. He will have individual attention and guidance in working out his training program.

6. The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

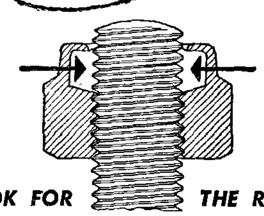
7. For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS A-C ALLIS-CHALMERS

Whenever fastening problems arise...



Consider ELASTIC STOP NUTS



LOOK FOR THE RED LOCKING COLLAR

It is threadless and resilient. Every bolt impresses (but does not cut) its full thread contact in the Red Elastic Collar to fully grip the bolt threads. In addition, this threading action properly seats the metal threads—and eliminates axial play between bolt and nut threads. All Elastic Stop Nuts—regardless of type or size—lock in position anywhere on a bolt or stud, maintain accurate adjustments and seal against liquid seepage. Vibration, impact or stress reversal does not disturb prestressed or positioned settings.

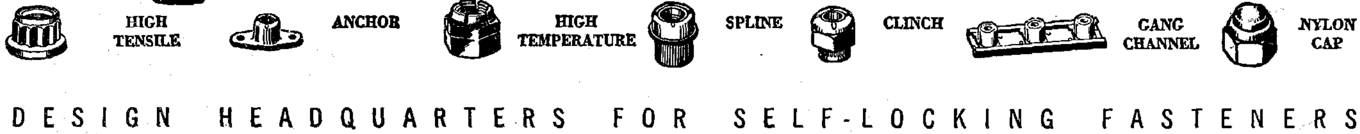
Whenever fastening presents a problem—ESNA is ready with a quick answer. More than 3000 types and sizes of self-locking vibration-proof fasteners—plus the "know-how" of ESNA engineers—are available here at ESNA.

ESNA has long been known as "design headquarters" for self-locking fasteners. Accepted by Army, Navy and Air Force, virtually every aircraft built in the past decade has been Elastic Stop Nut-equipped. On the railroads, in the oil fields, on automobiles and construction equipment, Elastic Stop Nuts manufactured to exacting quality control standards, are doing specialized jobs every day.

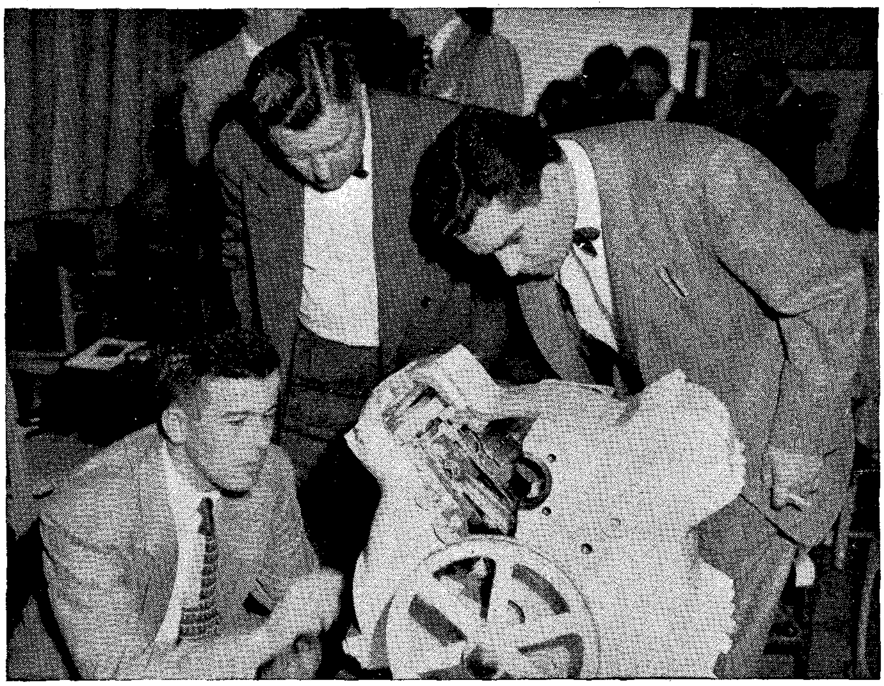
Be familiar with the design help ESNA offers. Write us for details on Elastic Stop Nuts. Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, N. J.

ESNA TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA



DESIGN HEADQUARTERS FOR SELF-LOCKING FASTENERS



Preparing for specific responsible positions with Trane in sales, research and product design, these graduate engineers are attending a streamlined six-month training course at full pay. This interesting course moves rapidly and adapts the graduate's knowledge of engineering to the position he has chosen.

Trane Offers Engineering Graduates

OUTSTANDING OPPORTUNITIES IN AIR CONDITIONING

Qualified graduate engineers can step quickly into an interesting and prosperous career in the rapidly growing field of air conditioning. The Trane Company, leading manufacturer of air conditioning, heating, ventilating and heat transfer equipment, is seeking graduates for responsible positions in sales, research, product design and production.

Those selected will join the Trane Graduate Training Program in La Crosse at full pay. Each man will receive a specialized course to assure personal success in the position he has chosen.

He will learn how Trane equipment is used in jet aircraft, tanks, submarines, ships, skyscrapers, factories, industries, homes and buildings of all types. He will see how rapidly air conditioning is becoming a necessity . . . how it is destined to become a standard requirement in homes, automobiles, schools, offices . . . everywhere.

Graduates move quickly into responsible, well paid positions. Men who joined the company through this training program include the president and numerous company officers, managers of most Trane sales offices and home office sales divisions.

Trane's record has been one of steady growth and leadership for nearly forty years, during both peace and war. Today, new Trane products are being developed constantly . . . creating new departments and promotions . . . assuring continued growth and business opportunities.

For an outstanding career in one of the fastest growing industries, consider your future in air conditioning with Trane. Write immediately to Milton R. Paulsen, Training Department Manager, for the brochure "Trane Graduate Training Program". Next six-month class starts in July

WHAT OTHERS SAY ABOUT TRANE

How much can graduates of their training program earn? What about competition? Is Trane strong financially? Does the company offer outstanding opportunities to young men?

For the unbiased answers, read FORTUNE magazine's report on Trane in their August, 1951 issue. Your library should have a copy. A reprint of this report is included in the "Trane Graduate Training Program" brochure which is in your Placement Office.

TRANE

THE TRANE COMPANY • LA CROSSE, WIS.

Eastern Manufacturing Division, Scranton, Pennsylvania
Trane Company of Canada, Ltd., Toronto, Canada
Sales Offices in 85 United States and 14 Canadian Cities

MANUFACTURING ENGINEERS OF AIR CONDITIONING, HEATING, VENTILATING EQUIPMENT istry division of the Air Research and Development Command.

Leo Brewer, Associate Professor of Chemistry at the University of California, has been chosen to receive the 1953 Baekeland Award of the American Chemical Society, for his work in fundamental inorganic chemistry at high temperatures. Leo served as a chemist with the Manhattan District Project from 1943 to 1946. In addition to his teaching duties now, he is a consultant at the University of California Radiation Laboratory and to the U. S. Atomic Energy Commission.

1944

David F. Walker now works for the Roscoe Moss Company in Los Angeles as their engineer. His work consists of supervising water well testing and development, maintenance of test engines, pumps and repair rigs, and design of new equipment for the field and factory where they produce well casing. Dave now has three little varmints, ages 5, 21, 32 months—all boys—who keep him occupied a good deal of the time. (Incidentally, he's looking for a four- or five-bedroom house to take care of future expansion.) He says that *Kenny Brown* '44, who is in charge of the Arizona operations of Roscoe Moss, now has four boys, ranging in age from 3 to 7.

1945

Major John S. Ingham, M.S., writes that he's got a little less than a half year to go on a three-year trick with the Air Force in Germany. His wife and three children are with him (John, Jr., who's 6; and Pat and Pam, twin girls, who are 4). John's had a chance to ski a little in Switzerland and Germany, and to hunt a little in Germany. Having recently seen some of the devastated areas in Holland, he urges support of any drive for clothing or other help for these people.

1947

Joe Rosener, Jr. and his wife announced the birth of their first child, Lynn Dee Rosener, born January 27. Joe is manager of Budgets and Methods at Western Lithograph Company in L.A. The Roseners are living in Pasadena.

1949

James A. McIntosh, Engr., and his wife announced the birth of a son, David, on January 6. They're living in North Coldwell, N. J. and he's working for the Mack Molding Company in Wayne, N. J.

Gene Mooring recently returned from a trip to Washington, D. C., where he attended the Plastics Industry Conference. Gene represented Douglas Aircraft of Santa Monica, where he's been employed since graduation, in the plastics section of the Materials and Process Group. The Moorings, now residents of Tarzana, have a daughter, Diane Eileen, who will be a year old this June.

While in the East, Gene visited *E. Dale West* '49, and his wife, at Silver Spring, Md. The Wests have two children—Jon and Janet Sue—and Dale's working for the National Bureau of Standards.

1950

John T. Mosich and his wife announced the birth of a daughter, Susan Louise, last December 27. Early in January, John, who works for C. F. Braun & Co., of Alhambra, Calif., was transferred to the company's Chicago office, where *Warren B. Leavitt*, '42, is District Manager.

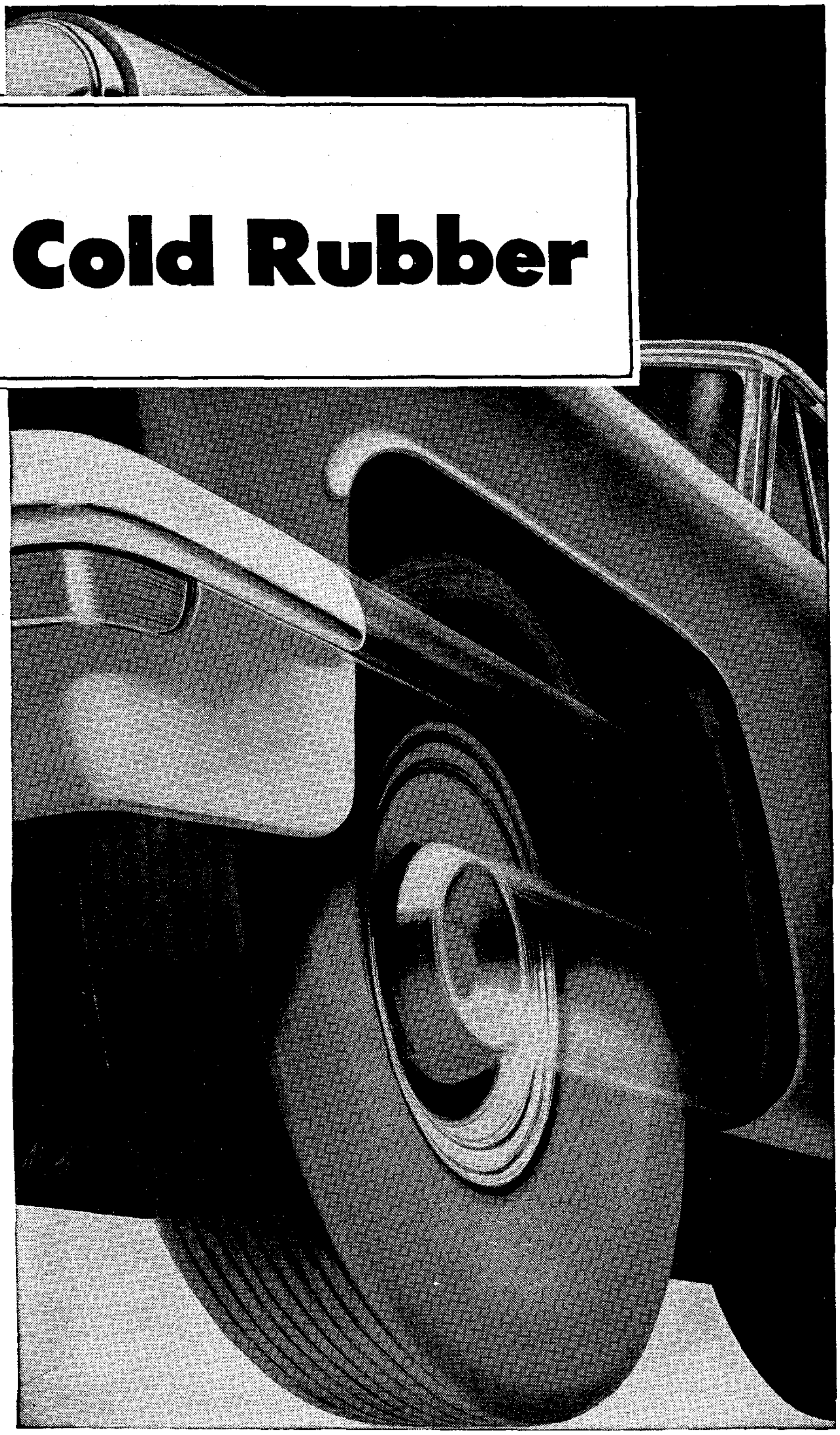
1951

Thomas W. Connolly, M.S. '52, was married in February to Joann Bauders of Arcadia. Attendants at the wedding included *Win Royce* '51, M.S. '52, *Dan Markoff* '50, and *James McCaldin* '50, M.S. '51.

Mrs. Connolly is a graduate of P.C.C., and is now enrolled in the Huntington Hospital School of Nursing. Tom is at Hughes Aircraft, doing control and computer work.

Joseph L. Mangin was married in June, 1951, now works for the Titanium Metals Corporation of America in Henderson, Nevada, as project engineer of the magnesium recovery department and the titanium ingot melting department. The Mangins have bought a house in Las Vegas.

Shift to Cold Rubber



CHEMICAL PROBLEM . . .

. . . automobile tires that last longer under the heat and abrasion caused by today's higher operating speeds.

SOLUTION . . .

. . . "cold rubber," so called because it is made at 5° C. Cold rubber production requires a special emulsifier to bring together its basic ingredients—butadiene and styrene—under refrigerated conditions. The emulsifier found most satisfactory today, as when GRS-10 was introduced in World War II, is Dresinate®—one of many chemical materials produced by Hercules for the rubber industry.

COLLEGE MEN . . .

This is but one example of the far-reaching chemical developments in which you could participate at Hercules—in research, production, sales, or staff operations. It suggests the ways Hercules' products serve an ever-broadening range of industries and end-uses.

Hercules' business is solving problems by chemistry for industry . . .

. . . insecticides, adhesives, soaps, detergents, rubber, plastics, paint, varnish, lacquer, textiles, paper, to name a few, use Hercules® synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products and other chemical processing materials. Hercules® explosives serve mining, quarrying, construction, seismograph projects everywhere.

HERCULES

HERCULES POWDER COMPANY INCORPORATED *Wilmington 99, Delaware*
Sales Offices in Principal Cities

EC53-3

Take Bill's word for it!

William Carpenter is a sales representative for Columbia-Southern, working out of the St. Louis district sales office. His job is an interesting one and a vital one in the fast-growing Columbia-Southern chemical business.

Bill studied engineering with the thought in mind of becoming a salesman. He has some sound reasoning to offer to the graduate. But let's start at the beginning of his story.

Bill entered Carnegie Tech, Pittsburgh, Pa., in 1942 but the war interrupted his college education for two years. He graduated as a chemical engineer in 1948.

He wanted to get into sales rather than production or engineering. He felt then, as he does now, that an engineering background is becoming an increasingly important one for the man who wants to move ahead in the field of selling. He believes that the vast amount of initiative and imagination in specialized sales work is based on a foundation of technical knowledge.

Bill looked around for quite a bit after graduation to find the right spot for his talents. He had many interviews but finally settled on Columbia-Southern. He was impressed with the caliber of people at Columbia-Southern . . . the type with whom he liked to work. He found Columbia-Southern a progressive, rapidly expanding company. He realized that the sound sales training program, supervised by the Technical Service Department, guaranteed complete understanding of his products. The program called for actual plant work in production, engineering, research and shipping—providing him with the thorough background which would be demanded by his customers.

Bill is glad he decided on Columbia-Southern. He now has full responsibility for all accounts assigned to him as sales representative in the Corporation's St. Louis District Sales Office.

Bill has this to say to the graduate: "Look for a company that is growing. Look for a company that will give you the opportunity to do the work you are best suited to do. Look for the organization which offers real opportunity for advancement."

Columbia-Southern has opportunities for graduates in all business and technical fields including engineering, research and development, sales, plant design, mining, construction, maintenance, production, accounting, transportation and related fields.

You are invited to write now for further information to our Pittsburgh address or any of the plants.

William Carpenter of Columbia-Southern, *left*, is shown in a sales interview with W. F. Schierhalz, Jr., Vice President and General Manager of St. Louis Solvents & Chemical Division, Fuel Oil Company of St. Louis.

COLUMBIA-SOUTHERN
CHEMICAL CORPORATION
SUBSIDIARY OF PITTSBURGH PLATE GLASS COMPANY
FIFTH AVE. AT BELLEFIELD · PITTSBURGH 13, PA.

PLANTS: BARBERTON, OHIO • BARTLETT, CALIFORNIA • CORPUS CHRISTI, TEXAS • LAKE CHARLES, LOUISIANA • NATRIUM, WEST VIRGINIA • **DISTRICT OFFICES:** BOSTON CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS HOUSTON • MINNEAPOLIS • NEW ORLEANS • NEW YORK • PHILADELPHIA • PITTSBURGH • ST. LOUIS • SAN FRANCISCO

8:30-9:15 A.M.—REGISTRATION
Dabney Hall of the Humanities

MORNING PROGRAM

9:30 to 10:20 A.M.
Your choice of the following:

A. THE ARVIN-TEHACHAPI AND BAKERSFIELD EARTHQUAKES

John P. Buwalda, Professor of Geology.

Not since 1857 has southern California experienced a series of shocks as strong as those occurring last summer in the San Joaquin Valley. Every modern device and technique were used for the subsequent vigorous geologic, seismic, and geodetic investigations. Now it is possible to summarize the up-to-date engineering knowledge accumulated and describe the unique geologic features observed.

B. THE GYROSCOPE

Leverett Davis, Jr., Professor of Theoretical Physics

Nearly everyone is familiar with the top, a simple form of gyroscope or rigid rotating body. The many ways in which the basic physical principles underlying the behavior of the rotating rigid body enter into our everyday life are rarely noticed, however. Dr. Davis will demonstrate the use of the gyroscope in artificial horizons, ship stabilizers, gyrocompasses, and monorail railroads.

10:20 to 10:50 A.M. COFFEE TIME

10:50 to 11:40 A.M.
Your choice of the following:

A. THE MODERN LOGIC

E. T. Bell, Professor of Mathematics.

Over the past 100 years a new logic has developed. This logic is quite different from the classic type known to Aristotle. Much of the superiority of the new logic over the old is due to the extensive use of symbolism. Dr. Bell will discuss the development of this logic, and show its usefulness in the solution of today's problems.

B. THE ATOMIC STRUCTURE OF ALLOYS

Gunnar Bergman, Assistant Professor of Mechanical Engineering and Chemistry.

What is a crystal? How are crystals arranged to form the structure of metals and alloys? Dr. Bergman will discuss the crystalline structure of solid solutions, intermetallic compounds, and the metallic elements.

11:55 to 12:45 P.M.
Your choice of the following:

A. FAREWELL TO THE HORSELESS CARRIAGE or The Whys and What-Fors of Automatic Transmissions

Peter Kyropoulos, Associate Professor of Mechanical Engineering.

For years we have been designing automotive power plants and transmissions separately and have "cobbled" them together as individual shelf items. This has clearly led us to a situation where the transmission-engine combination leaves much to be desired. The discussion will include an analysis of why the hydrodynamic transmission behaves the way it does, and what its limitations and capabilities are.

B. WE'RE MEETING THE VIRUS PROBLEM

Renato Dulbecco, Associate Professor of Biology.

Unknown to you, there has been a revolution in the ways of investigating the field of animal viruses. Time-consuming and inaccurate techniques are being discarded for precise and speedy methods of investigation. Diseases of exceptional social and economic significance are well on the way to control as a result of the new approach to investigation.

1:00 to 2:00 P.M. LUNCH—STUDENT HOUSES

AFTERNOON PROGRAM

2:30 to 3:20 P.M.

LIGHT, THE TIME MISER

Richard D. Feynman, Professor of Theoretical Physics.

Of all the time-saving gadgets invented by man, none will ever compete with light, the most cunning of all time-savers. This miser, whether travelling through space, vapor, liquid, or solid always takes the least time-consuming route. The precision surface of the 200-inch telescope mirror, the brilliance of the diamond, and the colors in the rainbow are results of light's time-saving behavior in its travel. A dynamic speaker modernizes and simplifies some of the old standby formulas.

3:30 to 4:20 P.M.

OPERATION FISH, A BOUT WITH A TROUT

William W. Michael, Associate Professor of Civil Engineering.

While most people regard fishing as only a sport, Professor Michael considers it a physical problem, and approaches the problem scientifically. As a result, he has probably caught more trout than any man alive, and is considered by sportsmen to be one of the country's leading experts on trout fishing. With the aid of slides and colored movies, Prof. Michael will relate some of his experiences, some of the scientific methods he uses, and possibly some of his secrets.

4:30 to 5:00 P.M.

GROUND-BREAKING CEREMONIES— NEW SWIMMING POOL

All alumni will appreciate this brief ceremony formally initiating the construction phase of the new swimming pool. The years of collection drives accompanied by generous contributions by the Alumni are now very close to the goal. Dr. DuBridge will describe the building program.

5:00 to 6:30 P.M. SOCIAL HOUR

Relax and meet your friends at the Elks Club, 400 West Colorado Street, Pasadena. Cocktails available. Dinner will be served at 6:30 in the club banquet room.

EVENING PROGRAM

6:30 P.M. DINNER
Elks Club—400 West Colorado Street, Pasadena
Dress—Informal for men and women.

AFTER DINNER

Introductions by John E. Sherborne, Alumni Association President.
Remarks by Dr. Lee A. DuBridge, President of California Institute of Technology.

ECONOMIC CHANGES AND THE NEW ADMINISTRATION

Robert R. Dockson, Economist, Bank of America.

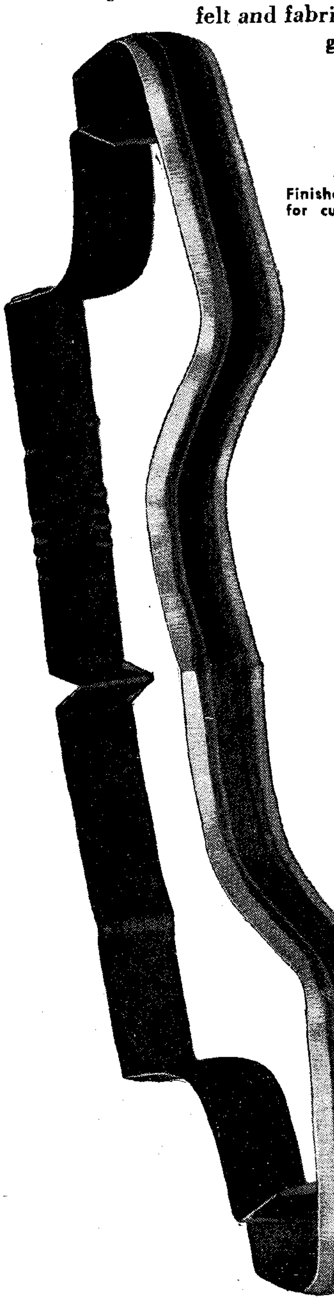
Our production facilities have been greatly expanded to meet the demands of the defense program and maintain a high standard of living. Within the next year Federal government expenditures are slated to taper off. What are the prospects for the American economy at this time? What are the inflationary and deflationary forces at work in the economy today, and how is the new administration strengthening or weakening these forces?

What's Happening at CRUCIBLE

about clicker die steel

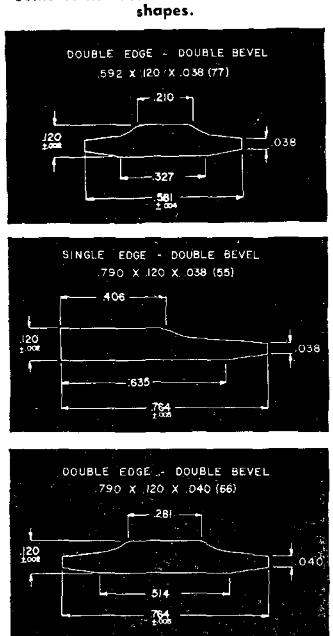
what it is

Clicker die steel is a special cold rolled alloy steel. It is used in making clicker dies for cutting leather, rubber, plastic, felt and fabrics of other compositions that go into the making of shoes and similar products.



Finished clicker die ready for cutting shoe leather.

Some of the clicker die steel standard shapes.



Wider shapes are used when dies are sized by surface grinding after forming and welding. Standard widths are provided when the dies are not to be surface ground.

how it is used

Clicker die steel is furnished to the die maker in either single or double edged form in one of several standard shapes. The die maker first shapes the die by bending the die steel to a pattern that provides the desired configuration, and then welds the two ends at a corner. He finishes the die by grinding a bevel on the outside of the cutting edge and filing the inside edge. Before the finished die is hardened and tempered, the die maker forms identification marks – combinations of circles and squares – in the cutting edge so that the material cut from it may be easily identified as to its size and style.

In the cutting operation, the leather or other material is placed on an oak block in the bed of the clicker machine. Then the die is placed by hand on the material which is cut as the aluminum faced head of the machine presses the die through it. The clicking sound which the head makes as it strikes the die is where the term "clicker machine" derived its name.

what it is composed of

Clicker die steel as produced by the Crucible Steel Company of America is a controlled electric steel in which the combination of carbon and alloy is designed for maximum toughness and proper hardness after heat treatment.

Experience has proved that cold finished clicker die steel is superior to hot rolled material for sizes approximately ¾ inch and narrower because of its lower degree of surface decarburization which permits the use of slightly thinner sections. Cold finished material also has a better surface finish with closer width and thickness tolerances and thinner edges that require less grinding and filing to complete the die.

CRUCIBLE'S engineering service

As with clicker die steel, the Crucible Steel Company of America is the leading producer of special purpose steels. If you have a problem in specialty steels, our staff of field metallurgists with over 50 years experience in fine steel making is available to help you solve it. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

CRUCIBLE first name in special purpose steels

53 *years of Fine steelmaking*

Midland Works, Midland, Pa. • Spaulding Works, Harrison, N. J. • Park Works, Pittsburgh, Pa. • Spring Works, Pittsburgh, Pa.
National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin

Printed in Pasadena PP 6

CALTECH CALENDAR

February 1953

ALUMNI ACTIVITIES

April 11	Annual Seminar
June 10	Annual Dinner Meeting
June	Annual Family Picnic

ATHLETIC SCHEDULE

VARSITY BASKETBALL

March 14, 2:15 p.m.
Douglas Bros. at Caltech

March 24, 3:00 p.m.
Caltech at Loyola

March 27, 3:00 p.m.
Caltech at LaVerne

March 30, 3:00 p.m.
Whittier at Caltech

April 1, 4:00 p.m.
Nazarenes at Caltech

April 4, 2:15 p.m.
Pomona at Caltech

April 7, 4:00 p.m.
Cal Poly at Caltech

VARSITY TRACK

March 13, 3:00 p.m.
LaVerne-Nazarenes at Caltech

April 3, 3:00 p.m.
Pomona at Caltech

April 11, 1:30 p.m.
Caltech at Whittier

VARSITY TENNIS

March 14, 1:30 p.m.
Loyola at Caltech

April 3, 3:00 p.m.
Pomona at Caltech

April 11, 1:30 p.m.
Caltech at Whittier

VARSITY GOLF

March 31, 1:30 p.m.
Pomona at Caltech

April 3, 1:30 p.m.
Caltech at Pomona

April 10, 1:30 p.m.
L.A. State at Griffith Park

VARSITY SWIMMING

March 14, 2:00 p.m.
Relays at Redlands

April 8, 4:30 p.m.
Compton J. C. at P. C. C.

April 10, 4:30 p.m.
Fullerton J. C. at P. C. C.

DEMONSTRATION LECTURES

Friday Evenings
7:30 p.m.—201 Bridge

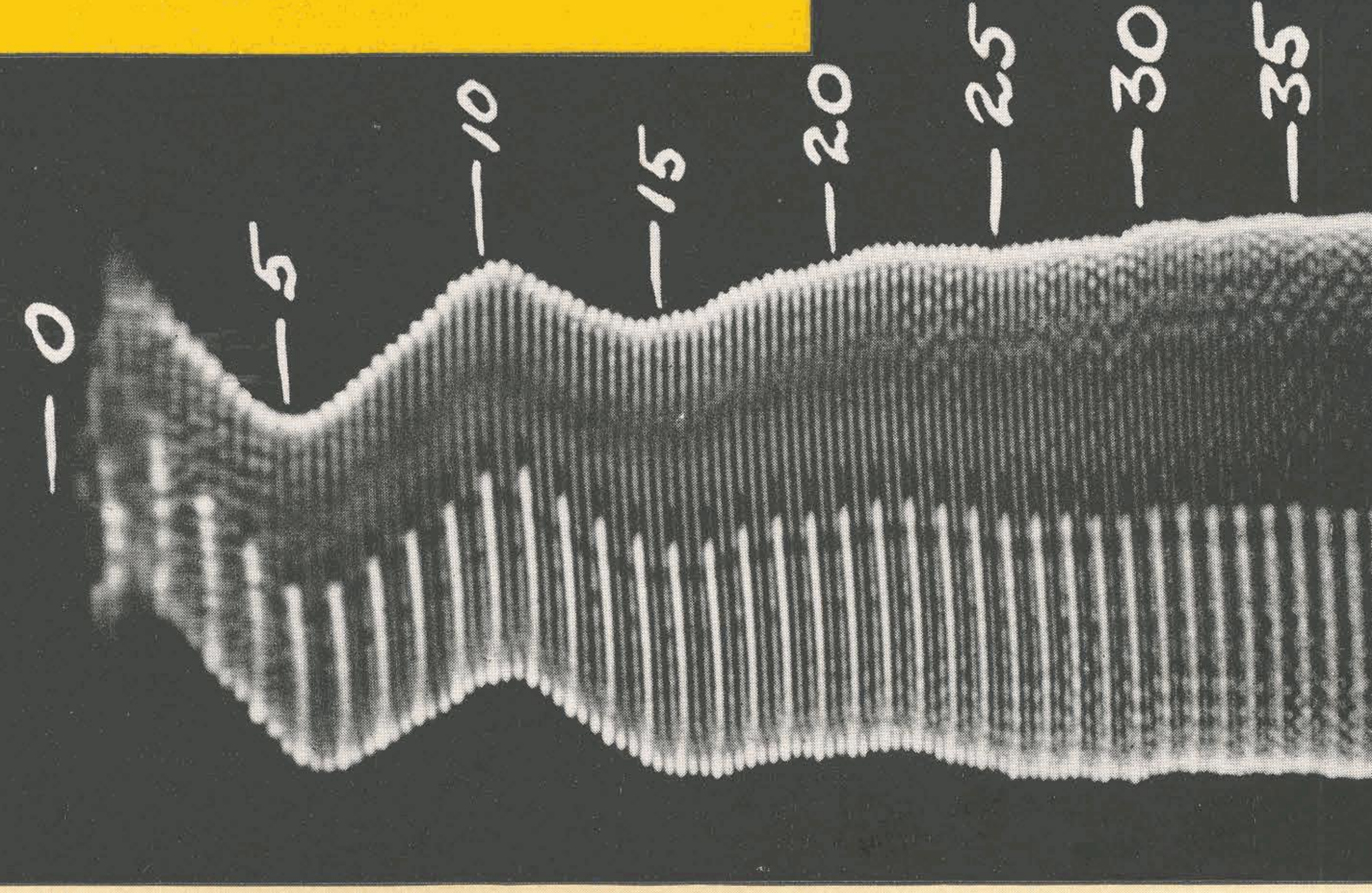
March 13 "X-Rays,"
by Professor J.W.M.DuMond

April 3 "The Principle of Least Time,"
by Professor R. P. Feynman

April 10 "Fuels, Flames and Rockets,"
by Professor S. S. Penner

It's fast–it's accurate–it's versatile

—so photography has become an important implement in engineering



This picture is a photographic recording of a cathode ray oscilloscope trace which shows the speed of the reaction of lithium borohydride with an aqueous acid solution.

PHOTO COURTESY OF THE DEPARTMENT OF CHEMISTRY, ILLINOIS INSTITUTE OF TECHNOLOGY, CHICAGO, ILL.

• In the laboratory, in the design department, the production shop and assembly line, in fact all through modern engineering operations, photography is revealing new information, recording facts, aiding new developments, saving time and conserving effort.

Photography can capture the fleeting flick of the cathode ray, trace, and record important engineering information. It can reproduce engineering drawings—microfilm valuable data for easy transportation or space-saving storage. And high speed movies can slow down fast motion so that it can be seen and studied.

In fact, there are so many ways in which photography aids engineering and so many new applications being found, that many well-qualified graduates in the physical sciences and in engineering have been led to find positions with the Eastman Kodak Company.

If you are interested, write to Business and Technical Personnel Department, Eastman Kodak Company, Rochester 4, New York.

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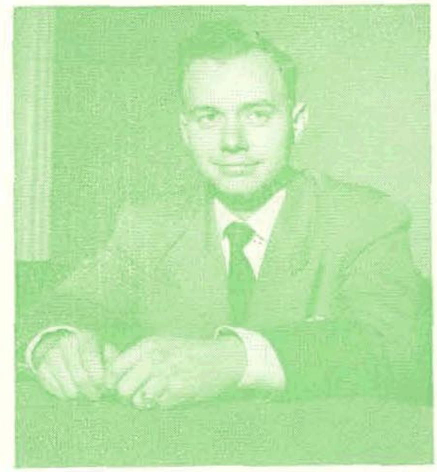
MY QUESTION TO THE G-E STUDENT INFORMATION PANEL:

"How does your business training program prepare a college graduate for a career in General Electric?"

...CHARLES O. BILLINGS Carnegie Institute of Technology, 1954



The answer to this question, given at a student information meeting held in July, 1952, between G-E personnel and representative college students, is printed below. If you have a question you would like answered, or seek further information about General Electric, mail your request to College Editor, Dept. 123-2, General Electric Company, Schenectady, New York.

R. J. CANNING, *Business Training Course* . . . General Electric's business training program offers the college graduate the opportunity to build a career in the field of accounting, finance, and business management in one of the most diversified companies in the country.

Since its beginning in 1919, more than 3,000 students have entered the program—one of the first training programs in business to be offered by industry.

The program's principal objective is to develop men well qualified in accounting and related business studies, men who can become administrative leaders in the financial and general business activities of the Company.

Selection of men for the program is based on interviews, reviews of students' records, and discussions with placement directors and faculty members. Selection is not limited solely to accounting and business administration majors. A large number of men in the program are liberal arts graduates, engineers, and men with other technical training.

When a man enters the program he is assigned a full-time office position in accounting or other financial work and enrolled in the formal evening education program. This planned classroom work is a most important phase of the program. The material presented is carefully selected and well integrated for the development of an adequate knowledge of accounting and business theory, procedures and policies followed by the Company, acceptable accounting and business practices of the modern economic enterprise, and as a supplement to the practical experience provided by the job assignment.

In general, the program trainee is considered in training for three years during which time advancements are made to more responsible types of accounting work. After completing academic training the trainee's progress and interests are re-examined. If he has demonstrated an aptitude for financial work he is considered for transfer to the staff of traveling auditors or to an accounting and financial supervisory position. From here his advancement opportunities lie in financial administrative positions throughout the Company. Trainees showing an interest and aptitude for work other than financial, such as sales, purchasing, community relations, publicity, etc., are at this time considered for placement in these fields.

Today, graduates of the program hold responsible positions throughout the entire organization. Management positions in the accounting and financial field throughout the Company, such as Comptroller, Treasurer, finance managers, secretaries, and others, are held in large part by graduates of the course. Men who have transferred to other fields after experience in financial work include public relations executives, managers of operating divisions and departments, presidents of affiliated Companies, officials in personnel, employee relations and production divisions, and executives in many other Company activities.

This partial list of positions now filled by former business training men is indicative of the career preparation offered by the business training program, and of the opportunities that exist for qualified men interested in beginning their careers in accounting and financial work.

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