E&S

ENGINEERING AND SCIENCE

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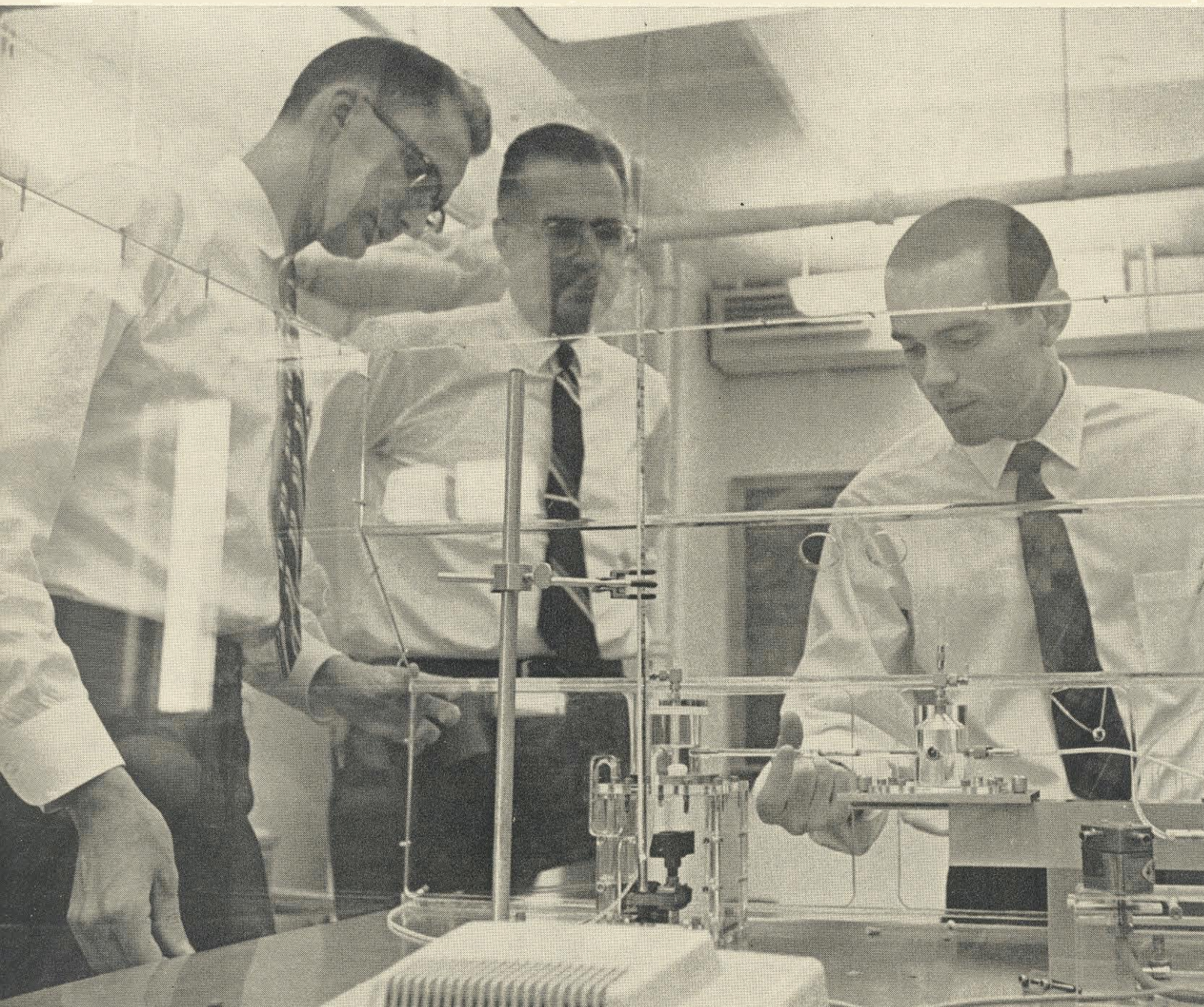

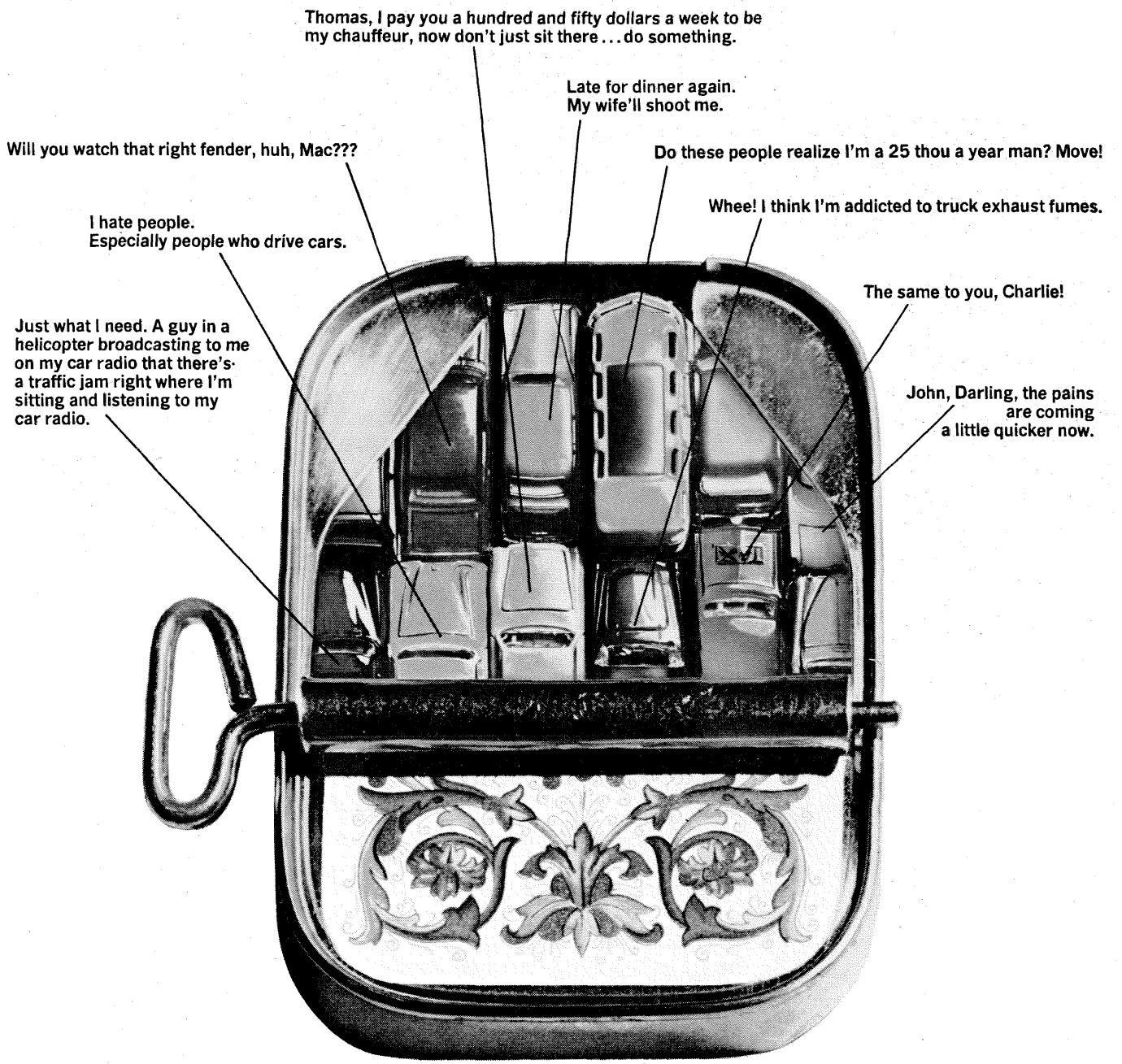

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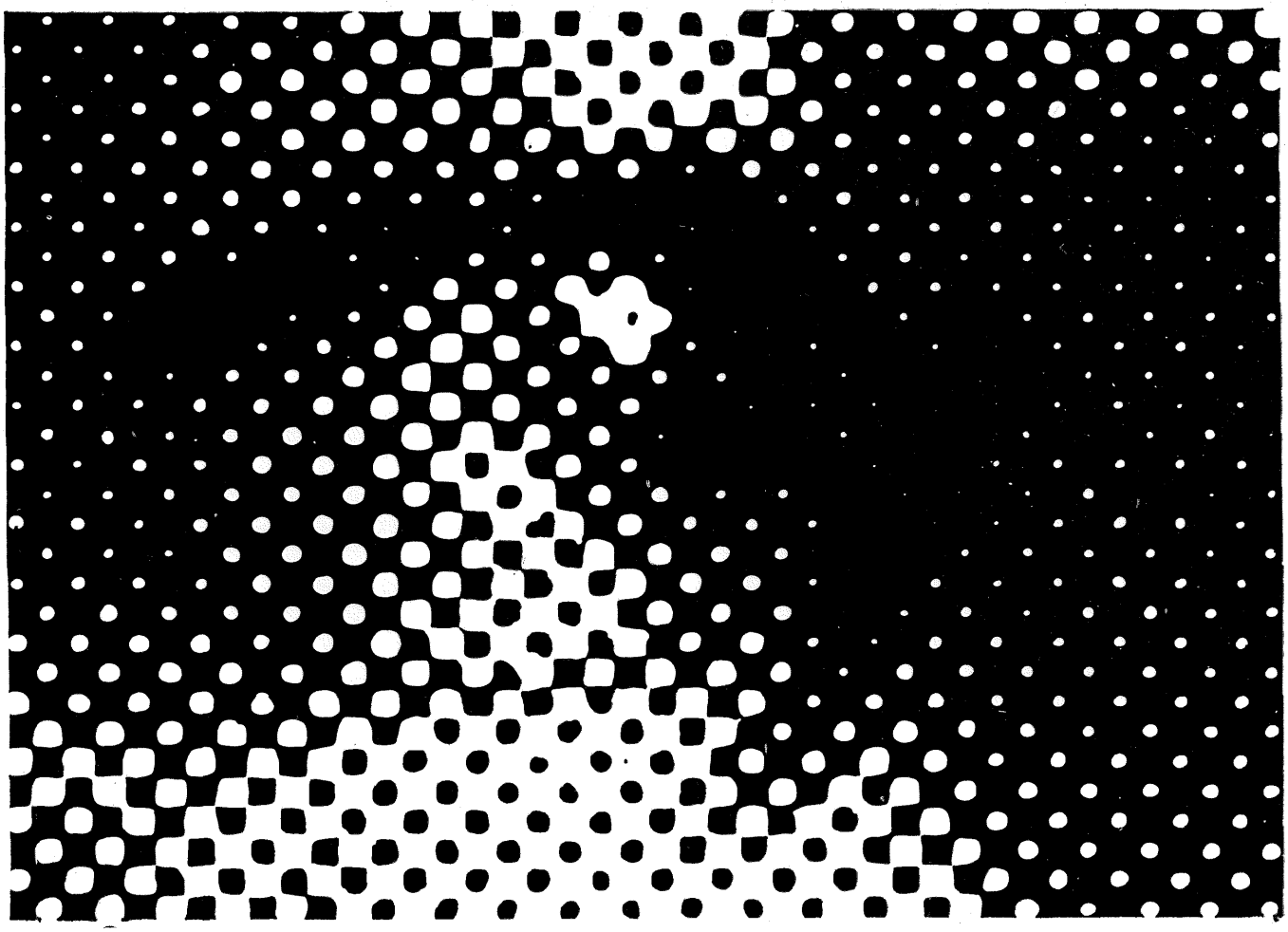

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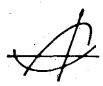

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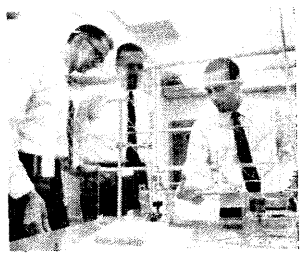
ENGINEERING AND SCIENCE

APRIL 1968 / VOLUME XXXI / NUMBER 7



ON THE COVER

William H. Corcoran (center), professor of and executive officer for chemical engineering, and graduate students Richard Jacobson (left) and Malcolm Morrison are responsible for introducing a new Caltech course (page 11) which centers around the study of the artificial kidney. The equipment shown on the cover, used to study blood flow, was designed under the supervision of Giles Cokelet.

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Editor and Business Manager—Edward Hutchings Jr.; *Associate Editors*—Bruce Abell '62, Phyllis Brewster, Julie Ann Davey, Jacquelyn Hershey, Kathleen Marcum; *Photographer*—James McClanahan.

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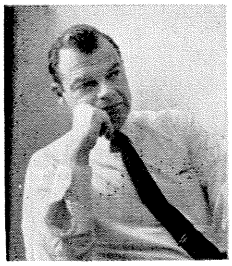
IN THIS ISSUE



RECOMMENDED CHANGES

Rolf H. Sabersky received his BS, MS, and PhD degrees from Caltech and has been a faculty member here since 1949. As a consulting engineer in the aerospace industry as well as a professor of mechanical engineering at Caltech, Dr. Sabersky is in a unique position to evaluate what needs to be done to prepare today's engineer for industry because he knows both the requirements of industry and the problems which face the young engineer. On pages 8-10, he expresses his views on the need for changes in engineering education.

A NEW APPROACH TO TEACHING

Basic engineering principles at Caltech are no longer routinely taught from textbooks. In a new course developed by William Corcoran, professor of chemical engineering and executive officer for the department, the artificial kidney is now used as a teaching aid. Dr. Corcoran describes this new method of teaching chemical engineering on pages 11-15.

A SPECIAL REPORT

A threatened crisis in the financing of higher education is an immediate concern to colleges and universities throughout the country. Recognizing the need for all U.S. institutions of higher learning to take a broad look at the nature of the impending trouble, the American Alumni Council has prepared a special report on this subject. "The Plain Fact Is . . . ," which appears on page 17 of this issue of *Engineering and Science,* will also appear in this month's issues of other college and university magazines. We present this report as a cogent statement of a general problem with specific application to the California Institute of Technology. On page 16 Caltech President Lee A. DuBridge underscores the significance of the report in his introductory statement, "The Investment We Cannot Afford Not to Make."

THE DRAFT

Although the hot breath of the draft seems a long way off to a college freshman, the concern of his friends, the seniors, is constantly and everywhere apparent. Caltech freshman Jim Cooper, an editor of the student newspaper, listens to his senior schoolmates and reports—on pages 40 and 41.

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LETTERS

Glendale

EDITOR:

I have just finished reading Robert A. Rosenstone's article, "A Look at the Radical Right Today," in the March issue of *E&S*. I vehemently object to the manner of including this article. Although the contents and its slant are repugnant to me, this is not the basis of my objection. I object because the author was in no way identified as to his relationship to Caltech, which would have allowed placing the article in its proper perspective. I believe in freedom of opinion and expression, even use of editorial prerogatives, but do not believe in foisting biased opinions upon a captive audience without identification of the source.

What body of opinion does Mr. Rosenstone represent? Or is this an aliquot of our expanded humanities curriculum, which is helping to broaden Caltech's undergraduates today? After perusing a myriad of Caltech bulletins, reports, and alumni directories, I stumbled on a clue that Mr. Rosenstone might be a visiting assistant professor of history —even maybe a student of Charles DeGaulle. Or am I stooping to his mastered technique of all-inclusive guilt by association?

As a life member of the Caltech alumni who contributed his way into the Golden Beaver Club, I feel that I have some stake in what comes out of C.I.T. I am not a member of the John Birch Society or the radical right, but if I were, I would not accuse everyone to the left of me as being part of the radical left.

GRIFFITH C. BARLOW, M.D. '48

Dr. Barlow's comments give us an opportunity to restate the editorial policy established by this magazine more than 20 years ago: Every article in Engineering and Science *has a direct connection with the California Institute of Technology. Either it is written by a staff member, a faculty member, a student, or an alumnus, or it is adapted from a lecture given on campus by a guest of the Institute, or it is about research being done at Caltech.*

Dr. Barlow's letter also reminds us to take nothing for granted—including the fact that we regularly identify our authors in a column called "In This Issue." On page 4 of the March E&S, *"In This Issue" identified Robert Rosenstone as assistant professor of history at Caltech. It can now be added that Dr. Rosenstone has a new book,* Protest From the Right, *published this month by Glencoe Press.*

San Marino

EDITOR:

A great piece of art work accompanying "The Kingdom of Good!" (March *E&S*, p. 24). Do you have a new staff artist not listed in your masthead?

MRS. THEODORE COMBS

Teresa Woodward did not sign her illustration, unfortunately, and E&S *did not list her in* Credits—*even more unfortunately.*

BOOKS

Town Origins

by John F. Benton

D. C. Heath and Company
Paperback *$1.95*

reviewed by Bettyann Kevles

The sprawling metropolises of contemporary civilization trace back to forces that led men away from fief and farm to create the towns of medieval Europe. Had medieval man been able to peer forward through time to today's urban glut or been aware of the seamy side of life in ancient Rome, perhaps he would have remained on the land. But he was largely oblivious of the past and mercifully unaware of the future. In any case, he had his reasons for becoming a townsman.

What these reasons were is a matter of historical controversy. John F. Benton presents the many sides of this question in his book, *Town Origins,* the newest addition to the distinguished Heath series, "Problems in European Civilization." In his lucid introduction Dr. Benton, who is associate professor of history at Caltech, discusses the major theories of medieval town origins as put forth by eminent historians from Western Europe, America, and the USSR. Then, following the format of the series, he introduces excerpts from some of their writings in which the historians offer opposing solutions to the puzzle of why towns—particularly medieval English towns—began.

These excerpts are followed by an extraordinarily broad and imaginative sampling of historical source material. They range from archaeological, numismatical, and etymological evidence to statistical data culled from ancient city gate and bridge toll receipts and the *Domesday Book,* to literary evidence in poetry and prose. Finally, Dr. Benton has prepared a set of maps which, if superimposed upon each other, reveal a vivid tale of change in medieval England. With this information, the reader can vie with the experts and decide for himself which forces were most responsible for the genesis of modern, urban civilization.

Bettyann Kevles is the wife of Caltech's assistant professor of history, Dan Kevles, and herself a high school teacher of European history.

Responsible Individualism

by Wallace Johnson '35

The Devin-Adair Company $4.50

reviewed by Theodore C. Combs '27

Wallace Johnson is a successful manufacturer and businessman. He owns a working ranch in northern California, where he and his son raise registered Hereford cattle. He is mayor of the city of Berkeley, and is a Caltech alumnus.

In this book, Mr. Johnson discusses the application of responsible individualism to current international, national, and even local issues. He cites a number of incidents confronting the city of Berkeley and describes how he conducted his "responsible" role in each case.

Readers of Mr. Johnson's book will be inspired to emulate his own conduct.

Scientific Progress and Human Values

Edited by Edward and Elizabeth Hutchings
With a preface by Lee A. DuBridge

American Elsevier Publishing Co., Inc. $7.50

Reviewed by Burton H. Klein, professor of economics

This is a fascinating book in which 20 distinguished physical and social scientists speculate about science and society. The book consists of the proceedings of the conference celebrating the 75th anniversary of the California Institute of Technology on October 25-27, 1966. It is not an easy book to summarize—and I shall not try. Instead, I shall say something about the ideas I found most interesting and about the ideas I failed to understand.

One of the most interesting sections of the book is "The Speculations of Science." Murray Gell-Mann leads off with a wonderfully clear statement on the need for a unified theory of particles. Then follows a discussion by Jesse L. Greenstein on the need for better observations and better theories about the stars and systems of stars. What he wants to know is where the planets come from, why they were formed, and whether solar systems are common. Again, the arguments are very persuasive. Equally interesting are Robert P. Sharp's speculations about the earth, which we seem to know almost as little about as the stars.

Another section of the book asks "Where is Biology Taking Us?" The two most interesting papers here are Robert P. Morison's and Robert L. Sinsheimer's. Morison presents some convincing arguments why we can "no longer keep our system of moral values and our system of scientific expertise in separate watertight compartments." Sinsheimer discusses the implications of DNA for science and for mankind.

Finally, there is an interesting panel discussion on "What Are the Urgent Problems?" by Don K. Price, Jr., James Bonner, Murray Gell-Mann, Carl Kaysen, and Simon Ramo. But before taking up some of their points I want to take up some other matters.

One thing I fail to understand is the apparently widespread belief that progress in scientific matters must be justified in terms of practical results. For example, Dr. Greenstein seems to be concerned about the terrible catastrophe that would be involved if, in the event of a nuclear war, neither the knowledge nor the means existed for evacuating the earth's remaining population to another planet. I too am concerned about this contingency, however small the probability of its occurrence. But I also believe that in planning for the worst that might occur, one must consider the effect of such planning on the *probability* of these things occurring. One wouldn't want to take out so much life insurance that he starved to death. And in our national security planning, I wonder if the emphasis given to preparing for the worst things has not already had a very unhealthy effect on the probability of their occurrence. Might we not do much better with a massive reallocation of resources to the *best* things that might happen? And this leads me to the question of the necessity of taking this kind of practical consideration into account in studying the stars. What's wrong with studying the stars just for the purpose of studying the stars?

Another example of emphasis on practical considerations is in Dr. Sinsheimer's article "The End of the Beginning," in which he says: "How will you choose to intervene in the ancient designs of nature for man? Would you like to control the sex of your offspring? It will be as you wish. Would you like your son to be six feet tall? Seven feet? What troubles you—allergy, obesity, arthritic pain? These will be easily handled. Viral and microbial disease will be easily met. Even the timeless patterns of growth and maturity and aging will be subject to our design."

At first this all sounds very appealing. But why in the world would anyone want to control the sex of his offspring? How can one really know beforehand whether he would like a boy, a girl, or twins? To put the question more generally, is science to become so powerful that nothing will be left to divine providence, experimentation, or just pure chance? May it not be quite impractical to contemplate such practical benefits?

SPACE BENEFITS QUESTIONED

In the case for the manned space program, I must confess serious difficulty in understanding *either* the scientific or the practical benefits. This case is put forth by George E. Mueller, NASA's Associate Administrator for Manned Space Flight. He argues, for example, that "the influence of our scientific and technological progress and prowess is and has been one of the deciding factors in keeping the peace over the past 20 years." I wonder whether too much reliance on such prowess hasn't been one of the principal causes of our difficulties—whether we would be in Vietnam if it were not for such heavy reliance on technological solutions to problems. Mueller goes on to claim that the space program has produced substantial benefits for the U.S. economy and that it could be of enormous help in connection with the problems of hunger and disease in underdeveloped countries. "For example," he says, "a doctor in a

continued on page 44

E&S
April 1968, Vol. XXXI, No. 7

Who Will Take the Lead in Engineering Education?

by Rolf H. Sabersky

Engineering as well as engineering education have undergone tremendous changes since just before World War II. So much, in fact, have concepts changed that in any discussion of engineering one has to define first of all what the word engineering is to mean. For our purpose let us define engineering in very broad terms—as the professional pursuit of solutions to technological problems.

This definition in itself gives no hint of the causes for the changes that have taken place. In fact it describes quite adequately the engineering activities of the earlier part of this century and before. In those earlier days, however, the application of rather simple technical knowledge and of systematically collected data was so successful in bringing about spectacular advancements in the technological fields that the practicing engineer seldom was forced to go beyond this body of rather empirical information to achieve the solution of the technological problems which presented themselves. But the need and desire for even greater technological achievements increased, and by the middle 1930s it had become evident that the fundamental facts of physics and the techniques of mathematics were tremendously effective tools in the quest for solutions to technological problems. The results of the use of these tools were nothing less than spectacular —the achievement of space flight and lunar exploration being among the most impressive.

It is to the credit of the engineering schools that they quickly realized the impact that a more thorough training in mathematics and physics could have on the scope and effectiveness of engineering. The next decade saw a complete change in the curriculum of essentially every engineering school in the country. This resulted in a heavy emphasis on mathematics and physics as well as in a reorientation of the engineering subjects to a more mathematical or analytical approach. The beneficial effect of these changes became apparent very promptly. The graduates who had completed the revised curricula were in command of a broader technical base, which made them capable of attacking a greater variety of problems and of making more original contributions.

This success was, of course, noted with great satisfaction on the campuses, and the trend toward more mathematics and the more analytical approach was accelerated. As a consequence, in the minds of the students the mathematician and the theoretical physicist emerged as persons to be emulated, and quite frequently they were asked to become members of the engineering faculties. Beneficial as all of these developments were, the preoccupation with the basic sciences led the engineering schools to forget more and more the central purpose of engineering, which is to solve technological problems. The pursuit of mathematics and physics became an end in itself, and the fact that these disciplines were introduced primarily to give the engineers better tools was remembered only rarely. As a result, in many schools engineering lost much of its identity, and the subjects taught and the research pursued began to lose contact with the reality of the technological problems which the professional engineer must solve.

Many engineering schools as well as members of the profession are aware of these difficulties and are seriously concerned. They feel that the contact with actual problems should

The central purpose of engineering is to solve society's technological problems. Have our academic institutions lost sight of this fact in educating young engineers?

be reintroduced into engineering education and research. Such a reorientation, however, is no longer easy to accomplish. The trend toward the point of view of physics and mathematics has gone so far that in many engineering faculties there remain relatively few members who are oriented toward and stimulated by technical problems as they occur in society. Most of the faculty is likely to be oriented toward applied mathematics, and even the experimentalists are inclined to select problems on the basis of their intellectual appeal rather than for their relation to technological needs. More than that, the present trend is particularly difficult to redirect because the teaching of theoretical disciplines and the pursuit of pure research are particularly suitable for an academic atmosphere. They attract brilliant intellects to the faculty as well as to the student body—people with a thirst for exact knowledge and an aptitude for its elegant mathematical formulation but who are generally impatient with any restrictions imposed by nonscientific requirements.

But patience, a willingness to admit the influence of nontechnical factors, and an appreciation of the importance of detail are all characteristics of a professional man who serves the public, and among these are engineers as well as physicians and lawyers. For such professional men the principal goal is always the solution of the problem as presented by the public. The solution is to be accomplished in the most effective way, and this will often demand the application of a rather routine procedure which may not be intellectually challenging.

Educating these two types of personalities within the confines of the same campus presents a most difficult problem. The interest in many basic subjects will be common to both, and, therefore, a direct comparison of the performance of the various groups in these subjects is unavoidable, not only among the students but also at the faculty level. The mathematician, for example, is likely to be better in mathematics than the engineer, the physicist better in physics, and so on. In an attempt to meet this problem, the engineering divisions of most of the leading schools have attempted to recruit a faculty and a student body which, subject by subject, could successfully compete with the physicist and the mathematician and could at the same time preserve the professional engineering character. This lofty goal has generally not been accomplished, and the faculties in engineering consist more and more of persons who have but little interest in applied problems. The composition of the student body has undergone similar changes, and in those cases where admission is based on competitive performance in mathematics and physics, enrollment in engineering has simply faded away.

This method of admission—based on mathematics and physics performance—is a common one and therefore of basic importance. To visualize its effects more clearly let us imagine that the education of physicians rather than engineers is the subject of discussion. The comparable situation would then be one in which future chemists, physicians and biologists would be accepted into a common first year on the basis of uniform requirements. Chemistry and biology might well be considered subjects fundamental to all of these profes-

sions, and the acceptance criteria could plausibly be designed to accept only those who excel in biology and chemistry.

Let us then say that the admitting school finds that fewer and fewer students select medicine each year and that most of them prefer to become research biologists and chemists. The school would then be faced with the alternative of either abandoning its role in the education of future physicians or of admitting students to the study of medicine who demonstrably had poorer grades in biology and chemistry than their classmates who planned to major in these subjects.

In the discussion of these alternatives there probably would be those who would feel it unthinkable to allow anybody to become a physician who was not a top performer in the fundamental subjects. Others, however, might feel that the performance in these subjects was only a part of the qualifications needed by a physician and not a determining index of the person's future professional performance. They might argue that it would be shortsighted to jeopardize the school's role in educating future physicians because of an artificial academic requirement. By continuing to educate the best qualified of those who wish to become physicians, the school would be able not only to add to the number of badly needed physicians but would also be able to continue its function of improving and advancing medical education itself. In this latter aspect in particular a forward-looking university could render an outstanding national service.

The hypothetical plight of the medical school *does* describe the actual one of the engineering schools today. Moreover, engineering is in dire need of an academic rejuvenation, as the profession itself no longer has a clear identity and does not present a clear image to the public and the prospective students.

Those who differ from this point of view often argue that technological development in the United States has been phenomenal, and so apparently the training given to the graduates of American universities must have been most beneficial to growing industry. Therefore, it would seem important to continue emphasizing the basic disciplines of mathematics and physics even to the exclusion of more applied subjects.

A closer look at industry, however, will reveal two facts: First, a significant number of present-day technical personnel received their training when there was an emphasis on applications. Second, the lack of people who are well trained in the fundamentals but who also have an understanding of the more practical aspects is becoming very evident. The gap between those interested in science for its own sake and those responsible for producing actual devices and concrete solutions is becoming wider. Such a divergence does not augur well for the development of technology.

In a more philosophical vein one might even remark that it is a sign of decadence when pure science is pursued only as an artistic endeavor without a simultaneous, parallel effort to *apply* the scientific findings to further the goals of society. It is the function of the engineer in the technological field, as it is the function of the physician in the area of life sciences, to establish a bridge between the "pure" and the "applied." A healthy, forward-looking society will therefore see to it that there shall be strong professional groups to maintain this bridge.

It is not clear at present who will accept the challenge of preventing a gap from developing between the "pure" and the "applied" in the technological area. It appears that academic institutions are in the most favorable position to bring about the change in trend. In particular, an institution with a high reputation for its standards and scientific competence could exert a powerful influence. Such an institution would be relatively immune from criticism implying that the renewed interest in the "applied" might be the result of lack of success in the field of the "pure." Even a small pilot program carried out by such a school and designed for the education of professional engineers might be most influential and encourage schools all over the country to focus their attention on this problem.

Indeed, the trend toward the introduction of more "pure science" into the engineering curriculum was brought about in the late 1920s by the pioneering spirit of only a few schools. Maybe those same schools will again take the lead in charting the course for sound professional engineering education.

Caltech answers the call for a change in engineering education with

A UNIQUE TEACHING METHOD

by William H. Corcoran

The development of artificial internal organs and the transplanting of such organs as the heart and the kidney are perhaps the most exciting advances in the field of medicine today. But equally exciting advances in technology have resulted from this work and have inevitably brought about a liaison between the medical and engineering professions—a liaison that is bound to lead to improved abilities in dealing with the technical aspects of difficult medical problems. These advances also furnish the basis for a new approach to engineering education—an approach which has met with great success at Caltech.

Last year, Caltech made a radical change in the teaching of chemical engineering. The introductory course in engineering for sophomores was built entirely around the study of problems based on hemodialysis and artificial kidneys. (Dialysis is the transfer of a dissolved substance across a membrane as a result of diffusion coupled with any bulk flow or fluid that might occur.) The course introduced such basic concepts as mass, energy, and momentum balances, stoichiometry, chemical equilibrium, and chemical kinetics by applying them to the problem of the treatment of kidney failure. The results of this new approach were so successful that the course has been made part of the regular curriculum.

The new framework not only allows a logical presentation of the concepts previously covered but introduces many other worthwhile principles of engineering interest. Because the course is introductory, all aspects of hemodialysis—engineering, medical, biological, and economic—are presented. Somewhat more than one-third of the three class hours per week are devoted to instruction by a member of the chemical engineering faculty on basic principles of thermodynamics, chemical equilibrium, and transport phenomena. These principles, including their use in mathematical models, are then applied to the problem of kidney failure.

Another one-third of the class hours are devoted to lectures by medical and professional people on such topics as renal function and failure; the design and function of necessary equipment for dialysis; sociological, medical, and economic problems of home and institutional dialysis; and the primarily medical problems of treatment for renal failure.

The remainder of the class time is spent on field trips to a hospital or manufacturing company to illustrate the application of informa-

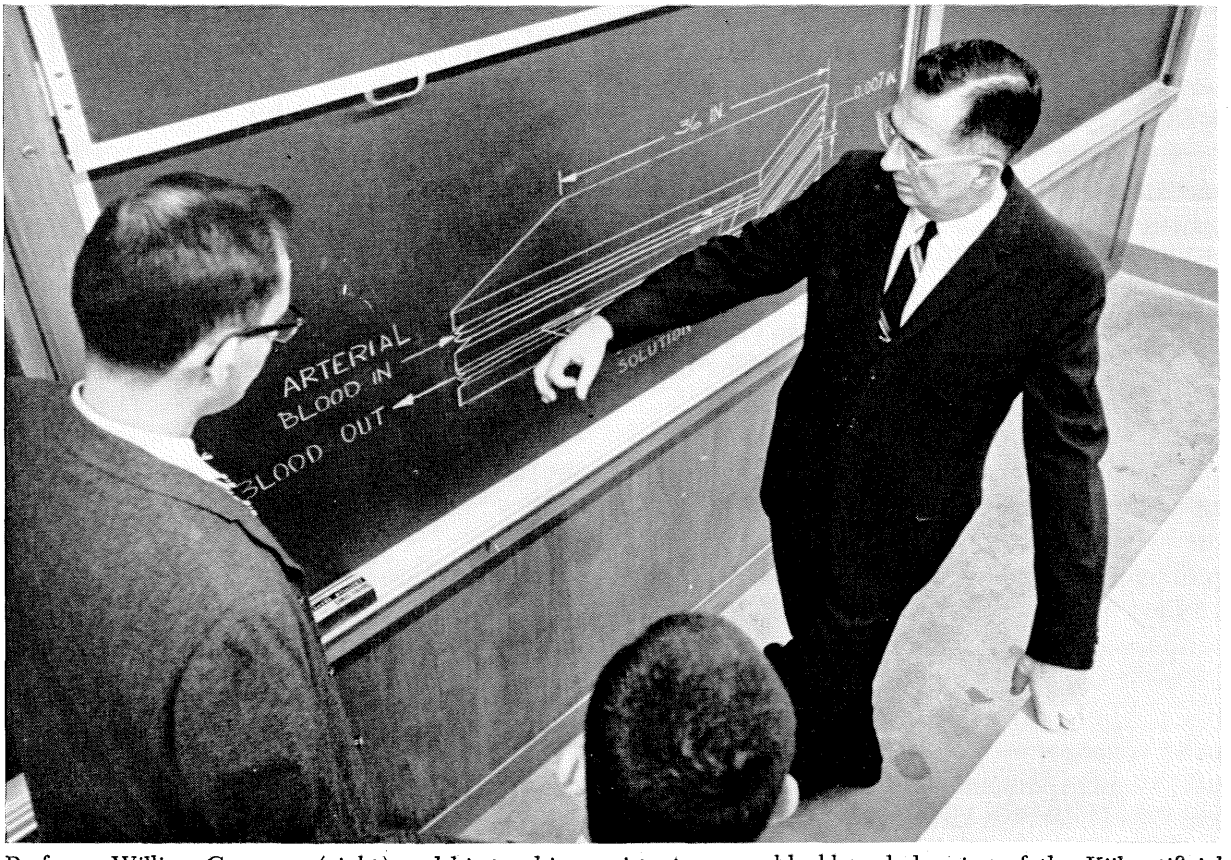
tion presented in the course.

The idea of using the artificial kidney to communicate engineering principles to students is based upon the fact that it demonstrates exceptionally fine examples of chemical engineering problems. The flow of blood from a patient's artery through an artificial kidney and back to the patient's vein—with the concurrent transfer of metabolic poisons to the dialysate fluid—presents excellent examples for study of fluid flow, material transfer, and energy transfer. In addition, the role of osmotic pressure in effecting solvent transfer across a cellophane membrane allows a real study of chemical equilibrium.

Combinations of these scientific and engineering principles in the framework of the capital costs of the equipment, its maintenance, and its efficient use provide good focus upon the techniques of cost accounting and the need for keeping economics continually in mind in the proper design of chemical systems.

Finally, in dealing with human beings, students get new insight into sociological needs and problems of human philosophy and psychology. In chronic kidney problems in human beings, the main avenue for removing undesirable metabolic waste products from the bloodstream is the use of hemodialysis exterior to the body. Techniques other than hemodialysis have been used, and practically every biological membrane has been tried. At the present time, though, peritoneal dialysis appears to be a useful technique for treatment of acute renal failure and removal of body poisons, while hemodialysis appears to be the preferred system for treating chronic renal failures.

Renal failure means simply that there is a loss of function, totally or partially, of the nephrons, which are filtration units of the kidney. There are some two milllion nephrons in the kidney, and when one is damaged and loses function, the process is irreversible. In normal excretion, one liter of fluid may be discharged per day by way of the kidneys. With renal difficulties, this quantity may be 70 percent less, with a concomitant building up of metabolic



Professor William Corcoran (right) and his teaching assistants use a blackboard drawing of the Kiil artificial kidney to demonstrate its design and function to a class in chemical engineering.

waste products in the blood plasma. Urea and creatinine are measures of the buildup of toxic waste products, and a toxic state known as uremia develops. The actual toxic substances which cause uremia have not yet been specified in physiological studies.

With normal renal function, the equilibrium concentration of urea nitrogen in the blood runs around 10 milligrams percent; this is 10 milligrams per 100 milliliters of blood. With 10 percent renal function, that number can approach 50 milligrams percent, and at that time the associated toxins would be influencing the body rapidly toward the state of uremia. Dialysis is then used to lower the content of the nitrogen-containing compounds of urea and creatinine and at the same time to remove the unknown toxic substances associated with uremia. Since the present methods allow removal of only 80 percent of the metabolic wastes, a person receiving hemodialysis treatment for renal failure is never completely well nor completely ill. Today an ordinary treatment for renal failure is one in which a patient receives two 12-hour dialyses during a week.

Today's patient pays as much as $12,000 annually to use an artificial kidney; the challenge to the engineer is to reduce these high costs by designing more efficient equipment.

Even though hemodialysis in an artificial kidney has been possible for at least 50 years, the first practical design was developed during World War II in Holland by Willem Kolff, M.D., who is now living in the United States. The design consisted mainly of a large rotating drum wound with cellophane tubing, with the unit immersed in a large bath of dialysate fluid. Blood which was heparinized flowed from the patient to a special coupling and then through the spiral path of tubing. Modifications of the Kolff design are in use in the United States and other parts of the world today.

In addition to the Kolff kidney, plate-type dialyzers have been developed which consist of sheets of cellophane mounted between flat parallel plates. One of the most common units of this type is the kidney first proposed by Frederick Kiil, M.D., of Norway and adapted by Belding Scribner, M.D., for use at the University of Washington Medical School. In his adaptation, cold dialysate fluid was circulated from a 380-liter tank through the dialyzer and returned to the tank. The dialysis is now carried out at essentially room temperature, but in the earlier work by Dr. Scribner it was performed at 20°C with the blood being rewarmed before return to the patient.

In the Kiil unit there is a low-pressure drop so that it is possible for the human heart to provide the pressure needed for reasonable flow of blood through the unit, whereas the Kolff system requires auxiliary pumping. The absence of a mechanical pump is helpful because of less trauma to the cell components of the blood.

Probably the main feature of the hemodialysis technique used today is the arteriovenous shunt, developed for convenience in getting into the patient's vascular system. This vascular prosthesis was developed in Seattle by Dr. Scribner and consists of a coil of Teflon or silicone rubber that is surgically and semipermanently mounted—typically in the forearm of the patient—providing a connection between an artery and a vein. When dialysis is necessary, the shunt and the exterior dialysis unit are connected. Thus a patient does not require a cutdown into an artery and a vein each time a dialysis is made. This is fortunate because the number of cutdowns possible within the framework of the body is finite due to the limited length of arteries and veins. These plastic shunts have been worn in place for periods up to a year and a half, and a new shunt has then been placed at a new site.

The cost for use of the Kiil kidney for hospitalized patients for two 12-hour dialyses a week for a year is roughly $8,000 plus an additional $4,000 for costs associated with occupancy of a hospital bed. The total cost of $12,000 may be somewhat low when considering that total annual costs as high as $35,000 have been reported. One of the major goals today is to reduce these costs. Significant prog-

ress has been made in this direction by way of a home unit for conduction of the hemodialysis procedure. Techniques for assembly and operation of equipment are learned in the hospital by the patient and another member of his family, and then the process is carried out in the home. Costs for home dialysis average from $4,000 to $10,000 per year including amortization of the equipment. Obviously, even further reduction in cost is desirable.

The challenge to the engineer, therefore, is to design equipment for hemodialysis that is convenient and comfortable and safe for the patient to use at low cost. Ideally such a unit would have a very small volume so that it could be contained readily on the exterior of a person's body and would be efficient relative to time required for reduction of metabolic wastes to an appropriate level. A small unit that would provide rapid removal of waste would, from a commonsense point of view, really be moving in the direction of the design of the natural kidney itself. Optimization studies show that the best type of unit, operating on pressure supplied by the human heart, would be one having essentially zero length in the direction of flow in the dialysis system, relatively low pressure drop, and hence significant width. Those boundary conditions come close to the human kidney system with its two million nephrons distributed between the two kidneys. Current efforts to produce a dialysis unit from many small-bore tubes mounted in parallel are moving in that direction.

A second technique, peritoneal dialysis, is not a dialysis system requiring transfers of blood from the patient to the exterior and return. Though it is simpler, it is not as effective as hemodialysis. It has had significant application in the treatment of acute renal failure because of the simple technique required in its use, whereas a hemodialysis system requires a team of specialists to equip the patient with the shunt and to get the equipment operating properly. In peritoneal dialysis, a catheter is inserted between the abdominal wall and the peritoneum by way of an incision near the umbilicus, and fluid is allowed to flow through the catheter into the peritoneal cavity. There is dialysis by way of transfer from the capillaries of the peritoneum to the fluid in the peritoneal cavity.

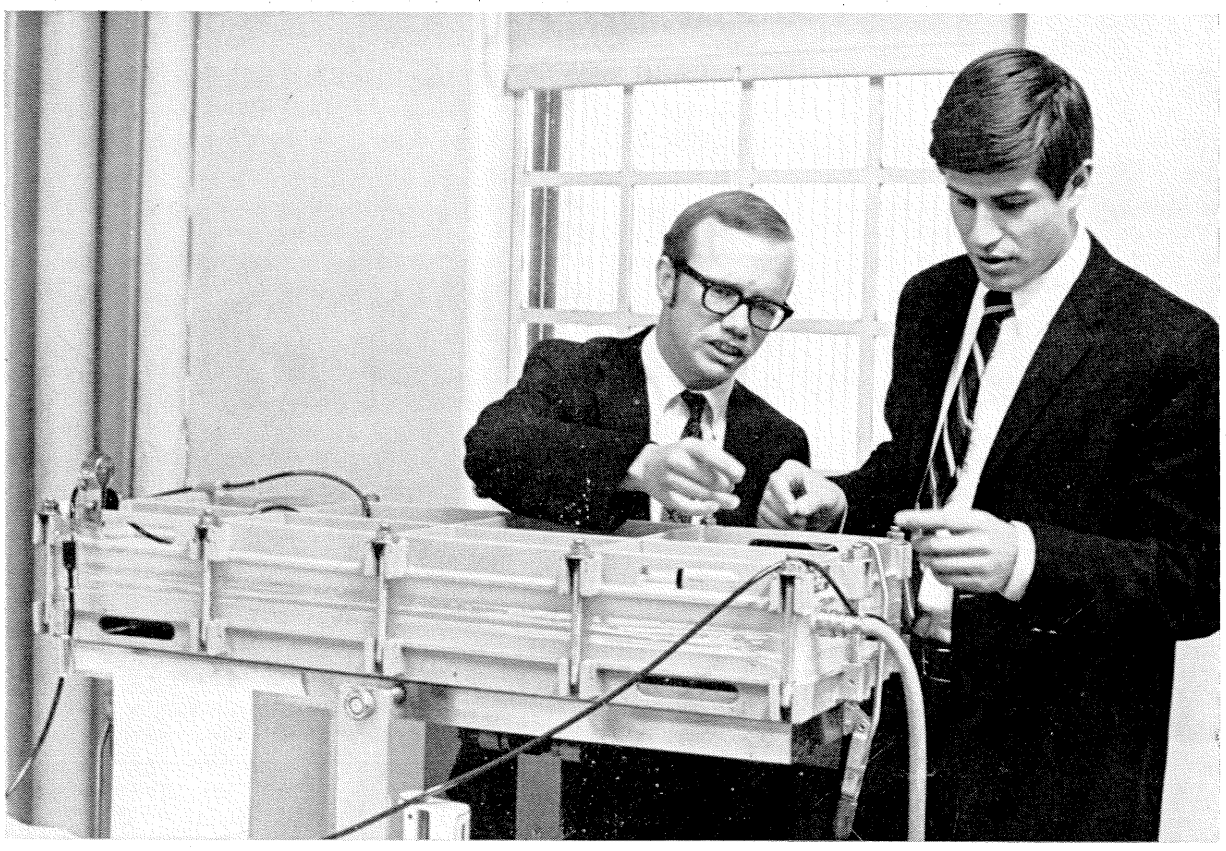
Because of the absence of flow in the peritoneal dialysis system in ordinary usage and the buildup of metabolites in the dialysate, the transfer of materials is not quite as rapid as in hemodialysis. That decrease in rate can be reduced somewhat by having the fluid move into and out of the peritoneal cavity on a continual basis, which requires significantly more dialysate fluid. Transfer can also be enhanced by vibration of the patient or by any other technique that decreases the effective thickness of the boundary layer in the transfer from the peritoneum to the fluid.

In actually seeing patients in a hospital, students get new insights into sociological needs and problems of human philosophy and psychology—problems they would not realize merely from classroom discussion.

No doubt other techniques for removal of metabolic wastes will be developed in the future. At the present time, however, the use of hemodialysis in the Kiil or Kolff kidney is the most satisfactory for continuing treatment of chronic kidney failure. In each case, there is need for significant engineering design in the improvement of the necessary equipment. Because of the need for improved engineering thinking in the systems of hemodialysis and peritoneal dialysis and because of the obvious interest in the use of artificial internal organs, the studies of these systems provide extraordinary means for communication of engineering principles to engineering and science students.

At Caltech, during the final three weeks of the course, students work individually or in pairs researching a topic of their choice in the field of hemodialysis. Some have done cost-reduction studies while others have conducted research on new, more efficient methods of dialysis and various approaches to home and hospital dialysis.

The course in use at Caltech was developed



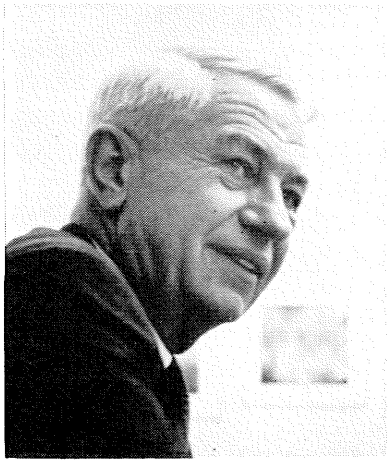
Larry Waterland and Bill Bradley inspect an artificial kidney in operation at a local hospital. The two sophomores are designing a new artificial kidney as part of their course in chemical engineering.

by Milton E. Rubini, associate professor of medicine at UCLA, visiting associate professor of chemical engineering at Caltech, and Chief of the Metabolic Section at Wadsworth Veterans Administration Hospital; E. A. Pecker, president of Biosystems, Inc.; Malcolm Morrison, a Caltech graduate teaching assistant in chemical engineering, and myself. Extraordinary assistance was provided by John R. De Palma, M.D., Mt. Sinai Hospital; Ralph M. Goldman, M.D., UCLA; and John E. Meihaus, M.D., USC. E. I. du Pont de Nemours & Company, Inc., provided financial support for the work at Caltech.

Subsequent course work in the style of that based on the artificial kidney can be imagined in the design of other artificial organs; however, it probably would not encompass the total combination of chemical and physical changes as seen in the framework of the artificial kidney. One of the most striking aspects of the artificial kidney study is the continuing development of the thought that, as improved equipment is obtained by way of engineering design, there will be more and more turning to the transplants of live organs. That opportunity would expand because of increasing ability to keep a person under appropriate physiological and medical control in the absence of kidney function until the time an appropriate transplant is put into place and is in operation. For example, with a very low-cost unit providing great efficiency in the removal of wastes, a person with renal difficulties would be put on that unit more readily than he is now on the more expensive system.

The artificial kidney is clearly the best artificial internal organ to study because it utilizes in a simple and straightforward fashion so many of the principles common to virtually all engineering problems. Other avenues have been used to introduce these engineering principles to students. None to date, however, has been quite as exciting as the use of the kidney, nor quite as complete relative to displaying the need for new approaches to the design of systems in which chemical reactions are occuring in the presence of flow.

A statement from President Lee A. DuBridge on



The Investment We Cannot Afford Not To Make

The problem of the financial support of higher education is a crucial one. It deserves penetrating analysis and widespread discussion. In each institution the analysis has surely been under way for many years; but more recent attempts to assemble the facts for many institutions and to discover the basic similarities and the general national trends have prompted wide discussion.

Two facts emerge: 1) On a national scale enrollments have been rising sharply; and 2) costs per student have been rising. In both cases the rates of increase have been larger than the rise of the Gross National Product. Hence a rapidly increasing portion of the GNP is being, and must continue to be, allocated to higher education. It is now about 2 percent.

Though these rising costs are alarming to many—as is pointed out in the special report, "The Plain Fact Is . . . ," which begins on the next page—they must be viewed in the light of McGeorge Bundy's comment, ". . . the American campus ranks with the American corporation a nong the handful of first-class contributions which our civilization has made to the annals of human institutions."

In other words, the American system of higher education is worth to our society far more than it costs. It will pay us to continually increase our support of higher education as one of the best—if not *the* best—investments that our nation can make.

To those who might say we cannot afford these costs, I reply, "We cannot afford *not* to make this investment."

Clearly, however, the rising costs do present a challenge of finding new sources of funds to keep higher education growing and especially to keep improving it.

There are, of course, only two sources of funds—voluntary contributions and taxes. Both must continue to increase at a rate adequate to meet the needs and to meet the growing opportunities to enrich our society.

State and local taxes must continue to be the mainstay of the public institutions. Federal funds should continue to support the national services that higher education renders, particularly advanced education and research. Private funds must play the essential role in supporting private colleges and universities.

Because of the rapid growth of public institutions, and because of the rapidly increasing costs of graduate education and research, tax funds will surely be needed to underwrite an even larger fraction of the total bill for higher education. But for the private institutions, rapidly rising contributions from the private sector are urgently required. Both to meet their needs and to preserve their precious independence, the private institutions must seek far greater philanthropic support.

It is inconceivable that a well-to-do society will neglect those great institutions which have contributed so mightily to make it well-to-do and which will contribute even greater increments in the future.

"A *crisis* in higher education?" Yes, perhaps. But a crisis of such a nature that it only becomes a great challenge.

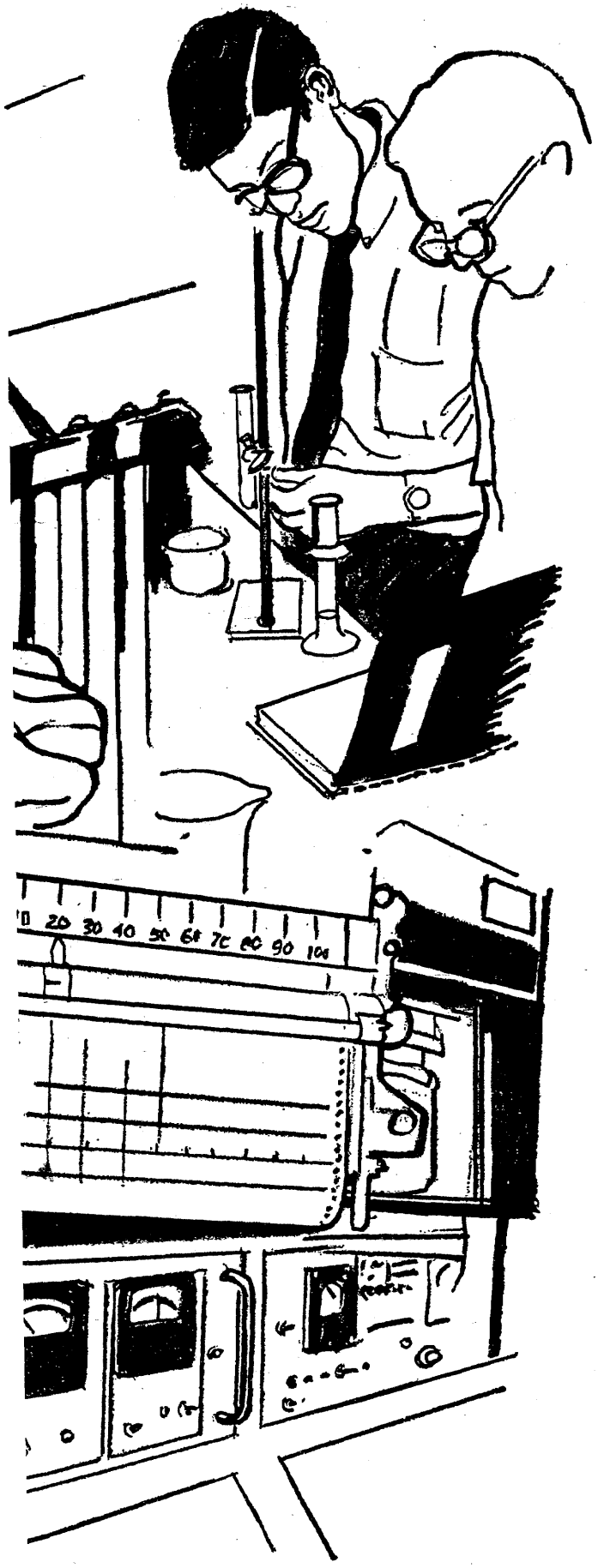
A Special Report

The Plain Fact Is...

...our colleges and universities "are facing what might easily become a crisis"

OUR COLLEGES AND UNIVERSITIES, over the last 20 years, have experienced an expansion that is without precedent—in buildings and in budgets, in students and in professors, in reputation and in rewards—in power and pride and in deserved prestige. As we try to tell our countrymen that we are faced with imminent bankruptcy, we confront the painful fact that in the eyes of the American people—and I think also in the eyes of disinterested observers abroad—we are a triumphant success. The observers seem to believe—and I believe myself—that the American campus ranks with the American corporation among the handful of first-class contributions which our civilization has made to the annals of human institutions. We come before the country to plead financial emergency at a time when our public standing has never been higher. It is at the least an unhappy accident of timing.

—McGEORGE BUNDY
President, The Ford Foundation



A Special Report

A STATE-SUPPORTED UNIVERSITY in the Midwest makes a sad announcement: With more well-qualified applicants for its freshman class than ever before, the university must tighten its entrance requirements. Qualified though the kids are, the university must turn many of them away.

▸ A private college in New England raises its tuition fee for the seventh time since World War II. In doing so, it admits ruefully: "Many of the best high-school graduates can't afford to come here, any more."

▸ A state college network in the West, long regarded as one of the nation's finest, cannot offer its students the usual range of instruction this year. Despite intensive recruiting, more than 1,000 openings on the faculty were unfilled at the start of the academic year.

▸ A church-related college in the South, whose denomination's leaders believe in strict separation of church and state, severs its church ties in order to seek money from the government. The college must have such money, say its administrators—or it will die.

Outwardly, America's colleges and universities appear more affluent than at any time in the past. In the aggregate they have more money, more students, more buildings, better-paid faculties, than ever before in their history.

Yet many are on the edge of deep trouble.

"The plain fact," in the words of the president of Columbia University, "is that we are facing what might easily become a crisis in the financing of American higher education, and the sooner we know about it, the better off we will be."

THE TROUBLE is not limited to a few institutions. Nor does it affect only one or two types of institution. Large universities, small colleges; state-supported and privately supported: the problem faces them all.

Before preparing this report, the editors asked more than 500 college and university presidents to tell us—off the record, if they preferred—just how they viewed the future of their institutions. With rare exceptions, the presidents agreed on this assessment: *That the money is not now in sight to meet the rising costs of higher education . . . to serve the growing numbers of bright, qualified students . . . and to pay for the myriad activities that Americans now demand of their colleges and universities.*

Important programs and necessary new buildings are

ALL OF US are hard-put to see where we are going to get the funds to meet the educational demands of the coming decade.

—A university president

being deferred for lack of money, the presidents said. Many admitted to budget-tightening measures reminiscent of those taken in days of the Great Depression.

Is this new? Haven't the colleges and universities always needed money? Is there something different about the situation today?

The answer is "Yes"—to all three questions.

The president of a large state university gave us this view of the over-all situation, at both the publicly and the privately supported institutions of higher education:

"A good many institutions of higher learning are operating at a deficit," he said. "First, the private colleges and universities: they are eating into their endowments in order to meet their expenses. Second, the public institutions. It is not legal to spend beyond our means, but here we have another kind of deficit: a deficit in quality, which will be extremely difficult to remedy even when adequate funding becomes available."

Other presidents' comments were equally revealing:

▸ *From a university in the Ivy League:* "Independent national universities face an uncertain future which threatens to blunt their thrust, curb their leadership, and jeopardize their independence. Every one that I know about is facing a deficit in its operating budget, this year or next. And all of us are hard-put to see where we are going to get the funds to meet the educational demands of the coming decade."

▸ *From a municipal college in the Midwest:* "The best word to describe our situation is 'desperate.' We are operating at a deficit of about 20 per cent of our total expenditure."

▸ *From a private liberal arts college in Missouri:* "Only by increasing our tuition charges are we keeping our heads above water. Expenditures are galloping to such a degree that I don't know how we will make out in the future."

▸ *From a church-related university on the West Coast:* "We face very serious problems. Even though our tuition is below-average, we have already priced ourselves out of part of our market. We have gone deeply into debt for dormitories. Our church support is declining. At times, the outlook is grim."

▸ *From a state university in the Big Ten:* "The budget for our operations must be considered tight. It is less than we need to meet the demands upon the university for teaching, research, and public service."

▸ *From a small liberal arts college in Ohio:* "We are on a hand-to-mouth, 'kitchen' economy. Our ten-year projections indicate that we can maintain our quality only by doubling in size."

▸ *From a small college in the Northeast:* "For the first time in its 150-year history, our college has a planned deficit. We are holding our heads above water at the moment—but, in terms of quality education, this cannot long continue without additional means of support."

▸ *From a state college in California:* "We are not permitted to operate at a deficit. The funding of our budget at a level considerably below that proposed by the trustees has made it difficult for us to recruit staff members and has forced us to defer very-much-needed improvements in our existing activities."

▸ *From a women's college in the South:* "For the coming year, our budget is the tightest we have had in my fifteen years as president."

WHAT'S GONE WRONG?

Talk of the sort quoted above may seem strange, as one looks at the unparalleled growth of America's colleges and universities during the past decade:

▸ Hardly a campus in the land does not have a brand-new building or one under construction. Colleges and universities are spending more than $2 billion a year for capital expansion.

▸ Faculty salaries have nearly doubled in the past decade. (But in some regions they are still woefully low.)

▸ Private, voluntary support to colleges and universities has more than tripled since 1958. Higher education's share of the philanthropic dollar has risen from 11 per cent to 17 per cent.

▸ State tax funds appropriated for higher education have increased 44 per cent in just two years, to a 1967–68 total of nearly $4.4 billion. This is 214 per cent more than the sum appropriated eight years ago.

▸ Endowment funds have more than doubled over the past decade. They're now estimated to be about $12 billion, at market value.

▸ Federal funds going to institutions of higher education have more than doubled in four years.

▸ More than 300 new colleges and universities have been founded since 1945.

▸ All in all, the total expenditure this year for U.S. higher education is some $18 billion—more than three times as much as in 1955.

Moreover, America's colleges and universities have absorbed the tidal wave of students that was supposed to have swamped them by now. They have managed to fulfill their teaching and research functions and to undertake a variety of new public-service programs—despite the ominous predictions of faculty shortages heard ten or fifteen years ago. Says one foundation official:

"The system is bigger, stronger, and more productive than it has ever been, than any system of higher education in the world."

Why, then, the growing concern?

Re-examine the progress of the past ten years, and this fact becomes apparent: The progress was great—but it did not deal with the basic flaws in higher education's financial situation. Rather, it made the whole enterprise bigger, more sophisticated, and more expensive.

Voluntary contributions grew—but the complexity and costliness of the nation's colleges and universities grew faster.

Endowment funds grew—but the need for the income from them grew faster.

State appropriations grew—but the need grew faster.

Faculty salaries were rising. New courses were needed, due to the unprecedented "knowledge explosion." More costly apparatus was required, as scientific progress grew more complex. Enrollments burgeoned—and students stayed on for more advanced (and more expensive) training at higher levels.

And, for most of the nation's 2,300 colleges and universities, an old problem remained—and was intensified, as the costs of education rose: gifts, endowment, and government funds continued to go, disproportionately, to a relative handful of institutions. Some 36 per cent of all voluntary contributions, for example, went to just 55 major universities. Some 90 per cent of all endowment funds were owned by fewer than 5 per cent of the institutions. In 1966, the most recent year reported, some 70 per cent of the federal government's funds for higher education went to 100 institutions.

McGeorge Bundy, the president of the Ford Foundation, puts it this way:

"Great gains have been made; the academic profession has reached a wholly new level of economic strength, and the instruments of excellence—the libraries and

Drawings by Peter Hooven

EACH NEW ATTEMPT at a massive solution has left the trustees and presidents just where they started.

—A foundation president

laboratories—are stronger than ever. But the university that pauses to look back will quickly fall behind in the endless race to the future."

Mr. Bundy says further:

"The greatest general problem of higher education is money .... The multiplying needs of the nation's colleges and universities force a recognition that each new attempt at a massive solution has left the trustees and presidents just where they started: in very great need."

THE FINANCIAL PROBLEMS of higher education are unlike those, say, of industry. Colleges and universities do not operate like General Motors. On the contrary, they sell their two primary services—teaching and research—at a loss.

It is safe to say (although details may differ from institution to institution) that the American college or university student pays only a fraction of the cost of his education.

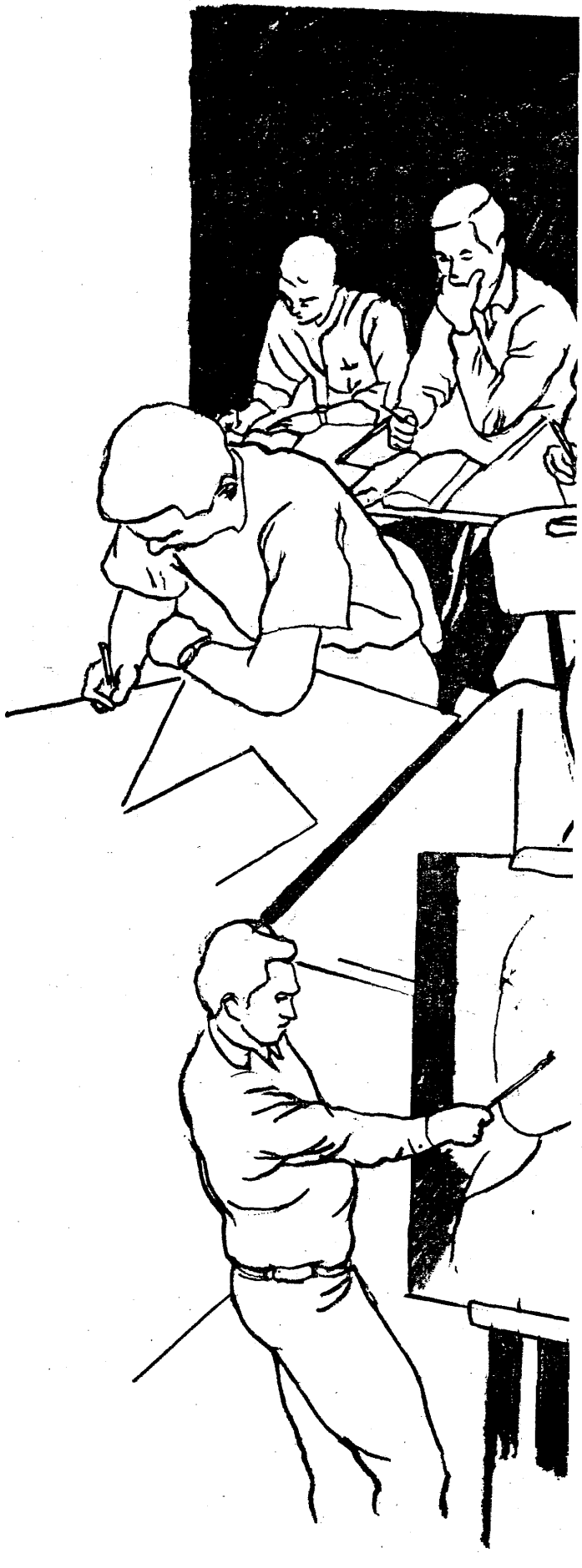
This cost varies with the level of education and with the educational practices of the institution he attends. Undergraduate education, for instance, costs less than graduate education—which in turn may cost less than medical education. And the cost of educating a student in the sciences is greater than in the humanities. Whatever the variations, however, the student's tuition and fees pay only a portion of the bill.

"As private enterprises," says one president, "we don't seem to be doing so well. We lose money every time we take in another student."

Of course, neither he nor his colleagues on other campuses would have it otherwise. Nor, it seems clear, would most of the American people.

But just as student instruction is provided at a substantial reduction from the actual cost, so is the research that the nation's universities perform on a vast scale for the federal government. On this particular below-cost service, as contrasted with that involving the provision of education to their students, many colleges and universities are considerably less than enthusiastic.

In brief: The federal government rarely pays the full cost of the research it sponsors. Most of the money goes for *direct costs* (compensation for faculty time, equipment, computer use, etc.) Some of it goes for *indirect costs* (such "overhead" costs of the institution as payroll departments, libraries, etc.). Government policy stipulates that the institutions receiving federal research grants



must share in the cost of the research by contributing, in some fashion, a percentage of the total amount of the grant.

University presidents have insisted for many years that the government should pay the full cost of the research it sponsors. Under the present system of cost-sharing, they point out, it actually costs their institutions money to conduct federally sponsored research. This has been one of the most controversial issues in the partnership between higher education and the federal government, and it continues to be so.

In commercial terms, then, colleges and universities sell their products at a loss. If they are to avoid going bankrupt, they must make up—from other sources—the difference between the income they receive for their services and the money they spend to provide them.

With costs spiraling upward, that task becomes ever more formidable.

HERE ARE SOME of the harsh facts: Operating expenditures for higher education more than tripled during the past decade—from about $4 billion in 1956 to $12.7 billion last year. By 1970, if government projections are correct, colleges and universities will be spending over $18 billion for their current operations, plus another $2 billion or $3 billion for capital expansion.

Why such steep increases in expenditures? There are several reasons:

▸ Student enrollment is now close to 7 million—twice what it was in 1960.

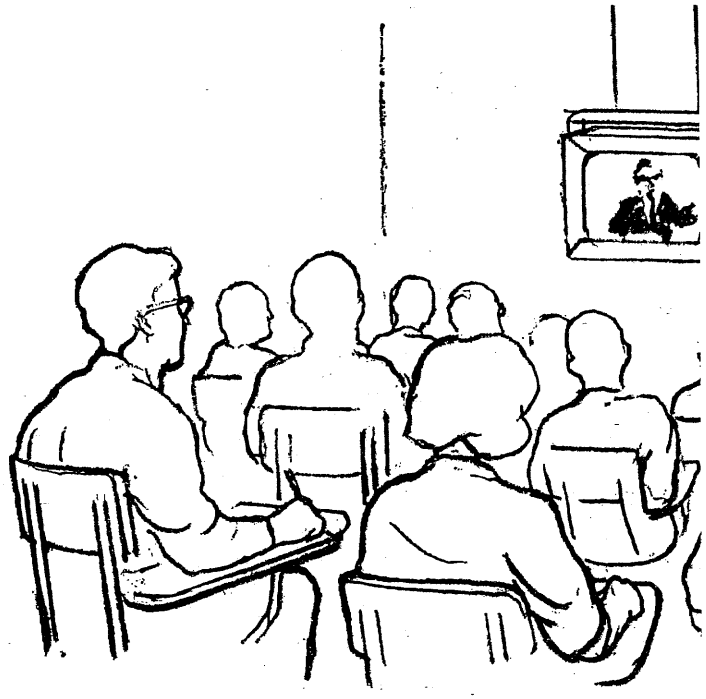
▸ The rapid accumulation of new knowledge and a resulting trend toward specialization have led to a broadening of the curricula, a sharp increase in graduate study, a need for sophisticated new equipment, and increased library acquisitions. All are very costly.

▸ An unprecedented growth in faculty salaries—long overdue—has raised instructional costs at most institutions. (Faculty salaries account for roughly half of the educational expenses of the average institution of higher learning.)

▸ About 20 per cent of the financial "growth" during the past decade is accounted for by inflation.

Not only has the over-all cost of higher education increased markedly, but the *cost per student* has risen steadily, despite increases in enrollment which might, in any other "industry," be expected to lower the unit cost.

Colleges and universities apparently have not improved their productivity at the same pace as the economy generally. A recent study of the financial trends in three private universities illustrates this. Between 1905 and 1966, the educational cost per student at the three universities, viewed compositely, increased 20-fold, against an economy-wide increase of three- to four-fold. In each of the three periods of peace, direct costs per student increased about 8 per cent, against a 2 per cent annual increase in the economy-wide index.



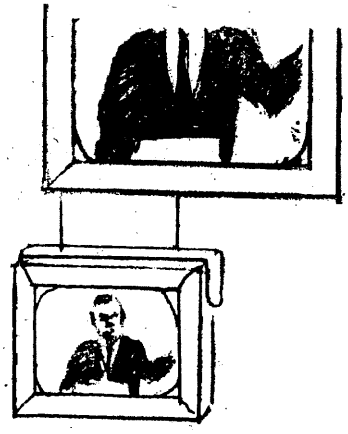
Some observers conclude from this that higher education must be made more efficient—that ways must be found to educate more students with fewer faculty and staff members. Some institutions have moved in this direction by adopting a year-round calendar of operations, permitting them to make maximum use of the faculty and physical plant. Instructional devices, programmed learning, closed-circuit television, and other technological systems are being employed to increase productivity and to gain economies through larger classes.

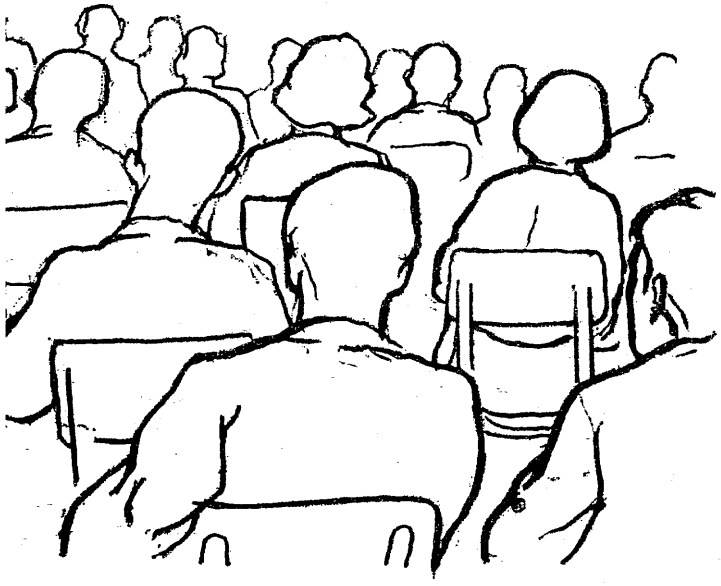
The problem, however, is to increase efficiency without jeopardizing the special character of higher education. Scholars are quick to point out that management techniques and business practices cannot be applied easily to colleges and universities. They observe, for example, that on strict cost-accounting principles, a college could not justify its library. A physics professor, complaining about large classes, remarks: "When you get a hundred kids in a classroom, that's not education; that's show business."

The college and university presidents whom we surveyed in the preparation of this report generally believe their institutions are making every dollar work. There is room for improvement, they acknowledge. But few feel the financial problems of higher education can be significantly reduced through more efficient management.

ONE THING seems fairly certain: The costs of higher education will continue to rise. To meet their projected expenses, colleges and universities will need to increase their annual operating income by more than $4 billion during the four-year period between 1966 and 1970. They must find another $8 billion or $10 billion for capital outlays.

Consider what this might mean for a typical private





university. A recent report presented this hypothetical case, based on actual projections of university expenditures and income:

The institution's budget is now in balance. Its educational and general expenditures total $24.5 million a year.

Assume that the university's expenditures per student will continue to grow at the rate of the past ten years—7.5 per cent annually. Assume, too, that the university's enrollment will continue to grow at *its* rate of the past ten years—3.4 per cent annually. Ten years hence, the institution's educational and general expenses would total $70.7 million.

At best, continues the analysis, tuition payments in the next ten years will grow at a rate of 6 per cent a year; at worst, at a rate of 4 per cent—compared with 9 per cent over the *past* ten years. Endowment income will grow at a rate of 3.5 to 5 per cent, compared with 7.7 per cent over the past decade. Gifts and grants will grow at a rate of 4.5 to 6 per cent, compared with 6.5 per cent over the past decade.

"If the income from private sources grew at the *higher* rates projected," says the analysis, "it would increase from $24.5 million to $50.9 million—leaving a deficit of $19.8 million, ten years hence. If its income from private sources grew at the *lower* rates projected, it would have increased to only $43 million—leaving a shortage of $27.8 million, ten years hence."

In publicly supported colleges and universities, the outlook is no brighter, although the gloom is of a different variety. Says the report of a study by two professors at the University of Wisconsin:

"Public institutions of higher education in the United States are now operating at a quality deficit of more than a billion dollars a year. In addition, despite heavy construction schedules, they have accumulated a major capital lag."

The deficit cited by the Wisconsin professors is a computation of the cost of bringing the public institutions' expenditures per student to a level comparable with that at the private institutions. With the enrollment growth expected by 1975, the professors calculate, the "quality deficit" in public higher education will reach $2.5 billion.

The problem is caused, in large part, by the tremendous enrollment increases in public colleges and universities. The institutions' resources, says the Wisconsin study, "may not prove equal to the task."

Moreover, there are indications that public institutions may be nearing the limit of expansion, unless they receive a massive infusion of new funds. One of every seven public universities rejected qualified applicants from their own states last fall; two of every seven rejected qualified applicants from other states. One of every ten raised admissions standards for in-state students; one in six raised standards for out-of-state students.

WILL THE FUNDS be found to meet the projected cost increases of higher education?

Colleges and universities have traditionally received their operating income from three sources: *from the students*, in the form of tuition and fees; *from the state*, in the form of legislative appropriations; and *from individuals, foundations, and corporations*, in the form of gifts. (Money from the federal government for operating expenses is still more of a hope than a reality.)

Can these traditional sources of funds continue to meet the need? The question is much on the minds of the nation's college and university presidents.

▸ **Tuition and fees:** They have been rising—and are likely to rise more. A number of private "prestige" institutions have passed the $2,000 mark. Public institutions are under mounting pressure to raise tuition and fees, and their student charges have been rising at a faster rate than those in private institutions.

The problem of student charges is one of the most controversial issues in higher education today. Some feel that the student, as the direct beneficiary of an education, should pay most or all of its real costs. Others disagree emphatically: since society as a whole is the ultimate beneficiary, they argue, every student should have the right to an education, whether he can afford it or not.

The leaders of publicly supported colleges and universities are almost unanimous on this point: that higher tuitions and fees will erode the premise of equal oppor-

TUITION: We are reaching a point of diminishing returns. *—A college president*

It's like buying a second home. *—A parent*

tunity on which public higher education is based. They would like to see the present trend reversed—toward free, or at least lower-cost, higher education.

Leaders of private institutions find the rising tuitions equally disturbing. Heavily dependent upon the income they receive from students, many such institutions find that raising their tuition is inescapable, as costs rise. Scores of presidents surveyed for this report, however, said that mounting tuition costs are "pricing us out of the market." Said one: "As our tuition rises beyond the reach of a larger and larger segment of the college-age population, we find it more and more difficult to attract our quota of students. We are reaching a point of diminishing returns."

Parents and students also are worried. Said one father who has been financing a college education for three daughters: "It's like buying a second home."

Stanford Professor Roger A. Freeman says it isn't really that bad. In his book, *Crisis in College Finance?*, he points out that when tuition increases have been adjusted to the shrinking value of the dollar or are related to rising levels of income, the cost to the student actually declined between 1941 and 1961. But this is small consolation to a man with an annual salary of $15,000 and three daughters in college.

Colleges and universities will be under increasing pressure to raise their rates still higher, but if they do, they will run the risk of pricing themselves beyond the means of more and more students. Indeed, the evidence is strong that resistance to high tuition is growing, even in relatively well-to-do families. The College Scholarship Service, an arm of the College Entrance Examination Board, reported recently that some middle- and upper-income parents have been "substituting relatively low-cost institutions" because of the rising prices at some of the nation's colleges and universities.

The presidents of such institutions have nightmares over such trends. One of them, the head of a private college in Minnesota, told us:

"We are so dependent upon tuition for approximately 50 per cent of our operating expenses that if 40 fewer students come in September than we expect, we could have a budgetary deficit this year of $50,000 or more."

▸ **State appropriations:** The 50 states have appropriated nearly $4.4 billion for their colleges and universities this year—a figure that includes neither the $1–$2 billion spent by public institutions for capital expansion, nor the appropriations of local governments, which account for about 10 per cent of all public appropriations for the operating expenses of higher education.

The record set by the states is remarkable—one that many observers would have declared impossible, as recently as eight years ago. In those eight years, the states have increased their appropriations for higher education by an incredible 214 per cent.

Can the states sustain this growth in their support of higher education? Will they be willing to do so?

The more pessimistic observers believe that the states can't and won't, without a drastic overhaul in the tax structures on which state financing is based. The most productive tax sources, such observers say, have been pre-empted by the federal government. They also believe that more and more state funds will be used, in the future, to meet increasing demands for other services.

Optimists, on the other hand, are convinced the states are far from reaching the upper limits of their ability to raise revenue. Tax reforms, they say, will enable states to increase their annual budgets sufficiently to meet higher education's needs.

The debate is theoretical. As a staff report to the Advisory Commission on Intergovernmental Relations concluded: "The appraisal of a state's fiscal capacity is a political decision [that] it alone can make. It is not a researchable problem."

Ultimately, in short, the decision rests with the taxpayer.

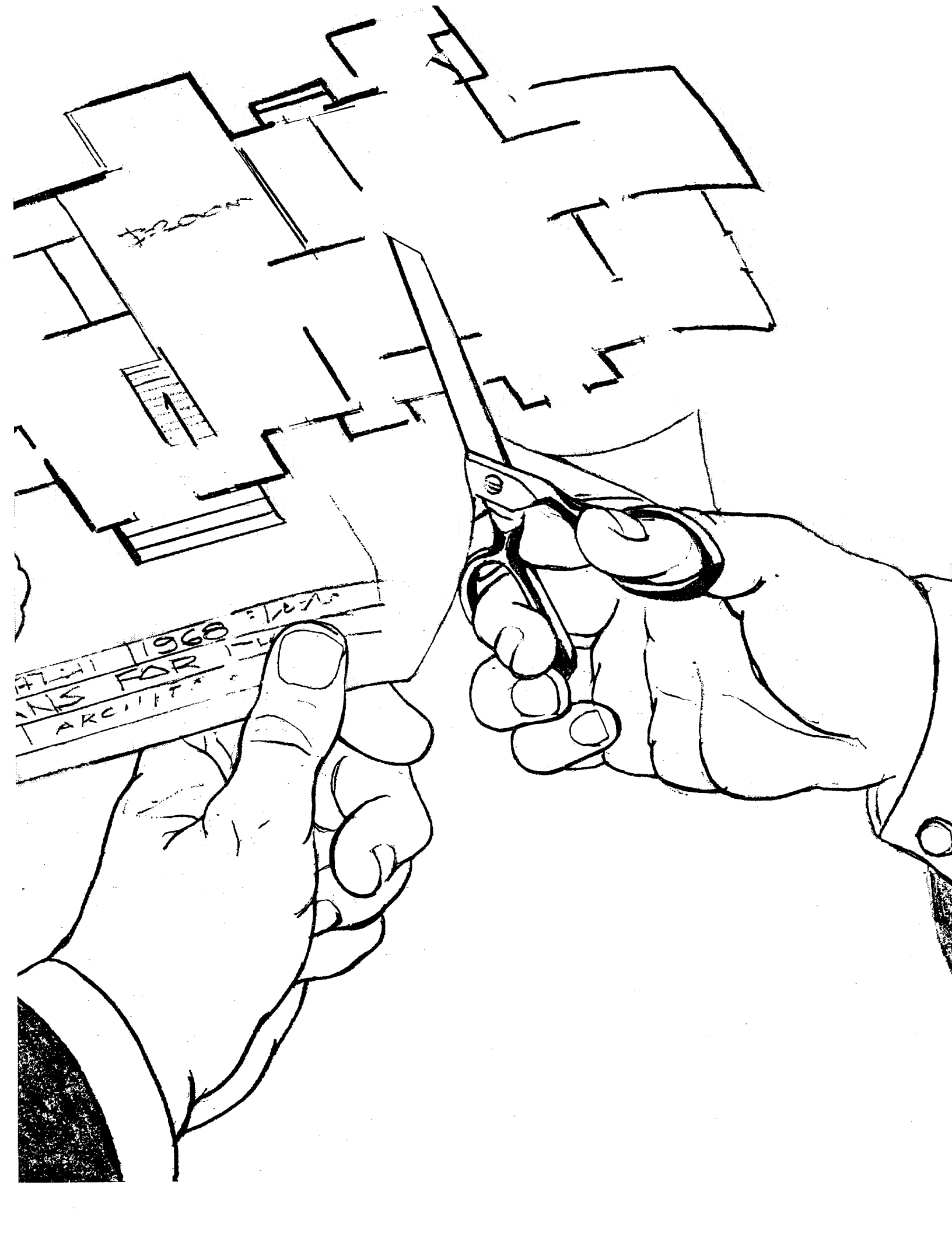
▸ **Voluntary private gifts:** Gifts are vital to higher education.

In private colleges and universities, they are part of the lifeblood. Such institutions commonly budget a deficit, and then pray that it will be met by private gifts.

In public institutions, private gifts supplement state appropriations. They provide what is often called "a margin for excellence." Many public institutions use such funds to raise faculty salaries above the levels paid for by the state, and are thus able to compete for top scholars. A number of institutions depend upon private gifts for student facilities that the state does not provide.

Will private giving grow fast enough to meet the growing need? As with state appropriations, opinions vary.

John J. Schwartz, executive director of the American Association of Fund-Raising Counsel, feels there is a great untapped reservoir. At present, for example, only one out of every four alumni and alumnae contributes to higher education. And, while American business corporations gave an estimated $300 million to education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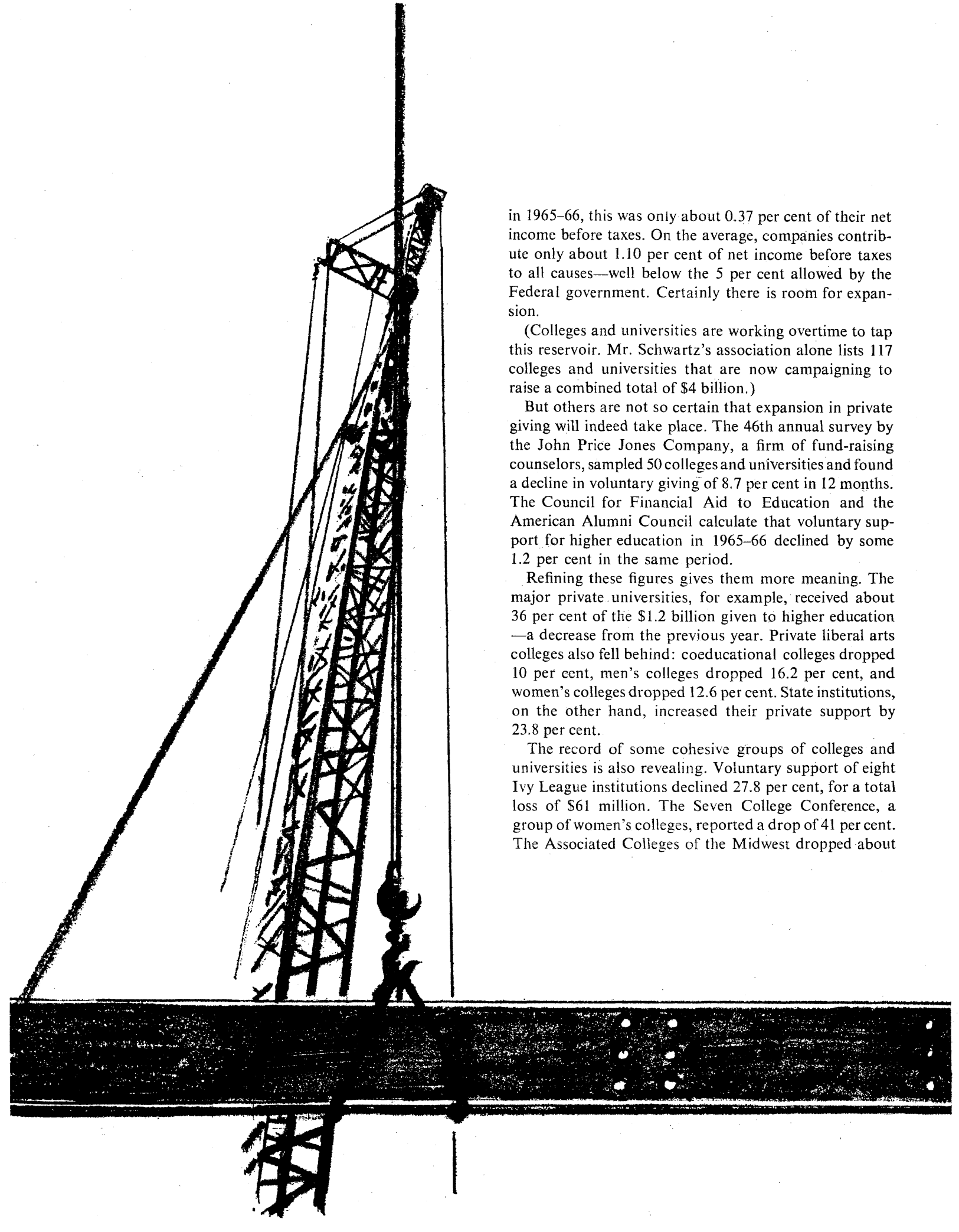

in 1965–66, this was only about 0.37 per cent of their net income before taxes. On the average, companies contribute only about 1.10 per cent of net income before taxes to all causes—well below the 5 per cent allowed by the Federal government. Certainly there is room for expansion.

(Colleges and universities are working overtime to tap this reservoir. Mr. Schwartz's association alone lists 117 colleges and universities that are now campaigning to raise a combined total of $4 billion.)

But others are not so certain that expansion in private giving will indeed take place. The 46th annual survey by the John Price Jones Company, a firm of fund-raising counselors, sampled 50 colleges and universities and found a decline in voluntary giving of 8.7 per cent in 12 months. The Council for Financial Aid to Education and the American Alumni Council calculate that voluntary support for higher education in 1965–66 declined by some 1.2 per cent in the same period.

Refining these figures gives them more meaning. The major private universities, for example, received about 36 per cent of the $1.2 billion given to higher education —a decrease from the previous year. Private liberal arts colleges also fell behind: coeducational colleges dropped 10 per cent, men's colleges dropped 16.2 per cent, and women's colleges dropped 12.6 per cent. State institutions, on the other hand, increased their private support by 23.8 per cent.

The record of some cohesive groups of colleges and universities is also revealing. Voluntary support of eight Ivy League institutions declined 27.8 per cent, for a total loss of $61 million. The Seven College Conference, a group of women's colleges, reported a drop of 41 per cent. The Associated Colleges of the Midwest dropped about

ON THE QUESTION OF FEDERAL AID, everybody seems to be running to the same side of the boat.

—A college president

5.5 per cent. The Council of Southern Universities declined 6.2 per cent. Fifty-five major private universities received 7.7 per cent less from gifts.

Four groups gained. The state universities and colleges received 20.5 per cent more in private gifts in 1965–66 than in the previous year. Fourteen technological institutions gained 10.8 per cent. Members of the Great Lakes College Association gained 5.6 per cent. And Western Conference universities, plus the University of Chicago, gained 34.5 per cent. (Within each such group, of course, individual colleges may have gained or lost differently from the group as a whole.)

The biggest drop in voluntary contributions came in foundation grants. Although this may have been due, in part, to the fact that there had been some unusually large grants the previous year, it may also have been a foretaste of things to come. Many of those who observe foundations closely think such grants will be harder and harder for colleges and universities to come by, in years to come.

FEARING that the traditional sources of revenue may not yield the necessary funds, college and university presidents are looking more and more to Washington for the solution to their financial problems.

The president of a large state university in the South, whose views are typical of many, told us: "Increased federal support is essential to the fiscal stability of the colleges and universities of the land. And such aid is a proper federal expenditure."

Most of his colleagues agreed—some reluctantly. Said the president of a college in Iowa: "I don't like it . . . but it may be inevitable." Another remarked: "On the question of federal aid, everybody seems to be running to the same side of the boat."

More federal aid is almost certain to come. The question is, When? And in what form?

Realism compels this answer: In the near future, the federal government is unlikely to provide substantial support for the operating expenses of the country's colleges and universities.

The war in Vietnam is one reason. Painful effects of war-prompted economies have already been felt on the campuses. The effective federal funding of research per faculty member is declining. Construction grants are becoming scarcer. Fellowship programs either have been reduced or have merely held the line.

Indeed, the changes in the flow of federal money to the campuses may be the major event that has brought higher education's financial problems to their present head.

Would things be different in a peacetime economy? Many college and university administrators think so. They already are planning for the day when the Vietnam war ends and when, the thinking goes, huge sums of federal money will be available for higher education. It is no secret that some government officials are operating on the same assumption and are designing new programs of support for higher education, to be put into effect when the war ends.

Others are not so certain the postwar money flow is that inevitable. One of the doubters is Clark Kerr, former president of the University of California and a man with considerable first-hand knowledge of the relationship between higher education and the federal government. Mr. Kerr is inclined to believe that the colleges and universities will have to fight for their place on a national priority list that will be crammed with a number of other pressing

COLLEGES AND UNIVERSITIES are tough. They have survived countless cataclysms and crises, and one way or another they will endure.

—A college president

problems: air and water pollution, civil rights, and the plight of the nation's cities, to name but a few.

One thing seems clear: The pattern of federal aid must change dramatically, if it is to help solve the financial problems of U.S. higher education. Directly or indirectly, more federal dollars must be applied to meeting the increasing costs of *operating* the colleges and universities, even as the government continues its support of students, of building programs, and of research.

IN SEARCHING for a way out of their financial difficulties, colleges and universities face the hazard that their individual interests may conflict. Some form of competition (since the institutions are many and the sources of dollars few) is inevitable and healthy. But one form of competition is potentially dangerous and destructive and, in the view of impartial supporters of all institutions of higher education, must be avoided at all costs.

This is a conflict between private and public colleges and universities.

In simpler times, there was little cause for friction. Public institutions received their funds from the states. Private institutions received *their* funds from private sources.

No longer. All along the line, and with increasing frequency, both types of institution are seeking both public and private support—often from the same sources:

► **The state treasuries:** More and more private institutions are suggesting that some form of state aid is not only necessary but appropriate. A number of states have already enacted programs of aid to students attending private institutions. Some 40 per cent of the state appropriation for higher education in Pennsylvania now goes to private institutions.

► **The private philanthropists:** More and more public institutions are seeking gifts from individuals, foundations, and corporations, to supplement the funds they receive from the state. As noted earlier in this report, their efforts are meeting with growing success.

► **The federal government:** Both public and private colleges and universities receive funds from Washington. But the different types of institution sometimes disagree on the fundamentals of distributing it.

Should the government help pay the operating costs of colleges and universities by making grants directly to the institutions—perhaps through a formula based on enrollments? The heads of many public institutions are inclined to think so. The heads of many low-enrollment, high-tuition private institutions, by contrast, tend to favor programs that operate indirectly—perhaps by giving enough money to the students themselves, to enable them to pay for an education at whatever institutions they might choose.

Similarly, the strongest opposition to long-term, federally underwritten student-loan plans—some envisioning a payback period extending over most of one's lifetime—comes from public institutions, while some private-college and university leaders find, in such plans, a hope that their institutions might be able to charge "full-cost" tuition rates without barring students whose families can't afford to pay.

In such frictional situations, involving not only billions of dollars but also some very deep-seated convictions about the country's educational philosophy, the chances that destructive conflicts might develop are obviously great. If such conflicts were to grow, they could only sap the energies of all who engage in them.

IF THERE IS INDEED A CRISIS building in American higher education, it is not solely a problem of meeting the minimum needs of our colleges and universities in the years ahead. Nor, for most, is it a question of survive or perish; "colleges and universities are tough," as one president put it; "they have survived countless cataclysms and crises, and one way or another they will endure."

The real crisis will be finding the means of providing the quality, the innovation, the pioneering that the nation needs, if its system of higher education is to meet the demands of the morrow.

Not only must America's colleges and universities serve millions more students in the years ahead; they must also equip these young people to live in a world that is changing with incredible swiftness and complexity. At the same time, they must carry on the basic research on which the nation's scientific and technological advancement rests. And they must be ever-ready to help meet the immediate and long-range needs of society; ever-responsive to society's demands.

At present, the questions outnumber the answers.

► How can the United States make sure that its colleges and universities not only will accomplish the minimum task but will, in the words of one corporate leader,

NOTHING IS MORE IMPORTANT than the critical and knowledgeable interest of our alumni. It cannot possibly be measured in merely financial terms.
—A university president

provide "an educational system adequate to enable us to live in the complex environment of this century?"

► Do we really want to preserve the diversity of an educational system that has brought the country a strength unknown in any other time or any other place? And, if so, *can* we?

► How can we provide every youth with as much education as he is qualified for?

► Can a balance be achieved in the sources of higher education's support, so that public and private institutions can flourish side by side?

► How can federal money best be channeled into our colleges and universities without jeopardizing their independence and without discouraging support either from the state legislatures or from private philanthropy?

The answers will come painfully; there is no panacea. Quick solutions, fashioned in an atmosphere of crisis, are likely to compound the problem. The right answers will emerge only from greater understanding on the part of the country's citizens, from honest and candid discussion of the problems, and from the cooperation and support of all elements of society.

The president of a state university in the Southwest told us: "Among state universities, nothing is more important than the growing critical and knowledgeable interest of our alumni. That interest leads to general support. It cannot possibly be measured in merely financial terms."

A private college president said: "The greatest single source of improvement can come from a realization on the part of a broad segment of our population that higher education must have support. Not only will people have to give more, but more will have to give."

But *do* people understand? A special study by the Council for Financial Aid to Education found that:

► 82 per cent of persons in managerial positions or the professions do not consider American business to be an important source of gift support for colleges and universities.

► 59 per cent of persons with incomes of $10,000 or over do not think higher education has financial problems.

► 52 per cent of college graduates apparently are not aware that their alma mater has financial problems.

To America's colleges and universities, these are the most discouraging revelations of all. Unless the American people—especially the college and university alumni—can come alive to the reality of higher education's impending crisis, then the problems of today will be the disasters of tomorrow.

The report on this and the preceding 15 pages is the product of a cooperative endeavor in which scores of schools, colleges, and universities are taking part. It was prepared under the direction of the group listed below, who form EDITORIAL PROJECTS FOR EDUCATION, a non-profit organization associated with the American Alumni Council.

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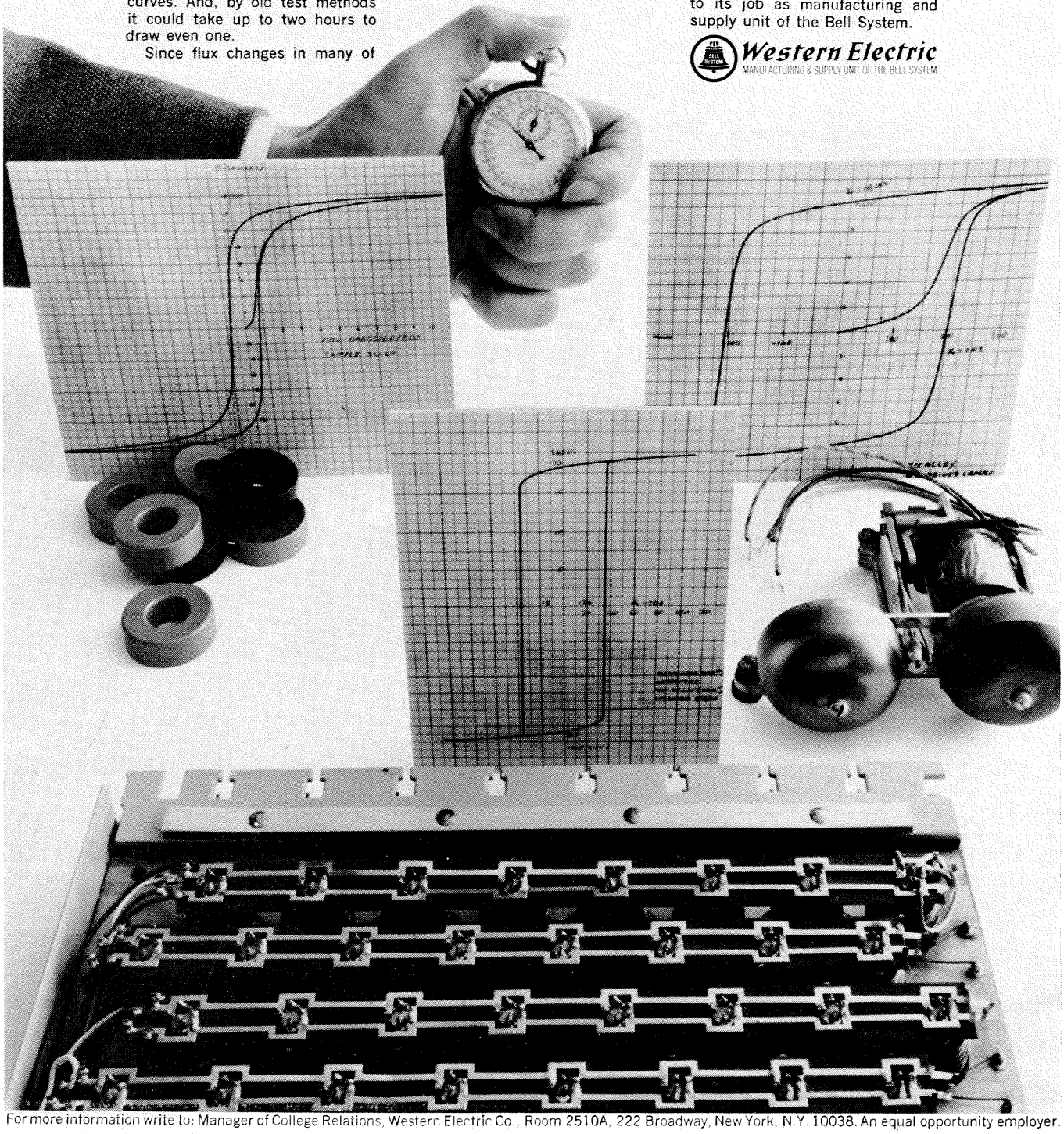

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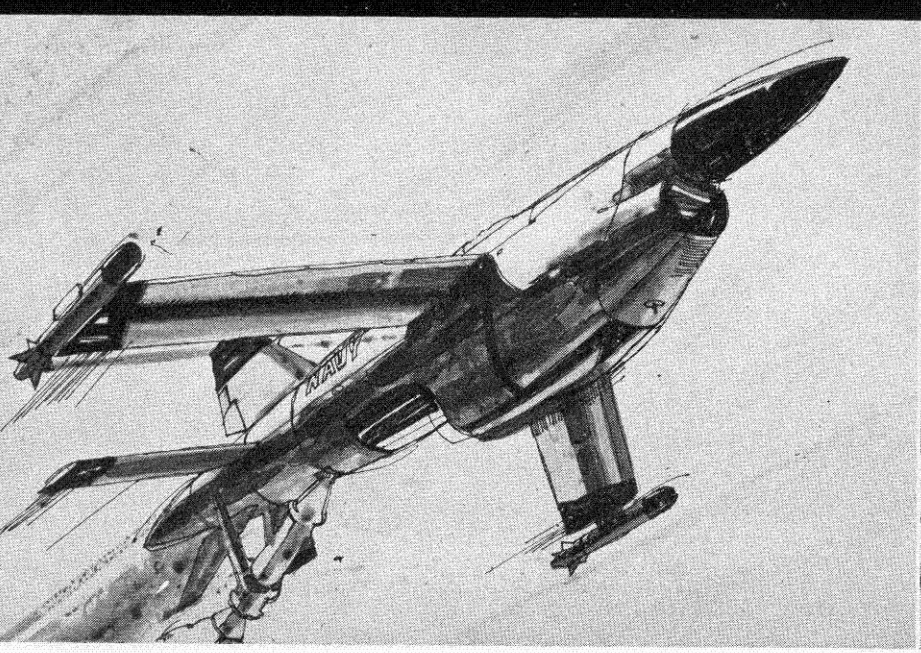

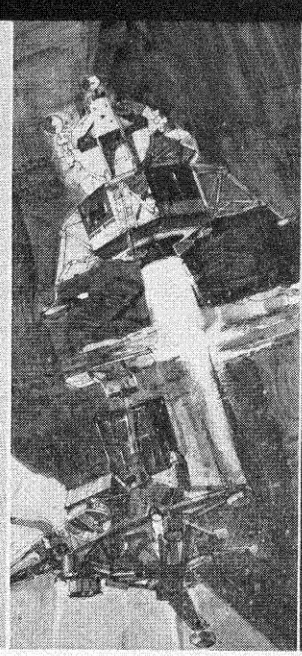

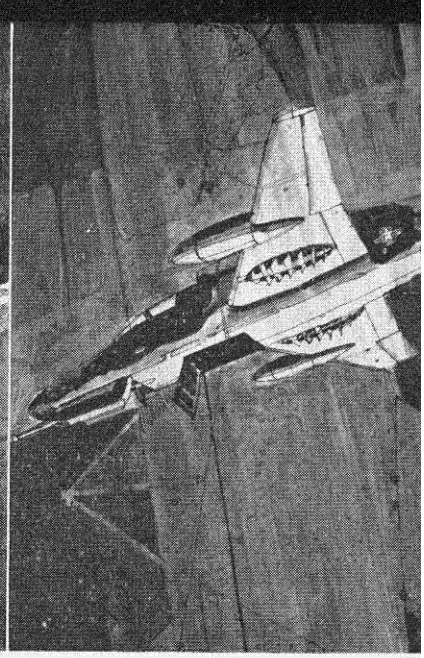

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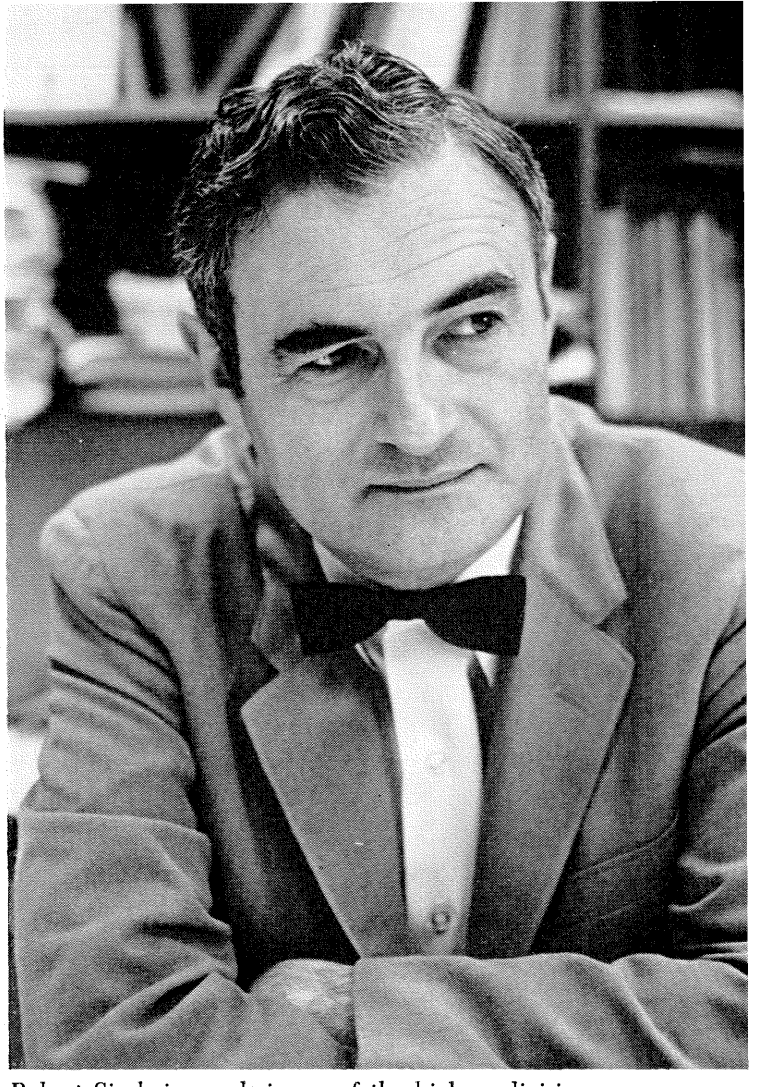


Robert Sinsheimer, chairman of the biology division

Biology Chairman

On April 1 Robert L. Sinsheimer, Caltech professor of biophysics since 1957, became chairman of the Institute's division of biology. He succeeds Ray Owen, who has held the position since 1961.

When Dr. Sinsheimer came to Caltech from Iowa State College, he continued his studies in biophysics and molecular biology, investigating the genetics of the virus Phi X 174. This work resulted in two significant discoveries—of the first single-stranded DNA and of the first ring-shaped DNA—both in Phi X 174. A more recent outcome of his work with Phi X 174 is the first artificial synthesis of active DNA from the virus—a collaborative effort with two Stanford University researchers.

While quietly and unobtrusively working toward this now widely publicized achievement, Dr. Sinsheimer has also been distinguishing himself in other areas.

It was not until 1965 when he gave his address, "The End of the Beginning," at the Institute's 75th Anniversary Conference that most of his colleagues became aware of his compelling prose style and his prophetic concept of the future.

On another level, his work with his large research group and on administrative committees both on campus and off has brought a recognition of his social consciousness and of his abilities to organize and direct action toward the solving of problems, meanwhile engendering goodwill in those working with him.

This goodwill is expressed by his colleagues who describe him as "a perceptive and deeply concerned intellectual leader" and as "a man with a great sense of responsibility for the roles of science, of higher education, and of biology in particular" and by Dr. Owen, who says that Dr. Sinsheimer's appointment had "the enthusiastic support of the personnel of the division and of the administration."

As resigning chairman Dr. Owen is looking forward to freedom from the heavy burden of administrative duties. He plans to return to his research in immunology, and he will spend more time teaching. He also will rejoin the admissions committee, and he has a number of external obligations which include the chairmanship of the National Science Foundation's advisory committee in biology and medicine and of the National Institutes of Health's immunology study section, and vice-chairmanship of the World Health Organization's committee on transplantation antigens.

Appearances to the contrary, Dr. Owen insists, "I'm going to *de*escalate. I'm going to enjoy what James Bonner calls a 'moderate reincarnation.' "

Biology's Ball

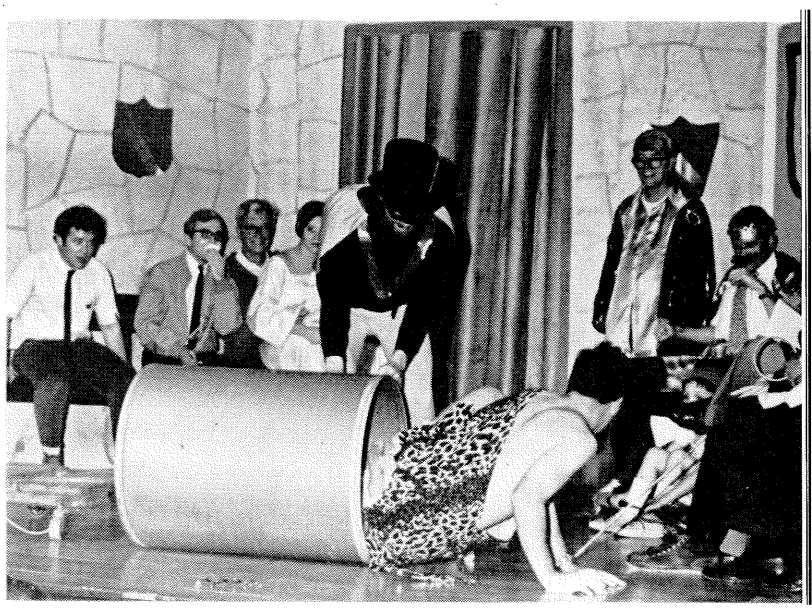
Officially he became chairman on April 1, but Robert Sinsheimer actually started his "reign" over Caltech's biology division at an informal and lively Inauguration Ball on April 6, organized by the division and advertised as "celebrating the accession of Prince Heimer to the throne of King May." (translation: Prince Heimer—Sinsheimer; King May—Ray Owen.—Ed.)

The entertainment highlight was a presen-

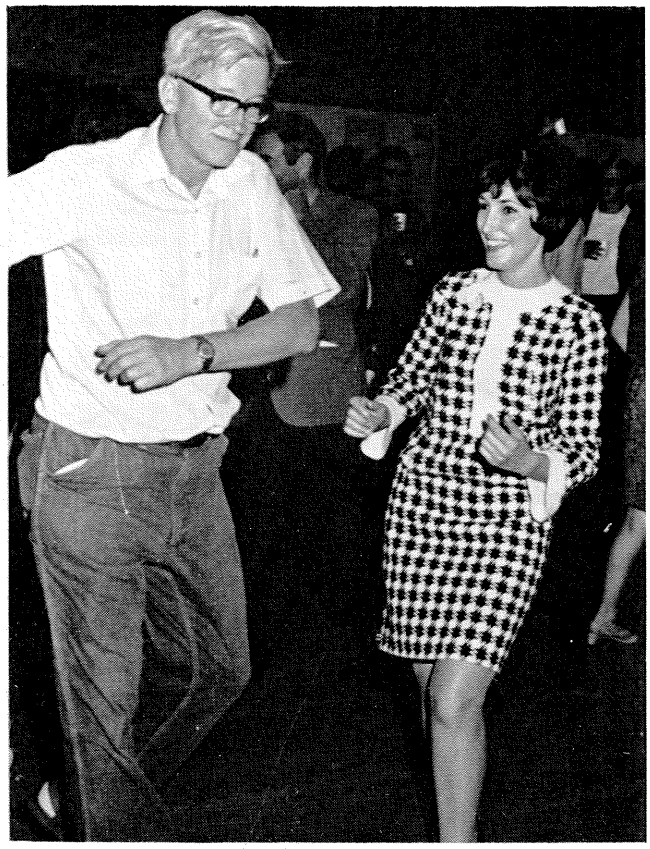
continued on page 38

Hero of the drama, Prince Heimer, makes magic in an oversized beaker and—poof—

First-nighters Owen and Sinsheimer applaud the players.



—creates a "sort-of primitive vital structure" in a leopard skin, bringing King May to his feet with praise and—



Biology's Max Delbrück and Yvonne Harrington swing out.

—earning, thereby, the right to the crown and to hear the King's rousing finale, "It's not my problem now."

tation by the biodramatic seminar of a musical fairy tale, *All the King's Men*, in which the monarch (played by professor of biology William Wood) calls together the princes of his kingdom to determine which is worthy to inherit the throne. In a satirical portrayal of the princely figures of the biology division (Princes Dullbrick, Boner, Retardi, Vinegar, and others—alias professors Delbrück, Bonner, Attardi, and Vinograd) each tries to prove himself in dramatic hilarity, but only Prince Heimer succeeds (by creating life in a large beaker) and wins the crown in a highly unconventional coronation.

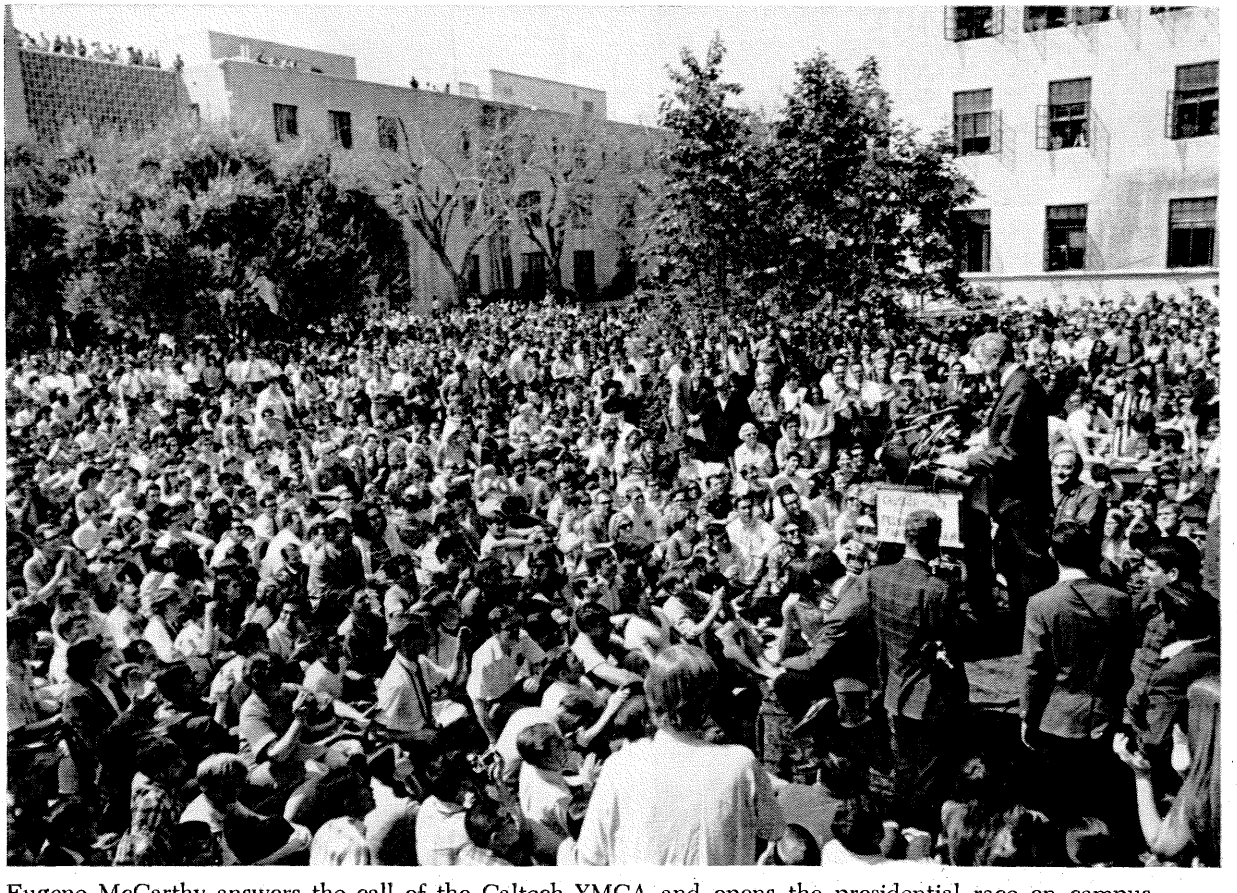
A thank-you to the offstage Ray Owen was emceed by Max Delbrück, professor of biology, who presented a "lecture in bio-astronomy" and with it a gift to Dr. Owen from his colleagues—a 30-lb stainless steel sundial. This spectacular engineering feat is the result of much research and collaboration by Institute astronomers, physicists, biologists, and engineers, and is inscribed: For Many Rays of Sunshine—To King Ray from his Princes.

McCarthy in Academia

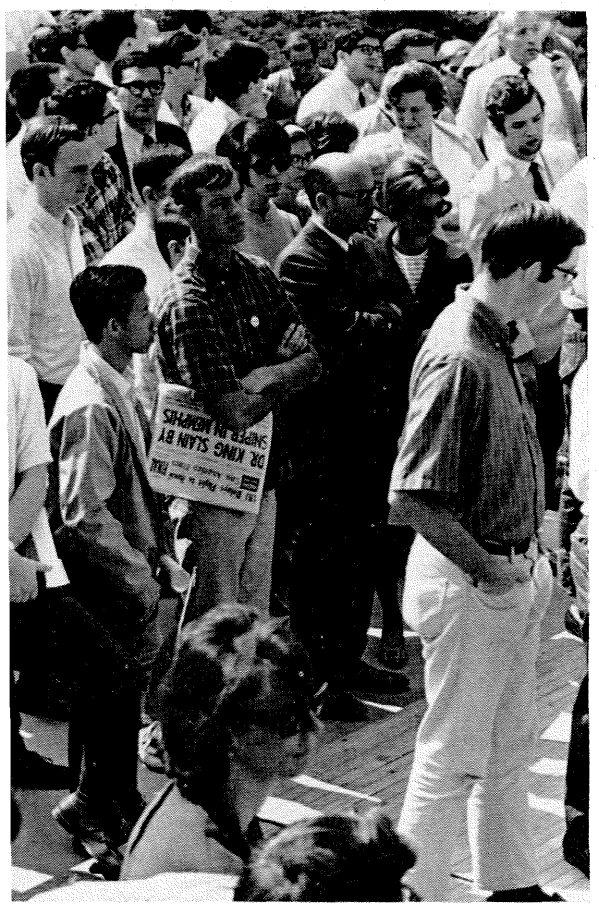
The occupants of three sleeping bags at the foot of the speaker's platform on the Olive Walk were the vanguard of a crowd of more than 3,000 who gathered at Caltech on April 5 to greet and hear Senator Eugene McCarthy.

Bodies in trees, on rooftops, hanging out of windows, and filling the hollow between Firestone and Winnett made up the assembled crowd of students and faculty and the politically active and curious of Pasadena.

Warm sunshine and the crowd's good spirits produced an enthusiastic welcome for the senator, who is the first presidential candidate to accept the invitation of the Caltech YMCA to its candidates' forum. The welcome was the most exuberant part of his visit, however. Eugene McCarthy smiled and waved with a reserve that characterized his entire appearance. He spoke of a "new politics of reason" and was himself the personification of the phrase. His words were supported by persistent applause which never broke into real en-



Eugene McCarthy answers the call of the Caltech YMCA and opens the presidential race on campus.



"The highest form of patriotism is to serve your country . . . in the name of truth."

thusiasm. The strongest response came when Senator McCarthy spoke in support of alternative service under the draft and of granting amnesty to those who leave the country.

From his opening, "This is the most pleasant setting I've spoken in in this campaign" to his closing, "If we do well in 1968, we'll just skip 1984," Senator McCarthy's was an academic appearance in an academic setting drawing an academic response.

Honors and Awards

H. Russell Bintzer, formerly vice president for development, has been named vice president for institute relations. Curzon Fager, the former development campaign coordinator, is now director of development.

Harold J. Wayland, Caltech professor of engineering science, has been named an associate editor of a new scientific journal, *Microvascular Research,* aimed at fostering communication among the physical, engineering, biological, and clinical sciences.

George S. Hammond, who is Caltech's Arthur Amos Noyes Professor of Organic Chemistry and acting chairman of the division of chemistry and chemical engineering, has been awarded the American Chemical Society's annual James Flack Norris Award for his research in physical organic chemistry.

Harold Babcock 1882-1968

Harold Delos Babcock, who was a member of the Mount Wilson and Palomar Observatories staff from 1909 to 1948 and father of Horace W. Babcock (the present director of the observatories), died on April 8 at the age of 86. In his many years' work as a solar astronomer, Dr. Babcock discovered that the sun's magnetic field reverses periodically. He also did significant work on the spectra of sun spots, especially in the infrared wavelengths. Much of his research was done with a small telescope at George Ellery Hale's private observatory near the Caltech campus. Dr. Babcock, although officially retired 20 years ago, worked at the observatories until very recently.

Speaking of the Draft

A Caltech freshman finds out what the seniors think about it.

In February 1967 the outlook for thousands of male college seniors throughout the country suddenly changed. On the recommendation of President Johnson and Selective Service Director Lewis B. Hershey, a provision of the 1967 Selective Service Act was activated.

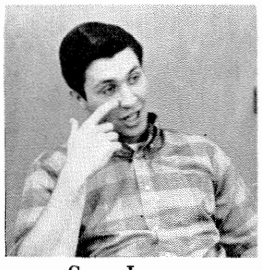
To graduating seniors and first-year graduate students, the provision means that they are almost certain to be drafted. According to Department of Defense estimates, 60 percent of the inductees in 1969 will hold degrees, as compared to 5 percent this year.

What does the Caltech senior think of this new Selective Service move? It was no surprise to find, in a random survey I conducted, that the seniors are virtually unanimous in their opposition to the draft. The reasons for their opposition, however, *were* surprising.

Only about one-fourth of the seniors questioned said their opposition to the draft was based directly on their opposition to the war in Vietnam. Craig Nelson summed up his position by saying he was against the war and against the draft. Greg Thompson stated, "If you have to draft people, a war is not worth fighting." Denis Elliott said, "The draft is unfair in a free society." Larry Ruzzo called the draft "the closest thing to involuntary servitude." Other seniors also compared the draft to slavery. John Lehman was the only senior questioned who directly stated perhaps the most fundamental opposition of all: "I don't want to die."

Most of the opposition to the draft, however, was based on the belief that the drafting of college seniors and first-year graduate students would be an economic and educational loss. Neil Wright argued that it will be a great waste to have people drafted who would have gone on to graduate school. Sam Logan pointed out that a person's talents could be utilized more effectively in the service after he had completed graduate education. Dick Ligon said the draft would put "useful people in useless jobs."

Both Ligon and Lou Felder were concerned about the effects of the draft on higher education. With the removal of many graduate students and prospective graduate students from the colleges, they believe that an even greater strain than at present will be placed on the colleges to provide teachers. Graduate students are now commonly used as teaching assistants. With the removal of many of the graduate students, these vital positions will be unfilled. Thus, colleges may either have to cut back enrollments or curtail faculty research to enable existing faculty members to teach more classes. Either of these alternatives, Ligon and Felder believe, is highly undesirable.



Sam Logan

"I feel I would be more valuable to my country, either in the service or a defense industry, after graduate education."

Fully substantiating these fears are two organizations that should know. A recent survey of 122 graduate and professional schools made by the Council of Graduate Schools and the Scientific Manpower Commission resulted in several predictions being made about the effect of the recent action on graduate schools.

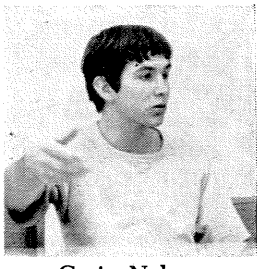
1.) Total graduate enrollment will fall 50 percent in the first-year graduate class.
2.) Seven out of ten male graduating seniors who

ordinarily would do graduate work will either enlist or be drafted.
3.) Some state universities, which rely heavily on graduate students to staff freshman courses in composition, foreign languages, and science, will cancel admission notices for one out of five freshmen this summer.
4.) Research projects will be disrupted and in some cases abandoned.
5.) The needed production of college teachers will be set back.
6.) Most universities will operate their graduate schools on a deficit next year due to loss of income from tuition.

Caltech has adopted as its official policy that of the Council of Graduate Schools, which states in part:

> We accept and endorse the principle that the national security transcends the interest of any individual or group of individuals, and that military service is an obligation of every able-bodied citizen . . . We believe that a system of selective service should be designed to create a minimum of disruption and uncertainty in the lives of those eligible for induction and that therefore the selection process should take place at a natural time of transition, that is, at the completion of high school . . . We believe that draft-eligible men should be inducted on the basis of random selection upon reaching the age of 19 . . . Men who are not drawn in the year of their prime age classification and who wish to pursue a degree program should not be in jeopardy again until they have completed their immediate degree objective.

Among Caltech seniors asked about alternatives to the present draft system, approximately half agreed with the alternative endorsed by the graduate school council. Lou



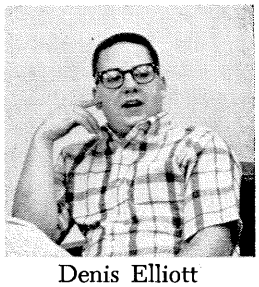
Craig Nelson

"I'm against the draft because I'm against the war."

Felder approved of the principle of two years' service to the country but felt that one should be free to choose alternatives to military service, such as work in the Peace Corps, or VISTA, or similar programs. About one-fourth of the seniors supported this alternative. The other fourth suggested military service on a voluntary basis only.

The final question put to the seniors was, "What are you going to do if and when you receive your induction notice?" Approximately 20 percent of the seniors stated that they would not serve under any circumstances and that they would go to jail instead. Only one said he would leave the country and go to Canada. More than 80 percent of the seniors questioned said they would put up no resistance and would be peacefully inducted. Many voiced the hope or expectation, however, that

"The draft is unfair in a free society."



Denis Elliott

they would be classified 4-F. Neil Wright stated that he would be classified 4-F for a psychological reason—incompatibility with the Army. And one senior had yet another course of action: "I would infiltrate the Army from the inside and do my bit to make it non-functional." He went on to say that if half of every platoon were disgruntled college students, the Army would soon cease drafting them.

Thus, the general outlook on the draft of Caltech seniors is opposition, but with little resistance or initiative to try to change things. In a way, they have decided that it is futile to try to change the decision of President Johnson and General Hershey, since professional educators have been struggling to do just that without success since before the Act was approved by Congress. As one anonymous dean stated in the *Los Angeles Times,* "Oh, everybody wants to do something about the draft—or so they say. Everyone clucks his tongue, but nobody is raising a finger to do anything about it." The dean quoted a proverb from the *Peanuts* comic strip which he felt President Johnson and General Hershey must live by: "No problem is so big or complicated that it can't be run away from."

The attitude of the seniors at Caltech might be best summed up by Bart Gordon, who said, "When you're drafted, you're drafted."

—JIM COOPER, '71

THE CALTECH ALUMNI ASSOCIATION— TODAY AND TOMORROW

The Caltech Alumni Association began nearly 53 years ago when the California Institute of Technology was Throop College of Technology. From the original small group of graduates who banded together—initially for friendship and social purposes and later for philanthropy—the Association has become an organization of more than 5,300 members and is an important medium of service and communications between the Institute and alumni.

The new Articles of Incorporation state that the Alumni Association exists for the purposes of: assisting the Institute in all possible ways toward enhancing its educational and cultural environment; improving and advancing the Institute itself; recognizing the basic obligations of all alumni to the Institute; rendering services to its members in strengthening the ties between the Institute and its alumni; preserving the associations formed among its members while they were students; and promoting relationships that are of benefit to the Institute, the students, and the Alumni Association.

The Association is a nonprofit California corporation whose activities are financed through membership dues, through offsetting charges for its programs, and through a subsidy from the Institute in the form of office space, secretarial help, and publications staff. It is managed by an elected volunteer board of directors and their officers, including the Secretary who manages the Alumni Office and the day-to-day business of the Association.

In the past few years, the Association has become aware of a growing need to reexamine its aims, purposes, organization, and financing, and to insure its continued effectiveness through definite planning for its future. After many meetings, committee studies, and conferences with members of the Institute administration, the board of directors wishes to report the highlights of its thinking in this issue of the Association's magazine, *Engineering and Science*, which is being sent to all alumni. We hope that many non-members, seeing *E&S* and learning of our expanded alumni program plans, will want to share in the Association's activities and services by becoming members.

In January 1966 the Alumni Association's board of directors authorized its president, Richard P. Schuster, Jr., '46, to form an Alumni Study Group to explore new ways in which alumni could assist the Institute, to consider areas of interaction among the Association, its members, all alumni, and the entire Institute community, and to recommend ways in which the Association could function more effectively. A group of 23 alumni, including 11 past presidents and 5 former board members, under the chairmanship of William F. Nash, Jr., '38, held a series of meetings devoted to careful examination of all these aspects of alumni-Institute relations. Their 18-page report was presented in October 1966. Subsequently the study group subcommittee chairmen further interpreted their recommendations, which centered in three main categories: Alumni-Institute Communications; Alumni Affairs Group Interactions; and Alumni Participation in Fund Campaigns.

Substantial implementation of the report's major recommendations has been made or incorporated into our future planning. The more important of these are presented here.

Articles of Incorporation. Amendments of the articles of incorporation were required to 1) expand the statement of purposes, 2) increase the number of directors from 12 to 16, 3) decrease the quorum required for membership changes of the bylaws from one-fourth of the membership to 150 members, and 4) to institute a formal property disposition clause. With the consent of the board and the membership, and with the assistance of our attorney, director Martin H. Webster, '37, the articles were filed with the Secretary of the State of California.

Bylaws Revisions. Bylaws can be revised at any regularly called meeting by a vote of three-fourths of all directors. Our bylaws have been surveyed and revised by the board and brought into conformity with the amended articles. Details of these changes will be sent to all members in the near future. The major changes include 1) termination of the Alumni Fund Council as a separate function and substitution of direct board liaison with the Institute's development division for assistance in fund-raising activities involving alumni, and 2) improvement in board liaison and strengthening of the Alumni Magazine Council.

Alumni Fund Council. This group was initially conceived by a few alumni, led by Howard B. Lewis, '23. Alumni giving grew remarkably under its guidance and in 11 years provided funds for the establishment of four alumni scholarships, the partial funding for construction of the Scott Brown Gymnasium and Alumni Pool, more than $500,000 for endowment and other designated purposes. It also helped in raising over $1 million in the 1957-61 development program. Board liasion with the Institute has been made a direct responsibility of the vice president of the association.

Publications. The board endorses the improvement of communications with the alumni, the Institute staff, and the student body. The magazine *Engineering and Science* was originally produced by volun-

tary alumni effort, but eventually the effort became too large to be handled in this way. In 1946 the Institute agreed to act as publication agent and to provide a professional staff. The board maintained its interest and direction through the Alumni Magazine Council, whose chairman was designated publisher. Richard C. Armstrong, '28, served in this capacity until 1967. During this time *E&S* achieved recognized excellence with Edward Hutchings, Jr., as editor. The council has now been reorganized under the chairmanship of Horace W. Baker, '35.

In March the board presented a 17-page report, "Action Program for the Association's Future," to Caltech President Lee DuBridge. In summary this report states that the Association can best serve the individual and the combined needs of the association and the Institute by: 1) improvement of programs to interest and obtain membership; 2) retention of the present membership structure in view of its success in focusing alumni interest and participation at a remarkably high level in comparison with other colleges; 3) employment of a full-time executive secretary with the Institute's help in order to assist in the conduct of the affairs of the Association; 4) improvement of our finances and attainment of our self-support goal by increases in membership dues.

Details of these recommendations will be reported later. However, the board of directors has voted unanimously to increase annual membership dues to $10 a year beginning 1968-69. Also the life membership fee has been increased from $100 to $150 effective July 1. For all those who receive their first Caltech degree in 1968 membership dues will be $5 for 1968-69.

Both the Institute and the board believe that their mutual needs can best be served by an independent, active, voluntary association of alumni who are interested in assuring the future of this institution. The Institute is cooperating through these recent actions:

1) They have agreed to obtain an executive secretary and are currently holding discussions to establish qualifications, salary, and functions.

2) The Institute's new publication for alumni, *Caltech News*, was established by joint association-Institute action in response to the Alumni Study Group's recommendation for more communication from the Institute to alumni. That this move has succeeded is evidenced by the enthusiastic response from the Caltech community; recent judging of *Caltech News* by the American Alumni Council rated it highest in a field of 58 submitted for review! This remarkable first-year success is largely due to the efforts and skill of editor Bruce Abell, '62.

3) In further recognition of the need for improving communications, the chairman of the Institute board of trustees, Arnold O. Beckman, '28, has invited the Association's president to attend meetings of the Caltech Board of Trustees and appointed him as an advisory member to the new Committee on Development. This committee is to review the Institute's educational program and plans for its financing, and advises on all aspects of development activity. The alumni president also now serves on the advisory committee of the board of directors of the Associates of the California Institute of Technology.

The Alumni Association directors hope that some of the enthusiasm and unity of purpose which they feel in our revitalized and expanded program will also be felt by alumni, and that this will result in the eventual advancement of both the association and the Institute.

Frederic T. Selleck, '49
President
Alumni Association

remote region, with few diagnostic facilities at his disposal, might 'call in' a patient's symptoms, via satellite, to a computerized data bank at one of the world's great clinics."

I don't deny that the space program *could* produce such a benefit. But I wonder whether the actual and potential benefits of the space program aren't in the nature of a new freeway from Pasadena to Newport Beach that would carry us through St. Louis en route.

Another of Dr. Mueller's arguments is that the space program is having an enormous effect on the education of scientists and engineers. I agree, but has the effect been a good one? It used to be that the commonly accepted definition of an engineer was someone who could make for a penny what it took a fool to make for a pound. Has the effect of advanced technological thinking been to turn that definition around?

It can be agreed, of course, that it would be better to compete with the Russians in space achievements rather than in missile and antimissile hardware. But wouldn't it be even better to compete in terms of real scientific achievements and in real economic benefits? And better still, instead of competing, work hard to find more ways to broaden our cooperation with them?

BLUEPRINT OF THE FUTURE

Let me turn more explicitly from issues of science and technology to issues involving the shape of our future society. Unfortunately, the only "blueprint" of future society we are given in the book is Daniel Bell's "The Post-Industrial Society: A Speculative View." I say "unfortunately" because if our society comes to accept his blueprint, I fear that we shall have a society that has not learned how to solve its more difficult problems. All will look neat, tidy, and well managed; but it will not be so. His is a picture of a society in which the scope of government has been greatly enlarged and which is ruled by members of a new technocratic elite who "with their new techniques of decision-making (systems analysis, linear programming, and program budgeting) have now become essential to the formulation and analysis of decisions on which political judgments have to be made."

To my way of thinking, Dr. Bell's advocacy of such a concept represents a fundamental misunderstanding of either what the real problems of government are or the role that systems analysis and other planning techniques can play in solving them.

CREATIVE DESTRUCTION

The fundamental problems of government are not in doing better what is already being done; they are, rather, in pursuing quite different objectives. In fact, to an alarming degree, the government is a series of highly inadequate monopolies which seem to regard as their main objective the protection of long-outdated, ideological crusades. Systems analysis, on the other hand, is mainly useful for finding better ways to implement existing objectives. It *can* be used to help bring about changes in objectives, but for that purpose it has very serious limitations.

The particular few pages in this book that I happen to like best occur in the final discussion entitled "What Are the Urgent Problems?" In it Dr. Gell-Mann points out that if society is to go forward we cannot continue to use science and technology for everything they might be used for, but rather that it will be necessary to be much more selective and have the courage to renounce a whole series of projects—"the project to build large, noisy aircraft, for example; or the project to fill the Rocky Mountain trench with water and carry all the water that falls onto Alaska into the Southwest; or the making of a huge population in addition to the one we have already." However, he is not very optimistic about the possibility of our being more sensible, because "the military and commercial rivalry of the Great Powers massively impedes these acts of renunciation. . ." and because "the structure of business and government, the pattern of our habits and traditions, our ways of thinking, our favorite metaphors and similes are such that it is very difficult to abandon these old drives which impel us to master, control, and destroy the environment around us. Without some change in our ways of thinking, without some kind of religious or spiritual revolution, it seems difficult to believe that we really can alter our direction within the next fifty or hundred years."

I would argue, in a somewhat different vein, that for society to move forward in more sensible directions there are some important jobs of creative destruction that have to be done: the cigarette industry; the advertising industry; an automobile industry which, when its bad effects are fully taken into account, may contribute nothing to the GNP other than in a job-creating sense; a kind of military establishment that puts far too much emphasis on large-scale violence (and because of that may one day get us all killed); the foreign service monopoly; and NATO, which stands in the way much more than it contributes to a solution to the problems of Central Europe. And I would not like to see these tasks of creative destruction left for a future generation to accomplish; the longer we wait the more difficult they will become.

SHREWD—BUT MORAL

How do we go about it? What will it take? A religious or spiritual revolution? I quite agree. But I think that something else will be required too; namely, a society that learns to build much more adaptive public and private organizations and that learns how to supply a much larger number of men and women who not only have a high sense of moral values and practical wisdom but who are also shrewd operators—men like Lincoln, Wilson, Roosevelt, and Truman. Perhaps the biologists can be of some help. But, on the other hand, the problem may be a simpler one of getting rid of some old-fashioned middle-class mores—and hence an appropriate task for the humanities people.

"The excitement in engineering doesn't all happen in a development lab."

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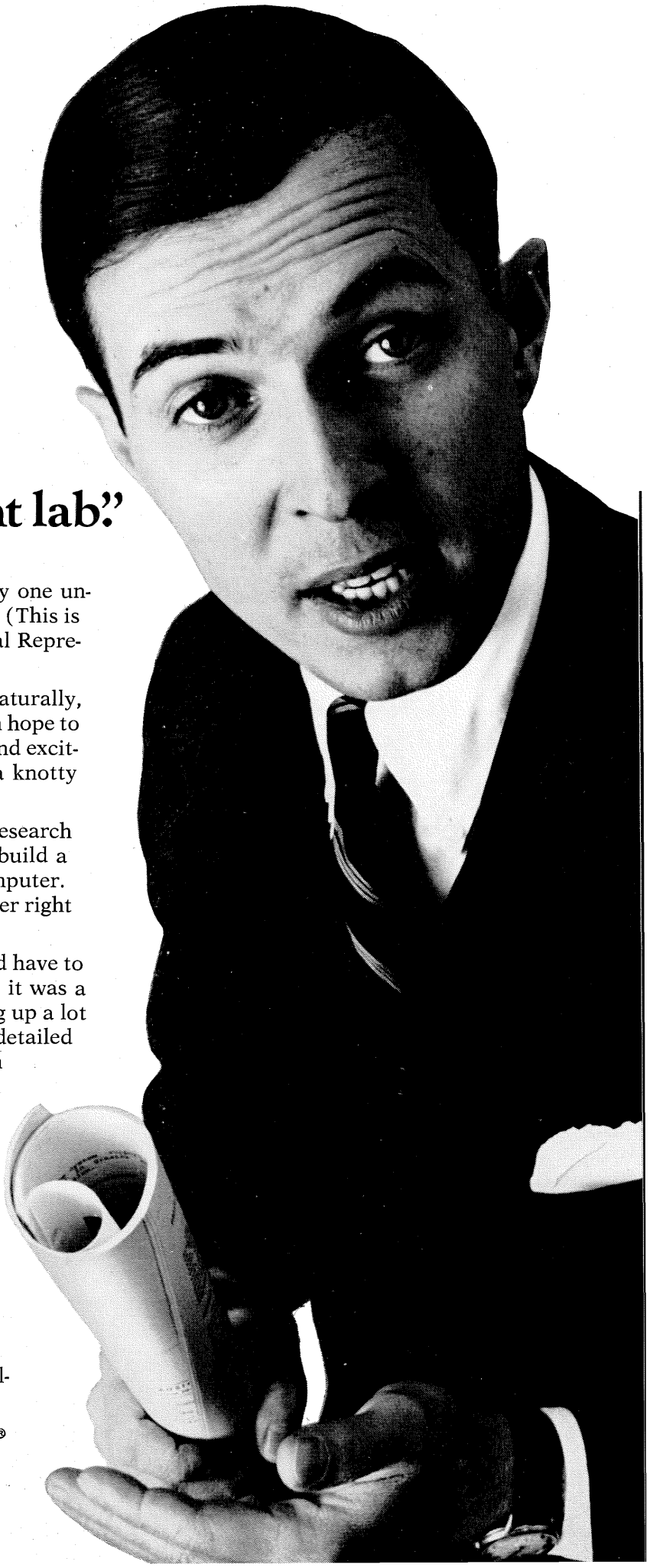

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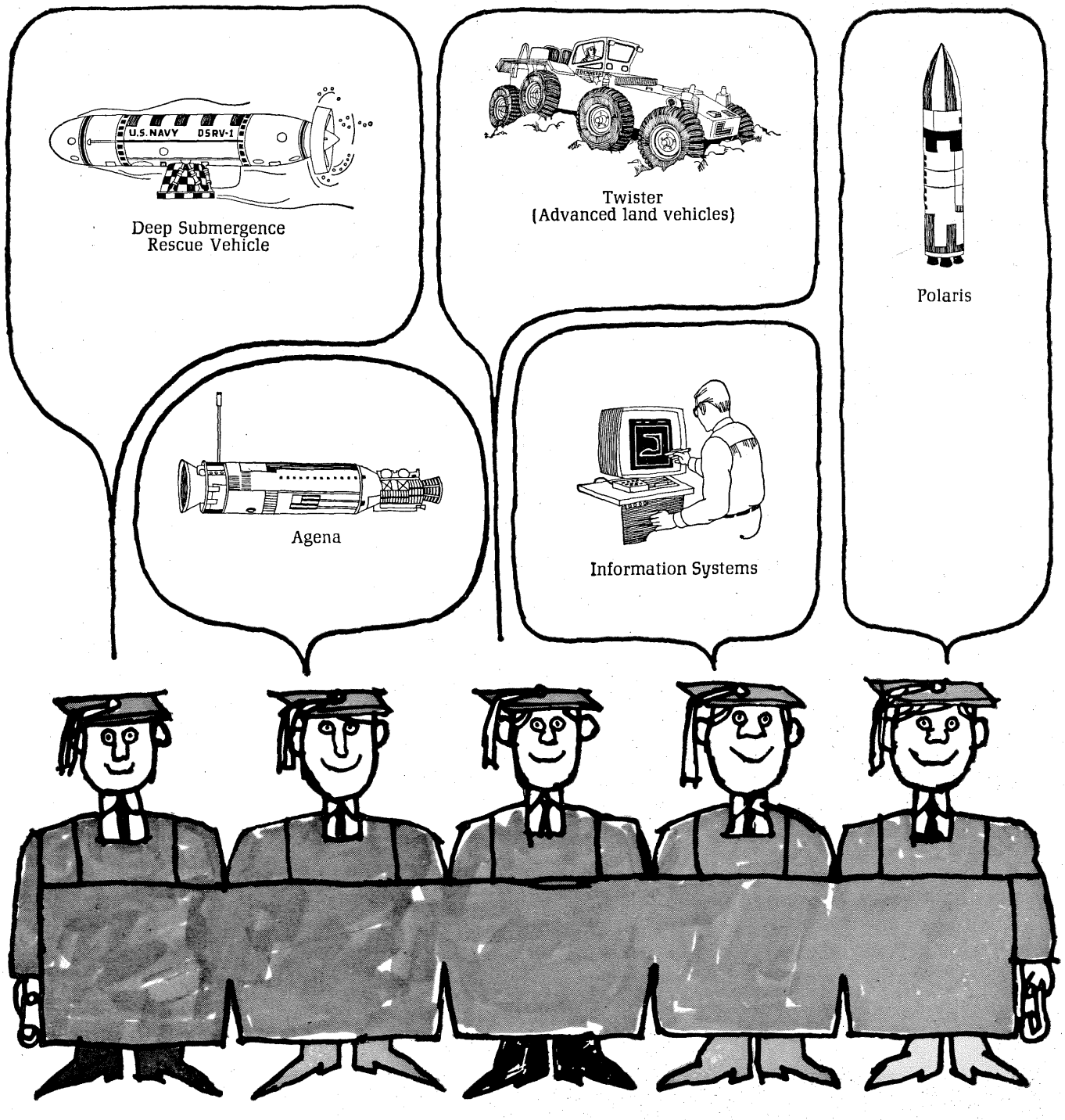

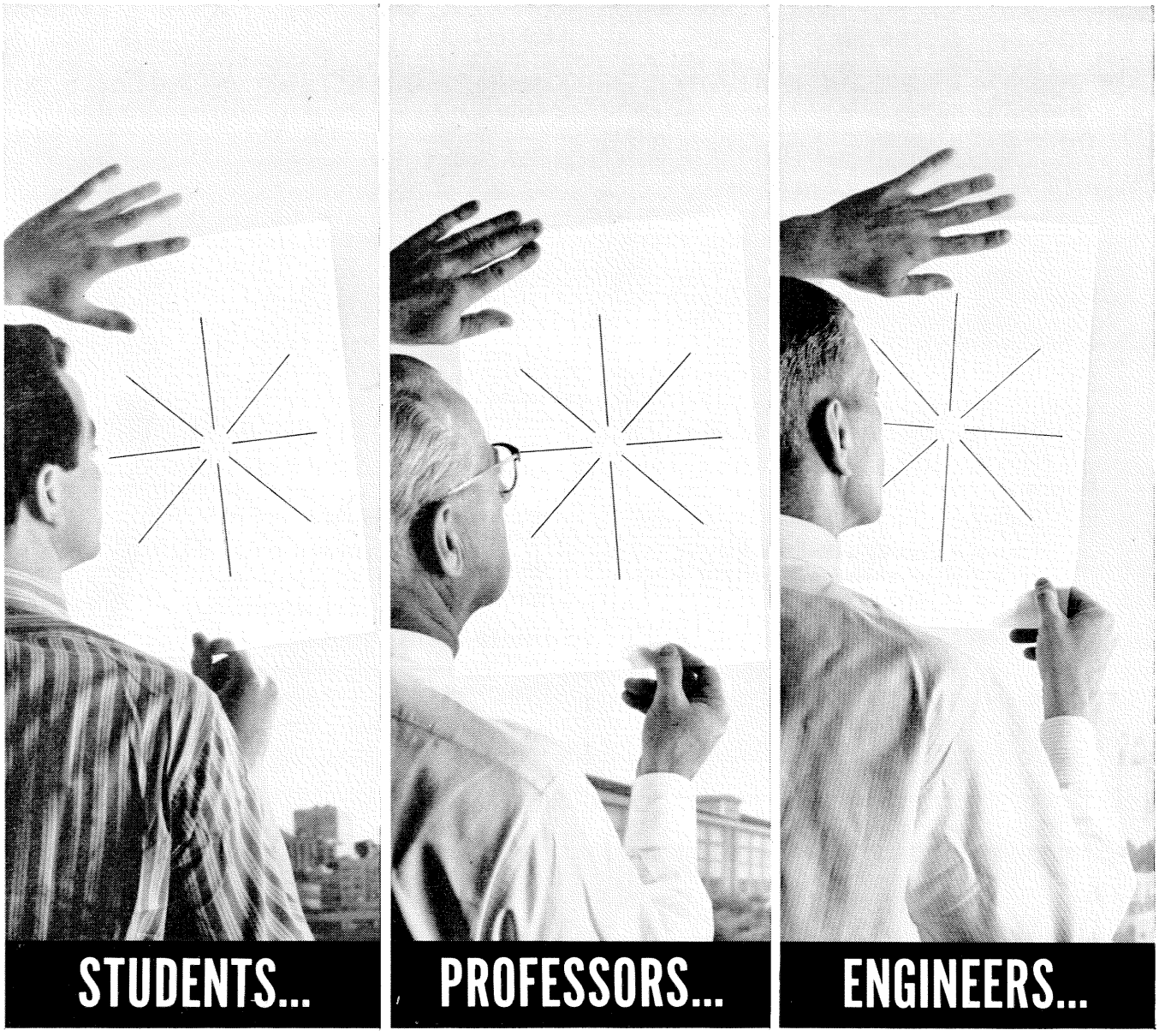

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