MAY 1969

ENGINEERING AND SCIENCE

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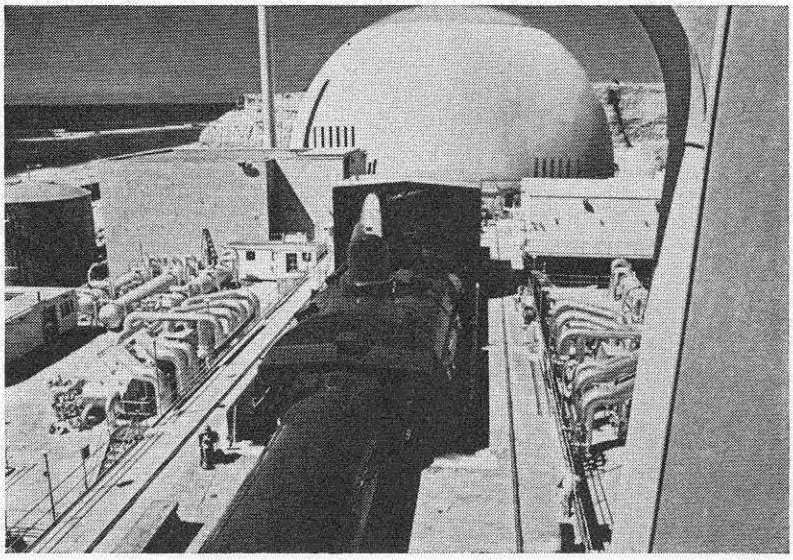

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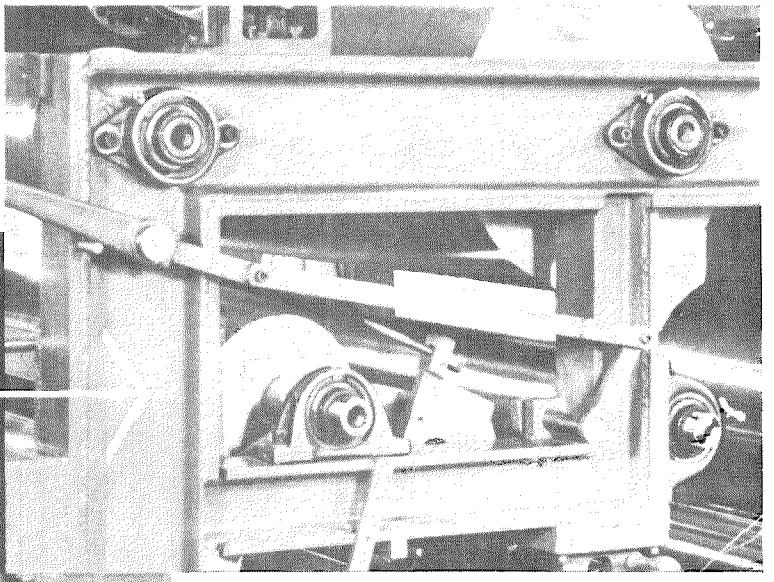

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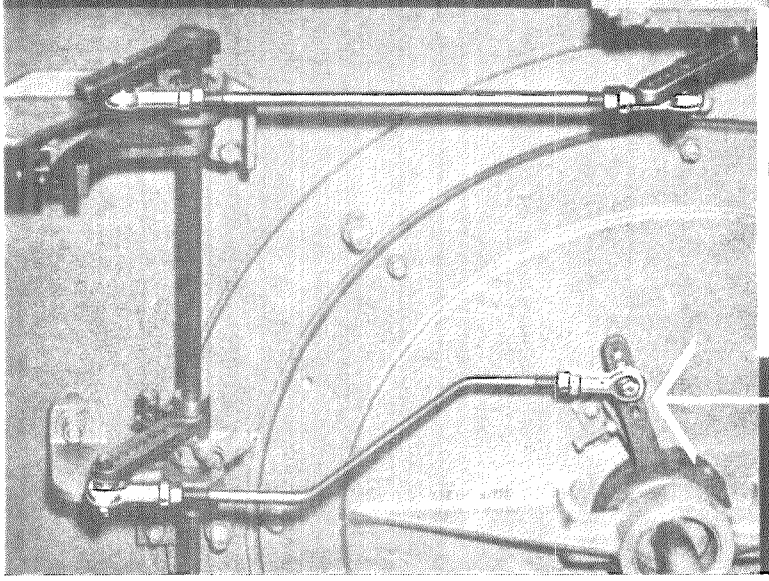

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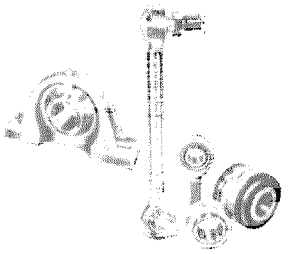

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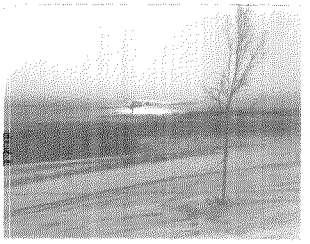

ON THE COVER

Sunset silhouettes an exhaust plume (from the University of Alaska's heating plant) rising above the dense ice fog emanating from Fairbanks six miles away. This unique type of air pollution is currently being studied by Caltech alumnus Carl S. Benson, PhD '60, associate professor of geophysics and geology at the University of Alaska. Now on sabbatical leave at the Scott Polar Research Institute in Cambridge, England, Benson reports some of his findings on page 15.

PHOTO CREDITS

6, 12, 13—Arnold Johnson / 14—James McClanahan / 15—Robert Chapman / 20, 21—Floyd Clark 22—Midge Quenell

Letters

Philadelphia, Pa.

EDITOR:

I entered Caltech as a rather bewildered freshman in September 1958 when Dr. Huttenback began his tenure as Master of Student Houses and therefore remember with considerable nostalgia many of the events of his narrative ("Confessions of a Genial Abbot" *E&S*—Feb., March, April 1969). I also recall with deepest gratitude the kindness, warmth, and sympathy of Dr. and Mrs. Huttenback, which greatly mitigated the succession of distressing psychic shocks I and my classmates experienced in our first few weeks. It is surely a pity that Dr. Huttenback was the author of his own reminiscences, since I fear modesty has prevented him from adequately celebrating the role he played in our lives.

Into this Eden of praise, however, I fear I must introduce the hissing of one snake, in the name of historical accuracy. In his role of professional historian I am sure Dr. Huttenback will forgive me. The article gives the impression that the proprietors of the anaconda [which, according to Dr. Huttenback, was being kept in a student's bathtub, but decided to investigate the plumbing and became arranged between two toilets, head up in one and tail up in the other] were living on campus in one of the student houses under the Master's jurisdiction. In fact, they shared an off-campus apartment. This in itself is a minor error that I would not have troubled to correct. What I strongly protest is the impression that might be left with the casual reader that we in the Houses had *bathtubs* and/or private toilet facilities. As anyone who lived on campus during that turbulent era could tell you (and probably would, if provoked), bathtubs would have been as much use to the typical undergraduate as suspenders to the anaconda.

JULIAN V. NOBLE '62

Chicago, Illinois

EDITOR:

In *The New Republic* for March 29 I find the statement: "Harold Brown, formerly a top Pentagon official, said two weeks ago that we must anticipate nuclear confrontations in which each side fires a limited number of ICBM's at the other side's missile sites. So, Mr. Brown argued, our missile sites need ABM protection."

This is so idiotic that I cannot believe Brown actually said it. I wonder if you can trace the quotation for me to the speech or article from which it was taken, and tell me where I can get hold of a copy of the original text.

MARTIN TANGORA '57

Who Said What, Where

The statement credited to Harold Brown in *The New Republic* has apparently been "adapted" from an interview with Dr. Brown conducted on January 21, 1969, in Washington, D.C., when he was still Secretary of the Air Force. The interview was printed in *The New York Times* for March 2, and the statement in *The New Republic* appears to have been taken from this portion of *The New York Times* article:

> Dr. Brown warned that while the current balance of power might deter nuclear war in most situations, it might not in a crisis in Europe in which both sides believed that their vital interests were threatened.
>
> Against that possibility, he feels, it may be necessary for the United States to anticipate a nuclear war in which each side fires a limited number of ICBM's at the other's weapons, rather than his cities.
>
> To prepare for that possibility, he says, the United States might better protect its offensive missiles so that it would not quickly be forced, by the loss of ICBM's on their pads, to have either to capitulate or to destroy the enemy's cities.

But the statement credited to Harold Brown in *The New York Times* has, in turn, been "adapted" from the original, and far longer, interview with *Times* reporter William Beecher. According to the direct transcript of this interview (and to that portion of it that seems to apply here) what Brown actually *said* was:

> MR. BEECHER: Do I understand, Mr. Secretary, that in the absence of a mutual limitation on strategic weapons, you think that both the United States and Russia must really provide enough ICBM's to wage protracted nuclear war, firing only against each others' weapon systems, rather than against cities.
>
> SECRETARY BROWN: At the moment, I don't think that is necessarily the correct posture. I am saying only that it is a factor that you have to consider in making your force decisions. It depends a great deal on the detailed characteristics of the system. Protracted war is something that, as I say, isn't very likely, but then a strategic war isn't likely in any form. One would have to look, and we have done some looking, at the details of what it takes to improve your situation so that you can have extended survivability of forces, not just survivability against one strike.
>
> MR. BEECHER: In terms of the psychology involved, do you think both nations would feel more secure if their rough numbers of strategic systems were about on a par?
>
> SECRETARY BROWN: I think that each nation has to feel that the situation is relatively stable. It may be that the way for each to feel that is to have roughly equal numbers of something. Numbers of missiles and numbers of bombers are typical examples, but I do have a feeling that the two sides may value different things. Their strategies may be different, their geography is different, their economics are different. I think the best thing is for each side to feel that it is at least equal and perhaps better than equal in something that is im-

continued on page 26

E&S
May 1969, Vol. XXXII, No. 8

Aims and Goals of the Institute: A Faculty Committee Looks to the Future

By C. J. Pings

For the last 40 years Caltech has been an institution in which the faculty has had unusual influence and control over academic affairs, and active participation in the democratic processes of faculty government has never been more apparent than at the present. Large numbers of our faculty sit on elected and appointed committees, both Institute and divisional. An outstanding example of faculty participation in a major issue was the special committee appointed to advise the trustees on the selection of a new President of the Institute. Similar but less publicized groups have advised the administration on the appointment of other campus officers in the last several years. A number of committees, both elected by the faculty and appointed by the President, have been working toward better communication with our graduate and undergraduate students. In numbers unprecedented, except for World War II, faculty members have become involved in the problems of our society. There has been a long tradition of significant Caltech faculty contribution to various advisory panels for the federal government; this has now been augmented by a large number of our faculty participating in the political and social issues of Pasadena, the Los Angeles Basin, the state of California, and the nation.

Concern and interest for the future direction of the Institute and its place in our society lay behind the request made by the faculty some two years ago for the appointment of a special committee to consider the long-range objectives of the Institute. The formation of this committee was authorized at a faculty meeting on February 1, 1967, and the members were appointed on June 1, 1967, by Jesse L. Greenstein, then chairman of the faculty. This group of 20 to 25 faculty members, known as the Aims and Goals Committee, has recently issued a preliminary report of the Committee's conclusions compiled after two years of study. The original Committee included no administrative officers, but since 1967 three members have assumed positions as division chairmen or executive officers; in each case the individual concerned raised questions of the propriety of further service on the Committee, but all have continued at the request of the remaining members.

The Committee met frequently during the summer of 1967 and during the 1967-68 academic year. This was an educational period, for it seemed unreasonable to attempt to project into the future without being well informed of past history, existing programs, and precommitments to future growth and development. During that year of study, real progress was made in understanding how the Institute operates, particularly the decision-making apparatus. The Committee then faced the difficult task of looking to the future, the resulting deliberations culminating in the provisional report just published.

In sending the report to the chairman of the faculty, the Committee noted:

"In preparing this report our objectives are rather modest. Primarily we are anxious to identify problem areas worthy of attention from either or both the administration and faculty. On issues so identified, we have attempted to indicate the range of views held by the Committee members. In certain cases the views so assessed are tantamount to a consensus. On the other hand, we have not let the absence of a unified Committee position deter the statement of a problem or an attempt to measure the spectrum of opinion on the subject.

"The ultimate disposition of this report will depend upon the will of the general faculty. Possibly our own reflections and the reactions of others will lead us to want to submit a revision as a final draft. In any event, we anticipate the dissolution of this committee before the end of 1969."

Committee members (left to right) George Hammond, Thayer Scudder, Robert Christy, David Smith, Thomas Lauritsen, C. J. Pings (chairman), Rochus Vogt, Herbert Keller, Rodman Paul, Norman Brooks, Fred Anson, Harry Gray, John Benton.

MEMBERS OF THE AIMS AND GOALS COMMITTEE

California Institute of Technology

CORNELIUS J. PINGS, Chairman
Professor of Chemical Engineering

FRED C. ANSON
Professor of Analytical Chemistry

JOHN F. BENTON
Associate Professor of History

NORMAN H. BROOKS
Professor of Civil Engineering

ROBERT F. CHRISTY
Professor of Theoretical Physics and Executive Officer for Physics

ROBERT S. EDGAR
Professor of Biology

ROY W. GOULD
Professor of Electrical Engineering and Physics

HARRY B. GRAY
Professor of Chemistry

GEORGE S. HAMMOND
Arthur Amos Noyes Professor of Chemistry and Chairman of the Division of Chemistry and Chemical Engineering

GEORGE W. HOUSNER
Professor of Civil Engineering and Applied Mechanics

FLOYD B. HUMPHREY
Associate Professor of Electrical Engineering

ROBERT A. HUTTENBACK
Professor of History; Master of Student Houses

HERBERT B. KELLER
Professor of Applied Mathematics

THOMAS LAURITSEN
Professor of Physics

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Professor of Mathematics

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THAYER SCUDDER
Associate Professor of Anthropology

ROBERT L. SINSHEIMER
Professor of Biophysics and Chairman of the Division of Biology

DAVID R. SMITH
Associate Professor of English

FREDERICK B. THOMPSON
Professor of Applied Science and Philosophy

ROCHUS E. VOGT
Associate Professor of Physics

The report has been broken down into nine chapters of varying length. The total report amounts to some 600 pages. All of the recommendations obviously are not of equal importance nor held with uniform conviction by Committee members. Some are truly long-range and fundamental, while others are more involved with details of problems of the immediate future. In the opinion of the chairman, the following are particularly important conclusions from the two years of work:

A. We are committed to continuation of our undergraduate teaching program, but there are opportunities for major improvements. Encouragement and support of innovation and experimentation with all aspects of education is needed.

B. Given a choice of growing or remaining excellent and unique, we choose the latter. Since there is little support for growth for its own sake, we need to find ways to change faster than we grow.

C. We support continuation of our strength in the humanities and social sciences, with cautious and controlled growth of our teaching and research in the social and behavioral sciences.

D. There is need for modernization of the faculty political structure and increased involvement of the faculty in advisory roles to various administrative officers.

E. We should seriously review whether the JPL association in its present form is in the continued best interests of the Institute.

F. Greater involvement of the Institute in the affairs of Pasadena and the southern California community is necessary.

The Committee is well aware of imperfections in its conclusions, but we view this as an initial step. Nothing of this type has been attempted before by the Caltech faculty (and, to our knowledge, few other faculties have engaged in such introspection). The Committee hopes that the publication of this initial report will elicit considerable thought and reaction from the rest of the faculty, administration, trustees, undergraduates, graduate students, employees, alumni, and friends of the Institute. Indeed, the chairman of the Committee herewith invites anyone interested in the aims and goals of the Institute to offer a reaction, preferably in writing, to any member of the Committee.

Following is a list of the chapters with a summary of the primary conclusions from each chapter.

I. INTRODUCTION consisting of a letter of transmittal and several appendices documenting the creation of the Committee and its initial activities.

II. GENERAL PROBLEMS OF GROWTH AND CHANGE AT CALTECH

1. We reaffirm our traditional aims, which were enunciated in 1921 as the pursuit of new knowledge and the education of exceptional people. We recognize that our efforts in research and education must have relevance to the aspirations of mankind, and we believe that we can best fulfill that responsibility if we take the long-range view.

2. Our tradition commits us to seek excellence through small size and a highly discriminate selection of fields of study. There appears to be no sentiment in the faculty for a growth in excess of a factor of two in the next decade, and the majority of our Committee feels that our growth should be limited even more sharply, perhaps to the extent that any growth in the undergraduate student body should be for the purpose of diversification or filling our currently underpopulated options.

3. There is a widely expressed desire to see a broadening of our intellectual base to include ventures into selected fields of social and behavioral sciences and humanities. At the same time, there are equally pressing ambitions for extension of our present work in the natural sciences and engineering. We need to find a way to change faster than we grow.

4. The present development plan places too much emphasis on facilities and too little on support for educational and research activities. Overcommitment of funds and space inhibits our flexibility and closes off options for new ventures. Our future depends upon our ability to attract outstanding people, and our plans should focus on this as the paramount need.

5. The Institute community needs to be more broadly informed and more actively involved in the planning process. Plans which affect the future of the Institute should be exposed to wide discussion before they have reached the stage of commitment. A faculty body should be charged with keeping itself informed of new developments and participating responsibly in their evolution.

III. INTRODUCING THE SOCIAL AND BEHAVIORAL SCIENCES AT CALTECH

6. The research areas in behavioral science that are now being opened up in biology and information

science seem to have not only promise but exciting possibilities. Support for them should be given a high priority, and they should not be held back from seeking additional funding from foundations because of any delays in starting the social sciences.

7. Until the mid-1950's the faculty of the Division of the Humanities and Social Sciences performed what was largely a service function, with little stress on scholarly endeavor. By leadership and example the present chairman of the Division has helped establish a tradition of teaching and research. The Committee supports the contention of most of the current faculty of the Division that, in the present competitive academic market, maintenance of a quality staff will be possible only if research is expected and encouraged. The Committee further urges a sympathetic recognition of the special problems that arise when faculty research is carried on without an accompanying graduate program.

8. The principal existing program in social science —that of the economists—is at a critical stage. A decision must be made immediately as to whether to commit the Institute to major support of this program, or to abandon all of it save the research efforts of individuals now on the faculty.

9. To continue along the present course in the social sciences, by hiring the additional persons that the remainder of the Rockefeller and Sloan grants would temporarily finance, will commit the Institute to a major long-range financial responsibility; for exhaustion of the limited Rockefeller and Sloan grants will leave Caltech with a program that is too incompletely staffed and conceived to attract outside funds, and yet cannot advance further without large additional moneys.

10. Support for a major commitment in the social sciences cannot be justified until and unless effective leadership, specially qualified in an appropriate social science discipline, is forthcoming.

11. If the decision is to make a major commitment, the following changes in emphasis and approach are recommended:

a. The "umbrella" approach should be abandoned in favor of more specific projects.

b. Accordingly, there should be a greater emphasis on the man rather than the program—on finding social scientists who are capable of developing their research as individuals, with only the relatively casual interchange that comes from having on the same campus men whose interests at times intersect.

c. There should be a determined effort to discover whether postdoctoral fellows could be used in the social sciences as effectively as they have been in the behavioral, so as to reduce the number of professorial appointments needed initially.

d. A comparable attempt should be made to discover whether a fairly extensive use of research assistants could take the place of graduate students during at least the initial phase of a program.

12. A review of the experience analyzed in this report strongly suggests that approval of any future major ventures into the social sciences should be contingent upon the following:

a. In the absence of a well-qualified man on our own faculty, a distinguished senior social scientist or a highly promising and widely known younger man should be recruited to serve as lead man.

b. Outside advice should be sought on a systematic basis.

c. In accordance with professional advice, "basic support should be guaranteed by the Institute" during the period of initial growth, until or unless grants can be obtained.

d. A satisfactory administrative status should be devised.

e. Provision should be made for special needs in regard to library, laboratory, and other physical facilities.

f. Consideration should be given to the possible effect of any proposed new program in diverting resources from existing programs or competing for space under the personnel ceiling. The anxieties that the social sciences have aroused in the minds of the humanists must not be repeated as between one social science program and a still newer one.

13. The Aims and Goals Committee is concerned that as yet there does not seem to be a provision for ever including psychology in the social science program, even though psychology is a discipline whose presence on the campus seems to be desired by both faculty and undergraduates, and even though experimental psychology is already a part of research in other divisions.

14. Because of their effect in diminishing one barrier to success in the social sciences, the Committee applauds the prospective increases in the library budget proposals for next year, which would virtually double the appropriation allocated directly to the social sciences and history.

15. Finally, the Aims and Goals Committee must

insist on recognition of a distinction that, however intangible, is nevertheless fundamental: The needs, preconceptions, and methods of social science will not necessarily be the same as those of the physical and natural sciences. Patterns of thought and action that have worked in the physical and natural sciences may at times be transferable to other fields, as the experience with the behavioral sciences suggests, but in other instances scientific patterns may be quite inappropriate. It is precisely because the social sciences promise to be different that some faculty members are urging support of them, in the belief that the campus needs greater diversity. But we cannot simultaneously seek diversity and yet also unconsciously expect conformity to the culture of a predominantly scientific community. A mutual attempt to understand each other will be the most important single prerequisite for success in any new undertakings that we, as "a company of scholars," may decide to venture.

IV. DECISION MAKING AT THE INSTITUTE

In its deliberations on decision making at the Institute, the Committee came to share a common perspective. Foci of responsibility and decision making should be defined and visible as much as possible. Equally important, serious efforts must be made to insure that all elements of the Institute can participate in advisory roles in shaping its future. We feel these conditions are necessary if we are to maintain on the part of the members of the Institute a sense of trust in one another and a sense of involvement and commitment ourselves.

In order to approach more closely these objectives, this Committee suggests careful consideration of the following recommendations:

16. The Board of Trustees should consider diversification of its membership.

17. Faculty representation at important decision-making meetings of the Board of Trustees should be strengthened.

18. Advisory faculty representatives should be included on trustee committees.

19. The Faculty Board perhaps should be converted into an "Institute Board" with representatives from administration, faculty, and students.

20. A mechanism such as a "Faculty Council" to explore and crystallize faculty viewpoints should be created.

21. The structure and duties of faculty committees should be periodically reviewed by an appropriate faculty agency such as a "Faculty Council."

22. Ex-officio chairmanships of faculty committees should be abolished.

23. Divisional chairmen should have limited tenure.

24. The divisional structures and their alignment should be periodically reviewed.

25. Improved mechanisms for interdivisional efforts and their support should be developed.

26. The role and powers of the Division Chairmen's Committee should be defined and formalized.

27. The membership of administrative committees should be periodically reviewed. There should be a larger turnover in membership, and the base of advisory responsibility among the faculty should be broadened.

28. New advisory faculty-student committees to the administrative branch of the Institute should be created.

29. Graduate and undergraduate students should be more effectively involved in the decision-making process of the Institute.

V. UNDERGRADUATE LIFE AND EDUCATION

30. The undergraduate operation is important and essential. The existing program has much to recommend it, but there are opportunities for major improvements which should be seized.

31. The feasibility of establishing a coordinate college near the Institute should be seriously considered.

32. The undergraduate student body should be enlarged only to try to provide greater diversity in student interests and option selections.

33. Major attention and support should be directed toward incorporating the student houses more fully into the academic life on campus.

34. Possibilities should be explored to facilitate greater amalgamation of the undergraduate and graduate students within the student houses and wherever else it seems feasible.

35. Every effort should be made to find a mechanism for housing women undergraduates within the existing student houses.

36. Much greater flexibility in the undergraduate curriculum is needed. Individual options should be encouraged to offer several alternative means for satisfying their requirements. The common freshman year should no longer be regarded as essential for all students.

37. Undergraduate research should be strongly

encouraged and made more readily available in the most popular options.

38. Innovation and experimentation with all aspects of undergraduate education should be encouraged, supported, and rewarded. It would be well to emphasize this intention by labeling a portion of the proceeds of the development plan for this purpose.

39. The committee lauds the recent proposal that the office of Vice President for Student Affairs be created to represent student interests at the highest levels within the Institute.

40. An enlarged and broadened psychological counseling service is urgently needed and should be provided.

VI. THE HUMANITIES AT CALTECH

41. The social and behavioral sciences present themselves as being relatively little different in method and attitude from the physical sciences, whereas the humanities, dealing as they do with value judgments, genuinely provide not only a counterbalance but a valuable complement in the Caltech educational process. The differences between the two should always be borne in mind as the Institute seeks out its future.

42. Many of the faculty and staff would like to see more humanistic and aesthetic ferment here, not simply for the undergraduates' benefit but in order to enrich their own lives and this community.

43. As the Division of the Humanities and Social Sciences expands into the social and behavioral sciences, there is danger that the traditional humanities will be swamped. The Aims and Goals Committee urges that the important role played by the humanities be protected, strengthened, and even somewhat expanded.

44. The Committee supports the strengthening of teaching and scholarly activity in psychology and philosophy.

45. Any expansion in the humanities will necessitate a much larger library. The current acquisition rate threatens to jam the Millikan Library in a few years. The Committee advocates that planning for a new library facility be undertaken now.

46. The Committee recognizes that the existence of humanities majors and the student demand for increased course offerings at an advanced level are creating problems which need study.

47. In attracting new faculty members in the humanities, the Institute must face the fact that good men in those disciplines also want those research and intellectual conditions which will allow them to advance their own scholarly development.

48. The Committee feels the efforts to enrich the intellectual experiences of our undergraduates will be greatly helped by exchange courses with other local colleges and universities (see also 31).

49. The Committee urges that funding be sought for an Institute of Advanced Study in the Humanities and Arts to serve as an instrument for bringing visiting scholars and artists-in-residence to Caltech.

50. As we view the future of humanities at Caltech, the Committee urges that we should not diversify at the expense of strength; we should select carefully the areas we wish to pursue.

VII. JPL, OFF-CAMPUS FACILITIES AND COOPERATIVE VENTURES

51. Laboratories or special facilities sponsored by the Institute in response to government requests, social needs, etc. should continue to be geographically and administratively isolated from the campus unless they are clearly related to the Institute's primary goals of teaching and research.

52. The Institute should periodically review its associations with various outside organizations which it sponsors or in which it participates. In particular the Committee believes that the need for Caltech help in the creation of an organization may indeed be important but that, after an appropriate incubation period, the sponsorship could well be terminated with no harm on either side. Initial agreements to participate in such programs should include explicit written provision for Institute withdrawal; in most cases there would be merit in term agreements which would permit the Institute involvement to automatically lapse unless positive steps were taken to arrange renewal.

53. The Aims and Goals Committee did not presume to discuss the future plans of JPL. However, the Committee did reflect on the future implications for the campus of the continued management of JPL by Caltech.

a. There has been very little involvement of faculty members in the research or space flight operations of JPL, but there are indications that the level soon will increase somewhat because of a more enlightened attitude of NASA. However, neither past nor future faculty participation in JPL activities is significantly dependent on the formal management relation.

b. There has been little participation by JPL

staff members in the teaching and research carried out on the campus, nor is it likely to increase.

c. The founding and early management of JPL by Caltech were clearly justified by patriotic duty. That factor is in the past, and the Committee recommends that it is now time to seriously review whether the association is in the continued best interests of the Institute.

54. There have been occasional proposals from some faculty members for the Institute to sponsor new laboratories of applied science in the Pasadena area. Even if such facilities would be useful to a segment of our faculty, the Committee believes that the creation and existence of such organizations are not critically dependent upon Institute backing.

55. The Committee anticipates a new pattern of federal science funding which will result in regional facilities for specialized research equipment. Some of these probably will be located on the Caltech campus, where they will be shared with qualified users from other schools. Care should be taken to provide for the Institute's graceful withdrawal from these arrangements when local interest in the facility wanes.

VIII. RELATIONS WITH THE COMMUNITY

56. It is the responsibility of the administration in consultation with the faculty to formulate policy as it relates to the community.

57. An appropriate Institute group or panel should be instructed to prepare a brief for the President and the Vice President for Institute Relations as the next step toward developing an Institute policy toward the community.

58. The time has come when the President and the faculty should be prepared to take a position on controversial community issues—as they relate, for example, to the Pasadena school system or to environmental and urban degradation in the Los Angeles Basin.

59. We foresee the possibility that a new type of national or international crisis (environmental degradation, for example) may require of Caltech something beyond a mere expression of opinion. In such a case, the Institute, consonant with its widened sense of social responsibility, may wish to involve itself more actively by sponsoring a major problem-solving venture analogous to the Institute's World War II activities.

60. While the Institute should never undertake commitments which bind its faculty without their consent, we believe the Institute, in widening its sense of social responsibility, should encourage interested faculty to pursue appropriate action programs voluntarily.

61. We endorse the Carnegie Report proposition that "the university can, in regard to controversial social issues such as racial integration in housing, look carefully at its own practices and adhere to high standards on its own campus."

62. Caltech must ensure that contractors doing business with the Institute comply with the equal opportunity provisions of the law. We are aware that this is already the policy of the Institute; we support its firm execution.

63. Caltech's public image needs to be greatly improved by a more broadly based public relations effort to portray more accurately what the Institute actually does.

64. The administration should investigate the extent to which Institute physical facilities are used for community activities and ascertain whether or not additional commitments are desirable.

65. The Institute needs to consider carefully the pros and cons of extending its widened sense of social responsibility to California as a whole.

66. Caltech's various contributions to the community should be carefully inventoried and publicized to clarify what is already done.

IX. GRADUATE STUDENTS & RESEARCH FELLOWS

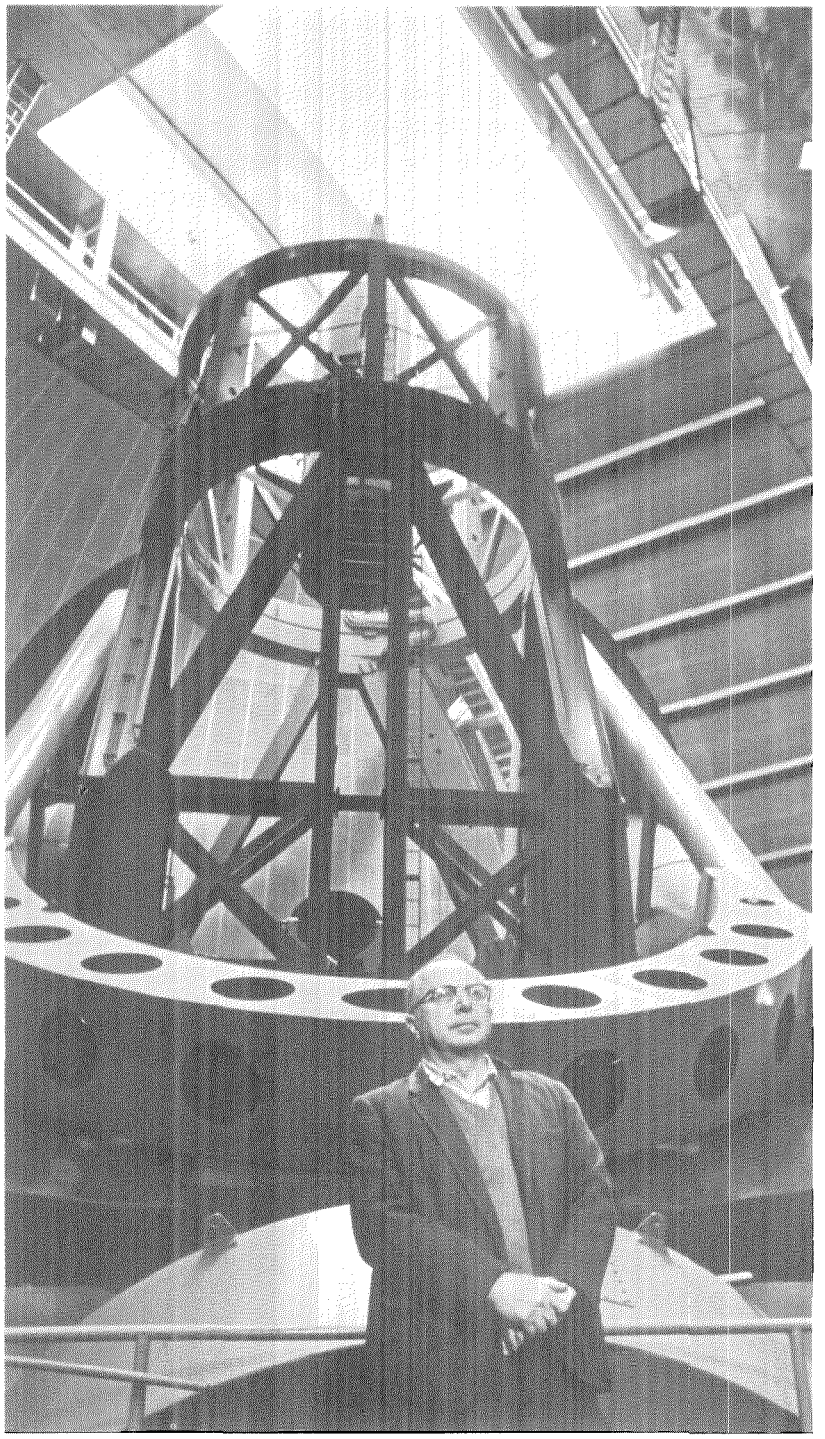
67. At the present time our program of teaching and research for graduate students matches rather well the capabilities and expectations of the students with the resources of the Institute. However, the Committee detects some signs that more and more of our graduate students are seeking an intellectual experience which is broader than, or different from, that of our traditional PhD programs.

68. We recommend that housing for married graduate students and research fellows, and their families, be provided at an early date.

69. Full faculty support should be given to the evolving Graduate Student Council and its associated committees within the divisions.

70. The Committee calls for greater recognition within the Institute community of the valuable dual role of our research fellows. This is our third tier of teaching, no less important than the training of undergraduate and graduate students; at the same time the research fellows make significant contribution in transmitting attitudes and real wisdom to our younger students.

A Night on Palomar Mountain



Jesse Greenstein and the 200-inch Hale telescope. Dr. Greenstein is professor of astrophysics and executive officer for astronomy at Caltech, and a staff member of the Mount Wilson and Palomar Observatories.

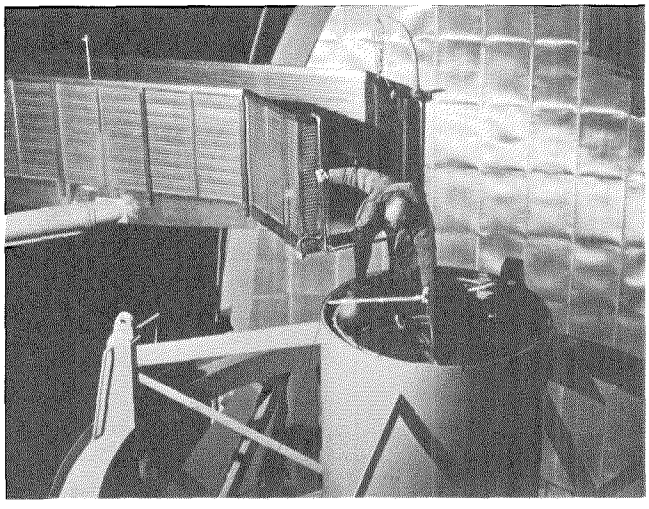
By unbreakable tradition, each astronomer makes his own observations at a large telescope. He is surrounded by engineering marvels and advanced electronic technology. But making a critical and delicate observation is still, ultimately, a one-man struggle. Bad weather, malfunction of equipment, cold, and lack of sleep are the enemies. It is therefore not just a scientific challenge. The romance and beauty of the night, of the half-seen, faint glow of starlight, promise excitement and mystery. The observing process is an irresistible adventure for me, even after 30 years. I am a telescope addict, and in love with a 500-ton steel and glass monster, at Palomar.

From Santa Barbara Street and Caltech (our Pasadena offices), every few days, a station wagon carries equipment, supplies, and one or two astronomers. Conversation during the 130-mile ride shows weather as the obsessive anxiety. Even the most distinguished member of the Mount Wilson and Palomar staff is assigned (a year in advance), at most, 25 nights a year—clear or cloudy. Success or failure may depend on tonight's work—and if failure tonight, next year may bring another chance. City and suburbs and freeways are replaced by a country road up scrubby hills, and a flat-topped 6,000-foot mountain. The first sight of the silver bubble of the great dome startles even the most unromantic.

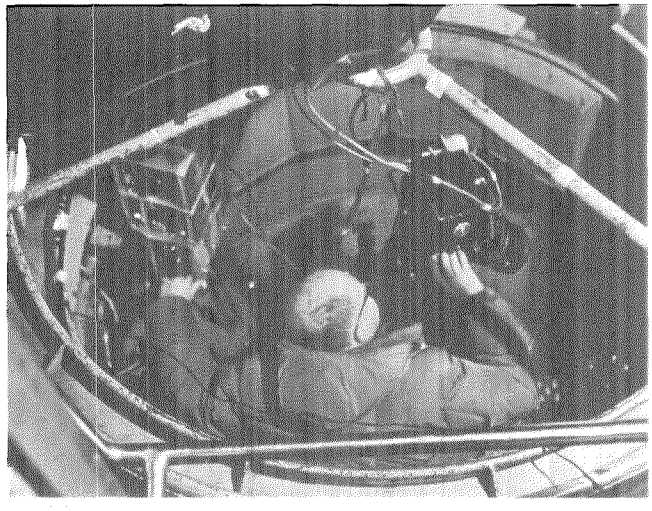
Inside, it is cold and quiet but, in the first hours, desperately busy as equipment is unloaded, mounted on the telescope, and tested. Each scientific problem requires its own special technique and auxiliary apparatus. Some observers use a roomful of electronic equipment. Mine is simpler, the prime-focus spectrograph, to be mounted at the top, looking down on the giant mirror. The cage, a six-foot-wide cylinder supported by thin steel fins, is reached by an elevator creeping 60 feet up the curved inside of the dome. We mount the spectrograph with its finely ruled diffraction grating and a three-inch solid quartz schmidt camera. By late afternoon all is adjusted, the photographic plates have been cut to correct size, and I can at last lean back inside the gray tube and the half-light for a moment to breathe the thin air, not of a

"A Night on Palomar Mountain" is scheduled to appear in *The 1970 Britannica Yearbook of Science and the Future* to be published in October 1969 by *Encyclopedia Britannica.*

By Jesse L. Greenstein



Greenstein is carried to the observing cage in an elevator which climbs 60 feet up the inside curve of the observatory dome.



Inside the cage, with spectrograph mounted, he adjusts his camera, checks his star charts, and settles in for the first cold hours of observation.

mountain, but of other, distant worlds.

By 6 p.m. (11 hours after the morning's alarm clock) I am ready to begin work. Dinner is brief; in the "monastery" where I will sleep I put on warmer clothes—an electrically heated flying suit—and then go back to the cage. Now the stars begin to show through the opened slit of the dome. A computing machine printout is my list of objects to be studied, with priorities and technical specifications, and I have star charts and the plates. Down below me the night engineer starts the generators, pumps, and telescope drive, and through the intercom his voice rises:

"Are you ready, Dr. G.?"

"Yes. Fix on finding star number 32; after I've focused, we'll go to the object."

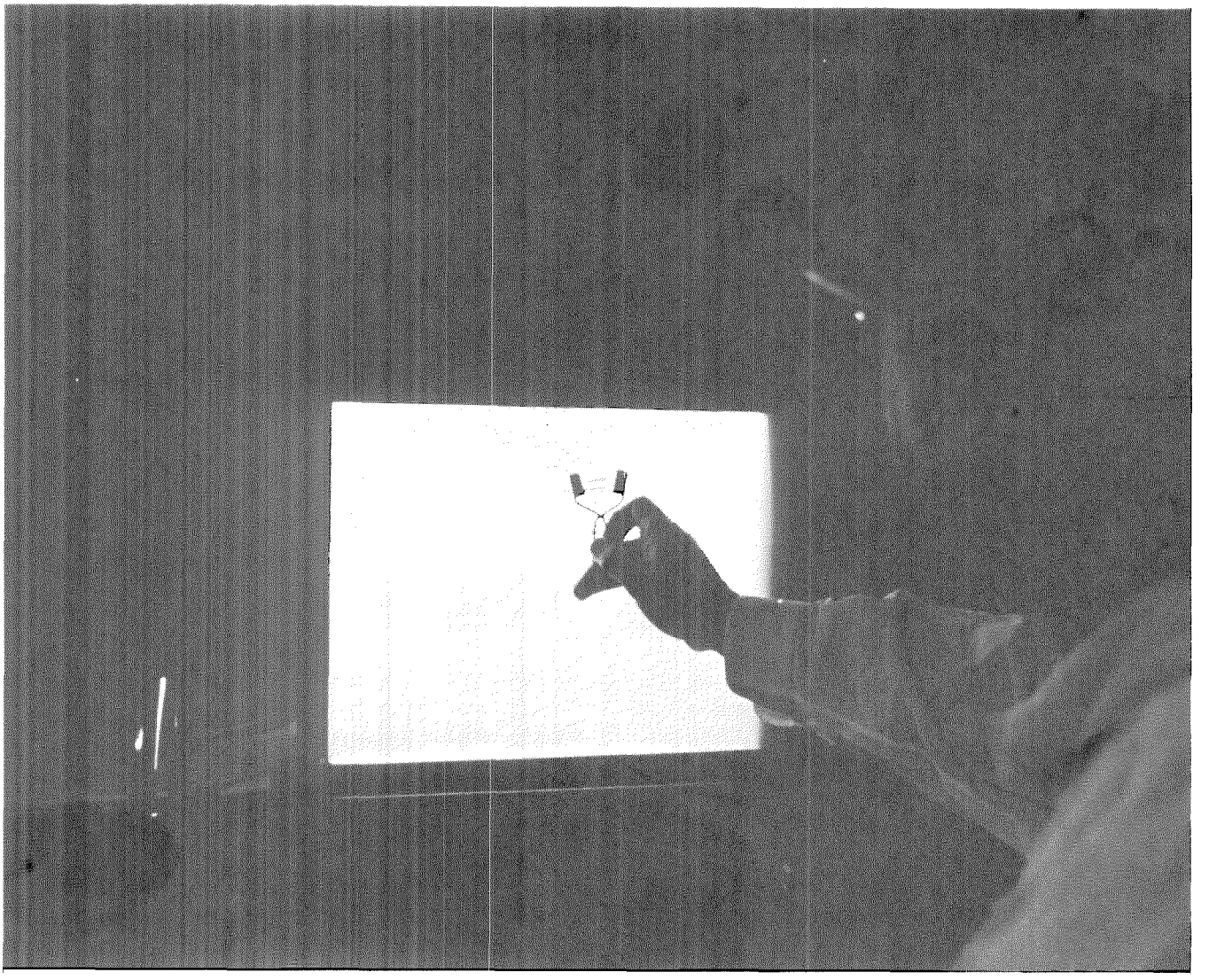
Relays bang; the motors roar through the loudspeaker, and the tube tilts downward and to the east, toward my celestial object. In the cage gravity goes mad; gimballed boxes swing, and I furiously crank my observing chair to a level position from which I can still reach the spectrograph and, I hope, survive the next four hours. The tube lurches as the brakes lock on; small motors hum for fine settings. Through the eyepiece I see a blue disk which sharpens into a star as I set the focus. If I am lucky, I have a dazzling point of light to center on the spectrograph slit, but, if the seeing is poor, a jumping blob.

"Good, we're centered and focused; let's go to the object—R Monocerotis."

The telescope slides a few degrees; I look down the tube at a black pool filled with tiny lights, the mirror 55 feet away catching starlight. Then, in the eyepiece is a strange, pale, white glow, shaped like a comet; at its tip, a star being born. Our view is as old as civilization; the light is 5,000 years old.

A bustle of final settings, calibrations, data for the observing record; I pull out the camera-cover slide, and the exposure begins. Then silence, only the distant pumps, and the passage of time. The telescope is turning 15 feet an hour to follow a star 3×10^{16} miles away! The star stays frozen on the spectrograph slit, but every few minutes I check and reset the fine motions of the telescope, perhaps a thousandth of an inch, to maintain centering. I retilt the seat. Once I climb on it to look out at the nearby sky; 42 degrees F feels cold if you sit still near midnight. What do I think of? Usually of nothing, hypnotized by the dulling reality of chill and fatigue, or of what I might have done incorrectly, or about the next exposure. But sometimes I think of what may be creating the dim glow I see.

Then a flurry of activity at the end of the exposure



The rewards of a night of observing—the photographic plates which record the spectra of half a dozen stars.

—reloading the camera in the dark—and the ride to the next object, back toward the east since the sky has turned 60 degrees. Another focusing, another faint star which is a suspected white dwarf—near the limit of vision and hard to find. We start a new exposure, for two more hours, and I think about superdense matter and, meanwhile, listen to my radio playing Mozart, who lived in a different world.

After midnight I climb out of the tube, to the elevator, to descend to the darkroom, and have lunch. The plates, still wet, show the nebula spectrum was well exposed. The faint white dwarf gave a narrow streak of blackened silver grains that tells me something new. Up the elevators to the cage, to new objects and another four hours. At the end of the last exposure, dawn begins; the telescope is set vertical; the motors stop. It is a sudden relief, in the lurching elevator with the giant dome closing, to be able to stand and feel the end of cramped muscles and nervous tensions—all pure joy.

By dawn I am in the monastery, completely darkened and quiet, to sleep five hours till breakfast. To the darkroom again at 1 p.m. to prepare for the next night. Are these objects interesting? Shall I change the program? It is the first of my four nights of this run. Tonight might be crucial; last night's plates suggested something new. I will be more tired; if there were only more time! Were I sensible, would I be an astronomer again? Of course, because next year, science will be better; new objects and instruments will be found; new ideas already are boiling, and there is so much unknown. What were all those flying specks of light in the mirror? What new marvels are waiting?

Ice Fog

By Carl S. Benson

A Caltech alumnus—and a fugitive from Los Angeles smog—finds a unique type of air pollution in Alaska.

Most people think of Alaska as a big place with a few people and clear air, and in general this concept is correct. However, there are exceptions. Much of Alaska's sparse population lives in crowded though isolated communities, some of which are small copies of urban areas in the United States to the south. Their similarities include, unfortunately, the most extreme cases of water and air pollution.

One of these communities is the Fairbanks-Ft. Wainwright area of interior Alaska, which has an interesting form of air pollution known as ice fog. Ice fog is produced when the water vapor output from urban environments meets an air mass which is too cold to dissolve it and cold enough to crystallize the condensed vapor into tiny (5 to 10 microns) ice crystals. The condition becomes increasingly serious as air temperatures go below −35 degrees C. The ice fog layer has a vertical thickness of about 10 meters and rarely exceeds 30 meters, but its thickness and density increase during extended periods when temperatures remain below −40 degrees. Then street level visibility becomes an acute problem, often being reduced to less than 10 meters, or "measured in arm lengths" in the popular vernacular.

Although reduction in visibility is serious in itself, it is only one of the more obvious manifestations of the problem. The stable air condition (little or no wind) during cold spells in Fairbanks produces concentrations of atmospheric pollutants which are as bad as any on earth.

My study of ice fog began as a purely glaciological one, but it soon blossomed into a study of air pollution—perhaps the first time these particular fields of study have blended.

Ice fog is low-temperature air pollution. It is unique and sufficiently well known to be classified as one of the four major types of air pollution: 1) coal smoke and gases—the major contributor in the industrial world; 2) specific toxicants—usually related to the effluent from a specific industrial source; 3) Los Angeles-type smog—identified by Caltech's A. J. Haagen-Smit to be the result of complex photochemical reactions involving unburned hydrocarbons, primarily from auto exhaust [*E&S*—May 1952], and occurring with varying intensity in metropolitan areas all over the world; 4) ice fog—sometimes called the Fairbanks-type air pollution.

Inversions form the essential ingredient in setting the stage for air pollution. Air temperature usually decreases with increasing altitude; when it *increases* with altitude, a temperature inversion exists. The air within an inversion layer tends to be stable because the colder, denser air lies at the bottom, and the possibility for vertical motion and mixing of the air is reduced. As the temperature gradient (the rate of change of temperature with altitude) within the inversion increases, so does the stability. The magnitude of the temperature gradient is often referred to as the "steepness" or the "strength" of the inversion.

There are two main types of inversion. One is a temperature inversion that forms in the boundary layer between two air masses. For example, in the Los Angeles area where cool air lying on the Pacific Ocean is overlain by warmer air, the temperature slowly decreases from ground level up to 400 or 500 meters; then it increases sharply as the overlying warm layer is encountered. The other type of inversion occurs at ground level when there is a net loss of heat from the earth's surface by outgoing longwave radiation. These radiation inversions become especially well developed at night over snow surfaces and are common both night and day in parts of the Arctic and Antarctic. They are also very common in Fairbanks.

Ice fog in the atmosphere makes visibility difficult in downtown Fairbanks even in the light of midday.

If we compare the air structure over Los Angeles and Fairbanks (right), we find that in the summer in Los Angeles there is a 400- to 500-meter average air thickness beneath the inversion. In the winter in both L.A. and Fairbanks the air is colder, and the inversion begins at ground level; thus there is scarcely any air available to disperse and carry away pollutants beneath the inversion layer.

The Fairbanks inversions are also stronger and longer lasting. Maximum gradients in the Los Angeles inversion are about 10 degrees C per 100 meters; those in Fairbanks nearly always exceed this and range up to 30 degrees per 100 meters. The Fairbanks inversions are not only among the steepest in the world, but they sometimes last for weeks at a time. During midwinter the sun is above the horizon for less than four hours per day at a maximum angle of less than 2 degrees. This nearly continuous nighttime environment is partly responsible for the strength and persistence of the surface inversions in the winter.

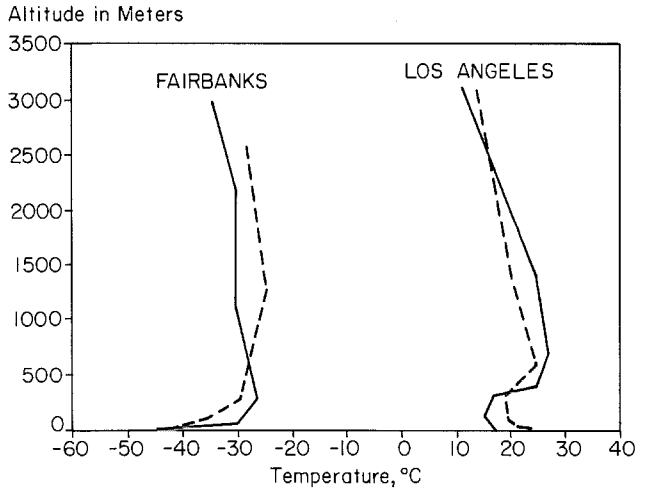
Topography is also important. Fairbanks is surrounded by hills on three sides, somewhat like the Los Angeles Basin. This provides wind protection, which enhances the formation of strong surface inversions and permits the air to stagnate in the city. The lowest air layer becomes virtually decoupled from the air aloft.

Most cities evolve enough heat to prevent low-level inversions from forming—indeed, it is rare to find inversions in the lowest 100 meters over cities, and the city influence is sometimes still evident as high as 200 to 300 meters above the surface. In Fairbanks, the city warms the air so that it is about 6

degrees warmer than that of the surrounding areas. This is a significant heat island in the Tanana Valley, but it does not destroy the strong surface inversions because they always involve temperature increases of more than 6 degrees C in the first 50 to 100 meters.

Exceptionally strong inversions, present when surface temperatures drop below −30 degrees and formed by radiative cooling from the surface, restrict turbulence in the lowest levels. Therefore the surface air layers have very low winds, almost always less than 2 meters per second. This is especially true for the bottom 200 meters of air contained by the hills around Fairbanks.

The existing air flow consists of katabatic (gravity drainage) winds which move down the Tanana Valley. This has led to a widespread misconception that the katabatic flow drains cold air from the hills onto the flats, and especially into the lowest pockets. This would be a happy circumstance, if it occurred, because such drainage would tend to flush the air pollutants out of the city. However, the air in the flats is so much colder, and therefore denser, than that moving down from the hills, that it cannot penetrate. It moves across the cold low-lying pool of air as if it were a lake. Thus, the only flushing mechanism for Fairbanks air during cold spells is turned off, and the dense surface layers are effectively decoupled from the air above. Unfortunately, it is precisely during these cold spells, when the air is most able to stagnate, that the rate of polluting the atmosphere increases because of increased demands for heat and power. Invariably, natural and man-made factors reinforce one another in ways which lead to intensification of the air pollution.



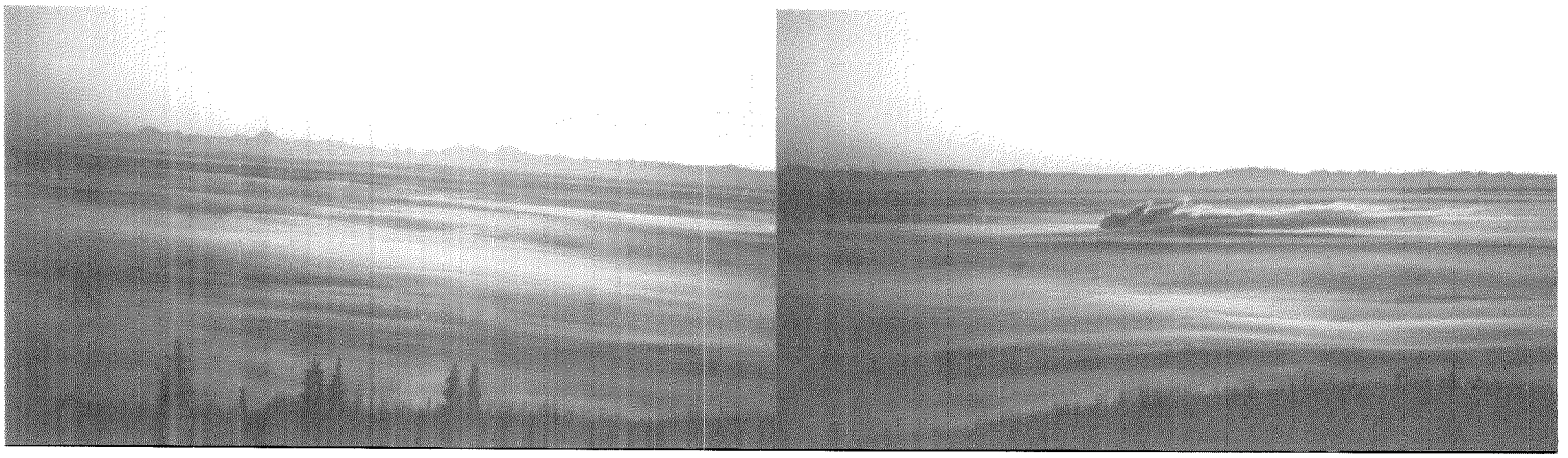
A comparison of air temperatures measured at various altitudes in Fairbanks and in Los Angeles shows the colder air in Fairbanks producing inversions at ground level. (Although Fairbanks is 135 miles above sea level and L.A. 38 miles, they have been plotted at a common altitude to compare their inversions and their altitudes.)

Fairbanks is ideal as an air pollution laboratory. The city is isolated—its nearest neighbor is Anchorage, a full day's drive to the south—and its sources of supply are limited almost exclusively to the Alaska Railroad, which is easy to monitor. Thus Fairbanks, at the end of the line, not only has a simple, two-layer atmosphere which serves to concentrate pollutants, but the sources of all its pollutants may be accurately measured as well. This ideal simplification is virtually impossible to duplicate.

One of the most interesting things about the Fairbanks air pollution is that atmospheric water itself is a pollutant, even in amounts that would be considered negligible at higher temperatures. It is surprising how much water vapor is put into the atmosphere by the activities of man. For example, the automobile creates water and carbon dioxide when gasoline is burned in the engine. The actual mass of water ejected as vapor from the exhaust is 1.3 times greater than the mass of gasoline burned. The amount of carbon dioxide produced is 3.1 times the amount of gasoline burned.

In the Fairbanks area more than 30,000 gallons of gasoline are burned every day. This alone results in a daily input into the atmosphere of 120 tons of water vapor and 295 tons of carbon dioxide. Similar relationships exist for fuel and coal. (The coal used in Fairbanks is slightly more complex than the liquid fuels because it contains some gravel, 10 percent ash, and 20 percent water.) The total input from all combustion products is 1,300 tons from water and 4,100 tons from carbon dioxide. This figure represents only 32 percent of the daily input of water from all sources.

The largest man-made source of water vapor in the Fairbanks-Ft. Wainwright area is the evaporative loss from power plant cooling waters. There are five power plants in the area, each using a large amount of cooling water. The designs for discharging this cooling water are crude, especially considering how greatly the discharge contributes to the ice fog. For example, one power plant discharges about 110 gallons of water per second at a temperature of 15 degrees C into a stagnant slough. The water remains, for 3 kilometers, as a stretch of open water which does not freeze even in the coldest weather. The resulting



This mosaic of four pictures, taken in December at sunset from Birch Hill, north of Fairbanks and Ft. Wainwright, shows (left) the eastern edge of the ice fog over Ft. Wainwright to the southeast; (above) the exhaust plume from

evaporative loss to the atmosphere is nearly 900 tons of water per day. The five power plants contribute a total of 23,400 gallons per minute. The evaporative loss from this source exceeds 2,500 tons of water per day and constitutes 64 percent of the total man-made input into the Fairbanks atmosphere.

The Los Angeles area puts far more water into the air by combustion than Fairbanks does. But air in L.A. at 20 degrees C can hold 255 times more water in solution, without condensing and forming fog, than air at —45 degrees C in Fairbanks. It is striking how little moisture is required to generate a dense fog when the saturative value for the air is less than 0.1 grams of water per cubic meter.

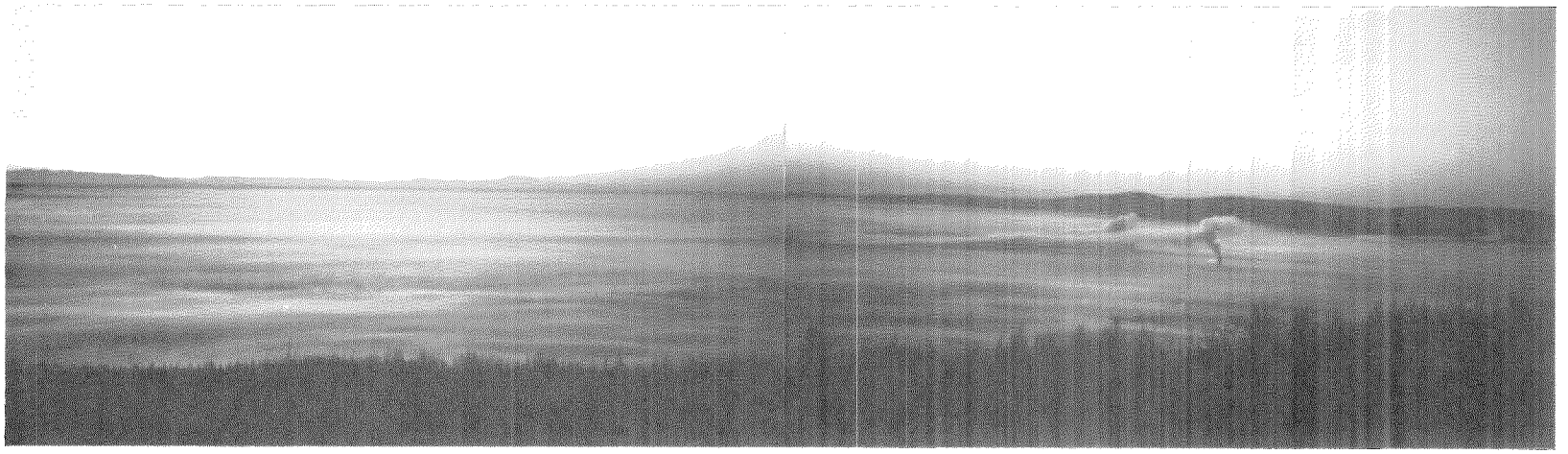
Under these conditions all sources of water vapor produce small (about 5-micron in diameter) spherical or columnar ice crystals which have an average specific surface area in excess of one square meter per gram (about 9 square feet) and terminal falling velocities of less than one centimeter per second. The large surface area allows the crystals to adsorb pollutants in the air, to the extent that 0.5 percent of their mass consists of foreign matter; the slow terminal velocity keeps them suspended in the slowly moving air.

It is impossible to eliminate all sources of water vapor into a cold atmosphere. Some of these are as basic as breathing itself. There are 30,000 people and about 2,000 dogs in the Fairbanks-Ft. Wainwright area. The air that they exhale is saturated with water vapor at a temperature of 35 degrees. The dogs breathe at an average rate of 5.2 liters per minute even when they are resting; this provides 7.5 cubic meters of air per dog, per day, with a moisture content of 40 grams of water per cubic meter. So the total moisture put into the air by 2,000 *Canis familiaris* is at least 0.6 tons per day. This is a conservative estimate, because all of the dogs don't rest all of the time.

The people must be separated into 20,000 males and 10,000 females. At rest, the lung tidal volumes are .75 liters for males and .34 liters for females. But the respiration rate is 11.7 per minute for both groups. These rates increase with activity. Respiration and tidal volumes for males doing light work are 17.1 per minute and 1.6 liters respectively, and for heavy work 21.2 per minute and 2.0 liters. As an overall average for an order of magnitude calculation, this results in 29 tons of water per day breathed into the air by *Homo sapiens* in the Fairbanks-Ft. Wainwright area.

Contributions to the total man-made input of 4,000 tons of water vapor to the area are:

Source	*Amount in tons per day*	*Percent*
Combustion products		
Gasoline	124	3
Fuel oil	202	5
Coal, domestic	207	5
Coal, power plants	760	19
Cooling water from power plants	2600	64
Miscellaneous sources (leaks from steam lines,	170	4



Ft. Wainwright's power plant penetrating the ice fog; (above) Mt. McKinley on the horizon some 160 miles away to the southwest; and (above) to the southwest the exhaust plumes from two power plants in Fairbanks.

houses, laundries, university mine shaft, sewage plant, people and animals breathing)		
Total	4063	100

It would be misleading to assign importance to the sources on a basis of quantity alone because the altitude at which the exhaust is put into the air is a critical factor. In the case of cooling waters, low altitudes and high input rates are combined. However, the 3 percent added by automobile exhaust contributes more frequently to ice fog than does the 19 percent from power plant exhaust stacks. The latter become very important when the thickness of the fog increases sufficiently so that the power plant exhaust plumes blend into it. The automobile is the worst source because it moves about and is concentrated where people concentrate. The altitude of its exhaust outlet is essentially at ground level, and it contains other undesirable products in addition to the water vapor.

A mass balance of the ice fog has been calculated by equating the rate of input from all sources to the rates of precipitation, evaporation, and growth of the fog. The present sources maintain a maximum ice fog volume of about 3 billion cubic meters over a fairly well-defined area of nearly 200 square kilometers. There are some fascinating dynamic problems of the air within this ice fog layer which are now being studied.

There are, of course, products other than water put into the air during the ice fog attacks. Combustion processes also introduce into the Fairbanks air mass:

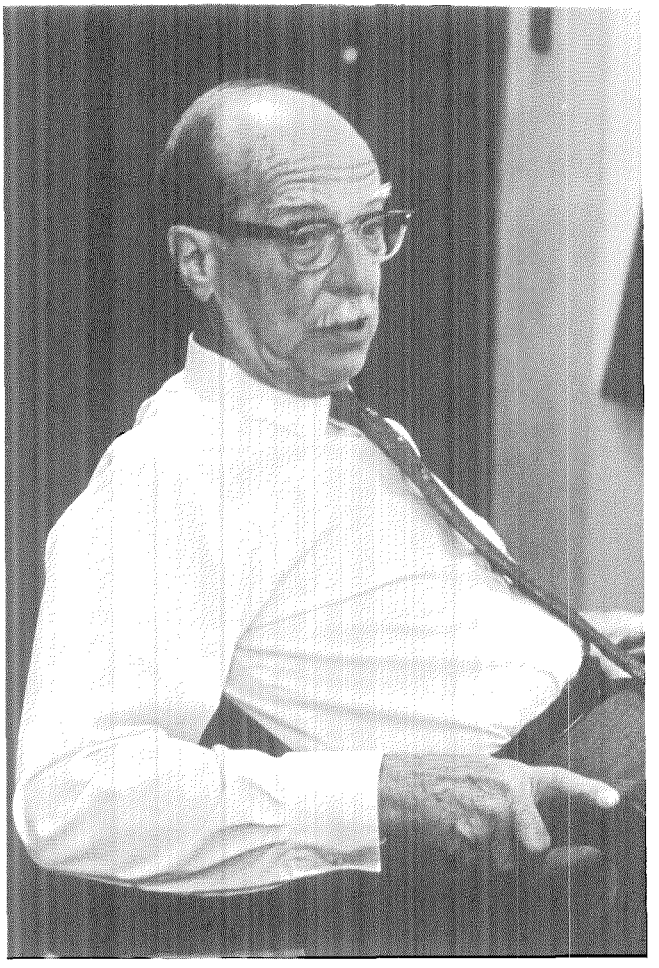
Compounds	*Amount (kilograms per day)*
Carbon dioxide	4,100,000
Sulphur dioxide	8,600
Lead in salts	60
Bromine in salts	46
Chlorine in salts	20

The last three of these products are from the tetraethyl fluid in gasoline. The concentration of lead in Fairbanks air during extreme conditions probably exceeds the values measured in most urban areas. So far we have measured concentrations of 6 micrograms of lead per cubic meter of air under conditions when a relatively weak inversion was present. This value may be one-half to one-third of the maximum values attained.

Our research on ice fog and the associated low-temperature chemical reactions in the air is just beginning. It is a serious problem and one that will continue to increase with population. One only wishes that the existence of ice fog was limited to that observed many years ago by a traveler to these parts:

"There was not a breath of air stirring . . . there were only a few clearings in the wood, but wherever the animals were you could discover their presence by the clouds of steam that rose from them high above the tops of the trees. Wherever a band of caribou was running, you could see a cloud of steam hovering over their trail and marking it out plainly for a mile behind them."

Retiring This Year



Foster Strong

T. Foster Strong

associate professor of physics, dean of freshmen, emeritus

Foster Strong came to Caltech in 1933 to get his master's degree in physics and has been here ever since. In July he retires as associate professor of physics and becomes dean of freshmen, emeritus.

Dean Strong describes himself as "one of the last of the Millikan crowd"— those who were drawn here by Millikan's dream and held here by his warmth and enthusiasm. With 32 years of teaching and 23 years as dean behind him, Foster Strong played a good part in making that dream a reality.

Strong earned his BS in civil engineering at the University of Wisconsin in 1922. For the next 11 years he worked in industry—with the Utah Power and Light Co., the U.S. Gypsum Co., the Certain-teed Products Corp., and the American Trust Co. of San Francisco—before he returned to academic life.

After he got his MS in physics, he stayed at the Institute and two years later started teaching physics here. During World War II he carried a large part of the teaching load in undergraduate physics.

In 1945 Strong was appointed dean of freshmen—a job which was supposed to take two-thirds of his Caltech time, but which (according to his colleagues) took more like 24 hours a day.

Caltech was one of the first schools in the country to have a dean of freshmen. With no precedent set, the job has been largely shaped by Dean Strong. The freshmen he has counseled and his colleagues on the faculty (as dean he has served on 13 to 15 committees a year) consider him conscientious, honest, and thoroughly dedicated to his work and to the Institute.

During his years as dean, Strong has had continued enthusiasm for teaching physics. "No matter how frustrating the problems of the dean's office were," he says, "I could always come away from the classroom feeling refreshed."

When he retires in July, he will still be involved in physics. Years ago he "made up" problems for his physics classes. As his students spread, so did the fame of his Strong Problems. In 1963 a publisher asked him to collect them in a book. Now, he says, he will have time to finish the project.

That is, if he can work it in between trips abroad. The Strongs, enthusiastic travelers, have immediate plans to visit the Dalmatian Coast in Yugoslavia and, later, one of their favorite world spots—Morelia, Mexico.

Paul Bowerman

professor of modern languages, emeritus

Paul Bowerman, once a free-lance writer and diplomat, has taught at Caltech for 24 years. He retires in July as professor of modern languages, emeritus.

Bowerman received his AB in English from Dartmouth College in 1920 and then took a teaching assignment at Robert College in Istanbul. The following year he spent traveling through Europe as a free-lance writer. Then, "hooked" on travel and convinced that the foreign service would give him a chance to see more of the world, he joined the State Department in 1923 as a foreign service officer. He spent the next 10 years in Germany, Canada, Yugoslavia, and Greece. (He learned of his impending assignment to open the first U.S. consulate in Iceland in 1929 and, through the help of State Department friends, narrowly escaped a position he still considers a "questionable honor.")

When he left the foreign service, he went back to school and got his MA at the University of Michigan, then came to the West Coast and continued his graduate work at USC, while teaching English there and at Caltech. Because of his background, Bowerman was prepared to teach German and French as well—and soon found himself doing just that. In 1945 he became assistant professor of modern languages at Caltech and in 1947 was made an associate professor.

Bowerman has seen a great expansion—and improvement —in the language program during his 24 years at Caltech. He

Paul Bowerman

Horace Gilbert

set up the first language lab here in 1959, and is justifiably proud of the new lab that went into operation this year. In 1966 he introduced an innovative two-year French course, primarily for graduate students, to fulfill the need for speaking as well as writing competency in the language. It was followed by German in 1967 and Russian in 1968. Another change he initiated—giving graduate students the option of taking a subject minor in French or German—will be implemented this fall, with plans to add Russian later.

Bowerman has no definite plans for his retirement, but will take the summer to "test my fitness for so much leisure." Then, if he can persuade his wife to retire from teaching also, he may begin his globe-trotting again.

Horace Gilbert

professor of business economics, emeritus

A telegram from a man he had never heard of—Robert Millikan—invited Horace Gilbert to Northampton to talk about a teaching job in 1929. Gilbert, who had received his master's in business administration—with distinction—from Harvard, was teaching business policy and economics there. He had scarcely heard of the California Institute of Technology. But a colleague said, "Good heavens, Horace. Millikan is the *Taussig* of physics!" So Gilbert went to Northampton—and to Caltech. He has been on the faculty ever since, and retires in July as professor of business economics, emeritus.

"I couldn't have had a finer group of students at any other school in the country," he says, "including Harvard Business School."

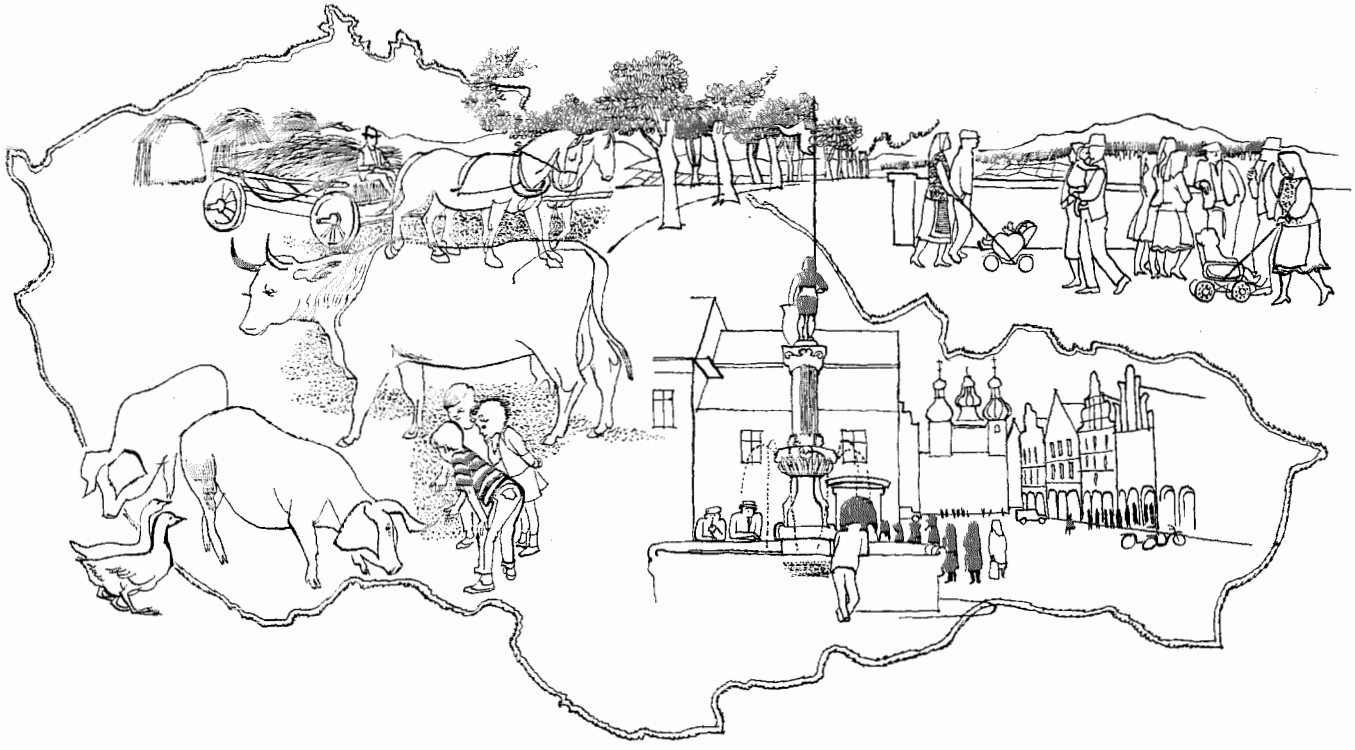
One of Gilbert's special contributions has been to provide generations of engineering graduate students with a realistic idea of how business operates. Today many of these men are executives in their own or other firms.

Gilbert's knowledge of economics has not been limited to business administration, however. His interest in international affairs and in travel has led him to become knowledgeable on industrial development in various countries and areas of the world—Germany, Soviet Russia, Japan, Southeast Asia, and the developing nations of Africa—and he has made repeated trips to these areas for firsthand observation.

Appropriately enough, Gilbert served for 16 years as chairman of the faculty committee on foreign students, and the Gilbert family befriended decades of foreign students who are now eager to repay their hospitality in countries all over the world.

Gilbert has also been in demand as an adviser to the government. During World War II he was principal production supervisor for the U.S. Air Force, and after the war served as a bombing analyst, U.S. Strategic Bombing Survey, Germany, and was a special consultant on Industrial Mobilization Planning for the Air Material Command. From 1949 to 1951 he was Industrial Economic Adviser on the staff of John McCloy, then U.S. High Commissioner for Germany. He is a longtime member of the Council on Foreign Relations in New York City and is currently chairman of the Los Angeles Committee on Foreign Relations.

When he retires, Gilbert says he plans to "work in the garden"—a standby occupation for retirees, but no offhand intention with him. He takes his agricultural activities seriously, and, if he can give his acre some time and attention between travel and consulting, he will no doubt bring off some successful development of his own.



An Astronomer in Czechoslovakia

By Robert F. Howard

A staff member of the Mount Wilson and Palomar Observatories reports on his six months at the Ondřejov Observatory near Prague—just before the political upheaval and invasion of that country.

Astronomy is one of the more international of the sciences, and this is particularly true of solar astronomy. It is a small field; we are all watching the same sun; and no one is in a good position to watch it all the time. As a consequence, international cooperation is quite common, and international meetings are almost never marred by political differences. Visits by American solar astronomers to the Soviet Union and Eastern Europe are fairly common. So, a trip to Czechoslovakia was not an unusual possibility for me to contemplate; in fact, it was a rather natural thing to do following a similar stay in 1964 at the Mount Wilson Observatory by a Czech solar astronomer with whom I had worked closely.

I spent an interesting and rewarding six months—from August 1967 to February 1968—at the Ondřejov Observatory near Prague, under the auspices of the Inter-Academy Exchange Agreement between the academies of sciences of the United States and Czechoslovakia. Fortunately my wife and three children were able to accompany me.

The Ondřejov Observatory, operated by the Astronomical Institute of the Czechoslovak Academy of Sciences, is located in the village of Ondřejov, 30

miles east of Prague. The observatory recently purchased an abandoned hotel in a region of summer homes a mile or two from Ondřejov, and here we took up residence for the first few weeks of our stay.

We enjoyed our summer place very much. It was isolated, but there were fascinating places in the neighborhood for the family to explore—the river, the fields of wheat and potatoes, the orchards, and the farm animals, which for our city-bred children were sources of awe and wonder. And nearby there was a beautiful, broad, four-lane concrete bridge, about 200 yards long, spanning a lovely green valley. But there was no road at either end of the bridge; it led from nowhere to nowhere. The story is that the bridge was built during the last years of the German occupation as a part of a proposed autobahn that was to connect Prague and Brno. It is a sad commentary on the state of the Czech economy over the last 25 years that the highway remains unbuilt. However, the bridge is a beautiful landmark in the rolling countryside around Ondřejov, and on Sunday afternoons the local people stroll up and down the bridge pushing their baby carriages.

LIFE IN PRAGUE

We had timed our stay in Czechoslovakia to begin shortly before the General Assembly of the International Astronomical Union held in Prague in August. Shortly after the end of the Assembly we moved from the country into an apartment in Prague so that we could send our children to the International School of Prague located at the American Embassy there. Housing in Prague is very tight, and the best the Academy could do for us was half of a large apartment; the other half was occupied by a Czech family. Despite language difficulties, we became good friends. There were six children altogether in the apartment, which rarely made for a dull day.

Living in Czechoslovakia involves some minor hardships to which a resident of southern California is not generally accustomed. Since all the shops are government operated, they tend to have the same hours, and these hours are short by our standards. Although there are stores near the center of Prague that might qualify as supermarkets, where we lived it was necessary to buy meat at a butcher shop, bread at a bakery, and milk at a dairy. And every place there were the inevitable queues—sometimes two queues; one to select the item and one to pay for it.

Marketing, therefore, was a daily chore that consumed a great deal of time. It was common practice for people to leave work to shop. In fact, it did not seem unusual for people to take off some hours or a whole day to handle their private affairs, which generally consisted of standing in long queues in government offices for one purpose or another. One of the services afforded us by the Czech Academy was to provide an assistant who spent a total of four or five days standing in queues for us in various government offices in connection with details such as visa extensions.

The International School of Prague was truly international in character. Nearly a hundred children of employees from many embassies attended, as well as the children of people such as ourselves and those who worked for international airlines or were newspaper correspondents. The principal, the textbooks, some of the teachers, and all of the methods were American. (Some of the teachers were Czechs.) In principle, the school was open to anyone, and the modest tuition could be paid in Czech currency. But there weren't any Czech children enrolled while we were there. Our children enjoyed it immensely and made great progress with their studies. Every day's play period with their school friends was a geography lesson. Among other things, they learned from their Egyptian friends that Egypt possesses the strongest army in the world.

ASTRONOMY AND ASTRONOMERS

The Czechs have put more resources into astronomy than any other Soviet satellite country has, and this has paid off in the sort of prestige that comes with a strong position in a pure science. For many years before World War II, Ondřejov Observatory, private and well equipped, provided a good and inexpensive nucleus for a modern observing station, and a young crop of astronomers in the early 1950's provided the initiative and drive necessary to secure the funds needed to carry on research. On the whole the observatory continues to be well funded in Czech currency. It recently purchased an 80-inch telescope from the East German Zeiss Company. But it is suffering more and more each year from the technological gap resulting from the fact that more sophisticated control and data-gathering, handling, and processing equipment is becoming available only to those who have dollars to pay for it—and dollars are in very short supply in Czechoslovakia.

Other troubles that hamper the work at the observatory seem to be a reflection, on a small scale, of the troubles that plague the Czech economy as a whole.

Despite the rather liberal spirit that appears to be widespread among the populace, the structure of their society is of a conservative revolutionary nature —much more so than in the Soviet Union. Salary scales are much compressed, so that the ratio of salaries between the lowest paid worker and the director of the institute or factory is surprisingly low —about two or three to one. Inefficiency and work that is slow almost to the point of sabotage are universal. For example, despite the fact that there were two employees to look after office supplies at the observatory—a function which does not even exist here except as a minor duty of a secretary—the supply of observatory stationery became exhausted in the middle of my stay there, and, because it required a long time to obtain stationery, we did without it for several months

One of the results of the compressed pay scales is that there is little incentive for a young person to go on and get a university degree. There is almost a total lack of people under the age of 40 in astronomy. There are only a handful of students, and there are the most active astronomers, who are in the age bracket 40 to 50; but in between there is a missing generation.

It is no picnic being an observatory director in Czechoslovakia. Much of the authority is delegated to the Labor Union, and the local (observatory) Communist Party seems to have some say in what goes on as well. This certainly makes an administrative nightmare out of running the observatory. The director is afraid to make any move which might offend the Party or the Union, and firing an employee is practically impossible except in the most extreme circumstances. In the lobby of the main office building there is kept a book in which each employee is expected to note each day the times of his arrival and departure. This regulation applies equally to the astronomers—a condition which the staffs of most academic or research institutions in this country would consider intolerable.

OF POVERTY AND EFFICIENCY

We were saddened by the dismal lives led by the vast majority of the Czech people. What we would consider poverty exists there on a scale unknown in this country. Prague is the only place where I have ever seen people scoop uneaten food from our plates as we rose to leave a restaurant. In some areas, however, the government has done a good job: garbage collection is efficient and clean, and rats have been practically eliminated; public transportation is convenient and inexpensive; and medical care is good and available to all. Doctors make frequent house calls to all, not just to foreign visitors. I suppose this is because very few people own cars. (The doctor arrives in a chauffer-driven car.)

OF POLITICS AND PROPERTY

In our small circle of Czech acquaintances who were not connected with the observatory, there were more than just a few who had spent some time in prison since 1948. Moreover, they seemed in no way to be ashamed of this fact. It is true that our circle of friends was probably not a random selection of Czech citizens; nevertheless, the large percentage who had been imprisoned surprised us. In all cases the offenses had been of a political nature. These people were full of stories of property that had been confiscated from them at the time of the Communist take-over, and they were full of disdain for the mess the Communists had made of the country after humiliating the capitalist and manager classes and declaring them to be a detriment to their society.

Occupation and domination by a foreign power is nothing new to the Czechs; they have suffered such treatment for centuries. In this age when young people all over the world are rebelling against the values of their elders, the youth of Czechoslovakia are taking a valiant nationalistic stand in favor of freedom of expression. Twenty years of propaganda in newspapers, banners, television, and textbooks seem to have had no positive effect whatsoever.

One incident sticks in my mind as having significance with regard to the attitude of the older generation. We were planning a trip by car to Slovakia, and an acquaintance was showing me a suggested route. For this purpose he used a prewar road map of the country, which was quite adequate since there had been no significant changes in the roads in 30 years. As we discussed the trip, one of our pro-Russian Czech friends entered the room. He picked up the map and was obviously admiring the fine quality of the paper and the convenient manner in which the folds had been arranged, despite the fact that it was a Czech product in the Czech language. My companion said to him in Czech, "It is prewar," which is a euphemism for pre-Communist. My leftist friend handed back the map with a look on his face that said, "Of course. How stupid of me. And in front of a Westerner, too."

Books

OPPENHEIMER

By Robert Serber, Victor F. Weisskopf, Abraham Pais, and Glenn T. Seaborg. Introduction by I. I. Rabi

Scribner's $5.95

reviewed by Robert F. Christy, professor of theoretical physics and executive officer for physics.

This thin volume consists of speeches delivered at the Oppenheimer memorial session of the American Physical Society held in April 1967 and published in *Physics Today,* October 1967. To this has been added an introduction by I. I. Rabi, who was unable to speak at the original APS session; a number of photographs, many contributed by Mrs. J. Robert Oppenheimer; and a selected bibliography, chronology, and biographical and reference notes.

The introduction by Rabi and the collection of photographs are very welcome additions to the original, and indeed tend to complete the picture of Oppenheimer. The photographs provide an excellent character study of Oppenheimer and also provide a collection of familiar faces, many now famous, which is replete with nostalgia for one who has grown up in the field of theoretical and nuclear physics. The introduction gives a brief account of Oppenheimer's early years, and attempts an overall appraisal of his place and contribution in physics. This is an interesting speculation on the correlation or lack of it between originality and creativity on the one hand and intellectual stature on the other.

Robert Serber's contribution covers Oppenheimer's prewar professional life. Serber is eminently qualified because of his own lengthy association with Oppenheimer, and he provides an excellent account of Oppenheimer's contributions to several basic areas of physics—the proton and antiproton, field theory and cosmic rays, and nuclear physics. This account even served to remind the reviewer of a forgotten paper contributed jointly with Oppenheimer at a Physical Society meeting in 1941. It also serves to remind us of the strange twists actually taken by science in the course of its development: Developments do not follow a simple, logical course. Serber also gives an account of Oppenheimer's teaching and his relationship with the growing band of students and "postdocs" in prewar Berkeley, whom he taught, led, and inspired.

Victor Weisskopf's contribution on the Los Alamos years is less specialized, dealing in broad terms with the general character of work at Los Alamos. He gives a good impression of the basic science, but even more, a feeling for Oppenheimer's remarkable ability to handle the group and lead their efforts to the atomic bomb.

Abraham Pais' "The Princeton Period" starts with a brief account of the theoretical physics conferences in 1947-49 which saw the birth of the new quantum electrodynamics — a most remarkable period in physics. Pais weaves Oppenheimer's interest into the general fabric of postwar physics but also discusses Oppenheimer's deep interest in the relation of science to our general culture.

Glenn Seaborg emphasizes Oppenheimer's public service and human contributions. He had known Oppenheimer in prewar Berkeley but concentrates on Oppenheimer's role as first chairman of the General Advisory Committee of the Atomic Energy Commission. During this period much of the course of our national policy in atomic energy was charted under his guidance. His leading role in formulating the Acheson-Lilienthal Report, aimed at international control of atomic energy for peaceful purposes, exemplifies his far-seeing humanitarian outlook. This approach, in the H-bomb debate, led him to recommend against a crash development program which would have stepped up the arms race. It led to his famous security hearing.

It is appropriate now to reflect on this period, for we are now in the middle of another major debate—on the ABM question. Perhaps this time we can turn aside from the road to escalated destruction and follow the path that Oppenheimer tried to lead us in—and failed. Seaborg closes by quoting a number of memorable passages from Oppenheimer's writings, which serve to remind us more than anything else of the "singular combination of talents of this extraordinary man."

THE GOLDEN GUIDE TO SCUBA DIVING

by Wheeler J. North

Golden Press, Paperback $1.00

As professor of environmental health engineering at Caltech, marine biologist Wheeler North's primary professional interest has been the ecology of the submarine kelp forests of California. To this end he has made several thousand undersea dives in two oceans and four seas, and in a normal year he spends about 500 hours under water. For more than ten years he has trained scientists and laymen in diving. His 160-page handbook covers the basic techniques and knowledge needed for exploring the underwater world—including information on training, safety, and equipment and on the observation, collection, and photographing of marine creatures. The book is generously illustrated with diagrams and photographs.

portant to it. And I think that if those things are different, both sides can feel that they have equality or better in what is important to them. One way to put it is that both sides can have second-strike superiority.

MR. BEECHER: What you are describing is a situation of mutual deterrence. Would you say that the two nations have already built enough strategic weapons for this mutual deterrence?

SECRETARY BROWN: I am not describing simply a mutual deterrence situation, I am describing a situation of stability. The question is, deterrence against what? I think that it may not be too hard to get mutual deterrence against unprovoked attack; attack where there is not a great deal of tension. Where there is tension, it is not clear to me that the same balance produces the same degree of deterrence. If one imagines a situation where each side considered its vital interests to be involved, and in which they somehow had gotten engaged, let's say in Europe as one example, then one side or the other may be impelled into dangerous acts despite the fact that each side correctly calculates that an all-out thermonuclear war is going to lead to its destruction, as well as the destruction of the other side.

MR. BEECHER: But in terms of the sizes of the two strategic forces, do you feel that at the present time the two nations have at least a kind of equilibrium in terms of mutual deterrence?

SECRETARY BROWN: I think that the present situation is relatively stable in terms of the weapon systems that exist, or are immediately programmed, and I think that may offer a real chance for arms limitations agreements that will maintain that stability.

Leroy, New York

HAROLD BROWN, PRESIDENT
CALIF. INST. OF TECHNOLOGY

Caltech's fund-raising campaign in 1968 found me delighted that Dr. DuBridge was stressing the role that Caltech could play in the "Science for Mankind." Certainly his poetic and rational appeal that ended "the first time man has gained the scientific knowledge to shape his destiny and shape it well" seemed to have the ring of a great humanist as well as that of a great scientist. *It appeared that Dr. DuBridge and I had arrived independently at the same conclusion*; the conclusion being that Caltech had spent, in recent years, an inordinate amount of its energies, resources, and prestige in joining with the military in planning a science for mankind's destruction rather than a science for mankind's physical and genetic salvation. A wish-fulfilling fantasy on my part, perhaps, but that was my interpretation of his appeal.

Now Dr. DuBridge has used his and Caltech's very considerable prestige to influence President Nixon in the President's decision to disperse the Anti-Ballistic Missiles—a decision, certainly, that will not hurt Caltech in the years immediately ahead but will jeopardize man's chances of civilized survival forever. Believe me, I recognize that Caltech is no longer Dr. DuBridge but I have listened and searched in vain for some sign indicating that the trustees, the administration and the faculty are not in agreement with him on this crucial matter.

My reaction to Dr. DuBridge's reversal of emphasis is one of ambivalence—a feeling of being deceived and a feeling of being reassured. Deceived because I felt my efforts and money would be used to help change Caltech's direction. Reassured in my long-held, reluctant and unhappy conclusion that institutions as well as individuals sell themselves on the open market to the highest bidder. Both feelings force me into withdrawing my remaining pledge to Caltech and its "Science for Mankind" and using the monies so withdrawn to help organizations with less conflict of interest and a more genuine concern for mankind.

ROBERT G. FUSSELL '35

A Reply From President Brown

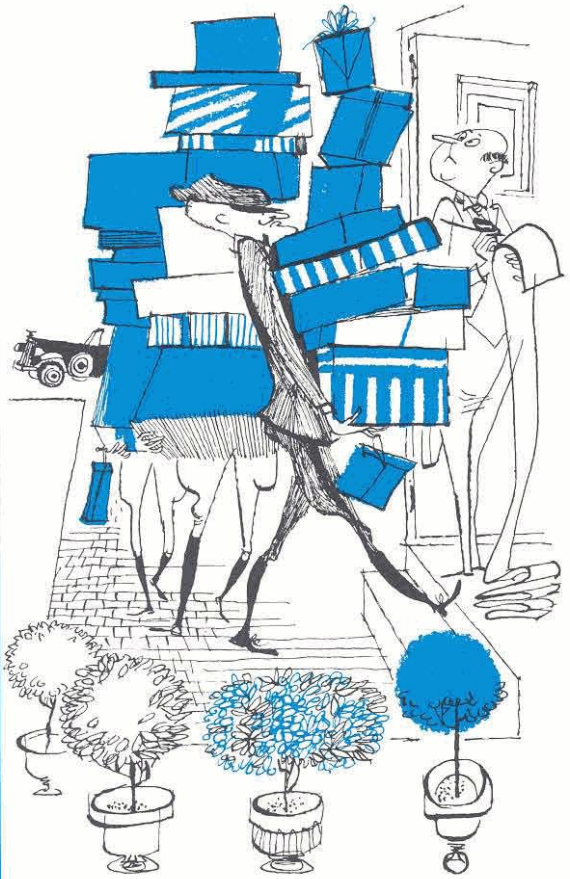
Along with many other people at the Institute, of varying views on national security matters, I share your belief in the importance to the future of mankind of finding ways to avoid the dangers presented by the existing large stocks of nuclear armament. In all such matters, individuals at Caltech are free to speak their personal views. In the particular case of the antiballistic missile, some of our students, trustees, faculty, and administration are undoubtedly for it, and some are against it. Currently, a petition to the President of the United States expressing opposition to the ABM is being circulated at Caltech, so the fact that you may not have heard any public expressions in opposition to the ABM does not mean that they have not been made; statements in favor of the ABM may also be made.

No such expressions, either pro or con, are expressions of an institutional policy or position on the part of the California Institute of Technology—which, *as an institution,* takes no stand on such issues. And, of course, Dr. DuBridge was speaking as a member of the national Administration, supporting the Administration's position, not as president or as ex-president of Caltech.

With respect to military research, you are probably aware that Caltech faculty or students do no classified research on campus. The work at the Jet Propulsion Laboratory, though some small parts of it may be classified, is almost entirely concerned with the unmanned exploration of the moon and the planets for the National Aeronautics and Space Administration. This lack of involvement with military research and development is in contrast with the situation at some other institutions; I say this not in criticism of them but merely to point out that in singling out Caltech you may not be looking at the best example for your objections.

Caltech has a long tradition of al-

lowing individuals associated with it to speak on public issues on which they may have some expertise, or even an unexpert opinion, provided that they speak as individuals. The Institute has maintained that position at times when some of the views so expressed by people associated with it were regarded as very unpopular, and it came under extreme pressure from a point of view quite different from the one which you present. We believe that our attitude is correct now, as we believe it was correct then. I continue to believe that important national issues, as well as the question of participation of the Institute, and their impact on the Institute should continue to be freely discussed. In that spirit I am submitting your letter and this response to it for publication in *Engineering and Science.*



Will of John B. Kelly, successful contractor and father of Grace Kelly in providing for his daughters stated that what he was about to give them "will help pay the dress shop bills which if they continue as they have started under the tutelage of their mother, will be quite considerable."

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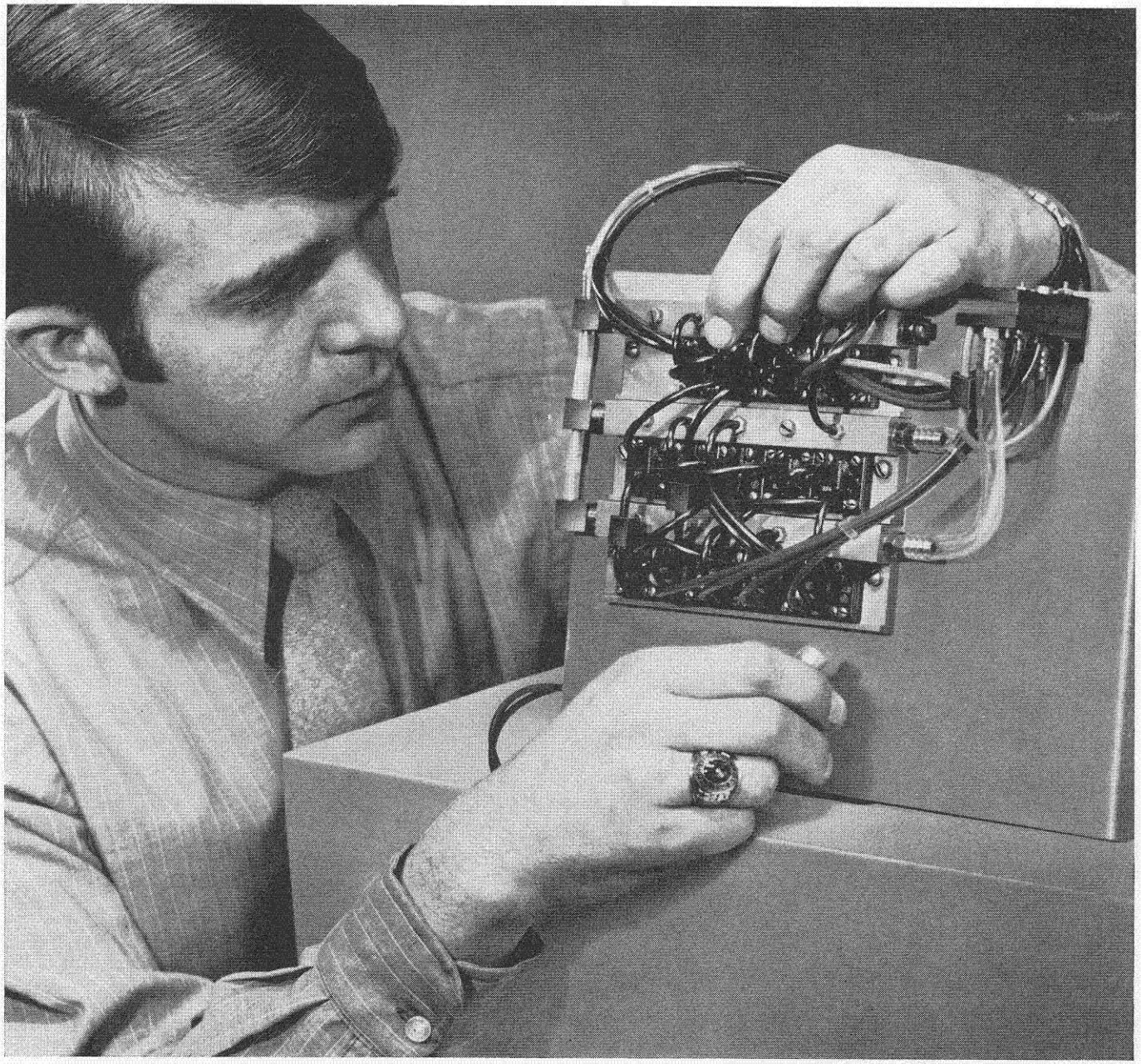

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