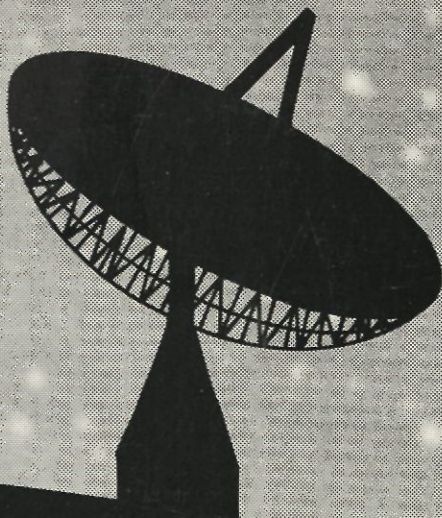


The
COLORADO
Engineer



NOVEMBER, 1966

Go Westinghouse, Young Man!

A modern fable with technical overtones

Once there was a young college senior named Jack who wanted desperately to climb the beanstalk of success, facing the kind of challenges his forefathers faced on the frontiers of early America.

But Jack wasn't sure which kind of beanstalk he wanted to climb.

His mother wanted him to take a job at the local store so he'd be close to home.

His friends urged him to join a protest movement.

His professors wanted him to go on to graduate school.

Then Jack met a Mr. Greeley from Westinghouse. Mr. Greeley was a recruiter of college students. He was a kindly man with a warm smile, and he explained how Jack could get an advanced tuition-free degree while working at Westinghouse.

Mr. Greeley also explained that Westinghouse, being a giant organization, was in a much better position than most to undertake projects that would benefit the less fortunate peoples of the world.

Mr. Greeley's advice was:

"Go Westinghouse, young man!"

And Jack did.

Given a choice of six large operating groups* within Westinghouse, Jack elected to join the Atomic, Defense and Space Group and was promptly assigned to work on an oceanographic project.

A fast learner, Jack took root quickly, reassuring his graying but still pleasant-faced mother, "Don't worry, Mom, I'm on my way to the top."

Though officially a trainee, Jack was a big help in the development of *Deepstar*—a Jules Verne-like undersea vehicle designed to explore the ocean depths. One of *Deepstar's* many missions was to search for food sources to meet the growing needs of a hungry world.

The project was an enormous success; Jack's management was delighted.

But before a grateful UNESCO could honor him publicly, Jack obtained a transfer to one of the many space projects Westinghouse coordinates.



Jack's assignment: help develop a rendezvous system for Gemini capsules.

To the news publications of the nation, this was the story of the year. In fact, one of the big syndicates assigned their most beautiful, technically oriented woman reporter to get an exclusive story from Jack . . . at any cost.

One night while returning from work . . . Jack was accosted by the beautiful young newswoman, who suggested that Jack give her an exclusive bylined story describing the project in detail.

Though taken aback by her beauty, Jack never lost sight of his duty. He pleaded with the reporter to hold her story until after the launching. She agreed on the condition that Jack would provide her with enough information for a subsequent story that would win her a Pulitzer Prize for news reporting.

The pressure on Jack and his closely knit engineering team tightened. By day, they'd work on the space guidance system; by night, Jack would feed background information to the beautiful, technically oriented reporter. It was hard work, but it was important work.

Finally the day arrived for which the world had long waited. America's two capsules rendezvoused successfully. Man-kind was now assured of a stairway to the stars.

While television-viewing millions rejoiced, Jack was as good as his word, offering the beautiful lady reporter the story she wanted so badly.

However, the girl, now smitten with Jack, turned her back on the Pulitzer Prize, preferring instead to join Westinghouse, attend its Advanced Education School and obtain a degree in engineering. (Women are welcome at Westinghouse, an equal opportunity employer.)

Now they both work at Westinghouse

—while Jack designs atomic reactors for America's newest missile-firing submarines, his beautiful ex-reporter wife, an education specialist, helps train Peace Corps volunteers for overseas duty—and they're only a bean's throw from the neat white cottage they share with his mother.

And they all lived happily ever after.

Moral: By planting your career seeds with Westinghouse, you, too, can climb the beanstalk of success, overcoming giant obstacles and earning a lot of golden rewards.



You can be sure if it's Westinghouse



For further information, contact the Mr. Greeley from Westinghouse who will be visiting your campus during the next few weeks or write: L. H. Noggle, Westinghouse Educational Center, Pittsburgh, Pennsylvania 15221.

*The Westinghouse Operating Groups: Consumer Products; Industrial; Construction; Electronic Components & Specialty Products; Atomic, Defense & Space; Electric Utility.

UNIVERSITY



OF COLORADO

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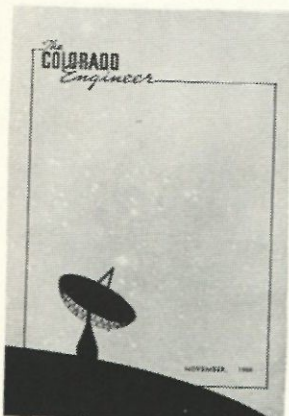
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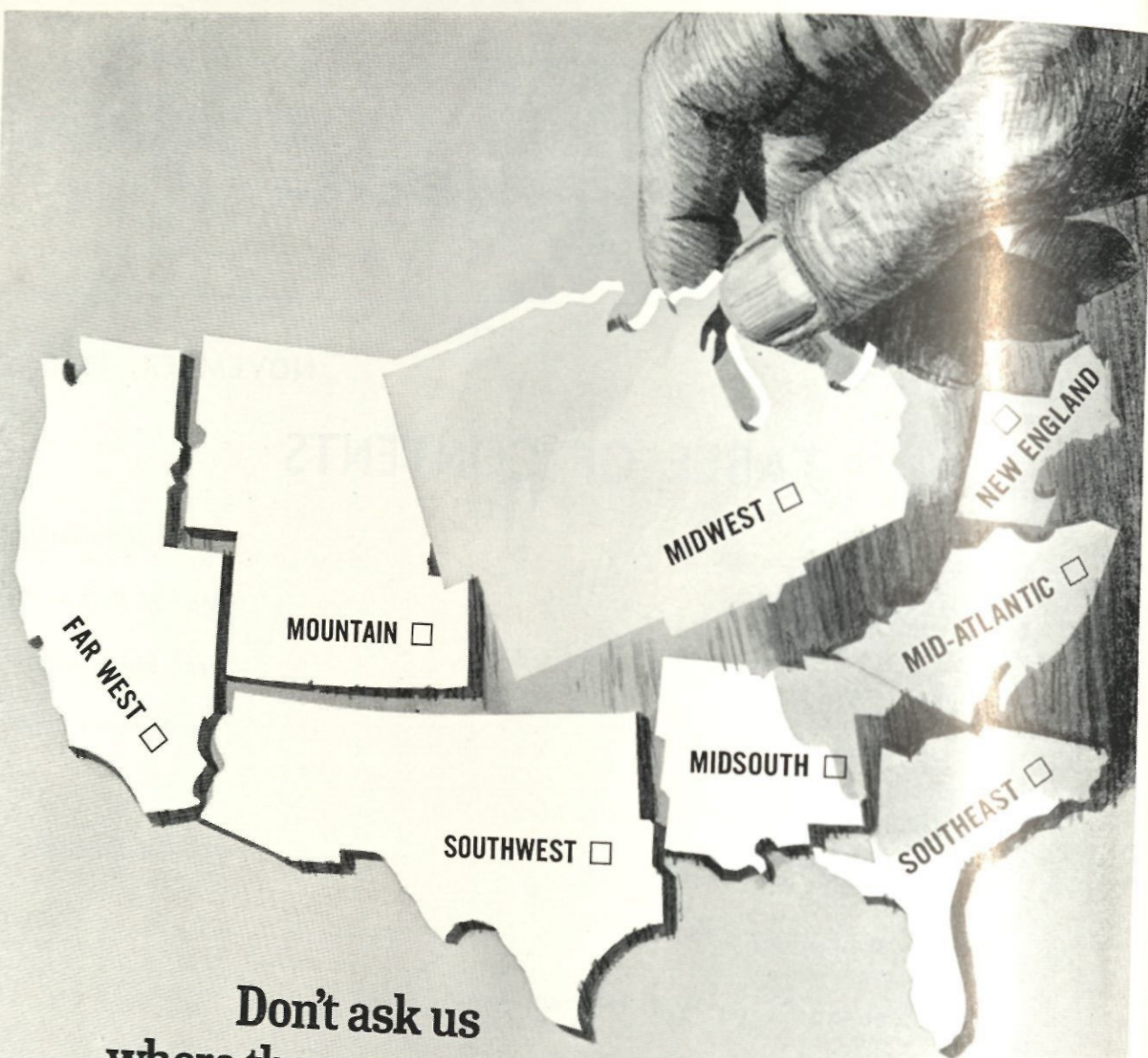
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This month's cover by Art Editor Steve Franek depicts the efforts of man to communicate with life outside our Earth. See "Hello, If You're Out There" by David Messerschmidt on page 15.

The Colorado Engineer is published by the students of the University of Colorado College of Engineering and does not necessarily reflect the opinions of the faculty and administration.



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This year Monsanto will have well over 1,000 professional openings for engineers, scientists and college graduates of all degree levels. That means the chances are excellent you can get a job you'll like in a location you want. As the map above shows, Monsanto Company has many good jobs available all over the country.

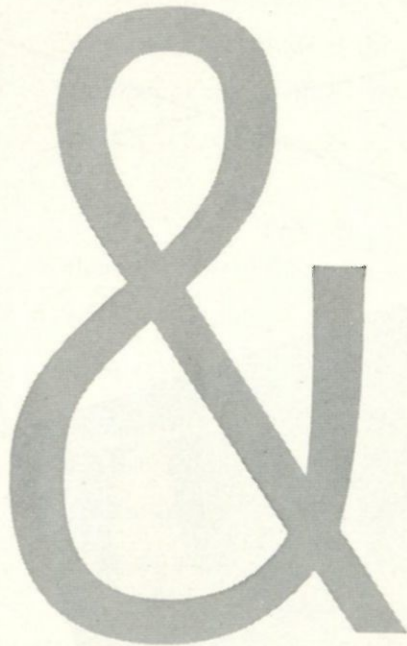
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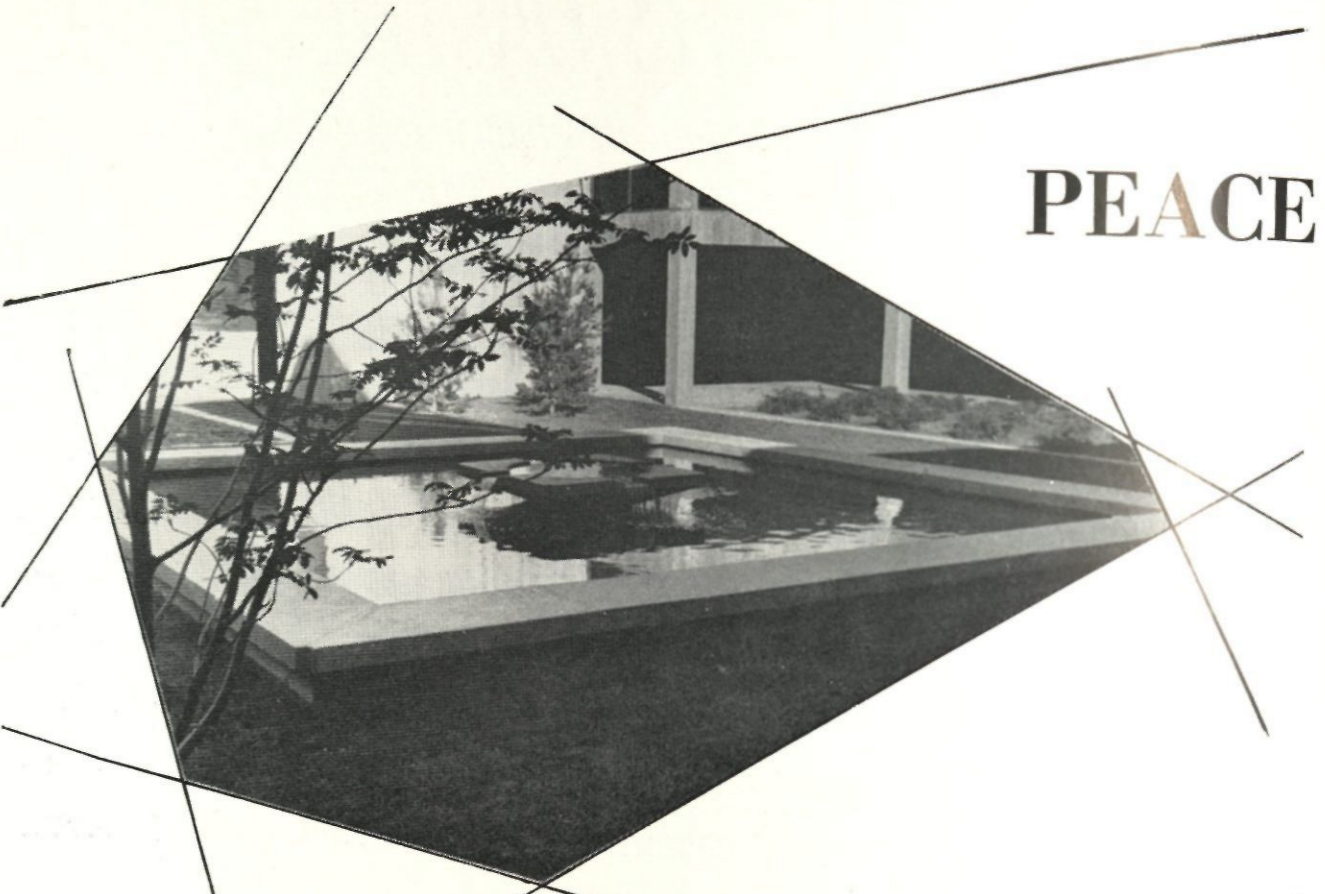
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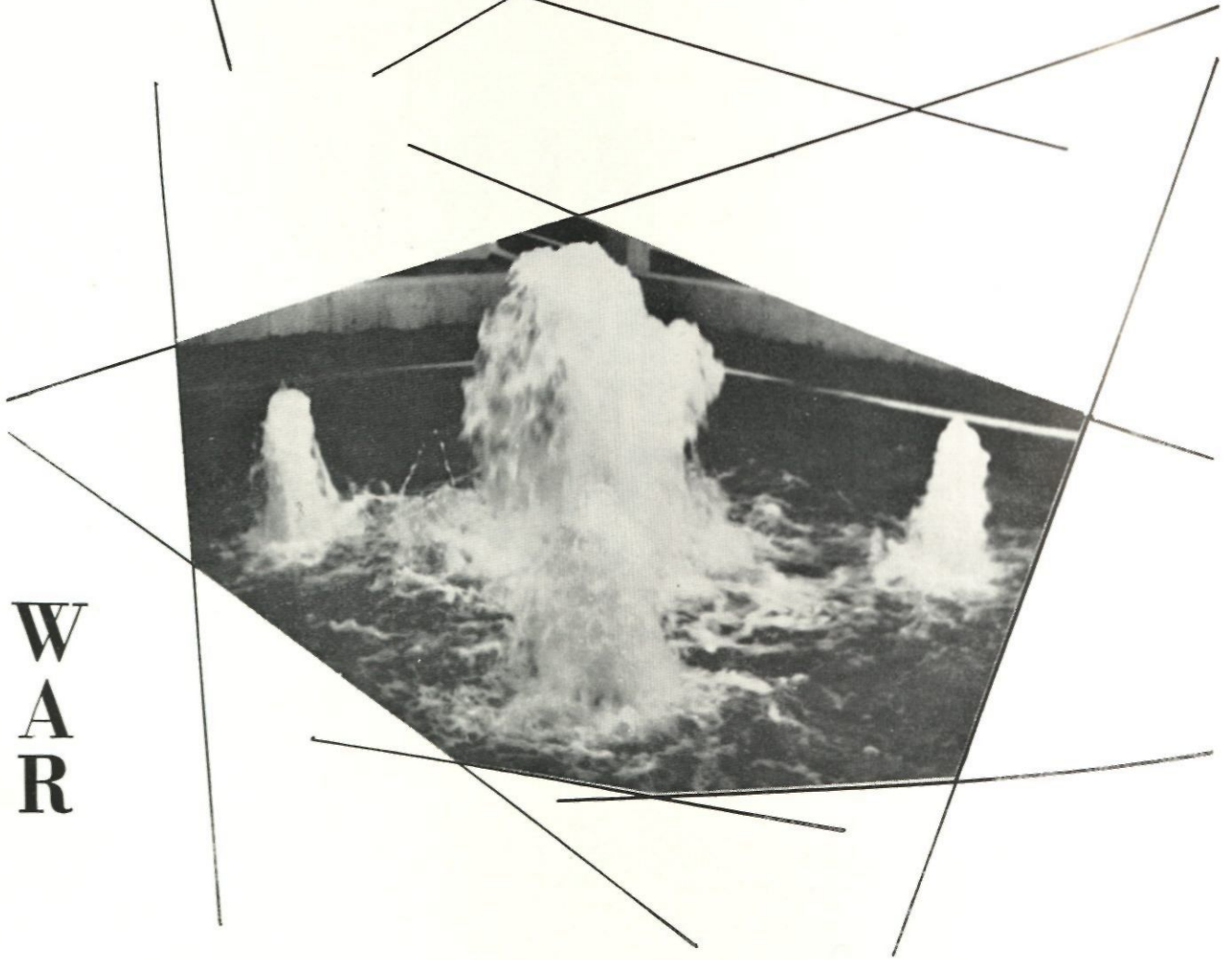
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THE GRADE

Students don't like it. Professors don't either. But they still have to live with it because neither can suggest a better method. Of what? It's called "grading"—what does it do?

Supposedly, grades measure your progress, show how much you have learned in relation to what your professor feels he taught you, rank you with your fellow students, inspire you to work hard, et cetera. But what do they really do? Are they beneficial or detrimental to the educational process?

It is debatable that they give a true, even a close indication of what you have learned. They rank you with your peers on performance on exams, which, in too many cases, reflect a professor who is not as good as he thinks he is when it comes to teaching. If the grades inspire or reward depends solely on the attitude of the student. But what do they prove? Is the honorary member more qualified than the average student to follow his chosen profession? Recent studies at Columbia have shown this not to be the case.

Why is it, then, that there is so much emphasis placed on grades rather than learning? The system is a hold-over from the time when the student was known individually to his professor and the grades he received were, in fact, a very accurate picture of his ability. Now, however, it is rare that this sort of relationship exists in a classroom situation and the grade is not this true reflection. Granted, some comparative system is needed and grades are the best thing going now. But with some effort to standardize the basic of the grading system, it will be improved.

—Kathy O'Donoghue

Photographs at left by David Lester.

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scientific and technological explorations of this century. The very existence of millions of people depends upon our meeting this challenge, for the clean, fresh water that is essential to all terrestrial life is in danger of depletion.

SPEARHEADING THE CRUSADE

The new Federal Water Pollution Control Administration has one of the most unique and all-encompassing missions ever granted a government organization. It is

to attack water pollution nationally, regionally, and locally *at the same time*, doing whatever must be done in six basic ways:

- 1/ **AID TO COMMUNITIES**—programs offering sanitary, civil, and industrial engineers the opportunity to plan, initiate, and review grants for waste treatment plants so urgently needed throughout the land.
- 2/ **ENFORCEMENT**—because water pollution ignores political boundaries, experts in the field—bacteriologists, biologists, chemists, hydrologists, sanitary engineers, limnologists, toxicologists, and lawyers, too—are needed to identify pollutants, locate their source, and work with official and volunteer groups to promote adherence to standards.
- 3/ **RESEARCH**—in thirteen new laboratories that will ultimately operate in critical areas, each dedicated to specific research tasks or water problems. This gives sanitary engineers, chemists, biologists, bacteriologists, hydrologists, geologists, oceanographers, limnologists, soil scientists, epidemiologists, and toxicologists the chance to attack the problem in their own area, in their particular specialty.
- 4/ **WATER BASIN IMPROVEMENT**—comprehensive programs for each of the 9 major river basins, bringing the administrator, the planner, the economist, and the computer expert into the new science of water management . . . into the building of mathematical models and the use of data collection and retrieval techniques.
- 5/ **ESTABLISHING WATER QUALITY STANDARDS**—vital action to let municipalities, industries, and other water users understand their responsibilities. Scientific and water resource management teams well-versed in the intricacies of water pollution control and abatement will be needed for FWPCA offices in almost every State.
- 6/ **TECHNICAL ASSISTANCE**—ultimately to be increased many times over in order to cope with new and unexpected problems ranging from fish kills to contaminated municipal water supplies. Great versatility on the part of engineers and scientists will be needed to find adequate, immediate solutions.

DRAMATIC GROWTH ALMOST INEVITABLE

Over 700 career positions—many of them in engineering—are to be filled this first year. This is just the beginning. What has taken decades to pollute will take decades to reclaim. During this period, there will be dramatic growth within the Administration itself, plus scientific, technological and managerial "spin-off" de-

velopments of individual significance . . . i.e., processing and packaging of fish and aquatic vegetation for mass feeding, new insight into public health and immunology, commercial use of recovered wastes, conservation and economical re-use of existing water, and so many more beyond today's state of knowledge.

INTERVIEWS ON CAMPUS

The FWPCA representative interviewing you will probably be a person with program responsibility, a technical man able to answer detailed questions about career opportunities in all areas. He will be offering positions starting at the GS-5 level (\$5,331 or \$6,387) and the GS-7 level (\$6,451 or \$7,729) with higher levels open to those with advanced degrees. All posi-

tions provide Career Civil Service benefits; and all applicants are considered on an equal opportunity basis without regard to race, creed, sex, or national origin. Contact your College Placement Office for an appointment or write to Administration headquarters for details.

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

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DECREASING ENROLLMENT

Our 1966-67 school year is off to a good start, and I am particularly well-impressed with the initiative taken by the Associated Engineering Students under Fred Stoppelkamp's leadership. Our faculty members seem to like our new building even more as we get settled into it. This month it was gratifying to have the over-all architecture of our building recognized nationally. We received one of the seven first-place awards out of 258 nominees for the most outstanding new educational building constructed in the United States with the assistance of Government support. The judging was done by the U. S. Office of Education and the American Institute of Architects.

Again this year we have had outstanding success in attracting highly-qualified new members to our engineering faculty. Your editor, Kathy O'Donoghue, is including a feature on the new and visiting faculty elsewhere in this issue.

George J. Maler is now Associate Dean of our College and will be particularly concerned with student development, industrial relations, and high school contacts. Our other Associate Dean, Dr. Klaus D. Timmerhaus, will continue to coordinate our undergraduate and graduate teaching and research programs. Former Dean and Professor Emeritus, Charles A. Hutchinson, remains with us as Director of our Engineering Alumni relations and part-time teacher in Mathematics.

This Fall, in our Boulder campus undergraduate enrollment in engineering increased from 1560 to approximately 1600 students, with a 25% increase on our junior and senior levels. However, as appears to be the general case across the United States, the number of new entering freshmen in engineering decreased significantly.

Discussion with other Engineering Deans throughout the United States indicates that the average drop in new engineering freshmen throughout the country is about 6%; we now have approximately 380 freshmen in the College compared to about 450 last year. The national decrease in students entering engineering as freshmen could be very serious considering the tremendous pressure industry is now putting on us to supply them with B.S. engineers. I repeatedly receive calls from men in industry asking if we could at least recommend someone for them to talk to about the possibility of a position. Also, the people in industry are becoming quite concerned about the extremely high salaries they must offer our graduates because of the shortage.

One answer to the national decrease in freshmen entering engineering is that more students are going into junior colleges and then transferring to universities. This suggestion is supported by the great increase we saw this year in our number of juniors and seniors, but I do not feel this is the real answer. Another possibility is that students are entering military service to get this out of the way before they start going to college. Again this answer is not satisfactory because the percentage drop nationally in engineering was far higher than the percentage drop in freshmen in general entering our universities. Another possibility, which I refuse to accept, is that our modern youth is not willing to tackle the rigorous program involved in receiving an engineering degree.

I believe that the real answer to the drop in entering freshmen in engineering lies partially in more students going to junior colleges and partially in the fact that the liberal arts areas dealing with social aspects,



DEAN MAX S. PETERS

such as Peace Corps Service, now are the glamour areas as far as high school students are concerned. Science, including mathematics, physics, chemistry, and engineering, does not seem to have the appeal that existed several years ago. This, of course, can be extremely serious to the future of our country, and I sincerely hope that our students, as well as those of us in teaching and industry, will recognize the grave consequences that can result if the attitudes and trends discussed continue.

If you agree with me that this is a serious problem, I would hope you would take every opportunity to talk to people from your local high school and perhaps even to attempt to have your high school invite you to give talks to organized groups. This might be a worthwhile project for AES to pursue. Deans Maler, Timmerhaus, and I would certainly be pleased to receive any suggestions or ideas you may have on this matter.

Those of you who are now in engineering are in a most fortunate situation because of the increasing demands for our graduates. I hope you will look to the future of our country and recognize that we need to convince the public about the excitement and importance of engineering as a career.

Max S. Peters
Dean

HOWARD HUGHES DOCTORAL FELLOWSHIPS. Applications for the Howard Hughes Doctoral Fellowships in engineering, physics, or mathematics are now available for the academic year beginning in Autumn 1967.

The program offers the qualified candidate an outstanding opportunity for study and research at a selected university, plus professional industrial summer experience at a Hughes facility. Each Doctoral Fellowship includes tuition, books and thesis preparation expenses, plus stipend ranging from \$2,200 to \$3,100, depending upon the Program year and the number of candidate's dependents. Full salary is paid the Fellow during his summer work at Hughes. Salaries are reviewed periodically and increased with the growth of the individual. Fellowships are awarded to outstanding students who have completed a master's degree (or equivalent) and have been accepted as a candidate for the doctoral degree.

HUGHES MASTERS FELLOWSHIPS. Approximately 100 new awards for '67-'68 are available to qualified applicants with a baccalaureate degree in engineering, mathematics or physics. Most of these awards are Work-Study Fellowships; a very limited number are Full-Study. Upon completion of the Masters Program, Fellows are eligible to apply for and are given special consideration for a Hughes Doctoral Fellowship.

Fellows who associate with a Company facility in the Los Angeles area usually attend the University of Southern California or the University of California, Los Angeles. Tuition, books and other academic expenses are paid by the Company, plus a stipend ranging from \$500 to \$850 for the academic year. A significant advantage offered by the Work-Study Program is the opportunity to acquire professional experience working with highly competent engineers and scientists while pursuing the M.S. degree. Selected Fellows have the option to work in several different assignments during the Fellowship period to help them decide

on their field of concentration and optimum work assignment.

Fellows earn full salary during the summer and pro-rata salary for 24 hours work a week during the academic year. The combined salary and stipend enables Fellow to enjoy an income in excess of \$6,500 per year during his two years as a Work-Study Fellow. Salaries are increased commensurate with professional growth and Fellows are eligible for regular Company benefits.

Work assignments are matched closely to the Fellow's interests. Primary emphasis at Hughes is research and development in the field of electronics for application to defense systems and space technology. Fields of interest include stability and trajectory analysis, energy conversion, structural design and analysis — computer and reliability technology, circuit and information theory, plasma electronics, microminiaturization and human factor analysis — research, development and product design on such devices as parametric amplifiers, masers and lasers, microwave tubes, antenna arrays, electron-tube and solid-state displays, and components — design analysis, integration and testing of space and airborne missile and vehicle systems, infrared search and tracking systems, and computer, data processing and display systems — theoretical and experimental work in solid-state and ion physics.

Citizenship: American citizenship and eligibility for security clearance are required.

Closing date for all applications: Early application is advisable. All materials should be postmarked not later than February 1 for the Doctoral Fellowships, and March 1 for the Masters Fellowships.

How to apply: To apply for either the Doctoral or Masters Fellowship, write to: Mr. James C. Cox, Manager, Personnel Administration — Corporate Industrial Relations, Hughes Aircraft Company, P.O. Box 90515, Los Angeles, California 90009.

Hughes Fellowship Programs

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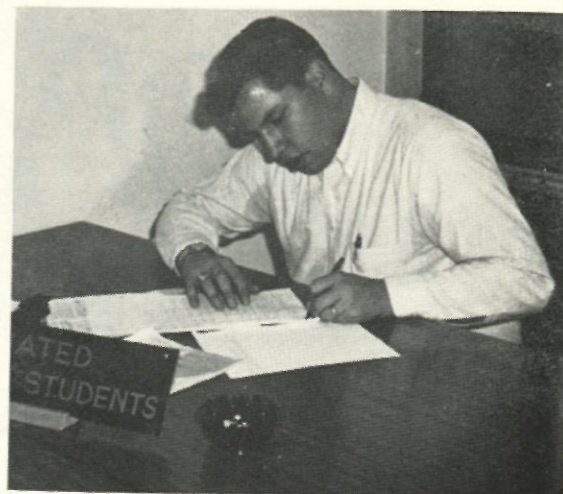
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AES 1966



FRED STOPPELKAMP
AES President

This year the College of Engineering is experiencing a new found togetherness. Having all departments located in one building and a vigorous faculty interest in students' problems has caused the inklings of a strong school spirit to be noted. As the hum-drum of registration dwindles and the pulse of initial organization begins to ebb, a new awakening of maturity, professionalism and honesty is fast beaming over the horizon.

Those who point their finger at the new Engineering Center and mutter "Ah, it's 'Nebraska Gothic,'" quickly become aware of their error once they tour our vast facilities, and discover that a true engineer is more directly interested in whether a product is functional than in its aesthetic value to art. The Engineering Center, though only constructed of cold steel and cement, has warmed up the attitudes and interest of almost all who own the gift of its use. Gone are the distractions of noise, sunlight glaring through a wind worn window, unbearable heat in summer and cold in winter, hasty walks between classes, "bangin-der-elbow" type class rooms and offices, and musty-crowded rest rooms.

Yes, though grey on the outside, inside the "Center" displays a cheery, air-conditioned, convenient motif of professional intellectualism. Graduate students now have office space and well stocked laboratories in which to research the future of the civilized

world. Student organizations are finding a more active interest in their societies from fellow students and faculty members. This added zeal for fellowship and sociability, although not entirely, has greatly been the effect of the Engineering Center, thus the new image of engineering students at the University of Colorado is fast becoming a reality. ALL of this has come about because of our "new home"—the Engineering Center.

It is the aim of the Associated Engineering Students (the student body of the College of Engineering) to compliment the new Center by fostering a new image of engineering students. To kick off this idea a combined Sorority-Engineer dance took place October 15th. Next came Homecoming which provided an opportunity for a display of our support of the C.U. Buffs. This display (float without wheels) was completely organized and built by a great bunch of freshmen engineers. Further social activities are being planned for the coming year with the intent of providing a chance for fellowship between engineers of all departments. After all, once we graduate and become working engineers it will be our plight to function as a team with engineers of other fields in order to perfect a design or a new concept.

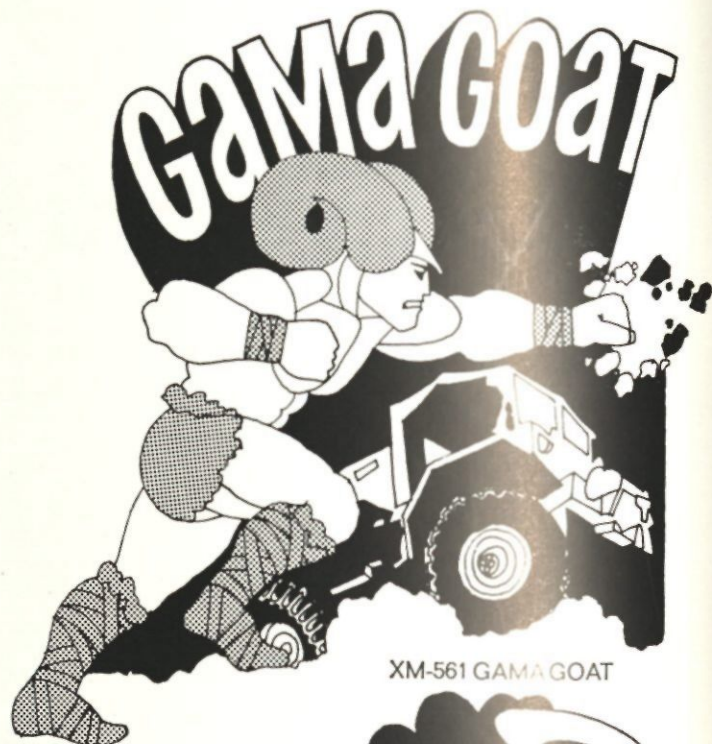
Tutoring services are being conceived and organized; tours of industrial installations throughout the Denver-Boulder area have already been

held and more are planned; films covering myriad topics have and will continue to be shown; student-faculty relationships throughout the campus are being researched; tours of the Center and open houses are being planned—all of these things are the result of much hard work on the part of the eight student branches of professional engineering societies and the six scholastic honor fraternities which embody the Control Board of the Associated Engineering Students. Without the terrific cooperation and immense assistance of the administration and faculty of the College of Engineering much of the above work would "... gang aft aglie." It is heart-warming to have such a great active faculty supporting the students, and providing incentive for us to push on for a more fruitful and well rounded education through hard work by all concerned.

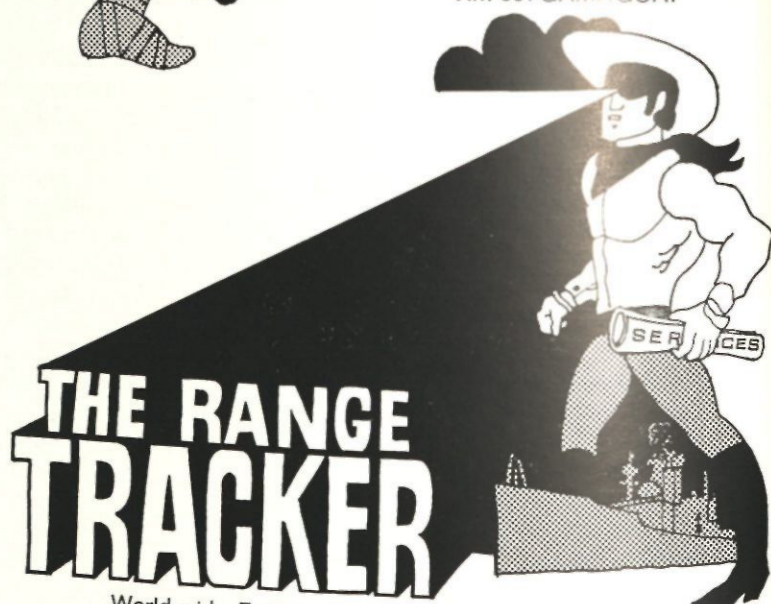
Our new Engineering Center, though not a Da Vinci, is our home and is an indication of the importance of engineering in today's society. It provides a pleasant environment for higher learning and is encouraging a new spirit to develop which will cause the University of Colorado's College of Engineering to rank even higher nationally than it now does. So, let's continue our endeavor to match the functionality of our new building with an ever growing spirit of pride because—WE'RE ENGINEERS.

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or "How to practice your one-upmanship on industry". We do it all the time at LTV Aerospace Corporation—dreaming up big shiny things like a plane's plane or a missile's muscle. In fact, our Hero engineers have come up with some of the nation's superest Super Stars. The word is out that there are some great star gazer spots open now (some earthy ones, too). So whether you're a circles, waves or angles engineer, you, too, can be a Hero in such areas as aerodynamics ☐ avionics and instrumentation ☐ airframes design ☐ systems analysis ☐ reliability ☐ dynamics ☐ systems design ☐ propulsion ☐ stress analysis ☐ industrial engineering ☐ technical administration . . . and others. Get the whole story. Ask your Placement Office, then write College Relations Office, LTV Aerospace Corporation, P.O. Box 5907, Dallas, Texas 75222. And when you write, be sure to ask, "how's your LTV bird". LTV is an equal opportunity employer.



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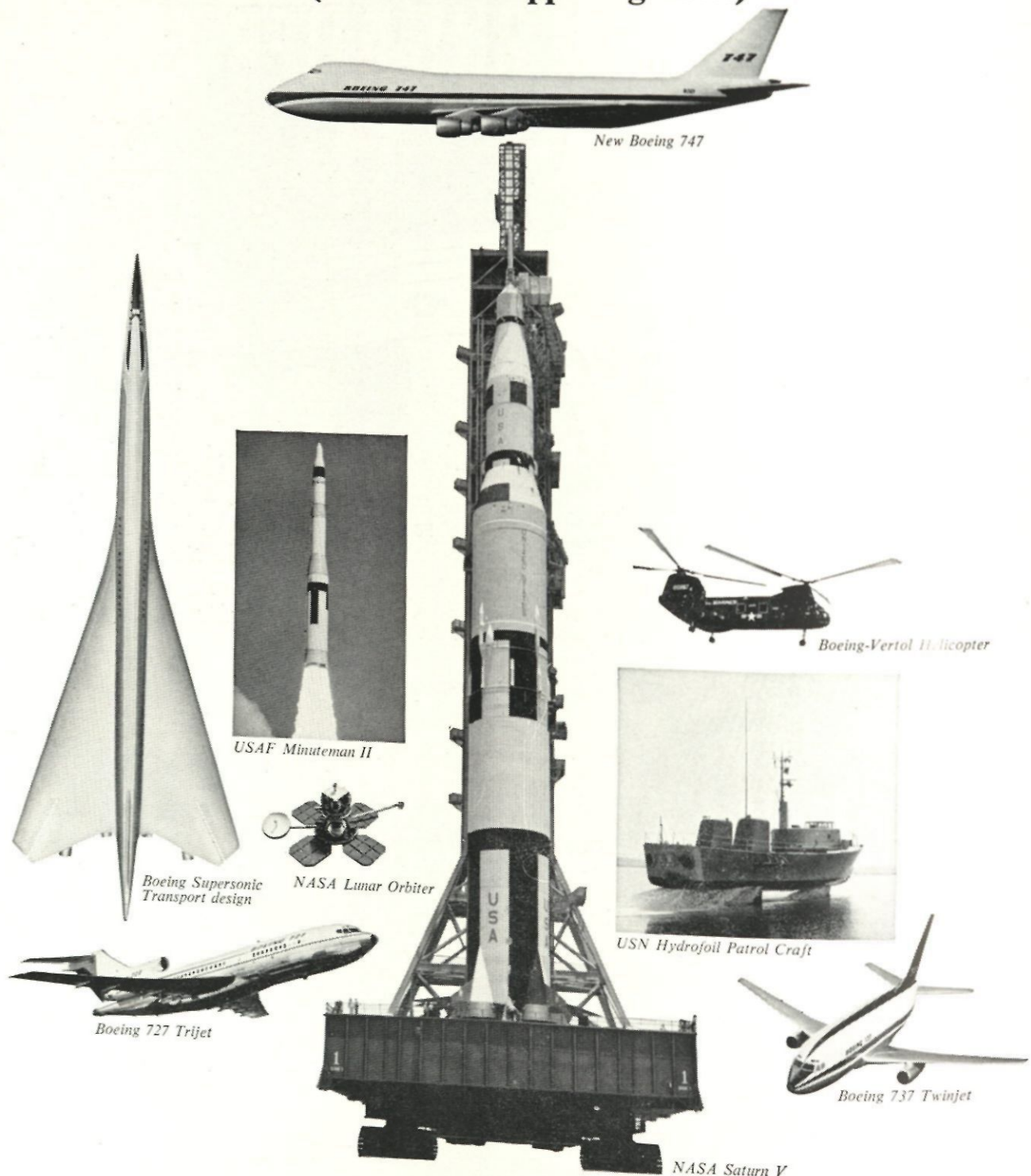
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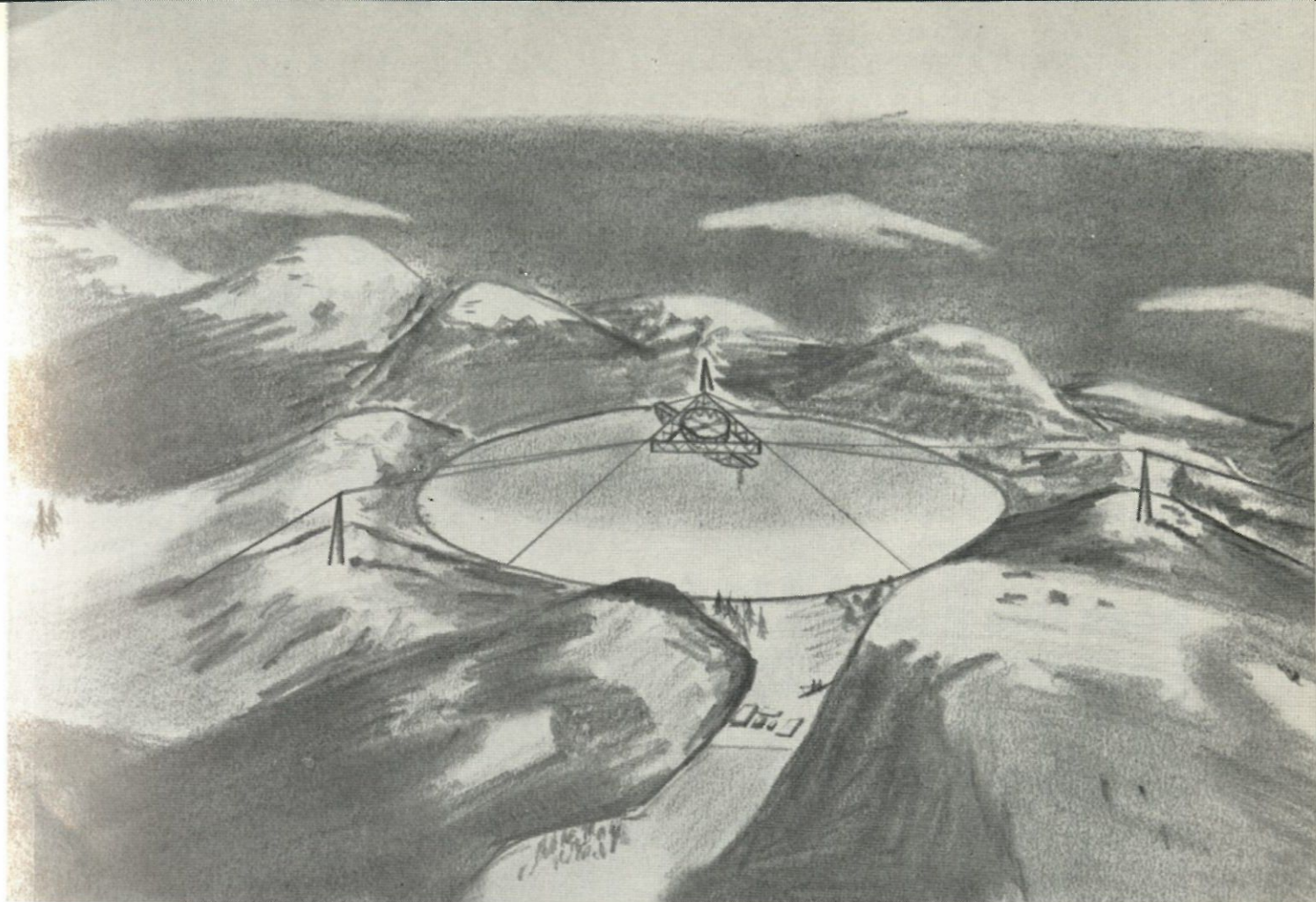
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Hello, If You're Out There

DAVID MESSERSCHMIDT

There has recently been considerable discussion of the possibility of the existence of intelligent life elsewhere in the Universe. In this paper I will attempt to describe in bare outline the arguments for the existence of extra-terrestrial intelligent life and then discuss the possibility of communicating with any such life which may exist.

Up until the middle 1930's, planetary systems were thought to be an extremely rare occurrence in the Universe. Until then the hypothesis of the English astronomer Julian Jeans that the solar system was formed as a result of a catastrophic collision of two stars generally prevailed. This is a very unlikely event since inter-

stellar distances are enormous in comparison to the dimensions of stars.

Recently, the hypothesis that planetary systems are a natural stage in the development of stars has been widely accepted. This hypothesis is supported by calculations of the formation of bodies out of nebulae. It is also confirmed by the experimental observation that a star in the dwarf stage (such as our sun) has a markedly decreased speed of rotation over its younger stages. By the law of conservation of angular momentum, this reduced angular momentum of the star could be the result of the motion about the star of small-mass cosmic bodies whose angular momentum is relatively large due to their large radii of revolution. It is interesting to note that if the total angular

momentum of the solar system were concentrated in the sun alone, its equatorial rotation speed would be identical to that of younger stars.

The English astronomer W. McCrea developed a quantitative theory which yields the same results. He hypothesized that the original nebula was broken into clusters in the course of condensation and that the interaction of these clusters produced a massive central body around which revolved a series of smaller bodies. Using this model, his calculations showed that ninety-six percent of the resulting angular momentum was concentrated in the orbital planetary motion—exactly the distribution of angular momentum in our own solar system!

(Continued on page 18)

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Better Things for Better Living . . . through Chemistry

(Continued from page 15)

Once it is hypothesized that there are trillions of other planets in the Universe, what is the probability of intelligent life existing on these planets? Presume, for a moment, that conditions similar to those on earth are necessary for the development of life. Then all of the following conditions are necessary:

1) The planet must not revolve too close to or too far away from the parent star in order for the surface temperature to fall within certain limits.

2) The planets can be neither too large nor too small. Small planets would be unable to hold an adequate atmosphere, and large planets would have atmospheres rich in light elements such as hydrogen which would preclude life as we know it.

3) The stars must be fairly old so that sufficient time has passed for life to appear and evolve.

4) The star must not be multiple. The resulting eccentric planet orbit would cause large temperature variations on the planet.

Even subject to these severe limitations there are probably planets in the Universe which could be cradles of life. (For a complete discussion of the chemical basis of life, the necessary conditions for its existence, and an excellent bibliography, see Reference (3).)

For the purposes of the rest of this paper assume that our galaxy does harbor extra-terrestrial intelligent life. The most obvious method of communicating with these beings is to go there ourselves. Let us next consider the feasibility of sending a

crew of men to visit these beings, or alternatively, of them sending a crew to visit us.

Interstellar Space Travel

In order to reach life outside our solar system it would be necessary to travel distances on the order of 10's to 1000's of light-years. In order to travel such distances in a time short with respect to the period of existence of life on earth, it is necessary that the spaceship travel near the speed of light (the ultimate speed limit of the universe according to the theory of relativity, which, for the purposes of this analysis, we shall assume to be correct). Not only would this high velocity shorten the time for the journey with respect to those who stay behind on earth, but, according to relativity, the time elapsed for the crew would be still shorter than the time elapsed back on earth. For example, if a spaceship were to be accelerated at 1 g over the first half of an 820 light-year journey and decelerated at 1 g over the second half of the journey, then the time elapsed for the crew would be 27 years and the time elapsed on earth before the spaceship returned would be 1500 years. Such a journey does not appear particularly difficult until one considers the energy required for that acceleration over that period of time.

The most efficient possible energy source according to relativity is the complete annihilation of matter to yield energy according to the equation $E = Mc^2$. Consider the following less ambitious journey: We want to reach a star 12 light-years away in 28 years earth-time. This journey would

require that the spaceship reach 0.99 times the velocity of light. The time elapsed for the crew would only be 10 years. Suppose we use as a propulsion system the annihilation of matter with anti-matter to yield gamma-rays. This is the most efficient possible propulsion system, but unfortunately it is not realizable with any present technology. Nevertheless, for a relatively small payload of 10 tons (a practical spaceship for such a long journey would most likely be much heavier) even this propulsion system would require at take-off 400,000 tons of fuel for the round trip! To accelerate 400,000 tons at 1g would require initially 10^{18} watts of power. Since this is more than the total power the earth absorbs from the sun, not only would one have to shield the crew from the gamma-radiation, but one would also have to shield the earth!

It appears that before we attempt to send a probe to a distant civilization it is necessary that we know where that civilization exists, and the use of radio or light communication seems to be a natural method of establishing that location. It is also possible that such communication can also be a means in itself for effective exchange of information.

The Possibility of Interstellar Radio Communications

We have seen that interstellar space travel would be an extremely costly and difficult proposition. By comparison, with what ease and cost could we communicate by radio waves? Modern radio equipment, such as that used in radio-astronomy, can identify a quite small radio signal. This is a much more practical approach at the present time to interstellar communication than space travel.

What is the basic limit on the distance over which an intelligible signal can be received on earth? This is determined by the size of the transmitting antenna, the transmitting power, and the size of the receiving antenna. The basic limitation on the smallest signal detectable is the thermal noise in the receiving equipment, noise emitted by our own atmosphere, and galactic noise emission. If the signal was transmitted by our present-day strongest transmitters, it could be received at approximately 100 light-years, using a 1000 foot diameter parabolic-reflector, such as is going to be built in Puerto Rico. Within this

(Continued on page 20)





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(Continued from page 18)

radius of earth there are approximately 10,000 stars. Using the present estimates of astronomers or the frequency of occurrence of intelligent life in the galaxy, it appears quite likely that strong radio signals originate from at least one of these stars. It would seem reasonable that we should listen for, and possibly transmit ourselves, radio signals. However, we have not as yet considered the many difficulties involved in interstellar radio communication.

The most apparent problem is that of determining what frequency or frequencies to which to tune our receivers. In order to detect signals in the presence of noise, it is necessary to use very narrow bandwidths so as to detect narrow-bandwidth signals and block wide-bandwidth noise. This makes the prospect of listening over broad frequency bands very impractical. When one investigates the frequency spectrum of the noise sources mentioned earlier, one finds that the frequency range of 1000 to 10,000 megacycles per second is optimum for receiving interstellar signals.

It so happens that in this range lies perhaps the most important frequency in radio astronomy: the frequency of 1,420.40575 Mc which is emitted by the hydrogen atom. It is quite likely, therefore, that any advanced civilization would have quite advanced equipment for receiving this frequency. Giuseppe Cocconi and Philip Morrison in their famous article in *Nature* first proposed that near this twenty-one cm line of hydrogen would be the best place to start in a search for interstellar signals.

Another Problem

The second difficulty, and a far more serious one, is the problem of making initial contact with the civilizations with whom we wish to communicate. If all these civilizations are attempting to receive signals and no one is transmitting, then obviously there are no signals to be received. Furthermore, an efficient transmitter, as well as receiver, must be aimed at only one star at a time. Hence, since the sender presumably does not know which stars may harbor civilizations capable of receiving his

message, and assuming he has a limited number of distinct transmitters, he must divide his transmitting time between stars. If he picks a short interval of transmission to each star (say one day) he can repeat his sequence of transmission every few hundred years and therefore reach an emerging civilization soon after it achieves the capability of detecting his signal. However, the probability of detecting his low-level signal out of the noise is proportional to the duration of the signal. Therefore, he can transmit to each star for a year (thereby increasing the probability of its detection) and transmit to that same star again in a few million years. Contact with a relatively nearby star would be more desirable since the time interval before a return message would be forthcoming would be much shorter, and hence he may choose to transmit longer or more often to nearby stars than to distant ones.

Likewise, if we wish to receive a signal and we have a limited number of receivers, then we must divide our listening time between all the stars

(Continued on page 23)

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DOUGLAS



(Continued from page 20)

within the range of our receiver. It is apparent that the probability of our listening to a particular star at the same time that a transmitter there is beaming signals our way is very small. If we miss their signal, we may not have another chance to receive it for a thousand or more years!

Transmission Also

Once we have received a signal, in order to establish contact we must be prepared to transmit back a signal which will inform the sender that he has reached us so that further contact may be established. Hence, it is imperative that we maintain transmitters, even if we only intend to use them in responding to a received signal.

The third problem, a minor one by comparison, is that of recognizing and interpreting a signal which is received. There are well known statistical tests which determine the degree of randomness of a signal and hence give us a good indication of whether a signal originated from an artificial source or not. A more difficult problem is that of deciphering the code to obtain any useful information it

may contain. There are well developed techniques and computer programs for deciphering secret codes which foreign nations have constructed, and given a sufficiently large sample of the the signal, it is generally assumed that its contents could be determined.

During the months of May, June, and July 1960 the 85 foot telescope at the National Radio Astronomy Observatory was employed with a special receiver to attempt reception of signals near 1420.4 Mc. The telescope was pointed at two stars, Tau Ceti and ϵ Eridani. No such signals were detected. This was a rather limited effort, and no conclusions were drawn except that more sophisticated automatic equipment is required for an effective effort.

Conclusion

In this paper the author has given a very brief discussion of the problems involved in interstellar communication. This discussion assumed that the presently accepted physical laws are correct and in particular that the theory of relativity is valid. The author believes that there is much to be gained by communication with a

technologically superior civilization, and that an effort in that direction is worthwhile in spite of the overwhelming difficulties involved.

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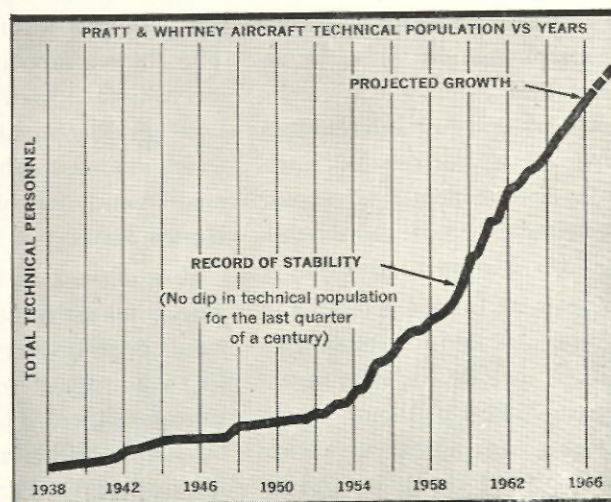
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After you are properly registered, you may select the companies with which you want to discuss employment. This is done in the Bureau's Sign-Up Room. You will have a better choice of appointment times if you sign up early, so be sure to watch for the weekly announcement indicating which companies will be interviewing in the near future. These announcements will be posted

on various bulletin boards all over the campus, and will also be published in the Colorado Daily.

When the time for your interview arrives, the company representative will meet you in the waiting room, introduce himself, and then conduct you to a private area where he will discuss employment opportunities with you. Before and during the interview, certain things should be kept in mind. A good checklist to follow might be:

1. Read about the company in the literature available in the sign-up room.
2. Be well-groomed and well-dressed.
3. Don't slouch or fidget during the interview.
4. Talk clearly, and use good grammar.
5. Play up your assets, but be honest in admitting your deficiencies.
6. Don't boast.
7. Light conversation can be introduced at appropriate times.
8. Make arrangements for further action or a follow-up interview.
9. "Thank you . . ." is the natural exit line.

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*The definitions and derivation, plus further information on satellite transmission degradation due to rainfall, may be found in the Bell System Technical Journal, Vol. XLIV, No. 7, Sept., 1965, p. 1528, which is available in most scientific and engineering libraries.

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The Development of PLUMBING

JORDAN PRIMACK

What is plumbing? How has plumbing evolved down through the centuries man has walked the earth? What has plumbing done and come to mean to civilization? These are the three basic questions that I propose to answer. Plumbing is generally regarded and spoken of lightly; however I plan to show ultimately that civilization is highly dependent upon this field. An example of my thesis is what has been said concerning the product plumbing is most dependent on . . . pipe:

The history of pipe is the history of civilization—upon no other single product have the great cities of the world depended in such large measure for their health and comfort.¹

What is plumbing? Before the history of plumbing can be understood and accepted, this inquiry should be answered. The *National Plumbing Code* book offers the most detailed description:

Plumbing is the practice, materials and fixtures used in the installation,

maintenance, extension and alteration of all piping fixtures, appliances, and appurtenances in connection with any of the following: sanitary drainage or storm-drainage facilities, the venting system and the public or private water supply systems, with or adjacent to any building, structure, or conveyance; also the practice and materials used in the installation, maintenance, extension or alteration of the storm water, liquid waste or sewerage and water supply systems of any premises to their connection with any point of public disposal or other acceptable terminal.²

To put it in more simple terms, plumbing is the installation, fitting, repairing and maintenance of pipes and fixtures for liquids and gases in and around a dwelling, be it for domestic, industrial, or commercial usage.

The primary purpose of a plumbing system is to afford convenience and comfort in a dwelling or other building. The supply pipes bring in fresh, wholesome water while the drainage pipes provide an adequate means of disposal of wastes. Not only are comfort and convenience served, but also

sanitation and health are served, for the possible damage to health resulting from impure water and improper drainage is self-evident.³

The Beginnings of Plumbing

How has plumbing evolved down through the centuries man has walked the earth? What has plumbing done for and come to mean to civilization? A hundred thousand years ago our ape-like ancestors lived in tree tops or crude caves. When thirsty, they knelt down by brooks and streams to drink. Perhaps those of higher intellectual powers learned to cup their hands so that drinking would be easier. The use of a hollow drinking vessel was the next step.

In time some ingenious individuals learned to lead water where they wanted it through trenches crudely dug in mud or sand. Still greater intelligence led to the use of a fallen hollow tree—probably the first water pipe. This method was used as late as the nineteenth century in the

United States as well as the rest of the world.⁴ The man who first learned to guide water from its source to his home was the forerunner of the Master Plumber of today. Thousands of years passed before our nearer ancestors learned to build cities and know the convenience of water systems.

In 2000 B.C., while Greece and Rome were yet savage states and when the civilizations of even Egypt and Babylon were young, there flourished on the island of Crete a thousand populous cities of which the chief one was Knossos. It was here that the great King Minos had erected an amazing palace, the remains of which indicate a luxury and refinement unmatched by any ancient civilisation.

The domestic wing of the palace consisted of at least three stories. Water was supplied through clay pipes, tapered so as to give the water a shooting motion, thus preventing the accumulation of sediment.

The waste line, large enough for a man to pass through, was ventilated by air shafts accessible through man-holes. Adjoining the queen's apartment was a bathroom. Two latrines on the upper floor were provided with small wooden seats. Outside the doorway a semi-circular hole in the floor led into a small duct toward which the floor was sloped. This was

for flushing purposes. A curious projection on the toilet drain is believed to have served as a balance flap to shut off sewer gases. Remarkable as it may seem, the modern vented toilet follows this installation in principle in minutest detail.

Pool of Siloam

As ancient Jerusalem was naturally deficient in water supply, King Hezekiah had a tunnel cut through a rocky hill to the "Pool of Siloam." This engineering feat, performed in 727 B.C. is the earliest known attempt to supply a city with water from a distance. The Pool itself was outside the city wall but was protected from invaders by being well within bow shot.

The tunnel, nearly a third of a mile long, shows by inscriptions near its mouth that boring through the rock began simultaneously at both ends. It tells in detail how, lacking proper instruments, the workmen failed to meet, although they could hear each other's pick blows. The point of junction is still marked by a sharp angle in the tunnel, showing that they missed meeting by three feet. Throughout the greater part of the work the workmen must have labored on their knees or even lying flat. This was the first major attempt at building a directed water system to

supply an entire town from a distant source.⁵

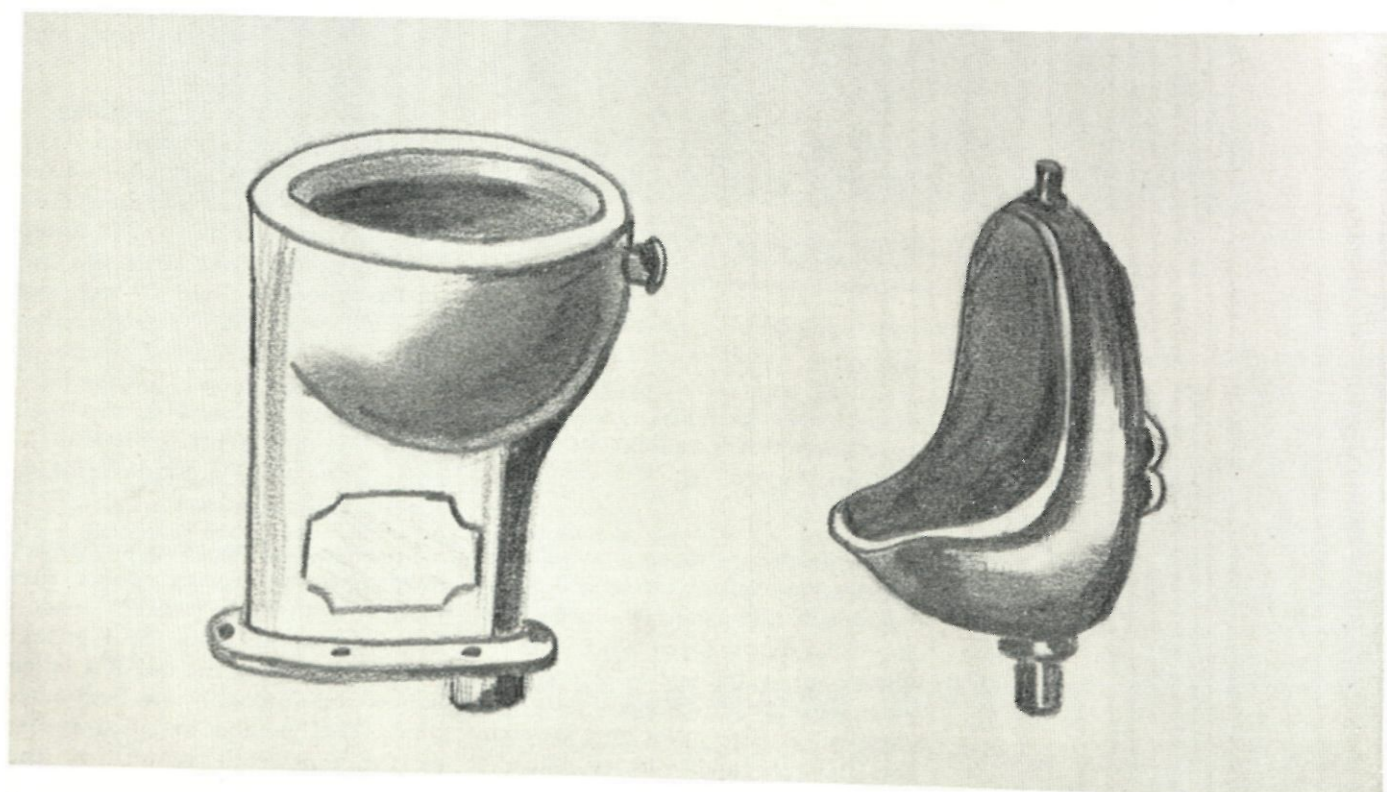
To the ancient Greek, with his vivid imagination everything in Nature possessed religious significance. Fountains and springs were believed to have mystical and medicinal powers and many a temple was built in their honor.

A free born citizen was always bathed at birth, marriage and after death. The water in which the bride was bathed at Athens was taken from a fountain with nine pipes. It was called Califfhoe, and was believed to assure a long and happy life. This fountain was also supplied for the most part by means of a conduit which brought water from the river Illisius. The conduit itself was very skillfully built, when one considers the crude tools they used.⁶

Plumbarius to Plumber

The sanitary worker of ancient Rome was known as a *Plumbarius*. This name derived from *Plumbum*, the Latin word for lead,⁷ and was applied to these workers because lead was the metal they used.

Down through the ages this name for sanitary workers has changed but little. From *Plumbarius* to *Plumber* was a comparatively simple change, probably brought about by the quick-



ening pace of progress and the necessity for brevity.

The Plumbarius, with his simple tools, also shaped lead to form frames for handbags, baskets, and similar articles. He was in reality, a tinker, working metal to suit the whims of his customers, when there was no demand for his services as a sanitary worker.

Metal Working

Gradually, however, the expansion of Rome's water supply system demanded more of the lead worker's time. Siphons and branches to the great masonry aqueducts required more skilled engineering and gradually these workers developed into specialists of uncanny skill.

Many veteran plumbers today can recall the time when they made their own lead pipes from sheetlead. The plumbarius in old Roman times had also to be his own pipe maker as well as plumber. This method then in use for forming pipe is interesting in that much of the procedure was still the same as late as fifty years ago, and this method is still used today to form various pieces of pipe, such as roof vents. In fact, I have worked with lead in this very same method.

Plates of lead which had been cast on smooth beds of sand were rolled into sheets 10 feet long, which in turn were bent around a wooden cylinder. The trough formed by the V-shaped edges provided space for soldering. Some of these pipes, with walls as thick as $1\frac{1}{4}$ inches and diameters as great as 27 inches are still in existence.⁸

The Romans

The water supply of ancient Rome came from eighteen different sources, and as is usually the case, these supplies varied in purity. Ten⁹ aqueducts, varying in length from eleven to fifty-nine miles, totaled three hundred fifty-nine miles,¹⁰ of which fifty-five miles were on arches. All together, the Romans built approximately two hundred aqueducts throughout their empire.¹¹ Water from the Anio aqueduct was used only for flushing sewers; Claudia water was reserved for the imperial table. Between these two, ranged the drinking and cooking waters, and soft but unsafe water which served for cleansing operations.¹²

Convenience in some cases required the use of the same structure for carrying water from three different sources. Separate channels, built at various times one above the other kept them apart. This indicates that the Romans recognized the value of water purity, and segregated the water supply according to their analyses.

From as far back as six centuries before Christ, Rome disposed of her sewage in true sanitary fashion and history records no such scourges as the Black Death and others that came later in Europe's history.

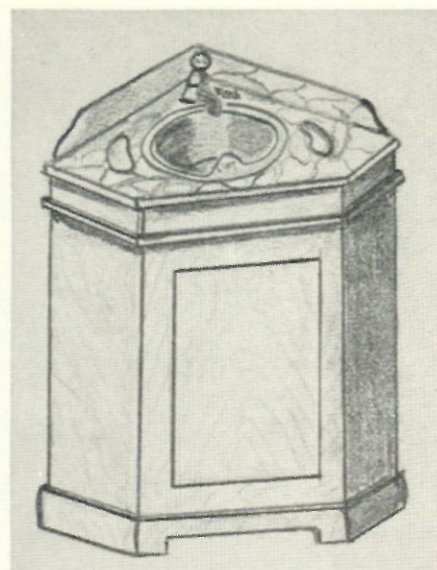
The Cloaca Maxima was Rome's main drainage trunk, formed of three concentric rows of enormous stones, piled above each other without cement. This mammoth tunnel was thirteen feet in diameter, being joined by numerous laterals. So well preserved is this tunnel that it is still used in the drainage of the modern city.

The Inca Plumber

The greatness of Ancient Egypt is common knowledge. But almost as long ago a race lived right here in our own new world whose skill in masonry was equal to, if not greater than that of the Ancient Egyptians. By carving huge stones in exactly matched interlocking angles so cunningly that it is impossible to insert a sheet of paper between the joints, the pre-Inca craftsmen reared a system of architecture without mortar that has defied time and the later efforts of human agencies to dismantle or destroy it.

They built complete city systems in the Andes and coastal plains of Peru with protective walls and aqueducts to bring them water from snow-bound mountain lakes. Water supply was vital to the life of vegetation, upon which the coastal pre-Incas lived, and when this was cut off in the mountains by the invading Incas, they were a beaten people.

The bath was once a part of Rome's pagan splendor. Everyone bathed. But, as the empire began to fall, the Christian Church perhaps believed that the practice of bathing loosened morals as well as dirt. This was not a fortunate step, however, logical it may have seemed to those who abhorred everything Roman, for in its wake followed fearful



plagues and pestilences throughout Europe.¹³

With sanitary measures abolished, whole cities were wiped out. Vessels drifted to shore, every man on board dead. Twenty-five million people — one fourth of the population of Europe — were destroyed by the Black Death.

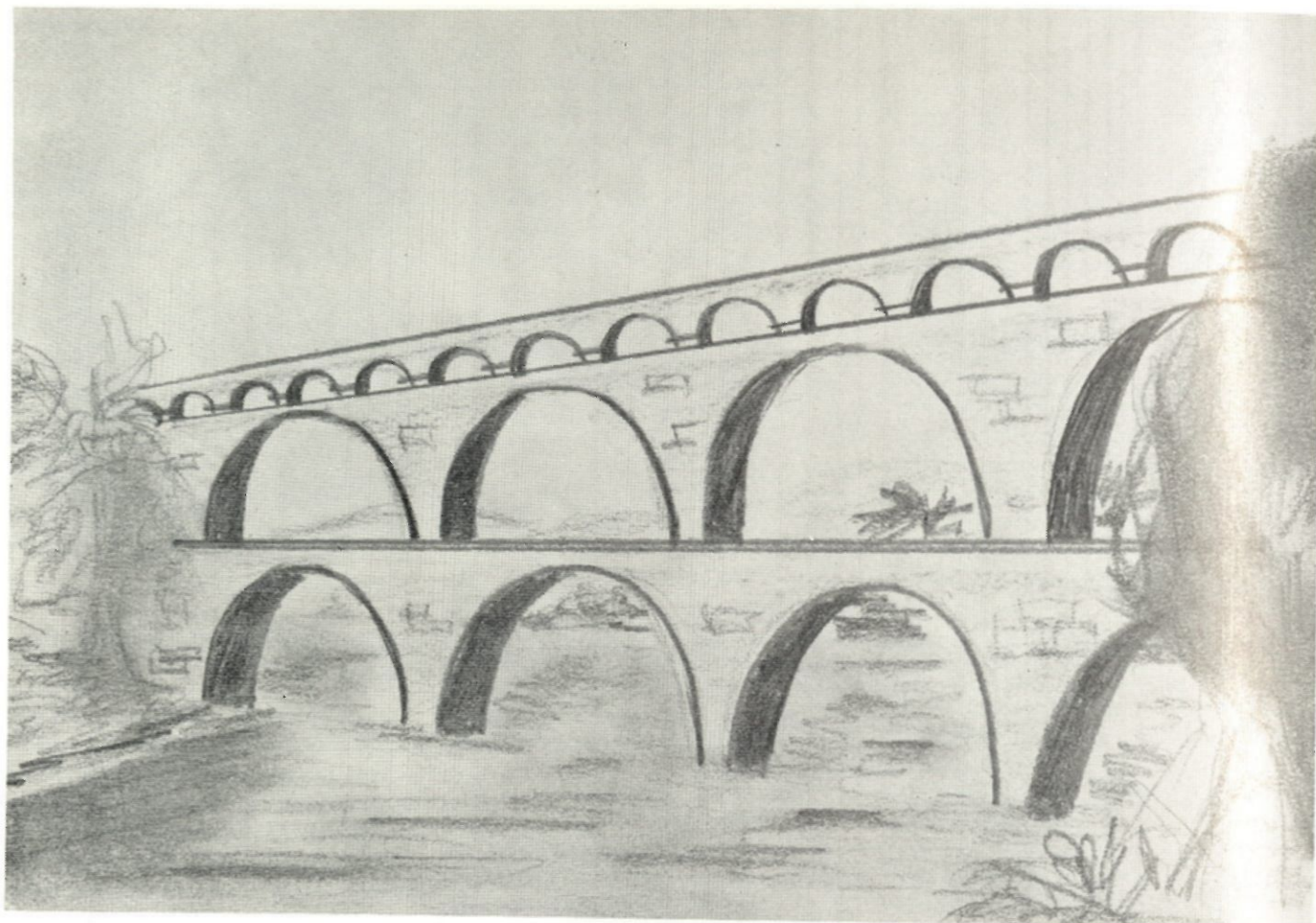
Through all this mire and filth, the spirit of religion burned brightly. Crusaders battled for the Holy Sepulcher and from Palestine they brought home new ideas of cleanliness and sanitation.¹⁴

This period of time after the fall of Rome was called the Dark Ages and well was it named, for little flourished except filth and disease.

A new birth of interest in plumbing was felt about the 12th century, during the Renaissance. In planning public works of that time, fountains of various kinds were extensively used by artists, architects and sculptors. They took the form of imitation springs, jets of a single powerful stream, cascades made of basins placed one above another, and hydraulic statutes or fountains in which a concealed pipe supplied the water. Here were conditions which called for a rebirth also of the plumbing industry.¹⁵

During the reign of Queen Elizabeth the first apprenticeship laws were passed. These compelled plumbers to serve an apprenticeship for seven years. In 1611 the First

(Continued on page 32)



(Continued from page 31)
Master Plumber's Association was formed.

The earliest installation of cast iron pipe for underground water conduit was laid by order of Louis XIV near Paris. The conduit ran from the reservoirs of Picardie to Montbaucourt. This system supplied the town of Versailles between 1664 and 1688.¹⁶ These pipe lines consist of pipes one meter in length, joined by means of bolted flanges, and were of considerable weight. This seemed to be a fairly successful method, for repair was only required to replace rusted bolts.¹⁷ Less than a century later, the city of Rheims installed a water system of lead; however, when new pump works were constructed, some cast iron pipe dating back to 1748 were found. At this time lead pipe was beginning to be the most highly accepted and used conduit. Again cast iron pipe made its bid to replace lead pipe.

In 1746 the Chelsea Water Company of London installed a twelve inch flanged cast iron pipe system. However, this attempt proved to be

less than successful when the system needed replacement in 1791 because of the joints "being perished."¹⁸

About 1785, experimental cast iron pipes with lead joints were laid and proved successful. So successful was this experiment that gradually the old lines were replaced by cast iron pipe with lead joints. In fact this same system was still in service in 1917.

Plumbing in U.S.

The United States was a little slower in developing plumbing methods, most of which were copied from Europe. In America, attempts were made with bored out logs, but trouble evolved from insufficient strength. Finally the Watering Committee decided to import a small quantity of cast iron pipe from England, for experimental purposes. This pipe proved so acceptable that gradually cast iron was substituted for wood. The imported pipe was of bell and spigot type in nine-foot lengths.¹⁹

The story of New York's water supply is typical of all big cities. In

New York bored logs were used in all early water systems, including that of the Manhattan Company, organized in 1799 by Aaron Burr. At the beginning of the nineteenth century, New York was not an especially healthy place to live; for during the hot season epidemics of yellow fever spread. Such was the severe epidemic of 1798, and it was blamed on inadequate and inferior water supply. Two very active citizens, Aaron Burr and Alexander Hamilton, who were still close friends at the time, spurred the new water system movement. They formed a company and finally received the go-ahead from the state legislature. The company dug a number of wells throughout the city and then this water was piped to the lower parts of the city. The distributing system was gradually extended throughout the city, south of City Hall.²⁰

In 1836, the system was extended north to total about twenty-five miles of mains and serviced two thousand houses. There was one drawback, however; the water was not clear. Although the water was wholesome,

nevertheless, many complaints were lodged. To quiet these complaints the state legislature granted the city the use of the Croton River. In 1834 a fifty foot dam was built on the Croton River, forty miles above the city. Water was then conveyed to the city through aqueducts. The crossing of the Harlem river was done by running the water through cast iron pipe. Finally the system hooked into the city's mains.

Water Requirement

The Old Croton Aqueduct system was designed to supply the city with thirty-six million gallons of water daily in 1842. By 1880 the city had grown and the daily requirement rose to ninety-five million gallons per day. The need therefore arose for a new water supply system. Between 1880 to 1884 an additional twenty-three million gallons were drawn each day from the Bronx and Byram Rivers.²¹

The second Croton Aqueduct was begun in 1884, and in 1891, the New Croton Dam was completed. The water problem seemed to have been solved until 1905 when once again the city's cry arose for more water. New York then required three hundred million gallons per day. The city received permission to construct the Catskill aqueduct to flow from the Ashokan Dam. This brought approximately five hundred million gallons of water daily to Manhattan.²²

By 1916, the Boroughs of Brooklyn and Queens required one hundred eighty-five million gallons daily. This they developed from wells and surface streams. By 1915 nothing but cast iron pipe was used for distribution of water throughout the city. Pressures varied from 25 to 300 pounds while the length of pipe run, totaled three thousand fifteen miles. This is the way it happened all over the United States. Thus by about 1915, cast iron pipe was the major conductor of water supply in the U.S., being used in all major cities such as Boston and Philadelphia.²³

The Bathtub

While the development of sophisticated water systems was being carried out, plumbing fixtures were also seeking refinement. In the United States, the first plumbing fixture in the home was the kitchen sink. This

eliminated the task of carrying water for cooking. If a public water supply was not available, water was provided by a cistern or well. The bathtub next became commercially available and finally, in 1871 a patent was granted for a water closet. A prime example of this later day evolution was the modern-day bathtub. The bathtub of today is a far cry from the one used in Ben Franklin's time. Then, it was considered unusual and even dangerous to bathe regularly, but Franklin defied public opinion. He adopted the

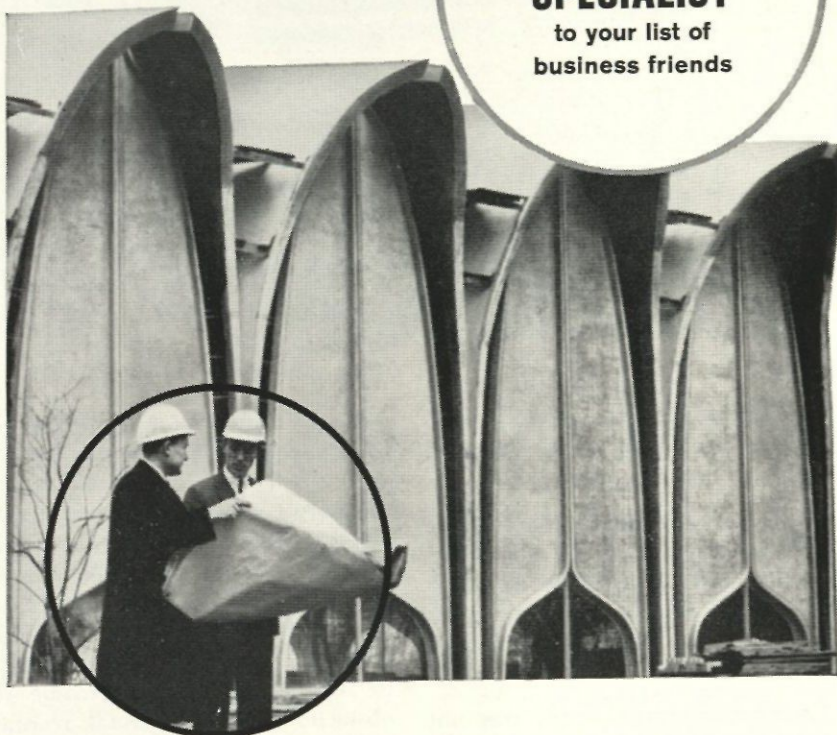
French and English custom of bathing in a giant, copper bathtub in the form of a slipper; the bather sat erect while the sides served as a protection from drafts.

About 1830, Lord Russell of England, invented a bathtub, the possibilities of which stimulated the imagination of an American named Adam Thompson. Upon returning from England, Thompson, with the aid of an American cabinet maker, built a mahogany bathtub seven feet long by four feet wide. It was lined

(Continued on page 34)

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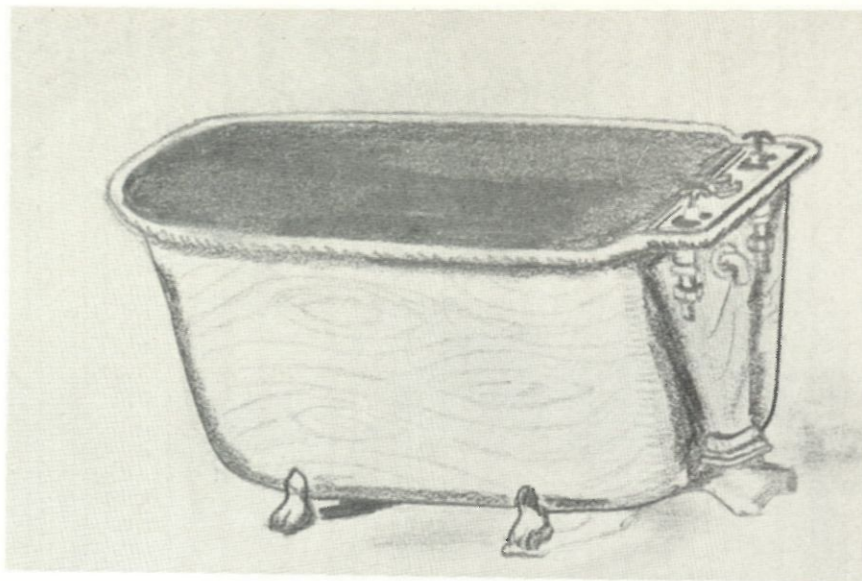


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(Continued from page 33)
with sheet lead and weighed almost a ton.

From his back yard pump, water was piped to a tank in the attic. The cold water pipe came direct to the tub, but the hot water pipe was coiled down the chimney, heating its contents on the way.

Thompson's development was not popular. Virginia placed an annual tax of thirty dollars on every tub brought into the state. Boston made bathing unlawful, except on medical advice.

Bathtubs have changed very little. The flush valve, however, in place of tanks for toilet flushing purposes, is a development that is a really modern improvement.

Numerous other technical advances have been made, plumbing methods have been adopted on a large scale, and plumbing codes developed. New materials have been introduced into today's plumbing field which were unthinkable fifty years ago. The most predominant and influential material is copper.

Copper pipe has opened a new vista in plumbing. This material is both easy to work with and capable of bringing water into our homes sparkling pure, and uncontaminated by rust. Copper has been enjoying acceptance in not only water supply but also sewage conduction. The major short-coming of copper is its lack of availability. Due to this shortage of copper, a new material developed — plastics.

Plastic plumbing is yet a new field. It has advantages over anything presently known, in that it is lighter, more corrosion resistant, immediately available, and can be worked without the use of expensive solder. In the near future, plastic could take over copper's place for plumbing. However, before plastic can come into its own, it must overcome such obstacles as cost, thermal resistance and acceptance by local codes, and trade unions. Undoubtedly, plastic will be the material of the future in the plumbing industry.

Plumbing Code

The last aspect to be covered concerning the evolution of plumbing is that of code. These codes assure primarily that all plumbing design and workmanship is of such quality that the health of building occupants will not be impaired. The two most common plumbing hazards are cross connections and conditions causing backflow of water. The National Plumbing Code defines a cross-connection as follows:

A cross-connection is any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other water of unknown or questionable safety, whereby water may flow from one system to the other, the direction of flow depending on the differential between the two systems.²⁴

Backflow and back siphonage are defined by the National Plumbing Code as follows:

Backflow is the flow of water or other liquids, mixtures, or substances into the distributing pipes of a potable supply of water from any source or

sources other than its intended source.²⁵

Back-siphonage is the flowing back of used, contaminated, or polluted water from a plumbing fixture or vessel into a water supply pipe due to a negative pressure in such pipe.²⁶

I hope that by this point the need for a plumbing code to set minimal standards is evident. This need was recognized by the U.S. Department of Commerce who authorized the publishing of *Recommended Minimum Requirements for Plumbing in Dwelling and Similar Building*, published in 1924. Several revisions were made, and the final version, *Recommended Minimum Requirements for Plumbing*, was published in 1932. The National Association of Master Plumbers published its *Standard Plumbing Code* in 1933. The latest revision of this was made in 1942.

In 1934, the subcommittee on Plumbing of the Building Code Committee of the U.S. Department of Commerce was discontinued. Therefore, the American Standards Association was given the task of establishing minimum requirements for plumbing.²⁷ Following approval of its findings, the committee assigned to this study was discontinued. The findings of the project were issued in 1951.²⁸

Finally the decision was reached that research into the field of plumbing was in order.

The requirements and recommendations were based on research in the field of plumbing partly financed by HHFA and the U.S. Department of Commerce conducted at the National Bureau of Standards, Washington, D.C., University of Iowa, University of Illinois, U.S. Public Health Service Environmental Center, Cincinnati, Ohio, and other nationally recognized laboratories.²⁹

The result of this research was compiled, received designation as an American Standard on January 25, 1955, and was published as the *National Plumbing Code* in that same year.³⁰

Conclusion

Although over 2000 years have passed since the birth of the industry, the plumbing fraternity still uses the metal that gave it its name. In recent years, however, lead is being used in more limited quantities, while another long known metal—brass—has largely superseded it because it provides all the corrosion resisting properties of lead without

its structural weakness. This evolution of material has come about through man's quest to improve upon the old. The purposes of plumbing again are to provide convenience and comfort as well as afford the best possible sanitary conditions. Knowledge brought improved standards of health, but not until recent years has the advance been so rapid. More plumbing progress has been made in the past fifty years than in the five hundred preceding years.

In water supply as well as drainage problems, the people of the Middle Ages failed to look back into history for object lessons. The result of their negligence is readily self-evident. The health officials and plumbers of today have learned to profit from experience and attempt to improve upon them. This is why the Plumbing Codes have been constantly revised and will continue to be. Experimentation and improvement is also seen in the recent development of new materials for

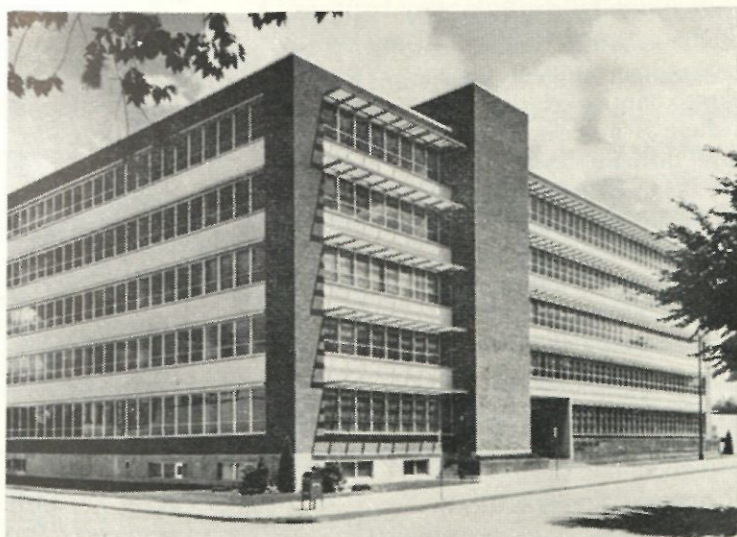
plumbing, such as aluminum, stainless steel and plastics.

Plumbing's primary contribution to civilization is sanitation. Without such rigid sanitary principles, civilization would fall into mire, filth and decay. This again has been shown to happen before in history. With the aid of the plumber, never again will civilization fall to such a low level of decay. Now it is up to the civilizations to keep from blasting the plumbers along with themselves from the face of the earth.

Notes

- ¹R. C. McWane, *Pipe and the Public Welfare*, New York: The Stirling Press, 1917, p. 9.
- ²National Plumbing Code, New York: The American Society of Mechanical Engineers, 1955, p. 20.
- ³Harold E. Babbitt, *Plumbing, 1st Edition*, New York: McGraw-Hill Book Company, Inc., 1928, p. 1.
- ⁴R. C. McWane, *op. cit.*, pp. 10, 17, 19.
- ⁵F. W. Robins, *The Story of Water Supply*, London: Oxford University Press, 1946, pp. 47 & 48.
- ⁶F. W. Robins, *op. Cit.*, pp. 52 & 53.
- ⁷Cassell's Latin Dictionary, New York: Funk and Wagnalls Co., 1959, p. 422.
- ⁸Joseph Primack, plumber, Littleton, Colorado.
- ⁹Friedrich Klemm, *A History of Western Technology*, Cambridge: The M.I.T. Press, 1964, p. 48.
- ¹⁰James Kipfinch, *Engineering and Western Civilization*, New York: McGraw-Hill, 1951, p. 19.
- ¹¹F. W. Robins, *op. cit.*, p. 58.
- ¹²*Ibid.* pp. 61-64.
- ¹³F. W. Robins, *op. cit.*, p. 91.
- ¹⁴F. W. Robins, *op. cit.*, p. 96.
- ¹⁵*Ibid.* pp. 81-83.
- ¹⁶R. C. McWane, *op. cit.*, p. 11.
- ¹⁷*Ibid.* pp. 12 & 13.
- ¹⁸R. C. McWane, *op. cit.*, p. 16.
- ¹⁹*Ibid.* p. 17.
- ²⁰*Ibid.* pp. 19-23.
- ²¹R. C. McWane, *op. cit.*, p. 25.
- ²²*Ibid.* p. 26.
- ²³*Ibid.* pp. 28 & 30.
- ²⁴National Plumbing Code, p. 16.
- ²⁵*Ibid.* p. 14.
- ²⁶*Ibid.*
- ²⁷National Plumbing Code, *op. cit.*, p. 111.
- ²⁸*Ibid.* p. IV.
- ²⁹*Ibid.*
- ³⁰*Ibid.* p. V.

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STATICS OF DEFORMABLE BODIES

SHIRLEY RHUDY

Nils O. Myklestad's new book, *Statics of Deformable Bodies* (The Macmillan Company, New York; Collier-Macmillan Limited, London. 1966. 336 pp., \$11.95) provides a new approach to an old subject. The book covers course-work that only a few years ago was called Strength of Materials. The title of the book is particularly appropriate because the book deals with forces acting on deformable bodies of various shapes.

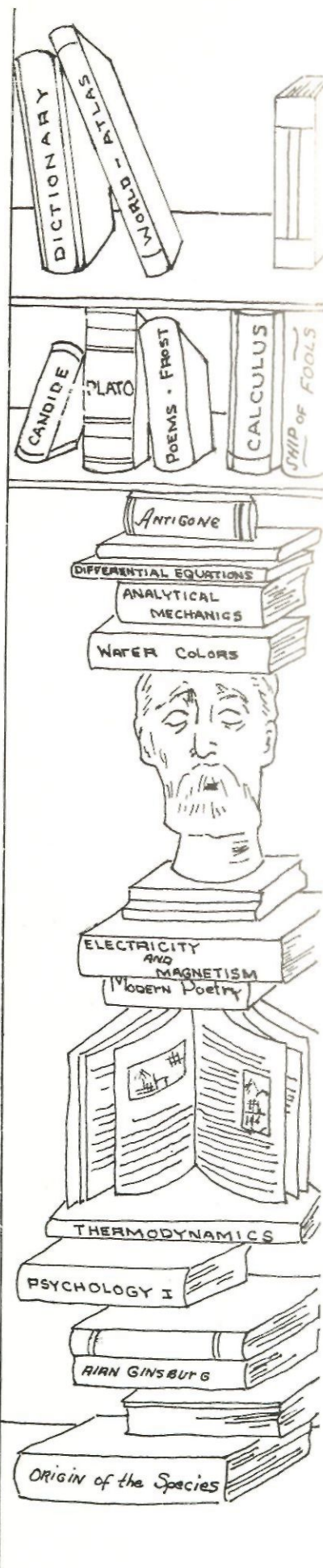
Most text books in the field are similar in that they make assumptions concerning the deformations, so that nothing need be said about the equilibrium at a point on the body. These assumptions produce an inevitable error in any calculation. Formerly a large factor of safety was included in the design to take care of such errors. Few engineers were required to learn from mistakes or from lack of exactness in calculation.

Myklestad feels that, with the development of lightweight structures, there is a new concept of probability of failure to replace the old one of a margin of safety. Every chapter of his book begins with an exact solution to an engineering problem against which a calculation may be checked. He attempts to show the student ways in which engineering calculations differ from actual stress conditions in a deformable body. However, he never tries to explain how the exact calculations are carried out. Perhaps this is not a fault in an introductory course, but I do think that the student could be given some

indication of the basic concepts involved.

Myklestad seems particularly fond of using Cartesian tensors in the solution of problems to give the student an understanding of the relation between stress and strain at a point. Even though the student may have had little experience with the use of tensors, he can understand the course-work if he starts at the beginning of the book. Chapter One gives a fairly detailed account of just what Cartesian tensors are and how they can be employed. Chapters Two and Three are also intended for review of force systems and rigid body statics. The remaining chapters cover stresses in various bodies—shafts, beams, columns, etc. Since the student finishes the first three chapters relatively well prepared, there is no reason why he should have difficulty with the remainder of the book. Examples are well-spaced to supplement and aid in solution of problems. Visual aids such as pictures and force diagrams are employed to make specific problems easier to understand.

Except for a few minor points (such as some clue as to how the exact solutions are derived), the book is a fine introduction to the mechanics in general (and statics, specifically) of deformable bodies. The book is designed as a text for undergraduate engineering students, but may be employed by graduate students and many practicing engineers. It is certainly a new and refreshing look at an old topic.





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ENGINEERING CENTER WINS NATIONAL AWARD

The University of Colorado's new Engineering Center has gained an honor award from the United States Office of Education, Bureau of Higher Education, in collaboration with the American Institute of Architects and the Educational Facilities Laboratories. President Smiley of the University of Colorado and William C. Muchow of Architectural Associates of Colorado, were notified of the honor by Peter B. Muirhead, Associate Commissioner for Higher Education, and William H. Scheick, Fellow of the American Institute of Architects.

The University of Colorado received the award in competition with 258 entries. Seven first honors were awarded, 20 awards of merit, and two special mentions. Other recipients of First Honor Awards were: The University of Tennessee, Mills College, Nazareth College of Rochester, the University of California at Santa Cruz, Tufts University, and the University of Illinois. Decisions were made by the jury for the 1966 Design

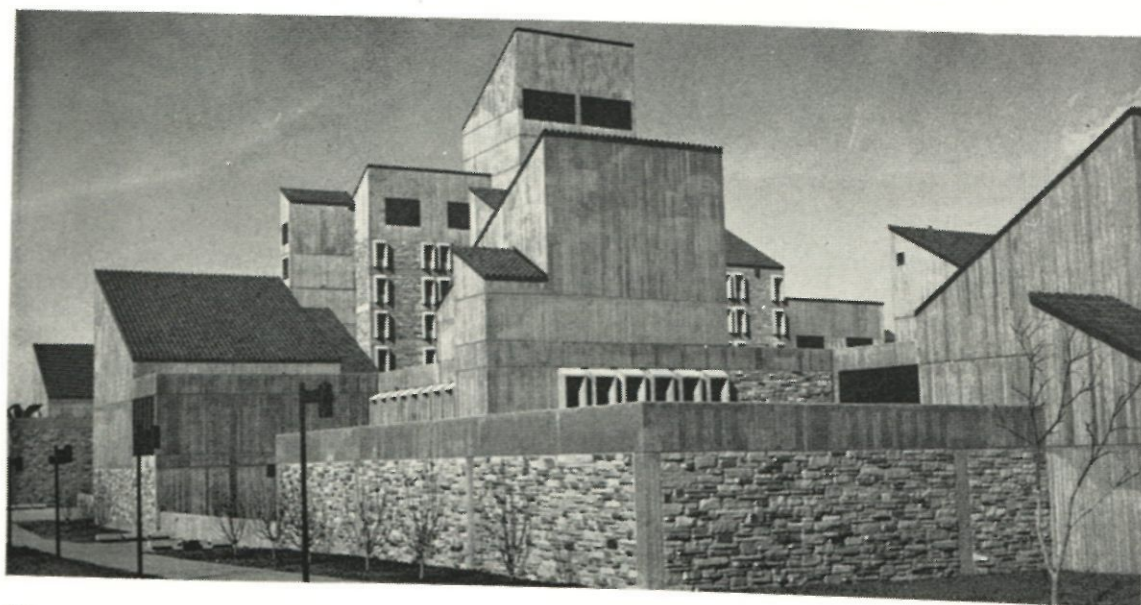
Award Program, which met early in October at the Bureau of Higher Education in Washington.

At ceremonies conducted in Washington, D.C., on October 18, the honor award was accepted on behalf of the University of Colorado by Max S. Peters, Dean of the College of Engineering. Certificates were presented by Commissioner Harold Howe II to architects and heads of award-winning institutions, and to general contractors of completed buildings. In addition, a bronze plaque was presented for installation in the Engineering Center. Slides of the 29 award-winning entries were shown, along with photographic displays and exhibits. The Engineering Center, completed and occupied in Phase I in the fall of 1965, was financed in part under the Higher Education Facilities Act of 1963.

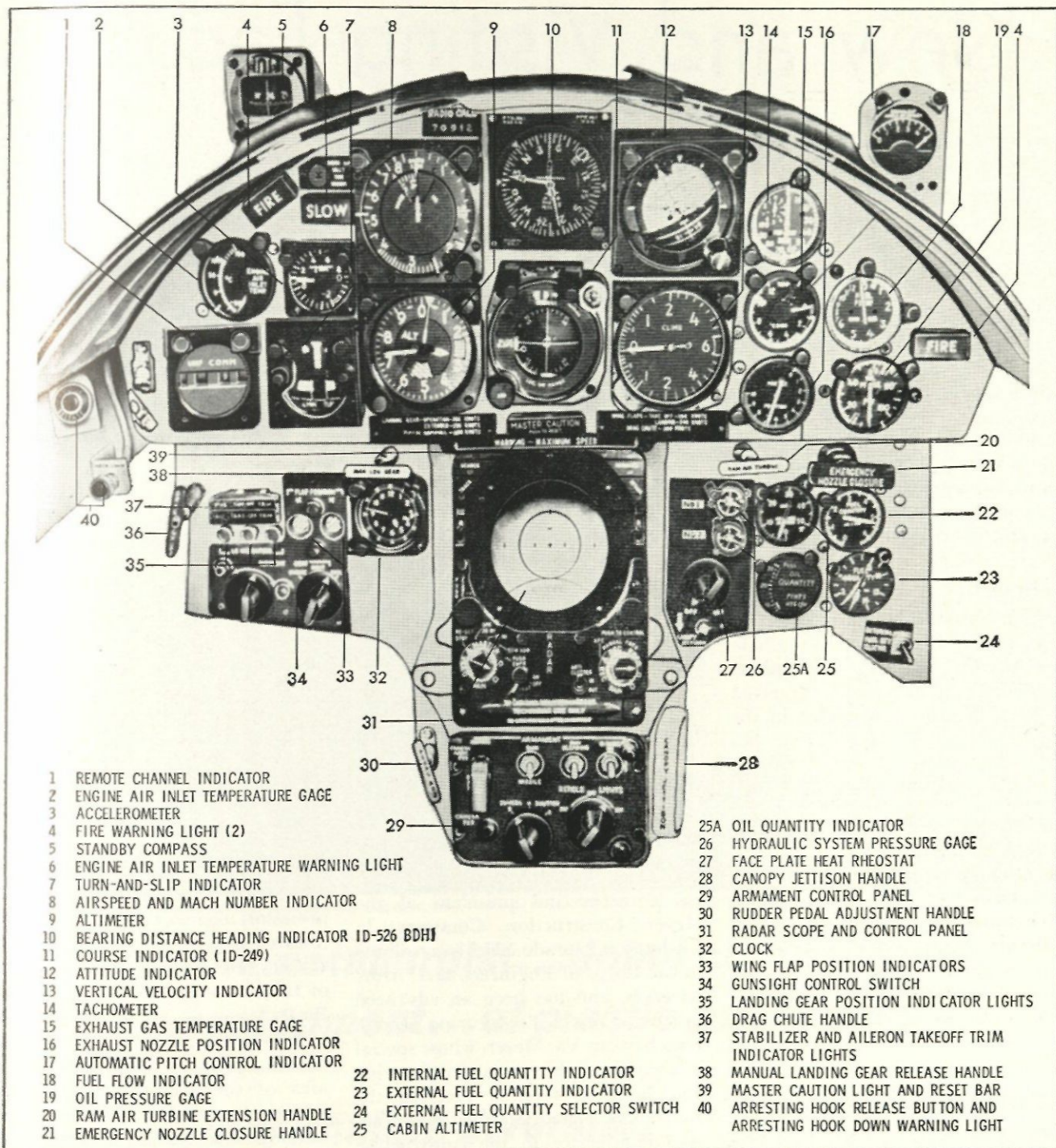
The Engineering Center was designed by Architectural Associates of Colorado, William C. Muchow of Denver, partner-in-charge, in colla-

boration with architectural consultant Pietro Belluschi, Boston, Massachusetts, and design consultants Sasaki, Dawson, DeMay Associates, Inc., Kenneth DeMay, principal, Watertown, Massachusetts. The Sasaki firm also serves as master plan consultant and landscape architect for the University of Colorado.

The purpose of the competition, according to U.S. Commissioner of Education Harold Howe II, is the "recognition of distinguished design." Special consideration is given to entries that "reflect careful analysis of the needs of a modern educational program, the changing nature of those needs, and designs that both meet today's requirements and are adaptable to unknown future requirements. Designs that reflect execution of a complex program, environmental harmony, and a realization that excellent architecture is not synonymous with higher costs also will be given recognition," he said.



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New and Visiting Faculty

AEROSPACE ENGINEERING SCIENCES

PAUL H. ZEIGER, assistant professor, joins the Aero department following a year at the University of British Columbia as assistant professor of electrical engineering. His undergraduate and graduate degrees were earned at MIT, where he was research assistant, instructor, and post-doctoral fellow. Zeiger's research interest is described as "how to put coordinates into the state spaces of physical systems in general and finite automata in particular." He has held a research appointment in the department laboratory during the past summer.

JOHANNES J. KANNE, visiting assistant professor, is a citizen of West Germany. He is professor of mechanics and hydrodynamics at the University of Bonn, from which he received his Ph.D. degree. A specialist in the field of plasma physics, Kahne has done research on current transition through a combustion plasma.

RICHARD E. MORTENSEN comes as visiting assistant professor from the University of California, where he has been a teaching fellow and is assistant professor specializing in circuit theory, linear systems analysis, probability and random processes. His NSF-supported doctoral research was on non-linear estimation and filtering of continuous-time stochastic processes.

ARCHITECTURAL ENGINEERING

DWAYNE NUZUM, assistant professor, is new to the School of Architecture this year. He comes from the University of Virginia, where he was assistant professor in the School of Architecture and Planning. Nuzum, a specialist in planning and urban design, is a University of Colorado graduate who earned his doctorate under a Fulbright grant at the Technical University of Delft, Holland. He brings to the architectural engineering program an emphasis on city planning.

RIGOMAR A. S. THURMER, assistant professor, who joined the faculty of the School of Architecture

in February 1966, is a graduate of the Munich Institute of Technology and the Harvard School of Design. More recently he has been an architectural designer and draftsman in New Canaan, Connecticut.

CHEMICAL ENGINEERING

RICHARD HERRING, visiting lecturer, is associated with Beech Aircraft in Boulder. A specialist in cryogenics, he earned his master's and Ph.D. degrees at the University of Colorado.

RICHARD B. STEWART, visiting lecturer, is well known to the mechanical and chemical engineering departments of the college; he has been associate professor and lecturer in mechanical engineering, and last spring directed chemical engineering students in research at the National Bureau of Standards, where he is in charge of the data compilation unit in the Cryogenic Data Center. Stewart is the thermodynamic analysis specialist for the Bureau's cryogenic laboratory.

CIVIL ENGINEERING

WALTER MEYER, visiting lecturer, is owner and president of the Meyer Construction Company in Littleton, Colorado. He is a colonel in the Corps of Engineers, U.S. Army Reserves, and has been an advanced instructor in the Engineering School, Fort Belvoir, Va. Meyer, whose special interest is architectural engineering and business, recently received the Bate-Petry Memorial Award for outstanding service to the construction industry of Colorado.

NAHIT KUMBASAR, visiting lecturer, is a specialist in structural dynamics who received his graduate training at the Technical University of Istanbul, Turkey, where he assisted in the Department of Reinforced Concrete Structure. He is a member of the Turkish Society of Civil Engineers.

ELECTRICAL ENGINEERING

FRED CHERNOW, associate professor, comes from the faculty at MIT, where he was assistant professor of E&M field theory and thermodynam-

ics, and was director of the photoconductor, semi-conductor and devices laboratory. His research interests are in wide-band-gap semi-conductors, electroluminescence, photoconductivity, ferroelectricity, thin films, single crystal growth, and ultra-high vacuum techniques. Chernow has worked on development of high-speed electrostatic memory storage and flat-panel TV display systems.

DONALD GAGE, associate professor appointed to the Colorado Springs Center, has been on the faculty at Michigan State University, where he most recently taught properties of solid state materials, solid state devices, electrical properties laboratory, and physical electronics. His Ph.D. work at Stanford in solid state devices resulted in publication by Stanford Electronics Laboratory of "A Study of Avalanche Transistors." His research has centered on the transient-radiation effects observed in semiconductor devices; recently he has developed a new viewpoint of storage time in transistors about which theoretical and experimental results have been published.

HARRY F. JORDAN, assistant professor, comes from a position as research assistant in the Department of Computer Science at the University of Illinois, where he was awarded the Ph.D. degree last June. As a physicist with a special interest in computer science, Jordan's research is in the area of computational problems in statistical mechanics, for which he has developed a strong background in statistical mechanics, probability theory, and numerical analysis.

WILLIAM G. MAY, assistant professor, has been for the past six years on the faculty at MIT, where he taught transistor device physics, circuits, and solid state physics. Awarded his doctorate from MIT two years ago, he has since been working under a Ford postdoctoral fellowship in engineering. He has investigated various wave phenomena in bismuth at microwave frequencies, and has worked on an instability in solid state plasmas. For some years May was en-

(Continued on page 42)



Mr. Stan Ladley, Senior Commercial Development Engineer, Past National President and Chairman of the Board—Jaycees.

"I'm a metallurgist...doing commercial development...of plastic packaging.

That's Phillips diversity."

"Being a metallurgist at an oil company seems strange enough. And when you add that I'm a Commercial Development Engineer, primarily dealing with plastic packaging, it sounds pretty improbable. It would be, anywhere but Phillips.

"Actually, when I started at Phillips, I worked on pipe. My interest led me from just metals into cement-lined pipe and other products, such as plastics. Then, realizing what some of the new materials could do, I involved myself more and more in expanding their use. This in turn resulted in my moving to the Commercial Development Division. You see, the chain of interests has its own logic.

"But when I was graduating from the

University of Illinois, I couldn't have foreseen that my interests would lead this way. It took a company as big, as diverse, and as flexible as Phillips to help me find out what I wanted. And then to help me do something about it.

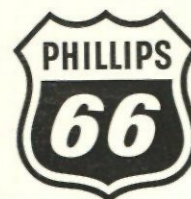
"The company helped me in another way, too. I felt a need to take responsible action in my community. I joined the Jaycees in the course of my outside activities and was elected National President. I'd say it was worth a Ph. D. in human relations. Phillips encouraged me all the way. Even to giving me leave of absence. Now, that's an unusual company."

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To get the full story on Phillips, contact James P. Jones, Phillips Petroleum Company, 104 F. P. Bldg., Bartlesville, Oklahoma 74003.

AN EQUAL OPPORTUNITY EMPLOYER



(Continued from page 40)
gaged in instrumentation and circuit design work for Bell Telephone Laboratories.

WILLIAM M. WAITE, assistant professor, comes to the department from a year of postdoctoral research under the National Science Foundation at the University of Sydney, Australia. He has been research assistant in acoustic data reduction at Columbia University, where he earned his Ph.D. His special electrical engineering interest is in computing science.

EDWARD T. WALL, associate professor, who is assigned to the Denver Center, has been working for the U.S. Bureau of Reclamation on development of mathematical models and programming of electrical engineering systems, and on development of control and instrumentation for transmission systems. Wall was associated for seven years with the aerospace division of the Martin-Marietta Company. He has taught electrical engineering at California Polytechnical College, the University of Maine, Lehigh University (from which he received his master's degree), and has lectured at the University of Denver on advanced servomechanisms.

NORRIS S. NAHAM has been appointed professor adjoint (with ESSA) to teach and supervise graduate work in the department. Simultaneously he fills a new appointment at the National Bureau of Standards Radio Standards Laboratory as a scientific consultant for high frequency. Nahman, who received his Ph.D. degree from the University of Kansas, has, for the past eleven years, been professor of electrical engineering there, and director of the electronic research laboratory. He is a senior member of IEEE and is on the national committee of URSI; he has served as technical advisor to the Department of Defense, the Martin Company, and various research organizations.

THOMAS L. DAVIS, of the National Bureau of Standards, has been appointed visiting lecturer for the next two academic years. Davis is an electronics engineer associated with ITSA, IER, and ESSA; he supervises the analog-to-digital conversion facility operated by the Ionospheric Telecommunications Laboratory. As a specialist in design and synthesis of

logic and data processing systems, he has been granted a patent for design of an encoder and decoder used in a VHF distribution system. Davis will lecture on circuit logic and digital instrumentation.

JEAN DE PRINS is visiting associate professor this year from the University of Brussels, where he is professor of physics, electronics, quantum electronics and graduate courses in masers, and where he organized a laboratory for teaching and research on frequency standards and time measurements. He has constructed a double beam ammonia laser and is doing measurements on the earth rotation speed variations. Research for his doctorate, earned at the University of Neuchatel, was on the NH_3 maser and rotation of the earth. De Prins is author of some thirty technical publications.

W. J. GAMBING is visiting professor for the current academic year from the University of Southampton, England, where he is professor of electronics. Author of more than fifty published technical papers, Gambing's research has been in the fields of gaseous, microwave, and quantum electronics. At Southampton he directs the faculty-student research group in quantum electronics. A British citizen, he earned his doctorate at the University of Liverpool.

LEONARD LEWIN, visiting professor, comes from England, where he is assistant manager of the Transmission Research Laboratory. He is an international authority on certain aspects of electromagnetic theory, particularly in the field of microwaves. Results of his research in waveguides, waveguide components, and microwave systems, have been published in over forty articles and books; best known is *Advanced Theory of Waveguides*. Lewin has taken an active part in solid state developments applicable to the microwave part of the spectrum and recently received the IEEE microwave prize for the best published paper of the year on electromagnetic theory in waveguides.

KWANG-HONG PAI, visiting assistant professor, comes to the department as a research fellow sponsored by the National Council on Science Development of the Republic of China. He is professor of electrical

engineering at National Taiwan University. Pai is a senior member of the Japanese Institute of Electrical Communication Engineers.

ENGINEERING DESIGN AND ECONOMIC EVALUATION

PHILLIP F. OSTWALD, assistant professor, comes from Oklahoma State University School of Industrial Engineering and Management where he taught undergraduate and graduate courses in industrial engineering. He has been a methods engineer and a time study engineer for radio fabrication and machine tool firms. During the past summer he was associated with the IBM plant in Boulder arranging engineering courses in an on-the-job education program for IBM engineers, physicists and mathematicians. Ostwald's special interests are in production engineering, engineering management, operations research, process engineering.

CHUNG HA SUH, instructor, comes from a teaching assistantship at the University of California, where he obtained his doctorate and where he taught machine design, engineering graphics, nomography, kinematics and dynamics of machinery. Suh is a graduate of Seoul National University, Korea, and has been chief of the Mechanical Engineering department at the Atomic Energy Research Institute of Korea.

MATHEMATICS

HENRY G. HERMES, associate professor, has for the past three years worked in the field of mathematical theory of optimal control, most recently on an optimum trajectory study, with NASA funds, for the Martin Company. He was assistant professor of mathematics at Brown University for two years, where he was a member of the Center for Dynamical Systems and the Research Institute for Advanced Study. Hermes has been a SIAM visiting lecturer to the University of British Columbia, and associate editor of the SIAM journal on control.

CALVIN C. BUTLER, assistant professor, has been a graduate fellow under a grant from the National Institute of Health at Colorado State University, where he was a research assistant and instructor in the physics laboratory. Butler's major interests are in the fields of physics, atmospheric science, and statistics.

ROBERT K. GOODRICH, assistant professor, completes two years of study as a National Science Foundation fellow for the Ph.D. degree, which he received from the University of Utah. As a specialist in functional analysis, his research has been on the equivalence of the Riesz representation theorem and the Hansdorff moment problem in the setting of topological vector spaces.

TERENCE J. REED, assistant professor, comes from an instructorship at the University of Minnesota, where he earned his doctorate with a study of quasiconformal mappings with given boundary values. He is a member of the American Mathematical Society and the Mathematical Association of America.

DONALD R. SNOW, assistant professor, also from the University of Minnesota, was a postdoctoral research fellow in the mathematics department and the Control Sciences

Center there. He holds a master's degree in mechanical engineering and has centered his research on the problems of optimal control treated by the methods of the calculus of variations. Snow has worked in the Lockheed research laboratory and in the Stanford Computation Center.

KARL H. USOW, assistant professor, was recently awarded the first Ph.D. degree granted by the Department of Computer Science at Purdue. His investigations in the field of approximation theory, with emphasis on computer oriented numerical techniques, combined special interests in numerical analysis and mechanical engineering. He has worked for General Motors and as project engineer for the U.S. Army Engineering Research and Development Laboratories at Fort Belvoir, Virginia.

ENGLISH IN ENGINEERING

JAN PINKERTON, lecturer, was for three years a teaching fellow at

Harvard, and more recently instructor of English at Hollins College. Mrs. Pinkerton's field of interest is American literature.

DONALD R. KING, instructor, a teaching assistant at the University of Colorado a few years ago, has since been a teaching assistant and instructor at the University of New Mexico, where he has been working toward his Ph.D. degree. King's field of interest is the Romantic period of English literature.

MECHANICAL ENGINEERING

SURESH T. GULATI, instructor, is a graduate of the University of Bombay and the Illinois Institute of Technology, and has been a teaching assistant in the department. His background is in the fields of dynamics, mathematics, stress analysis, and fluid mechanics.



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CRYPTIC AFRICANUS

DAVID LAWRENCE

"Cheerio, boys. Been working hard?"

Uncle Percy strode into our lab, still suntanned from his African adventures. My brother and I were surprised, to say the least, for his safari has been long overdue, and the authorities in Africa had assumed that he and his party were dead. Naturally, we had to hear his story.

"It's a long tale, boys, so I won't bore you with all the details. Suffice it to say that our guide, myself, and my colleague Aloysius were deep in the African jungles, searching for the ruins of a long-lost culture of mathematicians rumored to have lived there thousands of years ago.

"We had found nothing for days on end, although we were searching the area where legend said the culture had lived. This was not too surpris-

ing, for the jungle was so dense that we could have walked fifty feet from a city and not seen it through the foliage. Our spirits were dampened by the lack of results.

"We were heartened, however, when we found a stone pillar overgrown with jungle foliage. It was about five feet high, with no markings we could discover—but it was definitely man-made. We hoped that it was connected with the old culture, and we searched the surrounding jungle for a half day until Aloysius found another pillar about 300 paces from the first, deeper in the jungle.

"And there we were—three men and two enigmatic pillars in the midst of a green maze. We had nothing else to work from, so we followed the line determined by the two pillars, in the hope that they pointed the way to some relic of the old culture.

"The next pillar was 900 paces farther, and after that came one 600 paces on. According to our compass, all the pillars lay in a straight line, so we hurried on.

"For two days we followed the line of pillars. There seemed to be no rhyme or reason to their distances from each other, except that they were always in integral multiples of 300 paces apart. They lay in no progression that we could discover, for the distances between them varied irregularly. The more we thought about them, the more puzzled we became.

"At last we came to a pillar which was 150 paces from its neighbor. Astonished, we repaced the distance and found that it was correct. I sat down for a minute to consider this strange new fact, and at last the explanation hit me.



"Gentlemen," I said, "The object of our search lies 300 paces ahead of us!"

"We followed our course and found the ruins of an old temple 300 paces ahead, where I had predicted."

"You boys like mathematical puzzles. Remembering that the old culture was a mathematical one, and it probably believed in the magical properties of numbers, tell me what the principle of placement of the pillars was."

(I am passing the puzzle on to you. It requires no calculations to solve, only insight. It is the hardest of this set. DL)

"The jungle had pulled down most of the temple, but we could see the raised form of an altar there, with a gold table standing in a cleared space at its center. After determining that the inscriptions on the table related to celestial mechanics, Aloysius and I turned our attention to the remains of the walls.

"When we scraped the jungle vegetation from the walls, we could make out writings on them. Aloysius was familiar with the language in which they were written, and he translated for me. On one wall was a group of writing headed by the statement $a^n + b^n \neq c^n$. My gosh, I thought. Fermat's theorem, the bugbear of Western number theoreticians, the ultimate in mathematical puzzles, solved thousands of years ago by a tribe of natives . . . but the first step of the proof was all that remained. The rest of the wall had fallen away. Ah, well. We need a few impractical problems to occupy us these days.

"Aloysius and I had moved to another wall where we were engrossed in a proof of the five-color theorem when our guide broke a jewel-encrusted leg from the gold table and ran off into the jungle. That something was amiss, however, became apparent when a group of natives burst in upon us, trussed us up, and took us to another clearing where our treacherous guide was tied to a large wooden stake. We received the same treatment. Evidently these natives had adopted the worship of the old number temple, instead of its ideas, and we had committed a sacrilege in disturbing it. At any rate, the natives were angry.



"The firewood they were piling at our feet didn't bother us as much as the heaps of mushrooms, probably barbecue spices, they brought from the jungle. Our guide, lowering himself to the natives' level, said 'Oh, no. Burned at the stake, smothered in mushrooms!'"

"The poor devil. They killed him immediately. I knew then that Aloysius and I would have to work quickly to preserve our lives. I freed my arms from their bonds, whipped off my belt, put a half-twist in it, fastened it together, and told Aloysius what to say to the natives. I held the belt high as he made his speech.

"In our country," he said, "It is a sin to kill a man before the proper preparations have been made. The gods will be angry if you do not do one simple thing before you burn us—paint one side of this belt ceremonial red, and the other side ceremonial blue."

"While they were occupied at our task, I freed myself and Aloysius and we made good our escape into the jungle. They, unlettered savages that they were, remained engrossed in the task we had set them, and our escape went unnoticed until too late.

(Why? Another puzzle for you. DL)

"How we survived, what adventures we had, and how we eventually made our way back to civilization make too long a story for now. I will tell you about one curious problem we came across, however.

"At one point in our journey, we were nearly dead from thirst when we saw a group of trees in the distance. On that open plain, trees meant water, and we staggered towards them. As we approached, we saw that the trees grew in the form of a square, 200 feet on a side, with a tree at each corner. Alas, there was a lion shading himself under each tree, and the noise of our coming made them all stand up. Luckily for us, it was mating season, and their male pride overcame their hunger, for as each lion looked about, he saw the lion in a clockwise direction from himself, and each lion began running towards the lion he saw. Of course, they all collided in the middle of the square and we were able to visit the spring nearby and leave before they recovered.

"That episode gave us a puzzle to sustain us on many of the long, dry miles after. It is, how far did each lion run?"

(Answers to the African puzzles in the January Engineer. DL)

FALL 1966 HONORARY PLEDGES

TAU BETA PI

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Bebbee, Gary, A.E. & Bus.
Byrne, Warren, E.E.
Chiddister, Bruce, E.D.E.E.
Ehrlich, Steve, E. Phys.
Eiklid, Gunnar, C.E.

Name — Department

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Gibson, George H., E.E.
Hasund, Svein, M.E.
Johns, Vernon M., E.E.
Johnson, Richard A., E.E.
Miller, Max I., Grad. E.E.
Montelillie, Arthur, Undec.
Morehead, Joe, A.E.
Podolsky, Donaul M., A.E.

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Bender, Gary L., A.E.
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Bougar T. Factor, Chairman
Committee of the International
Society of Philosophical
Engineers

(Suitable for Framing)

It's a good system if you like it

There are slots.
Slots need people to fill them.
Someone exists who was born and educated to fill each slot.
Find him. Drop him in. Tell him how lucky he is.
Look in once in a while to make sure he still fits his slot.

This orderly concept has much to commend it, plus one fault: some of the people most worth finding don't like it. Some very fine employers have not yet discovered the fault. It is not up to us to point it out to them. Luckily for us, we needn't be so tightly bound to the slot system.

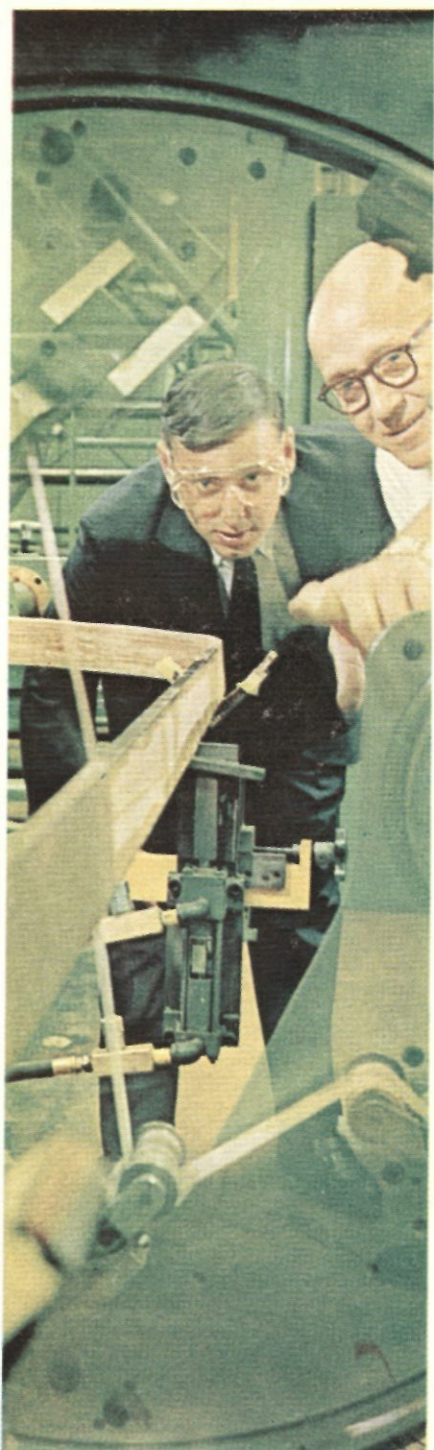
We can offer *choice*. A certain combination of the factors diversification, size, centralization, and corporate philosophy makes it feasible to offer so much choice.

Choice at the outset. Choice later on. Choice between quiet persistence and the bold risks of the insistent innovator. Choice between theory and practice. Choice between work in the North and South. Choice between work wanted by the government and work wanted directly by families, by business, by education, by medicine, by science. To the extent that the slot idea helps channel choice we use it, of course.

A corporation such as this is one means of coordinating the strength of large numbers of effective persons. You may feel that in the years ahead this type of organization must change. You may feel that it must not change. Either way, to get a chance to steer you have to come on board.

Advice to electrical engineers, mechanical engineers, chemical engineers, chemists, and physicists—still on campus or as much as ten years past the academic procession: while one starts by filling a slot, it soon proves more fun to make one. No detailed list of openings appended herewith. Next week it would be different. G. C. Durkin is Director of Business and Technical Personnel, Eastman Kodak Company, Rochester, N. Y. 14650.

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