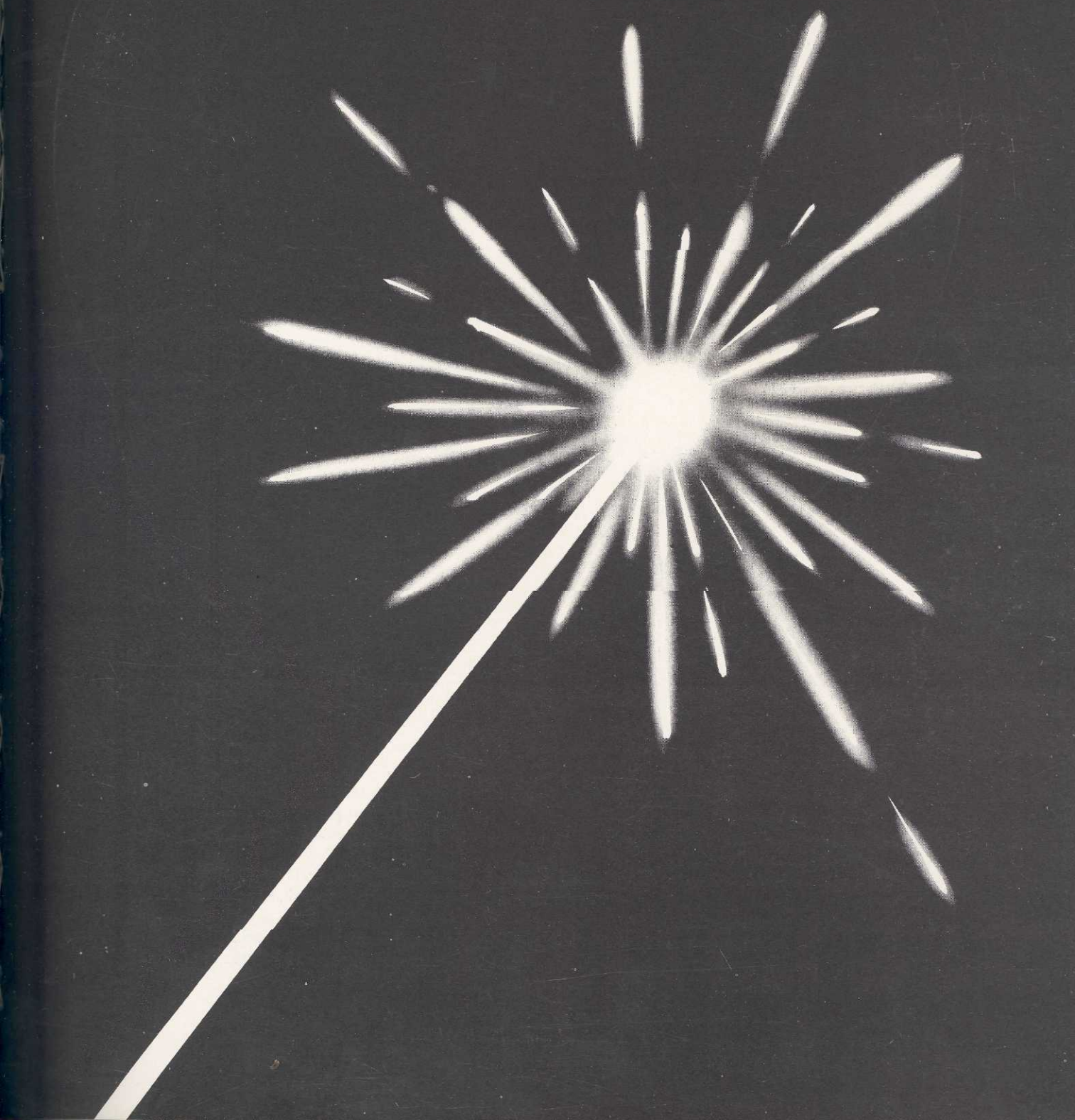
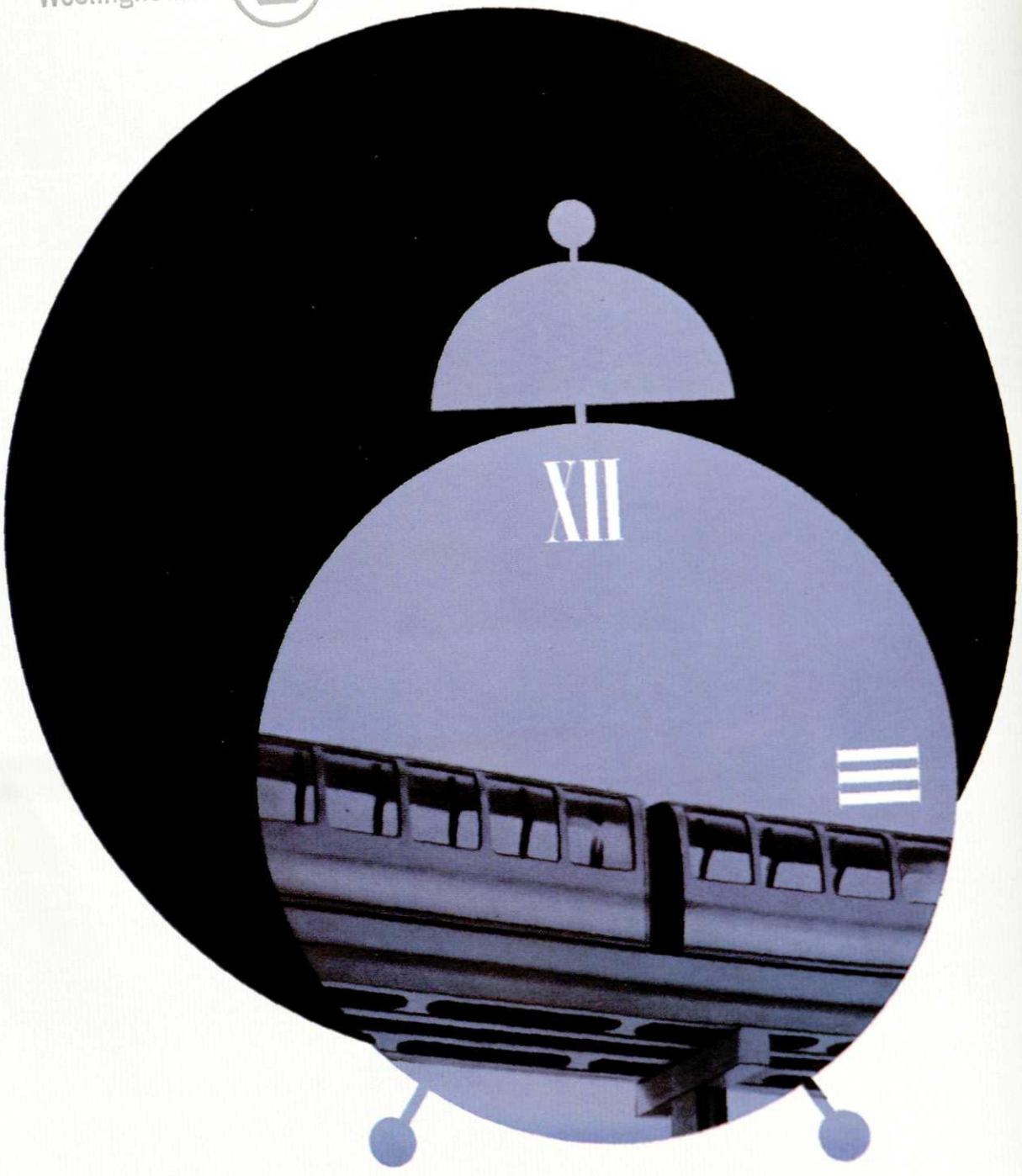
january, 1964

25¢

spartan ENGINEER



Westinghouse



Even at 3 in the morning... commuter service every 2 minutes

Urban planners figure the only way to solve the big-city traffic jams is to develop some method of mass transit that will be so frequent, so fast, so convenient that people will turn to it as their No. 1 choice, as they did years ago. The key to this kind of rider convenience is a computer-controlled system.

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For information on a career at Westinghouse, an equal opportunity employer, write to L. H. Noggle, Westinghouse Educational Dept., Pittsburgh 21, Pa.

If I join the Timken Company after graduation, what will they do for me?

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And yet, we think it has some validity. After all, a man's growth can depend as much on the company he works for as the company's growth depends on the man (remember, there are no statues to committees).

So to invest in your growth, and ours, every young graduate engineer who joins the Timken Company spends from one to four years in one of 22 individualized training programs.

Extensive training

Instruction takes place on the job and in training sessions. Later there are executive development programs at leading universities.

But don't misunderstand us. The Timken Company is not a graduate school. With us, you earn as you learn.

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We serve markets in 119 countries from 14 manufacturing plants located in Australia, Brazil, Canada, England, France, South Africa and the U.S. And we're still growing strong.

If you are, too, we'd like to hear from you. Write to Department MC for Career booklet.

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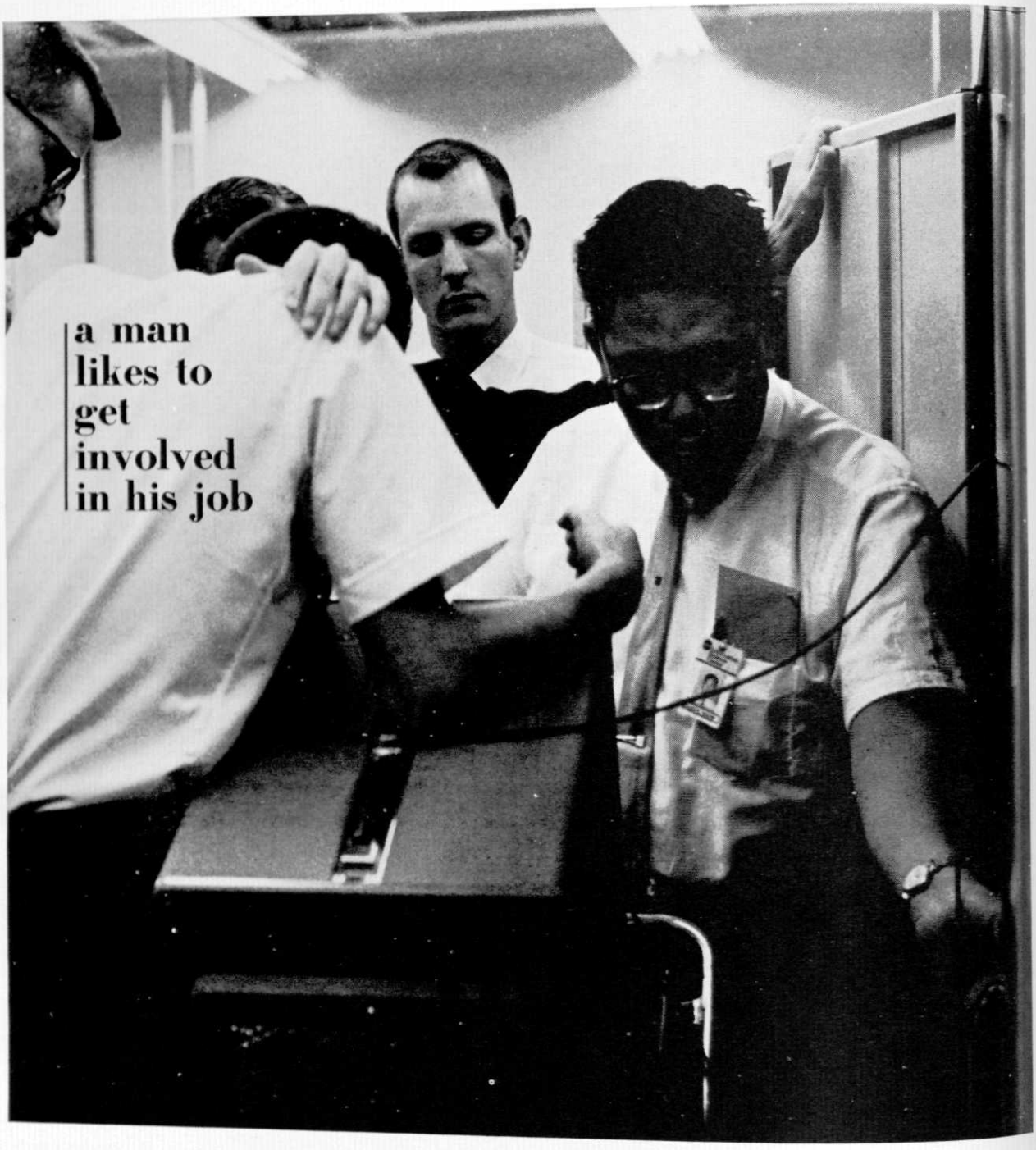

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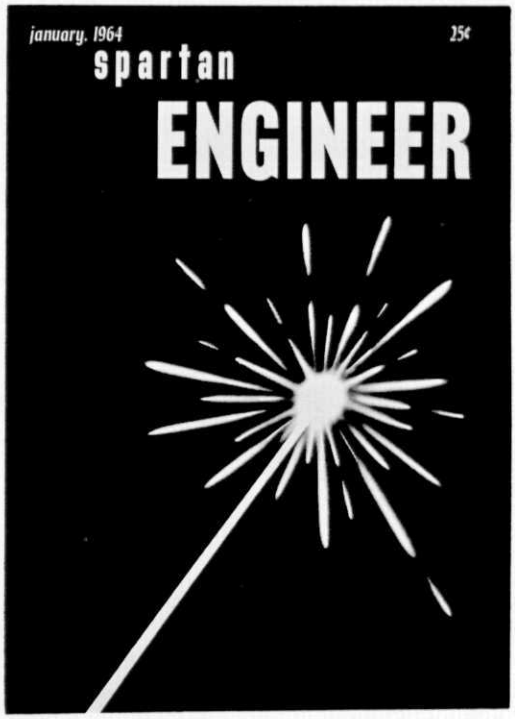
Volume 17 NO. 2 January, 1964



The January cover is an abstract entitled "A Beam of Light".

Member, Engineering College Magazine Associated
Chairman: Professor J. Gale Chumley, Louisiana Polytech Institute, Ruston, Louisiana

* *

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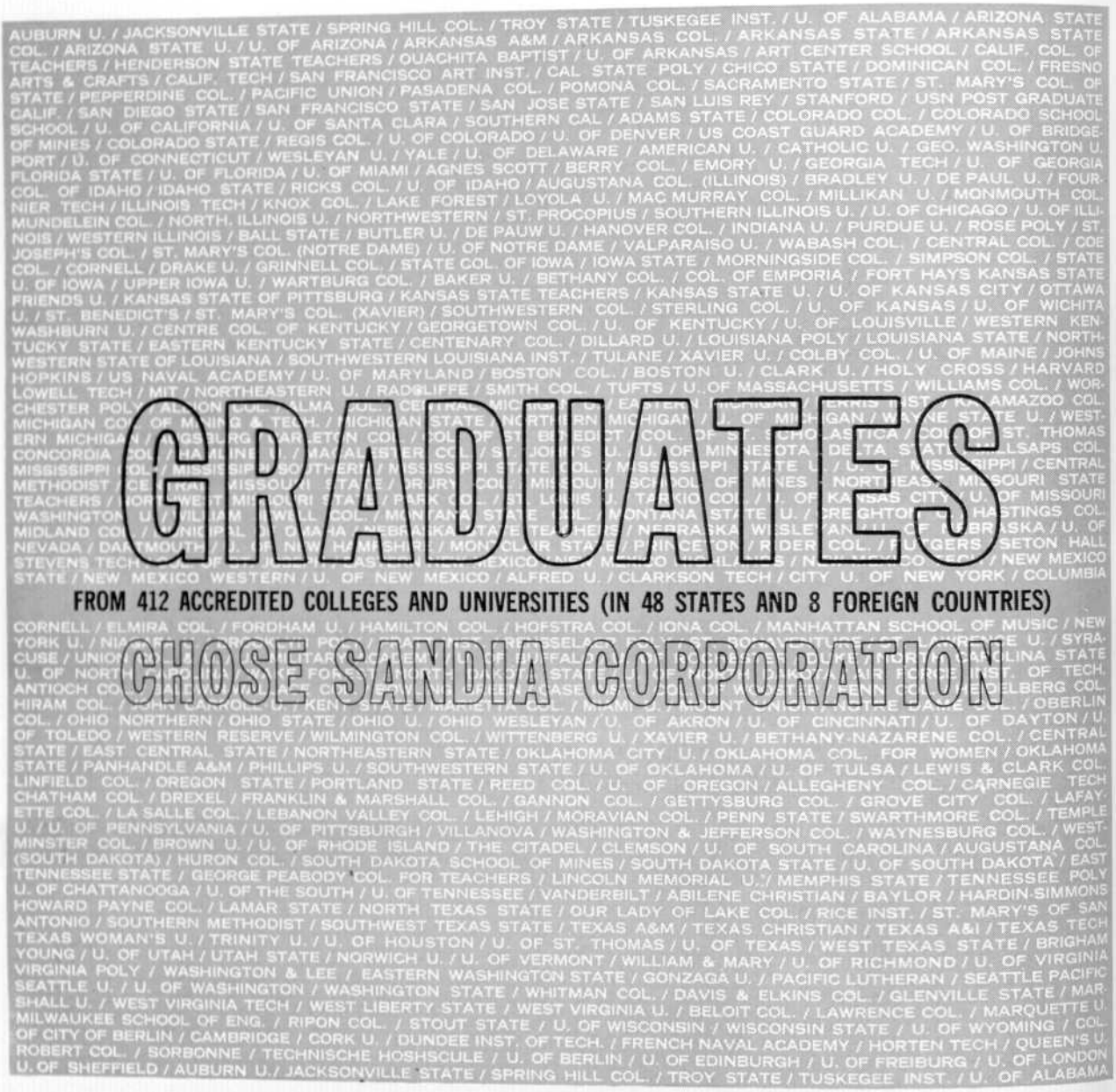

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- Sandia is engaged in research and development on ordnance phases of nuclear weapon design.
- Sandia scientists and engineers are doing related work in fields such as solid state physics, plasma physics, materials research, explosives technology, pulse phenomena, radiation damage, systems and component design, and test and development.
- Our $140 million laboratory offers the latest in scientific equipment.
- Sandia as a subsidiary of the Bell System draws upon the technical and industrial know-how of Western Electric, the Bell Telephone Laboratories, and other organizations within the System.

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If you are graduating with outstanding scholastic achievement in engineering or the physical sciences, the Sandia Corporation would like to arrange an interview.

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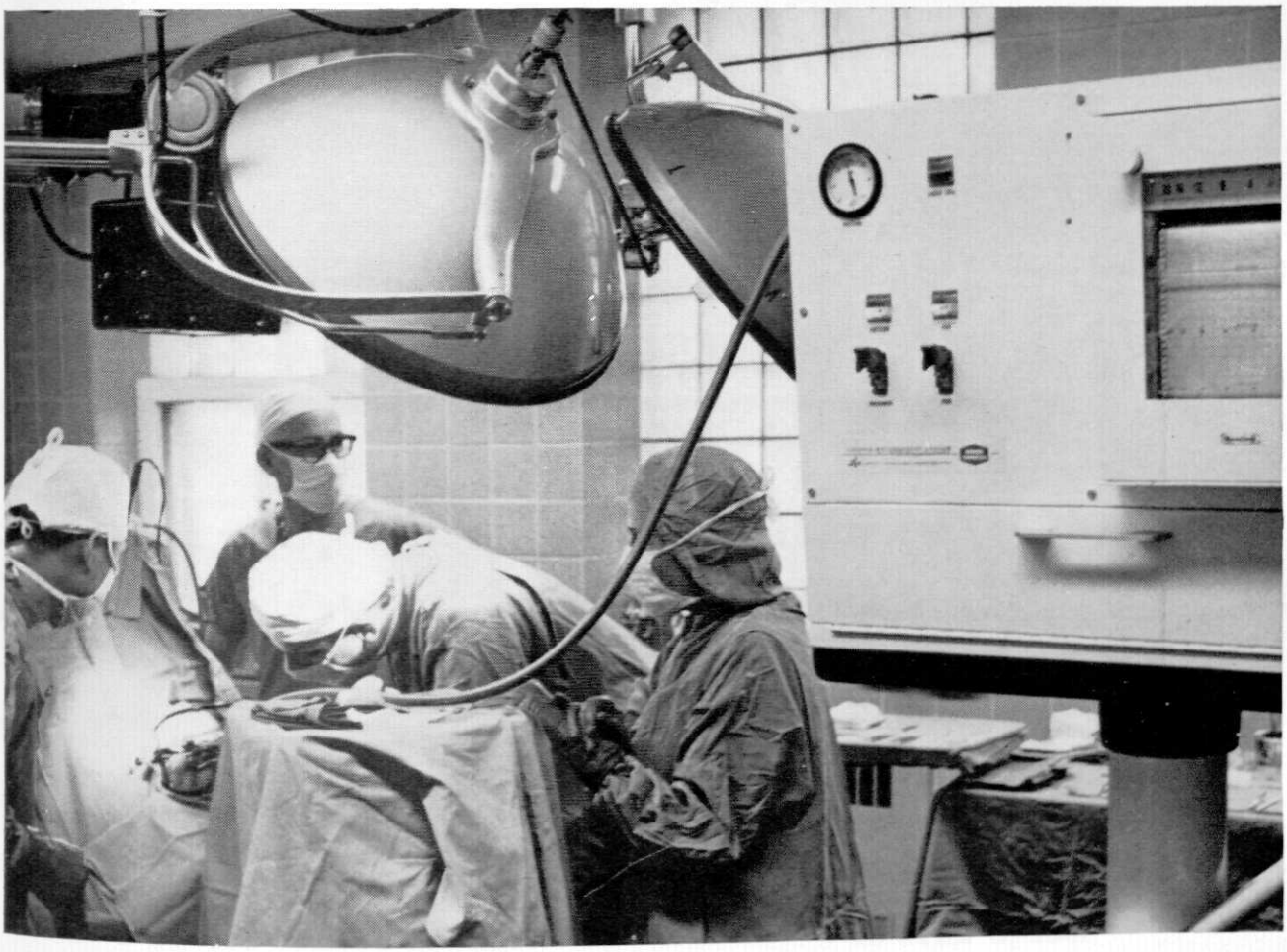

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For information, write Recruiting Department, Union Carbide Corporation, Linde Division, 270 Park Avenue, New York, N. Y. 10017.

A Linde assignment poses a challenge

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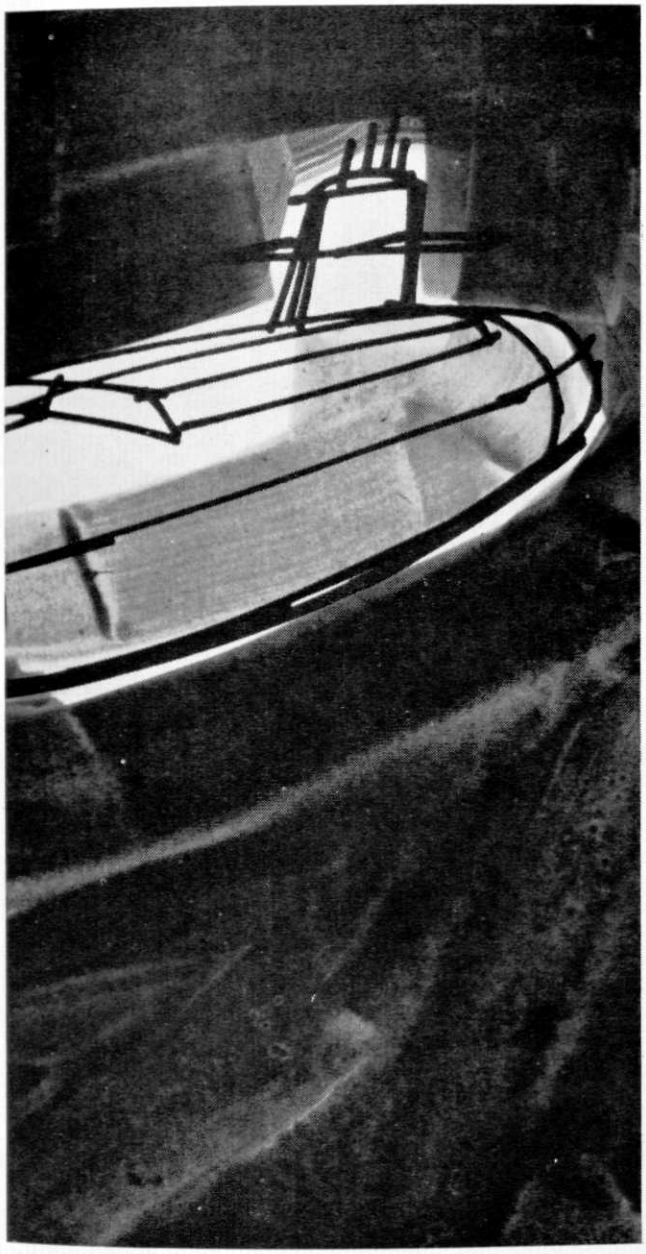

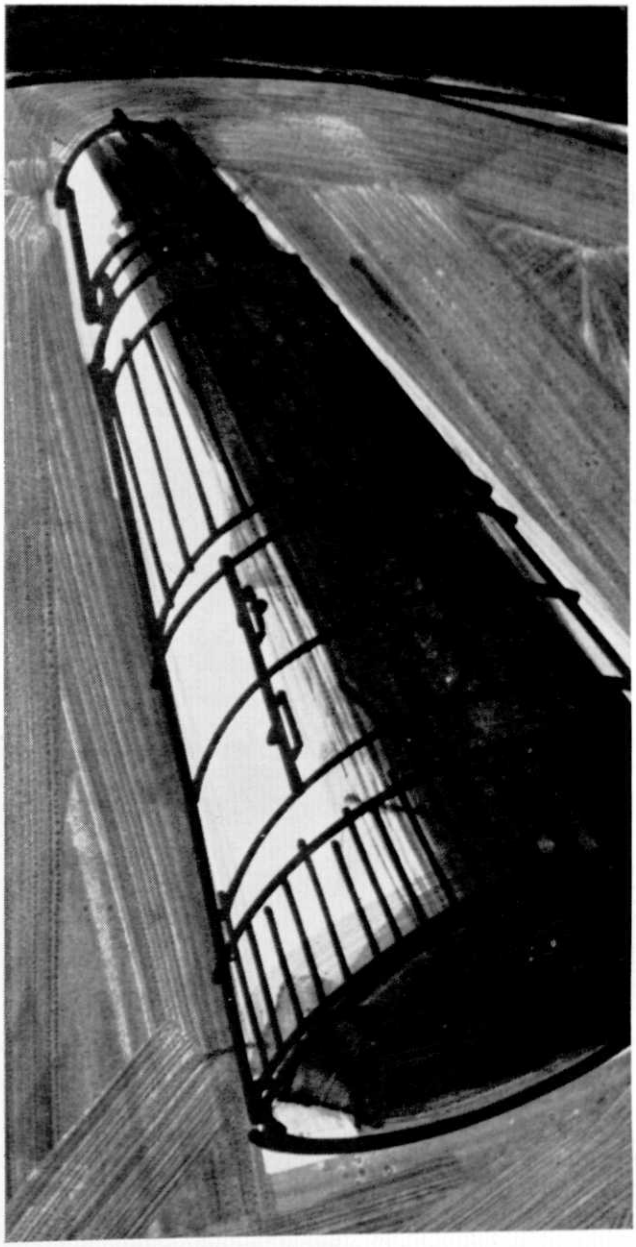

From the ocean's depths

to outer space.

The scope of projects under development at the Bendix Corporation ranges from advanced oceanics to a landing gear for lunar surface vehicles and countless things in between. College graduates find depth of technological challenge in their assignments, whether it be in the space, missile, aviation, electronics, automotive, oceanics or automation fields. Bendix employs top-notch engineers, physicists, and mathematicians at all degree levels. They enjoy the prestige of Bendix achievement and challenge.

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CREATIVE ENGINEERING FOR: SPACE □ MISSILES □ AVIATION □ AUTOMOTIVE □ OCEANICS □ AUTOMATION

Yep, I'm one of those guys too!

This is the phase of the term during which many of us have a strong desire to relax and ride along. We are not threatened with many tests and we have not learned enough to prompt extra study hours.

This attitude will lead to failure.

Even if the instructor has no formal tests to give you, it is a wise man who prepares his own. Through the use of these "personal tests," the student will quickly realize the large amount of knowledge that has already been presented and will begin an awareness of how much has passed him by. Perhaps we have not learned enough!

The usual course of students is to relax now and wait for mid-terms. When they come, he feels he does not know anything anyway, so why study? Having done rather poorly on the mid-term exams, he begins an all-night effort to catch up. This lasts one night. He promptly lapses into the phase of not worrying. When the finals appear, he once again does poorly and sometimes flunks the course.

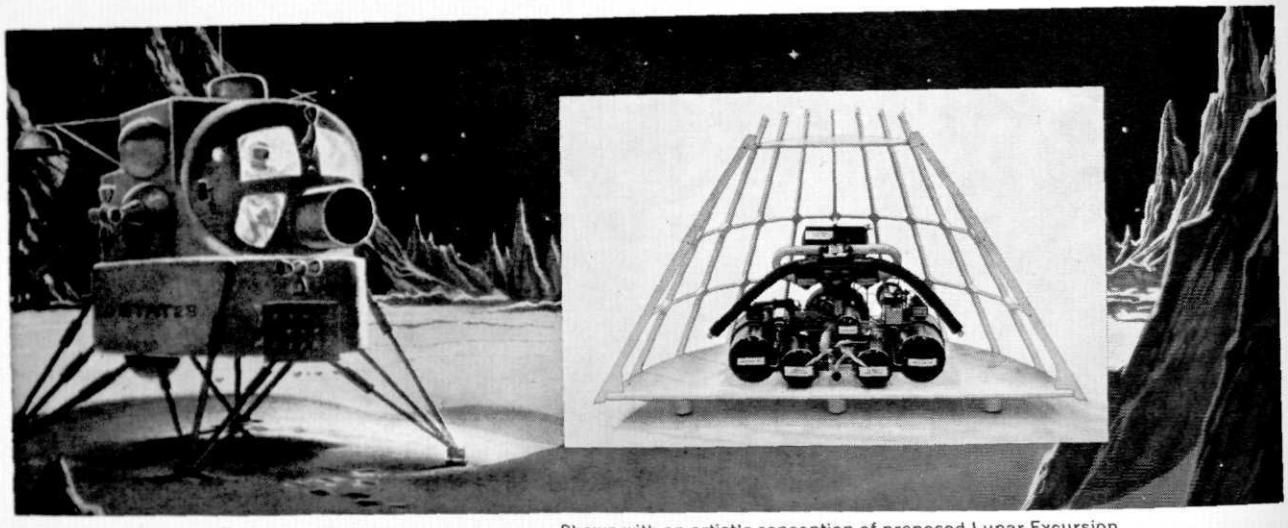
Why follow this sorry course of events and attitude? Now is the time to put in the extra hours so that when the exams come up, you have a firm base of knowledge from which to work. This constant effort will surely lead to the "B" which is dreamed of or even to the "A" which is forgotten.

John B. Locke

Continuing Construction on
New Science Complex at MSU.

WHAT YOU COULD BE ENGINEERING AT

Hamilton Standard



Shown with an artist's conception of proposed Lunar Excursion Module, a mockup of a typical spacecraft Environmental Control System currently under development at Hamilton Standard.

One possible assignment: participate in the advanced development program to produce the environmental control system for the Lunar Excursion Module. Utilize your training in:

heat transfer
thermodynamics
control dynamics (flow, temperature, pressure)
fluid dynamics
atmospheric supply for human life
contamination control for human life

to develop a regenerable system to provide for life support on long-duration space flights.

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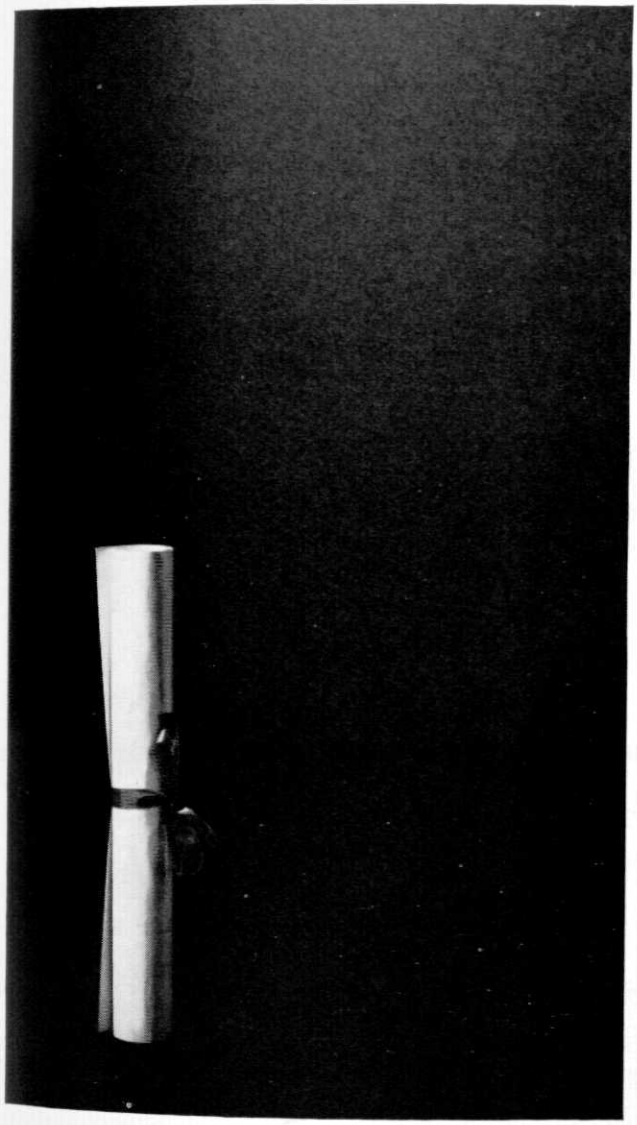

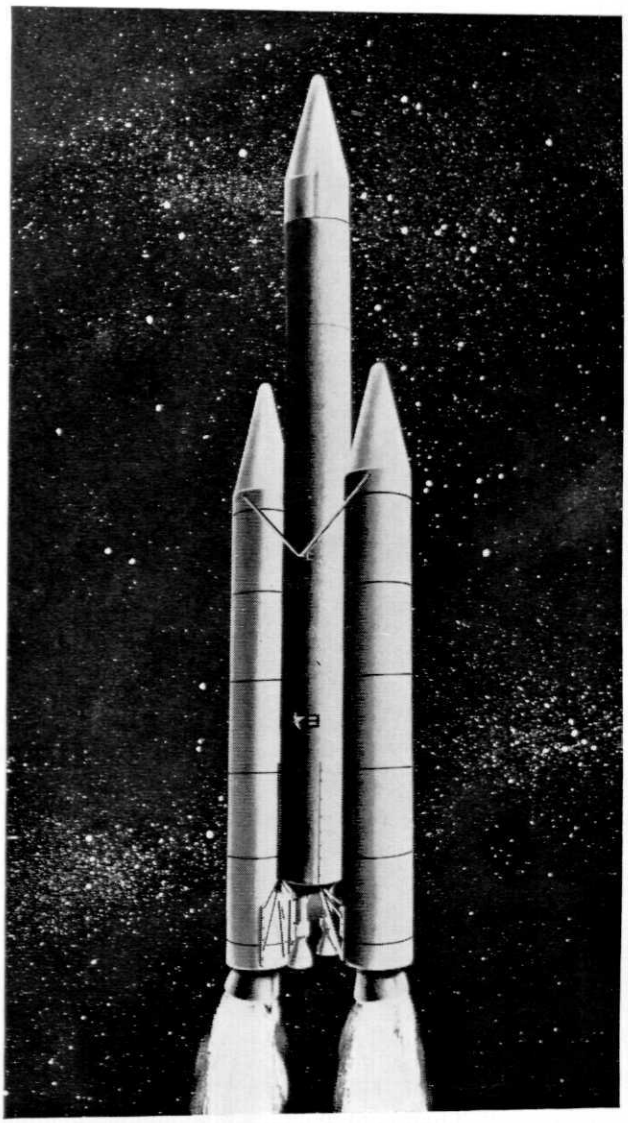

This could be the start of something . . . BIG!

If you are completing your BS or MS degree in EE, ME or Physics, AC-Milwaukee's "Career Acceleration Program" is the perfect way to launch an exciting career . . . and keep it moving! You will work on important inertial guidance and navigational system projects for Titan II and III, the Apollo Navigation-Guidance System, B-52C&D Bombing-Navigation Systems and other guidance and navigation projects for space vehicles, missiles and aircraft.

In AC's "Career Acceleration Program," you will spend one hour daily in formal class work, the remaining seven hours on a specific project. Courses include: ADVANCED THERMODYNAMICS, INERTIAL INSTRUMENTS, DIGITAL COMPUTERS, GUIDANCE EQUATIONS, BASIC ASTRONOMY, TELEMETRY and DATA ANALYSIS, plus mathematics and undergraduate disciplines, as required.

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For further information on AC's "Career Acceleration Program," contact your placement office or write Mr. G. F. Raasch, Director of Scientific & Professional Employment, Dept. 5753, AC Spark Plug Division, General Motors Corporation, Milwaukee 1, Wisconsin.

PhDs, please note: Positions are available in all three AC locations for PhDs, depending on concentration of study and area of interest. You are invited to contact Mr. Raasch for further information.

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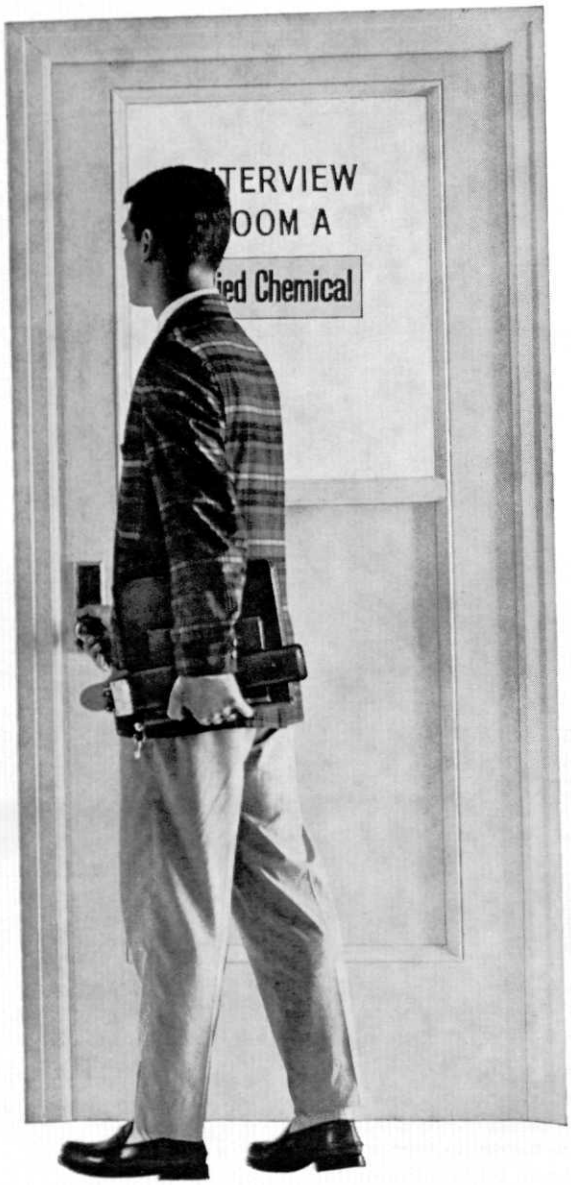

Come in–and bring your career questions

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From Phend

One of the greatest experiences one can have is to feel his thoughts flowing through channels of logic and grasping an idea, or with sudden insight, overrunning the defenses of a problem. To find order in a seemingly heterogeneous mixture of ideas is of exceptional value to the mind which appreciates the beauty of logic. It is an experience which a mature person will seek again and again, for he understands that each time it is felt he will mature even more. It is a rewarding experience because his mind has felt the impact of truth, and he understands this truth because the reasoning of his mind has established it.

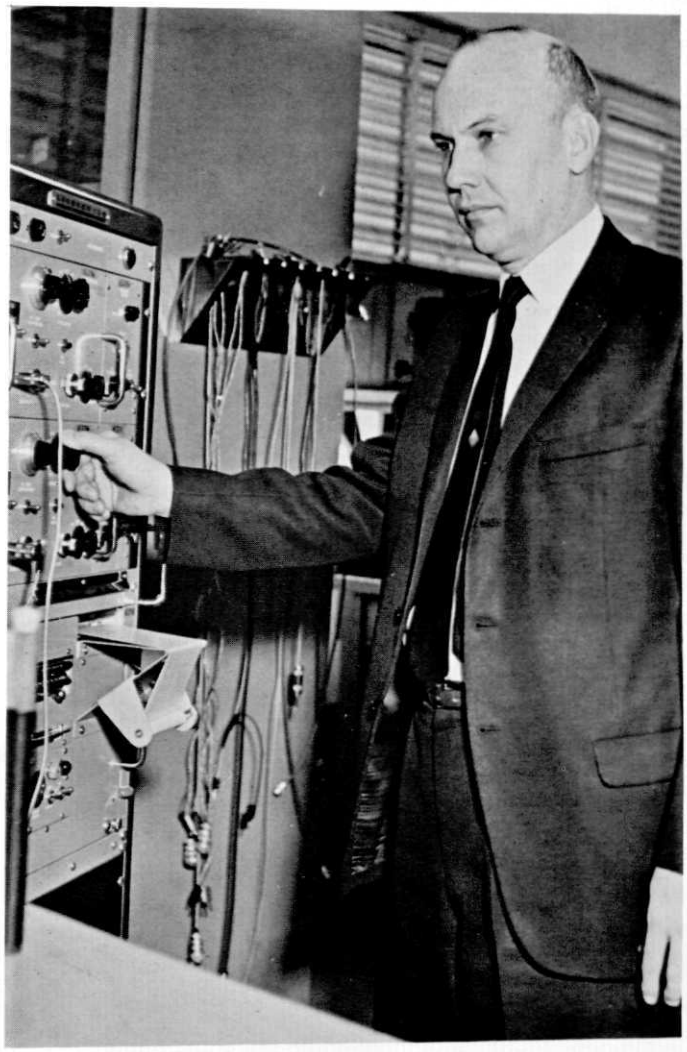
Reason was given us in order to discover truth. The discovery of truth alone would seem to be sufficient motivation for the use of reason, but it is not the only reward. The greater reward is the feeling of satisfaction that comes only when a man uses his abilities to overcome a challenge that is before him. Some men spend the greater part of their lives searching for this particular reward. No one who has ever found this satisfaction will wait long before seeking it again, perhaps under new circumstances.

When insight comes to a person, he understands what confronts him and what he must do about it. Often a sudden order and organization of thoughts will follow laborious moments of trial and error. The electrical engineer who envisions the design of a system is not so far removed from the freshman who discovers how to work a math problem. Each has to apply his abilities to the situation, and each feels the satisfaction of accomplishment.

Once insight comes to a man, however briefly, and he senses truth, he feels the need to pursue it. He becomes an individual searching for truth, first because he understands that he has the ability to find it, and second because he senses that when he does find it he will receive personal satisfaction. One who gains nothing from the university other than the experience of feeling his thoughts fall together in a logical order is a highly educated person.

FACULTY REVUE

by Phillip Kraushar



Dr. Herman E. Koenig

This issue brings us another of the men responsible for creating MSU's well-known Pilot Program: Dr. Herman E. Koenig, former chairman of the curriculum committee.

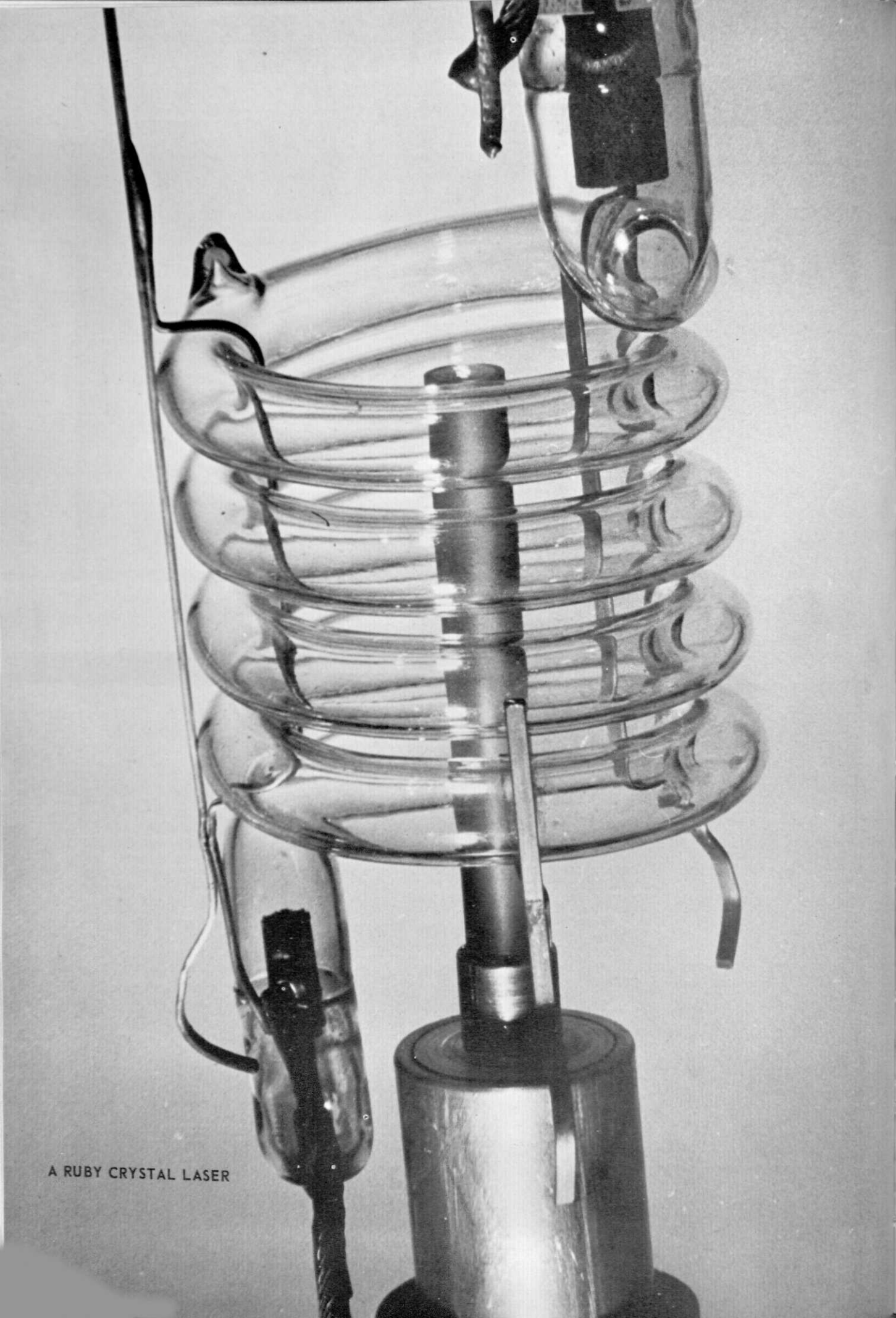
Dr. Koenig began his career in E.E. as an undergraduate at the University of Illinois in 1944. By 1953, he had received his B.S., spent a year with Delco Products, Division of General Motors, and earned his M.S. and his Ph.D. in Electrical Engineering at the University of Illinois. As a result of his Ph.D. thesis and early research work he was invited to join the "Energy Conversion Program" at Massachusetts Institute of Technology (1954-55) He returned to Illinois as an Assistant Professor for two years, before accepting an appointment as Associate Professor of Electrical Engineering at MSU. In 1959, Dr. Koenig was promoted to Professor of Electrical Engineering at Michigan State University.

In addition to his teaching and research activities, Dr. Koenig served as a consultant with Reliance Electric and Engineering Company from 1952 to 1956 and is currently a consultant for Leer-Sigler Co.

Dr. Koenig's interests are directed primarily in the area of the design and synthesis of physical systems. In this area he has written many technical articles and (with Professor W. A. Blackwell) a book, "Electro-mechanical Systems Theory," McGraw-Hill Book Company, Inc., 1961. This book presents a concept which is applicable to all kinds of physical systems made up of discrete components, not only electrical and electronic, but also hydraulic and mechanical, stratic structures, and others. Doctors Koenig and Blackwell developed the concepts and methods needed to formulate mathematical models of these many types of systems from the component models and their interconnections.

In addition to this work, Dr. Koenig helped establish a new curriculum, Systems Engineering, in the Department of Electrical Engineering at MSU. In the Pilot Program, he chaired the committee which integrated such traditional courses as electrical machinery, electrical networks, statics and dynamics, control systems, and electronic circuits into a unified discipline designed to give the undergraduate electrical engineering student a background in the general area of physical systems.

The results of these programs have added to a growing interest in new developments in engineering education.



A RUBY CRYSTAL LASER

A BEAM OF LIGHT

By John B. Locke

Conceive a beam of light. Aim a flash of it at an attacking missile and destroy it with the speed of light. Aim it at a person and perform delicate surgery. Focus this beam at a receiver far away and transmit many times the world's need of telephone, T.V. and radio messages.

You have conceived a laser.

Dr. Herbert Trotter Jr., chairman of the board of General Telephone and Electronics Laboratories, Inc., of New York, demonstrated and explained the operation and practical applications of the laser (rhymes with razor) to a symposium of MSU electrical engineering graduate students and faculty members.

With the use of Dr. Trotter's information, we shall partake a detailed explanation of the ruby laser (light amplification by stimulated emission of radiation). Let us begin with a review of some related physics and the quantum theory.

All matter is made of atoms. An atom consists of a nucleus and electrons in orbit about it. According to the quantum theory, the orbits or energy levels may exist only at specific distances from the nucleus, with none between. The farther out the orbit appears, the higher the energy level of the electron and the closer to the nucleus, the smaller the amount of energy.

An electron must absorb energy before it may move to a higher level, and, in reverse, the electron will radiate energy when it falls to a lower orbit. In moving to a lower level, an electron will radiate one photon of radiation, which is exactly equal to the energy the electron loses. Thus, if an electron absorbs a photon, it will jump to one higher energy level, thereby moving to the next orbit away from the nucleus. Also, following the spontaneous emission of a photon, the electron will move one orbit closer to the nucleus due to the lowering of the potential energy level of the electron.

In certain substances, another phenomenon is possible which is the basis for the laser. An electron may exist in a semi-stable level, such that when a photon of radiation of exactly the right frequency triggers the electron, it can cause it to fall to a lower level, thereby emitting a photon of radiation identical to, and in phase with, the one that stimulated the emission. Actually, this is an amplification or doubling of the photon radiation energy.

(Continued)

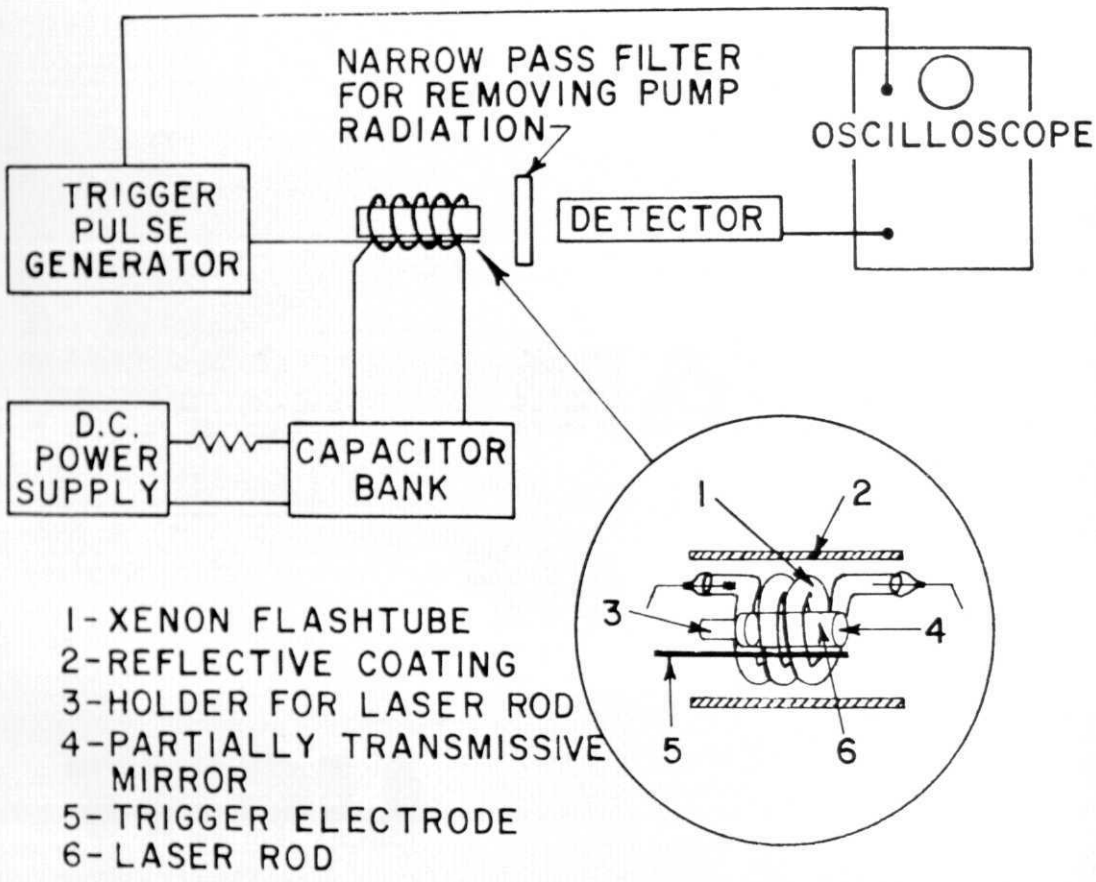


Diagram of apparatus for flash excitation of solid state laser.

A ruby cystal laser, the commonest, utilizes all of these principles. A ruby rod is enclosed by a xenon flash tube. When activated, the flash tube sends energy into the ruby rod. Some of the chromium atoms within the rod absorb some of this energy. An electron of one of these atoms absorbs a photon of radiation and jumps to a higher level. Then, by spontaneous emission, it falls down to a partially stable level, emitting some incoherent radiation. A stimulation then causes the electron to fall back to its original level, emitting a coherent radiation of 6943 Angstrom units. The ends of the ruby rod are polished and partly reflecting, so that as the stimulating photon of radiation passes through the rod it is amplified to some very small extent and then is reflected back through the rod to be amplified some more and so on. Though the amplification may be very small on each passage, the light is traveling back and forth with a speed of 3 x 10 cm. per sec., or 186,000 miles per second. This means that, with respect to time, the amplification becomes very great in a very short period, and the result is a very high energy light pulse output.

Dr. Trotter also explained the nature of coherent light which, in essence, is what the laser was developed to produce.

Incoherent light of the type a light bulb generates, can be broken down into a number of rays or beams. According to the quantum theory, radiation is a large number of individual photons which comprise a beam. Letting a "λ" represent a photon of energy, we can illustrate the nature of incoherent and coherent light.

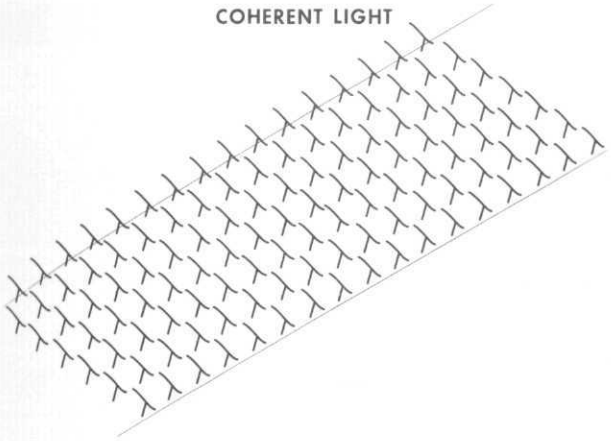
In figure 2 we see a beam of incoherent light with the photons in a disarray and having no order at all. Figure 3 represents a beam of coherent light with the photons in phase and of the same number in each row, which means the intensity and, therefore, the amplitude of the light is constant.

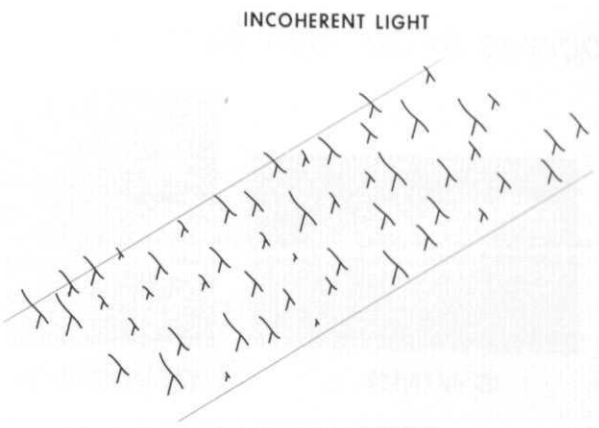
It is easily seen, as Dr. Trotter pointed out, that to modulate incoherent light so it could carry messages, would be impossible. Coherent light such as the laser's, however, can be modulated in three different manners. Amplitude modulation, phase modulation, and frequency modulation of a laser have all been achieved at General Telephone and Electronics Laboratories, Inc. These methods of modulation enable the laser beam to be used as a carrier wave to transmit messages. (See figures)

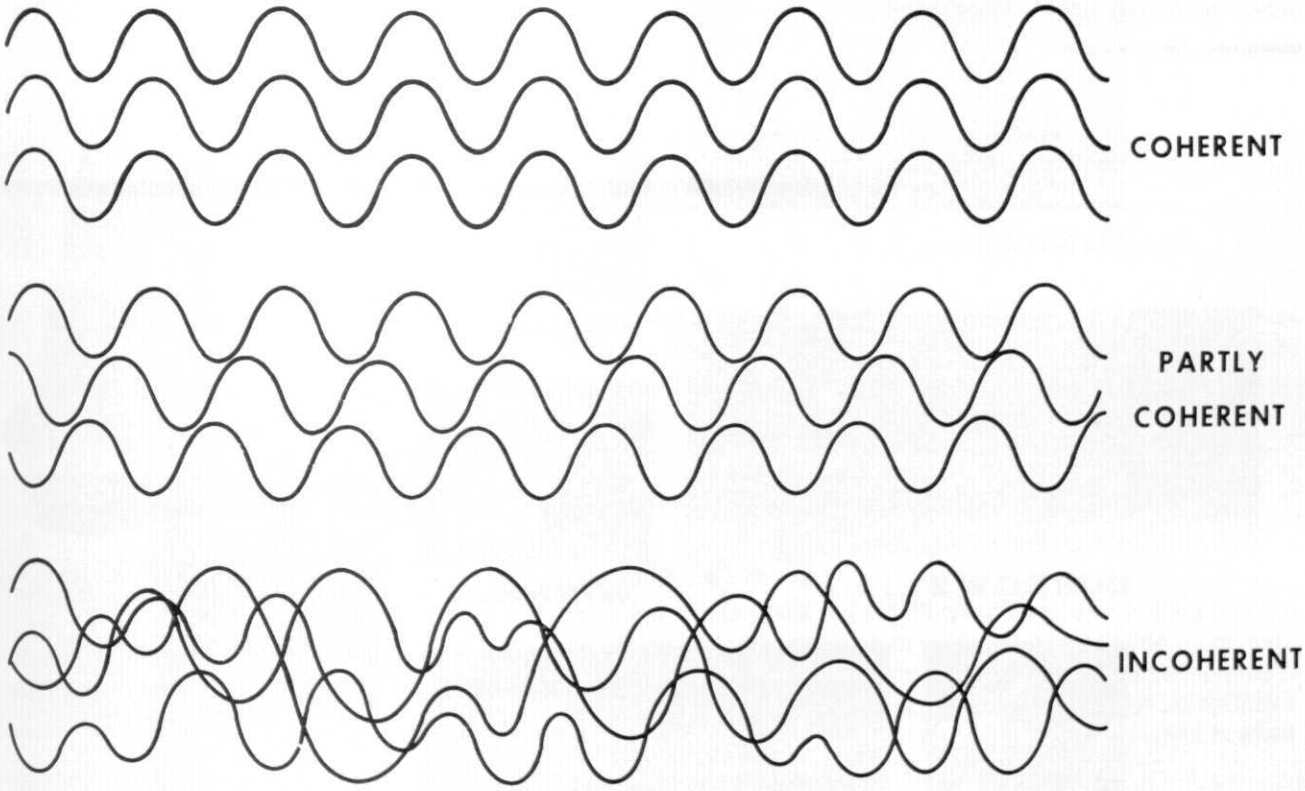
The light waves given off by the laser travel in almost parallel rays. By virtue of this, when a laser beam reached the moon, it would have lost little energy and be only a little more than a mile in diameter. With its ability to carry huge amounts of information, the laser makes terrestrial communications a fantastic possibility.

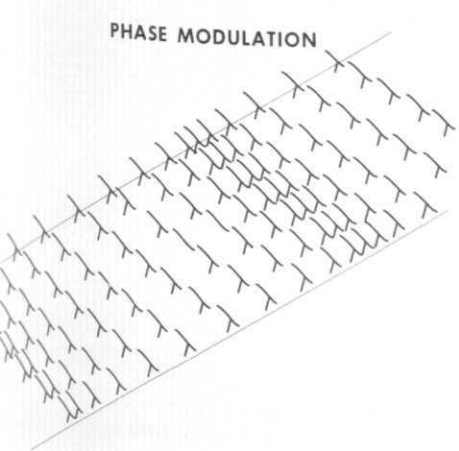
The beam from a ruby laser, lasting only one two-thousandth of a second, can produce a temperature of about 18,000 degrees Fahrenheit upon a minute spot. This means the beam might be used to drill diamonds, strike and destroy enemy missiles and planes, perform delicate surgery, and greatly increase the precision of radar.

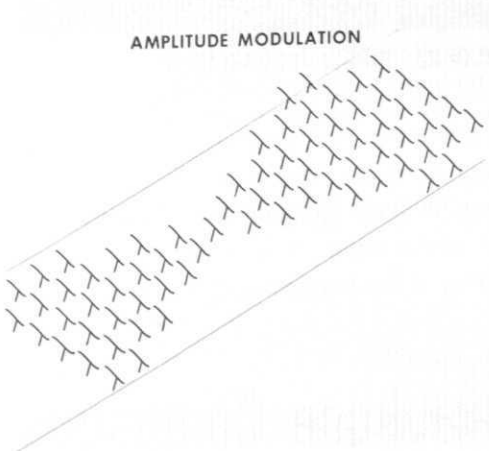
The possibilities for application of a laser are almost beyond realization. Research to find them is rapidly advancing. Many of the devices heretofore science fiction are now becoming reality.

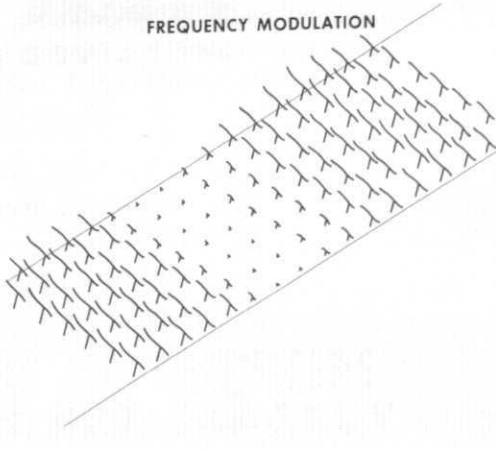

COHERENT LIGHT


INCOHERENT LIGHT


COHERENT
PARTLY
COHERENT
INCOHERENT


PHASE MODULATION

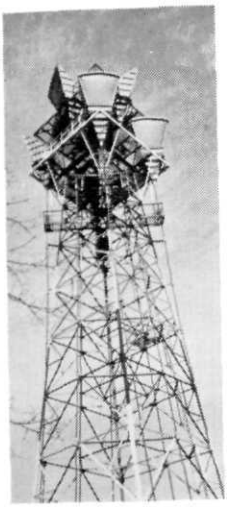

AMPLITUDE MODULATION


FREQUENCY MODULATION

Progress in the Bell System...

SWIMS...

ORBITS...



BEAMS...

FLASHES...

PUSHES...

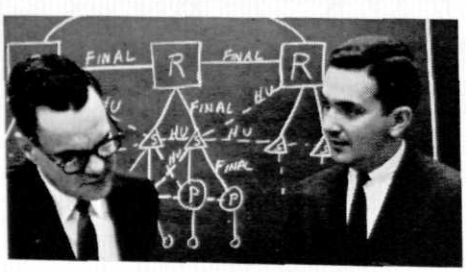
PULSES...

TALKS...

BURROWS...

WINKS...

BLINKS...



AND LIVES AND BREATHES...

Progress takes many shapes in the Bell System. And among the shapers are young men, not unlike yourself, impatient to make things happen for their companies and themselves. There are few places where such restlessness is more welcomed or rewarded than in the fast-growing phone business.

Bell Telephone Companies

ARE YOU INTERESTED IN...

CONSTRUCTION... WATER RESOURCES DEVELOPMENT...

IN THE GEOGRAPHICAL AREA OF YOUR CHOICE WITH THE CORPS OF ENGINEERS

DIVERSITY OF ACTIVITIES

The Corps of Engineers embraces virtually the entire range of modern engineering in the construction field. Projects include research into basic science, engineering investigations and regional planning; design, construction, operations, maintenance, and management of hydroelectric power dams, flood control facilities, harbors and navigable streams; design, construction and maintenance of family housing, runways, hangars, roadways, hospitals, and nuclear power installations; and construction of intercontinental ballistic missile and space launching sites. In addition are the allied fields of cartography, geodesy and engineer intelligence.

OPPORTUNITY

Opportunity is provided for progressive movement toward top positions for men with ability. You learn from top calibre professionals who have had many years of high quality experience.

LOCATION

Projects are located in every State and in many foreign countries.

A CAREER NOT A JOB

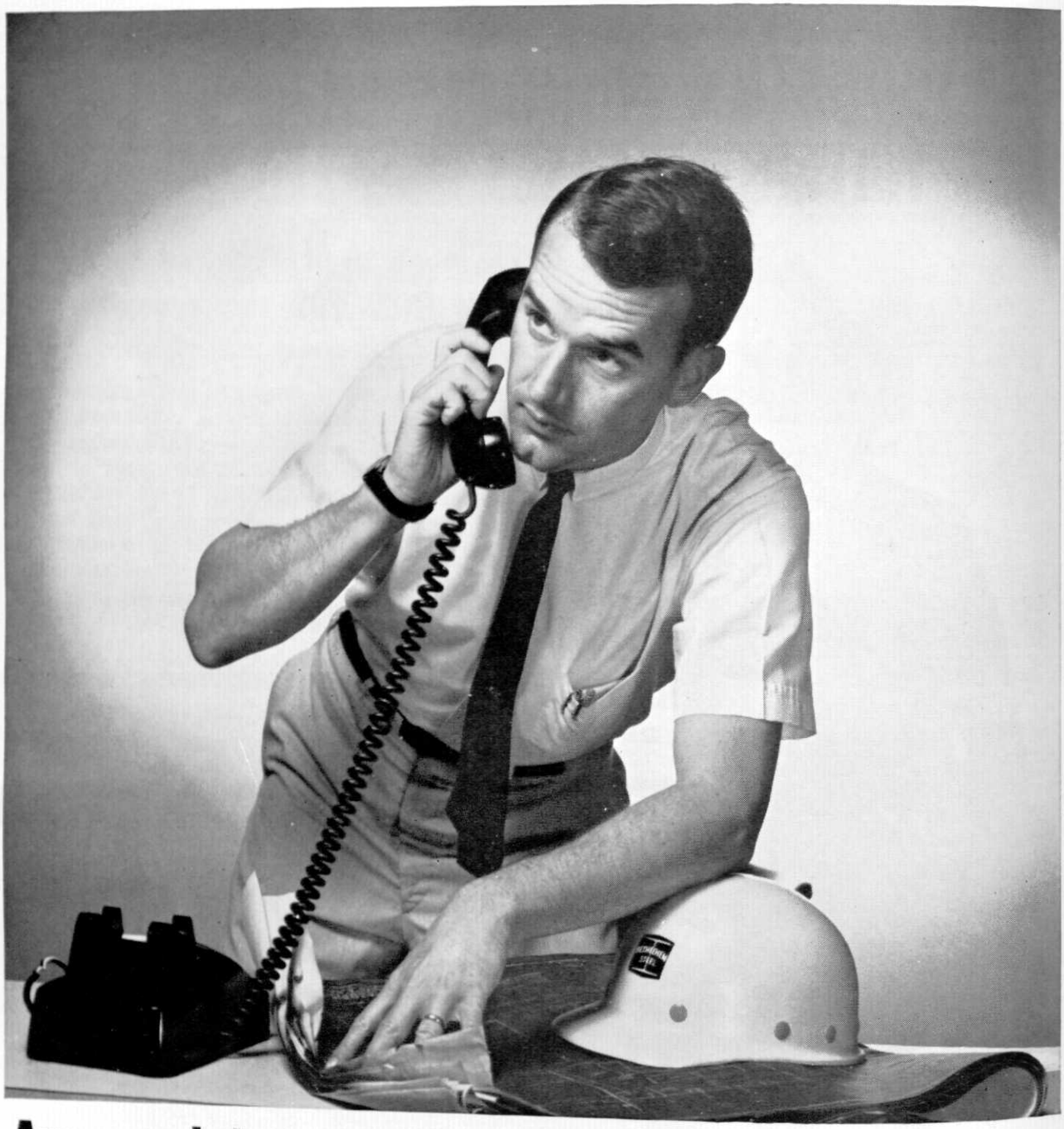
The Corps offers a well defined 18-month rotational training program for young graduate engineers covering all facets of the varied work program. This is followed by planned career development assignments. These assignments enable a young man to develop his special aptitudes in the engineering field. As he progresses, special attention is given to the development of managerial and executive abilities.

ADVANCED EDUCATION AVAILABLE

Attendance at special seminars, symposiums, and university courses and participation in professional societies and activities are encouraged, and sponsored when possible. Fellowships for advanced study and awards for outstanding achievement are also available.

FOR ADDITIONAL INFORMATION... and an illustrated brochure "Your Career", write to the Chief of Engineers, Department of the Army, Washington, D.C. 20315

CORPS OF ENGINEERS
DEPARTMENT OF ARMY
AN EQUAL OPPORTUNITY EMPLOYER



Are you interested in a career in management?

The key words are "career" and "management."

The Bethlehem Loop Course is designed not to place a man in a job, but *to start a man on a career*. Although we have a specific initial job assignment in mind for every man we recruit for the Loop Course, that assignment is just the first step toward increasing levels of responsibility.

The Bethlehem Loop Course is designed to train men for *management*. We select men whom we feel have the potential; we start them out with an intensive five weeks' course that gives them a comprehensive knowledge of the Company's operations; we follow this up with a training program at the facility or within the department to which he is first assigned. A steel plant man, for instance, will be given general plant training for a number of weeks; a sales looper trains for a full year before he starts actual selling.

Think it over. It should be abundantly clear that we have a big stake in our loopers. We do everything in our power to assure that you make good progress—the rest is up to you.

If you are interested in a *career* in *management* with one of the nation's largest and most dynamic industrial concerns, we urge you to read our booklet, "Careers with Bethlehem Steel and the Loop Course." You can get a copy at your Placement Office, or by sending a postcard to our Personnel Division, Bethlehem, Pa.

BETHLEHEM STEEL

BETHLEHEM STEEL

An equal opportunity employer

FUDGE FACTORS

MULTIPLY	BY	TO OBTAIN
Abamperes	10	amperes
Abamperes	$3x10^{10}$	statamperes
abamperes per sq cm	64.52	amperes per sq inch
abampere-turns	10	ampere-turns
abampere-turns	12.57	gilberts
abampere-turns per cm	25.40	ampere-turns per inch
abcoulombs	10	coulombs
abcoulombs	$3x10^{10}$	statcoulombs
abcoulombs per sq cm	64.52	coulombs per sq inch
abfarads	10^9	farads
abfarads	10^{15}	microfarads
abfarads	$9x10^{20}$	statfarads
abhenries	10^{-9}	henries
abhenries	10^{-6}	millihenries
abhenries	$1/9x10^{-20}$	stathenries
abmhos per cm cube	$1.662x10^2$	mhos per mil foot
abmhos per cm cube	10^3	megmhos per cm cube
abohms	10^{-15}	megohms
abohms	10^{-3}	microhms
abohms	10^{-9}	ohms
abohms	$1/9x10^{-20}$	statohms
abohms per cm cube	10^{-3}	microhms per cm cube
abohms per cm cube	$6.015x10^{-3}$	ohms per mil foot
abvolts	$1/3x10^{-10}$	statvolts
abvolts	10^{-8}	volts
acres	43,560	square feet
acres	4047	square meters
acres	$1.562x10^{-3}$	square miles
acres	5645.38	square varas
acres	4840	square yards
acre-feet	43,560	cubic feet
acre-feet	$3.259x10^5$	gallons
amperes	1/10	abamperes
amperes	$3x10^9$	statamperes
amperes per sq cm	6.452	amperes per sq inch
amperes per sq inch	0.01550	abamperes per sq cm
amperes per sq inch	0.1550	amperes per sq cm
amperes per sq inch	$4.650x10^8$	statamperes per sq cm
ampere-turns	1/10	abampere-turns
ampere-turns	1.257	gilberts
ampere-turns per cm	2.540	ampere-turns per in
ampere-turns per inch	0.03937	abampere-turnspercm
ampere-turns per inch	0.3937	ampere-turns per cm
ampere-turns per inch	0.4950	gilberts per cm
areas	0.02471	acres
areas	100	square meters
atmospheres	76.0	cms of mercury
atmospheres	29.92	inches of mercury
atmospheres	33.90	feet of water
atmospheres	10.333	kgs per sq meter
atmospheres	14.70	pounds per sq inch
atmospheres	1.058	tons per sq foot
Bars	$9.870x10^{-1}$	atmospheres
Bars	1	dynes per sq cm
Bars	0.01020	kgs per square meter
Bars	$2.089x10^{-3}$	pounds per sq foot
Bars	$1.450x10^{-5}$	pounds per sq inch
board-feet	0.2530	cubic inches
British thermal units	144 sq. in x 1 in.	kilogram-calories
British thermal units	777.5	foot-pounds
British thermal units	$3.927x10^{-4}$	horsepower-hours
British thermal units	1054	joules
British thermal units	107.5	kilogram-meters
British thermal units	$2.928x10^{-4}$	kilowatt-hours
Btu per min	12.96	foot-pounds per sec
Btu per min	0.2356	horsepower
Btu per min	0.01757	kilowatts
Btu per min	17.57	watts
Btu per sq ft per min	0.1220	watts per square inch
bushels	1.244	cubic feet
bushels	2150	cubic inches
bushels	0.03524	cubic meters
bushels	4	pecks
bushels	64	pints (dry)

MULTIPLY	BY	TO OBTAIN
bushels	32	quarts (dry)
Centares	1	square meters
centigrams	0.01	grams
centiliters	0.01	liters
centimeters	0.3937	inches
centimeters	0.01	meters
centimeters	393.7	mils
centimeters	10	millimeters
centimeter-dynes	$1.020x10^{-3}$	centimeter-grams
centimeter-dynes	$1.020x10^{-8}$	meter-kilograms
centimeter-dynes	$7.367x10^{-9}$	pound-feet
centimeter-grams	980.7	centimeter-dynes
centimeter-grams	10^{-5}	meter-kilograms
centimeter-grams	$7.233x10^{-5}$	pound-feet
centimeters of mercury	0.01316	atmospheres
centimeters of mercury	0.4461	feet of water
centimeters of mercury	136.0	kgs per square meter
centimeters of mercury	27.85	pounds per sq foot
centimeters of mercury	0.1934	pounds per sq inch
centimeters per second	1.969	feet per minute
centimeters per second	0.03281	feet per second
centimeters per second	0.036	kilometers per hour
centimeters per second	0.6	meters per minute
centimeters per second	0.02237	miles per hour
centimeters per second	$3.728x10^{-4}$	miles per minute
cms per sec per sec	0.03281	feet per sec per sec
cms per sec per sec	0.036	kms per hour per sec
cms per sec per sec	0.02237	miles per hour per sec
circular mils	$5.067x10^{-6}$	square centimeters
circular mils	$7.854x10^{-7}$	square inches
circular mils	0.7854	square mils
cord-feet	4 ft x 4 ft x 1 ft	cubic feet
cords	3 ft x 4 ft x 4 ft	cubic feet
coulombs	1/10	abcoulombs
coulombs	$3x9^9$	statcoulombs
coulombs per sq inch	0.01550	abcoulombs per sq cm
coulombs per sq inch	0.1550	coulombs per sq cm
coulombs per sq inch	$4.650x10^8$	statcouls per sq cm
cubic centimeters	$3.531x10^{-5}$	cubic feet
cubic centimeters	$6.102x10^{-2}$	cubic inches
cubic centimeters	10^{-6}	cubic meters
cubic centimeters	$1.308x10^{-6}$	cubic yards
cubic centimeters	$2.642x10^{-4}$	gallons
cubic centimeters	10^{-3}	liters
cubic centimeters	$2.113x10^{-3}$	pints (liq)
cubic centimeters	$1.057x10^{-3}$	quarts (liq)
cubic feet	$2.832x10^4$	cubic cms
cubic feet	1728	cubic inches
cubic feet	0.02832	cubic meters
cubic feet	0.03704	cubic yards
cubic feet	7.481	gallons
cubic feet	28.32	liters
cubic feet	59.84	pints (liq)
cubic feet	29.92	quarts (liq)
cubic feet per minute	472.0	cubic cms per sec
cubic feet per minute	0.1247	gallons per sec
cubic feet per minute	0.4720	liters per second
cubic feet per minute	62.4	lbs of water per min
cubic inches	16.39	cubic centimeters
cubic inches	$5.787x10^{-4}$	cubic feet
cubic inches	$1.639x10^{-5}$	cubic meters
cubic inches	$2.143x10^{-5}$	cubic yards
cubic inches	$4.329x10^{-3}$	gallons
cubic inches	$1.639x10^{-2}$	liters
cubic inches	0.03463	pints (liq)
cubic inches	0.01732	quarts (liq)
cubic meters	10^6	cubic centimeters
cubic meters	35.31	cubic feet
cubic meters	61,023	cubic inches
cubic meters	1.308	cubic yards
cubic meters	264.2	gallons
cubic meters	10^9	liters
cubic meters	2113	pints (liq)
cubic meters	1057	quarts (liq)

The Most Complete Conversion Table Ever Compiled

MULTIPLY	BY	TO OBTAIN
cubic yards	7.646×10^{5}	cubic centimeters
cubic yards	27	cubic feet
cubic yards	46,656	cubic inches
cubic yards	0.7646	cubic meters
cubic yards	202.0	gallons
cubic yards	764.6	liters
cubic yards	1616	pints (liq)
cubic yards	807.9	quarts (liq)
cubic yards per minute	0.45	cubic feet per second
cubic yards per minute	3.367	gallons per second
cubic yards per minute	12.74	liters per second
Days	24	hours
Days	1440	minutes
Days	86,400	seconds
decigrams	0.1	grams
deciliters	0.1	liters
decimeters	0.1	meters
degrees (angle)	60	minutes
degrees (angle)	0.01745	radians
degrees (angle)	3600	seconds
degrees per second	0.01745	radians per second
degrees per second	0.1667	revolutions per min
degrees per second	0.002778	revolutions per sec
dekagrams	10	grams
dekaliters	10	liters
dekameters	10	meters
dollars (U.S.)	5.182	francs (French)
dollars (U.S.)	4.20	marks (German)
dollars (U.S.)	0.2055	pounds sterling (Brit)
dollars (U.S.)	4.11	shillings (British)
drams	1.772	grams
drams	0.0625	ounces
dynes	1.020×10^{-3}	grams
dynes	7.233×10^{-5}	poundals
dynes	2.248×10^{-6}	pounds
dynes per square cm	1	bars
Ergs	9.486×10^{-11}	British thermal units
Ergs	1	dyne-centimeters
Ergs	7.376×10^{-8}	foot-pounds
Ergs	1.020×10^{-3}	gram-centimeters
Ergs	10^{-7}	joules
Ergs	2.390×10^{-11}	kilogram-calories
Ergs	1.020×10^{-8}	kilogram-meters
ergs per second	5.692×10^{-9}	Btu per minute
ergs per second	4.426×10^{-6}	foot-pounds per min
ergs per second	7.376×10^{-8}	foot-pounds per sec
ergs per second	1.341×10^{-10}	horsepower
ergs per second	1.434×10^{-9}	kg.-calories per min
ergs per second	10^{-10}	kilowatts
Farads	10^{-9}	abfarads
Farads	10^{6}	microfarads
Farads	9×10^{-11}	statfarads
fathoms	6	feet
feet	30.48	centimeters
feet	12	inches
feet	0.3048	meters
feet	.36	varas
feet	1/3	yards
feet of water	0.02950	atmospheres
feet of water	0.8826	inches of mercury
feet of water	304.8	kgs per square meter
feet of water	62.43	pounds per sq ft
feet of water	0.4335	pounds per sq inch
feet per minute	0.5080	centimeters per sec
feet per minute	0.01667	feet per sec
feet per minute	0.01829	kilometers per hour
feet per minute	0.3048	meters per minute
feet per minute	0.01136	miles per hour
feet per second	30.48	centimeters per sec
feet per second	1.097	kilometers per hour
feet per second	0.5921	knots per hour
feet per second	18.29	meters per minute
feet per second	0.6818	miles per hour

MULTIPLY	BY	TO OBTAIN
feet per second	0.01136	miles per minute
feet per 100 feet	1	per cent grade
feet per sec per sec	30.48	cms per sec per sec
feet per sec per sec	1.097	kms per hr per sc
feet per sec per sec	0.3048	meters per sec per sec
feet per sec per sec	0.6818	miles per hr per sec
foot-pounds	1.286×10^{-3}	British thermal units
foot-pounds	1.356×10^{7}	ergs
foot-pounds	5.050×10^{-7}	horsepower-hours
foot-pounds	1.356	joules
foot-pounds	3.241×10^{-4}	kilogram-calories
foot-pounds	0.1383	kilogram-meters
foot-pounds	3.766×10^{-7}	kilowatt-hours
foot-pounds per minute	1.286×10^{-3}	Btu per minute
foot-pounds per minute	0.01667	foot-pounds per sec
foot-pounds per minute	3.03×10^{-5}	horsepower
foot-pounds per minute	3.241×10^{-4}	kg.-calories per minute
foot-pounds per minute	1.260×10^{-5}	kilowatts
foot-pounds per second	7.717×10^{-2}	Btu per minute
foot-pounds per second	1.818×10^{-3}	horsepower
foot-pounds per second	1.945×10^{-2}	kg.-calories per min
foot-pounds per second	1.365×10^{-3}	kilowatts
francs (French)	0.193	dollars (U.S.)
francs (French)	0.811	marks (German)
francs (French)	0.03865	pounds sterling (Brit)
furlongs	40	rods
Gallons	3785	cubic centimeters
Gallons	0.1337	cubic feet
Gallons	231	cubic inches
Gallons	3.785×10^{-3}	cubic meters
Gallons	4.951×10^{-3}	cubic yards
Gallons	3.785	liters
Gallons	8	pints (liq)
Gallons	4	quarts (liq)
gallons per minute	2.228×10^{-3}	cubic feet per second
gallons per minute	0.06308	liters per second
gausses	6.452	lines per square inch
gilberts	0.07958	abampere-turns
gilberts	0.7958	ampere-turns
gilberts per centimeter	2.021	ampere-turns per inch
gills	0.1183	liters
gills	0.25	pints (liq)
grains (troy)	1	grains (av)
grains (troy)	0.06480	grams
grains (troy)	0.04167	pennyweights (troy)
grams	980.7	dynes
grams	15.43	grains (troy)
grams	10^{-3}	kilograms
grams	10^{3}	milligrams
grams	0.03527	ounces
grams	0.03215	ounces (troy)
grams	0.07093	poundals
grams	2.205×10^{-3}	pounds
gram-calories	3.968×10^{-3}	British thermal units
gram-centimeters	9.302×10^{-8}	British thermal units
gram-centimeters	980.7	ergs
gram-centimeters	7.233×10^{-5}	foot-pounds
gram-centimeters	2.344×10^{-8}	joules
gram-centimeters	10^{-5}	kilogram-calories
gram-centimeters	9.807×10^{-5}	kilogram-meters
grams per cc	5.600×10^{-3}	pounds per inch
grams per cc	62.43	pounds per cubic foot
grams per cc	0.03613	pounds per cubic inch
grams per cc	3.405×10^{-7}	pounds per mil-foot
Hectares	2.471	acres
Hectares	1.076×10^{5}	square feet
hectograms	100	grams
hectoliters	100	liters
hectometers	100	meters
hectowatts	100	watts
hemispheres (solid angle)	0.5	sphere
hemispheres (solid angle)	4	spherical right angles
hemispheres (solid angle)	6.283	steradians

MULTIPLY	BY	TO OBTAIN
henries	10^{9}	abhenries
henries	10^{3}	millihenries
henries	$1/9 \times 10^{-11}$	stathenries
horse-power	42.44	Btu per min
horse-power	33,000	foot-pounds per min
horse-power	550	foot-pounds per sec
horse-power	1.014	horsepower (metric)
horse-power	10.70	kg.-calories per min
horse-power	0.7457	kilowatts
horse-power	745.7	watts
horse-power (boiler)	33,520	Btu per hour
horse-power (boiler)	9.804	kilowatts
horse-power-hours	2547	British thermal units
horse-power-hours	1.98×10^{6}	foot-pounds
horse-power-hours	2.684×10^{6}	joules
horse-power-hours	641.7	kilogram-calories
horse-power-hours	2.737×10^{5}	kilogram-meters
horse-power-hours	0.7457	kilowatt-hours
hours	60	minutes
hours	3600	seconds
Inches	2.540	centimeters
Inches	10^{3}	mils
Inches	.03	varas
inches of mercury	0.03342	atmospheres
inches of mercury	1.133	feet of water
inches of mercury	345.3	kgs per square meter
inches of mercury	70.73	pounds per square ft
inches of mercury	0.4912	pounds per square in
inches of water	0.002458	atmospheres
inches of water	0.07355	inches of mercury
inches of water	25.40	kgs per square meter
inches of water	0.5781	ounces per square in
inches of water	5.204	pounds per square ft
inches of water	0.03613	pounds per square in
Joules	9.486×10^{-4}	British thermal units
Joules	10^{7}	ergs
Joules	0.7376	foot-pounds
Joules	2.390×10^{-4}	kilogram-calories
Joules	0.1020	kilogram-meters
Joules	2.778×10^{-4}	watt-hours
Kilograms	980.665	dynes
Kilograms	10^{3}	grams
Kilograms	70.93	poundals
Kilograms	2.2046	pounds
Kilograms	1.102×10^{-3}	tons (short)
kilogram-calories	3.968	British thermal units
kilogram-calories	3086	foot-pounds
kilogram-calories	1.558×10^{-3}	horsepower-hours
kilogram-calories	4183	joules
kilogram-calories	426.6	kilogram meters
kilogram-calories	1.162×10^{-3}	kilowatt-hours
kg-calories per min	51.43	foot-pounds per sec
kg-calories per min	0.09351	horsepower
kg-calories per min	0.06972	kilowatts
kgs-cms squared	2.373×10^{-3}	pounds-feet squared
kgs-cms squared	0.3417	pounds-inches squared
kilogram-meters	9.302×10^{-3}	British thermal units
kilogram-meters	9.807×10^{7}	ergs
kilogram-meters	7.233	foot-pounds
kilogram-meters	9.807	joules
kilogram-meters	2.344×10^{-3}	kilogram-calories
kilogram-meters	2.724×10^{-6}	kilowatt-hours
kgs per cubic meter	10^{-3}	grams per cubic cm
kgs per cubic meter	0.06243	pounds per cubic foot
kgs per cubic meter	3.613×10^{-5}	pounds per cubic inch
kgs per meter	3.405×10^{-10}	pounds per mil foot
kgs per square meter	0.6720	pounds per foot
kgs per square meter	9.678×10^{-5}	atmospheres
kgs per square meter	98.07	bars
kgs per square meter	3.281×10^{-2}	feet of water
kgs per square meter	2.896×10^{-3}	inches of mercury
kgs per square meter	0.2048	pounds per square ft
kgs per square meter	1.422×10^{-3}	pounds per square in

MULTIPLY	BY	TO OBTAIN
kgs per sq millimeter	10^{6}	kgs per square meter
kilolines	10^{9}	maxwells
kiloliters	10^{3}	liters
kilometers	10^{5}	centimeters
kilometers	3281	feet
kilometers	10^{3}	meters
kilometers	0.6214	miles
kilometers	1093.6	yards
kilometers per hour	27.78	centimeters per sec
kilometers per hour	54.68	feet per minute
kilometers per hour	0.9113	feet per second
kilometers per hour	0.5396	knots per hour
kilometers per hour	16.67	meters per minute
kilometers per hour	0.6214	miles per hour
kms per hour per sec	27.78	cms per sec per sec
kms per hour per sec	0.9113	ft per sec per sec
kms per hour per sec	0.2778	meters per sec per sec
kms per hour per sec	0.6214	miles per hr per sec
kilometers per min	60	kilometers per hour
kilowatts	56.92	Btu per min
kilowatts	4.425×10^{4}	foot-pounds per min
kilowatts	737.6	foot-pounds per sec
kilowatts	1.341	horsepower
kilowatts	14.34	kg.-calories per min
kilowatts	10^{3}	watts
kilowatt-hours	3415	British thermal units
kilowatt-hours	2.655×10^{6}	foot-pounds
kilowatt-hours	1.341	horsepower-hours
kilowatt-hours	3.6×10^{6}	joules
kilowatt-hours	860.5	kilogram-calories
kilowatt-hours	3.671×10^{5}	kilogram-meters
knots	6080	feet
knots	1.853	kilometers
knots	1.152	miles
knots	2027	yards
knots per hour	51.48	centimeters per sec
knots per hour	1.689	feet per sec
knots per hour	1.853	kilometers per hour
knots per hour	1.152	miles per hour
Lines per square cm	1	gausses
lines per square inch	0.1550	gausses
links (engineer's)	12	inches
links (surveyor's)	7.92	inches
liters	10^{3}	cubic centimeters
liters	0.03531	cubic feet
liters	61.02	cubic inches
liters	10^{-3}	cubic meters
liters	1.308×10^{-3}	cubic yards
liters	0.2642	gallons
liters	2.113	pints (liq)
liters	1.057	quarts (liq)
liters per minute	5.855×10^{-4}	cubic feet per second
liters per minute	4.403×10^{-3}	gallons per second
$\log^{10}$ N	2.303	$\log_e$ N or In N
$\log_e$ N or In N	0.4343	$\log^{10}$ N
lumens per sq ft	1	foot-candles
Marks (German)	0.238	dollars (U.S.)
Marks (German)	1.233	francs (French)
Marks (German)	0.04890	pounds sterling (Brit)
maxwells	10^{-3}	kilolines
megalines	10^{6}	maxwells
megmhos per cm cube	10^{-3}	abmhos per cm cube
megmhos per cm cube	2.540	megmhos per in cube
megmhos per cm cube	0.1662	mhos per mil foot
megmhos per inch cube	0.3937	megmhos per cm cube
megohms	10^{6}	ohms
meters	100	centimeters
meters	3.2808	feet
meters	39.37	inches
meters	10^{-3}	kilometers
meters	10^{3}	millimeters
meters	1.0936	yards
meter-kilograms	9.807×10^{7}	centimeter-dynes

THERE WILL BE AN EAGLE

ON THE MOON...

Our world-recognized trademark—"the P&WA eagle"—has been identified with progress in flight propulsion for almost four decades, spanning the evolution of power from yesterday's reciprocating engines to today's rockets. Tomorrow will find that same Pratt & Whitney Aircraft eagle carrying men and equipment to the moon and to even more distant reaches of outer space.

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Career boundaries with us can be further extended through a corporation-financed Graduate Education Program. For further information regarding opportunities at Pratt & Whitney Aircraft, consult your college placement officer—or—write to Mr. William L. Stoner, Engineering Department, Pratt & Whitney Aircraft, East Hartford 8, Connecticut.

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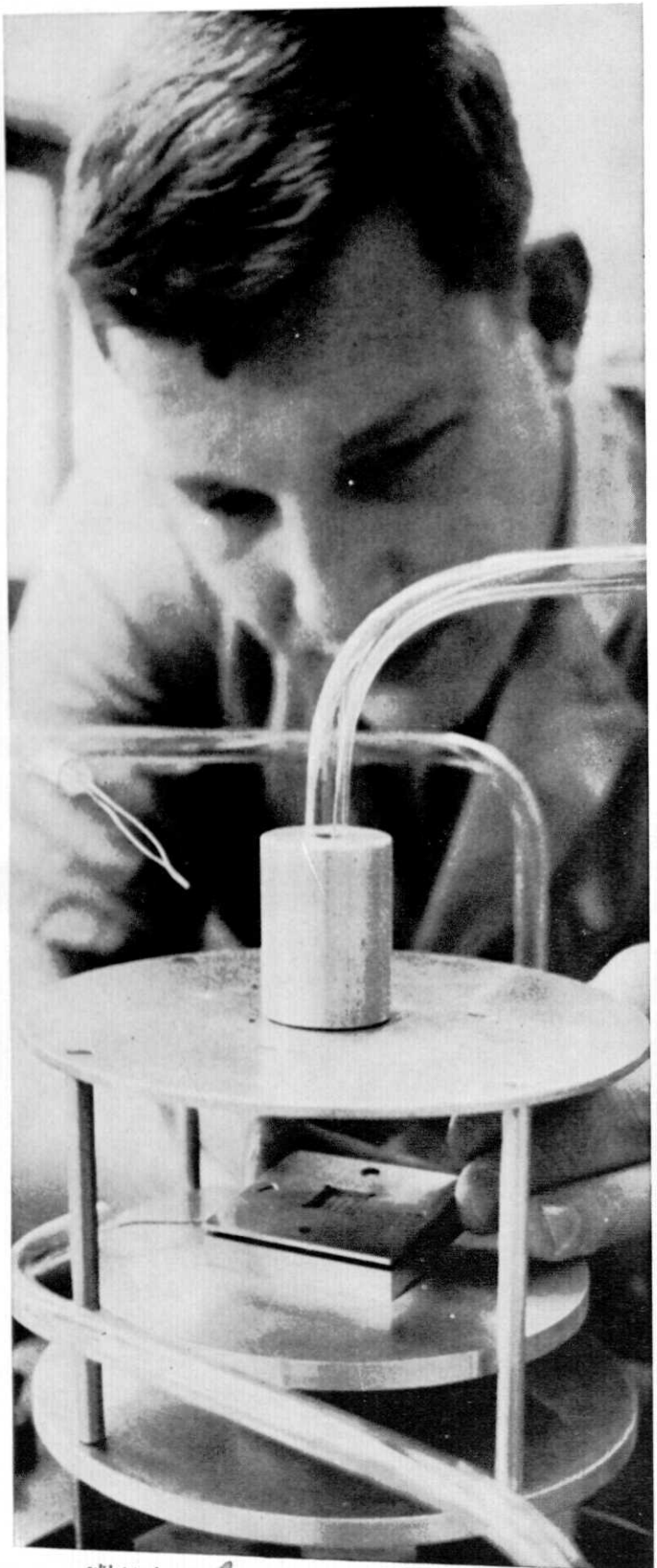

Delco Means Challenge to Ed Whittaker

■ Edward G. Whittaker, III received his BS Degree in Engineering Physics from Colorado University in January of 1963. Shortly thereafter he joined the Research and Advanced Development Group at Delco as a Physicist.

As Ed puts it, "Believe me, it's a real challenge for a guy fresh out of college to see an idea through from the development stage to the finished product. Here at Delco in my work on materials for new semiconductor devices the creative experiences are endless—and the atmosphere seems to encourage your best efforts."

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MISS ENGINEER

Carol Crupi

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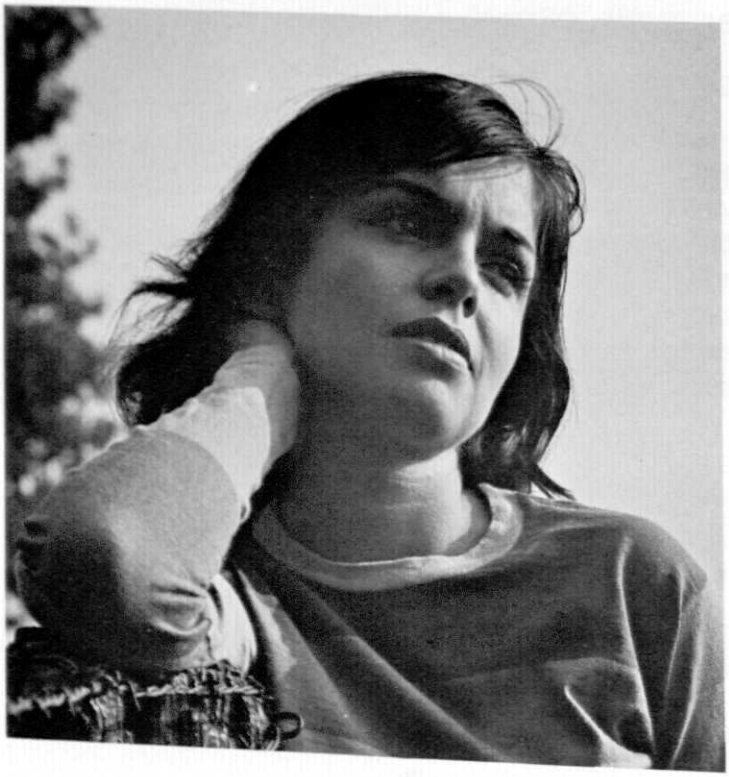
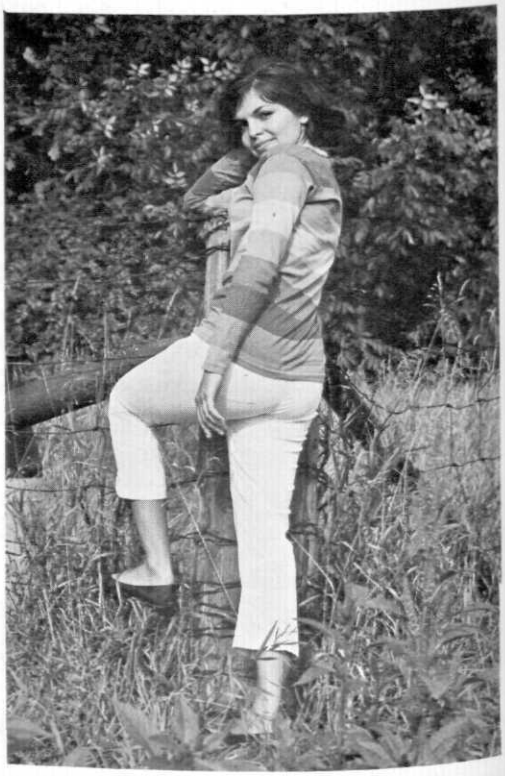
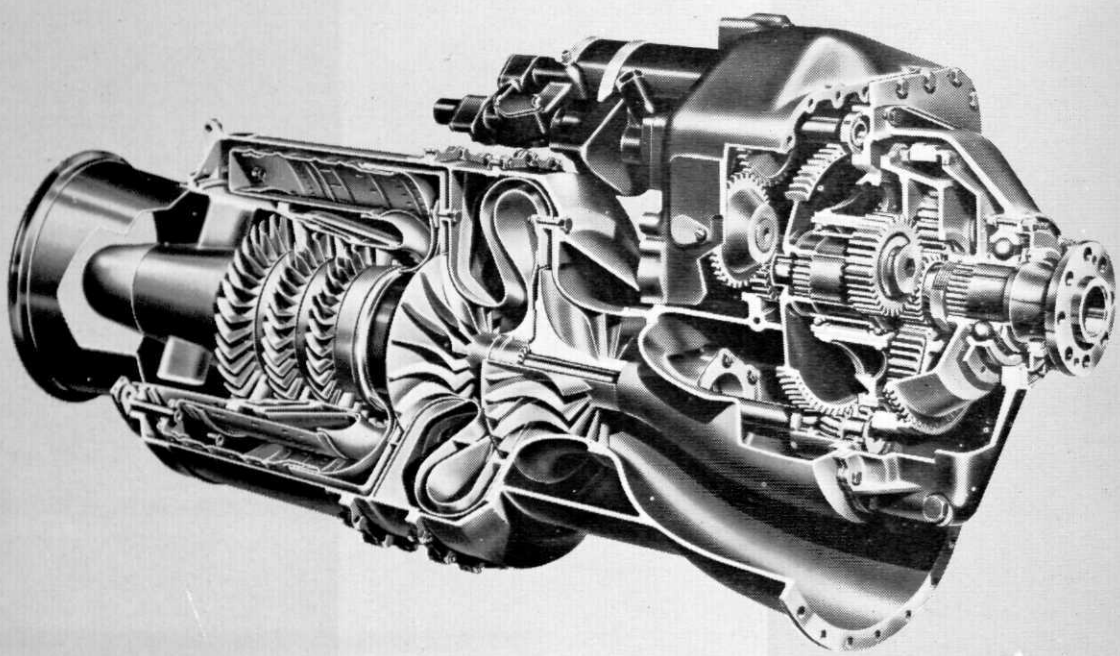
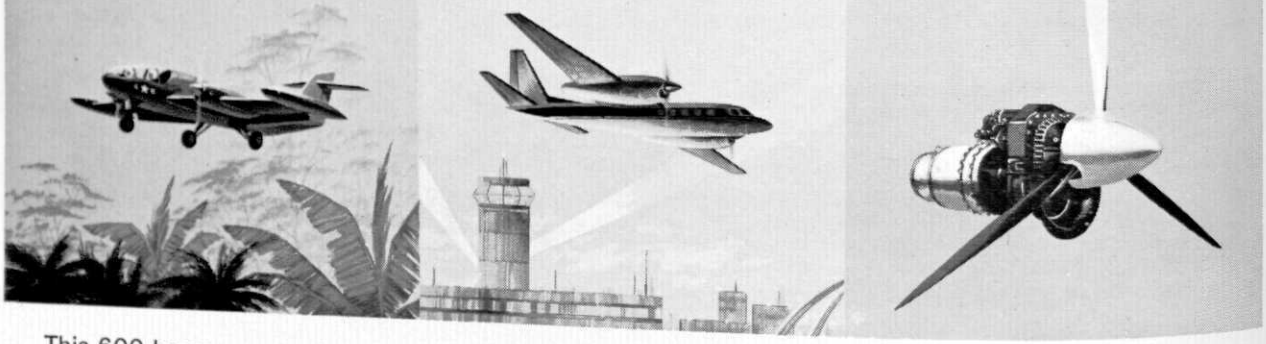




TURBOPROP ENGINE FOR LIGHT AIRCRAFT





This 600 horsepower turboprop engine is designed to power the new generation of light, fixed wing aircraft for both civil and military applications. • The Garrett-AiResearch TPE-331 has a specific fuel consumption of .62 pound per shaft horsepower-hour, and a weight to power ratio of .45 pound per horsepower. The engine has a response rate from flight idle to full power of approximately 1/3 of a second. A military version has been designated the T76 by the U.S. Navy. • Designed specifically as a prime power plant, the model 331 is backed by the company's experience in producing over 10,000 gas turbine engines. • The Model 331 engine is programmed for additional performance growth. The turboshaft version (TSE-331) has been flight tested as a power plant in rotary wing and vertical lift vehicles.

For further information about many interesting project areas and career opportunities at The Garrett Corporation, write to Mr. G. D. Bradley at 9851 S. Sepulveda Blvd., Los Angeles. Garrett is an equal opportunity employer.

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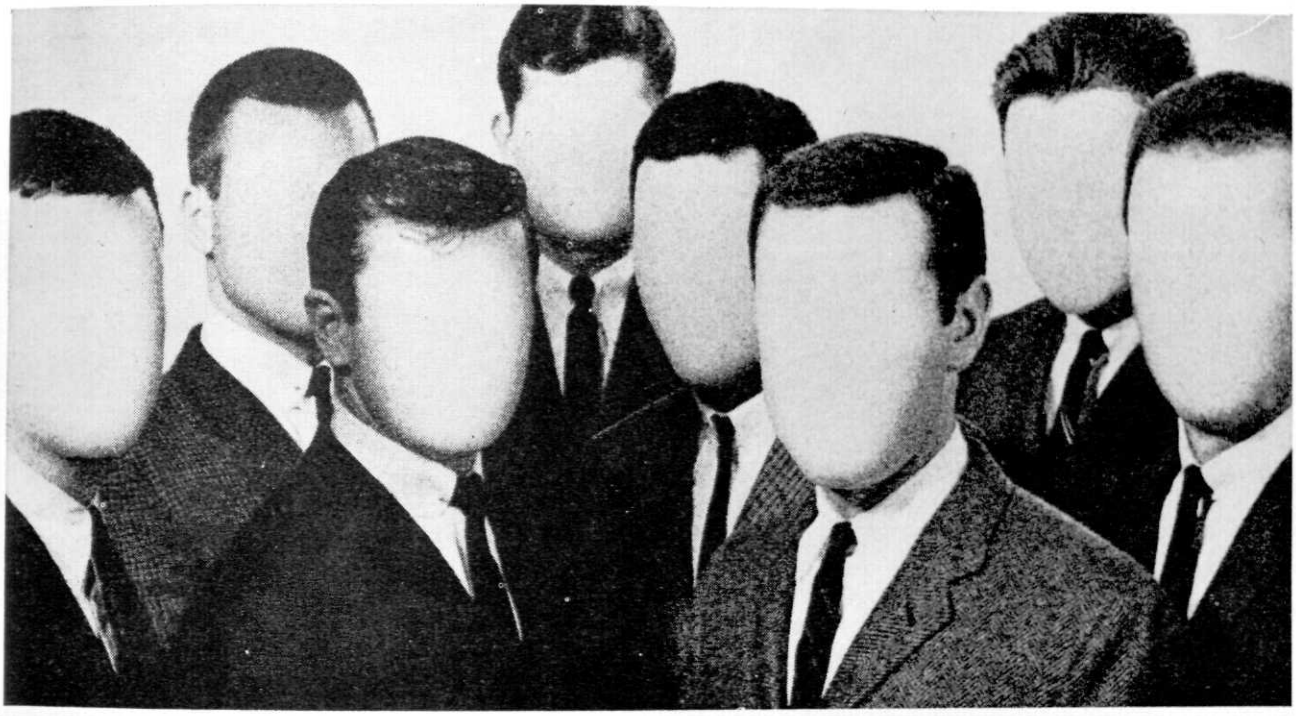

Must a big company be impersonal? We think not.

In fact, we go to great lengths to make certain that no one is ever "lost" at Dow. From the day a man first joins us, we follow his career with interest, make certain that his assignments give him every opportunity to develop and display his talents, and encourage him to accept ever-increasing responsibilities.

Because Dow is organized much like a group of small companies rather than a vast corporate complex, recognition comes quickly. Our transfer policy encourages lateral moves which aid the development and growth of the individual as well as the Dow organization. Promotions are made from within. Your future with Dow is virtually limitless.

Whether you're a chemist, engineer, biologist, mathematician, physicist—or student of any of a hundred other educational disciplines, you'll find that Dow respects and values you as an individual, encourages independent thinking and independent research.

Yes. People are the important figures at Dow. And, working together, they've compiled some impressive statistics. Research is continuous at 50 separate Dow laboratories. We manufacture at 30 locations in the U.S. Abroad, our manufacturing and marketing operations are located in 26 different countries. We serve more than 200 industries with some 700 items—ranging from chemicals and plastics to new consumer products. Sales have increased eightfold since World War II. Present plants are being expanded, new ones built.

And Dow offers not only a stimulating future, but a rewarding one as well. Many of our employee benefit plans are industry models, including our periodic stock purchase plans, sickness and accident benefits, life insurance, hospitalization insurance, annual salary review, pension and profit-sharing plan, and our educational assistance plans.

If you're looking for unlimited opportunity, look to Dow. For more information about us, see your College Placement Director, or write the Technical Placement Manager at any of our locations listed below. The Dow Chemical Company, Midland, Michigan. *An Equal Opportunity Employer.*

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DOW

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WE'D LIKE TO TALK TO YOU ABOUT THE GENERATION OF IDEAS!

At Detroit Edison, generation of ideas comes first. Here, an engineer has ample opportunity to put his training, his energy and his ideas into action. A good example of this is Detroit Edison's recent adoption of a new concept for the economic generation of power. Combining analog and digital computers with a telemetering system for data collection and communication is a concept that will insure peak operating efficiency in all six Edison plants. If you would like to see your ideas contribute to challenging projects, you may be interested in training as a Detroit Edison Engineer. Research, Electrical Systems and Production Engineering are three of the many challenging fields open to you at Detroit Edison. Write for our booklet about professional opportunities for graduates in our company—2000 Second Ave., Detroit 26, Michigan.

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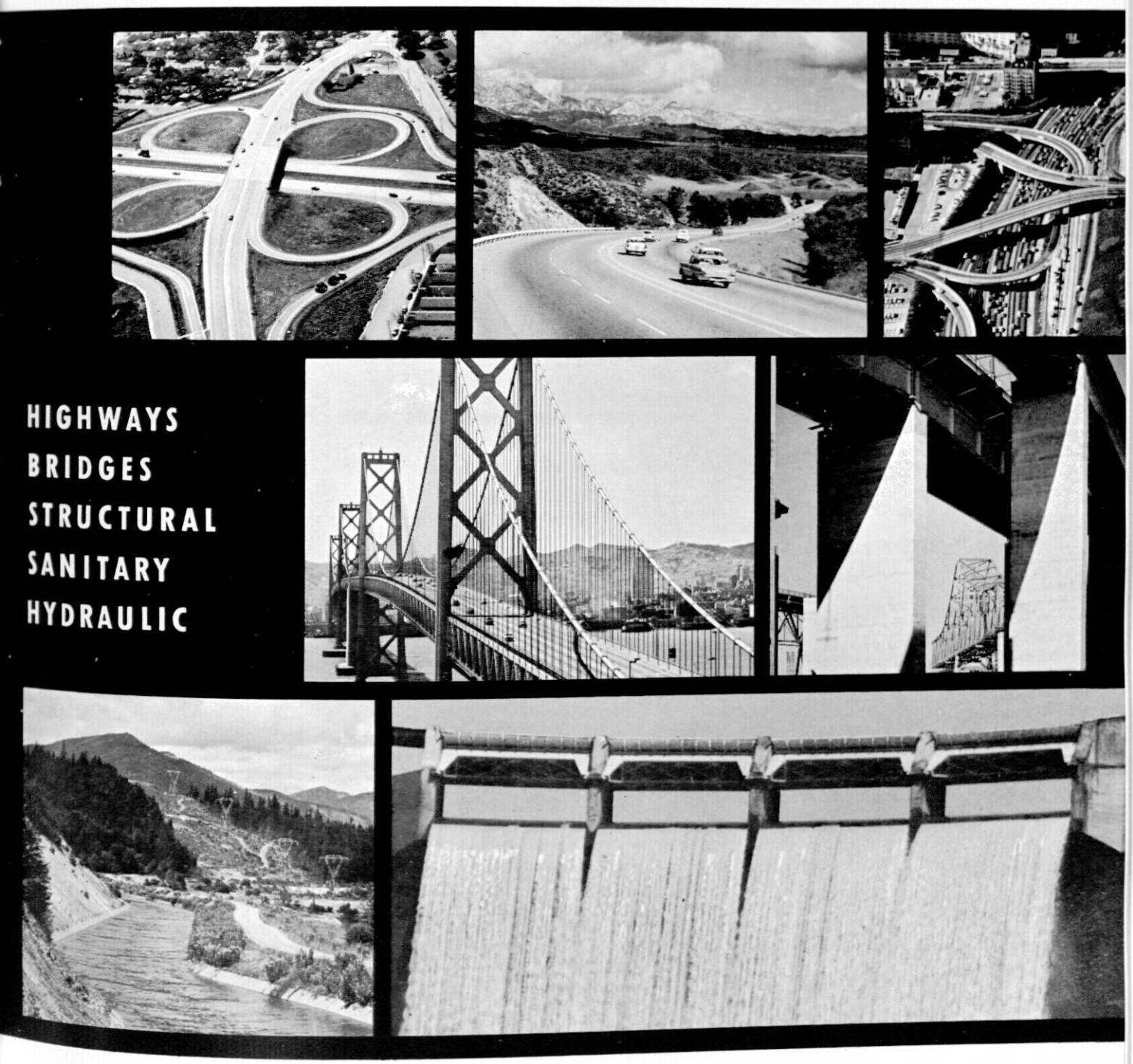
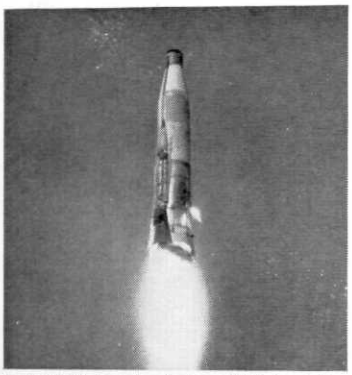
CHALLENGE IN CALIFORNIA

IN ALL PHASES OF CIVIL ENGINEERING

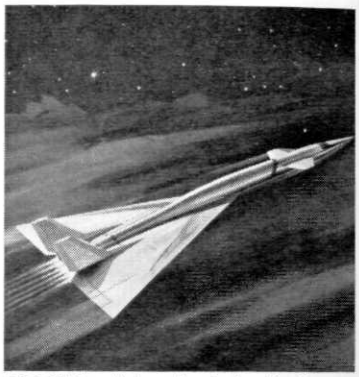


California's far-flung state engineering projects are no boom-time enterprises. They are sustained, long-range operations planned to keep pace with the continued growth of the West. We offer employment stability, good salaries, job rotation and professional advancement. Let us send you illustrated literature and campus interview schedule of our representatives. Please state your field. State Personnel Board, 801 Capitol Mall, Sacramento, California 95814.

PROBLEM: Find new techniques and equipment to reach oil and gas now inaccessible under the oceans.

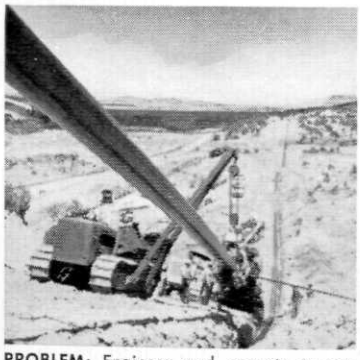


PROBLEM: Develop fuels and lubricants for space-age vehicles, such as greases to withstand 1000° F. temperature and almost absolute vacuum.

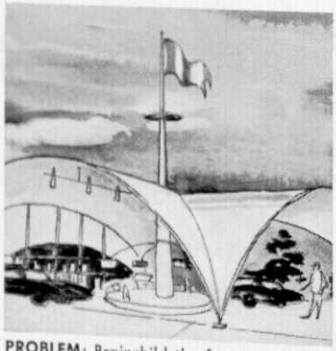


PROBLEM: Make chemical adhesives to bond wing structures of the 2000 mph Mach 3 plane of the 1970's.

PROBLEM: Improve the reliability and precision of automatic controls and new materials and equipment demanded by new oil and chemical processes.



PROBLEM: Engineer and operate tomorrow's petroleum transportation system to handle greater volumes faster throughout the nation.



PROBLEM: Brainchild the function, design, and locations of marketing outlets which future populations, cars and roads will demand.

Tough Problems Inspire Top Performance

The problems facing Shell are diverse and tough. And Shell's scientists, engineers, and other professionals prefer it that way. They know that their individual achievements and the success of the Company are determined by the size of the problems they tackle and solve. They have set for themselves the highest standards of performance.

These standards have enabled Shell to lead in advances in offshore exploration and production, new manufacturing processes, new products, efficiency in distribution and marketing, and to achieve a position as one of the nation's dynamic and progressive companies.

Shell's continuing dedication to excellence assures a variety of rewarding careers for graduates who also have set for themselves the highest standards of performance. Opportunities exist for graduates in engineering, chemistry, geology, geophysics, physics, mathematics and business.

Shell Representatives will be pleased to tell you more about the Shell Companies when they visit your campus. Or a resume sent to Manager, Recruitment Division, Dept. E, The Shell Companies, 50 West 50th Street, New York 20, N. Y., will receive full consideration. Candidates whose qualifications and interests match Shell opportunities will be invited to visit Shell installations for interviews.

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The Shell Companies
Shell Oil Company
Shell Chemical Company
Shell Pipe Line Corporation
Shell Development Company

SHELL

SIGN OF A BETTER FUTURE FOR YOU

THE COMPUTER INSTITUTE FOR SOCIAL SCIENCE RESEARCH

as told by Dr. Charles F. Wrigley, Director of the Institute to John B. Locke

Since their development, data processing computers have been exploited and utilized mainly for engineers. The Computer Institute for Social Science Research was established by Michigan State University to stimulate research into the use of computers as an aid to social science research and to encourage this type of research using computers.

The Institute was begun in September, 1963, by the College of Social Science and the Computing Laboratory.

Much of the research in social science, psychology, sociology and anthropology, political science, geology, education, history, linguistics, and others, involves too much clerical labor to make the research feasible. Many social scientists have been stalemated by this problem. The Institute is trying to unite these researchers and the potentialities of computers.

In addition to teaching and aiding researchers in the use of computers, most of the staff members of the Institute are engaged in their own computer-dependent studies.

The possibilities for the use of computers are mammoth. The Institute is stimulating research into these possibilities.

In the near future, a student may enter a classroom filled with individual consoles. The student will be assigned a console which will "ask" him a question. His answer will be relayed to a computer, analyzed, and an appropriate second question will be "asked."

A computer could be used to aid in complex business decisions, organizing libraries, translating foreign languages, or simulating complex social systems.

A psychologist would find a computer a marvelous aid in organizing large numbers of people while making a survey of reactions. His predictions could be made much more accurate with his ability to analyze larger groups and more factors.

Regulating the flow of traffic and examining traffic accidents are also benefitted by the use of computers.

Yes, the range of potential is wide and greatly unexplored. The Institute is the only one of its kind known and faces a large task.

The research section of the Institute is trying to obtain more people who are engaged in social science research. The technical section is teaching these people how to use the computer to enlarge their opportunities. Combined with the 3600 computer available at M.S.U., research in the social sciences should be able to advance significantly.

An ever-broadening curriculum at MSU

ENGINEERING 101

Computer Programming

by John Callahan

A new course was introduced this fall for all Freshman engineers. Running for three terms, at 1 credit per term, it is designed to provide an engineering student with the capability of writing his own basic computer programs. In addition, it provides the student with an introduction to the types of problems with which he will deal as an engineer.

Students begin in the fall with an introduction to Fortran computer language. During this first term the most frequently used portion of the Fortran Language is covered and students gain experience by writing programs for 5 assigned problems. Winter term is devoted to furthering basic programming skills with only a limited amount of new material added. Once again students work on a set of assigned problems. In the spring the course expands. In addition to increasing the student's skill at writing his own programs, it is planned to introduce him to the use of programs out of the Program Library. In this way the student will become familiar with the use of programs which would be too long or complex for an engineer to write himself. These Library Programs (written by professionals) serve as valuable tools which the engineer can make use of.

The formal classes consist of a lecture once a week. Students put in additional time on their own, writing programs and punching program cards. Room 372 Engineering Building, where cards are punched, has been equipped with 5 key punches and a tabulator. In addition there are 5 Graduate Instructors who assist students with their programs.

Programs, once prepared, are sent to the Computer Center, twice a day, where they are run on the 3600 Computer. These programs, the Final Examination, and the lecture attendance determine the Final Course Grade. There is no Midterm examination. There is also no required text for the course, however it is recommended that students read the Fortran 60 Reference Manual and the Fortran Primer.

In connection with the course, there is also a voluntary program. Students of ability, who desire a more comprehensive ability in programming, meet with Dr. M. C. Keeney for additional instruction sessions. Some of these students are already working as programmers on campus.

As a whole the course provides the engineering student with a basic ability in programming. No attempt is made to produce professional programmers, however the course does provide the future engineer with the ability to converse intelligently with professional programmers. In addition, it gives the student some idea of what a computer can and can't do and the knowledge to set up complex problems in a reasonable manner before presenting them to a programmer. Finally, it gives him the skill to program many of the problems he will deal with as an engineer.

Do YOU Want

EXPERIENCE

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The Spartan Engineer needs YOU

for these jobs -

writing

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copy reading

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Come to Room 144 Engineering Building

EDDIE AND ANNIE WERE LOVERS . . .

Once upon a time when t equals zero, there lived in a small cavity in a dielectic medium, a poor struggling dipole by the name of Eddy Current. He was deeply in love with a beautiful coil by the name of Ann Ion, the daughter of an influential force in the town, Cat Ion.

Eddy's first contact with her came at a time t equals a. As he passed by a beauty parlor on his periodic orbit, he saw her having a standing wave induced in her filaments. He made a fine sight in his beautiful doublet and it was a case of mutual polarization.

"YOU SHOCK ME"

By a coincidence they met at a dissipation function of the following night. After a few oscillations to the strains of a number (n) played by Mo Mentum and his Incadescent Tuning Forks, the couple diffused into the field outside.

"Gauss, Ann," he said, "You're acute angle; I am d (termined) that U shall marry me for I sphere that I shall never be happy without you."

"Oh, Eddy," she replied, "Don't be so obtuse. Integrate out here in the alpha rays tonight?"

"Ann, are you trying to damp my osculation? Can't you see I'm in a state of hysteresis over you?"

HE CAN'T RESISTOR

"Now, Eddy, be a discrete particle. What will father say?" Alas, there was also in this cavity a mean dipole who was resolved to marry the beautiful Ann, using coercive force if necessary. Hearing these murmurings of love, he went *pi*-i'd with fury, and crept stealthily upon the couple with velocity u, his joules drooling with the vestial erg that moved him.

"What the infra red are you doing here you flat-footed vial villain?" demanded Eddy. The situation grew tensor.

THE VECTOR!

Schmidt advanced to choke the beautiful coil: Eddy offered resistance R; His capacity C for absorbing the charge Q was low, and Schmidt suffered little lost work content in knocking him out to infinity with a severe blow on his negative charge. Eddy made a quick comeback with acceleration a, stripping off Schmidt's outer electrons. This so upset the villain's equilibrium that he was converted into cosmic radiation and vanished into the realms of space, leaving Eddy the resultant vector in the combat.

"Our love will not be transient," said Eddy as he formed a closed circle around her.

"Darling, we will raise a one parameter family of second infinitesimals," murmured Ann happily.

And as time t approached infinity, they lived happily ever after.

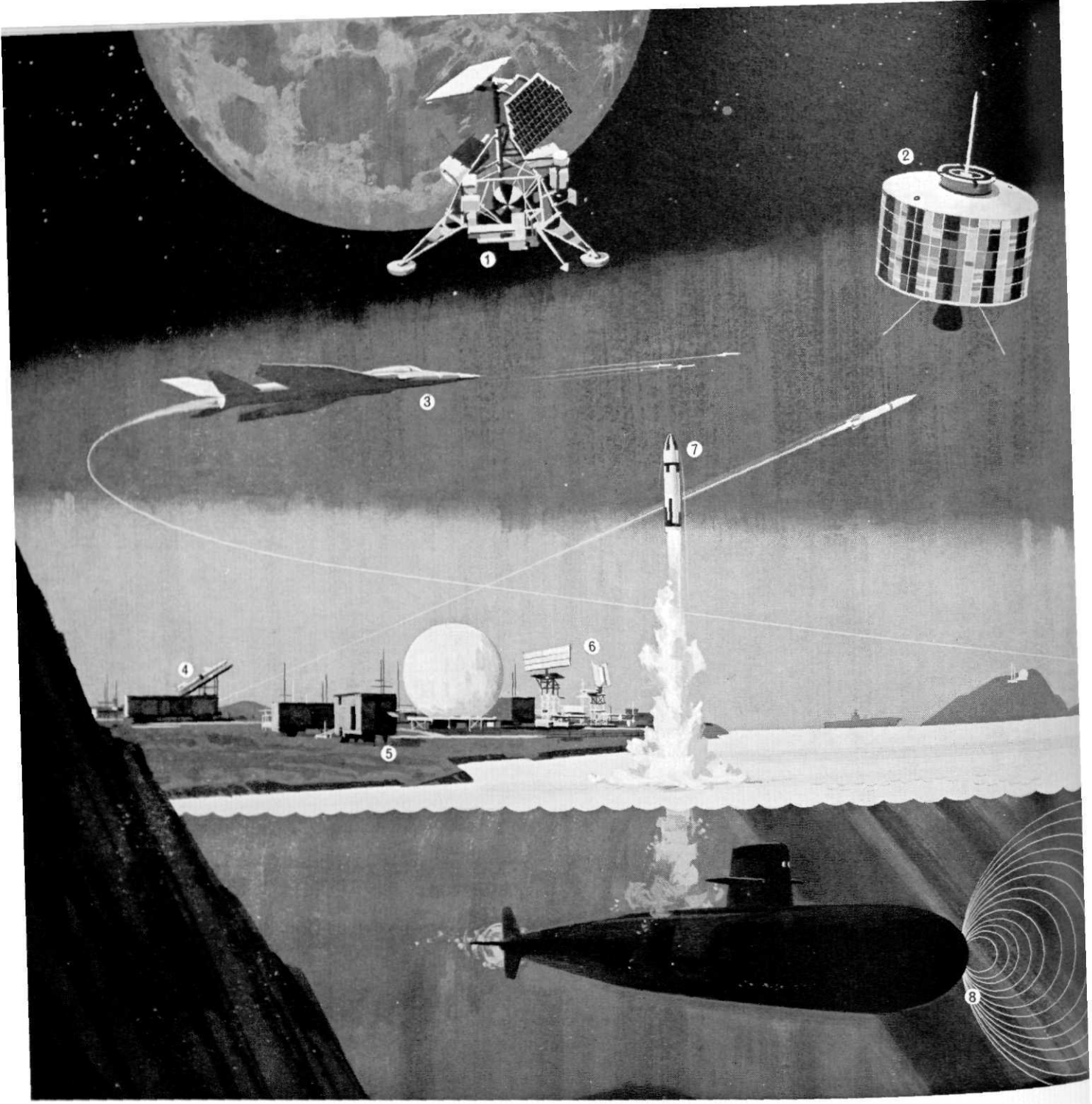
(Editor's Note: This is taken from the Wayne Engineer, who took it from the California Engineer, who took it from the Houston IRE section publication, who took it from the Kansas City IRE section publication, who couldn't remember where they got it.

This is the answer to November's Crossword

DO YOU KNOW WHAT YOU KNOW?

The person that knows it all knows that he knows it all and doesn't have to tell anyone. The person that doesn't know it all doesn't know that he doesn't know it all and has to tell everyone that he does know it all just for fun. Therefore, there are twenty-six letters in the alphabet.

by John B. Locke



Opportunities at Hughes for EE's—Physicists—Scientists:

from the ocean floor to the moon...and beyond

Hughes sphere of activity extends from the far reaches of outer space to the bottom of the sea... includes advanced studies, research, design, development and production on projects such as: ① **SURVEYOR**—unmanned, soft-landing lunar spacecraft for chemical and visual analysis of the moon's surface; ② **SYNCOM** (Synchronous-orbit Communications Satellite)—provides world-wide communications with only three satellites; ③ **F-111B PHOENIX** Missile System—an advanced weapon system designed to radically extend the defensive strike capability of supersonic aircraft; ④ **Anti-ICBM Defense Systems**—designed to locate, intercept and destroy attacking enemy ballistic missiles in flight; ⑤ **Air Defense Control Systems**—border-to-border control of air defenses from a single command center—combines 3D radar, real-time computer technology and display systems within a flexible communications network; ⑥ **3D Radar**—ground and ship-based systems give simultaneous height, range and bearing data—now in service on the nuclear-powered U.S.S. Enterprise; ⑦ **POLARIS** Guidance System—guidance components for the long-range POLARIS missile; ⑧ **Hydrospace**—advanced sonar and other anti-submarine warfare systems.

Other responsible assignments include: *TOW* wire-guided anti-tank missile, *VATE* automatic check-out equipment, Hard Point defense systems.... R & D work on *ion* engines, advanced *infrared* systems, associative computers, *lasers*, *plasma* physics, *nuclear* electronics, *communications* systems, microwave tubes, parametric *amplifiers*, *solid state* materials and devices... *and many others.*

B.S., M.S. and Ph.D. Candidates
Members of our staff will conduct

CAMPUS INTERVIEWS
February 17, 1964

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You'll find that at least a few of these six advantages are exclusive with the civilian Navy generally, and especially with the world-renowned Naval Ordnance Laboratory because of its perenially powerful role in government weaponry research. No "Blue Sky" promises here—you'll soon see why these advantages make sense individually, and why collectively they represent a career development opportunity you really should consider.

1 Vital assignments of national importance

Whatever programs you may work on . . . missile guidance, weapons systems, re-entry components, underwater ordnance, fire control, sonar, fuzes, sonobuoys, nuclear explosives, propellants, solid state, acoustics, infrared . . . you see and follow the big picture, from initial concept to fleet acceptance. *More than 95 major weapons devices developed at NOL are in fleet use today.*

2 Training programs encourage Breadth of Experience

During your first year you will rotate through four assignments in research, engineering, and evaluation. This enables you to understand the whole and to help select a permanent assignment area.

3 Wholly- or Partly-Paid Graduate Education Programs

Various accredited graduate programs, both with local institutions or the university of your choice, permit you to attain your advanced degrees. Many courses are held right at NOL, and enable young professionals to work full time while participating. Most such programs provide for reimbursement of tuition. Stipends, in some cases, are available.

4 Professional Stature and Future Opportunity

NOL retains patents in the employee's name for professional purposes, and for commercial rights in some instances. Attendance at professional meetings is encouraged, and there is ample opportunity to conduct foundational research. At the end of these four years, many doors to the future will be open to you . . . as a professional engineer with an unusually strong R & D background.

5 Top-Flight Equipment & Facilities

Because so much in-house work —$30 MILLION annually—goes beyond the existing and known, NOL has many of the finest research and development facilities available anywhere. NOL headquarters spread over nearly 1,000 acres of suburban Maryland just outside Washington, D. C. (now one of the nation's leading R & D centers). You may also work at NOL test facilities elsewhere in Maryland, in Virginia, and Florida . . . as well as with the operating units of the fleet.

6 Reach the $10,000 to $12,000 level within 4 years

New and virtually unknown is the fact that the new government salary structure lets you earn more than $10,000 within four years . . . PLUS all the benefits of Career Civil Service.

Watch for the NOL representative on campus

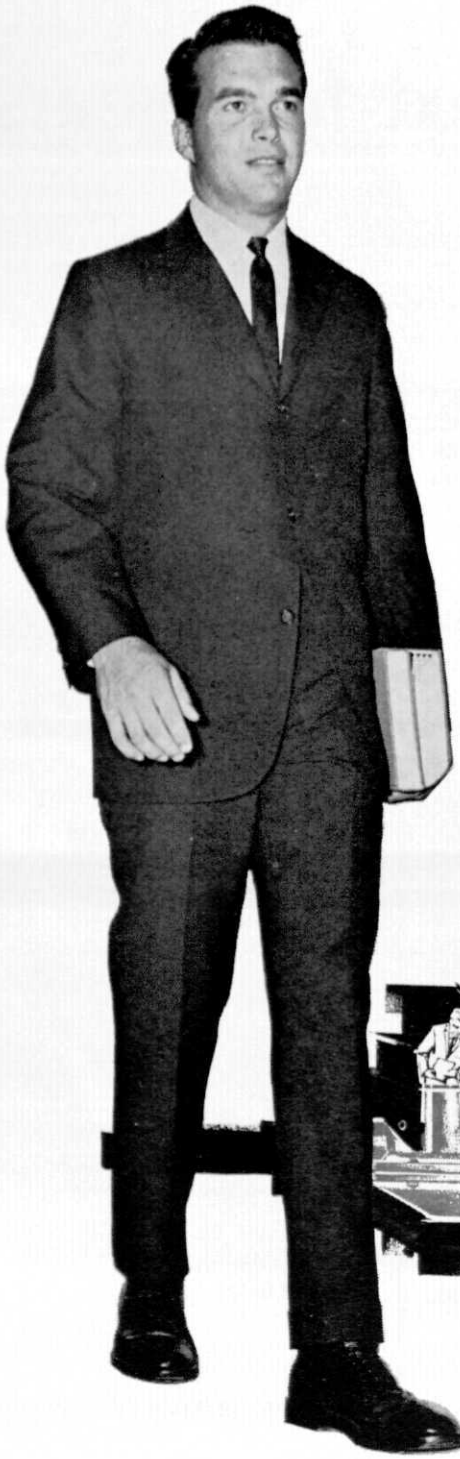
If you would like to contact NOL directly, write to Mr. Emil Kranda, Personnel Officer.

NAVAL ORDNANCE LABORATORY

NOL WHITE OAK

SILVER SPRING, MARYLAND

An Equal Opportunity Employer



Engineers

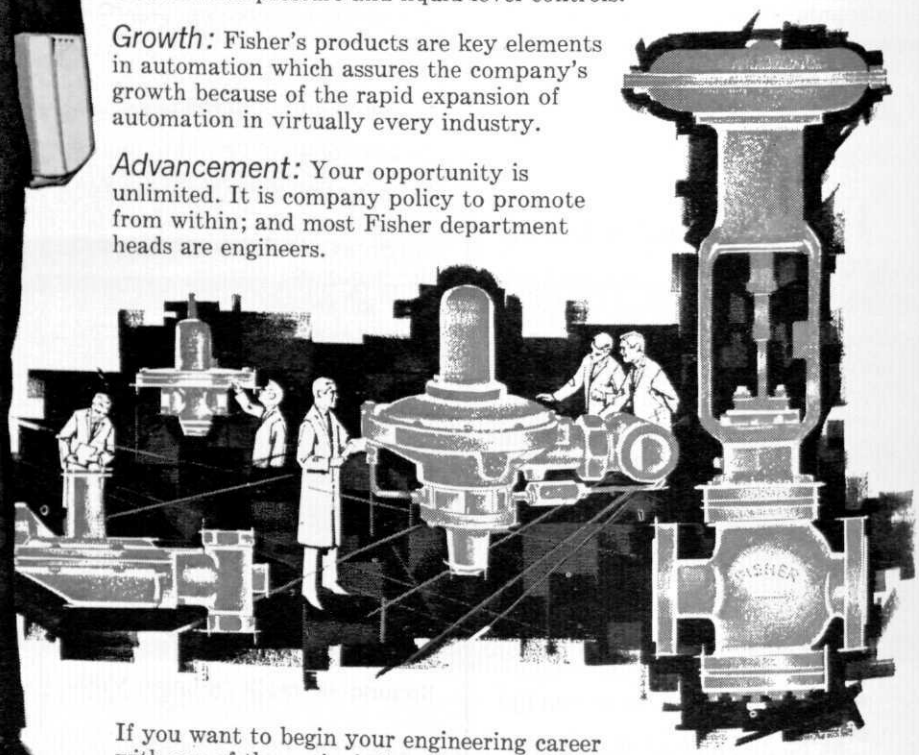
In Choosing a Career, Consider these Advantages—

Location: Fisher is basically an "Engineering" company with 1,500 employees located in a pleasant midwest community of 22,000. It's less than 10 minutes to the Fisher plant from any home in Marshalltown.

Type of work: You'll become a member of an engineering team that has produced some of the outstanding developments in the field of automatic pressure and liquid level controls.

Growth: Fisher's products are key elements in automation which assures the company's growth because of the rapid expansion of automation in virtually every industry.

Advancement: Your opportunity is unlimited. It is company policy to promote from within; and most Fisher department heads are engineers.



If you want to begin your engineering career with one of the nation's foremost research and development departments in the control of fluids, consult your placement office or write directly to Mr. John Mullen, Personnel Director, FISHER GOVERNOR COMPANY, Marshalltown, Ia.

If it flows through pipe anywhere in the world chances are it's controlled by...

FISHER® Controls SINCE 1880

How to tell a career from a job

A job is a job. A career is a place to grow. A career has a future. A job lives from day to day. In a job you get what you can, do what you must. In a career, rewards parallel your contributions.

We're a career company. More than a third of our 90,000 employees have been with us at least 15 years; 10,000 for more than 25 years. There are reasons for this. To assure growth we invest over $90 million a year in research. Fifty percent of last year's sales ($2.4 billion) came from products unheard of just 28 years ago. Because customers like these products, we've grown 750% since 1937.

Our career men share in this growth because we fill virtually all responsible positions from within. Our young men work in several areas to develop their capabilities. This way they can change positions without leaving the company.

There are job men and career men. If you seek a career, we'd like to tell you about an interesting and rewarding one at Du Pont. Write us a letter or clip and mail our coupon today.

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

An equal opportunity employer

TECHNICAL MEN WE'LL NEED FROM THE CLASS OF '64

Chemists	Industrial Engineers
Chemical Engineers	Civil Engineers
Mechanical Engineers	Physicists
Electrical Engineers	Metallurgists

E. I. du Pont de Nemours & Co. (Inc.)
2519-A Nemours Building
Wilmington, Delaware 19898

When I'm graduated, I'll be a_____.
(List profession)

Please rush me more information about how I might fit in at Du Pont.

Name_____

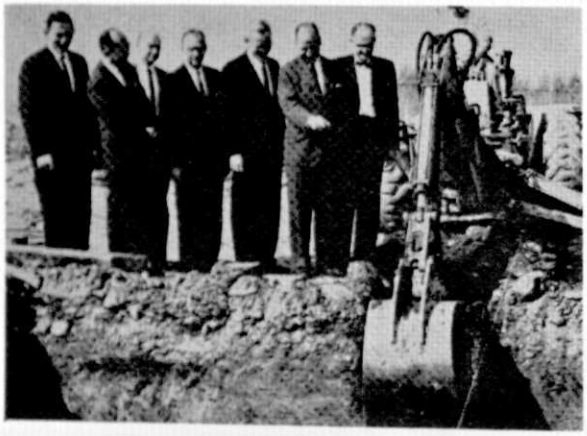
Class_____ Major_____ Degree expected_____

College_____

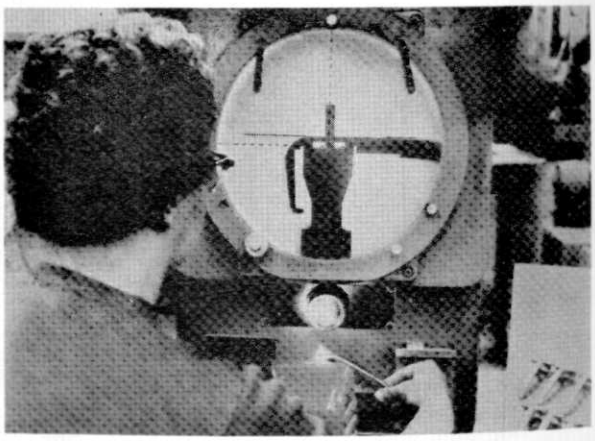
My address_____

City_____ Zone_____ State_____

GREAT MOMENTS IN MICHIGAN STATE ENGINEERING



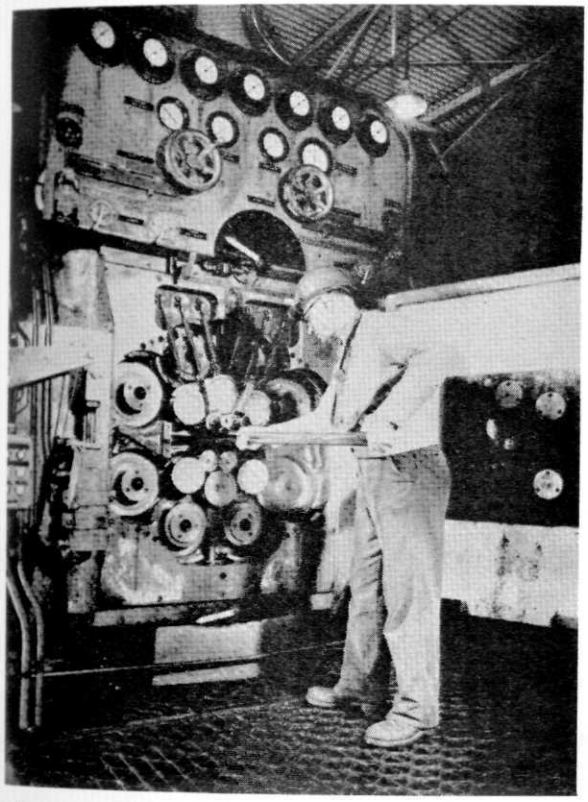
And here, gentlemen, is where the yellow went!



"John, how many times have I told you to quit making paper dolls on that machine?"

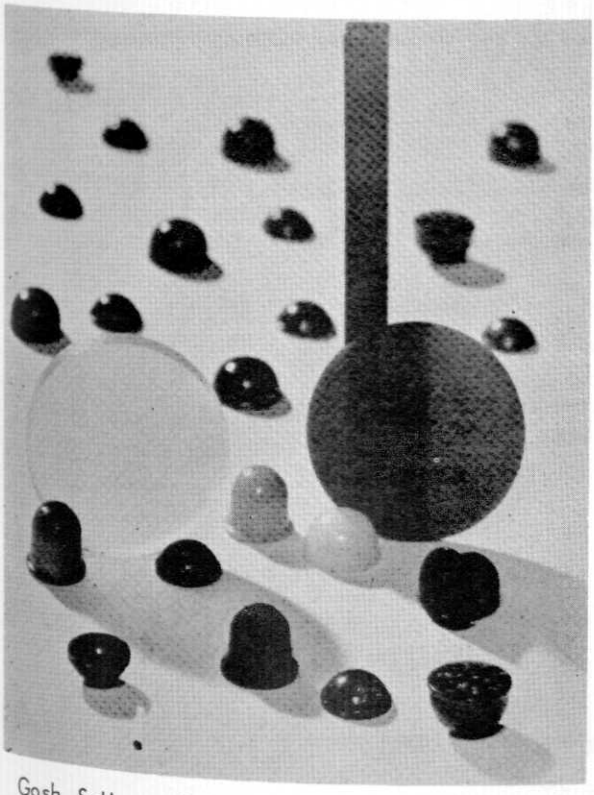
No, Chet, I think it needs a little more Vermouth!

It says, "Help! I'm trapped inside the Engineering 101 Keypunch machine!"

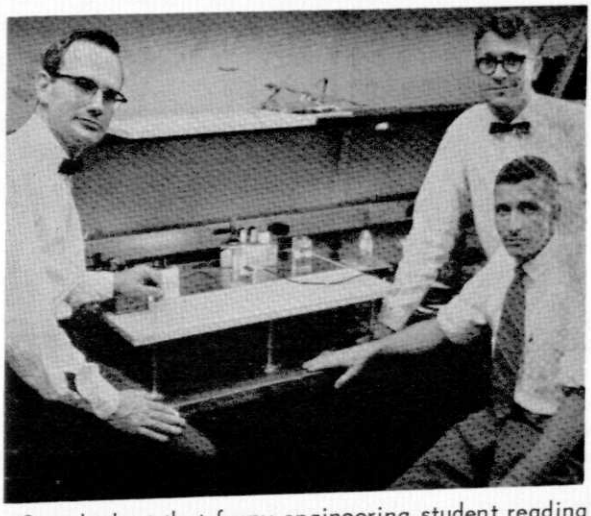


This is the last chunk of salami you're going to get, you monster!

Actually, folks, this was really made by Brand X.



Gosh, Sally, we have sure raised a lovely family!



Gee, look at that funny engineering student reading the Spartan Engineer.

At Sylvania Electronic Systems you can achieve both these objectives. To begin with, diverse programs give you a chance to enter practically any field in electronics: space-earth communications; electronic reconnaissance, detection, countermeasures; information handling; and complex systems for military command and control.

Here you can move about within the community of 20 interrelated research and advanced development laboratories located in a number of different locations including suburban Boston, Buffalo and San Francisco. Or you may prefer SES's Product Support Organization at sites throughout the world. Furthermore, three parallel advancement paths provide ample opportunity to further your career as a technical manager, technical specialist, or program/project manager—with equal rewards.

This major electronics division of Sylvania Electric Products Inc. coordinates for defense all technical personnel and facilities for General Telephone & Electronics Corporation.

For the talented young engineer or scientist eager to progress, career opportunities are now open. For further information see your college placement officer or write to Mr. Robert T. Morton.

SYLVANIA ELECTRONIC SYSTEMS
Government Systems Management
for GENERAL TELEPHONE & ELECTRONICS

40 Sylvan Road—Waltham 54, Massachusetts

An Equal Opportunity Employer

A student put a bottle of Scotch in his pocket. On the way across the street he was knocked down by an automobile. Picking himself up, he started to walk away when he felt something trickling down his pants leg.

"Oh, gosh," he groaned, "I hope that's blood."

Charlie Reynolds had been complaining to his wife for several weeks about all the new, mysterious aches and pains he had recently fallen heir too. Neither one of them could account for his troubles. Then one night, Charlie came home with the solution to his problem and informed his darling wife, "I finally found out why I've felt so over-all lousy the past few weeks. We got some new modern furniture at the office about a month ago, and I found out for the first time today that I've been sitting in the wastebasket."

A hamburger by any other name costs a lot more.

"Were you a bull or a bear in Wall Street?"

"Neither, I was a jackass."

A case was being tried in court. The lawyer for the defense was making his plea to the court and in the course of his speech said to the judge:

"Now, your honor, just suppose I saw you coming out of a gambling house --"

"Passing by one!" the judge hastily interrupted.

The conversation at a party was being monoplized by a self-styled war "hero" who insisted on going into great detail about his exploits. He seemed to be catching the attention of a quiet, elderly looking woman and was soon addressing his remarks to her.

"Why, after I got into the Air Force I shot down two bombers and four fighters. I also blew up three ammunition dumps," he boasted.

"And what happened then?" the lady inquired quietly. "Did you get sent overseas?"

This sign was recently posted on a golf course near Fairbanks, Alaska. "If ball is picked up by a bear, player may replace and add one penalty stroke. If player gets ball back from bear, take automatic par for the hole."

Daffynitions . . .

Coed: A sweater with an IQ.

Engagement ring: A learner's permit.

Middle age: When you start changing your emotions for symptoms.

Ash tray: Where you put your ashes when there is no floor.

The big day was here. The wonderful, gigantic bridge connecting two of the country's largest cities was being formally opened. At the height of the festivities, when thousands of people had thronged onto the bridge, the center span, with a crash heard for miles, fell into the bay, a mass of twisted girders and human bodies. The frenzied mayor, seeing the engineer, dashed up to him, "Look what you've done!"

The engineer, scratching his ear, replied, "I told Joe that decimal point was in the wrong place."

A Texas oil man was visiting New York. His city friends showed him all of the sights including the Empire State Building.

"Isn't that a gigantic structure?" asked the friend.

"Naw, that isn't so big," drawled the Texan. "We've got outhouses in Texas bigger than that."

"Well," drawled back the New Yorker, "I guess you need 'em."

An engineer of a large instrument company was looking over drawings and specifications for a new instrument which had been ordered by one of the firm's largest clients. Attached to the paper was the coded instruction, "MILTDD-41." Not being familiar with these designations the engineer looked in his technical journals, but was unable to find them. Finally he placed a long distance call to the customer.

"Would you mind telling me what 'MILTDD-41' means?" he asked.

"Sure, I'll tell you," the customer said. "It means, 'Make it like the damned drawing for once'."

Who is Olin?
What does Olin make?
What are the types of work at Olin?
What are the opportunities at Olin?

Who is Olin? Olin is a worldwide company with 39,000 employees developing, producing and marketing products from seven divisions: Packaging, Squibb, Winchester-Western, Chemicals, International, Metals and Organics. With corporate offices in New York City, the firm operates 56 plants in 30 states with plants and affiliates in 37 foreign countries.

What does Olin make? Major brand names include Squibb, Winchester-Western,® Waylite,® Ramset,® Roll-Bond;® with fully integrated product lines in industrial and agricultural chemicals, medicinals and pharmaceuticals, arms and ammunition, brass and aluminum, fine papers and transparent films, kraft papers, multi-wall bags and containers.

What are the types of work at Olin? Olin's great diversity provides a broad range of opportunities in the technical science and engineering fields. Emphasis is placed on the B.S. and M.S. chemical, industrial, mechanical and metallurgical engineering student for assignments in plant operations, process control, product development, quality control, production and marketing. Advanced degree M.S. and Ph.D. chemists and metallurgists work in central research and development improving existing products and developing new ones. Men with liberal arts and business backgrounds find rewarding career opportunities in the administrative functions, marketing, and some areas of manufacturing.

What are the opportunities at Olin? Olin recognizes people as its greatest asset. Your future growth and career is as important to the company as it is to you. Beginning with corporate and divisional orientations, you will be given thorough on-the-job training in your first job. You will learn and progress, according to your ability, working with skilled and experienced men in various assignments. For additional information about Olin please contact your Placement Office or write Mr. M. H. Jacoby, College Relations Officer, Olin, 460 Park Avenue, New York 22, N.Y.

Olin

460 Park Avenue, New York 22, N.Y.
"An equal opportunity employer."

An idea grows from one mind to another.

It may begin with nothing important. Just a word. Or a notion. But as each succeeding mind brings a fresh viewpoint, the idea begins to grow and mature.

If you like working in an atmosphere that breeds ideas, you'll like working at Northrop. Stimulating minds and stimulating projects are all a part of the climate here. We have more than 70 active projects in work, and we're constantly evaluating new lines of inquiry. Projects cover such fields as interplanetary navigation and astro-inertial guidance, aerospace deceleration and landing, man-machine and life support systems for space, automatic checkout and failure prediction systems, laminar flow control techniques and world-wide communications.

For more specific information, see your placement counselor. Or write to Dr. Alexander Weir, Northrop Corporation, Beverly Hills, California, and mention your area of special interest.

NORTHROP

AN EQUAL OPPORTUNITY EMPLOYER

Picture of a committee at work!

The man in the picture is a committee of one having a big meeting—with an idea.

He is working independently in one of nine modern engineering and research centers established by International Harvester—a company which has doubled its research and engineering budgets in the past ten years.

Few other companies have created so many new opportunities for college graduates with scientific ambitions.

If you are a mechanical, industrial, electrical, agricultural, chemical, ceramic, metallurgical, general or civil engineer...or a mathematician, computer technologist or program analyst, you are invited to learn more about new and challenging engineering assignments at IH now.

We are now interviewing men interested in careers in the design, development, engineering, manufacturing and testing of *more than a thousand different IH products.*

The men chosen will be recognized members of a team that is first in world production of heavy-duty trucks, farm tractors and agricultural equipment, a world leader in the manufacture of earthmoving and construction equipment and a pioneer in gas turbine development.

Would you like to get better acquainted? Just send the coupon below.

Using a mile of wire and 320 strain gages, a young engineer sets up static stress tests in the new IH Construction Equipment Laboratory.

International Harvester Company

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New booklet describes our engineering and research centers. For your copy, mail this coupon to: General Supervisor of Employment, International Harvester Company, 180 N. Michigan Avenue, Chicago 1, Ill.

AN INTERNATIONAL HARVESTER REPRESENTATIVE WILL BE ON YOUR CAMPUS SOON. IF YOU WOULD LIKE A PERSONAL INTERVIEW, PLEASE CHECK HERE ☐

NAME_____
(Please Print)

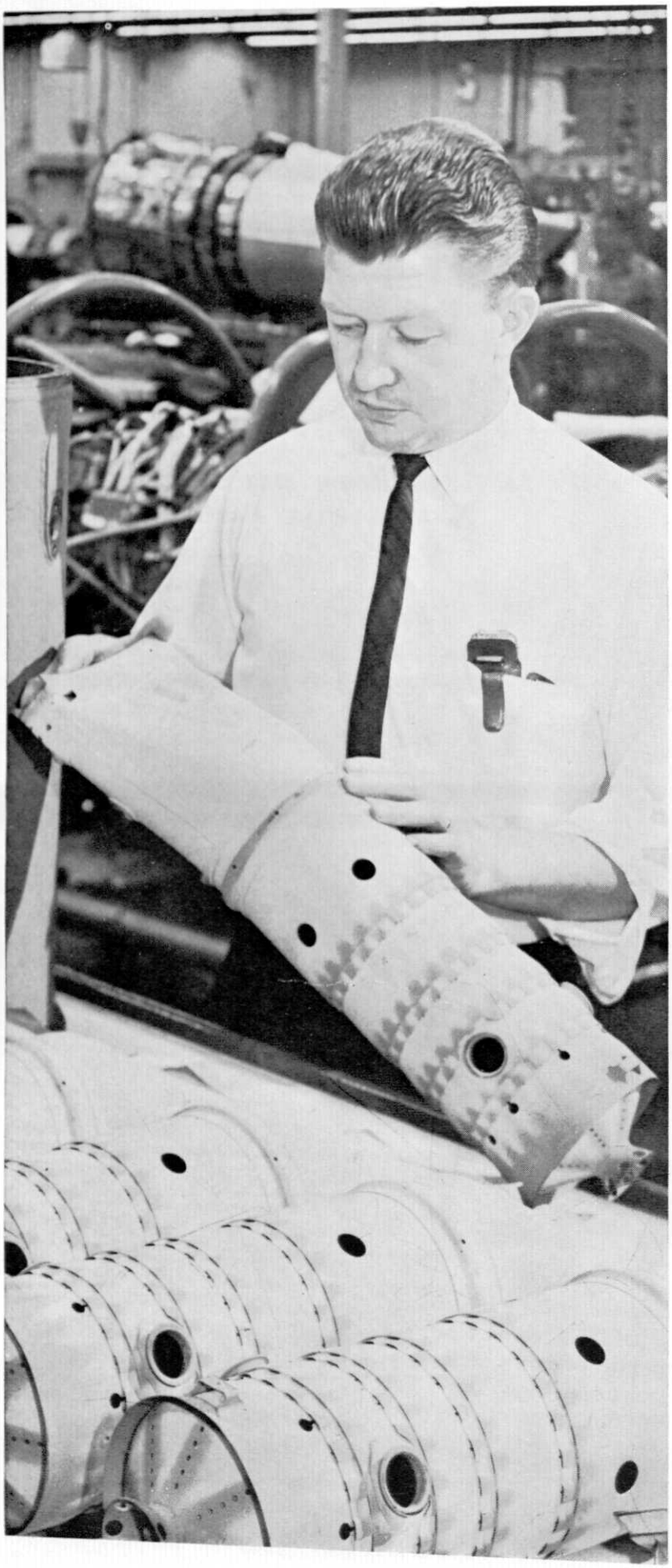
ADDRESS_____

CITY_____ STATE_____

MAJOR_____

SCHOOL_____

YEAR GRADUATING_____



■ Reuben C. Gooderum, BSME Wisconsin, 1962, is shown examining combustion liners after a thermal paint engine test at Allison Division, General Motors, Indianapolis, Indiana. Thermal paint, developed by Allison, is used to determine temperature gradients existing on engine parts.

Gooderum is one of the young engineers at Allison assigned to design and development of air-cooled turbine engine hardware. This work involves rig testing of turbine engine parts to determine optimum configurations. Parts later are endurance-tested on engines to prove the design.

New, air-cooled turbine blades developed by Allison engineering have permitted more than 250°F higher turbine inlet temperatures on turboprop engines, providing as much as 63% increased horsepower for the same engine envelope.

We think you, too, will like the creative climate at Allison, as well as the advantages of being associated with a long-established leader in the design, development and production of high performance aircraft engines. Talk to our representative when he visits your campus. Let him tell you what it's like at Allison where Energy Conversion Is Our Business.

An equal opportunity employer

Allison

THE ENERGY CONVERSION DIVISION OF GENERAL MOTORS, INDIANAPOLIS, INDIANA

GM GENERAL MOTORS

We are the chemical company that an electromechanical designer might be operating some day

The chemistry of photography is far from being all of chemistry that concerns us. Actually, it is rapidly going into hiding inside such machines as these automatic x-ray processors for hospitals, seen here under construction.

We need **electromechanical engineers** to design all kinds of automatic photographic apparatus that we have ideas for—big ones, little ones, simple ones, super-sophisticated ones, inexpensive ones to sell by the millions, very expensive ones for maybe internal use only.

We need **process engineers,** by which we mean those who figure out the best way to make what the designers have dreamed up.

We need **industrial engineers,** who work out the most rational relationships between apparatus and people—the people who work in the plants and even on occasion the people who buy or use our products.

This is a great place for all categories of engineers. However, we think in categories largely for hiring purposes. There is such a thing as mobility, and it doesn't have to be geographical.

Incidentally, we still need **chemical engineers.** Maybe you are one and maybe you join us and maybe you turn out to be such a whiz at your profession that after a while we ask you to operate an electromechanical plant for us.

EASTMAN KODAK COMPANY

Business and Technical Personnel Department, Rochester, N.Y. 14650

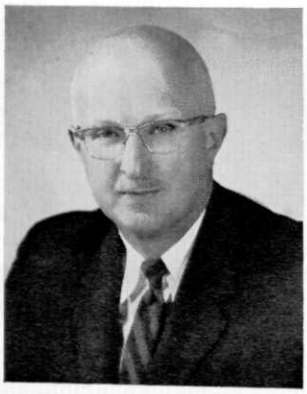
An equal-opportunity employer offering a choice of three communities:
Rochester, N.Y., Kingsport, Tenn., and Longview, Tex.

Kodak

GROWTH THROUGH TECHNOLOGICAL CHANGE

The Role of R&D in Industry

An interview with G.E.'s Dr. George L. Haller Vice President—Advanced Technology



As Vice President—Advanced Technology Services, Dr. Haller is charged with coupling scientific knowledge to the practical operating problems of a Company that designs and builds a great variety of technical products. He has been a radio engineer, both in industry and the armed services (Legion of Merit for development of radar counter-measures); physics professor at Penn State and dean of its College of Chemistry and Physics; and a consulting engineer. With G.E. since 1954, he has been manager of its Electronics Laboratory, and general manager of the Defense Electronics Division. He was elected a vice president in 1958.

For complete information on opportunities for engineers at General Electric, write: Personalized Career Planning, General Electric Company, Section 699-09, Schenectady, N. Y. 12305

Q. Dr. Haller, how does General Electric define that overworked term, Research and Development?

A. At General Electric we consider "R&D" to cover a whole spectrum of activities, ranging from basic scientific investigation for its own sake to the constant efforts of engineers in our manufacturing departments to improve their products—even in small ways. Somewhere in the middle of this range is an area we call simply "technology", the practical know-how that couples scientific knowledge with the engineering of products and services to meet customer needs.

Q. How is General Electric organized to do research and development?

A. Our Company has four broad product groups—Aerospace and Defense, Consumer, Electric Utility, and Industrial. Each group is divided into divisions, and each division into departments. The departments are like separate businesses, responsible for engineering their products and serving their markets. So one end of the R&D spectrum is clearly a department function—engineering and product design. At the other end is the Research Laboratory which performs both basic and applied research for the whole Company, and the Advanced Technology Laboratories which also works for the whole Company in the vital linking function of putting new knowledge to practical use.

Having centralized services of Research and Advanced Technology does not mean that divisions or departments cannot set up their own R&D operations, more or less specialized to their technical or market interests. There are many such laboratories; e.g., in electronics, nuclear power, space technology, polymer chemistry, jet engine technology, and so on.

Q. Doesn't such a variety of *kinds* of R&D hamper the Company's potential contribution? Don't you find yourselves stepping on each other's toes?

A. On the contrary! With a great many engineers and scientists working intensively on the problems they understand better than anyone else, we go ahead simultaneously on many fronts. Our total effort is broadened. Our central, Company-wide services in Research and Advanced Technology are enhanced by this variety of effort by individual departments.

Q. How is Advanced Technology Services organized?

A. There are three Advanced Technology Laboratories: Chemical and Materials Engineering, Electrical and Information Engineering, and Mechanical Engineering; and the Nuclear Materials and Propulsion Operation. The Laboratories do advanced technology work on their own, with Company funds, and on contract to product departments or outside customers and government agencies. NMPO works for the AEC and the military to develop materials and systems for high-temperature, high-power, low-weight nuclear reactors. ATS is the Company's communication and information center for disseminating new technologies. It also plans and develops potential new business areas for General Electric.

Q. So R&D at General Electric is the work of a great many men in a great many areas?

A. Of course. The world is going through a vast technological revolution—in the ways men can handle energy, materials, and information. Our knowledge is increasing exponentially. In the last five years we have spent more than half the money ever spent for research and development. To keep competitive, and to grow, industry must master that mountain of new knowledge and find ways to put it to practical use for mankind. Only by knowing his field well and keeping up with the rush of new developments, can the young engineer contribute to the growth of his industry—and society as a whole.

Progress Is Our Most Important Product

GENERAL ELECTRIC

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