

SCIENTIFIC AMERICAN



IONIZING RADIATION

FIFTY CENTS

September 1959

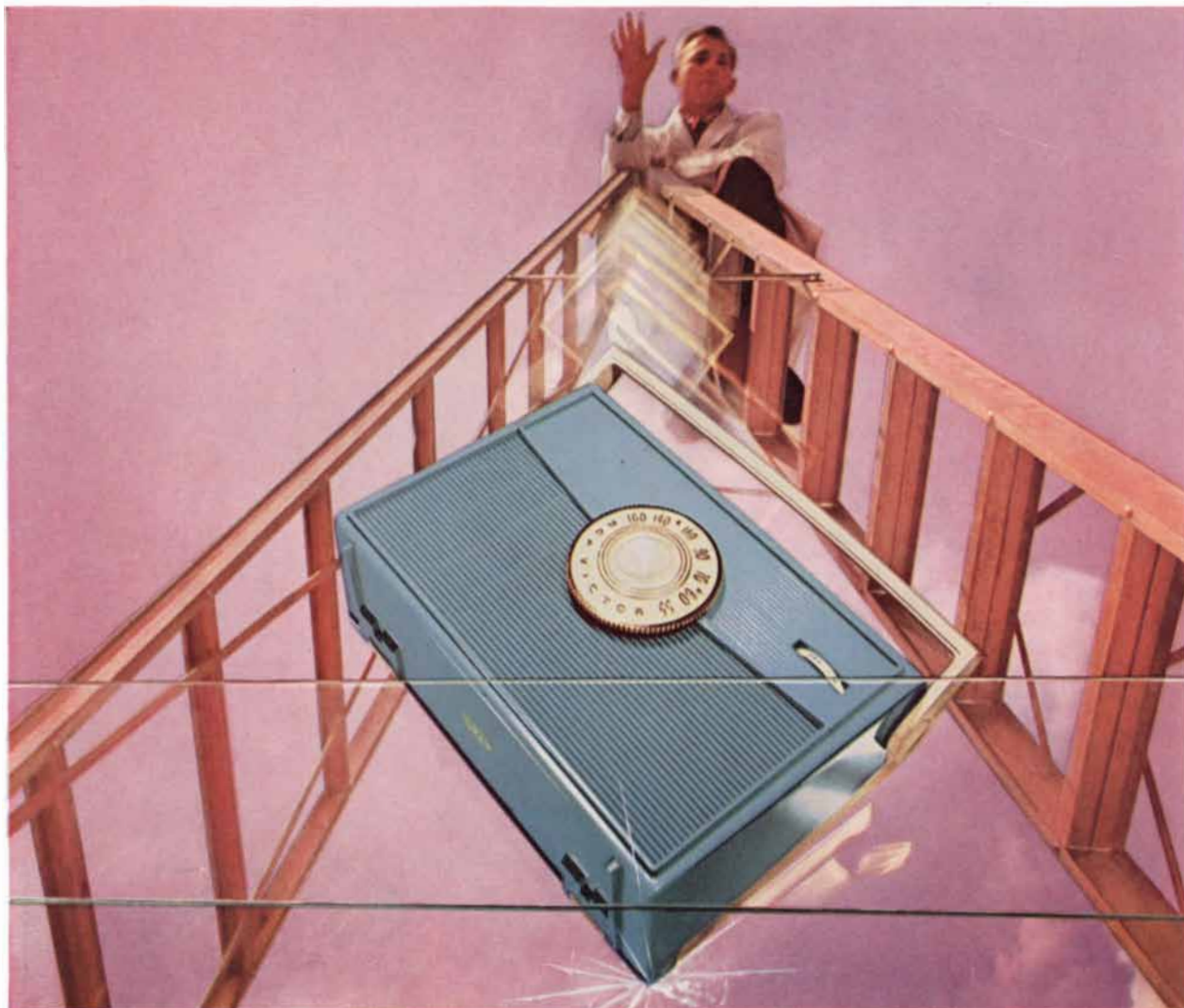


Photo courtesy Radio Corporation of America

Secret of a Smashing Success

Dropped 10 feet—this polystyrene radio case bounced, clattered, *but did not break*. It did not chip or crack—did not show a single mark of its high dive. Dramatic evidence, wouldn't you say, of the remarkable strength being built into modern plastics.

How to make tougher polystyrene—the material used in most radio cases—was long a priority project with all its manufacturers. Concentrated research and development finally solved the problem. The secret of success for many producers: combining the product with PLIOFLEX rubber.

Plioflex, with its unusually light color, high uniformity and particular physical properties, was selected over many other possible modifying materials. Experience has proved it to be the best choice to meet the exacting demands of the plastics industry.

Making more durable, more salable radio cases is but one of the many uses for the many types of PLIOFLEX. How can you use PLIOFLEX to advantage, either alone or in combination with other materials? Find out by writing to Goodyear, Chemical Division, Dept. I-9457, Akron 16, Ohio.



GOODYEAR

CHEMICAL DIVISION

Plioflex—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

FOR AIR AND SPACE VEHICLES...

Perfected Variable Increment Technique...

makes GEVIC* the most
versatile computer
available



SMALL—0.8 cu. ft.
LIGHT—45 lbs.

The new Variable Increment technique utilized in GEVIC provides the speed of an analog computer along with the accuracy and flexibility of a digital.

GEVIC can select any of several increments to correct the output carried over from the previous computer cycle.

The same sequence of operations is used for subtraction, multiplication, division, sine and cosine, addition, square root, filtering, integration, and differentiation. Any or all of these operations can be performed singly or simultaneously. The GEVIC design also incorporates a built-in test problem, which acts as a continuous checkout for the unit.

The modular construction of the circuits and the core diode

*General Electric Variable Increment Computer

design offer an inordinately high degree of reliability. The cores (made of special magnetic materials) perform with a nearly square hysteresis loop in combination with silicon diodes operated substantially below their normal rating.

GEVIC's small size and light weight makes it ideal for air and space vehicles of all types as well as for mobile ground-based installations.

GEVIC represents an entirely new medium of electronic computation and is considered a major breakthrough in computer technology.

For *brochure* and complete details . . . Write Manager — Armament Sales, General Electric Company, Light Military Electronics Department, Johnson City, N. Y. Dept. 13D.

Send for free
illustrated brochure.



LMED
LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL  ELECTRIC

LIGHT MILITARY ELECTRONICS DEPARTMENT
FRENCH ROAD, UTICA, NEW YORK

A DEPARTMENT IN THE DEFENSE ELECTRONICS DIVISION



Charles Darwin...on evolution

"It is interesting to contemplate a tangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent upon each other in so complex a manner, have all been produced by laws acting around us.... Thus, from the war of nature, from famine and

death, the most exalted object we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved."

— *Origin of Species*, 1859

THE RAND CORPORATION, SANTA MONICA, CALIFORNIA

A nonprofit organization engaged in research on problems related to national security and the public interest

ARTICLES

- 74 **WHAT IS IONIZING RADIATION?**, by **Robert L. Platzman**
A survey introducing an issue devoted to a force that can alter matter and man.
- 84 **THE CIRCULATION OF ISOTOPES**, by **J. R. Arnold and E. A. Martell**
They travel by air and water routes throughout the world and into living organisms.
- 94 **RADIATION AND THE CELL**, by **A. Hollaender and G. E. Stapleton**
Direct hits and chemical products of radiation damage specialized cell structures.
- 117 **IONIZING RADIATION AND THE WHOLE ANIMAL**, by **John F. Loutit**
Some effects of radiation are apparent, but others must be inferred indirectly.
- 138 **IONIZING RADIATION AND EVOLUTION**, by **James F. Crow**
Radiation causes mutation. Is radiation thereby an important factor in evolution?
- 164 **IONIZING RADIATION AND MEDICINE**, by **Shields Warren**
X-rays and isotopes can be made an unmixed blessing if the dosages are kept low.
- 180 **IONIZING RADIATION AND ORGANIC CHEMISTRY**, by **A. Charlesby**
Basic research is laying the foundations for a novel branch of chemical technology.
- 200 **IONIZING RADIATION AND METALS**, by **Douglas S. Billington**
Displacement of atoms by energetic particles yields new insight into the solid state.
- 219 **IONIZING RADIATION AND THE CITIZEN**, by **George W. Beadle**
How can mankind make the best use of radiation and minimize its hazards?

DEPARTMENTS

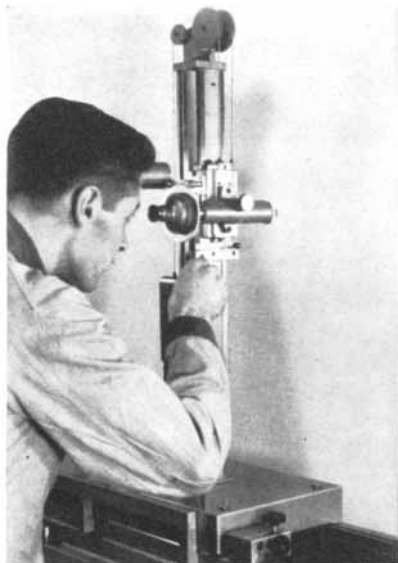
- 16 LETTERS
- 36 50 AND 100 YEARS AGO
- 54 THE AUTHORS
- 102 SCIENCE AND THE CITIZEN
- 236 MATHEMATICAL GAMES
- 249 THE AMATEUR SCIENTIST
- 267 BOOKS
- 288 BIBLIOGRAPHY

BOARD OF EDITORS Gerard Piel (Publisher), Dennis Flanagan (Editor), James R. Newman, E. P. Rosenbaum,
C. L. Stong, Esther A. Weiss

ART DIRECTOR James Grunbaum

GENERAL MANAGER Donald H. Miller, Jr.

ADVERTISING MANAGER Martin M. Davidson



M1238-1818 — Range 18" x 18", working distance 9" to infinity. Reads to 0.001" up to 24" working distance. Protractor ocular reads to 3 minutes of arc. Image is erect.


Cut inspection time in half

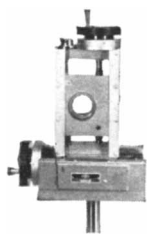
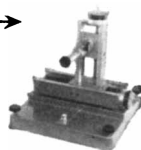
with new Gaertner
Coordinate Cathetometers


These convenient, reliable optical instruments permit making precise coordinate measurements in a vertical plane. The two dimensions are measured with one setting, object does not have to be rotated. Inspection time is cut in half and resetting errors eliminated.

Versatile Gaertner Coordinate Cathetometers are ideally suited for precision measurements on large objects; also objects or points in recessed, remote, or inaccessible locations. Applications include measuring jet engine sections, complicated castings, printed circuits, bolt holes and bosses on large piece parts, traces on cathode ray tubes, etc.

Because these are optical rather than mechanical measuring instruments, you make non-destructive measurements without contact, distortion, or concern about pressure being applied to the object when making a setting. Instruments available in English or Metric system.

M1236-46 — 
Horizontal range 6",
vertical range 4".
Reads to 0.0001",
working distance 5"
to infinity.



M1236-22 — 
Range 2" x 2", reads
to 0.0001". Working
distance 5" to infinity.
Shown with 19 mm
mounting rod, and without
telemicroscope. Instrument
permits precise coordinate
movement of other objects
such as photo cells,
probes, etc., in place
of telemicroscope.

Write for Bulletin 188-53

The Gaertner Scientific Corporation

1236 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335



THE COVER

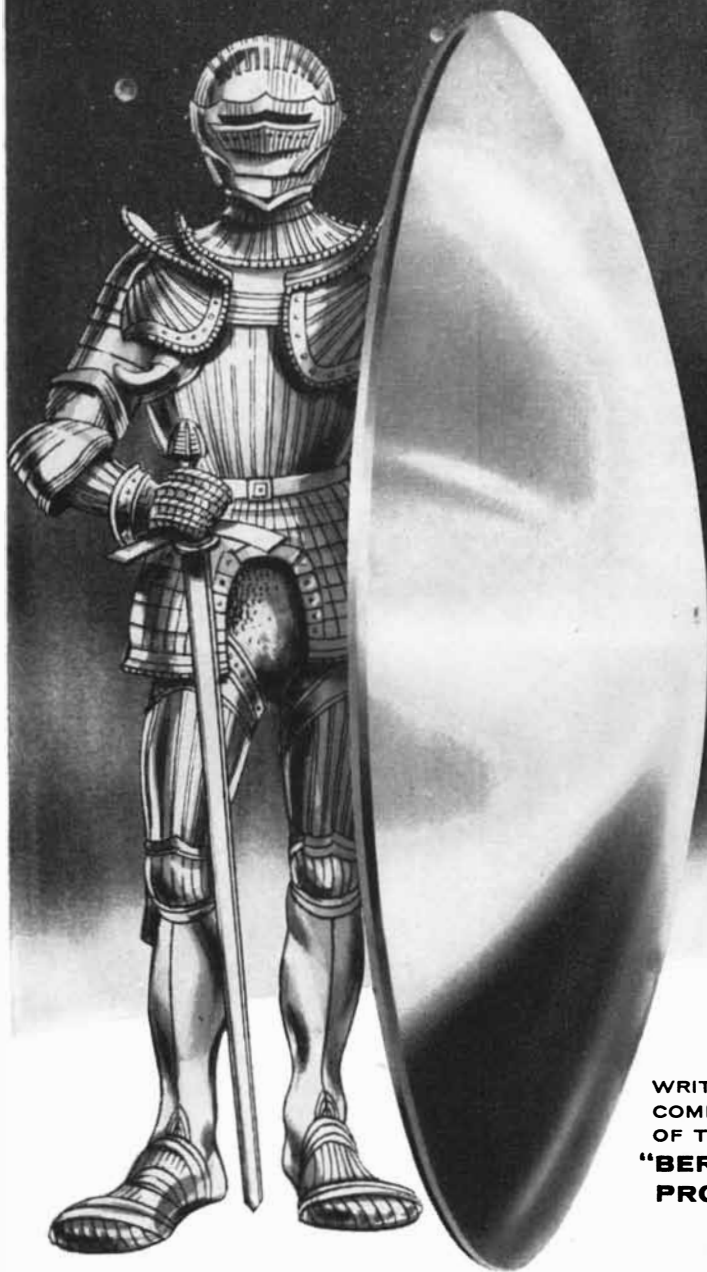
The photograph on the cover of this issue, which is devoted to the topic of ionizing radiation, shows a beam of ionizing radiation produced by a two-million-electron-volt Van de Graaff accelerator. At the top of the photograph is the bottom of a "scanner" which spreads the narrow beam of electrons from the accelerator. Blue glow in middle of photograph is emitted by air molecules that have been ionized by the electrons. At bottom are two dishes containing seeds under experimental irradiation. The facility is at the High Voltage Engineering Corporation in Burlington, Mass.

THE ILLUSTRATIONS

Cover photograph by William Vandivert

Page	Source	Page	Source
72	Herman Yagoda, Air Force Cambridge Research Center	166	Columbia-Presbyterian Medical Center
75	J. K. Bøggild, University Institute for Theoretical Physics	168	Paul Weller (<i>top</i>), James Egleson (<i>bottom</i>)
76	James Egleson	170	David L. Jofes, Cancer Research Institute, New England Deaconess Hospital
77	Bernarda Bryson	172	Paul Weller
79-83	James Egleson	173	Picker X-Ray Corporation
84	Herman Yagoda, Air Force Cambridge Research Center	174-181	Paul Weller
86-90	Irving Geis	182	George Adler and Robert F. Smith, Brookhaven National Laboratory
91-92	Emi Kasai	184-188	James Egleson
93	Irving Geis	190	William Vandivert
94	Arnold H. Sparrow and Robert F. Smith, Brookhaven National Laboratory	192	A. Charlesby
96-97	John Langley Howard	200	Bunji Tagawa
98	Emi Kasai	202-206	Oak Ridge National Laboratory
99-100	John Langley Howard	208	Bunji Tagawa
117	Torsten André	210	Bunji Tagawa (<i>top</i>), Oak Ridge National Laboratory (<i>bottom</i>)
118	Oak Ridge National Laboratory	219	United Nations
120-122	Evelyn Urbanowich	220-221	Emi Kasai
124	René Martin	222	J. H. Tjio and T. T. Puck, University of Colorado Medical Center
139	L. C. Dunn, Columbia University	236-238	Paul Weller
140-144	Eric Mose	240-244	Alex Semenoick
149-154	James Egleson	250-262	Roger Hayward
164	Eastman Kodak Company		

**SHIELD FOR THE
BATTLE OF SURVIVAL
IN SPACE**



QMV*
**BERYLLIUM
HEAT SINK**

(SIX-FOOT DIAMETER FORGING
PRODUCED FOR THE NASA SPACE-
CAPSULE TESTING PROGRAM)

WRITE FOR YOUR
COMPLIMENTARY COPY
OF THE CASE HISTORY
"BERYLLIUM IN
PROJECT MERCURY"



*QMV is a Trade Mark of THE BRUSH BERYLLIUM COMPANY

BRUSH BERYLLIUM

4301 PERKINS AVENUE • CLEVELAND 3, OHIO

beryllium • beryllium oxide • beryllium alloys



PLASTICS PLAY LEAD IN NEW SALES SEASON

Rapid-fire developments in versatile thermoplastic materials herald sure-fire successes on the sales front. As the new products make their public debut, plastics are increasingly conspicuous by their presence. These chemically engineered materials are lightweight, yet strong and durable. They save pennies on the production line, look like a million in the show window.

Take Styron Verelite, newest in the fast growing Dow line-up of polystyrene materials. Designed specially for interior lighting applications such as grids and diffusers for fluorescent fixtures, it's light-stabilized, offering superior resistance to yellowing. It is now available in several granulations for both extrusion and molding.

LIGHTWEIGHT STYRON MAKES VACUUM CLEANER SALES HUM

Dow thermoplastic replaces other materials, delivers production economy, attractive appearance.

The manufacturer of the compact vacuum cleaner shown below put plastics to full use in redesigning his product. The result is a lightweight, extremely portable and attractive unit that stimulates sales and gives the pro-

duction man fewer headaches.

Styron® 475, one of Dow's high impact thermoplastics, was used for the housing and other rigid parts. The flexible parts are vinyl. The cleaner is available in two models, one for the home (pictured below) and one for industrial use. Lightweight Styron 475 makes the industrial version ideal for cleaning radio tubes, electronic equipment and other products with hard-to-get-at corners and crevices.

In addition to a smartly styled appearance and a wide selection of colors, Styron 475 provides a warm touch pleasing to housewives. Compared to materials previously used, it trims costs by eliminating several fabrication and assembly operations. Like all Dow plastics, it gives the designer broad latitude and its quality is consistent and uniform. This contributes to greater production efficiency and fewer rejects.

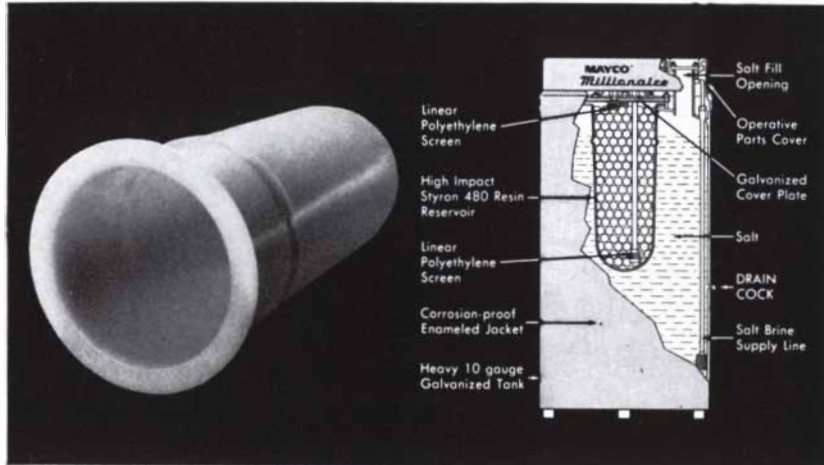


This compact, time and effort saving portable vacuum cleaner lightens the work of the housewife and maintenance man. Its components are molded of tough versatile Styron 475.

PLASTICS PERFORM

when pressure's on

This water softener creates a vacuum in its recharging cycle, producing up to 120 lbs. pressure on every square inch on the surface of the tank. That's one of the many reasons Styron 480, Dow's *extra* high impact thermo-plastic, with its great strength was chosen for the job. As Styron is rust-proof, there are no corrosion problems. The excellent moldability of Styron helped in making this large, tick-walled tank. This application is typical of many developed for manufacturers by a plastics molder offering integrated design and production services.

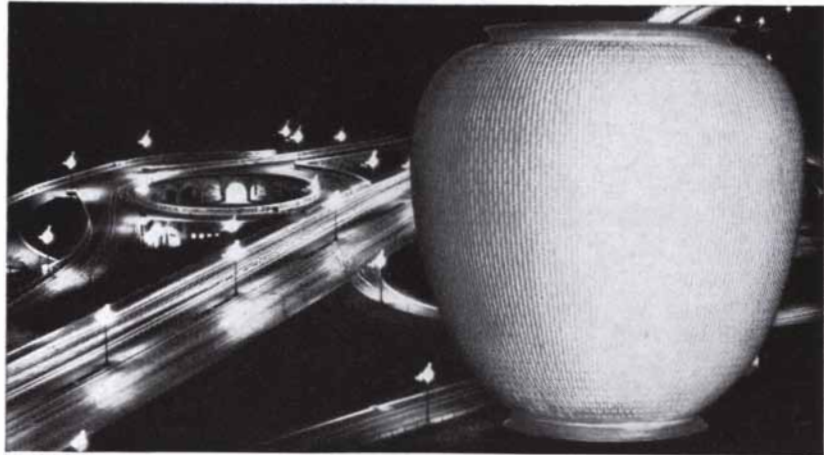


ZERLON* 150:

no break for boys

There'll be plenty of disappointment among the younger set when they discover their sling shots and air rifles won't shatter this street light globe. It's made of Zerlon 150, a new Dow plastic that combines outstanding transparency and strength. When struck sharply, Zerlon 150 "stars" rather than cracking or shattering. This property will sharply reduce maintenance and replacement costs for municipal governments. What's more, Zerlon 150 actually provides better transmission of light than the material normally used in this application. The globe is now in test service in a major U. S. city.

*TRADEMARK



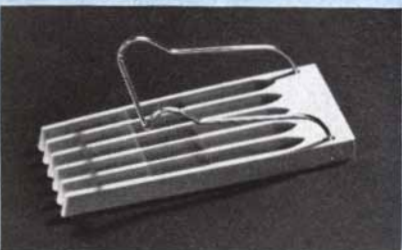
FOUR DISTINCTIVE PRODUCTS MADE OF DOW THERMOPLASTICS



STYRON 475. Even the time-honored thread spool can be improved by plastics! No wood grain imperfections to worry about in smooth-surfaced, colorful Styron 475.



POLYETHYLENE. The extremely intricate mesh design of this lace work bag thoroughly demonstrates the excellent flow characteristics of Dow Polyethylene 990M.



TYRIL®. Tyril, a copolymer of styrene and acrylonitrile, provides rigidity, craze resistance and freedom from cracking in this unique pants hanger.



STYRON 475. Fine surface gloss, impact resistance, color selection and excellent electrical properties make Styron 475 ideal for this indoor TV antenna housing.

FOR MORE INFORMATION . . .

about the versatile Dow plastics and the products discussed on these two pages, write to us today. **THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1512EQ9.**

THE DOW CHEMICAL COMPANY

Midland, Michigan



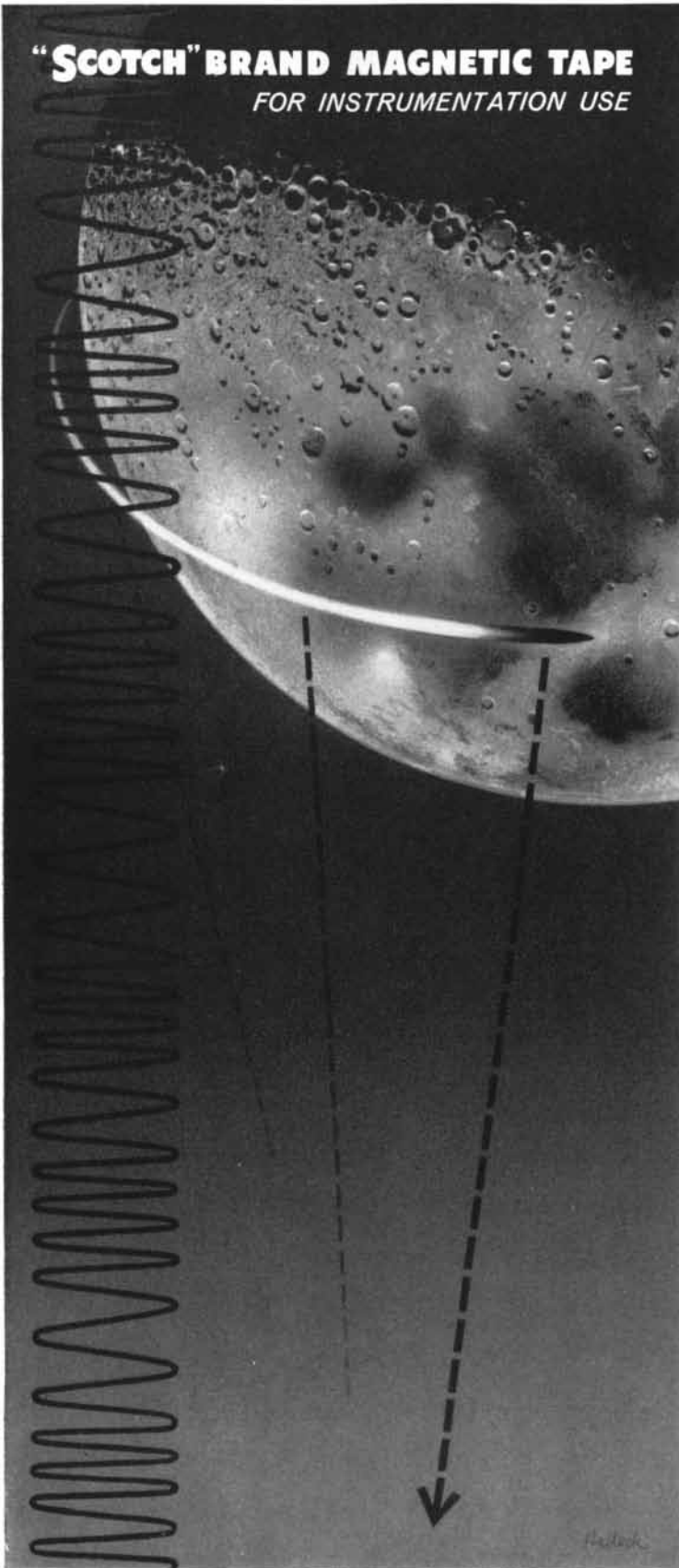
Industrial molding materials

•
Packaging materials

•
Paint and coating materials

•
Building products

"SCOTCH" BRAND MAGNETIC TAPE
FOR INSTRUMENTATION USE



**MAGNETIC MEMORY OF
16 CHANNELS
OF VITAL STATISTICS
—BEAMED FROM A
ROCKET IN FLIGHT**

Velocity. Altitude! Stress! Strain! Air pressure. Trajectory. Heat and cold. Shooting the moon or downrange, the missile man must record these—and more—when he sends his voyager out in the silent sea of space. For this sensitive task of simultaneously recording up to 16 channels of vital readings on the flight performance of a missile, "SCOTCH" BRAND Magnetic Tape has proven reliability.

Taken with more-than-human speed and accuracy, these telemetered magnetic notes can be checked and rechecked for clues to improved design.

"SCOTCH" BRAND Magnetic Tape — the first practical magnetic tape made — remains the leader as newer, more sensitive instrumentation tapes are developed for science, automated industry, and business. It will serve you, too. For information on tape constructions for your specific needs, write Magnetic Products Division, Dept. MBO-99, 3M Co., 900 Bush Ave., St. Paul 6, Minn.

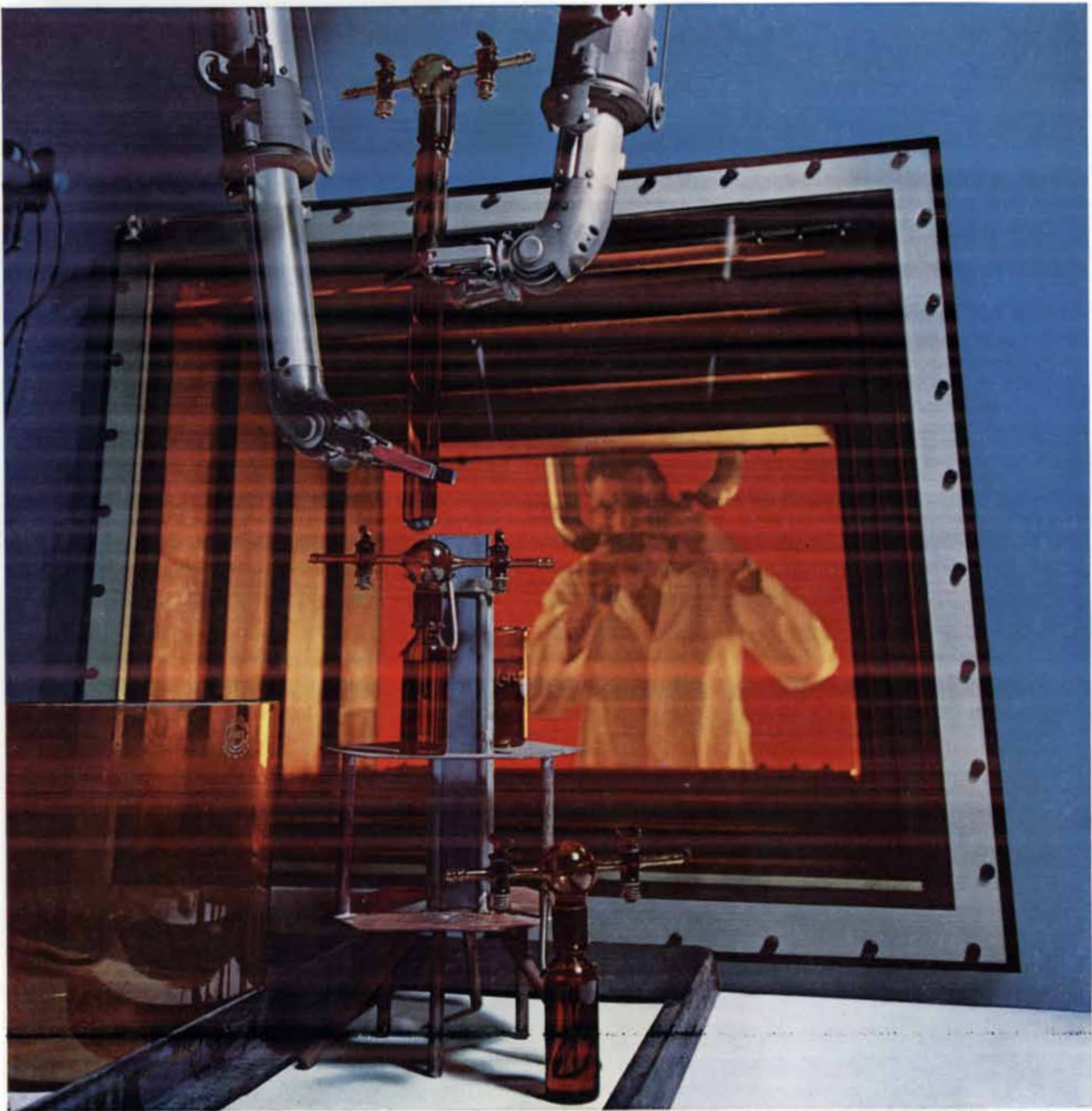
© 1959 3M Co.

*"SCOTCH" BRAND Magnetic Tape
—the memory of tomorrow*

The term "SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minnesota. Export: 99 Park Avenue, N.Y. Canada: London, Ont.

MINNESOTA MINING AND MANUFACTURING COMPANY
... WHERE RESEARCH IS THE KEY TO TOMORROW





No darkening, even under the most intense radiation, when you use Corning windows. Whether dry or oil-filled, the windows also resist corrosion and moisture. Windows come as packaged units, ready to install.

Why it's as easy to buy a hot-cell window as a test tube

You leave a hole in your hot cell . . . we'll do the rest.

That's the simple proposition made by the men who sell our radiation shielding windows. And they've backed it up in more than 400 installations.

You tell us the wall thickness and the peak energy level you'll be working at and the viewing area you'll need.

We do *all* calculations, provide designs and materials, and deliver a packaged window that's ready to install.

Three special glasses

We've developed three glasses to answer any radiation problem. The glasses are used singly or in combination, depending on your needs.

Corning Code 8362 is a cerium-stabilized, non-browning lead glass with a density of 3.3 gm/cc and a refractive index of 1.59.

Corning Code 8363 is a special, high-lead glass that weighs in at 6.2 gm cc and equals iron for shielding. R.I. is 1.98.

Corning Code 8365 is a cerium-stabilized, non-browning lime glass. Density is 2.7 gm/cc. R.I. is 1.52.

For complete details on these glasses and the service that goes with them, write for a copy of Bulletin PE-51. One of our men will be glad to work with you on your projects. Corning Glass Works, 49 Crystal St., Corning, N. Y.

CORNING GLASS WORKS
CORNING MEANS RESEARCH IN GLASS

CORNING CAN DO ALMOST ANYTHING WITH GLASS



Upjohn

The microcosm of living cells has long been the focus of medical research at Upjohn. Work in this field is important in the development of more than 500 Upjohn medical products. But it is more in terms of the future that the cell is a target of study. As knowledge of cell function is defined, medical research will design more potent and more specific medicines to conquer disease.



View of the new Upjohn model of a typical cell structure (enlarged 250,000 times), showing the Golgi complex (green) near the nucleus (red).

COUNTERMEASURES and the myxine glutinosa



COUNTERMEASURES and Instruments for Industry

The I.F.I. "Menagerie Series", familiar to most electrical engineers, graphically illustrates the contributions made by I.F.I. to this exacting field of countermeasure engineering upon which our very survival may well depend...

FORMIDABLE, INDEED, IS THE HORRENDOUS HAGFISH though small in size, his capabilities are enormous...

Seventeen inches of devastating destruction are represented in the pictures above. Appearing to be no more than another small eel, this specimen can, in a matter of hours, eat his way through the skin of his victim and then proceed to devour everything, except bone.

A small drone, equipped with devices to make it appear as one or more bombers when viewed on radar scopes, could very well carry an atomic warhead capable of delivering a devastating blow to a secondary target. Instruments For Industry has for many years perfected Army & Navy countermeasure devices.

COUNTERMEASURES and the testudinidea malaclemys



FORTUNATE, INDEED, IS THE TURTLE for he carries his countermeasure right on his back

Man on the other hand must devise his own countermeasures if he intends to survive in this day of modern warfare. Instruments For Industry is actively engaged in this field working in close conjunction with the Army, Navy, Marines and Air Force.

Recently developed is a portable unit which, in effect, places a "ceiling of safety" around personnel in the field making them invulnerable to ballistic attack. I.F.I. is proud of this opportunity to contribute to the defense of our services.



An I.F.I. "ceiling of safety" protects these men against surprise ballistic attack.

INSTRUMENTS FOR INDUSTRY, Inc.
101 New South Road, Hicksville, L. I.

Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet with John Hicks in an informal interview or send complete resume to: Dir. Personnel, I.F.I., 101 New South Road, Hicksville, New York.

Enlarged photos of the I.F.I. "menagerie" available on request to Dept. 201.



COUNTERMEASURES and the chameleon vulgaris



DECEPTION IS A FORM OF COUNTERMEASURE and at this the chameleon must be considered an expert

The approach to the problem of survival through countermeasures has been neatly solved by this handsome little fellow. By simply changing his color to match the surroundings the chameleon may take on the appearance of a brown twig, a green leaf or completely blend into the immediate area that surrounds him. This, in effect, is countermeasure in the truest sense. To confuse or mislead the enemy is often the problem faced by the military. Not to be outdone by the chameleon, electronic countermeasures have been developed which effectively confuse the enemy's radar action as well as many other forms of countermeasures. Instruments for Industry can supply exacting know-how and skill. The high degree of success achieved by I.F.I. is proof of ability.

the problem faced by the military. Not to be outdone by the chameleon, electronic countermeasures have been developed which effectively confuse the enemy's radar action as well as many other forms of countermeasures. Instruments for Industry can supply exacting know-how and skill. The high degree of success achieved by I.F.I. is proof of ability.



Only one target is a true target. The big question... which one?

Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet with John Hicks in an informal interview or send complete resume to: Dir. Personnel, I.F.I., 101 New South Road, Hicksville, New York.



INSTRUMENTS FOR INDUSTRY, Inc.
101 New South Road, Hicksville, L. I.



INSTRUMENTS FOR INDUSTRY, Inc.

101 NEW SOUTH ROAD HICKSVILLE, L. I., N. Y.

Graduate engineers with two or more years of circuit application in the fields of electronics or physics are invited to meet with Mr. John Hicks in an informal interview or send complete resume to: Dir. Personnel, I.F.I., 101 New South Road, Hicksville, New York.

LOW COST MISSILE BAIT!



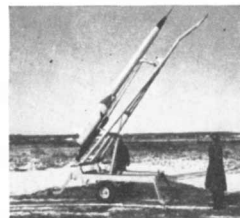
8442-AC



**POGO-HI
(II E3c)**



**P-107
AIR LAUNCHED**



**P-106
GROUND LAUNCHED**

AERONCA TARGET MISSILES PERFORM A VARIETY OF MISSION PROFILES... WITH SUBSTANTIAL ECONOMY

The adage "practice makes perfect" keynotes today's concept of missile warfare. Against supersonic targets, there isn't time for "the second barrel". Therefore, extensive operational testing of air defence systems . . . and training programs for personnel who operate them . . . must be conducted to assure national preparedness.

To accomplish this requirement at minimum cost, Aeronca has developed two expendable, lightweight, high-performance target systems under the Design-Tool-Produce envelope concept. These proprietary missile programs, the P-106 and P-107, are designed for supersonic performance and accurate scoring at all required altitudes, speeds and ranges. *And their production cost is projected to be substantially less than any current target missile system!*

Another Aeronca-produced missile project is *Pogo-Hi II E3c*. Ground launched to high altitudes, this target utilizes a radar reflective parachute and an infrared emitter package. It is used as "bait" for such current projects as *Nike, Talos, Sidewinder* and *Falcon*.

With integrated Design, Tooling and Production capabilities, Aeronca can produce weapon systems envelopes at either prime or subcontractor levels.



AERONCA manufacturing corporation

1722 GERMANTOWN ROAD • MIDDLETOWN, OHIO

Operational expansion has created openings for additional senior engineers. Write to W. W. Gordinier, Personnel Manager.



Major
**BREAKTHROUGH
 IN**

LOW COST* IRRADIATION

New
DYNAMITRON ACCELERATOR**
 FEATURES **10 TIMES MORE**
 PRODUCT THROUGH-PUT ...
 SAME CAPITAL INVESTMENT

TYPICAL LOW COST IRRADIATION APPLICATIONS

- FOOD** — for preservation and spoilage reduction
- DRUGS** — "cold sterilization" of antibiotics, surgical supplies and human tissue for transplant
- RUBBER** — vulcanization at a fraction of the time and cost
- PLASTICS** — cross-linking for increased temperature resistance, strength, insulating properties and chemical inertness
- CHEMICALS** — initiating and increasing catalytic reactions
- PETROLEUM** — "cracking" of crudes—higher yields
- ELECTRONICS** — semi-conductive material research and improvement of wire coatings
- RESEARCH** — basic research, higher yields, faster data accumulation

This entirely new concept in high voltage particle accelerators has broken the radiation "cost barrier." RDI's technological advance features **compactness, reliability, minimum maintenance and operating expenses, and low capital cost per kilowatt of radiation energy.**

RDI has constructed one of the largest radiation facilities in the country for the purpose of demonstrating practical industrial and military applications.

this is only the beginning—imaginative research and creative engineering will develop more new products and processes. For complete engineering information and technical advantages write today to Application Engineering.

RADIATION DYNAMICS, INC.

Westbury Industrial Park
 Westbury, Long Island

*\$4,000 PER KILOWATT OUTPUT
 **PATENTED





FIERY GASES glow as Sperry scientist studies magneto-hydrodynamic characteristics of molecules subjected to high current discharge. From this advanced basic plasma research will come microwave energy much more powerful than is now available and will perhaps explain the generation of microwaves by the sun and other galactic bodies.



RESEMBLING SEARCHLIGHTS—radars aboard cruiser *USS Galveston* depend on power from Sperry microwave tubes to launch and guide Navy's Talos missiles on precise course at supersonic speeds.



WORDS OR PICTURES are beamed cross country by microwave relays eliminating wires and damage from storms. Western Union system using Sperry microwave tubes handles up to 2,000 messages simultaneously.

NAVY CARRIER PLANE finds "home" by flying precise guidance signals powered by Sperry microwave tubes in TACAN, tactical air navigation system. (U.S. Navy photo.)



Developing The Power to Explore The Unknown

From harnessing signals that control missiles in flight and guide pilots to safe landings will come greater knowledge of outer space.

ONE OF A SERIES:

THE STORY BEHIND THE STORY of Sperry Electronic Tube Division

Twenty years ago a group of Sperry engineers began development of odd-looking devices to generate microwave energy. In doing so a new field of science was established—and the world gained a new and previously unharnessed power.

Modern radar, for example, owes its ability to "see" through fog and storm to microwave tubes which beam signals to distant objects—and with such precision

that returning signals form distinct images on the radarscope. Communications, national defense, entertainment—even food preservation—all have benefited from the ability to create and control this new power.

Radio astronomy—another new science—now reveals that the sun and other galactic bodies generate microwave energy—and probably have done so since the formation of the universe. Sperry's research of this solar microwave energy may permit radically new types of generators which will lead to a better under-

standing of outer space.

If you are interested in microwave tubes for any purpose, write Sperry Electronic Tube Division, Sperry Rand Corporation at either of its two modern plants—in Great Neck, New York and in Gainesville, Florida.

SPERRY



Inside the Hot Cell of the new Picker Research Center in Cleveland. Protected behind a five-foot thick window, the technician is loading a Picker-encapsulated Cobalt 60 radiation source into its shipping container.

What's YOUR interest in radiation?

- want to **try** it? _____ →
to find out what it can do for you?
(improve product quality, reduce cost, things like that)
- want to **use** it? _____ →
for industrial or medical radiography or therapy?
for research?
- want to **produce** it? _____ →
for bulk sterilization, product-irradiation?
- want to **measure** it? _____ →
to be sure there's no hazard?
to know the dose rate?
- want to **shield** it? _____ →
for personnel and public protection?
- want to **diffract** it? _____ →
for structure studies or fluorescent analysis?

WHATEVER your concern, we can probably help you

- we've the **background** for it _____ →
as leading producers of x-ray and isotope
radiation equipment, we've been *living*
with radiation for over 40 years
- we've the **facilities** for it _____ →
a Research Center with a million-curie hot cell,
gamma garden, hot laboratories
- we've the **will** for it _____ →
a Sales/Service network with local offices
in principal cities of the U.S. and Canada

Contact any Picker office (see local 'phone book) or write,
wire, phone Picker X-Ray Corporation, 25 South Broadway
White Plains, N. Y., WHite Plains 8-0080

if it has to do with **RADIATION** it has to do with



LETTERS

VALVES

for guaranteed leak-free operation:

- BELLOWS SEALED: Machined Brass & Stainless Steel
- FAIL-SAFE SOLENOID
- PNEUMATICALLY OPERATED



GAUGES & CONTROLS

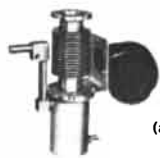
for exacting measurements



- IONIZATION GAUGES, Bayard-Alpert Type, Non-Burnout, Double Tungsten & Flanged
- ULTRA-STABLE IONIZATION GAUGE CONTROLS
- COLD CATHODE DISCHARGE GAUGES & CONTROLS
- THERMOCOUPLE GAUGES & CONTROLS

PUMPS

for high pumping speeds



- DIFFUSION PUMPS, low backstreaming & low ultimate pressure (air-cooled & water-cooled)
- MECHANICAL PUMPS, complete stock

ACCESSORIES

- STANDARD & VARIABLE LEAKS
- QUICK COUPLINGS, available water-cooled
- ELECTRIC DEGASSING GUN
- "O"-RING SEALED FLANGES
- & MANY OTHERS



IN HIGH VACUUM equipment

VEECO manufactures a complete quality line of vacuum components, Leak Detectors and High Vacuum Systems. For your free copy of the VEECO CATALOG, fill out the coupon and attach to your letterhead.



Veeco VEECO VACUUM CORP.

86-S Denton Avenue, New Hyde Park Long Island, New York

HIGH VACUUM & LEAK DETECTION EQUIPMENT

VEECO VACUUM CORPORATION

86-S Denton Avenue, New Hyde Park, L. I., N. Y. Gentlemen:

Please forward to my attention one (1) copy of your complete Catalog.

I would appreciate your Sales Engineer telephoning me for an appointment.

Name Title

Company

Address

City Zone State
(PLEASE ATTACH TO YOUR LETTERHEAD)

Sirs:

We have received a large number of letters commenting on our article ["Experiments in Color Vision," by Edwin H. Land; SCIENTIFIC AMERICAN, May]. Because many of these letters are thoughtful and detailed, it has been impossible to give each of them the equally thoughtful and detailed answer it deserves. We are thus compelled to answer the letters collectively. We hope that our correspondents will forgive us for grouping their questions and observations into classes.

Many have been able to repeat our experiments fairly well; many others have had trouble; a few have been so unsuccessful that they have questioned the validity of the experiments. These operational problems are the easiest to discuss and to respond to. When we go back over our work of the past five years and try to understand what we have done to effect continuous improvement in the beauty of our photographs as seen when finally projected, we are impressed by the following considerations:

1. Except for the requirement that the pictures be carefully registered in projection, there are no difficult problems whatsoever in viewing the pictures. Once two good black-and-white positive transparencies are available, they provide as reliable a color picture as any other kind of color photograph.

2. Taking the picture requires insight into the fundamental difference between exposing correctly when color is to be reproduced with two photographs, and exposing correctly when color is to be reproduced with three photographs. This difference exists independently of the eye and is purely photographic. When only two photographs are made, the photograph taken through the long-wave filter is expected to record wavelengths in the scene longer than roughly 580 millimicrons, and the photograph taken through the short-wave filter is expected to record wavelengths shorter than 580 millimicrons. This second photograph is given an unusual burden: it must discriminate between yellows and whites on the one hand, and blues and blacks on the other. The yellows are so close to white in brightness that they are likely to come out as transparent areas on the finished transparency; hence they are indistinguishable from white. Similarly, the dark blues are likely

to expose the original negative no more than black; thus they are indistinguishable from black. We have learned over the years to correct these difficulties by suitable exposure, so that the yellows are not overexposed and the dark blues are not underexposed. Now when a color picture is made with three photographs and a blue filter is used for the third, the whites for this third photograph will be fully exposed but the yellows will be only slightly exposed. The blues in turn will be well exposed, and the blacks will of course be dark. Thus the whole photographic scale is available in this third photograph to record what we might call the yellow-blue domain of the scene. The absence of this full photographic scale for yellows and blues when color is recorded with just two photographs may well be responsible for much of the unhappy history of two-color photography. Our work, which has been directed at insights into visual theory using photography as a tool rather than toward producing a color process, seems to have forced us to go farther toward good recording than most of the photographers of the past. It may well be that their occasional successes in handling this particular problem of exposure led to their enthusiasms, and that their failures in handling it led to their final disappointment. Be that as it may, the important point for a theory of vision is that once the photographs are well made, two of them suffice to produce a very satisfying gamut of colors, including those that characterize a slice of lemon, a slice of orange and a banana on the one hand, and Delft blue on the other. If any read-

Scientific American, September, 1959; Vol. 201, No. 3. Published monthly by Scientific American, Inc., 415 Madison Avenue, New York 17, N. Y.; Gerard Piel, president; Dennis Flanagan, vice president; Donald H. Miller, Jr., vice president and treasurer.

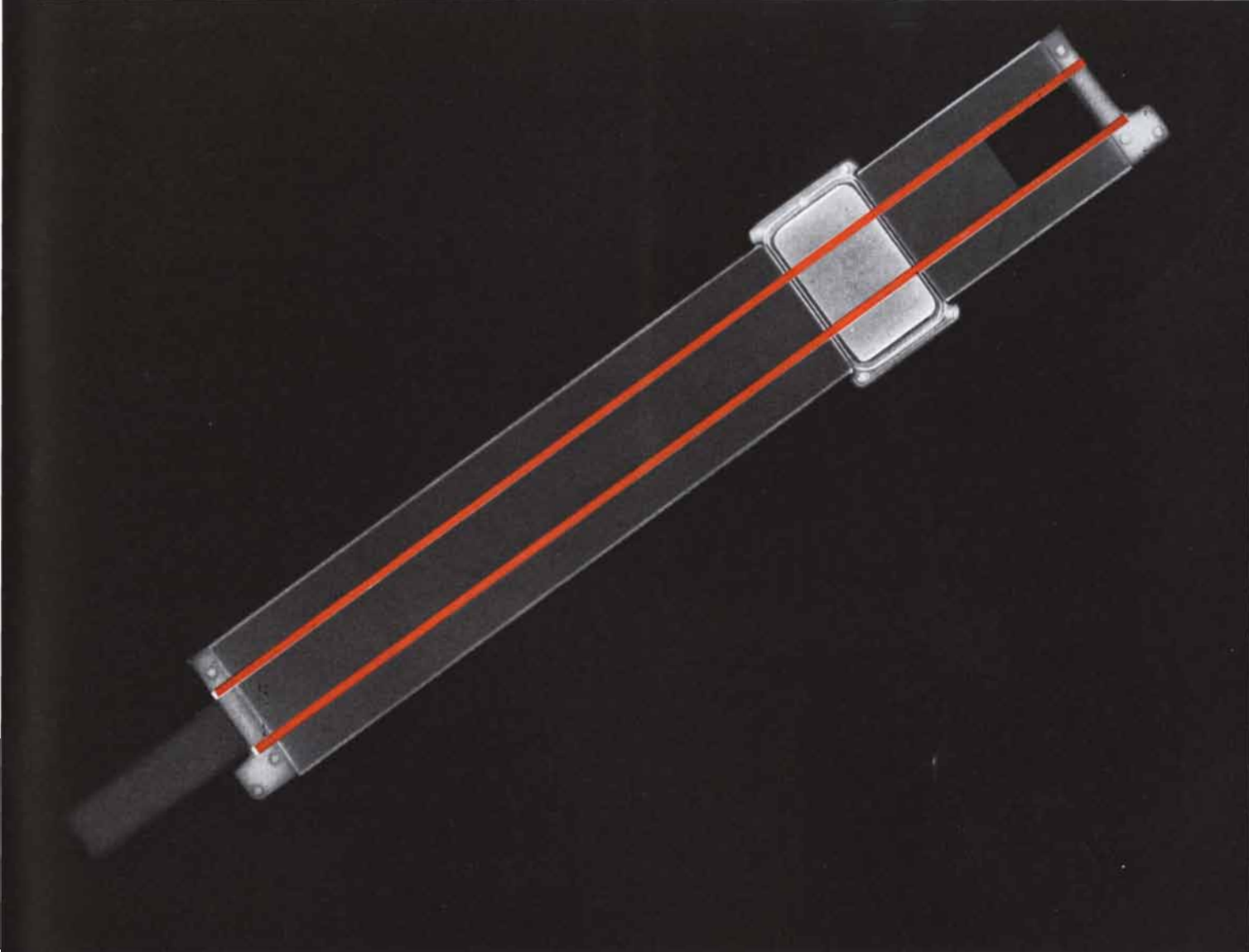
Editorial correspondence should be addressed to The Editors, SCIENTIFIC AMERICAN, 415 Madison Avenue, New York 17, N. Y. Manuscripts are submitted at the author's risk and will not be returned unless accompanied by postage.

Advertising correspondence should be addressed to Martin M. Davidson, Advertising Manager, SCIENTIFIC AMERICAN, 415 Madison Avenue, New York 17, N. Y.

Subscription correspondence should be addressed to Jerome L. Feldman, Circulation Manager, SCIENTIFIC AMERICAN, 415 Madison Avenue, New York 17, N. Y.

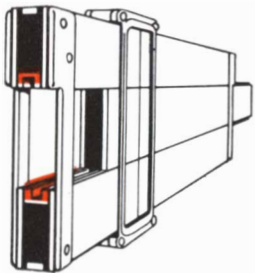
Subscription rates: one year, \$6; two years, \$11; three years, \$15. These rates apply throughout the world. Subscribers in the United Kingdom may remit to Midland Bank Limited, 69 Pall Mall, London S. W. 1, England, for the account of Scientific American, Inc.: one year, two pounds four shillings; two years, three pounds 19 shillings; three years, five pounds eight shillings.

Change of address: Please notify us four weeks in advance of change. If available, kindly furnish an address imprint from a recent issue. Be sure to give both old and new addresses, including postal zone numbers, if any.



Microglide* slide-rule by Eugene Dietzgen Co., Chicago, Ill.

THE INSIDE STORY: taking the stick-slip out of slip-sticks



The sliding scale of this slide rule runs in grooves of a TEFLON TFE-fluorocarbon resin. Smooth operation is assured by the very low static and dynamic coefficients of friction of the TFE resin, which eliminate any stick-slip type of motion.

Remarkable frictional properties are only one of the many design advantages offered by TFE resins. These tough materials have almost universal chemical inertness, resist heat and exhibit excellent dielectric strength . . . in

short, they offer a combination of properties unmatched by any other single material.

If you would like to find out more about how TFE-fluorocarbon resins make possible improved design, send for your copy of a booklet describing in detail the unique mechanical properties of these resins. Write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room T-399, Du Pont Building, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, Box 660, Montreal, Quebec.

*Microglide is the registered trademark of Eugene Dietzgen Co.



TEFLON[®]
TFE-FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

BETTER THINGS FOR BETTER LIVING THROUGH CHEMISTRY

**WHATEVER
MATERIAL
ADVANTAGES
YOU NEED...**



*from insulation
to isolation...*

**YOU'LL FIND THEM
IN A ^{plus} FELTS!**

Versatile A+ felts serve an almost infinite variety of purposes . . . muffling the roar of a jet . . . cushioning the vibration of a punch press.

They can be made soft and resilient—or tough and unyielding. They offer practical answers to thousands of design problems. Whatever your design need, in absorption, sealing, insulating, filtering, cushioning, polishing, or special fashion effects, A+ felts can help you meet it.

Send us your problem; our engineers will follow through promptly.



209 Glenville Road, Glenville, Conn.

Among our famous trademarks:
VISTEX—fiber-reinforced gaskets and seals; **WINDSOR FELT**—nonwoven bonded fabrics; **HUSHALON**—decorative and acoustical wall covering.

er of SCIENTIFIC AMERICAN would like to pursue these experiments further, he need only send me, at 730 Main Street, Cambridge, Mass., a self-addressed envelope. We will be pleased to send him a mimeographed memorandum setting forth the conditions of the experiments in greater detail.

All this leads us to another question raised by some of our correspondents, namely, can two photographs discriminate between a variety of blue of different saturations and a variety of greens? Is it not a mathematical necessity that certain greens will be recorded on black-and-white film like certain blues of different saturation? The answer is definitely yes. If our purpose were to use this particular work to make a "perfect" process for color photography rather than to investigate the visual processes, this would be a matter of concern. It is true that if only two photographs are made, certain greens will be recorded in the same way as certain blues. Nevertheless blues, greens, browns, grays, yellows, oranges, reds and whites are elicited with only two packages of information (as represented by the two photographs), and for the most part the colors are correctly associated with the appropriate objects. Furthermore, for nearly every object the color that is elicited cannot be predicted from classical color-mixing theory, and is predicted quite simply by means of the new coordinate system.

One must not confuse the question of how many of the range of classical stimuli exist at each point with the question of how many independent packages of information are used and combined to make the final record. It has come to be the custom over the years to characterize this dual projection as a two-color system. However, each point in the image may involve various amounts of James Clerk Maxwell's three primary colors. Thus it should be the burden of the classical color-triangle to predict the color at each point on the basis of the ratio of these three stimuli. But the composite colors that we actually see have no theoretical home until we introduce an idea that Thomas Young thought relevant: Extended areas of the retina are significant in determining the sensation for each point in the image. Thus far no theoretical rationale has been available to take us from the color triangle and its arithmetic to a description of the sensations produced in an image consisting of two packages of information.

We come then to an important group of letters which urge that by combining the color-mixing theory of Maxwell,

Young and Hermann von Helmholtz with the well-known phenomena that involve the effect on one point in the retina of stimuli at the other points, one would be led to expect—and it is implied one would be enabled to predict—the particular colors in images. (Most of these phenomena have been classed by writers in the past as adaptation or induction, adaptation implying a time element, and induction the notion that the induced color is not real. Adaptation is defined in *The Science of Color* as "change of sensitivity of the eye to meet the needs of vision," and induction as "adaptation caused by local or momentary exposure." A particularly important example of induction is complementary-colored shadows.) These correspondents feel that we have not given enough attention in our exposition to the history of adaptation and induction. Now insofar as adaptation implies that the colors in our images are the result of extended exposure of the observer's eye to the image, we are convinced that adaptation is irrelevant. We have already given evidence to support this—evidence which in general shows that these colors are immediately apparent. As for induction, insofar as it means that all of the retina which is exposed is involved in the sensation at each point in the image, we are in full agreement; indeed, that is the heart of our position. However, insofar as induction carries with it connotations of curious neurological mechanisms, of anomalies or aberrations, we are cautious about adopting such a term because it carries us from a simple set of laws to dependency on surmises about mechanisms still largely unknown. Insofar as "induced" is used as an antithesis to "real," we must stand our ground and insist not only that the colors produced by induction are just as real as any other colors, but also that without it many of the colors in everyday life would simply not be there.

While we heartily favor placing a high value on induction, we are at a loss to see what there is in the long history of it prior to the work of Deane B. Judd and Harry Helson in 1938 (except for the black-and-white experiment of C. Hess and H. Pretori in 1894) that would enable one to make any quantitative treatment of it whatsoever. From the middle of the 17th century to the middle of the 20th there are endless chronicles of amazement about colored shadows, and a variety of speculations about the reality of these colors so remote from the color associated with the wavelengths or wavelength mixtures of the stimuli. The speculations of von



PINCH PLASMA ENGINE NEW POWER FOR SPACE VEHICLES

"The experimental model of a new concept . . . a magnetic pinch plasma engine for interplanetary space travel is in operation at our laboratories," says Alfred Kunen (R) Project Engineer, Plasma Propulsion Project, shown with Milton Minneman of Republic's Scientific Research Staff, during actual operation of the engine. >>> Republic's plasma engine unique in that it utilizes intermingled positively and negatively charged particles in a single jet thrust, can operate on fuels more readily available than required for an ion engine, and attains greater thrust. By compressing these particles in an invisible cylindrical magnetic girdle and shooting plasma out the rear at tremendous velocities, sufficient thrust is generated to push a vehicle through the near-vacuum of outer space. >>> Republic is working on advanced plasma engine studies for the U. S. Navy Office of Naval Research and the U. S. Air Force Office of Scientific Research. >>> Today's pinch plasma engine is but one of many bold concepts under development at Republic to create for the space world of tomorrow. It is part of Republic's multi-million dollar exploration into the realm of advanced aircraft, missiles and space travel.

REPUBLIC AVIATION

FARMINGDALE, LONG ISLAND, N. Y.



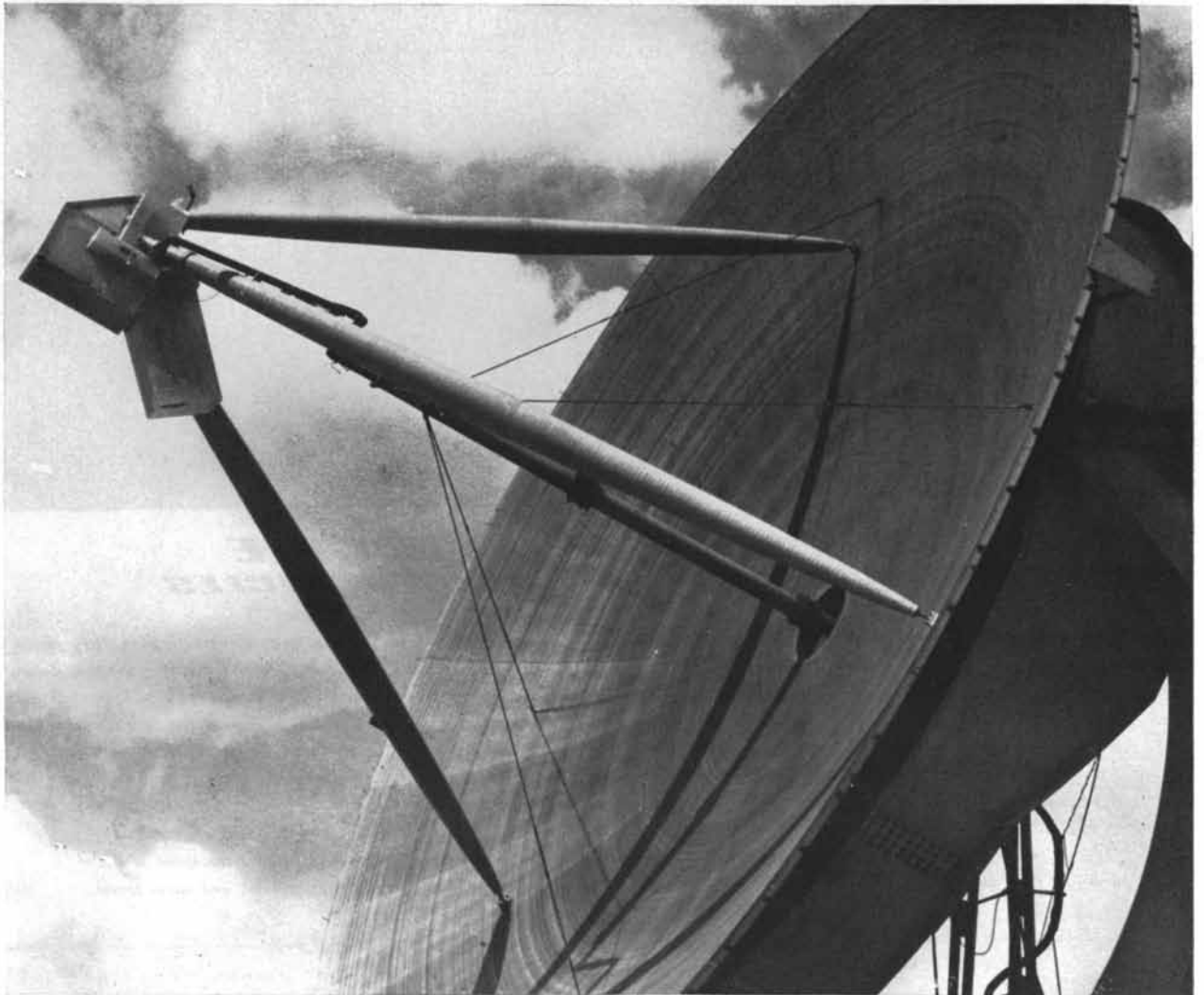
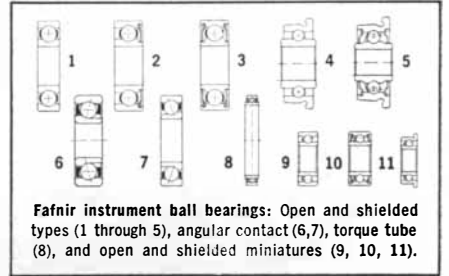
Designers and Builders of the Incomparable **THUNDER-CRAFT**



Republic's new \$14,000,000. Research and Development Center, is scheduled for operation early in 1960.

WHEN YOU WANT TO BE ALL EARS

When you are designing new radio telescope equipment . . . a new aerial camera . . . a new process control device . . . a new *anything* that calls for precision instrument ball bearings, you do well to turn to Fafnir. For no matter what your problem is . . . temperature extremes, low torque, load-life, low decibel readings . . . Fafnir can help you solve it. Fafnir has the *diversity* — a wide variety of ball bearing types, designs, steels, and tolerances — and the uniformly high standards of *quality* to meet your needs precisely. The Fafnir Bearing Company, New Britain, Connecticut.



FAFNIR
BALL BEARINGS

Guericke, Buffon, Priestley, Rumford, Goethe and Meyer led in this first phase to a solid and extended study by A. Kirschmann in 1890, and to a set of laws embodied in E. B. Titchener's text in 1901, which reads as follows:

"(1.) The contrast-effect is always in the direction of greatest qualitative opposition. (2.) The more saturated the inducing colour, the greater is the contrast-effect. (3.) The nearer together the contrasting surfaces, the greater is the contrast-effect. (4.) Colour contrast is at its maximum when brightness contrast is eliminated. (5.) The contrast-effect is enhanced by the elimination of contours."

Now some of these laws survive in the image situation, but many of them do not. None of them is in any sense a quantitative guide. We simply do not understand how anyone can suggest that these vague statements, largely inaccurate for images, having no quantitative components whatsoever, can be combined with the simple, rigorous, meticulous rules of color-mixing to produce a new arithmetic for predicting colors in images.

We believe that the reason induction did not develop into a science is that those who explored it tended to use what we regard as greatly oversimplified situations. We suggest that here is a domain in which an error in the technique of abstraction, a presumption that simplification of the field of view is permissible to understand the properties of an intricate field, prevented induction from becoming a mature principle. Our plea to contemporary experimenters is that they take any step away from normal, fully populated scenes with the utmost caution. We have shown elsewhere that presentations can be made which should be rich in color classically, but which—because of the hidden order that we have built into the presentation—show in some cases no color, and in others two colors but no color-mixing. On the basis of these experiments we feel strongly that no experimenter should make a general statement about sensations produced by an artificial set of visual stimuli unless he identifies meticulously the whole geometric structure of the field of vision and is willing to limit his conclusions to that particular structure.

It is significant that when Judd and Helson came in 1938 to quantify the appearance of colored objects seen under different illuminants, they could not draw on previous work on induction for any mathematical guidance whatsoever. Their formulas had to be based on direct observations of colors, and had to

be elaborated by means of adjustment and correction from these observations. By this important step they erased many of the fallacies in previous thinking on induction, and they introduced into the literature of vision—for the first time, so far as we know—the idea that it is fallacious to divide colors into real and unreal. We feel that the following statement of Helson's marks a significant point in the history of color vision: "The failure to recognize that a single principle operates in every act of vision has been responsible for the many conflicting views regarding the relation of contrast to constancy, of adaptation to constancy, and of constancy to conversion." This is a direct, realistic and unpretentious acceptance of the properties of surface colors as real phenomena. (For a moment this seemed like a period of Renaissance, with Judd and Helson bringing surface colors out of the world of mystery, and with Ralph M. Evans giving brilliant demonstrations by projection of the fact that not only could red and white be used, as was known since the work of W. F. Fox and W. H. Hickey in 1914, but that even red and yellow could be employed to produce sensations ordinarily associated with the short waves.)

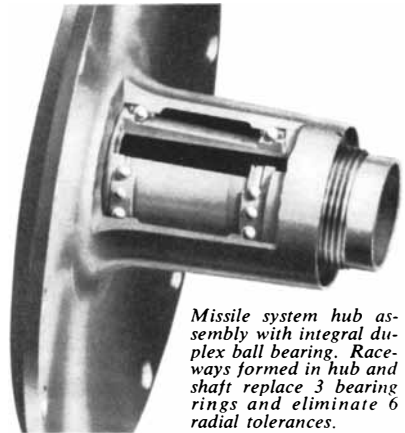
Judd and Helson's study dealt with the change of colors of samples with type of illumination and arrived empirically at a workable extension of the three-variable system to a six-variable system. Just how well Judd's formula will correlate with our coordinate system is not yet known, but there is already some evidence from Judd's recent calculations that there will be reasonable correlation. On the other hand, Judd's premises involved proximity in past time in a way that we have not found necessary, and his formulas do not predict the achromatic situations (the images in which colors either do not appear, or stimuli do not mix, even though classically a wide range of colors would be expected) which we believe to be perhaps the most significant part of our work. The use of the photographic medium greatly simplifies the study of the colors and their representation in the coordinate system, since it makes it unnecessary to carry out the computations for each point of the interaction between the illuminant and the absorption spectrum of the object.

What, then, is the relationship between the vague studies of induction, the precise studies of color-matching and our study of the nature of color in images? An aspect of this relationship is well illustrated by the curve bounding the region of achromatic wash in the

How to shrink a bearing assembly

Most assemblies using anti-friction bearings can be improved by machining the bearing races into their associated parts — or, to put it another way, by extending the bearing rings to include other rotating members.

This means combining the functions of two or more parts into each of one or more



Missile system hub assembly with integral duplex ball bearing. Raceways formed in hub and shaft replace 3 bearing rings and eliminate 6 radial tolerances.

bearing rings. The rings then can be made stronger and stiffer than the parts they replace — usually with a decrease in package size and weight. For missiles and other "one-shot" devices, this is the only way these advantages can be obtained.



Atomic reactor bearing of special configuration — or, if you prefer, assembly with "machined-in" bearing races.

Other benefits include predetermined fits, less tolerance build-up, more-rigid assemblies, and greater load capacity.

At ITI, such special-configuration bearings are a *full-time business*. So are bearings having heat or corrosion resistance, ultra precision, and other unusual properties. We design and make such bearings to individual requirements; and deliveries are faster than you might expect.

BULLETIN AFB-2 describes our work and tells much about special bearings. May we send you a copy? Write —



INDUSTRIAL TECTONICS, Inc.
3664 Jackson Rd., Ann Arbor, Mich.

FROM ΔΗΜΟΚΡΙΤΟΣ TO *Vitro*

400 BC TO 1959 AD



Old Democritus, the "Laughing Philosopher" who first dreamed up the atom, never heard of Vitro. But now Vitro, nearly 2,400 years later, is a leader in atomic energy.

Proof of Vitro's nuclear leadership, particularly in radiation technology, is that Vitro engineers have designed and engineered more "hot" laboratories than any other company.

Among the newest are the Cornell Center for Nuclear Technology, Ithaca, N. Y., a high level radiation facility at the Naval Research Laboratory, Washington, D. C., a 5,000-kw nuclear research reactor facility for CAMEN, an Italian Navy Department at Livorno, and the Ispra Center for Nuclear Research, also in Italy.

There are many other current nuclear contracts, including a plutonium laboratory, and a nuclear fuel reprocessing plant, both at Oak Ridge.

For design and engineering in the nuclear field, look to Vitro.

Vitro makes tomorrow's technology available today!

Vitro CORPORATION of AMERICA
261 MADISON AVENUE, NEW YORK 16, N. Y.

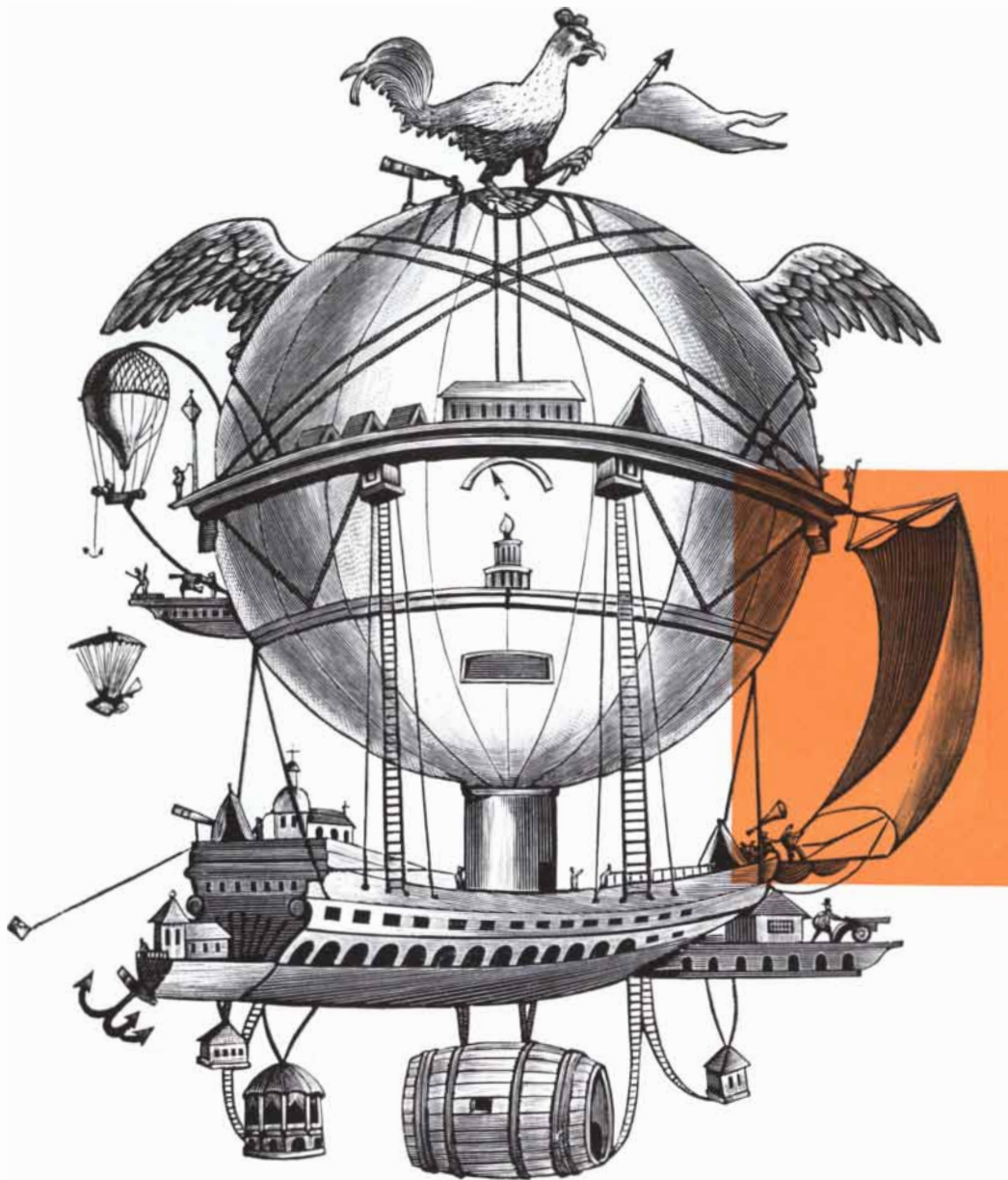
diagram on page 89 of our article in *Scientific American*. From some points of view it is not surprising that this curve closely resembles the curve arrived at by W. D. Wright and F. H. G. Pitt that delineates just noticeable differences in wavelengths. To us this is a satisfying example of the relationship between classical theory and the colors in images. We expect that in some such way every single great fact in classical theory will be involved ultimately in the description of colors as seen in images, but curiously not in the direct prediction of these colors. For this a new science of color in images is required.

There has been a group of excellent investigations having to do with neural mechanisms, with receptor theory, with retinal pigmentation, and also with a group of phenomena involved in special controlled situations such as color-matching, saturation, luminosity, purity, etc. There has been missing, however, what we regard as an important, exciting and fruitful investigation: the study of the properties of the whole image. It would be a sad thing for us if it were thought that our interest in this field of endeavor implied any trace of lack of appreciation for the solid values in the other fields of vision, but we would find it equally sad if those who have done so well in these other fields cannot see their way clear to join in this new adventure. The point of departure for this adventure is the discovery that the over-all visual mechanism has the capacity for discerning when an image on one band of wavelengths is functionally related to an image on another band of wavelengths, and has the competence to know, for example, that in spite of variation in ratios of stimuli from point to point in the field of view, no new information has been introduced if one image could have been derived by a simple formula applied to the other image.

We are happy to report that our triple-image illuminating monochromator is completed. We have been studying from the beginning of this investigation the question of whether objects projected with two packages of information and then looked at through a black tube change more than when projected with three. We will now be enabled to answer this question as well as the significant question of the role of the third package of information.

EDWIN H. LAND

Polaroid Corporation
Cambridge, Mass.



M. Marey Monge made no attempt to keep imagination in check when he conceived this military balloon in 1800. Complete with sail, the "dream" balloon was supposed to support an army of 4,000 in every way for months at a time. In this wood engraving, Brussel-Smith has included the most minute details of Monge's ambitious project.

IMAGINATION IN SPACE — Since Creation, man has looked out on space. At first, unknowing and incurious; then with the beginnings of understanding; now free and able to explore. Yet to move in space calls for wholly new concepts of energy.

This, then, is the working philosophy of Hercules in chemical propulsion: To design and manufacture highly concentrated packages of energy as propellants and rocket motors; each compatible, controllable, predictable; and each perfected for its specific mission.

HERCULES' BACKGROUND: A half-century of creative imagination in the evolution of propellants, from shotgun powder to the manufacture of the propellants for all the U. S. rockets fired during World War II, and now to space propulsion. Hercules facilities today encompass research, design, engineering, and staff organization for the production of the most advanced propellants. Illustrated brochure available on request.

HERCULES POWDER COMPANY

INCORPORATED

900 Market Street, Wilmington 99, Delaware

XP59-4



MYLAR® helps improve product performance . . . cut costs



TV producers can cut studio time . . . eliminate costly processing by using video recording tape made with "Mylar".

Tough, thin Du Pont MYLAR helped solve a problem in developing video recording tape for the TV industry



"Mylar" has high strength. With an average tensile strength almost $\frac{1}{3}$ that of machine steel, "Mylar" takes the crushing impact of fast traveling bowling ball.

Magnetic recording tape for use in electronic recording of sound and picture for TV broadcasting had to meet new standards of performance. The tape—called video recording tape—had to be thin enough to make intimate contact with revolving recording heads, yet tough enough to withstand relative recording speeds of 1,500 inches per second!

Alert tape manufacturers filled this need by using Du Pont "Mylar" polyester film as the base for video recording tape. "Mylar", which had already proved its reliability in missile tracking and data computing, provided the necessary strength and toughness in thin gauges to

meet the exacting demands of TV recording equipment.

This is but one of the many ways "Mylar" is helping industry improve product performance, develop new products and lower costs. Electric motors, for example, can be made smaller and more efficient with insulation of "Mylar". Manufacturers of electrical cable can cut material costs by using tough, thin "Mylar" as a core binder.

For additional information, write today for our new booklet. E. I. du Pont de Nemours & Co. (Inc.), Film Dept., Room SA-9, Wilmington 98, Del.

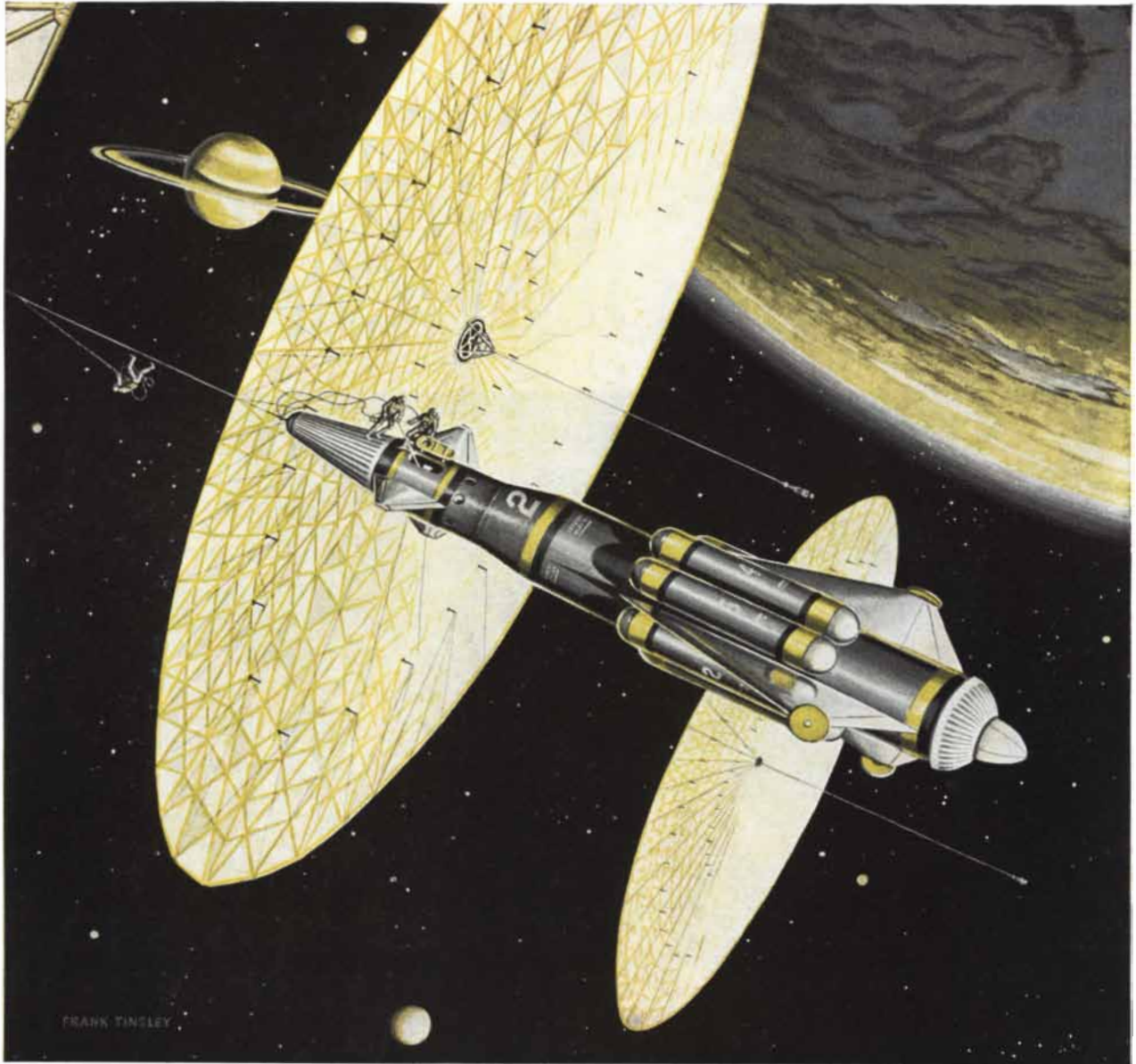
*"Mylar" is Du Pont's registered trademark for its brand of polyester film. Du Pont manufactures the base material "Mylar"—not finished video recording tape.



REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY





STEPS IN THE RACE TO OUTER SPACE

Solar Wind Ship

The large circular objects are Solar Wind Ships, capable of carrying astronauts on fuel-less journeys through the solar system, using the Sun's expanding flood of radiation—or "trade winds"—as a direct propulsive force. These trade winds are harnessed by sails of plastic film, coated with shiny evaporated aluminum.

Although the push of solar radiation is extremely weak—about the weight of four cigarettes per acre—it is ample in the friction-free, weightless vacuum of space to drive the Wind Ship at a constantly accelerating speed. For long trips into space, sails are several miles in diameter, cross-braced by plastic masts

and fine, glass filament rigging. In the center of the sail, an inflated wheel-shaped hull is mounted in a tripod arrangement. This hull, powered by solar batteries, can revolve in any direction, providing artificial gravity for its crew and functioning as a gyroscope to stabilize and control the attitude of the sail.

In the illustration, a flotilla of manned Solar Wind Ships is approaching Saturn. To the right is Titan, largest of Saturn's nine moons and the only satellite in the solar system known to have an atmosphere. In the foreground, a crew of astro-

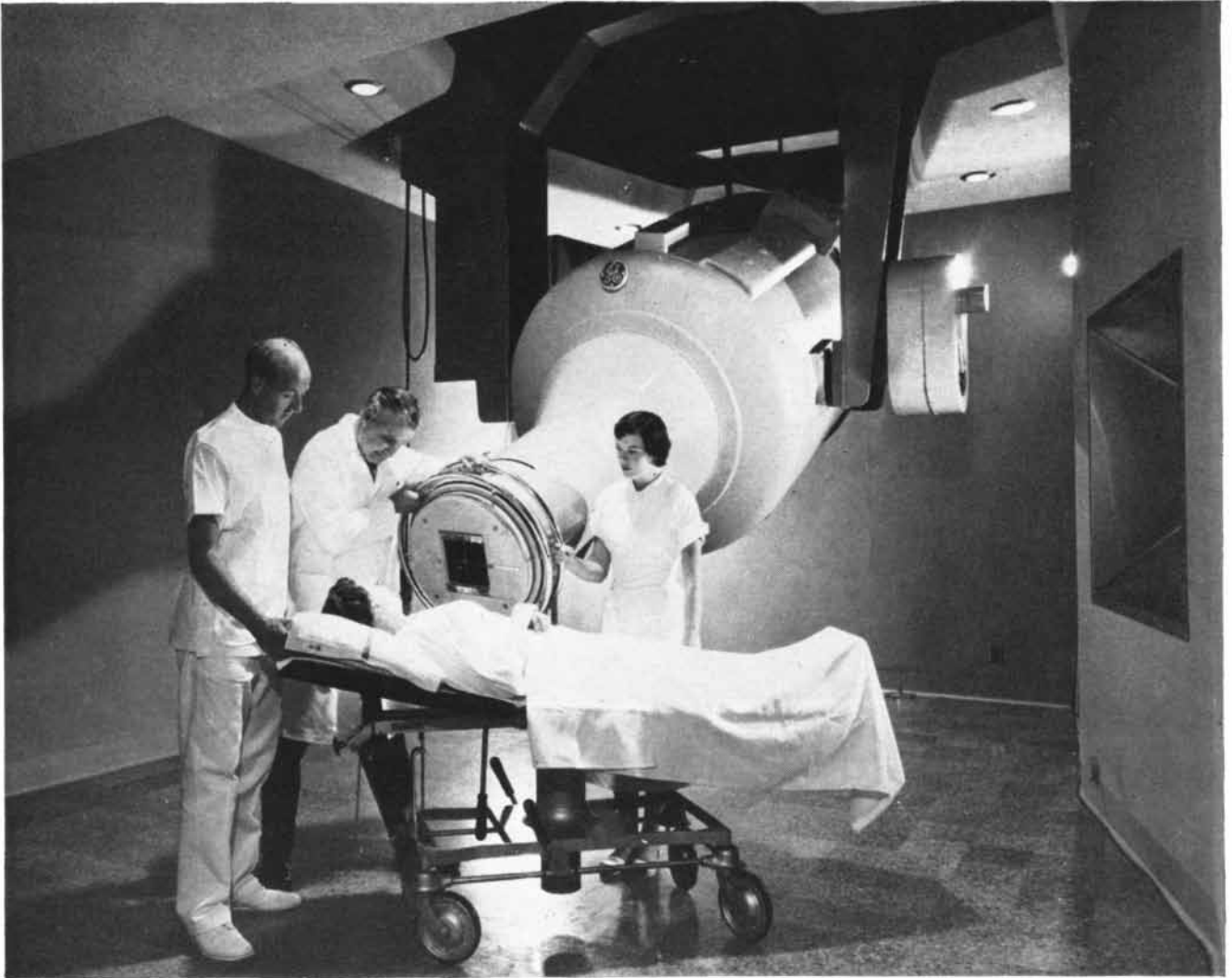
nauts enters a small ferry-rocket, towed behind the Wind Ship. Since the Wind Ship cannot land on any planet, they will explore Titan in the Atomic-powered rocket, then rejoin the fleet for the remainder of the trip to Saturn.

Inertial navigation systems will play an increasing role in the exploration of outer space. **ARMA**, now providing such systems for the Air Force ATLAS ICBM, will be in the vanguard of the race to outer space. **ARMA**, Garden City, N. Y. A Division of American Bosch Arma Corp.

AMERICAN BOSCH ARMA CORPORATION

How General Electric X-Ray is harnessing the powers of

HIGH-ENERGY RADIATION

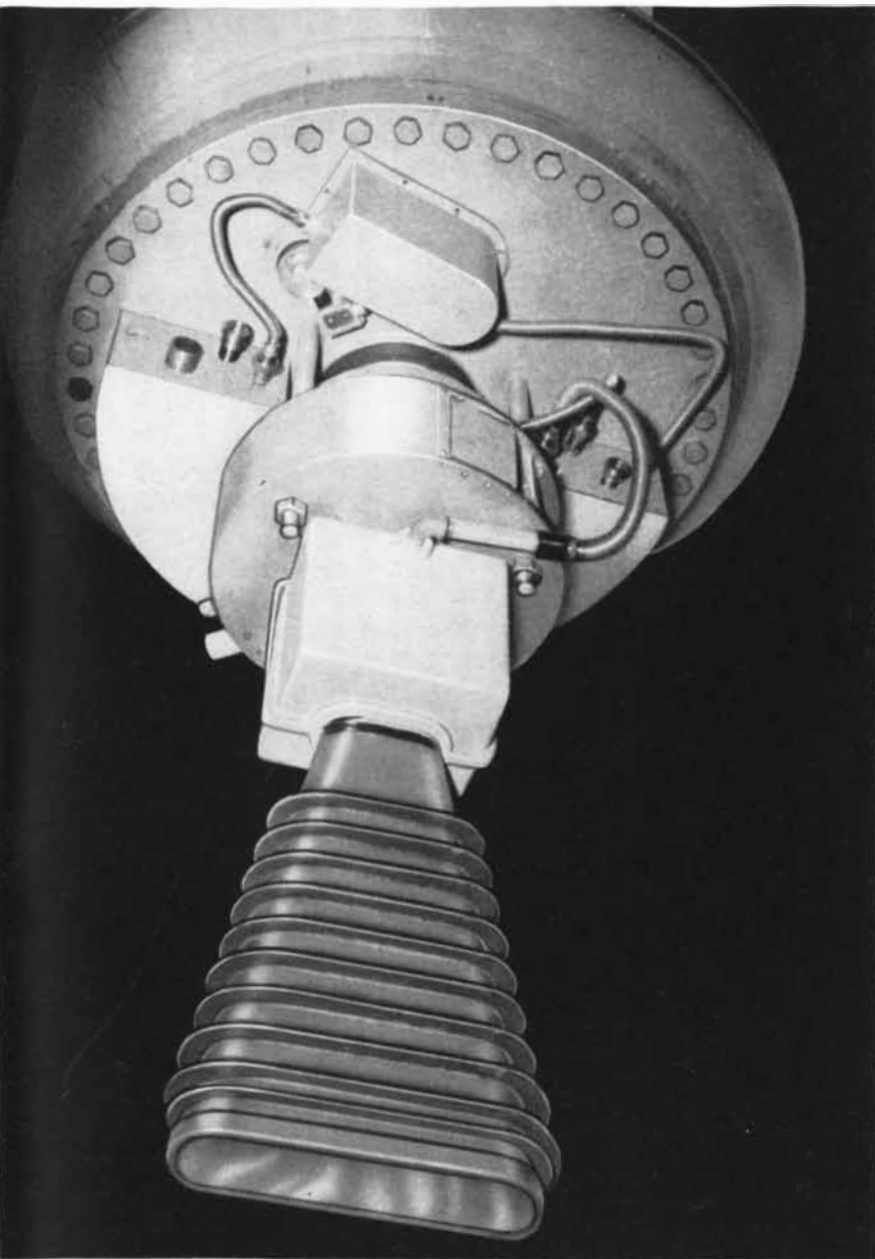


IN MEDICINE... The two-million-volt G-E Maxitron® 2000 x-ray unit you see here is medicine's heavy artillery in the war on cancer. X-ray therapy has shown itself to be an increasingly effective and valuable weapon in combating this malignant killer.

Today there are nine of these units — and 14 one-million-volt machines — operating in U. S. medical

centers. Significantly, not a single Maxitron 2000 tube has ever needed replacement — and the oldest has been in use nine years!

For more than a half-century G.E. has pioneered in the development of x-ray equipment for both diagnosis and therapy... helping protect the nation's health through detection and treatment of human ills.



IN INDUSTRY... Above: the business end of a 2-million-volt Electron Beam Generator. Expect small miracles from it — you're not likely to be disappointed.

What is it? General Electric equipment that produces high-energy electrons to alter the fundamental structure of matter. *What can it do?* Its high energy radiation beam is being used to cross link plastic for improved properties. Its beam is lethal to micro-organisms — can sterilize, preserve. And who knows what more may come from its unique talents as a chemical agent.

Other General Electric x-ray equipment is serving with distinction in a variety of industrial ways: research, quality control, product development. Above all, G-E x-ray application engineers have the all-important "know-how" you'll not find elsewhere.

More information? Consult the yellow pages of your telephone directory for the name of your nearest G-E x-ray representative, or write X-Ray Dept., General Electric Co., Pub. TT-94, Milwaukee 1, Wis.

Progress Is Our Most Important Product

GENERAL  ELECTRIC

GENERAL ELECTRIC X-RAY TODAY



For nondestructive inspection, G.E. offers a complete range of x-ray units.



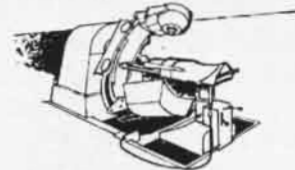
G-E x-ray diffraction and spectrographic equipment speeds quantitative and qualitative analysis.



G-E Hytafil measures level in sealed, opaque containers. Same principle is used to gage material thickness.



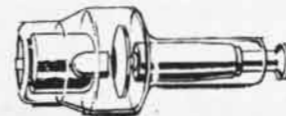
G-E x-ray microscope opens new fields of research to metallurgy, chemistry, medicine and biology.



Isotopic teletherapy makes use of radioactive sources.



G-E units for x-ray diagnosis enhance the radiologist's skills.



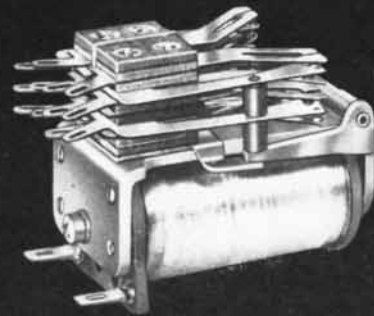
G-E X-Ray Tube Service maintains complete stocks at 40 convenient factory-operated district offices.



The complete range of G-E supplies and accessories offers the convenience of one source, the assurance of fast service.



An electric relay and the first electromagnetic telegraph were built by Henry in 1831, anticipating Morse by six years. At Princeton, N. J., he sent signals through a mile of wire, and stated that relays could extend his circuit indefinitely.



HOW JOSEPH HENRY RANG A BELL

Joseph Henry invented the electromagnetic relay in 1831, and then used it to ring a bell in the world's first telegraph circuit. Since that crude beginning, relays have been refined to remarkable reliability. For example, sixteen of the telephone type shown above, our LS, recently operated under load more than 213,000,000 times before a test was discontinued. A booklet giving complete engineering data of the test is yours for the asking.

Our engineers follow Henry's imaginative, yet practical, approach to scientific problems. Being relay specialists, they combine a firm knowledge of the state-of-the-art with creative initiative. The result is a reliable product designed for economical installation on modern production lines and delivered to you at the lowest possible cost.

Very likely, these relay specialists can lend valuable assistance to your projects. Write or call Zeke R. Smith, vice president, Engineering, or your nearest P&B sales engineer.



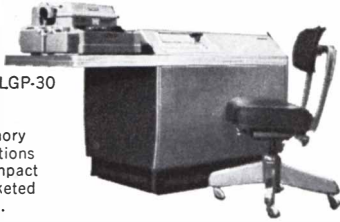
POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

In the missile: small transistorized general purpose digital computer for flight control and guidance. 2000-word magnetic-drum memory.



On the ground: LGP-30 general purpose computer with 4096-word memory for such applications as design and impact prediction. Marketed by Royal McBee.



At every stage, the success of a missile program depends upon a computer. Librascope computers, components, instruments and systems give right answers from original concept to final evaluation.

THE FIRST STAGE: Workable designs. **SECOND STAGE:** Trajectory and engineering computations required long before the launching. **THIRD STAGE:** Control, guidance; impact prediction. **FOURTH STAGE:** Data reduction and analysis. ■ Recognizing still a fifth stage, Librascope determines reliability in the lab. Environmental tests check equipment for temperature, shock, vibration, pressure and other "real" conditions likely to affect performance. Only positive answers will release Librascope equipment for field use.

MISSILE COMPUTERS

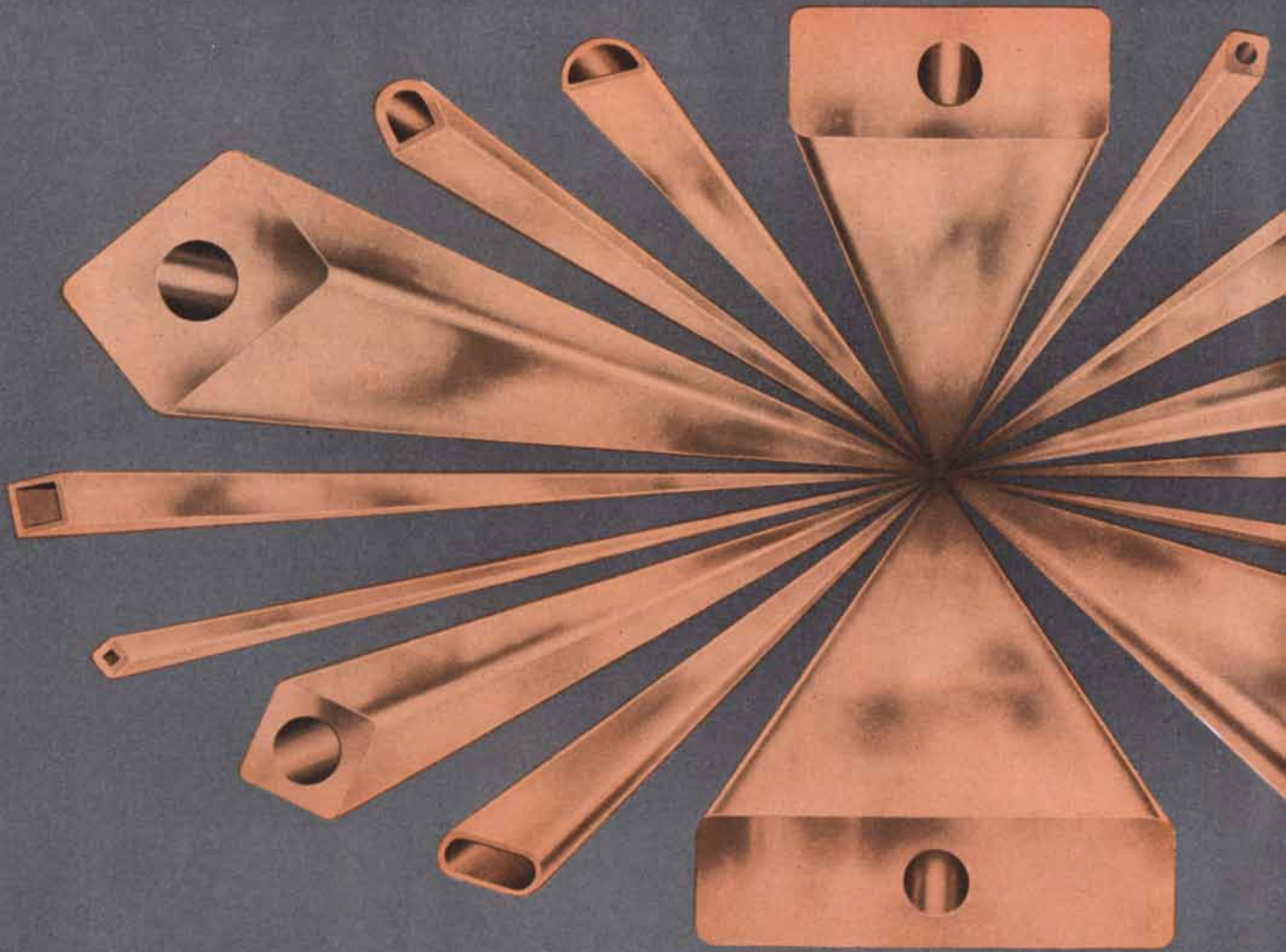
right
answers
when
you need
them!

For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

Librascope's technical ability to meet exacting requirements has ably served our many military customers in the development of missile programs. ■ For further information on Librascope's computer capabilities for missiles write:



LIBRASCOPE, INC. • 808 WESTERN AVENUE • GLENDALE, CALIF. • A Subsidiary of General Precision Equipment Corporation



THE SHAPE OF THINGS TO COME WITH ANACONDA

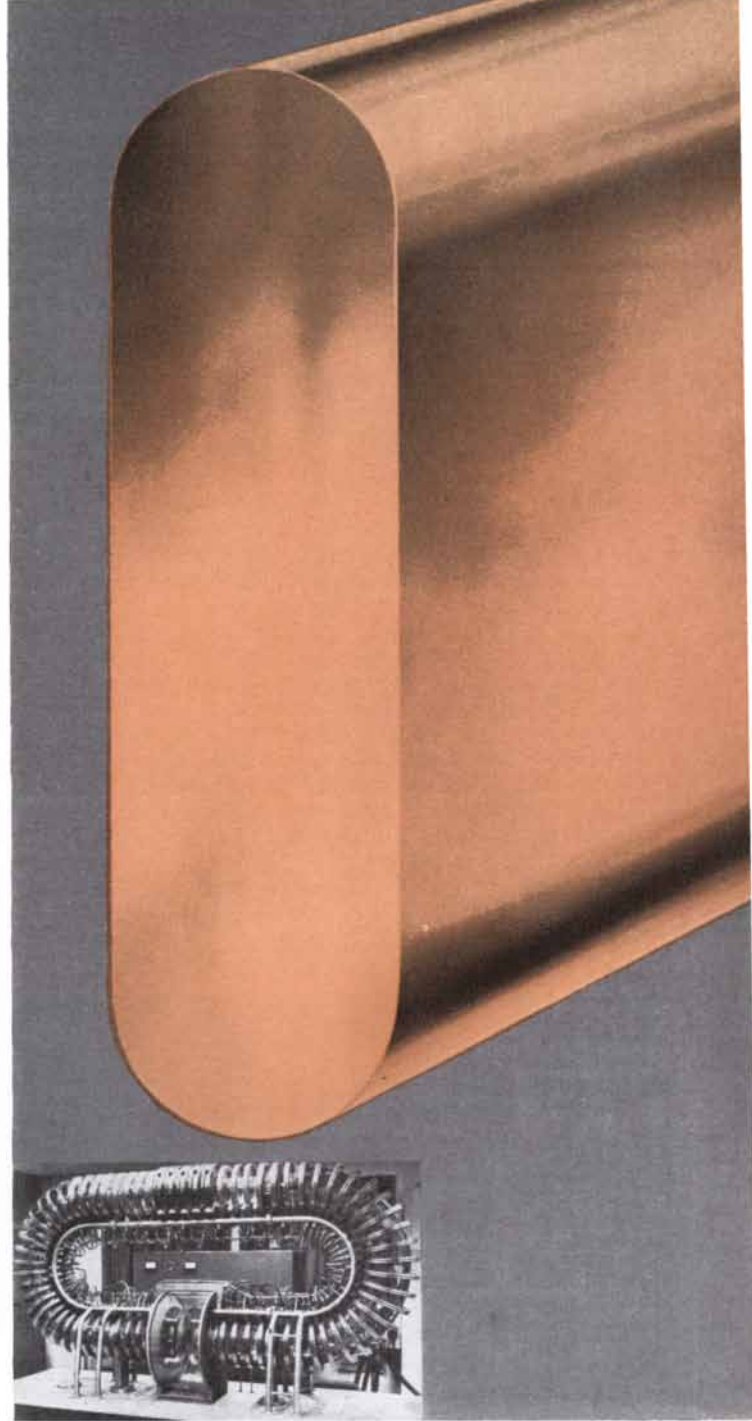
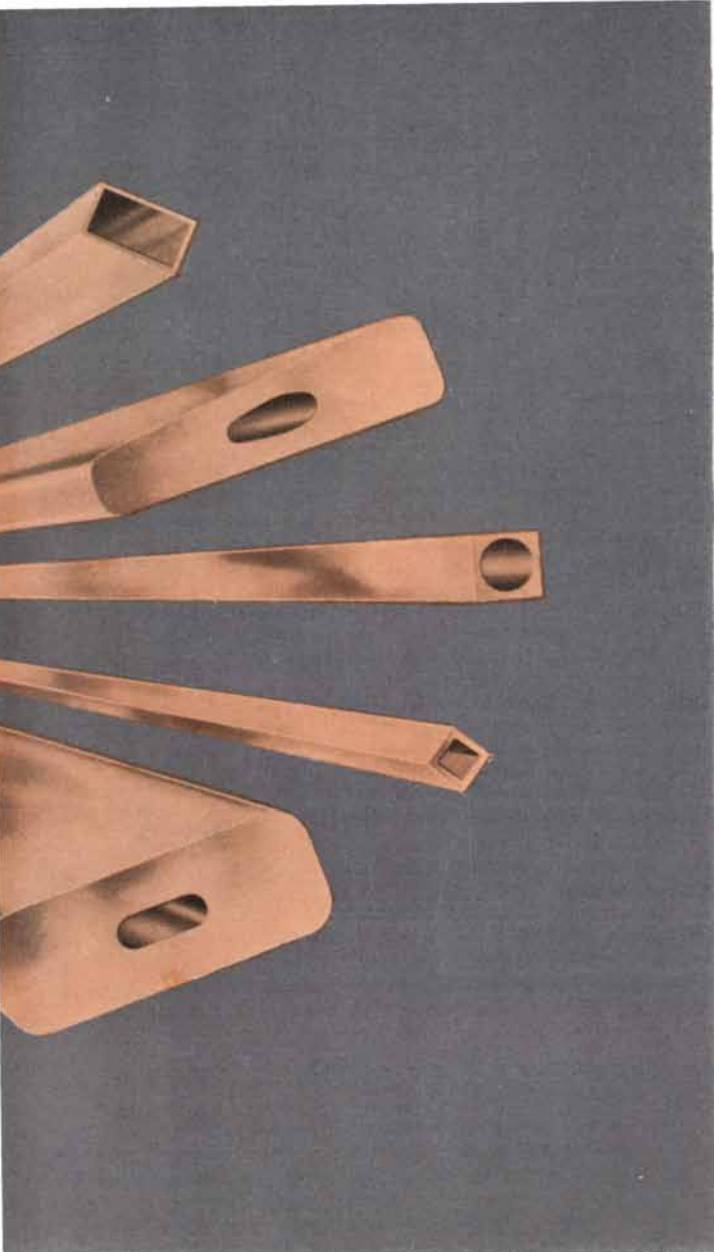
Fluid-cooled copper conductors. The growing need for compact electrical assemblies which can handle high current densities is leading to an ever-increasing variety of hollow, fluid-cooled copper conductors. The samples shown full size above give some idea of the range of sizes and shapes produced by The American Brass Company.

Nuclear physics magnets are, perhaps, the most spectacular applications of fluid-cooled conductors. These hollow conductors range from tube .182" square O.D. x .083" square I.D. to heavy rectangular bars with a round core for water cooling.

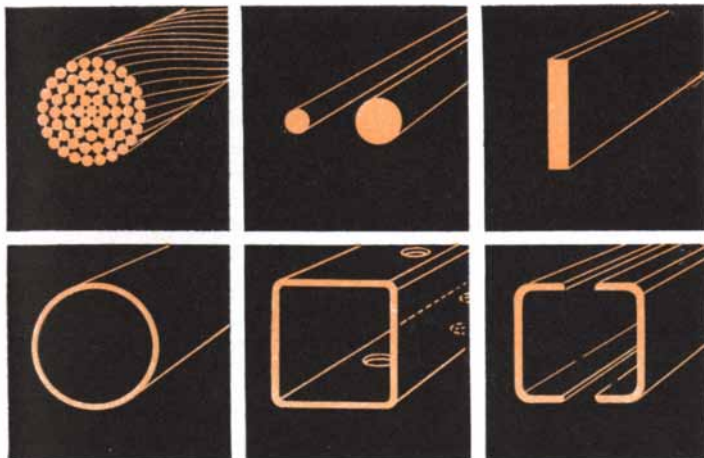
Industrial applications. The use of fluid-cooled conductors is growing rapidly in large electrical equipment. Generator output can be greatly increased, without increasing frame size, by cooling stator and

rotor bars. Fluid-cooled conductors are being used in heat sinks for rectifiers and induction furnace coils. Another interesting use is in compact water-cooled windings needed to provide very high flux densities in, for example, the ceramic magnet manufacturing process. These "solenoids" are being built for applications in which the current range is from a few hundred to about 2000 amperes.

Technical assistance. Whatever your problem—liquid-cooled field coils, rotor bars or a special-shape tubular conductor—technical specialists at The American Brass Company can help you work out the size and shape best adapted to your needs. See your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada write: Anaconda American Brass Ltd., New Toronto, Ont. 5942



ELECTRICAL COPPER



Standard Anaconda copper bus conductor shapes.

200,000 KW AT 750 VOLTS is maximum peak rating of twelve d-c generators providing power for the confining field coils in C Stellarator being built in the new fusion research facility at Princeton University. This power is needed to establish the maximum 50,000-gauss magnetic field, forming the walls around the reaction aimed at reaching 100 million degrees. A.E.C. demonstration model above shows one form of the Stellarator tube that has been considered. The big copper bus (top), 9 square inches in section and silver plated, will carry the tremendous power from the generators to the coils around the Stellarator tube. The American Brass Company has furnished the mile of bus required for the job to specifications of the Allis-Chalmers Manufacturing Co., Milwaukee, Wisc., which is assisting in the design and building of the C Stellarator.

ANACONDA[®]

ELECTRICAL COPPER PRODUCTS

Made by The American Brass Company

THE P-E SPECTRUM

news of advanced systems and instruments from Perkin-Elmer

NEW FAMILY OF AUTO-THEODOLITES "SQUARES-UP"
MISSILE GYRO CONTROLS BEFORE LAUNCHING

A new family of theodolites, sensitive to a fraction of a second of arc, or approximately the angle subtended by a dime a mile away, is helping to obtain the high order of accuracy demanded in long range missiles.

Shown in use here is a short range theodolite, one of two used to align Ford Instrument Company's inertial guidance system on the Army Jupiter.

These precise electronic-optical systems, developed by Perkin-Elmer, monitor the inertial guidance systems of missiles up to the moment of launch by continuous observation of the azimuth angle formed by the missile gyro platform, the theodolite and a known reference mark. Automatic correction signals, as required, are transmitted to the missile's gyro platform via a closed loop system between the theodolite and the missile. P-E theodolites provide working distances ranging from 0 to 1500 feet.

These theodolites are another example of Perkin-Elmer's ability to combine electronics and optics into high-accuracy systems.



LOW-COST INSTRUMENT ATTRACTS NEW USERS FOR INFRARED, SURVEY SHOWS

Since Perkin-Elmer introduced the first low-cost infrared spectrophotometer two years ago, infrared has become as basic a tool in the laboratory as the analytical balance. A recent survey of 150 representative purchasers of the P-E INFRACORD® spectrophotometer reveals that over half are first-time users of this powerful analytical technique.

A typical INFRACORD user, Endo Laboratories Inc., of Richmond Hill, New York, employs the instrument to check both pharmaceutical raw materials and final product. These quality-control tests take a fraction of the time previously required for conventional wet methods. For example, the conventional method of assaying Endo's Coumadin Sodium or Percodan, an analgesic preparation — complicated mixtures of narcotic alkaloids, sedatives and other drugs — in some cases took almost three days. With the INFRACORD, Endo chemists make a positive determination in 25 to 30 minutes. In raw material checks, the instrument provides a permanent record of its analyses for comparison with spectra of standard purity materials.

The INFRACORD is another example of P-E's more than fifteen years of infrared experience and development.

For information on Perkin-Elmer and the products it makes for a wide range of growing industrial, scientific and defense markets, write Perkin-Elmer Corporation, 915 Main Ave., Norwalk, Connecticut.

Perkin-Elmer Corporation
NORWALK, CONNECTICUT

ANALYTICAL INSTRUMENTS • MILITARY SYSTEMS
FINE OPTICS • PRECISION ELECTRONIC COMPONENTS



Survey parties from USS Skate, surfaced in Polar ice, exploring the great ice pack.

OFFICIAL U. S. NAVY PHOTO

UNDERWATER "TV EYE" USED BY ATOMIC SUB SKATE TO SURFACE WITHOUT DAMAGE IN POLAR ICE PACK

On its historic cruise to the Arctic, the atomic submarine Skate was able to find areas in which to surface though the average thickness of the ice was 12 feet. This epic event marked the first time a submarine was ever able to surface directly at the North Pole!

The answer: an underwater "TV eye"—a unique, closed-circuit television system developed by Bendix-Friez that enabled the Skate's crew to "see" the perpetually dark and treacherous underside of the craggy ice pack.

Consisting of a television camera mounted on the bow and viewing screen inside, this super-sensitive electronic device, which magnifies

light many thousands of times and literally sees in the dark, helped locate "ice lakes"—spots where the ice was thinnest so the Skate could surface without damage. Even during the winter when sunlight is negligible, either above or below the surface, it presented a probing picture never before seen by man.

There are a host of products designed and built by Bendix at work beneath the sea . . . sonar devices to detect enemy submarines; telephones for submarines; depth recorders; "fish finders"; "brains" to guide torpedoes and undersea missiles plus new types of hydraulic equipment for steering and diving operations and for con-

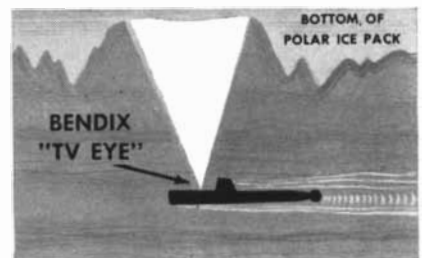


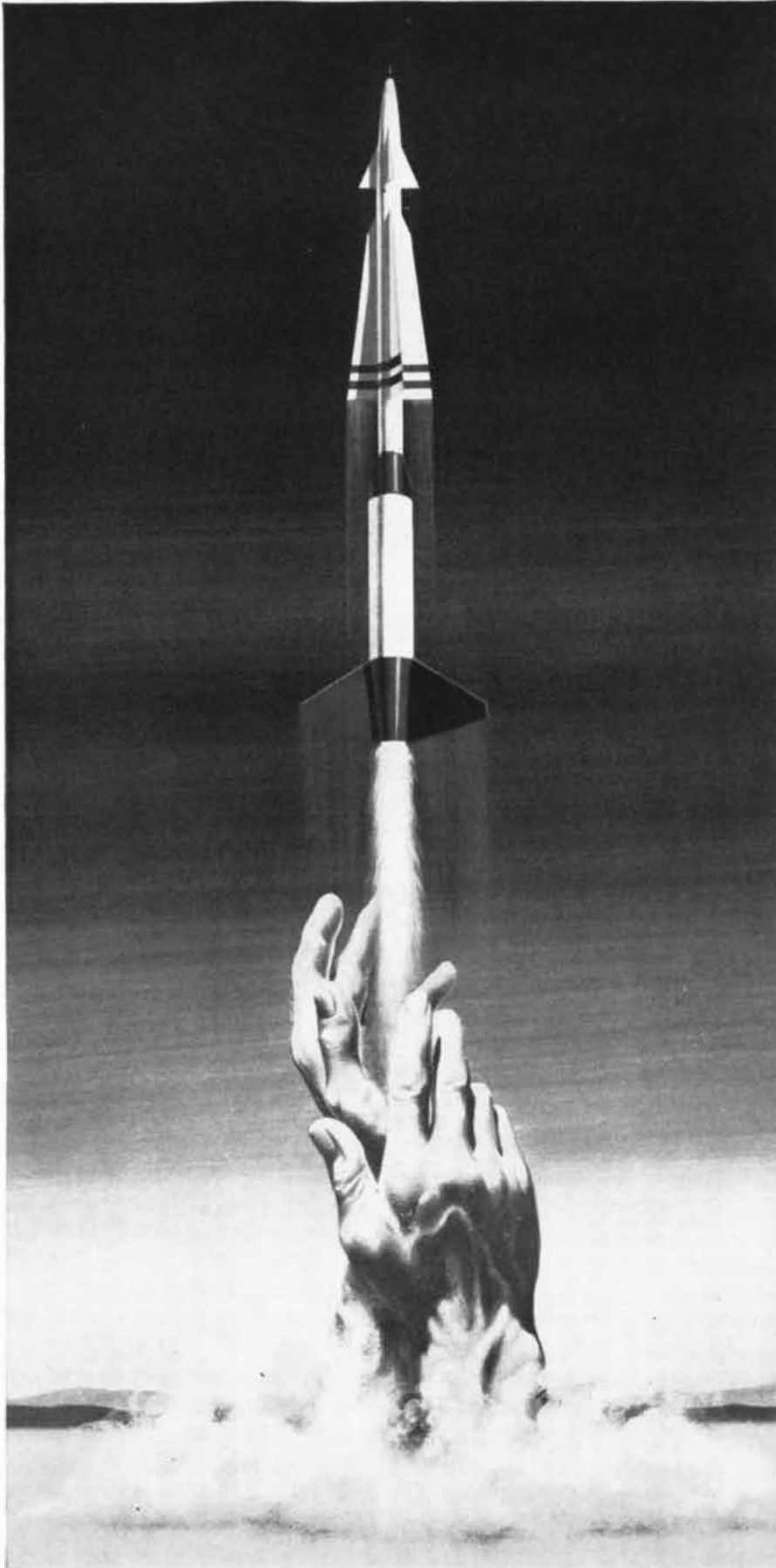
Diagram shows how Bendix electronic eye views underside of ice pack.

trolling a score of other all-important submarine functions including periscopes, radar antenna and snorkels.

A thousand products



a million ideas



rockets and missiles

Componentry capabilities of the Kelsey-Hayes Company as a supplier of precision propulsion assemblies, structural parts and exotic high temperature materials for first and second generation rockets and missiles include—
Swivel nozzles, hydraulic control systems and auxiliary power supply systems for thrust vector control; weldments, rocket and combustion chambers for liquid and solid propellant propulsion systems; inner cones, exhaust cones, rotating wheel assemblies; vacuum induction melted alloys to withstand corrosive and extremely high temperature atmospheres; advanced design, research and development in gas dynamics, internal ballistics, transient heat and thermal stress analysis.
Kelsey-Hayes Company,
General Offices: Detroit 32, Michigan

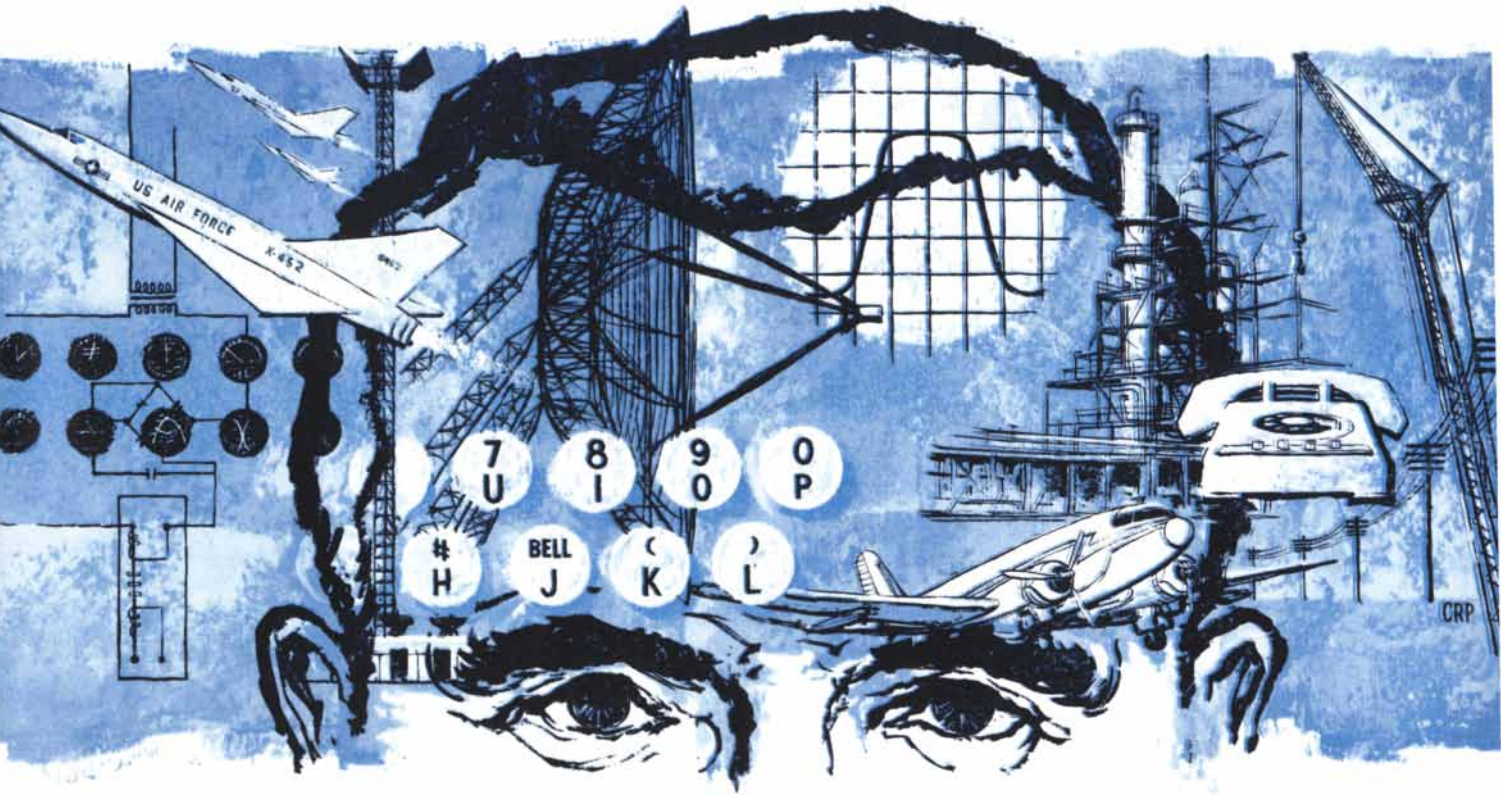
KELSEY- HAYES COMPANY

Automotive, Aviation and Agricultural Parts
Hand Tools for Industry and Home

18 PLANTS: Detroit and Jackson, Michigan; Los Angeles; Philadelphia and McKeesport, Pennsylvania; Springfield, Ohio; New Hartford and Utica, New York; Davenport, Iowa; Windsor, Ontario, Canada.



ALPHA



... MANAGEMENT BRAIN FOR SPACE AGE SYSTEMS

Alpha Corporation was established to expand upon Collins Radio Company's extensive program of design, engineering and installation of complex communication and navigation systems. The entire systems division of the parent company, including its executives and space age specialists, is being consolidated with Alpha.

Further, responsibility for the vast projects for government and industry in the Collins systems program is being assumed by Alpha . . . with its greatly augmented staff of

designers, engineers, scientists and constructors. Alpha is geared to handle turnkey technical projects of all magnitudes . . . on this continent and in foreign fields. In addition to intricate electronic equipment, Alpha will design and construct related roads, towers and buildings. Alpha trains client personnel or staffs and operates finished installations. Alpha, using the best equipment from throughout industry . . . is the hallmark of world-wide systems management dependability.



Alpha CORPORATION
A SUBSIDIARY OF COLLINS RADIO COMPANY

DESIGNERS, ENGINEERS, CONSTRUCTORS, WORLD-WIDE • RICHARDSON, TEXAS • TELEPHONE DALLAS Adams 5-2323 • CABLE ADDRESS: ALPHA DALLAS

Alpha capabilities include technical systems management in all fields, with special emphasis on: • Space vehicle tracking and communication
Test range instrumentation and communications • Voice, teletype and data transmission • Aircraft modification and overhaul
Integrated shipborne, airborne, and ground communications • High capability remote control and switching



Controlled machine-made Radiation

Modern Servant for Man

TODAY, in science, industry, and medicine, γ ionizing radiation from particle accelerators plays an increasingly important role. Safe, powerful, and efficient machines now pour out kilowatts of radiation power for industrial processes. Mass-production sterilization of surgical supplies with the electron beam is a reality. Controlled nuclear beams from HIGH VOLTAGE accelerators are probing secrets of nature at two-hundred laboratories in seventeen countries.

TOMORROW'S APPLICATIONS for machine-produced radiation are limited only by the ingenuity of man.

SPECIFIC INFORMATION on radiation applications, on Van de Graaff and microwave linear accelerators for research, therapy, and production-line uses, and on installation requirements is yours for the asking — from the leading firm in the field of particle accelerators and their development.

High Voltage Engineering Europa (N.V.)
Electronized Chemicals
High Voltage Servicing Company, Ltd.



HIGH VOLTAGE ENGINEERING
CORPORATION
BURLINGTON MASSACHUSETTS

50 AND 100 YEARS AGO



SEPTEMBER, 1909: "The search for the North Pole, which began in the Middle Ages, seems to have culminated in the success of Dr. Frederick A. Cook of Brooklyn, N. Y. Although no definite scientific proof is as yet available of Dr. Cook's claim, there can be but little doubt of his great triumph."

"Within a few days after the announcement of the discovery of the North Pole, it was followed by news that another American explorer had reached the same goal. After Commander Peary's expedition of 1906, when he reached 87 deg. 6 min. N. lat., then the 'farthest north,' he determined to make one more effort to reach the Pole. The *Roosevelt*, equipped by the Peary Arctic Club with all the material and scientific instruments which have been proved to be most essential in polar exploration by Commander Peary's 23 years of experience, left New York on July 6th, 1908. The ship proceeded *via* Etah in Greenland to Cape Sheridan in Grant Land and there the expedition passed the winter. The sledge expedition for the Pole left the *Roosevelt* in three divisions on February 15th, 21st and 22nd, the total of all divisions being seven whites and 59 Esquimaux, with 23 sledges drawn by 140 dogs. All the divisions assembled at Cape Columbia by February 27th. Open water delayed the entire party till March 11th, when the lead was sufficiently frozen over to be crossed. A few days later the ice parted exactly where the main party was encamped, nearly causing the loss of dogs and sledges, but after an exciting period dashing from one moving floe to another, better going was reached. After having crossed the 88th parallel Capt. Bartlett, the sturdy navigator of the *Roosevelt*, who has borne the brunt of the pioneering work, reluctantly turned back with the two Esquimaux of the last supporting party, the provisions carried being insufficient to last more than six men and 40 dogs for the week or more estimated to be required to reach the Pole and return. Peary then determined to try and reach



Edwin Felch, project director in charge of developing the Titan guidance system, holds the "voice" of the ICBM.

V VOICE OF A GUIDED MISSILE

This is a missile-borne transmitter. It is the "voice" of a missile in flight . . . part of a new radio-inertial guidance system developed by Bell Telephone Laboratories for the Ballistic Missile Division of the Air Force.

This versatile system helped deliver the nose cone of a Thor-Able test missile precisely to its South Atlantic target area—5000 miles from Cape Canaveral, Florida. So accurately was the nose cone placed that a waiting group of ships and planes retrieved it in a matter of hours. It was the first nose cone ever to be recovered after so long a flight.

The command guidance system which made such accuracy possible combines precision tracking radar with a special Remington Rand Univac computer. Fed a steady stream of signals from the missile-borne transmitter, the ground-based equipment compares the missile's flight path with the preselected path. Corrective steering orders are computed and transmitted automatically to the missile. The ground

station monitors the progress of the flight continuously and obtains immediate evaluation of mission success. And since the principal control equipment is kept on the ground, expendable hardware in the missile itself is minimized.

This radio-inertial guidance system is a product of the Bell Laboratories-Western Electric development-production team. It is in production at Western Electric for the first operational squadrons of the Titan intercontinental ballistic missile.

Bell Labs scientists and engineers developed the world's most versatile telephone network and much of our nation's radar. They have constantly pioneered in missile systems. From their storehouse of knowledge and experience comes this new achievement in missile guidance.

BELL TELEPHONE LABORATORIES

World center of communications research and development





How to get the tubing you need for fuel element cladding

In determining the practicability of materials under consideration for tubing used as fuel element cladding in nuclear reactors, the following factors must be considered and properly evaluated:

1. Type of fuel—ceramic or metallic matrix
2. Environment—temperature, pressure and corrosive conditions encountered
3. Neutron economy—whether materials like zirconium, columbium, vanadium or Zircaloy, which have the best nuclear characteristics, are to be used; or whether less effective substitutes must suffice as a cost consideration
4. Standard of reliability and integrity—what is wanted, what it is possible to produce, what is economically feasible
5. Dimensional requirements—OD, ID or wall thickness or any combination of these; straightness of tubing; and tolerances to be held

Only after these factors have been determined and given due relative weight by both the Metallurgical and Production Departments can a satisfactory recommendation be made. Let us take a composite inquiry to show what Superior does to give its customers the utmost satisfaction.

Analysis: Seamless 304, .002% max. cobalt limitation, chemistry restriction.

Sizes: .443 in. \pm .0005 in. OD x .423 in. \pm .0005 in. $-$.0000 in. ID. Cut lengths, tolerances, \pm $\frac{1}{64}$ in.

Tests: Ultrasonic nondestructive, to a 3% wall defect level; helium leak test; autoclave corrosion test; 2-hr. hydrostatic test.

Other Requirements: Dye penetrant inspection; no chlorinated lubricants or cleaning fluids permitted; identification of raw material through to finished tubing—top, middle and bottom of ingot.

Here is the tubing that was supplied by Superior and the requirements which it met after extensive discussions with the customer's engineers:

Analysis: 304L because of application temperature. The best reasonable available level of cobalt is .05% max. By special

melt we could get .01% max. By converting ingot we could get a .003% max.—but we aimed for .002%.

Sizes: Tolerances of \pm .001 in. OD and $+.$ 001, $-.$ 000 in. ID. Since ID was the prime limiting factor we air-gaged to insure these tolerances.

Ultrasonic Test: We agreed upon a defect level of 10% of the wall, since the wall thickness was less than .040 in. We also recommended Eddy current, since the tubing was below $\frac{1}{2}$ in. OD x .049 in. wall.

Helium Leak Test: Customer waived this test when told of its impracticability. More recently it has been dropped from Nuclear Military Specifications. Test is used on completed assemblies only.

Autoclave Corrosion Test: Customer indicated time and temperature of test. We performed it.

Hydrostatic Test: The impracticability and high cost of this 2-hr. test was discussed with customer. It was decided to limit it to the completed pressure vessel.

Dye Penetrant Inspection: Performed according to specifications.

Chlorinated Lubricants or Cleaning Fluids: We explained that chlorinated materials are used in redrawing stainless steels and many other metals. This is general procedure in all tube processing plants. Customer unhesitatingly withdrew restriction.

Identification: This specification can be readily met to the point where the material is extruded. Thereafter, while possible, it is extremely impracticable and costly.

Since there is no such thing as a standard fuel element and each new reactor suggests modifications and improvements in design, it is necessary to compromise to satisfy all requirements. Superior's experience in the nuclear and missile field can help you in developing fuel element cladding. Data Memorandum No. 20 gives a rundown of our background and some of the tubing available. Write for a copy today. Superior Tube Company, 2052 Germantown Ave., Norristown, Pa.

the Pole in five forced marches allowing less than a day for each. An observation at noon on April 6th showed that they were only a little over three miles from the Pole, so the remaining distance was apparently covered before a rest was taken. The first 30 hours at the Pole were spent in making observations and taking pictures. A sounding was made through a crack in the ice five miles from the Pole, 1,500 fathoms of wire finding no bottom. Speed was urgent on the return journey and Peary was singularly fortunate in escaping open leads in the ice, which had delayed the return of the supporting parties. By continued rapid traveling, Cape Columbia was reached on the 23rd of April. On July 18th the ice was sufficiently open for the *Roosevelt* to be removed from her berth. She fought her way south and reached Indian Harbor September 5th to send the now historic telegram: 'Stars and Stripes nailed to North Pole.'

"The natural feeling of exultation following the announcement of the discovery of the North Pole was quickly dimmed by the criticisms and accusations which followed the first cable dispatches, which made it patent to all that the claim of one of the explorers was to be disputed by his rival. We have here no mere difference of opinion between two private individuals. One of the disputants, at least, by virtue of the fact of his bearing a high commission in his country's service, must necessarily speak and act as a distinguished representative of his native land. Whatever of disappointment or of fancied or actual wrong may have been felt by the sender of that accusing dispatch from Labrador, any consideration of the dignity of the Navy and of the nation should have sealed his lips."

"The first real aviation meeting held anywhere in the world took place last week near the city of Rheims, France. Altogether there were 38 aeroplanes entered in the various contests and races, for which \$40,000 in cash prizes were offered. Glenn H. Curtiss won the Bennett International Aviation Trophy, averaging 47.04 miles an hour for the 20 km. (12.42 mi.) course. In addition Mr. Curtiss carried off the first prize (\$2,000) in the 30-kilometer speed contest. The real race was between Curtiss and M. Louis Blériot, the champions of the biplane and the monoplane type of flying machine respectively. The other speed contest, for one circuit of the 10-kilometer course, was won by M. Blériot, who covered the distance at

Superior Tube
The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to $\frac{3}{8}$ in. OD—certain analyses in light walls up to $2\frac{1}{2}$ in. OD
West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

CAN YOU SPOT THE MAN RESPONSIBLE FOR THE GREATEST MILITARY SYSTEMS OF HIS TIME ?

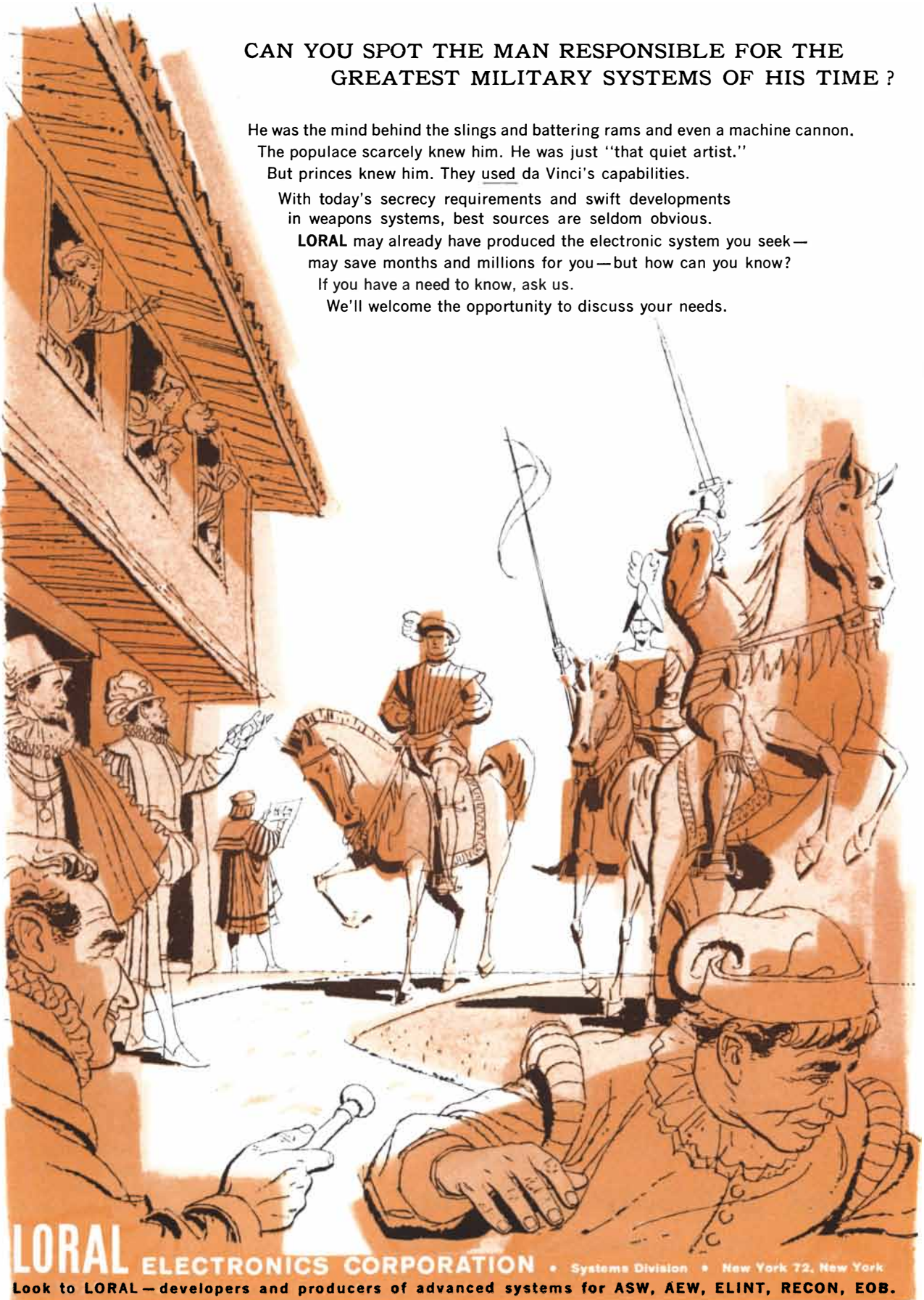
He was the mind behind the slings and battering rams and even a machine cannon.
The populace scarcely knew him. He was just "that quiet artist."
But princes knew him. They used da Vinci's capabilities.

With today's secrecy requirements and swift developments
in weapons systems, best sources are seldom obvious.

LORAL may already have produced the electronic system you seek—
may save months and millions for you—but how can you know?

If you have a need to know, ask us.

We'll welcome the opportunity to discuss your needs.



LORAL ELECTRONICS CORPORATION • Systems Division • New York 72, New York

Look to LORAL—developers and producers of advanced systems for ASW, AEW, ELINT, RECON, EOB.



A Critical De-Icing Problem Solved by COX for REPUBLIC

The unique electric de-icing system which protects the air inlets of the Republic F-105B was designed and is produced by Cox.

By using a stainless steel sandwich structure and very high watt densities, this dependable cyclic system requires less than 3,000 watts to protect more than 1,000 square inches of inlet surface. The structural weight increase is less than ten pounds.

Cox & Company, Inc. is a major source for new design and volume production in the fields of de-icing, temperature control and special heating elements for military equipment.

COX & COMPANY, INC.

115 EAST 23 STREET, NEW YORK 10, N. Y.
Engineering Representatives Coast to Coast

47.78 miles an hour. A record for distance was made on August 26th by M. Hubert Latham with his No. 29 Antoinette monoplane. The flight, totaling 95.88 miles, was a complete vindication of the Antoinette motor which, it will be remembered, failed Latham twice when he attempted to cross the English Channel. The height competition was also won by Latham, who reached a height of 155 meters (508.5 feet), as recorded by a barometer upon his monoplane."

"A knowledge of the mass and size of the two units of electricity, the positive and the negative, would give us the material for constructing what may be called a molecular theory of electricity, and would be a starting point for a theory of the structure of matter; for the most natural view to take, as a provisional hypothesis, is that matter is just a collection of positive and negative units of electricity, and that the forces which hold atoms and molecules together, the properties which differentiate one kind of matter from another, all have their origin in the electrical forces exerted by positive and negative units of electricity, grouped together in different ways in the atoms of the different elements.' Sir J. J. Thomson."



SEPTEMBER, 1859: "A party of American engineers, under the charge of the Navy Department, are about to proceed to the Isthmus of Darien to search for a practical route for a ship canal across the Isthmus; they are instructed to explore the coast of the Caribbean Sea with a view to test statements that there is such a depression of the eastern Cordillera as to admit of the easy construction of a ship canal; the country west thereof to the Pacific Ocean being without any considerable elevation. Should the party not be able to find the gap referred to, they may proceed to the Pacific side of the continent, and seek a practical route for a canal along the line traversed by Surgeon Caldwell, U.S.N., in 1857. This gentleman, inspired by the reports of old residents in respect to the existence of a region nearly level stretching across the continent, proceeded with a small party from the excellent bay of San Miguel, several miles in a north-easterly direction, up the

Navigation · Propulsion · Armament



Photo: Courtesy Electric Boat, Div. General Dynamics Corp.

U.S. Atomic Subs Depend On Ball Bearings In Over 100 Vital Positions!

Some of the most unique and precise equipment ever engineered is in United States atomic subs . . . with New Departure bearings in many vital positions!

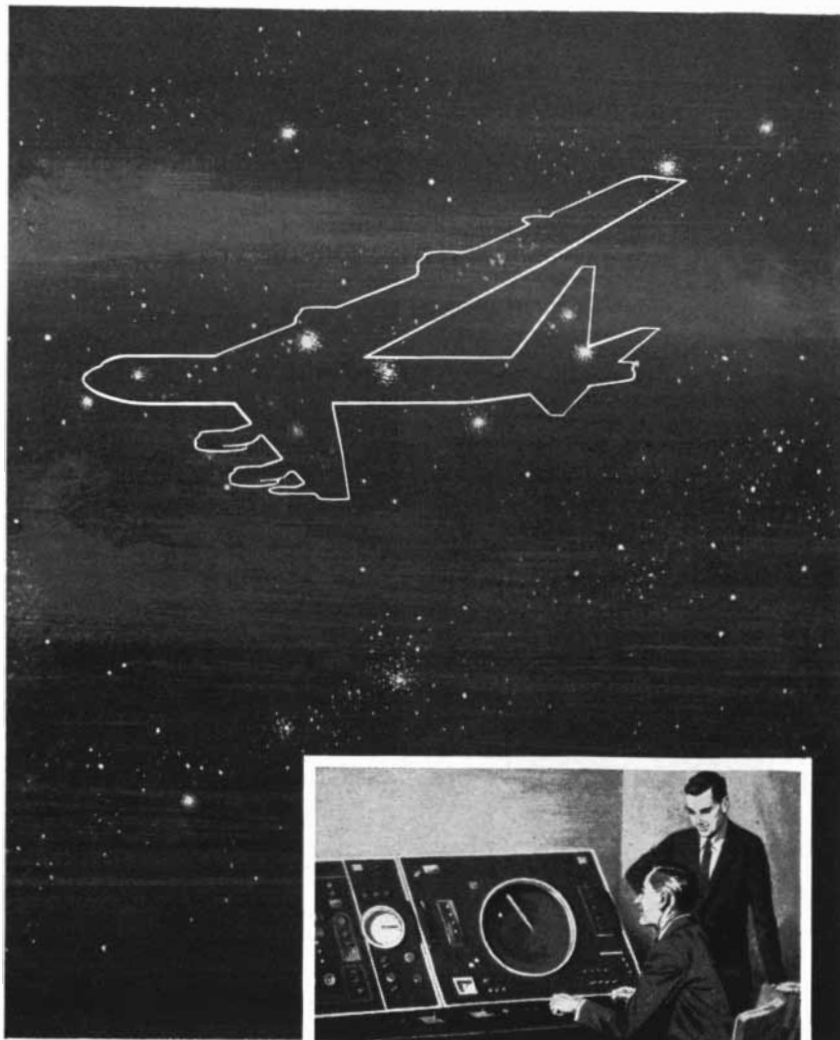
In the submarines' guidance system, New Departure gyro ball bearings help contribute to unerring undersea navigational accuracy. These bearings have been credited with reducing random drift rate to 0.25 degrees per hour.

Many of the atomic power plants that have supplied record-breaking propulsion without refueling, are equipped with New Departure precision ball bearings in reactor control arms, water pumps, and other essential applications.

If you have a vital precision bearing problem, why not call on N/D, too? New Departure's advanced facilities for research, development and production, are your assurance of the ultimate in ball bearing design and precision manufacture.


NEW DEPARTURE
DIVISION OF GENERAL MOTORS, BRISTOL, CONN.
NOTHING ROLLS LIKE A BALL

SYLVANIA ELECTRONIC SYSTEMS...IN SIMULATION



Creating electronic "realities" in a low-cost manageable package

SIMULATING CONDITIONS of actual operations for flight trainers, radar operators, or space travelers is an experienced and growing facility of Sylvania Electronic Systems.

Good examples are Sylvania's participation in the Navy's Universal Digital Operational Flight Trainer and "ACTER," a new Sylvania development which will add ECM conditions to existing radar training gear.

Undoubtedly the simulation of space travel can be enhanced mater-

ially by current simulation projects.

In simulators or trainers, as in every major area of electronic systems, Sylvania can assume full responsibility from system analysis and management through research and engineering, product design, production to field engineering.

Sylvania welcomes the opportunity to outline its special talents and capabilities to you or your organization personally. Simply address your inquiry to division headquarters, address below.

Sylvania Electronic Systems
A Division of Sylvania Electric Products Inc.
63 Second Avenue, Waltham, Mass.

 **SYLVANIA**
Subsidiary of
GENERAL TELEPHONE & ELECTRONICS 

navigable river Savana, and thence east across the country to a point not far in a direct line from the Atlantic."

"Messrs. Editors:—I have just observed, in the *SCIENTIFIC AMERICAN* of the 3rd inst., an error in your notice of the "great trial of reaping and mowing machines which recently took place at one of the royal farms in France." You stated as follows:—"After a few turns in the field, the contest lay between Burgess & Key's (Allen's Patent) and Wood's (stated to be Manny's Patent) reapers, in which the former took the lead, and was unanimously awarded the first prize; the latter the second." I herewith send you an extract from the Paris correspondence of *The New-York Tribune*, in regard to the trial referred to, the publication of which extract in your journal will correct the previous error, and be only an act of justice to myself. The Paris letter writer states "Three prizes were to be given to each class; a large gold medal, the 'prize of honor' to be given to the incontestably best machine among them all, and the first of the three prizes for foreigners, were handed over to Mr. McKenzie, who ran with the machine sent by the Burgess & Key from London, which is the original McCormick reaper." As may be inferred from the above extract, Burgess & Key, of London, are licensees and manufactures of my reaping and mowing machine.' C. H. McCormick."

"The great event of the past week has been the departure of the *Great Eastern* down the river Thames on her first trial trip to sea. Fears were entertained that when the fastenings were loosened she would not be very manageable, but it is stated that the very first turn in the river demonstrated that she was as completely under control as any river steamer. Thus far the *Great Eastern* has given evidence of being the fastest steamship in the world. This she ought to be, as, according to scientific deduction, ships increase in speed according to their size, if the model is good and the power proportional to the tonnage. On Sept. 8th she left the Nore and steamed off majestically for Portland (England), where she was to remain until Sept. 17th, on which day she will proceed to Holyhead, and from that port will commence her transatlantic voyage. It was anticipated that she would reach Portland, Maine, in from six to seven days after leaving Holyhead. Should this trip prove successful, the Cunard Company will at once undertake to build a vessel of equal size."

HAYNES

ALLOYS



RESEARCH REPORTS

Developing new metals and improving current ones to combat the devastating effects of high heat, corrosion, erosion, and abrasion, are the primary objectives of the advanced Research and Development Laboratories at Haynes Stellite Company. HAYNES Tantalum, described below, is one of their more recent achievements. Others will be described in future Research Reports.

Design engineers, metallurgists, and physicists may see in these new metals and alloys opportunities for a breakthrough in applications where limited properties of other metals have presented obstacles. Our research scientists, engineers, and technicians will gladly help you discover whether they can help improve your products.



LARGEST Tantalum Lined Reactor

An outstanding example of what can be accomplished with the greater sheet width and improved welding characteristics of HAYNES Tantalum is shown above. The vessel—the largest tantalum-lined reactor ever constructed—is a 30-gallon unit designed to operate at 630 deg. F. and 500 psi. Every part that will be exposed to corrosives, including the agitator, is made, or sheathed with, HAYNES Tantalum. For full details on this new material, write for descriptive booklet.

HAYNES Tantalum

Close to 100% pure, chemically. It is produced by the consumable-electrode process. Practically inert to a wide variety of corrosive media, with these added advantages: *Wide* sheets with improved welding characteristics, making it easier to use in chemical and pharmaceutical equipment where corrosion and product contamination must be minimum. Pictured is tantalum reactor liner being welded inside tank of inert gas.

HAYNES

ALLOYS

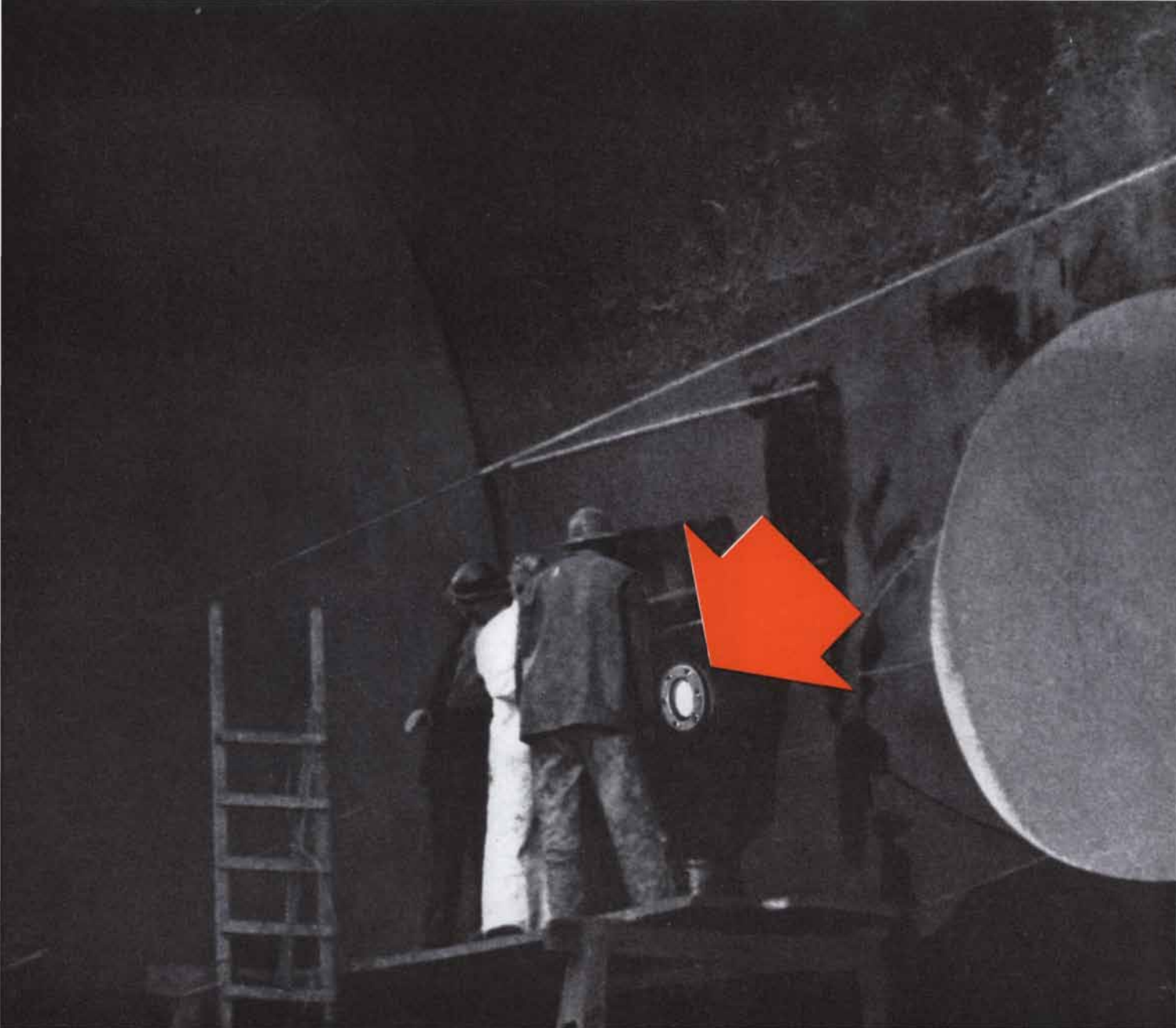
HAYNES STELLITE COMPANY

Division of Union Carbide Corporation
Kokomo, Indiana

UNION
CARBIDE

Address inquiries to Haynes Stellite Company, 420 Lexington Ave., New York 17, N. Y.

"Haynes," "Haynes Stellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation



PROTECTION OF SHIP'S HULL AND PROPELLER AGAINST CORROSION . . .

Where any metal but Platinum



PLATINUM DOES IT FOR LESS. Experience proves that platinum anodes used in the impressed current system of the type shown provide sure protection of ship hulls and propellers against corrosion... and do so economically. Equipment (called CAPAC* and designed by Engelhard Industries, Inc., Instrument Division) is being used on commercial vessels and pleasure craft as well as on atomic submarines and other Navy ships.

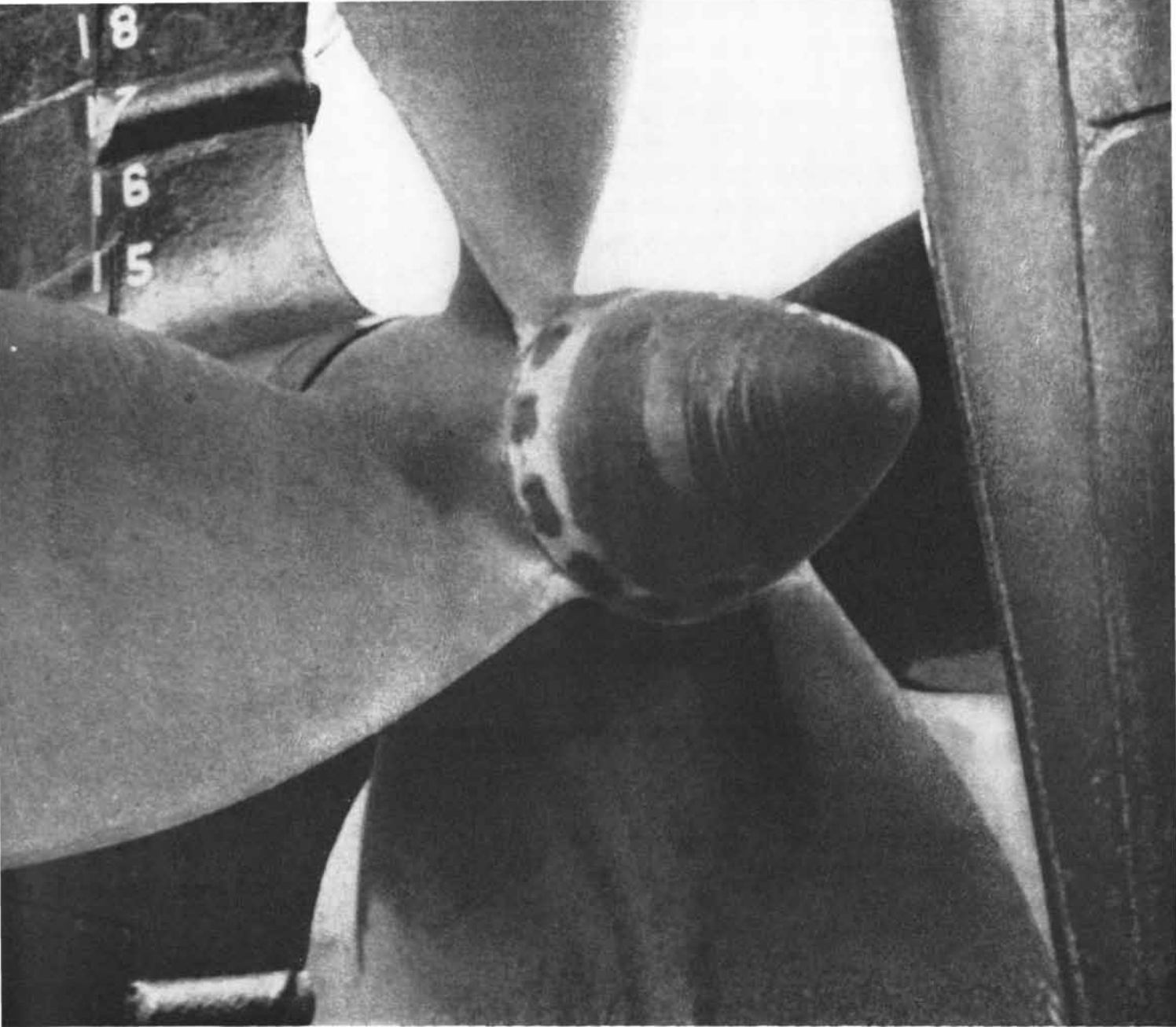
Who would think that the platinum metals provide a practical way to protect steel against attack by sea water?

But that's how underwater corrosion is being defeated today. In an automatic system, CAPAC*, devised by Engelhard Industries, Inc., Instrument Division, comparatively small anodes feed a corrosion-stopping protective electrical current to the hull and propeller.

Long life... obtainable only with platinum surfaced anodes... brings the real cost of this underwater protection system so low that it has become standard equipment on week-end sailors' steel-hulled pleasure boats.

A platinum metal may economically solve your problem

Where underwater hull protection is a problem . . . where a combination of severe corrosion and erosion must be met, as in the case of spinnerettes for rayon production . . . where wear-resisting, non-tarnishing surfaces are required, such as for printed electrical circuits . . . where product purity must be retained despite high temperatures, as in the case of lens glasses . . . or



would cost too much...

where peak catalytic efficiency is required, as in the refining of high octane gasoline... the platinum metals have proved to be the most economical for certain critical equipment.

Industry is going to higher temperatures and higher pressures. Perhaps your own progress has been blocked by the limitations of materials to withstand such severe conditions. The platinum metals have removed many barriers. Have you considered them for your problem?

Platinum, palladium, rhodium, ruthenium and iridium have unique potentials, well worth your attention. Specialists are prepared to work closely with you in evaluating these metals for new commercial and scientific uses.

As a first step, write us for additional data on the outstanding characteristics and successful applications of the six platinum metals and their alloys—indicating your field of interest or how we might be of assistance.

*Registered trademark of Engelhard Industries, Inc.

CAN THESE PROPERTIES OF THE PLATINUM METALS HELP YOU?
Exceptional Chemical Inertness Superior Wear Resistance High Temperature Stability Peak Catalytic Activity Low Vapor Pressure

The six platinum metals are:

**PLATINUM • PALLADIUM • RHODIUM
RUTHENIUM • IRIIDIUM • OSMIUM**

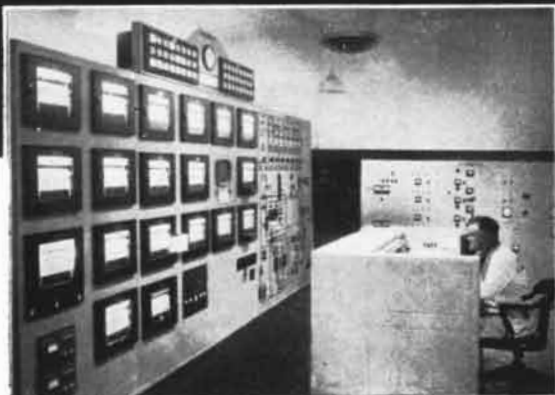
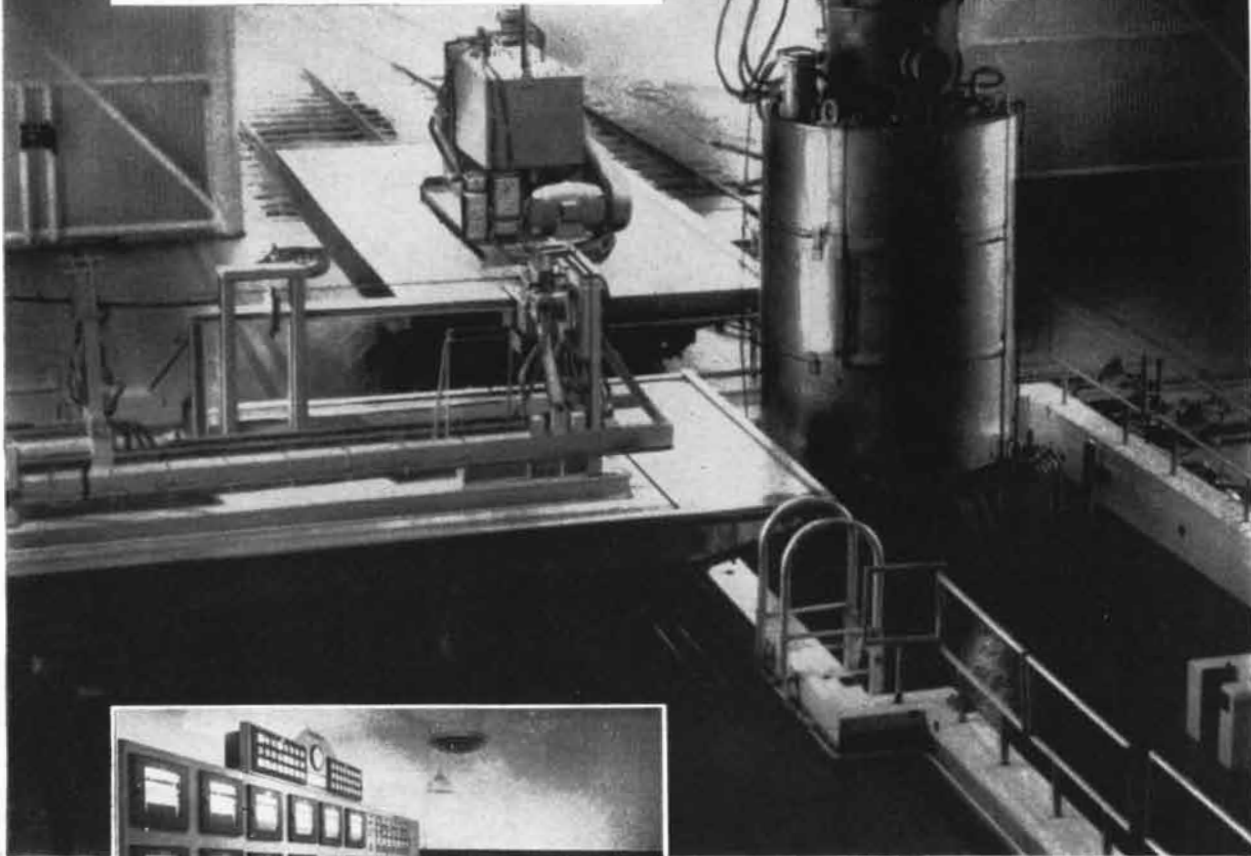


PLATINUM METALS DIVISION, The International Nickel Company, Inc., 67 Wall Street, New York 5, N.Y.

RADIATION EFFECTS REACTOR (RER)

Now in Operation

A part of the Georgia Nuclear Laboratories located near Dawsonville, Georgia, the RER is an Air Force owned facility (AFP #67). RER is operated by Lockheed Nuclear Products as a part of its diverse activities in the design and development of nuclear power applications.



LOCKHEED NUCLEAR PRODUCTS

*3272 Peachtree Rd., N. E.
Atlanta 5, Ga.*

*Tel. CE 3-7104
Cable: MALOCKHEED*

LOCKHEED AIRCRAFT CORPORATION
Georgia Division

Q. Why are Grape Growers like Rubber Researchers?



A. *Exciting advances in both fields are directly related to chemical progress pioneered by Merck. Thanks to GIBREL®—Merck's new plant growth stimulant—grape growers are able to increase berry size and crop yield by as much as 50%. Farmers everywhere are vitally interested in more efficient crop production with GIBREL. Its "vitamin-like" action triggers normal growth in many plants by supplementing the growth-promoting substances naturally found in plants.*

Another Merck chemical, MAGLITE® Y, meets the special processing requirements of the rubber industry's

most important new synthetic—a heat-resistant elastomer with promising applications in jet aircraft tires and other rubber products that must perform under extremely high temperatures. A reactive magnesium oxide, MAGLITE is also available in D, K and M grades that are particularly well suited for various product or processing needs of many different elastomers.

MAGLITE and GIBREL are representative of Merck research and production that speed progress in nearly every field served by chemistry. For technical information bulletins on either product write to Department SA-4.

MERCK & CO., INC. • Chemical Division • Rahway, New Jersey





SETTING THE PACE

Entering an entirely new field of science involves many firsts... but unquestionably, one stands out: THE FUNDAMENTAL DECISION... in this case—to convert enriched UF_6 to uranium metal and compounds for use in nuclear reactors. Mallinckrodt made this decision and acted on it... before any sizable commercial market was evident. As a result, Mallinckrodt was FIRST...

- ... to develop processes meeting requirements for safety and criticality.
- ... to receive a license from the A. E. C. to convert uranium hexafluoride.
- ... to receive a permit from the Bureau of Explosives covering the design of shipping containers acceptable to the Bureau and the I. C. C.
- ... to manufacture and ship uranium metal and compounds both domestically and in export.
- ... to develop processes for materials with special physical characteristics such as UO_2 Shot (spherical) and UO_2 Special Dense (for swaging).
- ... AND NOW—Mallinckrodt has erected the most modern and automated facility for producing ceramic shapes of UO_2 .

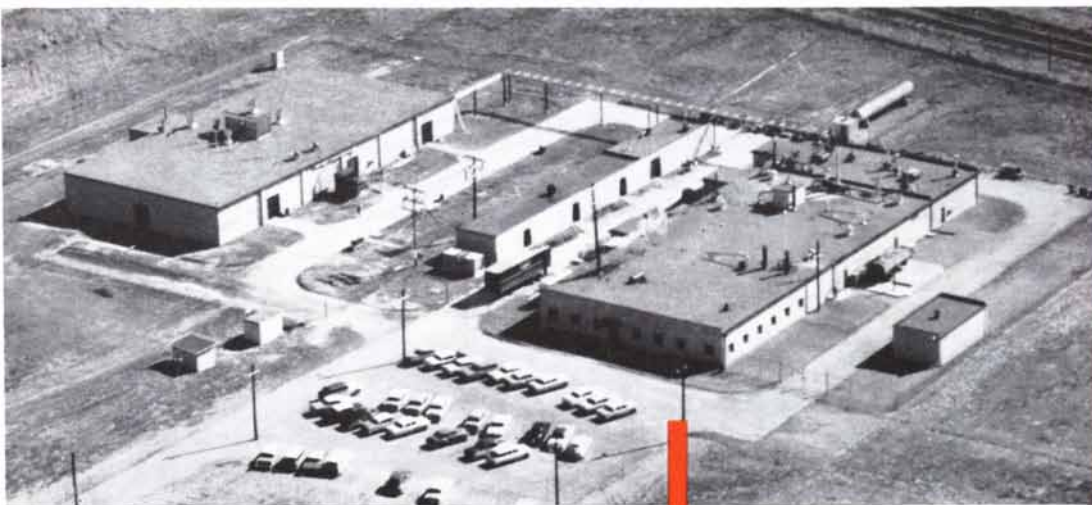
IN NUCLEAR FUEL PROGRESS

Mallinckrodt has been a pioneer on the frontiers of nuclear science since 1942. At that early date in the atomic age, Mallinckrodt had built and operated the first full-scale plant for producing highly purified uranium dioxide. This compound—of a purity previously unknown—was used in making uranium metal for the first self-sustaining chain reaction at Stagg Field in Chicago. Since that time, Mallinckrodt has continuously produced high-purity uranium compounds and metal.

In 1956, Mallinckrodt became the first private firm to produce enriched uranium compounds for commercial uses. Since then, Mallinckrodt has processed more than 200,000 pounds . . . and has supplied fuel in research or production quantities for every private power reactor project in this country.

Research on new uranium compounds and on improvement of those presently in use is continuing. Progress in nuclear fuel development is the goal of our entire organization.

If you have a nuclear fuels project, Mallinckrodt's experienced engineers are available for consultation.



Aerial view of Mallinckrodt's rapidly expanding plant at Hematite, Mo. Starting with 16,000 sq. ft. in 1956 . . . 4,400 sq. ft. were added in 1957 and 12,600 sq. ft. in 1958. The total 33,000 sq. ft. of plant area now devoted to the processing and handling of nuclear fuels. In addition, sales, administrative and analytical laboratory facilities are maintained in St. Louis.

**MALLINCKRODT
NUCLEAR
CORPORATION**

ST. LOUIS 7, MISSOURI



FROM ONE EXTREME TO ANOTHER



Challenging jobs requiring engineering skill as well as metal fabricating experience have a way of coming to Bliss. They may be projects involving massive size, like the 140-foot diameter radio telescope shown above... or the precision machining of missile parts similar to the one at the left.

Whatever it is, if it's made of metal, you'll find that Bliss has the skills and facilities to take it from idea to completed project.

These abilities have made Bliss a leading producer of steam catapults for carrier aircraft, overrun barriers, precision machined missile parts, antennas, atomic assemblies and special machinery; everything from small parts with tolerances running to the ten-thousandths to complete turn-key plants.

What does your job involve?

*BLISS is more than a name
... it's a guarantee*

E. W. BLISS COMPANY
Canton, Ohio

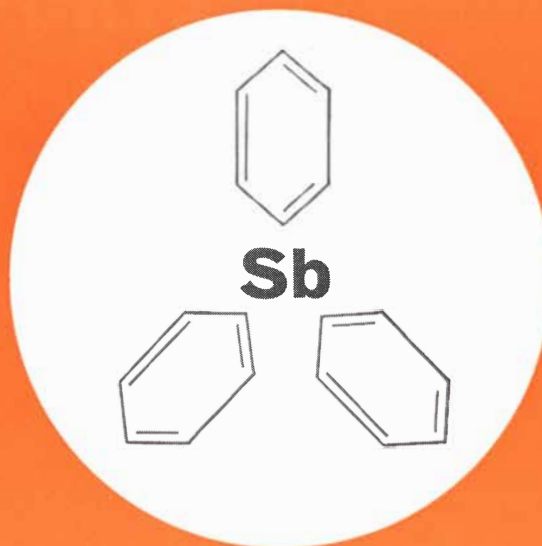
BLISS
SINCE 1857

2 new M&T Organometallics



TRIPHENYLPHOSPHORUS

- * Forms phosphonium salts
- * Forms oxides and sulfides
- * May be halogenated to triphenylphosphine dihalides
- * Wittig reaction intermediate to convert an aldehyde or ketone to an olefin.
- * Is a white crystalline solid
- * Available in 10, 50 and 150 lb. fiber drums

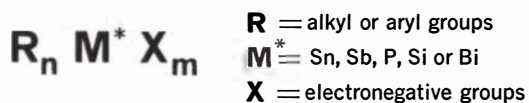


TRIPHENYLANTIMONY

- * May be halogenated to triphenylantimony dihalides
- * Forms Stibonium salts
- * Co-catalyst in converting trienes to aromatics and hydroaromatics
- * Reacts with nitric-sulfuric acids to give trinitro derivatives
- * Is a white crystalline solid
- * Available in 10, 50 and 200 lb. fiber drums

Triphenylantimony and triphenylphosphorus are two more results of M&T's long standing leadership in the development of organometallics. Requests (on letterhead, please) from development men for literature and samples will be welcomed. Ask, also, for a complete list of M&T organometallics.

M&T's "ORGANOMETALLICS UNLIMITED"



This general formula has been the basis for hundreds of organometallics prepared by M&T. Let us check our files on any compound of specific interest in your development work.

M&T Chemicals

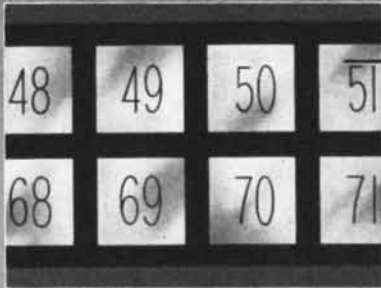
COMMERCIAL DEVELOPMENT DIVISION

Metal & Thermit Corporation

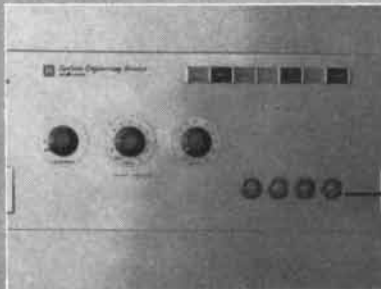
Dept. S, 100 Park Avenue, New York 17, N. Y.

Sn Sb P organometallics
Si Ti Zr and inorganics

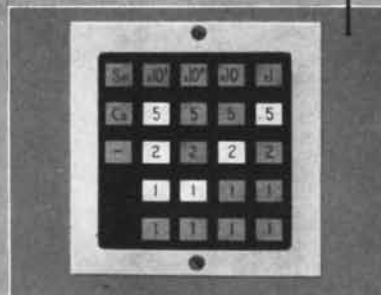
New packaged



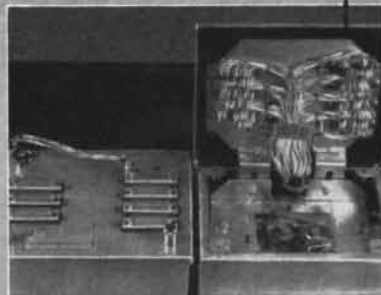
THREE 40-POINT ANNUNCIATORS make it easy for the operator to tell at a glance which variables are off-normal.



DIGITAL VISUAL DISPLAY and variable selector switches make it easy to select any single variable and watch all trends and changes continuously.



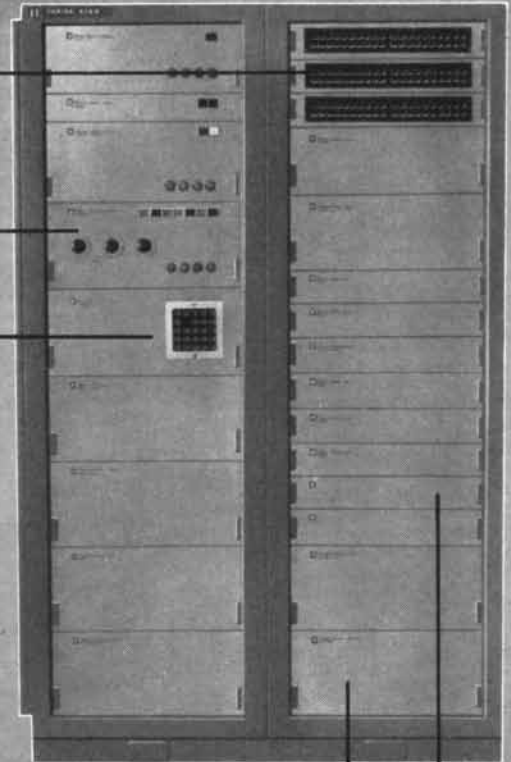
SERVICING IS SIMPLIFIED by an indicator-light panel showing the completion of each step in the analog to digital conversion. The sequence programmer can be changed from automatic to hand advance to permit operator to check each step.



UNIQUE INPUT SELECTOR is unusually dependable because of its sealed, oil-immersed construction. Servicing is normally limited to visual inspection every 6 months. Drawers pull out so voltage checks can be performed without shutting down system.



PINBOARD PROGRAMMING adds flexibility. You can change the logging or scanning sequence at will . . . substitute one type of input for another. Range, span, and zero adjustment are set by inserting pins in their proper places. No calculations are required. The pinboards are pinned in familiar units of measurements.



Honeywell logger-scanner

... accurate within $\pm 0.1\%$ of reading

... pinboard programming for maximum flexibility

Here's a standard, all-purpose 120-point logger-scanner system with features formerly found only in more expensive, custom-designed equipment . . . the first of several packaged logger-scanners being introduced by Honeywell. It offers the ultimate in accuracy, flexibility, dependability and simplicity of maintenance. Wide ambient temperature operating limits—60 to 120°F—eliminate the need for special air conditioning equipment.

The Series 3120 accepts signals from primary measuring instruments—thermocouples, flow, pressure or other transducers. It measures these signals, digitizes them, and prints their values in immediately usable form. A thermocouple reference oven can be supplied to accommodate three types of thermocouple inputs—types T, J, and K—which are automatically linearized over their entire range to within 0.1% accuracy.

The operator can select either automatically or manually initiated logging cycles. He can set the system to log all variables automatically at preset intervals, or manually energize the system to operate on demand, between logging cycles.

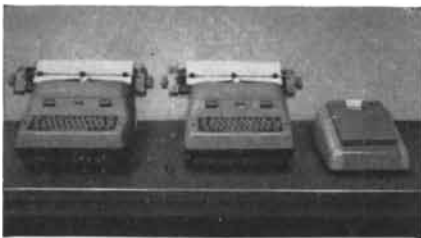
Between logging cycles, the system can scan off-normal alarm points—high, low or both—at a rate of 7 points per second. Upon detecting an off-normal point, the system sounds an alarm, lights a point-identification light, and prints the time, point number and off-normal value on adding machine tape. During log cycles, off-normal points are printed in red on the log sheet.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell



First in Control



TWO TYPEWRITERS permit a single line log allowing columnar comparisons. Separate alarm printer records all off-normal variables.



STANDARD MODULAR COMPONENTS are assembled on chassis mounted as individual drawers in relay racks. All drawers are connected by plugs for easy servicing.

NEW GIANT narda SONBLASTER



Generator G-5001
500 watts output

Transducerized Tank NT-5001
Capacity: 10 gallons
Dimensions: 20" L x 11½" W x 10" D

Generator features tank selector and load selector switches on front panel to operate one or two NT-5001 tanks alternately. Other combinations of tanks and submersible transducers available from stock; larger tanks available on special order.

\$1325

For mass-production cleaning and high capacity chemical processing!

Here's a new Narda SonBlaster ultrasonic cleaner with tremendous cavitation activity and generating capacity! Featuring full 500 watts output, this SonBlaster is available with a fully transducerized giant 10-gallon capacity tank. In addition, it will operate from six to 10 Model NT-605 high energy submersible transducers, at any one time, in any arrangement in any shape tank you need up to 70-gallon volume.

Install this new Narda SonBlaster, and immediately you'll start chalking up savings over costly solvent, vapor or alkaline degreasing methods! You'll save on chemicals and solvents, cut maintenance and downtime, eliminate expensive installations, save on floor space, and release labor for other work. But perhaps most important, you'll clean faster, cut rejects, and eliminate bottlenecks.

Whether you're interested in mass-production cleaning or degreasing of mechanical, electronic, optical, or horological parts or assemblies... rapid, quantity cleaning of "hot-lab" apparatus, medical instruments, ceramic materials, electrical components or optical and technical glassware... or in speeding up metal finishing and chemical processing of all types—you'll find this new SonBlaster will do your work faster, better and cheaper. Write for more details now, and we'll include a free questionnaire to help determine the precise model you need. Address: Dept. SA-20.

Consult with Narda for all your ultrasonic requirements. The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers which can be adapted to any size or shape tank you may now be using. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available for immediate delivery from stock—and at the lowest price in the industry (\$175 up)!

For custom-designed cleaning systems, write to our Industrial Process Division; for information on chemical processing applications, write to our Chemical and Physical Process Division; both at the address below.



THE AUTHORS

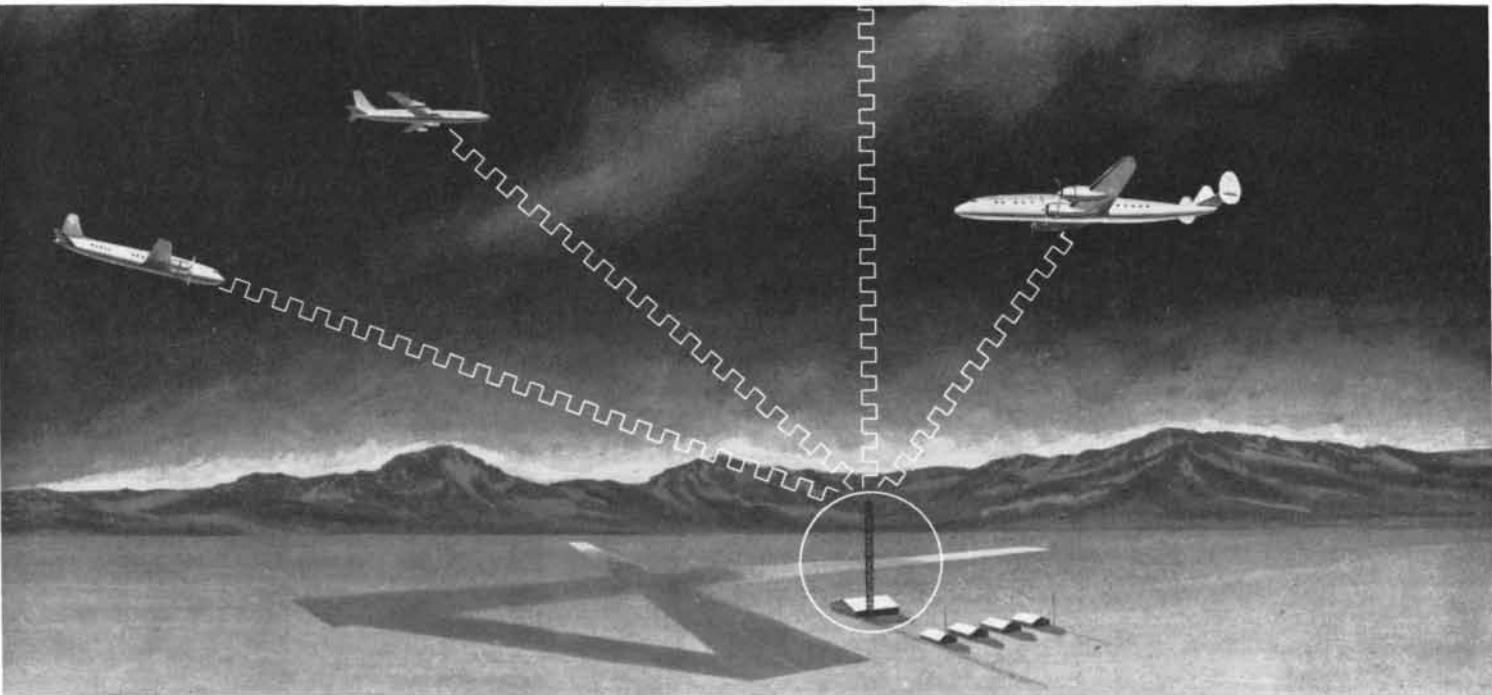
ROBERT L. PLATZMAN ("What Is Ionizing Radiation?") recently became senior physicist at the Argonne National Laboratory, where he is forming a group of workers to study fundamental problems of the action of ionizing radiation. He is also chairman of the newly organized Subcommittee on Effects of Ionizing Radiations of the Committee on Nuclear Science, National Research Council. A native of Minneapolis, he received his Ph.D. in 1942 at the University of Chicago. He worked on the atomic-bomb project and after the war received two Guggenheim fellowships to study with Niels Bohr in Copenhagen. He was a professor of physics at Purdue University for 10 years. Platzman will spend the coming academic year as a Fulbright professor at the University of Paris.

JAMES R. ARNOLD and E. A. MARTELL ("The Circulation of Radioactive Isotopes") are radiochemists with, respectively, the University of California School of Science and Engineering at La Jolla, and the Air Force Cambridge Research Center. Arnold was born in 1923 in Metuchen, N. J., and earned his Ph.D. degree at Princeton in 1946, having been associated with the atomic-bomb project for two years. He then held fellowships at the Institute for Nuclear Studies of the University of Chicago and in the laboratory of George B. Kistiakowsky at Harvard University. In 1948 he returned to Chicago to work with Willard F. Libby on radiocarbon dating, and in 1949 he became an assistant professor at the Institute for Nuclear Studies. In 1955 he joined the chemistry faculty at Princeton University. His current post is associate professor of chemistry at La Jolla, where he is doing research on radioactive isotopes produced by cosmic rays, especially isotopes found in meteorites. Martell took a degree in civil engineering in 1942 from the United States Military Academy. He earned his M.S. degree in physical chemistry at the University of Chicago, and took a Ph.D. there in 1950 in radiochemistry. He also worked under Libby. From 1950 to 1954 he was with the Armed Forces Special Weapons Project, planning and directing experiments in nuclear radiation and in the fallout effects of atomic weapons. He directed experimental programs for several atomic- and hydrogen-bomb tests. Later he was the principal investigator at the

**new
wings
for
words**

AGACS

pronounced
"AJAX"



AGACS, Experimental Automatic Ground/Air/Ground Communication System is a new concept in Air Traffic Control Communications to meet the accelerated pace of increased air traffic. Primary objectives are efficient usage of frequency spectrum, added safety through increased reliability and reduced burden to pilot and controller, and adaptability to all classes of aircraft. AGACS provides compatibility with existing ground and airborne communication equipment, selective addressing of information, and a minimum number of frequency changes during flight. The system utilizes two-way time division data transfer over existing ground

and air communication links to provide an automatic, mutual exchange of information. The airborne facilities display to the pilot the last significant Air/Ground and Ground/Air message quantities, while the controller may recall from central memory-storage equipment the last Air/Ground and Ground/Air message quantities for display. The AGACS program is still in the developmental stage. In August, 1959, RCA provided initial models of both airborne and ground equipments for the Bureau of Research and Development of the Federal Aviation Agency for extensive experimentation and flight tests.



Tmk(s) ®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, N. J.

FOR MORE
INFORMATION

GREATER
ACCURACY

EASIER
READABILITY

Specify



**Industrial
Products
Division**



LARGE SCREEN OSCILLOSCOPES

Why squint at a conventional 5" scope when an ITT Large Screen Oscilloscope can assure you faster and more accurate observation and measurement without operator fatigue?

Use of magnetic deflection systems makes large-screen display practicable and permits close control over linearity and orthogonality. The large display provides vernier readability that increases speed of operation, reduces reading errors and operator eye strain, and permits observation of minute details that might remain unnoticed on a conventional scope.

APPLICATIONS

ITT Large Screen Oscilloscopes are precision engineered for effective use in such operations as Telemetry, Production Testing, Waveform Analysis, Computer Readout, X-Y Plotting, Data Plotting, and Medical Observation. Their large screen size makes them ideally suited for teaching, demonstration, or exhibition.

CHOICE OF MODELS AND SIZES

ITT Large Screen Oscilloscopes are available in either 17-inch or 21-inch rectangular tube models, cabinet or rack mounted. Models are also available without sweep and sync circuits for monitoring.

Write, Wire, or Phone for complete technical data and price information on Large Screen Oscilloscopes as well as other products of ITT Industrial Products Division, including Swept Frequency Generators, Storage Tube Scopes, Test Instruments, Custom Power Equipment, and Closed-Circuit Television.



Industrial Products Division

INTERNATIONAL TELEPHONE & TELEGRAPH CORPORATION
15191 BLEDSOE STREET • SAN FERNANDO, CALIFORNIA
TELEPHONE EMPIRE 7-6161

Chicago "Sunshine" project, studying the world-wide distribution of strontium 90. He is now chief of the nuclear studies branch at the Air Force Cambridge Research Center, directing research on the geophysical aspects of world-wide fallout and on the natural radioactivity of the atmosphere.

ALEXANDER HOLLAENDER and GEORGE E. STAPLETON ("Ionizing Radiation and the Living Cell") are, respectively, the director of and a biologist in the Biology Division of the Oak Ridge National Laboratory. Hollaender, a native of Germany, took his degrees at the University of Wisconsin, receiving a Ph.D. there in 1931 and remaining as a National Research Council fellow. He was an investigator for the Rockefeller Foundation in 1934, and then served for three years as investigator in charge of radiation work for a National Research Council project at Wisconsin. He joined the National Institutes of Health, working in biophysics, in 1937, and rose to the rank of head biophysicist, serving in that post from 1946 to 1950. He also became director of the Oak Ridge Biology Division in 1946. Other posts include the presidency of the Comité International de Photobiologie and chairmanship of the World Health Organization committee to study the effects of radiation on human genetics. Stapleton was born in Chicago in 1919 and attended school in Denver. He took his bachelor's degree at Regis College in Denver, and his master's degree (in 1943) at Saint Louis University. He then joined the atomic-bomb project and was sent to Oak Ridge, where he helped initiate a research program on the biological effects of nuclear radiations. He received his Ph.D. from the University of Tennessee in 1952. His chief research work is concerned with "the basic mechanisms involved in the lethal and mutagenic action of ionizing radiations."

JOHN F. LOUTIT ("Ionizing Radiation and the Whole Animal") has since 1947 been director of the British Medical Research Council Radiobiological Research Unit. He was born in Australia and educated at the University of Western Australia and the University of Melbourne. He was a Rhodes Scholar, and has received several degrees from the University of Oxford, including that of doctor of medicine. He also studied at the University of London. Loutit served as director of the Radiobiological Research Unit of the Atomic Energy Research Establishment at Harwell from 1947 to 1958. He was made a Fellow of the

Cast Fine Detail Quickly



STRIP IT



MOLTEN METAL

Parting is easy... Silastic RTV seldom requires the use of a release agent: The mold strips easily from most surfaces. In cases where a release agent is needed, a simple solution of household detergent does the job.

Symphony in RTV. Just to illustrate how accurately Silastic RTV reproduces detail, Dow Corning has made Silastic RTV molds of 33 $\frac{1}{3}$ and 45 rpm records, then cast plastic records from them. Result: excellent sound fidelity!



IDENTICAL TWINS

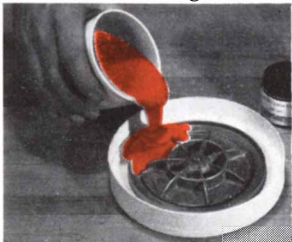
Choose your cure. Some types of Silastic RTV set up to solid rubber five minutes after the catalyst is mixed in. Others cure in 24 hours... stay "open" and workable a long time. Write for details!

SILASTIC RTV SILICONE RUBBER

flows in and around complex shapes; sets up in minutes

The incredibly life-like hand above was cast of rubber. It was made from a mold of the same material: Silastic RTV, the Dow Corning fluid silicone rubber that vulcanizes at room temperature.

The striking detail reproduced here — detail that would stir the heart of a Madame Tussaud — can be duplicated by you in your own plant. With ease. Simply pour liquid Silastic RTV into or around any object you wish reproduced. Wait a short time while the fluid sets up to form rubber. No heat-vulcanizing is needed. Now strip the rubber away and you have a mold for making exact reproductions. Into this you can pour a variety of casting materials including many plastics, molten metals... even more Silastic RTV.



POUR IT

The Perfect Prototype... Silastic RTV is the answer to a prototype-part maker's prayer. Because of its heat resistance — temperatures to 500 F are easily withstood — many molten substances can be cast directly in Silastic RTV. If you want to make a limited run of some part, for use as test models, samples or giveaways, you can do it with only one mold.

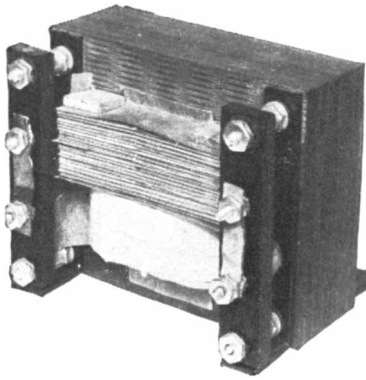
Free Sample. Write on your letterhead for data and sample of Silastic RTV. Address Dept. 9821.



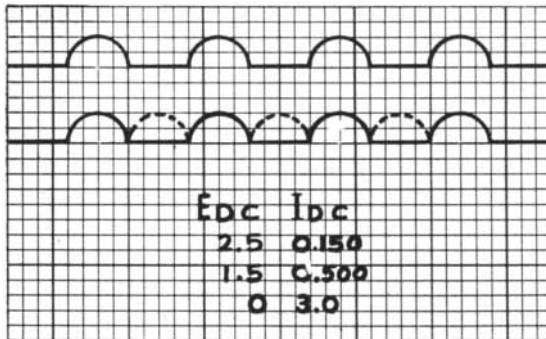
Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

What can you do with a DC TRANSFORMER?



We call this a DC transformer. Plug it into any 120 volt 60 cycle circuit and it will deliver 150 ma @ 2½ volts DC; 500 ma @ 1½ volts DC, or 3 amps short circuited. Connections available for half wave or full wave dc output.



We don't know what possibilities a unit like this may have. Presently it is the result of a challenge between our engineers to build an AC to DC conversion unit without independent components. In the future this may be the prototype of equipment that may have far reaching significance.

In the meantime we have a genuine DC transformer. Do you have any ideas as to how this basic idea can be put to practical use?

Send your letters to Mr. Lou Danko, Special Products Dept., Acme Electric Corporation, Cuba, N. Y.

Acme  Electric

ACME ELECTRIC CORPORATION

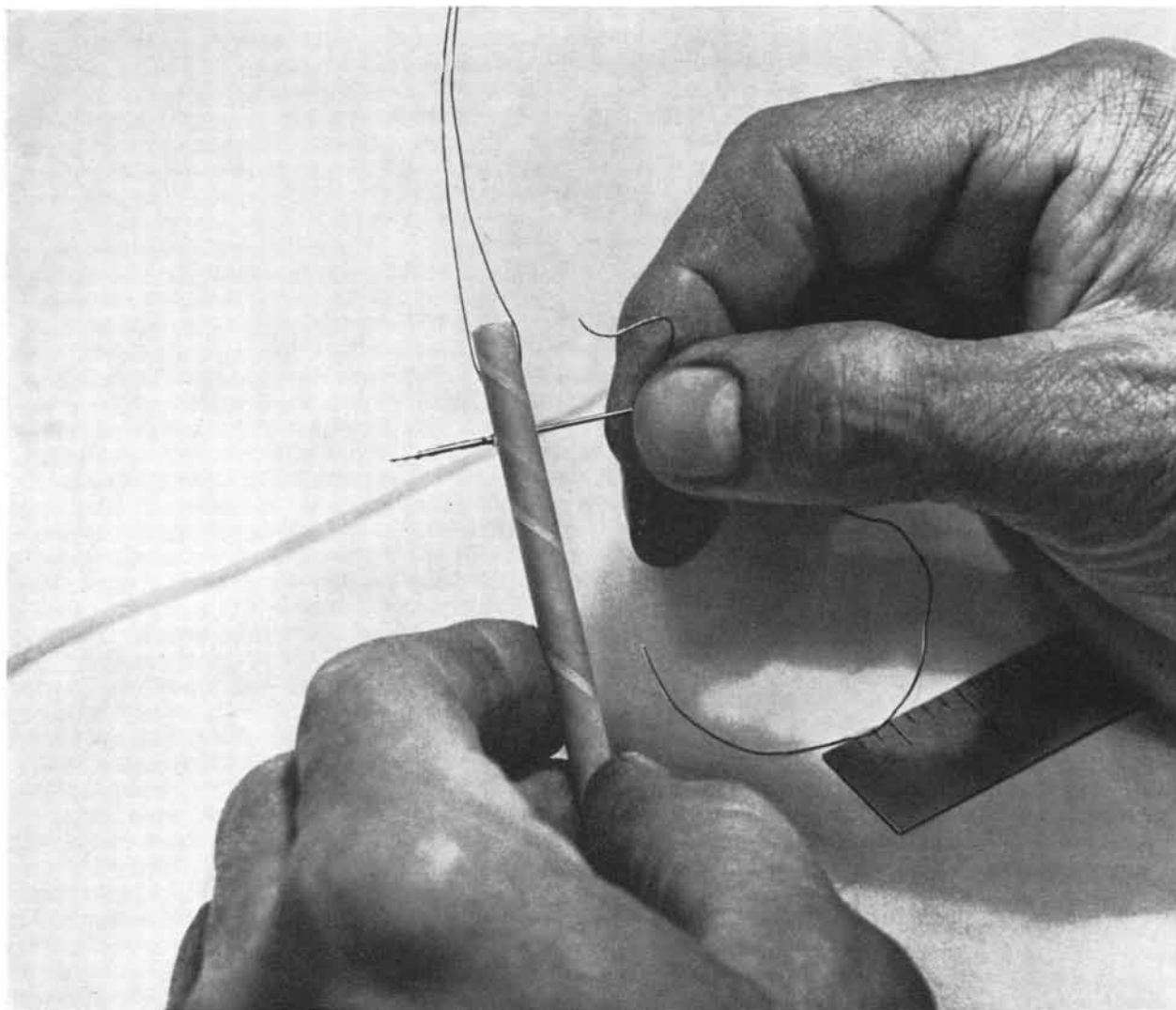
69 WATER STREET • CUBA, NEW YORK
WEST COAST: 12822 YUKON AVE. • HAWTHORNE, CALIFORNIA

Royal College of Physicians in 1955, and a Commander of the Order of the British Empire in 1957.

JAMES F. CROW ("Ionizing Radiation and Evolution") is professor of genetics and chairman of the Department of Medical Genetics at the University of Wisconsin. He grew up in Kansas and attended Friends University at Wichita. "I started out to major in music, but discovered I wasn't talented enough, and shifted successively to physics, then to chemistry and finally to biology. I took a course in genetics . . . and decided that this was the most interesting of the biology courses and something that I would like to pursue." He took his Ph.D. in genetics at the University of Texas in 1941, and taught at Dartmouth College until he joined the Wisconsin faculty in 1948.

SHIELDS WARREN ("Ionizing Radiation and Medicine") is professor of pathology at the Harvard Medical School and scientific director of the Cancer Research Institute at the New England Deaconess Hospital. He is a graduate of Boston University, and took his M.D. degree at Harvard in 1923. He has been studying the effects of ionizing radiation for many years, and in 1945 was chief of the Navy's Medical Field Team in the Technical Commission to Japan. He served in 1946 as executive officer of the Naval Medical Research Section of the Bikini bomb test, and in 1947 as senior medical officer of the Atomic Casualty Investigation in Japan. He has helped direct and advise the Atomic Energy Commission Division of Biology and Medicine since 1947. In 1955 he became U. S. representative on the United Nations Scientific Committee on the Effects of Atomic Radiation. Since 1955 Warren has been chairman of the National Academy of Sciences Committee on Pathologic Effects of Atomic Radiation, and a member of the Committee on Genetic Effects of Atomic Radiation. He has also been chairman of the National Research Council Committee on Atomic Casualties.

A. CHARLESBY ("Ionizing Radiation and Organic Chemistry") is professor of physics at the Royal Military College of Science in England. He was born in London in 1915 and was educated there and on the Continent. He studied physics under Sir George Thomson at the Imperial College of Science and Technology, and subsequently taught and did research on electron diffraction and the structure of organic materials, particu-



How to Test a Solid Rocket Motor

In the early stages of research for new or improved propellants incongruous combinations of materials are often brought together in the chemistry laboratory—in this case, a common drinking straw, a strand of copper wire, a small batch of propellant and a sewing needle. The work shown here is a step in an experiment to test burning characteristics of a new high-energy propellant formula. The propellant, having been extruded into the straw, is threaded with a strand of copper wire. Later the “motor” is hooked into a specially designed apparatus that ignites the propellant and records and evaluates its performance.

From the igniting of grams of fuel in the chemistry labs to the test-firing of huge motors on the 2,000,000 lb. thrust test stands at THIOKOL'S Utah facilities, research paces and supports every phase of the design, develop-

ment and production of a rocket powerplant.

In its Rocket and Chemical Divisions, THIOKOL boasts one of the finest scientific research teams in rocketry—an expanding group, continually in search of new members.

For qualified chemists, there exists stimulating work in **polymer research, in propellant analysis and formulation, in high vacuum techniques, and through the entire spectrum of high energy fuel.**

Doors are open, too, to research engineers and scientists with interest or experience in:

Solid State Physics, High Temperature Gas Dynamics, Electronics of Rocket Exhaust, Electromagnetics, Thermodynamics, Magneto hydrodynamics, Astronautical Systems Analysis, Ion and Plasma Propulsion, Nucleonics, and other phases of advanced propulsion work.

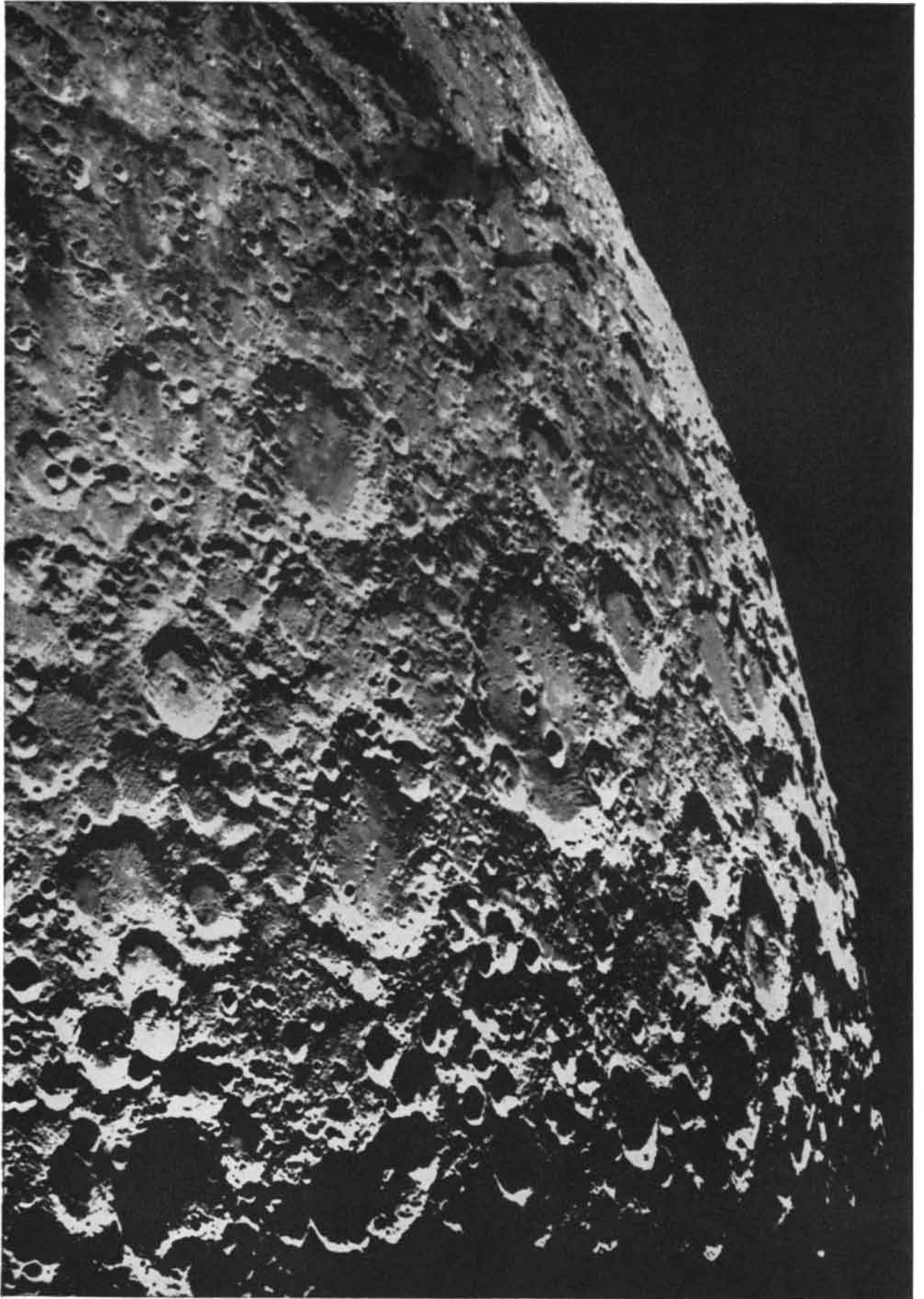
You'll work in areas that are good places to live—Denville, New Jersey; Huntsville, Alabama; Marshall, Texas; Moss Point, Mississippi; Brigham City, Utah; Trenton, New Jersey; Bristol, Pennsylvania. When you think of opportunity for yourself and your family, think of THIOKOL. Write to: Personnel Director at any plant address listed above.

Thiokol®

is Research to the Core

THIOKOL CHEMICAL CORPORATION
Bristol, Pennsylvania

®Registered trademark of the Thiokol Chemical Corp. for its rocket propellants, liquid polymers, plasticizers and other chemical products.



**THE
MILITARY
REQUIREMENTS
FOR
MOON BASE**

This is the title of one of four major space proposals developed by Martin for the military and astroscientific branches of our Government. The importance of this proposal is two-fold: the inevitability of an actual moon base program by this country within the next 5 years, and; the fact that we could and can undertake such a project now — not in theory but in “hard” engineering design. For Martin’s eight divisions add up to one of the top capabilities in the free world for man’s first ventures in space-planetary exploration.

MARTIN
BALTIMORE • DENVER • ORLANDO

larly plastics. Charlesby was in charge of a group at Harwell studying radiation effects in materials, and in 1955 he joined the newly established research laboratory near Cambridge and set up the first industrial radiation research group in Great Britain.

DOUGLAS S. BILLINGTON (“Ionizing Radiation and Metals”) has for a decade been director of the Solid State Division of the Oak Ridge National Laboratory. A native of Spearfish, S.D., he took his Ph.D. in chemistry at the University of Iowa in 1942. He was one of the small group of students interested in the solid state in the 1930’s, and held several jobs in industrial laboratories, since most universities were not then active in this field. He was a metallurgist at the Naval Research Laboratory in Washington from 1946 to 1949, and also worked at Oak Ridge in that period.

GEORGE W. BEADLE (“Ionizing Radiation and the Citizen”), Nobel laureate for his work in biochemical genetics, is head of the division of biology at the California Institute of Technology. For the past year he has been Eastman Visiting Professor at the University of Oxford. He was born in 1903 in Wahoo, Neb., the son of a farmer. Beadle would probably have become a farmer himself but for the influence of a high-school science teacher, Mrs. J. C. Higgins, now of Jackson, Neb., who so fired his imagination that he determined to become a scientist. The late Professor Frank D. Keim at the University of Nebraska introduced him to genetics. After some time at Cal Tech, he went to Paris to work with Boris Ephrussi at the Institut de Biologie Physico-chimique. He returned for a year at Harvard University, and in 1937 went to Stanford University as a professor. There he worked with the chemist Edward L. Tatum. They decided to use the red bread-mold *Neurospora crassa* in genetic experiments, and it was for their work with this organism that they shared half the 1958 Nobel prize in medicine. In 1946 he succeeded Thomas Hunt Morgan, also a Nobel laureate, as head of the Cal Tech biology division.

ROBERT W. WHITE, who in this issue reviews *Psychoanalysis, Scientific Method and Philosophy*, edited by Sidney Hook, and Philip Rieff’s *Freud: The Mind of the Moralist*, is professor of clinical psychology and chairman of the Department of Social Relations at Harvard University.

Now there are

2

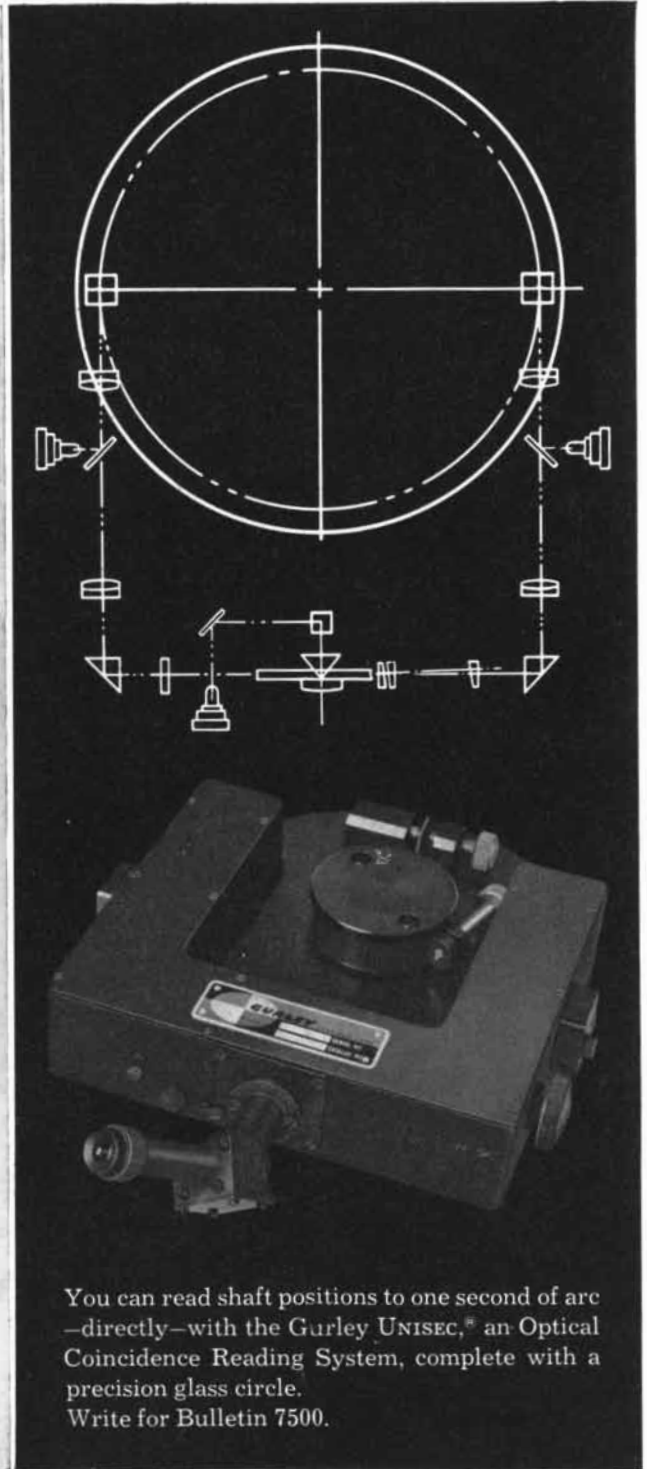
ways to read angles...

Photoelectrically with a Gurley Encoder

Optically with a Gurley UNISEC®



Angles may now be read photoelectrically with the Gurley Precision Shaft Position Encoder. The information can be transmitted anywhere, in digital form.
Write for Bulletin 8600.



You can read shaft positions to one second of arc—directly—with the Gurley UNISEC,® an Optical Coincidence Reading System, complete with a precision glass circle.
Write for Bulletin 7500.



W. & L. E. GURLEY, 562 FULTON STREET, TROY, NEW YORK

THERE
IS
NO
BETTER
WAY
THAN
WITH

LIQUID OXYGEN

Liquid oxygen is the safest, most efficient oxidizer commercially available for missile and rocket propulsion systems. It is stable, non-toxic, non-corrosive, and easy to dispose of when necessary. That's why it is used in IRBM and ICBM motors.

Large volumes of liquid oxygen can be stored indefinitely in LINDE designed and built storage units — right where it is needed. Vaporization losses are minor — can be held to *less than 5 per cent per year*.

Using LINDE's methods, liquid oxygen can be transferred safely from storage — without pumps — ten times faster than previously.

LINDE can supply large quantities of liquid oxygen almost anywhere in the nation — quickly, and at a cost of only pennies per pound.

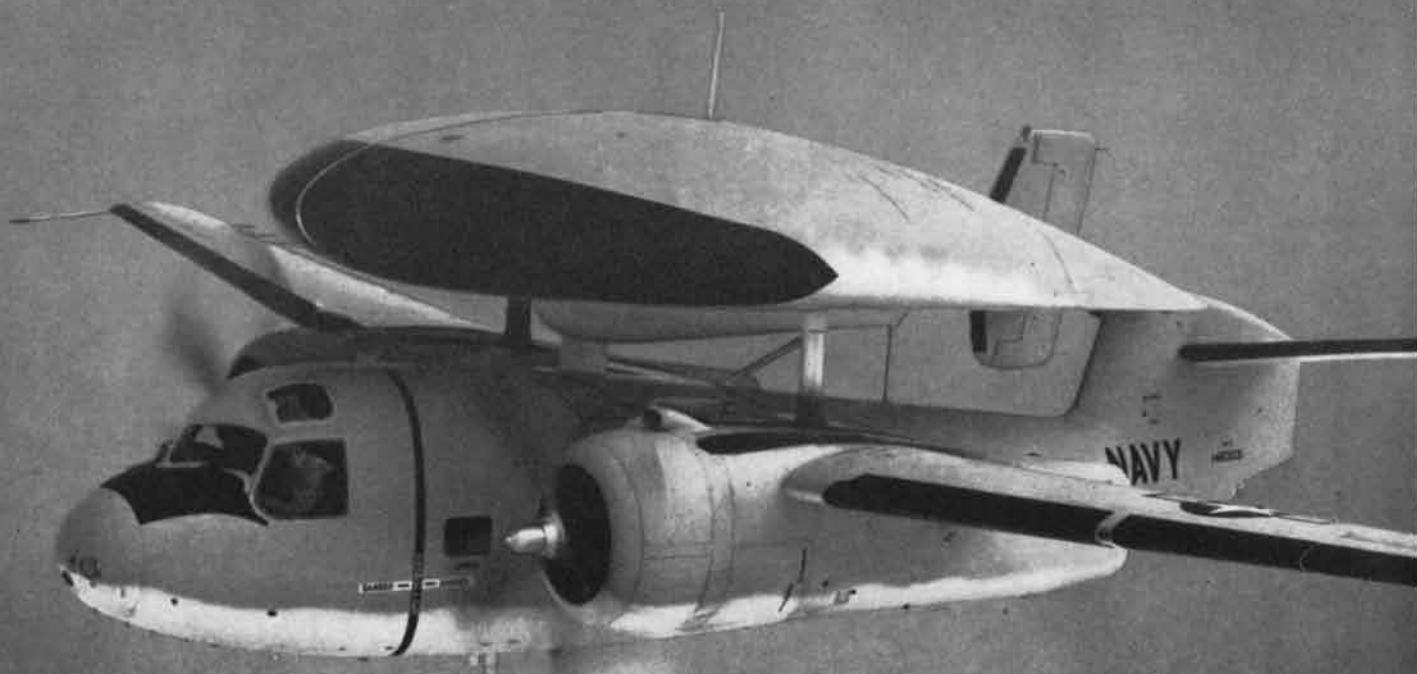
If you are concerned with the nation's vital missile and rocket development program, take advantage of LINDE's more than 50 years of experience in producing, transporting, and storing liquid oxygen. Call the LINDE office nearest you, or write: LINDE COMPANY, Division of Union Carbide Corporation, Dept. SA-09, 30 East 42nd Street, New York 17, N. Y.

Linde
TRADE-MARK

UNION
CARBIDE

"Linde" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.





GRUMMAN AIRCRAFT ENGINEERING CORPORATION

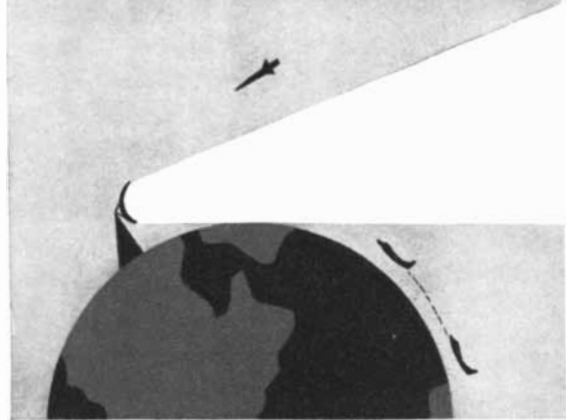
PEACE TAKES A LOT OF WATCHING!

That's why the U. S. Navy will send eyes aloft to scan the seas and skies beyond our shores. The eyes, with this special kind of vision, are early warning aircraft. Many will be WF-2 "Tracers", produced for the Navy by Grumman.

WF-2's "see" via a saucer-shaped radome that houses super-sensitive, long-range electronic detection equipment. Operating from aircraft carriers far out at sea, "Tracers" patrol the extremities of our defense perimeter. And, detect the approach of aircraft or missiles that might invade the privacy of a nation's peace.

Bethpage • Long Island • New York

Electronics Engineers, for career opportunities at Grumman Aircraft, see page 282.



Low-flying "enemy" aircraft or missiles are undetected by ground radar because, as the diagram shows, the range of ground-level radar extends no further than the horizon.



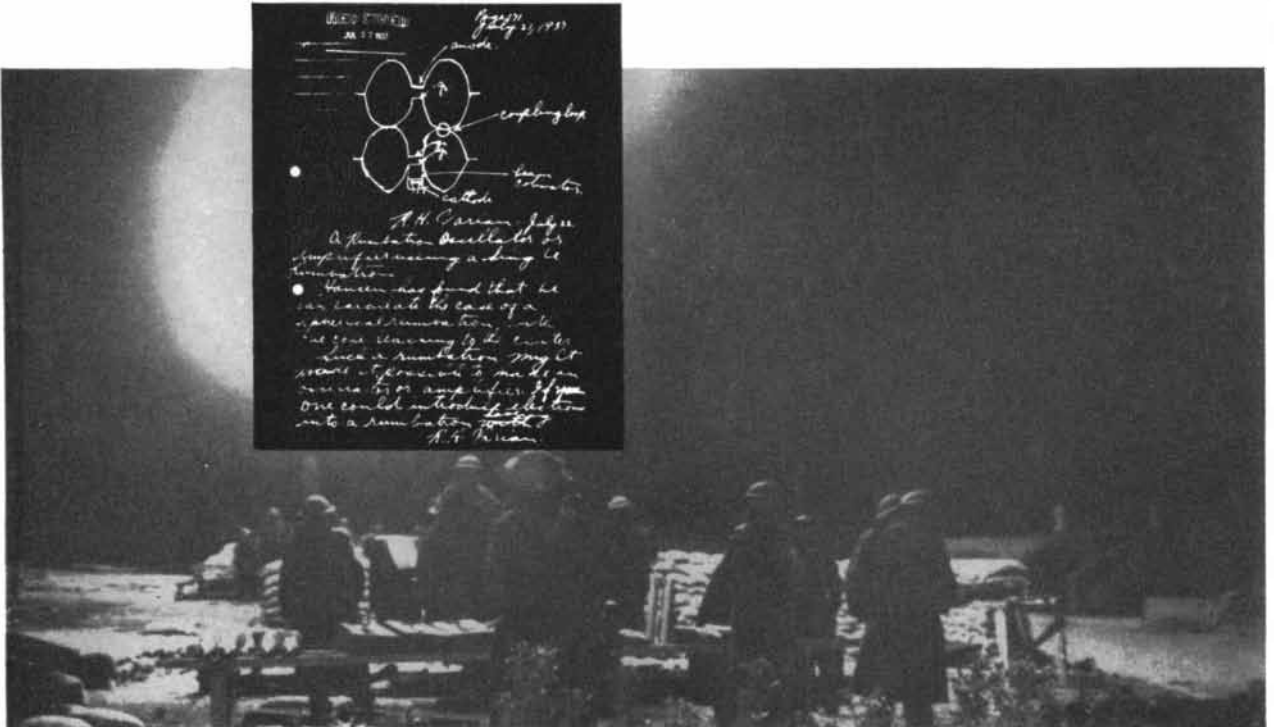
Detection range is increased appreciably when the radar detection equipment is airborne directly over the ground installation.



The scope and effectiveness of radar detection are extended dramatically with WF-2's operating off fast, mobile and far-ranging aircraft carriers at sea.



THE SKETCH THAT HELPED WIN A WAR



This sketch, drawn in 1937 by Dr. Russell Varian, Founder and Board Chairman of Varian Associates, led to the development of the klystron — and mobile radar. Dr. Varian's achievement played a vital role in the successful air defense of Great Britain and the ultimate air superiority of the Allies during World War II.

Less than a decade after this historic first practical use of radar, Varian Associates was established to manufacture klystrons and continue the development and improvement of this important new device which is acknowledged to be the foundation of microwave electronics. Today, as the largest manufacturer of klystrons, Varian produces more than 100 types and sizes for a vast variety of commercial and military uses.

The creativity and technical excellence responsible for this accomplishment has found expression in other Varian developments and products, such as NMR and EPR Spectrometers, free-precession magnetometers, graphic recorders, laboratory magnets, Vaclon® High Vacuum Pumps, traveling wave tubes and linear accelerators.

At Varian, the inventive process, creative initiative and the "science of practicality" in volume production combine to produce ever-greater quantities of components, instruments and systems of unexcelled performance and reliability.



VARIAN associates

611 HANSEN WAY • PALO ALTO, CALIFORNIA

DOMAC LABORATORIES, INC., BEVERLY, MASSACHUSETTS / VARIAN ASSOCIATES OF CANADA, LTD., GEORGETOWN, CANADA



He has brainstorm ...to order

He's one of a group of AMF scientists who develop solutions to the utterly original problems of modern defense and human penetration of space. He doesn't build *better* mousetraps. His business is completely new kinds of traps for mice that have never been caught.

Examples: A method of recovering potable water from human waste fluid, the major source of water in a sealed space vehicle... Methods of analyzing the effects of a nuclear blast on the earth's crust, how it changes the character of soil and rock, how its shock is propagated, what sort of building structure will withstand it... Platforms on which will be mounted primary standards calibration instruments for missile guidance systems. These platforms must be so vibration-free that natural earth movements must be compensated for. Platform vibrations are limited to millionths of an inch... A method of predicting temperatures in missile nose cones upon re-entry.

Single Command Concept

These samples of creative ingenuity reflect the resourcefulness AMF brings to any assignment.

AMF people are organized in a *single operational unit* offering a wide range of engineering and production capabilities. Its purpose: to accept assignments at any stage from concept through development, production, and service training... and to complete them faster...in

- *Ground Support Equipment*
- *Weapon Systems*
- *Undersea Warfare*
- *Radar*
- *Automatic Handling & Processing*
- *Range Instrumentation*
- *Space Environment Equipment*
- *Nuclear Research & Development*

GOVERNMENT PRODUCTS GROUP,
AMF Building, 261 Madison Avenue,
New York 16, N. Y.



In engineering and manufacturing AMF has ingenuity you can use... **AMERICAN MACHINE & FOUNDRY COMPANY**



TO FILL THE SUIT . . . TO MAN THE PLANE

THIS IS ERCO'S ROLE IN THE DEFENSE PICTURE. COMBINING ENGINEERING KNOW-HOW AND VAST PRODUCTION FACILITIES. ERCO HAS WORKED HAND-IN-HAND WITH THE AIR FORCE AND NAVY IN THE DEVELOPMENT OF ELECTRONIC SIMULATORS FOR AERIAL WEAPONRY. ERCO HAS DESIGNED AND MANUFACTURED TRAINING DEVICES FOR MORE TYPES OF MILITARY AIRCRAFT THAN ANY OTHER COMPANY.



HERE IS A REPRESENTATIVE PORTION OF THE AIRCRAFT FOR WHICH ERCO HAS DESIGNED AND MANUFACTURED SIMULATORS.

DESIGNED AND BUILT BY **ERCO**
 NUCLEAR PRODUCTS — ERCO, DIVISION OF **ACF** INDUSTRIES, INC., RIVERDALE, MARYLAND



SMALL A. C. MOTORS

Consider the many advantages of using precision miniature a.c. motors. Output performance equals that of larger conventional motors—so you can offer smaller, lighter, more compact designs than your competitor. And you can offer superb reliability. When you design around precision miniature motors, their price in quantity is competitive with larger ordinary motors. Globe is the largest precision miniature motor specialist and is working with people like you right now to gain these benefits.

Get in touch with Globe early in the design stage. Very probably Globe has already made a motor close to your requirements. You'll receive a recommendation for your specific job, and get custom prototypes promptly.

Globe's induction and hysteresis-synchronous a.c. motors provide up to 4.5 oz. in. of torque—up to 200 in. lbs. with a planetary gear reducer! Sizes start at one inch in diameter, and can include such special features as integral brakes, clutches, speed reducers, etc. Please request Bulletin ACM. GLOBE INDUSTRIES, INC., 1784 Stanley Avenue, Dayton 4, Ohio. BALDWIN 2-3741.

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS. ACTUATORS.
TIMERS. GYROS. STEPPERS. BLOWERS. MOTORIZED DEVICES

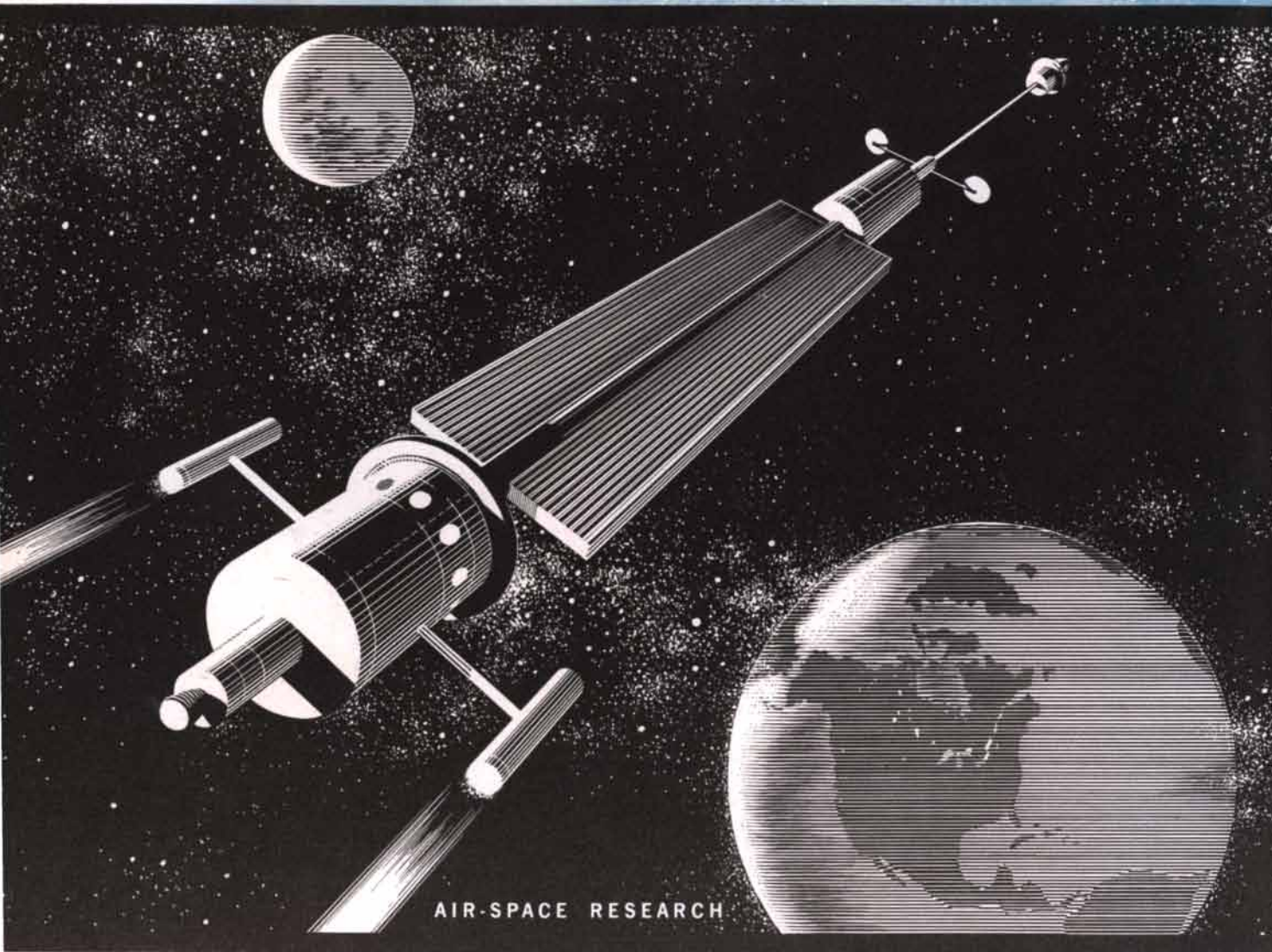
GLOBE

New Concepts for the Space Age

Mark 15 Years of Progress by MARQUARDT

When founded in 1944, Marquardt was an organization devoted exclusively to research and development of the ramjet propulsion principle. Today, in its fifteenth year, the Corporation employs more than 5,000 in the crea-

tion and exploration of new concepts for the space age. Marquardt is now diversified, operating in five basic areas—all primarily related to the search for earlier and ever more effective solutions to space-age problems.



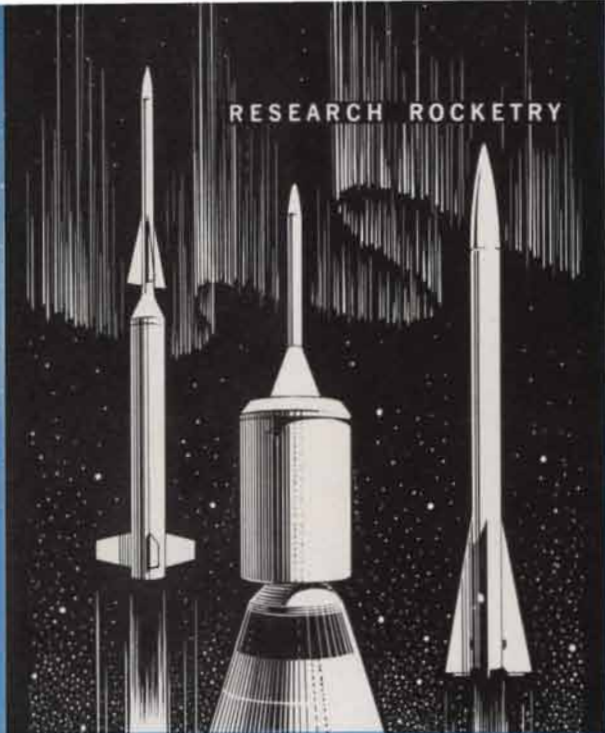
NEW CONCEPTS IN AIR-SPACE RESEARCH spring from ASTRO—Marquardt's Air-Space Travel Research Organization—where studies of an ionic rocket capable of powering future space vehicles are in progress. Other imaginative ASTRO studies span a broad spectrum including high-energy fuels, exotic materials, nuclear powerplants, advanced optics, cryogenics, space medicine, communications and guidance.

NEW CONCEPTS IN POWER SYSTEMS are in the making at Marquardt's Power Systems Group. Within the Group, Propulsion Division is engaged in continuing studies of a Hyperjet (rocket-ramjet) configuration capable of lifting future satellites from launch pad to upper atmosphere. Controls and Accessories Division is currently developing attitude controls for reconnaissance satellites, while Test Division is capable of ground-testing space-age hardware.

NEW CONCEPTS IN MANUFACTURING are typified by the first-of-its-kind Hufford Spin-Forge at Marquardt's Ogden Division. This 250-ton machine will contribute advances in space-age metal working state-of-the-art, while augmenting the Division's production of supersonic ramjet engines for the Boeing Bomarc IM-99.

NEW CONCEPTS IN SPACE-AGE TRAINING are an important product of Marquardt's Pomona Division—creators of a unique system which realistically simulates a 4,000 mile mission on an 8-foot map. The system will ground-train air and spacemen without risk and at great savings in cost.

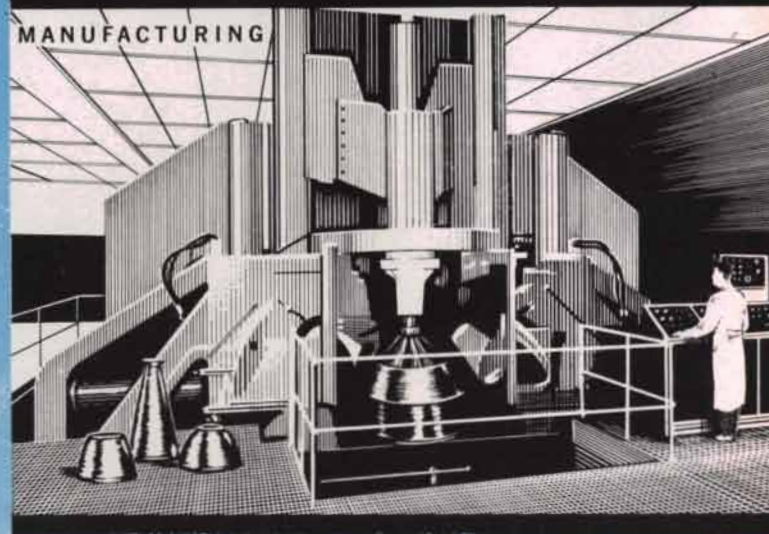
NEW CONCEPTS IN RESEARCH ROCKETRY and instrumentation come from Cooper Development Corporation, a Marquardt subsidiary. Cooper has contributed to programs including Explorer and Sunflare projects, and Falling Sphere—is now at work on Project Mercury.



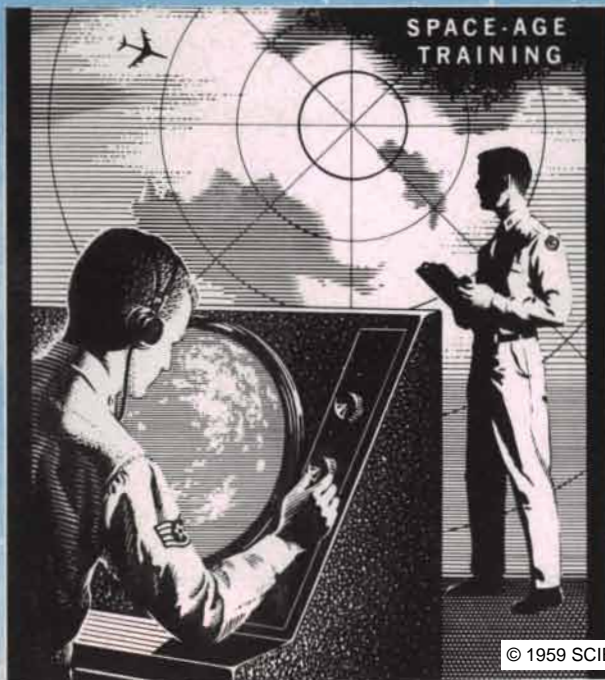
RESEARCH ROCKETRY



POWER SYSTEMS



MANUFACTURING



SPACE-AGE TRAINING

Engineers and scientists capable of making contributions in these and related areas are invited to write The Marquardt Corporation, Corporate Offices, 16555 Saticoy Street, Van Nuys, California; or

THE *Marquardt* CORPORATION

POWER SYSTEMS GROUP AND ASTRO
 16555 Saticoy Street, Van Nuys, California
 POMONA DIVISION
 2709 North Garey Avenue, Pomona, California
 OGDEN DIVISION
 1000 West 33rd Street, Ogden, Utah
 SUBSIDIARY: COOPER DEVELOPMENT CORPORATION
 2626 South Peck Road, Monrovia, California





Ionizing Radiation

This issue of SCIENTIFIC AMERICAN is devoted to the single topic of ionizing radiation.

Ionizing radiation consists of electromagnetic waves or material particles that have sufficient energy to ionize atoms or molecules (that is, to remove electrons from them), thereby radically modifying their chemical behavior. The molecules most sensitive to this action are those involved in the structure and function of living matter.

Life on earth has always been exposed to ionizing radiation. Most of this radiation comes from radioactive atoms occurring naturally in rock, soil, water and air and incorporated in the tissues of living organisms. But the intensity of radiation at the surface of the earth is relatively low. The ionizing radiation from the sun and other stars that flows through space is almost entirely filtered out by the earth's atmosphere. Were it not for this shelter, life processes could not go on.

Since the beginning of this century human activities have been increasing the volume of ionizing radiation on earth. Medical X-rays, which have done so much to conserve life, have increased the average exposure of much of the world population to as much as 100 per cent above the natural-background rate. With the advent of nuclear technology this exposure is increasing. Fallout from the testing of nuclear

weapons has measurably increased the background of ionizing radiation in all parts of the world. Nuclear power-plants produce huge quantities of radioactive material, the containment and disposal of which raise serious technical problems, quite apart from the danger of accident. Some of this material is finding its way into science and technology as a source of ionizing radiation for new and diverse applications.

Men are concerned with this increase in ionizing radiation not only because it can affect the health and welfare of the living generation, but also because it deranges the hereditary mechanism and could blight the lives of their offspring through many generations to come. If nuclear weapons are ever used in war, ionizing radiation might well extinguish the human species.

How can men secure the benefits of ionizing radiation, and minimize the dangers? Such questions arise with every innovation in technology. But they raise compelling moral issues in connection with ionizing radiation because the consequences of its use or abuse may spread so widely in space and time, as has been demonstrated by the fallout of man-made radioactive isotopes.

To employ ionizing radiation wisely and safely men must know more about it. In this issue 11 investigators present a summary of the relevant knowledge. They also offer their judgments and recommendations under many headings. As the reader will find, they do not agree on all the facts nor do they arrive unanimously at the same conclusions. In the last analysis, with the interests of all men at stake, all must join in seeking to understand ionizing radiation and in making rational choices based upon that understanding.

COSMIC-RAY PARTICLES produced the dark tracks in this nuclear-emulsion photograph by ionizing silver bromide molecules in the emulsion. A cosmic ray enters the picture from the top; it collides with a nucleus in the emulsion and shatters into several fragments. The short tracks along the path of the primary particle were made by electrons. The photograph was made by Herman Yagoda of the Air Force Cambridge Research Center.

What Is Ionizing Radiation?

In their ability to penetrate matter and displace electrons in atoms and molecules, the various forms of this radiation have deep significance for science, technology and the future of man

by Robert L. Platzman

Ever since the discovery of X-rays in 1895 and of radioactivity in 1896, penetrating ionizing radiations have played a central role in the advance of modern physics and allied sciences. These versatile tools possess several novel attributes. One is their penetrating power: they can pass through matter, some of them for considerable distances and with little degradation of their energy. Another (not possessed by all of them) is their electric charge, which creates intense disturbances in the balance of the electrical forces that hold the constituents of atoms and molecules together. But the most salient property of ionizing radiations is their great energy, which permits the physicist to deal with single atomic particles. Nobody can observe a single atom in ordinary matter; for the most part physics and chemistry make their measurements on vast numbers of similar atoms. However, alpha particles, which are bare nuclei of helium atoms having enormous kinetic energy, are by virtue of that energy individually detectable. It is this incomparable delicacy that underlies many of the most celebrated discoveries in 20th-century physics.

The penetration of high-energy radiation into matter has two complementary aspects: the effects of the interaction upon the radiation and the effects upon matter. It is the first of these, which may be called radiation physics, that has received almost exclusive attention in the past. High-speed particles are, in a sense, probes that permit exploration of the inner structure of matter. Their deflection during penetration provides a measure of the forces to which they are subjected in the interior of atoms and molecules. Pioneering studies of electron penetration by Philipp Lenard and by J. J. Thomson late in the 19th century,

and of alpha-particle penetration by Ernest Rutherford early in the 20th, led to a progressively deeper understanding of the structure of the atom, culminating with Rutherford's discovery in 1911 of the atomic nucleus. In the ensuing years refinements of the same mode of attack helped to establish the arrangement of electrons in atoms, of atoms in molecules and of atoms and molecules in liquids and solids. Similar techniques utilizing particles of greater energy later made it possible to examine the arrangement of neutrons and protons in the atomic nucleus and even the inner structure of the nuclear particles themselves. At the same time experiments on individual collisions between energetic particles or photons and atoms or molecules have been an invaluable proving ground for testing a host of different aspects of the quantum theory of physics.

Until comparatively recent years, on the other hand, the effects of ionizing radiations upon matter have been accorded far less attention. Scattered, conspicuous phenomena were recorded, and inquiry into their mechanisms was pursued by a handful of dedicated workers. But the fundamental problem attracted little in the way of vigorous and systematic attack until the sudden emergence of nuclear technology called serious attention to a lack of basic understanding. This new interest admittedly stems from pressing practical questions: physical ones, such as the modification of the mechanical, thermal and electrical properties of solid materials that are exposed to radiation; chemical ones, such as the potentialities for the use of radiation in industrial chemistry; and biological ones, such as the effects of radiation on human health. But the study of radiation action presents a multiplicity of novel and fundamental challenges and

offers promise of providing new knowledge on the deepest levels. Thus the widespread current activity in research on radiation action, facilitated by the availability of radiation sources having unprecedented variety and intensity, is motivated by expectation of both practically useful and fundamentally important results.

The varieties of ionizing radiation, whether corpuscular or electromagnetic [see illustration on page 76], produce in different ways the same sorts of ultimate effects on matter. They are called "ionizing" because a principal property—and often their most conspicuous one—is their ability to eject planetary electrons from atoms and molecules. The products of this reaction are ions: the negatively charged electron and the electron-deficient and thus positively charged atom or molecule. Ionizing radiation is often called high-energy radiation because its units have energies that are vastly greater than the binding energies of valence electrons in atoms or molecules, which are of the order of 10 electron volts (ev), and of atoms in molecules, which are about five ev. The high-speed atomic particles of corpuscular radiation ordinarily carry tremendous energies, most commonly from one to 10 million electron volts (Mev). Electromagnetic radiations are classed as ionizing radiation if their ultimate units (photons) have very high energy, and are then called X-rays or gamma rays. The photons of gamma rays from cobalt 60, for example, have energy of about one Mev. (Historically the term X-rays was reserved for photons from X-ray tubes and the term gamma rays for those from radioactive substances. This distinction is now obsolete, because the energy ranges of these two sources overlap

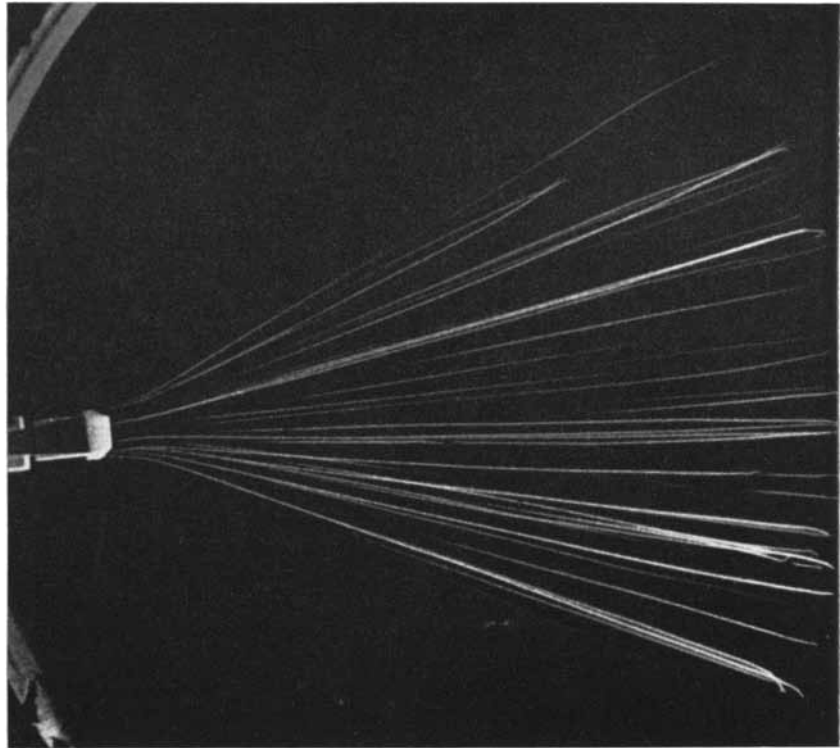
broadly. There is no difference between X-rays and gamma rays in nature or behavior. In contemporary usage the term "X-ray" is more often applied loosely to photons below about .1 Mev, and "gamma ray" to photons of greater energy.)

Particles and photons of intermediate energy, say 20 to 100 ev, produce ionization and behave like high-energy radiations in many other respects. They have negligible penetrating power, however, and are entirely absorbed by the surface regions of liquids and solids. The photons of far-ultraviolet radiation from the sun are absorbed in the earth's upper atmosphere, maintaining there the electrified shells of the ionosphere that play such an important part in radio communication.

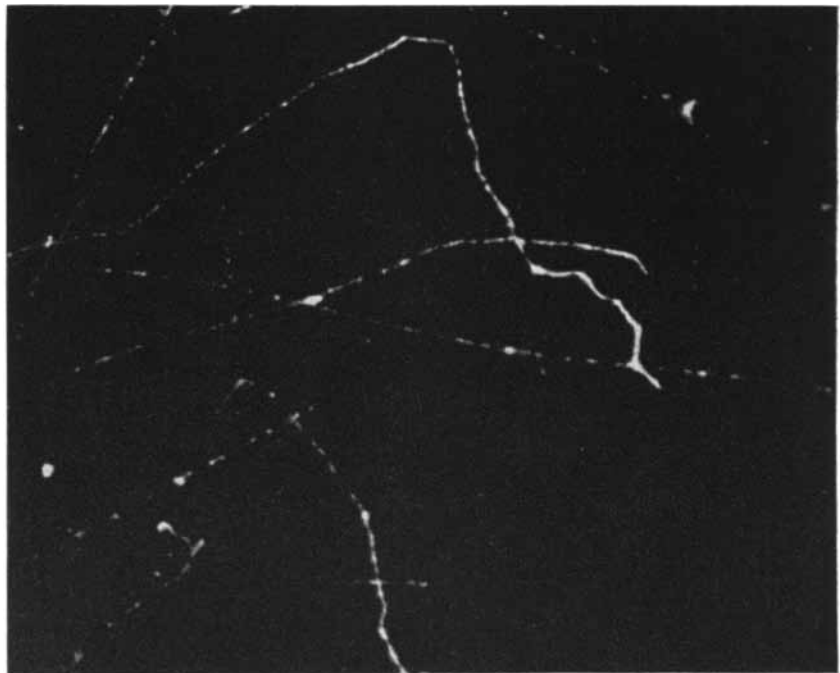
The interaction of each type of radiation with matter depends upon the mass and the charge, if any, of the radiation as well as upon its energy. Because high-energy neutrons, for example, have no electric charge, they interact feebly with atoms and therefore have great penetrating power. Eventually they give up their entire initial kinetic energy to the atomic nuclei that they happen to strike directly. In recoiling from these collisions the atoms lose one or several of their orbital electrons and themselves become charged particles.

Because X-rays also have no charge, they too have great penetrating power. They disappear in various absorption processes by which their energy is transformed into the kinetic energy of one or several electrons ejected from molecules of the penetrated medium. These energetic electrons, which again are electrically charged secondary particles, pursue their own paths through the medium, losing energy to it as would any electron of the same kinetic energy.

It is electrically charged particles that produce the overwhelming preponderance of the acts of energy-transfer which give ionizing radiations their significance in nature and technology. When a swiftly moving electron, alpha particle, proton or deuteron penetrates matter, the molecules near which it passes are subjected to an intense, transient electrical force. Since the binding of electrons in molecules is purely electrical in character, the new force is devastating. The organization of electrons within each molecule is disturbed, and many molecules along the path of the particle remain "excited" or ionized after the particle has passed. These two types of primary effect are very different in nature. In an excited molecule the acquired



ALPHA PARTICLES emitted by the source at left leave heavy tracks in a cloud chamber. Each track consists of a dense cylinder of ions on which water droplets have condensed. The alpha particles travel in straight lines and cease to ionize the gas after they have traveled a well-defined distance, called the range. The tracks of the particles are bent near the end as a result of collisions with atomic nuclei. Such collisions are more apparent at the end of a track because they are more likely when the alpha particle has been slowed down.



BETA PARTICLES, or high-speed electrons, originating at the left leave these tracks in a cloud chamber. The ions in the tracks are much farther apart than those in the tracks of alpha particles. As the electron slows down, its path becomes more erratic and the ions are formed closer together. At the very end of an electron track the proximity of the ions approximates that in an alpha-particle track. Both the alpha- and beta-particle photographs were made by J. K. Bøggild of the University Institute of Theoretical Physics in Copenhagen.

IONIZING RADIATION	SYMBOL	MASS	CHARGE
ELECTRON	◦	1	-
PROTON	●	1,836	+
NEUTRON	○	1,839	0
DEUTERON	●○	3,671	+
ALPHA PARTICLE	●● ●●	7,296	++
X-RAY OR GAMMA RAY	⤴	0	0

PRINCIPAL FORMS of ionizing radiation are listed. All are particles of matter with the exception of X-rays and gamma rays, which are electromagnetic waves. The deuteron consists of a proton and a neutron; the alpha particle, of two protons and two neutrons. Some of the mass of the constituents of deuteron and alpha particle is transformed into the energy which binds them together.

energy alters the motion of the planetary electrons, whereas one of these electrons is actually released and wanders away from an ionized molecule. More energy is required to ionize a molecule than to excite it, but not a great deal more. On the average, some 10 to 20 ev of energy are transferred in each primary event, and the penetrating particle is thereby imperceptibly decelerated. Although the loss of kinetic energy occurs in discrete amounts, the changes are so minute compared to the total kinetic energy that the slowing-down can be considered, for most practical purposes, to be a continuous process. Eventually the particle is brought to rest and is no longer able to affect the medium.

From the excitation and ionization of large numbers of molecules flow a host of secondary consequences that are now attracting the interest of investigators both inside and outside the field of physics proper. Free ionized molecules have a high chemical reactivity which is powerfully disturbing in whatever milieu they appear. The excitation of a molecule, short of ionization, entails the reorganization of the electrons that hold its constituent atoms together. One or several of the weakened bonds tend to rupture, loosing stable and unstable fragments into the environment. These and the diverse sequences of events that follow may be triggered by any one of the various types of ionizing radiation. As William H. Bragg stated in 1912, "the forms of radiation differ in degree rather

than in kind" in their effects on matter.

The observation of the primary effects of ionizing radiation gives us many of our most important methods for detecting and measuring the radiation itself. One of the most reliable is the ionization of gases, observed by Henri Becquerel a few months after his discovery of radioactivity. Since a single alpha particle from radium, for example, produces 137,000 positive ions and an equal number of electrons when it is completely absorbed in air, the consequent electric current can be measured with the aid of an amplifier. The ions formed in a gas (ions of nitrogen and oxygen molecules in the case of air) are usually exceedingly reactive; they often undergo chemical change during the time required to collect them at an electrode. The total electric charge, however, is not thereby altered. For this and numerous other reasons the ionization method of detection has proved remarkably trustworthy. Ionization chambers are widely employed to count energetic particles and to determine their individual energies.

A simpler device, the electrical counter invented by Rutherford and Hans Geiger in 1908, employs high voltages to break down the gas, once a passing particle has supplied an initial requirement of ions. Such a device yields a burst of current strong enough to be observed without amplification. Although useful for counting large numbers of ionizing particles, the electrical counter cannot determine their energies. The most common variety, the Geiger counter, has applications ranging from refined physical experiment to uranium prospecting, and can even be found in the Sears Roebuck catalogue.

The second basic method of detection rests upon the emission of light by excited molecules. When an isolated atom is excited, it must lose its excitation energy and return to its lowest energy-state by emitting one or several photons. Since few atoms exist in isolation, however, the excitation energy is usually dissipated by collisions with other atoms or molecules, and diverted to forms of energy other than light (*e.g.*, heat). When a molecule is excited, the initial conversion of energy can be internal; the bonds between atoms in the molecule are ruptured, and the excitation energy is converted into the chemical energy of the reactive molecular fragments. Indeed, very few molecules emit light when they are irradiated. There are, however, special substances in which the excitation energy is not degraded;

they therefore emit light copiously under irradiation. Such substances can serve both to count energetic particles and to measure their energy. Inorganic crystals such as zinc sulfide have this property, and they find common use on the screens of television tubes. Electrons accelerated in the tube (which ordinarily have energies of some thousands of electron volts and are therefore typical ionizing radiation) impinge upon the screen and are absorbed; the resulting excitation leads to the emission of light.

An alpha particle impinging on zinc sulfide provokes the emission of a burst of photons, some 10,000 in number. Although this scintillation is very faint, it can be observed by the unaided (but dark-adapted) human eye. Most of the epochal discoveries of early nuclear physics, among them the discovery by Rutherford of the atomic nucleus and of the first nuclear transmutation, depended upon the visual observation of alpha-particle scintillations. In contemporary instruments either inorganic crystal phosphors such as zinc sulfide, or organic substances (usually mixtures of aromatic compounds), serve as scintillating media, and the human eye is replaced by an electrical device that converts the burst of light into an electrical signal.

Chemical reactions, engendered by both excitation and ionization, furnish a third important mode of observation and measurement. The blackening of photographic emulsion, a chemical effect that gave Wilhelm Conrad Roentgen the first clue to the existence of ionizing radiation, is still useful both for observing individual particles and for determining total amounts of radiation. The Fricke dosimeter, developed by the pioneer U. S. radiation chemist Hugo Fricke, depends upon another chemical reaction, the oxidation of ferrous sulfate dissolved in sulfuric acid, to give an accurate measure of absorbed energy.

Radioactive substances and man-made machines provide the two most important sources of ionizing radiation. In radioactive disintegration the reorganization of the constituents of the atomic nucleus imparts great energy to the emitted particle or photon. In machines electrical power supplies this energy.

Naturally occurring radioactive substances emit three different kinds of radiation: alpha particles, beta particles (high-energy electrons) and gamma rays. Virtually exploding, the disintegrating nucleus hurls out the alpha particle or beta particle, and in some cases gamma rays as well. Some 30 different

naturally occurring isotopes emit alpha particles, most of them with energies between five and 10 Mev, and a like number emit beta particles, with energies chiefly between .1 and 2 Mev.

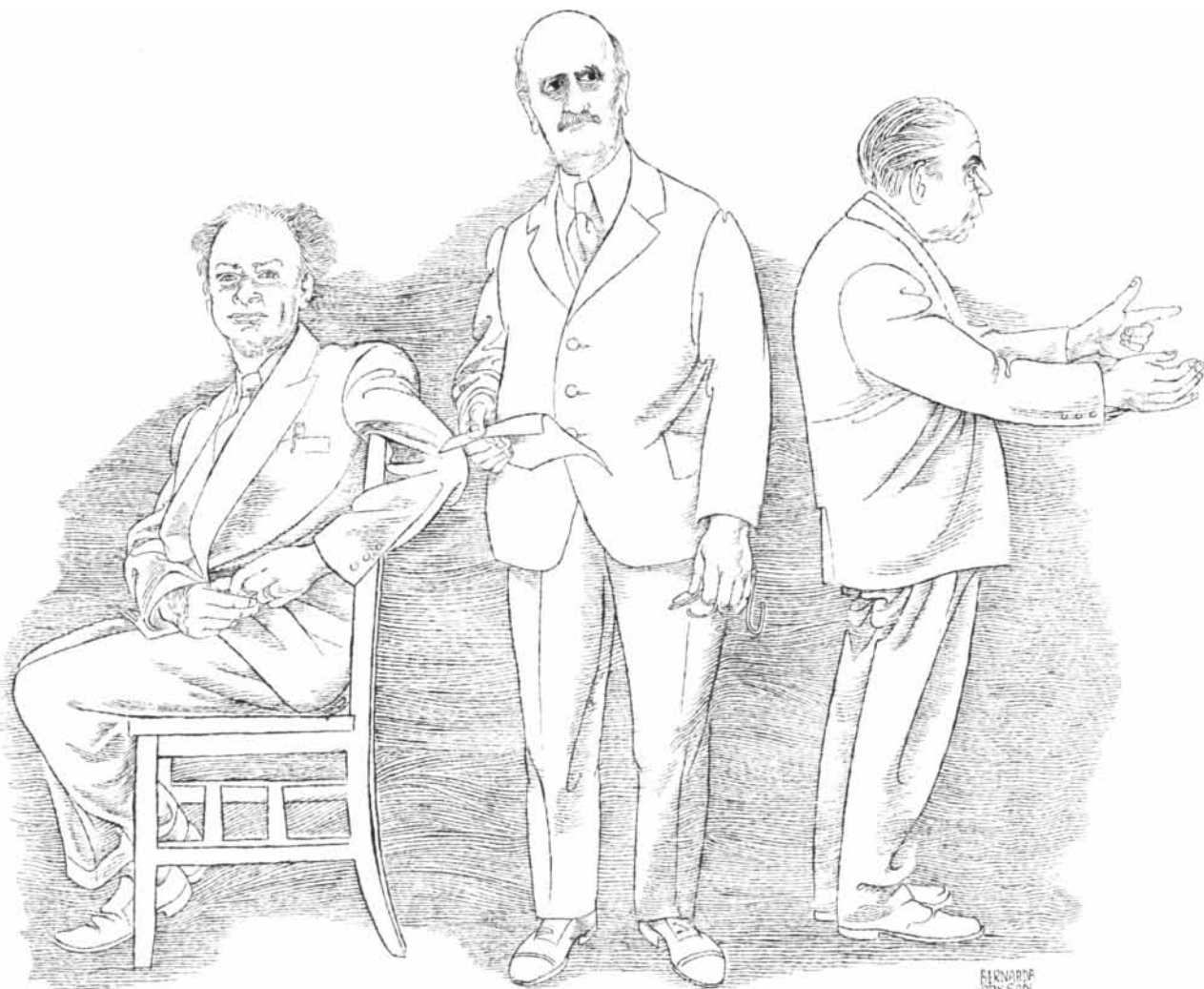
Uranium and thorium, and their families of decay products, comprise the main source of natural radioactivity. As James R. Arnold and E. A. Martell explain in the article that follows, these elements are widely distributed throughout the crust of the earth, occurring highly concentrated in certain minerals and in very dilute form practically everywhere. Another ubiquitous source of natural radiation is the radioactive isotope potassium 40, an emitter of one-

Mev beta particles which comprises one out of every 10,000 potassium atoms in all rocks, soils, waters and living things (including people). In addition to these elements, which have been here since the earth originated and will remain for billions of years, there exist other radioactive atoms, of lower abundance and usually of a more transient nature. Cosmic rays, to which the earth is constantly exposed, are themselves ionizing radiation of highly varied content. And the cosmic rays, in their passage through the earth's atmosphere, produce a quantity of atomic debris, part of which is radioactive.

To the natural abundance of radio-

active isotopes man-made nuclear reactors, military and nonmilitary, have been adding steadily rising amounts of radioactive wastes, intentional and inadvertent. Radioactive isotopes can also be produced by bombarding stable isotopes with energetic atomic particles from an accelerator or a nuclear reactor. These artificially radioactive materials chiefly emit beta particles and gamma rays. Cobalt 60, for example, is manufactured by exposing rods of cobalt to the neutrons inside a reactor. It is a powerful and invaluable source of gamma radiation.

X-ray machines employ a high voltage to accelerate electrons boiled from a



“THREE B’S” of ionizing-radiation physics are the late Sir William Bragg (center), Niels Bohr (right) and Hans A. Bethe (left). Bragg laid the experimental foundations of knowledge of the penetration of ionizing radiations into matter. He discovered that alpha particles travel in straight paths, that they lose energy gradually and that they have a well-defined range. He made extensive measurements of the ionization of gases by various kinds of radiation. His findings were incorporated in his classic *Studies in Radio-*

activity, published in 1912. Bohr published two celebrated papers in 1913 and 1915 which set forth the theoretical principles used to deal with the loss of energy by fast-moving charged particles. His *The Penetration of Atomic Particles through Matter*, published in 1948, is also a classic. Bethe wrote a monumental 76-page paper that applied the principles of modern quantum physics to the excitation and ionization of matter by energetic charged particles. The paper was published in 1930, when he was 24 years old.

hot cathode through a vacuum and into abrupt collision with a target plate. In this way part of the kinetic energy of the electrons is transformed into high-energy photons. Roentgen's original tube operated on 40,000 volts; X-ray machines in common use today operate on thousands to millions of volts. In general, the greater the voltage, the greater the energy of the X-ray photons and the greater their penetrating power.

Complex accelerators such as the cyclotron, the Van de Graaff generator and the linear accelerator, all now available commercially, can accelerate charged particles to energies up to many millions of electron volts. These engineering masterpieces employ electrical power to maintain elaborate electrical and magnetic fields, constraining the particles to move under acceleration by the electric field.

For the chemist and the biologist interest in ionizing radiations begins with the excited and ionized molecules produced by primary and secondary charged particles. The potency of ionizing radiation in chemistry and in life

processes is a consequence of the extreme reactivity of these energy-rich, chemically activated molecules. If the energy absorbed by such molecules were merely degraded into heat, instead of augmenting their electronic energy, ionizing radiations would have little significance outside of physics.

An activated molecule may, but need not, lead to a permanent effect. The evolution of the action of radiation, from the primary exciting or ionizing event to the end product, is the most fascinating front now being explored by investigators. The sequence of events, which takes but a tiny fraction of a second, may be divided into three stages, with a fourth and far longer stage to follow in the case of living matter. In the first, or "physical," stage the incident radiations and their secondary particles impart energy to numerous molecules, yielding electrons and excited and ionized atoms and molecules as the primary products. The primary products are located near the particle paths and are therefore distributed nonuniformly in space. Cloud-chamber and nuclear-emulsion pictures make it possible to visualize these events,

although these pictures reflect the situation in later stages of its evolution.

There follows instantly the "physicochemical" stage, in which the primary products undergo secondary reactions; the ions collide and react with normal molecules and the excited molecules spontaneously dissociate. Eventually, in the brief time-scale of the reactions, this stage yields a combination of stable molecules (some or all of which may be different from those originally present) and chemically unstable species (usually the molecular fragments known as free radicals).

The third, or "chemical," stage now ensues. The free radicals react with the milieu and with each other, ultimately producing the final chemical products. Elsewhere in this issue A. Charlesby reviews the interesting and potentially fruitful reactions that occur in this stage. Each of these stages is briefer in duration than the one that follows it. In water or biological tissue, for example, the physical stage requires only about 10^{-13} (.0000000000001) second; the physicochemical stage, about 10^{-11} second; the chemical stage, 10^{-6} second or somewhat more.

In biological systems there follows a fourth stage in which the organism, through its hierarchy of organizational levels, responds to the foreign chemical substances present at the conclusion of the chemical stage. The biological stage is usually protracted and can persist for days and even years, as the articles by Alexander Hollaender and George E. Stapleton and by John F. Loutit explain. Present-day understanding of the processes in the first, or physical stage, is advanced. But knowledge of what occurs in the other stages, including the biological, is inchoate.

Many of the phenomena induced by ionizing radiation are encountered with other forms of activation. For example, free radicals are produced as intermediates by the absorption of ultraviolet radiation and even in many ordinary chemical reactions. But the action of ionizing radiation has three distinctive characteristics. First, the excitation energy of the primary products is uniquely great. Free ionized molecules are virtually unknown to chemistry and biology except as the primary products of ionizing radiations. Second, the ionizing particle arrays the activated molecules in nonuniform spatial arrangement along its track. In activation by ultraviolet rays, chemical action or ultrasonic waves, the effects are randomly distributed in the medium. Finally, the individual acts

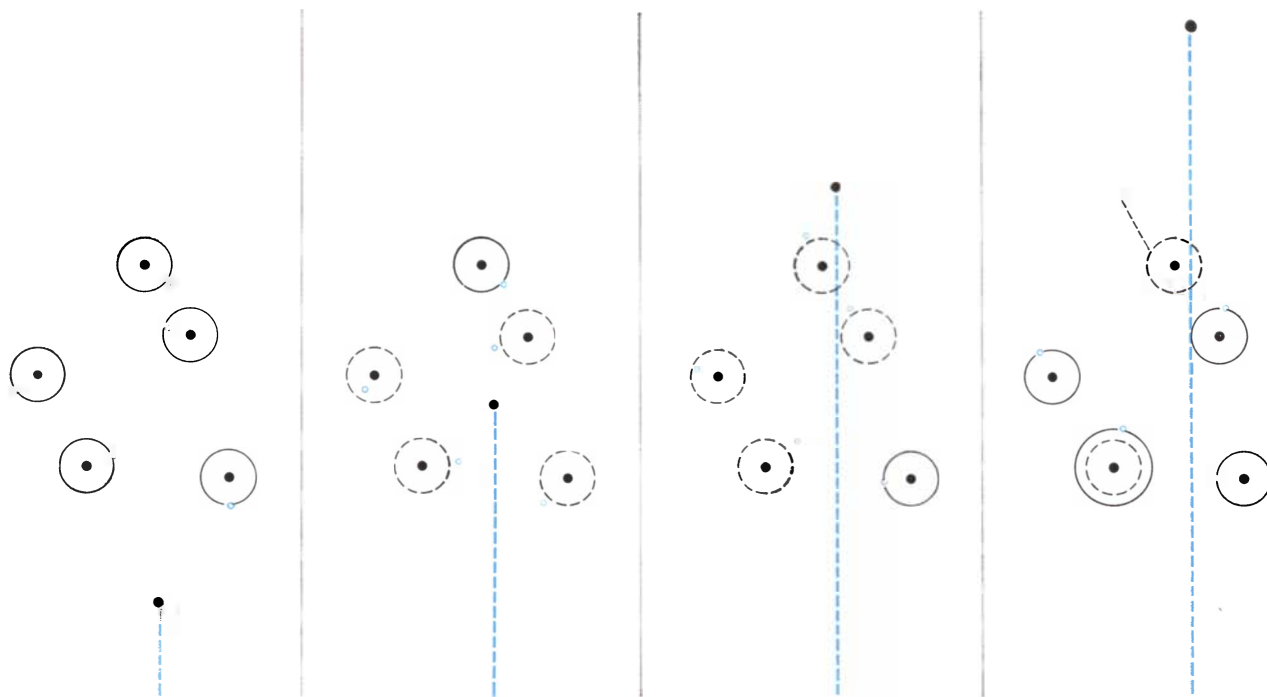
A Glossary of Ionizing-Radiation Units

Curie (*abbreviated c*): A measure of radioactivity in terms of the rate of atomic disintegrations. A piece of matter has an activity of one curie if 37 billion of its atoms disintegrate each second. This figure originated in the use of radium as a standard: One gram of radium has an activity of almost exactly one curie. Other substances disintegrate at different rates. Thus one gram of strontium 90 has an activity of 147 curies. Depending on the kind of atom, each disintegration results in the emission of an alpha particle or a beta particle and often gamma radiation as well. The effect of radioactivity on a neighboring substance depends on the type and energy of the emissions as well as on their rate.

Rad: The unit of radiation dose; defined in terms of the energy absorbed by irradiated material. An "absorbed dose" of one rad means that each gram of matter exposed to radiation absorbs 100 ergs of energy. To give some idea of the size of the unit, 420,000 rads would raise the temperature of water by one degree centigrade, assuming that all the absorbed energy is converted into heat.

Roentgen (*abbreviated r*): For many years the customary unit for amount of radiation, and used in several places in this issue. It is defined in terms of ionizing effect: one roentgen of radiation produces about two billion (or a total of precisely one electrostatic unit) each of positive and negative ions in one cubic centimeter of dry air at standard conditions (zero degrees centigrade and a pressure of 760 millimeters of mercury). The unit is useful only for X-rays and gamma rays of low or medium energy. One r of such rays to water or soft tissue administers an absorbed dose of very nearly one rad. For other types of radiation the relationship between the r and the rad is difficult to establish, and the rad is the superior unit.

Rem: A biological measure of dose that takes into account the comparative biological effectiveness of the type of radiation as well as the amount of absorbed energy. By definition one rad of X-rays, gamma rays or beta rays is equivalent to one rem. One rad of alpha rays, however, is equivalent to about 10 rem.



PRIMARY EFFECTS OF A CHARGED PARTICLE on a gas are schematically depicted. In the first drawing the particle approaches five gas molecules; the small colored circles represent only one electron in each. In the second drawing the particle disturbs the

electrons in four of the molecules. In the third it has traversed the fifth molecule. In the fourth drawing it has receded, leaving one molecule ionized (*top*) and one in an excited state (*bottom left*). The others have reverted to the original state.

of ionization along the track separate electric charges in the molecules with extreme suddenness. In substances such as water and proteins, where molecules are oriented by the unequal distribution of charge within them, this provokes a violent response.

The rate at which a charged particle loses energy in matter during the physical stage depends very much upon certain of its qualities. When a charged particle interacts with a molecule, the degree to which the molecule is disturbed is determined by the electric force exerted by the particle upon electrons within the molecule. We should expect, therefore, that the greater the charge of the particle, the greater the probability of energy transfer. The force exerted is also inverse to the speed of the particle, because a slower particle exerts its force over a longer time. Theories devised by Niels Bohr and by Hans A. Bethe permit accurate prediction of the energy loss per unit distance of penetration—an important concept in radiation studies called stopping power or linear energy-transfer (abbreviated LET). The theories show that the LET is proportional to the square of the charge, and also, approximately, to the inverse square of the speed. Whether the charge is positive or negative is of no consequence.

As a particle penetrates matter it gradually slows down; its LET therefore increases.

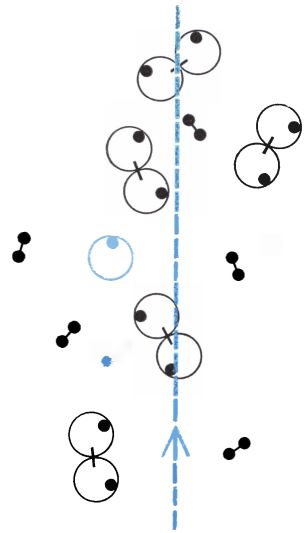
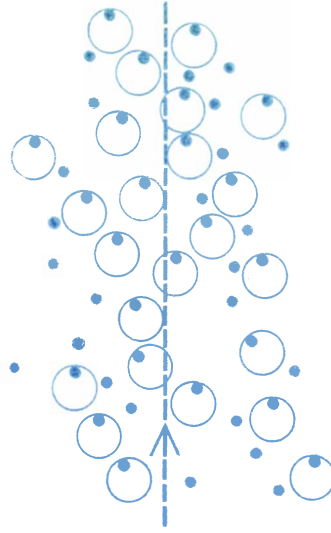
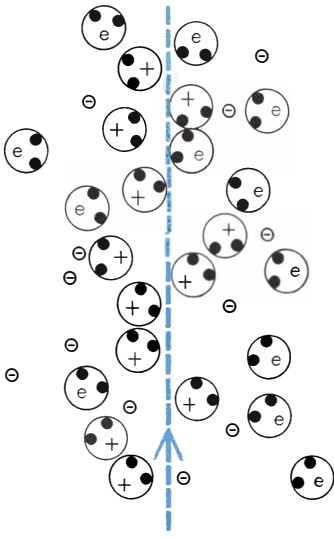
It is instructive to compare the LET of an alpha particle with that of an electron of comparable energy. Since the alpha particle has much greater mass, it must have much lower speed. In addition, its charge is twice as large. For both reasons the LET of an alpha particle is hundreds of times greater than that of a high-energy electron. On the other hand, the range of an alpha particle—the total distance it traverses before coming to rest—is correspondingly shorter. The alpha particles emitted by isotopes occurring in nature have ranges in air of a few inches; electrons of comparable energy travel more than 50 feet. In a liquid or solid the close packing of molecules, as compared to their wide separation in gases, drastically reduces both of these distances by a factor of roughly 1,000.

The geometries of particle paths also differ. Heavy projectiles such as alpha particles or protons are negligibly deflected when they transfer energy to the vastly lighter electrons. They therefore move in straight lines. But a penetrating electron, because of its small mass, is easily deflected; consequently it pursues an erratic course (particularly after it has been slowed down to an energy that is well below one Mev), as electron

tracks in cloud chambers clearly show.

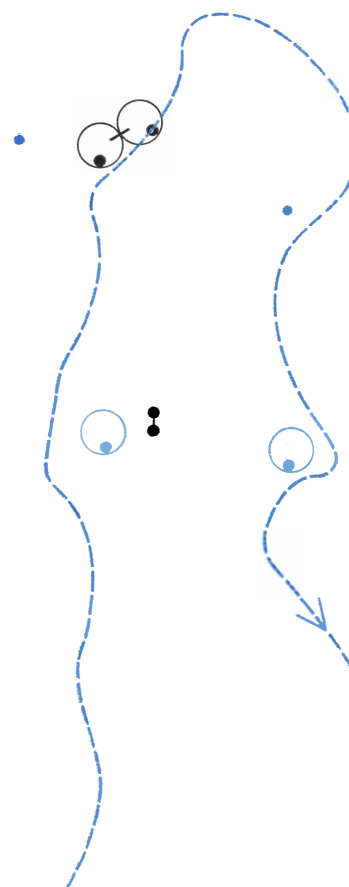
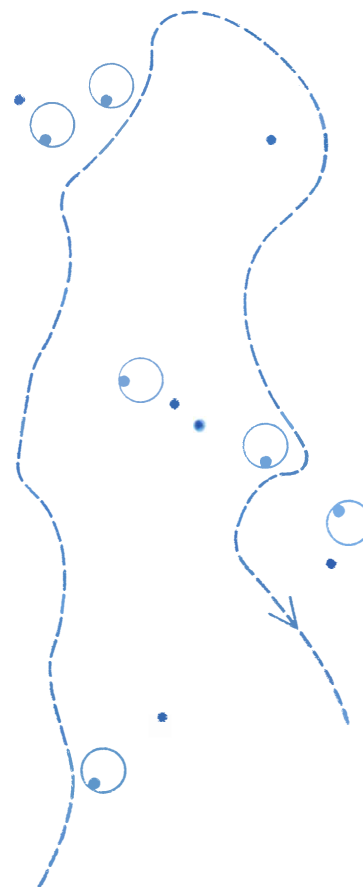
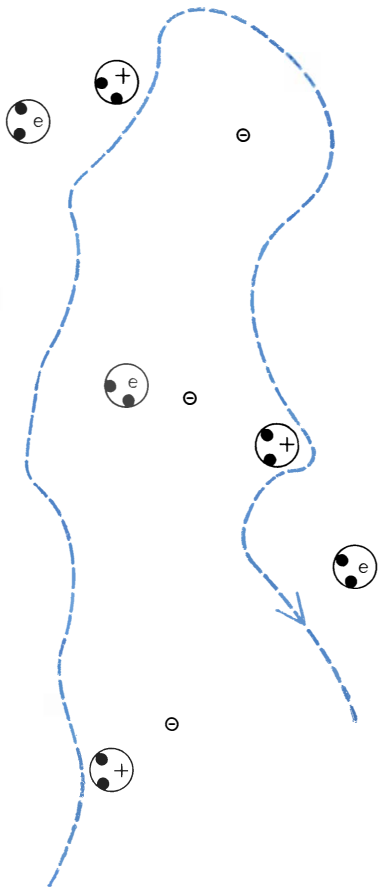
X-rays behave in an entirely different manner. A single photon passes unaltered by numerous molecules until, by chance, it interacts with a single molecular electron and transfers part or all of its energy. Thus the X-ray photon is not gradually absorbed, as charged particles are; rather, an X-ray beam is gradually attenuated as photons disappear from it. Complete attenuation is never attained; for example, a few inches of water reduce the intensity of a beam of one-Mev gamma rays by a factor of .5, eight inches by a factor of .25, 12 inches by a factor of .125, and so on. X-rays have far greater penetrating power than charged particles. The differences are illustrated by the compound radiation from radium. An ordinary piece of paper will absorb the alpha particles emitted by radium; a quarter-inch of glass is required for the beta particles; the gamma rays can be detected beyond several inches of lead.

Although the spatial arrangement of activated molecules is decisively dependent upon the type of radiation, their nature and number are not. Some 10 or 15 ev are expended, on the average, for each activated molecule formed, and excitations and ionizations are nearly equal in number. In the physicochemi-



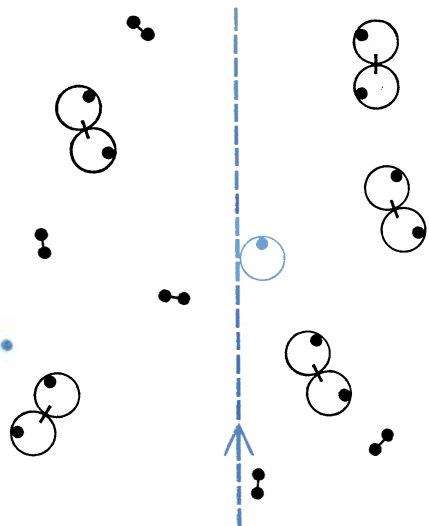
ALPHA PARTICLE with an energy of six million electron volts decomposes water according to this scheme. The first drawing depicts the end of the "physical" stage, lasting about 10^{-13} second. In the wake of the particle are excited water molecules (e), positive water ions (+) and electrons (-). Normal molecules are not

shown. The second drawing depicts the end of the "physicochemical" stage, lasting about 10^{-11} second. Hydrogen atoms (colored dots) and hydroxyl radicals (colored circles with dot inside) are now in the wake. The third and fourth drawings depict the "chemical" stage, which may last 10^{-9} to 10^{-6} second. Some of the hydrogen

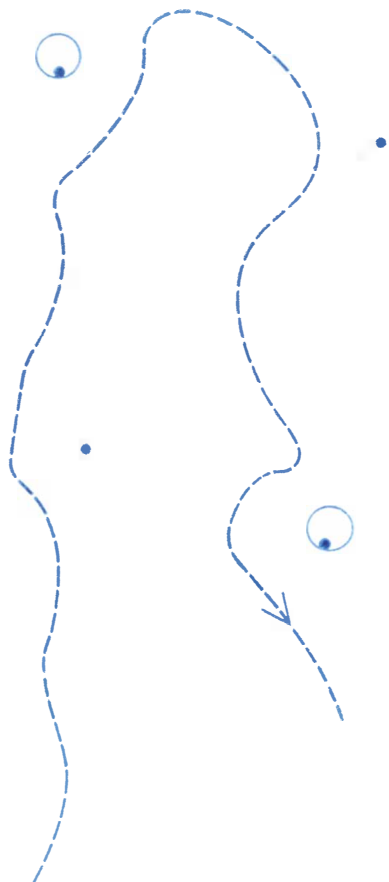


BETA PARTICLE OF 3,000 electron volts is unable to decompose pure water appreciably. The four stages shown here are the same as those for the alpha particle. However, because of the smaller

electric charge and greater speed of the electron, the hydrogen atoms and hydroxyl radicals are not formed so close together. Hence fewer radicals unite to produce hydrogen and hydrogen per-



atoms and hydroxyl radicals have recombined into normal water molecules (*not shown*); others have formed hydrogen molecules (*paired dots*) and hydrogen peroxide molecules (*paired circles with dots inside*).



oxide molecules before diffusing away from track. Most of the molecules are destroyed by radicals that have escaped combination.

cal and chemical stages, however, the spatial proximity of primary products often has a potent influence. Such influence is termed a track effect, and it plays an important part in subsequent events. Track effects are the chief cause of differences in the chemical (and biological) effectiveness of various radiations. They are generally absent in gases but are often prominent in liquids and solids, in which the tracks tend to persist for far longer times. Thus alpha particles and beta particles are equally effective, for the same energy absorption, in causing the polymerization of gaseous acetylene; but alpha particles are very efficient in decomposing liquid water, whereas beta particles are virtually without influence.

We still know comparatively little about events in the physicochemical stage. Some information on the consequences of excitation is provided by photochemistry (the study of the chemical action of visible and ultraviolet radiation) and by the analysis of the spectrum of light absorbed by molecules. The absorption of light produces excited molecules, and does so under controlled conditions without the complicating formation of ions. An excited molecule will often break in two, and it will do so very quickly. The time required is only about 10^{-13} second for small molecules and somewhat longer for larger ones. The two fragments may, however, recombine and dissipate the energy of union as heat, particularly if the system is a liquid or solid, in which the fragments are hemmed in by other molecules and restrained from escaping.

Dissociation into free radicals is the most probable consequence of excitation in almost all inorganic molecules and most organic ones. Aromatic compounds, which are characterized by the six-carbon-atom benzene ring, are an exception. Most of them are able to convert electronic energy into heat, that is, into vibrational energy of their atoms. If the molecule can withstand this internal heating until the heat is able to flow away, it will survive primary excitation.

Ionized molecules have many interesting and curious traits, some of which have been revealed only recently. They are very reactive, often seizing upon a neighboring, neutral molecule and exchanging an atom or group of atoms with it. If they do not happen to have such an encounter, they may undergo drastic internal reorganization. For example, the molecule of the aromatic compound toluene is readily ionized by loss of a hydrogen atom from its methyl side group

(CH_3); it thereupon incorporates the extra carbon atom from that side group in its hexagonal benzene ring to form a perfectly symmetrical seven-sided ring [see illustration on page 83]. Apparently the familiar prescriptions of chemical valence are disregarded by ions, perhaps more often than we yet appreciate.

Positively charged ions must eventually, of course, capture an electron—or a negative ion—and regain their electrical neutrality. But in many systems this process proceeds so slowly that it occurs long after ionic processes such as those just described have been completed. In all systems the physicochemical stage must be a complex one, with many different, and often violent, reactions proceeding simultaneously.

An exception to this general statement must be made with respect to the class of atomic solids, that is, metals, semiconductors and some insulating crystals. Electronic excitation and ionization have almost no permanent effect on these materials. The binding of electrons to the atoms in their structures is such that a disturbance in electronic motion is quickly dispelled. Nevertheless, some types of radiation cause marked alterations. Such effects arise from disordering of the local arrangement of atoms in the solid. Atoms can be displaced when struck by a penetrating particle with a mass of atomic magnitude, such as a proton or alpha particle, but not by an electron, which has so little mass. The observable effects in these solids, discussed in this issue by Douglas S. Billington are of great interest to students of the solid state.

The conclusion of the physicochemical stage leaves the system in a more subdued state, again at normal temperature, but strewn with molecular debris. The spatial distribution of the molecular fragments still reflects their origin near the linear tracks of energetic charged particles, although the initial compactness is now dispersed to a greater or lesser extent. In the chemical phase that follows, free radicals are the principal actors. These highly reactive molecular fragments diffuse away from the zones of high concentration, and concurrently react with one another or with such susceptible stable molecules as may be present. Since they live much longer than their precursors, free radicals are a vehicle for extending the influence of primary activation in both time and space. They can often attack a substance that is present in relatively small amount, small enough so that it does not itself become engaged in the physical or

physicochemical stages. This indirect action is a common effect and in living systems is an important pathway to the ultimate biological consequences.

Free radicals are not peculiar to radiation action, most of them being known or surmised as intermediate species in photochemical or ordinary chemical reactions. Much of the present activity in radiation chemistry stems from the ready opportunity of generating large numbers of free radicals. In many chemical systems it is possible to measure the number of free radicals produced in irradiation. This is accomplished by adding a foreign substance, called a "scavenger," that reacts with radicals to form an observable product. Some scavengers that find common use are DPPH (diphenylpicrylhydrazyl), iodine,

acrylamide, benzoquinone and oxygen.

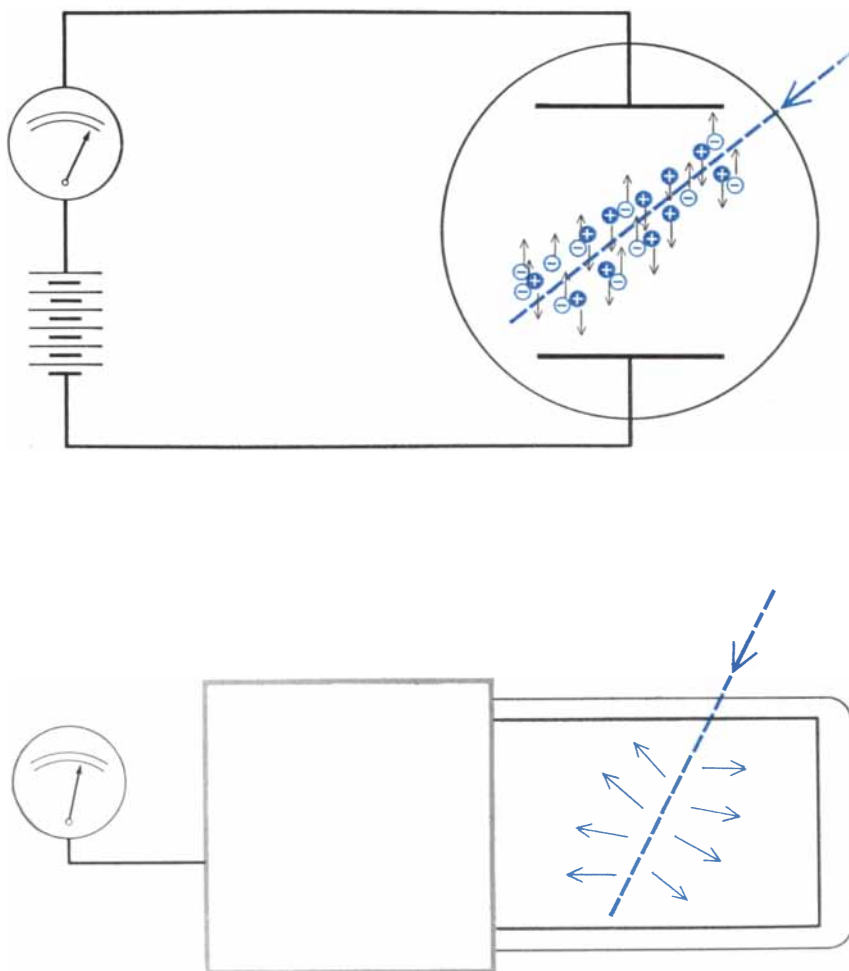
Chemical changes caused by radiation from radioactive substances were noticed by the earliest investigators. Pierre and Marie Curie, for example, commented in 1899 that such radiation partially transforms oxygen into ozone. This reaction is a common one, being responsible for the oxidation of exposed metal surfaces and the deterioration of such materials as greases in the vicinity of a radiation source.

The radiation chemistry of gases has been investigated for six decades, for the past five under the leadership of S. C. Lind, now at the Oak Ridge National Laboratory. As a rule the number of molecules decomposed by radiation roughly equals the total number of primary products. The correspondence

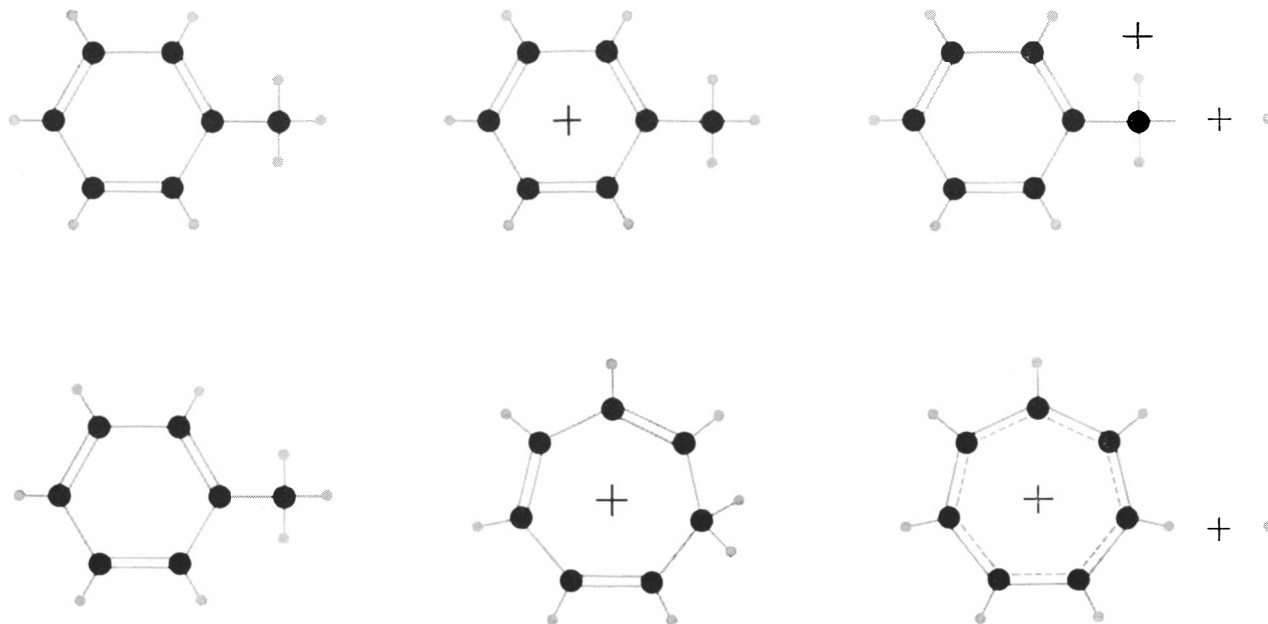
is inexact, however, because it is mediated by the complex processes of the physicochemical and chemical stages. It may even be effaced. Carbon dioxide (CO_2), for example, is hardly affected at all by radiation, presumably because reactions between free radicals lead to the reformation of CO_2 molecules. At the other extreme, a small dose of ionizing radiation will completely convert a mixture of hydrogen and chlorine into hydrogen chloride. This is the result of a chemical chain-reaction: A free hydrogen atom (H), formed by the dissociation of an excited hydrogen molecule (H_2), reacts with chlorine (Cl_2) to form HCl and a free Cl atom; the latter then reacts with an H_2 molecule to yield another HCl and a free H atom. Thus the H and Cl atoms function as catalysts and can unite vast numbers of H_2 and Cl_2 molecules. Ionizing radiation often breaks down inorganic gases into their elements. Gaseous organic compounds, on the other hand, react to irradiation in a more complex manner. The molecules of aliphatic hydrocarbons, for example, dissociate in a variety of ways, and the numerous fragments then react to yield a product that is a highly complex mixture, containing both smaller and larger molecules.

Because of the commercial possibilities inherent in the effort, the investigation of the action of radiation on organic liquids, especially petroleum products, now engages many laboratories. At the present time industrial application of radiation is slight. But there is widespread belief that another decade will see radiation in common use as a manufacturing tool. Organic radiation chemistry is, however, of great interest in its own right. It is an invaluable arena for investigating reactions of organic free radicals, and indeed provides information on many radicals, as well as excited and ionized molecules, that are not otherwise accessible to study.

All organic compounds evolve hydrogen upon irradiation. Part of this hydrogen is formed by dissociation at a carbon-hydrogen bond, resulting in a free H atom and a free radical. In many cases the H atom then proceeds to react with an intact molecule, yielding an H_2 molecule and a second free radical. The two radicals may then react with each other to form any of a variety of products, or they may combine to yield a molecule twice as large as the original one. This sort of doubling is very common among organic compounds. It is the prototype of cross-linking in giant organic molecules, which is technological-



IONIZING RADIATION IS MEASURED by two basic methods: ionization and excitation. At top is a schematic drawing of an ionization chamber. When an energetic charged particle traverses the chamber, it ionizes many molecules of gas. A voltage across the two plates sweeps positive ions to one plate and negative ions to the other. The resulting current is indicated on a meter. At bottom is a scintillation counter. When an energetic charged particle penetrates a special scintillating substance, the substance emits a flash of light. The light, trapped by a reflector, is converted into pulse of current by photomultiplier (gray square).



TOLUENE MOLECULE (*top left*) behaves oddly when it is ionized. The carbon atoms in the molecule are represented by black balls; the hydrogen atoms, by gray. According to ordinary chemistry, the ionized molecule (*top center*) may lose a hydrogen atom

but should still retain its basic six-sided ring structure (*top right*). Seymour Meyerson and his collaborators have demonstrated, however, that the ionized toluene molecule forms a seven-sided ring, and that when it loses a hydrogen it is symmetrical (*bottom*).

ly the most promising development in the field.

The breakdown of organic molecules invariably leads to a great number of different products. Paraffin hydrocarbons, especially, can fragment almost anywhere along their molecular chains, although there are preferred locations for the break. Most organic compounds have a normal radiosensitivity; that is, the number of molecules decomposed is approximately equal to the total number of primary excitations and ionizations produced by irradiation. Hence one molecule is decomposed for each 10 to 15 ev of energy absorbed. Aromatic substances, however, are more resistant to radiation. In contrast to the aliphatics they do not fragment but rather tend to form aggregates or multiples of the original ring structure.

Because water occupies a central role in inorganic chemistry, because it is vitally important in reactor technology and because it constitutes a major portion of the bulk of living matter, radiation chemists have given closer study to this simple substance than to any other. The events of the physicochemical stage are still quite unknown. But it has proved possible to devise consistent mechanisms for the chemical stage in a great variety of different dilute aqueous solutions on the basis of a simple hypothesis: that free H atoms and free hydroxyl (OH) radicals are the sole re-

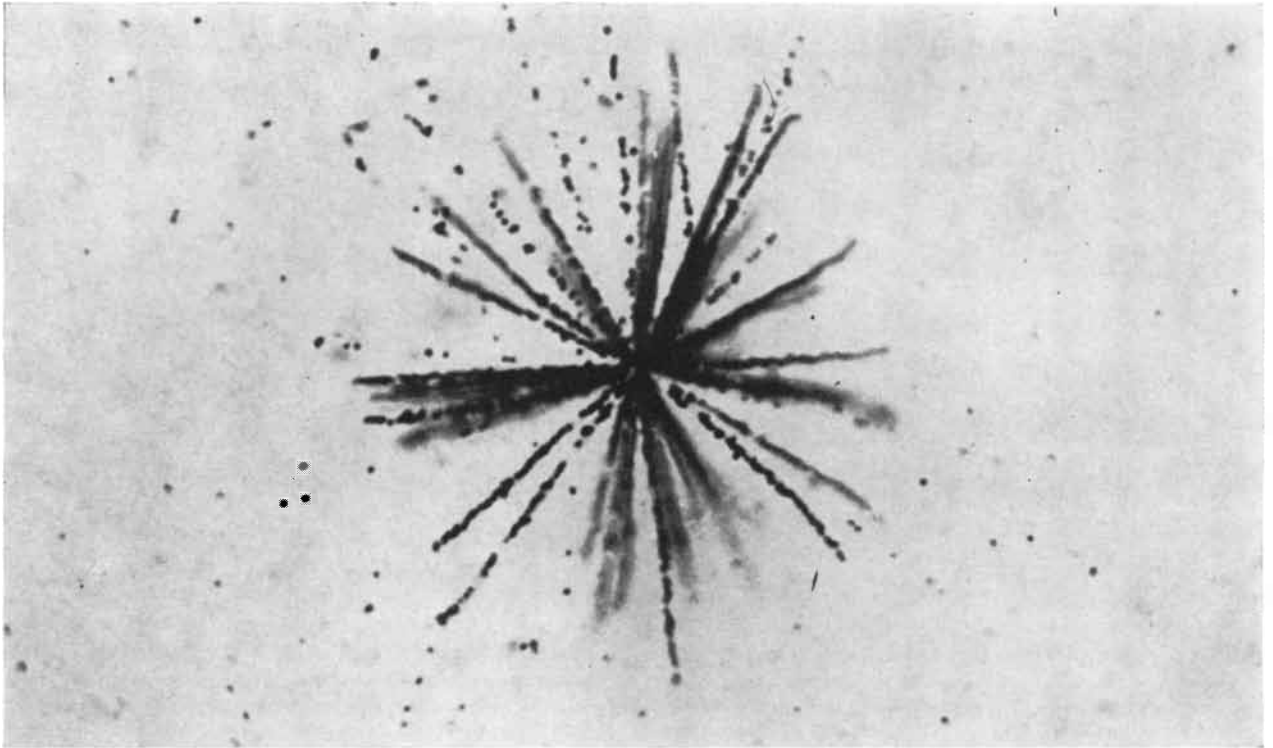
maining products at the conclusion of the physicochemical stage. Presumably both excited and ionized H_2O molecules contribute to the formation of H and OH.

Track effects dominate the action of ionizing radiation on water. Under the action of beta rays or X-rays, which create no compact tracks, pure, air-free water remains stable. On the other hand, it decomposes readily into hydrogen and hydrogen peroxide under irradiation by particles with high LET, such as alpha particles. This gross difference in behavior finds ready interpretation in terms of the proximity of radicals along the track. The H atoms and OH radicals form principally within a narrow cylindrical region around an alpha-particle track, and in this region of extreme concentration they react rapidly. Roughly half of the H atoms encounter OH radicals and reform water, but the other half collide with H atoms and produce H_2 . The OH radicals behave in like manner, combining with free hydrogen atoms to yield H_2O or with each other to form hydrogen peroxide (H_2O_2). Consequently about half of the water molecules decomposed initially by the radiation lead to final products, and very few radicals escape the reaction zone.

In the case of electron irradiation, which has a lower LET, few H atoms and OH radicals are formed in close enough proximity to react before they diffuse away into the body of the liquid.

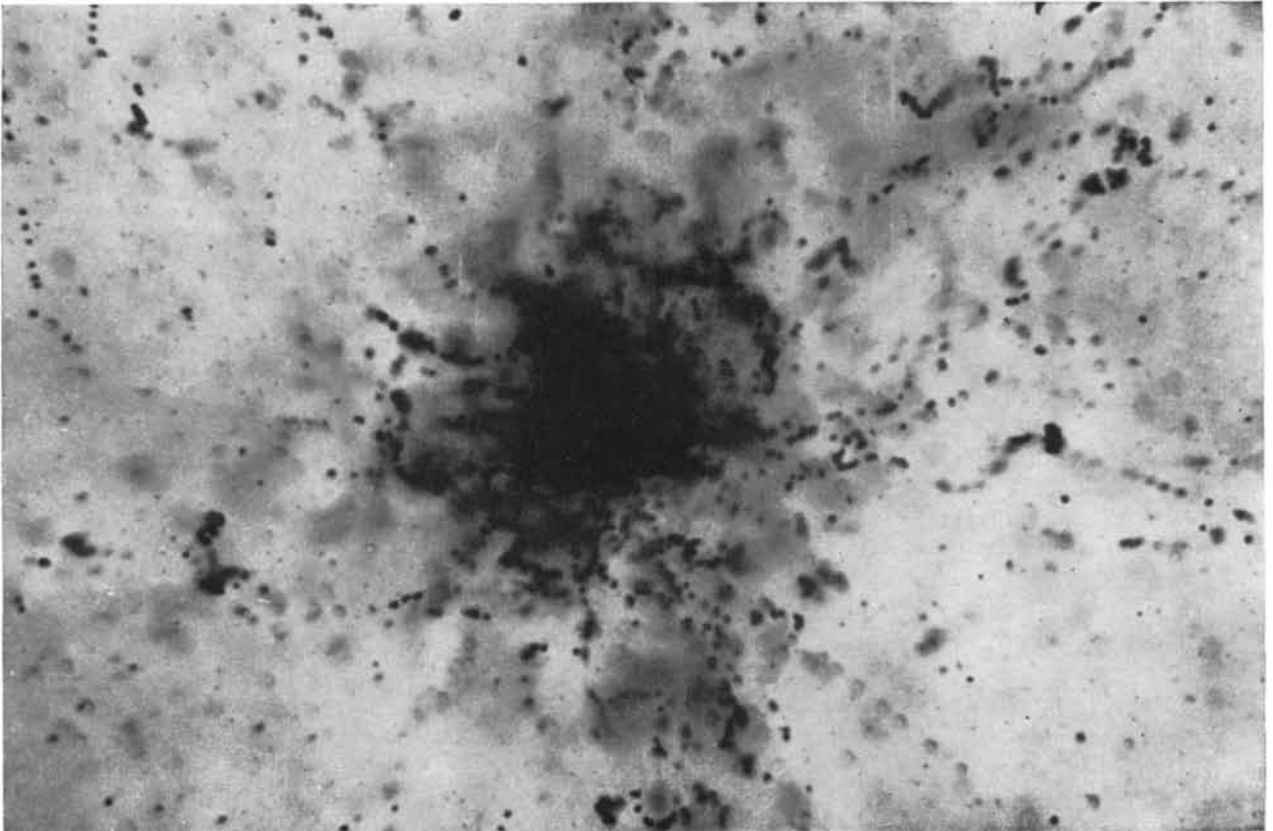
There they decompose such H_2 and H_2O_2 as may have been formed. If the water contains dissolved oxygen, its resistance to radiation of low LET vanishes. The H atoms react with O_2 to form the hydroperoxy radical HO_2 , a much less reactive species, and this permits the decomposition of water to proceed unhindered. The hydroperoxy radical is implicated in many breakdown processes in which oxygen or air is present, as in biological systems.

Thus the action of ionizing radiation on matter always involves intricate mechanisms, notwithstanding the occasional superficial simplicity of its ultimate products. I hope that the reader may have savored the appeal of research in the field, and the challenges rooted in this very complexity. Among these challenges—it is almost a hallmark—is the diversity of scientific knowledge that the interpreter of radiation action must command. At the very least, mastery of many different branches of both physics and chemistry is exacted, and biological systems add a third dimension. The comfortable professional isolation of physicists, chemists and biologists is not respected by an alpha particle penetrating a living cell. Other articles in this issue will show many parts of the field in which valuable information has already accrued. One cannot divine what new horizons will be revealed.



NATURAL RADIOACTIVITY in the atmosphere is shown by this nuclear-emulsion photograph of tracks (enlarged 2,000 diameters) emitted by a grain of dust. The tracks are produced by alpha

particles; their length identifies the dust as polonium, a decay product of uranium 238. The photographs on this page were made by Herman Yagoda of the Air Force Cambridge Research Center.



MAN-MADE RADIOACTIVITY in the atmosphere produced this second nuclear-emulsion photograph. The irregular tracery surrounding the dust particle is produced by beta particles. The char-

acter of these emissions identifies the substance as a fission product formed in a nuclear explosion, but poor definition makes precise identification impossible. The enlargement here is 1,200 diameters.

The Circulation of Radioactive Isotopes

Man's experiments with nuclear explosions have stimulated him to study the distribution of radioisotopes in his environment. These investigations have clarified many geophysical processes

by James R. Arnold and E. A. Martell

Life has evolved on earth in a haven relatively free of ionizing radiation. The fast-moving particles and hard electromagnetic radiation that impinge upon our planet from the sun and from elsewhere in our galaxy barely trickle through the sheltering atmosphere. Radiation from space accounts for only a quarter of the natural "background" radiation at the earth's surface. The balance comes from radioactive isotopes in rocks, soils, waters and the atmosphere.

The study of radioactivity in our environment has acquired new significance since man began to contribute measurable amounts to the total through his experiments with nuclear fission and fusion. Fortunately for us radioactive atoms are still rare, so that sensitive methods of detection are usually required. The high energy associated with nuclear processes makes it possible, however, to detect events on the scale of single nuclei. Moreover, the virtually unchangeable rate of decay (half-life) of each nuclear species allows high precision in the interpretation of data. Thus it has been possible to develop an increasingly reliable description of the world-wide transport and distribution, via the atmosphere and waters of the earth, of minute quantities of natural and man-made radioisotopes. These same studies have enhanced our understanding of the circulation of the atmosphere and the oceans.

Considerations of human welfare have prompted investigation of still a third major system of transport. This is the biosphere, with its intricate food chains that tie together the existence of living organisms. Radioactive zinc taken up in the sea by microscopic marine organisms may appear on the table in the tissues of a fish; radiostromium from the soil of a

meadow may similarly be present in a glass of milk.

Until 1932, when Frédéric and Irène Joliot-Curie produced the first artificial radioisotopes, the natural variety stood alone. Not until the first nuclear explosion in 1945 did man-made transmutations begin to influence the environment at large. Even today natural radioisotopes irradiate human beings far more intensely than man-made fallout.

Since radioisotopes are unstable by definition and thus are constantly decaying, why do they occur in nature at all? There can be only two reasons: either they were made long ago and their half-lives are long enough to permit them to persist, or they are still being made. Isotopes of both types in fact exist.

The long-lived "old" isotopes so far discovered range from neodymium 144, which has a half-life of about 5,000 trillion years, to uranium 235, which has a half-life of 710 million years. No radioisotope with a half-life of less than 710 million years occurs in this group. This fact, among others, enables us to date the formation of the earth's elements at between five and 10 billion years ago. More than a dozen long-lived natural radioisotopes have been discovered, and the list continues to grow as our methods for detecting them become more sensitive. However, three of them—uranium 238, thorium 232 and potassium 40—generate the overwhelming bulk of natural radiation in our environment.

The location of these isotopes within the earth depends not on their nuclear properties but on their chemistry. All three are easily oxidized metals. Their oxides are relatively low in density and thus occur in the crust of the earth rather than in its dense mantle and metallic core. Perhaps half of the radio-

activity in the earth lies within 40 miles of the surface. This concentration significantly increases the radiation to which all living things are exposed—and makes uranium and thorium available to man's uses.

The radiation from isotopes in the crust is rapidly attenuated as it passes through rock and soil; most of the radiation that reaches living organisms originates less than six inches below the surface. The average surface radioactivity is on the order of two curies [*see glossary of terms on page 78*] per square mile, though values in different places vary by a factor as large as five. In general, the more acid rocks, such as granites, are more radioactive than the alkaline basalts; limestones show especially low radiation levels.

The radioactivity of potassium 40 ends with its transformation into stable calcium or argon. Uranium and thorium, however, decay into long series of radioactive "daughter" elements with half-lives ranging from several hundred thousand years down to microseconds. In impermeable rocks and other sealed reservoirs parents and daughters remain trapped together; their abundance with respect to one another dates the formation of the rock. Elsewhere they take different paths [*see illustration on next two pages*]. Thus radon, a gas, diffuses out of soils into the air. Its decay products constitute the chief natural source of atmospheric radioactivity. Radon itself has a four-day half-life and so reaches the upper atmosphere only in minute quantities. Its concentration at various altitudes tells us something about the rate at which air mixes.

As rocks weather away, some of the radioisotopes find their way in solution to the sea. Thorium quickly combines with constituents of sea water to form

insoluble compounds that precipitate onto the ocean floor. Uranium precipitates far more slowly, so that its concentration in sea water reaches the comparatively high value of three parts per billion. Potassium also tends to be carried to the bottom; though virtually all of its compounds are soluble, its ions are adsorbed on particles of clay and other ion-exchange materials. This segregation of thorium and potassium lowers the already low concentration of radioisotopes in sea water; thus fishes suffer less external radiation than men.

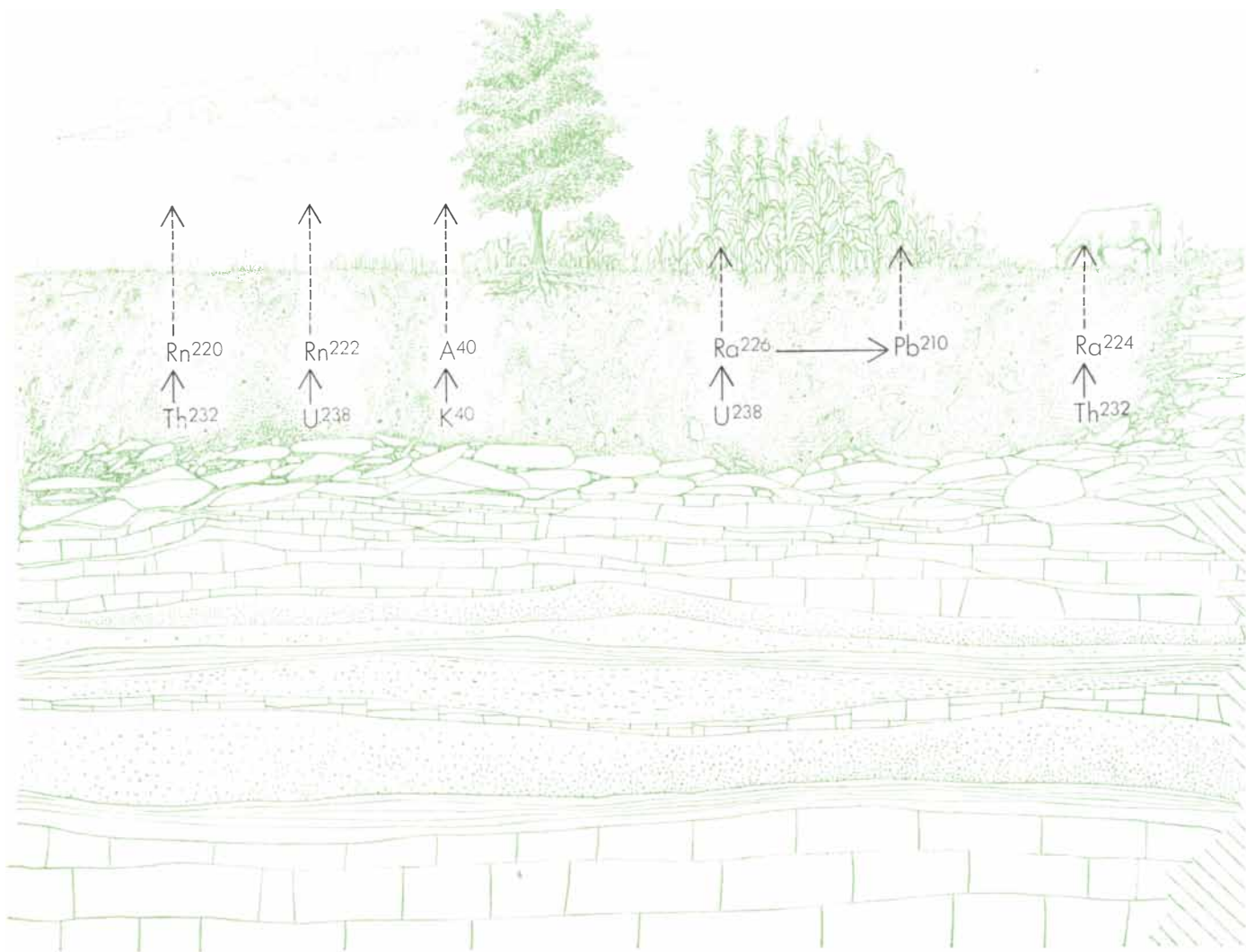
In sea water the chemical transformations of decaying uranium lead to some unexpected effects. The second long-lived daughter of uranium 238 is thorium 230 (ionium). Its salts, like those of thorium 232, quickly precipitate into the

constantly forming marine sediments. The precipitated ionium, however, eventually decays into radium, part of which dissolves out of the sediments and back into the bottom waters, whence it drifts upward. Its concentration in the ocean, like that of radon in the atmosphere, falls off from the bottom of the ocean to the top and provides an index of the slow mixing of the ocean waters.

Neither uranium 238 nor thorium 232 enters appreciably into the metabolic processes of living organisms, and neither do most of their descendants. The radiation that man receives from these elements is thus largely external. However, radium 226 and lead 210, of the uranium series, and radium 228, of the thorium series, can be taken up by plants and so travel eventually to man. In the

human body they concentrate in bone and thus by themselves contribute about half as much radiation to the skeleton as do all their relatives put together. Potassium also enters into biological processes, and distributes itself through the soft tissues. It provides the bulk of the natural radiation that originates within the body.

Just after World War II Willard F. Libby at the University of Chicago opened up a whole new field of natural radioactivity. He began the study of radioisotopes produced by the most energetic radiations known: cosmic rays. These particles crash into the upper atmosphere and there shatter nuclei of nitrogen, oxygen and other atmospheric gases. On the average these collisions



TRANSPORT OF RADIOISOTOPES from soil and rocks to atmosphere, living organisms and ocean is shown in this schematic diagram. Solid-line arrows indicate radioactive decay; broken-line arrows, physical transport of isotopes. Uranium 238 (U^{238}),

thorium 232 (Th^{232}) and potassium 40 (K^{40}) are the three chief natural radioisotopes. In soils U^{238} and Th^{232} both release radon (Rn), a decay product, into the atmosphere; K^{40} releases traces of stable argon (A^{40}). Radium (Ra) and lead 210 (Pb^{210}), radio-

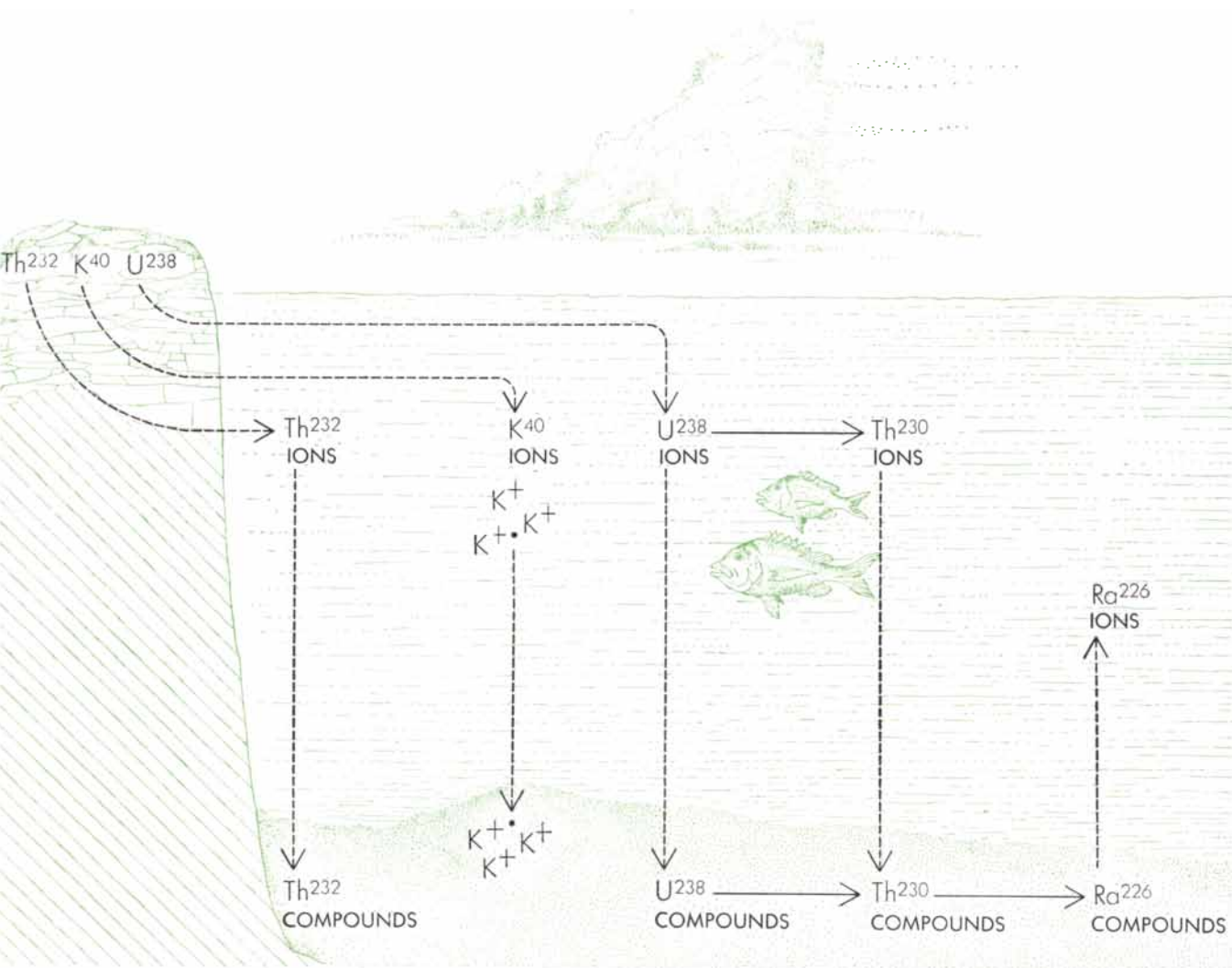
transmute about four atoms per gram of air per minute in the region between seven and 15 miles above the ground. Some of the new atoms are stable and so are indistinguishable from "old" atoms of the same nuclear species. Some, however, are radioactive and can be detected by sensitive methods. The most interesting of these is carbon 14, formed by the interaction of a secondary neutron and an atom of nitrogen [see top illustration on next page]. Because neutrons are common products of nuclear reactions, and nitrogen is the principal constituent of the atmosphere, carbon 14 is relatively abundant—perhaps we should say only slightly rare. The carbon 14 produced by cosmic rays accounts for about one atom of atmospheric carbon in a trillion.

The distribution of carbon 14 in the

atmosphere and at the surface depends on its chemical properties, which are of course identical with those of ordinary carbon (carbon 12). Most carbon 14 exists in the form of carbon dioxide; thus it is carried in the turnover of carbon dioxide from the atmosphere into the oceans and through the biosphere. Delicate measurements of the differences in radioactive carbon dioxide in different places show that on the average a carbon dioxide molecule spends five years in the atmosphere, five years in the surface layers of the ocean and 1,200 years in the deep waters. Such calculations are made possible by the long half-life of carbon 14 (5,600 years) and the precision with which its concentration can be measured. If the time-scale of the turnover of carbon dioxide were extremely short

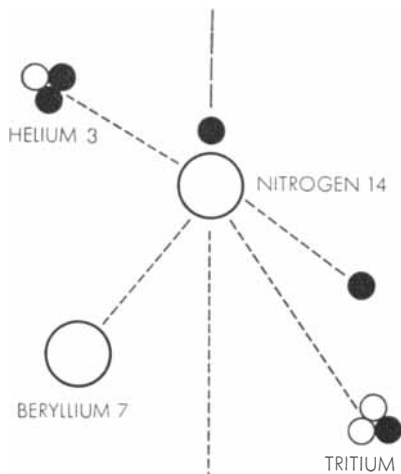
with respect to the half-life of carbon 14, all parts of the atmosphere-ocean exchange system would maintain approximately the same ratio of carbon 14 to stable carbon 12. However, if carbon 14 atoms are "kept waiting" (as they are at the interface between the atmosphere and the oceans), some of them will decay in the air rather than in the water, giving atmospheric carbon dioxide a slightly higher radioactivity. Measurable differences of this sort actually exist; they enable us to plot the planetary circulation of carbon dioxide.

Since living organisms consist almost entirely of carbon compounds and water, carbon 14 is concentrated as it passes through the biosphere. Its internal emissions in human tissues amount to about 1 per cent of the background radiation.

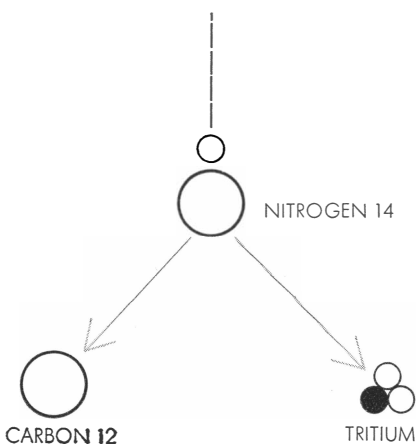


active decay-products of uranium and thorium, can be absorbed by plants and then by animals. Thorium washed into the ocean rapidly precipitates as insoluble compounds. Potassium remains in solution, but some of its ions become attached to particles of clay

(black dots) which fall to the bottom. Uranium precipitates more slowly than thorium. Its decay product, thorium 230, precipitates rapidly, but decays into radium, some of which dissolves back into the ocean. Diagram does not show all steps of the decay reactions.



CARBON 14 is formed in the atmosphere by a two-stage process. A high-energy proton (black sphere) from space shatters a nitrogen atom; one of the fragments, a neutron (white sphere), reacts with another nitrogen atom, yielding carbon 14 and a proton



TRITIUM (hydrogen 3) is produced by a similar process; in this case the reaction between the neutron and the nitrogen atom yields tritium and carbon 12. Tritium can also be produced by the shattering of a nitrogen atom, as shown in the drawing at top.

The relative abundance of carbon 14 in organic substances gives the archaeologist a technique for dating wood, bone and other old organic materials.

Man's consumption of fossil fuels during the past 50 years has been decreasing the radioactivity of atmospheric and biological carbon. Because the carbon 14 in coal and oil has long since decayed, the carbon dioxide from the combustion of these substances, amounting to about 15 per cent of the mass of atmospheric carbon dioxide, is nonradioactive and has diluted the carbon 14 content of the atmosphere. As the inert carbon dioxide has mixed into the oceans our consumption of fossil fuels has provided a sort of tracer experiment in reverse.

Another cosmic-ray product of great scientific interest is hydrogen 3 (tritium). Tritium is formed by a number of processes, most often by the transmutation of atmospheric nitrogen atoms. Only about 20 pounds of natural tritium exist on earth, the bulk of it in the oceans. Combining with oxygen to make water, it reaches the earth as rain or snow. With a half-life of only 12.5 years it does not travel nearly so far as carbon 14 before disintegrating. Water samples from different sources show marked differences in tritium content. Because of the vast quantity of normal water in the ocean, water evaporating from the ocean surface has a low tritium content; as the water moves upward in the atmosphere its activity is increased by tritium from above. Water evaporated from land, on the other hand, consists mainly of recent precipitation relatively rich in tritium. As an air mass moves across a continent it is enriched with tritium from below as well as above. The cycle is closed when the rain falls on the ocean, and its load of tritium mixes into the surface water. A significant amount of tritium is also carried into the deep ocean before it decays.

The tritium picture has been badly blurred in recent years by the relatively enormous quantities of the isotope released in the testing of thermonuclear bombs. Some puzzling recent measurements have suggested that even apart from bomb tests the earth contains much more tritium than can be accounted for by cosmic-ray production. Studies now under way may resolve this problem before long.

One does not use a grandfather clock to time a footrace, nor a stop watch to reckon the passing of the seasons. An isotope "clock" must likewise be chosen for its appropriateness to a particular scale of time. The best uranium measure-

ments, for example, are accurate to no more than 20 million years—a small error in measuring the age of the earth but hopelessly too large to resolve the comparatively recent onset of the Ice Age. As our list of cosmic-ray-produced isotopes expands, we are finding that nature has been remarkably accommodating in providing clocks suitable for a variety of measurements. Thus beryllium 10, with a half-life of 2.5 million years, promises to help fill the gap between uranium and carbon-14 dates. Silicon 32, with a half-life of 700 years, may enable us to time processes of oceanic mixing for which the carbon-14 clock is too slow and the tritium clock too fast. Phosphorus 32, beryllium 7 and sulfur 35, with half-lives of a few weeks, serve to clock the much faster processes of atmospheric circulation. Certain man-made isotopes, principally those generated in nuclear explosions, are beginning to be used for the same purpose.

Starting with the first thermonuclear explosions in 1952, the testing of nuclear weapons has been radically altering the relative abundance of radioactive isotopes in the environment. The energy yield of all the tests conducted by the three nuclear powers prior to the tacit agreement to suspend tests in November, 1958, had added up to 174 megatons (equivalent to the yield from 174 million tons of TNT), of which 92 megatons came from the fission of heavy nuclei and 82 megatons from the fusion of light nuclei. From these tests, as their principal radioactive by-product, came more than 4.5 tons of fission products: the direct offspring of the fission of uranium and plutonium, which are produced at the rate of roughly 100 pounds per megaton of fission yield. Thermonuclear explosions in addition yield tritium as a direct product of the fusion reaction; the total output to date is estimated at 100 pounds, about five times the amount of natural tritium. Other isotopes arise as secondary products of the interaction of neutrons with the materials of the bomb and the gases of the atmosphere, and with the substances in the soil and sea if the burst is at the surface. Among these isotopes the most abundant is carbon 14.

Produced at a considerably higher rate over the past seven years than the natural product of cosmic-ray neutrons, the man-made carbon 14 now in circulation around the earth amounts to about one ton and equals about 1 per cent of the total natural abundance. Most of it is still in the atmosphere compounded in carbon dioxide. In living organisms it has

raised the carbon-14 content as much as 10 per cent above normal, a situation that may confuse future archaeologists.

The fission products liberated by the nuclear explosion would be cause for greater concern than they have aroused were it not for the fact that most of them are so short-lived. Roughly speaking, the radioactivity of the fission-product mixture decreases by 90 per cent for each seven-fold increase in time following the explosion that produced it. Thus the level of activity seven hours after the explosions is about a tenth the level after one hour; two weeks (about 7³ hours) later the activity has dropped to about a thousandth the one-hour figure.

Of the more than 90 different radioisotopes identified among the fission products, two have figured at the center of scientific and public concern: strontium 90 and cesium 137. Both are produced in substantial quantities by nuclear fission, both have relatively long half-lives (about 25 and 30 years respectively) and both become engaged in the metabolism of the human body. Neither element is a normal constituent of biological processes. But the chemistry of strontium resembles that of calcium. Like calcium it concentrates in the bone, where its radioactivity may give rise to leukemia and bone tumors. Strontium 89, a short-lived fission product, follows the same metabolic pathway. Cesium, on the other hand, somewhat resembles potassium and its radioisotope concentrates in the soft tissues of the body, with particular hazard to the genes.

Tests so far have produced about 140 pounds of strontium 90, with a total radioactivity of nearly 9.2 million curies. By the end of 1958 decay had reduced these figures to about 130 pounds and 8.5 million curies; cesium 137 radioactivity at the same time amounted to 15 million curies.

Two other isotopes, iodine 131 and barium 140, have recently attracted attention. Barium, like strontium, concentrates in the skeleton; iodine, in the thyroid gland. Because they have short half-lives, radioiodine and radiobarium have been at near-zero levels since early this year. Other bomb products, such as radioisotopes of zinc and cobalt, may play a minor role in marine ecology, because some oceanic organisms concentrate relatively enormous quantities of these elements in their tissues. However, only minute quantities of these isotopes are likely to reach human beings.

The distribution of strontium 90 and other fission products, and hence their

effects on man, depend largely on the type and location of the explosion that produced them. Surface explosions over land vaporize and irradiate great quantities of soil and so yield a heavy local fallout; 80 per cent of it comes down in a matter of hours, spreading downwind from the site of the explosion in an irregular elliptical pattern. Over water the close-in fallout drops to as low as 20 per cent of the total. Although contamination of areas adjacent to testing sites has occurred, local fallout has played only a small role in human affairs. In war, however, local fallout from a megaton weapon would deliver lethal external gamma radiation to unsheltered people in areas of thousands of square miles, and the strontium 90 would render soils unfit for agriculture over even larger areas for generations afterward.

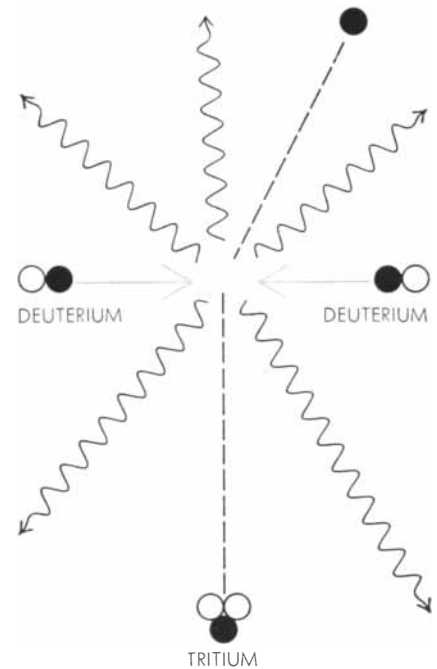
Detonations of 100- to 200-kiloton yield at or near the surface propel their fission products no higher than the troposphere, the turbulent lower layer of the atmosphere. Convection currents in the troposphere rapidly mix air from various altitudes, so that tropospheric fallout comes down in a few months at most. Most of it is scavenged by rain or snow, with the larger particles simply drifting to earth. Since tropospheric winds rarely cross the Equator, most tropospheric fallout remains in the hemisphere where it originated. It accounts for only a small percentage of the fallout from weapons tests.

High-yield nuclear tests thrust their radioactive clouds into the stratosphere, where vertical mixing of air is slow and precipitation nil. The tiny radioactive particles (less than 1/10,000 inch in diameter) remain aloft for periods ranging from months to years, and are spread over large parts of the earth's surface by high-altitude winds. Stratospheric fallout, which accounts for about two thirds of total fallout, is the dominant source of artificial radioactivity that weapons tests have introduced into the environment.

The first observations of stratospheric fallout indicated that it remained aloft for five to 10 years—long enough to become evenly distributed between the Northern and Southern hemispheres. This comported with the idea that the stratosphere was a continuous, stable envelope enclosing the turbulent air masses of the lower atmosphere. Recently, however, the record revealed that the fallout has tended to concentrate in the North Temperate Zone and to come down at a maximum rate in the

spring. Some investigators proposed that seasonal and latitudinal variations in the transport of air from stratosphere to troposphere might be responsible. However, this hypothesis did not explain the absence of comparable concentrations in the Southern Hemisphere.

By measuring the ratios of long-lived to short-lived fallout isotopes in rainwater, investigators have been able to establish the time and place of the explosions that generated the fallout. Since the initial proportion of one fission product to another is about the same in each nuclear explosion, such measurements make it possible to extrapolate backward from the observed ratios and thus to estimate the dates of the original explosions. Recent interpretations of these measurements have revealed the existence of stratospheric fallout much "younger" than five years. During the summer of 1958, a separate study of rainfall from the tropical air masses that move up over the U. S. from the Gulf of Mexico showed that the extrapolated time of origin of the fallout delivered by this rainfall matched the dates of certain U. S. medium-yield tests conducted several months previously. Fallout in rains from "polar" air masses during the same period had apparently originated in high-yield Soviet tests conducted a



MAN-MADE TRITIUM is a by-product of some thermonuclear (fusion) reactions, such as that between two deuterium (hydrogen 2) atoms; proton (black sphere) is another by-product. The reaction also yields energy in the form of gamma rays (wavy arrows).

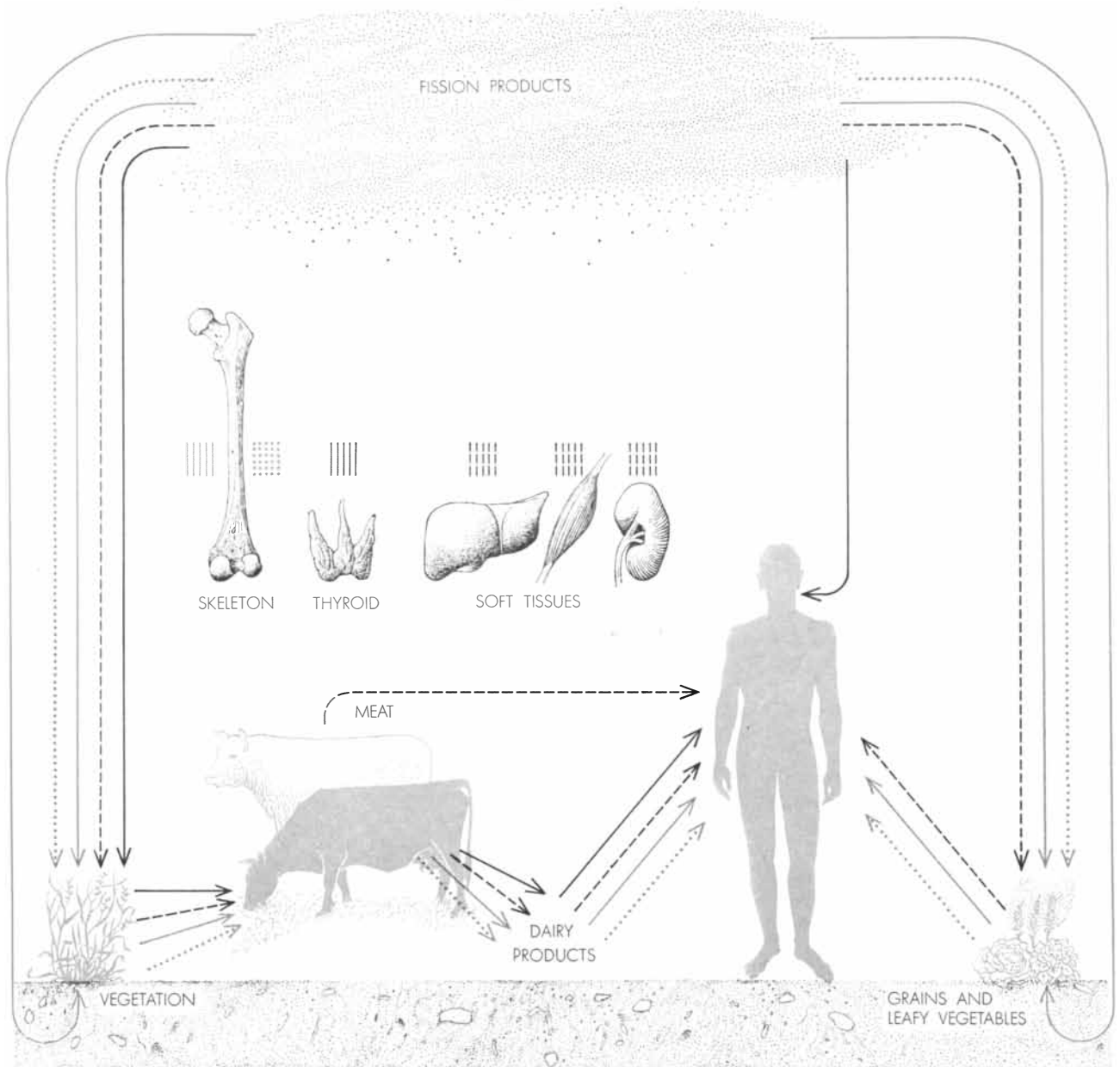
little earlier. The highest concentrations of strontium 90 were invariably associated with the Soviet tests.

The unexpected rapidity of the stratospheric fallout from Soviet tests focused attention on a peculiarity of the tropopause, the boundary between stratosphere and troposphere. Over the Equator, the tropopause lies about 10 miles up. Over the middle latitudes it

dips sharply to about six miles. Here the jet streams—high-altitude winds that blow from west to east parallel to this dip—create a gap in the tropopause. Several meteorologists had already called attention to the possibility that the stratosphere and the troposphere exchange air through the gap.

A little calculation showed that Soviet fallout injected into the lower stratosphere could have been carried by the

movement of stratospheric air through the tropopause gap into the troposphere, where vertical mixing would bring it fairly rapidly to earth [see illustration on page 93]. Fallout from U. S. and British high-yield tests, all of which have taken place near the Equator, has been evenly distributed over the world. Soviet tests, on the other hand, have been carried out north of a latitude of 50 degrees. Substantially all the fallout they have



PATHS OF ENTRY by which fallout reaches human beings are shown schematically for the five fission products of greatest biological importance. Strontium 89 and 90 (solid colored arrows) reach man through the soil and, more directly, by contaminating surfaces of plants. Cesium 137 (broken black arrows) forms insol-

uble compounds in soil and thus reaches us only by the more direct paths. Iodine 131 (solid black arrows) and barium 140 (dotted arrows), because of their short half-lives, reach man only as surface contaminants and (in the case of iodine) by inhalation. Once absorbed, the isotopes concentrate in different parts of the body.

produced has remained in the Northern Hemisphere. Most of it has reached or will reach the ground in the densely populated North Temperate Zone. The spring peaks in fallout evidently stem from the timing of the Soviet tests, which have been conducted in the autumn and winter.

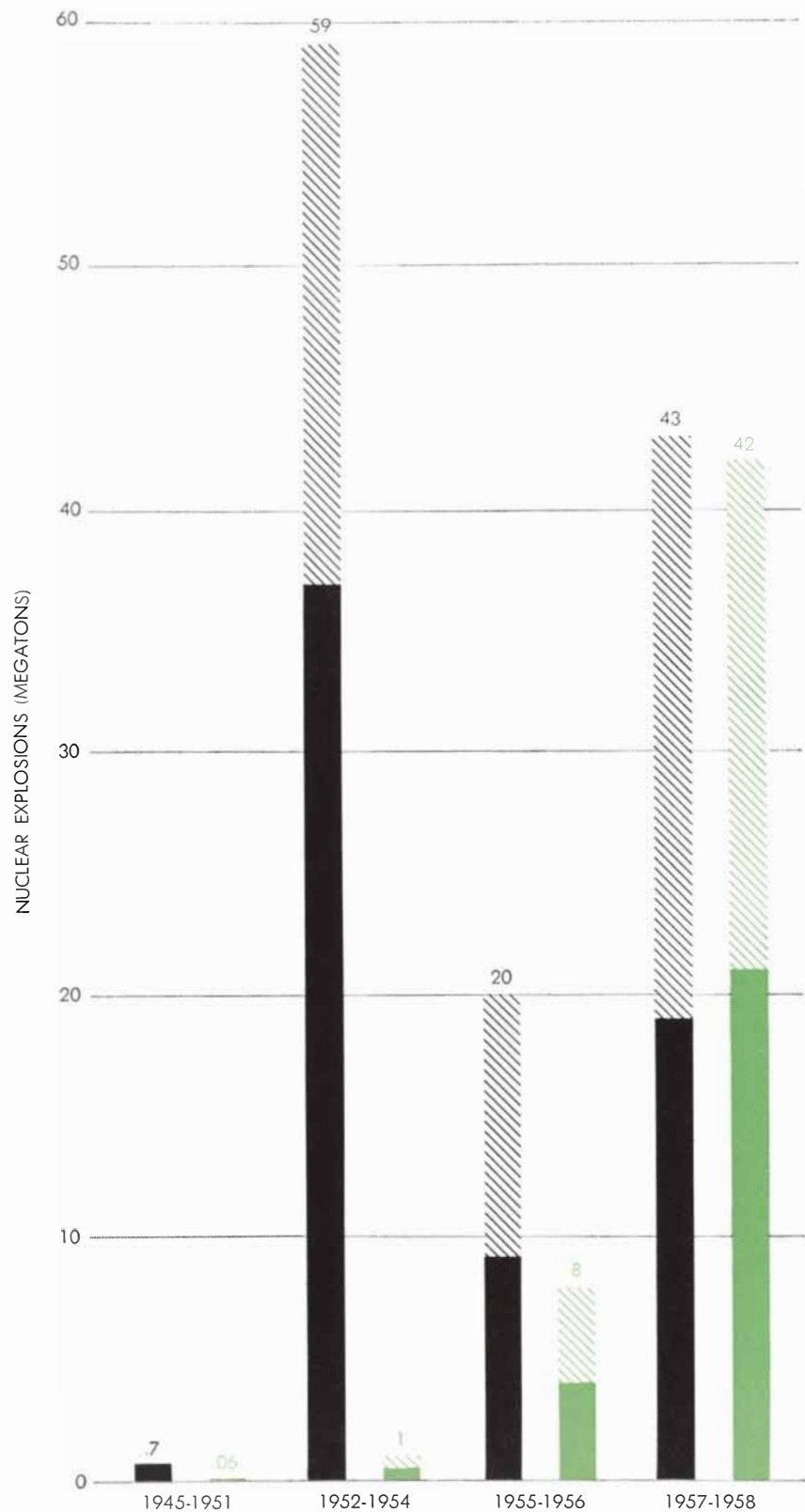
The tests in the U.S.S.R. last October gave strong confirmation to this theory: they produced a record peak in the fallout of strontium 90 over the Northern Hemisphere this past spring. Short-lived fission products appeared in this fallout in high concentrations, while throughout the Southern Hemisphere they remained near zero.

These findings with respect to man-made fallout suggest that a similar pattern may be found in the distribution of "fallout" from cosmic-ray action. Because the magnetic field of the earth funnels cosmic rays toward the poles, the major production of natural radioisotopes occurs in those latitudes and would presumably come to the surface via the gap in the tropopause.

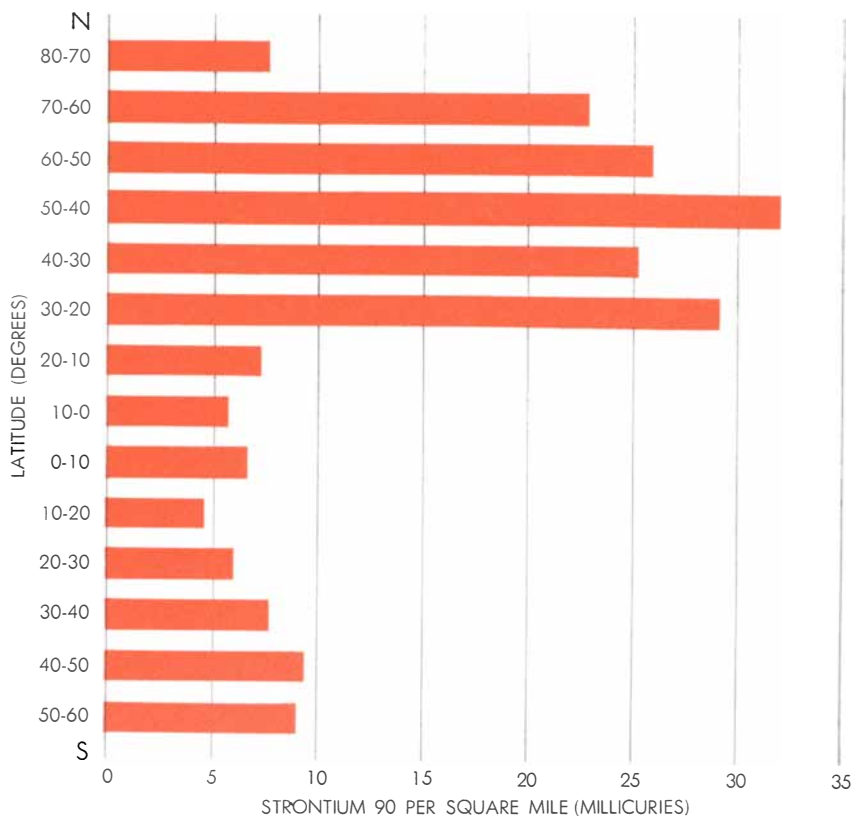
The revised picture of atmospheric circulation makes it possible to forecast with some assurance the present and future distribution of strontium 90. From the nine million curies of this isotope produced to date, local fallout on U. S. and British test sites or in the Pacific Ocean subtracted three million curies at the outset. The Soviet tests produced little local fallout, since few or none of them were surface shots. Thus essentially all the remaining six million curies were injected into the stratosphere.

On the basis of a recent world-wide survey of strontium in soils, made by L. T. Alexander of the U. S. Department of Agriculture, it appears that 3.2 million of these six million curies had already come down to earth by October, 1958: 2.4 million in the Northern Hemisphere and .8 million in the Southern. The strontium reached a peak concentration, averaging about 33 millicuries per square mile, between 40 and 50 degrees north latitude. As for the 2.8-million-curie balance still in the stratosphere, the atmospheric circulation data indicate that most of it will have fallen out by 1965. Coming down in the same geographic pattern, it will approximately double the radioactivity of the soil produced by strontium 90 as of October, 1958. The fallout of cesium 137 should follow a similar pattern, and will contribute a somewhat higher radioactivity to the soil.

So long as these man-made radioisotopes remain on the ground, their



INCREASE IN NUCLEAR EXPLOSIONS since 1945 is depicted in this chart. Black bars indicate U. S.-British explosions; colored bars, Soviet tests. Fission explosions, indicated by solid parts of the bars, are the chief source of man-made environmental radioactivity, yielding about 100 pounds of fission products per megaton. Fusion reactions, shown by hatching, produce almost no fallout. The proportion of fission to fusion in Soviet tests is estimated.



CONCENTRATION OF FALLOUT in the Northern Hemisphere is shown on this chart, based on a world-wide study of strontium in soils by L. T. Alexander of the U. S. Department of Agriculture. The concentration results from the peculiarities of atmospheric circulation shown on the opposite page. Fallout still aloft will roughly double these figures by 1965.

activity constitutes only a small addition to the external background-radiation to which living things are exposed. But once they are entrained in the chemistry of the biosphere their effective activity is heightened by concentration, and they irradiate living cells and tissues from within. Not many fission products find a place in biochemistry. The few that do follow various pathways in the food chain and some of them ultimately arrive in the tissues of human beings.

Strontium 90, for example, can be picked up from the soil in the metabolism of a plant, ingested by a dairy cow and delivered to the table in milk or butter. It may, however, skip one or more of these links in the food chain and arrive as a mere surface contaminant adhering to leafy vegetables and grain. Cesium 137, on the other hand, tends to form insoluble compounds in the soil and thus does not enter into plant metabolism. It is, however, ingested by beef or dairy cattle as a contaminant of grasses and passed on in meat or milk.

At each stage in the food chain the nutritional processes of the plant or animal tend to discriminate against strontium 90 in favor of its chemical analogue,

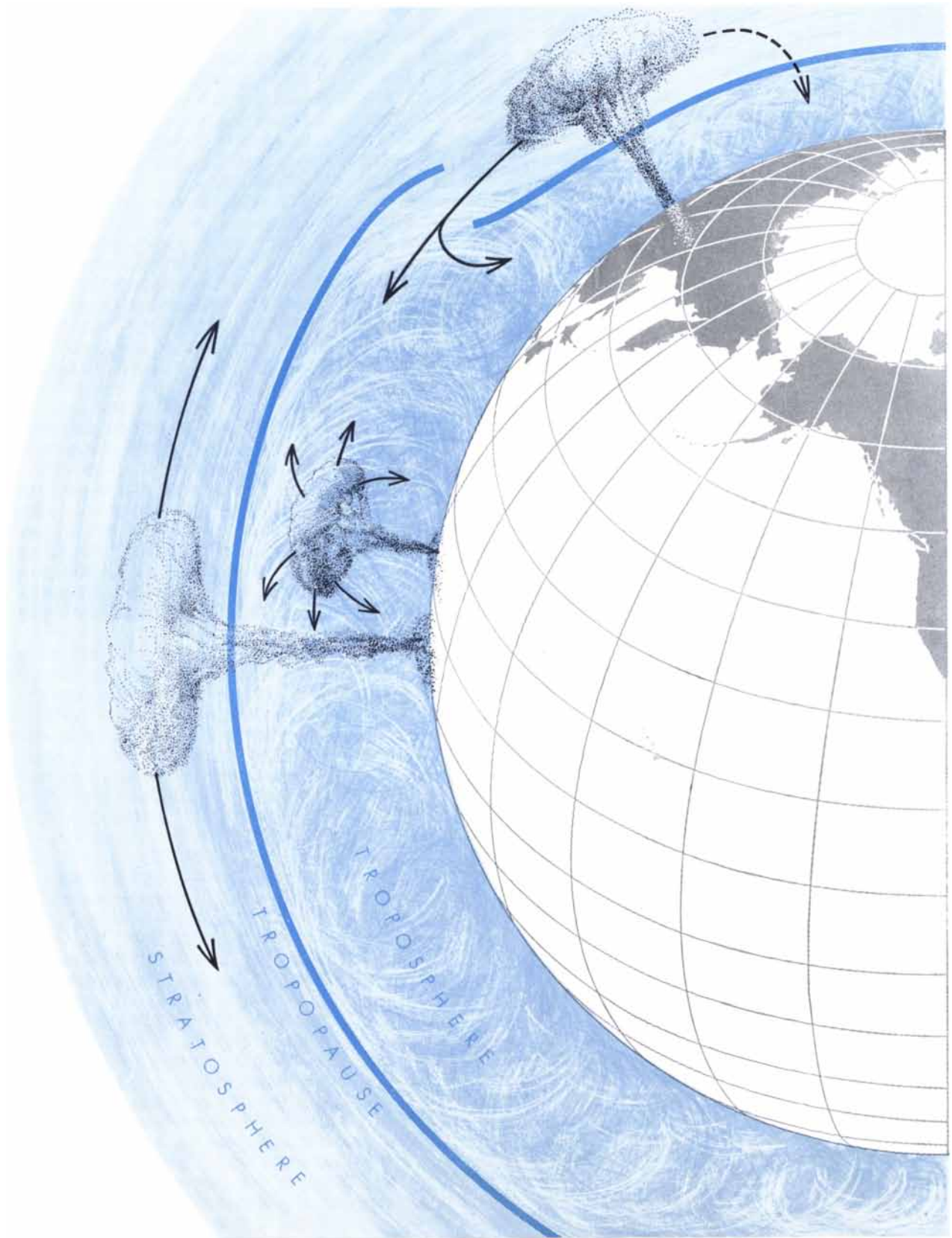
calcium. Thus the ratio of radiostrontium to calcium will decrease as the two move together up the chain. At the first stage it seems that the strontium-calcium ratio in the plant varies not only with the ratio in the soil, but also with the character of the soil and ground cover, the method of cultivation and the type of plant. For example, in a soil matted with roots the radiostrontium coming down from above will not be so quickly diluted with calcium and so will be absorbed by the plant in a higher ratio to calcium. In animals, according to C. L. Comar of Cornell University, the chemical balance of metabolism regulates the strontium-calcium ratio more rigorously; the animal preferentially incorporates calcium into its tissues and rejects strontium. The ratio in a cow's milk is about 11 per cent of the ratio in the animal's fodder. In the human body the ratio diminishes still further; Comar estimates that the overall decline in the ratio from plant to man will be 90 per cent in the case of the average U. S. citizen, who obtains most of his calcium from dairy products. Where people live on a cereal diet and get most of their calcium from plants, without the intervening dis-

crimination by animal metabolism, the drop is smaller. In any case the introduction of the radioisotopes into the tissues raises the effective biological activity far above the contribution that the same quantity of radioisotopes makes to external background radiation. Clearly the subject of biological transport of fallout requires much more research.

Some recent tracer experiments promise to refine our knowledge of the fallout of natural and man-made radioactivity and of its ultimate distribution over the earth. During the U. S. nuclear tests of last summer, rhodium and tungsten were incorporated into some of the bombs. Neutrons from the explosions partially transformed them into the radioisotopes tungsten 185 and rhodium 102. The travel of these isotopes in the atmosphere can be followed easily. Tungsten 185, with a half-life of 74 days, was injected by several medium-yield explosions into the lower stratosphere. Several laboratories are sampling stratospheric and surface air and analyzing precipitation at a number of points in order to follow its history; the findings of this study should be published by the end of this year. Rhodium 102, with a longer half-life of 210 days, was chosen to study the longer-term processes at higher altitudes, and so was injected chiefly into the upper stratosphere. By comparing its history with that of the tungsten we should obtain some useful measurements of the effect of altitude on residence time and distribution of fallout.

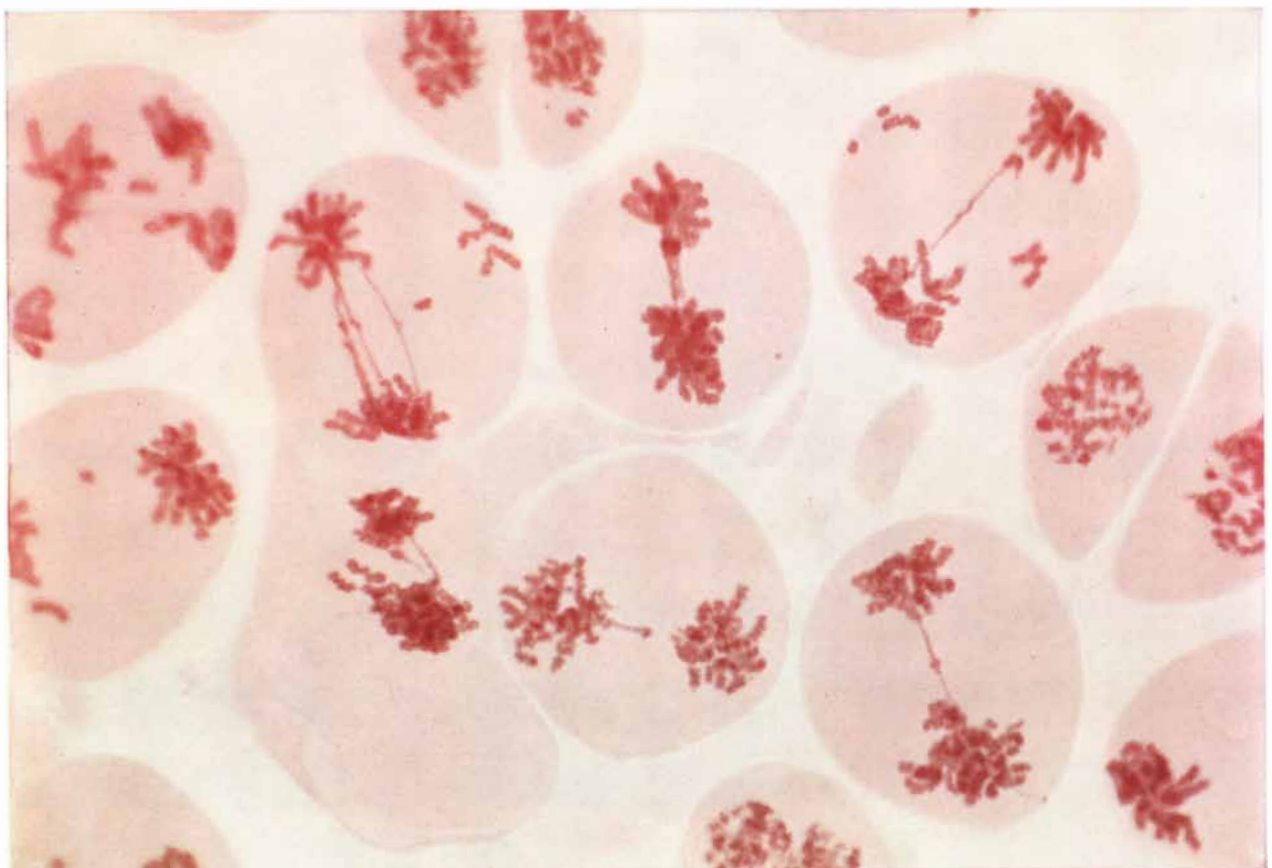
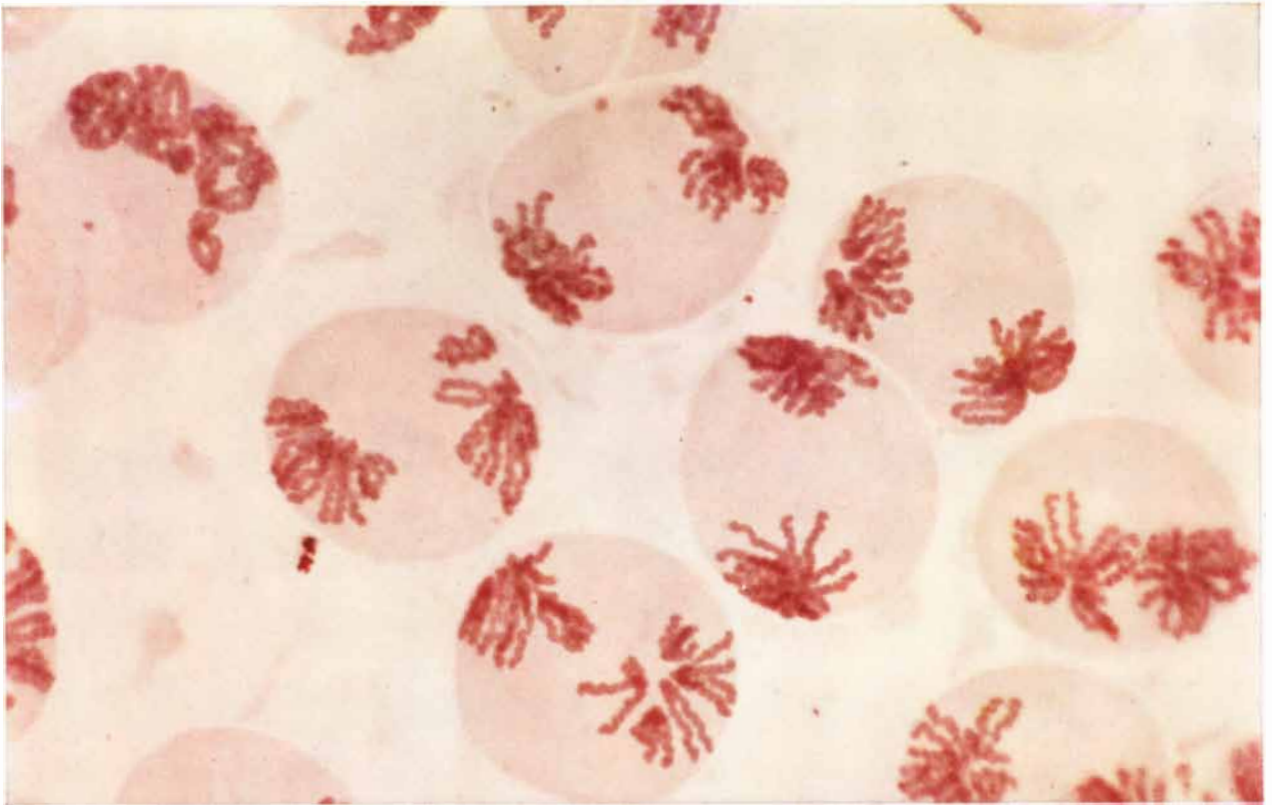
The waste products of nuclear reactors constitute an additional source of man-made radioisotopes. These wastes, mainly fission products, pose many of the same biological problems as bomb debris. Indeed in the long run—barring a nuclear war—radioactive wastes will far outweigh the products of nuclear explosions. Fortunately man can decide within wide limits when and where he will release these substances into the environment. Our expanding knowledge of the atmosphere and ocean should enable us to do so in such a way as to minimize their effect on living organisms.

As this article is written, international discussions of a ban on the testing of nuclear weapons are continuing at Geneva. Such a ban would bring an end to this peculiar form of atmospheric contamination. As a consequence it would certainly improve our opportunity to investigate the fallout of both natural and artificial radioactivity and thus to learn more about the circulation of the oceans and the atmosphere.



DISTRIBUTION OF FALLOUT depends on the size and location of the original explosion. High-yield test near the Equator (*left*) thrusts its fission products into the stratosphere, where horizontal circulation slowly spreads it over both hemispheres. Low-yield test (*left center*) does not reach the stratosphere; vertical mixing in the troposphere brings down its debris into one

hemisphere in a matter of weeks. Debris from high-yield Soviet test at high latitudes (*top*) will be carried by horizontal circulation through tropopause gap and to some extent through the tropopause itself at higher latitudes (*broken arrow*). Most of it will come down over the North Temperate Zone. The scale of the atmosphere and the explosions is greatly exaggerated for purposes of clarity.



EFFECT OF RADIATION ON CHROMOSOMES is depicted in these photomicrographs made by Arnold H. Sparrow and Robert F. Smith of the Brookhaven National Laboratory. At top are cells from the wake-robins plant (*Trillium erectum*); their threadlike

chromosomes have been stained with acetocarmine. At bottom are cells in same stage of division that had earlier been exposed to 50 r of X-rays. In many of these cells are fragments of chromosomes and chromosome bridges. The cells are enlarged about 1,000 diameters.

Ionizing Radiation and the Living Cell

The primary site of the biological effects of radiation is in the cell. The specialized structures of the cell, including the genes, are damaged not only by direct hits but also by the chemical products of radiation

by Alexander Hollaender and George E. Stapleton

The processes of life involve a relatively low turnover of energy and a high degree of self-regulating harmony. In contrast, ionizing radiation conveys huge packets of energy and, upon interaction with living matter, provokes anarchy. The consequences may run, in extreme circumstances, to the derangement of the hereditary mechanism or to the death of the organism. In every case the ultimate damage arises from the injury done to individual cells. But injury to the cell must itself be understood in terms of the events that occur in the substance of the cell along the path of the ionizing ray or particle. Like the ionizations that mark the track of a particle in a cloud chamber, these are discrete and specific events in which particular molecules are involved. The biological outcome thus depends not so much on the amount of energy impinging on the cell as on the energy absorbed by the molecules caught in the track of ionization.

As Robert L. Platzman has observed elsewhere in this issue [see "What Is Ionizing Radiation?," page 74], free ionized molecules are uncommon in biology except as the primary products of ionizing radiation. These may be otherwise intact molecules, with one or more electrons stripped from them, or the ionized fragments of larger molecules. In their highly reactive state they enter almost instantly into reactions with one another and with neighboring molecules, producing as their end products new substances strange to the chemistry of the cell. The unstable secondary products, notably free radicals and peroxides, relay the disturbance in turn to other molecules in the cell, enlarging the area and scope of the injury. It is in the secondary, chemical phase of this process that the biologist begins his studies. Recent in-

vestigations have indicated that a limited portion of the damage is amenable to experimental modification. Experiments on this line have begun to elucidate the steps between the primary physical event and the biological expression of its impact upon the cell.

Many years ago radiobiologists first noted that the number of cells inactivated by a given exposure to radiation is a simple function of the number of living cells present. In other words, the fraction of cells damaged per unit dose is constant. Investigators also observed that the number of cells in which genetic mutation occurs follows the same rule. Thus the biological effects show up in accord with the randomness of events along the paths of ionizing particles. J. A. Crowther of the University of Cambridge therefore postulated about 35 years ago that the death or inactivation of a cell results from a "hit" on a sensitive spot. Implicit in the hit theory was the assumption, later confirmed by experiment, that certain biological consequences may follow from the passage of a single particle or from the ionization of a single molecule or cellular structure. Crowther's hit theory was duly amended by the "target" theory, which postulates that the incidence of hits is related to the size of the sensitive structure or molecule: the fewer the hits required to inactivate the cell, the larger the structure must be.

Radiobiologists thus found themselves in possession of a technique for determining the size, shape and structure of key submicroscopic parts of the single cell. In order to ensure that the effect under investigation is the direct result of the primary ionization, the technique requires the removal of water and other molecules that aid in the transfer of

energy from the primary event. Although the effects observed on dehydrated cells are not necessarily comparable to the effects on cells in their natural state, such investigations have yielded important information. Inactivation studies using particles of various energies have provided the basis for constructing models of virus particles and bacterial spores which in some cases have shown a close resemblance to the structures later observed by electron microscopy. Since high-speed electrons have a low probability of hit, as Platzman explains in his article, they are used to measure the volume in which a collision will produce inactivation. For example, the three-dimensional structure of bacterial spores was plotted with electron beams of various energies, from a beam that was barely able to penetrate the spore coat to one that could permeate the sensitive material within the spore. On the other hand, the high probability that an alpha particle will interact with molecules in its path makes it possible to use these particles to find the cross-sectional area of the structure under investigation. The same technique has even been applied to the determination of the shape and size of individual biological molecules.

In the opinion of some biologists, however, the dehydration necessary for these studies removes precisely those complicating indirect and secondary reactions that are of significance in the intact living cell. Since the cell is 75 per cent water, it is apparent on the basis of abundance alone that more energy is absorbed by the water molecule than by any other molecule in the cell. The peroxides and free radicals that result from the ionization of water are among the most important toxic agents involved in the ultimate inactivation. By diffusing

through the water in the cell these agents may act directly on the target molecule or indirectly via the reactive products of their action on other molecules.

C. A. Tobias of the University of California and Raymond E. Zirkle of the University of Chicago have proposed a working model for such indirect effects in the inactivation of yeast cells. They visualize the target molecule as surrounded by a liquid medium; the target can be considered "hit" if it interacts with activated molecules or free radicals diffusing to it from the medium. As a picture of the usual course of events in the cell, this model is sustained by experiments in which yeast, bacteria and other cells are exposed in the frozen state to ionizing radiation. The cells prove to be remarkably insensitive in this condition, undoubtedly because freezing curtails the process of diffusion. The same line of reasoning suggests that compounds which react with the oxidizing agents produced by irradiation should be able to intercept these agents before they interact with sensitive material. Such reducing compounds, especially the mercaptoalkylamines, have proved to be fine protective agents, reducing the radiation sensitivity of some bacteria as much as freezing or dehydration does.

Franklin Hutchinson of Yale University has recently shown that the mean diffusing distance of the reactive intermediates produced by radiation is in the neighborhood of 30 angstrom units (an angstrom unit is a hundred millionth of a centimeter). In other words, the indirect effects occur close to the track of the ionizing particle. Hutchinson bases this determination on his measurement

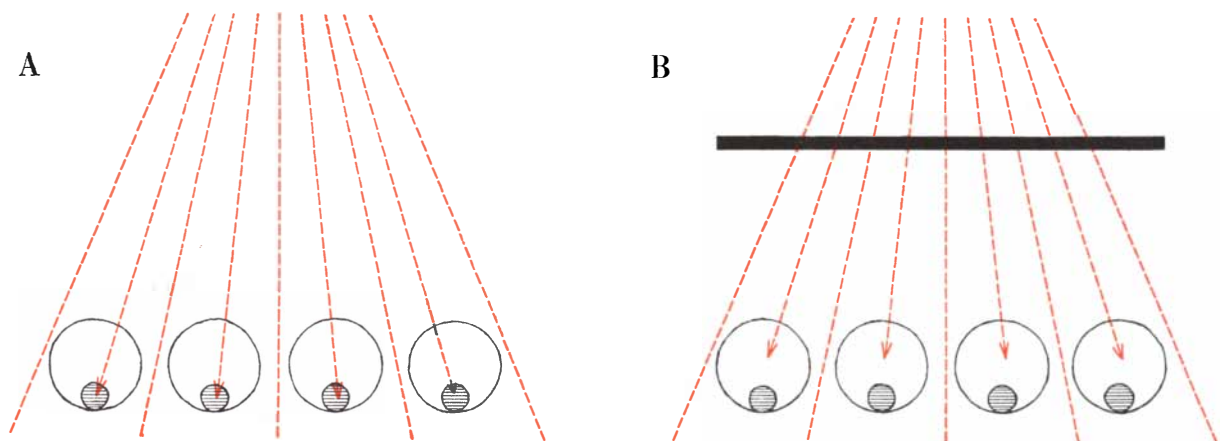
of the relative sensitivity of two enzymes and a coenzyme in normal and dried yeast cells. His data also show that in the normal cell indirect inactivation is of greater importance for smaller molecules, and conversely that inactivation by direct hits is more likely for large molecules. In the case of an enzyme isolated from the cell, Walter M. Dale of the University of Manchester has shown that the proportion of effect due to indirect action increases as the enzyme is diluted and the ratio of water molecules to enzyme molecules is increased.

The passage of energy from molecule to molecule seems to be enhanced if the two are joined in some fashion. For example, when the enzyme hyaluronidase is irradiated dry in the presence of hyaluronic acid (its substrate, or the substance upon which it acts), it is inactivated by a single ionization anywhere in the enzyme-substrate complex, indicating that energy migrates from one molecule to the other. On the other hand, no energy passes between individual protein molecules in a pure enzyme preparation. When low-voltage electrons with limited range are allowed to impinge on dried preparations of the enzyme invertase, only the molecules actually struck by the particles are inactivated. It may be that the binding of the molecules in the enzyme-substrate complex is sufficient to permit migration, whereas energy cannot migrate in molecules not bound to one another.

As one might expect, the structure in the cell that proves to be most sensitive to ionizing radiation is the nucleus—the coordinating and directing center of the cell and the bearer of its genetic plan. Zirkle made this finding almost 30 years

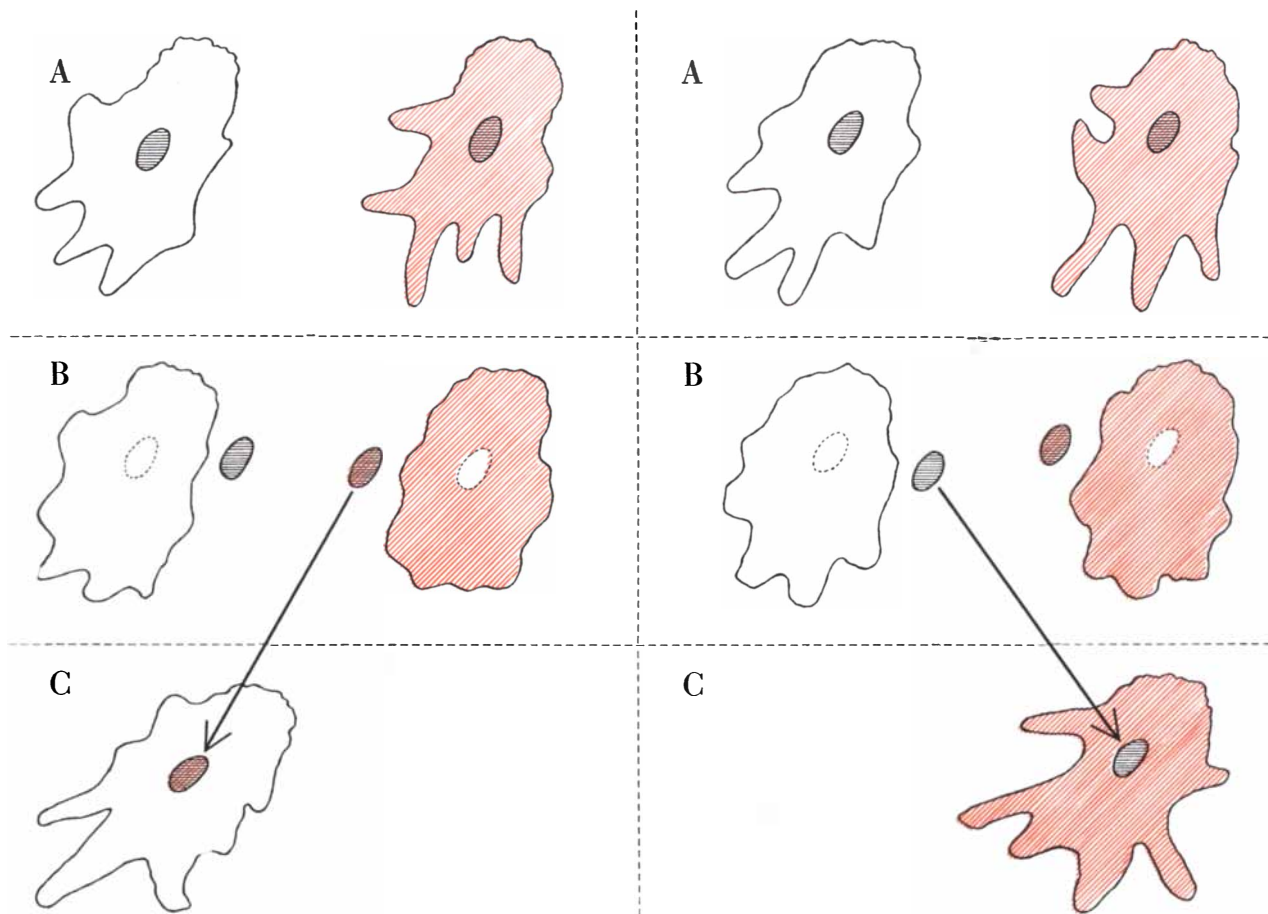
ago in what is now regarded as a classic experiment. He used fern spores that have an eccentric nucleus, the location of which is marked by an easily recognized spot on the coat of the spore. Zirkle could thus selectively expose the nucleus or the cytoplasm (that part of the cell which lies outside the nucleus) to a beam of alpha particles [see illustration below]. He observed that irradiation of the cytoplasm inhibited certain processes of germination—cracking of the spore coat, production of chlorophyll, cell division—but that irradiation of the nucleus inhibited these processes at much lower doses. More recently R. C. von Borstel has performed similar experiments at the Oak Ridge National Laboratory; he employed the egg of the wasp *Habrobracon*, which also has an eccentric nucleus. Von Borstel found that, on the average, a single alpha particle traversing the nucleus of the wasp egg prevents hatching, whereas it takes a million alpha particles traversing the cytoplasm of the egg to produce the same quantitative effect. Extremely narrow beams of radiation are now widely used in such studies, and the investigator is able to observe directly the effects of the irradiation on the structure and function of the cell under the microscope and to record his observations by microcinematography.

J. F. Danielli and Muriel Ord of Kings College in London, and Daniel C. Mazia and Henry I. Hirshfield, who were then at the University of Missouri, carried this line of investigation further, employing the delicate technique of microsurgery to transplant the nucleus of the single-celled amoeba to another amoeba. They found that the transplanting of an irradiated nucleus to an unirradiated cell



FERN SPORES (large circles) lined up with their nuclei (small hatched circles) at one side were exposed to alpha particles by Raymond E. Zirkle of the University of Chicago. When the cells were exposed without an absorbing filter (left), the particles penetrated both the cytoplasm (open area) and the nucleus. When they

were exposed with a filter (right), the particles could only penetrate the cytoplasm. Because certain germination processes of the cells exposed without a filter were inhibited by smaller doses of radiation than cells exposed with a filter, Zirkle concluded that the nucleus was more sensitive to radiation than the cytoplasm.



TRANSPLANTATION OF NUCLEI in the amoeba by several workers also demonstrated that the nucleus was more sensitive than the cytoplasm. At left the nucleus of an irradiated amoeba (*col-*

ored) is transplanted to an unirradiated amoeba; the latter survives about three days. At right the nucleus of the unirradiated amoeba is transplanted to irradiated one; latter survives some three weeks.

is significantly more often lethal than the transplanting of a healthy nucleus to an irradiated cell. Cells with an irradiated nucleus usually died within three days; an amoeba with an irradiated cytoplasm was slow in dividing but could survive for three weeks or more. The irradiated cytoplasm actually relayed the ionization damage to the unirradiated nucleus; when the nucleus was transplanted again to a cell with unirradiated cytoplasm, this also behaved abnormally.

The greater resistance of the cytoplasm to injury by radiation is probably related to the fact that it contains many multiples of each of its important structures; the nucleus, in contrast, rarely possesses more than one or two sets of chromosomes, its most important components. The spores of some fungi, however, contain various numbers of identical nuclei. When these are irradiated, the number of spores killed by a given exposure is in inverse proportion to the number of nuclei present. The cell dies

only after the last nucleus is inactivated. Similarly, in certain yeast cells that have one, two, three, four or more identical sets of chromosomes, much less radiation is needed to inactivate cells that have only one set.

Among the enzymes in the cytoplasm that conduct the principal energy-exchange functions of the cell, the ones that contain sulfhydryl groups (SH) are perhaps the most sensitive to ionizing radiation. Relatively small doses of ionizing radiation markedly reduce their biological activity. The inactivation apparently results from the oxidation of the sulfhydryl groups [see illustration on next page]. These enzymes, in consequence, are prey especially to the reactive intermediates liberated by the irradiation of the water in the cell, and the rate of inactivation is higher in dilute solutions. Characteristically the sulfhydryl groups appear in two places in the structure of an enzyme, either enclosed in the folds of the molecule or exposed in external active centers. The latter are of course more accessible to the effects of

oxidizing agents. But by the same token they should also be accessible to reducing agents that can effect a reversal of the oxidation. Experiments by the late E. S. Guzman Barron of the University of Chicago showed that enzymes containing exposed sulfhydryl groups can indeed be reactivated in this way.

Some cell damage can also be explained on the basis of changes induced by radiation in the permeability of the cell membranes. Such membranes not only envelop the cell itself but also divide the nucleus from the cytoplasm and provide containers within the cytoplasm that enclose enzymes with their proper substrates and separate them from other materials of the cell on which they might act. According to Z. Bacq of the University of Liège and Peter Alexander of the Chester Beatty Research Institute in London, irradiation may damage the membranes and permit enzymes to leak out. Increases in enzymatic activity often observed after irradiation of cells might be a result of this mechanism. A change in membrane permeability might also

be a factor in enzyme inactivation; a released enzyme might inactivate other enzymes with which it normally does not make contact.

Ionizing radiation may thus kill or injure the living cell in a variety of ways. But radiation also has far-reaching effects upon the most intricate of all life processes: the genetic mechanism by which the cell transmits its hereditary plan to its daughter cells. This plan is encoded in the genes contained in the chromosomes of the nucleus. The loss of some genes, damage to their structure or changes in the order in which they appear on the chromosome can have significant effects on the daughter cells if, indeed, the daughter cells are capable of life. The remainder of the nuclear material seems to be set aside for constructing the elaborate mitotic apparatus which ensures the equal distribution of the genetic material when the cell divides. Damage to the nucleus shows up in several ways: in "stickiness" of the chromosomes early in mitosis, in breakage or deformity of the chromosomes, in hereditary differences in the daughter cells. Radiation often causes damage that can be seen under the microscope: aberrations resulting from the breakage of two or more chromosomes and the subsequent rejoining of the broken ends. Fragments of different chromosomes may end up connected to one another, and one of these combinations may then lack the special structure called the centromere which is needed if the chromosome is to take part in mitosis and to be passed on to daughter cells. When the cell divides, the piece without a centromere is lost, and the daughter cell usually dies because it cannot survive lacking such a large number of genes. Broken chromosomes can form many

other combinations, but a large proportion of the aberrations produced are lethal.

Chromosome breakage can be caused not only by direct hits but also indirectly by reactive substances produced in the water surrounding the chromosomes. J. M. Thoday and John Read at the University of Sheffield found some years ago that many more chromosomal aberrations are produced in the root cells of the broad bean (*Vicia faba*) when the cells are exposed to X-rays in the presence of atmospheric oxygen than in its absence. At the Oak Ridge National Laboratory Sheldon Wolff and his associates have recently demonstrated that there are several intermediate steps between the absorption of energy and the final observable effect; the cell must be actively metabolizing and, particularly, synthesizing protein before the breaks can rejoin.

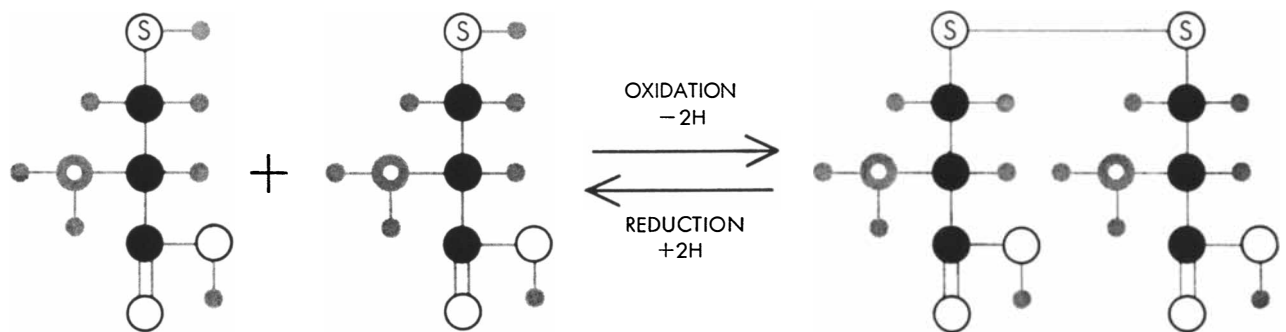
As James F. Crow and George W. Beadle demonstrate elsewhere in this issue, radiation-induced changes in the individual genes are perhaps more important than gross structural changes in the chromosomes. Charlotte Auerbach of the University of Edinburgh found that several chemical agents can produce gene mutations similar to those induced by ionizing radiation, suggesting that mutations might be a secondary result of radiation. In support of this interpretation a number of investigators have discovered that the observed frequency of mutations varies with the concentration of oxygen in the medium during irradiation. L. J. Stadler of the University of Missouri, who discovered that radiation induces gene mutations in plants, found some years ago that more mutations appear in plant cells when they are irradiated wet.

Investigators are now engaged in radiation experiments on the genetic sub-

stance itself, deoxyribonucleic acid (DNA), separated from the chromosomes of the cell. When the material is isolated together with the protein with which it is normally associated, the preparation has a gel-like quality indicating a degree of polymerization and hence an organized structure consistent with its function. Under extremely small doses of radiation the nucleoprotein is depolymerized and loses its gel-like quality. But Berwind P. Kaufmann with M. H. Bernstein at the Carnegie Institution of Washington prepared a synthetic combination of DNA and protein by mixing DNA and cattle serum albumin, and found that this preparation depolymerizes more easily under the influence of X-rays than does either of its constituents.

DNA can be isolated from one strain of a microorganism and then used to confer hereditary characteristics of this strain on another strain of the same species. Exposure of the isolated DNA before it is reacted with the recipient strain makes it possible to detect loss of biological activity as a consequence of radiation. Such a test is more sensitive than the observation of gross physicochemical changes. Raymond Latarjet of the Institut du Radium in Paris and other workers have performed experiments of this kind. They find that the capacity of DNA to transfer hereditary characteristics is destroyed by small doses of ultraviolet radiation or X-rays or by peroxides at low concentrations. Even a minor alteration in the DNA molecule can drastically affect the rest of the cell, since DNA bears the information required for the synthesis of other key cell constituents.

A number of experiments suggest that the inhibition of the synthesis of DNA is even more important than the degradation of existing DNA. If DNA syn-



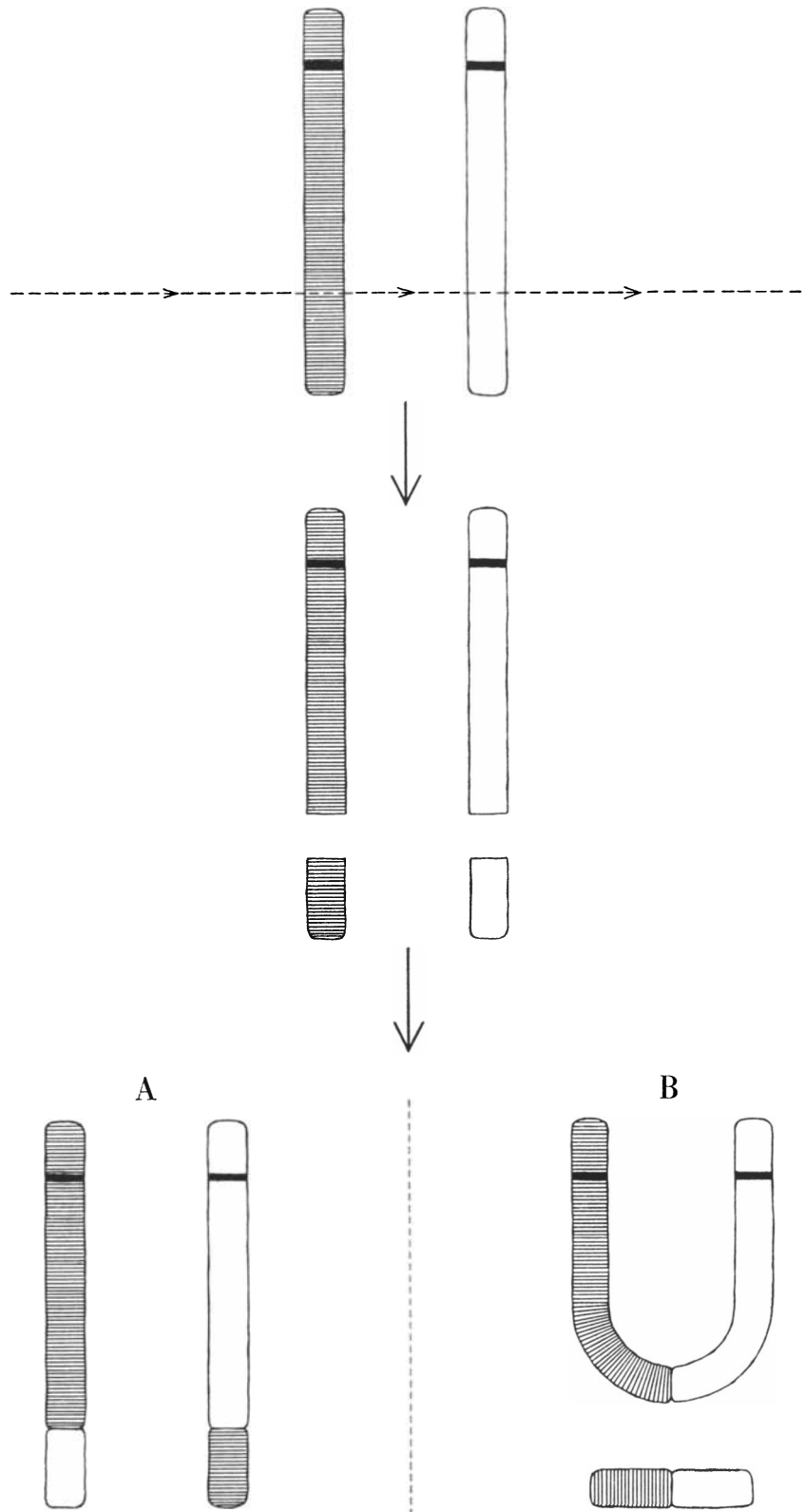
● CARBON ● HYDROGEN
○ OXYGEN ⊙ SULFUR
⊙ NITROGEN

ENZYMES CONTAINING SULFHYDRYL GROUPS (SH) are especially sensitive to ionizing radiation. Such enzymes are apparently inactivated by the oxidation of sulfhydryl groups in their cysteine amino acid units. At left are two molecules of cysteine. When their sulfhydryl groups are oxidized (lose hydrogen atoms), their sulfur atoms join to form a disulfide bridge in the enzyme. The process is reversed by reduction (adding hydrogen).

thesis is inhibited, the cell cannot divide, even though growth processes continue and the mass of the cell increases. This phenomenon has also been observed in cells that have been chemically treated to incorporate abnormal molecular subunits into their DNA.

Irradiation thus sets off a chain of reactions, at each step increasing the extent of damage several-fold. The first step is the direct action of the ionizing radiation which may itself strike an important target. In the next instant the ionized and excited molecules in the path of the ionization embroil neighboring molecules in reactions producing a variety of unstable and reactive end-products that spread the damage to target molecules untouched by the primary event itself. T. Alper of the Hammer-smith Hospital in London has suggested that an ionized or activated molecule may react with a variety of molecules in its immediate vicinity for a period of about a millionth of a second, the molecules being brought together by diffusion through the water within the cell. Certain molecules apparently remain in the activated state longer than others, and can continue to degrade or inactivate a target substance for hours after the actual exposure to radiation. This effect, which is not yet fully understood, is seen in the inactivation of DNA, of enzymes or of virus particles and even of whole bacterial cells held in the presence of hydrogen peroxide after irradiation. The reaction is stopped or prevented only by a substance capable of decomposing the peroxide. The final phase of damage results from the deranged metabolic performance of injured cell structures, and is expressed in the inhibition of cell division, in inactivation and death, or in the distortion of the genetic process.

The ultimate effects of irradiation on the living cell may be greatly affected by the physiological state of the cell and by treatment after irradiation. Cells in the "resting" stage between divisions are much less sensitive to radiation than are cells in the act of dividing. Investigators at Oak Ridge have observed that beta-mercaptoethylamine, a sulfhydryl compound, can protect bacteria and fungi against radiation-induced mutations. Such varied postirradiation treatments as starvation, inhibition of protein synthesis with antibiotics or by nitrogen starvation, lowered temperature or the addition of certain nutritional factors to the growth medium can lower the death rate in certain cell populations. It is especially significant that in certain types of living cell the same postirradiation



BREAKAGE OF TWO CHROMOSOMES by a single ionizing particle can have various effects. At top the particle (*broken line*) passes through the two chromosomes. The black segment near the top of each chromosome represents the centromere, the point at which two opposing threads of the mitotic apparatus pull the daughters of each chromosome apart during cell division. The broken chromosomes (*middle*) may simply reconstitute themselves. They may also exchange fragments as shown at A; in this case they can divide normally. Finally they may exchange fragments as shown at B; one of new chromosomes lacks a centromere and cannot divide. Thus the daughter cells lack this chromosomal material and die.

treatments that reduce the rate of cell deaths also reduce the number of observable mutations. These studies suggest that the mutation-inducing or lethal damage does not become established in living cells until some time after irradiation, and that the abnormal or inadequate metabolic processes resulting from the injury must intervene to fix it irreversibly.

It is not to be inferred that all radiation damage is significantly amenable to pre- or post-irradiation treatment. There must also be a portion of the damage, especially that produced by direct energy absorption in key molecules, that is not responsive to treatment at all. This undoubtedly represents a considerable portion of the effects observed, and ex-

plains why even the smallest dose of radiation seems to do some irreversible harm to the cell.

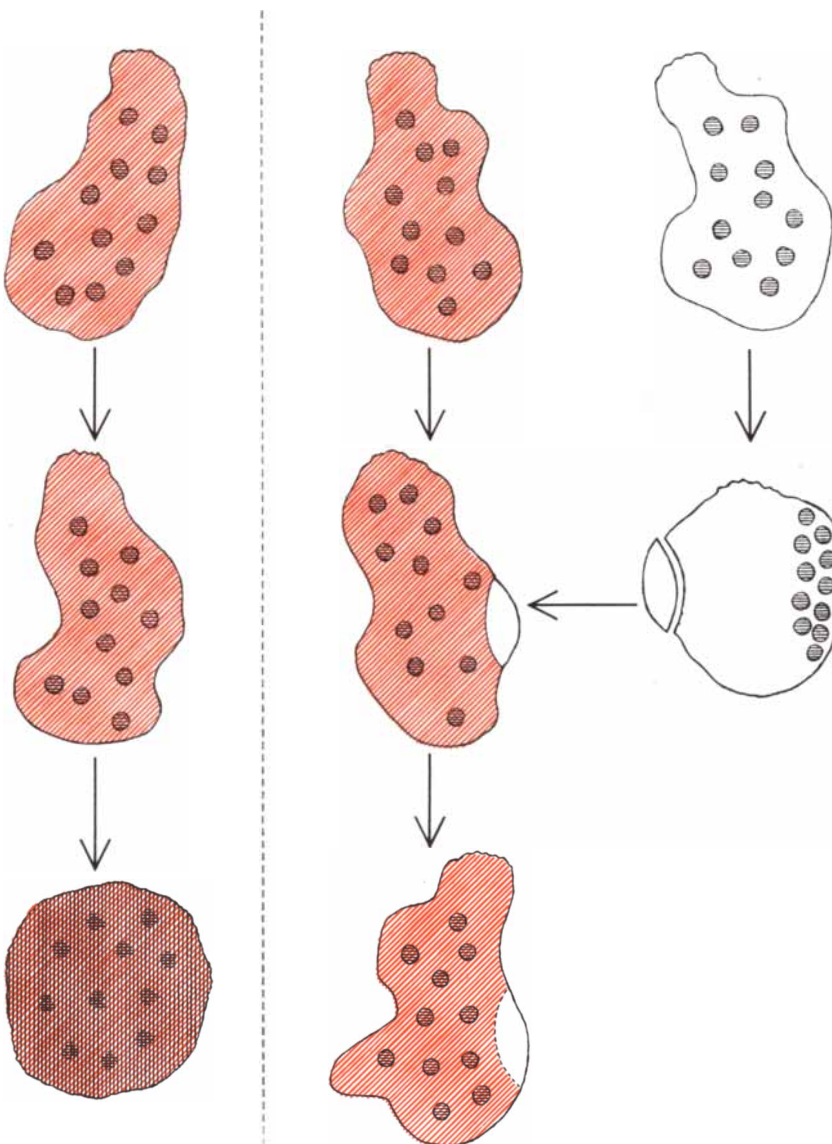
Certain experiments indicate that some cells have a capacity for spontaneous repair. Working with the amoeboid protozoon *Pelomyxa*, E. W. Daniels of the Argonne National Laboratory has demonstrated that processes in the cytoplasm can enable the cell to recover after irradiation. When *Pelomyxa* is irradiated, it is slow to divide. But when Daniels injected a bit of cytoplasm from an unirradiated *Pelomyxa* into an irradiated one, the irradiated protozoon proceeded to divide at its normal pace. This work does not necessarily imply that cytoplasmic injection can repair nuclear damage;

here the critical damage may have been restricted to the cytoplasm.

There is some evidence that if the rate of irradiation is low enough, repair mechanisms can operate during the irradiation and reduce permanent damage to the cell. W. L. Russell of Oak Ridge has recently shown that the frequency of radiation-induced mutations in the precursors of the sperm and egg cells of the mouse depends on the rate at which the radiation is administered. The mutations are more numerous if the precursor cells are subjected to a given amount of radiation over a short period than if they are exposed to the same amount of radiation spread out over a longer period. Only the immature sex cells of the mouse, however, demonstrated this variability of response to the dose rate. The mature sex cells exposed to radiation showed no corresponding change in the incidence of mutations.

What are the implications of all this experimental work for higher forms of life, including man? It is difficult to extrapolate findings from the single cell to the human organism. From what we know about the vulnerability of the cell during division and about the sensitivity of the cell nucleus, however, we can predict that the tissues most vulnerable to radiation will be those containing cells with relatively little cytoplasm and those multiplying most rapidly: the blood-forming tissue of the bone marrow, the tissues of the reproductive organs and embryonic tissues. We know that the whole animal can recover spontaneously even from what might appear to be lethal damage. The mechanism of this recovery is difficult to examine in detail. Probably undamaged cells provide materials for the recovery of damaged ones, multiply to replace those lost and neutralize the toxic substances. Many important cell systems can repair themselves after relatively low doses of radiation. When they are destroyed by larger doses, it is sometimes possible to replace them by transplantation. These and related matters are discussed in greater detail in the article that follows.

In sum, cell studies have served to elucidate the basic mechanism by which ionizing radiation damages the living organism. They have provided no evidence that there is a true threshold of dosage below which ionizing radiation produces no harmful effects; even at low dosages the effects are still appreciable. But cell studies have also demonstrated that it is possible to modify, at least to some extent, the most important effects of radiation.



CYTOPLASM WAS TRANSFERRED from an unirradiated *Pelomyxa* to an irradiated one by E. W. Daniels of the Argonne National Laboratory. When *Pelomyxa*, which has several nuclei, is irradiated, it dies or is slow to divide (left). When an unirradiated *Pelomyxa* is centrifuged so that its nuclei are at one side, a bit of its cytoplasm can be transferred to an irradiated one (right middle). Irradiated cell then survives and divides at its normal pace.

Kodak reports on:

why the radiologists, cardiologists, urologists, internists, laryngologists, and neurosurgeons got together...
new life for the old telescope or copying camera... a method for forecasting titanic stress in fine detail

Cinefluorography

On the other side of town, on November 14 and 15 of last year, there was held the First Annual Symposium on Cinefluorography of the University of Rochester School of Medicine and Dentistry.

To the masses, many of whom may live longer or at least enjoy themselves more than if this conclave had never convened, it would have been mildly interesting to know that x-ray movies of the innards in action had so far advanced from a stunt (for TV science programs) to a diagnostic routine as to make it a subject for a convention. Very mildly interesting, on a November Saturday which already offered the intellectual challenge of picking point spreads for the football games.

To the 150-odd ambitious, clear-eyed radiologists, cardiologists, urologists, internists, laryngologists, and neurosurgeons who came from all over, it was far, far more than a chance to flee the daily hurly-burly for an unequivocally tax-deductible weekend. At this time and place began the process of shaping into standard working technique all the individual improvisations, frustrations, and foolish pioneer feelings experienced late at night in deserted laboratories by medical men coping with electronics, optics, photographic sensitometry, and random fluctuations at the quantum level.

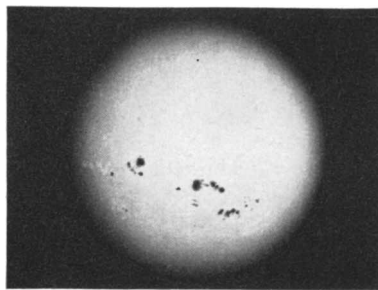
To certain elements of the electronics industry the symposium brought visions of a well-bred market for advanced merchandise, quite free of the fearful dependence on military spending and of the fearful perils of appliance merchandising. If the electronics boys in 1953 hadn't brought out image amplifiers that multiply fluoroscope image intensity a thousandfold or more so that film can be exposed without frying patients, there would have been no symposium. Their emissaries sat unabashed among the M.D.'s.

To the University of Rochester it was a chance to become the national cinefluorographic capital. It had become involved with the subject as early as 1929. To have one member of its radiology department such an expert on motion picture quality that he had produced Poe's "The Fall of the House of Usher" to supra-professional cinematic standards had helped enormously. We helped, too.

To us, doomed by our charter to the endless pursuit of monetary gain, the symposium was important for stimulating sales of *Kodak Cineflure Film*, a product which uniquely combines extreme speed to green light with very high contrast. It is obtainable from most x-ray dealers.

To Charles C Thomas, Publisher, Springfield, Ill., the symposium provided a title he is publishing this month, *Cinefluorography. It contains all 19 papers and the discussion thereof. For a free copy of a bibliography of cinefluorography, write Eastman Kodak Company, Medical Division, Rochester 4, N. Y.*

De orbe... de urbe



This picture of the solar disk with sunspots and bright faculae was taken on *Kodak Autopositive PB Film* at the prime focus of a 6-inch *f/15* reflecting telescope at 1/100 second without a filter or any interposed optics. The $\frac{3}{4}$ " negative image can stand a lot more enlargement. Alas, there is no room for that here, or for an explanation of why this particular film was chosen. To read all about it, send for a preprint of "Photographing the Sun" to Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y. If you've made a reflecting telescope and sometimes wonder why, you may find a soul-satisfying answer in that article.

The space here must serve more pressing needs having to do with another product called "Autopositive," the new *Kodagraph Autopositive Projection Paper*. This paper you put in an enlarger or copying camera and use for reproducing drawings or documents at any desired magnification or minification. Black photographs black, and white photographs white. The negative-to-positive jazz is avoided, and even the conventional hypo fixing bath is replaced by a jet of plain water. For information on where to buy it and how to use it, write Eastman

Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y.

Photoelasticity by the slice

Westinghouse, long known as a hotbed of photoelastic activity, has been nice enough to cast upon the waters of industrial co-prosperity a piece of technique that could help sell more *Kodak Contour Projectors*. No time must be lost in spreading the word. Too long have we touted photoelastic stress analysis with no brighter prospect of gainful return than seeing a little film put to good use in recording the pretty patterns.

Westinghouse took one of these projectors of ours, a non-photographic optical-mechanical device intended for the checking of dimensions on enlarged images of mechanical parts, and they turned it into a magnifying polariscope. This they did in the interest of reaching reasonable decisions on the mechanical design details to enable a nuclear reactor pressure vessel to withstand the titanic stresses that it must bear.

Scale models were built out of a certain transparent epoxy resin which not only exhibits the well known differential retardation between light polarized parallel and perpendicular to the stresses, but can retain the effect "frozen in" after the pressure is released and the model is literally sliced up in various planes of interest to the stress analysts. Instead of yielding average values of stress over the areas where electrical resistance strain gages happen to be bonded, this method shows how the stress pattern builds up to ominous levels at points suspected or not. The *Kodak Contour Projector* is what brings the stress analyst in close, past the gross structure of the pattern, to the all-important fine details where structural failure starts.

Don't bother Westinghouse for a description of the optical, mechanical, and electrical additions they've made to the projector. It's enough that they are publishing a full description of the analytical method (Proceedings of the Society for Experimental Stress Analysis, 17, No. 1). They're not interested in selling projectors. Eastman Kodak Company, Special Products Division, Rochester 4, N. Y., is.

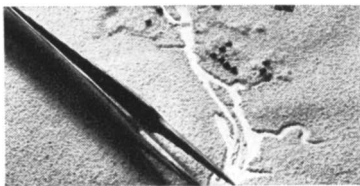
This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

Kodak
TRADE MARK

● **FIELD TESTS**
 ● **SIMULATORS**
 ● **MAPS AND SURVEYS**
to speed your R & D programs

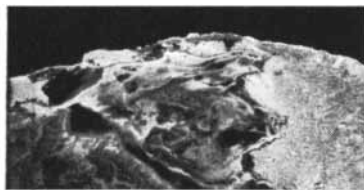
Can your research and development program use expert hands to evaluate guidance and positioning systems? Field-test new instrumentation? Produce models, simulators, or maps and surveys?

AERO Service Corporation can provide these skills. Our experience in airborne geophysics, geodesy, photo interpretation, model making and mapping is helping to advance important projects. For example . . .



RADAR TRAINING MAPS

Problem: develop ultra-sonic and light reflective relief models to simulate radar return patterns. Thiokol maps (4 x 6 ft.; 9 x 36 ft.) with textured surface and target reflectors were made for the Air Force. For Navy uses, light reflective maps were formed in .030 vinyl, shaded gray for levels of target return.

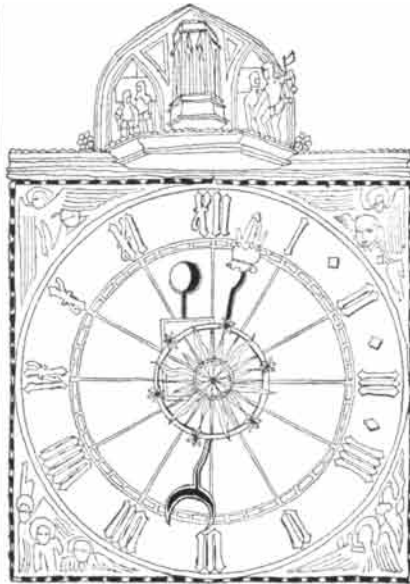


SPEEDING THE DEW LINE

Within a single short season, AERO provided engineering maps for Dew Line stations over 3,000 miles from Alaska to Baffinland. Air photos were interpreted and topographic mapping done; followed by airborne recording of terrain profiles, then ground studies. A staff of 50 men completed the survey *on schedule*.

Is there a need for AERO's skills in your program? Whether it's a large project or limited pilot study, AERO engineers will be pleased to discuss our special capabilities and experience. Write for special facilities report.

AERO SERVICE CORPORATION
 Philadelphia 20, Pennsylvania



International Medical Institute

President Eisenhower's call in his State of the Union message two years ago for U. S. support of medical research abroad is about to bear fruit. Early in August the House Subcommittee on Health and Safety concluded hearings on a bill to set up an agency to encourage international cooperation in medical research and to provide U. S. grants to foreign investigators. The bill was passed by the Senate by a 63-17 vote in May. Completion of House action is expected at the present or next session of Congress.

The agency would be known as the National Institute for International Medical Research and would become another of the U. S. Public Health Service's numerous National Institutes of Health. The new institute would be authorized to spend up to \$50 million annually for training personnel and planning and conducting research on disease and rehabilitation of the physically and mentally handicapped. Studies could be conducted in the U. S. or abroad. A National Advisory Council for International Medical Research would be organized to advise the Surgeon General on the activities of the institute and to review financial grants.

The President called for U. S. aid to foreign medical research as part of a wider program of aid to science abroad and for increasing scientific and cultural contacts between the U. S. and the U.S.S.R. and the countries of eastern Europe. The international medical institute bill was introduced in the Senate soon afterward by Lister Hill of Ala-

SCIENCE AND

bama, a Senator with a strong interest in health legislation. When Senator Hill reintroduced the measure last January in the new Congress, it bore the names of 63 members of the Senate as co-sponsors. During six days of Senate hearings, no witness appeared against the bill, and it was enthusiastically endorsed by a list of organizations and individuals taking in nearly the whole of the fields of medicine and public health.

Rocket-Age Projects

Contracts have been awarded by the National Aeronautics and Space Administration for a start on two much-discussed rocket-age projects. Atomic clocks, to be placed aboard earth satellites as a means of testing parts of the special and general theories of relativity, are to be designed and built by the National Bureau of Standards, Massachusetts Institute of Technology and Hughes Aircraft Company. A small seismograph, rugged enough to withstand launching in a rocket and subsequent landing upon the moon, is to be developed by Columbia University's Lamont Geological Observatory and the California Institute of Technology.

Even before the launching of the first artificial satellite it was widely suggested that the clock paradox of special relativity—the slowing-down of a moving clock—might be tested by putting an atomic clock into orbit and comparing the frequency of the clock's "ticks" (the radio waves the clock generates) with the frequency of a similar clock on earth. More recently it has been pointed out that an orbiting clock can also provide a check upon one of the predictions of the general theory of relativity—a hypothesis hitherto difficult to test because many of the effects it forecasts are too small to be observed. General relativity predicts an increase in the energy of radiation falling through a gravitational field, for example, in the radiation falling upon the earth from a source at some distance from the earth. In the case of radiation from a constant-frequency source—such as the radio waves from an atomic clock—the increase in energy would result in an increase in frequency (the so-called gravitational blue shift); *i.e.*, the clock would appear to run fast [see "Artificial Satellites and

THE CITIZEN

the Theory of Relativity," by V. L. Ginzburg; SCIENTIFIC AMERICAN, May].

Atomic clocks can be made to measure time with an accuracy approaching one second per 1,000 years—precision enough to allow detection of both the special-relativity "slow-time" and general-relativity "fast-time" effects. More than one clock is likely to be put into orbit, because the slow-time effect should be most evident in satellites below 2,000 miles of altitude, while the fast-time effect is expected to be strongest at altitudes above 2,000 miles.

The lunar seismograph to be designed at Columbia and Cal Tech will weigh between 10 and 20 pounds and is to detect crustal movements resulting either from internal activity of the moon or from the impact of meteorites on the moon's surface. Information on such movements, telemetered back to earth, will provide clues to the moon's internal and surface composition, as well as data on the size and velocity of meteoric particles in space. Several types of lunar seismograph, varying in sensitivity, frequency response and other characteristics, will probably be developed. Target date for the landing of the first seismograph on the moon is 1964 or 1965.

Test-Ban Developments

A group of experts from the U.S.S.R., Great Britain and the U. S. last month recommended the use of satellites for detecting high-altitude nuclear explosions. Their report to the Geneva conference stated that five or six vehicles, weighing several thousand pounds each and traveling at altitudes of more than 18,000 miles, could survey the entire earth and the space around it. The necessary instruments for satellites and associated ground stations were said to require no fundamental advances in technology. However, the experts acknowledged that the system would be very expensive and technically difficult to achieve. They also proposed less ambitious schemes with orbits only 300 to 450 miles above the earth. These would leave some gaps in surveillance at lower altitudes.

As the talks at Geneva continued, the U. S. Atomic Energy Commission was reported by *The New York Times* to be "quietly preparing for immediate resumption of nuclear testing if the nego-

RADIOACTIVE MATERIAL HANDLING investigations are safely carried out with this Stokes prototype vacuum furnace. It is remotely operated by manipulators and other external controls. This installation represents another specific requirement met through Stokes flexibility.

PLUTONIUM MELTING AND CASTING will soon be easily accomplished by this Stokes vacuum furnace being assembled for shipment to customer's plant. The entire system will be enclosed within a vacuum dry box for "clean handling" and operation: another example of Stokes design concept flexibility.



URANIUM MELTING ON A PRODUCTION BASIS is accomplished by this Stokes induction melting furnace. Designed for safety and convenience, the furnace is serviced from the top and features a removable bottom section to facilitate handling of poured materials. It is typical of Stokes inherent flexibility.



nuclear flexibility

Metallurgical investigations are leading to new, practical applications: plutonium melting and casting, uranium melting on a production basis and new methods of handling radioactive materials . . . are just a few. At Stokes, extensive design experience and manufacturing facilities work hand-in-hand to make these developments possible. Stokes pioneered in the application of vacuum metallurgy to the nuclear field. In the modern Stokes laboratory, vacuum melting, casting, heat-treating and pelletizing experiments are providing new methods of overcoming traditional bottlenecks.

Stokes experience and aggressive developments in the field of nucleonics can go to work for you. Whatever your requirements, the inherent flexibility of Stokes design concepts is assurance that your stringent needs can be met. Why not investigate further by writing or calling Stokes today.

Vacuum Metallurgical Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

AO Offers Low-Cost Stereophotomicrography

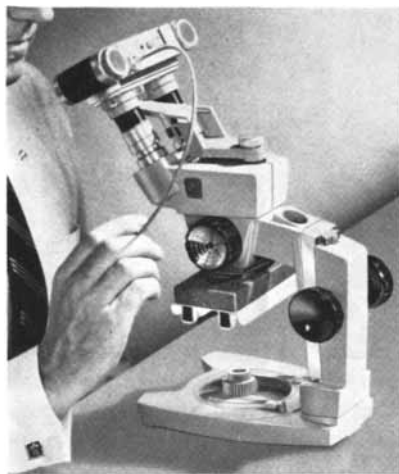
... in just three easy steps



1 SET the focusing adjustment on your AO Spencer Cycloptic Stereoscopic Microscope, to bring specimen into sharp focus. Camera is mounted directly to Cycloptic...out of the way...ready for instant use.



2 SWING the mounted 35 mm Graflex Stereocamera into position over eyepieces. Designed exclusively for Cycloptic, special compensating prisms in adapter unit render camera parfocal with microscopes' optical system. Set camera for bulb exposure. No further adjustment is necessary.



3 SNAP shutter with cable release. You photograph the sharp three-dimensional image exactly as you saw it. Your film processor will supply stereo mounted photographs. Now you have permanent, three-dimensional photomicrographs, in black-and-white or color, for future reference.



The full-size Graflex Stereoviewer, with built-in light source, completes this easy-to-use 3-D photo package. You can review your findings over and over again...anytime...anywhere. Here is everything you need for three-dimensional photomicrography... unique... easy-to-use. Available only from American Optical.

Ask your AO Sales Representative or write:

tations with the Soviet Union for a ban collapse." The preparations include the digging of tunnels in Nevada for underground explosions and maintenance work on the Eniwetok proving grounds.

The voluntary one-year moratorium on U. S. tests, which began with the Geneva talks, expires on October 31. At a recent committee hearing in the House of Representatives AEC chairman John A. McCone said he "would not continue this present type of ban" if negotiations extended beyond that date. "I would think," he continued, "that at the end of the year this policy should be very carefully reconsidered. I feel that we have been extremely patient in those negotiations and I do not think that we should find ourselves in a position of stopping testing just for the purpose of sitting at a conference table."

U.S.S.R. Census

The first results of a census taken last January reveal that the population of the U.S.S.R. has the extraordinarily high ratio of 55 females for every 45 males. Virtually the entire deficit of men is in persons over the age of 32, and is due to losses of men in World War II. Usually estimated at three to seven million, these losses may actually have been very much larger.

A preliminary report on the Soviet census, translated from *Izvestia*, is published in the July issue of the *Population Bulletin*. The report discloses numerous striking changes in the population of the U.S.S.R. since the last census was taken in 1939.

Present-day Russia has moved far from the predominantly rural nation of World War I. Almost 100 million of the U.S.S.R.'s 208.8 million people live in cities. Cities with a population of 200,000 or more number 72. Urban growth has been especially rapid since 1956. In that period more than 200 new cities have been established and the urban population has risen by 16 million. Despite the emphasis upon the development of Siberia, however, only 30 per cent of the population—urban and rural—lives in and beyond the Urals, as compared with 25 per cent before World War II.

The natural increase (excess of births over deaths) of the Soviet population is currently about 3.5 million annually. Births number more than 25 per 1,000 of population per year, or more than five million per year. Deaths total 1.5 million annually, for a crude death rate of 7.5 per 1,000 per year. The latter is one of the world's lowest crude death rates



Dept. U178
 Please send full information on AO Spencer 637 Stereocamera attachment.
 Also include information on AO Spencer Cycloptic Stereoscopic Microscopes.
 Name _____
 Address _____
 City _____ Zone _____ State _____



AT RAYTHEON—

Scientific imagination focuses on
HEAT SEMICONDUCTIVITY

Pyrographite shows the greatest anisotropy of heat conduction of any known substance, for it conducts heat 500 times better in one of its planes than the other. Along the surface, its plane of conduction, pyrographite has the highest thermal conductivity of any substance yet discovered—30% higher than copper. Pyrographite has a destruction temperature of 6600° F.

In the longitudinal plane of the monatomic carbon molecules that form the hexagonal crystals of pyrographite, atoms are spaced at 1.42 Angstrom units; the spacing between the longitudinal planes is of the order of 3.40 Angstrom units. The unique heat transport characteristics result from the high degree of orientation of the longitudinal layer planes.

Pyrographite, which has a high strength-to-weight ratio, can be used for re-entry bodies and rocket nozzles where it has excellent erosion resistance at temperatures up to 6000° F. It also has application in nuclear reactors.

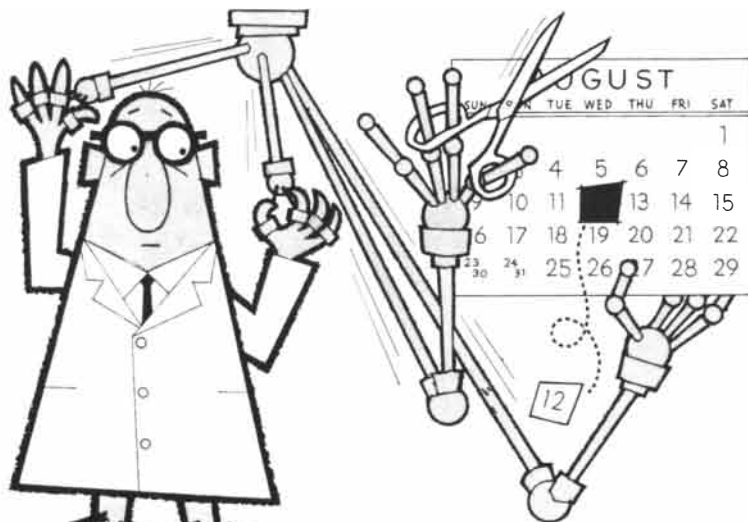
The study of pyrographite and similar materials by such men as R. J. Russell, S. F. D'Urso and E. F. Keon is representative of the basic research at Raytheon—where scientific imagination is broadening man's knowledge.



RAYTHEON COMPANY, Waltham, Mass.

Excellence in Electronics





Man's Eternal Struggle with the Machine

The man who made tomorrow come— just one day early!

Name was John. Deceptively mild in appearance. Rather quiet. Seemed to have a manner of knowing what he was doing. Yet, there was an undercurrent of impatience about him. The kind of fellow you'd expect to find in research . . .

The day? An otherwise everyday. Because John lived an otherwise everyday life. Except for his work with the *you-know-what*.¹

How he changed the calendar won't be easy to tell, because of the security involved. (Probably should spell that with big letters, like this—SECURITY!) But we'll try anyway . . .

John was deeply involved in a project to develop a *something-something*.¹ Never been done before, and nobody thought it could be. They even assigned one of those aggravating target dates.

¹Classified

²Incidentally, John's source of help for his "impossible" welding problem was four brothers named Sciaky. They direct a unique organization of highly trained, experienced people. The same as John and his colleagues, they share one common characteristic—scientific imagination and daring. As you might expect, we can't write about

But John was moving with dispatch in spite of it all. Had no real problems till he got to putting the *handle-bars*¹ on the *buggy-whip*.¹ Then—nothing. The wheels kept falling off.

Here was a critical problem in joining. Not John's specialty by any means. But what *he* didn't know never concerned him. Only what he *had to find out*. So, he simply looked over his sources in industry for someone who would know. Some organization with the facilities, experience and interest in "impossible" welding problems.²

John found this special source, of course. And, like "Tom Swift and his Electric Grandmother," he completed his task. As a matter of fact, John delivered his prototype and substantiating data the day before it was required!

any of the numerous projects Sciaky has worked on, either—SECURITY, you know. But you can get the facts directly from them. You'll find their two basic products are welding research, and precise—repeat precise equipment for resistance welding, fusion welding, electron beam welding (the only American licensee of the Commissariat A L'Energie Atomique en France), etc.



**Chicago • London
Paris • Los Angeles**

for information contact: Sciaky Bros., Inc.,
4938 West 67th Street, Chicago 38, Illinois.

76AR599

and reflects the high percentage of young persons in the U.S.S.R.

World War II cost the U.S.S.R. not only many millions of young men, but also a sizable part of the generation now coming of age. This is the result of a sharp decline in births and high child and civilian mortality during the war period. Analysis of figures in the census report indicates that the population within the present boundaries of the U.S.S.R. had a natural increase of not quite two million or 1.2 per cent a year in the decade before the war. If it had been possible to maintain the 1.2-per cent rate—let alone reach the present annual increase rate of 1.75 per cent—throughout the war, the U.S.S.R. would now have a total population of 235 million or more.

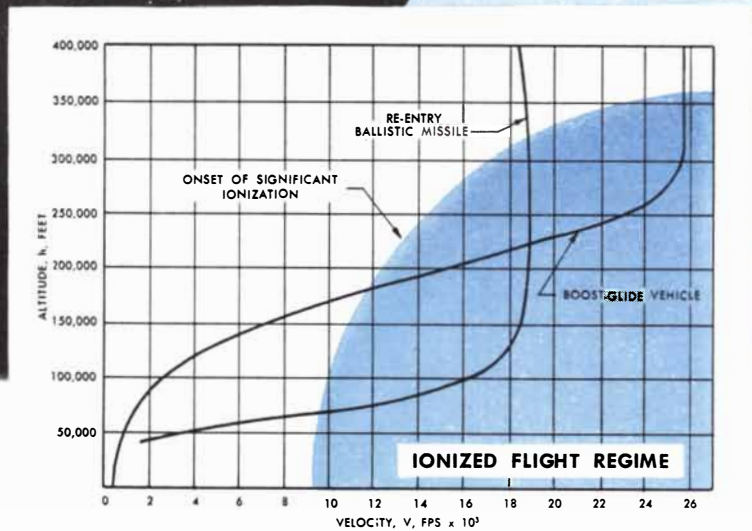
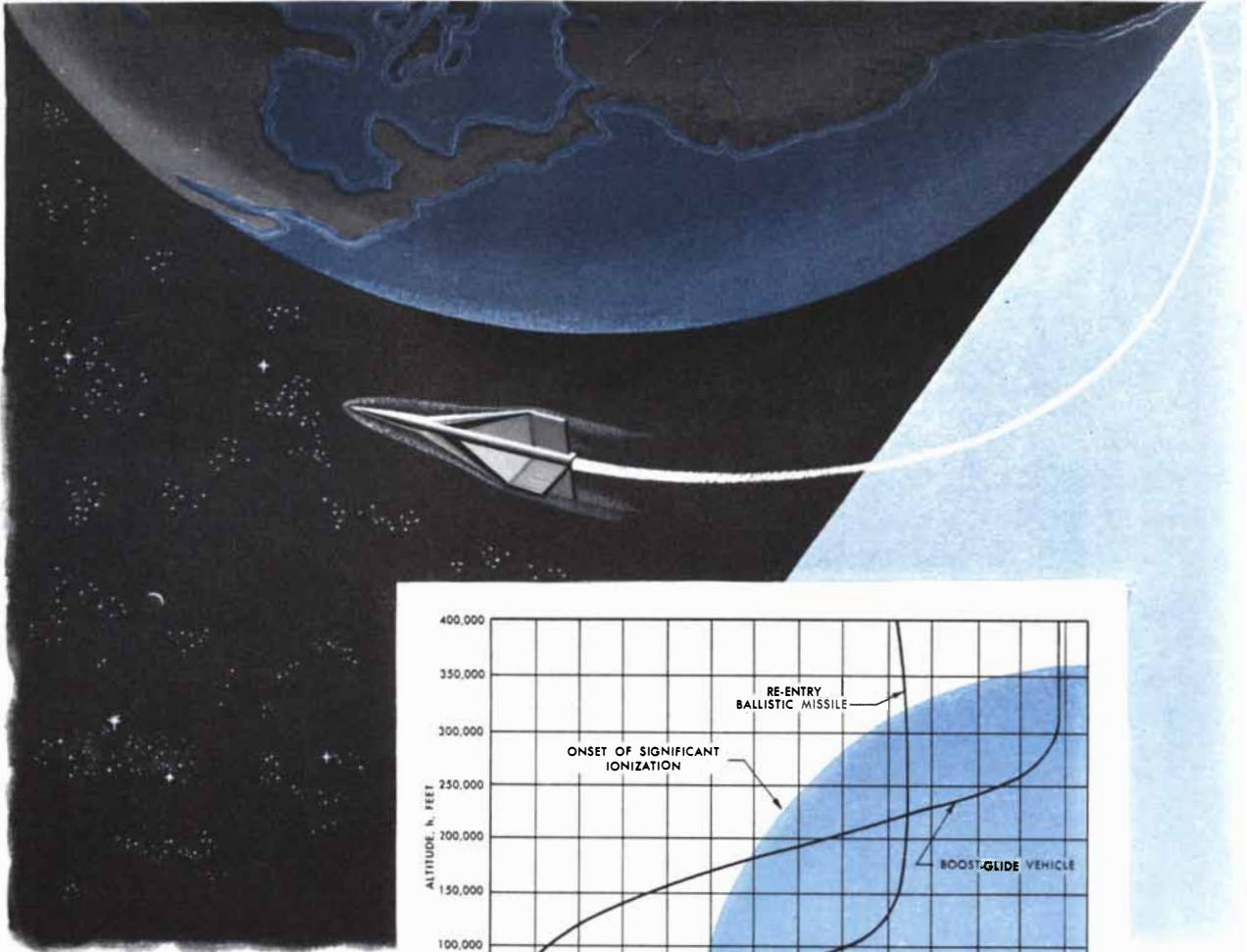
Tunnel Diode

A new entry in the burgeoning field of solid-state electronics promises to outperform the transistor in many important respects. Reports from several laboratories indicate that the tunnel diode, as the device is called, will make possible faster switches and less noisy, higher-frequency amplifiers and microwave oscillators.

As with transistors and most other semiconductor devices the functioning of the tunnel diode depends on the transfer of electric charge across a "p-n" junction. But the method of transfer is different and the action quicker.

A p-n junction is the region between a p-type semiconductor, containing mobile positive charges in the form of "holes" (vacant electron sites in the atoms of the crystal) and an n-type, containing mobile negative electrons. The opposite sides of the junction acquire a charge that resists the motion of electrons and holes across it. In the older devices the charges pass through only with the help of an outside voltage, which gives them enough energy to surmount the potential barrier.

According to the laws of quantum mechanics, however, another passage-way exists. Regardless of its energy, an electron approaching one side of a potential barrier has a small but finite probability of disappearing from that side and simultaneously appearing on the other. It is as if the electron tunneled under the barrier. Last year a Japanese physicist, Leo Esaki, discovered that the tunnel effect can produce substantial currents across p-n junctions. The semiconductor must be heavily "doped" with impurities to give a high concentration of movable charges, and



COMMUNICATION

... through a plasma sheath

When man goes into the outer atmosphere, communication with ground installations will be a major problem. The shock wave preceding a hypervelocity vehicle flying at altitudes between 70,000 and 350,000 feet will cause the oncoming air to be heated to extremely high temperatures. Result: a sheath of ionized particles around the vehicle.

Communication through this plasma cannot be achieved with conventional equipment. That's why Bendix Systems Division is engineering a communications system in frequency bands specifically designed to penetrate the hypersonic shock layer. The solutions of these problems are common to hypersonic flight and ballistic missile re-entry.

The Bendix Systems Division, using the nearby University of Michigan's Ford Nuclear Reactor, is also developing radiation-resistant communication equipment to provide extreme reliability over long operating periods. These techniques are applicable to both nuclear-powered vehicles and space programs.

Bendix communications experience is also being applied to other programs for which the Systems Division has management and engineering responsibility—the Navy's EAGLE System and the Air Force's AN/AMQ-15 Weather Reconnaissance System, for example.

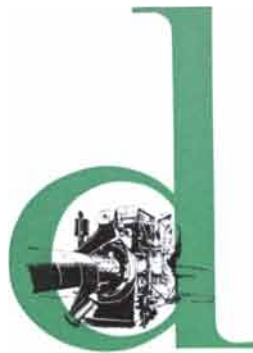
Better engineers and scientists are invited to write for further information on Bendix Systems Division.

Bendix Systems Division
ANN ARBOR, MICHIGAN



dearborn research leads the way in all fields of corrosion control

PIPE LINE corrosion specialists call for both mechanical and chemical protection and get it with Dearborn's NO-OX-ID coatings and wrappers . . . underground and underwater protection that lasts for decades.



ON RAILROADS, Dearborn's water treatment formulas and sludge solvents keep diesels running longer and cleaner. NO-OX-ID coatings add years of life to trestles and bridges. Exclusive pressure washing systems and cleaners keep rolling stock bright . . . reduce maintenance costs.



SHIP OWNERS depend on Dearborn's NO-OX-ID coatings for long term protection against the continuous corrosive attack of inland and salt waters.

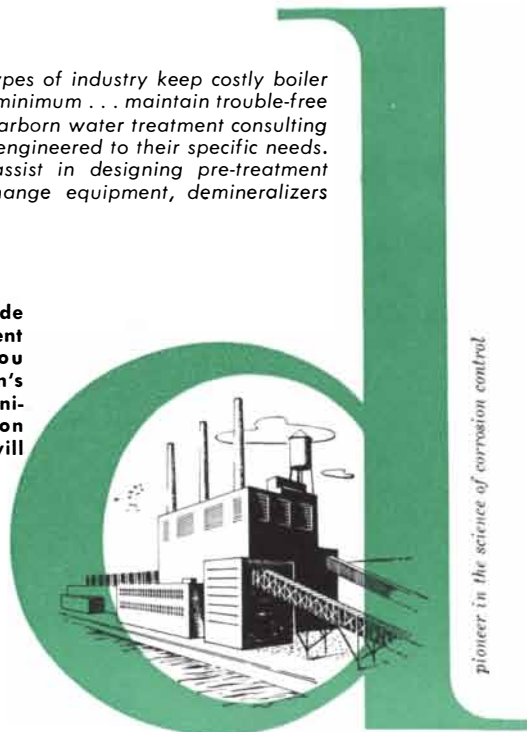


POWER ENGINEERS in all types of industry keep costly boiler down-time and repairs at a minimum . . . maintain trouble-free cooling systems . . . with Dearborn water treatment consulting service and test equipment engineered to their specific needs. Dearborn engineers also assist in designing pre-treatment systems including ion-exchange equipment, demineralizers and softeners.

If your responsibilities include any phase of water treatment or corrosion control, you should be receiving Dearborn's valuable research and technical bulletins. A request on your Company letterhead will bring them regularly.

DEARBORN CHEMICAL COMPANY

Executive Offices:
Merchandise Mart • Chicago 54
Plants and Laboratories: Chicago
Linden, N. J. • Los Angeles • Toronto
Honolulu • Havana • Buenos Aires



pioneer in the science of corrosion control

the junction must be very thin. Such a junction constitutes a tunnel diode.

The action of the device depends on certain peculiarities in the tunneling current. With no outside voltage across the junction the electrons on either side reach a common energy-level, and tunnel with equal ease in both directions. There is no net current. If a small voltage is applied, raising the energy of the n-type conduction electrons, they find themselves opposite a band of unoccupied energy-states in the p-type material. The n-to-p tunneling increases and a net current appears. At a greater voltage, however, the n-type electrons reach the level of the so-called forbidden gap of energies in the p-type material. Now they cannot move across the junction, and the current decreases. Eventually, if the voltage is made high enough, the n-type electrons spill over the top of the potential barrier in the ordinary way, so that the current increases again.

Over the range where an increasing voltage causes the current to decrease, the diode has "negative" resistance. Any negative resistance element can be made to act as an amplifier or oscillator.

In vacuum-tube and transistor amplifiers, electrons (or holes) must pass from an emitter to a collector through a region where their motion is influenced by the input signal. This transit requires a minimum time, placing an upper limit on the frequency at which the devices can work. In the new diode, tunneling electrons set up virtually instantaneous surges of current through the whole semiconductor. Hence the possible frequency response is much higher. Also, at certain points small voltage changes cause the diode to flip almost instantaneously from one positive resistance to another. Thus it can act as a fast switch.

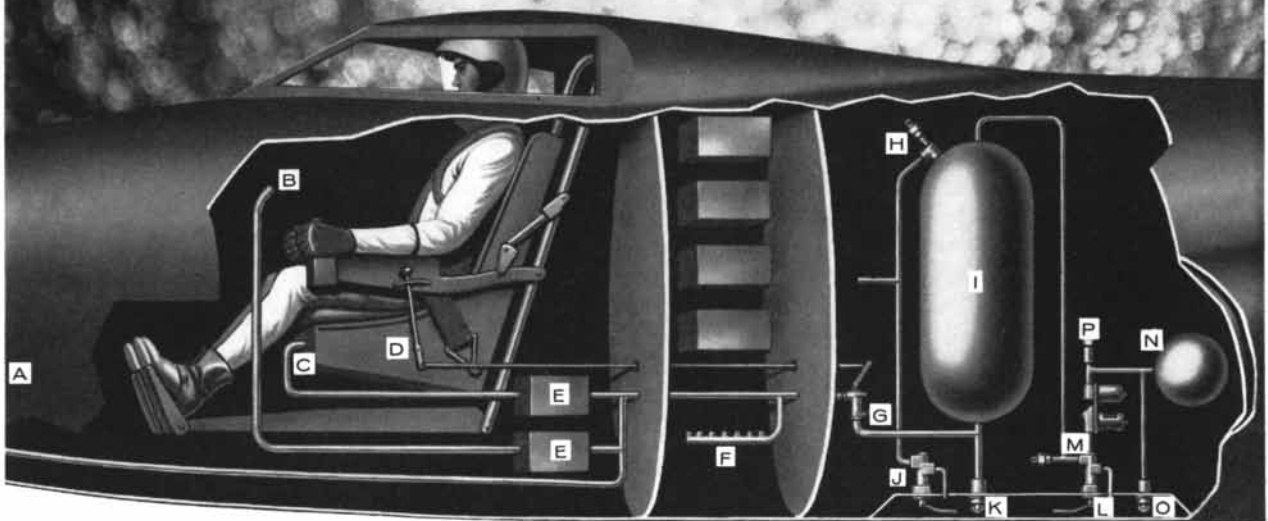
An announcement from the General Electric Research Laboratory says that tunnel-diode amplifiers already operate at 2,000 megacycles, the upper limit of the transistor. Frequencies of more than 10,000 megacycles should be possible, at noise levels very much lower than transistors can attain. The rapid switching action of tunnel diodes will find applications in computers and control circuits, particularly for nuclear reactors. Heat and atomic radiation do not disturb the tunnel effect so much as they do the transistor action of semiconducting crystals.

Virus-Destroying Bacterium

Viruses that destroy bacteria are familiar, especially the numerous strains that prey on the *Escherichia coli* organ-



USAF X-15 carries its own atmosphere



AN ENTIRELY NEW CONCEPT IN PRESSURIZATION AND COOLING . . . A Nose cone cooling, B Cabin pressurization and cooling, C Suit pressurization and cooling, D System control, E Heat exchangers, F Electronic bay (cooling and inerting), G Supply valve, H Nitrogen relief valve, I Liquid nitrogen storage tank, J Liquid nitrogen vent valve, K Liquid nitrogen filler valve, L Helium vent and buildup valve, M 2-stage helium regulator, 4400-65 psi, N High pressure helium storage, O High pressure helium filler valve, P Helium relief valve.

• *The AiResearch Pressurization And Air Conditioning System* in North American's X-15 is a radical departure from normal pressurization and cooling techniques, also pioneered by AiResearch, which up to now have utilized outside air surrounding the aircraft. When the X-15 manned spacecraft climbs into space beyond the earth's atmosphere, it will carry its own atmosphere in the form of liquid nitrogen dispensed through a self-suf-

ficient AiResearch pressurization and air conditioning system for the pilot and vital equipment.

X-15 applications include: pressurizing and ventilating the cockpit and the pilot's flight suit inside of which he breathes pure oxygen; cooling and pressurizing electronic equipment and inerting its environmental atmosphere; cooling the plane's nose cone; and, operating pneumatic equipment.

High pressure helium gas is metered

to a flexible expulsion bladder forcing nitrogen out of the storage tank, insuring a normal flow at all times.

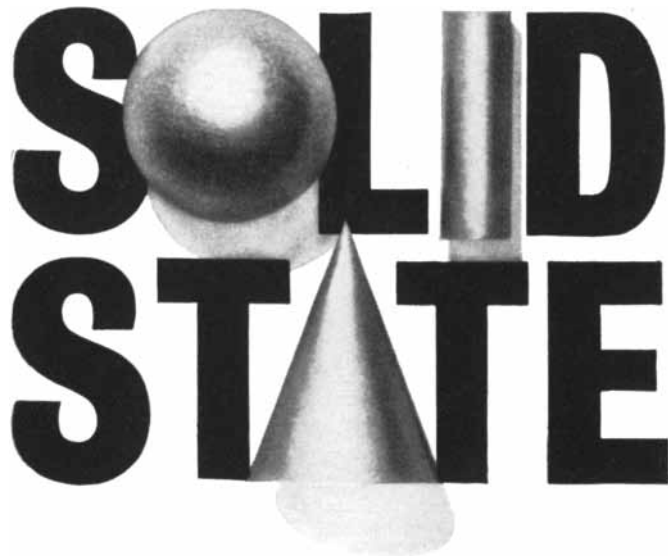
From the B-29 to the modern jet airliner and now the X-15, AiResearch pressurization and cooling of these history-making aircraft exemplify the company's continued world leadership in the pioneering and advanced development of pressurization and refrigeration systems for high altitude, high speed flight. Your inquiries are invited.

THE GARRETT CORPORATION
AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

*Explore new areas
at IBM in*



The IBM solid state program ranges from basic research to product development. In order to develop new laminar materials for overlaying solids, IBM is studying the behavior of molecules adhering to a surface in an ordered array. Other projects involve a new ferrite core which will function normally at 500°C. and a one-million bit magnetic memory drum weighing only five pounds. Assignments are now available in such related areas as circuit design, cryogenics, inertial guidance, logic, magnetics, optics, radar, semiconductors, and transistors.

A career with IBM offers excellent advancement opportunities and rewards. You will enjoy professional freedom. Comprehensive education programs are available as well as the assistance of specialists of diverse disciplines. Working independently or with a small team, your contributions are quickly recognized. This is a unique opportunity for a career with a company that has an outstanding growth record.

Qualifications: B.S., M.S., or Ph.D. in E.E., M.E., Physics, Mathematics, or Physical Chemistry—and proven ability to assume a high degree of technical responsibility in your sphere of interest.

For details, write, outlining background and interests, to:

**Mr. R. E. Rodgers, Dept. 65911
IBM Corporation
590 Madison Avenue
New York 22, N. Y.**

IBM®

INTERNATIONAL BUSINESS MACHINES CORPORATION

ism and provide investigators with a handy tool for studying virus genetics. There also exists at least one species of bacterium able to destroy a virus.

The virus-destroying bacterium is a newly identified yellow organism named *Flavobacterium virurumpens* by its discoverer, Benjamin E. Volcani of the University of California Virus Laboratory. Volcani recovered the microbe from the mud of a creek crossing the Berkeley campus. The virus it destroys is the organism that causes the mosaic disease of tobacco.

The yellow bacterium dissects the tobacco-mosaic virus into an assortment of rodlets, granules, doughnut-shaped fragments and fragments of irregular shape by attacking the virus protein enzymatically. Four or five points in the virus's protein coat appear particularly susceptible to the bacterium's action.

Volcani's discovery not only points to the possible existence of other virus-destroying bacteria; it also furnishes a new means of degrading viruses to determine their structure. Hitherto physical and chemical procedures have been the chief reliance of researchers seeking to break down tobacco-mosaic and other viruses for study.

Equatorial Electrojet

Variations in the earth's magnetic field, as measured at ground observing-stations, have long been attributed to electric currents circulating in the ionosphere. Rockoons (rockets fired from balloons) sent aloft during the International Geophysical Year confirmed the existence of these "dynamo currents." They have also led to the discovery of at least three currents, instead of the expected one, in the region of the magnetic equator: two flowing from west to east, and one, just to the north, flowing in the opposite direction.

Data on the triple equatorial electrojet were obtained on three rockoon flights near Fanning and Jarvis islands in the Pacific. The rockoons were launched from the Navy icebreaker *Glacier* under the direction of James A. Van Allen and Laurence J. Cahill, Jr., of the University of Iowa. They carried miniaturized proton precession magnetometers to record the absolute intensity of the magnetic field on the way up and down.

The first of the three data-yielding flights was made at latitude three degrees 23 minutes north and longitude 158 degrees 41 minutes west. At an altitude of 104 kilometers the rocket's magnetometer recorded a change in magnetic



NO PREMIUM IN PRICE:

ONLY IN PERFORMANCE!

True only of Cooper Alloy stainless valves, in use in diversified applications in the chemical processing, petrochemical, pharmaceutical, pulp and paper, and similar high-corrosive industries. These valves are widely respected for their ability to deliver top performance under the most adverse of operating conditions, year in, year out.

These are the quality factors which have earned for Cooper Alloy the reputation as the first-line producer of corrosion-resistant stainless steel valves and fittings. The quality of *your* product requires a like quality in the process equipment used to make it.

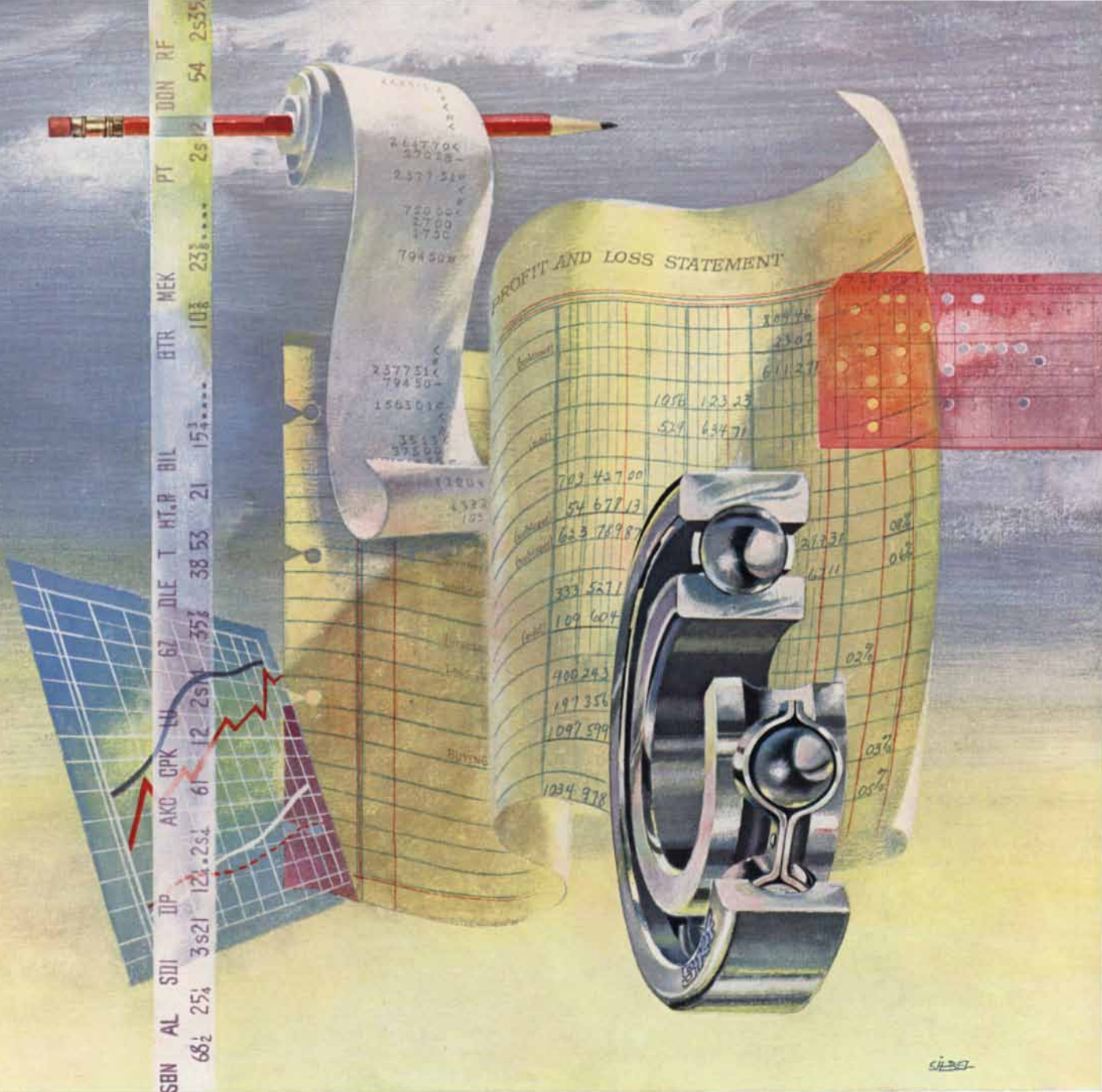
Your process and *your* product deserve Cooper Alloy valves and fittings.

For Corrosion Control


COOPER  ALLOY



Corporation, Hillside, New Jersey

Stainless steel valves, fittings, castings; Plastic pumps, valves, fittings



HOW TO ILLUSTRATE A PROFITABLE IDEA

When  developed an advertisement entitled "Parts Determine Profits", artist Fritz Siebel was commissioned to create the illustration. The result of his effort appears above. Perhaps you saw the original

ad in *Business Week*. In it  pointed out how a single bearing failure can halt production, boost operating costs and otherwise eat away profits. To avoid these penalizing possibilities it was also suggested that the manufacturers—or users—of equipment containing ball or roller bearings might profit by asking  for an impartial bearing analysis. Do the products you build—or buy—contain bearings?

SA-7820



flux indicative of an east-west current.

The other two flights that penetrated the electrojet were made almost due south of the first one: just above the geographic equator, and at two degrees five minutes south. Both of these flights encountered a west-east current 97 kilometers above the earth. At 110 kilometers the current density dropped off, but not to zero. At roughly 117 kilometers the magnetic flux changed again, suggesting the existence of a second west-east current. One of the rockets reached an altitude of 129 kilometers, sufficient to carry it to the apparent center of the upper west-east current.

The equatorial currents are believed due to tidal movement of ions in the upper atmosphere under the influence of the sun and moon. Additional flights will be needed to permit estimates of actual current densities, which vary from hour to hour and day to day.

Diagnosis by Computer

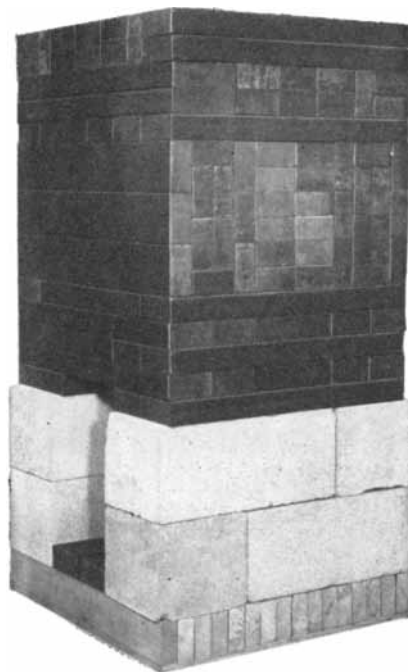
In diagnosing illness the physician's usual starting point is to take the patient's medical history. Unfortunately not all physicians are equally skilled in questioning, nor do all have time to take a proper history. As a result Keeve Brodman of the Cornell University Medical College 10 years ago devised a medical-history questionnaire to be filled out by the patient himself.

Brodman and his colleagues have now carried the self-questionnaire a step farther. In studying the patient's history the physician makes deductions from particular combinations of patients' answers—a process that digital computers can be geared to perform. A computer was accordingly equipped with questionnaire answers pointing toward 60 common ailments, obtained by analysis of questionnaires filled out by 5,929 patients admitted to New York Hospital during an 18-month period a decade ago. Questionnaires filled out by 2,745 patients in 1956 and 1957 were then run through the machine.

The computer selected the proper diagnosis in 44 per cent of the questionnaires examined. (What the patients actually suffered from was, of course, known from hospital records.) Later, in a special test involving 350 questionnaires also analyzed by a physician, the computer battled 48 per cent as against 43 per cent for the physician.

Brodman sees rapid interpretation of medical interviews in mass surveys, not replacement of the individual physician, as the primary application of diagnosis by computer.

3000 POUNDS OF LEAD WEIGH EXACTLY 1½ TONS;



*may require reinforced floors; cost approximately \$800.00; and are altogether superfluous with the availability of the new **Amperex**® Type 18515/Type 18517 Low-Level Beta Counter.*

In recent years, the measurement of low level radiation has become increasingly important, particularly in connection with the radioactive contamination of the atmosphere, water supplies, food-stuffs, and the waste material from medical, radiochemical and nuclear laboratories. Hence, an acute need has developed for a reliable, ultrasensitive Geiger counting system which combines accuracy and compactness at a moderate cost.

The new Amperex Type 18515/Type 18517 low level beta counter tube configuration now makes such a system possible. A single cosmic ray guard tube, Type 18517, now replaces an entire array of up to thirty guard tubes heretofore required in low background systems.

A system utilizing the new Amperex tubes requires only 400 lbs. of lead shielding to achieve backgrounds in the order of 1 cpm—thus eliminating as much as 3000 lbs. of shielding material necessary for a conventional system.

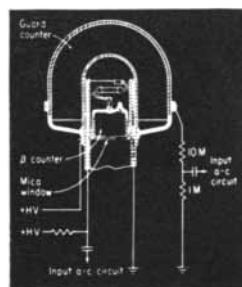
The resultant simplification in circuitry, plus the elimination of multi-guard tube malfunctions, provides a dramatic increase in system reliability.

By virtue of its unique design, the beta detection efficiency of the Amperex 18515 beta tube greatly exceeds that obtained by any previous halogen-quenched, thin-window tube.

Because of its unique construction, processing, and gas mixture, the cosmic ray efficiency of the guard counter is virtually 100%. Hence, *NO* cosmic ray can actuate the inner tube without simultaneously actuating the guard counter.

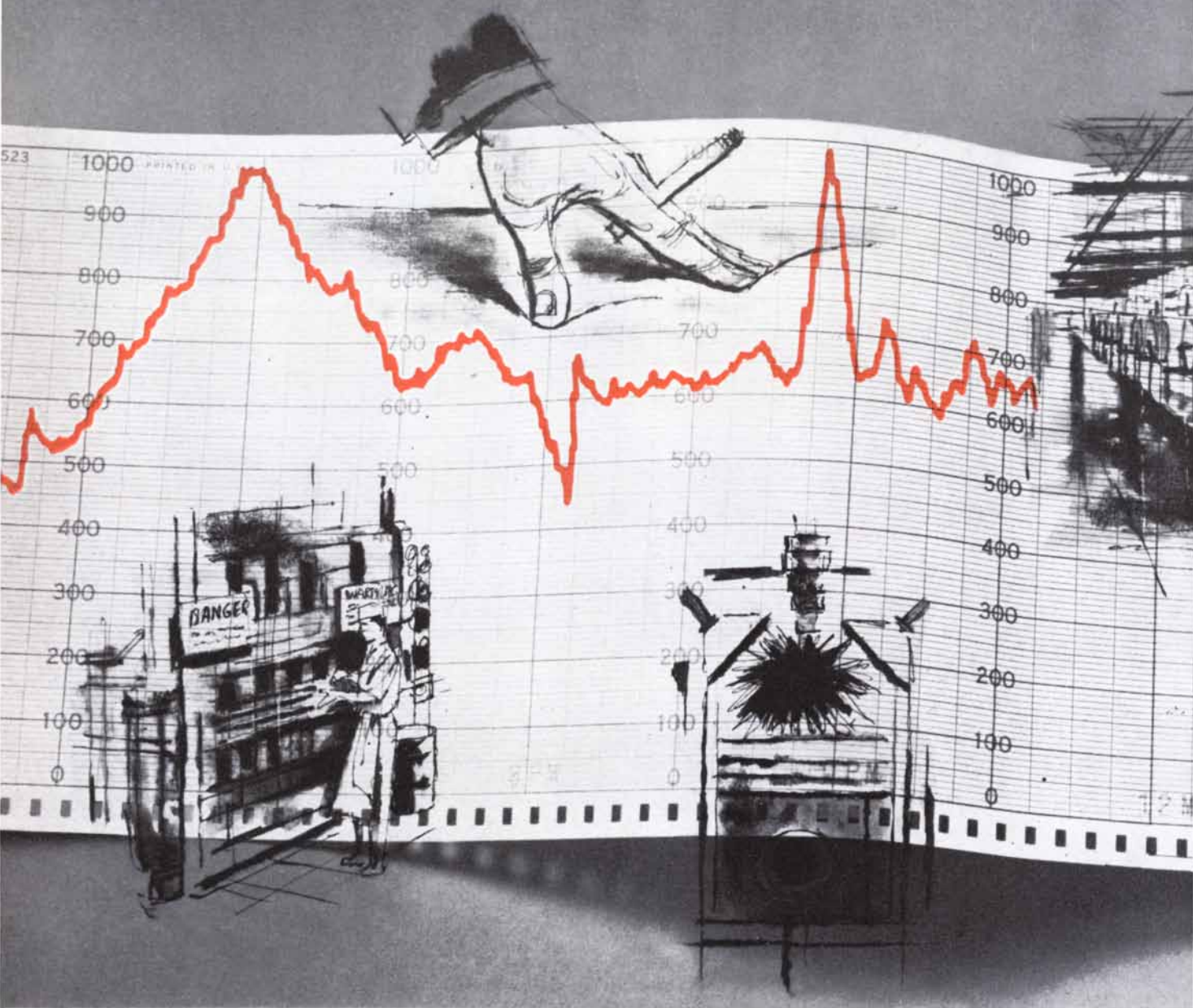
Thus, AMPEREX has again turned its 'proprietary' manufacturing techniques to the implementation of another significant new development in radiation measurement from the research laboratories of Philips of the Netherlands.

For additional information, write to Semi-Conductor and Special Purpose Tube Division, Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.



ask **Amperex**

about their full range of radiation counters, high temperature radiation counters, photomultipliers, photo-sensitive devices, indicator tubes, premium electron tubes and semi-conductors.



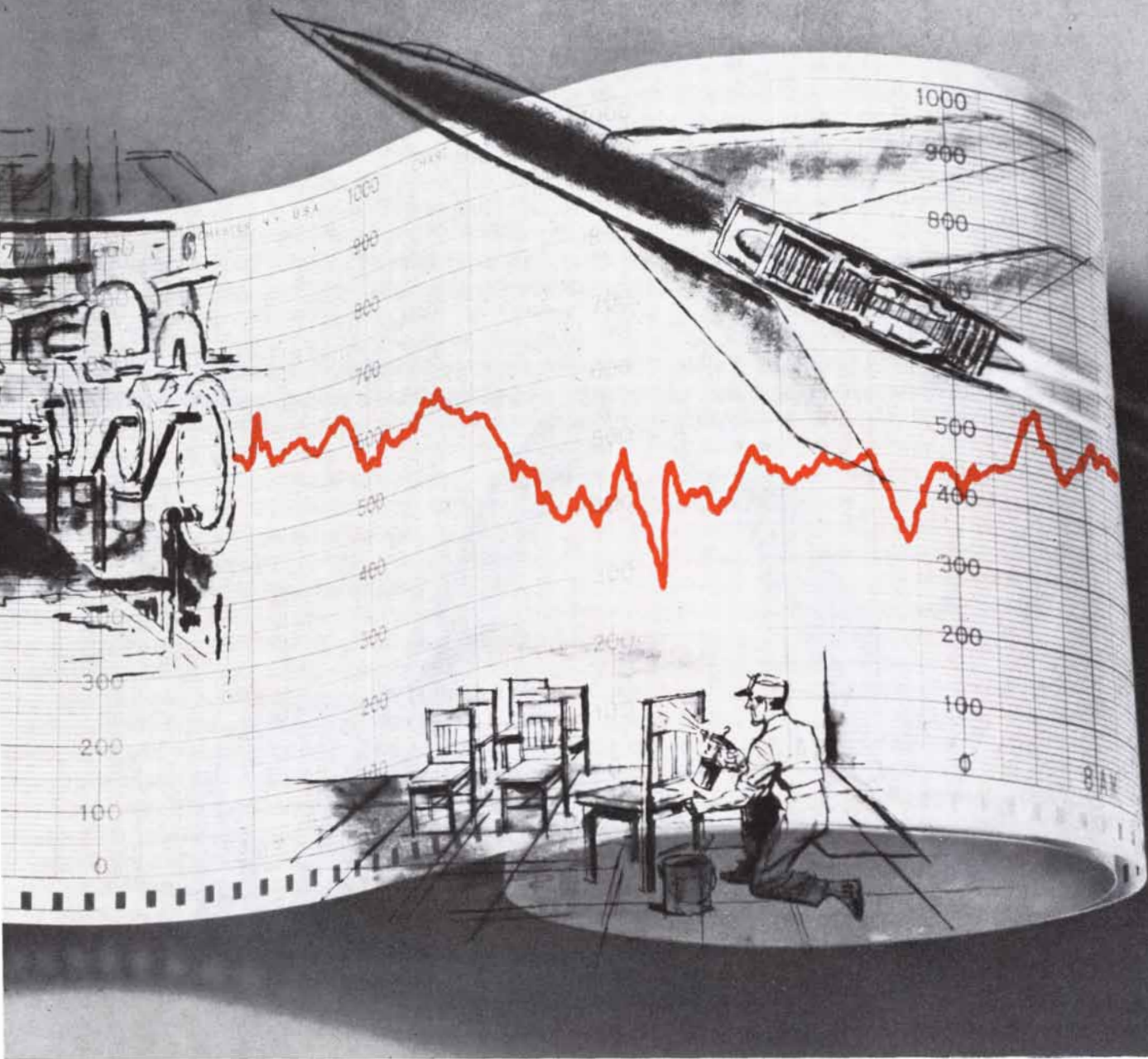
To tame heat and

Does heat or flame present a hazard in your business or product, or set a limit to the efficiency of equipment?

If so, Celanese has some chemical answers for you:

We have developed—and produce—fire-resistant synthetic lubricants and hydraulic fluids, fire resistant plasticizers, fire-retardant additives for paints and varnishes, motor fuel additives that improve combustion, and heat-resistant lubricants for high temperature applications. These products are typical examples of the contribution of Celanese to safety and progress in American industry. Take advantage of our long experience in reducing the hazards and losses of heat, fire and explosion. If you have such a problem, why not ask us to help? Write Celanese Corporation of America, Chemical Division, Dept. 582-S, 180 Madison Ave., New York 16.

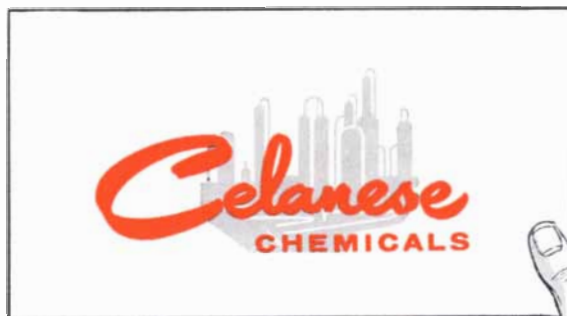
Celanese® Celluflex® Cellulube® Cellutherm™



keep fire friendly

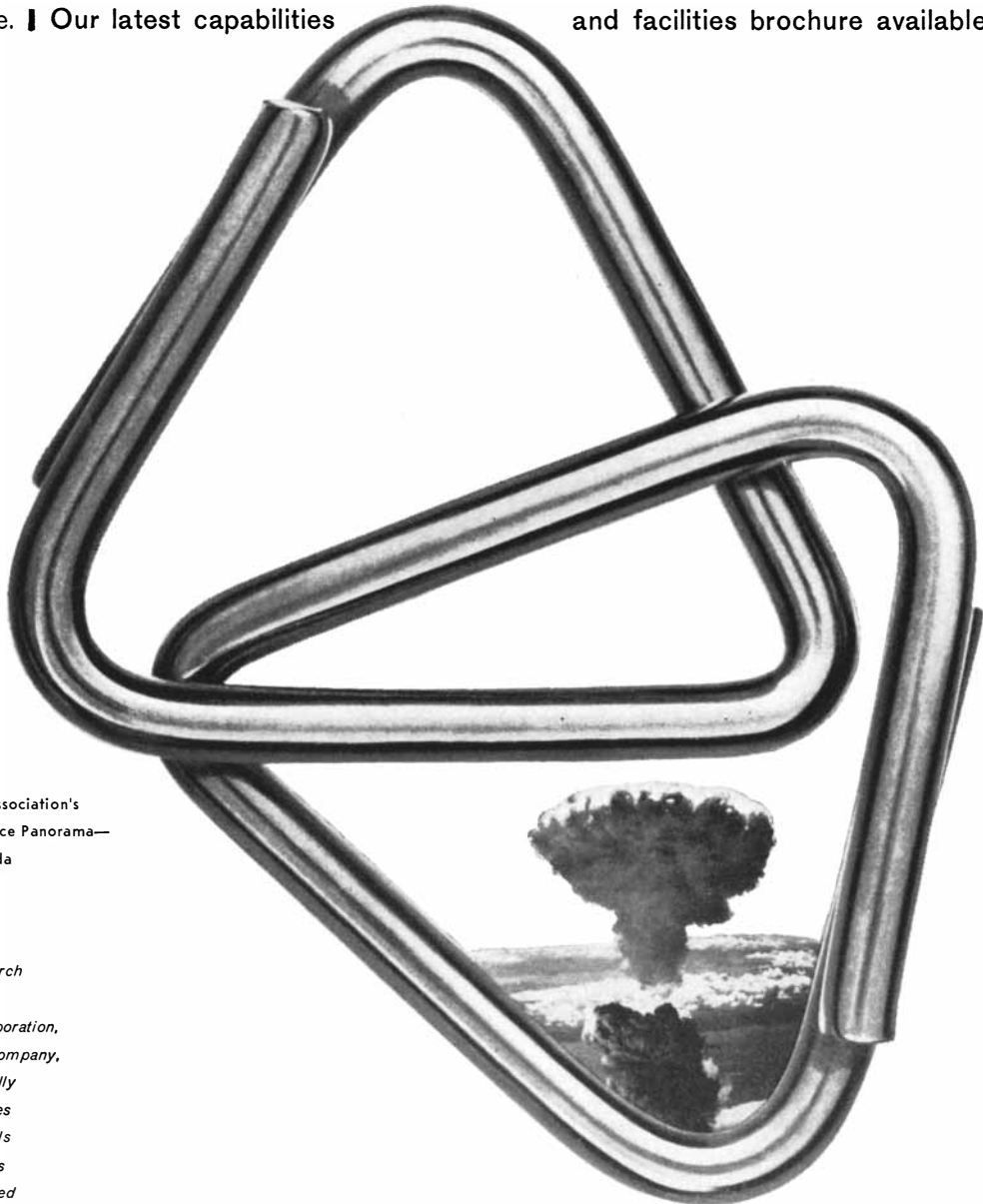
LEFT TO RIGHT

- Cellulubes, fire-resistant hydraulic fluids for safer operation of die casting machines, hydraulic presses and other power transfer units near potential sources of ignition.
- Celluflex plasticizers add fire resistance to urethane foams and other plastics.
- Fuel additives improve performance characteristics of gasolines.
- Cellulubes, combustion-resistant lubricants for air and gas compressors, also reduce maintenance costs.
- Celluflex plasticizers contribute the property of fire retardance to paints and varnishes.
- Cellutherm high temperature lubricants for faster jet engine speeds.



Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
 Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Ave., New York 16, N. Y.

SOLVING THE PUZZLES OF NUCLEAR DETONATIONS As a prime participant in all major Atomic Energy Commission tests since 1951, Allied Research engineers, scientists and technicians are continually contributing to the advancement of knowledge of nuclear detonation phenomena and effects. ■ The company's recognition in this field can be attributed not only to the development of new concepts, devices, instrumentation and data reduction methods but also to the practical application of the results, for example, in aircraft and missile structural and protective design criteria. ■ Similar recognition of Allied Research's work on the frontier of knowledge has occurred in many other areas of interest...*aerodynamics...applied mechanics...aircraft operations...chemistry...electronics and instrumentation...geophysics...meteorology...nuclear weapons effects...propulsion...physics research...systems engineering...vibration engineering...weapons systems analysis.* ■ These unusually broad capabilities have created outstanding opportunities for those dedicated to working on the frontier of knowledge. ■ **Our latest capabilities** and facilities brochure available on request.



Visit us
at the
Air Force Association's
1959 Aerospace Panorama—
Miami, Florida
Sept. 2 to 6—
Booth 1148.

*Allied Research
and Vertol
Aircraft Corporation,
the parent company,
offer unusually
broad abilities
and potentials
both in terms
of experienced
personnel and
physical facilities.
Why not
investigate the
Vertol/Allied
joint capabilities!*



ALLIED RESEARCH ASSOCIATES, INC.

43 LEON STREET, BOSTON, MASSACHUSETTS • GARRISON 7-2434

A SUBSIDIARY OF VERTOL AIRCRAFT CORPORATION

Ionizing Radiation and the Whole Animal

The cells of the whole animal form an interconnected society, making the effects of radiation more difficult to trace. Some effects are apparent; others can only be inferred indirectly

by John F. Loutit

The authors of the preceding article have outlined the effects of ionizing radiation on the living cell. An organism such as a mouse or a man consists of course of many cells. But such an organism is much more than that. It is a society of specialized and interdependent cells. What happens when a society of cells is exposed to ionizing radiation? Even if we knew exactly how each of the cells is affected, we could not answer the question for the organism as a whole. Radiation damage to one organ can disturb the functioning of another. The cooperative action of cells and tissues in a many-celled organism profoundly complicates the primary effects of radiation. Given time, this action can also mitigate or reverse some of the effects.

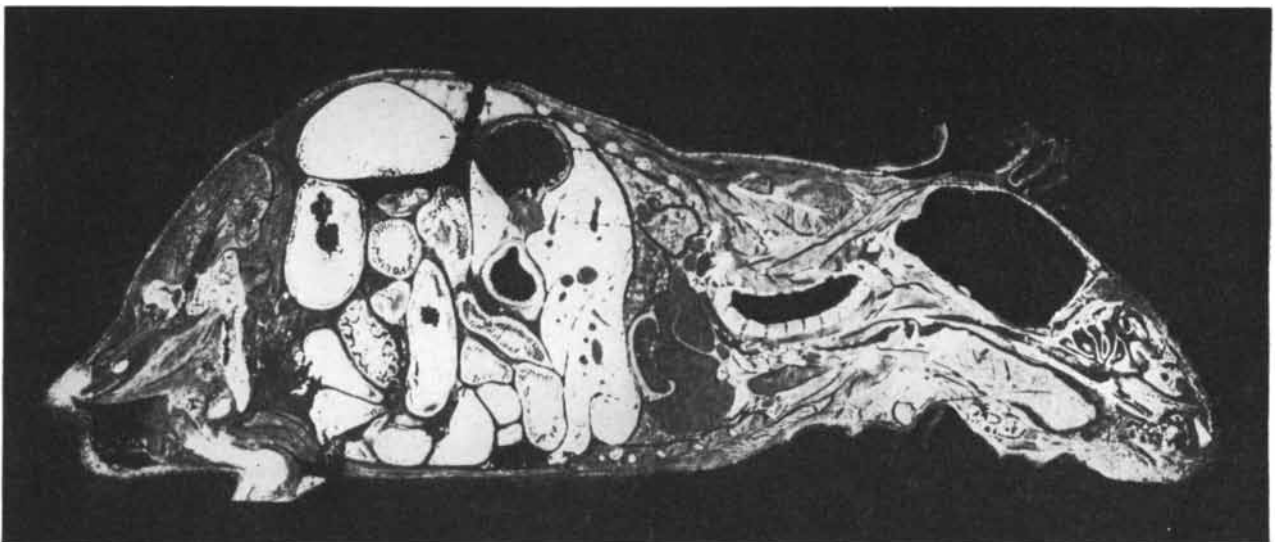
There is a great deal we do not know about these processes, and our ignorance has more to do with fundamental bio-

chemistry and physiology than with radiation. Obviously more investigation is needed. Meantime ionizing radiation produced by human activities raises problems that may affect all the organisms that now inhabit the earth. These problems must be appraised with the help of the biological and medical tools currently at hand.

The range of the problems should be clearly understood at the outset. At one extreme we are concerned with doses of radiation large enough, and delivered quickly enough, to produce detectable effects in an individual organism. Here there are symptoms for the physician to perceive, tissue changes for the pathologist to examine or for the chemist to analyze.

At the other extreme we have to do with doses so small or so slowly delivered that their direct physiological effects, if any, are too faint for us to recognize. In

such cases we can try a statistical approach; for example, we irradiate a large number of mice and try to find out whether more of them develop leukemia than do an equal number of nonirradiated animals. In the absence of statistical data for small doses, as is usually the case for human beings, a dubious form of extrapolation is sometimes attempted: If a dose of 500 rads [*see glossary of terms on page 78*] of mixed gamma rays and fast neutrons from an atomic bomb appears to cause 3,500 cases of leukemia per million people exposed, then one rad of X-rays should cause seven cases. Such a calculation has an appealing simplicity. It is easy for the layman to understand and may even be tempting to the nonmedical investigator. To those who have investigated the complex problems of cancer, however, the simple computation seems unwarranted. It is in this area, therefore, that much



RADIOAUTOGRAPH OF MOUSE given radioactive tetracycline shows that distribution depends on biochemical behavior of the molecules to which radioactive atoms (in this case tritium) are

attached. Here the concentration was greatest in liver, kidneys, lymphoid tissue and skeleton. The autograph, by Torsten André, was made by placing section of mouse on photographic plate.



WHOLE-BODY IRRADIATION OF MICE is carried out at the Oak Ridge National Laboratory in this room. The cylindrical shielding-can on the floor contains a cobalt-60 source. The animals are placed in their cages on racks above and around the source.

misunderstanding arises. We shall have more to say about the matter later. Let us begin, however, by considering the more apparent effects.

Enough radiation will kill any organism. An overwhelming dose kills instantly; a smaller, but still lethal, dose causes death within hours, days or weeks. Organisms vary widely in their sensitivity to radiation—much more widely than the cells of which they are constituted. In general, the more complex the organism, the more vulnerable it is. It takes about 20,000 rem to kill a snail, a few thousand to kill a lizard, a few hundred to kill most mammals.

Furthermore, individuals of the same species react differently. Because of this variation we frequently use as a measure the dose that is lethal to 50 per cent of the individuals exposed, abbreviating it as LD_{50} . The “acute LD_{50} ” (the single dose that will be fatal to 50 per cent of the exposed individuals within 30 days) for man is 300 or 400 r for 250-kilovolt X-rays; for monkeys, about 500 r; for mice, about 600 r [see top chart on page 120]. Immature and senile animals are more sensitive than young adults.

These figures refer to a single burst of radiation delivered to the whole body. As might be expected, much high-

er doses are tolerated when only a part of the body is exposed. Here the effect will depend on the amount and kind of tissue that is irradiated, its vulnerability to radiation and its role in the economy of the organism. A man could absorb a few hundred rads in his hand, say, with virtually no effect on his body as a whole. However, an equal dose to the abdomen would have serious consequences. Moreover, the rate at which radiation is received has a great deal to do with its effect. A much larger quantity of radiation can be tolerated if it is divided into small fractions and delivered at intervals than if it is administered all at once. By dividing and spreading the dose radiotherapists can treat cancerous tissue with thousands of rads without excessive damage to the patient.

What happens to the body of an animal when it receives a dose of radiation in or near the lethal range? The most critically sensitive tissues are the lining of the intestine and the bone marrow and lymphoid tissues that manufacture blood cells. Intestinal damage causes the body to lose water and salts. If the dose is big enough, say two or three times LD_{50} , the injury is irreversible and death follows in a few days. At smaller but still lethal doses the situation corrects itself and the most serious problem becomes

the loss of blood-manufacturing tissue. Death is now delayed for several weeks. It may be due directly to anemia, or to infection following the destruction of white blood cells.

Accompanying these specific effects, whether or not they are severe enough to be fatal, is a generalized reaction called the radiation syndrome. Its first manifestation is radiation sickness, characterized by nausea and vomiting, usually together with a profound lassitude. Subsequently the patient may bleed from the gums or nose, and after 10 days or so may lose some hair. The initial radiation sickness does not seem to depend on damage to specific organs. It follows whenever too much tissue receives too big a dose, whether accidentally or deliberately, as in cancer therapy. The whole clinical picture suggests a general intoxication. Presumably substantial masses of tissue break down, releasing into the general circulation substances that are normally bound within the cells. But even in 1959 this explanation remains a hypothesis subject to further research. No one has thus far identified the toxic substances.

Is there any treatment for these acute reactions to exposure? So far as the radiation syndrome is concerned, we cannot hope to find a specific treatment until we

SERVING SAFETY THROUGH SCIENCE

Today a busy man's wife and little daughter received a long-distance message from him. In spite of a heavy overcast, his plane arrived at its destination safely. A normal event *today*...but how was it made possible?

Over a hundred years ago (so the story goes) a man and his daughter were walking by a railroad track. A train passed. It blew its whistle—a high-pitched sound as it approached and a deep-pitched moan as it disappeared. The little girl asked: "Why is that?" The question intrigued her father, and Christian Doppler investigated. His research—and the effect it defined—became part of our scientific heritage.

The Doppler Effect—a scientific truth which explained the change in pitch of sound waves—applied equally to light waves. It enabled astronomers to measure the speed at which distant stars move toward or recede from us. It applied to radio waves as well and led to the development of AID (Automatic Instantaneous Direction-finding) which enabled the busy man's plane to arrive at its destination safely.

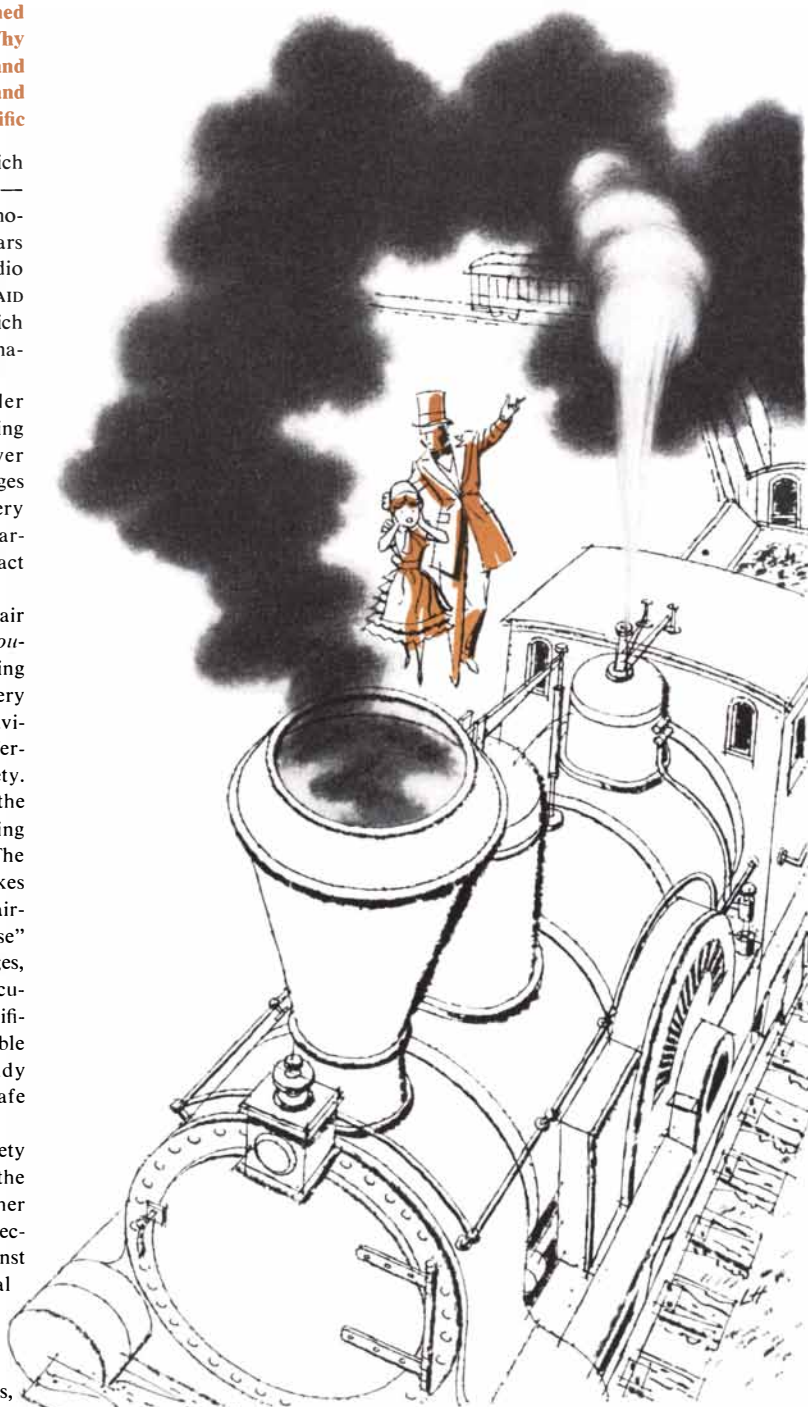
For some time now SERVOFLIGHT® Doppler Direction Finding Systems have been demonstrating a reliability, bearing stability, and speed never before attainable...even at intercontinental ranges as well as near crowded airports. At this very moment a pilot may be asking: "What is my bearing?"—and before his last word is out, his exact bearing is known.

This is but *one* aircraft...*one* aspect of air safety. Taking a larger perspective, we see *thousands* of aircraft filling the airlines and approaching airports every day of the week over the world over. Every one of them, minute-by-minute, needs *accurate* navigational bearings—undistorted by signal interference—if increasing air traffic is to move with safety.

SERVO CORPORATION OF AMERICA is meeting the need for such an air navigation system by utilizing the Doppler Effect in a newly developed way. The SERVOFLIGHT VHF Doppler Omnicrange System makes possible reliable guidance and navigation along airways throughout the world. It provides "on course" indications so reliable that even mountains, bridges, hangars, and tall buildings cannot distort the accuracy of the ground station signals. Of great significance, too, is the fact that this system is compatible with the 104,000 omnicrange receivers already installed in commercial aircraft, thus keeping safe an investment of over \$300,000,000.

Such use of scientific concepts serves the safety of all... and there are many examples, such as: the SERVOFLIGHT Radio Theodolite for tracking weather balloons; the patented SERVOSAFE® Hot Box Detective* for protecting railroad rights-of-way against train derailments caused by overheated journal boxes; infrared safe-control devices for industry, and military surveillance and reconnaissance systems for safety against surprise attack.

With every division, all products and services, SERVO CORPORATION serves safety through science.



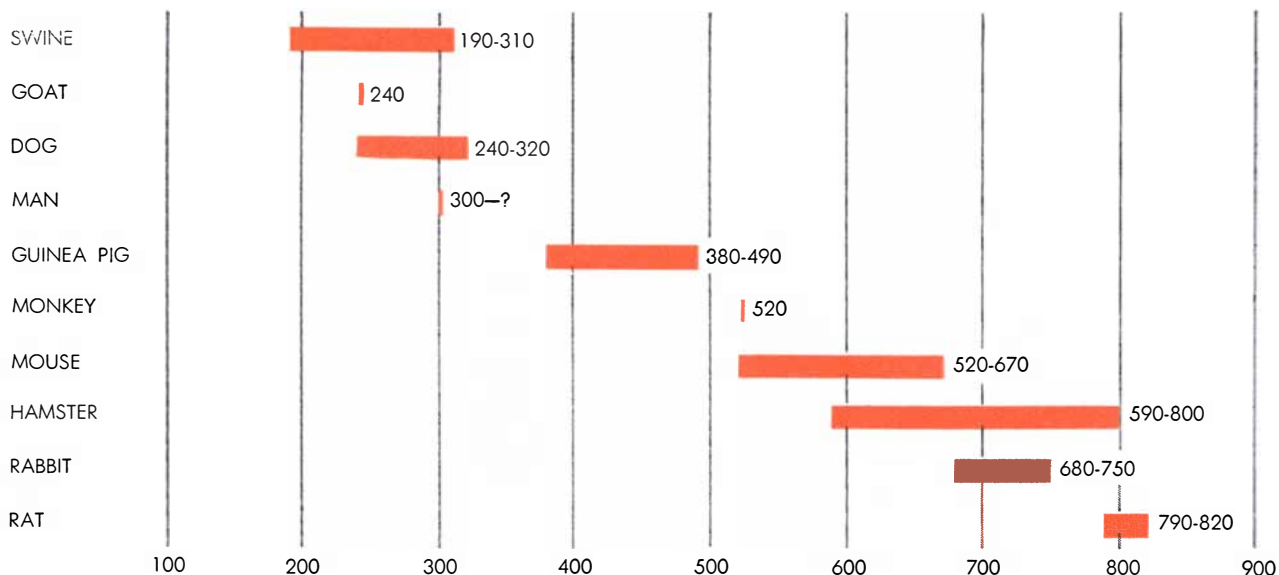
SERVO CORPORATION OF AMERICA

*Protected by U.S. Patent No. 2,880,309. Other U.S. & Foreign Patents Applied For.



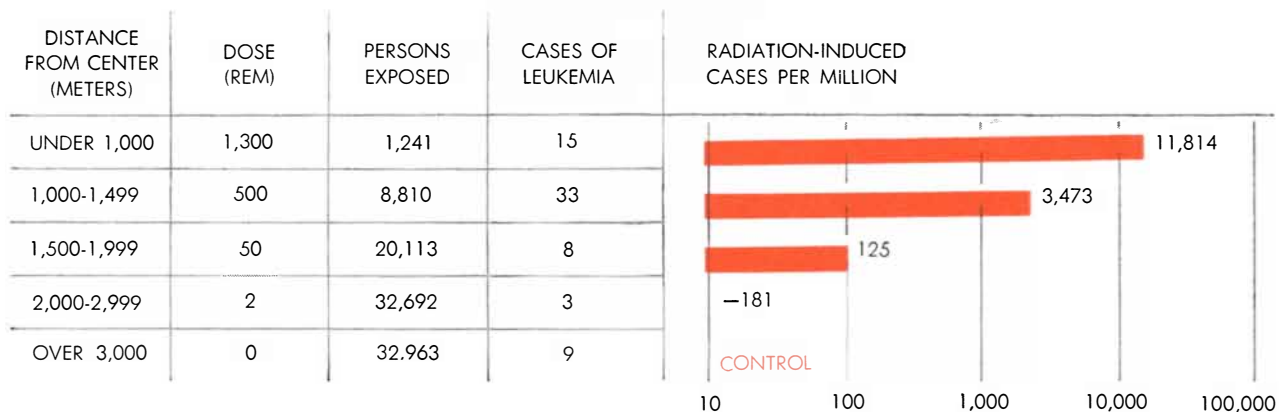
111 New South Road, Hicksville, L. I., New York

© 1959 SERVO CORPORATION OF AMERICA



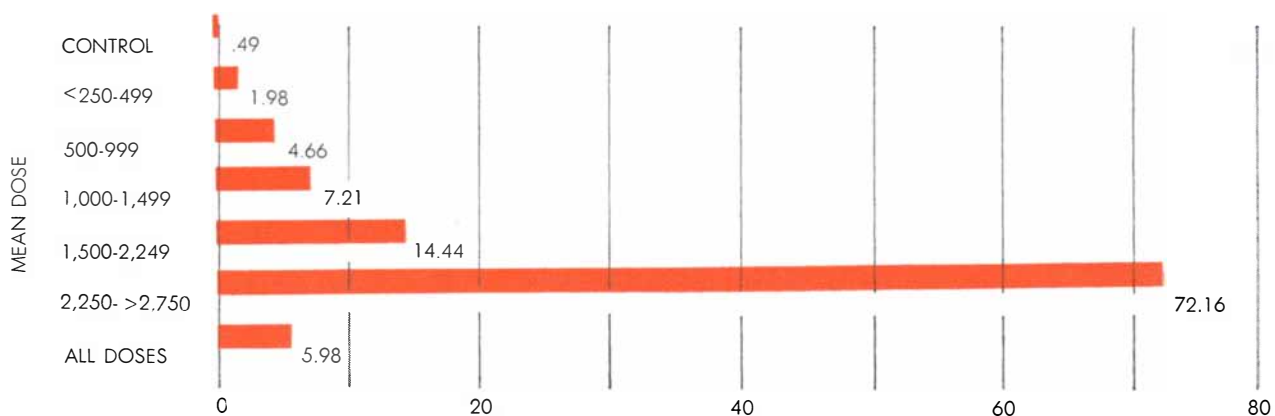
ACUTE LD₅₀ (the single dose of radiation that will kill 50 per cent of the exposed individuals within 30 days) has been estimated for various mammals in a number of experiments. The sharp values for the goat, man and monkey reflect limitations in the

amount of experimental data rather than precise knowledge. The figure for man is subject to considerable uncertainty. The dose unit in this chart is the rem [see glossary of terms on page 78]. As used here it is roughly equivalent both to the rad and the r.



HIROSHIMA SURVIVORS within 2,000 meters of the point above which the atomic bomb was exploded developed more cases of

leukemia than in the general population. Bars show incidence (per million people) attributable to radiation for the period 1950-57.



FRACTIONATED DOSES OF X-RAYS to the spines of British patients suffering from an arthritic disease called ankylosing

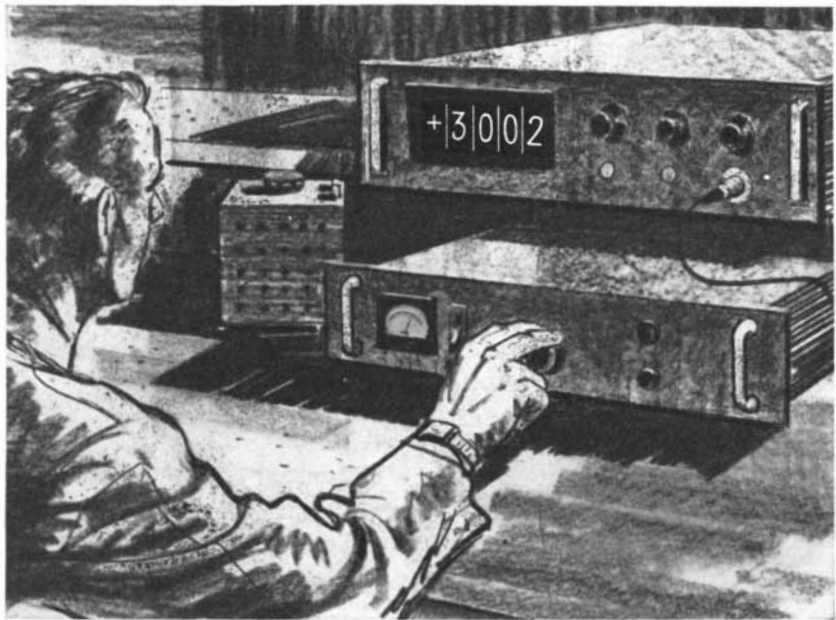
spondylitis also produced an increased incidence of leukemia. Bars show number of cases of leukemia per year per 10,000 men.

have a clearer picture of its cause. We do know that rest and proper diet promote recovery. Antibiotics help control infection. As to intestinal damage, no method has yet been found to assist the body's own repair mechanisms. The situation is more hopeful, however, in the case of the blood-forming tissues.

Ten years ago Leon O. Jacobson, then at the University of Chicago, showed that mice whose blood-manufacturing system had been destroyed by a lethal dose of radiation could be kept alive by implanting or injecting normal blood-forming tissue from healthy animals. Subsequent investigation has proved that this tissue acts as a functioning graft in the irradiated mouse. Under ordinary circumstances this could not happen; the host would become "immune" to foreign tissue and reject it. But the same radiation that affects the blood-forming system also destroys the capacity to produce an immune response. Thus it seems that the cells of the donor actually repopulate the bone marrow and the pulp of the spleen, where blood cells are manufactured, and in addition the lymphoid tissue responsible for immunity.

Whether the procedure would be equally effective in man is not certain. It happens that the dose of radiation necessary to inactivate the mouse's immunological system permanently is very nearly the same as the lethal dose. In the dog, however, it is considerably greater than the lethal dose, and in man it may also be greater. Even so, tissue transplants can be of some help. This was demonstrated recently after an accident at a nuclear reactor in Yugoslavia. Several persons exposed to intense radiation were treated in Paris. The French physicians judged from biological reactions that five of the Yugoslav workers had received lethal doses, and gave them transfusions of normal bone marrow. Four of the patients improved dramatically and eventually recovered. Subsequent studies showed that the marrow grafts were not permanent, and possibly did not include the lymphoid system. Apparently the irradiation had blocked the immune response of these individuals for a limited time only, and had not injured their blood-forming system beyond repair. Temporary acceptance of the foreign cells gave time for the repair to operate.

In addition to seeking cures for radiation damage, we should like to find ways to prevent or reduce it in the first place. At present this is only a hope. As the authors of the preceding article have pointed out, ionizing radiation produces many of its effects indirectly, by forming free radicals and peroxides. In in-



Modernize Your Measurements With This Low-Cost Digital Potentiometer

Fast . . . accurate . . . easy-to-read digital measurements of any parameter that can be converted to DC voltage are yours with the NLS 481 Industrial Voltmeter — a fully automated potentiometer. Temperature, pressure, salinity, weight, flow, speed, liquid level, angle, acceleration, magnetism, distance — almost anything can be measured automatically with the NLS 481 . . . and the results clearly displayed by inch-high, illuminated numerals on the 4-digit readout. Only NLS — originator of the digital voltmeter — offers a precision instrument of such high performance for such a small investment. Write today for complete information concerning this versatile instrument.



\$1285

COMPLETE, F.O.B. DEL MAR, CALIF.

- Internal standard cell permits verification of calibration.
- Can be read at distances up to 30 ft.
- Easily converted to a ratiometer for analog computer readout.
- High input impedance (10 megohms).
- Measures DC voltages from one millivolt to 1,000 volts.
- All controls and connectors are located on the front panel.
- Accessory converter permits measuring AC voltages.
- Modern one-package design — 5¼ inches high, 15¼ inches deep for mounting in standard 19-inch rack.
- Available from stock for immediate delivery.



Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA

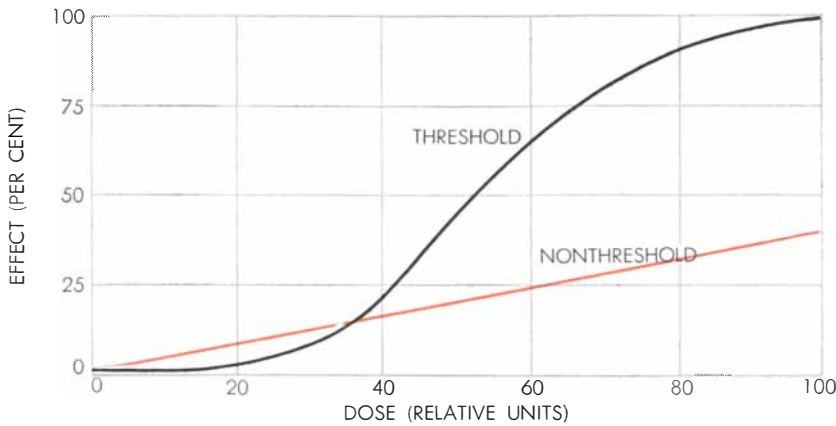
Please rush me complete information about the NLS 481.

Name _____

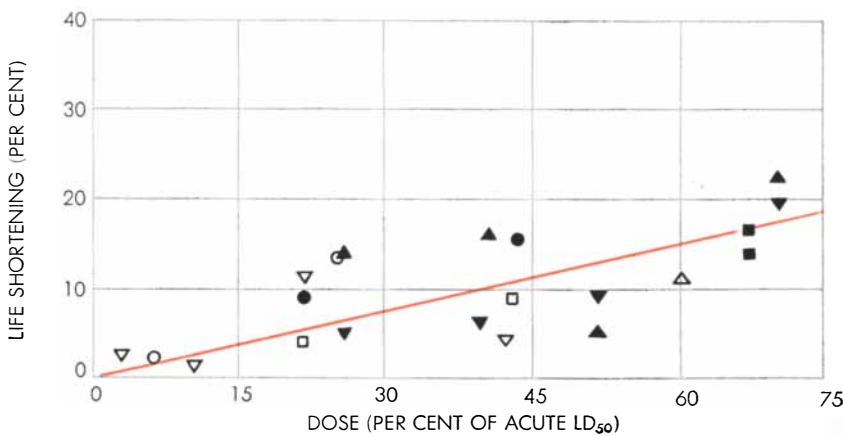
Company _____

Address _____

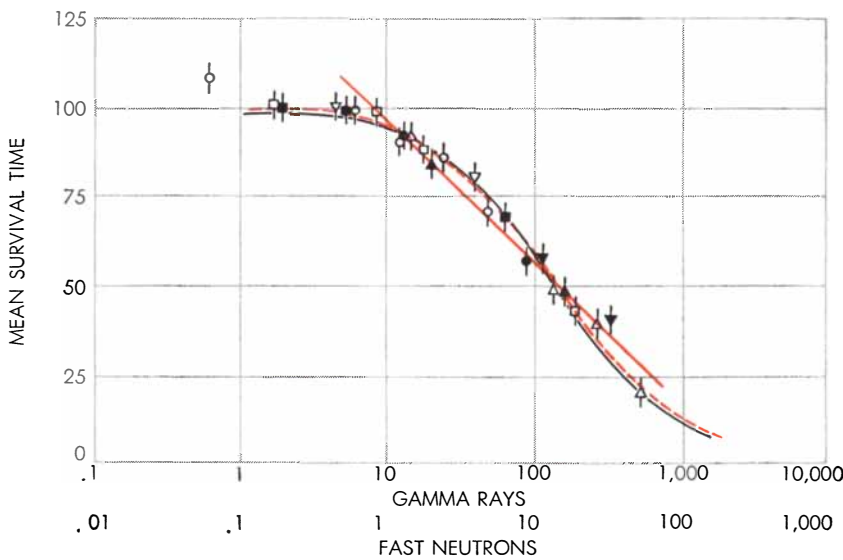
City _____ Zone _____ State _____



EFFECT OF RADIATION can be of two types, threshold or nonthreshold. In the former case small doses produce no detectable effect, shown by the fact that the S-shaped curve runs along the baseline for some distance before turning upward. In the latter case any dose, no matter how small, has some effect. In practice the shape of the curve is often uncertain.



SINGLE DOSES of radiation have shortened the lives of mice and rats in a variety of controlled experiments. The effect may have no threshold. Acute LD₅₀ is the dose fatal to 50 per cent of the subjects in 30 days. Various symbols represent data from different experiments. This graph and the one below, as well as the charts on page 120, are based on the 1958 Report of the United Nations Scientific Committee on the Effects of Atomic Radiation.



WEEKLY DOSES of fast neutrons or gamma rays have also shortened the lives of mice and rats. Three curves appear to fit the data almost equally well. All indicate that there may be a threshold for the life-shortening effect when small, repeated exposures are involved.

dividual cells it is possible to reduce these effects several-fold by cutting off the oxygen supply or by adding certain substances. Only some of the substances can be used on intact animals. Most of them are toxic, and even in limited doses lower the body temperature profoundly. They do seem to give some protection against radiation, but how they operate is uncertain. Possibly they reduce the supply of oxygen in radiation-sensitive tissue, but other physicochemical mechanisms have also been proposed. In any case, none of them has practical value as yet.

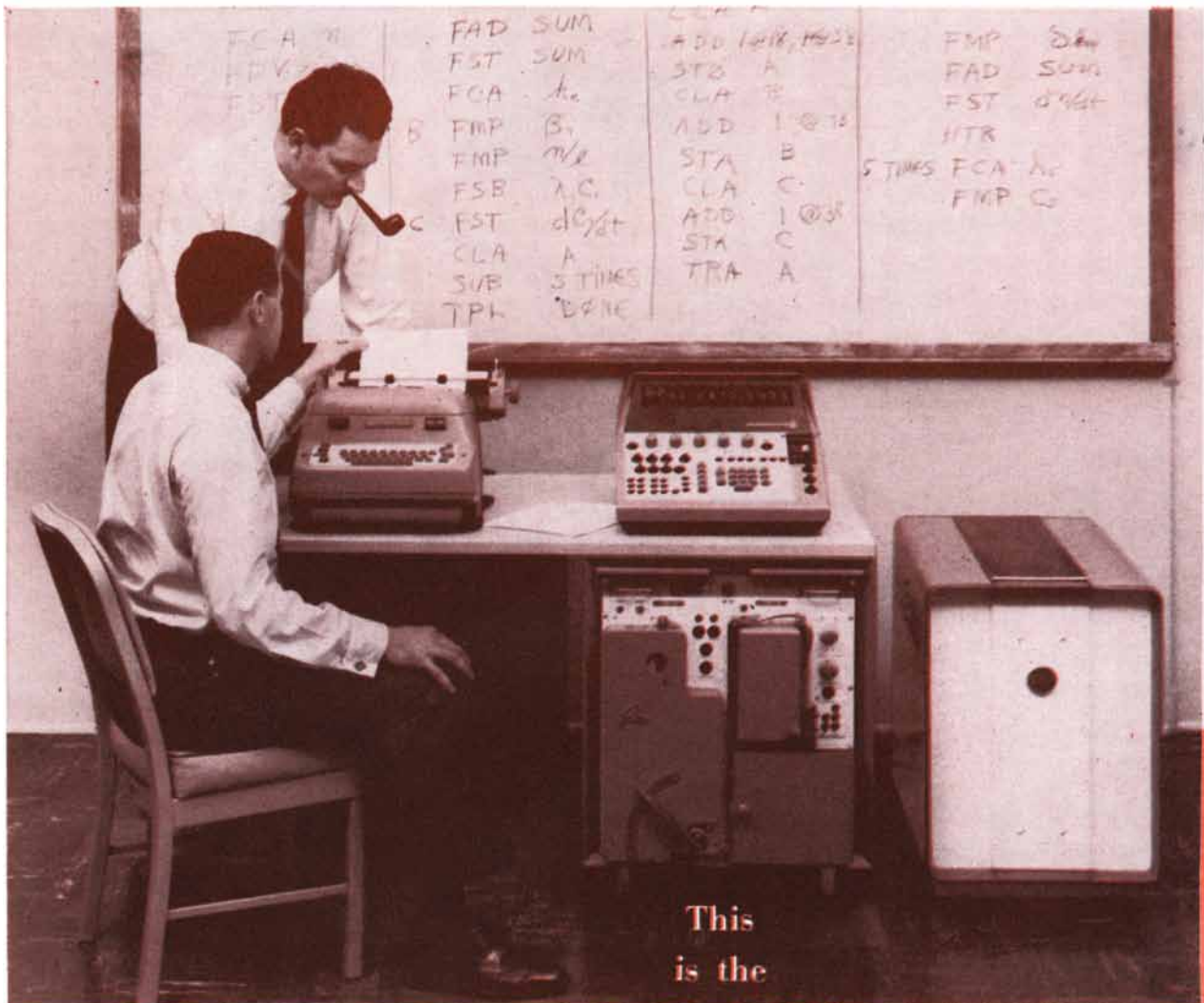
Thus far we have been speaking of the immediate response of the organism as a whole to a massive dose of radiation. This is only part of the story. Some effects manifest themselves more slowly, appearing months or years after exposure. Furthermore, repeated doses that are too small to produce any immediate reaction may eventually have an effect. Many of the early workers in radiation learned this by fatal experience.

Radiologists, then working with low-voltage X-ray machines, were exposed to radiation of low penetrating power. They absorbed most of their dosage in the skin. After a time they developed superficial lesions that resembled a sunburn but were much slower to appear and to heal. When the burns did heal, they left permanent scars. And the process of repair often carried with it further long-term changes. Years later many of the scars became cancerous.

Those researchers who dealt with more penetrating radiation also suffered delayed effects. As might be expected, most of the injuries were to the blood-forming tissues. Death from anemia and its complications was not uncommon. And as with the skin, so with the bone marrow. If the original injury repaired itself, malignant changes later led in a number of cases to leukemia.

This disease, in which the blood-forming tissue produces too many white cells, takes several forms in man. It can be acute, leading to death shortly after its appearance, or chronic but ultimately fatal. Two different types of white cell, known as granulocytes and lymphocytes, may be involved. Chronic lymphoid leukemia, the incidence of which increases with age, has not been shown to be induced by radiation. But there is good evidence both from the early radiologists and from more recent experience that chronic granulocytic leukemia and various types of the acute disease have followed overexposure to radiation.

The atomic bomb explosions at Hiro-



This
is the

RECOMP digital computer

It has a
storage capacity
of 8,000 instructions
... and it's
low-priced

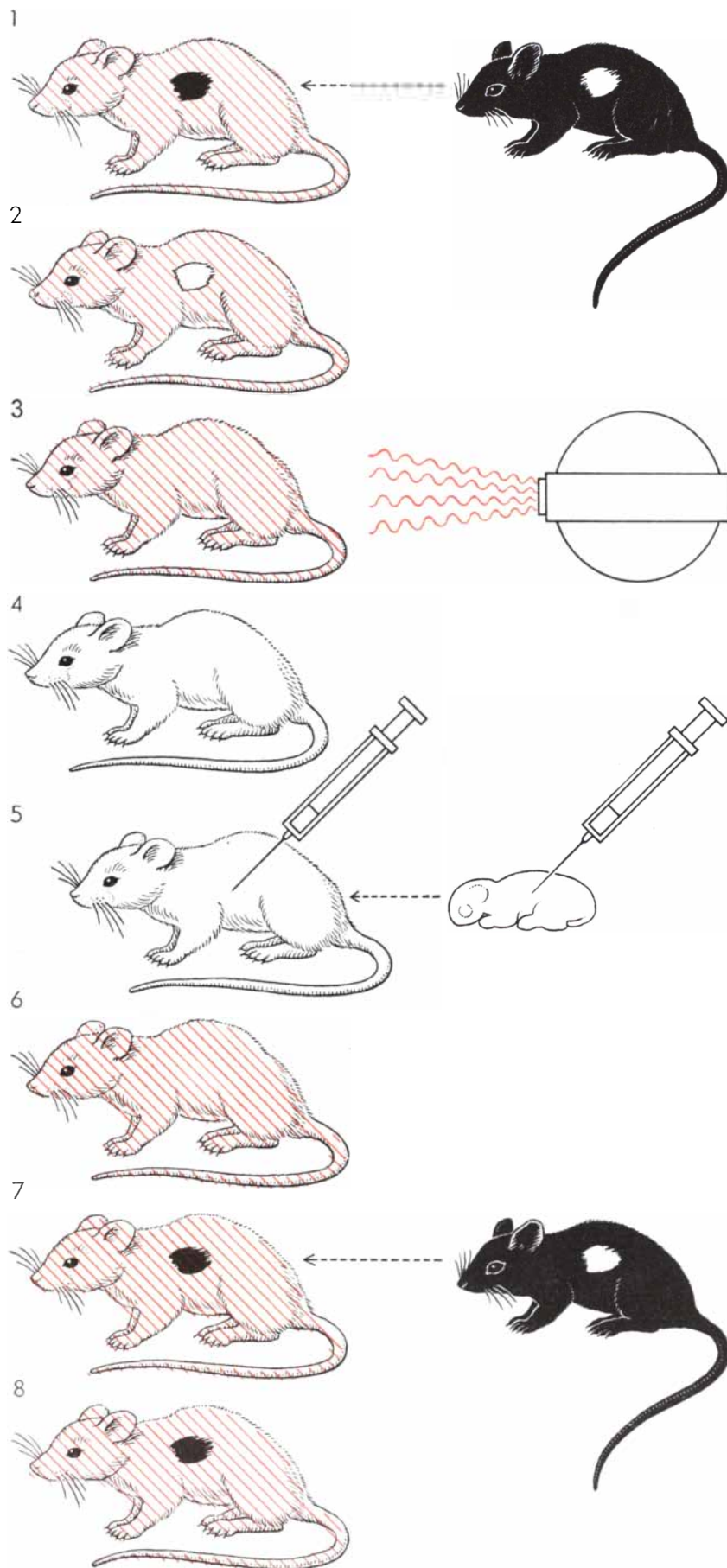
No problem is too complex to tackle with Recomp—and you can afford to put it wherever it's needed to break up computer-time bottlenecks. It's easy to use, too; engineers quickly learn to program their own problems. *Other Recomp features:* a command structure of 49 arithmetical and logical commands—including 9 built-in floating point commands... standardized teletype tape configuration... all-transistorized... 400-character-a-second input... electronic console that puts all basic controls within fingertip reach... simplified coding. Recomp gives you far more capacity, versatility, and trouble-free service for your money. It's available for sale or lease. *There's no extra equipment to buy... no cost of installation.* Please write for complete literature. Industrial Products Division, Autonetics, Dept. 19, 3584 Wilshire Boulevard, Los Angeles 5, California.



This engineer learned to program Recomp in two days

Digital computers by **Autonetics**

A DIVISION OF NORTH AMERICAN AVIATION, INC.
Other offices: Dayton, Ohio; Washington, D.C.



shima and Nagasaki undoubtedly increased the incidence of leukemia among survivors who were within a mile or so of the explosion center [see middle chart on page 120]. These people received doses of from 50 to 1,300 rads, presumably to the whole body. Intermittent exposures of parts of the body can also cause the disease. A British study has documented this in a group of men suffering from an arthritic spinal disease known as ankylosing spondylitis, or "poker back." The patients had been treated with X-rays concentrated on the spine, the total dose varying from 250 r to more than 2,500 r. Again the subsequent incidence of leukemia was substantially greater than that for the general population [see bottom chart on page 120]. On "a working hypothesis that, for low doses, the incidence of leukemia bears a simple proportional relationship to the dose of radiation," the authors of the study concluded that a dose of 30 to 50 r to the whole marrow would be likely to double the natural incidence of leukemia.

According to a recent report from the University of Oxford, the human fetus is very much more sensitive in this respect. The Oxford investigators studied the fetal history of children who had died of leukemia or other forms of cancer before the age of 10. A preponderance of these children proved to have been exposed to radiation during pelvic X-ray examinations of their mothers. Such an examination gives a dose of about two r to the fetus. Those receiving it proved about twice as likely as other children to die of malignant disease before their 10th birthday.

We should note that in all these instances, including the small doses to unborn children, the radiation was re-

TISSUE TRANSPLANTS that would be impossible in normal mice will "take" in irradiated animals. In the experiment represented schematically at left, skin from a mouse of one strain is grafted onto a normal animal of another strain (1). (Colored hatching indicates that animal has functioning blood-forming tissue.) The graft is rejected (2). Mouse is given a lethal dose of radiation (3), which destroys its blood-forming tissue (4) and the tissue responsible for its immune reaction to foreign grafts. Blood-forming tissue from the liver of a fetal mouse is injected (5), the blood-building system is restored (6) and the mouse recovers. The irradiated animal will also accept a foreign skin graft (7 and 8).

Pure MgO



International's MgO has the purity others lack because it's . . .

produced by thermal decomposition

Disappointed with conventional magnesium oxides? Then try International's. *It's the only MgO produced by thermal decomposition.* And the difference is amazing! Electrically furnaceed, this MgO has achieved the highest resistivity and refractory properties of any commercially available magnesium oxide.

You'll find International MgO relatively low in cost. Now improved production facilities are geared to produce any quantity you need.

For further details, fill out and mail the coupon . . . you can count on a prompt reply.

Here's how IMC does it!

CONVENTIONAL PROCESSES

↓
Magnesium Chloride MgCl₂
 (Contained in sea water, well brine, bittern.)
 +
Lime CaO
 (Contained in dolomite, sea shells, etc.)
 ↓
Magnesium Hydroxide Mg(OH)₂ + heat
 ↓
Magnesium Oxide MgO

INTERNATIONAL'S UNPARALLELED PROCESS

Magnesium Chloride
MgCl₂ + heat
 ↓
Magnesium Oxide + Hydrochloric Acid
 MgO HCl
 ↓
 heat → MgO

And here's the result!

MgO	99.5%	Cl	0.03	Density	75 lbs./cu. ft.
Si ₂ O ₂	Nil	CaO	0.05	Low Boron, too,	
SO ₄	0.03	Fe ₂ O ₃	0.05	upon request!	

INTERNATIONAL MINERALS & CHEMICAL CORPORATION

Administrative Center: Skokie, Ill. • Phone ORchard 6-3000 • 485 Lexington Ave., New York 17 • Midland, Texas

Producers of Living Minerals



INTERNATIONAL MINERALS & CHEMICAL CORPORATION POTASH INDUSTRIAL • Skokie, Illinois

This coupon will bring you complete descriptive data and specifications, plus a sample of (check one) . . .

POWDERED MgO GRANULAR MgO PELLETIZED MgO

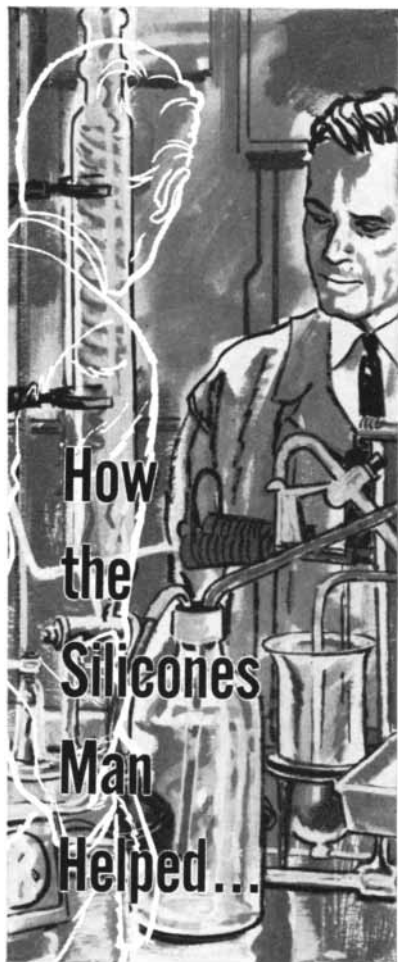
Name

Firm

Address



41-59



GREATER HEAT AND WEATHER STABILITY FOR COLD-BLENDED METALLIC PAINTS

Manufacturers of automotive components—manifolds mufflers, tailpipes—can lengthen the life of parts subject to wetting and oxidation with a silicone resin specially designed by UNION CARBIDE. Industrial stacks, ducts, vents, ovens, conveyors, and other equipment get longer-lasting protection. Many other producers and users of metal products will find benefits from metallic-pigmented paints made with the new silicone resin.

When used for cold-blending with alkyd, melamine, and acrylic resins, the new silicone product gives coatings greatly increased thermal stability and weather resistance. Blended with aluminum and other metallic pigments, the resin mixtures supply all the desirable high-temperature properties of straight silicones at a lower cost.

Paint formulators will find numerous other advantages by using this silicone resin.

The term "Union Carbide" is a registered trade-mark of Union Carbide Corporation.



SILICONES

Its compatibility with organic systems is superior to resins traditionally employed. The inherent film toughness and adhesiveness of organics is retained—blends are easy to prepare, apply, and cure. Substantial savings in materials result, since only low concentrations of the resin are required.

The new UNION CARBIDE silicone product can also be cold-blended with organics to meet applicable military specifications.

EXTENDING THE USES OF SILICONE WATER REPELLENTS

Water repellents formulated with silicones are now standard in specifications for above-grade masonry by many engineers and architects. The silicone resin penetrates into pores and crevices, eliminating water seepage and checking efflorescence. A special type of silicone resin was developed for use on concrete highways, bridges, dams and airport runways, which is effective in minimizing the cracking and spalling caused by alternate freezing and thawing conditions.

Cooperative efforts of asbestos shingle manufacturers and the Silicones Man have resulted in another silicone water repellent that keeps asbestos shingles clean and colorful, despite the weather. The silicone resin, by lining tiny cracks and crevices in the asbestos composition, prevents entry of rain-borne dirt and other soiling particles. Foreign material that settles on the surfaces is rinsed away by the rain. Since the silicone is colorless and transparent, the shingles retain their original color and appearance.

CAR OWNERS (AND THEIR WIVES) WILL BE GLAD TO HEAR ABOUT THIS

Here's what the operators of a certain government transportation unit do to eliminate hard-to-find squeaks in their fleets of vehicles: They apply just a bit of silicone lubricant to the rubber weather stripping and fan belts. This not only cuts out squeaks for several months, it restores flexibility to the rubber. Despite the weather—rain, heat or cold—it won't turn sticky or messy . . . doesn't harm paint or metal.

The Silicones Man is accustomed to helping solve problems like these . . . and he may be able to help you, too. For background information on these and other applications, write Dept. IF-0904, Silicones Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Toronto 7.

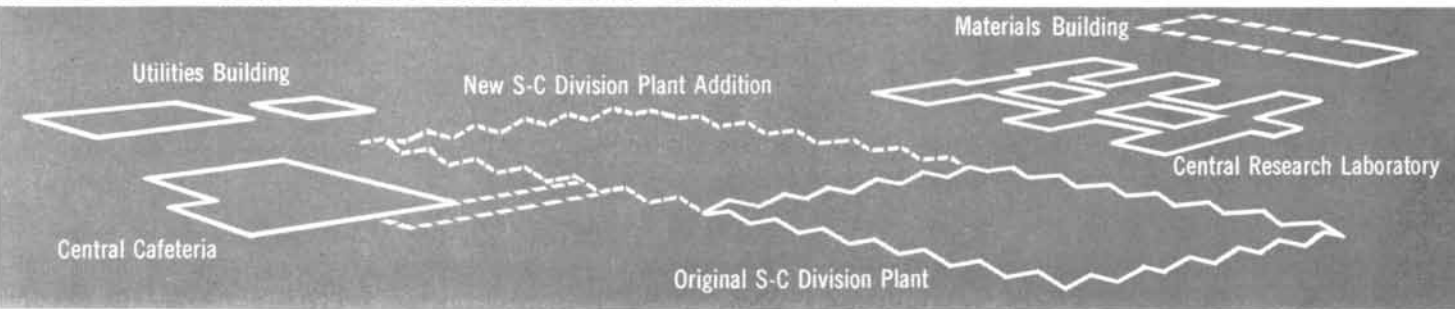
ceived at a substantial rate. Whether very much lower dose-rates can also cause leukemia is a question to which we shall return later.

Delayed effects of radiation are also observed in bone. Large therapeutic doses (1,000 r or more) have destroyed bone tissue and led to fractures. Much of what we know about bone damage, however, we have learned from the famous U. S. case of the luminous-watch-dial painters, who were chronically exposed to radiation from within their own bodies. They had inhaled and swallowed radium and mesothorium which were used in luminous paint. From the lungs and gut these elements passed into the general circulation. Being chemically similar to calcium, they were eventually incorporated more or less permanently in the bones of the workers.

Those whose skeletons had taken up more than 10 microcuries of radioactive material suffered acute destruction of bone and marrow, and died within a few years as a result of this direct damage. (Each microcurie of radium delivers an average dose of about 30 rads per year.) For "burdens" of one to 10 microcuries the bone lesions were less acute; the affected workers lived longer, some long enough to develop bone cancers. There were very few cases of leukemia, however. At levels below one microcurie only rarely have serious changes been noted, and below a third of a microcurie no changes of significance have been observed. Some of the workers have now been under observation for as long as 30 years after their contamination.

Nuclear fission has added to the environment another bone-seeking radioactive isotope: strontium 90. Workers actively handling this material might conceivably take enough of it into their bodies to produce long-term damage. As practically everyone knows, strontium 90 has been released into the atmosphere by the testing of nuclear weapons, and small quantities of it have found their way through the food cycle into the bodies of human beings. The amounts involved, however, are very much smaller than those we have been discussing. Measurements on young children, whose rapidly growing bones incorporate strontium at a maximum rate, have shown burdens up to a few thousandths of a microcurie. The corresponding dose-rate is in the neighborhood of .01 rad per year.

Various human tissues in addition to those already mentioned exhibit special reactions and sensitivity to radiation. For example, cataracts have been produced



The world's largest semiconductor plant ...more than doubles in size!

By early 1960, more than 700,000 sq ft of plant space in Dallas will be devoted to the development and production of high quality semiconductor products by Texas Instruments. Although the original 310,000 sq ft plant — still the industry's largest — was completed only last year, growing mass-production requirements for TI semiconductors and components led to this additional expansion. This giant new plant will further serve TI goals of lowering semiconductor unit costs through high-volume production while rigidly maintaining high standards of reliability.

The Central Research Laboratory, located on the same 300-acre tract, houses creative personnel and facilities for basic research on semiconductors and related materials. Supporting buildings complementary to semiconductor development and manufacture scheduled for completion this year include a Materials building for the manufacture of high purity semiconductor and allied materials, a Utilities building and a Central Cafeteria... all integrated toward the production of semiconductors and components of ever increasing performance and reliability.

Only advanced facilities can produce advanced components.

These newest TI technological facilities are specifically geared to supply customer needs, both present and future, further insuring new and finer electronic components... in advance of user requirements.



Bedford, England semiconductor plant of Texas Instruments Limited. 32,000 sq ft facility is now in complete operation with a new 115,000 sq ft building, shown here, scheduled for completion in late 1960.

- germanium and silicon transistors
- silicon diodes and rectifiers
- tan-TI-cap** solid tantalum capacitors
- precision carbon film resistors
- sensistor* silicon resistors

TEXAS



INSTRUMENTS
INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
DALLAS, TEXAS

YOUR NEXT BREAKTHROUGH

may well
come with our help

Many a research project at some point falters for lack of a faster, keener, or more accurate means of sensing and processing the data. Let us tell you how such barriers are now being overcome by new, rapid photographic processing and electro-optical techniques. This is a field of instrumentation in which we are pre-eminent.

**Photo
Mechanisms, inc.**

Huntington Station, New York • Telephone HAmilton 3-4411

OPTICAL AND PHOTOGRAPHIC INSTRUMENTATION FOR GOVERNMENT AND INDUSTRY

in the lens of the eye by doses of a few hundred rads to parts of the body which include the eyes. Heavy irradiation of the lungs in radiotherapy causes a slowly developing, progressive inflammation known as radiation pneumonitis. The gonads are particularly vulnerable. Single exposures as low as 30 r can produce temporary sterility. Smaller, repeated doses have a similar effect, and larger exposures lead to permanent loss of fertility, especially in females.

In general, cells in the process of division are especially sensitive to radiation. In the adult organism division is responsible for the continuous renewal of blood cells, skin and intestinal lining and for the production of sperm. These systems, as we have seen, are among the most easily affected by radiation. As would be expected, the developing embryo (particularly at the stage where the various tissues are being organized) is liable to damage that is irremediable. Doses of 25 r or more at this stage may lead to serious malformations.

As a final comment on the detectable effects of radiation, it should be said that neither individual organisms nor their descendants seem able to develop tolerance, as is the case with some other poisons. Small doses, given steadily or repeatedly at intervals, do not increase the body's resistance to radiation, whatever else they may do.

We turn now to effects of very small quantities of radiation on the human organism. In studying the biological effects of chemical agents such as drugs, we generally use a particular type of graph to analyze the experimental data. Along the horizontal axis of the graph we measure dose on a logarithmic scale; along the vertical, the effect as a per cent of the maximum. In almost every case the resulting curve is S-shaped, running closely parallel to the horizontal axis for some distance before it turns upward. This means that below a certain dose we can detect no effect whatever [see top chart on page 122]. In other words, there is a threshold for the action of the agent. Not all dose-effect curves have the standard shape, however. Another possibility is a straight line running up from the zero point or from a point on the vertical axis. Such a line indicates that any dose, however small, has a measurable effect.

Now in the case of radiation effects, especially the effects of high dose rates on mammals, the lines on the graphs usually turn out to be curved, not straight. On the other hand, it has been



SHE
OWES HER
SUCCESS TO
VELSICOL
W-617

... the product that puts "can-do" in "do-it-yourself" paints!

The electron micrograph behind the young lady shows why millions of Americans can become expert painters, and can afford to paint more often. It shows the spherical configuration and uniform size of resin particles in Velsicol's W-617 emulsion paint base. W-617 is a water emulsion of light colored thermoplastic hydrocarbon resin. The average diameter of W-617 resin particles is .125/micron. Natural rubber latex particles have an average diameter of .600/micron. Latices and emulsions of small particle size have more binding power. They will take higher pigment or filler loadings without losing film strength. Penetrating characteristics are improved. The uniform size of the dispersed resin particles increases film smoothness. W-617 is one of many new products of Velsicol research that is now in commercial production. For more news about this product, and other developments of Velsicol research, please mail the coupon.

MAIL COUPON FOR LITERATURE!



LOOK FOR THIS MAN
... your Velsicol Representative,
who can help you make
better products for less!



VELSICOL CHEMICAL CORPORATION
330 East Grand Avenue, Chicago 11, Ill.
International Representative: Velsicol International Corp., C.A.
P. O. Box 1687 • Nassau, Bahamas, B.W.I.

- Please send technical literature on W-617.
 Please have salesman call. SA-99
 Please send test sample.

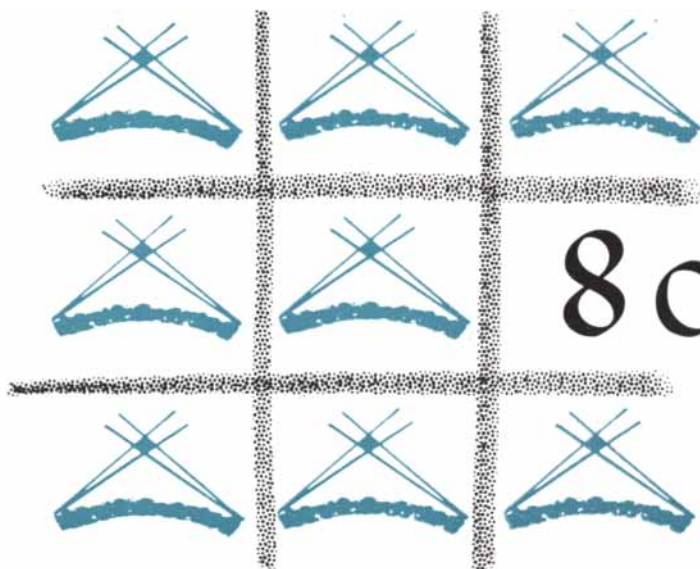
Name _____
Company _____
Address _____
City _____ Zone _____ State _____

A whole new world of communications has emerged from the utilization of tropospheric scatter. For the first time, voice and teletype messages can be clearly received far beyond the horizon at all times, regardless of atmospheric or electromagnetic disturbances.

Long-range communication between radar outposts and Free World defense headquarters is no longer subject to disruption by weather conditions, and the same reliability is assured for civil telephone systems using tropo scatter.

It was radio equipment by REL which first proved the practicability of tropo communication in the Far North, and of transmission across large bodies of open water. Today, tropo apparatus designed and built by REL may be found halfway around the world.

Eight of the nine major networks in operation or on order utilize equipment designed and manufactured by REL. More kilowatt miles of tropo equipment by REL are in use or in production than those of all other companies combined—significant proof of REL's world leadership in tropo scatter.



8 out of 9

Radio Engineering Laboratories·Inc

A subsidiary of Dynamics Corporation of America

Dept. S • 29-01 Borden Ave • Long Island City 1, NY





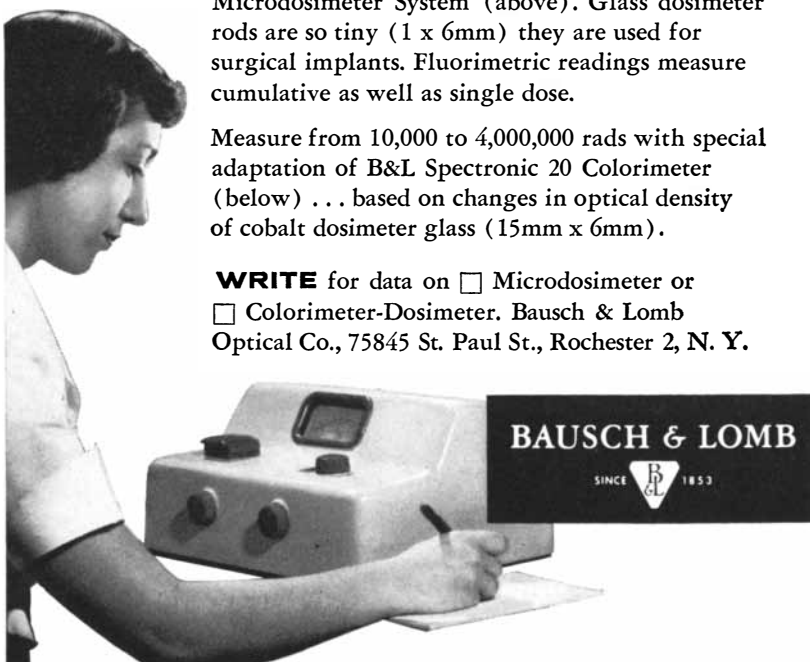
Measure cumulative radiation from 10 to 4,000,000 rads

Here are two new ways to measure exposure and absorption of Beta, Gamma and X-rays. Both have been proved in two years of pre-release testing at major centers of medical and technological research.

Measure from 10 to 10,000 rads with the B&L Microdosimeter System (above). Glass dosimeter rods are so tiny (1 x 6mm) they are used for surgical implants. Fluorimetric readings measure cumulative as well as single dose.

Measure from 10,000 to 4,000,000 rads with special adaptation of B&L Spectronic 20 Colorimeter (below) . . . based on changes in optical density of cobalt dosimeter glass (15mm x 6mm).

WRITE for data on Microdosimeter or Colorimeter-Dosimeter. Bausch & Lomb Optical Co., 75845 St. Paul St., Rochester 2, N. Y.



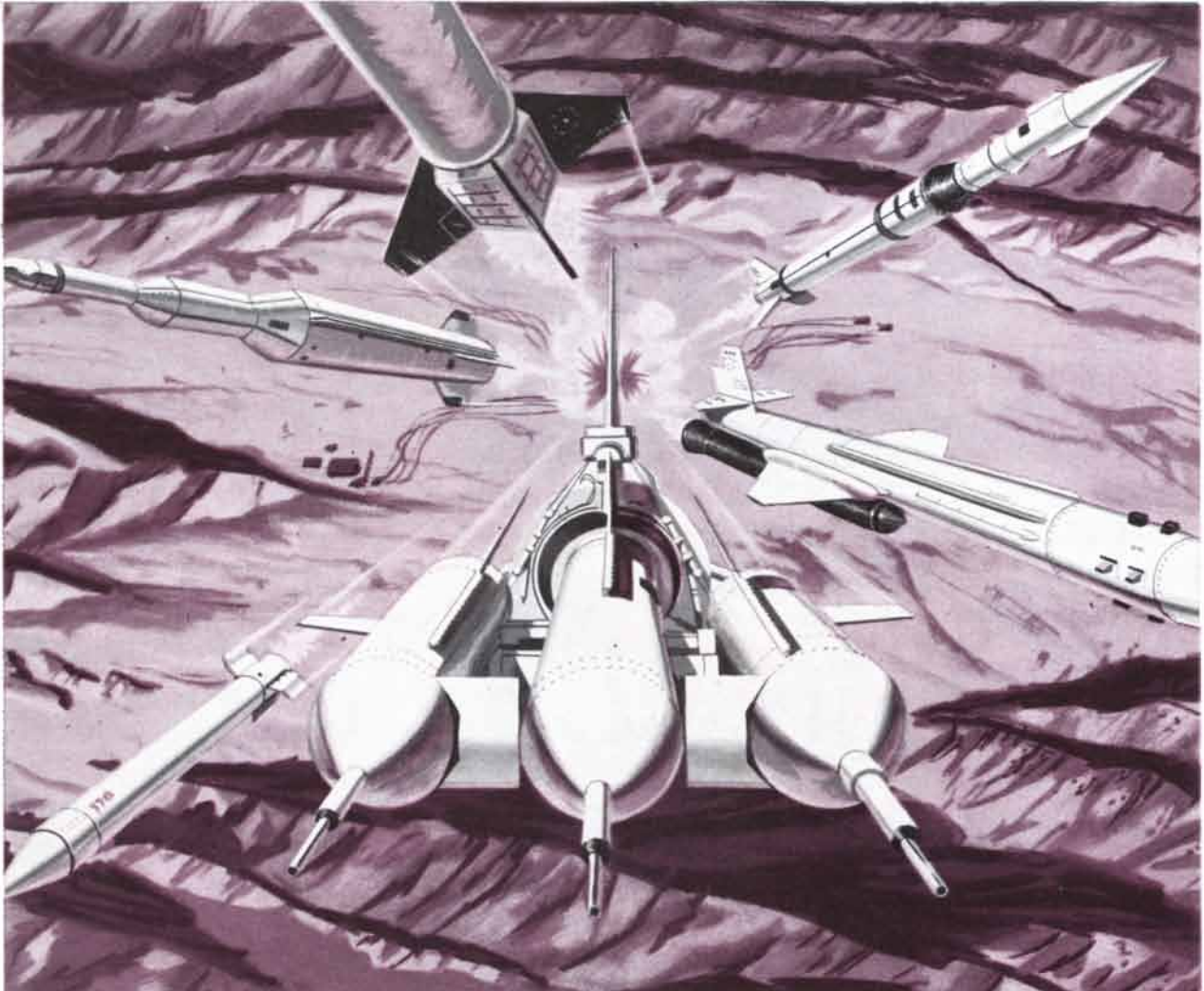
suggested that certain effects may be of the linear, nonthreshold type. This is perhaps more likely where dose rates are low (and where experimental data are difficult to obtain).

The capacity of X- and gamma-rays to cause point mutation in germ cells has been classically considered a universally linear effect. Any dose, no matter how small, was supposed to yield its proportionate share of mutations. Now, as the authors of the preceding article have mentioned, studies at the Oak Ridge National Laboratory indicate that the matter is not so simple. The mutability of the germ cell varies with its stage of development, and at some (but not all) stages the mutability may apparently change with dose rate.

Potentially valuable sources of information on the effects of low dose rates are to be found in human populations living in areas with a relatively high background of radiation. Such populations exist in parts of Kerala, in southern India, where the soil contains unusually large concentrations of thorium. It would be most desirable to compare the records of vital statistics for these people with records for similar groups living in regions of normal background-radiation. As yet, however, the necessary records are not in existence.

Lacking direct evidence as to very low dose-rates we can only fall back on the scanty records of human beings whose occupations have exposed them to intermediate but uncertain quantities of radiation, and on inferences, carefully drawn, from animal experiments. What can we say about leukemia, one of the radiation effects for which a linear relationship has been suggested? U. S. radiologists, but apparently not their British colleagues, have suffered a significantly higher death rate from the disease than have appropriate controls. Their total exposure is unknown, but it must have been intermittent, not uniform over the body, and received at substantial dose-rates.

Leukemia is a spontaneous disease of animals other than man. Mice are subject to both the lymphoid and the granular types; the former is more common. A suitable course of whole-body irradiation will greatly increase the incidence of lymphoid leukemia in mice: Given a series of intermittent exposures at high dose-rates, nearly 100 per cent of experimental animals will die of the disease. On the other hand, my colleague R. H. Mole has found a different situation at lower dose-rates. The induction of leukemia in mice receiving a total of 1,000 r in the same over-all period varies



RADIOSONDE X-17 WALLOPS ISLAND ROCKET CREE SPAEROBEE X-7

ELECTRICAL CONNECTORS FOR TEST AND RESEARCH MISSILES

Ideas are the payload aboard these vehicles. From the wealth of data they radio back to recording stations, concepts grow to maturity or become stepping stones to further advance.

In the complex electronic systems that guide these missiles and telemeter their findings to earth, electrical connectors are *the most critical links*. Integrity and design flexibility for missile electronic systems are assured by electrical connections of the

compression type. Burndy, which over 25 years ago pioneered the compression principle of electrical connections and has led in this application ever since, is uniquely equipped for current development problems. Burndy's design groups are working closely with manufacturers of missiles and components on a systems approach to integrating connectors with the other vital components of electrical and electronic circuits.

From prototype, thru pilot run to production line—billions of connections depend on

BURNDY

OMATON DIVISION

Norwalk, Connect. • Toledo, Ohio • Toronto, Canada • In Europe: Antwerp, Belgium



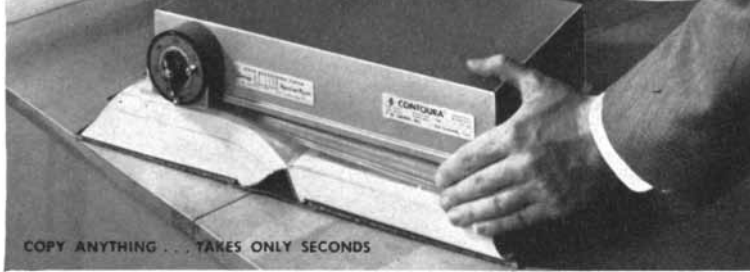
59.16

R.F. SWANSON

PORTABLE

PHOTOCOPIER

COPIES ANYTHING ... ANY CONTOUR

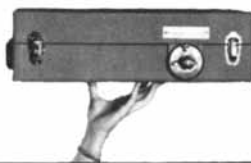


COPY ANYTHING ... TAKES ONLY SECONDS

use flat to copy flat documents



feather light ... take it anywhere



development once ... or weeks later at home or office



CONTOURA

PORTABLE

write for complete illustrated folder

MADE BY F. G. LUDWIG, INC., 518 COULTER AVENUE, OLD SAYBROOK, CONN.

free
send
for it!



ALLIED'S 1960 ELECTRONIC SUPPLY GUIDE

World's Largest Stocks of Electronic Equipment for Scientific and Industrial Use

Lists the products of over 600 electronic parts manufacturers, with full specifications. Buy at factory prices:

- Semi-Conductors
- Special-Purpose Tubes
- Connectors
- Test Equip. & Meters
- Relays
- Resistors, Controls
- Transformers
- Switches, Timers
- P. A. Equipment
- Hi-Fi Equipment

One order to Allied fills the whole bill, saves you time and money. Write today.

FREE catalog **ALLIED RADIO**

ALLIED RADIO CORP., Dept. 40-J9
100 N. Western Ave., Chicago 80, Ill.

Send FREE 1960 ALLIED Catalog.

Name _____

Address _____

City _____ Zone _____ State _____



FAST, SIMPLE, ECONOMICAL METHOD TO CUSTOM BUILD SCIENTIFIC ENCLOSURES

Widney DORLEC

prefabricated cabinet frame components over 300 styles and types in 3 radii



Design and assemble fully radiused cabinets to specific dimensions without machining. Prefabricated die cast duraluminum corners and extruded duraluminum sections. Unlimited versatility! Currently used by leading manufacturers and laboratories. The answer for any scientific, commercial or government application.



For literature, write Dept. YM429
BRITISH INDUSTRIES CORP.
Port Washington, L. I., N. Y.

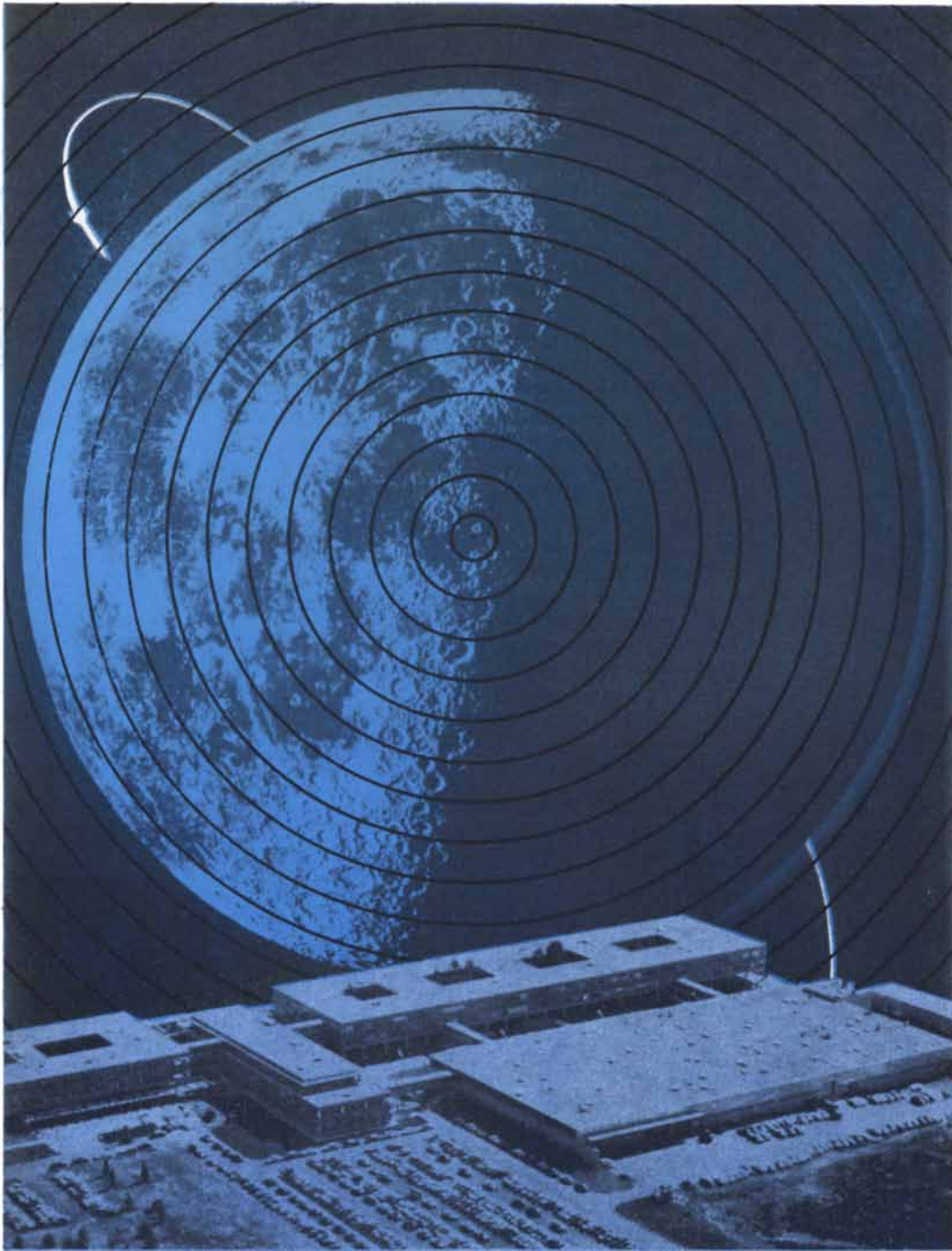
from the substantial, when the dose is given in fractions at a high rate, to the negligible when given continuously at a low rate. Such experiments lend support to the concept of a threshold; they are certainly at variance with a linear relationship unrelated to dose rate.

Another matter that has received a good deal of attention is the possibility that small doses of ionizing radiation may shorten life. Of course a person who dies of leukemia or bone cancer has been cut off before his time. But it is suggested that, in addition to such obviously lethal damage, radiation can cause a nonspecific reduction in longevity. It may accelerate the process of aging throughout life, or hasten the onset of senescence.

As always, we have very little evidence concerning human beings. A study of a few years ago indicated that U. S. radiologists die younger than other medical workers. However, upon further analysis the age distribution within the two groups proved to be different. The radiologists were generally younger, and the age of death of curates is notoriously less than that of bishops. British radiologists, an even smaller population than those in the U. S., live a normal term. Those of the earliest generation had a high rate of skin cancer, as one might expect. But there is no evidence of a nonspecific reduction in their life span.

Many investigators are working on the problem with animals. In some experiments the subjects are given single doses of various sizes and their subsequent term of life compared with that of non-irradiated controls. In others the animals are exposed at regular intervals starting at various ages and continuing for the rest of their lives. On the whole, a single irradiation appears to shorten the life span by an amount proportional to the dose; that is, the effect appears linear. However, in animals receiving daily irradiations of varying amounts, the results tend to exhibit a threshold. No significant change has been measured in mice that were subjected to five rads or less per week.

In any event all such results should be interpreted with the greatest caution. So far as nonspecific aging effects are concerned, we must be certain that the pattern of death is the same for the different experimental groups. For instance, if one scheme selectively produces a crop of radiation-induced leukemias where another does not, a comparison of the two sets of data will prove little about nonspecific aging. Until we



Space age research gets a new headquarters—One of the largest and best-equipped research facilities in the nation is the new 16-million-dollar Avco Research Center at Wilmington, Massachusetts. Here, research and development in space age technology is already being conducted in areas ranging from missile re-entry to satellite design. From work such as this—and equally important work at the nearby Avco-Everett Research Laboratory—will come further contributions to national security and the conquest of space.

ORIGINAL CAREER OPPORTUNITIES FOR QUALIFIED SCIENTISTS AND ENGINEERS...WRITE AVCO TODAY.

Avco

AVCO MAKES THINGS BETTER FOR AMERICA / AVCO CORPORATION / 750 THIRD AVENUE, NEW YORK 17, N. Y.

BUD

Trans-air BLOWER

**dissipates heat
in electronic
cabinets and
racks . . .**

Operates better, occupies less space
and is the lowest priced unit of equal
capacity and performance.

May be used as an exhaust or intake
depending upon mounting position.
Operates on 110 V., 60 cycle current.
Delivers either 550 or 250 cfm. air dis-
placement at 0° static pressure. Oilite
bearings; oil impregnated, fiber glass dis-
posable filter. Thermal overload protection
to prevent over heating. Automatic re-set.
Quiet operation. Minimum vibration. Size
is 5 1/4" x 17" x 14 1/2". Fits in standard
19" wide housings.

BUD RADIO CORP.

2121 East 55th Street
Cleveland 3, Ohio

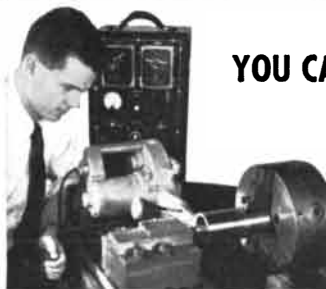
know more about the causes of death in the various populations, the pathologist like myself profoundly distrusts those who juggle numbers. Still more does he distrust those who attempt to translate the results of animal experiments directly to man. A man is not a mouse multiplied in size, life span and other biological characteristics. Each has its own racial character. At best the mouse is a model; it can easily become a siren. Experiments with mice can elucidate principles that may apply to man, but they cannot by themselves supply numbers to put into a human equation.

Since time is a factor for which there is as yet no substitute, many of our questions are likely to remain open for generations. Meanwhile we can say that dose-rates 1,000 times greater than background produce no demonstrable shortening of life in mice. Radiologists of a former generation probably took as great a dose with no decrease in life span.

Each advance in man's power over nature has brought with it an element of danger. Atomic energy is no exception. Consciously or unconsciously we adopt a policy of acceptable risk in every facet of our lives. Society must decide what risk it will accept in the development of atomic energy; the scientist must make clear the potential gains and losses.

Thus far, as we have seen, the limits of risk are not completely outlined, and research continues on the biological effects of ionizing radiation. Some problems, such as life-shortening, may not be solved completely for a long time. Others we are liquidating more quickly. Among these we might mention the accurate measurement of dose, particularly from internal sources, and the determination of the relative effectiveness of various kinds of radiation.

In the meantime we continue to explore the beneficent possibilities of nuclear fission and other aspects of radiation. Certainly we should proceed cautiously, within limits that seem reasonable in the light of expanding knowledge. If one microcurie of radium causes only minor effects in the body, and a third causes none that we can observe, is it not reasonable to set .1 microcurie as a limit for occupational exposure? If external radiation 1,000 times background produces no apparent damage, is not 50 times background an acceptable risk for radiation workers, as has been recommended? Perhaps the figures will need revising as time goes on. But they seem to be adequate guideposts for the present.



YOU CAN SEE **WHY** WITH **FASTAX**

PROBLEM: Differences in power consumption, chip formation and tool life when machining Titanium and steel.

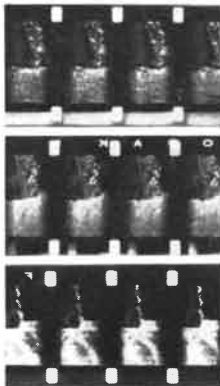
SOLUTION: A high speed motion picture study of chip formation process of SAE 1020 and SAE 1112 steel being machined under same conditions as Titanium.

1: FASTAX High Speed Camera taking movies at 7,500 frames per second through a microscope. Actual frames from movies shown below.

2: SAE 1020 steel. Large built-up edge at cutting speed causes poor surface finish. Shear angle is low, resulting in very thick chip and consumption of considerable power in removing metal.

3: SAE 1112 steel. Built-up edge is absent due to lower friction on tool face . . . improved surface finish. Shear angle is higher and chip thinner. Power consumption is lessened.

4: TITANIUM (Ti 150A). No built-up edge. Surface finish is excellent. Shear angle high, but not constant in value. Chip forming process is cyclic. Since thin chip, power consumption is low. Tool life shorter because of metal structure.



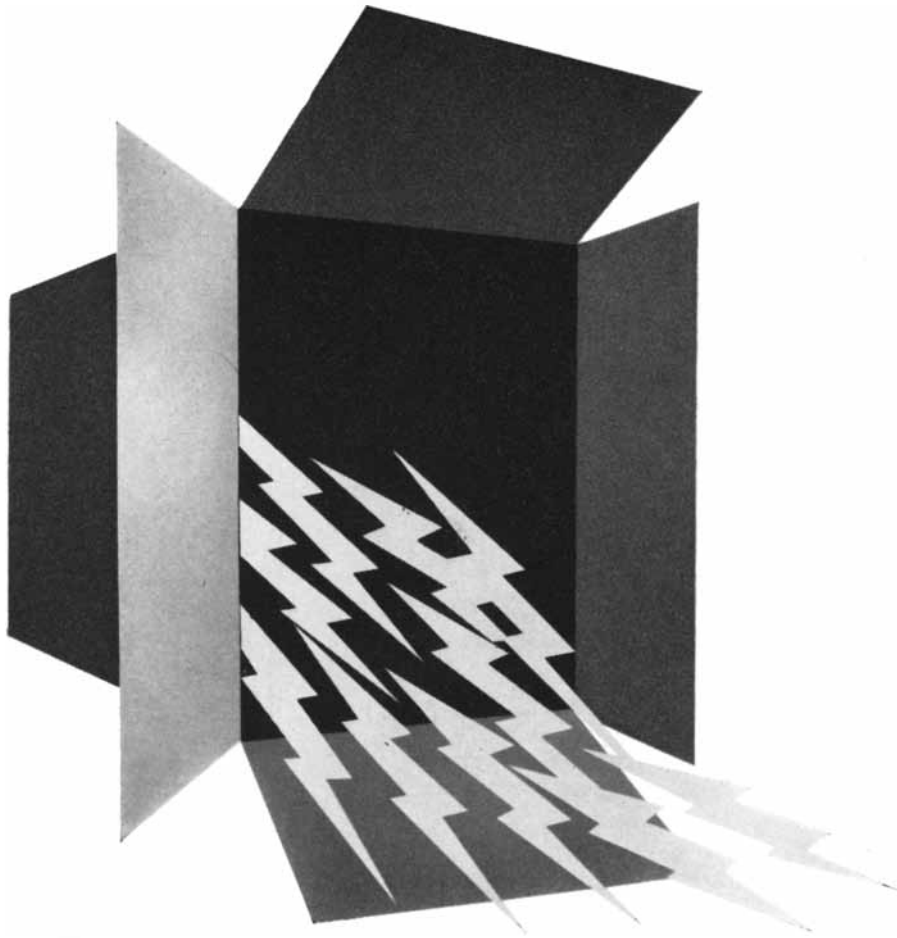
This is just another industrial production problem solved through the eye of a FASTAX High Speed Motion Picture Camera—one of 26 different models available for solving your problems.

WRITE us your design or production problems. High Speed photography can be the answer. New bulletin available.

WOLLENSAK

OPTICAL COMPANY • ROCHESTER 21, N. Y.





Power in “packages”—for every power need

ITT's unique concepts in power conversion bring new efficiency and economies

PUSH a button—throw a switch! Out of ITT “packages” of power come the exact voltages for countless electronic applications.

Power in static “packages” provides vital military equipment with the utmost in dependable power supply—gives industry uninterrupted DC service and saves the cost of DC generators and their upkeep.

ITT's new idea in power supply

Among the many important areas where ITT “package” power systems are meeting the highest standards of performance are space and aviation.

ITT “packaged” power controls landing gear, operates navigation, communication, counter-measures, missile-launching and the many other systems that give our jets combat capacity.

All DC power for the supersonic B-58 comes from an ITT integrated power system—a *first* in the industry.

ITT-designed power systems serve the B-52 and other famous aircraft, as well as ground-based and seaborne electronic systems.

“Building blocks” for any DC output

From these major contributions to military power supply, ITT System companies have developed complete capabilities for engineering modular-type, “building block” power systems for the most sophisticated needs of industry.

ITT “packaged” power concepts embrace every field of manufacturing. Hundreds of equipment designs are ready at ITT to meet the broad and expanding range of today's DC applications—from the simplest DC motor to

the most complex techniques for automation and data processing systems.

If you require DC output for *any* purpose, investigate these unmatched capabilities. For complete information, write to ITT Industrial Products Division, 15191 Bledsoe Street, San Fernando, California.



... the largest American-owned world-wide electronic and telecommunication enterprise, with 101 research and manufacturing units, 14 operating companies and 130,000 employees.

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION 67 Broad Street, New York 4, N.Y.

ITT COMPONENTS DIVISION • ITT FEDERAL DIVISION • ITT INDUSTRIAL PRODUCTS DIVISION • ITT LABORATORIES • INTELEX SYSTEMS INCORPORATED
 AIRMATIC SYSTEMS CORPORATION • KELLOGG SWITCHBOARD AND SUPPLY COMPANY • ROYAL ELECTRIC CORPORATION • AMERICAN CABLE & RADIO
 CORPORATION • FEDERAL ELECTRIC CORPORATION • ITT COMMUNICATION SYSTEMS, INC. • INTERNATIONAL ELECTRIC CORPORATION • INTERNATIONAL
 STANDARD ELECTRIC CORPORATION • LABORATORIES AND MANUFACTURING PLANTS IN 20 FREE-WORLD COUNTRIES

How Du Pont Fibers Are Solving Product and Process Problems

• Hardly a month goes by that someone doesn't think of a new way to use Du Pont fibers. Sometimes fibers simply replace other basic materials because they perform better – or more economically. And, in other cases, these fibers are selected to do jobs that couldn't be done before.

The reason: Even though, as industrial materials, man-made fibers are new, all of them – from nylon to "Teflon" TFE fiber, – cover a wide range of properties. And, unlike those of natural fibers, their properties can be tailored to suit specific needs.

Today, you even find them replacing such materials as steel and wood. Take the case of "Teflon" TFE fiber. It's used as a non-lubricated bearing in applications too rigorous for the toughest plastics and metals. You'll find a few other examples at right.

Du Pont has the experience and technical know-how to help you evaluate these fibers for your own products or processes. It's available to you for the cost of a 4-cent stamp.

DU PONT FIBERS FOR INDUSTRY



REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
... THROUGH CHEMISTRY

*Registered Du Pont trademarks

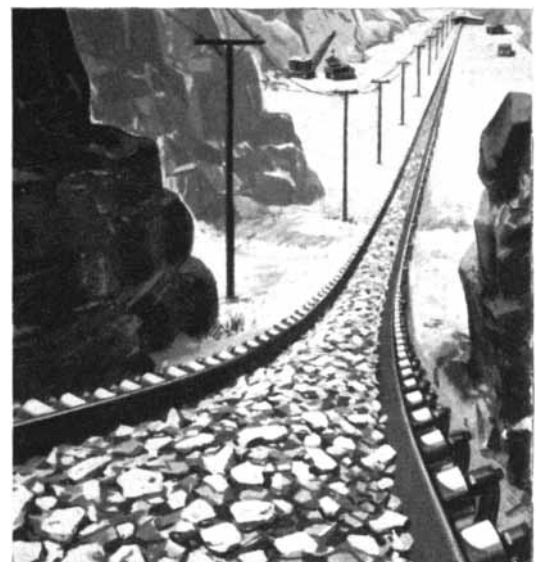
E. I. du Pont de Nemours & Co. (Inc.)
Textile Fibers Department
5518-B Nemours Building, Wilmington 98, Delaware

Please send me more information on industrial applications of Du Pont fibers. I am interested in evaluating these materials for: _____

Name _____

Address _____

City & State _____



WORLD'S LONGEST SLOPE CONVEYOR will carry 700 tons of taconite per hour, traveling at a speed of 460 fpm. The ore will be carried upward approximately 800 ft. The belting – over 7,500 ft. long, with a center distance of 3,791 ft. – is reinforced with Du Pont high-tenacity rayon and nylon. The light weight and high strength of these fibers help make so long a conveyor-belt system economically feasible.

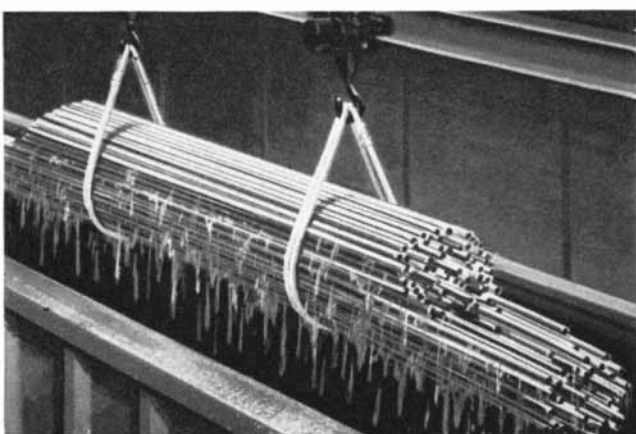


CUTAWAY SHOWS
OUTER LAYER OF
NYLON FABRIC
AND RUBBER

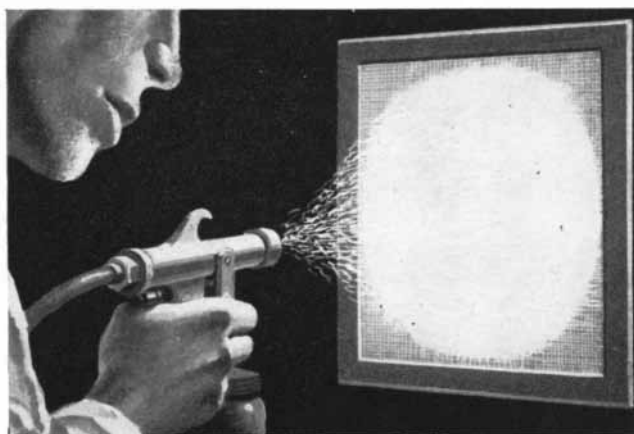
INNER LAYER
OF ALUMINIZED
"DACRON"

THE FIRST MAN IN SPACE may carry his own atmosphere with him in a special multi-fabric protective suit. Such experimental suits have an outer layer of nylon fabric and rubber. Owing to the strength and stretchability of nylon, the suit allows freedom of movement, yet protects the astronaut from possible explosive decompression which

would boil his blood in seconds. Also in the suit may be a temperature-resistant layer of aluminized "Dacron". This is designed to maintain the space man's body at normal temperature, even though he may be subject to the intense cold of space and the extreme heat generated by the re-entry into the earth's atmosphere.



ACID-RESISTANT ROPE SLINGS made with $\frac{3}{4}$ " filament rope of "Dacron" polyester fiber support up to 5,000 pounds of stainless-steel tubing in pickling operations. The tough, low-stretch properties of "Dacron" permit repeated immersion of these slings in acid pickling baths for continuous periods of service up to six months long. When slings of "Dacron" are used instead of stainless-steel chains, dents and handling marks on the tubes are drastically reduced, with a resultant saving in cost.



HIGH-EFFICIENCY SUPERFINE FILTERS are easily produced in a new process utilizing "Dacron". This method involves spraying a 10% solution of polystyrene in methylene chloride at 50 psi onto a backing mesh of "Dacron". The solvent evaporates almost instantaneously, leaving thin fibers less than 1 micron thick and 1 in. long. The mesh of "Dacron" is then peeled off, and the mat is rolled to produce a completely organic filter that retains 99.5% of the particles it picks up, down to 0.01 micron.

Ionizing Radiation and Evolution

Living things evolve as a result of random mutations in hereditary characteristics that survive when they make the organism more fit. What role does ionizing radiation play in the evolutionary process?

by James F. Crow

The mutant gene—a fundamental unit in the mechanism of heredity that has been altered by some cause, thereby changing some characteristic of its bearers—is the raw material of evolution. Ionizing radiation produces mutation. Ergo, ionizing radiation is an important cause of evolution.

At first this seems like a compelling argument. But is it really? To what extent is the natural rate at which mutations occur dependent upon radiation? Would evolution have been much the same without radiation? Is it possible that increased exposure to radiation, rising from human activities, has a significant effect upon the future course of human evolution?

Radiation has been of tremendous value for genetic research, and therefore for research in evolution. To clarify the issue at the outset, however, it is likely that ionizing radiation has played only a minor role in the recent evolutionary history of most organisms. As for the earliest stages of evolution, starting with the origin of life, it is problematical whether ionizing radiation played a significant role even then. Laboratory experiments show that organic compounds, including the amino acid units of the protein molecule, may be formed from simple nitrogen and carbon compounds upon exposure to ionizing radiation or an electric discharge. But ultraviolet radiation serves as well in these demonstrations, and was probably present in large amounts at the earliest ages of life. In the subsequent history of life the development of photosynthesis in plants and of vision in animals indicates the much greater importance of nonionizing radiation in the terrestrial environment.

Nonetheless, as will be seen, man presents an important special case in any

discussion of the mutation-inducing effects of ionizing radiation. The mutation rate affects not only the evolution of the human species but also the life of the individual. Almost every mutation is harmful, and it is the individual who pays the price. Any human activity that tends to increase the mutation rate must therefore raise serious health and moral problems for man.

H. J. Muller's great discovery that radiation induces mutations in the fruit fly *Drosophila*, and its independent confirmation in plants by L. J. Stadler, was made more than 30 years ago. One of the first things to be noticed by the *Drosophila* workers was that most of the radiation-induced changes in the characteristics of their flies were familiar, the same changes having occurred repeatedly as a result of natural mutation. Not only were the external appearances of the mutant flies recognizable (white eyes, yellow body, forked bristles, missing wing-veins); it could also be shown that the mutant genes were located at the same sites on the chromosomes as their naturally occurring predecessors. Thus it seems that radiation-induced mutants are not unique; they are the same types that occur anyhow at a lower rate and that we call spontaneous because we do not know their causes.

The prevailing hypothesis is that the hereditary information is encoded in various permutations in the arrangement of subunits of the molecule of deoxyribonucleic acid (DNA) in the chromosomes. A mutation occurs when this molecule fails, for some reason, to replicate itself exactly. The mutated gene is thereafter reproduced until its bearer dies without reproducing, or until, by chance, the altered gene mutates again.

A variety of treatments other than radiation will induce mutation. Most agents, including radiation, seem to affect the genes indiscriminately, increasing the mutation rate for all genes in the same proportion. But some chemical mutagens are fairly selective in the genes they affect. It is even conceivable that investigators may find a chemical that will regularly mutate a particular gene and no other. This will probably be very difficult to achieve: A mutagen capable of affecting a specific gene would probably have to have the same order of informational complexity as the gene itself in order to recognize the gene and influence it.

Moreover, different mutant genes known to be at different locations on the chromosome frequently produce effects that mimic each other. Geneticists who work with fruit flies are familiar with several different genes that result in indistinguishable eye colors. This is not surprising when we consider the complexity of the relationship between the genes and the characteristics that they produce. There are many different paths by which any particular end-point may be reached; it is to be expected that many different gene changes can lead to the same result, though the chemical pathways by which this is accomplished may be greatly different.

To consider another kind of example, many insects have come to survive insecticides. They do so by such diverse means as behavior patterns that enable them to avoid the insecticide, mechanisms that interfere with the entrance of the insecticide into the body, enzymes that detoxify the insecticide, and by somehow becoming able to tolerate more of the insecticide. All these modes of survival develop by selection of mutant genes that are already present in low

frequency in the population. This is one of the characteristic features of evolution: its opportunism. It makes use of the raw materials—that is, the mutant genes—that happen to be available.

As a first conclusion it appears that radiation-induced mutations do not play any unique role in evolution. The same gene mutations would probably occur anyhow. Even if they did not, the same end result could be achieved with other mutants.

One might still suspect that spontaneous mutations are caused by natural radiations. This was quickly ruled out as a possibility in *Drosophila*. For one thing, the spontaneous-mutation rate is strongly dependent upon temperature, which would be surprising if mutation were a simple and direct consequence of

radiation. But much more decisive evidence comes from the fact that the amount of natural radiation is entirely inadequate to account for the rate of spontaneous mutation. The natural-mutation rate in *Drosophila*, if it were caused solely by radiation, would require 50 or more r [see *glossary of terms on page 78*]. Yet the amount of radiation received by a fly in the 12-day interval between egg and mature adult is about .004 r. Natural radiation would have to be increased more than 10,000 times to account for the natural *Drosophila* mutation rate! Thus, in *Drosophila* at least, radiation accounts for only a trivial part of the spontaneous rate. The same is true for mice. Although the fraction of spontaneous mutations that owe their origin to radiation is higher than that

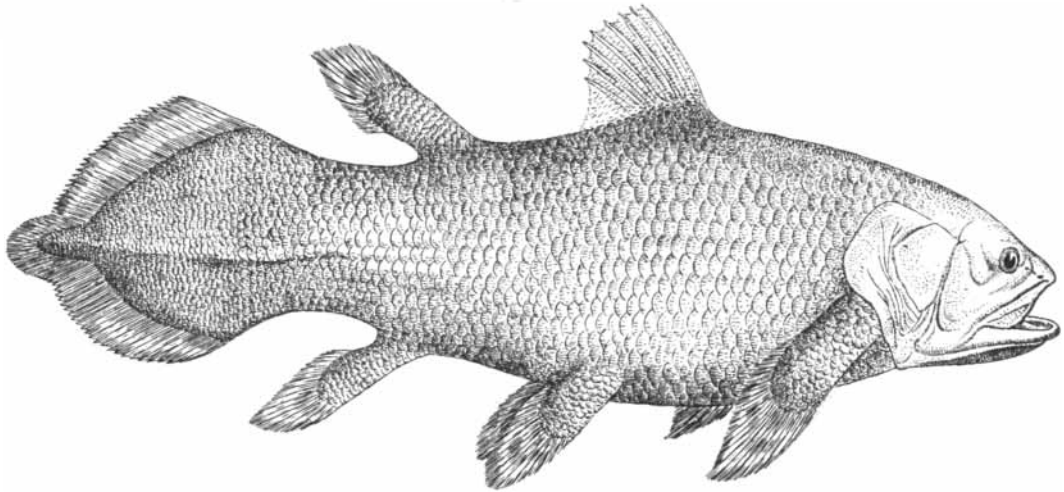
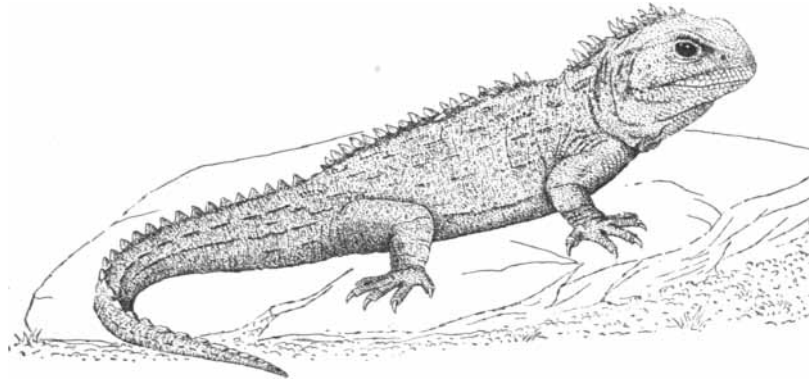
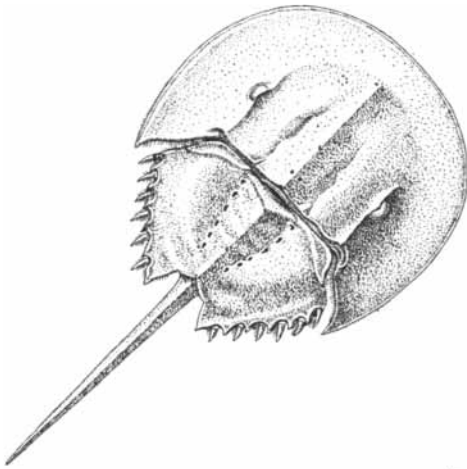
in *Drosophila*, it is still less than .1 per cent.

It is clear that natural-mutation rates, if they are measured in absolute time-units, cannot be the same in all organisms. One example will demonstrate this decisively. The spontaneous-mutation rate in *Drosophila* is such that about one embryo in 50 carries a lethal mutation (a mutation harmful enough to cause death) that occurred during the preceding generation. Most such mutations are recessive, that is, they have a lethal effect only when they are in a double dose, but this does not prevent the death; it only postpones it. The reproductive life-cycle in man is approximately 1,000 times as long as that of a fly: some 30 years as compared with 12 days. If the



MUTATION of a single gene in a mouse results in offspring that have an unusually short tail (*skeleton at left*). A mouse that receives such a mutant gene from both of its parents has more serious defects, including the absence of the lower part of its spine (*skele-*

ton at right); it dies soon after birth. These specimens were prepared in the laboratory of L. C. Dunn of Columbia University. The soft tissues were treated with strong alkali and glycerin to make them transparent; the bones were stained with a red dye.



RATE OF EVOLUTION in certain organisms is extremely slow. Depicted in these drawings are four animals that have not changed

appreciably over a period of millions or even hundreds of millions of years. At top left is the horseshoe crab; at top center, the tuatara;

absolute mutation-rate in man were the same as that in *Drosophila*, each human embryo would bear an average of 20 new lethal mutations; man would quickly become extinct.

Actually, if the rate is measured in mutations per generation, the spontaneous-mutation rate of those few human genes whose mutation rates can be effectively measured is roughly the same as that of *Drosophila* genes. The rule seems to be that the absolute mutation-rate divided by the generation period is much more nearly constant from one species to another than the rate itself. The implication of this is exciting. It can only mean that the mutation rate itself is capable of modification; that it, too, is changed by natural selection. By being brought into adjustment with the life cycle, the underlying mechanism of evolution itself is undergoing evolution!

It appears, however, that the rates of radiation-induced mutations are not as readily modified. If these rates were being adjusted along with the rates of mutations from other causes, we would

expect that mice would show a lesser response to radiation than do fruit flies because their life cycle is longer. The facts are otherwise; mouse genes average some 15 times as many mutations per unit of radiation as *Drosophila* genes.

This strongly suggests that the process whereby mutations are produced by radiation is less capable of evolutionary adjustment than other mutation-producing processes. The implication is that organisms with a long life-cycle—Sequoia trees, elephants, men—have a larger fraction of mutations due to natural radiations. It may be that the majority of mutations in a very long-lived organism are due to radiations. Possibly this sets an upper limit on the length of the life cycle.

Unfortunately the rate of radiation-induced mutations is not known for any organism with a long life-cycle. If we assume that the susceptibility of human genes to mutation by radiation is the same as that of mouse genes, we would conclude that less than 10 per cent of human mutations are due to natural

radiations. But the exact fraction is quite uncertain, because of inaccurate knowledge of the rate of spontaneous human mutations. So it cannot be ruled out that even a majority of human mutations owe their origin to radiation.

Thus the over-all mutation rate is not determined by radiation to any significant extent, except possibly in some very long-lived organisms. In general, radiation does not seem to play an important role in evolution, either by supplying qualitatively unique types of mutations or by supplying quantitatively significant numbers of mutations.

There is another question: To what extent is the rate of evolution dependent on the mutation rate? Will an organism with a high mutation-rate have a correspondingly higher rate of evolution? In general, the answer is probably no.

The measurement of evolutionary rates is fraught with difficulty and doubt. There is always some uncertainty about the time-scale, despite steady improvements in paleontology and new techniques of dating by means of the decay

Janitrol Reports

on aircraft and missile components



at bottom center, the recently discovered coelacanth; at the far right, the opossum.

of radioactive isotopes. In addition there is the difficulty of determining what a comparable rate of advance in different species is. Is the difference between a leopard and a tiger more or less than that between a field mouse and a house mouse? Or has man changed more in developing his brain than the elephant has by growing a trunk? How is it possible for one to devise a suitable scale by which such different things can be compared?

Despite these difficulties, the differences in rates of evolution in various lines of descent are so enormous as to be clear by any standard. One criterion is size. Some animals have changed greatly. The horse has grown from a fox-sized ancestor to its present size while many other animals have not changed appreciably. (The British biologist J. B. S. Haldane has suggested that the word "darwin" be used as a unit for rate of size change. One darwin is taken to be an increase by a factor e per million years. By this criterion the rate of evolution of tooth size in the an-

Cooling with Boiling Water

This Janitrol "water boiler" heat exchanger serves as an air conditioner for hot pilots at supersonic speeds. High temperature air passes through unique tubular structure made of extremely thin plates, and water on the primary side of the exchanger boils. Sufficient heat is extracted to enable mechanical cooling equipment to complete the job. Long experience with high temperature alloys



in foil-thin sheets have enabled Janitrol to achieve significant weight savings as well as excellent heat transfer efficiency, simple manifolding, and design freedom of value to engineers trying to shoe horn the components into odd spaces.



Million BTU per Hour

If you like your heat wave in small packages – to heat buildings or vehicles for personnel comfort, to process fluids,

to prevent freezing in transit or storage – here's a liquid heater of modest dimensions that puts out up to a million Btu per hour, can operate on almost any fuel (gas, diesel fuel, JP-4 and LP gas) and starts reliably down to -65°F . Output is variable: it will maintain liquid at any specified temperature (within reason). Other Janitrol heaters of less impressive capacity are serving reliably on emergency fire-fighting vehicles to keep fluids fluid at all times all year round.

Birth of a Notion

A good measure of Janitrol confidence in the future of the aero-space age is its new research, development, and manufacturing facility in Columbus, which includes among other things one of the industry's best privately owned high altitude chambers (shown below). The six-foot diameter, twenty-foot long chamber simulates altitudes up to 100,000 feet plus, temperatures down to -80°F .

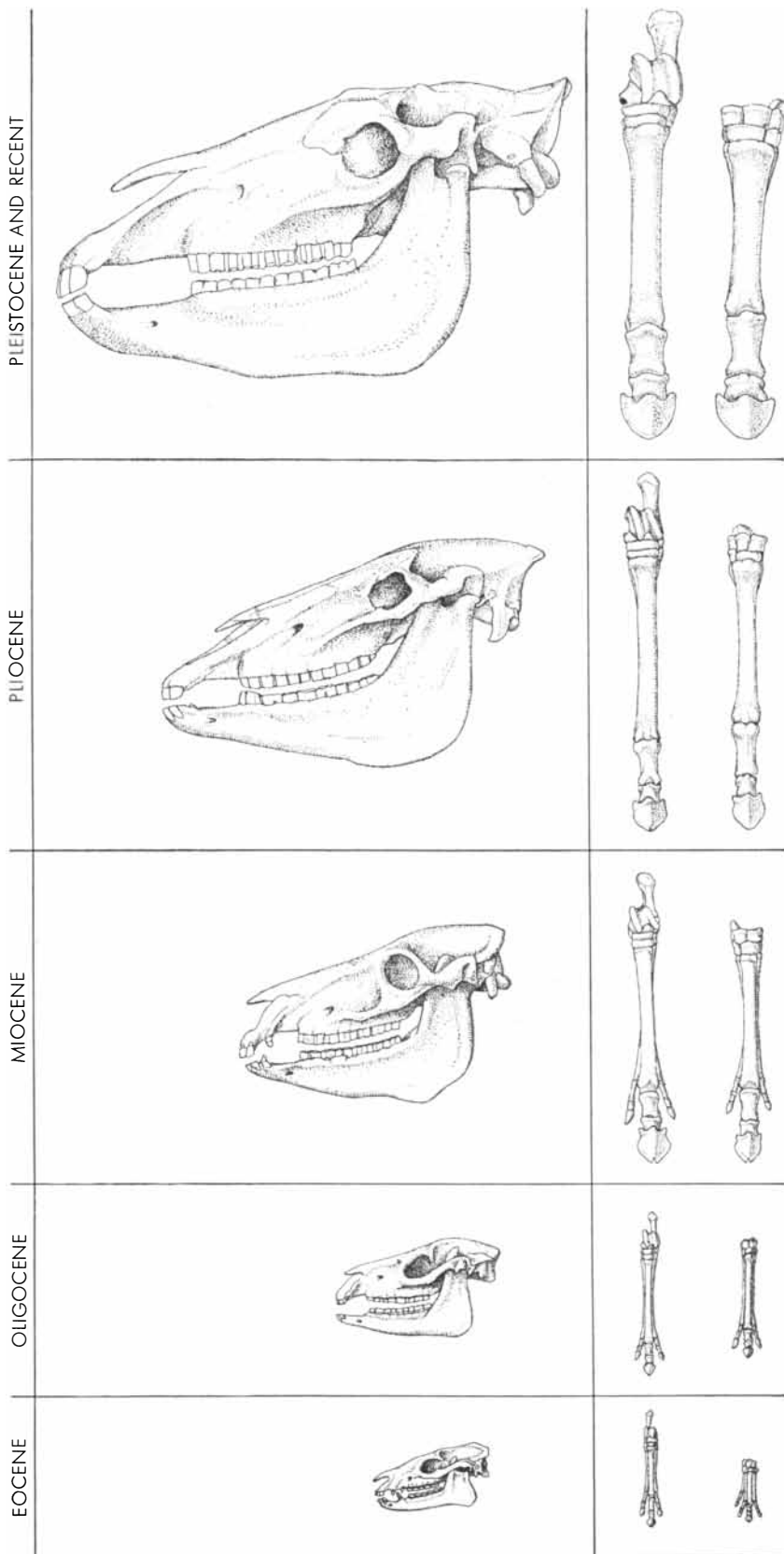


If you need help in the design of pneumatic controls, heat exchangers, duct supports, and couplings – or the development of a sub-system involving air handling – you'll find Janitrol people talk your language.

We invite you to write for a brochure entitled "Janitrol Resources," giving a clear picture of our extensive capabilities. Janitrol Aircraft Division, Surface Combustion Corporation, 4200 Surface Road, Columbus 4, Ohio. BRoadway 6-3561.



**pneumatic controls • duct couplings and supports • heat exchangers
combustion equipment for aircraft, missiles, ground support**



RAPID RATE OF EVOLUTION is illustrated by the horse. Comparisons of the skulls, hindfeet and forefeet of animals of successive periods indicate the changes which led from a fox-sized ancestor in the Eocene period, 60 million years ago, to the modern horse (top).

cestors of the horse was about 40 millidarwins.)

More difficult to quantify, but more significant, are changes in structure. Some animals have changed very little in enormous lengths of time. There are several examples of "living fossils," some of which are depicted on the preceding two pages. During the time the coelacanth remained practically unchanged whole new classes appeared: the birds and mammals, with such innovations as feathers, hair, hoofs, beaks, mammary glands, internal temperature-regulation and the ability to think conceptually. What accounts for such differences in rate?

The general picture of how evolution works is now clear. The basic raw material is the mutant gene. Among these mutants most will be deleterious, but a minority will be beneficial. These few will be retained by what Muller has called the sieve of natural selection. As the British statistician R. A. Fisher has said, natural selection is a "mechanism for generating an exceedingly high level of improbability." It is Maxwell's famous demon superimposed on the random process of mutation.

Despite the clarity and simplicity of the general idea, the details are difficult and obscure. Selection operates at many levels—between cells, between individual organisms, between families, between species. What is advantageous in the short run may be ruinous in the long run. What may be good in one environment may be bad in another. What is good this year may be bad next year. What is good for an individual may be bad for the species.

A certain amount of variability is necessary for evolution to occur. But the comparison of fossils reveals no consistent correlation between the measured variability at any one time and the rate of evolutionary change. George Gaylord Simpson, now at Harvard University, has measured contemporary representatives of low-rate groups (crocodiles, tapirs, armadillos, opossums) and high-rate ones (lizards, horses, kangaroos) and has found no tendency for the latter to be more variable. Additional evidence comes from domesticated animals and plants. G. Ledyard Stebbins, Jr., of the University of California has noted that domesticated representatives of slowly evolving plant groups produce new horticultural varieties just as readily as those from more rapidly evolving groups. Finally, the rates of "evolutionary" change in domestic animals and plants under artificial selection by man



Royal Precision

LGP-30

Large-scale electronic computation at desk-side

Operating from any convenient wall outlet, the powerful, low-cost LGP-30 gives you the full flexibility of stored-program operation with an unusually large memory of 4096 words—*2000 more than the next computer in its class!*

Because the LGP-30 command structure and controls have been remarkably simplified, you require only minimum experience. You get complete format control...alpha-numeric input-output via keyboard or punched paper tape. No additional equipment is required for operation although, if desired, a high-speed photoelectric reader—with or without mechanical punch—is available.

The greatest computer value in the market, the LGP-30 requires no expensive installation or air-conditioning. It may be either purchased or leased. Customer training is free. An extensive library of programs and sub-routines is available—as well as membership in an active users organization.



Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For complete information and specifications, write **ROYAL MCBEE CORPORATION**, data processing division, Port Chester, New York

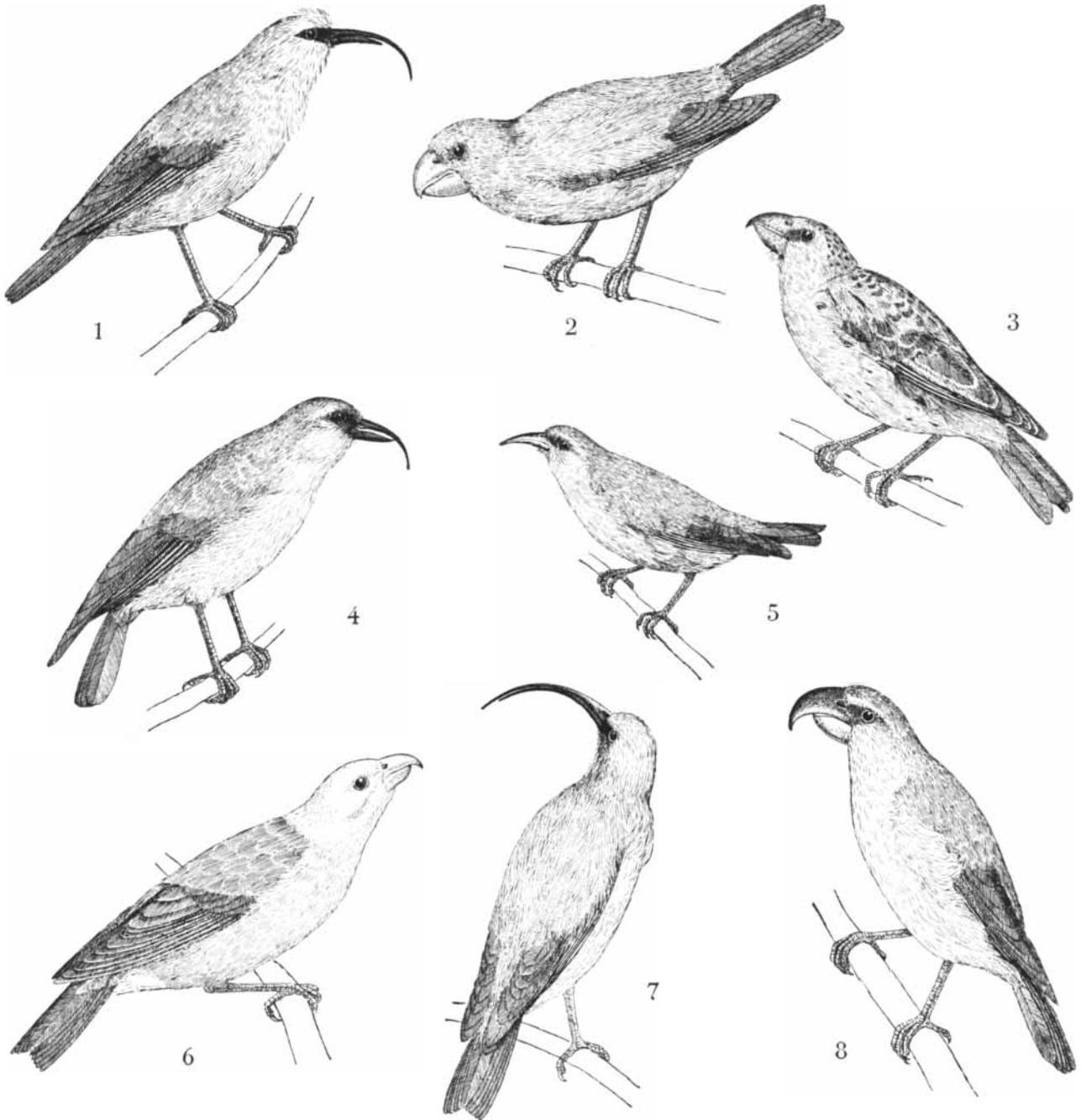
are tremendous compared with even the more rapidly evolving natural forms—perhaps thousands of times as fast. This can only mean that the genetic variability available for selection to work on is available in much greater abundance than the variability actually utilized in nature. The reasons why evolution is so slow in some groups must lie elsewhere than in insufficient genetic variability.

Instances of rapid evolution are prob-

ably the result of the opening-up of a new, unfilled ecological niche or environmental opportunity. This may be because of a change in the organism itself, as when the birds developed the power of flight with all the new possibilities this offered. It may also be due to opening-up of a new area, as when a few fortunate colonists land on a new continent.

One of the best-known examples of

rapid change is to be found in the finches of the Galápagos Islands that Charles Darwin noted during his voyage on the *Beagle*. Darwin's finches are all descendants of what must have been a small number of chance migrants. They are a particularly striking group, especially in their adaptations to different feeding habits. Some have sparrow-like beaks for seed feeding; others have slender beaks and eat insects; some resemble the



HONEY CREEPERS of Hawaii are a striking example of rapid evolution. Dozens of varieties, adapted to different diets, arose from a common ancestor. The long bills of *Hemignathus lucidus affinis* (1), *Hemignathus wilsoni* (4) and *Hemignathus o. obscurus* (7) are used to seek insects as woodpeckers do or to suck nectar. The beaks

of *Psittirostra kona* (2), *Psittirostra cantans* (3), and *Psittirostra psittacea* (6) are adapted to a diet of berries and seeds. *Loxops v. virens* (5) sucks nectar and probes for insects with its sharp bill. *Pseudonestor xanthophrys* (8) wrenches at hard wood to get at burrowing insects. Some of these species are presently extinct.

EXTENSIVE DOW PRODUCTION FACILITIES FASHION VARIED NEW MAGNESIUM WARES

Coiled sheet, thin wall castings, many other production items are now available from Dow's big rolling mill, foundry and fabrication facilities.

Manufacturers on the alert for improved materials and production methods would enjoy a quick tour of the four Dow plants that turn out magnesium products. New ways of forming and fabricating magnesium now being practiced in these plants open up new areas of use for the lightweight metal.



TOOLING PLATE, extra flat, is annealed to eliminate residual stresses.

At the huge Madison, Illinois, rolling mill, for example, they're making magnesium sheet that doesn't require stress relief after welding. This is a major step forward in light metal technology and a boon to manufacturers using magnesium assemblies. Madison has also increased the maximum width of sheet to six feet. Five different sheet alloys, including elevated temperature alloys, are now available either flat or in coils.

To keep abreast of the rapidly increasing demand for precision jigs and fixtures, Madison keeps a close watch on the tolerances of Dow magnesium tooling plate. Typical flatness tolerances, for example, are 0.010 inches in any six feet. This means greater ac-

curacy and less machining for users of Dow tooling plate. A mammoth 13,200 ton extrusion press, also located at Madison, is now turning out magnesium extrusions up to 30-inch circumscribed circle in size.

Over in Bay City, Michigan, interesting things are happening, too. At the well-equipped Dow magnesium foundry, largest in the U. S., sand and permanent mold castings of all sizes and shapes are being produced on a volume basis. Complete facilities are maintained for heat treatment, styrene DMI impregnation and chemical treatment. A well-staffed quality control team makes sure that all specifications are met or exceeded, and that the most modern equipment and techniques are fully utilized.

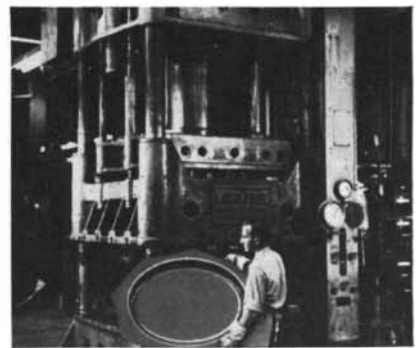
The Bay City foundry casts many complex and difficult designs. Large castings with walls as thin as 0.100 are now being produced. Other useful developments include cast-in tubeless passageways for use as hydraulic lines, special coring techniques for casting enclosed shapes and new magnesium casting alloys.



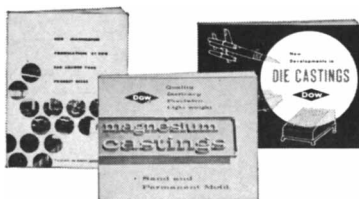
DOW FOUNDRY offers production capacity for sand and permanent mold castings of all sizes.

A new die casting plant is now on stream at Bay City. This facility houses the most advanced magnesium die casting equipment, including cold chamber metering units which automatically feed metal to the machines and contribute to unusually high production rates. To assure close alloy composition control in both die casting plant and foundry, a direct reading spectrometer provides frequent and precise analyses of the molten metal. Similarly, X-ray equipment is also available where radiography is needed in quality control.

The Dow fabrication plant, also in Bay City, offers capacity for volume work on magnesium assemblies. Here, too, developmental work on magnesium is constantly in progress. The plant is set up to handle large or small jobs, and plenty of both. Its activities include deep drawing, bending, spinning, stamping, piercing, machining, arc and spot welding, assembly, chemical treatment and painting. This plant has pioneered many "firsts" in magnesium production, such as hot drawing, spot welding and automatic welding.



LARGE DRAW PRESS at Dow's fabrication plant forms magnesium sheet in one operation.



WRITE TODAY for more information about Dow's magnesium production facilities. Request "Fabrication Brochure", "Foundry Brochure", "Die Casting Brochure" or all three. **THE DOW METAL PRODUCTS COMPANY**, Midland, Michigan, Sales Department 1351EQ9.



THE DOW METAL PRODUCTS COMPANY

Midland, Michigan

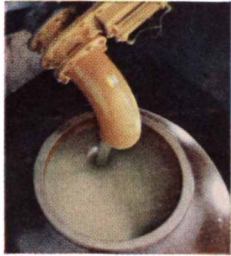
A Division of The Dow Chemical Company

At Eastman



QUALITY CONTROL

is a company's conscience "at work"



You can measure a company's conscience by the care taken to uphold the quality of its products.

If those products are plastics, uncompromised control is a "must"...for plastics are unique materials. Perhaps no other class of raw materials used by the manufacturing industries has so many variable—yet controllable—physical properties. Flow or moldability, stiffness, heat resistance, weather durability, color, light transmission, hardness... are just a few of the properties that can be custom tailored to meet the needs of a specific application or a specific fabricating procedure. Such flexibility in setting the physical properties of a raw material is an advantage which must be protected by accurate control. For once an acceptable formulation has been created and sold to satisfy both performance and production demands, it is necessary to maintain those properties within extremely

**Tenite is more than a trade name for Eastman's plastics
...it's a pledge of promised performance**

narrow limits to assure trouble-free molding operations as well as satisfactory service.

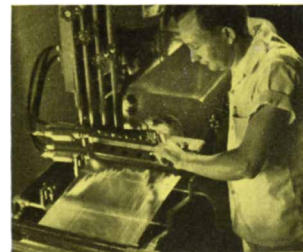
At Eastman, Tenite Quality Control is the vigilant watchdog over the production of all Tenite plastics. This group has the continuing responsibility to conduct all necessary testing to forestall deviation from the specifications set for each of the many formulations.

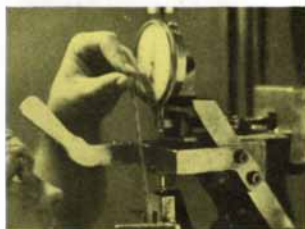
So varied and so complete is the testing done by Tenite Quality Control, that this one control section of Eastman requires a staff of over 100 trained personnel.

Acting as a nerve center, sensitive to any factor that could swing a formulation away from its prescribed limits, Quality Control approves or rejects the results in all phases of the production of every pound of Tenite plastic made.

Control of quality begins with approval of the basic raw materials. Even though most

of the basic materials that go into Tenite plastics are supplied by other members of the Eastman industrial family, Tenite Quality Control has the final voice in the acceptance or rejection of these materials. At Kingsport, Tennessee, where Butyrate, Acetate and Propionate are made, raw materials such as cellulose esters, plasticizers, colorants and other additives are rigorously tested and graded on their suitability for compounding into clear transparent plastic or into transparent, translucent or opaque colored plastics. Indicative of the care taken to assure shipments of Tenite plastics that are right for each use, is the fact that no order for Tenite Butyrate, Tenite Acetate or Tenite Propionate is filled "out of stock." Every order for these three plastics





s made to order as a separate batch, custom-produced to meet the exact specifications as requested.

At Longview, Texas, where Tenite Polyethylene in both low- and medium-density grades is produced via continuous processing, Quality Control maintains a constant check on the purity of the ethylene gas as it enters the reactors.

During production of both cellulosic and polyethylene plastics, various tests are conducted at intermediate stages to insure proper control of the chemical reaction. Similarly, after production, samples of the plastics are carefully molded by Quality Control to be sure their forming characteristics are suited to the customer's fabricating equipment. In addition, flow, color, along



with physical and chemical stability are also checked. If any special qualities, such as fire retardance or resistance to ultra-violet have been specified, Quality Control runs extra tests on the plastic before shipment to confirm that these requirements have been met.

Color gets particular attention. Over the years, Tenite plastics have won an enviable reputation for accurate color matches. To date, plastics in more than 40,000 different colors and color effects have been produced by Eastman.

Finally, after Quality Control has been satisfied that the Tenite plastic will fully meet all specifications of the customer's order, it is approved for shipment. Even after shipment, Quality Control remains in the picture. Physical samples of all plastics shipped are kept for six months. In addition, all records on the processing of these shipments are retained for five years. Result: Quality Control has a continuing record as a guide in filling subse-

quent orders with exact duplications of the original plastic.

Ever since Eastman began producing plastics in 1932, an alert awareness has existed that users of plastics have a critical need for material that is consistent in its performance and handling properties shipment after shipment. If one word were to be singled out to describe the outstanding virtue of Tenite plastics, it would have to be chosen from such adjectives as *uniform, consistent, unvarying, dependable*. But whatever the word, the end-result has been satisfaction for our customers... and for us.

And, after all, that's the purpose of having a conscience.

The full story of the detailed testing that underwrites the reputation of Eastman plastics, is told in "QUALITY CONTROL," a 20-page booklet. For your free copy or more information on Tenite plastics, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSFORD, TENNESSEE.



TENITE

BUTYRATE • POLYETHYLENE • PROPIONATE • ACETATE

Dependable plastics by Eastman



A Military Messenger That Puts Red Tape to Rout

AE
CAN
DO

Imagine global communications that *automatically* route messages to the proper commands – give instant priority to emergency traffic. It *has* been done, by Automatic Electric.

How? Messages arrive at Teletypewriter Switching Centers on coded teletypewriter tape. The codings determine whether the message has a single or multiple destination, where it is to go, and its degree of priority. Telephone switching equipment selects the proper outgoing lines, retransmits the message to one or more points.

Making machines like this think automatically is AE's business. That is why the armed services and industry can confidently seek the solutions to automatic control from AE. The fact is, *almost every device or system that is operated automatically uses the type of switching and relay units originated or manufactured by Automatic Electric.*

In problems of communications or control, AE is at your command. Whether you need engineering advice, basic components or a control "package," write the Director, Industrial Products Engineering, Automatic Electric, Northlake, Illinois.



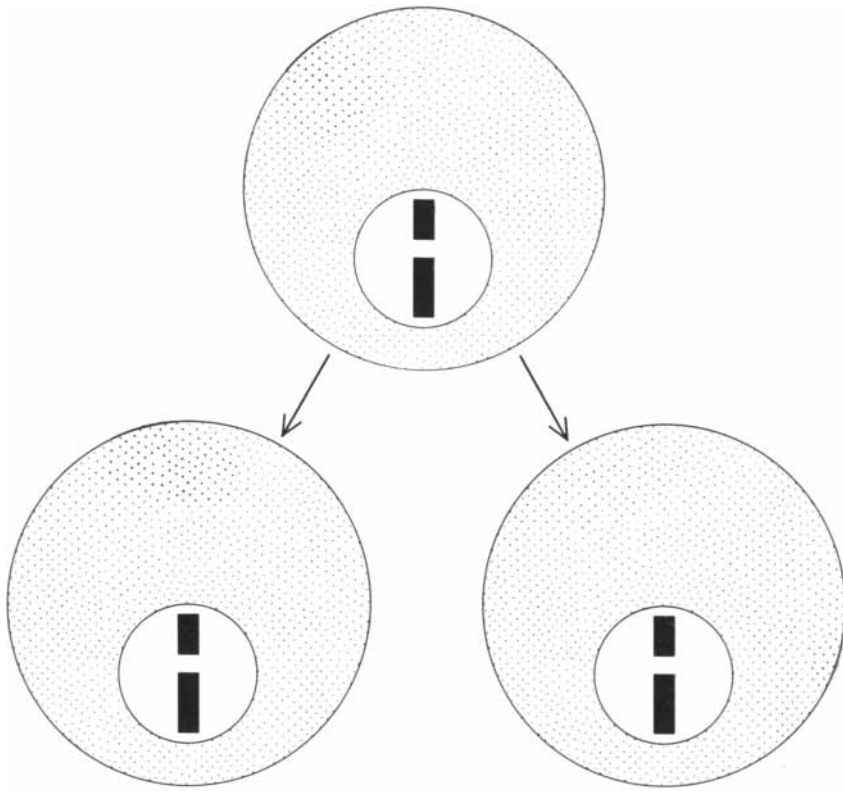
MAKING

IDEAS

WORK

AUTOMATICALLY

AUTOMATIC ELECTRIC 
Subsidiary of
GENERAL TELEPHONE & ELECTRONICS



ASEXUAL REPRODUCTION permits little variability in a population; the evolution of asexual organisms depends entirely on mutation. At top is a schematic diagram of an asexual cell. Within its nucleus (*open circle*) are chromosomes (*rectangles*). When the cell divides (*bottom*), its two daughter cells have replicas of the original chromosomes and are exactly like the parent. To simplify the diagram only two of the chromosomes of a cell are shown.

woodpeckers and feed on insect larvae in wood; still others feed with parrot-like beaks on fruits. The woodpecker type is of special interest. Lacking the woodpecker's long tongue it has evolved the habit of using a cactus spine or a twig as a substitute—it is the only example of a tool-using bird. In the rest of the world the finches are a relatively homogeneous group. Their tremendous diversity on these islands must be due to their isolation and the availability of new, unexploited ecological opportunities. A similar example of multiple adaptations is found in the honey creepers of the Hawaiian Islands [*see illustration on page 144*].

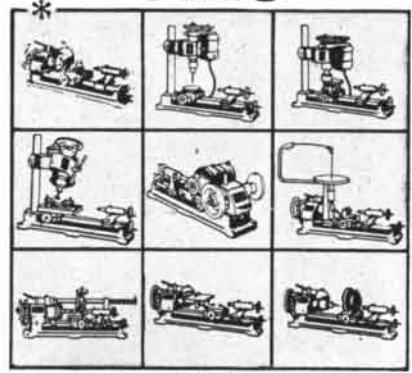
When paleontologists look into the ancestry of present-day animals, they find that only a minute fraction of the species present 100 million years ago is represented by descendants now. It is estimated that 98 per cent of the living vertebrate families trace their ancestry to eight of the species present in the Mesozoic Era, and that only two dozen of the tens of thousands of vertebrate species that were then present have left any descendants at all. The overwhelmingly probable future of any

species is extinction. The history of evolution is a succession of extinctions along with a tremendous expansion of a few fortunate types.

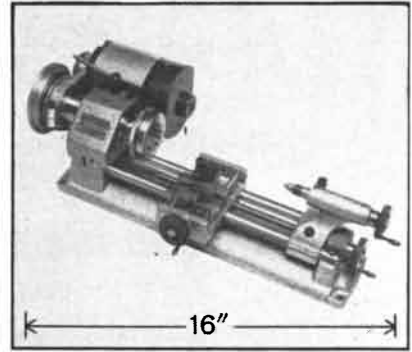
The causes of extinctions must be many. A change of environment—due to a flood, a volcanic eruption or a succession of less dramatic instances—may alter the ecological niche into which the species formerly fitted. Other animals and plants are probably the most important environmental variables: one species is part of the environment of another. There may be a more efficient predator, or a species that competes for shelter or food supply, or a new disease vector or parasite. As Theodosius Dobzhansky of Columbia University has said, "Extinction occurs either because the ecological niche disappears, or because it is wrested away by competitors."

Extinction may also arise from natural selection itself. Natural selection is a short-sighted, opportunistic process. All that matters is Darwinian fitness, that is, survival ability and reproductive capacity. A population is always in danger of becoming extinct through "criminal" genes—genes that perpetuate themselves at the expense of the rest of the population. An interesting example is the so-

THIS



IS



UNIMAT

THE IDEAL MINIATURE MACHINE
SHOP FOR RESEARCH LABS
AND MODEL SHOPS

MULTI-FUNCTION PRECISION MACHINE TOOL OCCUPIES NO MORE SPACE THAN A TYPEWRITER! Engineers and Designers supplement their sketches and blueprints with machined-to-scale models anybody can "read". Technicians in research labs turn out machine work with amazingly small tolerances, down to .0004-of-an-inch! Manufacturers developing new products find UNIMAT indispensable in the mock-up shop. Hundreds † of efficiency-minded companies, hospitals and government agencies are now putting their UNIMATS to a thousand-and-one uses... it's the practical machine for making small parts! Let us tell you how they can serve you.

***BASIC UNIMAT** includes motor, lathe and components for converting to drill press, tool and surface grinding machine, and polisher-grinder. Low-cost attachments: jig saw, threader, circular saw, indexer-divider. Plus complete range of machine accessories.

†**TO MENTION A FEW:** Atom Products Division of GE, U.S. Naval Research, Bell Telephone Laboratories, Westinghouse, Pratt & Whitney, Raytheon, NYU-Bellevue Medical Center, Smithsonian Institute, General Motors.

Write for illustrated literature and price list
AMERICAN-EDELSTAAL/UNIMAT DIVISION
DEPT. D1, 350 BROADWAY, NEW YORK 13, N. Y.



THE RAW MATERIALS OF PROGRESS

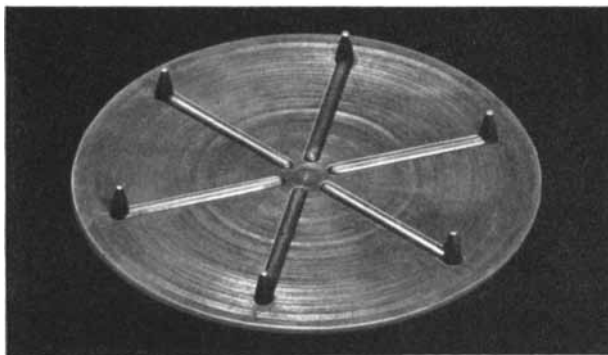
fluor

BRAND ELASTOMER

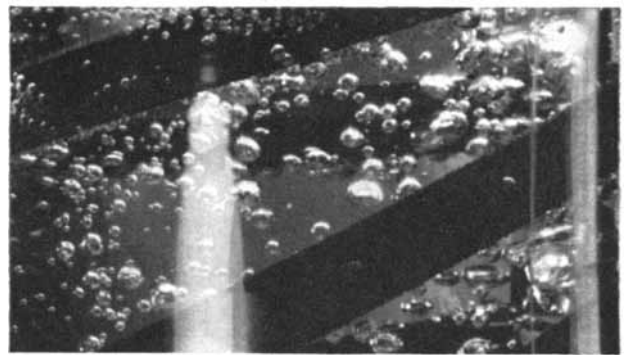
New FLUOREL Brand Elastomer is a highly fluorinated synthetic rubber that successfully resists corrosive chemicals, fuels, solvents and ozone

FLUOREL Elastomer is rated for continuous long-time service at 400°F . . . tolerates 600°F temperatures, and higher, for reduced periods under some service conditions. In addition to good thermal stability, ease of processing, non-combustibility, and excellent resistance to compression set are other outstanding features.

FLUOREL Elastomer greatly extends the performance range of applications requiring elastomeric materials. Its many exciting possibilities make it an important member of the ever-expanding family of 3M organic fluorine compounds. For complete data, write: 3M, Chemical Division, Dept. KAM-99, St. Paul 6, Minn.



EASE OF PROCESSING is shown by this disc. Note the reproduction of machine marks from mold surface. FLUOREL Elastomer is sold by the 3M Company as a gum. It can be readily mold processed on standard rubber compounding and fabricating equipment. It may be molded, extruded and bonded to most metals.



WHEREVER THE HEAT'S ON, put FLUOREL Elastomer to work for you. It's in use now or under evaluation in the missiles and aircraft, automotive and chemical processing industries for oil seals, "O" rings and gaskets. Other suggested uses: fire walls, air ducts, fuel cells, fuel and hydraulic hose, diaphragms and tank linings.

*The term "Fluorel" is a trademark of Minnesota Mining and Manufacturing Company

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

... WHERE RESEARCH IS THE KEY TO TOMORROW

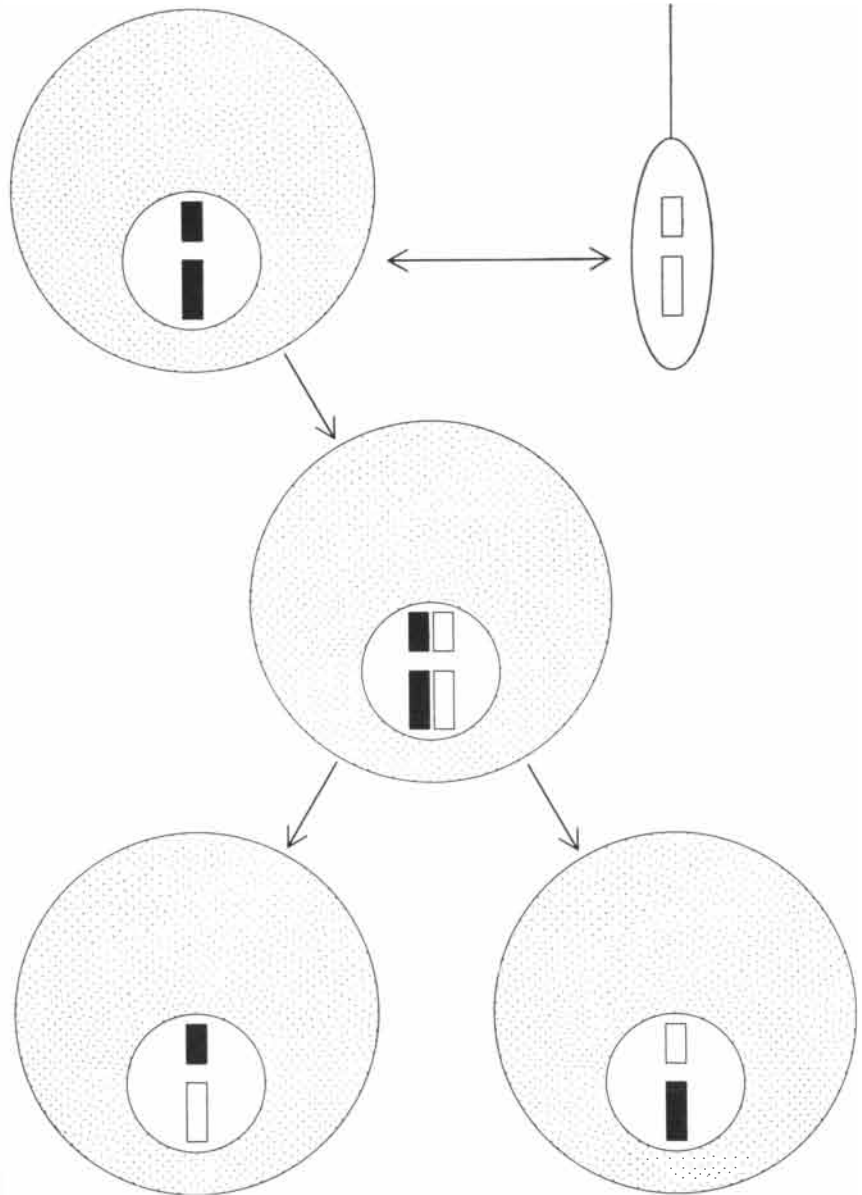


eI*

called SD gene, found in a wild *Drosophila* population near the University of Wisconsin by Yuichiro Hiraizumi. Ordinarily the segregation ratio—the ratio of two alternative genes in the progeny of any individual that carries these genes—is 1:1. In this strain the segregation is grossly distorted to something like 10:1 in favor of the SD gene; hence its name, SD, for segregation distorter. The SD gene somehow causes the chromosome opposite its own chromosome to break just prior to the formation of sperm cells.

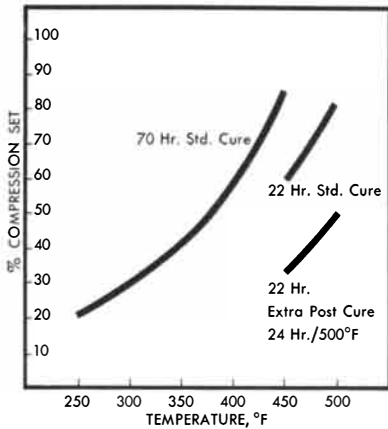
As a result the cells containing the broken chromosome usually fail to develop into functional sperm. The SD-bearing chromosome thus tends to increase itself rapidly in the population by effectively killing off its normal counterpart. Such a gene is obviously harmful to the population. But it cannot be eliminated except by the extinction of the population, or by the occurrence of a gene that is immune to the SD effect.

A similar gene exists in many mouse populations. Causing tail abnormali-

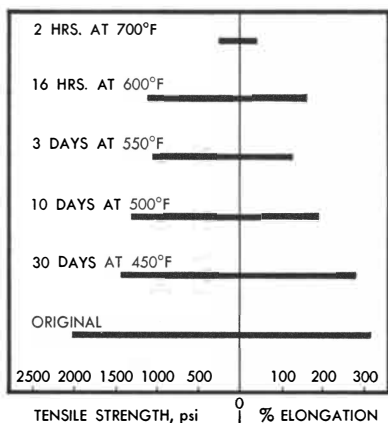


SEXUAL REPRODUCTION, also depicted in highly schematic form, depends on the union of two cells that may be from different lines of descent. At top left is an egg cell; at top right, a sperm cell. Each contains one set of chromosomes (*rectangles*). They join to form a new individual with two sets of chromosomes in its body cells (*center*). When this organism produces its own sperm or egg cells (*bottom*), each receives a full set of chromosomes. Some, however, may be from the father and some from the mother. Evolution in sexual organisms thus does not depend entirely on new mutations, because the genes already present in the population may be combined in different ways leading to improvements in the species.

Charts below illustrate FLUOREL Elastomer resistance to compression set and heat. COMPRESSION SET (ASTM D-395-52T, Method B)

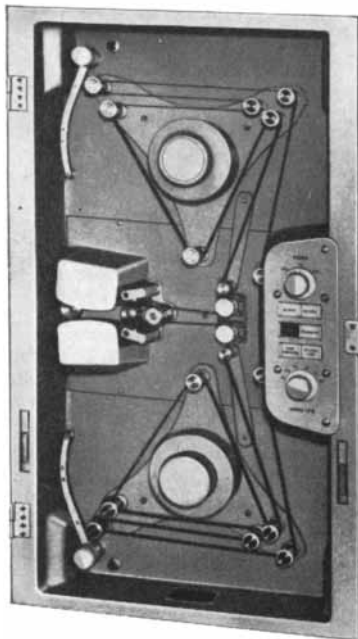
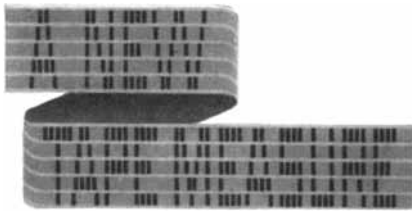


THERMAL STABILITY (Circulating Air Oven)



3M CHEMICAL DIVISION, MANUFACTURERS OF:
 Acids • Resins • Elastomers • Plastics • Oils,
 Waxes and Greases • Dispersion Coatings
 • Functional Fluorochemicals • Surfactants
 and Inert Liquids

IN...YOUR...FUTURE...




Tape loop transport is part of Honeywell nuclear reactor SCRAM monitor which is used to remember what happened at 19 critical points both before and after a scram or other off-normal condition.

The dashes in the above tape symbolize electrical pulses recorded on magnetic tape. Such pulses can precisely represent time, temperature, rate, vibration, pressure, direction, and a host of other variables, in either analog or digital form.

Taped data can speed test analyses, monitor operations, program equipment, and serve as accessible, compact storage, all automatically. The resultant savings in time and expense are yours.

MINNEAPOLIS-HONEYWELL,
10721 Hanna St., Beltsville, Md.

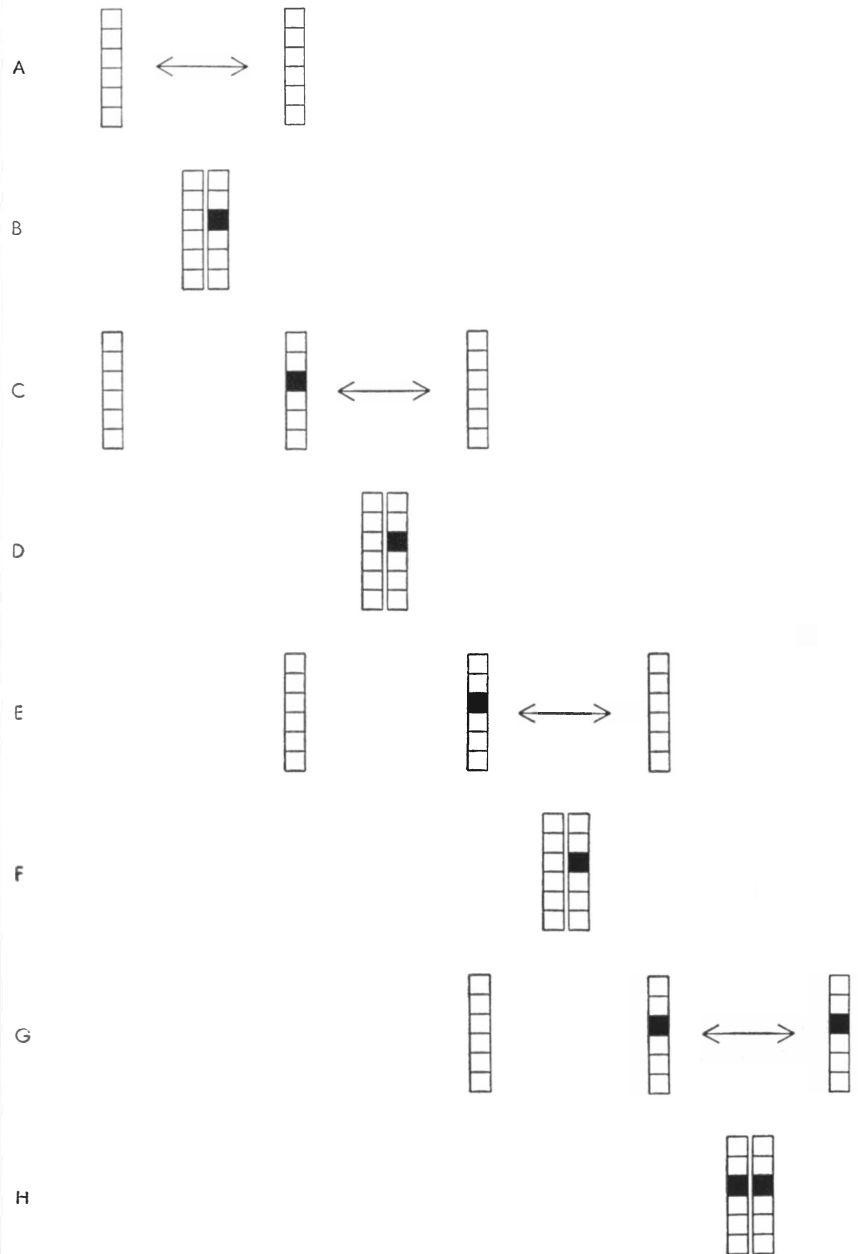
Honeywell

 First in Control

ties, it is transmitted to much more than the usual fraction of the offspring, though in this case the detailed mechanism is not known. L. C. Dunn of Columbia University has found this gene in many wild-mouse populations. Most of these genes are highly deleterious to the mouse (a mouse needs a tail!), and some are lethal when they are borne in a double dose, so that the gene never complete-

ly takes over despite its segregational advantage. The result is an equilibrium frequency determined by the magnitude of the two opposing selective forces: the harmfulness of the gene and its segregational advantage. The population as a whole suffers, a striking illustration of the fact that natural selection does not necessarily improve the fitness of the species.

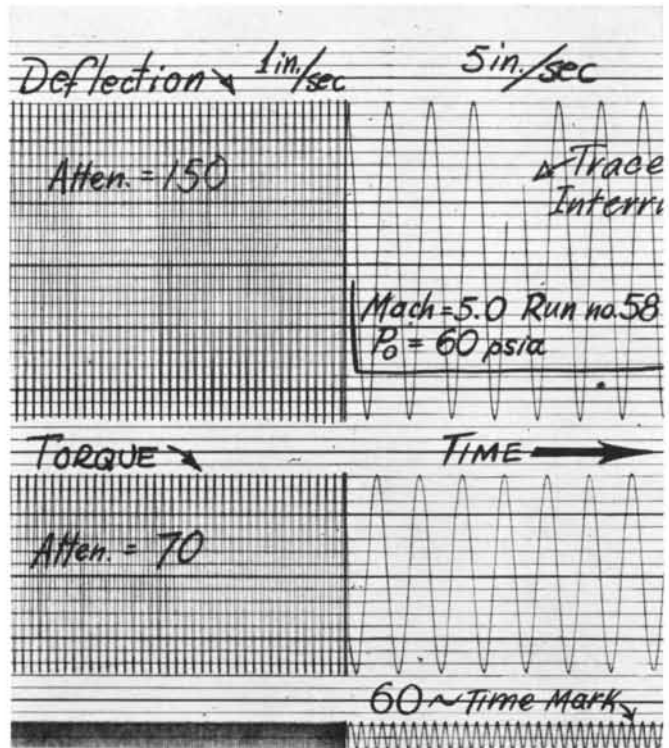
A gene causing extremely selfish, anti-



RECESSIVE MUTATION cannot be expressed in a sexual organism unless the corresponding gene of the paired chromosome has the same defect. Thus a harmful mutation can remain latent for generations. In this diagram the bars representing chromosomes are divided into squares, each symbolizing the gene for a different character. In row A the chromosomes of normal parents are paired (arrows). In row B a gene of their offspring mutates (black). In row C the mutant gene has been transmitted to the next generation but is still latent because the other parent has supplied a normal gene. This continues (rows E and F) until two individuals harboring the mutant gene mate (row G). The full effect of the mutation, harmful or otherwise, is expressed in offspring receiving a pair of mutant genes (row H).

In science...

This "diary" of an airframe in wind-tunnel flight is an instantly-readable record taken on a Model 906A Visicorder by ARO, Inc., at the USAF Arnold Engineering Development Center, Tullahoma, Tennessee, the ARDC wind tunnel facility. This record measures damping-in-pitch derivatives for a clipped-delta-wing-body configuration over a Mach number range of 2.0 to 5.0 so that these measurements could be compared with Mach number trend predicted by theory. The values discovered through this experiment showed discrepancies from theoretical values because the theory pertained to simpler bodies than that used in the tests. The new set of Visicorder data will result in more accurate predictions for future design.



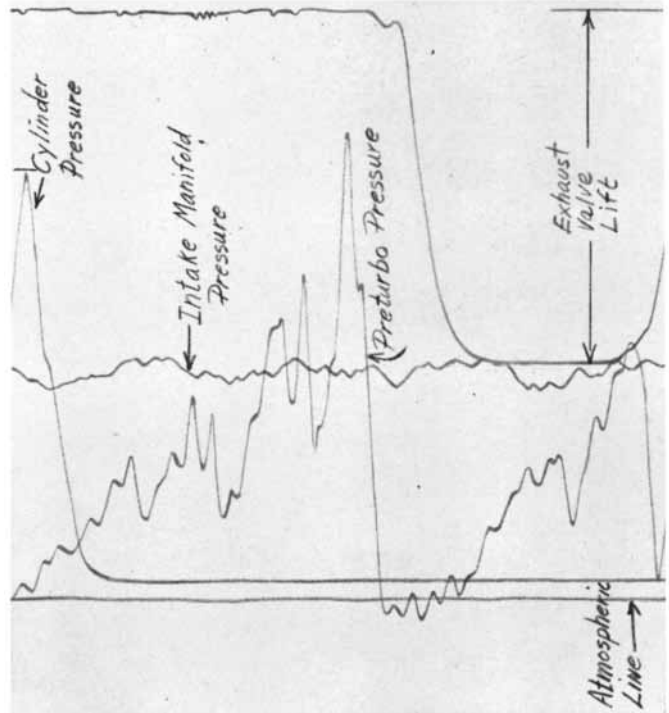
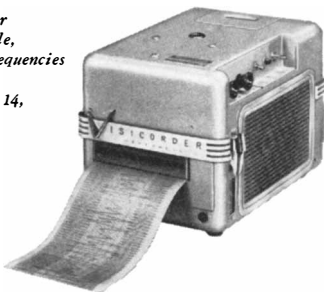
these are records of leadership

In industry...

This "cardiogram" of a diesel engine was taken on a Model 906 Visicorder by research engineers at the Worthington Corporation. It is a directly-recorded chart of pressure variations in the exhaust manifold, cylinder, and intake manifold of a Worthington Tripower diesel operating at 450 RPM and developing 265 HP per cylinder. These pressure-variation studies enable Worthington engineers to determine optimum valve timing and engine configuration, and led to changes in the Tripower engine for best performance. In these and in hundreds of other scientific and industrial applications, Visicorders are bringing about new advances in product design, computing, control, rocketry, nucleonics, and production.

For information on how to apply the unlimited usefulness of the Visicorder to your specific problems, phone your nearest Honeywell Industrial Sales Office.

The Honeywell Visicorder provides instantly-readable, high-sensitivity data at frequencies from DC to 5000 CPS. There are models with 8, 14, or 36-channel capacities.



Visicorder records 2/3 actual size.

Honeywell

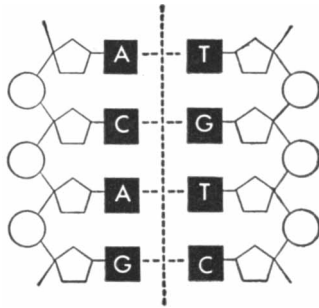


Industrial Products Group

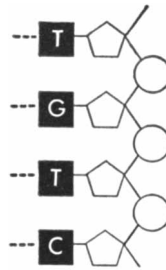
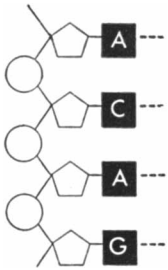
Reference Data: Write for Visicorder Bulletins 906A and 1012.

Minneapolis-Honeywell Regulator Co., Industrial Products Group, Heiland Division, 5200 E. Evans Ave., Denver 22, Colorado

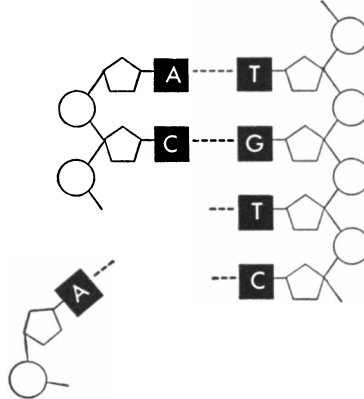
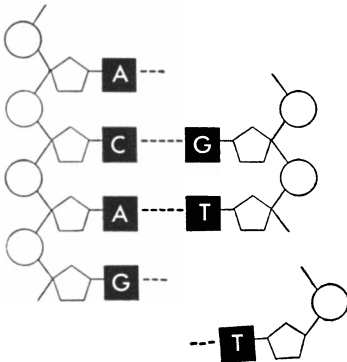
1.



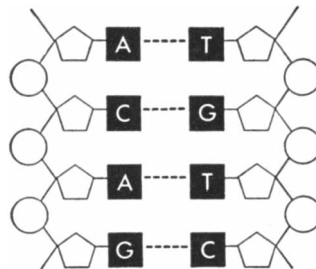
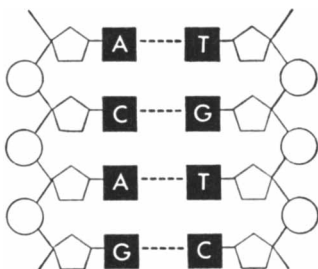
2.



3.



4.



THE GENETIC MATERIAL, deoxyribonucleic acid (DNA), consists of a chain of sugar units (*pentagons*) and phosphate groups (*circles*) with side chains of bases: adenine (A), cytosine (C), thymine (T) and guanine (G). One possible mechanism for replication postulates that DNA normally contains two complementary strands, linked A—T and C—G (1). The chains then separate (2), and separate precursor units assemble along each chain (3). When they are completed, the double strands are identical to the original (4).

social behavior—for example genes for cannibalism or social parasitism—could have similar effects in the human population. Any species must be in constant danger from the short-sightedness of the process of natural selection. Those that are still here are presumably the descendants of those that were able to avoid such pitfalls.

Aside from mutation itself, the most important evolutionary invention is sexual reproduction, which makes possible Mendelian heredity. The fact that such an elaborate mechanism exists throughout the whole living world—in viruses and bacteria, and in every major group of plants and animals—attests to its significance.

In a nonsexual population, if two potentially beneficial mutations arise in separate individuals, these individuals and their descendants can only compete with each other until one or the other type is eliminated, or until a second mutation occurs in one or the other group. A Mendelian species, with its biparental reproduction and consequent gene-scrambling, permits both mutants to be combined in the same individual. An asexual species must depend upon newly occurring mutations to provide it with variability. Sexual reproduction permits the combination and recombination of a whole series of mutants from the common pool of the species. Before they enter the pool the mutants have been to some extent pretested and the most harmful ones have already been eliminated.

Suppose that a population has 50 pairs of genes: Aa, Bb, Cc, etc. Suppose that each large-letter gene adds one unit of size. The difference between the smallest possible individual in this population (aa bb cc . . .) and the largest possible (AA BB CC . . .) is 100 units. Yet if all the genes are equally frequent, the size of 99.7 per cent of the population will be between 35 and 65 units. Only one individual in 2^{100} (roughly 1 followed by 30 zeros) would have 100 size units. Yet if the population is sexual, this type can be produced by selection utilizing only the genes already in the population.

This example illustrates the evolutionary power of a system that permits Mendelian gene-assortment. In an asexual system the organism would have to wait for new mutations. Most of the size-increasing mutations would probably have deleterious side effects. If the asexual organism had a mutation rate sufficient to give it the potential vari-

ability of a sexual population, it would probably become extinct from harmful mutations.

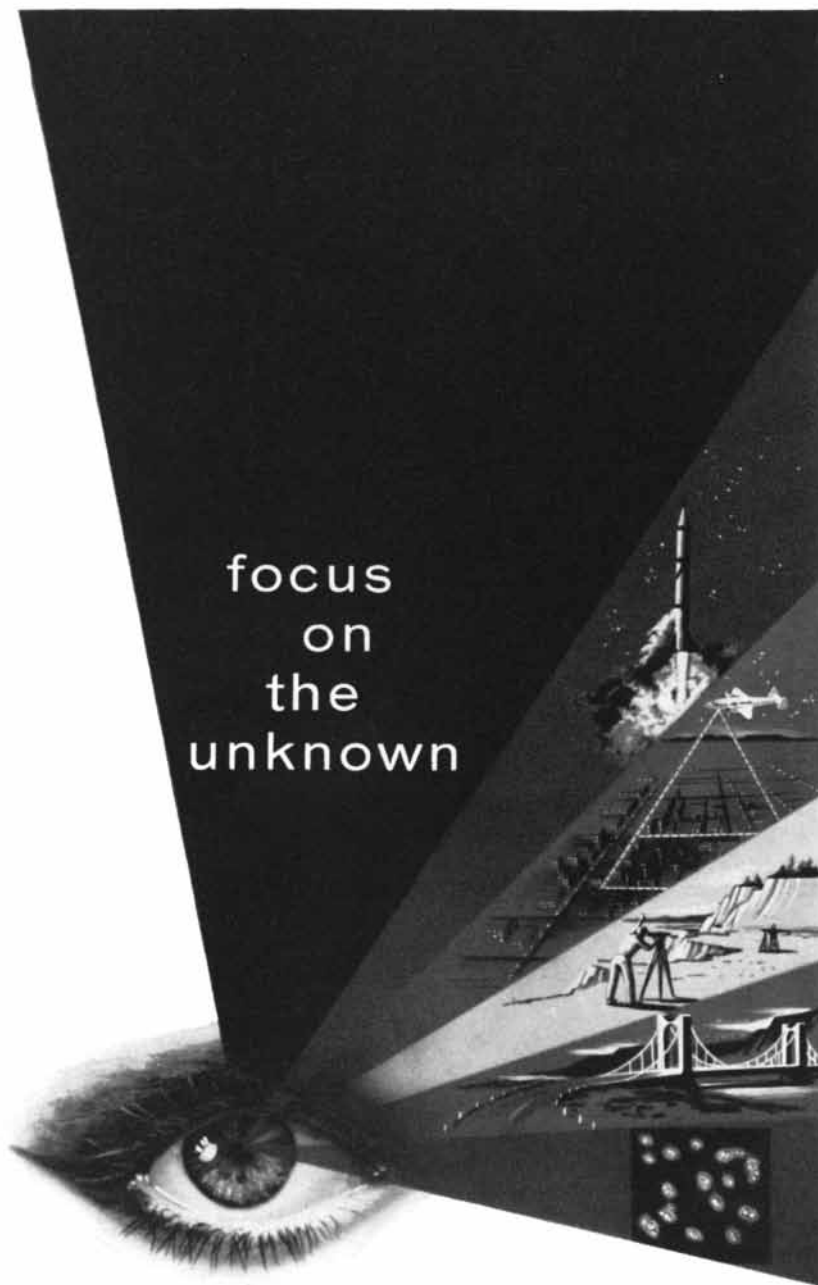
The very existence of sexual reproduction throughout the animal and plant kingdoms argues strongly for the necessity of an optimum genetic variability. This is plain, even though there is no consistent correlation between evolution rates as observed in the fossil record and the variability of the animals observed. It must be that a certain level of genetic variability is a necessary, but by no means sufficient, condition for progressive evolution.

Evolution is an exceedingly complex process, and it is obviously impossible, even in particular cases, to assign relative magnitudes to the various causal factors. Perhaps species have become extinct through mutation rates that are too high or too low, though there is no direct observational evidence for this. Probably many asexual forms have become extinct because they were unable to adapt to changes. Other forms have become overspecialized, developing structures that fit them for only a particular habitat; when the habitat disappears, they are lost. The population size and structure are also important. To be successful in evolution, by the criterion of having left descendants many generations later, a species has the best chance if it has an optimum genetic system. But among a number of potentially successful candidates, only a few will succeed, and probably the main reason is simply the good luck of having been at the right place at the right time.

Of all the natural selection that occurs, only a small fraction leads to any progressive or directional change. Most selection is devoted to maintaining the status quo, to eliminating recurrent harmful mutations, or to adjusting to transitory changes in the environment. Thus much of the theory of natural selection must be a theory of statics rather than dynamics.

The processes that are necessary for evolution demand a certain price from the population in the form of reduced fitness. This might be said to be the price that a species pays for the privilege of evolving. The process of sexual reproduction, with its Mendelian gene-shuffling in each generation, produces a number of ill-adapted gene combinations, and therefore a reduction in average fitness. This can be avoided by a non-sexual system, but at the expense of genetic variability for evolutionary change in a changing environment.

The plant breeder knows that it is



A rocket is 2 degrees off course...a satellite will enter orbit at 0642 GMT...the elevation to point 6 is 4° 10' 12"...the distance from point 2 to point 3 is 478 feet 4 inches...the sebaceous growth is nonmalignant...the blood count is normal.

Seeing the unseen, determining the unknown...this is the prime role of precise optics and associated equipment. The power, precision and versatility of optical engineering instruments and research microscopes is today placing the human eye and interpretive mind within view and evaluating distance of yesterday's unknown.

We are justly proud that our instruments have become standards for quality, precision and performance throughout the civilized world...for surveying, photogrammetry, research and scientific exploration.

We invite your request for literature describing Wild instruments in your field of interest.

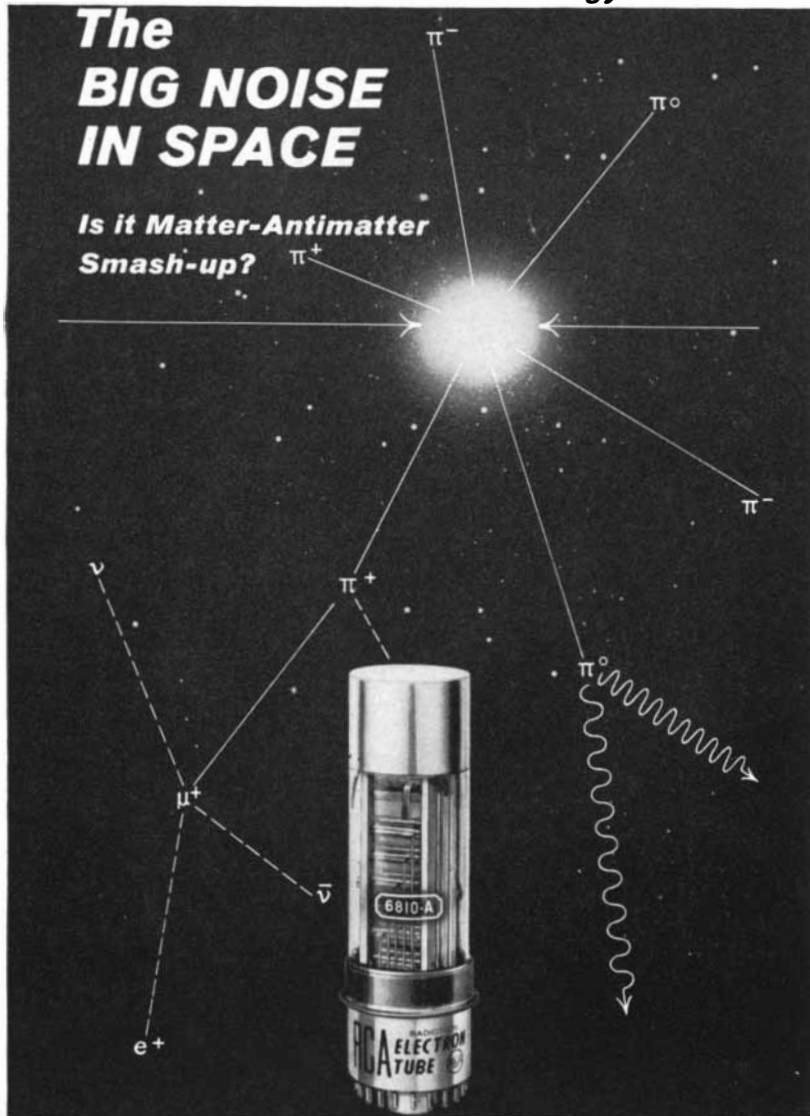


MAIN AT COVERT STREET, PORT WASHINGTON, NEW YORK • PORT WASHINGTON 7-4843
In Canada - Wild of Canada Ltd., 157 MacLaren St., Ottawa, Ontario

Another RCA Contribution to Energy Detection

The BIG NOISE IN SPACE

Is it Matter-Antimatter
Smash-up?



This is Messier 87—one of many galaxies and nebulae radiating radio energy throughout time and space.

What primeval force motivates this celestial radioactivity?

Until an RCA Multiplier Phototube successfully recorded the antiproton at 75 to 77 percent of the speed of light, this phenomenon was indeed wrapped in a physical enigma. Now, the discovery of the antiproton lends support to the theory of antimatter.

Thus, today, many cosmologists share a speculation that radio emission from the stars is caused by energy released in space when antimatter and matter collide.

Here is just one example of the many applications of RCA Multiplier Phototubes on the frontier of scientific research. To illustrate, RCA Multiplier Phototubes are helping to detect brain tumors—measure thyroid absorption of Iodine 131—decode antiquity by means of Carbon 14 dating—identify Cerenkov light-radiation angles—measure Gamma, Beta, and Cosmic radiation miles out in space.

For copy of technical catalog CRPD-105A describing RCA Photosensitive Devices including Multiplier Phototubes just write:
RCA Commercial Engineering, Section I-95-Q, Harrison, N. J.



RADIO CORPORATION OF AMERICA
Electron Tube Division
Harrison, N. J.

easy to maintain high-yielding varieties of the potato or sugar cane because they can be propagated asexually. But then his potential improvement is limited to the varieties that he has on hand. Only by combining various germ plasms sexually can he obtain varieties better than the existing best. But the potato and cane breeder can have his cake and eat it. He gets his new variants by sexual crosses; when he gets a superior combination of genes, he carries this strain on by an asexual process so that the combination is not broken up by Mendelian assortment.

Many species appear to have sacrificed long-term survival for immediate fitness. Some are highly successful. A familiar example is the dandelion; any lawn-keeper can testify to its survival value. In dandelion reproduction, although seeds are produced by what looks superficially like the usual method, the chromosome-assorting features of the sexual process are bypassed and the seed contains exactly the same combination of genes as the plant that produced it. In the long run the dandelion will probably become extinct, but in the present environment it is highly successful.

The process of mutation also produces ill-adapted types. The result is a lowering of the average fitness of the population, the price that asexual, as well as sexual, species pay for the privilege of evolution. Intuition tells us that the effect of mutation on fitness should be proportional to the mutation rate; Haldane has shown that the reduction in fitness is, in fact, exactly equal to the mutation rate.

The environment is never constant, so any species must find itself continually having to adjust to transitory or permanent changes in the environment. The most rapid environmental changes are usually brought about by the continuing evolution of other species. A simple example was given by Darwin himself. He noted that a certain number of rabbits in every generation are killed by wolves, and that in general these will be the rabbits that run the slowest. Thus by gradual selection the running speed of rabbits would increase. At the same time the slower wolves would starve, so that this species too has a selective premium on speed. As a result both improve, but the position of one with respect to the other does not change. It is like the treadmill situation in Lewis Carroll's famous story: "It takes all the running *you* can do, to keep in the same place."

A change in the environment will

Another RCA Contribution to Energy Radiation

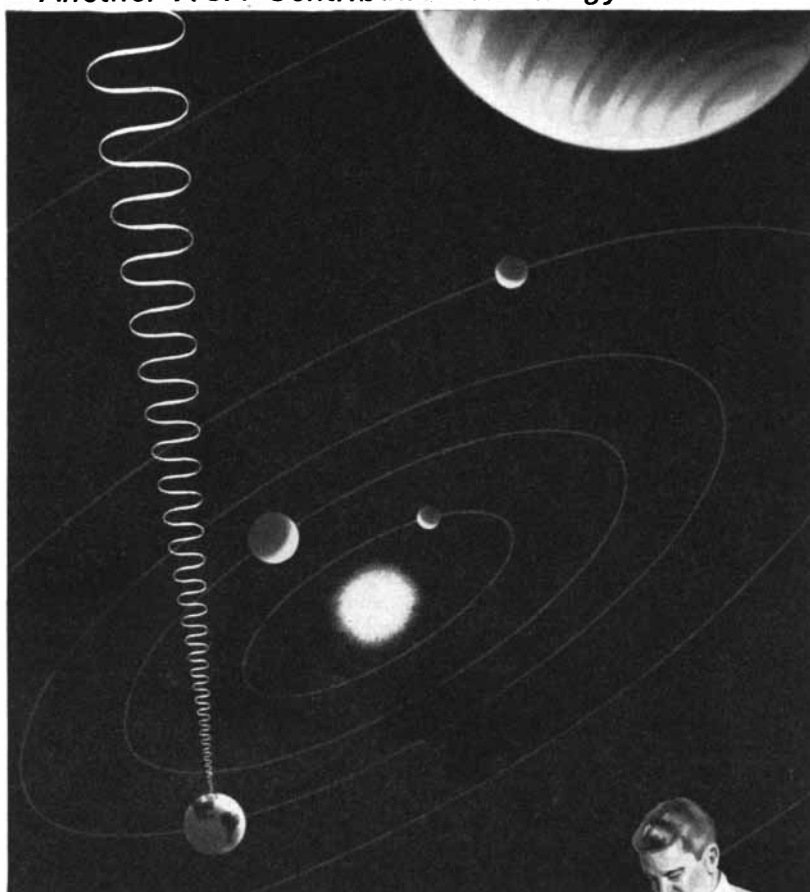
cause some genes that were previously favored to become harmful, and some that were harmful to become beneficial. At first it might seem that this does not make any net difference to the species. However, when the change occurs, the previously favored genes will be common as a result of natural selection in the past. The ones that were previously deleterious will be rare. The population will not return to its original fitness until the gene numbers are adjusted by natural selection, and this has its costs.

Just how much does it cost to exchange genes in this way? Let us ask the question for a single gene-pair. If we start with a rare dominant gene present in .01 per cent of the population, it requires the equivalent of about 10 selective "genetic deaths" (*i.e.*, failure to survive or reproduce) per surviving individual in the population to substitute this gene for its predecessor. This means that if the population is to share an average of one gene substitution per generation, it must have a sufficient reproductive capacity to survive even though nine out of 10 individuals can die without offspring in each generation. The cost is considerably greater if the gene is recessive. The surprising part of this result is that the number does not depend on the selective value of the gene. As long as the difference between two alternative genes is small, the cost of replacing one by the other depends only on the initial frequency and dominance of the gene and not at all on its fitness.

If the gene is less rare, the cost is lowered. Thus the species can lower the price of keeping up with the environment by having a higher frequency of deleterious genes that are potentially favorable. One way to accomplish this is to have a higher mutation rate, but this, too, has its price. Once again there is the conflict between the short-term objective of high fitness and the longer-term objective of ability to change with the environment.

There are known to be genes that affect the mutation rate. Some of them are quite specific and affect only the mutation rate of a particular gene; others seem to enhance or depress the over-all rate. A gene whose effect is to lower the mutation rate certainly has selective advantage: it will cause an increase in fitness. This means that in most populations there should be a steady decrease in the mutation rate, possibly so far as to reduce the evolutionary adaptability of the organism. This is offset by selection for ability to cope with fluctuating environments.

How does man fare in this respect?



THE MOST POWERFUL ELECTRON TUBE ... ON EARTH



Inspired by man's relentless effort to smash through the barriers of space, time, and work, RCA announces the successful completion of tests on a Super-Power Electron Tube that can produce 5 million peak watts and do it—at an average power level of 300,000 watts and at a frequency as high as 450 megacycles/sec.

Think of it—within the geometry of a single tube no bigger than a nail keg lies the potential ability to deliver power enough to explore the possibilities of interplanetary communications, intercontinental television, super-radar on a global scale. Here is super-power for industry—in electronic heating, radiology, irradiation, and sterilization.

Envisioned by the Radio Corporation of America almost 2 decades ago, Super-Power Tubes today are doing astonishing things on a broad technological front—"blasting" atoms in particle accelerators, delivering the electronic energy it will take to accomplish thermonuclear fusion, strengthening the hand of missile-guidance systems, and increasing the reliability factor of communications circuits in scatter-transmission applications.

Can RCA Super-Power Electron Tubes help you in your research and industrial programs? To find out, jot down your requirements and send them to RCA Commercial Engineering, Section I-95-Q, Harrison, N. J.



RADIO CORPORATION OF AMERICA
Electron Tube Division

Harrison, N. J.

Camera Size Only 6-5/8" x 2"

NEW



DAGE NUCLEAR TV CAMERA

DEPENDABLE FOR HIGH RADIATION AREAS

Now the advantages of closed-circuit TV can be fully utilized in high radiation areas. The breakdown of electrical components by radiation has been overcome by Dage's new Miniature Radiation Resistant Television Camera which places susceptible components in an amplifier unit outside the radiation field. See Homogeneous Reactor Quarterly Project Report for April 30, 1959.

The ability to withstand extreme radiation dosage, coupled with extreme compactness and remote handling ease, are good examples of Dage's specialized design capability. Write us today for additional information on your specific television problems.



New Industrial TV Cameras

Two new 600-line resolution cameras for many industrial uses: remote operations, instrumentation, inspection, security, safety, communication, etc. Model 70-A with random interlace, Model 71-A with positive interlace picture. Dage manufactures a complete line of quality closed-circuit TV cameras, monitors, controls and accessories for all purposes.



DAGE TELEVISION DIVISION Thompson Ramo Wooldridge Inc.
1909 West 10th Street, Michigan City, Indiana



wunder-buy! It's the family car built for fun! Peppy, roomy, unlimited visibility. All-aluminum air-cooled rear engine . . . can't overheat ever! Superb roadability. Does up to 70 mph. Hoards gas! Up to 50 mpg on regular gas. PRINZ-ly style.

NSU PRINZ

FROM WEST GERMANY

\$1398

P.O.E. N.Y.
HIGHER WEST COAST



U. S. IMPORTER: FADEX COMMERCIAL CORP. Executive offices and showroom, Dept. SC9, 487 Park Avenue, New York 22, New York. Dealers from coast to coast. Overseas delivery arranged for your European pleasure. Write for literature and address of your nearest dealer.

From the standpoint of his biological evolution, is his mutation rate too high, is it too low or is it just right? It is not possible to say.

In general one would expect the evolutionary processes to work so that the mutation rate would usually be below the optimum from the standpoint of long-term evolutionary progress, because selection to reduce the mutation load has an immediate beneficial effect. Yet selection for a mutation-rate-adjusting gene is secondary to selection for whatever direct effects this gene has on the organism, such as an effect on size or metabolic rate. So we do not have much idea about how rapidly such selection would work.

Our early simian ancestors matured much more rapidly than we do now. This means that the mutation rate would have to be lowered in order to be brought into adjustment with the lengthening of our life cycle. To whatever extent the adjustment is behind the times, the mutation rate is too high. Furthermore, if it is true (as it appears to be) that radiation-induced mutation rates are less susceptible to evolutionary adjustment than those due to other causes, then an animal with a life cycle so long that it receives considerable radiation per generation may have too many from this cause.

I think it is impossible, however, to say whether man has a mutation rate that is too high or too low from the viewpoint of evolutionary advantage. It is worth noting that man, like any sexually reproducing organism, already has a tremendous store of genetic variability available for recombination. If all mutation were to stop, the possibilities for evolution would not be appreciably altered for a tremendous length of time—perhaps thousands of generations. Consider the immense range of human variability now found, for example the difference between Mozart, Newton, da Vinci and some of our best athletes, in contrast to a moron or the genetically impaired. Haldane once said: "A selector of sufficient knowledge and power might perhaps obtain from the genes at present available in the human species a race combining an average intellect equal to that of Shakespeare with the stature of Carnera." He goes on to say: "He could not produce a race of angels. For the moral character or for the wings he would have to await or produce suitable mutations." Surely the most hopelessly naive eugenicist would settle for considerably less!

I would argue that from any practical



Nuclear training in our academic institutions is a major factor in the dynamic growth of radiation in industry, medicine, and biological research. Development of radioactivity detection and measuring instruments for nuclear training has been a specialty at Nuclear-Chicago for more than twelve years.

If your responsibility is to education . . . or the practical application of radiation to industrial, medical, or research problems . . . we will be glad to show you how our instruments can be used in your program.



355 East Howard Avenue • Des Plaines, Illinois

Now with ONE instrument the versatile Cary Model 31 Electrometer...



- Measure C^{14} and H^3 activity to 10^{-12} Curies
- Measure electrical properties: detect 10^{-17} amps; 20 microvolts;

• and make a variety of other precise measurements

Besides being the most accurate, convenient and inexpensive instrument for determining C^{14} and H^3 , the CARY Model 31 may be used to perform a variety of other tasks in the laboratory.

FOR EXAMPLE,
The 31 may be used as:

- A sensitive detector for beta and gamma radiation. May often serve as a substitute for geiger or proportional counters.
- A spectrometer for measuring alpha energy in the presence of substantial beta and gamma emissions.
- A monitor for gamma background, surface alpha contamination, or air contamination.
- A DC amplifier for semi-conductor studies, pH measurement (detects changes to .0005 pH), insulation leakage measurements, determination of grid currents on vacuum tubes and many other measurements of electrical properties.

So, if you are considering instrumentation to perform these tasks, investigate the CARY Model 31. Its versatility, reliability, speed and compactness will save time, money and bench space.



For complete information on the Model 31 and other Cary Electrometers, write for data file HLL-99

Other Cary Instruments:
UV-Visible-Near IR and Raman Spectrophotometers



APPLIED PHYSICS CORPORATION • 2724 SOUTH PECK ROAD • MONROVIA, CALIFORNIA

standpoint the question of whether man's mutation-rate is too high or too low for long-term evolution is irrelevant. From any other standpoint the present mutation rate is certainly too high. I suspect that man's expectations for future progress depend much more on what he does to his environment than on how he changes his genes. His practice has been to change the environment to suit his genes rather than vice versa. If he should someday decide on a program of conscious selection for genetic improvement, the store of genes already in the population will probably be adequate. If by some remote chance it is not, there will be plenty of ways to increase the number of mutations at that time.

There can be little doubt that man would be better off if he had a lower mutation-rate. I would argue, in our present ignorance, that the ideal rate for the foreseeable future would be zero. As George W. Beadle makes clear in the last article of this series, the effects produced by mutations are of all sorts, and are mostly harmful. Some cause embryonic death, some severe disease, some physical abnormalities, and probably many more cause minor impairments of body function that bring an increased susceptibility to the various vicissitudes of life. Some have an immediate effect; others lie hidden to cause their harm many generations later. All in all, mutations must be responsible for a substantial fraction of human premature death, illness and misery in general.

At the present time there is not much that can be done to lower the spontaneous-mutation rate. But at least we can do everything possible to keep the rate from getting any higher as the result of human activities. This is especially true for radiation-induced mutations; if anything they are probably more deleterious and less likely to be potentially useful than those from other causes. It is also important to remember that there are very possibly things in the environment other than radiation that increase the mutation rate. Among all the new compounds to which man is exposed as a result of our complex chemical technology there may well be a number of mutagenic substances. It is important that these be discovered and treated with caution.

The general conclusion, then, is that ionizing radiation is probably not an important factor in animal and plant evolution. If it is important anywhere it is probably in those species, such as man, that have a long life span, and at least for man it is a harmful rather than a potentially beneficial factor.



For advanced fuel...hydraulic...lube systems,

New materials prove ideal in handling

temperature extremes -350° F. to $+750^{\circ}$ F.

Working with two remarkably versatile elastomers, C/R Sirvene engineers are producing flexible molded parts for many vital fuel, lubricating, hydraulic and pneumatic systems. One, Viton-A*, can be compounded to produce parts that function dependably at 600° F., and for short periods up to 750° F. The other important feature of Viton compounds is their excellent resistance to corrosive chemicals, chlorinated solvents as well as both synthetic and petroleum base fuels and lubes. At the other extreme, C/R compounded Silastic LS-53** parts are providing low temperature operation down to -80° F. They also exhibit excel-

lent resistance to synthetic and petroleum base fluids up to 350° F., and function well in propane up to 500° F. For temperatures as low as -350° F., C/R recommends Teflon* compounds.

C/R Sirvene engineers have an intimate knowledge of these elastomers. They also have perfected special techniques in processing which still further improve the physical properties of the molded parts. If your problem involves high or low temperatures, close tolerances, and compatibility in advanced design fuel, lubricant or hydraulic systems, get in touch with us at once. We have the skill and the facilities to help you.

* DuPont registered trademark

**Dow-Corning registered trademark

CHICAGO RAWHIDE MANUFACTURING COMPANY

SIRVENE DIVISION, 1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS

Offices in 55 principal cities. See your telephone book.

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

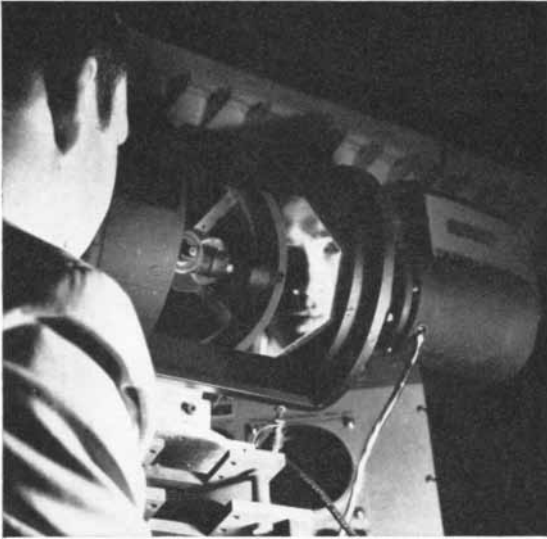
Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic gears



CAPABILITIES FOR DEFENSE

FROM THE SEA COMES A MAJOR THREAT ...



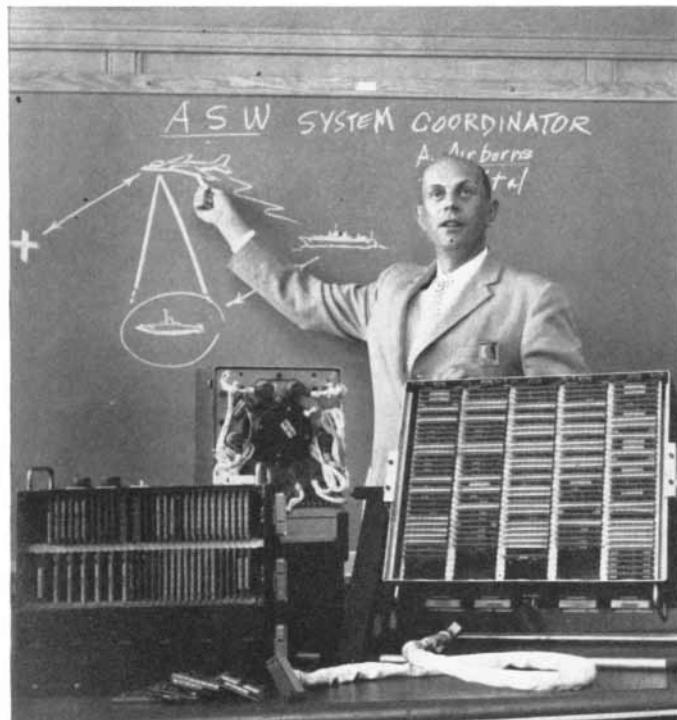
The environment of the sea favors the submarine. This makes antisubmarine warfare—from detection to kill—one of the most formidable tasks faced by the U. S. Navy. Missile-firing nuclear subs further complicate this acute defense problem. ASW calls for all the imagination, skill and resourcefulness that industry, in its assisting role, can bring to bear.

Westinghouse is engaged in a program to help our forces deal with this increasingly urgent challenge. The corporation's facilities—from research laboratories to manufacturing divisions—are working to help solve this threat.

A BROAD WESTINGHOUSE

IMAGINATION: Westinghouse developments in scanning systems, cells and special circuitry make possible detection of submarines in a tactical environment.

Developments in computer techniques and components provide the means for fully integrated ASW weapon systems, assuring early detection and sure kill. Typical is this new digital computer from the Westinghouse AIR ARM DIVISION.





ASW PROGRAM IS HELPING TO MEET THIS MENACE



SKILL: New radar equipment is in the design and test stage at the AIR ARM and ELECTRONICS DIVISIONS. These Westinghouse radar developments will add effectiveness to ASW search and detection operations in a manner and to a degree never before achieved.

The precision-guided ASTOR torpedo system, provides a powerful weapon in effectively attacking enemy submarines. The ASTOR was designed and built for the Navy by the Westinghouse ORDNANCE DEPARTMENT.



RESOURCEFULNESS: From Westinghouse RESEARCH LABORATORIES comes special knowledge needed for the ASW program. An example is fundamental work aimed at understanding underwater sound "scatterers."

Westinghouse

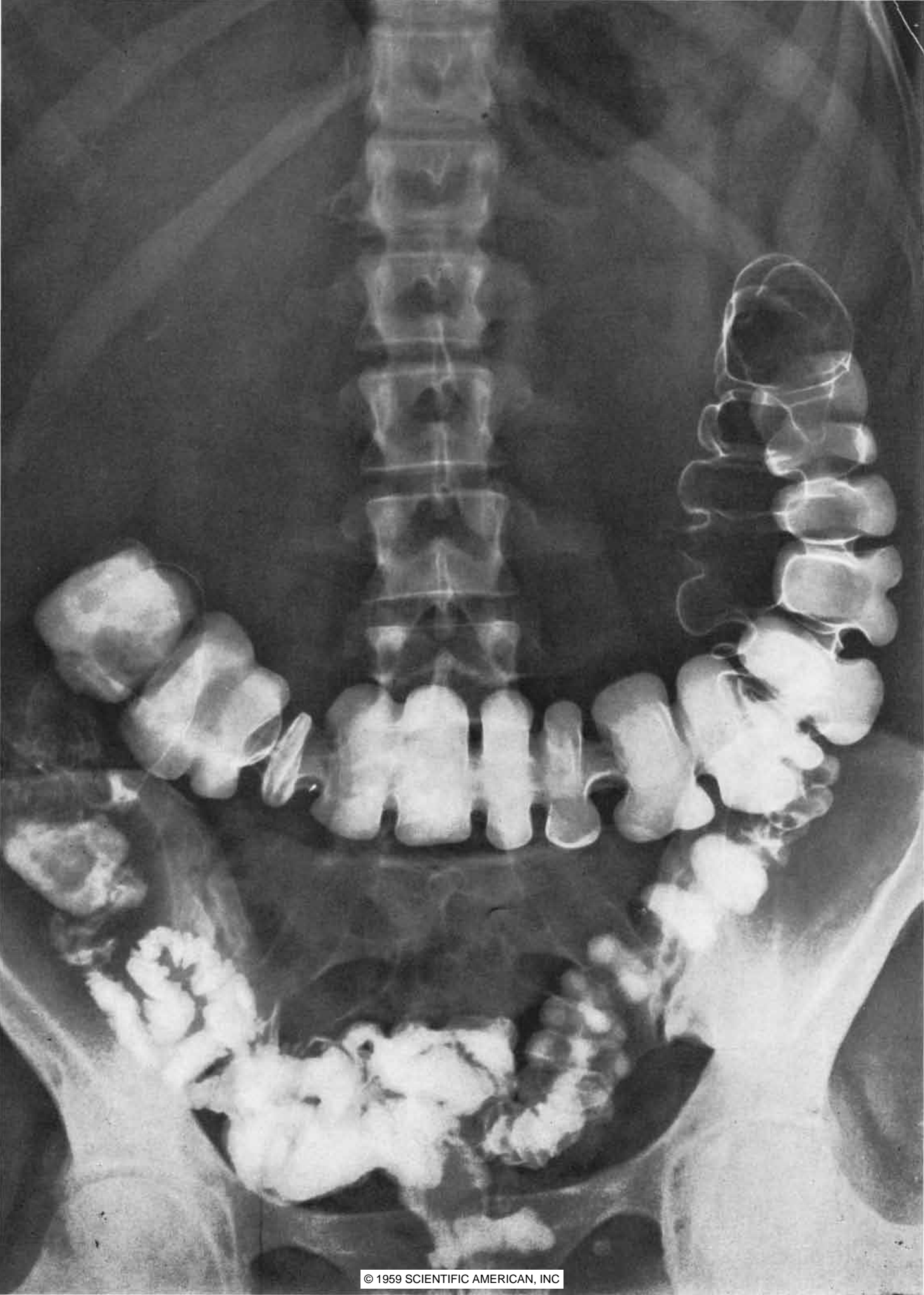
DEFENSE PRODUCTS

1000 CONNECTICUT AVENUE, N. W., WASHINGTON 6, D. C.

- AIR ARM DIVISION
- AVIATION GAS TURBINE DIVISION
- ELECTRONICS DIVISION
- AIRCRAFT EQUIPMENT DEPARTMENT
- ORDNANCE DEPARTMENT
- W A S P

YOU CAN BE SURE... IF IT'S Westinghouse





Ionizing Radiation and Medicine

X-rays have done much to conserve human life, but they have also doubled the exposure of people in advanced nations to radiation. The physician now has many ways to reduce the dosage to patients

by Shields Warren

If we could ask a physician of 1890 what he needed most to assist him in the diagnosis and treatment of disease, he might well reply: "A way of seeing inside the human body." This fantastic dream was soon to be realized. In 1895 Wilhelm Conrad Roentgen discovered X-rays, the first form of ionizing radiation known to man.

The modern physician employs the X-ray photograph and the fluoroscope to see bones, blood vessels, the lungs, the heart and practically every other internal organ. He utilizes the ionizing radiation of radioactive isotopes to "see" inside organs such as the thyroid gland and to measure their performance. And the uses of ionizing radiation go beyond diagnosis to therapy. The physician employs large doses of radiation to kill malignant cells, controlling the radiation so that it will do maximum damage to these cells and minimum harm elsewhere.

As other articles in this issue point out, however, the powerful diagnostic and therapeutic tool of ionizing radiation is also capable of injuring the patient and of causing genetic mutations. The conscientious physician is aware of these dangers and takes measures to minimize them. (Some patients, made fearful by the recent arousal of public interest in ionizing radiation, have the notion that exposure to X-rays will make them radioactive. This, of course, is nonsense. Ra-

diation is present only while the X-ray machine is operating.)

Roentgen himself saw the first interior "view" of living human tissue when he unintentionally fluoroscoped his own hand while holding a bit of lead between a fluorescent screen and the cathode-ray tube that produced his X-rays. Describing the scene, Otto Glasser has written: "One can only imagine how this first ghostly shadow picture of the human skeleton within living tissue affected the observer: doubt must have been followed by wonder and perhaps a reluctance to continue experiments that promised to bring him disrepute in the eyes of his colleagues. At that point (in November, 1895) he determined to continue his experiments in secrecy until such time as he himself was certain of the validity of his observations." A few days later Roentgen made the first X-ray photograph, or radiograph, of human tissue when he used the newly discovered rays to picture his wife's hand. Frau Roentgen, according to Glasser, shuddered when she realized she was looking at her own skeleton. Roentgen, a physicist, was so well aware of the implications of his discovery for medicine that he gave the first report of it to the Physical Medical Society of Würzburg rather than to an organization of physicists.

In making the radiograph of his wife's hand, Roentgen applied the principle that the shadow cast by X-rays varies in density with the density of the substance through which the rays pass. Because bones are denser than soft tissues, they more effectively absorb X-rays. Variations in the density of bone show up plainly, and permit us to examine this tissue in detail. Soft tissues, however, consist largely of water, and X-rays alone cannot clearly distinguish one

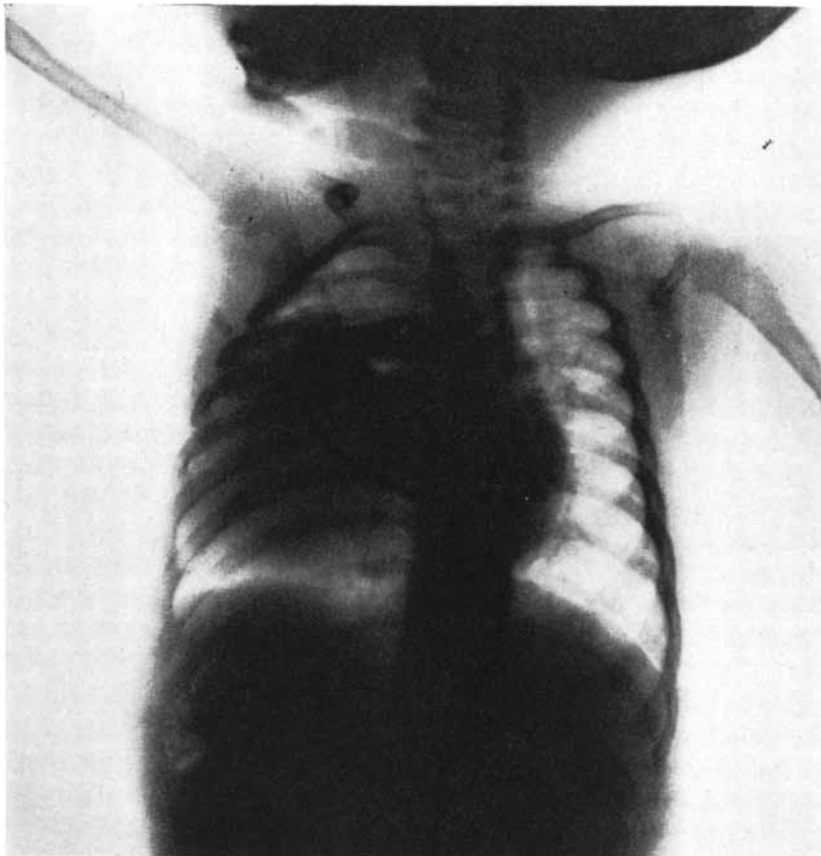
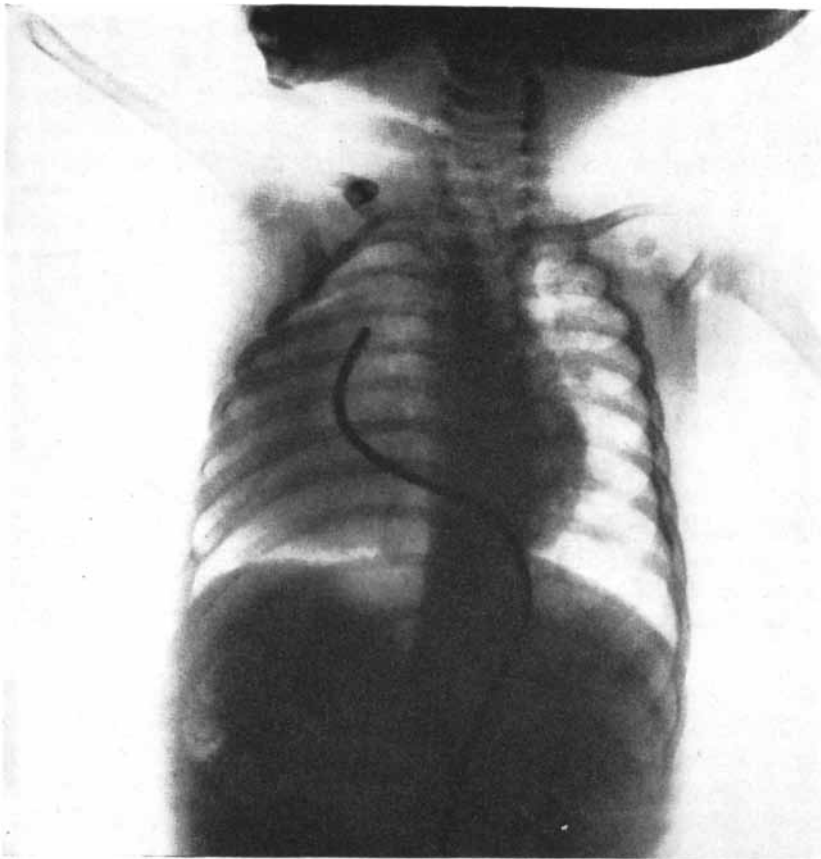
organ from another. Because fat is less dense than other soft tissues, it absorbs less X-radiation. Air is still less dense, so the air-filled lungs are most transparent to X-rays and appear darkest on the X-ray negative.

When an X-ray machine is set at 40,000 volts (40 kvp in radiation terminology), almost any tissue will stop some of its radiation and cast a shadow on film. At 80 to 100 kvp, a common setting for the diagnostic X-ray machine, the radiograph displays shadows differentiating air space, fat, other soft tissue and bone. Certain physical characteristics of X-rays enable the radiologist to use higher voltages and special techniques to obtain on film a faint but usable image of the lungs, for example, without the interfering image of the ribs. Other techniques are capable of producing stereoscopic pictures of the interior of the body.

Injured or diseased tissue often appears on radiographs lighter or darker than surrounding tissue, due to departures from normal density. By itself, of course, the radiograph or fluoroscope image presents only a shadow or silhouette of the subject. A physician who has not had training or extensive experience can overlook significant but subtle variations in the density of the image.

When the objective is to look at a particular internal organ, the physician undertakes to fill the organ, by one means or another, with a material that is relatively opaque to X-rays. A stomach or intestine filled with barium sulfate, which the patient has simply swallowed, stands out in silhouette on a fluoroscope screen or photographic film, clearly differentiated from surrounding tissues. A stomach ulcer will be an outward bulge in the silhouette; an intestinal block, a constriction of the opaque area. To per-

X-RAY PHOTOGRAPH on opposite page reveals a normal colon (loop extending across picture). The colon has been made visible with a meal of radio-opaque barium sulfate. Some small intestine is visible near the bottom. The radiograph clearly shows variations in the thickness of the bones.



CATHETER IN THE HEART OF AN INFANT (*top radiograph*) was inserted through a leg vein. In bottom radiograph a radio-opaque solution has been injected to make heart visible. A series of pictures made within a few seconds shows how heart is working and its defects.

ceive such abnormalities the physician must often view the organ silhouette from various angles; when he uses the fluoroscope, he may move the patient about or manipulate the organ from outside the body. The physician also studies the rate of motion of the intestinal contents by timing the passage of the radio-opaque material.

The heavy and correspondingly dense atoms of iodine frequently contribute the desired X-ray opacity to compounds used for making internal organs visible in radiography. Recently solutions of iodine compounds have made it possible to look inside the living human heart. A metal-tipped rubber tube, or catheter, is slipped into the heart via a vein or artery of the leg, arm or neck. Since the catheter is radio-opaque, the physicians observe its progress in a fluoroscope. When the tip of the catheter is in place, they inject the radio-opaque solution, then make as many as 12 radiographs a second from the front and side simultaneously. Such radiographs provide insight into the performance as well as the anatomy of the heart, and give the surgeon a secure background for proceeding with the radical operations that are now performed on this vital organ.

Certain organs preferentially take up iodine compounds. The liver, for example, absorbs iodophthalein and similar compounds and concentrates them in the gall bladder. This makes the gall bladder visible under X-rays, and gallstones or other abnormalities stand out. The kidneys, ureters and other organs can be visualized by similar methods.

The exposure to ionizing radiation during a given diagnostic X-ray procedure can vary by a factor of 10 or more, depending on the patient and his condition, on the machine and its accessories and on the physician and his knowledge and ability. When radiography is conducted by a competent physician, however, it requires a surprisingly small dose of radiation, even to the skin. A complete gastrointestinal survey with barium, using both the fluoroscope and radiographs, produces a skin dose of from five to 50 r [see glossary of terms on page 78]. The testes or ovaries receive a smaller but still measurable dose. Radiographic examination of the pelvic area of a woman can result in large doses of radiation to the ovaries, and, if the woman is pregnant, to the entire body of the fetus; the skin dose varies widely, depending upon the position of the patient and the technique used. The dose to the fetus is .4 r to seven r per examination, with



MAXWELL MAGNETICS and MICROWAVE

Creative Imagination was for James Clerk Maxwell the catalyst that united a profound physical intuition and a formidable mathematical capacity in a brilliant formulization of electromagnetics—the basis of all today's practical electromagnetic applications.

At National Co. creative imagination is transmuting observed physical phenomena and mathematically formulated theory in such applications as long range microwave transmission—extending further our practical control of physical phenomena.

The implications of these new means of communications are manifold and the applications multitudinous.

National Co. is a community of minds and talents that enjoys the challenge and the prestige of success in such advanced fields as multipath transmission, noise reduction, correlation techniques for signal processing, Tropospheric scatter systems, Ionospheric scatter systems, molecular beam techniques, long range microwave transmission and missile check-out equipment using microwave and digital techniques.

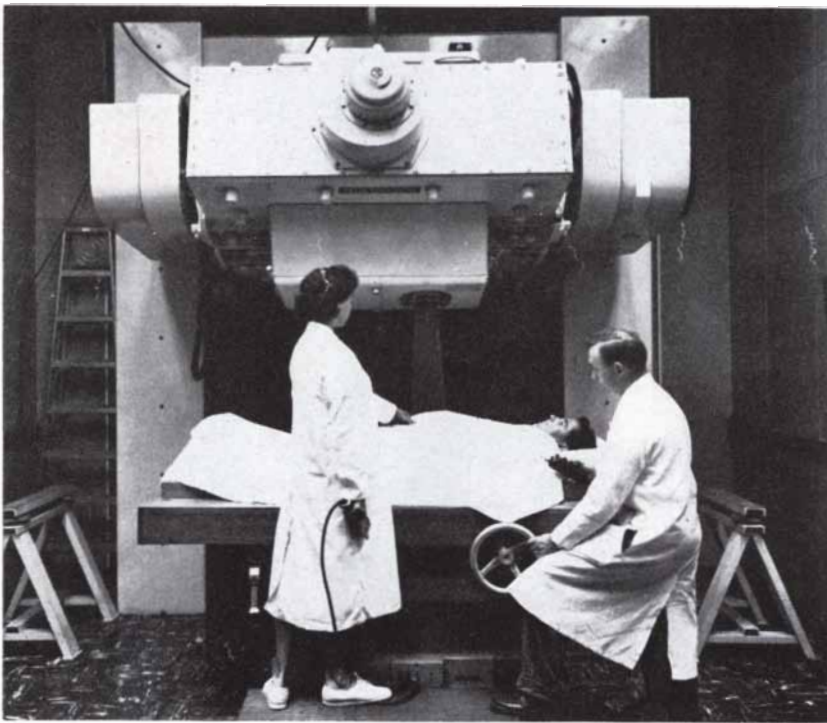
National Co. has grown with the Tradition of New England electronics. Your needs and problems receive exceptional attention at National Co., because, here, *creativity is required, recognized and rewarded.*

Write or phone

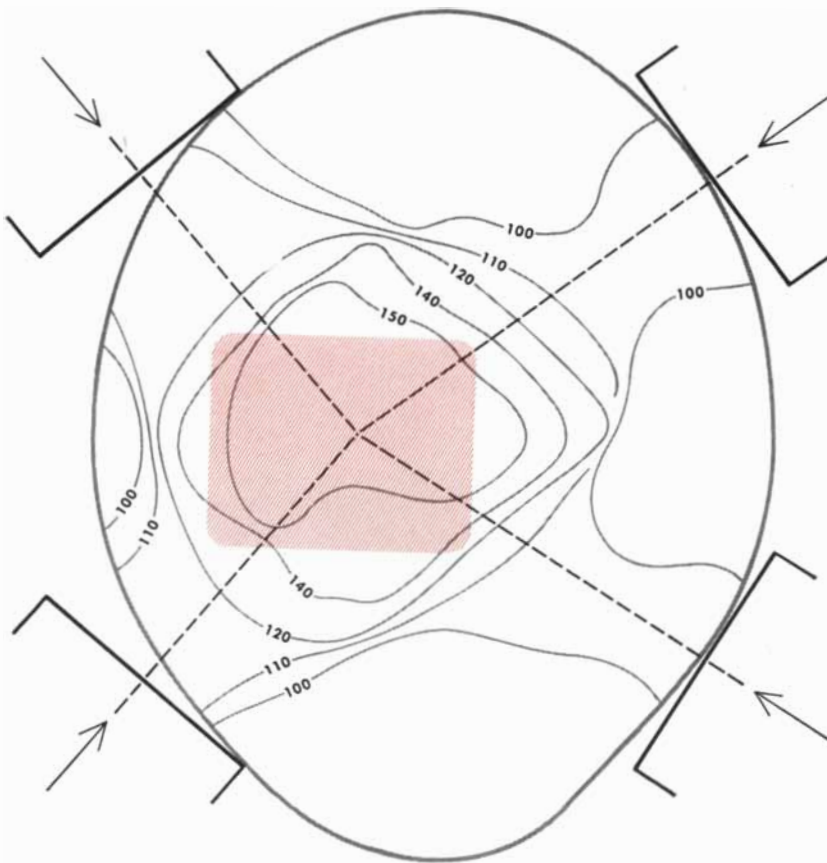
 *tuned to tomorrow* **National** 

National Company, Inc., Malden, Mass.

MANUFACTURERS OF MATERIEL AND EQUIPMENT FOR U.S. DEFENSE



A 22-MILLION-VOLT BETATRON ACCELERATOR at Columbia-Presbyterian Medical Center in New York produces extremely penetrating X-rays for treatment of deep cancers. A lucite guide extends from X-ray port on machine to delineate abdominal area to be treated.



PLAN OF TREATMENT OF BRAIN TUMOR shows skull from top. Betatron will be aimed from four different angles in successive treatments and tumor (shaded) will receive most irradiation. Contour lines indicate relative amount of radiation in various regions.

similar doses to the ovaries. Because of the large dose involved the procedure is avoided if at all possible, especially during the first three months of pregnancy, when the fetus is most susceptible to radiation effects.

In general, much larger doses of radiation result from fluoroscopy than from radiography. The exposure is of least significance, both from the standpoint of body damage and of the genetic hazard, when X-rays are used to examine the limbs. As John F. Loutit has explained elsewhere in this issue, there is a considerable difference between exposing a limited region of the body to 25 r and exposing the entire body to the same dose. The skin over the region being examined will also sustain a much larger dose than the internal organs.

The fact that radiation can damage living tissue became apparent soon after the discovery of X-rays and radioactivity. The early investigators found themselves suffering intractable burns and even more serious injuries. Many of these later became cancerous. The destructive effect of the new radiations suggested that they be used to attack diseased tissue. It was observed that X-rays were especially damaging to rapidly dividing cells, such as appear in cancerous tissue. Soon physicians were employing X-rays for the therapy of cancerous and non-cancerous tumors, in some cases with apparently good results.

Physicians nowadays have come to limit radiation therapy largely to malignant tumors and to benign tumors that present surgical difficulties. Among the noncancerous, superficial conditions still sometimes treated with X-rays, however, are hemangiomas (the "strawberry marks" on the skin of young children), warts, ringworm and acne. The use of X-rays to treat such skin conditions is not desirable, except as a last resort. In the treatment of benign skin tumors the dose is much smaller than the 5,000 r (or more) administered in skin cancer. In the treatment both of deep-seated and of superficial cancers radiation is given a few hundred r at a time, so that between treatments the normal tissue in the region can recover to some extent from radiation damage.

Radiation is also used (and sometimes misused) to treat nonmalignant conditions within the body. The painful and crippling rheumatic disease ankylosing spondylitis ("poker back") was until recently quite frequently treated with radiation. Now radiation is becoming a "last resort" treatment. The dosage to bone marrow is fairly high, and studies in Great Britain, cited by Loutit, indicate



Just a wavelength from ANYWHERE... via **AIRCOM**

**Why Philco has been
selected to modernize
the world's largest
communications system**

AIRCOM is the vast, global network of electronic communications that links every base, outpost and aircraft of the U. S. Air Force. It is the world's most extensive integrated communications system.

Recently awarded the contract to modernize and expand AIRCOM, Philco was selected by the Air Force for its proven ability in systems management and its extensive experience in global communications.

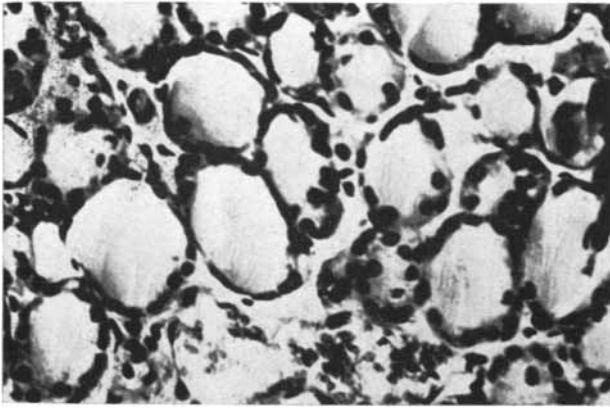
The modernized AIRCOM System will utilize advanced techniques in both point-to-point and air-to-ground communications. It will provide greater traffic capacity, maximum reliability and complete compatibility of all USAF communications equipment.

In the world of advanced electronics . . . in communications, data processing, missiles, satellites, weapons systems and radar . . . look ahead and you'll choose Philco.

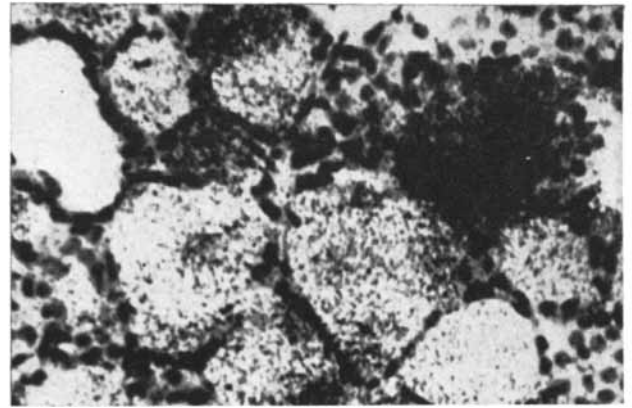
PHILCO[®]

GOVERNMENT & INDUSTRIAL DIVISION

4700 WISSAHICKON AVE., PHILADELPHIA 44, PENNA.



THYROID-GLAND FOLLICLES in photomicrograph at left contain colloid (*white blobs*) surrounded by barely visible cells. At right similar follicles have absorbed radioiodine and blackened a



photosensitive emulsion in contact with them. Thyroid tissue and emulsion on it were photographed through microscope, enlarged 400 times. The dark follicle at upper right was the most active one.

that the treatment increases the incidence of leukemia. The pituitary gland may be irradiated in cases of infertility or certain hyperthyroid conditions. Hyperacidity of the stomach in older people, when it does not respond to other treatment, is sometimes alleviated by radiation.

For therapeutic radiation purposes we now recognize three types of malignant tumor: radiosensitive, radioresponsive and radioresistant. The first type will regress and sometimes disappear after exposure to 2,500 r or less. A radioresponsive growth will regress with 2,500 to 5,000 r, and a radioresistant one will not regress below 5,000 r. Radioresistant tumors are generally not treated with radiation because the damage to surrounding tissue is too great. Cancers of the intestine especially tend to be resistant, and since normal intestinal cells divide rapidly, they are almost as sensitive to radiation as the cancer cells. One of the principal problems in the radiotherapy of cancer is that the cancer cells tend to become resistant to radiation. If the first series of treatments does not succeed, it is often found that the renascent tumor has become radioresistant and that further radiation is valueless.

High-powered machines have greatly improved the treatment of deep cancer. Thirty years ago it was a rare X-ray machine that operated in the range of 100,000 volts. Today many medical centers have two-million-volt equipment, and the largest centers have machines that develop 20 million to 100 million volts. Comparable to the two-million-volt machines are the "bombs" that contain radioactive cobalt, an especially powerful source of high-energy gamma rays.

Cancers of the larynx, the cervix, the uterus and the bladder often respond

successfully to supervoltage radiation. Treatment by radiation, as opposed to surgery, makes it possible to save the affected organ and to reach inoperable cancers. Supervoltage machines can deliver a larger dose to a deep tumor with less systemic and skin response from the patient. To minimize skin effects and concentrate the radiation on the target within the body, the radiation may be directed into the patient from a different angle during each successive treatment; the patient may also be placed in a special chair or litter and rotated during a treatment, with the tumor at the center of rotation.

X-rays are often used for merely palliative treatment. In leukemia small doses of radiation administered to the whole body can kill many of the leukemic cells and relieve the distress of the disease, occasionally prolonging life for years.

Within the past several years investigators and clinicians have developed the possibility that whole-body irradiation might be employed to suppress the immune or antibody response so that the patient can accept a tissue graft from another individual. Normally the body will reject foreign tissue, and such grafts have until now been successful only between identical twins. Whole-body irradiation, destroying the blood-forming tissues where antibodies originate, makes it possible to transplant blood-forming and other tissues to experimental animals from animals of different species. In humans the results are not yet clear-cut. In the case of six Yugoslav physicists who sustained lethal doses of radiation in a reactor accident early this year, further irradiation of the bone marrow made them at least temporarily receptive to bone marrow from donors. The treatment is credited with helping five of the victims to survive. A similar procedure

attempted in a Boston hospital last spring helped to effect an apparently successful graft of a whole kidney to a young woman, though the patient died later of other causes. In such operations it may prove desirable and necessary to employ fetal bone-marrow, which does not bear antibodies of its own to evoke reaction in the patient. In England radiotherapists have performed successful "autografts" of bone marrow. Finding it necessary to subject the thorax or entire trunk to heavy irradiation, they have withdrawn the patient's own marrow from the sternum, the bone in the midline of the chest, and from pelvic and spinal bones. After the treatment they have restored the marrow to the bone, where it resumed its normal functions undamaged by irradiation.

While X-ray machines are still the major source of ionizing radiation for medical diagnosis and treatment, radioactive isotopes are becoming more and more important. Before the advent of the nuclear reactor, radioactive isotopes were obtained for medical purposes almost entirely by laborious bombardment in cyclotrons. Today a wider variety and a much larger quantity of such isotopes are manufactured in reactors. The most useful to medicine are cobalt 60, phosphorus 32, iron 59, iodine 131, sodium 24 and gold 198.

Iodine 131 is widely used in diagnosis and therapy because it has a short half-life and emits high-energy beta particles and gamma rays. Its physical half-life of 8.05 days and its biological half-life (the time it takes the body to excrete half the material) combine to give it an "effective half-life" of six to eight days. Sodium 24 has a physical half-life of 15 hours and a shorter effective half-life in the body. In contrast, radium, which is

The Legendary Firebird, the Phoenix, rose young and strong again and again from flames . . . this is the Norton Firebird . . . symbol of the exciting new fused materials made in Norton's electric furnaces.



NITRIDES: gifts of the Firebird

Like the fabled Phoenix, Norton NITRIDES acquire their wonder-working capabilities in intense heat. In electric furnaces of several types they are chemically formed and physically "tempered" to fit the rigorous requirements of modern industry.

Here, versatile BORON NITRIDE attains the properties of a heat-resistant lubricant, an anti-sticking agent, a high voltage and temperature dielectric, and an excellent thermal insulator. TITANIUM NITRIDE develops characteristics ideally suited to the requirements of special cru-

cibles, components and cermets, particularly resistant to attack by molten media at elevated temperatures.

Norton NITRIDES have many different applications. Solve *your* products and processing problems with these *Gifts of the Firebird*. Technical help with specific uses upon request.

Gifts of the Firebird: compounds of silicon • zirconium • boron • aluminum • magnesium • titanium • chromium . . . including many borides • carbides • nitrides • oxides.



FACT-FILLED CATALOG Available

Write to NORTON COMPANY, Electro-Chemical Division, 548 New Bond Street Worcester 6, Massachusetts.



ELECTRO-CHEMICALS

Making better products . . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

taken up by the bones, has a half-life of 1,620 years and an effective half-life longer than the human life-span.

Tests with compounds of iodine 131 are replacing the basal metabolism (oxygen consumption) test as a means of determining whether a thyroid gland is overactive, underactive or normal. Since iodine is a key element in the thyroid hormone, a certain fraction of the diagnostic dose concentrates in the thyroid gland. Measurement of the radioactivity in the gland shows how much iodine is being retained and thus indicates the rate of thyroid activity. A hyperactive thyroid may absorb up to 80 per cent of the diagnostic radioiodine, while a hypothyroid gland will absorb less than 15 per cent. With a scintillation counter to scan the gland, the radioactivity will even produce a "map," locating sites that have absorbed abnormal amounts of iodine. The dose of radiation to the thyroid gland from a diagnostic test is about four r; the whole-body dose is negligible.

In thyroid cancer physicians may administer sufficient radioiodine to give the thyroid gland 5,000 r or more of radiation exposure. The concentration of the element in the gland is such that the whole-body exposure does not exceed

75 r. During the treatment the patient is sufficiently radioactive to make it necessary to isolate him. A nurse who stays with him for more than two hours a day may receive a radiation dose greater than that permitted for radiation workers.

The usefulness of radioactive iodine is not limited to the thyroid. It may be used, for example, to locate brain tumors; the isotope tends to concentrate in the tumor because the tumor has a richer blood supply than normal brain tissue. Counters in several positions around the head indicate the direction of the most intense radiation and locate the tumor.

The injection of a known quantity of fluid containing a known concentration of a radioactive isotope provides an elegant method for computing the volume of blood in the body. Simple arithmetic yields the blood volume when the concentration of the isotope in the blood has been measured. The rate of blood flow can also be calculated by using a radioactive isotope of short biological half-life. Measurement of the time between the injection of the material in one part of the body and its appearance in another part, after passage through the heart and lungs, gives an index of circulatory-system output. A similar pro-

cedure can be used to locate abnormalities such as an occlusion in the circulatory system. In diagnosis of kidney abnormalities the concentration of radioactive iodo-Pyruvate, measured by scintillation counters placed over each kidney, shows how much work each is doing. In certain kinds of anemia, radioactive iron helps to determine the age of red blood cells.

Useful as the radioisotopes are proving to be in diagnosis, they have been disappointing in the field of treatment. The ideal would be a whole arsenal of radioisotopes, each of which would concentrate selectively in one organ. The only isotope other than iodine 131 that has such selectivity and has found significant clinical application is phosphorus 32. It is the treatment of choice in polycythemia vera, a rare disease involving the overproduction of red blood cells, and it is helpful in some types of leukemia. The phosphorus has a tendency to concentrate in the bone marrow; by killing some of this tissue it cuts down the overproduction of red or white blood cells. A few patients treated in this way 20 years ago are still doing well.

Otherwise the radioisotopes in general



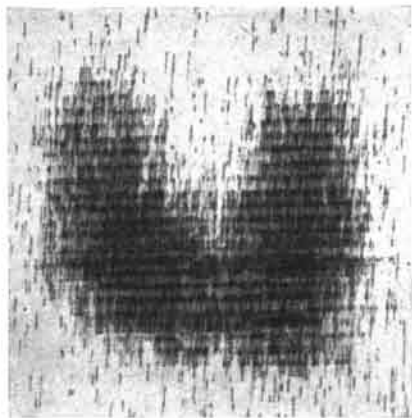
SCINTILLATION COUNTER DRAWS "MAP" of thyroid gland after patient has taken diagnostic dose of radioactive iodine solu-

tion. The counter is on a clockwork mechanism, moves back and forth above the throat and makes a mark on paper for each pulse

use are biochemically inert or are encapsulated in inert materials to insulate them from the patient's body chemistry. Radioactive gold, for example, is employed as a palliative in terminal treatment of cancers of the chest or abdomen. Radioactive cobalt is cheaper than radium and is now replacing it; the cobalt needles can be placed at specific locations in or on the body to attack localized growths. Similarly, tiny beads containing yttrium 90, which has a physical half-life of 64 hours, are being embedded in deep-seated tumors. The beta rays they emit have been found less damaging to normal tissues than radiation from outside the body.

The neutron flux of the nuclear reactor that produces these isotopes may itself find direct application in therapy. At the Brookhaven National Laboratory neutrons are being used in the experimental treatment of brain tumors. The stable element boron, injected into the patient's bloodstream, is preferentially absorbed by the tumor. Eight minutes after the injection, with the boron approaching peak concentration in the tumor, a port into the pile beside the patient's head is opened. The boron absorbs neutrons from the reactor, becomes unstable and in breaking down to lithium emits an alpha particle, which at short ranges is biologically the most potent form of ionizing radiation. The port into the pile is closed after 20 minutes because then the boron has begun to move into the normal brain tissue.

In the 64 years since Roentgen's discovery the medical applications of radiation have approximately doubled the radiation dose received by the population of Western nations. Committees of the U. S. National Academy of Sciences, the United Nations and other bodies have estimated that natural background-



of radioactivity. The "map" it draws is shown at right. This gland is a normal one.

ANOTHER FIRST...



THE ONLY

Electro-Reliable

A.C. TIMING MOTOR

Thinner... Quieter...

More Reliable... More Versatile

FINGER-THIN...

Only 9/16 Inches Short... Only 1 3/4 Inches in Diameter... very compact... reduces the size of your equipment.

WHISPER-QUIET...

Strictly an electrical motor... practically noiseless... no rattling of gears or ratchets.

HIGH TORQUE...

1/4 oz. inch at the rotor with an instantaneous start and stop... requires only 2 1/2 watts... can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY...

Longer life... no one-way gears or ratchets to fail... provides millions of operations without any trouble.

SPECIFICATIONS

Standard Voltage Ratings:
6, 12, 24, 115, 230 Volts
Frequency:
60 CPS Standard
25, 50 CPS Available
Power Input: 2.5 Watts
Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: 1/4 oz.-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: 7/8 inch



WITH INTEGRAL GEAR TRAIN

© 1959



Send for Special Illustrated Bulletin AWH MO-806
The A.W. HAYDON Company

243 NORTH ELM STREET
WATERBURY 20, CONNECTICUT

Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

BESELER - KALVAR SLIDE - O - FILM "USES IN INDUSTRY" AWARD

FREE! SABENA

JET'N'COPTER "HOLIDAY ABROAD"



©1959 Charles Beesler Company

Find a new use for SLIDE-O-FILM, the new "Wonder Film" that requires no chemicals or darkroom! Just add your idea—it may come "right off the top of your head"—to the fast growing list of uses in your industry!

If your idea produces the Award-Winning Use—YOU'RE OFF TO BRUSSELS AND EUROPE BY NEW SABENA JET, AND TO THE "HEART OF PARIS" BY HELICOPTER... A GLORIOUS "HOLIDAY ABROAD" FOR TWO!

SLIDE-O-FILM, a new Physical system of photography, is exposed by light and developed by heat, makes projection positives from negatives or negatives from color or Polaroid® transparencies in just 2 minutes—without darkroom, chemicals or special equipment!

Submit your idea now for slides of new products or processes, lab setups, microscope specimens, training series, sales presentations, etc. made with this new film that costs so much less than older methods... yours may easily be the award winner of the ONCE-IN-A-LIFETIME "HOLIDAY ABROAD!"

Pick up an "Awards" application when you buy SLIDE-O-FILM from your dealer or send coupon for full details and Sample Kit that contains all materials you need to win.

CHARLES BESELER COMPANY

235 S. 18th St., East Orange, N. J.

Please send full details on Slide-O-Film "Uses-In-Industry" awards and Slide-O-Film Sample Kit. (25¢ enclosed to cover mailing and handling costs.)

Name _____
Address _____
City _____ Zone _____
State _____

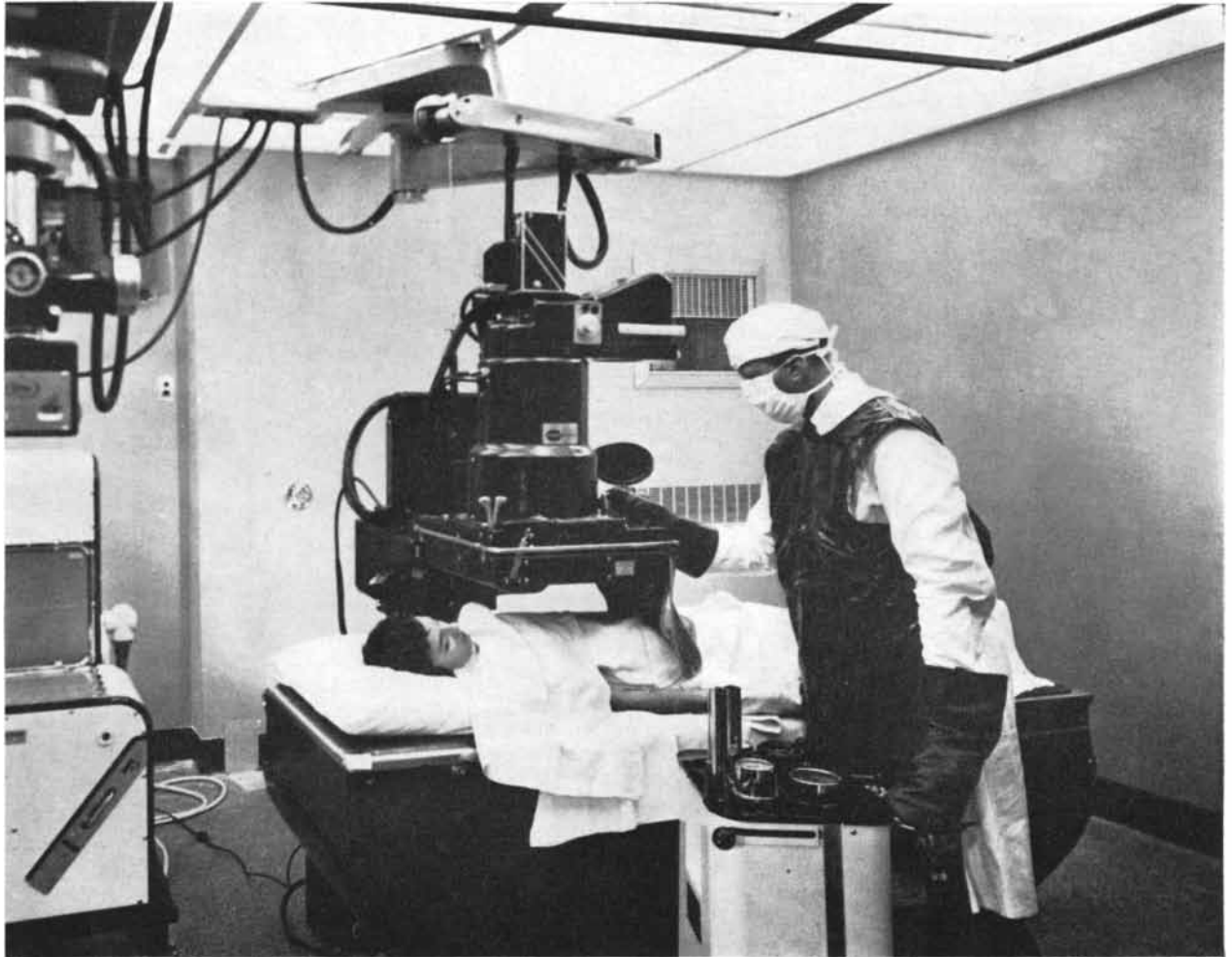


IMAGE AMPLIFIER FOR FLUOROSCOPY (*vertical black object*) lets the physician use his daylight vision, see more than with the unaided fluoroscope and reduce patient exposure by a factor of

four. The radiologist here is wearing leaded gloves and apron to protect himself from radiation. This photograph and the one on page 172 were made at Columbia-Presbyterian Medical Center.

radiation gives man an average dosage of three to five r from birth to age 30, roughly the reproductive span. These same groups estimate that the dosage from medical and dental radiation in the same period equals the background dosage. Radioactive fallout from tests of nuclear weapons, which has caused such public concern, contributes 10 per cent of the medical dosage, provided the present test suspension continues.

Conscientious physicians are fully aware of the biological price that must be paid for the advantages of radiation. They take steps to minimize the radiation exposure of their patients, particularly the exposure of the gonads in patients who have not yet passed the reproductive years. They are also careful to protect themselves and their aides; leaded gloves and aprons and radiation badges to keep track of exposure are standard equipment in a well-managed radiological department, and the ma-

chines are shielded to contain stray radiation.

Over the years the profession has been taking active measures to reduce the exposure that must attend the use of radiation. The physician has his machines calibrated so that he knows the radiation output required for all the major procedures. He takes care to place the X-ray tube at the proper distance from the patient; the intensity of radiation falls off as the square of the distance, and there is an optimum distance for each procedure. In radiography the X-ray tube should be three to six feet from the patient; in fluoroscopy, at least 18 inches away. Modern dental X-ray machines are commonly and safely used closer to the patient.

A simple filter, the equivalent of 2.5 millimeters of aluminum, now eliminates the diagnostically useless "soft" or longer-wave radiation that is entirely absorbed by the skin. Other accessories to cut radiation include lead diaphragms

and lead tubes or cones to confine the X-ray beam to the precise region under study or treatment. Adjustable lead shields or aprons to protect the patient's gonads are desirable. The film cassettes, or holders, should be equipped with intensifying screens, which fluoresce strongly under very little radiation and thereby amplify the action of the radiation. New fast films and methods of forced film-development have contributed in a major way to reducing the exposure necessary to accomplish a given purpose.

Unfortunately a few old-fashioned radiologists, and too many physicians who are not radiologists, are still not doing all that they might to decrease their own and their patients' exposure in fluoroscopy. The simplest way to decrease the time of exposure in this procedure is for the physician to allow sufficient time for his eyes to become adapted to the dark of the examination room. Under the pressure of daily practice many physicians



Irradiation of Organic Compounds Begins at Western Reserve

Fifteen-inch Diameter Irradiation Chamber Will Provide Up To 5×10^5 Roentgens/Hour

A Model "L" Hotrodder irradiation unit has been put into operation at Western Reserve University, Cleveland, Ohio, to test irradiation effects on organic compounds.

At Western Reserve, a group of young scientists led by Dr. R. F. Firestone, has obtained AEC approval for experimentation with halogenated methanes and simpler aliphatic hydrocarbons. Halogenated methanes are of special interest to the group because of the unusual and apparently inconsistent behavior of several members of this class under the influence of ionizing radiation. Dibromodichloromethane, bromoform, chloroform, and carbon tetrachloride are being used in the first year's experiments.

In the compact cylindrical irradiation chamber used by Western Reserve, 100 curies of cobalt 60 wafers are stacked to form a single rod-shaped source. This source shape permits a high radiation rate at uniform flux density. Samples can be inserted and withdrawn from the chamber in complete safety with a special sample changer. The chamber can contain many test tube or larger samples.

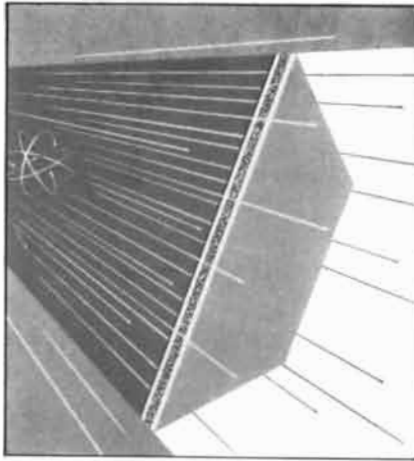
A further safety feature is an electro-mechanical interlock which prevents any movement of the source shield while the source itself is in an exposed position. When in its stored position—for sample changing—the source is safely contained in an easily movable shield which doubles as an approved shipping container.

Nuclear Systems Division of The Budd Company designed and built this Hotrodder for Western Reserve University so that it could be used safely and conveniently under normal laboratory working conditions. Nuclear Systems also encapsulated its cobalt 60 source. The unit was designed to hold surface radiation to a safe limit with five times the amount of cobalt presently used.

The device is one of a series of portable Hotrodder irradiation facilities available from Nuclear Systems.

Information about irradiation units for research is available from Nuclear Systems Division, The Budd Company, 2450 Hunting Park Avenue, Philadelphia 32, Pennsylvania.





Sketch shows general construction. As a B₂C dispersion in metal, Boral has predictable properties at elevated temperatures.

BORAL... THE "SANDWICH" THAT SOLVES NEUTRON SHIELDING PROBLEMS

Boral is a uniform dispersion of boron carbide crystals in aluminum, with a cladding of commercially pure aluminum.

Boral is a very effective shielding material against the passage of thermal neutrons.

Any concentration of Boron Carbide up to and including 50% is now possible. Available from 1/16" thick to 3/4" thick in standard sizes of 30" x 48", 15" x 96", and 15" x 48". Other sizes on request. The approximate weight per square foot of 1/4", 35% Boral plate is 3.4 pounds.

TYPICAL and POTENTIAL APPLICATIONS

- A. Reactor Shields
- B. Neutron Curtains
- C. Shutters for thermal curtains
- D. Safety rods
- E. Storage and shipping containers for fissionable material to avoid critical mass.
- F. Fabricated boxes for electronic equipment and other radiation-sensitive devices.
- G. Protective shields for easily activated components of aircraft, particularly engines.

Brooks & Perkins, the first commercial producer of Boral, invites you to send for technical data and literature.

BROOKS & PERKINS, INC.

1920 W. FORT STREET, DETROIT 16, MICHIGAN
Offices in Washington and New York

Acknowledged
EXCELLENCE
BASED ON RESEARCH



LEAKPROOF
CHROME PROTECTED
SEALED-in-STEEL
GUARANTEED!



Radar-Lights

CORROSION-PROOF
PORTABLE LIGHTS

BURGESS BATTERY COMPANY

FREEPORT, ILL. • NIAGARA FALLS, CANADA

\$520,000,000

more or less, is being saved by industry every year through the use of radioisotopes. The exact figure is unknown—AEC has said \$1 billion—NICB has said only \$40 million. We averaged them. Either way, it is a lot of money.

If your firm is not participating, we suggest that you consider attending our one week program

"NUCLEONICS for the EXECUTIVE"

next scheduled for October 12-16, and find out first hand where your operations might benefit from the utilization of radioisotopes. The program includes

Fundamentals of Radioactivity Radiation, Health and Safety Applications—Isotopes and Power Nucleonics in American Business Seminar

NUCLEONICS for the EXECUTIVE is one of 12 regularly scheduled programs offered by RES, including HEALTH PHYSICS, BASIC NUCLEONICS, APPLIED NUCLEONICS, TRACERS and RADIOCHEMISTRY, ISOTOPE RADIOGRAPHY, etc. Write L. P. Farrell

RADIATION ENGINEERED SERVICES

Lafayette and Water Streets
Norristown, Pa. **BR 2-3656**

do not allow sufficient time for dark-adaptation, and so must turn up the X-ray beam to produce a brighter image on the screen. A 10-minute adaptation period makes the physician's eyes 10 times more sensitive to light than a three-minute period; an 18-minute adaptation period makes his eyes 100 times more sensitive. Dark-adaptation can also be achieved by wearing red goggles, but busy practitioners find this just as inconvenient as staying in a dark room.

A new development that reduces the need for dark-adaptation is the image-amplifier. Its complex electronic and optical system so greatly intensifies the fluoroscope image that the screen may be observed with daylight vision. Such an intensifier cuts radiation exposure by a factor of four or more, and lets the radiologist see more than ever before. Because the cost of these machines is high, they are found only in large hospitals and the offices of a few radiologists.

In view of the need to protect the genetic resources of the population, as well as the welfare of the patient, it is becoming a general rule not to use X-rays unless there is a specific indication for this use. Public-health officials now discourage mass chest X-rays in areas where the incidence of tuberculosis is low. Careful and conscientious case histories, accompanied by all the necessary laboratory tests, can obviate the need for many X-rays. Most pediatricians have given up routine X-ray examinations of healthy children. Because they are growing, children are particularly sensitive to radiation, and should be exposed to it only when it is absolutely required.

Like the surgeon who tries to leave the smallest possible scar, the radiologist who is proud of his profession and his own skill watches every detail in order to leave as little radiation "scar" as possible. Other physicians who employ radiation should have the same attitude.

The patient need not fear ionizing radiation in the hands of a skilled practitioner. There is no question that this boon conferred upon us by Roentgen, Henri Becquerel, Marie and Pierre Curie and other workers has been a mighty force for the conservation of life, and will continue to be so. It has also taken a few lives, particularly among the physicians who have used it to benefit others. But as our methods have improved and as more and more physicians apply the latest techniques for minimizing dosage, the dangers have been decreasing and the benefits mounting. The objective in medicine, at least, is to make ionizing radiation an unmixed blessing.

CRYOGENICS IN NUCLEONICS

Cold solutions to hot problems are finding increasing use in nucleonics and radiochemistry.

- Basic research in radiation damage has been carried on at 20°K and colder in the graphite-moderated reactor at Oak Ridge National Laboratory.
- Charcoal adsorption beds refrigerated at 100°K are used to remove radioactive gases from reactors. They are especially attractive because of their compactness.
- Deuterium separation by fractional distillation of liquid hydrogen at approximately 20°K is one of the more economical processes available.

Throughout industry, low-temperature techniques are solving problems economically and often providing answers to problems otherwise insoluble. Arthur D. Little, Inc., has played a leading role in applying cryogenics to problems in many technical fields.

Arthur D. Little, Inc.

CAMBRIDGE • CHICAGO • SAN FRANCISCO
NEW YORK • WASHINGTON • SAN JUAN • EDINBURGH

You may be interested in the following articles and papers. Please indicate those you desire and attach to your letterhead.

- "TECHNIQUES AND EQUIPMENT UTILIZED IN LOW-TEMPERATURE REACTOR IRRADIATIONS," R. R. Coltman, T. H. Blewitt, & T. S. Noggle, *Review of Scientific Instruments*
- "LOW-TEMPERATURE ADSORPTION," H. E. Hoelscher, *Kelvin Scale*
- "SOME ASPECTS OF HEAVY-WATER PRODUCTION BY DISTILLATION OF HYDROGEN," B. M. Bailey, Second United Nations International Conference on the Peaceful uses of Atomic Energy
- "RADIATION, A TOOL FOR INDUSTRY," S. E. Eaton & M. Michaelis, presented before 7th Annual Conference, Atomic Energy for Industry

Your request will receive the prompt attention of: Director of Public Relations,
Arthur D. Little, Inc., 21 Acorn Park, Cambridge 40, Mass.



Industry's chemicals:

WHAT'S MAKING NEWS?

If an annual report makes its readers expand with pride, it may be because sales have broken through to new highs. But just as often, it's because management has been able to push operating costs to new lows. This might be the result of a production short cut, an improved process, or a whole new plant. And sometimes, it's as simple as putting a new chemical in the right place at the right time. A few cases in point are reported below.

You may wish to check certain items in this advertisement and forward to those concerned in your company.

ROUTE TO:

New chemicals influence future car designs

Many of the designs planned for the automobiles of tomorrow call for specialized chemicals to make them tick. A peek at the work now in progress in Dow's Automotive Chemicals Development Laboratories shows what will be required of the antifreezes, lubricants and other automotive fluids of the near future.

Wondrous engineering advances await automobile owners of a few years from now. One may be a single unit that combines the present day functions of the transmission and rear axle. Another may cool the engine by boiling a liquid. No one can say for sure which of these and dozens of other innovations will be given the nod by automakers, but one thing is certain: Many new chemical fluids will be needed to make them feasible . . . chemical fluids far different than those used in cars today.

These new fluids are today being developed by creative chemistry, such as the experimental work being carried on in Dow's two new Automotive Chemicals Development Laboratories. Located in Midland, Michigan and Freeport, Texas, the two laboratories comprise extensive research facilities strictly devoted to automotive chemistry. Dow research chemists are currently concerned with many different projects involving the engine, cooling system, transmission, brake system and other important automotive areas.

One interesting area of study concerns viscosity index improvers for

lubricating oils. V.I. improvers help extend the range of temperature conditions under which lubricants can operate. For example, an engine oil standing idle at ten degrees below zero is apt to be pretty heavy and syrupy. But at normal engine operating tem-

peratures of 200 degrees and above, the same oil would "thin out" considerably. V.I. improvers give oil better consistency at both temperature extremes—and at all points in between.

Work on synthetic lubricants for transmissions is closely related. Heavier fluids are needed to carry the increased "loads" required of contemplated transmission designs. Fluids of higher density may permit smaller, more efficient transmissions.

Dow has long been active in the important area of antifreeze and cooling system research. This interest comes naturally, as Dow supplies several different formulations of ethylene glycol



Alleviation of rust and corrosion in the cooling system of today's automobile engine is the subject of continuing study in the Dow Automotive Chemicals Laboratories.

antifreeze to major oil companies and automotive manufacturers. Much of this work is concerned with improving the characteristics of today's all-winter antifreeze. Some, however, is on a strictly speculative basis—such as the engine that is cooled by boiling.

Other projects under way at Dow include the development of improved brake fluids, gasoline additives and several other specialized chemicals. Whatever direction automotive designs take in the next few years, Dow hopes to be ready with new chemical fluids that will meet their requirements.

DOW LOOKS TO FUTURE WITH GLYCERINE

Glycerine, one of the chemists favorite workhorse chemicals, promises to grow in popularity in the years to come. The reason . . . stated simply, it is glycerine's versatility in so many industries.

Paper, dynamite, food, paint, tobacco, polyurethane, cosmetic and drug manufacturers have long admired glycerine—and not just for its sweet taste. For many years, it has saved many hundreds of thousands of chemicals processing dollars for tight-fisted management teams.

The future for glycerine users . . . very rosy, indeed. In fact, Dow proudly announces that an improvement in manufacturing technique has led to an even finer quality in Dow's synthetic glycerine. Coupled with product improvement is another glycerine plant in Freeport, Texas.

What does this mean . . . Dow hints profit-minded production men are re-evaluating glycerine. They are using it to replace less versatile processing chemicals. Result . . . improved product and rising product profit curve.

HAIL THE LOW-PRESSURE COOKER!

In processing plants, getting the right amount of heat to the right place is frequently a serious problem. More and more, management men are turning to Dowtherm® A, a heat transfer medium with a number of definite advantages over both direct fire and steam. Dowtherm A has super-high heat stability in the 350°F to 750°F range, permitting pinpoint heat control. It transfers heat at high temperatures with much less pressure than steam. At 700°F, for example, steam exerts a pressure of 3,000 lbs. per square inch. At the same temperature, Dowtherm A pushes out with a pressure

of only 110 lbs. per square inch. Processors are invited to utilize Dow's years of heat transfer experience.

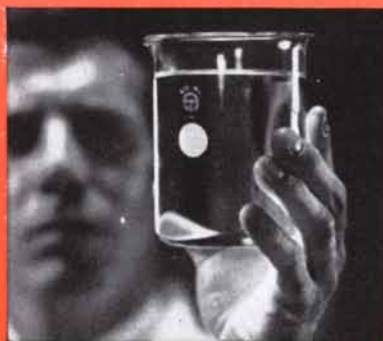


Pinpoint temperature control in 350°F-750°F range can accurately be achieved with Dowtherm.

YOUR INQUIRY WELCOMED. If you would like to know more about the Dow chemicals discussed in this advertisement, or others you may have heard about, write to us today. **THE DOW CHEMICAL COMPANY, Midland, Michigan, Chemicals Merchandising Department 607EQ9.**

DOW CHEMICALS

busy behind the industrial scene



SEPARAN®—An old friend to the mining and pulp and paper industries, Separan flocculants settle solids in solution quickly and efficiently.



BROMINE—Dow continues as a major producer of bromine and brominated products whose uses range from fire retardants to pharmaceuticals.



PHENOL—As an adhesive component, phenol helps adhere plywood sections. Phenolic resins are used to make tough, heat resistant counter and table tops, durable varnish and lacquers.



CAUSTIC SODA—Abundant supply of Dow Caustic guarantees quality product delivered when and where you need it. Four producing plants and nine terminals serve U.S. industry.

DOW CHEMICALS BASIC TO INDUSTRY.

Glycols, Glycol Ethers
Amines and Alkylene Oxides
Solvents • Benzene Derivatives
Inorganic Chlorides • Germicides
Alkalies and Halogens
Fungicides • Herbicides • Fumigants
Hundreds of other Chemicals
Plastics • Magnesium

THE DOW CHEMICAL COMPANY

Midland, Michigan



Ionizing Radiation and Organic Chemistry

In one of its many industrial applications, ionizing radiation is used to break organic molecules into ions and free radicals. These fragments often recombine to form compounds with novel properties

by A. Charlesby

In ionizing radiation the organic chemist has a tool that enables him to tear molecules into reactive fragments. When a high-energy particle penetrates an organic compound, the valence electrons that form the chemical bonds in its molecules absorb minute portions of the huge energy carried by the radiation, and the bonds are broken. For an instant free electrons, ionized and highly excited molecules and finally free radicals pervade the immediate environment of the molecules. The ordered structure of the target substance is powerfully disturbed as these fragments enter avidly into reactions with one another and with molecules not directly affected by the radiation. When equilibrium is restored, the chemical bonds are re-established in new configurations; new molecules have been synthesized and new properties imparted to the substance.

With ionizing radiations available in plentiful supply over the past decade, it was reasonable to expect that they might evoke important innovations in chemistry. Imaginative chemists envisioned the creation of an entire new chemical-process industry and a route to syntheses not otherwise attainable. They saw, for example, how radiation could be used to develop physical properties under precise control in such substances as natural rubber and polyethylene, to produce hybrid materials containing the best features of familiar natural or synthetic materials and to promote reactions that cannot be started by heat, pressure or catalysts.

These possibilities remain as attractive as ever, but their realization on the industrial scale has been rather slow. For the most part other techniques can accomplish the same end results, and the cost of radiation is high. Cheaper sources

of radiation will ultimately make more radiation processes economically attractive. The principal advances will come, however, with deeper understanding of what transpires in the chaotic instant between the primary physical impact of the radiation and the final chemical changes observed in the system.

The radiochemist has many questions in common with the radiobiologist. This in itself is testimony to the size and intricacy of the molecules put together by contemporary organic chemistry. Like the giant molecules assembled in the living cell, the polymer molecules of synthetic fibers and plastics consist of repeating chains built up of dozens, hundreds or even thousands of simple units called monomers. Both kinds of giant molecule are highly sensitive to radiation. In a structure containing thousands of chemical bonds the breaking of a single bond—a chemical change as low as .01 per cent—can radically alter such macroscopic properties as viscosity. Man-made polymers have served effectively as models for their considerably more complex natural counterparts in a number of decisive experiments. Much that has been learned about living matter applies also to synthetics.

As Alexander Hollaender and George E. Stapleton have observed in this issue, the presence of either water or oxygen greatly amplifies the indirect effects of ionizing radiation on the large molecules in the cell, via the secondary action of free radicals and peroxides. The same holds true for synthetic polymers. Radiobiologists were puzzled to discover that higher temperatures appeared to increase the number of hits on target molecules in the cells. The finding that the same effect occurs in synthetic polymers made it unnecessary to postulate any elaborate biological mechanism to ex-

plain this result. Synthetic polymers have also been used to study ways to increase the resistance of cells to irradiation. Both polymers and cells, it turns out, can be protected by incorporating radiation-resistant groups into their structures; I need hardly emphasize the much greater simplicity of the polymer experiments.

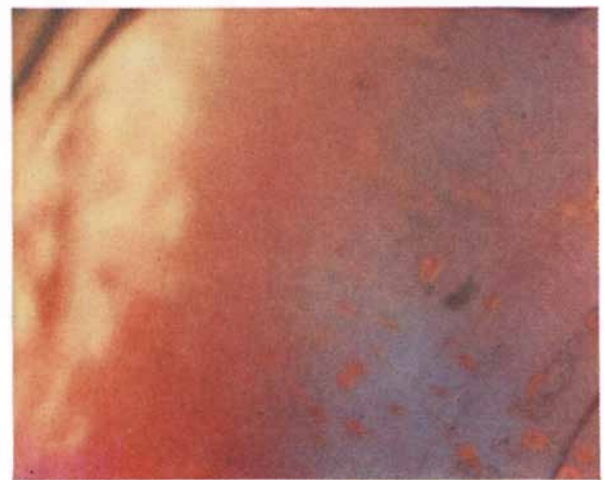
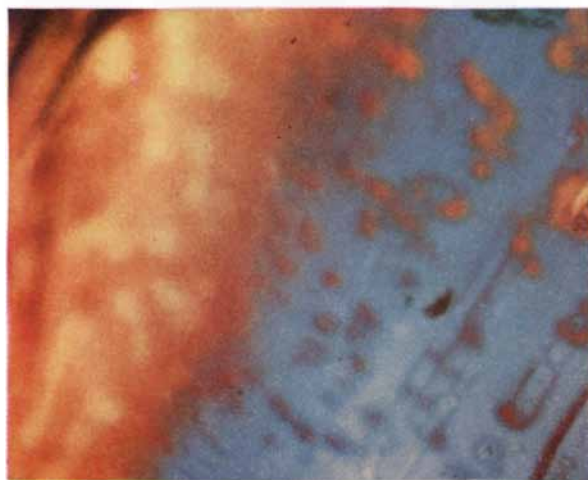
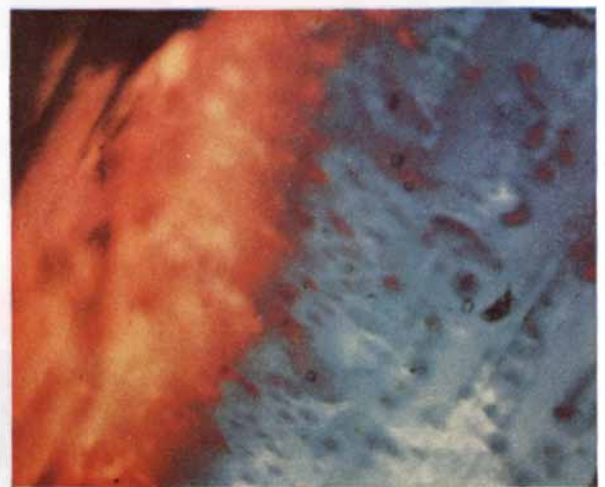
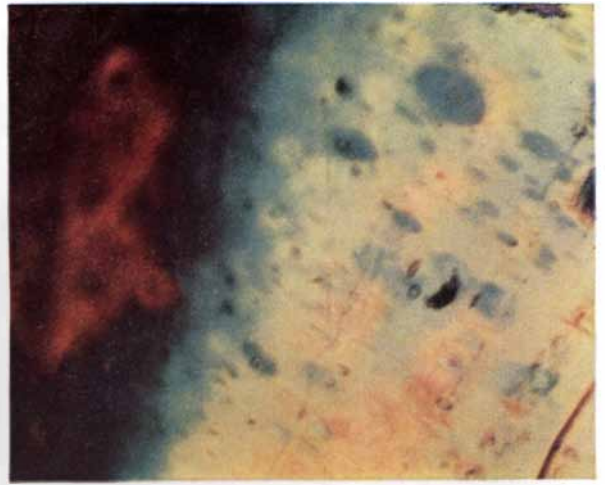
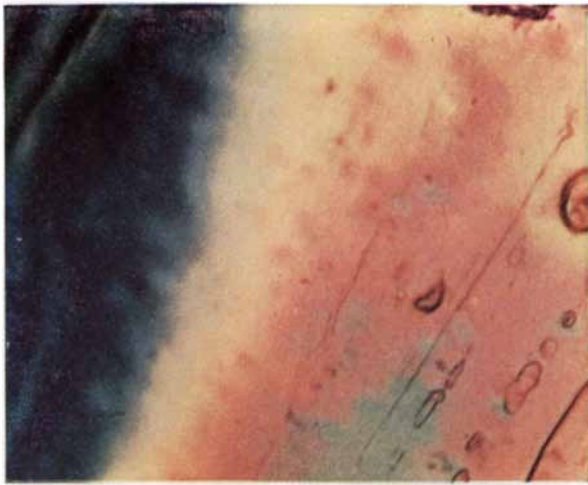
One of the most alluring prospective applications of ionizing radiation in industrial chemistry is in the synthesis of polymers. Certain polymers—among them polyethylene, which is used in the greatest variety of applications—are assembled by the process of “addition” polymerization. In one method the monomer solution is seeded with free radicals of the monomer, that is, a monomer with an unpaired electron, or open chemical bond, at one end. The unpaired electron readily hooks the radical to another monomer. The result is a two-monomer unit that in turn has an unpaired electron at its end; so starts a chain reaction that builds up a polymer of considerable length. Because ionizing radiation produces huge numbers of free radicals in organic compounds, as Robert L. Platzman has explained in this issue, it naturally occurred to many chemists that radiation might be employed to initiate the process of addition polymerization. The process can, in fact, be made to produce polymers that are already widely synthesized by conventional methods. However, attempts to produce new polymers require doses of radiation too large to be economically feasible.

Addition polymerization can also be triggered by ions of the monomer, that is, by electrically charged monomers that have lost an electron as the result of ionization. Here again the use of ionizing radiation remains a laboratory pro-



IRRADIATED ORGANIC MATERIALS such as teflon (*top*) and polyethylene (*bottom*) will combine with solutions of dye-accepting polymers to produce copolymers that can be dyed brilliant colors. Both polyethylene and teflon are normally colorless and

very resistant to dyes, as is shown by the weak tints produced by dyeing commercial teflon (*longer strips*). An undyed strip of teflon is shown for comparison at far right. The materials were irradiated and dyed in the laboratory of Radiation Applications Incorporated.



A SOLID POLYMERIZES in these time-lapse photomicrographs of an acrylamide crystal. Frame at top left, made 76 hours after the crystal was exposed to a million rads of gamma radiation, shows dark edge of an almost completely polymerized area. Frame at top right shows the same area after another 48 hours. Frame at middle

left, made 13½ hours later, shows small polymerized areas beginning to form ahead of main one. Last frame, made 100 hours later, shows reaction almost completed. Photomicrographs were made by George Adler and Robert F. Smith of the Brookhaven National Laboratory, who used crossed polarizers with a red compensator.

ess. It has been found, however, that irradiation of the monomer produces a much greater yield in the presence of finely powdered zinc or of silica or even of glass beads. This surprising result has instigated research into the question of the influence of surface effects and catalysts on radiation-induced reactions.

Ionizing radiation can also bring about the peculiar phenomenon of solid-state polymerization, which would have been difficult to foresee, let alone study, without such radiation. Under irradiation the molecules of certain crystalline solids (e.g., acrylamide) link to form polymers. Although the substance is not visibly altered, its structure is completely rearranged. The process can be followed microscopically by observing the gradual changes in color fringes as the material polymerizes [see illustration on opposite page]. As J. B. Ballantine of the Brookhaven National Laboratory has pointed out, the different rates of polymerization in various regions of a crystal are an indication of its internal strains. This raises the possibility of using such techniques to study irregularities in the structure of certain crystals.

Up to this point we have been discussing the use of radiation to synthesize polymers, a technique that has not been a commercial success. This is not the case, however, with the technique of using radiation to modify existing polymers. When exposed to radiation, all the polymers studied so far are either degraded to form smaller molecules or cross-linked to form larger ones. Which of the two reactions a particular polymer undergoes depends mainly on the structure of its monomer units, although the precise mechanism of both these reactions is still warmly debated. Polymers composed of monomers containing a single chemical side-group tend to be cross-linked, while polymers whose monomers contain two side-groups tend to be degraded. In both types of molecule, radiation apparently breaks the main chain. Chain fragments with no bulky side-groups tend to reunite quickly, but those with two side-groups tend to be pushed apart, making the break permanent.

Generally degradation involves what the term implies: Because the individual molecules are shorter the material becomes more soluble, less viscous and mechanically weaker. In polymethylmethacrylate (Lucite) both the main chain and the side chains that branch from it are fractured. This liberates hydrogen, carbon monoxide and carbon dioxide, which remain trapped in the molecular structure; upon subsequent heating



TI Needs More Glenn Penisten's BS EE '53 Oklahoma State University

SENIOR ELECTRICAL ENGINEERS

Men like Glenn Penisten are needed for high-level development and supervision — EE's who have 3 to 10 years experience in specialties such as missile guidance, servo-mechanisms, telemetry, digital circuitry, infrared — design or systems studies. Following such a specialty Glenn Penisten has advanced rapidly in his 3 years at TI, and now leads several missile and space projects. Such experience can be used immediately. Your resume will get prompt attention by John R. Pinkston.

PROFESSIONAL
PLACEMENT

APPARATUS
DIVISION

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE
DALLAS 9, TEXAS

FOR SALE

100-Mev Betatron

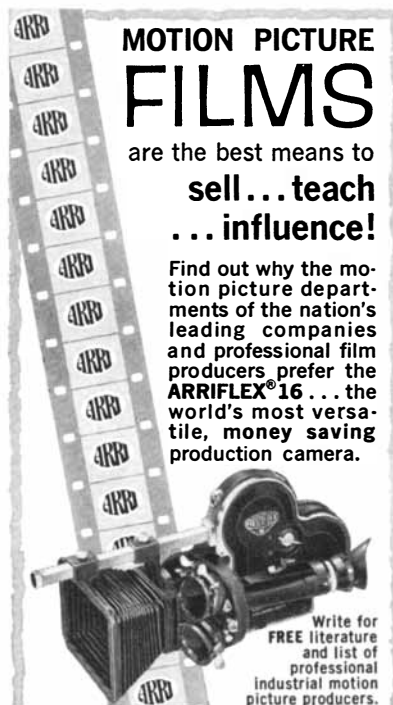
This electron accelerator is complete and in excellent operating condition. Constructed by General Electric Co., it has been used for several years in basic research problems in a university laboratory. Could be central instrument of physics laboratory in educational institution or private corporation. For further information, contact:

Clement Mokstad
Research Institutes,
University of Chicago
5640 South Ellis Avenue
Chicago 37, Illinois
Midway 3-0800, Ext. 3701

MOTION PICTURE FILMS

are the best means to
sell... teach
... influence!

Find out why the motion picture departments of the nation's leading companies and professional film producers prefer the **ARRIFLEX®16**... the world's most versatile, money saving production camera.



Write for
FREE literature
and list of
professional
industrial motion
picture producers.

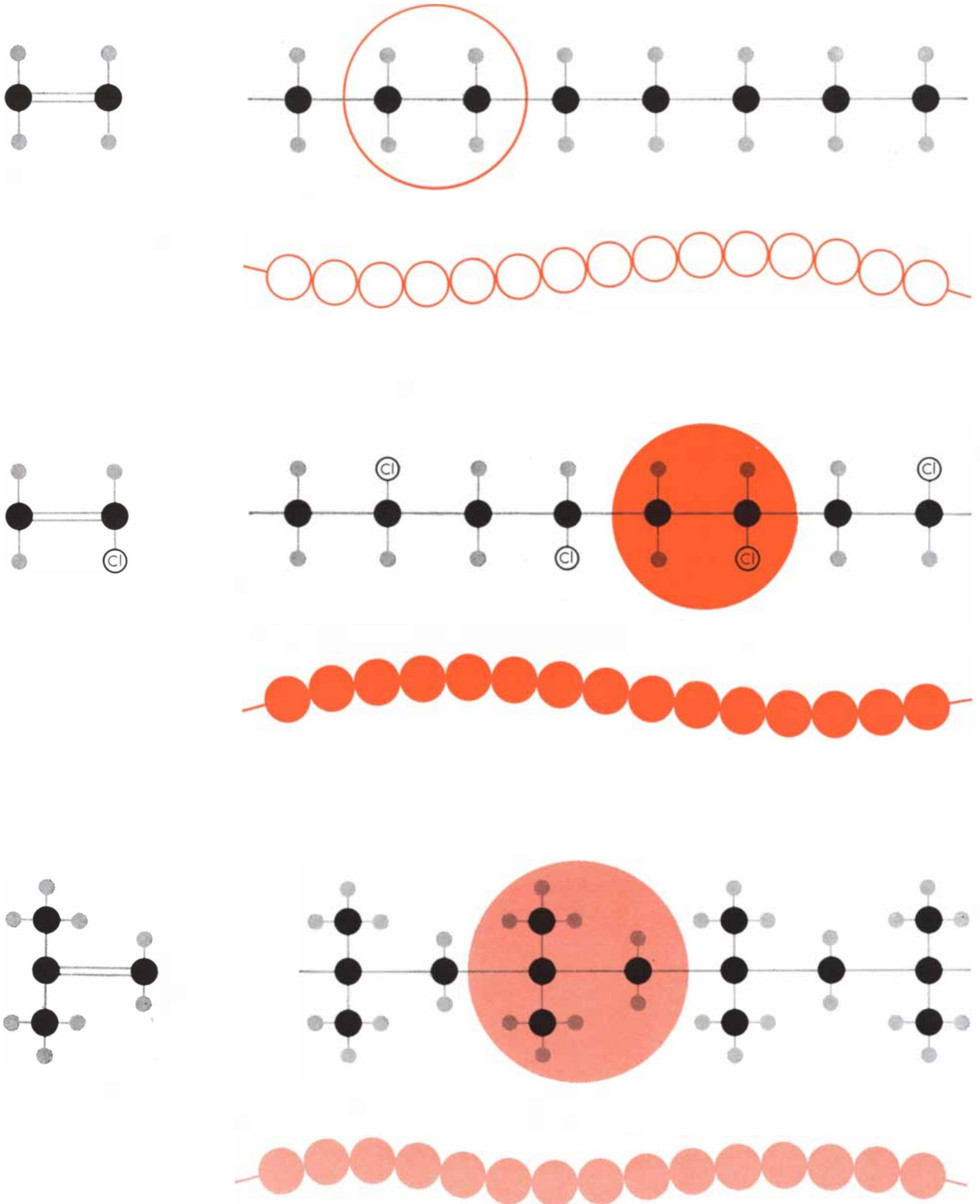
ARRIFLEX
CORPORATION OF AMERICA

257 5 PARK AVENUE SOUTH, NEW YORK 10, N. Y.

name

address

city zone state



MONOMERS FORM POLYMERS by linking together in long chains. The three monomers shown here with their respective polymers are ethylene (*top left*) and polyethylene (*top right*); vinyl chloride (*middle left*) and polyvinyl chloride (*middle right*); isobutylene (*bottom left*) and polyisobutylene (*bottom right*).

These compounds are composed of atoms of carbon (*black balls*), hydrogen (*gray*) and chlorine (*white*). The large colored circles show the monomer units incorporated into polymers. The strings of small colored circles beneath them show a small fragment of a polymer chain, which may contain thousands of such monomer units.

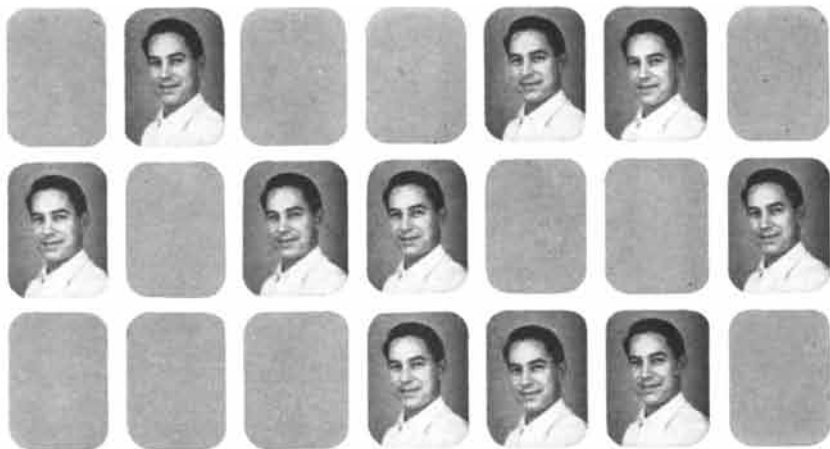
these molecules come together to form bubbles that foam the plastic into a spongy mass [see bottom illustration on page 190].

While degradation involves a fracture of the polymer's main chain, cross-linking apparently results from the coupling of the side-chains of two or more polymer fragments. The main chains of two adjacent molecules can also form direct carbon-to-carbon cross-links when radiation removes one hydrogen atom from each chain. Cross-linking profoundly affects the macroscopic properties of a polymer. When the number of cross-links is low (about one link per 100 monomers), and the chains have adequate flexibility, the polymer will form a highly elastic material such as rubber. When the number is high (about one cross-link for every three or four monomers), it will form a more rigid material which fractures readily and has many of the properties of glass.

In the pilot plant, at least, ionizing radiation has served well in the task of cross-linking natural rubber. Cross-linking converts this rather impure polymer into the tough elastic material that serves so many important purposes in our civilization. Ordinarily rubber is cross-linked by vulcanization, a complex chemical process that introduces sulfur links between the rubber molecules. Irradiation accomplishes the same purpose by inducing direct carbon-to-carbon links between adjacent molecules. Since the number of cross-links is directly proportional to the dose of radiation, some parts of a piece of rubber can be made more elastic than others. Rubber can also be given different elastic properties in different directions simply by stretching it and irradiating it in this orientation. Chemically vulcanized rubber, however, is a relatively cheap product, produced by a process that has been developed over many years to a state of high technical efficiency. The curing of rubber by radiation is regarded as commercially unfeasible in the U.S., but the U.S.S.R. has announced that it has the process working on a factory scale.

The commercial outlook is brighter for irradiated silicones, the synthetic polymers that are often used as high-temperature rubbers. Silicones are readily cross-linked by small doses of radiation, and because they are expensive to begin with, the cost of irradiating them represents only a small percentage of their final price. There is also strong evidence that irradiated silicones are superior to chemically cross-linked ones.

Irradiation imparts to polyethylene significant properties that fit this ubiq-



TI Needs More John Maxwell's BS EE Louisiana Polytechnic Institute

MICROWAVE ENGINEERS

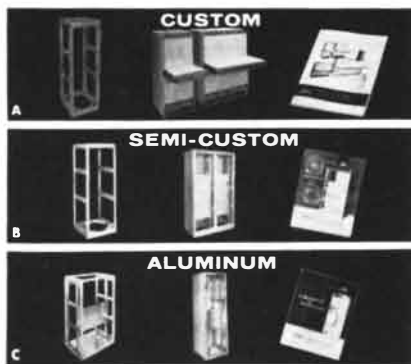
Men like John Maxwell are needed for high-level development and supervision — EE's who have 3 to 10 years experience in development, design and testing of microwave and high powered transmitter equipment prototypes. John has almost 9 years at TI, and now leads ASR transmitter and automatic performance monitor projects. Such experience can be used immediately. Your resume will get prompt attention by John R. Pinkston.

PROFESSIONAL
PLACEMENT

APPARATUS
DIVISION

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE
DALLAS 9, TEXAS

THE AMCO MODULAR INSTRUMENT ENCLOSURE SYSTEM



TWO COMPLETELY NEW LINES ADDED IN STEEL AND ALUMINUM TO GIVE
3 COMPLETE MODULAR FRAME LINES IN ONE OVER-ALL SYSTEM

A. Custom Line. Removable multi-panel, cowlings (19" width increments). Custom appearance for series mounting—space-saving and ideal for complex consoles. Double channel 16 gauge steel. Meets EIA standards.

B. Semi-Custom Line. Multi-width cowlings for single-unit appearance with frames in series. 19" wide panels, any thickness, can be recessed to any depth. Extra rugged, 14 gauge steel, box-type channel construction. Conforms to EIA mounting.

C. Aluminum Line. Box extrusions, cast corners for fast, easy assembly of cabinets any size from 7" to 20" in height, width or depth. Lock by hand, built-in locking device. All sizes standard.

D. Accessories. A full line of Amco integrated accessories (blowers, slides, mounts, lighting, etc.)

Cost savings. Orders can be grouped for best discount. Free Amco pre-assembly. **3 week delivery on standard parts!**

Send for free literature

Amco ENGINEERING CO.
7333 W. Ainslie Street, Chicago 31

DIRECTLY MEASURES DEWPOINT TEMPERATURES DOWN TO -100° F.



W-C DEWPOINT INDICATOR

The W-C Dewpoint Indicator quickly and accurately determines moisture content in gases. Its method of operation is direct, based on the formation of an actual dew spot. Its measurements are absolute, independent of the test-gas temperature. Its dewpoint range is broad, from ambient down to -100° F. (0.0003% moisture by volume).

Deriving moisture-content equivalents from the dewpoint temperature readout is practically effortless: a quick-comparison table does the work without calculations.

Conveniently portable, the Indicator operates on a self-contained power supply. Recording/controlling types are also available.

For more information, request Bulletin DPI-4.

WEIGHING & CONTROL COMPONENTS, INC.
206-T Lincoln Ave., Hatboro, Pa.

S.A. 2050



Eastman 910 Adhesive solves another production bottleneck

Electro-Voice, Inc., of Buchanan, Michigan, manufactures miniaturized phonograph cartridges, called "Power-Point," for high-fidelity audio systems.

The cartridge consists of a jewel-tipped ceramic transducer in a plastic boot, encased in nylon. Assembly is handled on a conveyorized production line and depends on rapid bonding of the components to obtain economical high-volume output.

The critical bonding problem is solved with Eastman 910 Adhesive.

Immediately following hand assembly, a drop of the adhesive is applied to the tiny components. *Moments later, a permanent bond is formed...* and the unit moves on, without delay.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?



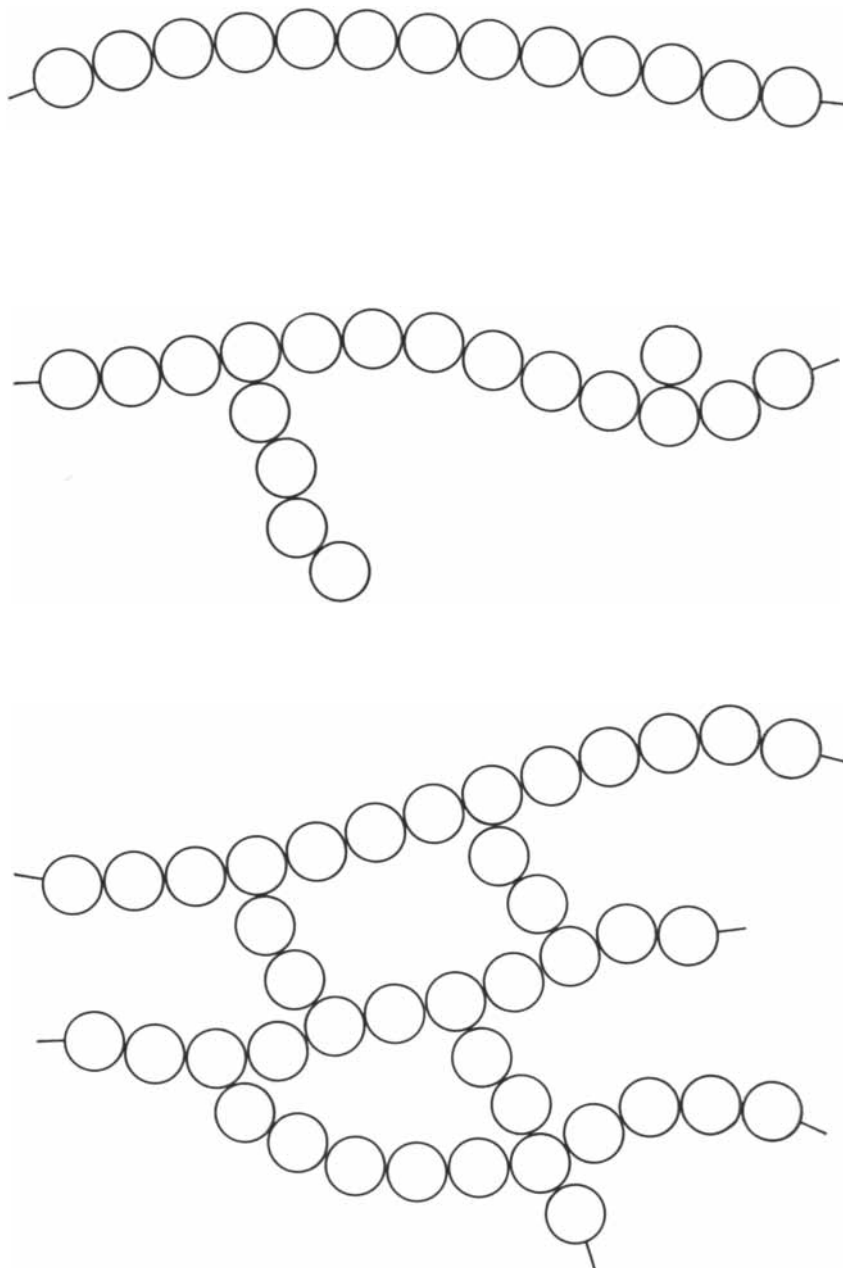
**Bonds Almost Instantly
...Without Heat,
Pressure or Catalyst**

For a trial quantity (1/3-ounce) send five dollars to Armstrong Cork Company, Industrial Adhesives Division, 9109 Inland Road, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Division, Dept. S-9, Kingsport, Tenn.

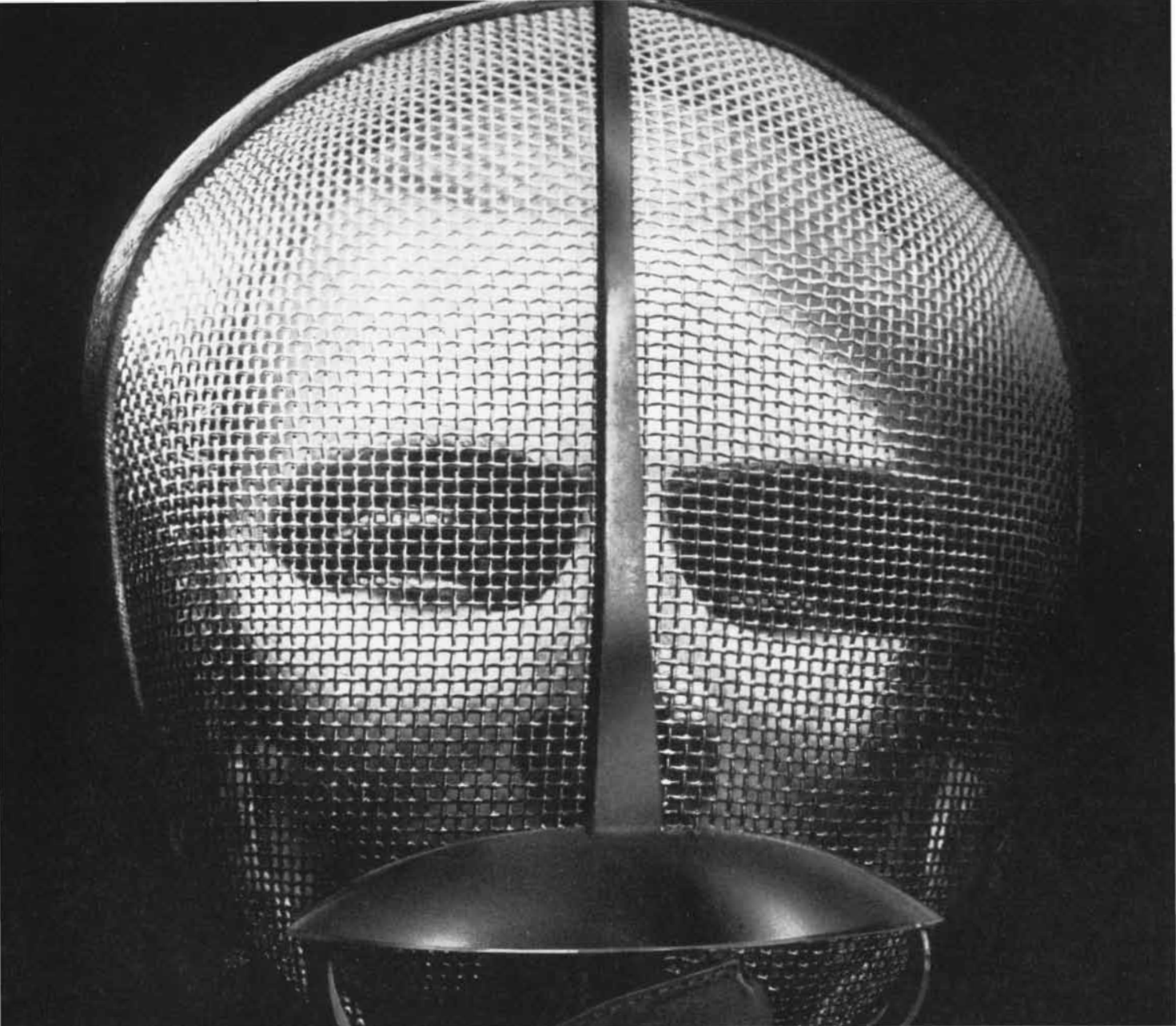
uitous plastic for service in certain technical applications. Commercial grades of polyethylene soften and eventually melt to a viscous fluid at temperatures between 240 and 275 degrees Fahrenheit, depending on their degree of crystallinity. Irradiation somewhat lowers this melting point, but improves temperature resistance by inducing the formation of cross-links. The irradiated polyethylene melts to a rubber-like material that does not flow at these higher temperatures and regains its original

properties on cooling. In service as an insulator of heavy-duty electrical cables, it withstands temperatures of 300 to 400 degrees F. and justifies its high cost.

Irradiated polyethylene can also be made into a plastic sheet that is heat-sealable but resistant to melting. Foods can be wrapped in it, cooked and sterilized, and then stored almost indefinitely, with the food visible to periodic inspection. I have prepared and "canned" some excellent omelets with this material, using a pair of scissors to cut the sheet



CHAIN STRUCTURE is one basis for classifying polymers. Linear or one-dimensional polymers such as natural rubber have either straight chains (*top*) or branched chains (*middle*). Such chains can link together to form either two-dimensional sheets or three-dimensional networks (*bottom*). Vulcanized rubber is an example of a three-dimensional polymer.



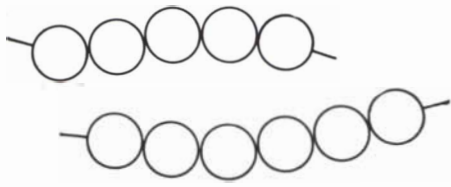
En Garde!

Melpar is an arsenal of technology supplying vital electronic elements linked to the nation's alert, en garde defense posture. Advancing the state of the electronic art is our mission — involving original conception, design, expedited production, and logistics support. Melpar equipment is created and produced for world-wide governmental, industrial and space application.

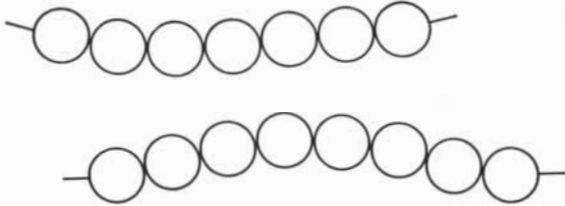
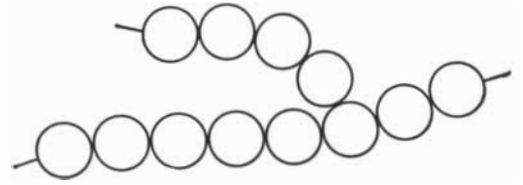
MELPAR  **INC**

A SUBSIDIARY OF WESTINGHOUSE AIR BRAKE COMPANY

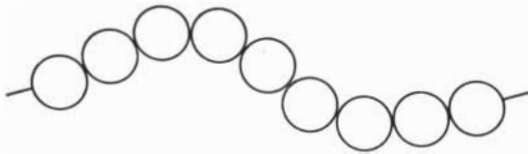
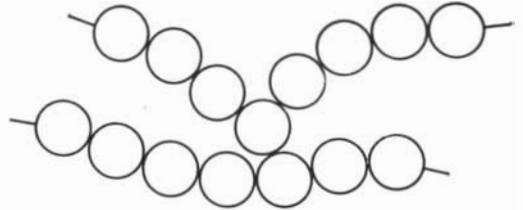
For details on provocative job openings in advanced scientific engineering areas, write to: Professional Employment Supervisor
3607 Arlington Boulevard, Falls Church, Virginia



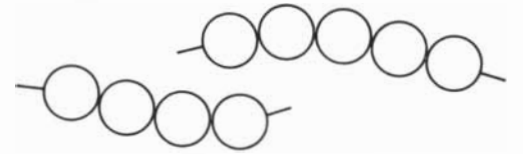
RADIATION



RADIATION

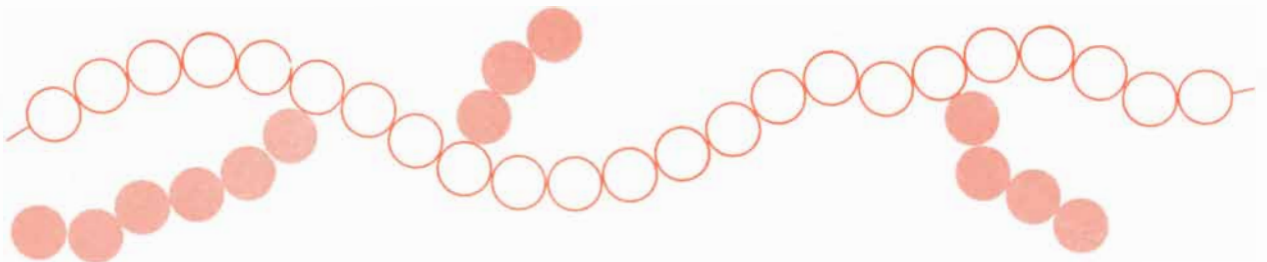


RADIATION



RADIATION CHANGES POLYMERS by breaking the chemical bonds holding the polymer chain together. The broken chain frag-

ments may then recombine in new arrangements (*top*), be cross-linked (*middle*) or be degraded into smaller fragments (*bottom*).



COPOLYMERS are hybrids composed of two or more different types of monomer. Random copolymers (*top*) consist of monomers linked together in no particular order. Block copolymers (*center*)

contain similar monomer units strung together in groups or "blocks." Graft copolymers (*bottom*) have side-chains of one type of monomer "grafted" onto a main chain of a different type.

and a flatiron to seal the package and cook the eggs. Even at present radiation costs this particular process is not excessively expensive.

In many applications, however, the use of radiation is limited by its current high cost. One way to reduce the cost of irradiation is to add allyl (C_3H_5) groups to the polymer. When these groups are exposed to radiation, they initiate a chain reaction in which each allyl group, as it becomes linked to the polymer chain, stimulates the formation of another active site on the polymer molecule. The reaction stops only when all the active sites have linked. Such reactions can produce a great number of cross-links with a relatively modest radiation dose.

Some polymers are resistant to radiation and cross-link only sparsely. A given dose of radiation induces the formation of only a 20th the number of cross-links in polystyrene, for example, that it does in natural rubber or polyethylene. Characteristically the structures of these polymers include benzene rings, and the benzene ring is distinguished for its stability under irradiation. This refractory behavior may be turned to account by incorporating benzene rings into other polymer structures to produce radiation-resistant materials for use in intense radiation fields. Here the designer must be wary both of the tendency to cross-linking and of susceptibility to degradation. While many polymers degrade into sticky fluids under strong or prolonged radiation, lubricating oils become polymerized and cross-link into gummy residues.

Just as cross-linking can appear on occasion as an undesirable phenomenon, so constructive uses may be found for the process of degradation. The natural polymer cellulose, for example, is easily degraded by radiation. It has been suggested (perhaps jocularly) that a suitable degree of degradation might "predigest" the large cellulose molecules in sawdust to yield a nourishing cattle fodder. Degradation might also be employed to produce a hybrid of cellulose and nylon: By exposing a mixture of the two substances to radiation, it might be possible to produce polymer fragments that would link together to form a hybrid which combined the best properties of both its parents.

Such a hybrid is known as a copolymer. In the case of the cellulose-nylon combination the idea is that irradiation would fracture the cellulose chain and permit segments of nylon to fit themselves into the backbone of the new



... they're both
my babies

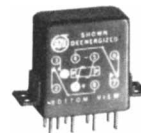
... but
what a
difference

Despite their identical appearance, those young innocents are barely fraternal. They *are* destined for fame, but along different Roads of Life.

The one on the left latches magnetically, eats only 50 mw. and works best in a circuit designed expressly with his characteristics in mind. He's also a few months older than his colleague, and has already made solid friends with at least one big military group. They like his particular combination of magnetic latching operation, high sensitivity, and ability to take 30 g's of vibration to 5000 cycles and 100 g shocks both on paper and in the flesh.



The little fellow on the right, on the other hand, offers a ready replacement suitable for existing equipment where standard DPDT switching is needed and the signal level is up around 200 mw. As such he's looking forward to making an even wider circle of friends than his companion — especially since he can take just as much vibration and shock and is put together with exactly the same care and high class materials.



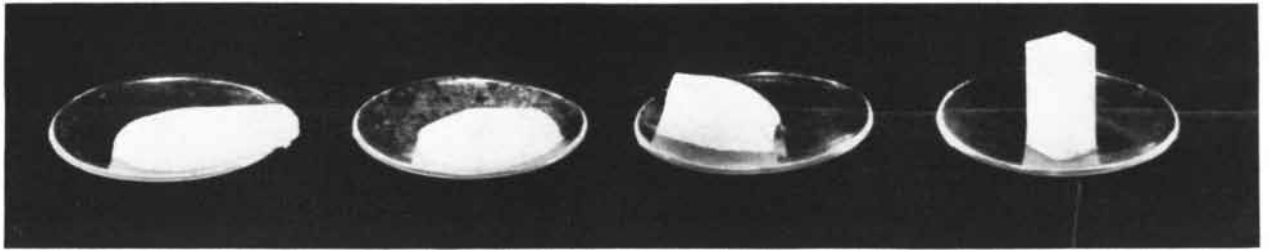
Both of these hermetically sealed prodigies are described in their birth certificates which you can get for the asking. If you think the 50 mw., magnetic latching, left-hand one is for you, ask for the Series 32 specs; if it's the right-hand, "on-off" one you're interested in, specify Series 33. Don't try to go by looks — everything's coming in crystal cans these days.

*
Sigma Corporate Image

SIGMA

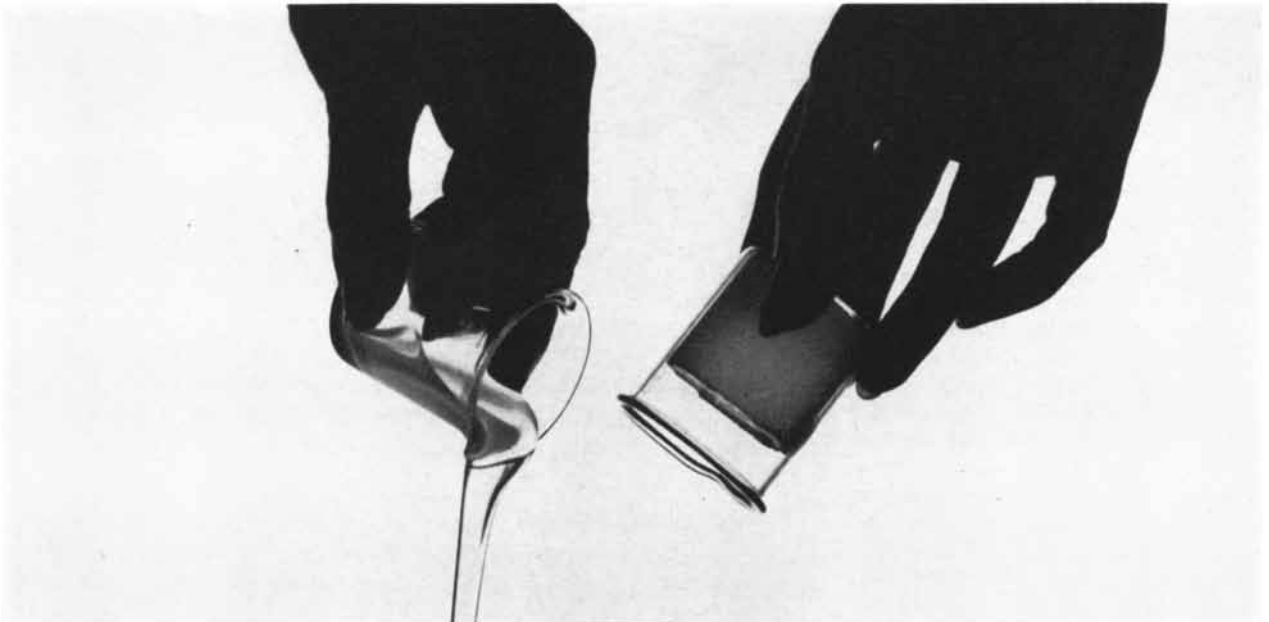
SIGMA INSTRUMENTS, INC.
40 Pearl Street, So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1939)



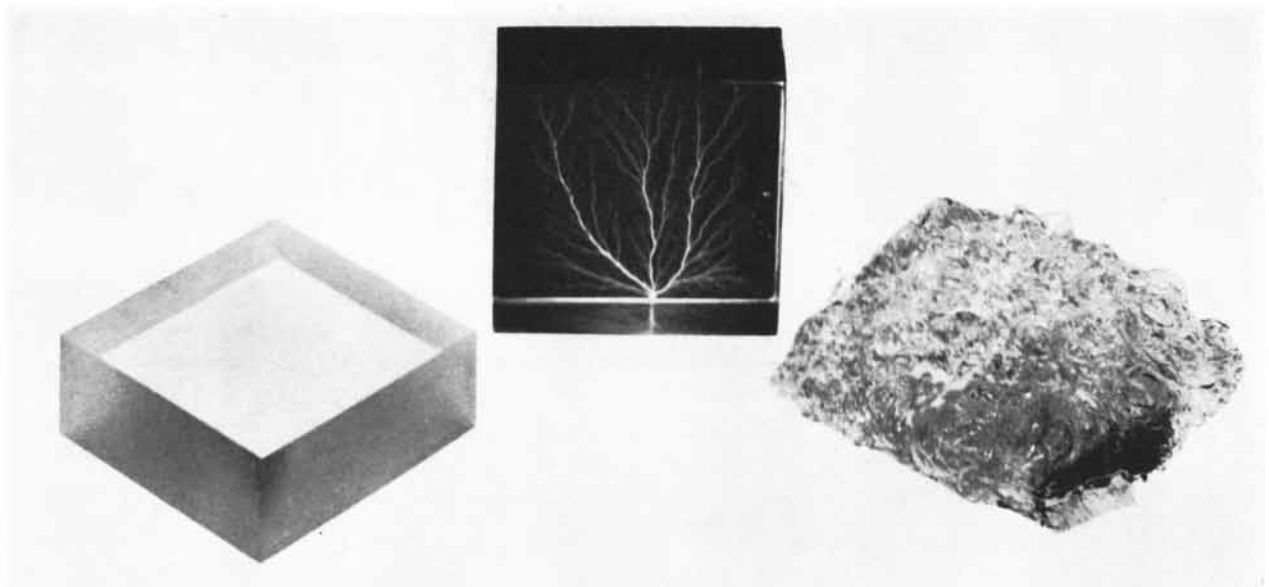
IRRADIATED POLYETHYLENE is more resistant to heat than the unirradiated material. Here four polyethylene blocks were heated for one hour at 390 degrees Fahrenheit. The block at far right was previously exposed to a dose of 20 million rads of cobalt-

60 gamma radiation; the block next to it received seven million rads; the next block, two million rads. Block at far left was not irradiated. The plastics photographed in the demonstrations on this page were irradiated by Radiation Applications Incorporated.



IRRADIATED POLYESTER RESIN changes from a syrupy liquid to a hard, tough solid. Resin pouring from the beaker at left

has not been irradiated; that in the beaker at right has been exposed to 750,000 rads of gamma rays from a cobalt-60 source.



IRRADIATED LUCITE (polymethylmethacrylate) becomes a foamy mass (*right*) when heated. When exposed to an electron beam, a Lucite block becomes impregnated with free electrons; if

the block is then electrically grounded, the sparking of the discharging electrons forms the crack patterns known as Lichtenberg figures (*center*). An unirradiated Lucite block is shown at left.

molecule, forming a "block" copolymer [see bottom illustration on page 188].

Irradiation can also be used to excite active centers of polymerization on the backbone of a polymer, permitting it to initiate the polymerization of one of its side-chains. In such polymerizations monomers of a different type may be "grafted" on a polymer's molecular backbone. Such graft copolymers have already been successfully produced. For example, irradiation promotes the grafting of dye-accepting monomers to the surface of teflon, a notably tough and chemically inert polymer, making it possible to label this material with colors when it is used to insulate electrical conductors. The grafting of polystyrene to the surface of teflon film similarly permits one side of this otherwise unobtainable material to be attached to other substances, while the other side retains its chemical inertness and high temperature-resistance.

Such are the possibilities, hopes and promises of ionizing radiation as applied to chemical technology. Much that is known to be technically feasible remains economically impracticable. To go from the processing of such special-purpose materials as silicones and teflon to the processing of commonplace industrial polymers requires much cheaper sources of radiation. One can envision nuclear-power stations and chemical-processing plants working side by side. One can also envision the difficulty of reconciling the very different interests of the chemical engineer and the nuclear-power engineer. Considerable structural changes would be necessary to accommodate a high flow of irradiated materials through any existing nuclear reactor designed primarily for research or for power production. On the other hand, the fuel rods in nuclear reactors must be replaced periodically and the used rods stored for a while before they can be processed for the extraction of plutonium and fission products. At certain plants the fuel rods are already serving as irradiation sources during this "cooling-off" period; their declining radioactivity must, of course, be allowed for in the scheduling of chemical processes. When the fission products have been extracted, these too may act as radiation sources, especially the long-lived isotopes cesium 137 and strontium 90. Finally elements such as cobalt may be irradiated in a reactor to produce powerful radiation sources.

At present high-voltage electrical machines provide ionizing radiation at much lower cost. Generating two million volts or more, they produce their effects



MISSILE DESIGN WITH HITCO IN MIND

HITCO is one of the world's leading developers and manufacturers of ultra-performance thermal materials capable of resisting extremely high temperatures, even up to 15,000°F. for short duration! Call or write us for Capabilities Brochure and complete Technical Data.



- REFRASIL Materials
- HITCO Metal Blankets
- THERMO-COUSTI Materials
- THOMPSONglas Materials
- ASTROLITE Reinforced Plastics
- HITCORE Structural Core Materials
- HITCO Electric Blankets

H. I. THOMPSON FIBER GLASS CO.

1733 Cordova Street • Los Angeles 7, Calif. • REpublic 3-9161



Now available in standard tube, crucible and combustion boat shapes

For temperatures to 4600°F. (2538°C). Possesses one of the highest melting points of all commercial refractories.

Great chemical inertness. Won't erode when melting steel or high temperature alloys... or react when firing titanates or sintering metals... or embrittle platinum.

Leco zirconia ware... crucibles for melting special alloys, tubes for high-temperature combustion or gas synthesis, heat treating and sintering furnaces, and kiln furniture. We will be happy to quote on custom ware.

Leco also specializes in Zircon (ZrSiO₄) Ware
Write Today for TECHNICAL DATA CATALOG

LABORATORY EQUIPMENT CORP.
4009 Hilltop Road, St. Joseph, Michigan

Lafayette 14" TRANSPARENT CELESTIAL GLOBE

- ★ Adjustable Satellite Orbits
- ★ Satellites Travel around Earth Automatically
- ★ Adjustable Sun and Moon
- ★ Adjustable Lunar orbital inclination
- ★ 80 Constellations—including all stars of 1st, 2nd, 3rd, and 4th Magnitude.
- ★ Similar devices used by the Navy—Air Force—and Marines.



Only 59.50

A true "mechanical universe." Designed for and dedicated to those who recognize the challenge and adventure that lie on the frontiers of space. An easily understood working model of our universe. Permits comprehensive explorations in time and space beyond the earth atmosphere. Traces the orbits of man made satellites. F-400Net 59.50

FREE — 308 Page CATALOG—1960 Edition — FREE

CUT OUT AND PASTE ON POST CARD

LAFAYETTE RADIO DEPT. SA 19
P.O. BOX 222 JAMAICA 31, N. Y.

Send FREE LAFAYETTE Catalog 600

Name.....
Address.....
City..... Zone..... State.....

MA59

MINIATURIZATION AWARD

Miniature Precision Bearings, Inc., cordially invites you to participate in the 1959 Miniaturization Award competitions. The Miniaturization Award for 1959 will be presented during the spring of 1960 at the 3rd Annual Awards Dinner in New York City. The Award symbolizing Miniaturization is a bronze sculpture by a leading American artist. Certificates of Excellence will also be awarded for additional outstanding entries.

PURPOSES

In addition to stimulating public knowledge in the industrial advancement of miniaturization, the MA 59 competition promotes national recognition of award winning companies, individuals, or organizations.

JUDGING OF ENTRIES

Entries will be judged by an independent committee of members of the electronics, metalworking, research and publishing fields.

ENTRIES

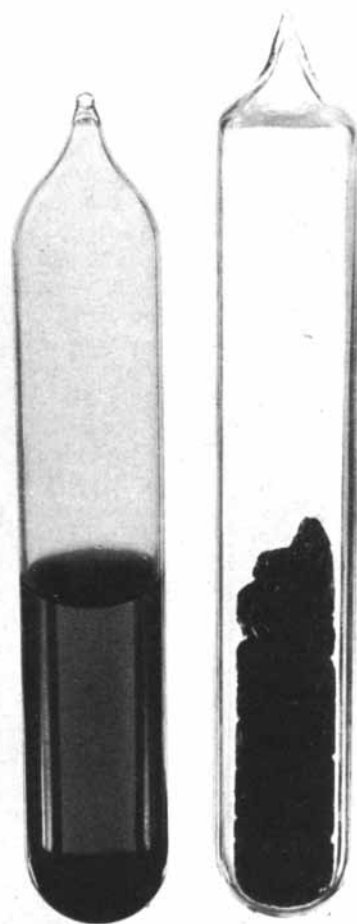
For a brochure giving criteria, upon which the entries are judged and other details of the competition, write Miniaturization Awards Committee, Box 604, Keene, N.H.

This brochure outlines the manner in which entries should be submitted and gives information on past winners. Because entries should be received by January 20, 1960, prospective entrants should secure the MA 1959 brochure as soon as possible.

by means of their primary electron-beams, or by secondary X-rays when the electron beams impinge on a target.

For some purposes there are advantages to be gained by using one of these sources of radiation as opposed to the other. But in a wide range of applications they are interchangeable and directly competitive. As the supply of fission products increases and the cost of processing them comes down, one may expect to see an economic battle between the electrical and the nuclear-engineering industries to provide power for the new field of radiation chemistry.

But economics is not the sole barrier to progress in radiation chemistry. Equally important is the great deal that the radiation chemist has yet to learn about his subject. No theory yet ad-



IRRADIATED OIL becomes cross-linked, changing from a liquid (*left*) to a gummy solid (*right*) that does not flow or melt.

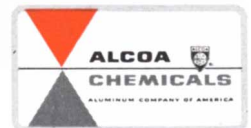


Don't let rising process heats ruin your refractories

...or your profits... *mix imagination with Alcoa Aluminas*

The steady increase in general process temperatures poses no problem at all for refractories fortified with ALCOA® Aluminas. Their refractoriness rises in direct proportion to the amount of alumina in their composition. These high-purity aluminum oxides also add greatly to strength and stability under load at elevated temperatures. And high-alumina refractories are chemically stable, immune to both oxidizing and reducing atmospheres. They offer just one more illustration of the many good reasons why makers and users of a variety of products have found it pays to *mix imagination and engineering with Alcoa Aluminas . . . to make an old product better or a new product possible*. Discover what ALCOA Aluminas can do for your own product or process. Outline your requirements in a letter to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 701-J Alcoa Building, Pittsburgh 19, Pennsylvania.

For finer products...let Alcoa add new dimension to your creative thinking!



For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

THE MARCHANT DECI·MAGIC



... the calculator "programmed" for scientists and engineers who want to concentrate on the problem instead of the machine.

Fast, accurate calculations are simple with the Deci·Magic automatic calculator because there are no complicated set-ups, no confusing controls.

To set decimals, you simply touch one key to set them *all*—in the problem *and in the answer*. Then you just "write" the problem in the keyboard as you would on paper. Deci·Magic does the rest, and delivers your answer with the decimal point in the right place — *all automatically*. With a Deci·Magic calculator, anyone on your staff can get correct answers quickly . . . gaining more time for *creative* productivity.

This remarkable ease of operation is illustrated in "Marchant Methods

for Science and Engineering," a brochure that shows how simply and swiftly the Deci·Magic delivers the answers to 21 actual problems, using mathematical formulas frequently encountered in science and engineering.

For an actual demonstration of the Deci·Magic on your own types of calculations, just call your nearby Marchant office.



For a free copy of "Marchant Methods for Science and Engineering," send coupon below.



Less time working out problems, more time using the answers . . . because Deci·Magic gives you

- Automatic control of dials, decimals and carriage
- One-touch decimal setting for both problem and answer
- Progressive dial proof of all entries, all results
- Automatic single-entry squaring
- Automatic accumulation of products or quotients
- Automatic zeros

MARCHANT CALCULATORS

Division of SMITH-CORONA MARCHANT INC.
OAKLAND 8, CALIFORNIA

MARCHANT CALCULATORS • OAKLAND 8, CALIFORNIA

Please send me a free copy of "Marchant Methods for Science and Engineering."

NAME _____

L-9

PLEASE ATTACH COUPON TO YOUR ORGANIZATION'S LETTERHEAD

vanced explains, for example, the peculiar electrical behavior of polymers under irradiation. Many polymers are very effective electrical insulators, a property they retain even after severe radiation damage. However, at radiation doses and intensities far too low to cause any observable chemical change, they can suffer a considerable reduction in their insulating capacity. They ultimately recover, but the time it takes them to do so varies from polymer to polymer.

One theory states that ionization liberates either electrons or protons which are free to flow as current under the pressure of an external electrical field. It accounts for the gradual decay of these currents by assuming that the wandering electrons must first be trapped by some impurity atom, then released by thermal agitation and finally recaptured by electron-deficient molecules. The experimental conductivity observed, however, is remarkably consistent, and bears no relation to the presence of impurities.

An alternative theory suggests that the conductivity is due to the motion of "holes" of the sort that occur in semiconductors. These holes are simply the charged vacancies left when an electron or proton is ejected from a molecule in a crystal lattice. Another electron or proton may fill the hole, creating another hole in the place it vacates in the lattice; thus, like a wandering proton or electron, the hole appears to move through the material. But there are indications that the hole tends to migrate to certain preferred positions in a given molecule. Here the study runs into the even more fundamental question of "energy transfer," the mysterious process in certain organic molecules by which incident energy absorbed at random migrates to specific sites and produces nonrandom chemical changes.

Most studies of irradiated polymers have been carried out on solids in which the polymer molecules are held almost immobile. Comparatively little attention has been paid to the behavior of polymers in solution, in which the chemical groups involved may move about. This is a significant gap in the work of radiation chemistry, because polymers in solution offer much better analogies to biological systems. Moreover, solution studies permit the comparison of the direct effects of radiation on the polymer itself and the indirect effects that are mediated by the action of the radiation on the solvent.

One set of experiments, using water as the solvent, has led to a most surprising result. Certain polymers that do not

METALGRAMS



... news about metals and metal chemicals

*Electromet brand ferroalloys,
pure metals and metal chemicals*

Purity previously unattained commercially is now available in Union Carbide Metals' high-purity chromium. This product was introduced in 1958 in response to the requirements of nuclear energy development and high-temperature alloy research. Union Carbide Metals can now offer high-purity chromium having a total impurity level as low as 300 ppm. The newest of the 44 grades of "Electromet" chromium is available in semi-commercial quantities at considerably less than the price of iodide chromium. Write for Data Sheet CR1-S3.

* * *

Acetylacetonate derivatives of the transition metals (for example, chromium, cobalt, manganese, vanadium, iron, and nickel) have recently been made available in research quantities by Union Carbide Metals. These "Electromet" acetylacetonate compounds provide a convenient means of putting the metals in solution in organic systems; the compounds are chelated, non-ionizing substances, slightly soluble in water. They form solutions which are neutral and resistant to hydrolysis. The acetylacetonates are available in the form of pure, crystalline powders of medium bulk density. Bulletin AAl-S3 gives details.

* * *

Time-saving mixes, having proved their worth in the kitchen, have now moved into the metallurgical field. Examples of this concept are Union Carbide Metals' more than 15 titanium alloy addition agents. The first of these was 85% vanadium-aluminum, developed in 1954 to expedite commercial production of the high-strength 60% aluminum-40% vanadium alloy. The list now includes a tantalum-columbium-aluminum combination for the new 8-8-1 alloy. Data Sheet AT1-S3.

* * *

Among the Union Carbide Metals family of oxides are columbium and tantalum oxides. Both have high dielectric constants useful in electronics. Columbium oxide is also an intermediate material for producing compounds with great hardness and high melting point. Tantalum oxide is a source for tantalum carbide, a cutting tool additive which increases resistance to abrasion and oxidation. Send for Data Sheet OX1-S3.

* * *

Substantially improved specifications for vanadium metal, particularly as regards gaseous impurities, have been announced by Union Carbide Metals Company. Through the use of improved production methods, hydrogen content has been cut by 90 per cent and nitrogen and carbon contents by 50 per cent. Analyses of 500- and 1000-pound lots show that the sum of carbon, oxygen, hydrogen, and nitrogen is in the range of 0.1 per cent. Write for Bulletin VM1-S3.

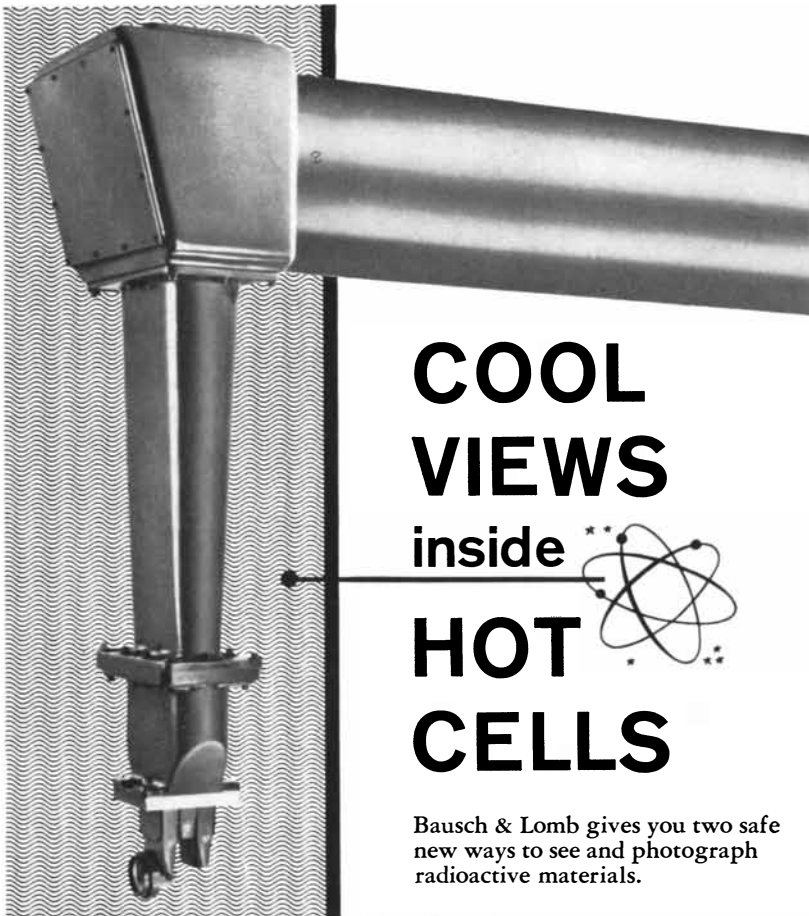
* * *

Stainless steel shapes of more than 95 per cent theoretical density have been made from Union Carbide Metals' new stainless steel powder. The composition of the powder is similar to Type 316 or CF-Mo alloys. Mechanical properties of the sintered shapes closely approach those of wrought shapes. Union Carbide Metals field consultants, working with metal powder fabricators, are developing the promising potential for this stainless steel powder in many uses, including gears, bushings, and other shapes exposed to aggressive corrosion environments. Data Sheet SS1-S3 gives additional information.

* * *

Union Carbide Metals Company, Division of Union Carbide Corporation, P. O. Box 330, Niagara Falls, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

The terms "Electromet" and "Union Carbide" are registered trade marks of Union Carbide Corporation



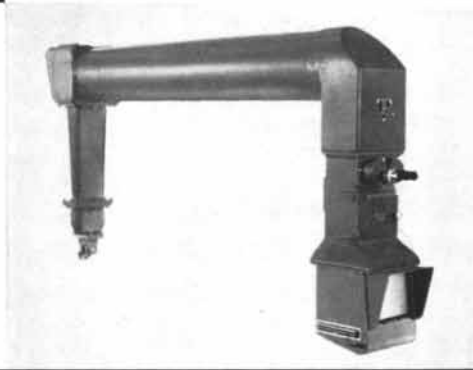
COOL VIEWS inside HOT CELLS



Bausch & Lomb gives you two safe new ways to see and photograph radioactive materials.

Bausch & Lomb REMOTE CONTROL Stereomicroscope

- Sharp 3-D views of standard laboratory instrument quality
- 5 x 7" stereo camera
- 1/2X to 30X magnification
- Non-browning optics



Bausch & Lomb REMOTE CONTROL Metallograph

- Direct views or photography, by bright field or polarized light
- 25X to 2000X magnification
- Non-browning optics

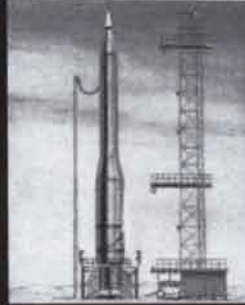


Write for Manual D-287, containing specifications, technical data and photographs. Bausch & Lomb Optical Co., 59445 St. Paul Street, Rochester 2, New York.

cross-link easily and even degrade when they are irradiated as solids have been found to cross-link readily in solution. The molecules link up into a network that gels suddenly, absorbing the water in which they are dissolved to form a jelly-like material. As continued irradiation increases the number of cross-links, the network gradually shrinks, wringing out some of the water. The presence of certain radiation-protective molecules will greatly increase the dose of radiation required to bring the reaction about, and this provides a measure of the degree of protection offered.

In these studies the concentration of the polymer in the solution is especially significant. One might expect that fewer cross-links would be formed at low concentrations, when the polymer molecules are far apart. But instead the dose required for network formation decreases as the concentration is reduced. The explanation lies in the indirect effect of the radiation: Radicals formed in the water react in some way with the polymer molecules, causing them to cross-link. As the polymer concentration is reduced, there is a larger number of radicals available to attack each polymer molecule, and the polymer may be cross-linked by very small doses.

If the concentration is reduced still further, a new pattern of behavior emerges. Instead of forming networks, the polymer apparently degrades. This transition, which occurs in a very narrow range of concentrations, has several possible explanations. One postulates that unspecified active groups are formed on the polymer; if one of these groups meets another in a given time, they will react to form a cross-link. In very dilute solutions, however, such an encounter does not occur soon enough, and the activated polymer molecule degrades by main-chain fracture. Thus radiation initiates a concentration-dependent competition between cross-linking and degradation. Another explanation depends on the fact that networks can be formed only by the linking of active sites on separate molecules. Below a certain concentration this becomes even less probable than the linking of active sites on the same molecule. The latter process tightens up the molecule and reduces its over-all size, making cross-linking with other polymer molecules even less likely. The elucidation of such questions as these will surely enhance the usefulness of ionizing radiation in polymer chemistry. But it will also contribute significantly to our understanding of the effect of radiation on the molecules that conduct the intricate processes of life.



FOR RADAR AND
MISSILE TRACKING

ANOTHER

VARIAN FIRST

INTERNAL CAVITY PULSE AMPLIFIER
KLYSTRON with 75 KILOWATTS
average output

- RUGGED
- NON CRITICAL
- HIGH PERFORMANCE
- SINGLE PUSH-BUTTON OPERATION



1.25 MEGAWATTS PEAK POWER

Varian's VA-842 is the world's largest internal cavity Klystron. It produces the tremendously high average power of 75 kilowatts for long pulse radar and missile tracking. Features include a pulse duration time of 2000 microseconds; tunable frequency range of 400 to 450 megacycles; 40 db stable RF power gain.

Varian makes a wide variety of Klystrons and Wave Tubes for use in Radar, Communications, Test and Instrumentation, and for Severe Environmental Service Applications. Over 100 are described and pictured in our new catalog. Write for your copy — address Tube Division.



VARIAN associates

PALO ALTO 7, CALIFORNIA

Representatives throuout the world

KLYSTRONS, TRAVELING WAVE TUBES, BACKWARD WAVE OSCILLATORS, HIGH VACUUM PUMPS, LINEAR ACCELERATORS, MICROWAVE SYSTEM COMPONENTS, R. F. SPECTROMETERS, MAGNETS, MAGNETOMETERS, STALOS, POWER AMPLIFIERS, GRAPHIC RECORDERS, RESEARCH AND DEVELOPMENT SERVICES



Curtiss-Wright Research Reactor Core—4 Megawatt

Taking note of a Calculated Conquest

Almost two decades have passed since the first controlled nuclear chain reaction. This significant victory over the atom revealed new fields of endeavor for science, for industry, for education, and for the military. At Curtiss-Wright the conquest of the atom's nucleus has had its meaning in a new line of products and services and a new research approach.

NUCLEAR PRODUCTS—Curtiss-Wright has developed and introduced products such as the remotely controlled Puff Camera for radiographic use in hard-to-reach places. Betagages control the thickness of many sheet materials during manufacture and Gammagages tell the density of free-flowing products. Curtiss-Wright nuclear products also include power reactors, research and training reactors, nuclear instrumentation and controls for atomic submarines and Curmet reactor tubing.

NUCLEAR SERVICES—Gamma and neutron irradiation facilities are available for short- or long-term irradiation of organic or inorganic materials with gamma dose rates up to 1 million rads per hour or thermal neutron fluxes up to 4×10^{13} neutrons/sq. cm/sec. Other featured nuclear services include radioactive source encapsulation (microcurie to megacurie range), gamma radiation spectroscopy, and hot cell irradiations.

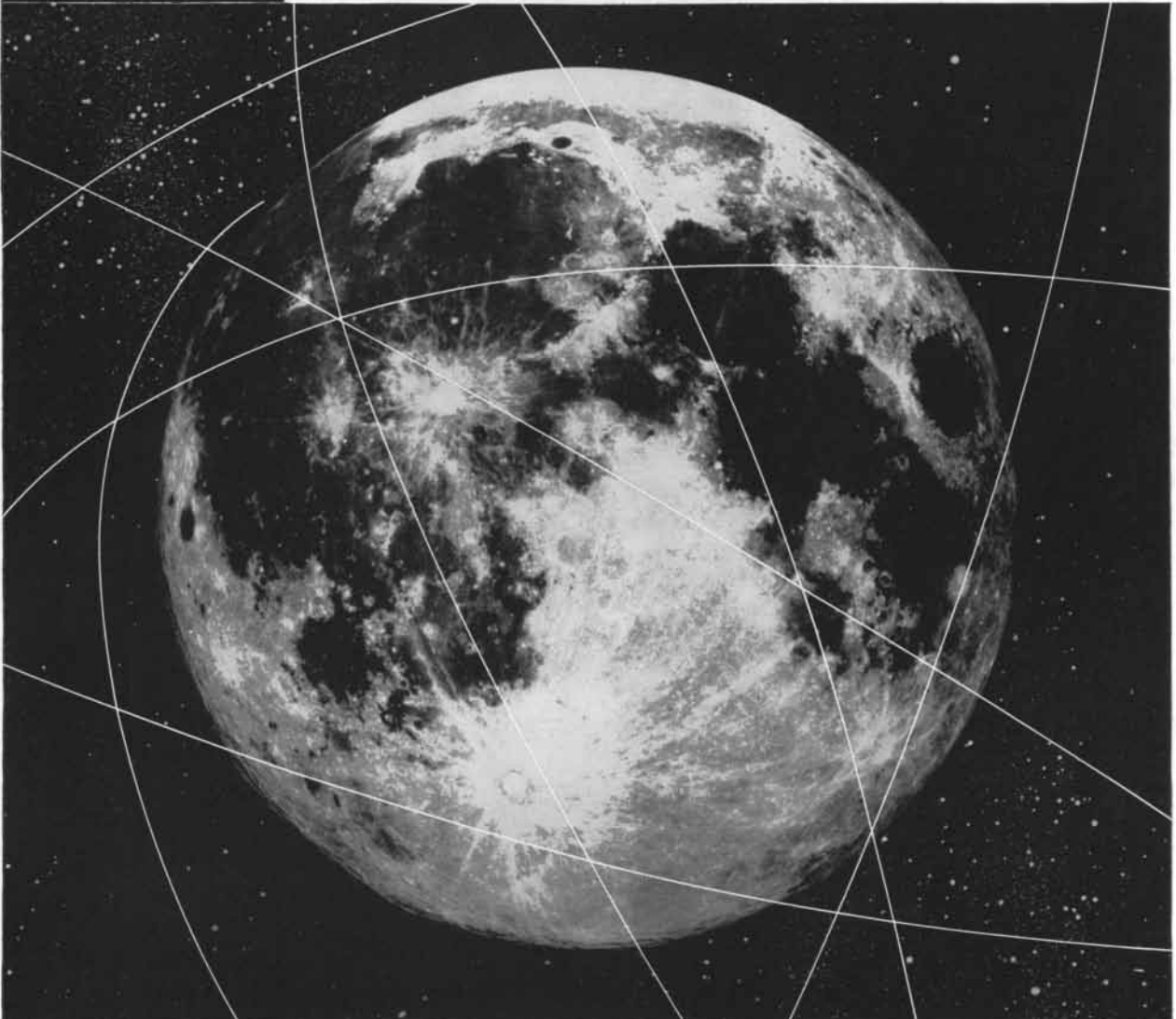
NUCLEAR RESEARCH—Curtiss-Wright scientists have made significant advances in food irradiation processes. The first large-scale High Intensity Food Irradiator will be completed next year for the U. S. Army. This group has also designed reactor fuel elements and rod control drives, reflector elements and radiation monitoring instruments.

For further information, write: Director of Nuclear Sales,
Curtiss-Wright Corporation, Quehanna, Pennsylvania.

CURTISS-WRIGHT 
CORPORATION • WOOD-RIDGE, N. J.



... first in today's front page developments



TO THE MOON...OR BEYOND...

Verlort can track it. As an example of Reeves Systems Engineering and production capabilities, Very Long Range Tracking Radar (VERLORT) was successfully designed and produced within a period of six months to meet urgent requirements of the DISCOVERER ground-tracking program.

This remarkable beacon radar system can achieve extreme tracking ranges... to the moon and beyond. Ingenious circuit design eliminates the possibility of either range ambiguity or interference between transmitted and received signals.

Equally advanced research and development, teamed with complete, full-scale production facilities, are available for the solution of your own pressing problems in the fields of missile and vehicle guidance, tracking and fire control systems, computer systems, and components.

REEVES INSTRUMENT CORPORATION

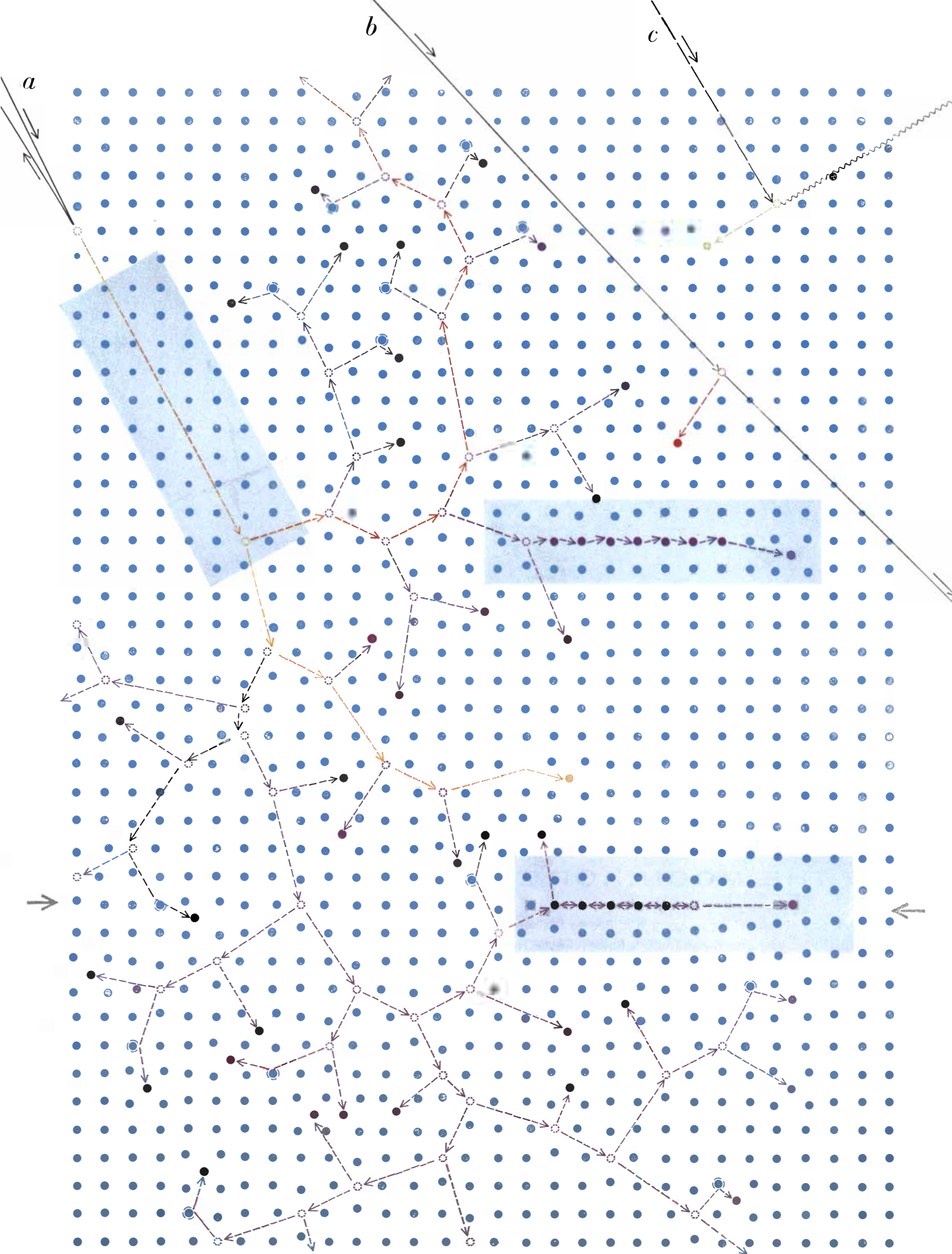
A Subsidiary of Dynamics Corporation of America—Roosevelt Field, Garden City, New York

7RV59

**a highlight on
CREATIVE
SYSTEMS
ENGINEERING
at Reeves**

Qualified engineers seeking rewarding opportunities in this and other advanced fields are invited to get in touch with us.





Ionizing Radiation and Metals

The effects of radiation on metals result from the displacement of entire atoms in a crystal, not from ionization. These atomic displacements yield new insight into the nature of the solid state

by Douglas S. Billington

Long before the uranium in the fuel element of a nuclear reactor has been consumed in fission, the fuel element becomes swollen, elongated, blistered and embrittled by the flux of high-energy particles within. A graphite moderator, which slows down the fast neutrons from the fuel elements to the slower "thermal" speeds needed to support the chain reaction, loses much of its thermal conductivity and suffers dimensional changes under the action of those neutrons. Similar damage is sustained by the metal control-rods that absorb the excess neutrons and so serve to maintain the reaction in a steady state.

Here is ample evidence that high-energy radiation—which so powerfully disrupts living matter and substances composed of organic molecules—may also have significant effect upon inorganic crystalline solids. There is a substantial distinction to be drawn, however, between the effects observed in organic and inorganic matter. John F. Loutit has pointed out elsewhere in this issue that a dose of 300 or 400 r [see glossary of terms on page 78] of ionizing radiation

to the whole body is nearly always fatal to man. What is the effect of a similar dose of radiation to a piece of metal, or ceramic? The answer, in the case of almost all inorganic crystalline solids, is: No effect is detectable. It is only at the heart of a nuclear reactor that the destructive action of ionizing radiation upon such materials becomes a matter of concern, and even there it primarily affects materials that are involved in the nuclear reaction itself. The uranium-graphite reactor at the Oak Ridge National Laboratory has been in continuous operation for 16 years. The fuel elements and control rods have of course been replaced several times during this period. But the thick walls of concrete that shield the scientists and engineers who work around the reactor remain unaffected by the huge volumes of intense radiation they have absorbed over this long period. All of the structural components of the reactor are still sound and will continue to be serviceable for an indefinitely long time to come.

The stability of inorganic solids under irradiation is best understood in terms

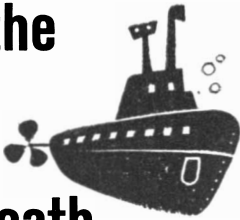
of the events that take place on the microscopic scale. Ionizing radiation is disruptive to organic and living matter precisely because it ionizes, that is, tears electrons from their moorings in atoms and molecules and thereby breaks the chemical bond. In the case of most inorganic solids, however, this ability of radiation to cause ionization results in no significant change in properties. The electrons in metals are not bound to any one atom but are shared by all; in other words, metals in the solid state are permanently ionized. However, when a particle or photon of radiation carries sufficient energy, it may, by a simple billiard-ball type of collision, knock atoms out of their positions in the lattice structure of the crystal. Now the displacement of whole atoms does alter the properties of the metal in significant ways. But it takes radiation of considerable energy and intensity to make these changes show up on the macroscopic scale.

Such radiation is available only in the interior of a nuclear reactor, from certain extremely active radioisotopes

SEQUENCE OF EVENTS following bombardment by a fast (one- or two-million-electron-volt) neutron (a) in the idealized lattice of a copper crystal is depicted on the opposite page. Red line traces path of atom displaced by neutron; yellow line traces path of second atom in sequence of collisions; purple lines show paths of subsequent atomic collisions. The great majority of displaced atoms (darkest dots) come to rest interstitially, distorting the lattice by forcing adjacent atoms out of position. Vacancies left by interstitials (broken circles) distort lattice by allowing adjacent atoms to collapse inward. Before stopping, displaced atoms may have only enough energy left to deliver glancing blows in collisions, enhancing thermal vibration of other atoms (circled dots) but not displacing them. The 60,000-electron-volt energy of the first atom shrinks the apparent diameter of atoms along its path (blue area at left). The arrows in the margins point to

extra plane of atoms (a "dislocation") which ends in middle of lower blue area at right. Same area shows a focusing collision: Impact is squarely on axis of travel of displaced atoms, causing each atom to spring forward, collide with the next and return; the last atom is permanently displaced. Upper blue area at right shows defocusing collision. Impact is just off the axis of travel of the displaced atoms, causing atoms to follow jagged path, each one knocking the next out of position and replacing it. Some neutrons pierce the lattice with no effect; others (b) may dislocate only one atom. A slower moving (1/40-electron-volt) thermal neutron (c) may be absorbed by nucleus of an atom. The atom is thereby transmuted; it emits a gamma ray and recoils to an interstitial position. In a crystal the events charted here in two dimensions occur in three dimensions. The diagram is based on drawings that were prepared by O. S. Oen of the Solid State Division of the Oak Ridge National Laboratory.

how the triton holds its breath



The Triton, latest and largest atomic sub, can hold its breath for weeks under water. 148 men live safely, work efficiently, breathe easy. The recirculated air they breathe is kept pure and odor free with activated charcoal filters. Why not "up periscope" on other uses for activated charcoal.

how to bar the tar



A vapor trap no bigger than a cigarette filter—now, oddly enough, goes on a cigarette that's making big news. Vapor phase contaminants such as tars are hauled up short by activated charcoal built into the filter. Maybe you are a pipe smoker—or a non-smoker—and worry about contaminants in other forms. Try activated charcoal. It'll knock the tar out of your problems.

how to keep your spirits



Distillers who store alcohol in barrels watch the level go down as the age goes up. Now—distillers may use activated charcoal to turn costly vapors into pure liquid form, fresh as the dew—with very attractive savings. Activated charcoal recovers many expensive vapors for as little as 2c per gallon.

activated charcoal



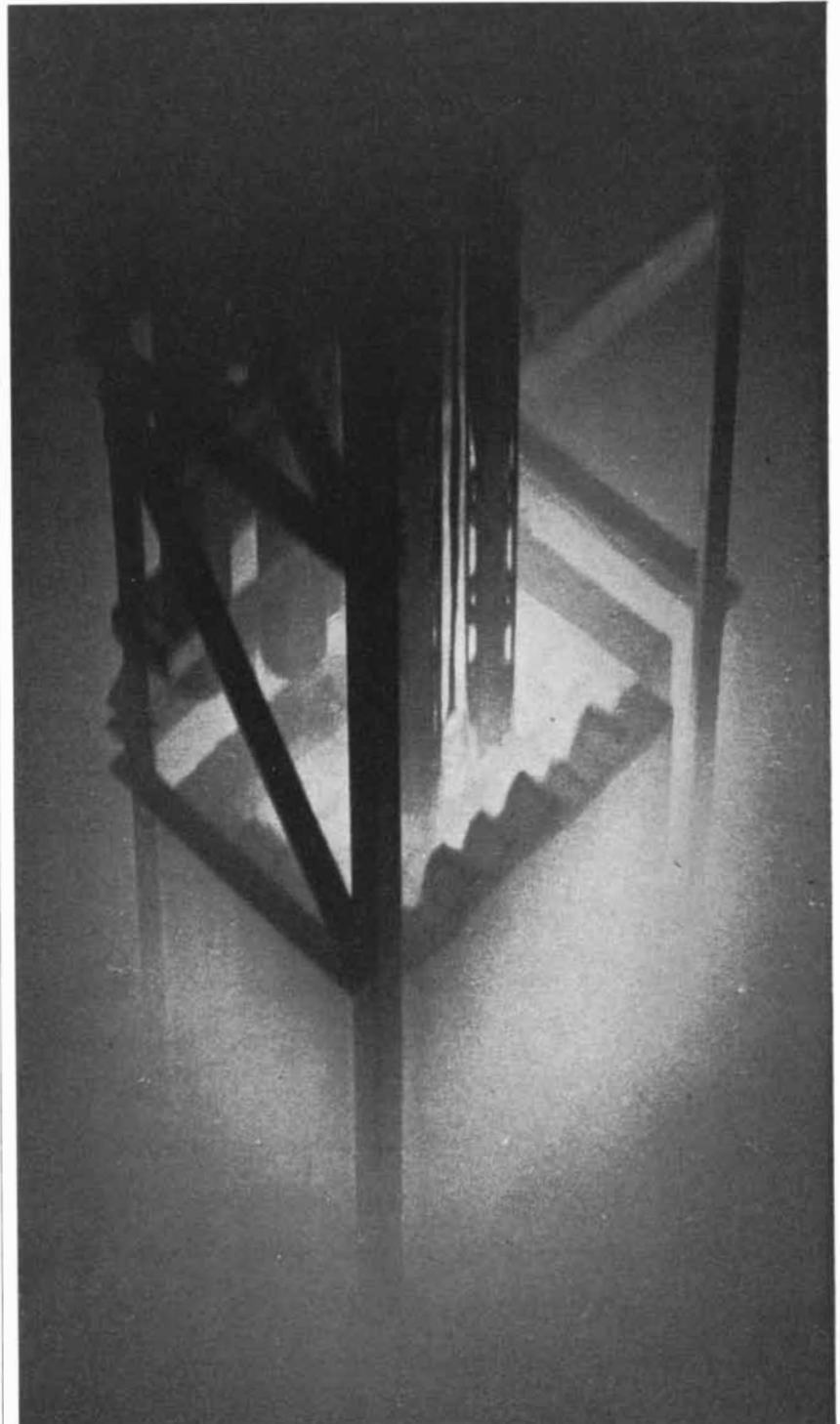
Activated charcoal (or carbon), a hard, granular, black material, acts as a molecular sponge, purifies air, gases, liquids—recovers solvents—removes odors and impurities—does hundreds of jobs. Write for Bulletin E-188-D. Barney-Cheney, Columbus 19, Ohio.

Barney-Cheney

and from high-energy accelerators. Particles of sufficient energy can exert even more extreme effects on the microstructure of solids. When the two or more fragments of a fissioning uranium atom fly apart with a total energy of 160 million electron volts, each yields up its share of this enormous energy within

.001 inch; the spectacular changes in the fuel rod are the result. The neutrons and other particles in the reactor may cause transmutation of atoms into radioisotopes of their own or other species, thus modifying the properties of a material in a most radical way.

In choosing or developing materials



SWIMMING-POOL REACTOR at the Oak Ridge National Laboratory is used for irradiation experiments. Bright glow surrounding the core is Cerenkov radiation, produced by electrons which travel through water at speeds greater than the speed of light in water.

Arnold Builds World's Largest Permanent Magnet...Used in Atomic Research

Vital Statistics on the Big Magnet

Here's how the world's champion permanent magnet weighed in: 1720 pounds of Alnico V in the assembly . . . a keeper weighing 225 pounds . . . a total shipping weight of a little over 2 tons.

Overall dimensions of the magnet assembly, as illustrated at right, were 52½" x 36" x 10", with a gap length of 16.5". The gap volume was 1584 cu. inches, and the density at the center of the gap was 1100 gauss.

Approximately 500,000 ampere turns were required to magnetize the big unit, which was shipped magnetized and keepered. It was designed for use in auxiliary equipment serving a breeder reactor for the Argonne National Laboratory, operated by the University of Chicago for the U.S. Atomic Energy Commission. Actual service is in an electro-magnetic pump for pumping fluid metals.

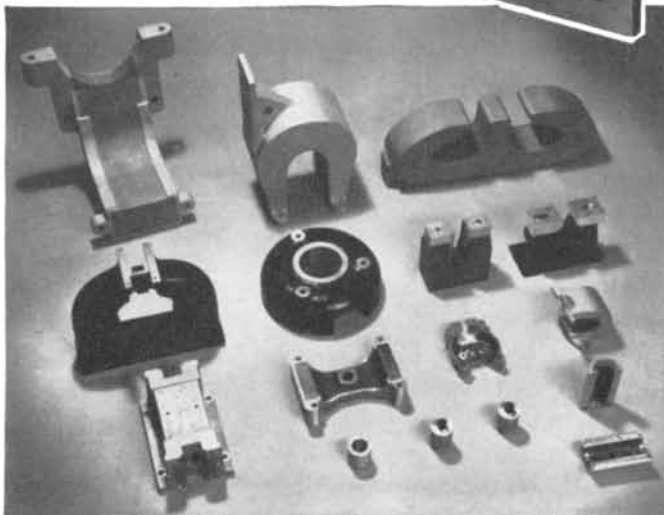
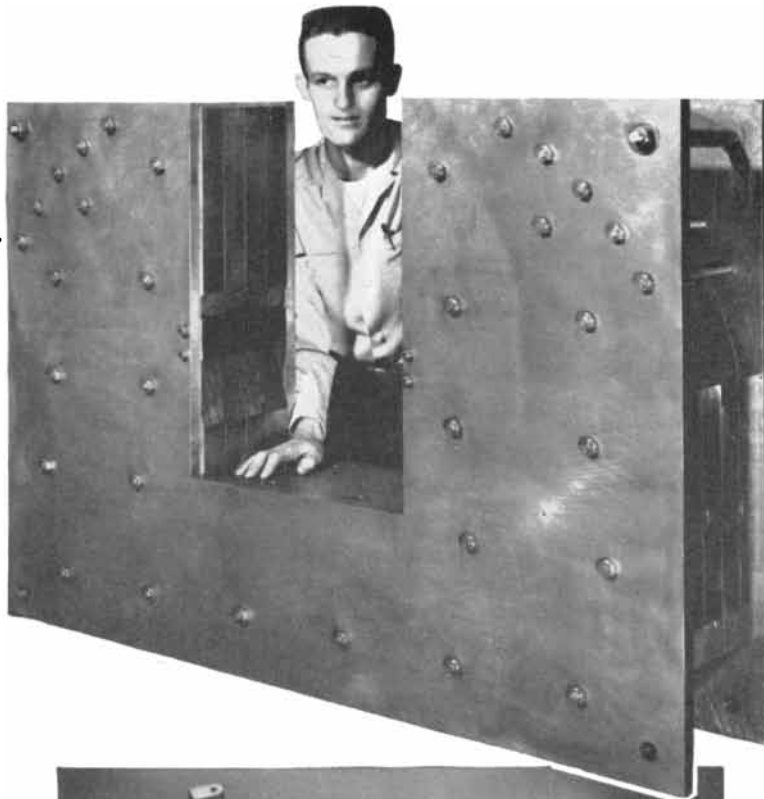
Vital Suggestion for Your Requirements

The facilities and wealth of experience that produced this world's largest permanent magnet are ready to bring you advantages, too.

Arnold permanent magnets are available in all types of Alnico and other magnet materials, from large castings like the Argonne unit to very small sintered parts weighing less than a gram. Many sizes and types of Alnico magnets are carried in stock for immediate delivery.

Special assemblies—such as rotors, traveling wave tube and magnetron magnets, etc.—may be supplied jacketed to facilitate mounting and give added protection to the magnet. Arnold also can supply large magnet assemblies for mass spectrometer and other measuring applications, where a high degree of stability and uniformity of field is required.

● Ask for a copy of Bulletin GC-106C, for more information on Arnold permanent magnets and other products, (tape cores, powder cores, etc.) Write *The Arnold Engineering Company, Main Office and Plant, Marengo, Illinois.*

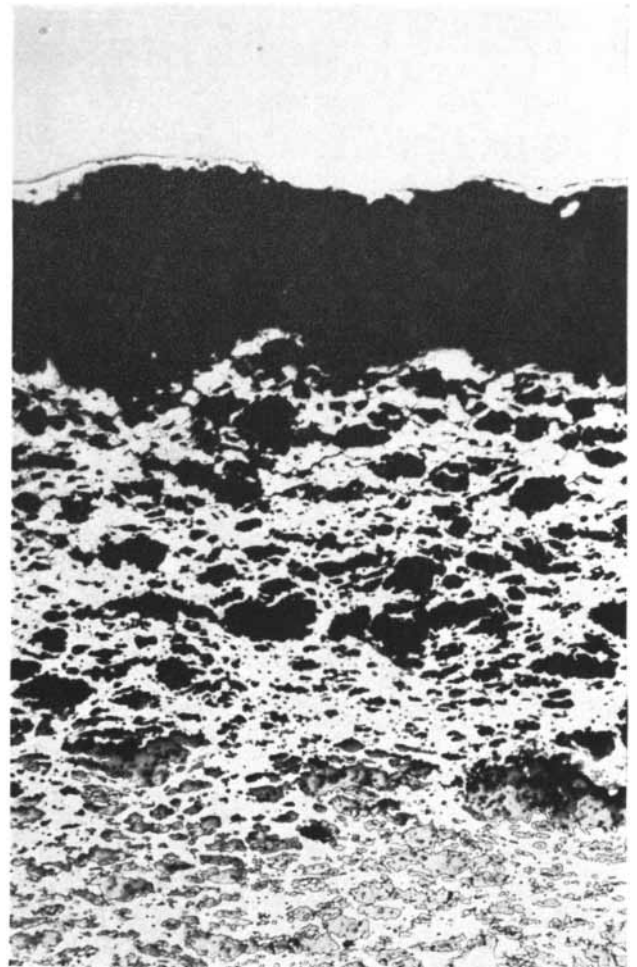
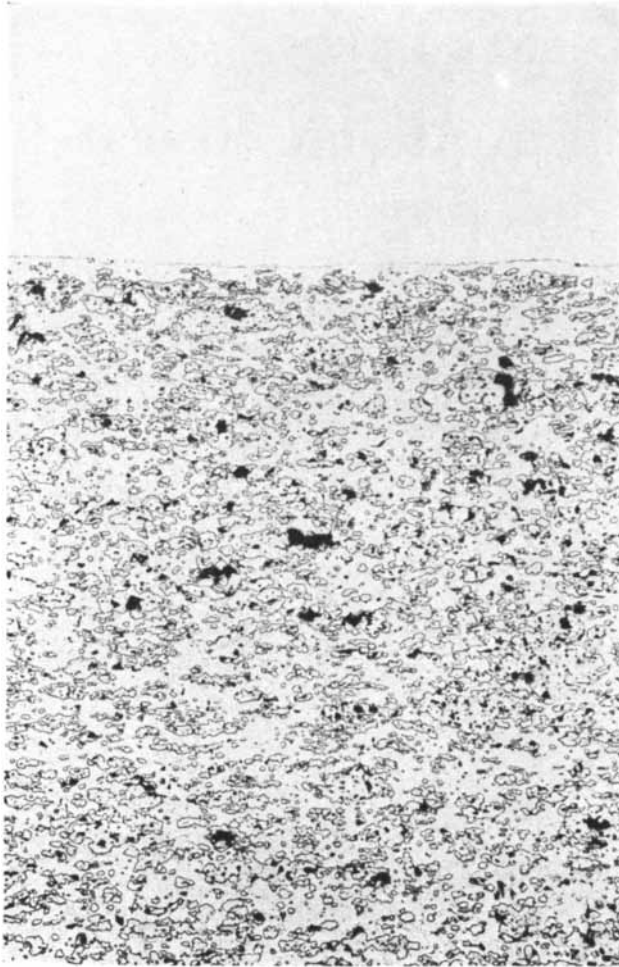


Top: the world's largest permanent magnet, built by Arnold for Argonne Labs, was designed to supply a field of 1100 gauss in a gap of 16½ inches. Bottom: a typical group of the permanent magnet assemblies that Arnold supplies for rotors, traveling wave tube, wave guide and magnetron magnets, mass spectrometer and other measuring applications, etc.

 **ARNOLD**
SPECIALISTS in MAGNETIC MATERIALS

BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES
Find them FAST in the YELLOW PAGES

ADDRESS DEPT. SA-99



RADIATION DAMAGE to reactor control rod is illustrated in these photomicrographs (magnification 100 diameters). Unirradiated rod (left) consists of boron granules in iron, encased in a

sheath of stainless steel (top). Neutrons from reactor transmute boron to lithium and helium (right). Expanding helium bubbles (dark areas) cause rod to swell and separate steel jacket from it.

of construction, reactor scientists and engineers have had to contend with these effects in materials that must also stand up under extreme conditions of temperature, corrosion and, at times, pressure. From the beginning, therefore, they have been exposing inorganic crystalline solids to the flux of the reactor and studying the consequences in terms of strength, electrical conductivity and other significant properties. These investigations have now laid the basis for an entirely new experimental approach to fundamental questions about the solid state.

Until the advent of the nuclear reactor the metallurgist depended upon the same three methods for altering the properties of his materials that were known to the smiths of the Bronze Age. These are the introduction of impurities, or alloying; plastic deformation, by hot-forging or cold-working; and heat-treating, by slow cooling or fast quenching. Irradiation now gives the art and science of metallurgy a fourth technique, one

that can accomplish some of the same effects as each of the others but one that affords unexampled control over the variables in the experiment. In the traditional techniques the entire mass of the material under study is necessarily involved. With high-energy radiation, events involving a single atom or a few atoms at a time may be observed and known degrees of alteration may be effected in the material.

Metals derive their characteristics both from the perfection and the imperfection of their internal structures. Just below the macroscopic level that we see and touch is the so-called microstructure, that is, the small crystals or grains which become visible at magnifications of 100 or 200 diameters. This structure resembles a flagstone pavement. The irregularly shaped crystals fit fairly closely; such impurity grains as may be present appear as pebbles between the flagstones. At the atomic level the internal structure of each crystal is more regular. Here, in

the precise geometrical array of the lattice, are ranks and files of atoms in perpetual thermal vibration, and, whirling tightly about each, a complement of electrons. Pervading the entire space of the metallic crystal lattice is a "gas" of free electrons which binds the atomic nuclei together and which also gives the metal its characteristic conductivity. Here and there an atom of an alloying metal or impurity may occupy a lattice site and warp neighboring atoms in the lattice out of position. Elsewhere a lattice site may be vacant, and the surrounding atoms move slightly into the vacancy, partially filling it. An occasional atom may be forced into an interstitial position between the ranks and files of atoms, placing the basic periodic structure under strain and forcing adjacent atoms slightly out of place.

The stage is now set for the action of a high-energy particle. When a fast neutron, traveling with a million electron volts of energy, hurtles into a

One of the leading figures in nuclear reactor development in this country, J. M. Harrer, MSE, participated in the Geneva Conferences and similar nuclear activities in Norway, France, Italy and Australia. He is Chairman, Chicago Section of the American Nuclear Society, Chairman of the AIEE Subcommittee of Reactor Instrumentation, and a member of 12 other nuclear groups. He is presently Associate Director, Reactor Engineering Division, Argonne National Laboratory which is operated by the University of Chicago for the AEC.

His problem:

To develop an economically practical nuclear power reactor

*The name of this
scientific American:*

*J. M. Harrer,
Argonne National Laboratory*



"In our search for an economically feasible nuclear reactor, we have reasoned that if we can learn to bring together the rare elements of human know-how at the right time—and under the right conditions—we'll release a chain reaction of ideas that lead to a successful design." So comments J. M. Harrer, Associate Director of Reactor Engineering, Argonne National Laboratory, Lemont, Ill.

Harrer's emphasis on human resources has produced results. His staff, working with control engineers, has been able to automatically position the reactor control rods which function as throttles in

keeping reactor output at the required level. His team has also developed a highly desirable "zero steam bypass" for boiling water reactors which saves the significant percentage of reactor output formerly used as a control "cushion."

Other reactor engineering accomplishments of the Argonne facility include: first significant amount of electric power from a nuclear reactor, first atomic power to light an entire town, first completely integrated breeder reactor . . . as well as basic development for military reactors. Advances such as these bring America much closer to the reality of economical nuclear power.

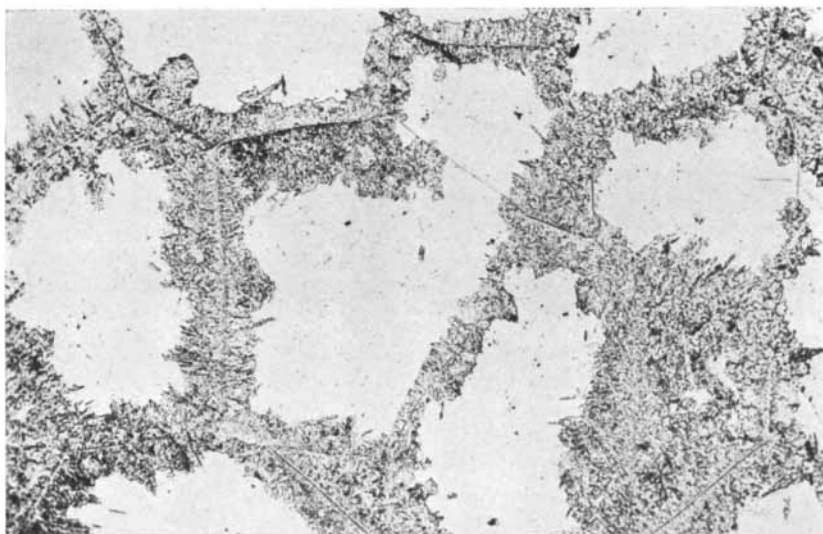
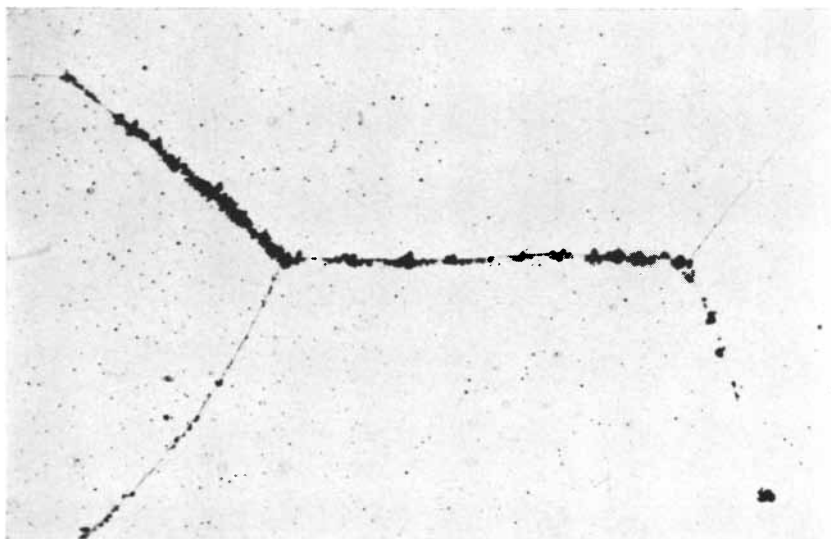
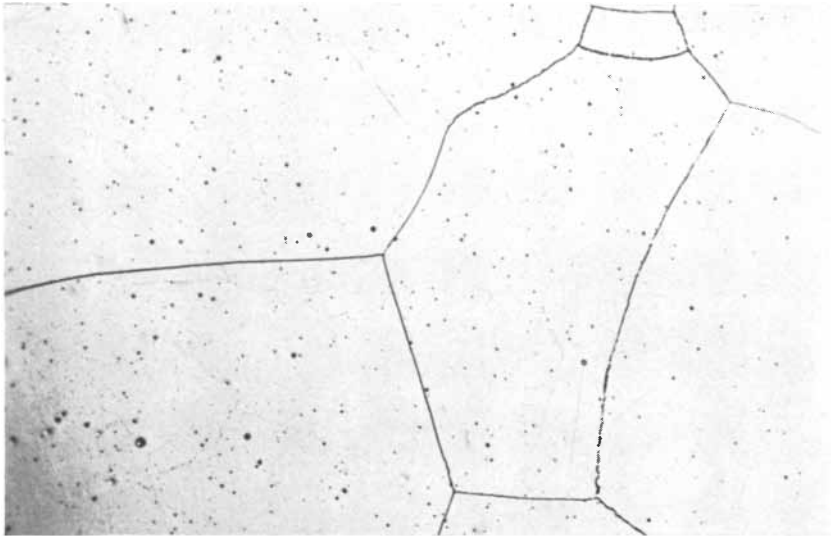
Leeds & Northrup men work closely with Harrer's team of scientists, converting ideas into controls that do the required job . . . frequently in unexplored areas of the nuclear control science.

Look closely at the many L&N installations in the atomic energy field . . . in any major industry . . . and you'll see the kind of quality which scientifically-minded leaders respect.



LEEDS & NORTHROP
4935 STENTON AVE. PHILADELPHIA 44

QUALITY systems engineering



PHASE PRECIPITATION of beryllium from a nickel-beryllium alloy is illustrated in these photomicrographs. Crystal grains magnified 250 diameters (*top*) are supersaturated with beryllium. Heating causes excess beryllium to precipitate along grain boundaries. Successive stages of the process are seen magnified 250 diameters (*middle*) and 100 diameters (*bottom*). The same effect can be produced in a copper-beryllium alloy by radiation.

crystal lattice and collides with an atom, it bounces off like a billiard ball. The atom recoils violently (in a typical metal such as copper its energy may be as much as 60,000 electron volts) and leaves behind a vacancy. As it rushes through the lattice, its high velocity reduces the probability of interaction with other atoms, in effect making them smaller [see illustration on page 200]. The migrant atom expends a great deal of energy tearing away the outermost electrons from the atoms it fleetingly encounters. This is ionization, but the few electrons thus freed make an insignificant addition to the gas of electrons that pervades the metal. The still-recoiling atom expends more of its energy exciting other electrons, making them jump momentarily from inner to outer orbits around the lattice atoms. These encounters slow its headlong flight sufficiently to give interatomic forces more time to act. The atom now begins a series of collisions with other atoms that sends them recoiling into collisions with still others. With the remainder of its energy the migrant atom sets the last atoms along its path into heightened thermal vibration and thus, in a burst of heat, it forces itself into an interstitial position in the lattice. Meanwhile the neutron has set other atoms in the lattice off on similar careers, directly and indirectly knocking hundreds of atoms out of their positions before it expends its energy.

From this account of the action of a single particle, it is clear that radiation must heighten those properties of a solid which derive from its imperfections, that is, from the presence of vacancies and interstitials in the lattice. Such lattice-defects explain many of the important and interesting properties of metals that are inexplicable in terms of an ideal lattice. The introduction of defects into metals by means of irradiation is now confronting theory with a rich new realm of observation.

One phenomenon in metals which depends upon vacancies and which is affected by irradiation is diffusion, the process by which atoms of various kinds mix. When copper and zinc, for example, are placed in good contact and heated, the atoms of the two metals intermingle in the zone of contact, with the result that the two metals may even be welded together. The concept of a perfect, rigid lattice had indicated that the energy required for one atom to force its way past another was too high to account for the rapidity with which welding takes place. The notion of the vacant lattice-site, however, furnishes an excellent mecha-



Are all
low-price
computers
small-scale?

Answer: **All but this one.**

Here is a *medium*-scale general purpose digital computer, and the only small-scale thing about it is the price. It's the low-price Bendix G-15.

Part of the remarkable success of the G-15 is due to that low price. One user writes, ". . . the nearest competitor to the G-15 costs five times as much."

There are many other reasons hundreds of computer experts have chosen the G-15. Versatility is one. The G-15 can handle problems encountered in any business or industry — from accounting to engineering to pure research. Also, simplified programming methods allow your engineers or scientists to solve their own problems on the computer.

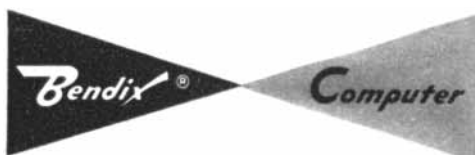
A broad line of accessories means the G-15 is expandable. As the work increases, you can add magnetic tape units, punched card equipment, and other accessories. Don't forget, however, that the basic G-15, with its photoelectric paper tape reader-punch and electric typewriter, is more than adequate for most problems.

Other features you will like are: true alphanumeric input-output, high internal speed, buffering, large program library and user's exchange group, and fast nation-wide service.

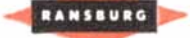
Complete details will be sent upon request. Mention specific problems where the G-15 may be helpful, and we will be glad to advise you.

DIVISION, DEPT. C-14, LOS ANGELES 45, CALIFORNIA

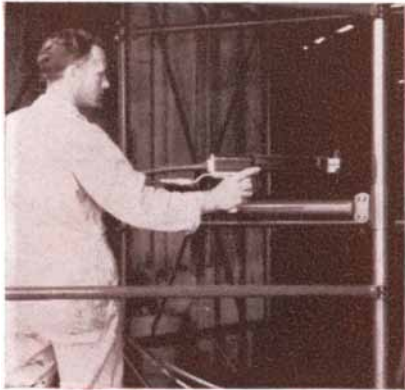
Experienced programmers, sales and service personnel . . . share our growth. Contact O. P. Staderman, Director of Marketing.



**FASTER...CLEANER...
MORE ECONOMICAL
WHEN YOU PAINT
WITH THE**



Electrostatic Hand Gun



Gator Boat transport trailers are painted in less than half the time—with half the paint—with the new Ransburg Electrostatic Hand Gun.

For instance

Peterson Bros., Inc., Jacksonville, Florida and Ft. Wayne, Indiana, world's largest manufacturer of boat trailers for the Marine Industry, switched from air hand spray to Ransburg No. 2 Process Electrostatic Hand Gun at the Fort Wayne operation in the finishing of their big custom line boat trailers and their Gator line of Marine Trades Equipment.

Paint saving with the Ransburg Hand Gun is estimated at 50 to 60% over the former method. Construction of their products (they use a lot of tubular steel) is ideal for Hand Gun application because of the "wrap-around" characteristic of Electro-Spray.

Painting is done now in an open spray room where two water-wash booths stand idle. Not needed! Maintenance in the paint room has been reduced 75%, for where they used to have to clean up the room sometimes twice a week (mostly on overtime) it now goes two or three weeks without cleanup.

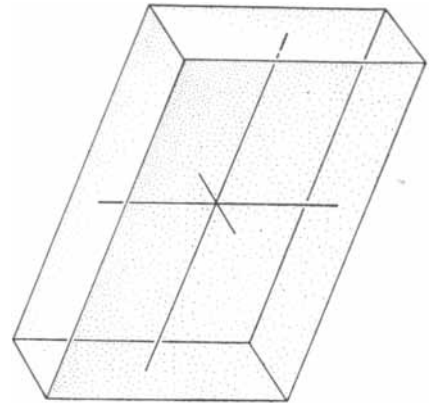
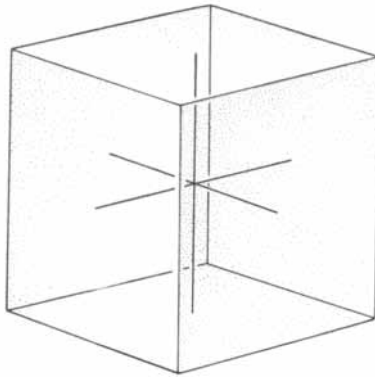
One of Peterson's biggest products now painted electrostatically is a boat transport trailer, Model 807, built to haul six 16-ft. runabout boats. The trailers are over 31-feet long; overall height is 11'-2" and almost 8' wide. With air spray, it used to take 8 hours, or more, to paint the big vehicles. Now, with Ransburg No. 2 Process Electrostatic Hand Gun, one operator does the job in only 3½ hours. And, with half the paint!

NO REASON WHY YOU CAN'T DO IT, TOO!

Write for information and literature about this revolutionary, new painting tool. See how the Electrostatic Hand Gun can save time . . . paint . . . and cut costs in YOUR finishing department. If your production justifies conveyorized painting, it'll pay you to investigate Ransburg's automatic electrostatic spray painting equipment. Write for our No. 2 Process brochure which shows numerous examples of modern production painting in both large and small plants.

RANSBURG
Electro-Coating Corp.

Box-23122, Adv. Dept., Indianapolis 23, Indiana



CRYSTAL LATTICE consists of repetitions of a basic atomic arrangement, or unit cell. Two of the possible structures are shown here: cubic (left) and monoclinic (right).

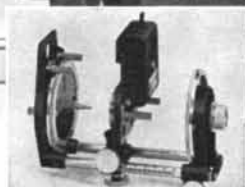
nism for diffusion. Instead of forcing its way past the next atom, an atom has merely to move into a vacancy left by that atom; in doing so, it creates a vacancy for the atom in line behind it, and so on. Since heat increases the vibrations of atoms at their lattice sites and thereby encourages them to create vacancies, it is easy to see why heat promotes the welding of copper and zinc. In fact, zinc diffuses into copper about 100 million million times faster at 300 degrees centigrade than it does at room temperature. Irradiation similarly enhances diffusion. During nuclear bombardment at low temperatures, the intermingling of the atoms of zinc and copper proceeds at a rate characteristic of much higher temperatures. In other words, under bombardment the solid acts hotter than it really is.

Another property that may be modified by the creation of vacancies is the geometry of the crystal structure itself. If copper is alloyed, for example, with beryllium in the ratio of seven copper atoms to each atom of beryllium, the solid solution of the two elements at room temperature contains two distinct cubic lattice-structures, or phases. One, the so-called alpha phase, is a face-centered cubic crystal (a cube with atoms at the center of each face and at each corner); the other, the beta-prime phase, is a body-centered cubic crystal (one with an atom in the center of the cube and others at each corner). When the temperature of this alloy is raised to 850 degrees centigrade, all the beryllium atoms go into solution with the copper, joining with them in the alpha phase. If the alloy is now rapidly cooled, as by quenching, the solution becomes supersaturated and the alloy is "frozen" in the alpha phase. The atoms will not move from their positions because their thermal

vibrations at room temperature do not give them enough mobility to rearrange themselves into the beta-prime phase in less than 1,000 years. But if the material is now exposed to neutron bombardment in a reactor, the introduction of vacancies causes the excess beryllium to leave the alpha phase and precipitate in the beta-prime phase, as though 1,000 years had passed or heat had been applied.

At the Oak Ridge National Laboratory and other centers a similar process has been demonstrated in an alloy containing three atoms of copper to one of gold. The alloy is exposed to irradiation in the "disordered" condition, that is, with the atoms of copper and gold occupying random positions in the face-centered cubic lattice. Under irradiation the copper atoms take positions on the faces of the cubes, while the gold atoms assume corner positions. The same transformation can be achieved by heating. But the alloy assumes this "ordered" configuration at much lower temperatures under neutron bombardment. Investigations at the Brookhaven National Laboratory have shown that the crystallographic rearrangement that converts white tin into gray tin can also be accelerated by irradiation. There now seems to be no doubt that irradiation introduces vacancies in crystal structures. Thus a process that is either too slow to observe at room temperature or too fast to observe at higher temperatures may now be brought under experimental control and observation.

The interstitial atoms, as well as the vacancies they leave behind, play a decisive role in the behavior of metals, notably in their plasticity. Crystals owe this quality in part to the presence of extra and incomplete planes of atoms in their lattices. Under shearing stress, which itself may multiply their number,



FLAT CAMERA



CYLINDRICAL CAMERA



GUINIER CAMERA



STRESS CAMERA



STEREO-MICROCAMERA

NOW FOR AS LITTLE AS \$4,000 !

Complete RCA X-Ray Diffraction Equipment for all Types of Film Studies

Think of it—a complete x-ray diffraction facility for film studies can be yours now for less than \$4,000.00. A typical installation could include: a Crystalloflex II X-Ray Diffraction Generator complete with two powder cameras, a flat camera, and a stereo-microcamera, a copper target x-ray tube and camera carriers. Other combinations, with prices varying according to the selection, could include both one and two radian cylindrical cameras, flat cameras and the very versatile 70mm. film with one radian cylindrical camera which can be used for powder diffraction, symmetrical back reflection work and rotating crystal layer line diagrams. A wide variety of additional cameras, x-ray tubes with other targets, and attachments for special specimen handling are also available.

Cameras used with the Crystalloflex II can be operated simultaneously at four x-ray ports, each of which is equipped with an individually timed shutter. Rating of this compact table model is 25 to 60 KV in 5 KV steps. Tube current control is continuous from 0 to 40ma. Overall size of the unit is 24" wide x 32" high x 22" deep. The Crystalloflex II can also be tilted so that the tube may be operated horizontally. All these features make this generator an excellent tool for chemists, metallurgists, physicists and biologists whose research projects usually entail a high volume and wide variety of film work.

RCA also offers the Crystalloflex IV console model generator, and the world's most complete line of attachments and accessories for x-ray diffraction and spectroscopy including an exceptionally versatile group of cameras, pole figure goniometer, single crystal layer line and micro-fluorescence attachments.

Contract services on RCA X-Ray diffraction equipment and electron microscopes are available through eleven regional offices of the RCA Service Company.

For more information about this advanced equipment or a quotation on your requirements, write: Radio Corporation of America, Dept. Y-111, Building 15-1, Camden, N.J.



RADIO CORPORATION of AMERICA
CAMDEN 2, N. J.



DICK ELLIOTT
Hayes Sales Engineer
and General Sales Manager
 personally invites you to

“SOLVE YOUR HEAT TREAT PROBLEM IN OUR LAB”

Ever since 1918, C. I. Hayes has maintained a laboratory of the latest *production-line* furnaces and allied equipment (not lab models) on which actual heat treating processes can be duplicated and evaluated. Here you can take an active part in developing the best heat treat procedure for your needs. You participate in developing equipment that's exactly right for your work.

CUSTOMERS ARE WELCOME to make use of the lab without cost or obligation. Hayes equipment *plus* our engineering know-how *plus* the Hayes library of case histories — this combination is ready to help you solve your problems . . . either with standard or special furnaces.



HAYES SHOWED THE WAY — others followed. There are several “Chinese copies” of the Hayes lab in industry today . . . proof positive that the right way to solve heat treat problems is the Hayes way — by experimentation and demonstration — not by “sweet talk”.



WANT RESULTS GUARANTEED? Won't you please take advantage of our lab and its range of furnaces and atmosphere generators . . . whether you're hardening low carbon steel, sintering refractory metals, or brazing stainless. Let us show you how to improve your product, reduce costs, and speed production.

BULLETIN 1961 gives full lab details . . . write for your copy today.

C. I. HAYES, INC.

Established 1905

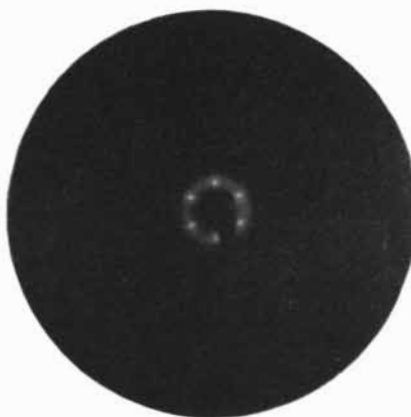
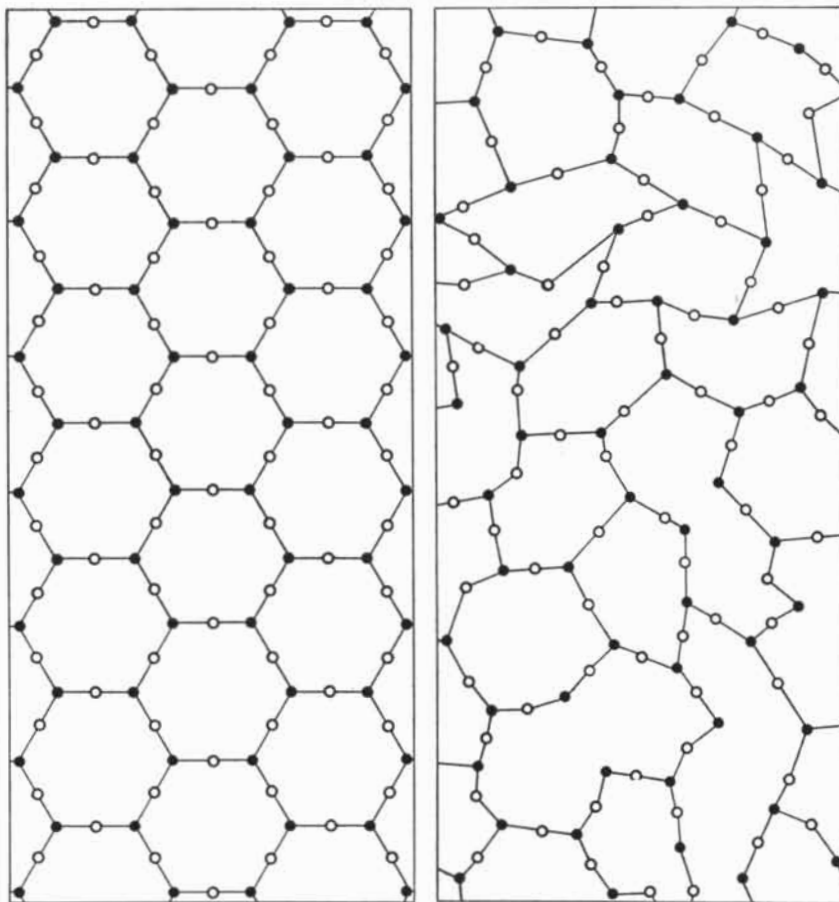
835 WELLINGTON AVE. • CRANSTON 10, R. I.



It pays to see HAYES for metallurgical guidance, lab. facilities, furnaces, atms. generators, gas and fluid dryers.

these “dislocations” travel through the lattice by successively displacing adjacent planes, thus permitting the stress to be exerted against one lattice plane at a time. In the absence of dislocations, the stress would have to move all the lattice planes simultaneously. Now lattice defects may cancel the effects of

dislocations. An interstitial or vacancy in the plane along which the dislocation moves will impede the movement of the dislocation and thus will tend to strengthen the crystal. Neutron bombardment introduces interstitials and vacancies, and by doing so can increase the strength of metal crystals—in the case



QUARTZ CRYSTAL-LATTICE is destroyed by radiation. Orderly arrangement of silicon atoms (solid dots) and oxygen atoms (open dots) in a normal crystal (top left) produces the X-ray diffraction pattern of bright spots in the photograph (bottom left). Irradiating the crystal breaks some interatomic bonds and displaces atoms (top right). Because disordered structure can no longer diffract X-rays coherently the pattern disappears (bottom right).

DESIGNED IN CELANESE FORTIFLEX...



CONTAINER FOR VAPORIZER
Molded in Fortiflex for General Electric, Bridgeport, Conn.,
by Air Formed Products Corporation, Nashua, N. H.

Blow molded plastic puts steam in vaporizer design

Sometimes a material and a process make a natural team—as in the case of Fortiflex linear polyethylene and blow molding. Together, they make it possible to redesign products for better quality and greater economy.

For example, Celanese Fortiflex provides increased safety in this blow molded bottle for a new G.E. vaporizer. The sturdy, rigid bottle is unbreakable and heat resistant. It withstands boiling temperatures without softening. Blow molding makes it possible to produce this difficult shape quickly and economically in large-scale production. Eliminated are such expensive requirements as interior matching cores commonly used in the injection molding of hollow objects. With a capacity of nearly a gallon, the bottle weighs little more than 12 ounces and provides steam for 12 hours without refilling. Molded-in bottle colors are pink and blue.

If you need a hollow component that has good strength, why not see whether a blow molding of Fortiflex will meet the requirements? We'll be glad to send you information on both process and material.

Celanese® Fortiflex®

Fortiflex...a Celanese plastic

Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N.Y. 16

TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS			
			A-20	A-70	A-250	A-500
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	-200	-180	-160	-100
Impact Strength, izod. (1/4" x 1/2" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile		%	25	25	25	25
Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	n _D ²⁵	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	150,000
Water Absorption (1/8" specimen, 24 hr. immersion @ room temp.)	D-570-54T	% wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0
*Mold Shrinkage, length		in./in.	0.03 to 0.05
width		in./in.	0.02 to 0.04

Measured on injection molded tensile bar. Mold shrinkage depends on part design and molding conditions.

Celanese Corporation of America, Plastics Division,
Dept. 151-S, 744 Broad Street, Newark 2, N. J.

Please send: more information on, test quantities of Fortiflex.

Name _____ Title _____

Company _____

Address _____

City _____ State _____



Reliability is a most important characteristic of KENNAMETAL*

One of the most important contributions made by Kennametal to any project is *reliable performance* . . . delivering the expected service under given conditions. That's why Kennametal is used more and more where it is found or feared that other materials just aren't good enough.

DEPENDABLE resistance to abrasion . . . for such parts as spray nozzles, seal rings, bushings, pulverizing hammers, compacting dies, non-lubricated guides and gripping jaw applications.

DEPENDABLE resistance to corrosion, cavitation and wear . . . vital parts for valving and hydraulic systems, parts for chemical processing equipment exposed to mineral acids, red fuming nitric acid, slurries and similar highly corrosive agents.

DEPENDABLE strength at high temperatures . . . Kentanium* compositions for gas turbine components, sensing elements for jet stream thermostatic controls, parts to handle glass in semi-plastic state, flame burner tips, hot rod mill guides, tip wear rings for scarfing torches. Kentanium retains high strength at temperatures to 2200°F—high stiffness/weight ratio.

DEPENDABLE resistance to deformation . . . spindles for precision grinding, grooving blades, boring bars, compressor cylinder liners and components for high pressure valves. (Kennametal has a YME up to 94 million psi . . . 3 times that of hardest steel.)

For more information, send for: Booklet B-111A, "Characteristics of Kennametal" and Booklet B-444A, "Kentanium."

Write to KENNAMETAL INC., Department SA, Latrobe, Pennsylvania.

7231

*Trademark



of copper multiplying its flow-resistance 10-fold.

But at the same time that irradiation increases the strength of metals, it decreases their electrical conductivity. Any departure from perfect order in the crystal lattice—such as impurity atoms, interstitials or vacancies—increases the scattering of electrons and thus interferes with their ordered flow in an electric current. The effect of irradiation is demonstrated by the results of experiments performed at low temperature in a reactor at Oak Ridge. Ordinarily reduction of the temperature of copper, or other conductors, increases their conductivity; with the thermal vibrations of the lattice atoms reduced, the scattering of electrons is correspondingly reduced and current flows more freely. Neutron irradiation reverses this low-temperature effect. The conductivity of copper at four degrees absolute (degrees centigrade above absolute zero) has been reduced by 90 per cent under neutron bombardment in the reactor.

Subsequent warming of the metal restores most of its conductivity. Because the interstitials are in the most unstable configuration, their increased thermal vibration gives them enough mobility to return to the normal, and more stable, positions in lattice sites, annihilating the corresponding vacancies. In effect the interstitials introduced by irradiation at low temperature are frozen in. Careful reheating "thaws" them slowly, making it possible to observe the return of conductivity.

Atoms of an impurity or alloying metal have an effect on conductivity similar to that of interstitials or vacancies. All alloys of copper, for example, exhibit a conductivity lower than that of copper itself. The different electronic structure of the impurity atom distorts the regularity of the lattice, causing electron scatter.

Impurities have the opposite effect in semiconductors, which have a paucity of free electrons to begin with. A properly selected impurity (a "donor") will contribute extra electrons to the number of the electrons in the material and thus enhance conductivity. Certain semiconductors, by the same token, show a large change in conductivity when they are irradiated; interstitial atoms may ionize, thereby increasing the number of electrons free to move in an applied electric field. In those semiconductors which carry current by the organized motion of "holes," irradiation generates free electrons by ionization which disorganizes the motion of the holes and decreases conductivity in much the same way as

crystal defects scatter the current-carrying electrons in a conductor. Thus though the ionizing effect of radiation is of small consequence in metals, it does significantly affect the properties of semiconductors.

The ionizing effect of radiation is important also in ionic and covalent crystals. When sodium chloride, an ionic solid, is exposed to X-rays, the crystal rapidly darkens and may even become opaque. The effect can be explained in part by other factors, but one must conclude that ionization also plays a role. Ionization causes a pronounced change in the structure of covalent crystals such as quartz and diamond. These crystals are bound together by valence electrons that form a precise pattern of bonds, producing highly symmetrical lattice structures. Neutron bombardment knocks whole atoms from their lattice positions, and these atoms, by ionizing the covalent bonds, disrupt the orientation of other atoms in the lattice. Macroscopically the crystals remain unchanged, but X-ray diffraction photographs show that the ordered structure of the crystalline solid has given way to an amorphous structure; quartz comes to resemble silica glass and diamond is converted to a graphite-like solid.

Certain transformations that occur in the crystal structure of uranium-containing solids demonstrate another way in which irradiation may alter the properties of solids. In this case the process turns on the behavior of a single fragment ejected in the fissioning of an atom of uranium. Such a fragment is many times heavier than a neutron and it carries an electrical charge. As a result it expends most of its enormous energy ionizing and exciting the lattice atoms along its path and gives up another portion in billiard-ball collisions. The rest of its energy it transfers to a large number of atoms in near-collisions and glancing blows that do not displace them from their positions but set them in violent thermal vibration. Together these atoms act as if they had suddenly been heated to an extremely high temperature, well above 1,000 degrees C. This "thermal spike" lasts no more than one ten-billionth of a second and may involve as few as 1,000 atoms. Though its duration is short, the thermal spike lasts long enough, by the time-scale of the vibrational frequencies of atoms, to permit many processes to occur. In zirconium oxide that contains uranium as a minor impurity, tiny crystals characteristic of a high-temperature phase appear; the quick cooling of the spike apparently



Bulova assigns project authority and responsibility to one man.

The Bulova Project Manager is a customer's man. He holds full responsibility for meticulous control over every phase of a single project—including direct-line communication with the client.

Reporting directly to the President, the Bulova Project "Exec" heads up a task force of specialists specifically

assigned to his project. Though this task force changes during programming, the Exec doesn't. He's Bulova's unique single management control over that project.

Experience in precision design and precision manufacture is the Bulova tradition, the Bulova capability. It has been for over 80 years. For more information write—

Industrial and Defense Sales • Bulova, 62-10 Woodside Avenue • Woodside 77, New York





TO A PHYSICIST'S PHYSICIST

At the Atomic Power Department of Westinghouse the foremost authorities on industrial nuclear technology are endeavoring to make atomic power readily and economically available. Now, you can take part in this stimulating program to give the gift of nuclear fire to the wheels of industry. Westinghouse gives you the opportunity to gain recognition for your work and at the same time to take advantage of all the facilities of this unique laboratory. Your assignments will bring you into contact with other scientists whose interests parallel your own. In this atmosphere of scientific enlightenment there are few restrictions on information. Today, at Westinghouse you can add your contribution to this field of the future.

Working at the Atomic Power Department will enable you to take advantage of what has been called the Renaissance City of America — Pittsburgh. Here, the presence of the atomic age is strikingly evident by the number of world-renowned research centers devoted to nuclear science. In addition to all of this, you have the advantage of gracious suburban living.

SENIOR SCIENTIST . . . PhD physicist or mathematician with an unusual degree of alertness and initiative. MS in physics or mathematics with several years experience in either reactor calculations or critical experimentation.

SCIENTIST . . . PhD in physics with experience in the Atomic Field desirable, but not essential; or BS degree with 5 years experience in the nuclear field ORSORT or nuclear engineering background acceptable.

SCIENTIST . . . PhD in physics or related fields. Must have the type of personality that lends itself to LRMD work and in addition possess a high degree of creative ability.

Send resumé to Mr. C. S. Southard,
Westinghouse Atomic Power Dept., P.O. Box 355, Dept. W-34, Pittsburgh 30, Pa.

Westinghouse

FIRST IN ATOMIC POWER

prevents reversion to the low-temperature phase. What is more interesting, X-ray diffraction studies show that the crystallites of the converted phase may contain several million atoms, many more than could have been directly involved in interaction with the fission fragment. Apparently the tiny crystal that first condenses from the spike in the high-temperature phase acts as a center of nucleation which grows as adjacent atoms are incorporated into its lattice structure.

It is highly unlikely that any of the experiments thus far conducted with the effects of radiation on solids can ever be engineered into industrial processes. One can perfectly well make some metals harder and stronger by neutron irradiation. However, this is an expensive way of doing what metallurgists learned to do cheaply long ago. Even if one could afford it there would remain the hazard of radioactivity due to the transmutation of the metal or one of its impurities to a long-lived radioactive species. Residual radioactivity could be avoided by the use of electrons or gamma rays, but then one would have to settle for mere surface-hardening. This effect can be accomplished more cheaply and surely by such chemical processes as carburizing or nitriding.

It appears, then, that the principal use of radiation in industries that process inorganic solids will be X-ray photography. The future may, of course, bring uses we cannot foresee.

Meanwhile radiation promises to become an ever more productive research tool in the hands of the solid-state physicist. Great interest centers at present upon the use of radiation in combination with low temperatures. The introduction of excess vacancies and interstitials at room temperature and below makes it possible to speed up solid-state reactions that are otherwise too slow to observe. The introduction of defects at temperatures near absolute zero followed by slow-heating permits correlation of their behavior with change in any selected characteristic, under ideally controlled conditions.

Already irradiation studies have shown that some commonly accepted ideas about the nature of solids are incomplete and in some cases erroneous. They have accordingly inspired new lines of study in unirradiated solids. Since the demands of technology now exceed our basic understanding in this field, it is plain that every addition to knowledge achieved by radiation techniques will find speedy application in industry.

99.999+% Pure

INDIUM

available in ingot, stick, foil, sheet, and wire

Indium is a silvery white metal, non-tarnishable, very soft, malleable, ductile and crystalline. It is diamagnetic.

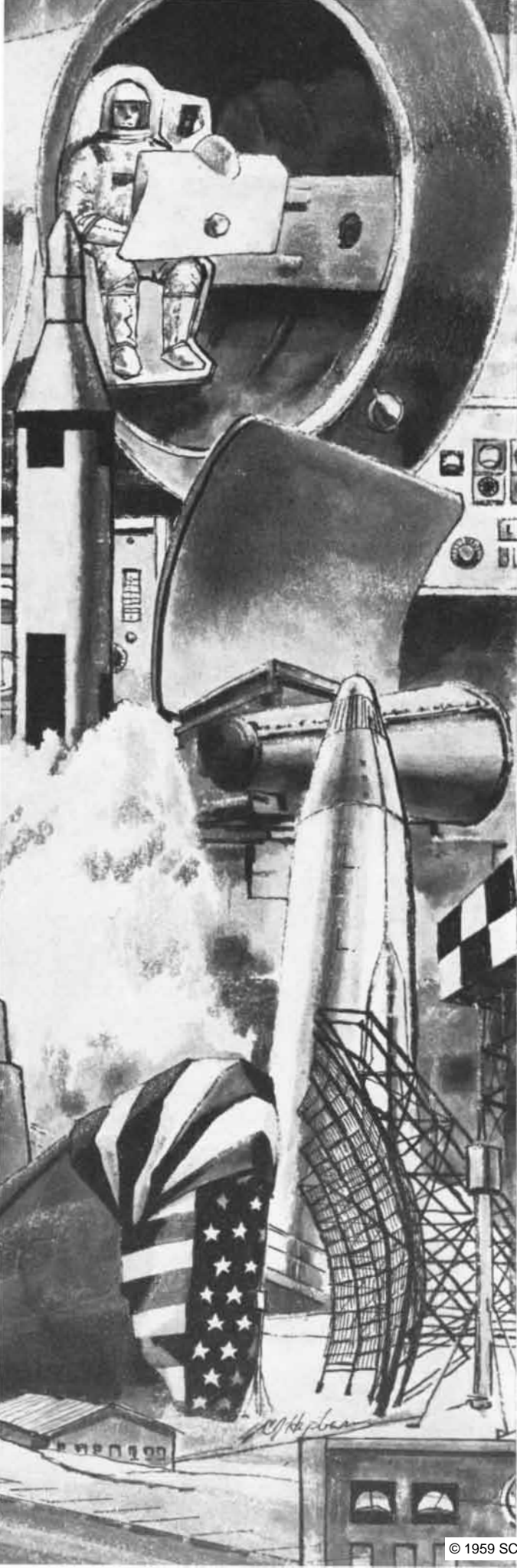
ASARCO

PHYSICAL CONSTANTS

Atomic number	49	Brinell hardness	0.9
Atomic weight	114.76	Modulus of elasticity, psi	1,570,000
Boiling point	2000°C (3632°F)	Melting point	156.17 ± .05°C (313.1 ± .1°F)
Crystal structure.....	Face-centered tetragonal	Nuclear Data	
Density at 20°C (68°F)		Stable Isotopes (113,115)	2
g/cc	7.31	Thermal neutron cross section (2200 m/s)	
lbs/cu. in.	0.264	Absorption (barns)	190 ± 10
troy ozs./cu. in.	3.85	Scattering (barns)	2.2 ± 0.5
Electrical resistivity (microhm-cm)		Solidification shrinkage	2.5%
(solid) 20°C (68°F) .....	.9	Specific heat (cal/g/°C)	
(at melting point) 156°C (313°F) .....	.29	(solid) 20°C	0.057
Electrochemical equivalent		Specific volume (cc/g)	
In +++ (mg/coulomb)	0.39641	20°C (68°F)	0.136
Electrode reduction potential		Thermal conductivity (cal/sq. cm/cm/°C/sec)	
In +++ (H ₂ = 0.0 volt)	0.34	20°C	0.057
Latent heat of fusion (cal/g)	6.8	Valence.....	Usually 3, but also 2 and 1
Latent heat of vaporization (cal/g)	468	Vapor press. (mm Hg)	
Linear coefficient of thermal expansion/1°C... ..	33 x 10 ⁻⁶	1249°C (2280°F) .....	.1
Mechanical properties:		1466°C (2671°F) .....	.10
Tensile strength, psi	380	1756°C (3193°F) .....	.100
Elongation (% in 1")	22	1863°C (3385°F) .....	.200
		1982°C (3600°F) .....	.400

For further information on ASARCO High Purity Elements, write on your company letterhead.

WRITE: AMERICAN SMELTING AND REFINING COMPANY, 120 BROADWAY, NEW YORK 5, N. Y.



*General Electric moves to
provide a more effective*

DEFENSE

Top systems management, technical talent are concentrated in Defense Systems Department with a charter geared to modern defense needs for:

- **Systems-oriented management**
- **Pinpointed authority, responsibility**
- **Full back-up resources**

RICHARD L. SHETLER
General Manager
Defense Systems Department

Richard L. Shetler is General Manager of the Defense Systems Department. One of the Company's outstanding system managers, Mr. Shetler's experience has included responsibility for some of the longest range radar systems ever built in this country.



KARSH, OTTAWA

SYSTEMS CAPABILITY

Accelerating technological change, coupled with the increased complexity and wider variety of choice of weapons and weapons systems, has profoundly altered the defense requirements on industry.

In line with this requirement, General Electric's Defense Systems Department, headquartered in Syracuse, New York, draws together under one roof, the systems capabilities and long-range planning functions required to draw on all of General Electric to provide the total solution to specific defense problems of the military departments of the Department of Defense and other government agencies.

UNIQUE SYSTEMS ORGANIZATION

The Defense Systems Department is a unique department within General Electric's Defense Electronics Division. Completely systems-oriented, DSD has no need for equipment design or fabrication facilities. While it determines the specifications to be met, the Defense Systems Department assigns design and fabrication functions to other General Electric departments or to some subcontractors among the 45,000 suppliers to General Electric.

But overall responsibility to the customer for the complete weapon or support system always remains within the Defense Systems Department. This responsibility is fulfilled through the Department's

- Systems-oriented program management
- Competent systems engineering
- Continuous program evaluation
- Efficient specification and procurement

These specific capabilities permit the Depart-

ment to deliver the total system requirement on time, with the right quality, and at the specified price.

AUTHORITY, ACCOUNTABILITY

As the focal point within the Company for a specific system effort, the Defense Systems Department program manager has complete responsibility and accountability plus the authority necessary for the timely execution of the particular program.

OUTSTANDING COMPETITIVE ADVANTAGES

The Defense Systems Department offers its customers outstanding qualifications for meeting total prime and support system requirements including long-range planning and feasibility studies. For example, it has . . .

Demonstrated systems competence: Recent examples include the highly successful radio-command guidance system for the USAF's ATLAS ICBM which precisely guided the Atlas into orbit around the earth on December 18, as part of Project SCORE.

Full back-up resources: The full range of General Electric's scientific, engineering and manufacturing skills supports DSD capabilities.

For example, the Company's research and development programs, carried on by over 100 laboratories at an annual cost of 300 million dollars, provide the depth of knowledge for vital technological break-throughs.

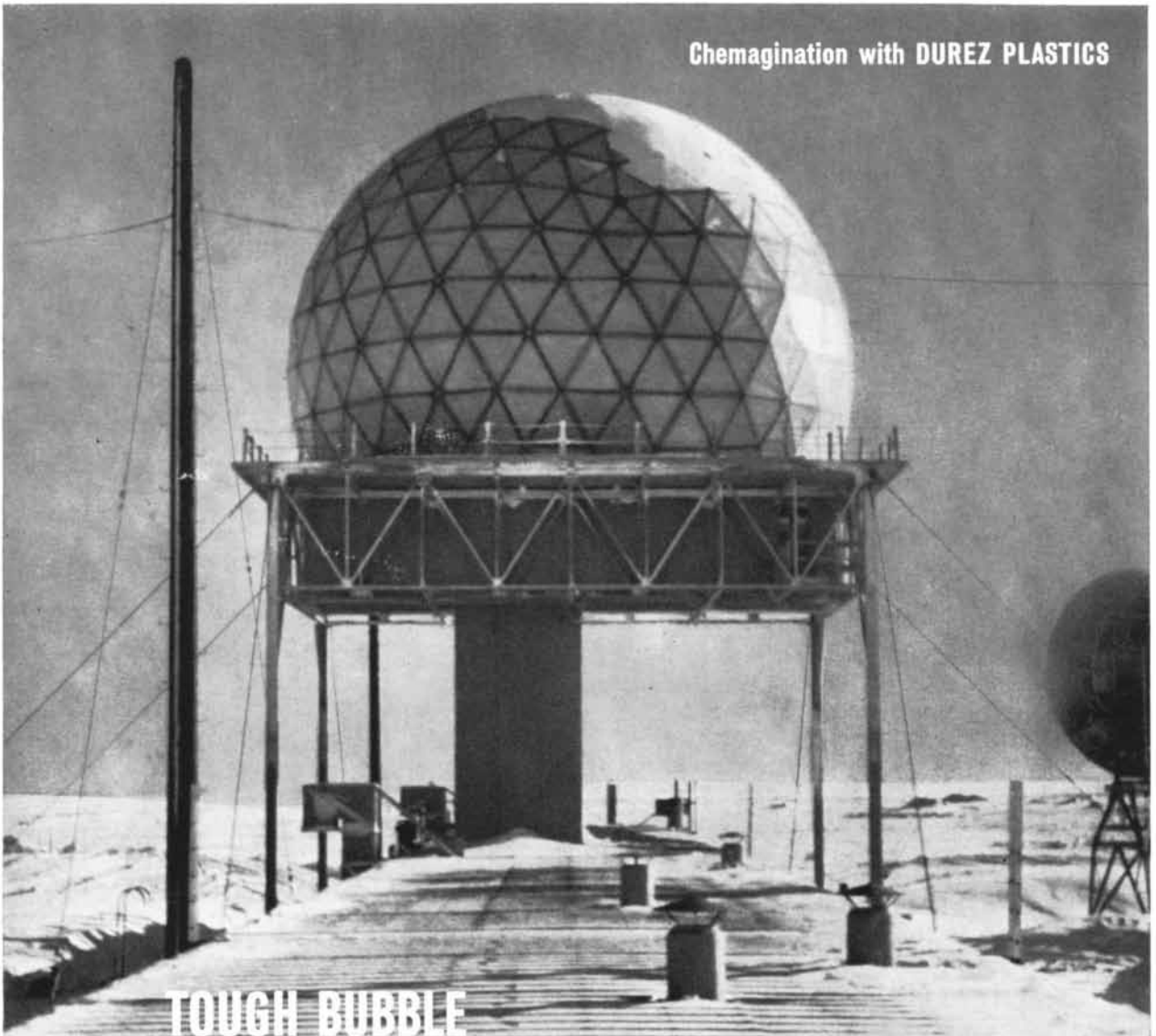
For more information—or for a copy of brochure GED-3760, describing the Department's defense systems capabilities—write to R. L. Shetler, General Manager, Defense Systems Department, P.O. Box 457, Syracuse, New York.

226-1

Progress Is Our Most Important Product

GENERAL  ELECTRIC

Chemagination with DUREZ PLASTICS



**TOUGH BUBBLE
THAT EVEN A WILLIWAW
CAN'T BURST**

Photo courtesy—International Telephone and Telegraph Corporation

Take a 150-mile-an-hour wind. Freeze it to 50 below zero. That's a williwaw.

Now raise a structure four stories high and 55 feet across. A structure to house delicate radar equipment. A structure that's *cardboard-thin* — but *doesn't waver even when a williwaw hits it*.

Do this, and you'll get an inkling of the punishment that Hetron® plastic takes in DEW-Line radar domes like the one above.

Strength isn't the only reason why Hetron was chosen for these big domes. This Durez plastic has an inherent ability to discourage fire. It can't contribute to a blaze, or cause one to spread. That's important when you're

1,000 miles from the nearest fireplug.

This unique strength-safety combination is the reason behind Hetron's wide use by government and industry — in light-diffusing windows for factories and schools; in corrosion-resistant tanks, blowers and ducts; in fire-safe luggage pods for transoceanic jet airliners; in Coast Guard lifeboats, Navy landing craft, sport cruisers, industrial utility boats.

Hetron is just one of many plastics

from Durez—plastics known the world over for their ability to solve tough problems.

If you'd like a descriptive folder on Hetron, just write us. If you're currently having problems with thermo-setting plastics, we'd appreciate the chance to give you our personal attention. Address DUREZ PLASTICS DIVISION, Hooker Chemical Corporation, 9409 Walck Road, North Tonawanda, New York.

DUREZ PLASTICS DIVISION

9409 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION



Ionizing Radiation and the Citizen

How can mankind secure the demonstrated benefits of radiation and minimize the hazards that attend it? The question assumes that the species will not exterminate itself in a nuclear war

by George W. Beadle

In a few short years the science and technology of nuclear physics have come to affect the lives of all men. As the authors of the preceding articles in this issue have made abundantly clear, the nuclear age is attended by unprecedented new risks and hazards.

By far the greatest hazard, as everyone knows, is the threat of nuclear war. Nuclear weapons could bring civilization to a catastrophic end. Yet no one seems able to find a workable formula for avoiding this danger that is at once foolproof and acceptable to all nations. To many men the complete abolition of nuclear weapons is the only sure solution. This must remain an unrealistic

hope until ways are found for extending the ban to armed conflict itself. What is to prevent nations that have not renounced war from rebuilding their armories of nuclear weapons?

In their failure to settle their differences by peaceable agreement the major nations are engaged in a mad nuclear arms race. Each hopes to deter potential enemies by the threat of instantaneous and annihilating retaliation. All know the danger of the game. None appears to see how to stop in a manner that will guarantee security for all.

Meanwhile the hazard of nuclear armament becomes progressively more grave. Existing weapons are more widely

dispersed, and the responsibility for using them is delegated to lower ranks of command. The risk of accident or poor judgment increases correspondingly. In the recent report issued by the American Academy of Arts and Sciences (*The Nth Country Problem: A World-Wide Survey of Nuclear Weapons Capabilities*) it is made clear that at least a dozen nations, in addition to the Big Three, have economic resources and manpower sufficient to arm themselves with these weapons. Will they not be tempted to enter the race in increasing numbers for national prestige if not for defense? Can they be dissuaded by any real hope of a just and effective solution? Failing this,



UNITED NATIONS SCIENTIFIC COMMITTEE on the Effects of Atomic Radiation meets periodically. A U. S. representative at

this March, 1959, session was Shields Warren (at left, chin in hand), author of "Ionizing Radiation and Medicine" in this issue.

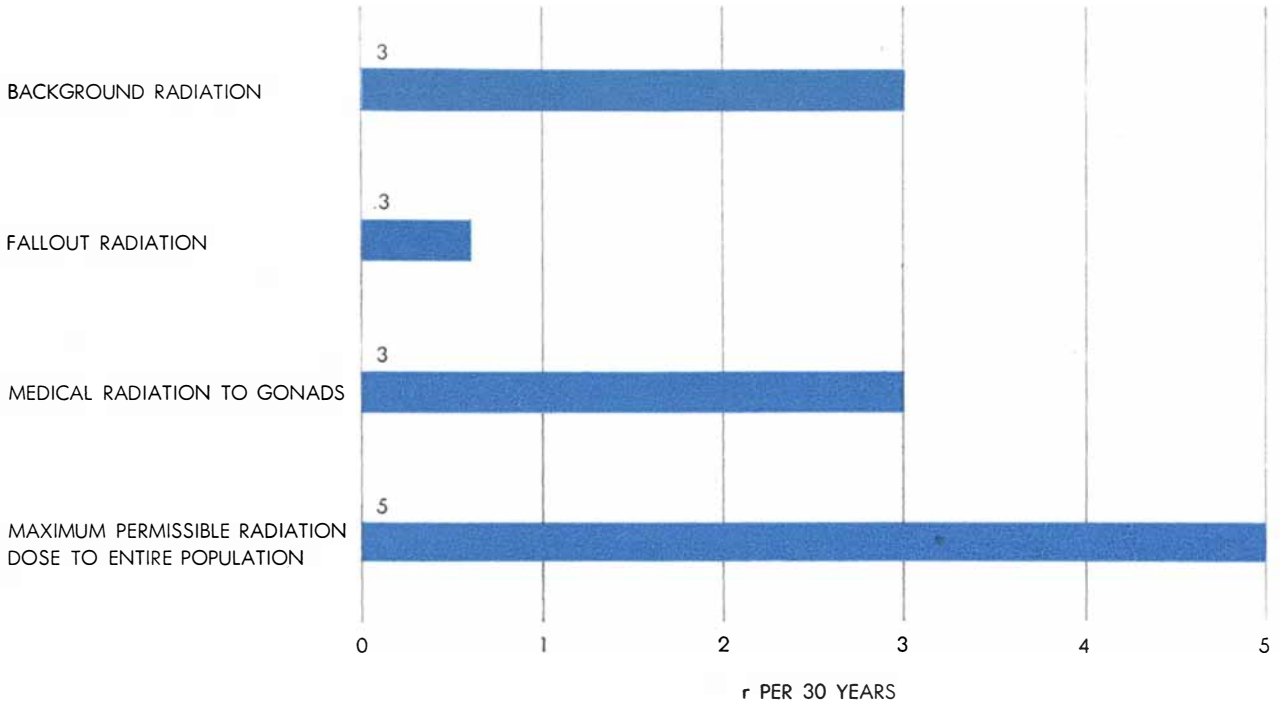
can they be convinced that they will be better off if they do not join the competition? It is true that capability of small-scale retaliation is a highly vulnerable intermediary position along the road to full retaliatory power. But will this argument carry conviction, coming

from nations that have already arrived at the latter stage, or think they have?

The only practicable solution may lie in a pedestrian step-by-step approach. Certainly the present attempts to effect a permanent ban on the testing of nuclear weapons deserve full support,

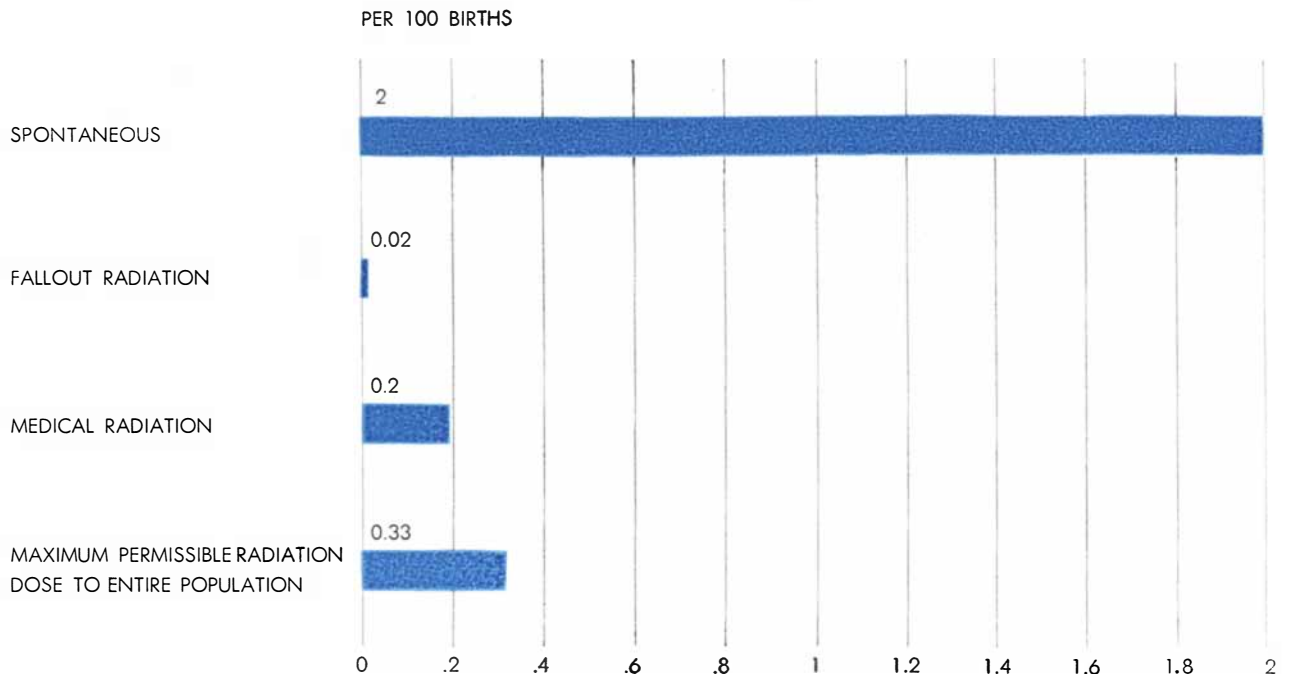
if only because this is the sole first step that appears to have a reasonable chance of acceptance.

Termination of the tests, which have increased exponentially in number for 14 years, will eliminate one nuclear hazard. The hazard of fallout is quantitatively



ESTIMATED RADIATION DOSE for average U. S. resident during reproductive years is represented by top three bars. Fallout

estimate applies only if nuclear weapons tests cease. Permissible dose at bottom is in addition to medical and background doses.



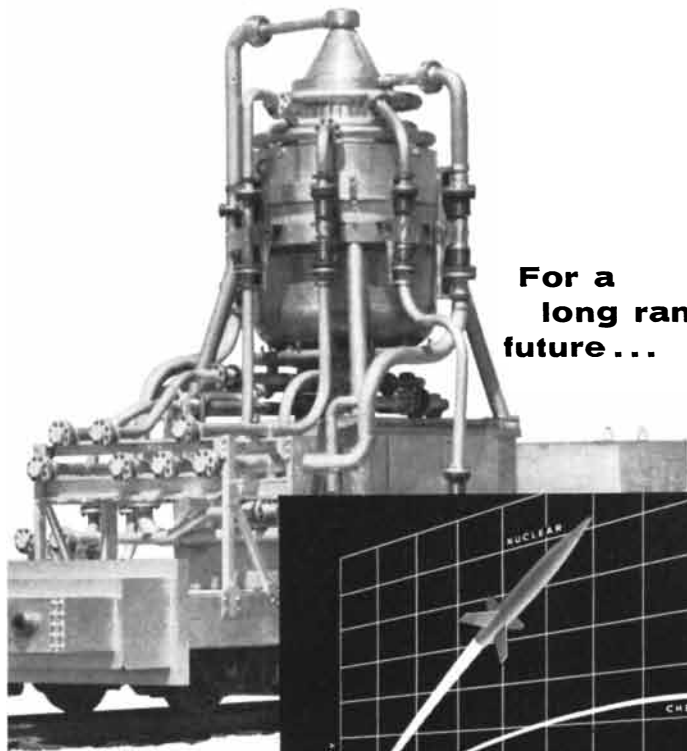
INDIVIDUALS BORN WITH NEW MUTATIONS, per 100 births, and causes of mutations are charted at left. At far right are totals

of new mutations. Background radiation is responsible for some of the spontaneous mutations. All the figures on this chart are very

small but qualitatively large, because of its embarrassing moral aspects. In addition, the mere fact of agreement will encourage negotiation on other issues.

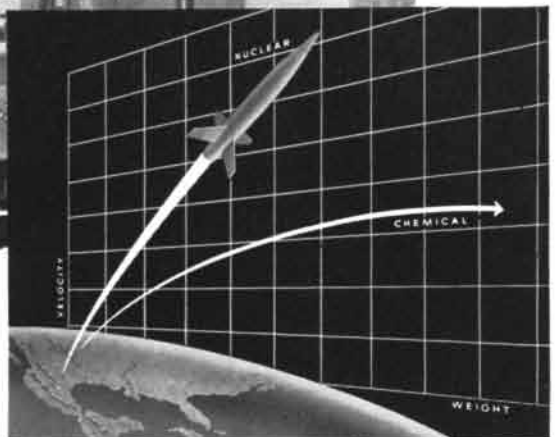
But even if we succeed in taking this step and all the ones that must follow to achieve permanent peace, we will by no means be done with the hazards of radiation. We will have greatly reduced the risk of exposing large segments of the world population to high-level radiation. But there will remain the delayed effects of fallout and the increasingly important hazards of the peacetime uses of radiation. Power-reactor accidents may occur, as they already have; the radioactive by-products and spent fuels of reactors will need to be contained and safely disposed of; radiation and radioisotopes will be finding wider use in technology as well as in scientific and industrial research. The medical profession must continue its evaluation of the risks attending diagnostic and therapeutic irradiation of patients and its efforts to reduce these risks to the essential minimum.

What are the hazards to health of ionizing radiation and how great are they in given situations? After the millions of words that have been written and spoken there remain much uncertainty and confusion in public understanding. Why is



Kiwi A

**For a
long range
future . . .**



NUCLEAR ROCKET PROPULSION

One of the most important programs at Los Alamos is Project Rover—research and development work aimed at utilizing nuclear energy for rocket propulsion. Investigations are being made in the fields of heat transfer, neutronics, fluid dynamics and rocket engine controls. Of special interest is the field testing of reactor concepts.

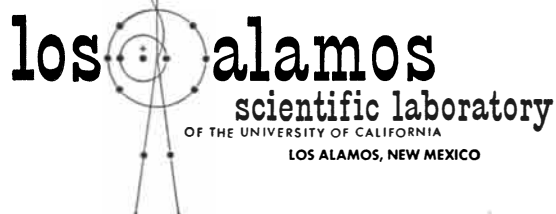
The Laboratory is interested in inquiries from physicists, physical chemists, metallurgists and engineers who wish to engage in any phase of this well-rounded research program.

Write to:

Director of
Personnel
Division 59-90

IN U. S. PER YEAR PER 4,000,000 TOTAL BIRTHS	IN WORLD PER YEAR PER 80,000,000 TOTAL BIRTHS	IN WORLD PER GENERATION PER 2,400,000,000 TOTAL BIRTHS
80,000	1,600,000	48,000,000
800	16,000	480,000
8,000	160,000	4,800,000
13,000	270,000	8,000,000

rough estimates, and are subject to at least a five-fold uncertainty in either direction.





HUMAN CHROMOSOMES are enlarged some 2,000 diameters in this photomicrograph made by J. H. Tjio and T. T. Puck at University of Colorado Medical Center. The chromosomes are from a female body cell grown in tissue culture. There are 46 of them.

it not possible to give simple answers to straightforward questions?

We are told at various times and by investigators of repute that fallout does no biological harm; that there is some damage but that it is negligible with respect to our defense needs; that present fallout levels, by producing several hundred thousand genetic mutations per generation on a world-wide basis, do enormous biological harm. Whom shall we believe?

We read in a reputable scientific journal that present and foreseeable levels of strontium 90 in human bone are unlikely to produce a single case of leukemia. But in another issue of the same journal we find it argued that the concentration of strontium 90 may already be approaching harmful levels in the bones of some individuals and may well be responsible for hundreds of new cases of leukemia in the next generation. Is there a "right" answer?

Should school children be given annual X-ray examinations? The truck continues to make its rounds and many

schools still request its services. Do the advantages outweigh the risks?

In occupational exposure to ionizing radiation, is there a zone of greater danger as exposure approaches "permissible" levels? "Permissible" implies no risk, but the maximum permissible occupational exposure is several hundred times larger than fallout exposure per given period. Is this not inconsistent with the statement that even low exposure—as from fallout—produces mutations?

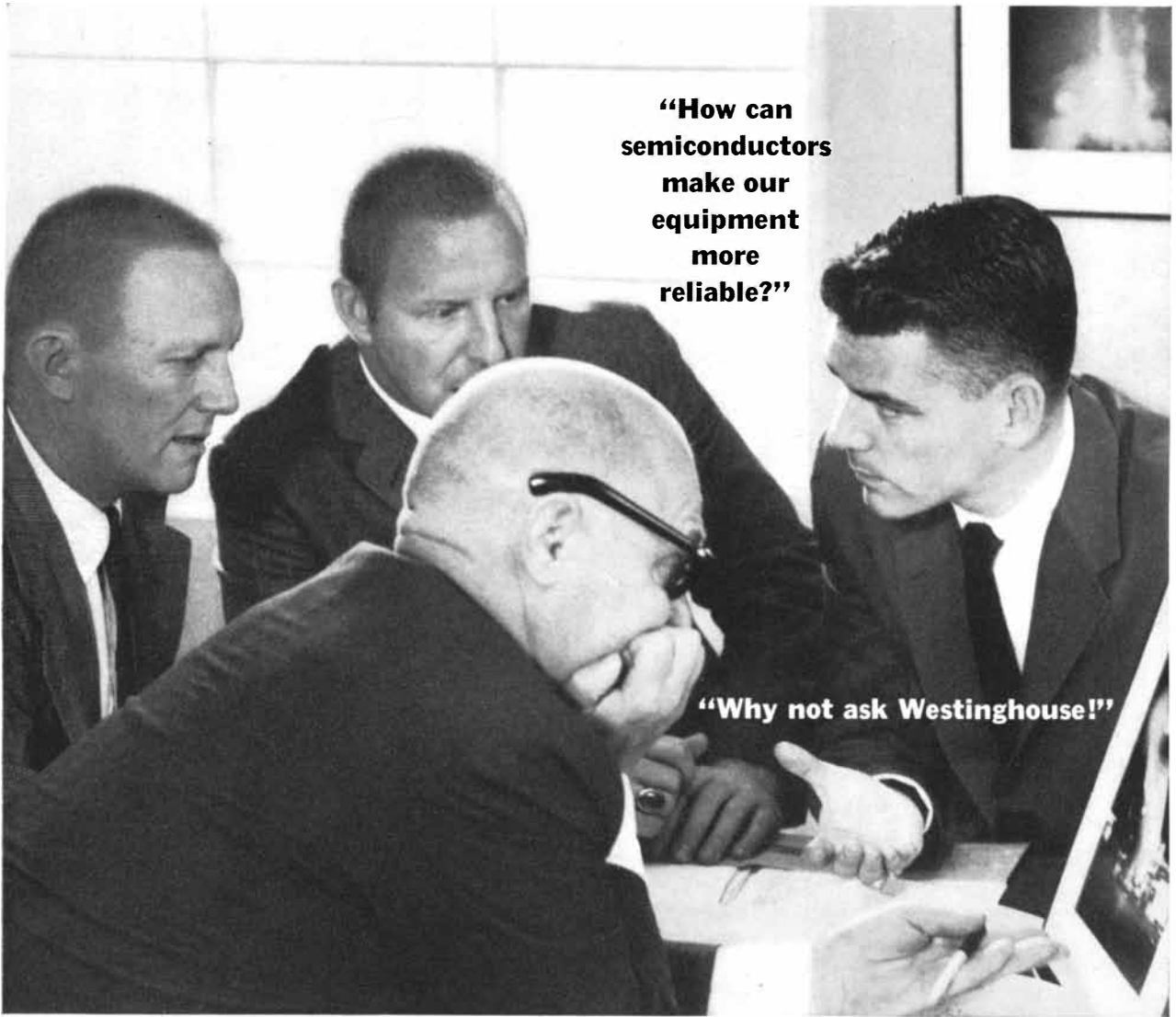
To arrive at sensible assessments of radiation hazards it is necessary to understand the reason for the conflict in opinion and information. Such assessments are imperative; the health and survival of hundreds of thousands of individuals are at stake. As for succeeding generations, if we now seriously underestimate genetic hazards, the harm that is done will persist, in some degree, for centuries to come. Nor can we postpone decisions until we have final and complete answers.

It is not in the nature of science to give final and complete answers. The

probability is that there will always be diverse, tentative or contradictory answers to fundamental scientific questions. The best that can be hoped is that responsible citizens will make a greater effort to understand the knowledge at our disposal at any given time and to comprehend the social implications of this knowledge.

The preceding articles in this issue have presented a review of the state of knowledge of ionizing radiations. To place this knowledge in the perspective of public policy it will be useful to summarize here the biological aspects of the situation.

Whole-body exposure of man to penetrating ionizing radiation in large doses of 400 to 600 or more r units [*see glossary of terms on page 78*] delivered over a short period of hours or days causes cell and tissue damage so extensive that successful repair may be impossible. Death results within days or weeks, the interval depending on the exposure. On the other hand, the same amount of



**“How can
semiconductors
make our
equipment
more
reliable?”**

“Why not ask Westinghouse!”

Do you have the problem of insuring equipment reliability under severe operating conditions? Are you faced with the problem of selecting semiconductor devices to meet your requirements?

Consider the reliability insurance you get with the Westinghouse WX1015 and WX1016 silicon power transistors. Only at Westinghouse can you get these transistors that are 100% power tested under actual load rated specifications in voltage ratings from 30 to 200 volts, V_{CE} . These devices can operate efficiently in the power range of one kilowatt at temperatures up to 150°C. The low saturation resistance, e.g., 0.5 ohms, insures a very low voltage drop and very low power losses (ideal for a power switch). Their power dissipation capability of 150 watts is made possible by the low thermal resistance of .7°C per watt (ideal for amplifier or series regulators).

Thousands of these transistors have

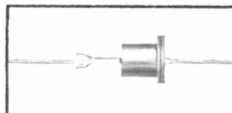
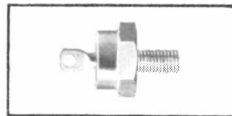
proved their reliability in such applications as inverters and converters, data processing circuits, servo output circuits, series regulated power supplies and as power amplifiers.

Westinghouse also has the most complete line of silicon power rectifiers ranging from ½ amp to 240 amp. Literally, millions of these rectifiers have proven their reliability in military and industrial applications.

New and better semiconductor products are constantly being developed in the 175,000 square foot Westinghouse Semiconductor Plant at Youngwood, Pennsylvania.

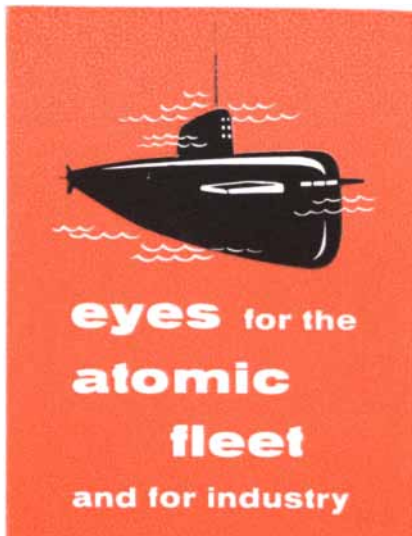
Watch for the new 30 amp silicon power transistors and 50 amp silicon trinitor (controlled rectifier), soon to be made commercially available.

For complete information on semiconductor products, contact your Westinghouse representative.



YOU CAN BE SURE...IF IT'S

Westinghouse
Semiconductor Dept. Youngwood, Pa.



The command "Up periscope" brings into play the submariners' visual link with the world above the surface of the sea. These complex, highly precise instruments perform their vital viewing and sighting functions in all kinds of weather and under widely varying light conditions. Almost all U.S. submarines including those of the atomic fleet are equipped with periscopes designed and manufactured by Kollmorgen.

This is a specialized field of endeavor—so is the development of nuclear hot cell viewing systems, bunker periscope systems, inspection and alignment instruments and much of our other work.

We offer the services of a completely integrated design and manufacturing facility for solving problems in remote viewing, inspection, measurement and photography of objects and processes under adverse conditions. A new brochure describes our fields of interest and the facilities with which we work. You may have a copy by writing Dept. 199.



KOLLMORGEN
optical corporation
NORTHAMPTON, MASSACHUSETTS

radiation received over a much longer time, say months or years, permits such recovery processes as the replacement of cells by the division of still-viable cells and the successful resorption and elimination of breakdown products. Consequently the individual may survive and show little direct evidence of injury.

The chance of death after exposure to lethal radiation doses may be greatly reduced by certain therapeutic measures now under development. Of these the replacement of blood-cell-forming tissues by means of bone-marrow transplantation is one of the most promising. Non-lethal doses of something like 100 r units given at one time produce immediate damage, but it is to a considerable extent repairable. Such symptoms as change in the number and proportion of blood cells of various types, subcutaneous bleeding and loss of hair provide means of estimating exposure where this is not otherwise known.

In experimental animals, the mouse for example, sublethal doses of radiation appreciably reduce the life span. It is almost certain that this also occurs in man. Most investigators agree that there is no threshold below which ionizing radiation has no effect on living matter. On the other hand, some believe that there may be a minimum effective dose or dose rate for particular effects such as life-shortening, as John F. Loutit points out elsewhere in this issue. Unfortunately the quantitative relation between the degree of exposure and the reduction in longevity is difficult to determine even in experimental animals. If the relation is linear—that is, directly and simply proportional to exposure—down to low levels of radiation, and if the reduction of longevity in man is proportionately the same as in the mouse, the life-span reduction per r of total-body exposure could be something like one to 10 days.

In mice and in men heavy radiation-exposure increases the incidence of various forms of cancer. Radiologists and heavily irradiated survivors at Hiroshima and Nagasaki, for example, show an incidence of leukemia 10 or more times higher than that of roughly comparable but unexposed individuals. Here again the exact relation between dose and incidence is not known; measurements are subject to large sampling errors. Even in mice the data are ambiguous. It may well be that the relation differs for different types of malignant disease. The most pessimistic assumption holds that the relation of disease to exposure is linear down to the lowest possible doses, and that the effect of intermittent and slowly delivered radiation is strictly

cumulative. If this is the case, the probability that a person will develop leukemia appears to be approximately one in one million for each r of exposure per year. There is some evidence that prenatal exposure results in an even higher incidence of leukemia per r during the childhood years.

In several respects the genetic hazard is the most difficult and serious aspect of the problem of radiation. Genetic mutations are almost always harmful. Transmitted to descendants, they may express themselves over many successive generations.

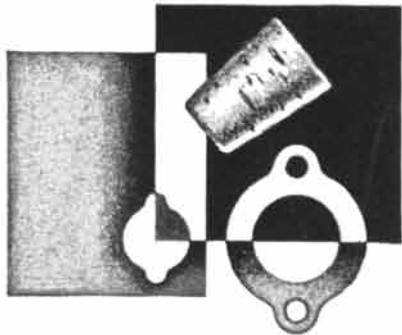
It is now almost certain that in all cellular organisms (and in some viruses) molecules of deoxyribonucleic acid (DNA) bear the primary hereditary directions for the numerous processes that interact in development and function. Thus in man the DNA molecules in the chromosomes of the fertilized egg-cell are believed to carry the specifications by which the egg cell grows into an individual.

These specifications are "written" in a kind of molecular code; its basic symbols are the four kinds of units called nucleotides. Genetic directions are somehow spelled out by the sequence of these units, of which there are about 200 million in the 46 chromosomes of a human body-cell. Each grouping of 1,000 or so units of DNA is called a gene; each gene "tells" the body how to conduct some vital function; for example, how to assemble the proper amino acids (from the 20-odd kinds available) in the proper sequence to make an essential protein constituent of hemoglobin.

The individual's total DNA code is multiplied many times in the course of his life cycle and is ultimately passed on to the next generation. The details of this replication process are beginning to be understood; in fact, the process will proceed under relatively simple conditions in a test tube. Its precision is high. The probability of a genetically significant and easily detectable mistake during the 20 to 40 successive replications per generation is estimated at about one in a million for each gene. If there are 10,000 kinds of genes (an estimate subject to a large error), the chance that there will be a mistake of any kind in a given egg or sperm is only about one in 100.

Such mistakes are, like typographical errors, changes in the sequences of symbols in the code. The replication of DNA molecules is purely mechanical; therefore a sequence of incorrect symbols will be replicated as faithfully as if it were a correct sequence. Errors of this sort—

CREATIVE IMAGINATION *in Specialty* PAPERS[★]



★ **Mix cork in paper to make a gasket?** HOW! Paper is made from a liquid batch. Cork floats. So how do you distribute it evenly throughout the batch? The Garlock Packing Co. came to Knowlton and the problem was solved. The resulting gaskets seal better, last longer, cost less.

KNOWLTON LIKES THE JOBS THAT STUMP OTHERS!

Beginning where others give up is a specialty with Knowlton. Perhaps you think that paper could never be made for the specific use you have in mind. But consider paper's fundamental characteristics: relative lightness, economy, availability, uniformity.

Sharpen Your Pencil . . . and Look Again!

Paper-base components may well cost you a tiny fraction of components made of metal, cloth, glass, or plastics. And they may also give you vastly improved performance. Let Knowlton's research, technical and pilot-plant facilities solve your problem simply, efficiently, and economically.

A Few Conventional Uses of Knowlton Papers To . . .

Conduct	Dialyze	Cushion
Laminate	Shape	Rupture
Copy	Insulate	Shield
Contain	Record	Synthesize

Development Possibilities are Unlimited.



WRITE for free copy of the helpful book, "Creative Imagination in the Development of Technical and Industrial Papers." PHONE or WIRE for a sales engineer to call.



mutations—are not repaired except by the rare reversal of the process by which they occurred. There is no proofreader in the system. And such errors are likely to lead to significant errors of development or function; for example, defective hemoglobin. Since there are many ways to make hemoglobin incorrectly and only one way, or possibly a few ways, to make it correctly, mutations are much more likely to be deleterious than neutral or favorable.

If the mutant genes are replicated faithfully, with no correcting mechanism in the system, they should accumulate progressively generation after generation. Why then do species not mutate themselves out of existence? The answer is that natural selection rejects those individuals in whom deleterious mutations occur. Selection is a kind of inspector that discards the bad sets of specifications. This rejection of unfavorable mutations has been called "genetic death" by H. J. Muller. In man it may occur in many ways: death in the embryonic stage, death near or after birth, death prior to reproduction, failure to produce an average number of offspring, or failure to reproduce at all. L. S. Penrose of the University College London has estimated that in Europe and the U. S. the members of a given generation are the offspring of only 50 per cent of the members of the preceding generation. Thus "genetic death" may not mean literal premature death of individuals; it may, and frequently does, mean elimination of a particular line of descent on the instalment plan over many generations, without anyone being quite aware that it is happening.

The genes of all species, including man, are subject to varying rates of "spontaneous" mutation of which we do not know the cause. There are many ways, however, to increase the frequency of mutation, among them high temperatures, a variety of chemical treatments, and high-energy radiation. Ionizing radiation sufficiently penetrating to reach sperm and egg cells or their precursors is a particularly effective way of increasing mutation.

We may now summarize with some assurance the genetic hazard of radiation as follows: Radiation-induced mutations, like other mutations, however induced, are mostly deleterious. Under a given set of conditions, mutations appear to be induced in linear proportion to exposure; thus there is probably no threshold below which radiation will produce no mutations. Since there is no repair mechanism, once the mutation



New "cartridge-type" alloy bearings of tin, copper, lead and zinc will soon go into service on freight cars after 2 years of tests on U.S. railroads. Life expectancy of new bearing is said to be 25 years—compared to 3½ years for conventional bearings. It will require only minimum maintenance.

Greater creep resistance—that is the quality imparted to titanium with the addition of tin. Some titanium alloys contain as much as 22.5% tin. The most successful contains 2.5% tin and 5% aluminum. It is principally used for jet aircraft parts requiring maximum strength in the range of 600-1100°F.; in high-strength welded assemblies; and in jet engine combustion chamber casing and other uses requiring a better combination of toughness, fatigue strength, and creep resistance at elevated temperatures.

Electrodeposited coatings of tin-zinc have aided in solving auto fuel system problems caused by corrosive action of some fuels on carburetor parts.

A tin-cadmium alloy coating, according to research reports, has excellent resistance to salt spray, jet fuels, high temperature synthetic oils, organic acid vapors; very little embrittling effect on hardened steel.



Write today for more data on these items or for a free subscription to TIN NEWS—a monthly bulletin on tin supply, prices and new uses.

The Malayan Tin Bureau
Dept. 15J, 1028 Connecticut Ave., Washington 6, D.C.

the

LIGHT
AND
ACCURATE



ACCELEROMETER

... only three ounces in weight, this rugged unit has 0.5% linearity to half range, 2% to full range.

CONSTANT-DAMPED



... requiring NO HEATERS, with compensated damping 0.5 ± 0.1 from -45°F to $+230^{\circ}\text{F}$.

the

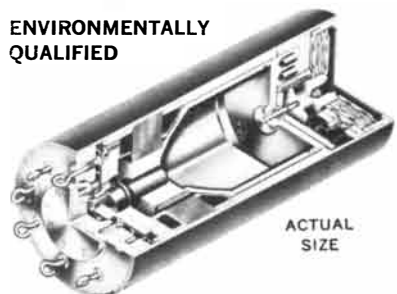
AP-S1 SPRING-RESTRAINED PENDULOUS



ACCELEROMETER

... input ranges, full scale, ± 2.5 to 1000 G's. Full scale output 7v at 400 cps excitation. Resolution 0.01% of full scale.

ENVIRONMENTALLY QUALIFIED



the

lightness you need and the accuracy you've been seeking ... in the AP-S1

ACCELEROMETER

For full information, write AMERICAN-STANDARD*, MILITARY PRODUCTS DIVISION 100 Morse Street, Norwood, Mass.

*American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation.



process is complete, mutations induced at different times will tend to accumulate in a line of descent until this tendency is just counterbalanced by natural selection. Ultimately, therefore, each new deleterious mutation must be compensated for by genetic death in the Muller sense.

From data on mice, fruit flies and other organisms it is estimated that the level of exposure of sperm and egg cells or their precursors to ionizing radiation sufficient to double the spontaneous-mutation rate probably lies between 10 and 100 r. Taking 30 r, the geometric mean, as a reasonable guess for the doubling dose in man, it is possible to estimate in a very rough way the number of mutations for various levels of exposure to radiation.

If there is one spontaneous mutation in each 100 egg or sperm cells per generation, as suggested above, there will be two such mutations in every 100 individuals. Exposure to 30 r would double this. The exposure from fallout to date is liberally estimated at a cumulative .3 r in the 30 years of the average human reproductive lifetime. According to this estimate, fallout would increase the spontaneous-mutation rate by 1 per cent. The mutation rate calculated in a similar way for medical radiation runs considerably higher: at 10 per cent of the spontaneous rate, as shown in the bottom chart on pages 220 and 221. The maximum permissible occupational exposure allows for an increase of more than 50 per cent over the spontaneous rate. It should be emphasized that these are exceedingly rough estimates and may be too high or too low by a factor of five or more.

Although most geneticists will agree that the foregoing statements about radiation-induced mutations are reasonably well established, and that the estimates of the number of new mutations resulting from given amounts of radiation are at least plausible guesses, there remain many unanswered questions. For example, are malignant diseases the result of mutations in ordinary body cells, as contrasted with those that occur in germ cells? Although there is sufficient circumstantial evidence to convince many geneticists that some malignant diseases are the result of mutations in body cells, the answer is in most cases not positively known. Until recently no effective techniques were available for the genetic investigation of body cells. In whatever way malignant diseases arise, however, there is no doubt that high levels of radiation induce them effectively. As for low levels of exposure, the question of exact relation of exposure to incidence

must remain open until better data are available.

A difficult question is: What is the magnitude of the burden added to society by a given increase in mutation rate? Suppose, for example, that fallout were to add 5,000 to 120,000 additional mutations and perhaps five to 40 additional deaths from leukemia in each generation in the U. S. What would this mean in terms of social burden?

The answer is not known. Perhaps it cannot be, for social burden consists of diverse components that cannot be summed. The cost of caring for a mentally defective person in an institution may be calculable in dollars, but how does one assess the unhappiness and mental anguish of the victim and the victim's family? Furthermore, even though we have some notion of the manner in which genetic deaths occur, and even if we could evaluate them in terms of social burden, we still could not arrive at a proper accounting, because we do not know in what relative proportions the various kinds of genetic deaths occur. It is also important to remember that the more considerate of its unfit individuals a society becomes, the greater will be the burden of a given mutation rate. On the other hand, there is a correction of unknown magnitude for coincidental elimination of two or more unexpressed mutations in single individuals who merely fail to reproduce. What we do know with some confidence is that the social burden of mutation will be increased by radiation in approximate proportion to the increase in mutation.

In view of these uncertainties about the harmful effects of exposure to low levels of radiation, is it possible to arrive at safe "permissible" upper limits of exposure for such groups as industrial workers, X-ray technicians and the public at large? If there is no threshold, the answer is clearly that it is impossible to establish any "safe" exposure other than zero, in the sense of having eliminated all risk. The best alternative is to establish permissible levels for which risks are below specified levels. This is exactly what the various commissions and committees responsible for setting permissible exposures attempt to do. The task is not an easy one, for adequate data are difficult to obtain even with animals.

A recent study by Carol W. Buck of the University of Western Ontario will serve to illustrate some of the difficulties. Let us suppose that the relation of leukemia to radiation is linear at all levels, and that for each r of total-body exposure the annual increase in deaths

ENGINEERS • SCIENTISTS



Invites You to Investigate the
PROFESSIONAL OPPORTUNITIES
AVAILABLE
in Integrated System Engineering

MITRE, a research and development organization, is responsible for providing engineering solutions to the problems involved in integrating the many varied Air Defense systems. Formed under the sponsorship of the Massachusetts Institute of Technology, this independent non-profit corporation has undertaken a long-range work program which requires a spectrum of skills in engineering and the physical sciences.

These skills are utilized in the design, development and evaluation of the diverse components, equipments and subsystems from which evolve total systems. These subsystems consist of radar systems, communications, data links, computers, data processing systems, and defensive weapons. This continuing system engineering function takes cognizance of the immediate and long-term threat, the total defense technology—both present and projected—and the complex logistics of air defense with a programmed methodology that insures the best possible defense system, at minimum cost, for any given time period.

Technical Staff appointments are currently being made in the following areas:

- SYSTEM DESIGN
- COMPONENT RESEARCH and DEVELOPMENT
- REAL-TIME COMPUTER CONTROL SYSTEMS
- DETECTION TECHNIQUES
- OPERATIONS ANALYSIS
- WEAPONS SYSTEM INTEGRATION
- HUMAN ENGINEERING
- COMMUNICATIONS SYSTEMS
- ELECTRONIC WARFARE
- INTEGRATED SYSTEM EVALUATION

The openings are available at the MITRE facilities
in suburban Boston, Massachusetts – Fort Walton Beach, Florida
– and Montgomery, Alabama.

To arrange an immediate confidential interview, send resume to
Dana N. Burdette, Personnel Director

THE MITRE CORPORATION

244 WOOD STREET – LEXINGTON 73, MASSACHUSETTS

A brochure more fully describing MITRE and its activities is available on request.



A TALENT FOR AIRBORNE ELECTRONICS

STROMBERG-CARLSON
A DIVISION OF **GENERAL DYNAMICS**

1400 N. GOODMAN STREET • ROCHESTER 3, NEW YORK



NEW DEVELOPMENTS IN AIR NAVIGATION AND COMMUNICATIONS:

1. For tracking missiles and drones: the AN/DPN-50, a rugged, powerful, airborne C-band chain radar beacon. Range up to 1,000 miles with exceptional reliability, low weight, small volume.

2. The AN/ARN-52 (XN-1): high-performance TACAN transceiver for any aircraft, from helicopter to supersonic jets. The only TACAN transceiver with the reliability and flexibility of solid state design. 50% less power required and 50% lighter than existing equipment.

3. An air-to-ground Automatic Binary Data Link...

Economical: requires no special radio set, no high-speed printer.

Compatible: Simultaneous voice and data transmission by multiplexing on any voice channel. Data output feeds any standard teletypewriter.

Brochures on request.



from this disease is one for every million individuals. This is a value that appears reasonable for high levels of exposure. If a population were exposed prior to age 30 to an average of five r above the natural and medical background, how many individuals would have to be observed to establish a statistically significant increase in leukemia?

The answer is six million people, and they would have to be observed for a period of at least a year. In this number there would be, on the average, 30 new cases of leukemia each year attributable to the five r. This additional number, over and above the 200 cases expected without those added by radiation, would be just statistically significant. To be certain that the added radiation was responsible, there would of course have to be a control rate based on an unirradiated population similarly observed and comparable in all other respects. Even if one observed a smaller population for a correspondingly longer time, say 600,000 people for 10 years, the difficulties in meeting these requirements in human populations are formidable. They are so great that the study has not been done at this level of radiation even with an animal as favorable as the mouse.

It is obvious that we cannot for a long time arrive at better than the roughest kind of approximation in establishing permissible exposures. Right now it is difficult to see how we can improve on what the International Commission on Radiological Protection has done. This agency defines the maximum permissible dose for an individual as "that dose, accumulated over a long period of time or resulting from a single exposure, which in the light of present knowledge carries a negligible probability of severe somatic or genetic injury." It recommends that the total permissible genetic dose prior to age 30 "to the whole population from all sources additional to the natural background should not exceed five r plus the lowest practicable contribution from medical exposure."

Buck's calculations show how difficult it would be to establish whether this level of radiation to the general population would increase the incidence of leukemia by as many as five cases per million persons per year. If the entire population of the U. S. were to be exposed for generations to the maximum permissible level, it would be exceedingly difficult to exclude the possibility that the incidence of leukemia would increase by as many as 850 cases per year, or 50,000 per generation.

In addition to these difficulties, it should be remembered that ionizing

radiation cannot be detected by the unaided human senses. Furthermore, overt signs of its harmful effects are often delayed for many years.

From the beginning of man's experience with ionizing radiation he has consistently underestimated its hazards. In fact, the tendency has been to underestimate not only the effects of a given exposure but often the amount of exposure as well. The exposures due to medical radiation have often been found to exceed estimates. And more recently there has been underestimation of the radiation from strontium 90 and carbon 14, two of the biologically most significant radioisotopes produced in tests of nuclear weapons. Permissible exposures have been revised downward repeatedly. Have we now reached the end? Many informed persons think not.

Incomplete knowledge thus plays a large part in public confusion and misunderstanding. It is easy to see why a qualified investigator inclined to look at the matter in the most favorable light could reasonably say that the number of persons genetically affected by fallout per year in the U. S. population might be less than 200; that the majority of these might be counterbalanced by such factors as early embryonic deaths and slight reductions in fertility; that genetic deaths of this kind would be largely undetected, even in individual cases; that the added social burden could be negligibly small. He might reason: Why worry until more compelling evidence requires it?

At the other extreme an equally qualified worker could easily feel obligated to emphasize the least favorable possibility: that fallout might well be producing as many as 800 or more new mutations per year in the U. S., or 400,000 or more per generation on a world-wide basis. On this basis he could well argue that the fallout hazard is by no means an unimportant problem for society.

It is clear that the tendency to take one or the other of these extreme positions with regard to genetic and other hazards will be strongly influenced by attitudes toward the problem of world peace. The individual who is convinced that national defense through massive build-up of nuclear weapons is at the moment the only tenable safe position will be likely to regard the development and testing of such weapons to be of such overriding importance that the uncertain, unmeasurable and possibly small damage to the population seems of relatively little importance. In contrast, another individual who is convinced that



Solar-power electrical plants

Development of a self-contained solar-power electrical system for a space vehicle is now beyond the working-model stage at the TAPCO Group. Perfection of a practical small-envelope system involves a number of sub-projects... the mechanical effect of meteors on the solar collector, a compact solar boiler system, a simple, long-lived vapor-driven turbo-alternator, a self-erecting radiation collector, and self-contained orientation controls.

Impact effects of micro-meteors on materials suitable for structures exposed and the solar-energy-gathering devices erected on space vehicles are under study. A 150-kv. electric-field accelerator at TAPCO hurls micron-size charged particles against targets of evaporated aluminum on glass or of solid copper. Size, depth, and contour of the craters formed are evaluated for use in designing the shell and collector structure.

To solve the basic problem of knowing "which way is the sun?" TRW has designed a device to continuously direct the collecting mirror so that the sun's rays remain focused on the boiler.

Mercury is the heat-exchange medium for the Rankine cycle power-conversion unit of the TAPCO-developed solar-power electrical system. A simple boiler vaporizes the mercury by using direct solar heat while the vehicle is on the bright side of the earth. A heat-of-fusion storage system keeps the boiler and turbine operating at full power during the dark-side orbit of the vehicle.

The mercury vapor is used to drive a small turbo-alternator. Experience of the TAPCO Group in designing and manufacturing over 2,000 turbo-alternators for APU's extends into the basic design of the solar power system. Additional refinements include an unusual method of using liquid mercury as the bearing lubricant for the rotating machine to avoid problems of wide ambient temperature range, long unattended life of the vehicle, and possible contamination of orthodox lubricants by the vaporized mercury in case of seal failure.

Let us tell you about the unusual abilities and facilities we can put to work on *your* project.



TAPCO GROUP
Thompson Ramo Wooldridge Inc.

Dept. SA-1959 • Cleveland 17, Ohio

the only completely safe position will be attained through nuclear disarmament, and that we must get on with it immediately, tends to look for all possible arguments against nuclear weapons and will therefore be likely to cite the grimmer estimates.

There is no effortless way for the concerned citizen to arrive at an opinion. He must consider all aspects of the problem—risk of nuclear war included—hear all arguments, weigh all evidence and hope to arrive at a conclusion that makes sense to him. The scientist with special knowledge has a responsibility to make the facts available in as objective a manner as possible. As a citizen he has the obligation to help interpret them in terms of public policy.

The area of scientific confusion regarding radiation hazards can of course be greatly reduced by the direct procedure of adding to present knowledge. This work now engages many investigators in government agencies, industry and academic institutions. The process can and should be speeded up in all reasonable ways. Additional manpower is needed and, above all, new ideas. For example, the application of the techniques of microbiology to human-cell populations *in vivo* and *in vitro* promises a new approach to questions about human genetics. Existing manpower can be used to better advantage and at little additional expense.

Members of the medical profession are in an especially favorable position for learning about human genetics. Collectively they have occasion each year to examine millions of individuals. Unfortunately most physicians are not sufficiently well prepared to ask the right questions and make the right observations to add to the store of genetic knowledge of man. With only a little effort they could be equipped for the task. For example, medical records as kept by private practitioners, by clinics and by hospitals could be enormously improved from the standpoint of their genetic information.

In the long run more nearly adequate genetic training in medical schools will be the answer. Entirely aside from radiation hazards, this is necessary and desirable; it is increasingly apparent that the relative importance of genetic disease is great and will become greater as other diseases are conquered. Already some 160,000 infants are born each year in the U. S. with significant genetic defects, many of which constitute important medical problems.

For these reasons census procedures

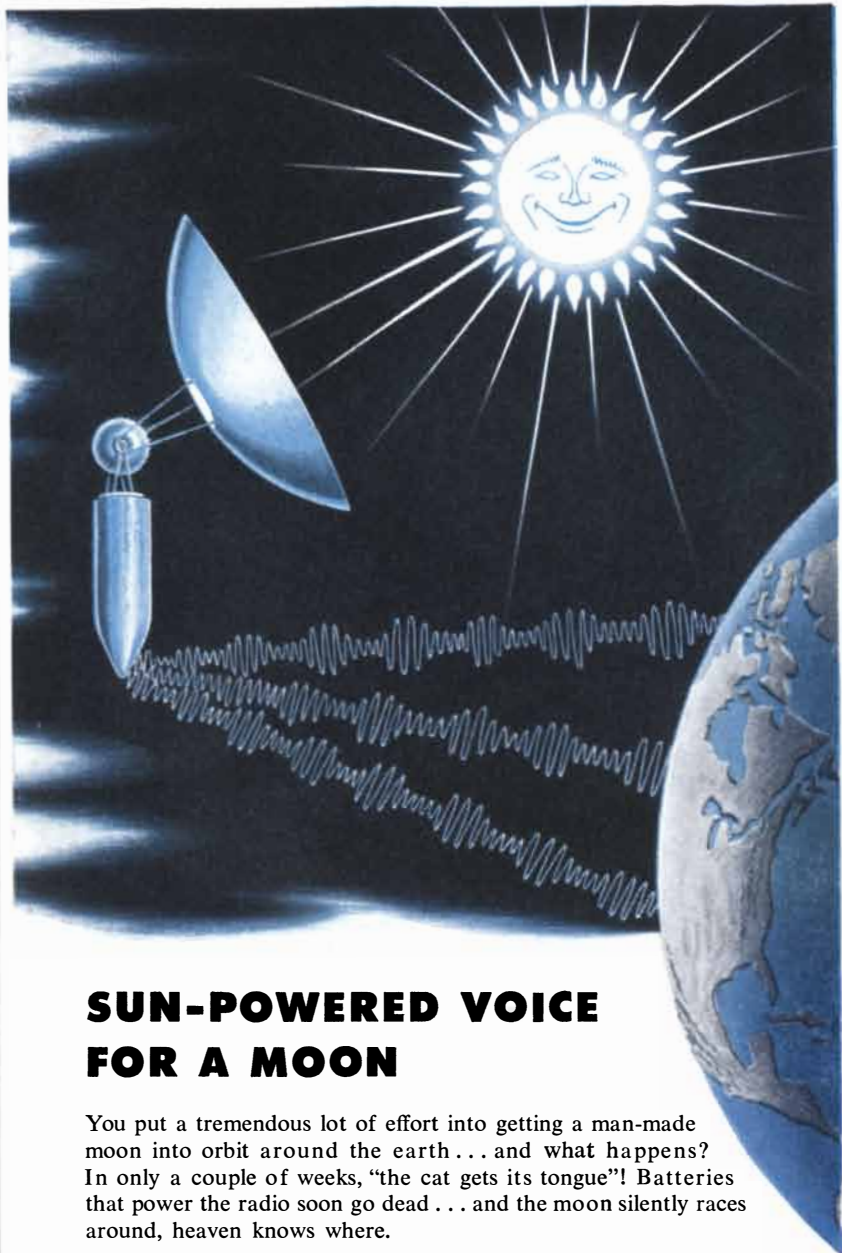
and records should also be revised to encompass genetic data. A pilot study is now under way in Canada, designed to find out how this might best be done. There is every reason for other nations to consider such actions.

It is well known that unambiguous communication is difficult even among investigators in the same scientific discipline. This is true especially in the area of radiation hazards, where probability arguments are so often involved. Since the incidences of radiation damage are often very low, the evaluation of their significance usually involves statistical methods of the most sophisticated kind. Scientists, who should understand statistics, have been known to be confused about them.

Consider a specific example. Shortly after World War II geneticists were asked whether long-term studies of the survivors of the bombing of Hiroshima and Nagasaki should be made to see if evidence of genetic damage could be found. Simple preliminary calculations suggested that significant results would be hard to obtain. On the assumption that man is about as mutable per unit of radiation as the fruit fly or mouse, the detectable genetic effects would be near the borderline of statistical significance—maybe just over, maybe just under. Despite this and other difficulties the study was made, for there was both a clear obligation and an opportunity to add significantly to knowledge of the genetic hazards of radiation.

The results were pretty much as predicted: There were at first no demonstrable effects that were statistically significant. What did this mean to laymen—and, it should be added, to some scientists? The result was often taken to mean that there was no effect. The correct interpretation was that from this study alone it could not at the time be said whether the effect was zero, or as great as that expected in mice, or at a level between the two. We are not in any way justified in concluding that radiation is less effective in producing mutations in man than in mice. The data do indicate that the genes of man are not more sensitive than those of the mouse by any large amount, and that is gratifying to know.

World-wide radioactive contamination by the testing of nuclear weapons raises moral problems of a new kind. It has not previously been possible for any one nation to alter the global environment in a manner clearly harmful to other nations. A nation accused of such contamination is naturally reluctant to face the issue squarely. The temptation is



SUN-POWERED VOICE FOR A MOON

You put a tremendous lot of effort into getting a man-made moon into orbit around the earth... and what happens? In only a couple of weeks, "the cat gets its tongue"! Batteries that power the radio soon go dead... and the moon silently races around, heaven knows where.

To make "moons" talk back for years, the TAPCO Group has developed an ingenious electric-power station to fit into a satellite's nose. A sun-loving reflector focuses the sun's heat... the mercury turns into vapor... turns a tiny turbine... and drives an alternator... which generates several kilowatts of electric power for the moon-riding radio transmitter.

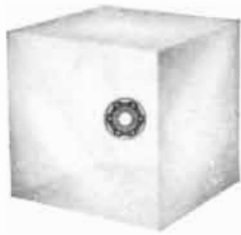
Abilities such as this one are at work every day at the TAPCO Group... solving electrical, electronic, missile, space vehicle, and metallurgical problems. Tell us your problem... we'll deliver the answer... AND the complete system, subsystem, or any part.



TAPCO GROUP
Thompson Ramo Wooldridge Inc.

Dept. SA- 2959 • Cleveland 17, Ohio

DESIGNERS AND MANUFACTURERS OF SYSTEMS, SUBSYSTEMS AND COMPONENTS
FOR THE AIRCRAFT, MISSILE, ORDNANCE, ELECTRONIC, AND NUCLEAR INDUSTRIES



"Every cubic inch of space is a miracle."

Walt Whitman

The miracle you get out of a cubic inch depends a good deal on what you put into it.

For example, exploring outer space requires much more than conserving a missile's inner space. Failure of a single device, no matter how minuscule, can end a flight. The dependability of countless miniaturized devices is vital to progress — not only in space travel but throughout industry.

MPB bearings are leading examples of modern miniaturization, not only in airborne and other scientific equipment, but in an ever-increasing number of industrial applications. MPB offers over 500 types and sizes of miniature bearings, with O.D.'s ranging from $\frac{1}{2}$ to $\frac{1}{10}$ " and with specials provided on request. For a complete catalog, write to **Miniature Precision Bearings, Inc.**, 1209 Precision Park, Keene, N. H.

MPB helps you perform miracles in miniaturization

MPB
MINIATURE PRECISION
BEARINGS, INC.

rather to avoid the issue by alleging that the harm does not exist or that it is insignificantly small. Once significant harm is admitted, the issue can no longer be evaded, for morality is qualitative, not quantitative.

During war, standards shift. Mutual harm is then inflicted in the name of self-defense or rightful causes. Neutrals inadvertently caught between belligerents may then accept injury that would not otherwise be tolerated. There is a close analogy in the case of individuals. Society permits individuals to commit acts in self-defense that would not otherwise go unpunished. Again, innocent bystanders may be hurt in the process.

A large portion of the confusion that arises in disagreements about nuclear weapons results from failure of the adversaries to make clear whether they are arguing on the basis of a peacetime or wartime moral standard. Which moral standard is applicable during a cold war? Does the potential enemy follow the same standard? Although attempts to define moral standards may not help in arriving at final agreement, they may nevertheless establish that the basic issue is not one of science at all.

What should the citizen conclude about ionizing radiation? Having heard what the scientist has to say about it, and having checked a few references to be sure that what he has been told is good science, he might find the following considerations decisive in his thinking: Ionizing radiation has always been with us and will be for all foreseeable time. Our genetic system is probably well adjusted by natural selection to normal background-radiation. Added radiation will increase the frequency of mutations; most of these will be harmful. Exposure to radiation in large amounts will increase malignant disease; small amounts may possibly do the same, in proportionately lesser degree. In view of these potentially harmful effects every reasonable effort should be made to reduce the levels of ionizing radiation to which man is exposed to the lowest levels that can reasonably be attained.

As to fallout from nuclear-weapons tests, the citizen will conclude that it contributes in a small way to world-wide levels of radiation. For this reason alone the tests should be discontinued, or conducted in such a way as not to lead to atmospheric contamination. Additionally, as a hopeful first step toward a final solution of the problem of nuclear war, every possible effort should be made to discontinue the tests altogether.

Medical radiation, if properly used,

is of great benefit to man. The citizen will accordingly support the investigation of ways to reduce the exposure, especially to the gonads of persons who may still reproduce, without sacrifice of clearly established diagnostic or therapeutic benefits. Radiologists estimate that progress in this direction can be expected before many years to reduce medical radiation to the gonads by a factor of five to 10—perhaps to an average value for the entire population of .5 r per reproductive generation. For the same reason exposure from industrial and experimental radiation sources should be held at minimum levels. This means that adequate shielding must be engineered into power reactors and other sources of radiation. Safe, permanent methods of waste disposal can and must be developed.

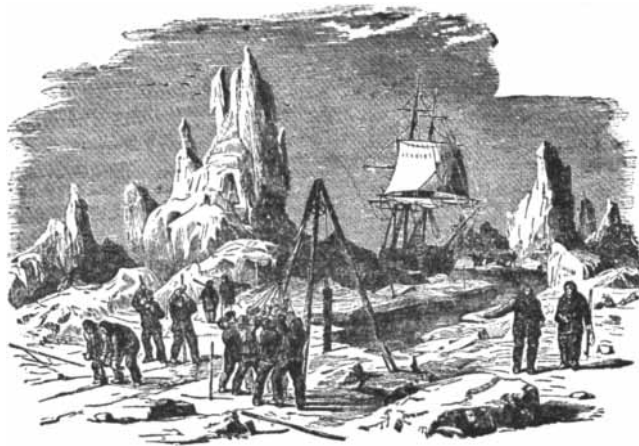
If all reasonable measures are taken, it does not seem an unreasonable hope that present levels of radiation exposure in the U. S. can be appreciably reduced—perhaps to an average level of less than one r above natural background.

With the millennium—when the citizenry has achieved sophistication in science, when wars have been abolished, when populations are stabilized at levels compatible with food supplies, when medicine has conquered the last infectious disease and corrected most genetic ailments—it may at last become essential to take a hard look at man's long-term evolutionary past and his prospects for the future.

Painful questions will have to be asked. It may become important, for example, to determine whether conquest through war, with subsequent replacement of one population by another, has been important in man's evolution. Did the conquerors differ genetically from the conquered? If so, was the effect favorable for the species (assuming that man will by then have arrived at some sensible definition of "favorable")? For the same reasons it may become essential to ask whether man's evolution has been held back because his system of controlling populations has made insufficient provision for natural selection.

Finally, assuming that medicine will have become highly successful in circumventing genetic death, will the net effect of medical practice have been unfavorable to the genetic capital of mankind? It is not inconceivable that by asking such questions man may one day find himself in the paradoxical position of searching for wiser and more humane ways than he now knows to counteract the undesirable evolutionary effects of too much success.

ON TO M^cMURDO S^d!



[VOL. II N^o VI]

Yes, the first Irish Geophysical Year Expedition is preparing to push off to Antarctica or so we [The Whiskey Distillers of Ireland] understand. Good news, good news to know our spirit of scientific enquiry at last will crystallize, if only into ice. ¶ The purpose of the expedition—we explained it last time but it will do no harm to cover it again, we suppose—is the study of “How Today’s Man Relates To The Irish Whiskey Around Him.” And why some relate more than others. And how to encourage this healthy interaction. Call it an anthropological expedition, except there are no native cultures down there and you must bring along your own; otherwise it would be a wild penguin chase don’t you see? ¶ You’ll note that the Recruitment and I. D. Card Application Form shown asks you to state whether you are Irish Whiskey Drinkers or Non-Irish Whiskey Drinkers. The latter will form the Control Group once at McMurdo but should [for scientific reasons] proceed there on their own independent of the various south-bound parties of burnished, emphatic Irish Whiskey Drinkers, attractive travelling companions though they may be. ¶ Once you have arrived at Little Ireland the following time table may be useful:

- First Day:* Set up camp; divide party as follows: Wood Gatherers, Irish Whiskey Drinkers, Control Group, Nurses.
- Second Day:* Set up scientific instruments.
- Third Day:* Turn scientific instruments “on.”
- Fourth Day:* Irish Whiskey Drinkers pair off with Control Group for one-teach-one indoctrination.
- Fifth Day:* Control Group report to Canteen; buy Irish Whiskey. Unsupervised activity.
- Sixth Day:* Organize softball league, Irish Coffee Fanciers vs. Irish Whiskey Purists; Control Group vs. Canteen Staff; or Nurses against the rest of the camp. Losers stand treat.
- Last Day:* Police area; Wood Gatherers pick up empties.

Bon voyage! Meanwhile, the paper work:

IRISH GEOPHYSICAL YEAR EXPEDITION RECRUITMENT FORM

Whiskey Distillers of Ireland

Box B186c, Dublin (Air Mail 15c; Ship 8c; Post Cards 5c)

Please send me my I. D. Card and engrave my name on the I. G. Y. Honour Roll which you will publish later.

— I am an Irish Whiskey Drinker. — I am a Non-Irish Whiskey Drinker. I am further qualified to serve as a :

Wood Gatherer; Nurse; (other) _____

Name _____

Address _____

City _____ State _____ Country _____

FLIGHT SCIENCES



FLIGHT SCIENCES: Principle of the step or multi-stage rocket, considered fundamental to the art of modern missiles and space flight, was set forth as long ago as 1650 by Kazimierz Siemienowicz, lieutenant-general of ordnance to the king of Poland. His design featured a 3-stage rocket with each step having its own gunpowder fuel, fuse, and nozzle.

EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

Pioneering work at Lockheed is being conducted in free molecular flow in orbital flight; high altitude atmospheric properties; trajectory studies and missile flight dynamics; celestial mechanics with emphasis on orbital tracking predictions and de-orbiting.

Lockheed's capabilities in gas dynamics and thermodynamics are unsurpassed in private industry. Basic work is being performed in boundary layer flow and heat transfer; cooling and insulation; thermodynamic flight test; instrumentation; rocket motor controls and nozzle structures; reentry and materials; thin film thermometry; and measurements of dissociation and re-combination reactions.

Fundamental studies include hypersonic aerodynamics; environmental effects on satellite surfaces; magnetohydrodynamics; ultra-violet and infrared radiation from high temperature air flows; structure of hypersonic shock waves; new measurement methods; analysis of boundary layers near melting surfaces and study of lag or non-equilibrium in high speed flow through shock waves.

Equipment includes an electrically-driven wind tunnel—fastest in industry—which produces airflows to Mach 20-plus and stagnant temperatures approaching 16,000°F, with an instantaneous power output of 20 million kilowatts. A spark-heated, magnetically driven research shock tube produces velocities of over Mach 250 and temperatures of 500,000°F, and a specially designed, electric gun has accelerated projectiles to speeds approaching 20,000 ft/sec.

Major emphasis in structures concerns the design of reentry bodies, thrust termination and underwater launching devices. The Navy Polaris FBM required the solution of complex structural problems necessitated by the unique launching environment—water.

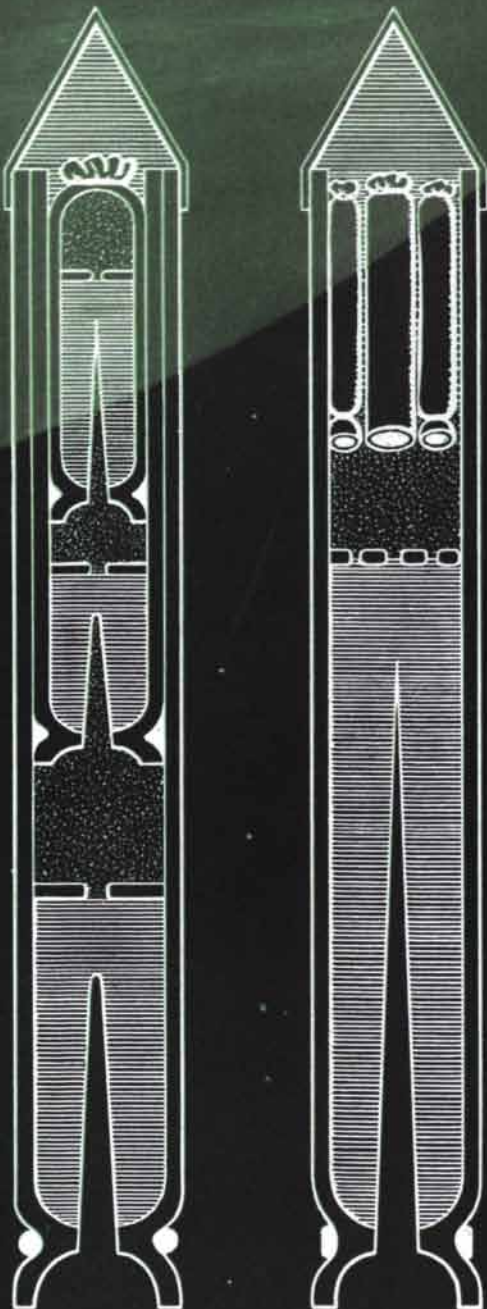
Other significant work has been accomplished in diversified aspects of aerodynamic and hydrodynamic load distribution, aeroelastic effects, studies of special dynamic problems arising from aerodynamic disturbances, cavitation, launching conditions and thermal problems relating to analysis of a complex structure taken through a complete time-temperature environment.

Lockheed Missiles and Space Division programs reach far into the future and deal with unknown environments. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. I-36, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

Lockheed MISSILES AND SPACE DIVISION

Weapons Systems Manager for the Navy POLARIS FBM; DISCOVERER SATELLITE; Army KINGFISHER; and Air Force Q-5 and X-7

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO • HAWAII



MATHEMATICAL GAMES

Concerning mechanical puzzles, and how an enthusiast has collected 2,000 of them

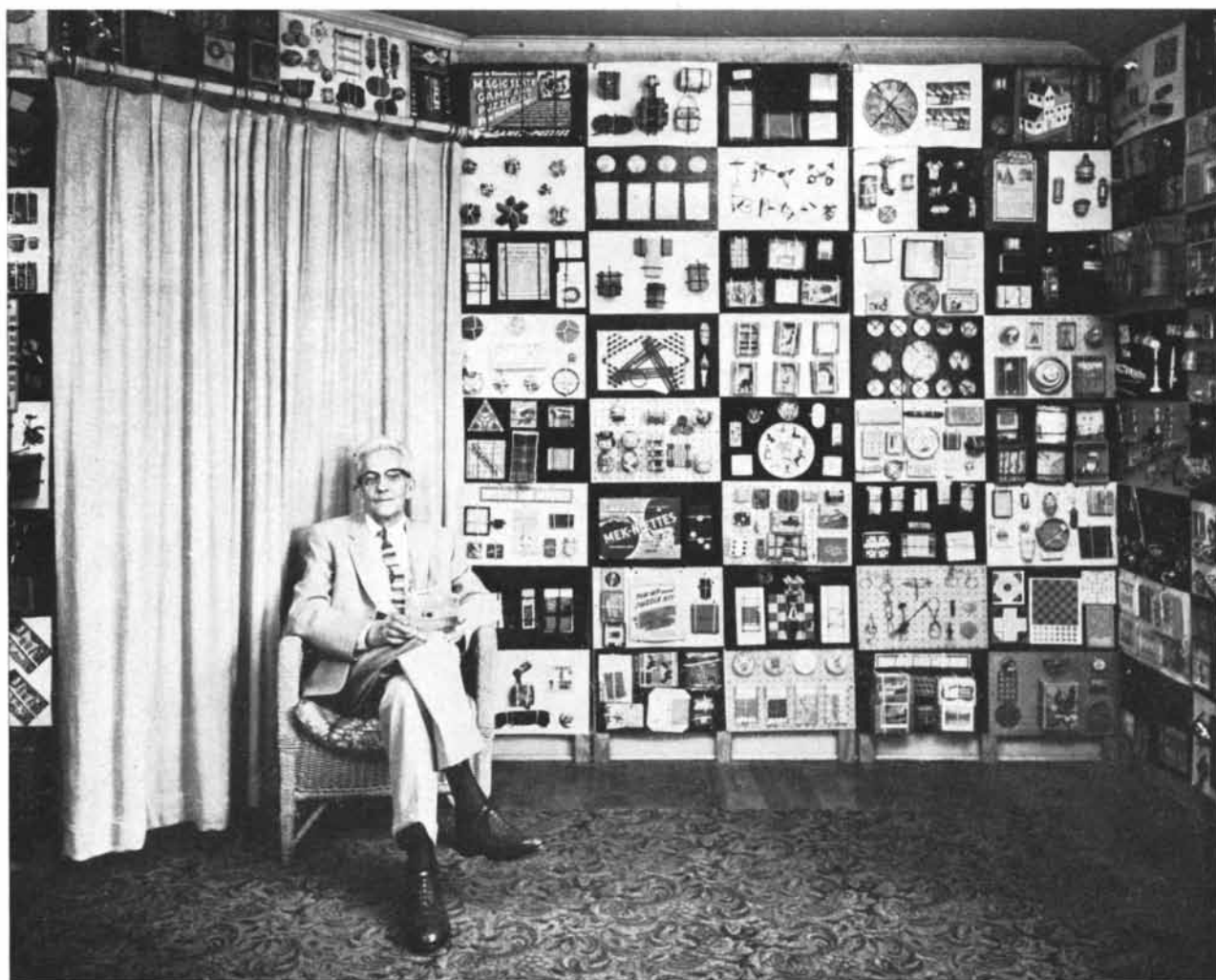
by Martin Gardner

Mechanical puzzles, in contrast to the pencil-and-paper variety, are puzzles requiring some sort of special equipment that must be operated by hand. The equipment may be nothing more than a few pieces of cardboard, or it may be an elaborate con-

struction of wood or metal that is beyond the ability of most home craftsmen to duplicate. Manufactured puzzles of the mechanical type, sold in toy and novelty shops, are often extremely interesting from a mathematical standpoint, and for this reason are sometimes collected by students of recreational mathematics. The largest such collection known to me is owned by Lester A. Grimes, a retired fire-protection engineer who lives in New Rochelle, N. Y. (A

smaller collection, though stronger on 19th-century items and old Chinese puzzles, is owned by Thomas Ransom of Belleville, Ont.) Grimes's collection numbers about 2,000 different puzzles, many of them exceedingly rare. The following account is based largely on this collection.

No history of puzzles has been written, but there is little doubt that the oldest mechanical puzzle is the ancient Chinese puzzle-game of tangrams. Known in China as the *ch'i ch'iao t'u* (meaning "ingenious seven-piece plan"), it has been a popular Oriental pastime for several thousand years. In the early 19th century it became a fad in western countries, and it is said that the exiled Napoleon whiled away his hours with a set. The name tangrams (unknown in China) seems to have been coined by an anonymous U. S. or British toy manufacturer in the mid-19th century. Many books of tangram figures



Lester A. Grimes of New Rochelle, N. Y., and some of his 2,000 mechanical puzzles



what is light?

A candle in a dark room?

Transverse and/or Visible electro-magnetic waves?

A universal constant?

How many wave lengths in a photon?

Is light affected by gravity?

A full appreciation of light and all its phenomena is essential to the successful completion of our energy conversion mission.

We use this knowledge constantly—as, for example, in our recent development of a photo-voltaic conversion system and a mechanical-optical system to convert light energy to electrical energy.

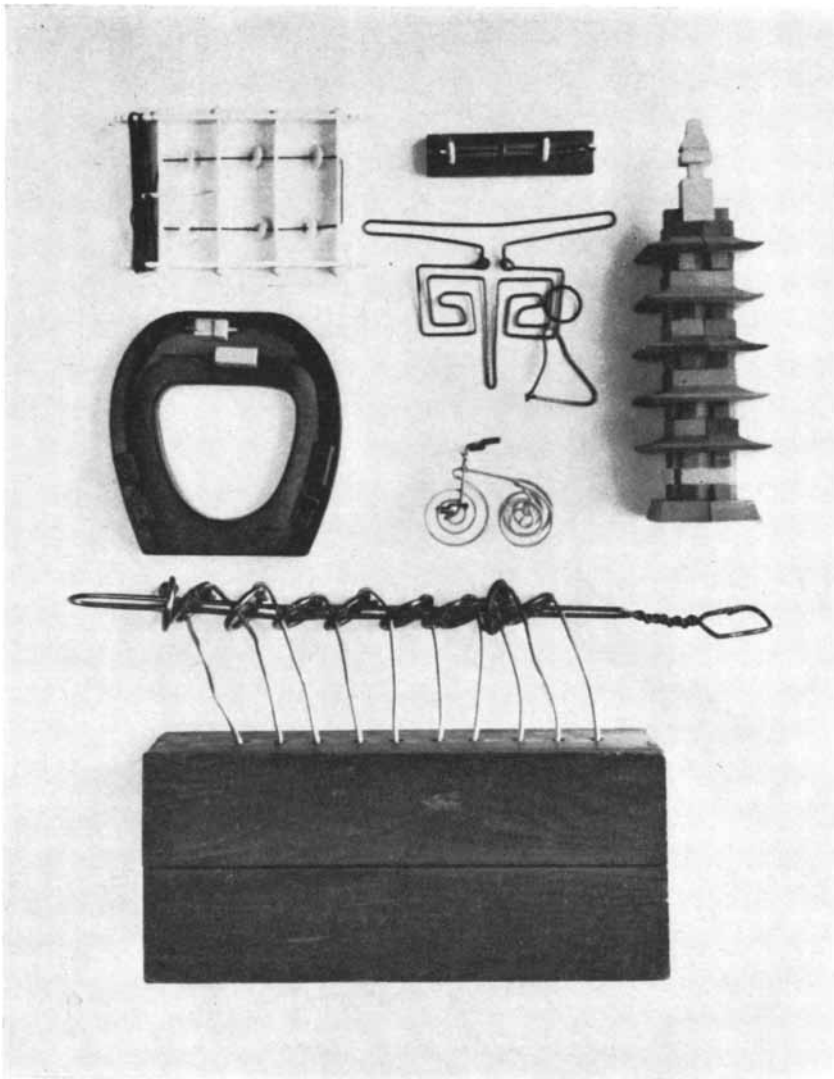
To aid us in our inquiries we call on the talents of General Motors Corporation, its Divisions and other individuals and organizations. By applying this systems engineering concept to new research projects we increase the effectiveness with which we accomplish our mission—exploring the needs of advanced propulsion and weapons systems.

If you have advanced academic recognition and appropriate experience in the field of science and research, we would like to hear from you. Write R. C. Smith, Salaried Personnel, Dept. E-1.

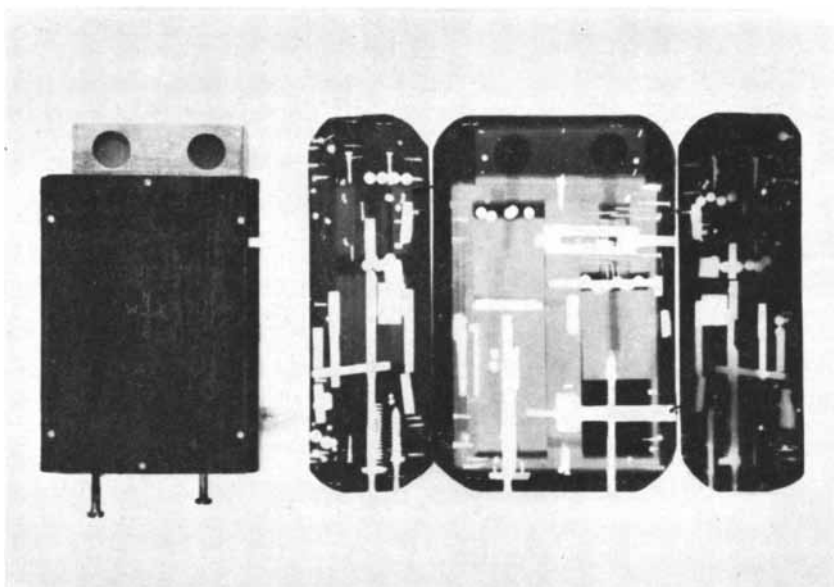
Energy conversion is our business



Division of General Motors, Indianapolis, Indiana



A small sampling of Grimes's puzzles



To solve and keep one of his puzzles (left) Grimes had to have it X-rayed (right)

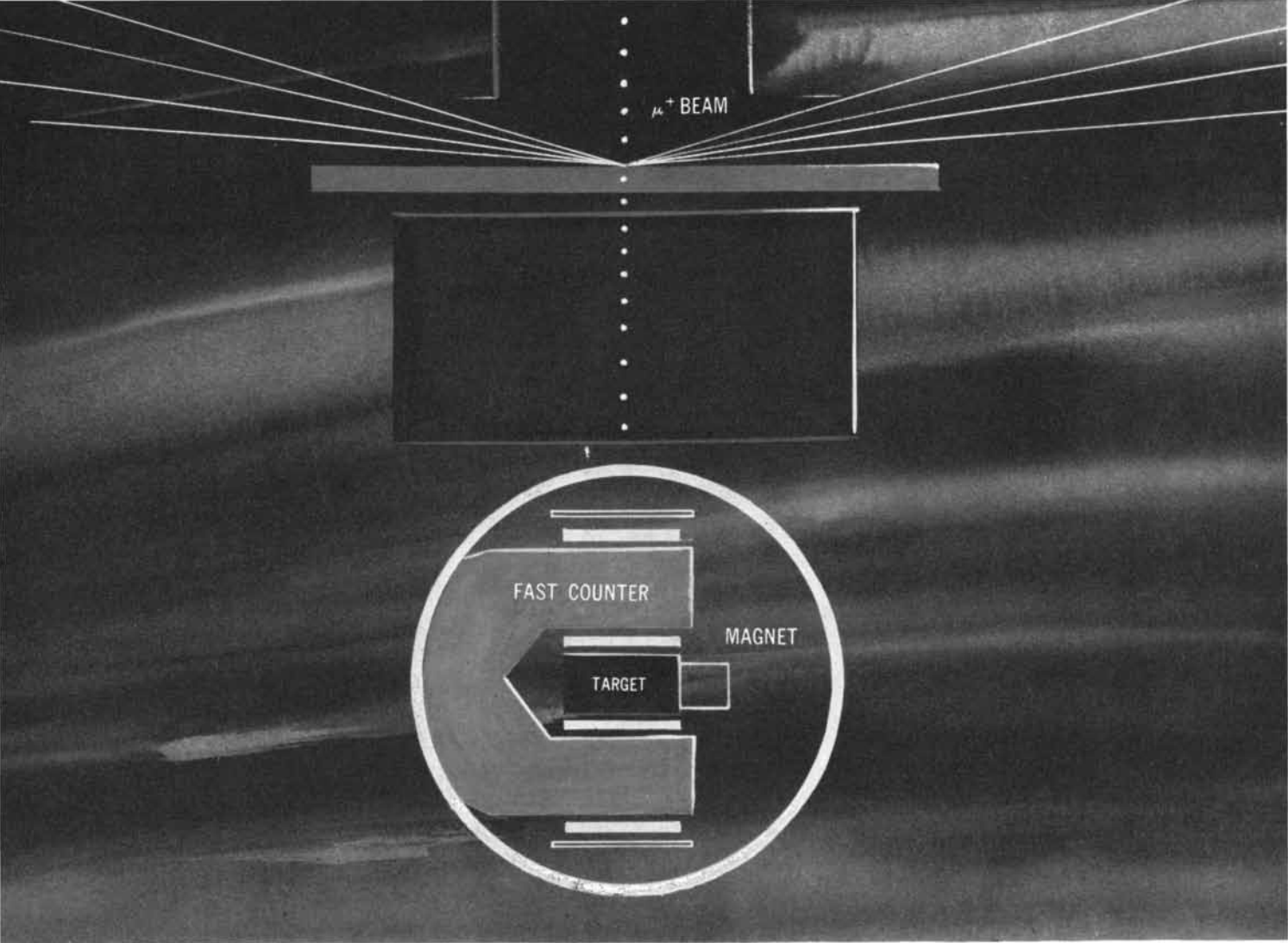
have been published, one of them a booklet by the famous U. S. puzzlist Sam Loyd that is highly prized by collectors.

Dissection puzzle-games similar to tangrams have appeared from time to time (the ancient Greeks and Romans amused themselves with a 14-piece dissection of a rectangle), but tangrams has outlived them all. To understand why, you need only cut a set of "tans" from a square of heavy cardboard, then try your skill at solving a few tangram puzzles or devising some new ones. The illustration on pages 240 and 241 shows how the square is dissected. The rhomboid should be colored black on both sides so that it can be turned over if desired. All seven tans must be used in every figure. Only the geometrical patterns require a bit of effort to solve; a variety of picture-figures are included to show the graceful effects that can be achieved.

Simple dissection-puzzles of this type occasionally provoke mathematical problems that are far from trivial. Suppose, for example, you wish to find all the different convex polygons (polygons with no outside angles less than 180 degrees) that can be formed with the seven tans. You might find them by prolonged trial and error, but how can you prove that you have indeed discovered all of them? Two mathematicians at the National University of Chekiang—Fu Traing Wang and Chuan-Chih Hsiung—published a paper in 1942 on just this problem. Their approach was ingenious. Each of the five largest tans can be divided into isosceles right-angle triangles congruent with the two small tans, so that altogether the seven tans are made up of 16 identical isosceles right-angle triangles. By a clever chain of arguments the two Chinese authors show that 20 different convex polygons (not counting rotations and reflections) can be formed with 16 such triangles. It is then easy to prove that exactly 13 of these 20 polygons are tangrams.

Of the 13 possible convex tangrams, one is a triangle, six are quadrilaterals, two are five-sided and four are six-sided. The triangle and three quadrilaterals are shown in the illustration. It is a pleasant but by no means easy task to discover the other nine. Each can be formed in more than one way, but there is one hexagon that is considerably more elusive than the other 12 figures. Its construction will be depicted in this department next month.

Another popular genus of mechanical puzzle, species of which can be traced back many centuries, involves counters or pegs that are moved across a board according to prescribed rules in order to



Report from IBM



Yorktown Research Center, New York

THE IMPORT OF POLARIZED MESON BEAMS

Study of meson decay has led to further confirmation of parity nonconservation in "weak" interactions of high-energy particles by a group of scientists of the Columbia University Physics Department and the IBM Watson Laboratory at Columbia. Their work has also uncovered important new knowledge of the meson particle itself.

When T. D. Lee and C. N. Yang first proposed their now famous hypothesis of parity nonconservation, they pointed out that it implied a polarization of the spin of the μ meson emitted from stopped π mesons. About two years ago, precise experiments by R. L. Garwin and L. M. Lederman

verified this predicted polarization with meson beams extracted from the Columbia University Nevis Cyclotron. More recently, polarized meson beams were used to measure accurately the magnetic moment of the μ meson. This experiment required apparatus for measuring time to 2/10,000 of a microsecond.

As a result of these studies and other independent investigations, the meson is now probably better understood than any particle except the electron. In fact, polarized meson beams have become a powerful tool for exploring magnetic fields in nuclei, atoms and interatomic regions.

IBM® RESEARCH

*Investigate the many career opportunities available in exciting new fields at IBM.
International Business Machines Corporation, Dept. 659I, 590 Madison Avenue, New York 22, New York*

**mold reactor
fuel elements in
precision glass**

New idea if you're in reactor fuel business.

Elements injection cast in precision bore high silica glass tubes. Seventeen inches long.

Precision shrunk by F&P to bore diameter of 0.1475 ± 0.0005 in.

Absolutely straight, uniform. Interesting?

Doesn't even scratch surface! Regularly hold bore to ± 0.0001 in., can go to ± 0.00005 in. Also control o.d., taper, concentricity, length . . . you name it.

Almost makes glass new design material!

More ideas, information Catalog 80-23. Write for copy, or send sketch.

Fischer & Porter Co.,
611 County Line Road,
Hatboro, Pennsylvania

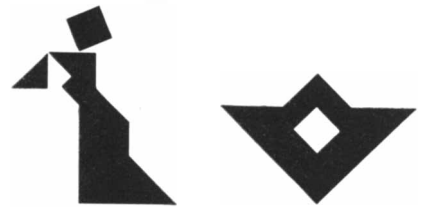
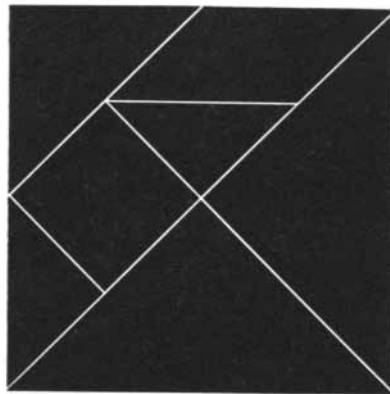
FP

achieve a certain result. One of the best puzzles of this type, widely sold in Victorian England, is shown in the illustration at the top of page 242. The object of the puzzle is to exchange the positions of the black and white pegs in the fewest number of moves. A move is either (1) from one square to an adjacent vacant square, or (2) a jump over an adjacent peg to a vacant square. A peg may jump a peg of the same or opposite color. All moves are "rook-wise"; no diagonal moves are permitted. Most puzzle books give a solution in 52 moves, but Henry Ernest Dudeney, the English puzzle expert, discovered an elegant solution in 46 moves that will be explained here next month. Perhaps a reader will find a still simpler one, but this is unlikely because 46 moves has been the record for many decades. The puzzle can be worked by placing small counters on top of the pegs in the illustration. The squares are numbered to facilitate recording the answer.

This and the preceding puzzle were singled out because the reader can construct them with little effort. Most of the

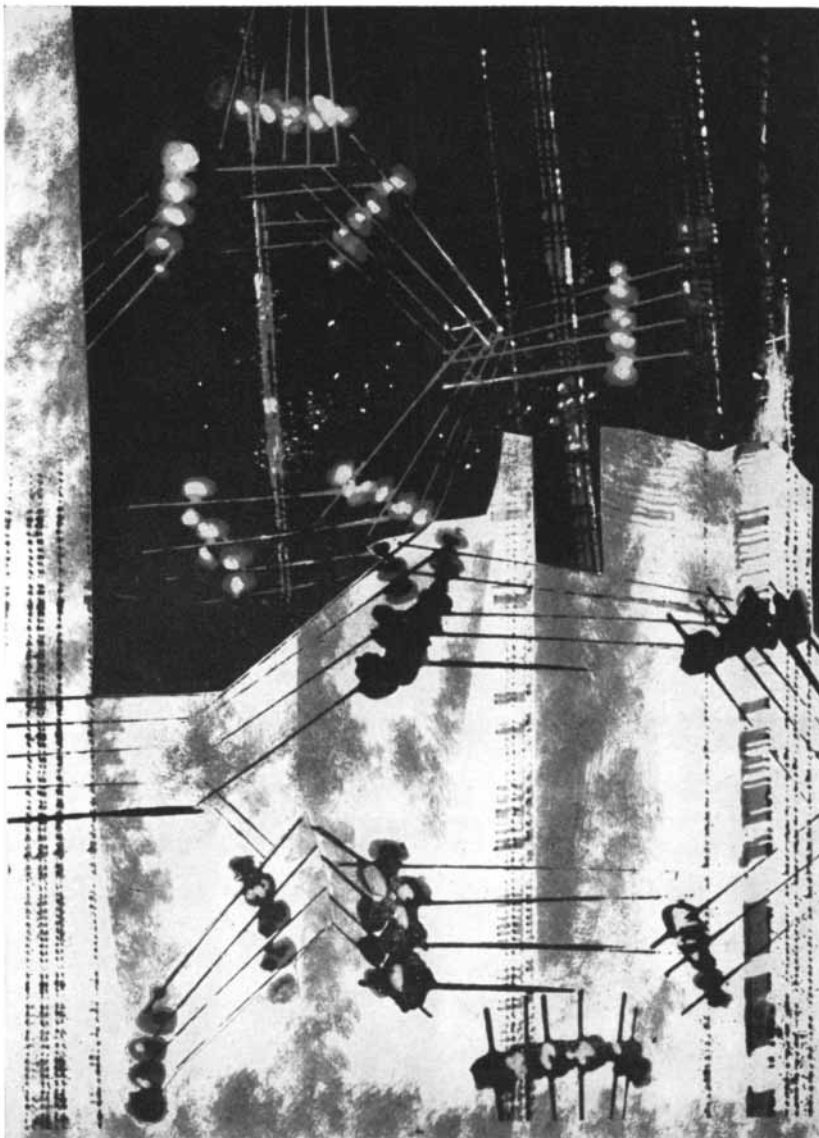
puzzles in Grimes's collection cannot be made easily; since they must be handled to be appreciated, I shall content myself with a brief description of their variety. There are puzzle boxes, purses and other containers to be opened by cleverly hidden methods, hundreds of odd-shaped wire puzzles to be taken apart, silver bracelets and finger rings made of separate pieces that interlock ingeniously, cords to be removed from objects without cutting or untying, glass-topped dexterity puzzles containing objects that are rolled or shaken into desired positions, rings to be removed from rods, eggs to be balanced on end, mazes in three dimensions, Chinese puzzles of interlocked wooden pieces, and hundreds of curious puzzles that defy all classification. Who invents such toys? To trace them back to their origins would be an impossible task. In most cases it is not even known in what country a puzzle originated.

There is one happy exception. A section of Grimes's collection is reserved for about 200 remarkable puzzles invented and constructed by L. D. Whitaker, a

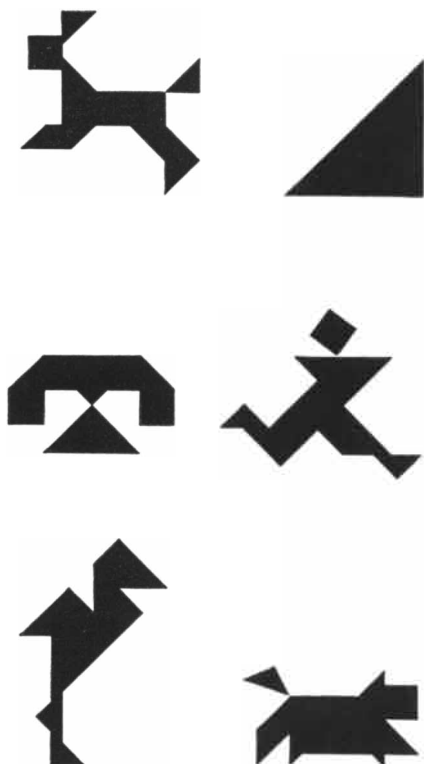


Chinese tangrams (top left) and some of the figures that can be made

retired veterinarian of Farmville, Va. The puzzles are beautifully made of fine woods (Whitaker turns them out in a basement workshop), and many of them are enormously complicated and diabolically clever. A typical puzzle is a box with an opening at the top into which you drop a steel ball. The object is to get the ball out through a hole in the side of the box. One is allowed to manipulate the box in any manner, provided, of course, it is not damaged or taken apart. Much more is required than just tipping the box to roll the ball through concealed passageways. Certain impediments must be removed by tapping the box in certain ways. Other barriers have to be lifted by applying magnets or blowing through small holes. Interior magnets are so placed that they grab the ball and hold it. You are unaware of this because there are dummy balls inside that you hear rattling about. On the outside of the box there may be wheels, levers and plungers of various types. Some of them must be manipulated a certain way to get the ball through the box; others are there



Electronics in Art created for RCA by A. W. Gale



with the seven "tans"

A NEW DIMENSION

IN SCIENTIFIC OPPORTUNITY

FOR SCIENTISTS - ENGINEERS

RCA's continuing research and development program—which recently produced the *dramatic nuvistor concept*—has a limited number of challenging project assignments available to qualified scientists and engineers. You are invited to inquire about these key positions if you have a degree in...

ELECTRICAL ENGINEERING • CERAMICS • PHYSICS • METALLURGY

Phone or write: Mr. J. F. McPartland • Dept. J-270 • HUmboldt 5-3900



RADIO CORPORATION OF AMERICA

Electron Tube Division • Harrison, New Jersey



NEW PRECISION

for your films



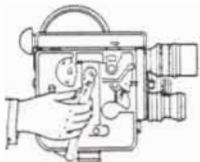
H-16 REX

NEW BOLEX H-16 REFLEX!

*New Variable Shutter Adds
Exposure Control to 16mm Movies*

CONTROL EXPOSURE more precisely than ever before—cut down glare . . . sharpen fast-action subjects . . . and wash out unwanted backgrounds. Makes possible perfect fades and lap dissolves.

SHOWN ON CAMERA is the REXO-FADER, a fading device that automatically times fades for pre-set number of frames. Optional at \$37.50.

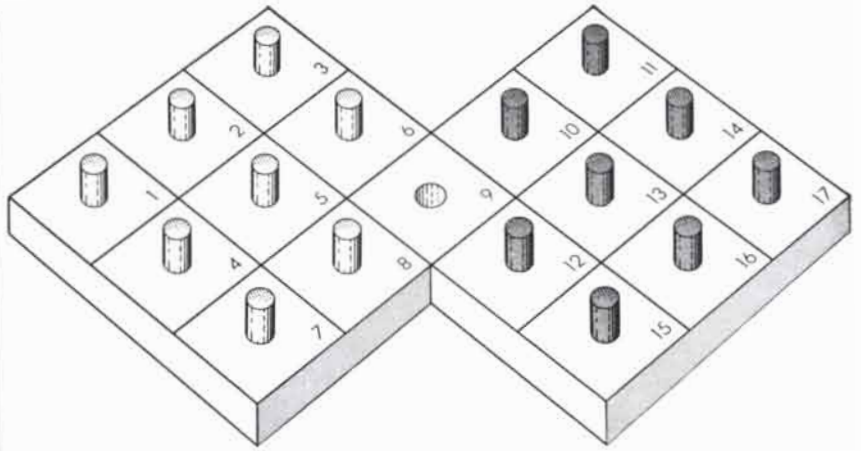


WITH THE BOLEX REFLEX SYSTEM, you view and focus through the shooting lens. No parallax, no figuring distance. Insures exact centering of subject in macrophotography—field scenes without a doubt about focus.

OTHER H-16 REX FEATURES: governed speeds from 12 to 64 fps, footage and frame indicators, time exposure setting, plus over 10 other professional extras as standard equipment. Priced from \$400.00 with Lytar 1" F/1.8 lens. Lenses shown are optional at extra cost. Available on convenient terms; write today for literature and the name of your Bolex dealer.

All prices include Federal Excise Tax where applicable.

BOLEX
PAILLARD Incorporated
100 Sixth Avenue, New York 13, N.Y.



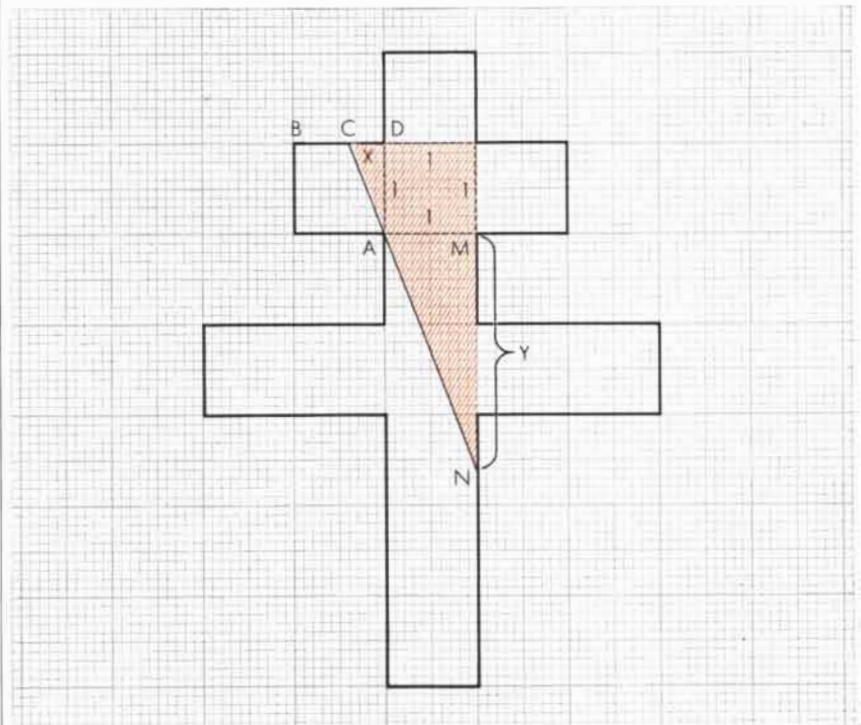
How can the black and white pegs be transposed in the smallest number of moves?

just to confuse you. It may be necessary at some point to push a pin through an inconspicuous hole.

For several years Grimes and Whitaker had an arrangement whereby Grimes received a new puzzle at regular intervals. If he solved it in a month, he was permitted to keep it; otherwise he had to buy it. In some instances the challenge was accompanied by vigorous side bets. Once Grimes worked for almost a year on a Whitaker puzzle without cracking it. He had gone over it with a small compass to locate all concealed magnets. He had carefully probed all

the openings with bent wires. The bottleneck was a plunger that had to be pushed in, but apparently some interior steel balls prevented this. Grimes correctly deduced that these balls were to be tilted out of the way, but all his attempts to do this were unsuccessful. He finally solved the puzzle by having it X-rayed. The prints disclosed one large cavity into which four balls had to be rolled, and a smaller cavity into which a fifth ball had to be maneuvered. When all five balls were out of the way, the plunger yielded.

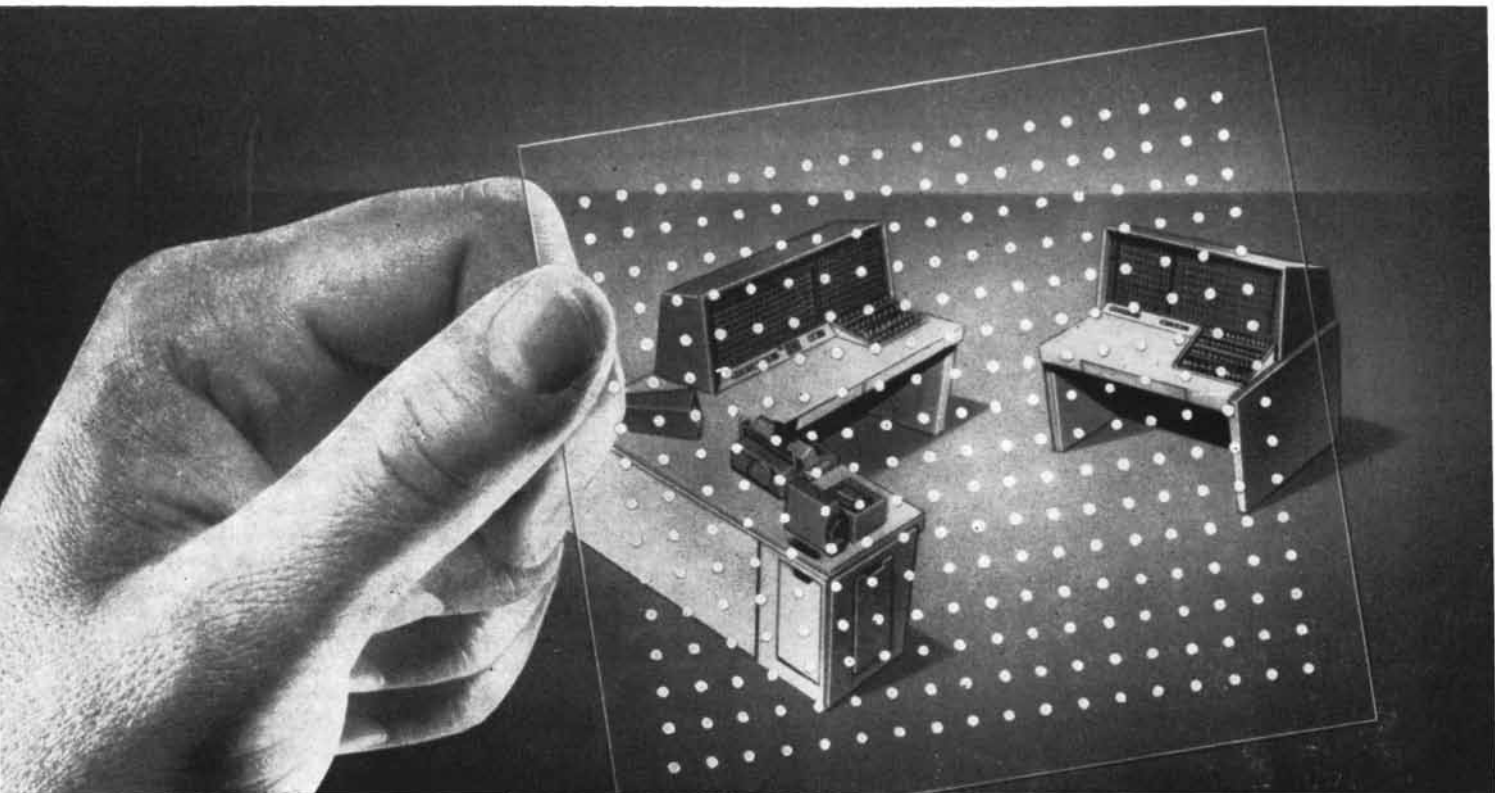
The rest of the puzzle was not so diffi-



Solution to last month's problem of bisecting the Cross of Lorraine (see also page 244)

Deposited Memory Cores

One of the many areas of advanced research and development now open to engineers and scientists at Remington Rand Univac



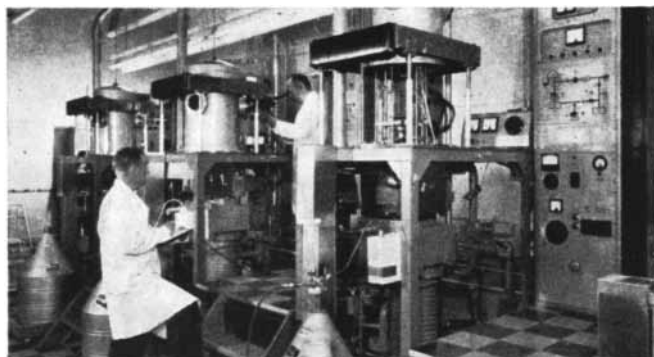
In the very composition of matter lies the key to a whole new range of digital computer capabilities. Solid state research has been vitally important to the outstanding reliability of Univac® military computers. One of the most interesting current programs involves a searching study of ferro-magnetic domain behavior as applied to computer memory elements. An important result of this program is the use of thin film memory cores produced through vacuum deposition of molten metals. Switching time of deposited cores is in some instances as fast as 1/40 to 1/50 micro-second. Use of these thin (.1 microns) deposits is an important step toward micro-miniaturization of computer components. The evaporative process also promises to greatly simplify and speed up quantity production of memory units.


This is one example of a variety of programs currently in progress at Remington Rand which offer opportunity for advanced work in your field of interest. In all of them you will find the advanced facilities and the favorable environment which foster original, imaginative research and development.


If you have experience and education in a scientific field that has application to the computer technology, we invite inquiries pertaining to career opportunities.

Send complete resume of education and experience to:

R. K. PATTERSON, Department S-10



ADVANCED EXPERIMENTAL 
equipment for production of deposited core memory elements employs vacuum chambers utilizing both oil and mercury diffusion pumps.

ELECTRON MICROSCOPE 
capable of 200,000 X magnification permits intensive study of ferro-magnetic domain structure in investigating various metals and alloys used for memories.



Remington Rand Univac

DIVISION OF SPERRY RAND CORPORATION
2750 West 7th Street • St. Paul 16, Minnesota



MISSILE ENGINEERS

Inauguration of a new weapons systems program at Raytheon has created exceptionally rewarding openings for Junior and Senior engineers with missile experience in the following areas:

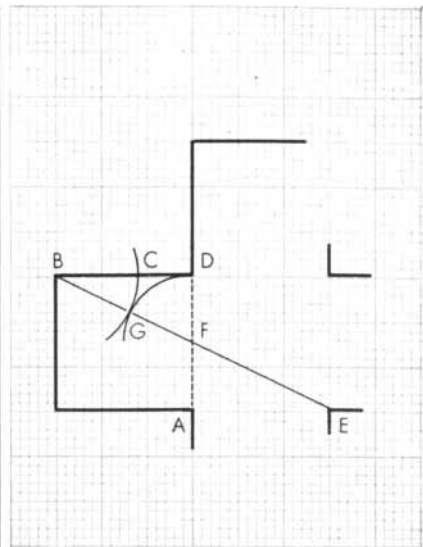
- Microwave design—
- component and antenna
- Aerodynamics
- Communications systems
- Digital programming
- Guidance systems
- Radome design
- Computer systems
- Heat transfer
- Radar systems
- Inertial reference systems
- Feed-back control
- Auto-pilot
- Ground support
- Electronic packaging
- Radar systems—project management
- Electromechanical engineering background in missile control and auto-pilot design—project management
- Mechanical engineering background in ground handling of large missile systems—project management

Living and working in the suburban Boston area offers many advantages. Relocation assistance and liberal benefits.

Please forward
resume to:
Mr. W. F. O'Melia
Employment Manager
Raytheon Company
Bedford, Massachusetts
or call collect:
CRestview 4-7100
Extension 2138



**MISSILE
SYSTEMS
DIVISION**



More on the Cross of Lorraine problem

cult, though at one point it required three hands. While the right and left hands applied pressure at certain spots, another plunger, attached to a strong spring, had to be pulled out. Grimes finally managed it by tying one end of a cord to the plunger and the other end to his foot!

Last month's problem of bisecting the Gaullist cross can be solved algebraically by letting x be the length CD [see illustration at the bottom of page 242], and y be the length MN . If the diagonal line bisects the cross, the shaded triangle must have an area of $2\frac{1}{2}$ square units. This permits us to write the equation $(x + 1)(y + 1) = 5$. Because triangles ACD and AMN are similar, we can also write the equation $x/1 = 1/y$.

The two equations combine to give x a value of $\frac{1}{2}(3 - \sqrt{5})$. BC therefore has a length of $\frac{1}{2}(\sqrt{5} - 1)$, or .618+, which is the reciprocal of phi (1ϕ). In other words, BD is divided by C in golden ratio. The lower end of the diagonal line similarly divides the side of the unit square in golden ratio. The bisecting line has a length of $\sqrt{15}$.

To find point C with compass and straight-edge we can adopt any of several simple methods that go back to Euclid. One is as follows:

Draw BE as shown in the illustration above. This bisects AD , making DF one half of BD . With the point of the compass at F , draw arc of circle with radius DF , intersecting BF at G . With point of compass at B , draw arc of circle with radius BC , intersecting BD at C . BD is now divided into the required golden ratio.



The care and feeding of a missile system

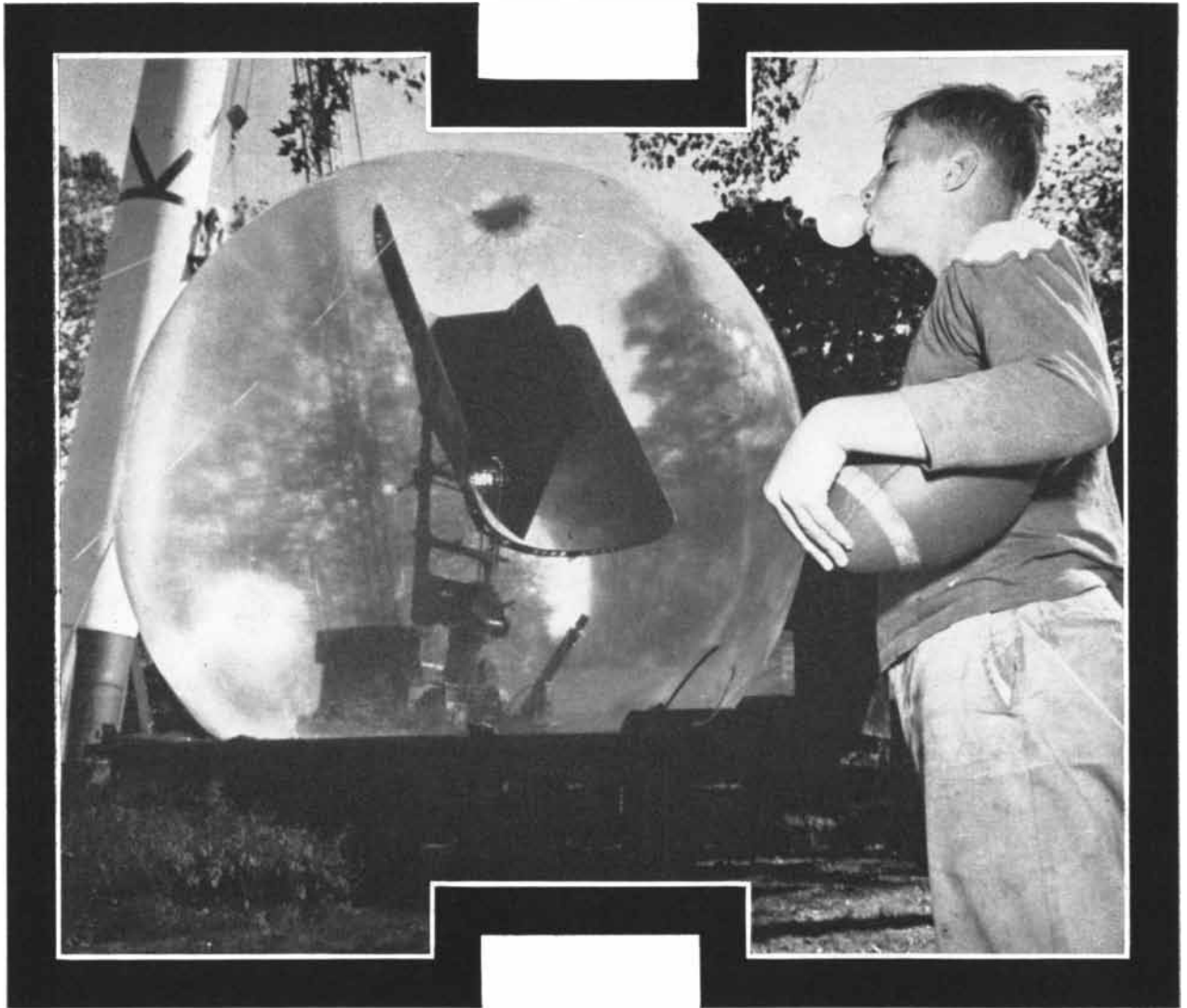


It takes more than pressing a button to send a giant rocket on its way. Actually, almost as many man-hours go into the design and construction of the support equipment as into the missile itself. A leading factor in the reliability of Douglas missile systems is the company's practice of including all the necessary ground handling units, plus detailed procedures for system utilization and crew training. This complete job allows Douglas missiles like THOR, Nike HERCULES, Nike AJAX and others to move quickly from test to operational status and perform with outstanding dependability. Douglas is seeking qualified engineers and scientists for the design of missiles, space systems and their supporting equipment. Write to C. C. LaVene, Box 620-N, Douglas Aircraft Company, Santa Monica, California.

Alfred J. Carah, Chief Design Engineer, discusses the ground installation requirements for a series of THOR-boosted space probes with Donald W. Douglas, Jr., President of DOUGLAS

MISSILE SYSTEMS ■ SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND-HANDLING EQUIPMENT

A new dimension in



bubble blowing

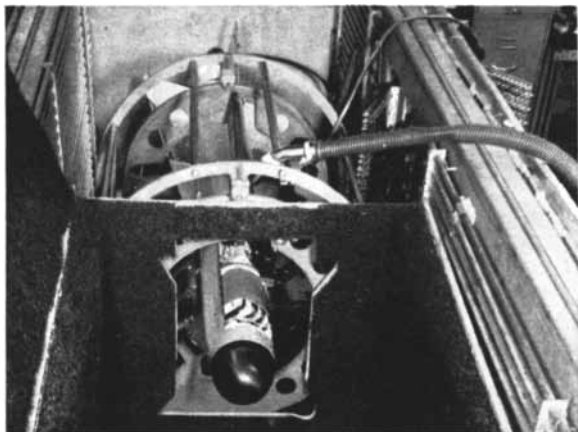
This plastic bubble protects the antenna of a radically new aerial three-dimensional radar defense system.

Sensitive to the inadequacies of conventional radar systems, engineers at Hughes in Fullerton devised a radar antenna whose pointing direction is made sensitive to the frequency of the electromagnetic energy applied to the antenna. This advanced technique allows simultaneous detection of range, bearing and altitude...with a single antenna.

Hughes engineers combined this radar antenna with "vest-pocket sized" data processors to co-ordinate antiaircraft missile firing. These unique data processing systems provide:

1. **Speed**—Complex electronic missile firing data was designed to travel through the system in milliseconds, assuring "up-to-date" pinpoint positioning of hostile aircraft.
2. **Mobility**—Hughes engineers "ruggedized" and miniaturized the system so that it could be mounted into standard army trucks which could be deployed to meet almost any combat problem—even in rugged terrain.
3. **Reliability**—By using digital data transmission techniques, Hughes engineers have greatly reduced any possibility of error.

Result: the most advanced electronics defense system in operation!



Falcon air-to-air guided missiles, shown in an environmental strato chamber are being developed and manufactured by Hughes engineers in Tucson, Arizona.

Reliability of the advanced Hughes systems can be insured only with the equally advanced test equipment designed by Hughes El Segundo engineers.



Other Hughes projects provide similarly stimulating outlets for creative talents. Current areas of Research and Development include advanced airborne electronics systems, advanced data processing systems, electronic display systems, molecular electronics, space vehicles, nuclear electronics, electroluminescence, ballistic missiles...and many more. Hughes Products, the commercial activity of Hughes, has assignments open for imaginative engineers to perform research in semiconductor materials and electron tubes.

Whatever your field of interest, you'll find Hughes diversity of advanced projects makes Hughes an ideal place for you to grow... both professionally and personally.

Newly instituted programs at Hughes have created immediate openings for engineers experienced in the following areas:

Infrared	Thin Films
Plasma Physics	Microwave Tubes
Digital Computers	Circuit Design & Evaluation
Field Engineering	Systems Design & Analysis
Quartz Crystal Filters	Logical Design
Communications	Semiconductor Circuit Des.

*Write in confidence to Mr. Mike Welds
Hughes General Offices, Bldg. 6-H9, Culver City, Calif.*

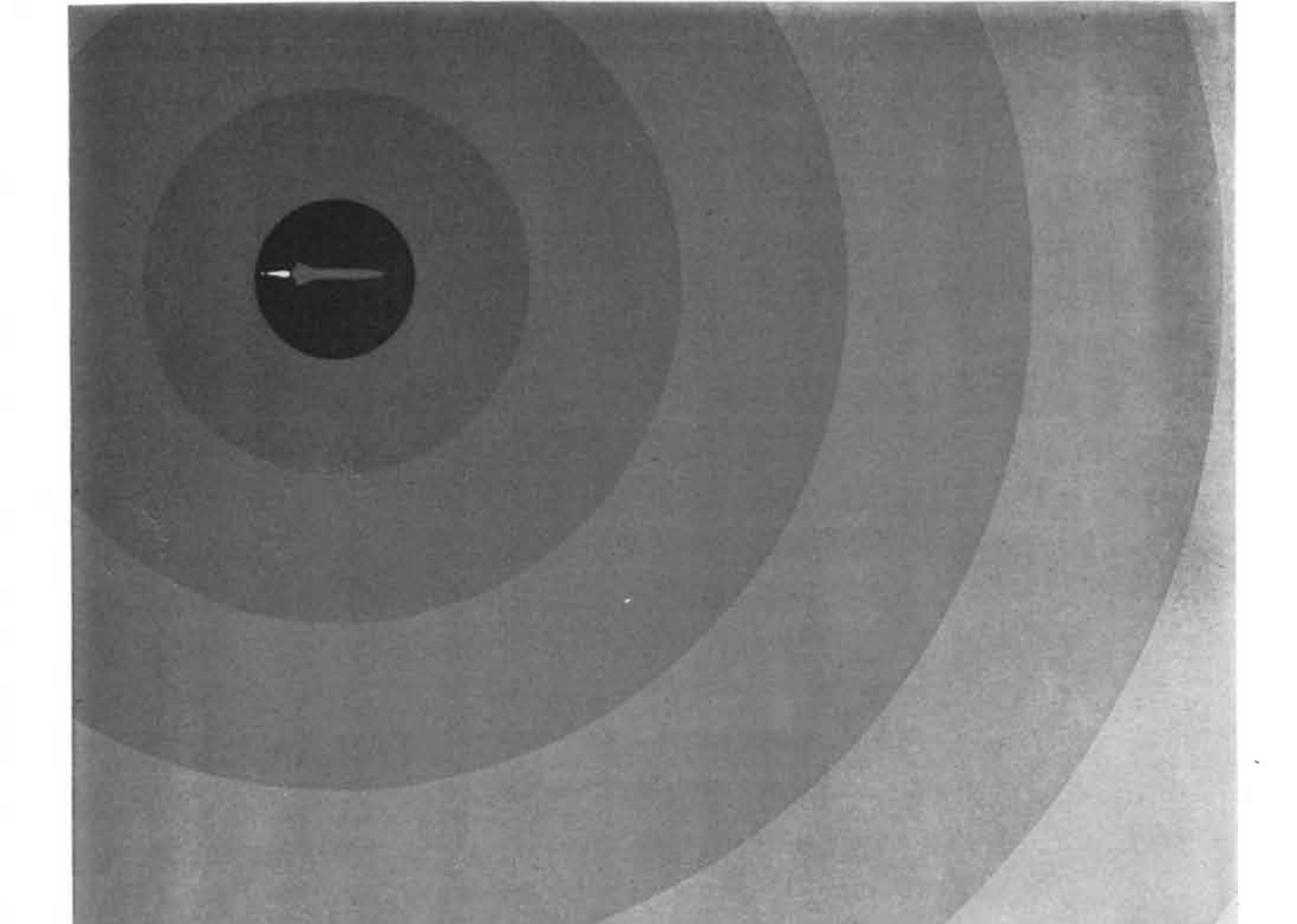
© 1959, H. A. C.

HUGHES

*The West's
leader in
advanced
ELECTRONICS*

HUGHES AIRCRAFT COMPANY

*Culver City, El Segundo, Fullerton, Newport Beach,
Malibu and Los Angeles, California
Tucson, Arizona*



Infrared Systems...

CAPABLE OF SELECTING THE TARGET IN ANY ENVIRONMENT

The scientists and engineers engaged in Infrared Systems research at the Ramo-Wooldridge division of Thompson Ramo Wooldridge Inc. have successfully developed infrared systems possessing unique capabilities for solving target discrimination problems. Advanced electronic and infrared techniques have been combined to produce superior detection systems for airborne and ground-based applications. Programs are now underway to provide infrared systems for guided missiles, anti-aircraft fire control, air collision warning, and advanced weapons systems.

■ *Scientists and engineers with backgrounds in infrared systems, electronic systems technology, computers, or data processing are invited to explore current opportunities at Ramo-Wooldridge. Please address inquiries to Mr. D. L. Pyke, Ramo-Wooldridge, P. O. Box 90534, Airport Station, Los Angeles 45, California.*



Thompson Ramo Wooldridge Inc.

Main offices • CLEVELAND 17, OHIO • LOS ANGELES 45, CALIFORNIA



THE AMATEUR SCIENTIST

An amateur's controlled experiments measure the effects of a tranquilizing drug on rats

Conducted by C. L. Stong

How is it that so many new drugs have been added to the armamentarium of medicine in recent years? A large part of the answer lies in the intensified application of the art of the controlled experiment. In an earlier epoch of medicine useful drugs were simply handed down from one generation to another, that is, they had been discovered by virtually accidental experiments on human patients. Today the process is vastly accelerated not only by our advanced knowledge of microbiology and human physiology but also by controlled experimentation on large numbers of laboratory animals. The scope of such experiments is ambitious, but the principles involved are relatively simple, and can even be applied by the amateur. A nice example is submitted by Sarah E. Southwick of Midland, Mich., who is presently a student at the University of Michigan.

"For my science fair project during my senior year in high school," Miss Southwick writes, "I set up a controlled experiment to test the effect on rats of chlorpromazine, one of the new tranquilizing drugs. Tranquilizers were making news at the time, particularly in the treatment of mental disease, and this caught my interest. According to medical reports, the side effects of the tranquilizers had not been fully catalogued, and it seemed likely that a science fair project based on one of them would have a good chance of scoring high on originality.

"Chlorpromazine has the property of quieting mental patients who are restless, overactive and abnormally elated. Would the drug have a similarly depressing effect on normal animals? If so, how would it affect other aspects of their functioning?"

"As subjects for the experiment I ob-

tained six white rats, all males from the same litter. During the first phase of the experiment three rats were selected at random for treatment and the remaining three were reserved as controls. Each animal was tagged for identification. Midway through the experiment the treatment was switched; the controls were put on the drug, and the group previously treated became the controls. I called this the 'crossover' phase. It served as a check against previous results. Otherwise all animals were maintained under identical conditions as closely as possible, and each was given a standard ration of food and water on a fixed schedule. The experiment continued for five months as a spare-time activity.

"A thorough physical examination was made of each animal at the beginning of the experiment, both to assure that the animals were in good health and to provide comparison data for subsequent use. The effects of the drug were then observed by measuring changes in activity, intelligence, blood composition, pulse rate, body temperature, weight, respiratory rate, external features, sexual behavior, internal organs and metabolism. The animals were treated by administering chlorpromazine along with their food, initially at the rate of five milligrams of the drug per kilogram of body weight. After one week the dose was increased to 15 milligrams; somewhat later, to 20 milligrams.

"Reaction to the drug was immediate. The treated rats became quieter than the control group. Their movements were slower and more deliberate. To measure the difference I designed a 'jiggle cage' consisting of a box of quarter-inch wire mesh covered at the bottom with a sheet of heavy aluminum foil of the kind used by bakers. The cage was suspended by a weak spring from the bottom of a small table consisting of a seven-inch square of half-inch plywood fitted with legs of wooden dowel stock. The movements of the caged rat caused the cage to jiggle up and down and actuate the handle of a telegraph key in contact with the bottom of the cage. The key closed an electrical circuit between a battery and the

coils of a modified buzzer. The buzzer contacts were closed; a wire stylus was attached to the armature. The stylus pressed against the smoked drum of a kymograph on which the movements of the rat registered as sharp vertical pips in an otherwise smooth trace. I borrowed the kymograph from the biology department of the Midland High School. It is not too difficult, however, to make such a drum recording-device. One is described, in fact, in 'The Amateur Scientist' for July, 1957. A recording speed of some three inches per second, equivalent to the speed of a six-inch drum turning at about one revolution per minute, is adequate for this experiment.

"The activity of each rat was measured daily for one hour in darkness (when rats are commonly most active). Copies of two recordings are shown in the accompanying illustration [bottom of next page]. These show the activity of the same rat before and after the drug had been administered.

"The effect of chlorpromazine on intelligence was tested by means of a changeable maze in which both the pattern of the paths and the obstacles (rectangular partitions) could be altered. The animal was required to crawl under a partition or jump over it, depending on whether the partition was turned so that its opening was at the top or at the bottom. The maze was covered so the animals would not be distracted during the run. To test the adjustment of the rats to change the maze was altered four times for each group of animals during the course of the experiment. In the beginning the control rats required about seven runs to learn the maze, during which the time of the run dropped from eight minutes to 30 seconds. The treated group required substantially more practice to achieve comparable performance; at first these rats actually lost ground. The reaction of the rats was even more significant during the crossover phase of the experiment.

"During the crossover phase the rats in the control group learned to run the maze, with practice, in five seconds. When they were under the influence of

YOUR LOGICAL CHOICE IS A UNITRON REFRACTOR

The beginner, advanced amateur, and professional alike turn to UNITRON for combined optical and mechanical excellence. Invest in a UNITRON—the telescope that has stood the test of time.



UNITRON 2.4" Altazimuth Refractor with UNIHEX

Complete with eyepieces for 100X, 72X, 50X, 35X; UNIHEX Rotary Eyepiece selector; altazimuth mounting with slow motion controls; tripod; 5X viewfinder; sunglass; and cabinets. **only \$125**



UNITRON'S 6" and 4" Equatorial Refractors

17 UNITRON REFRACTORS TO SELECT FROM

SATELLITE TELESCOPE.....	\$ 75
1.6" ALTAZIMUTH	75
2.4" EQUATORIAL	225
3" ALTAZIMUTH	265
3" EQUATORIAL	435
4" ALTAZIMUTH	465
4" EQUATORIAL	785
6" EQUATORIAL	5125

All instruments fully guaranteed. Shipment express collect. Prices include Standard accessories. Send check or M.O. or 20% deposit with balance C.O.D.

TIME PAYMENT PLAN AVAILABLE!

GET UNITRON'S FREE CATALOG and 38 page OBSERVER'S GUIDE. This valuable introduction to astronomy is yours for the asking.

Contents include—

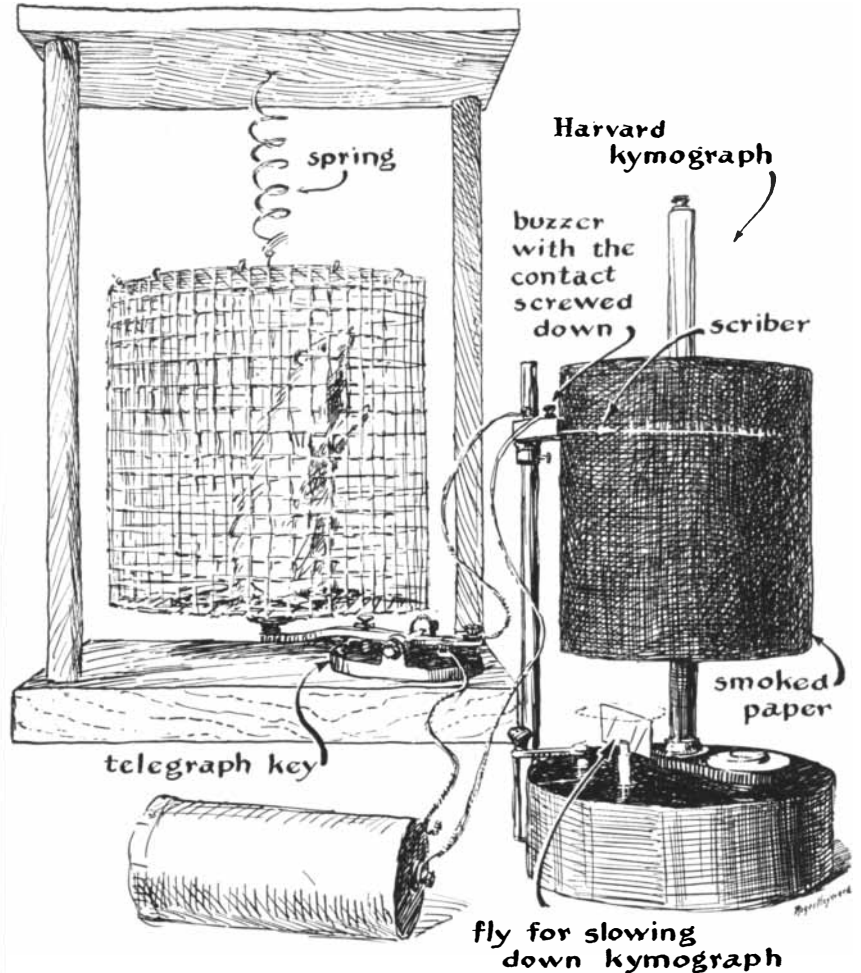
- Observing the sun, moon, planets and wonders of the sky
- Constellation map
- Hints for observers
- Glossary of telescope terms
- How to choose a telescope
- Amateur clubs

Send for your copy to Dept. 6-U



UNITRON

INSTRUMENT DIVISION of UNITED SCIENTIFIC CO.
204-206 MILK STREET • BOSTON 9, MASS.

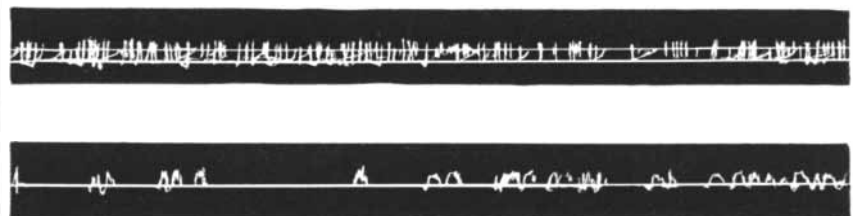


Cage, telegraph key and kymograph to measure the activity of a rat

chlorpromazine, however, none of these rats could do better than one minute. In contrast, the previously treated rats, after recovering from the drug, learned to run a new pattern in five seconds. Furthermore, when the crossover phase was started, the drug caused the controls to forget a maze pattern they had mastered. From this it would appear that the drug has a depressing effect on memory as well as on intelligence.

"Does the drug similarly depress organic functions? This was investigated in part by examining changes in the blood of the rats. The blood was taken

by clipping the tip of the rat's tail. Incidentally, I quickly learned that rats are not as cooperative in all parts of the experiment as one could wish; blood sampling is a case in point. I first tried to hold the animals in one hand while taking the specimen with the other, but soon adopted the technique of wrapping them in a towel. Later I borrowed a glass vessel especially designed for the purpose. Standard clinical pipettes were used for withdrawing two specimens of blood from each rat: one specimen to ascertain the number of red blood cells; the other to test for the number of white



Top record reflects activity of untreated rat; bottom record, activity of treated rat

GET READY FOR THE SPACE and SCIENCE ERA! SEE SATELLITES, MOON ROCKETS CLOSE-UP

AMAZING OPTICAL BUYS

and OTHER SCIENTIFIC BARGAINS



Terrific Buy! American Made! OPAQUE PROJECTOR



Projects illustrations up to 3" x 3½" and enlarges them to 4 ft. wide. No film or negatives needed. Projects charts, diagrams, pictures, photos, lettering in full color or black-and-white. Operates on 115 volt, A.C. current, 6-ft. extension cord and plug included. Operates on 60 watt bulb, not included. Size 12" x 8" x 4½" wide. Weight 1 lb., 2 oz. Plastic case with built-in handle.
Stock No. 70,199-S.....\$7.95 Postpaid

American Made—Over 50% Saving STEREO MICROSCOPE



Years in development. Equals \$300 to \$400 instrument. Precision American made. Used for checking, inspecting, small assembly work. Up to 3" working distance. Clear, sharp, erect image. Wide, 3 dimensional field. 2 sets of objectives on rotating turret. 23X and 40X. 10 Day Free Trial.
Stock No. 85,056-S.....\$99.50
f.o.b. Barrington, N.J.

Low Power Supplementary Lens Attachment for above Stereo—provides 15X down to 6X with clear, extra large 1½" field at 6X.
Stock No. 30,276-S.....\$7.50



ASSEMBLED AND READY TO USE!

Photographers! This is an actual photograph of the moon taken through our Astronomical Telescope by a 17-year-old student.

See the Stars, Moon, Planets Close Up! 3" ASTRONOMICAL REFLECTING TELESCOPE 60 to 160 Power—An Unusual Buy!

Famous Mt. Palomar Type

You'll see the Rings of Saturn, the fascinating planet Mars, huge craters on the Moon, Star Clusters, Moons of Jupiter in detail. Galaxies! Equatorial mount with lock on both axes. Aluminized and overcoated 3" diameter high-speed f/10 mirror. Telescope comes equipped with a 60X eyepiece and a mounted Barlow Lens, giving you 60 to 160 power. An Optical Finder Telescope, always so essential, is also included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART, and 272 page "Astronomy Book."

Stock No. 85,050-S.....\$29.95 Postpaid

HELPFUL NEW BOOK for the AMATEUR "HOW TO USE YOUR TELESCOPE"



A down-to-earth introduction to Astronomical Telescopes and the stars. Clear, simple language—profusely illustrated. Contains moon map, diagrams.

Tells how to select and use Telescope—all about power, mounts, eyepieces, collimation, Barlow Lenses—guide to stars and Planet observation.
Stock No. 9055-S 32 pages Only 60¢ Postpaid.

4¼" REFLECTING TELESCOPE! Up to 270X!



With this scope you can see everything as above but with greater power plus will split finer stars. Mirror has twice the light gathering power. Mirror guaranteed to give theoretical limit of resolution. Rack and pinion focusing, hardwood tripod, real equatorial mounting—only one adjustment follows stars! Aluminum tube. 6 power finder telescope. 2 standard size eyepieces and mounted Barlow lens give you powers of 40X, 80X, 120X, and 270X. Low-cost accessory eyepiece available for higher powers. Free handbook and Chart. Shipping weight 25 lbs.

Stock No. 85,006-S.....\$74.50 f.o.b. Same Telescope as above but equipped with Electric Clock Drive—Stock No. 85-094-S.....\$111.50 F.O.B. Barrington, N. J.

NEW BINOCULAR-TO-CAMERA HOLDER



For Exciting Telephoto Pictures

Bring distant objects 7 times nearer with a 35 mm. camera. 7x50 binocular and our NEW BINOCULAR - TO - CAMERA HOLDER. Ideal for long-range shots of wild life, ships, planes, people, etc. Camera and binoculars attach easily. Use any binocular or monocular—any camera, still or movie. Take color or black and white. Full directions for taking telephotos.
Stock No. 70,223-S.....\$11.50 postpaid

NEW! STATIC ELECTRICITY GENERATOR



Sturdy, Improved Model!

See a thrilling spark display as you set off a miniature bolt of lightning. Absolutely safe and harmless. Sturdily made—it stands 14" high. Turn the handle and two 9" plastic discs rotate in opposite directions. Metal collector brushes pick up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping spark. Countless tricks and experiments. 24 page instruction booklet included.
Stock No. 70,070-S.....\$12.95 Postpaid

8 POWER ELBOW TELESCOPE—WAR SURPLUS

Terrific Bargain! \$200 Gov't Cost—Only \$13.50

Big 2" objective, focusing eyepiece 28mm focal length—Amici erecting system—turret mounted filters, clear, red, amber and neutral—reticle illumination. Sparkling, clear, bright image—6° field (325 ft. at 1,000 yds.). Focus adjusts 15 ft. to infinity. 28mm F.L. eyepiece alone is worth more than \$12.50.
Stock No. 70,173-S.....\$13.50 Postpaid

WAR SURPLUS!-INFRARED SNOOPERSCOPE

Govt. Cost \$900—Bargain at \$39.50

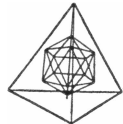


Converts infrared to visible light. See in total darkness without being seen. Use in lab, factory, classroom, etc. Completely portable. Operates on two flashlight batteries (not included). Image is quite good, may be made even better by careful focusing. Size 11½" x 8". Weight with carrying case 12 lbs. No infrared light source is furnished. (See below).
Stock No. 85,098-S.....\$39.50 f.o.b. Barrington, N.J.

INFRARED LIGHT SOURCE AVAILABILITY! You will need a 6-volt transformer or 6 V auto battery to operate.
Stock No. 80,035-S.....\$10.00 postpaid

D-STIX Construction Kits

Shape Your Ideas Fast!



Scientists, executives, planners, designers—all find D-STIX simplify visualization and demonstration of complex ideas. D-STIX—colored wood sticks ¼" thick and "easy-on" rubber joints approx. 3/16" diam.—help you work out molecular structures, geometric figures, structural members, shapes, models of scientific apparatus. Used by professional men, educators, hobbyists. Big basic kit contains 230 or 370 pieces. Additional parts in supplementary kit. Far superior to kits of wood or metal. Money-back guarantee.

Stock No. 70,209-S (230 pcs).....\$3.00 ppd.
Stock No. 70,210-S (370 pcs).....\$5.00 ppd.

ASTRO COMPASS AND STAR FINDER



Gov't Cost \$75—Price \$14.95 postpaid
Determines position of stars quickly. Shows various celestial coordinates. An extremely useful star finder which can be rotated through 60° angles along calibrated degree scale. Has single eye lens with viewing stop, two spirit levels for aligning, tangent screw with scale for fine precision readings, azimuth scale graduated in two-degree intervals, adjustable tilting azimuth scale for angle reference of stars on distant objects. War Surplus. Gov't cost \$75. Instructions, carrying case included.
Stock No. 70,200-S.....Only \$14.95 postpaid

GIANT MAGNETS! TERRIFIC BARGAINS!

War surplus—Alnico V type! Horseshoe shape. Tremendous lifting power. 5 lb. size. Dimensions: A—3¼"; B—2¾"; C—4¾"; D—1¼"; E—1¼"; F—2½". Strength is about 2,000 Gauss. Will lift over 125 lbs.



Stock No. 70,183-S.....\$8.50 Postpaid
15-¾ lb. size. Approximately 5,000-6,000 Gauss ratings. Will lift over 250 lbs.
Stock No. 85,088-S.....\$22.50 F.O.B. Shipping wt. 22 lbs. Barrington, N. J.



BUILD A SOLAR ENERGY FURNACE

A Fascinating Science Project!

A tremendous new field. You can build your own Solar Furnace for experimentation—many practical uses. It's easy—inexpensive—use your scrap wood. We furnish instruction booklet. This sun powered furnace will generate terrific heat 2000° to 3000°. Fuses enamel to metal—produces many unusual fusing effects. Sets paper aflame in seconds. Use our Fresnel Lens—14¾" diameter . . . f.l. 14".
Stock No. 70,130-S package of 1....\$ 6.00 Postpaid.
Stock No. 70,131-S package of 2.... 11.00 Postpaid.

REPLICA GRATING—Low, Low Cost Take Unusual Color Photos At Night!

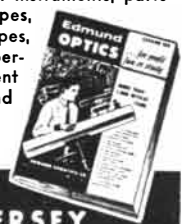


It's here—after decades of effort. Replica Grating—on film—at very low price. Breaks up white light into full spectrum colors. An exciting display. 13,400 lines per inch. Diffraction Grating has been used to answer more questions about the structure of the material world and the universe than any other single device. Use it for making spectroscopes, for experiments, as a fascinating novelty. First time available such large size—so cheaply—comes in clear plastic protector.

Stock No. 50,202-S—includes 2 pcs. 8" x 5½"—1 transmission type, 1 reflecting type. \$2.00 postpaid.

WRITE FOR FREE CATALOG-S

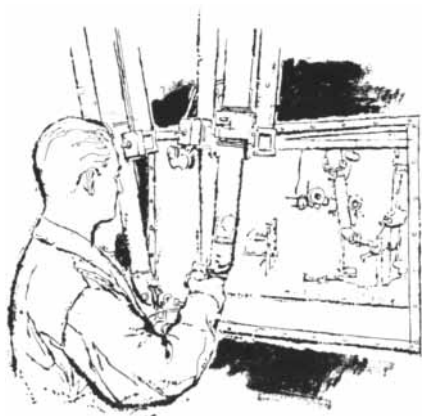
100 Pages! Over 1000 Bargains! Optics for the Space Era! Huge selection of lenses, prisms, war surplus optical instruments, parts and accessories. Telescopes, Microscopes, Satellite Scopes, Binoculars, Infrared Snooperscopes, science experiment items, math learning and teaching aids.
Request Catalog-S.



ORDER BY STOCK NUMBER . SEND CHECK OR MONEY ORDER . SATISFACTION GUARANTEED!

EDMUND SCIENTIFIC CO., BARRINGTON, NEW JERSEY

FISSION PRODUCTS NOW AVAILABLE



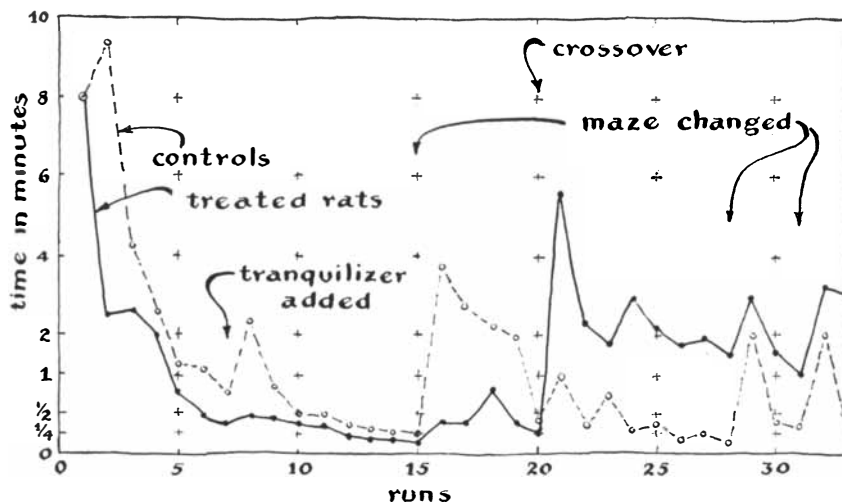
For the first time, *kilocurie* quantities of long-lived radioactive fission products are available for your development work. The new Fission Products Pilot Plant at Oak Ridge National Laboratory makes it possible to distribute these isotopes at greatly-reduced prices:

- Cerium-144
- Cesium-137
- Promethium-147
- Strontium-90
- Technetium-99

As the nation's principal supplier of isotopes, the Laboratory offers more than 300 radioactive and stable isotope products. Requests are invited for information concerning compounds for source fabrication. Oxides, fluorides, chlorides, and plate sources are available. Whatever your needs, we are ready to help you. Write to: Isotopes Division, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tennessee.



ISOTOPES DIVISION
Oak Ridge National Laboratory
Operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION



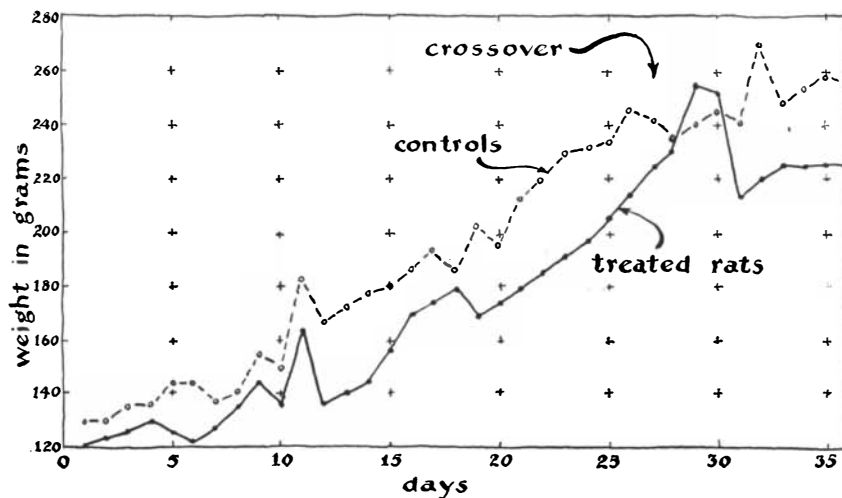
Graph compares the performance of treated and untreated rats in a maze

blood cells. The pipettes are fitted with a short length of suction tubing; one simply places the glass tip in the fluid and withdraws enough to reach the .5 mark etched in the glass. Sufficient diluting fluid is then drawn into the pipette to reach the top mark. When one is sampling white cells, the top mark is 11; in the case of red cells the mark is 101. The diluting fluid for white cells (which causes the red cells to disintegrate) consists of one part by volume of hydrochloric acid to 100 parts of distilled water. The red-cell specimen is diluted by a fluid consisting of .5 gram of mercuric chloride, five grams of sodium sulfate and one gram of table salt dissolved in 200 cubic centimeters of distilled water. This solution causes the white cells to disintegrate.

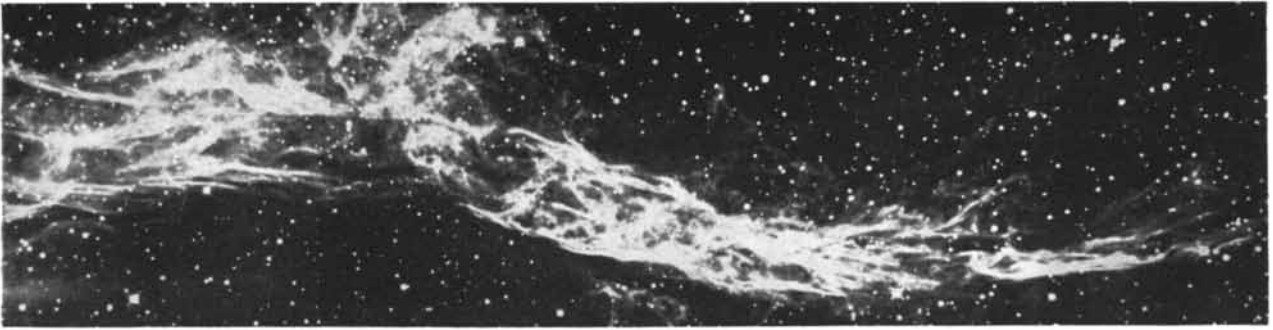
"Blood cells are counted with the aid of a special chamber that divides the field of view into a pattern of uniform

squares, somewhat like a sheet of graph paper. If one encounters difficulty in procuring a counting chamber, a rough estimate of change in the relative number of white cells and red cells can be made by comparing stained specimens. I borrowed a chamber.

"The red-cell count remained constant throughout the experiment for both treated and untreated rats. But the white-cell count increased substantially during the time the animals were on the drug, averaging 22,000 cells per cubic millimeter during treatment as against a normal count of 14,000. Counts were taken of all rats once each week for the first three weeks after the beginning of treatment. Measurements made during the crossover phase were identical with those recorded at the beginning of the experiment. In one exceptional case, however, both groups yielded identical counts. This occurred after the experi-



Graph compares the weight of treated and untreated rats



Space Technology Laboratories' new corporate symbol represents a bright history in a stimulating age. ★ STL has provided the over-all systems engineering and technical direction for the Air Force Ballistic Missile Program since it was assigned the highest national priority in 1954. Five years of accelerated effort produced epic advances in science and technology, and propelled the art of missilery through three distinct generations of progress. STL contributed technical leadership to the science/government/industry team which has built this solid, expandable foundation for future advances in space, and is daily adding new strength to our national security. ★ In addition to its major management functions, STL also conducts advanced space probe experiments for the Air Force at the direction of such agencies as NASA and ARPA. ★ To those scientists and engineers with capabilities in propulsion, electronics, thermodynamics, aerodynamics, structures, astrophysics, computer technology, and other related fields and disciplines, STL now offers unique professional opportunities. Inquiries regarding staff positions at STL are invited.



a new symbol
for a new era of
technology

Space Technology Laboratories, Inc. P. O. BOX 95004, LOS ANGELES 45, CALIFORNIA

Infrared Optical Systems

Prototypes or production runs in Cassegrain or catadioptric forms—short and long focus—have been satisfactorily supplied. If you have a problem we will be pleased to discuss it.



P
H
O
P
H
O
N
I
X

At the crossroads of opportunity for men with vision in Electronic Engineering.

**GOODYEAR
AIRCRAFT
CORPORATION**
ELECTRONIC LABORATORY

**WE HAVE OPENINGS IN OUR
MODERN LABORATORIES FOR
ADVANCED ENGINEERS AND
SCIENTISTS IN ELECTRONIC
RESEARCH AND DEVELOPMENT**

Long range research and development projects.

Graduate studies available under company financed evening courses.

LEISURE LIVING AT ITS BEST
"IN THE VALLEY OF THE SUN"

Send resume to: A. E. Manning

Engineering and Scientific Personnel

GOODYEAR AIRCRAFT
LITCHFIELD PARK
PHOENIX, ARIZONA
Similar opportunities available in our
Akron, Ohio, Laboratory

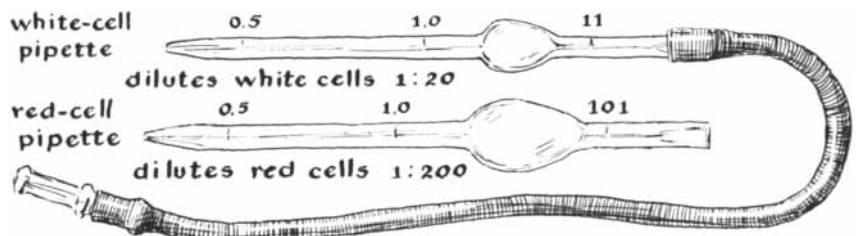
ment had been running two months and suggests that the rats may have developed some tolerance for the drug.

"Stained blood-specimens were examined with the aid of a microscope equipped with a 10-power eyepiece, an oil-immersion objective of 97 power, and dry objectives of 10 power and 43 power. The combinations of eyepiece and objectives gave magnifying powers of 970, 100 and 430 diameters. The instrument was borrowed from the Midland Hospital.

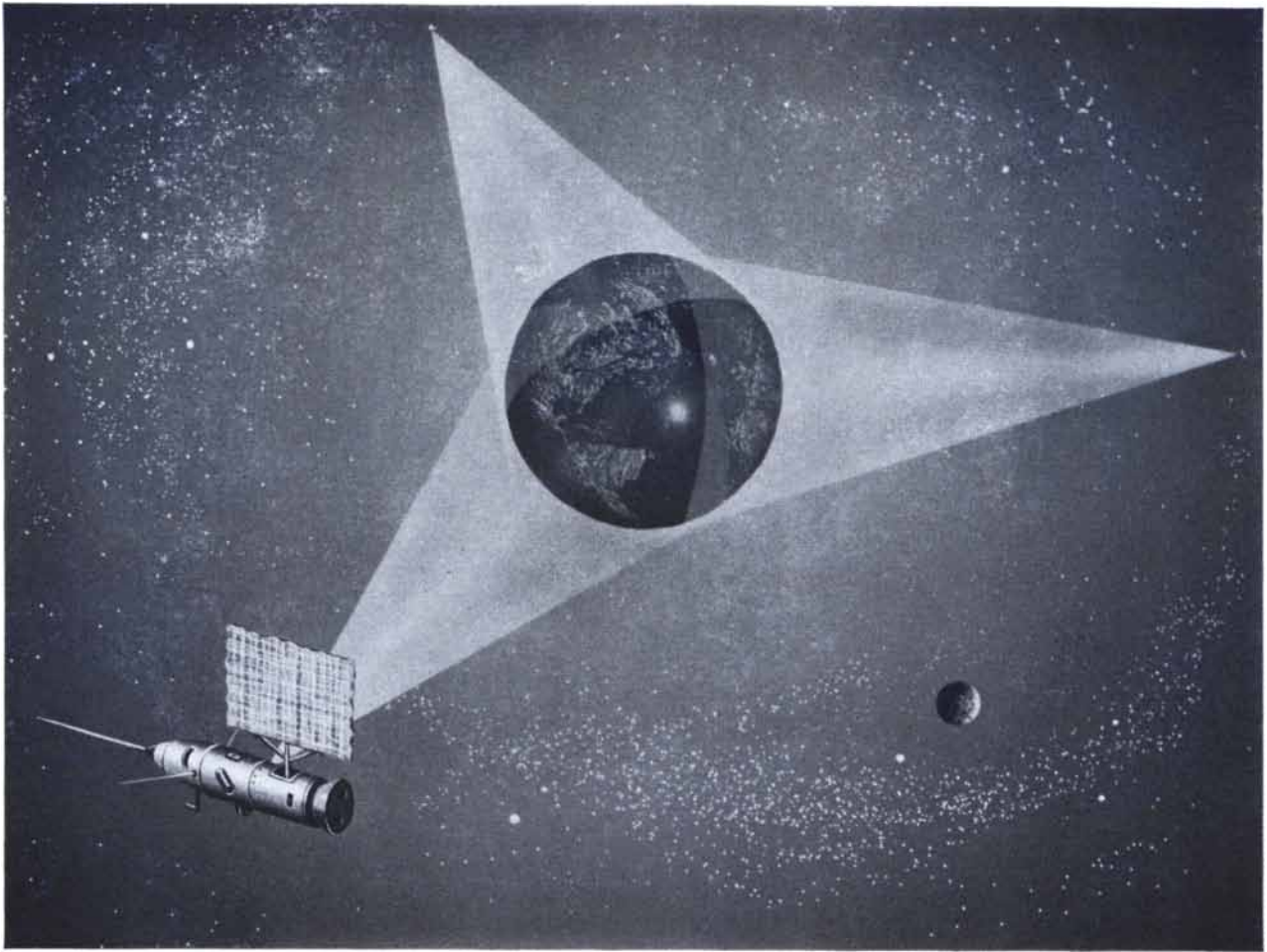
"The technique of making differential smears is not difficult if one carefully follows a standard procedure. The microscope slides must be cleaned thoroughly. Ordinary household detergents, particularly those containing a soft abrasive powder, make a satisfactory cleaning agent. A drop of blood is first placed near the end of a freshly cleaned slide. The end of a second slide is then held

at an angle of about 45 degrees at a point between the drop and the center of the second slide, so that the drop wets the lower surface of the upper slide. The fluid will immediately spread by capillary attraction across the line of contact between the two slides. The second slide is then quickly pushed forward toward the far end of the first. This distributes the specimen *behind* the top slide in a film which adheres to the lower slide. Do not place the drop in front of the top slide and push it with the end of the glass; the cells will be forced to flow between the two slides and may be broken.

"The smear is allowed to dry until it becomes tacky, and then is stained. I used Wright's stain, which can be procured through most drugstores. It is made into a solution consisting of .3 gram of powdered stain mixed with three grams of glycerin and 97 cubic centimeters of methyl alcohol. A drop of



Pipetting a specimen of rat blood



THE FAR REACHES OF MAN'S KNOWLEDGE

Over the years ITT Laboratories has made significant contribution to advancing the state of the art in electronics. Today highly evolutionary progress is moving apace in such areas as broadband communications systems, low-noise parametric amplifiers, atomic clocks, inertial navigation systems, high density storage tubes, and space guidance, navigation and flight control. Major achievements are resulting in stored program digital computers and digital communications.

While engineers and scientists at ITT Labs meet the urgencies of today, they are simultaneously exploring the far reaches of man's knowledge, accepting small failures, making small successes, to unlock the doors to revolutionary achievements in electronics.

Communications, as essential to civilization as food and shelter, is an area of unlimited chal-

lenge which constantly occupies our efforts. To find more room within the radio spectrum for electronic communications — from direct current to the cosmic rays — is a major goal. Revolutionary ways to extend communications is another. We foresee early success with single satellite systems of the delayed-transponder type, and possibly passive reflector satellites. In only a few years ITT's "Earth Net" communication system may be a reality, providing global communications via three satellites in orbit. Within a generation, world-wide television may be a commonplace.

Positions of responsibility, challenge and reward are open to engineers with minimum B.S. degree and U.S. Citizenship. For information regarding specific positions, write G. T. Wall, Technical Placement Director.

ITT LABORATORIES

A Division of International Telephone and Telegraph Corporation
500 Washington Avenue, Nutley, New Jersey
Fort Wayne, Indiana • San Fernando and Palo Alto, California



900X "MICROBE HUNTER"

- The only Microscope in its class featuring **GRADE A optics!**
- **Power Range 25X, 50X, 75X, 100X, 150X, 200X, 300X, 400X, 600X, 900X**
- **Full Range Fine Adjustment**
- **Safety Stop on Coarse Adjustment**



This instrument—made to our rigid design specifications—has wide usage in schools, laboratories and law enforcement agencies. All of the most needed features have been incorporated to meet the requirements for diversified micro-studies. Highly recommended for serious hobbyist desiring exceptional quality at modest cost. Power range from 25X to 900X in 12 possible combinations. Geared rack and pinion coarse focusing. Micro-motion fine focusing of full range—12 complete revolutions. Safety stop prevents over rise. 38mm dual surface (plano/convex) mirror. Fixed square stage. 70mm X 80mm. Rotating 5-hole, disc diaphragm. Three Huygenian eyepieces of 5X, 10X and 15X. Four achromatic objectives of 5X, 10X, 40X and 60X. Over-size base insures stability and protects objectives. Body tilts through 60°—perfectly balanced at any angle. Complete with upright, wooden carrying case.

F-338—List \$69.95.....Net \$39.95

(Add \$1.00 for postage and handling)

OLIVER GARFIELD CO., INC. Dept. SA99
108 E. 16 ST., N. Y. 3, N. Y.

New "Mechanical Educator" to IMPROVE MEMORY

Inability to recall names, places, facts quickly is a common, often costly, shortcoming that can now be easily overcome with the aid of a new device for self-instruction, memory and concentration training. This versatile new educational tool can also be used effectively in language learning, speech correction and improvement, in mastering tables, formulae—anything to be memorized—faster than ever.

DORMIPHONE Memory Trainer

- Speeds up learning processes
- Aids concentration
- Provides entertainment

Using a new recording principle, the Memory Trainer records, instantly plays back, and automatically repeats speech, music, or any spoken or broadcast material by clock control, through a built-in speaker. No reels of tape to snarl or rewind. Completely portable. Ideal aid for home, school, industrial safety training use. So simple to use, children benefit—so helpful and practical. It is used by educators, psychologists, people of all ages and professions.



SELF-CONTAINED RECORDING CARTRIDGES

from 30 seconds to 55 minutes
Easily removed. Can be stored or "erased" instantly and re-used repeatedly. Just record, flip a switch for play-back and listen!
Write TODAY for FREE folder with complete information

Modernophone, Inc.
220-099 Radio City
New York 20, N. Y.

MODERNOPHONE, INC. Circle 7-0830
220-099 Radio City, New York 20, N. Y.

Gentlemen: Please send me your FREE Booklet. I am interested in learning more about the Dormiphone Memory Trainer and what it can do for me. No obligation—no salesman will call.

Name.....
Address.....
City..... Zone..... State.....

My main interest in the Memory Trainer is for:
 Language Learning Speech Improvement
 Memorization School or College Work

the solution is applied to the slide and allowed to stand for three minutes. A drop of buffer solution is then added. This consists of 1.63 grams of potassium phosphate and 3.2 grams of sodium phosphate dissolved in a liter of distilled water. The ingredients of both formulas, incidentally, may be cut in proportion if smaller quantities are desired. After the buffer has worked five minutes the slide is washed gently with distilled water, permitted to dry in open air and then placed under the microscope for examination.

"The differential smears from rats under treatment showed a 20-per-cent increase in the white cells known as lymphocytes, and an equal decrease in neutrophil white cells. Again, however, one measurement made two months after the beginning of the experiment proved exceptional and suggested the development of tolerance to the drug.

"As another index of reaction to the drug the pulse rate of all animals was taken twice during each phase of the experiment. This proved somewhat difficult because the pulse rate of a healthy rat is about 375 beats per minute, and, as I discovered, this rate is almost doubled by the administration of chlorpromazine. Accordingly accurate counts could not be made by listening to the rats' heartbeats with a stethoscope. I solved the problem with the aid of an ordinary magnetic-tape recorder. The rat was held against the microphone and a recording of the heart sounds made at a tape speed of 7.5 inches per second. The record was next played back at 3.25 inches per second and the beats counted by ear against a stop watch. The count was then multiplied by two. (The absolute tape speed, which varies with the make of the machine, is not important. One is only concerned with the ratio of speeds.) Rats tend to become excited when placed against the microphone, so they should be permitted to settle down for a few minutes before the recording is made. The pulse rate of tranquilized rats averaged 639.6 beats per minute, as against 389 beats per minute for the controls. The slightly higher-than-normal rate of the controls is explained by the excitement of the rats at being handled.

"The body temperature of tranquilized rats was also found to be abnormally high, averaging 100.1 degrees Fahrenheit as against an average of 99.7 degrees for the controls. The average difference is not great. But in every instance the lowest temperature observed in a treated animal was above the highest temperature among the controls.

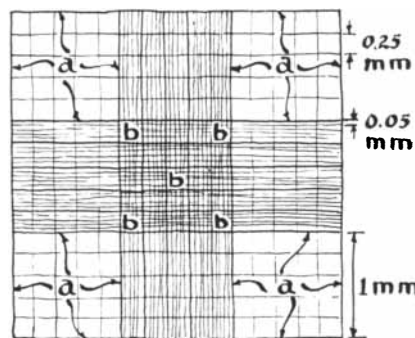
This fact, when considered together with the elevated lymphocyte and neutrophil counts, suggests that the tranquilized rats had contracted an infection of some sort. This was further indicated by their behavior. Some appeared to be sick part of the time. The temperatures were taken with a conventional rectal thermometer.

"A careful record of body weight was made daily, along with the weight of food and water consumed. Early in the experiment the ratio of water to total body weight changed in a direction that suggested that the drug was causing dehydration, but this was not supported by the crossover observations. Both groups made comparable gains in weight throughout the experiment, as indicated by the accompanying graph [bottom of page 252].

"Chlorpromazine lowers the respiratory rate of rats substantially. Tranquilized rats average 72 inhalations per minute as against 95 for the controls. The rates coordinate well with the relative activity of the two groups. Counts were taken three times during each phase of the experiment.

"A close check was made throughout the experiment of the external appearance of the rats in both groups. I observed a number of obvious differences. Minor skin eruptions developed within a few days after each animal was put on the drug. In addition, the hair of the treated rats became rough and shed readily. In the case of the first group to receive the drug, violent muscle tremors occurred when the animals awakened from sleep. This, however, was not observed in the group treated during the crossover phase. The behavior of the groups also suggested that, at least in rats, chlorpromazine acts as a sexual stimulant.

"Tendencies to jaundice sometimes



number of white cells in areas 'a'
times 50 = cells per cubic mm
number of red cells in areas 'b'
times 10,000 = cells per cubic mm

Pattern of chamber for counting blood cells



What lies beyond?

This eternal enigma has generated a new concept of the engineering organization at Convair/Fort Worth . . . blending the contributions of each individual into the best combination of ideas through highly inter-related, smooth flowing and carefully coordinated functions. The imaginative thinking resulting from this finely-drawn engineering organization is currently exemplified by the B-58, which a few short years ago lay beyond the then-known state of the art.

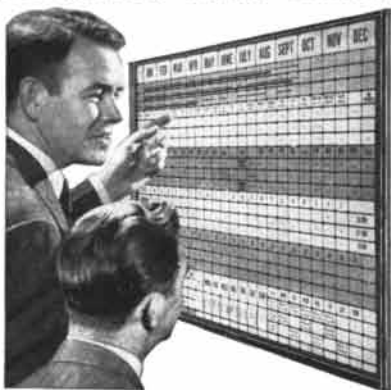
Experienced, well-trained men, seriously interested in projects to stimulate and satisfy

an inquiring mind, and in freedom to exercise creative ability, are invited to investigate the engineering opportunities in the continual search for new ideas . . . new concepts . . . at Convair/Fort Worth.

Complete details are available on request. Send a resume of your training and experience for *evaluation by engineers* in the area best suited to your qualifications. Do it now . . . your contribution may be precisely what we need, particularly if your capabilities are in the areas of electronics, radome design and test, structures, or structural design.

CONVAIR / FORT WORTH
P. O. BOX 748-S
A DIVISION OF
GENERAL DYNAMICS

You Get Things Done With Boardmaster Visual Control



- ★ Gives Graphic Picture of Your Operations—Spotlighted by Color
- ★ Facts at a glance — Saves Time, Saves Money, Prevents Errors
- ★ Simple to operate — Type or Write on Cards, Snap in Grooves
- ★ Ideal for Production, Traffic, Inventory, Scheduling, Sales, Etc.
- ★ Made of Metal. Compact and Attractive. Over 400,000 in Use

Complete price **\$49⁵⁰** including cards

FREE 24-PAGE BOOKLET NO. C-200
Without obligation

Write for Your Copy Today
GRAPHIC SYSTEMS

55 West 42nd Street • New York 36, N. Y.

ASTRONOMICAL 6" DIA. AIR SPACED TELESCOPE OBJECTIVE

Hard coated on 4 surfaces

f/10—60" focal length MOUNTED \$175.00
UNMOUNTED \$150.00
f/15—90" focal length MOUNTED \$175.00
UNMOUNTED \$150.00

The effective aperture of the above lenses is six inches. The black anodized aluminum mount fits into seven inch dia. aluminum tubing.

MOUNTED AIR SPACED OBJECTIVES

The finest American Made, hand-corrected air-spaced astronomical objectives; mounted in black anodized aluminum cells.

DIA.	F.L.	PRICE	PRICE
3 1/4"	48"	Coated \$32.00	Not Coated \$28.00
4 1/4"	62"	Coated \$69.00	Not Coated \$60.00

"BIG" LENSES Our selection of diameters and focal lengths is the largest in the United States available for immediate delivery. Perfect magnesium fluoride coated and cemented achromatic telescope objectives. Aluminum tubing and cells available for lenses listed below. Send for complete list of other diameters and focal lengths.

Dia.	F.L.	EACH	Dia.	F.L.	EACH
2 1/8"	10"	\$12.50	3 1/4"	26"	\$28.00
2 1/8"	11.8"	12.50	3 1/4"	28"	28.00
2 1/8"	13"	12.50	3 1/4"	30"	28.00
2 1/8"	15.4"	9.75	3 1/4"	34 1/2"	28.00
2 1/8"	20"	12.50	3 1/4"	40"	30.00
2 1/8"	23 1/2"	12.50	4"	34 1/2"	60.00
2 1/8"	30"	12.50	4 1/4"	36"	60.00
2 1/8"	40"	12.50	4 1/4"	38"	60.00
2 1/8"	50"	12.50	4 3/8"	42 1/2"	67.00
3 1/4"	15"	21.00	5 1/8"	24 3/4"	75.00
3 1/4"	19 1/2"	28.00	5 1/8"	24 3/4"	85.00
3 1/8"	24 1/2"	22.50			

*Not coated

We can supply ALUMINUM TUBING for the above lenses.

8 POWER ELBOW TELESCOPE 8x50

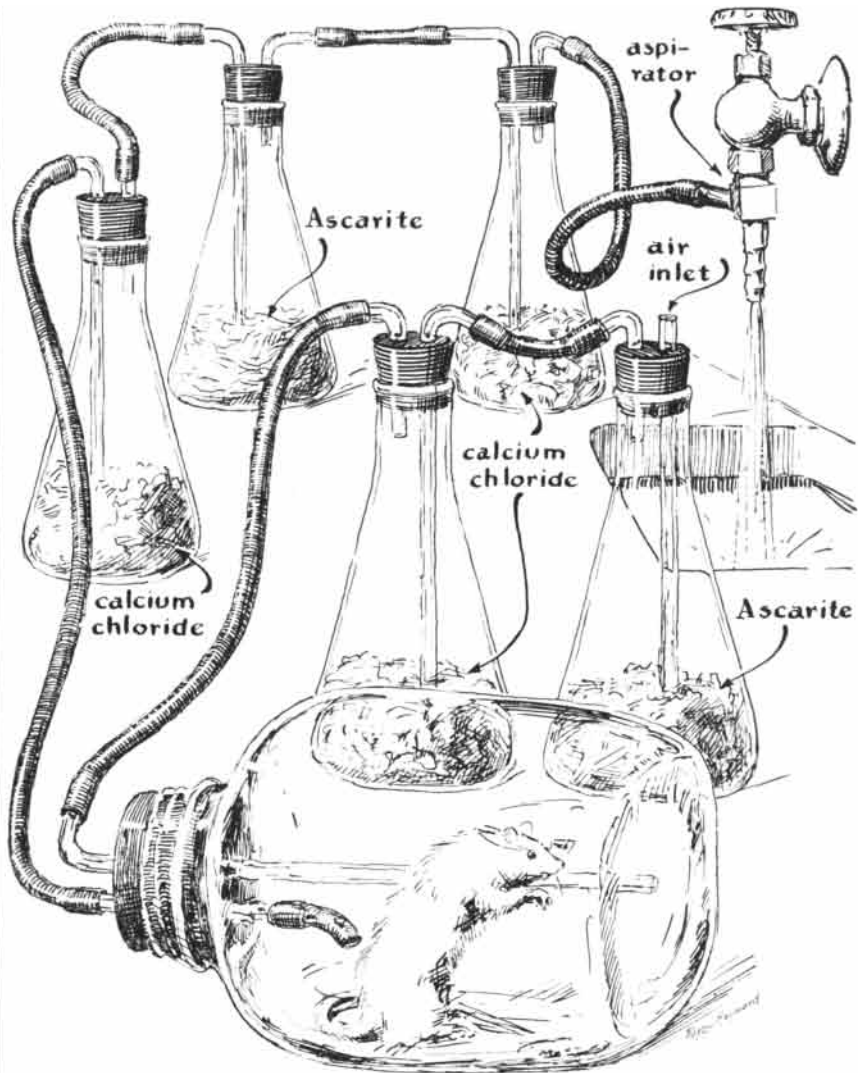
This M-17 telescope has a brilliant image 48 degree apparent field—325 feet at 1,000 yards. It has a 2" objective, focusing eyepiece 28mm focal length with an Amici erecting system. Turret mounted filters, clear, red, amber and neutral. Lamp housing to illuminate reticle for nighttime use. Truly the biggest bargain you were ever offered. Original Government cost \$200.



UNCOATED \$13.50
COATED \$17.50

Free Catalogue "MILLIONS" of Lenses, etc.
We pay the POSTAGE IN U.S.—C.O.D.'s you pay postage—Satisfaction guaranteed or money refunded if returned within 30 days.

A. JAEGER'S 891A Merrick Road LYNBROOK, N.Y.



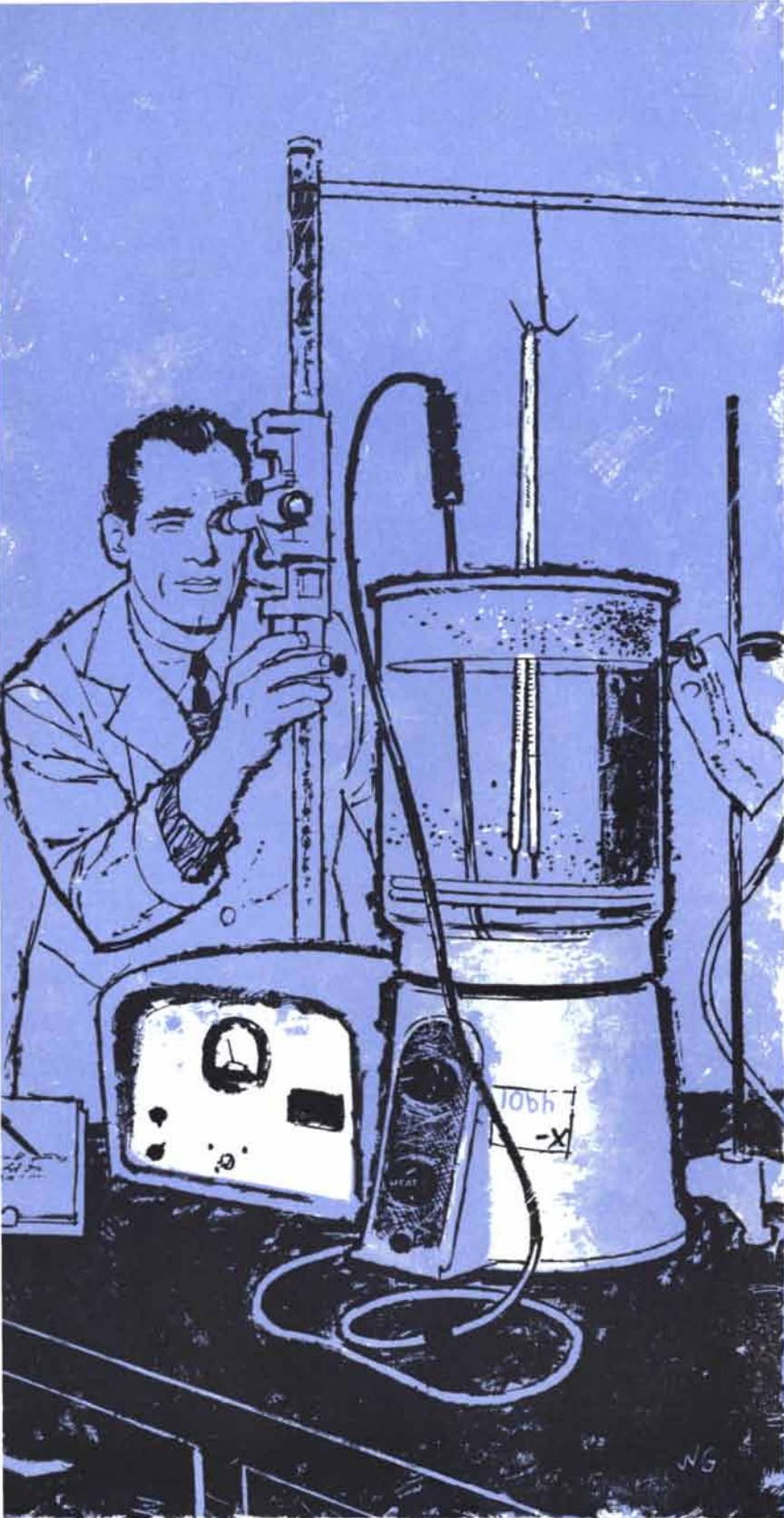
Respiratory quotient of treated and untreated rats was determined in this apparatus

follow the administration of chlorpromazine, according to reports in the professional journals. This reaction appeared in both groups of rats approximately two weeks after treatment was started. Their eyes became pale and their feces lost color. To check possible damage to the liver an autopsy was performed on one control and one treated rat 17 days after the beginning of the crossover phase. Sections of liver tissue were taken from both rats and preserved in xylol. Both specimens showed abnormality. The damage appeared more extensive in the animal that was undergoing treatment at the time the autopsy was performed. This part of the experiment was interesting, but because the observations were limited to two animals the result could not be considered conclusive.

"No diabetic effect was observed. The qualitative test for this reaction was

made by a procedure which I learned at the Midland Hospital that requires the use of chemically treated test-strips that one must either purchase or borrow. The strip is dipped in the urine of the animal; if sugar is present, the tip of the stick turns blue within a minute.

"Metabolism was measured by a variation of the method devised in 1890 by the noted British physiologist J. S. Haldane [see "The Amateur Scientist"; August, 1957]. Essentially the test consists in supplying the animal for a known interval with air containing a minimum of water vapor and carbon dioxide and then subtracting the weight lost by the animal from the weight of the water vapor and carbon dioxide exhaled during the test interval. This gives the weight of oxygen absorbed by the animal, and when this figure is divided into the weight of exhaled carbon dioxide (adjusted for the molecular weights of oxy-



At Avco . . .

SPACE RESEARCH WITH "BUILT-IN" STANDARDS

Today's complex weapons systems require new levels of precision in every subsystem, every component, virtually every part. Primary standards are a point of departure for any research and development program that is to lead to a workable, reliable, modern weapons system.

At Avco's Research and Advanced Development Division, scientists and engineers are designing advanced re-entry vehicles and research equipment that will open the door to further advances in space flight. Built into this program are standards laboratories designed to ensure that the requirements of space-age precision will be met.

By "building in" its own reference standards and calibration laboratories, Avco has established a firm base for research and development. The laboratories provide the Avco Research Center with its own primary standards, to which working, secondary standards are regularly compared. These laboratories cover electrical, radio frequency and physical measurement calibration, with secondary calibration laboratories for electrical, electronic and electromechanical measurements.

A dynamic program of standards research is carried on within these laboratories to develop tools of measurement that will ensure the even greater reliability required of future weapons systems. This standards research program exemplifies the spirit of scientific support for development programs that is found throughout the division. It is part of an approach that enables scientists and engineers at the Research and Advanced Development Division to benefit from an interchange of information and ideas among all levels and all areas of effort.

Avco
Research & Advanced Development
DIVISION

For information on unusual career opportunities for exceptionally qualified scientists and engineers, write to: Scientific and Technical Relations, Avco Research & Advanced Development Division, 201 Lowell Street, Wilmington, Mass.

AN INVITATION TO JOIN ORO

Pioneer In Operations Research

Operations Research is a young science, earning recognition rapidly as a significant aid to decision-making. It employs the services of mathematicians, physicists, economists, engineers, political scientists, psychologists, and others working on teams to synthesize all phases of a problem.

At ORO, a civilian and non-governmental organization, you will become one of a team assigned to vital military problems in the area of tactics, strategy, logistics, weapons systems analysis and communications.

No other Operations Research organization has the broad experience of ORO. Founded in 1948 by Dr. Ellis A. Johnson, pioneer of U. S. Opsearch, ORO's research findings have influenced decision-making on the highest military levels.

ORO's professional atmosphere encourages those with initiative and imagination to broaden their scientific capabilities. For example, staff members are taught to "program" their own material for the Univac computer so that they can use its services at any time they so desire.

ORO starting salaries are competitive with those of industry and other private research organizations. Promotions are based solely on merit. The "fringe" benefits offered are ahead of those given by many companies.

The cultural and historical features which attract visitors to Washington, D. C. are but a short drive from the pleasant Bethesda suburb in which ORO is located. Attractive homes and apartments are within walking distance and readily available in all price ranges. Schools are excellent.

For further information write:
Professional Appointments

**OPERATIONS RESEARCH
OFFICE** **ORO**

The Johns Hopkins University

6935 ARLINGTON ROAD
BETHESDA 14, MARYLAND

gen and carbon dioxide), the result is equal to the respiratory quotient of the animal. My apparatus consisted of an air pump (a water-powered aspirator) and five flasks of one liter each connected in series [see illustration on page 258]. The initial flask in the series contained approximately 600 cubic centimeters of 'Ascarite,' a commercial preparation that has the property of absorbing carbon dioxide. The second flask held a comparable amount of anhydrous calcium chloride, which absorbs water vapor. The intake of the second flask was coupled to the exhaust of the third, a wide-mouthed jar capped with a close-fitting stopper, which served as the animal chamber. The intake of the animal chamber led respectively to flasks of calcium chloride, Ascarite and calcium chloride. All containers and the animal were weighed individually before and after a test interval of one hour. The weight (in grams) lost by the rat was then divided into the product of the weight gained by the fourth and sixth flasks multiplied by .7282 (the ratio of the molecular weights of oxygen and carbon dioxide).

"Only two animals remained in each group at the time the respiratory quotient was measured, the other pair having been used for the autopsy. The respiratory quotients of the rats then under treatment were .56 and .58, whereas those of the control rats were .82 and .65. Here again the sample was too small to yield reliable figures. Differences in the individual determinations show a spread, however, which suggests that the lower activity of the tranquilized rats is accompanied by a correspondingly low respiratory rate.

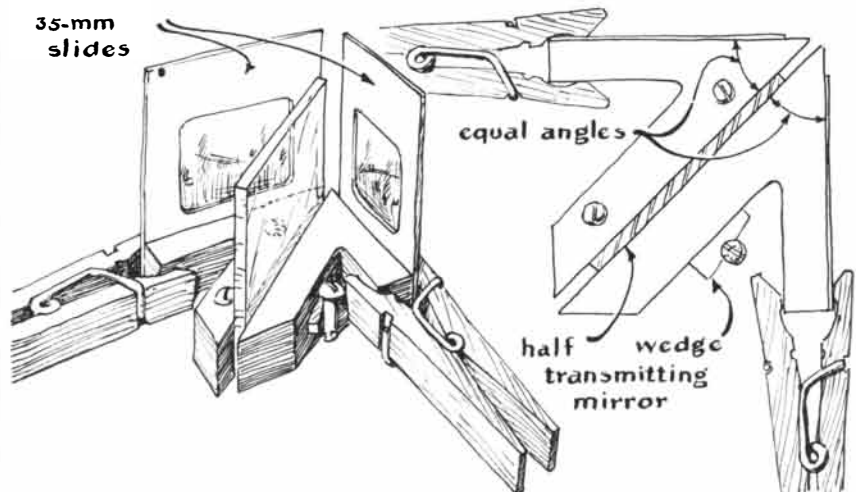
"From this experiment it would seem that a rat is tranquilized by the steady

administration of chlorpromazine, but with at least temporary cost to its health. The drug depresses the animal's memory and intelligence, alters the composition of its blood, invites infection, increases its pulse and body temperature, lowers its metabolism, induces abnormal sexual stimulation and damages its skin, hair and liver."

Many readers of this magazine have undertaken to repeat some of the experiments in color vision recently described by Edwin H. Land [see "Experiments in Color Vision"; SCIENTIFIC AMERICAN, May]. In one of these experiments Land made two black-and-white photographs of a colored scene, one photograph through a red filter and the other through a green filter. Positive transparencies were then made of both photographs. When the "red" transparency was projected on a screen through a red filter, and the "green" transparency projected without a filter, the superimposed images reproduced the original scene in full color.

Most amateurs who have repeated this experiment have used two 35-millimeter slide projectors—one borrowed from a friend. The experiment was then prematurely terminated by the necessity of returning the borrowed projector. Jeremy M. Palmer of North Hollywood, Calif., solved this problem by means of a gadget that can be built in 15 minutes.

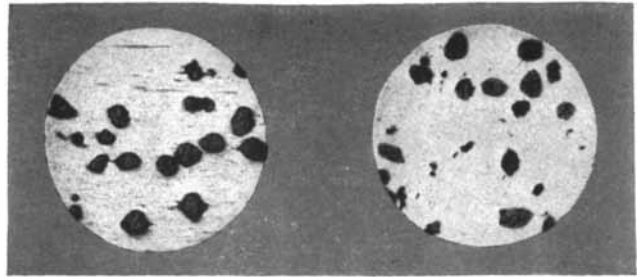
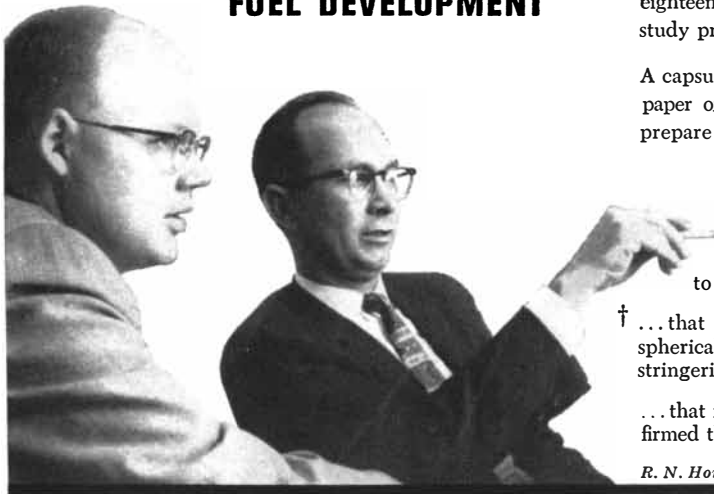
On the face of a block of wood half an inch thick and 2½ inches square Palmer makes two saw cuts a quarter of an inch deep; one cut is parallel to one edge of the block and the other cut is parallel to an edge at a right angle to the first. A third cut is then made diagonally across the face of the block. This bisects the right angle made by the previous



Roger Hayward's device to observe slides made by the Land technique

A Study
in Applied
Creativity
at KAPL
— directed
to Engineers
& Scientists
to whom an
environment
of academic
freedom
is of first
importance...

**NARROWING
THE "DEPARTURE
FROM IDEALITY"
IN DISPERSION
FUEL DEVELOPMENT**



† Longitudinal section of 200- μ UO_2 dispersed in Zircaloy matrix. 30X. BF. Reduced approximately 38% for reproduction.

† Transverse section of 200- μ UO_2 dispersed in Zircaloy matrix. 30X. BF. Reduced approximately 38% for reproduction.

Scientists have long been cognizant of the theoretical advantages of applying the dispersion theory to reactor fuel elements. Ideally this concept could be utilized to extend substantially fuel rod life in high performance water cooled reactors.

But it remained for KAPL Metallurgists Dr. A. P. Beard and R. N. Honeyman to solve basic problems of process metallurgy involved and achieve *actual fabrication* of zirconium-alloy base dispersion elements which were a significant step closer to the theoretical ideal.

Encouraged by Dr. C. E. Weber, Manager of Basic Materials Development, and a leading figure in Dispersion Element research — and aided by consultation with specialists in several KAPL laboratories — Beard and Honeyman successfully completed evaluation of the irradiation behavior of their first samples in September 1958, only eighteen months (and 2 volumes of experimental data) after the study program was formally initiated.

A capsule description of their findings appears below. Reprints of a paper outlining the experimental method and techniques used to prepare laboratory samples will be furnished on request.

Summary of Findings: Dispersion Fuel Study

... showed that mechanical attritioning could be used to prepare zirconium powder with high corrosion resistance.

† ... that extrusion of dispersions of 200 micron dia. particles of spherical UO_2 & UC could be achieved at 750° C with little or no stringering and no reaction between particles and Zircaloy matrices.

... that irradiation behavior of zirconium base dispersion fuels confirmed theoretical concepts of such systems.

R. N. Honeyman (l.) and A. P. Beard (r.)

Engineers and scientists who appreciate an environment where free inquiry and creative initiative are encouraged are invited to investigate these immediate openings: Mechanical metallurgy * Mathematical statistics & design of experiments (PhD) * Mathematical analysis & computer programming * Theoretical reactor physics * Experimental reactor physics * Advanced numerical analysis (PhD) * Advanced engineering mathematics (PhD) * Materials irradiations experiments * Shielding design * Reactor materials development * Powerplant performance evaluation * Analytical chemistry, X-ray diffraction * Applied ceramics * Radiochemistry * Reactor structural design * Primary & secondary systems design * Chemical analysis, vacuum techniques * Reactor instrumentation * Nuclear analysis * Reactor operation * Computer operations * Materials quality control * Coolant technology * Process development metallurgy

Send your resume in confidence, including salary requirement. We are interested in your technical achievements and interests.

(U.S. citizenship required)



Address: MR. A. J. SCIPIONE, DEPT. 59-MI

Knolls Atomic Power Laboratory
OPERATED FOR A E.C. BY

GENERAL ELECTRIC

SCHENECTADY, N. Y.

Nuclear Research at **BATTELLE**

Chemists, physicists, engineers, and mathematicians at Battelle have in progress studies ranging from those concerned with reactor design and engineering to problems of radiation in space.



Battelle's nuclear research facilities include hot-cell laboratories (left), critical assembly laboratory (center), 2-megawatt pool-type research reactor (right), radioisotope laboratories, gamma-irradiation laboratory, materials and component laboratories, and a new plutonium laboratory.

From a modest beginning in the pre-war years when accelerator-produced isotopes were first used in studying wear phenomena, Battelle's interest in nuclear subjects has grown to encompass numerous areas. Studies of nuclear theory; the use of radiation to effect chemical reactions; nuclear-powered propulsion devices for aircraft and ships; applications of radioisotopes in industry, agriculture, and medicine; and others today attract those who are interested in, and qualified for, careers in research.

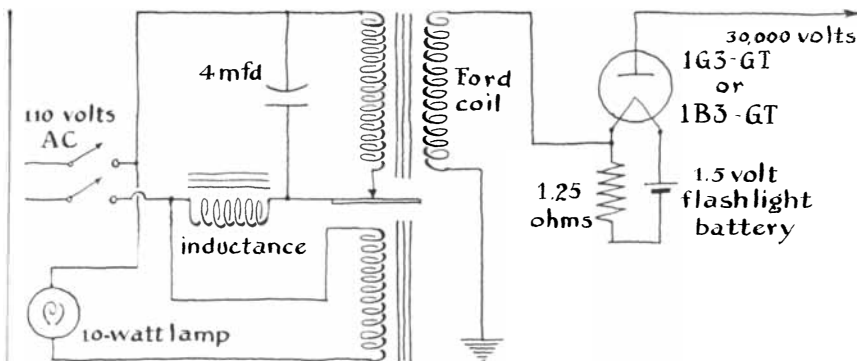
Battelle is proud of its staff which has been a continuing contributor to the progress of nuclear science. Much of the world's uranium production is based on an ion-exchange process pioneered here. Staff members participated, too, in the development of the Nautilus, the Materials Testing and Shipping-port reactors, to mention just a few. Today that staff is particularly devoted to the peacetime applications of atomic energy.

Careers in research at Battelle offer real opportunity for individual and professional growth. For more information, write Russell S. Drum,

BATTELLE
MEMORIAL INSTITUTE
505 King Avenue, Columbus 1, Ohio



Dedicated to the
advancement of science



Circuit diagram of an amateur's high-voltage power supply

cuts. Two 35-millimeter slides made by Land's technique are placed in the right-angle cuts. A microscope cover-glass, mounted in a cardboard slide holder, is inserted in the diagonal cut. The cover glass functions as an optical beam-splitter. When one looks through it directly at one slide, the other is seen simultaneously by reflected light and in register if the two slides are properly positioned. One slide is lighted by reflection from a colored card and the other by reflection from a white card.

Roger Hayward, who illustrates this department, recommends a more elaborate version of Palmer's device. He makes a pair of wooden brackets with faces at an angle of 45 degrees and sandwiches a half-silvered mirror between them. The slides are clamped to the outer surfaces of the assembly (which meet at a right angle) by means of spring clothespins, as shown in the illustration on page 260. "Palmer's gadget works," writes Hayward, "but the slides tend to jiggle out of register in the saw kerfs. Clothespins, my favorite laboratory clamps, provide solid support. The substitution of a half-silvered mirror for the cover glass increases the brilliance of the image greatly because plain glass is a poor reflector."

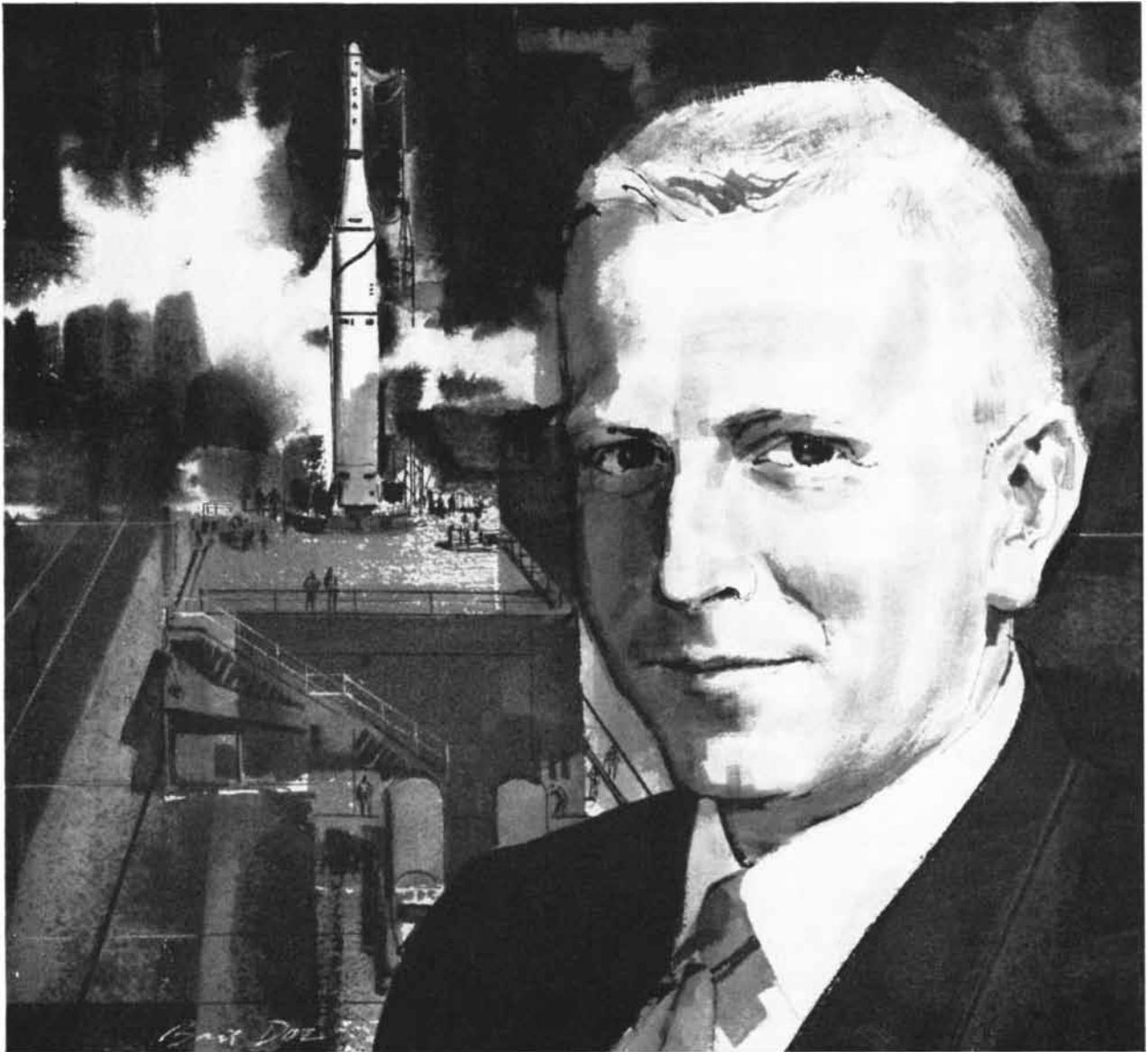
William Tyrrel of Hempstead, N. Y., submits a solution for another problem that confronts many amateurs: the construction of a safe and inexpensive source of high voltage required for the operation of Crookes tubes and similar apparatus. "In the years before sources of alpha radiation became available," he writes, "I constructed a high-voltage, low-current supply for neutralizing the static charge that builds up on the paraffin ribbon from a microtome. It was based on a modified spark-coil from a Model-T Ford. The coil was driven by a 110-volt, alternating-current source, and the output was rectified by a vacuum-

tube diode. The Model-T coil gave better results than any other.

"The coil was taken apart and the windings immersed for an hour in a mixture of melted paraffin containing about 3 per cent of beeswax at a temperature of 130 degrees Fahrenheit. The primary and secondary windings were next separated and fitted with leads of flexible lamp cord. The assembly was then potted in the wax, with the leads extending from the box.

"A vibrator of the type used in the power supply of automobile radios was substituted for the one with which the coil is fitted and was connected with the primary winding [see illustration on this page]. For maximum output the vibrator contact must close at the instant a four-microfarad line-capacitor reaches full charge. The time of closure is determined by the value of an iron-core inductance of the type used in 'B' battery eliminators, which is connected in series with the capacitor and is adjusted either by removing iron laminations from the core of the inductance or by adding capacitance. The proper adjustment must be determined experimentally. The coil that drives the armature of the vibrator is energized by the line voltage through a 10-watt lamp. Hence the device operates at 60 cycles per second, and a unidirectional voltage pulse appears at the output every half cycle. The quality of the output is improved by the addition of a rectifying tube of the high-voltage type used in power supply of television sets. The cathode of the tube operates at 30,000 volts above ground potential, so it must be energized by an insulated source. I used a flashlight battery. The current drain is low, however, so a cell will give many hours of service.

"Ford coils can still be procured from at least two of the large mail-order firms and from some of the suppliers who cater to those who make a hobby of restoring antique automobiles."



C. D. Boyce

October 1958, when the Thor-Able lunar probe soared 79,000 miles, was a time of quiet pride for Clay Boyce. Design engineer Boyce was responsible for successfully predicting the in-flight performance of the Aerojet second stage of the Able vehicle.

Clay Boyce has gone on to become an Aerojet Systems Division group leader, in charge of design and installation for the next generation of Able upper-stage vehicles for

scientific and military applications. You'll agree, a mighty important assignment for a BSME still in his twenties.

Clay Boyce, with Aerojet since 1955, exemplifies the possibilities that exist at Aerojet for professionally gifted younger men to perform tasks of engrossing interest. We'd be delighted to hear from *you*. Write: Director of Scientific and Engineering Personnel, Box 296P, Azusa, California, or Box 1947P, Sacramento, California.

Aerojet-General[®] CORPORATION

AZUSA AND NEAR SACRAMENTO, CALIFORNIA • A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY



Proceed- OPERATION EXPANSION

September 1, 1959 — Raytheon Government Equipment Division today announced a major expansion into five operating subdivisions: Submarine Signal, Airborne Electronic, Systems Management, Heavy Electronic, and Santa Barbara.

Made necessary by expanding product activity, the decentralization has created managerial and technical staff positions in all areas.

Engineers and scientists of established technical competence are invited to investigate the several opportunities present in the area encompassing their particular interest.

Inquiries should be forwarded to Mr. Donald Sweet, Engineering and Executive Placement, Government Equipment Division, Raytheon Company, 624A Worcester Road, Framingham, Mass.



H. R. OLDFIELD, JR.
Vice President & General Manager
Government Equipment Division

GOVERNMENT EQUIPMENT DIVISION



EXCELLENCE
IN ELECTRONICS



SUBMARINE
SIGNAL

AIRBORNE
ELECTRONIC

SYSTEMS
MANAGEMENT

HEAVY
ELECTRONIC

SANTA
BARBARA



SUBMARINE SIGNAL

Newport, Rhode Island
W. Rogers Hamel,
General Manager

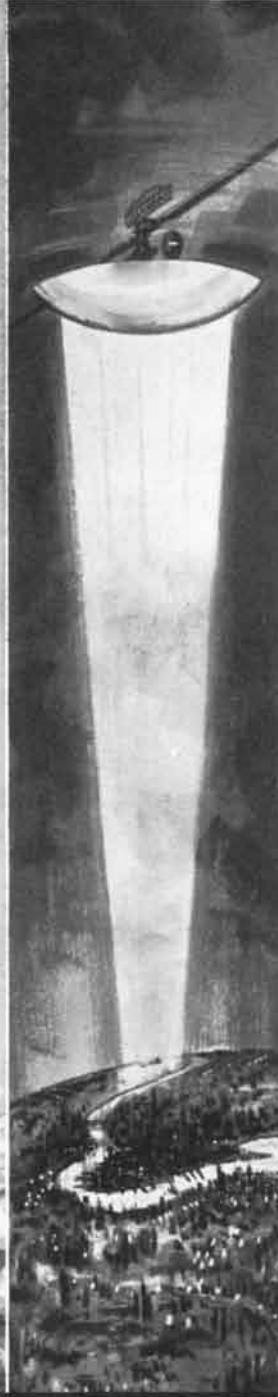
Engineering, Marketing, and Production of comprehensive anti-submarine warfare systems. Major products: underwater detection, navigation, communications and fire control equipment.



AIRBORNE ELECTRONIC EQUIPMENT

Maynard, Sudbury, Waltham, Massachusetts
Glenn R. Lord,
General Manager

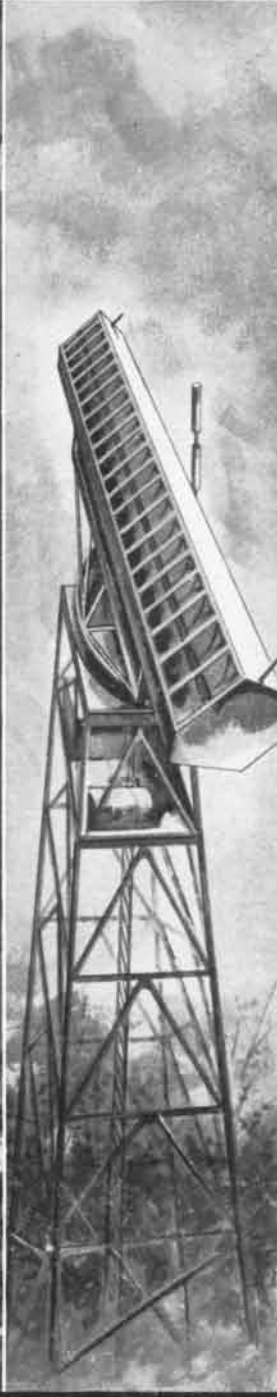
Engineering, Marketing, and Production of advanced aerospace systems. Major products: navigation, search, and fire control apparatus for manned aircraft, unmanned aircraft, and space vehicles.



SYSTEMS MANAGEMENT

West Newton, Massachusetts
Harold M. Hart,
General Manager

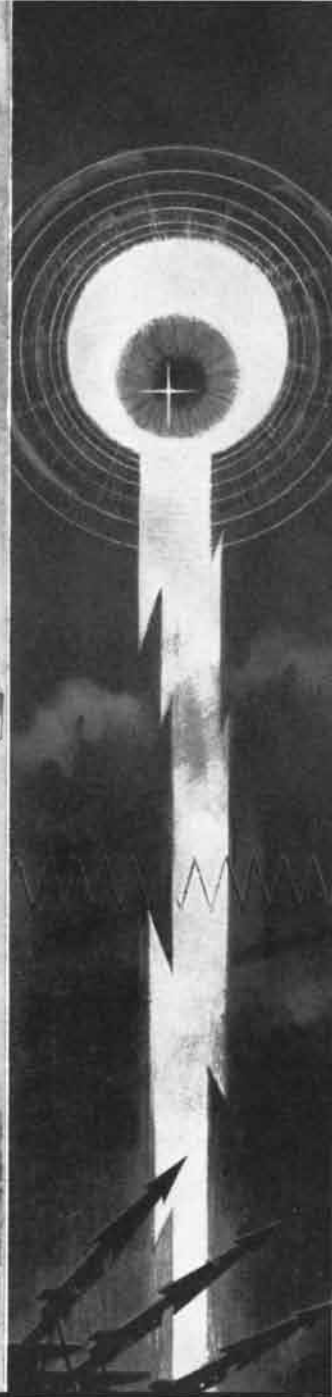
Engineering, Marketing, and Management of major electronic system programs. Activities include systems synthesis, learning machines, weapons studies, microwave supported platform.



HEAVY ELECTRONIC EQUIPMENT

Wayland, North Dighton, Massachusetts
Fritz A. Gross,
General Manager

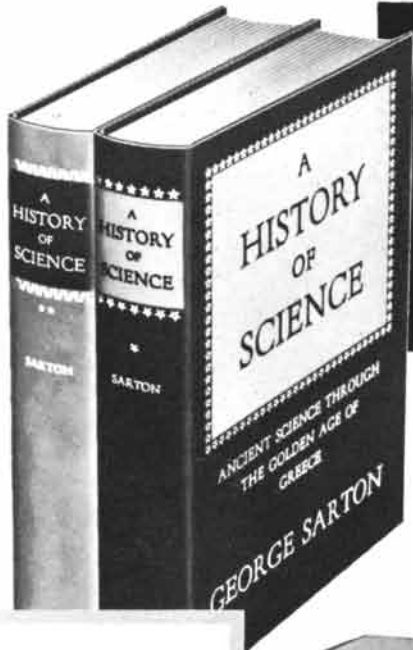
Engineering, Marketing, and Production of long range surface radars, ordnance and communications systems. Products encompass 800-ton ground warning systems, missile fire control radars, 96-voice channel pulse code modulation equipment.



SANTA BARBARA

Santa Barbara, California
Gordon S. Humphrey,
General Manager

Engineering, Marketing and Production of infrared and countermeasures devices. Projects involve active and passive ECM equipment for aircraft, missiles, and satellites, infrared guidance, mapping, and fire control components.



The Library of Science

INVITES YOU TO ACCEPT

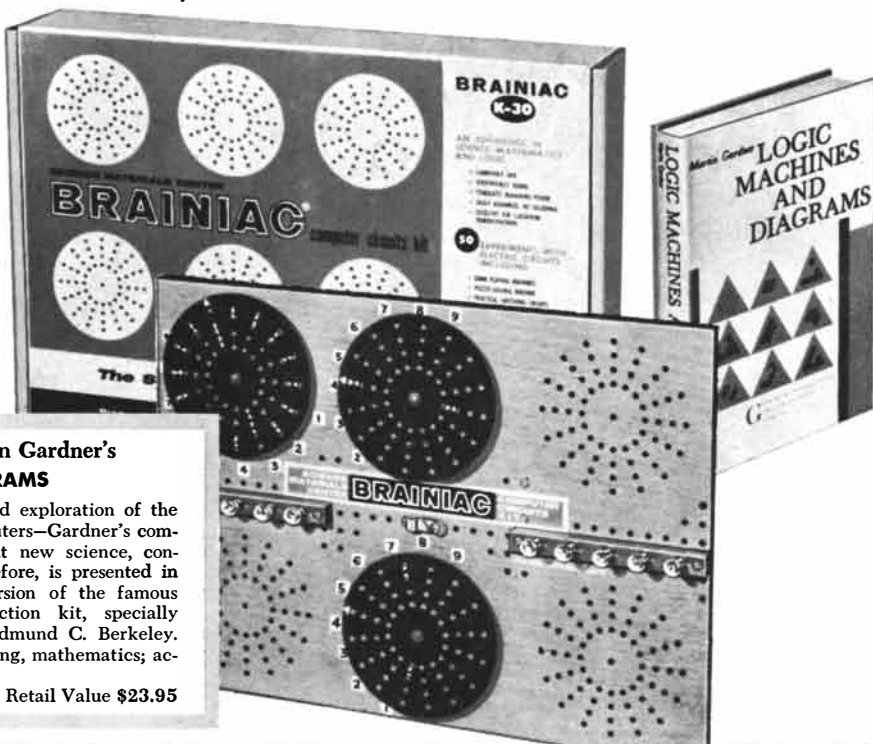
FREE with membership
either of these unusual works
of scientific exploration

To nearly 50,000 working scientists, educators and other readers of broad scientific interests, The Library of Science regularly makes available the choicest works in every major area of the sciences—always at meaningful savings. By joining now, for example, you may choose any of the six timely and authoritative volumes listed below as your first Selection—and receive one of the valuable sets pictured, as a welcoming gift. As a member, you need purchase as few as five more Selections in the next 24 months from the 75 or more offered at reduced Member's Prices. After every fourth Selection, you receive a Free Bonus Book of your choice.

A HISTORY OF SCIENCE By George Sarton

The leading scientific historian of our time re-creates the development of the sciences of antiquity, from pre-historic times through the last century B. C. "Not simply a history of scientific discovery, but a large-scale history of civilization itself." *Scientific American*. Two volumes, 1200 pages.

Retail Value \$22.00



BRAINIAC K-30 KIT and Martin Gardner's LOGIC MACHINES AND DIAGRAMS

An unusual opportunity for firsthand exploration of the principles and applications of computers—Gardner's comprehensive survey of this important new science, containing material never published before, is presented in combination with an improved version of the famous Brainiac "electric brain" construction kit, specially adapted for us by its originator, Edmund C. Berkeley. Kit solves problems in logic, reasoning, mathematics; accompanied by 64-page manual.

Total Retail Value \$23.95

The Library of Science

L-28

59 Fourth Avenue, New York 3, N. Y.

Enroll me as a member and send my choice of Membership Gift, along with my first Selection at the reduced Member's Price, as indicated below. I need take as few as 5 more Selections during the next 24 months, and I will receive a free Bonus Book of my choice after every four Selections.

Membership Gift _____

First Selection _____

Additional Selections Desired _____

Name _____

Address _____

City _____ Zone _____ State _____

CHOOSE YOUR FIRST SELECTIONS from among these six important works

MATTER, EARTH AND SKY

By George Gamow
"A most fascinating journey of the entire physical cosmos" (*The New York Times*), with "one of the foremost interpretive writers in the field" (*Science*).

LIST PRICE \$10.00
Member's Price \$6.50

THE NEW GOLDEN BOUGH

By Sir James G. Frazer
Frazer's seminal work of cultural anthropology—revised to incorporate modern scientific findings and condensed into a single, 738-page volume by Theodor H. Gaster.

LIST PRICE \$8.50
Member's Price \$5.95

MATHEMATICS IN WESTERN CULTURE

By Morris Kline
"A highly successful attempt to describe some of the outstanding events in the history of mathematics." *The American Scientist*.

LIST PRICE \$8.00
Member's Price \$5.75

FRONTIERS IN SCIENCE

Edited by Edward Hutchings, Jr.
Latest findings in the important areas of contemporary research—Pauling, Oppenheimer, Beadle, Hoyle, 25 others.

LIST PRICE \$6.00
Member's Price \$4.95

THE LOGIC OF SCIENTIFIC DISCOVERY

By Karl R. Popper
The distinguished scholar's major contribution to the philosophy of science, published for the first time in English.

LIST PRICE \$7.50
Member's Price \$5.50

THE LAWS OF NATURE

By R. E. Peierls
"A remarkable insight into the logic and unity of physics... how the separate ideas fit together to make a wonderfully coherent structure." *Scientific American*.

LIST PRICE \$4.50
Member's Price \$3.95



BOOKS

Discussions of the scientific validity of psychoanalysis, and of Freud the moralist

by Robert W. White

PSYCHOANALYSIS, SCIENTIFIC METHOD AND PHILOSOPHY, edited by Sidney Hook. New York University Press (\$5).

FREUD: THE MIND OF THE MORALIST, by Philip Rieff. Viking Press (\$6).

The first half of the 20th century has seen mankind scale astounding heights of rationality and fall to incredible depths of irrationality. If we fix our eyes on scientific achievement, we discover a world transformed for human use and happiness, but if we think of political history, we peer into mires of passion, hate and murder. Many thoughtful people, living in an age of such promise and such betrayal, have found a needed symbol and hero in Sigmund Freud, the man who dared look steadily at the dark forces within us and who held out hope, however cautiously, that they might be better governed. Freud can be seen as the scientist of the irrational, who used our best instrument—scientific method—to investigate our worst selves, and who told us, in the cool disillusioned spirit of the scientist, what chances we might have of happiness. It may be that Freud is climbing to the status of a modern Copernicus or Darwin; at all events it is a task of our period to come to terms with what he said.

Freud's contribution amounted to a revolutionary picture of human nature. It was worked out in the course of treating neurotic patients, and its strongest factual root still lies in those very intimate thoughts and feelings which only a sick person seeking help would be willing to disclose. Freud hunted relentlessly for meaning—motivational meaning—in the dreams, errors, resistances and symptoms of his patients, and he satisfied himself that these were all manifestations of instinctual energies struggling for discharge through the many barriers imposed upon them by civilization. He saw the young child as a creature of love and hate, of sex and aggression, whose

strivings had to be much sacrificed to the demands of constraining parents. These contests more or less permanently shaped the child's personality. If the instincts were too badly defeated, neurosis might follow in later life, and the early inhibitions could be undone only by a protracted process of recollection which brought the ancient issues back into adult consciousness. The grave irrationalities in human behavior could thus be traced to repressed and distorted instincts, driven to unconscious cover by the constraints of the family circle.

The two books reviewed here aim in different ways to come to terms with this revelation. One of them, a symposium of philosophers and psychoanalysts, invites us to consider whether or not Freud really demonstrated his contentions about human nature. Do the theories of psychoanalysis deserve to be considered scientific? The other book, a detailed analysis of Freud's writings by a sociologist, hunts out the moral values that lie hidden in Freud's vision of personality and of psychotherapy. To anyone who is trying to reach a judgment on the significance of Freud's work, these two questions—how true is it all, and what are its moral implications?—are bound to be highly pertinent.

We begin with the scientific problem. The symposium, organized by Sidney Hook at New York University, brought together a distinguished group of psychoanalysts and philosophers who were told to be concerned "solely with psychoanalysis as a scientific theory." U. S. philosophy is currently much interested in the methodology and philosophy of science, so there was no doubt that the philosophers would come with well-sharpened knives. In retrospect Hook, who describes himself as "a seat-caloused veteran of innumerable conferences and institutes," calls this meeting unique in his experience for its "sense of absorption and intellectual excitement among the participants." Could this be because the philosophers, long smarting from Freudian interpretations of their concerns, were at last joined to attack psychoanalysis on its weakest flank?

At all events the psychoanalysts seem to have been much on the defensive. In the book, at least, they are badly outnumbered, being represented in only three of the original nine papers and one of the 19 contributions submitted afterward by other participants. And they must have been aware that the cards were stacked against them, affording no chance to overwhelm with clinical evidence or to dazzle with penetrating intuitions. Forced to stand on the bedrock of cold logic, they pointed to the unfinished, tentative character which Freud himself attributed to his theories, and they made much of the difficulty of precise observation in their realm. But they still claimed scientific status, resting their case mainly on two points. They maintained, in the first place, that the situation in which observations are made—the therapeutic situation wherein the analyst makes himself more or less a blank screen and the patient talks about whatever comes into his head—is sufficiently standardized to permit comparable observations on different days and with different patients. As the psychoanalyst Lawrence S. Kubie expressed it, free association is "our only approximation to a technique by which to secure relatively unweighted representative samples of all that is going on in the mind," with a minimum of interference and distortion by the observer. In the second place, observations made in this way, set in the context of much previous observation, make predictions possible—"predictions of various degrees of precision or reliability," in Heinz Hartmann's words, "but as a rule superior to any others that have been attempted in the psychology of personality." Indeed, the whole technique is full of predictions. Quite early the analyst can foretell what problems will next appear, what childhood situations will presently come to light, what points will offer the most stubborn resistance; and there are ways of judging from the patient's subsequent behavior the correctness of the interpretations whereby the analyst attempts to advance his patient's insight. In all this discussion there was scarcely

**OXFORD
Scientific Texts**

**The Theory of
Elementary Particles**

By JAMES HAMILTON. This volume illustrates the mathematical methods used in investigating elementary particles. Some of the techniques discussed are: the addition of angular moments, angular correlations, isotopic spin, charge conjugation, time reversal, parity violation, the renormalized perturbation theory of the S-matrix. (*International Series of Monographs on Physics*) 49 text figures. \$12.00

**The Determination of
Molecular Structure**

By PETER JAFFREY WHEATLEY. This is an introduction to all of the main physicochemical methods that can be used for determination of the dimensions and configuration of molecules. Among the methods discussed: pure rotation and vibration-rotation spectra; electron diffraction; X-ray diffraction including determination of molecular symmetry and molecular parameters; neutron diffraction; classical stereochemical methods; etc. 152 text figures. \$5.60

**Experimental Techniques in
Low Temperature Physics**

By GUY KENDALL WHITE. Primarily this study provides information and technical references for physicists, physical chemists, metallurgists, and engineers. It deals with the production and measurement of very low temperatures; with the handling of liquefied gases on the laboratory scale; the principles and some details of the design of experimental cryostats, including the problems of heat transfer and temperature control; etc. 145 illustrations. \$7.20

**Elementary Practical
Hydraulics of Flow in Pipes**

*A Text and Reference Book for
Engineers and Draughtsmen*
By C.T.B. DONKIN. This is a combination of textbook and handbook intended for those who are responsible for the design, layout, installation, and operation of circulating systems for fluids. 45 text figures. \$3.40

At all bookstores

OXFORD UNIVERSITY PRESS

New York 16

a hint that a psychoanalyst might ever mention the unconscious determinants of philosophy. It remained for a philosopher, Morris Lazerowitz, to declare that "psychoanalysis can alone discover for us what philosophers really say, as against what they delusively appear to say." Many pages of the book, marked by something sharper than intellectual excitement, are used up in refuting this bit of extravagance.

The heaviest artillery directed at the psychoanalysts came from Ernest Nagel, who aimed his fire both at the logic of Freudian theory and at its method of gathering facts. "A credible theory," he said, "must not only be *confirmed* by observational evidence, but it must also be capable of being *negated* by such evidence," and he pointed out several Freudian propositions, such as those concerning instincts, energy levels, and the interrelations of id, ego and super-ego, which could not possibly be proved false by any conceivable empirical state of affairs. He was also impressed that Freud stuck to the Chevalier de Lamarek's view of inheritance and did not think its rejection by all competent biologists refuted any of his own premises; "it is therefore pertinent to ask what could refute those premises and whether they are at all refutable." These are severe strictures, but they were directed against those aspects of Freud's theorizing that are most metaphorical and that might well prove superfluous if one undertook to build a tighter theory on the basis of his facts. But what about those facts? Are they unequivocal, or does the method of observation poison them from the start with questionable theory?

Here Nagel attacked the very points on which the psychoanalysts tried to rest their case. However neutral the observer may try to be in the psychoanalytic situation, the technique requires that at suitable points in the patient's free associations he offer interpretations as to what he thinks is going on. To an unknown degree—and there are no outside observers to judge in what degree—he "directs the course of the narrative"; the free associations are never left to speak for themselves. Strictly speaking, the patient's response to an interpretation, whether it be agreement, denial, new insight, anxiety or a sense of relief, can never be considered competent evidence for the truth of the interpretation. And when connections with childhood experience are pointed out, they cannot, even if they are correct in the given case, become the basis for causal generalizations unless there is a control group in which the postulated cause and effect never occur

singly. What do these criticisms mean for psychoanalytic theory? Nagel concluded: "I can only echo the Scottish verdict: Not proven."

In a way there could hardly be a more crashing anticlimax. Who has supposed that psychoanalytic doctrine was proven, in the strictly logical sense? To see force in Nagel's closing remark we have to know that he is speaking as a logical positivist, and that the members of this school of philosophy hold extremely rigorous standards for admission to the charmed circle of scientific knowledge. Only propositions that can be proved under controlled conditions can be considered scientifically confirmed. The point is dramatized in a contribution by Michael Scriven, who proposes an elaborate and rather impractical experiment to test the proposition that psychoanalytic therapy produces significant improvement in patients. Scriven declares that in the absence of such a crucial test "we are wholly ignorant, I repeat, *wholly ignorant*" concerning the proposition. Obviously we are not wholly ignorant about what has happened in thousands of treated cases, some of which, at least, have been much improved when they left the doctor. What Scriven means by "wholly ignorant," therefore, is not what we mean in ordinary speech. He means that no test has ever been made which fully excludes the possibility that improvement was due to factors other than the treatment, however remote such a possibility may seem to both analyst and patient. And when Nagel denies Freudian theory the status of science, he means that it has not brought its propositions to the level of indisputable proof.

Very much in the spirit of Nagel's cannonade, Hook pressed a question he claimed to have been asking in vain for 40 years. What kind of evidence, he demanded, would psychoanalysts accept "which could lead them to declare in any specific case that a child did not have an Oedipus complex?" The intent of this question is, of course, to determine whether or not one of Freud's most central proposals about the child's emotional development is cast in such a form that some kind of empirical evidence would show it to be false. If it is cast in such a form, then one can look for the evidence, and if this can never be found the theory stands confirmed. But if, on the other hand, there is no conceivable way to prove the theory false, there is also no way to prove that it is true. That psychoanalysts had been unwilling for 40 years to entertain this query seems rather to their discredit, even though the ques-

Important news about the first books to come out of the Physical Science Study Committee



THE SCIENCE STUDY SERIES



During the past three years the Physical Science Study Committee, a group formed at M.I.T., has been working on a program of fundamental importance: to reshape the teaching of physics in secondary schools in the United States.

One vital part of this work has been the commissioning of distinguished scientists to write books which will explain the essence and satisfactions of their work to searching minds of all ages. The first five Science Study Series books, in soft covers and designed for wide distribution and sale at popular prices, are now being published by Doubleday Anchor Books.

During the coming year, at least fifteen of these cogent, readable, illustrated books will be made available. Ultimately, the Science Study Series will comprise more than seventy paper-back volumes. They will range over the key topics of modern physics and geophysics. They will highlight the relationships between the physical sciences and the life sciences. They will revive the most stirring eras in scientific history and the lives of the great scientists. Although an occasional classic will be included in the Series, most of the titles are being especially written to meet the vast and ever-growing needs of an American public whose future may well depend on its scientific awareness.

In addition to the books listed elsewhere in this advertisement, future volumes are now being prepared by such eminent scientists and authors as I. Bernard Cohen, Rene Dubos, Freeman J. Dyson, Laura Fermi, Donald G. Fink, William A. Fowler, Alan

Holden, Bernard Jaffe, Alexander Kolin, Philip Morrison, Robert M. Page, Bruno Rossi, Victor F. Weisskopf, Jerome B. Wiesner, and Robert R. Wilson.

"There just weren't any such books when I was a high school student. How lucky those who want to learn about science will be to have them. These books are written by men who know first-hand what is important and what isn't, what is known and what still is not understood, what can be validly explained in simple terms and what can't. And, through the facts and explanations glows a true and real background of science and scientists which no non-participant could provide..."—JOHN R. PIERCE, Director of Research, Communications Principles, Bell Telephone Laboratories.

"The Series is superb . . . The discussions are clear and to the point, and certainly should prove thrilling and exciting reading, not only to youngsters but to intelligent oldsters as well."—CHAUNCEY D. LEAKE, President-Elect, American Association for the Advancement of Science.

Board of Editors

- PAUL F. BRANDWEIN
*The Conservation Foundation;
Harcourt, Brace and Company*
- JOHN H. DURSTON
PSSC; Educational Services Incorporated
- FRANCIS L. FRIEDMAN
Professor of Physics, M. I. T.
- SAMUEL A. GOUDSMIT
*Chairman, Physics Department,
Brookhaven National Laboratory*
- BRUCE F. KINGSBURY
PSSC; Educational Services Incorporated
- PHILIPPE LECORBEILLER
*Professor of Applied Physics and General
Education, Harvard*
- GERARD PIEL
Publisher, Scientific American
- HERBERT S. ZIM
Golden Press



The first five titles in the Series
to be published September 10:

THE NEUTRON STORY

By Donald J. Hughes, Brookhaven National Laboratory. An absorbing survey of the nature and the uses of the neutron in the atomic age. "Most concise and clear introduction to neutron physics."—HAROLD T. PETERSEN, JR., Westinghouse Science Talent Search Winner, Valley Stream, New York 39 drawings, index, 95¢

MAGNETS: The Education of a Physicist

By Francis Bitter, M.I.T. "MAGNETS is a little gem. It is a masterpiece. This combination of autobiography and popular scientific exposition is very rare and extraordinarily effective in humanizing the whole subject."—B. ALDEN THRESHER, Chairman, College Entrance Examination Board 27 drawings, index, 95¢

SOAP BUBBLES AND THE FORCES WHICH MOULD THEM

By Sir Charles Vernon Boys. "SOAP BUBBLES is a superb classic that I am delighted to have available once more. It is as fresh as ever, and remains just the sort of book by a distinguished scientist . . . that can capture the imagination of the young (and the old)."—DEREK J. DE SOLLA PRICE, The Institute for Advanced Study 69 drawings, 95¢

ECHOES OF BATS AND MEN

By Donald R. Griffin, Harvard University. How bats, porpoises, beetles, electrical engineers, and blind men use echoes to navigate. "An almost ideal popularization of science: lucid without being condescending, authoritative and thoroughly scientific, but more fascinating than most novels."—GEORGE GAYLORD SIMPSON, American Museum of Natural History 15 drawings, index, 95¢

HOW OLD IS THE EARTH?

By Patrick M. Hurley, M.I.T. Provocative new theories on the origin and nature of the earth, with emphasis on recent findings on the earth's interior radioactivity. 27 drawings, 8 halftones, index, 95¢

Forthcoming titles available
early in 1960 include:

The Physics of Television • Galileo • Crystals and Crystal Growing • Radio Astronomy • The Birth of a New Physics • Waves and the Ear

The Science Study Series is available wherever Anchor Books are sold, and is distributed to high school students and teachers by Wesleyan University Press, Columbus, Ohio.

For further information, please write to

DOUBLEDAY & COMPANY, INC., 575 MADISON AVENUE, NEW YORK 22, N. Y.



IMPORTANT NEW BOOKS

SPACE FLIGHT—Volume I Environment and Celestial Mechanics

by **Kraft A. Ehricke**

First in a three volume work, this book covers the space flight concept: its development and the utility aspects, astronomy from an astronautical scientist's and engineer's viewpoint and important celestial mechanical aspects of space flight. October 650 pages about \$15.00

THE HUMAN ELEMENTS IN RESEARCH MANAGEMENT

by **B. C. Noltingk**

This book is devoted to human relations in the scientific field. The author believes that research management is a matter of good personal relations which can better be obtained by a person who understands men than from a person with only long years of responsibility. His main theme is the importance of people against the background of all aspects of the functioning of a laboratory.

89 pages \$1.95

BRIMSTONE: THE STONE THAT BURNS

by **Williams Haynes**

The properties, production and distribution of sulphur are fully described in this panorama of the American sulphur industry, from earliest pioneering days in the Louisiana swamps right up to today's important new sulphur recovery developments in France and Canada.

350 pages \$5.95

SPACE AGE DICTIONARY edited by **C. H. McLaughlin**

Definitions and descriptions, in non-technical language, covers all the important topics in the field of rockets, satellites and space travels. Specially prepared drawings graphically demonstrate the flight paths of rockets, orbits of satellites, etc. plus 54 recognition silhouettes of important American rockets and missiles.

128 pages about \$5.95

RADIO STUDIES OF THE UNIVERSE

by **R. D. Davies and H. P. Palmer**

This book covers the new science of radio astronomy—the study of the Universe using radio waves—from its rapid growth after World War II to the modern aerials, associated with the refined receivers of today.

200 pages \$5.00

FINITE MARKOV CHAINS

by **John G. Kemeny and J. Laurie Snell**

This brief treatment presents, for the first time in English, the basic ideas of finite Markov chains, an increasingly important area in probability theory. By concentrating their attention solely on finite chains, the authors are able to give a thorough development with a minimum mathematical background required.

October 275 pages about \$5.00

VAN NOSTRAND

120 Alexander Street, Princeton, New Jersey

tion might need recasting in order to be really fair. But now at last, in unreported discussion and in a subsequent contribution by Jacob A. Arlow, they endeavored to give Hook satisfaction. The attempt shows how difficult it is to satisfy a philosophic expert on scientific method. The acceptable evidence seemed to indicate a wholesale arrest of development, suggesting that only idiots would lack the Oedipus complex. Hook still wanted to know "in what circumstances the behavior of a nonidiotic child would be necessary and sufficient evidence that he had not achieved the oedipal phase of development." Let us hope that a further reply and clarification will come in less than 40 years.

Some of the philosophers were impressed by Nagel's stringent demands, but many of them, especially in the subsequent contributions, hastened to defend psychoanalysis. Was it really sensible, they asked, to deny a promising branch of inquiry the title of science, especially in a time when this term carries so many overtones of goodness and righteousness? Was it helpful to ask for crucial experiments in a realm where crucial experiments are just about impossible? There appeared to be considerable feeling that Nagel had drawn too tight a leash, that Freud's creation should be accorded the privileges of scientific youthfulness and inherent imprecision. Some contributors implied that logical positivism would disqualify all naturalistic, descriptive science, thus discouraging the valuable efforts of thousands of workers who by careful observation and dispassionate judgment stood as exemplars of the scientific spirit. There was even a suggestion that Nagel's requirements would prove too much for physical science. Philipp Frank put in a reminder that the law of conservation of energy cannot be demonstrated generally, but only under certain restricted conditions; that some thinkers consider it tautological; and that others have used this argument "to prove that the general laws of traditional science are not better confirmed than the principles of theology." Surely we should not require that psychoanalysis surpass the rigor of physics.

In such fashion logical positivism won the battle and lost the war. Under the pitiless glare of logic Freud's theories looked loose and leaky, but many participants continued to regard them as embodying highly probable insights into human nature. In taking such a stand they were, of course, making a judgment about uncertainties. But this is no different from what we all do when we make

Ready now

ATLAS OF GAMMA-RAY SPECTRA FROM RADIATIVE CAPTURE OF THERMAL NEUTRONS

by **L. V. GROSHEV, V. N. LUTSENKO,
A. M. DEMIDOV, V. I. PELEKHOV.**

translated from the Russian by
J. B. SYKES (Harwell)

This atlas contains, in tabular and graphical form, details of the gamma-ray spectra which are emitted following the capture of thermal neutrons.

\$20.00

BIBLIOGRAPHY OF THE STABLE ISOTOPES OF OXYGEN (O¹⁷ and O¹⁸)

Edited by **D. SAMUEL and F. STECKEL.**

A complete record of papers published up to the end of 1957

\$7.50

AN INTRODUCTION TO THERMONUCLEAR RESEARCH

by **Dr. ALBERT SIMON.**

Nine lectures given at Oak Ridge, dealing with the basic problems of controlled fusion research. \$5.50

In preparation

ATOMIC RADIATION AND POLYMERS

by **A. CHARLESBY.**

This book reviews the many scientific papers on the subject and covers the changes produced in materials by atomic radiation from reactors or by electron radiation from high voltage sources. \$17.50

HEALTH PHYSICS INSTRUMENTATION

by **JOHN S. HANDLOSER.**

Contains descriptions, characteristics and uses of the common types of radiation detection used by health physicists. \$6.00

RADIATION PROTECTION

Recommendations of the International Commission on Radiological Protection

Published for the Commission.....50c

Report of Main Commission: In preparation. Committee Reports. I—Permissible dose for external radiation. II—Permissible dose for internal radiation* (in press \$5.00). III—Protection against X-rays up to three million volts and gamma-rays from beam equipment. IV—Protection against X-rays above three million volts and heavy particles, including neutrons and protons. V—Handling of radioactive isotopes and the disposal of radioactive wastes. (Part I).

*The Bibliography for Biological Data \$7.50.



**PERGAMON PRESS,
INC.**

122 East 55 St., New York 22, N.Y.

decisions about human affairs, private or public. We run our lives on estimates, not proofs; we send for the doctor when we are ill, even though we know he can only guess what might make us better. Most people who have heard free associations, given them or done experiments involving them, are much impressed by the things that come to light, and they judge it improbable that all these things were in some way suggested from outside, even though, under the circumstances, there is always a chance that they might have been so suggested. We constantly live by such judgments, making our bets as to what is probably the true state of affairs; we offer no apologies for balancing weights of evidence in our minds when they cannot be measured in objective scales. Logical positivism does not want to dignify this universal but fallible operation by the name of science. Yet Freud conceived himself to be a scientist, made his momentous observations with patient care, and left a body of doctrine that most of us perceive as scientific in intent, however faulty may be the fulfillment.

We must account for the fact, however, that the gist of Freud's contribution is accepted today by thousands of thoughtful people who have had no direct experience with free association in the technical sense. What is the appeal of his doctrines to these mere readers of his work? For an opinion of this point we turn to the book by Philip Rieff, who says: "It is precisely its combination of strict medical judgments with a sweeping criticism of the contemporary moral climate that has elevated Freudianism to its present position of intellectual affluence." Science conceives itself to be ethically neutral except on issues of truth and untruth. A system of psychotherapy, however, can never be ethically neutral: There is always an implication of good and bad, desirable and undesirable, even if it is expressed (a little metaphorically) as health and illness, in any procedure that undertakes to bring about changes of personality. But Rieff's remark clearly implies more than this minimum commitment to good against evil. Viewing Freud as "the presiding figure in our culture," he extracts from his writings an impressive—though not strictly measurable—body of evidence that Freud was a significant modern moralist, a man who "derived lessons on the right conduct of life from the misery of living it."

The reader of this book should not be in a holiday mood. Rieff's tremendous scholarship and rich reflections fill his pages with memorable treasures but pre-



1. HANDBOOK OF AUTOMATION, COMPUTATION, AND CONTROL Vol. 2: Computers and Data Processing

Edited by E. M. GRABBE, SIMON RAMO, and DEAN E. WOOLDRIDGE, Thompson Ramo Wooldridge Inc. Full details on design of analog and digital computers and their applications in science, engineering, and business. This is the latest volume in a complete treatment of all aspects of automation and control, giving practical data for research, design, and development. Vol. 2, 1959. 1096 pages. \$17.50. Vol. 1, Control Fundamentals, 1958. 1020 pages. \$17.00. Vol. 3, Systems and Components. In press.

2. SPACE TECHNOLOGY

Edited by HOWARD S. SEIFERT, Space Technology Laboratories, Inc. With 38 contributors. For the first time in one collection all phases of space technology receive serious analytical attention. Material is grouped into five major areas: 1) ballistics and flight dynamics; 2) propulsion; 3) communications and guidance; 4) man in space; and 5) scientific uses of space. The 500 references are a valuable guide to important parts of a vast literature. 1959. 1172 pages. \$22.50.

3. ASTRONOMY

By THEODORE G. MEHLIN, Williams College. A truly readable treatment using a fresh approach. It plunges immediately into the great sweep that is modern astronomy. First describes tools of the trade, then covers the life of a typical star. Chapters on the sun, binary stars and intrinsic variables, stellar systems, and the solar system. 1959. 392 pages. \$7.95.

4. MOLECULAR SCIENCE AND MOLECULAR ENGINEERING

By ARTHUR R. VON HIPPEL, M.I.T., and 22 other authors. A revolutionary stride beyond earlier materials engineering studies. Where once the trial-and-error study of existing materials held sway, with the concept of molecular engineering you can build safeguards against failure into materials and get true criteria for their ultimate performance. A Technology Press Book, M.I.T. 1959. 446 pages. \$18.50.

5. TIME, LIFE, AND MAN: The Fossil Record

By RUBEN ARTHUR STIRTON, University of California. Brings the entire science of paleontology into focus, giving a readable account of principles and methods. Covers the classification of plants and animals (condensed), the sequence of life and environments, and devotes special attention to such subjects as dinosaurs, horses, ammonites, birds, and man. 1959. 559 pages. \$9.00.

6. SCIENTIFIC RUSSIAN

By GEORGE E. CONDOYANNIS, St. Peter's College. Primarily for beginners with no knowledge of Russian, who wish to gain a reading knowledge of scientific and technical articles. Uses the reading rather than the grammarian's approach, and is identical in purpose to the author's earlier *Scientific German* and *Locke's Scientific French*. 1959. 228 pages. \$3.50.

7. THE LANGUAGE OF PSYCHOLOGY

By GEORGE MANDLER, Harvard University, and WILLIAM KESSEN, Yale University. An analysis of scientific language in psychology, tracing its development from the vernacular to the formulation of explicit theories. Stresses recent developments in the logic and philosophy of science, and covers the use of psychological findings and theory for an understanding of traditional philosophical problems. 1959. 301 pages. \$6.75.

TRIAL ORDER

JOHN WILEY & SONS, INC.

SA-99

440-4TH AVENUE, NEW YORK 16, N. Y.

1 2 Send the books circled on 10 days' approval. Within 10 days of receipt I'll remit full price plus postage or return books postpaid.

3 4 Name.....

5 6 Street.....

City..... Zone..... State.....

7

Check here to save postage. Enclose full amount with order and we pay postage. Same return privilege.

From the frontiers of
biology, provocative
answers to some of the
most urgent political
and ethical questions
of our time . . .

nature and man's fate



A distinguished and stimulating new book by **GARRETT HARDIN**

Leading his readers through the fascinating worlds of past discovery and present-day research, Professor Hardin presents a full discussion of the lives and works of such distinguished scientists as Darwin, Mendel, Haldane and Muller. In the process, he has created a challenging, brilliantly written exploration of such significant areas as . . .

SURVIVAL — Why is "One World" the road to extinction?

ATOMIC RADIATION — How nuclear dangers relate to evolution.

EQUALITY — Why must democracy be rebuilt on the axiom of human inequality?

RUSSIA — The repression of "undesirable" scientific knowledge.

COMPETITION — What choice does man have in a world governed by competition?

HUMAN WASTE — Why is inefficiency essential to human survival?

DEFECTIVE INHERITANCE — The scientific and emotional problems of eugenics.

"One of the best books of its kind"
—ASHLEY MONTAGU

"The writing is extraordinarily clear, and the treatment of human evolution and of the role of human genetics in our social affairs is interesting, informative and very important." — CONWAY ZIRKLE

392 pages, 8 pages of illustrations
\$6.00 at all bookstores

RINEHART

clude both a brisk pace and an orderly unfolding of the argument. Those who believe that one man alone in his study can contribute more than 50 men chattering at a symposium will very likely feel that our present pair of volumes constitutes a case in point. If we reduce Rieff's argument to a simple summary, it cannot be on the analogy of boiling down maple syrup, where what goes up in steam is merely superfluous water. All of the book is nourishing, even when it seems to stray from its theme.

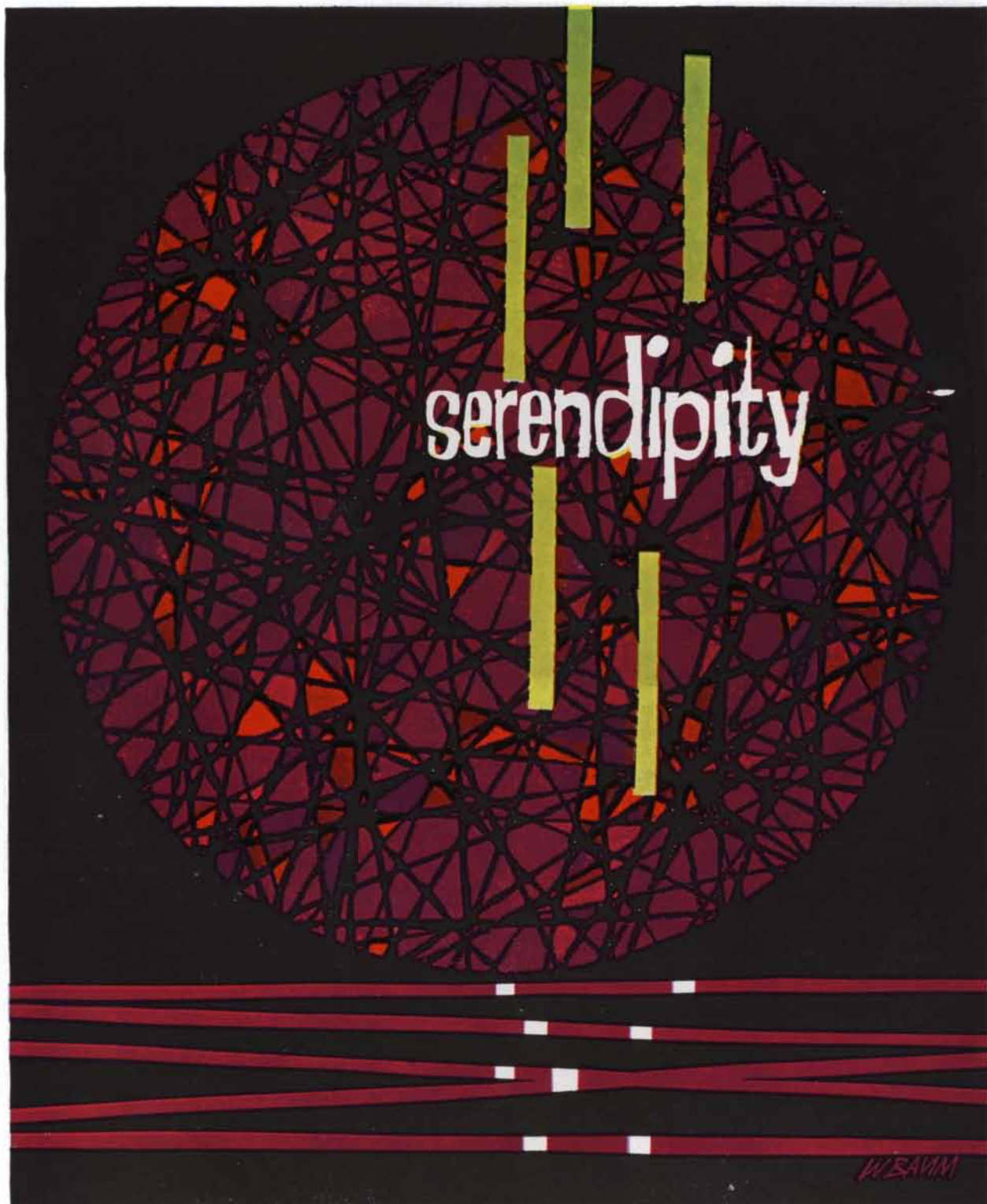
Freud's implicit morality can best be approached by considering what is supposed to happen to the neurotic patient during treatment. The patient is told to tell everything and conceal nothing that passes through his mind, an instruction that soon proves to set a taxing ethical ideal of honesty. In particular he is warned to suppress nothing in the interests of conventional decency, for this will only distort the revelation of his real motives. In technical terms, the job to be done is to unmask and neutralize the superego, the irrational force established in the child's mind by parental punishments and prohibitions. If the crippling anxieties and guilt feelings engendered by the superego can be lifted, if repression can be abolished, the instinctual urges need no longer express themselves in the indirect, distorted forms that constitute neurotic symptoms. Instead, they are governed by the realistic ego and are guided by adult, conscious judgment. The goal of treatment is thus to free the patient from the irrational anxieties that have come to beset him as a consequence of his childhood training to be a member of civilized society.

If we looked no deeper, this account of the patient's progress could easily pass for a movement in the direction of health. But neither Rieff nor Freud allows us to look no deeper. Freud's writing did not stop at patients and therapy. If one overlooked a polemical intent in his clinical papers, in spite of the constant dramatic opposition between the unhappy instincts and an overbearing culture, one could certainly not miss it in *Civilization and Its Discontents*, where the toll taken by civilization from man's instincts was explicitly mourned, or in *The Future of an Illusion*, where for once with obvious passion he unmasked what he conceived to be the stupidity and cruel repressiveness of religion. It is worth noting that Freud's anger against religion was not a personal rebellion against early teachings, of which he had none; his image of religion was usually that of Viennese Roman Catholicism,

with its hierarchy of authority, its pressure toward conformity and its anti-Semitism. This was the culture toward which he felt such a powerful antipathy. Producing neurosis was but one of the evils he laid at its door. Civilized pretensions in general annoyed him: "There are many more hypocrites than truly civilized persons." The world needed a whole new standard of righteousness.

With convincing detail Rieff shows us the intrusion of Freud's moral values into his scientific theories. The superego, as he described it, seemed to be roughly equivalent to conscience, which is generally assigned a constructive part in behavior, but he made it infantile, irrational and in cases of neurosis harshly punitive. Feelings of guilt he considered to be symptoms of neurosis. Freud thus circumscribed and made evil the traditional forces for good, but correspondingly he greatly enlarged the meaning of sexuality and greatly improved its ethical position. Rieff points out that he "concentrated in the attributes of sexuality every variety of emotion: sympathy and attachment, respect and contempt, parental love and filial piety, friendship and enmity." Thus many a virtue hitherto claimed by the moral hypocrites turned out to be a manifestation of the very urge they most strenuously denied. Freud's *Three Contributions to the Theory of Sex* is seen by Rieff to be at once "an oblique 'scientific' plea for great sexual latitude" and "a way of scoring points against the repressive order." Freud's formulation also involved the contention that sexuality, being a fundamental instinct, can never be fully tamed. "In sexuality," says Rieff, "and in the products of fantasy (dreams, wit and art) a refuge from society is created. At the same time these activities defy society and triumph over it; they are a mode of blasphemy."

This revelation of Freud's ethical mission should not, however, be carried to the point of seeing in him a Romantic champion of sexual liberation. There is no hint of the noble savage in his view of the child's "polymorphous perverse" sexual life. There is nothing lyrical about his drily scientific account of sexual impulse. Indeed, Rieff considers that his whole idea about sex has an element of harshness, an air that it was a little nasty after all, and a sad feeling about the fleeting character of satisfaction. "The erotic life, like the economic, becomes under Freudian guidance an area for methodical self-examination and systematic improvement. . . . In this sense, although Freud is critical of middle-class moralism, he himself may be charged



creating new engineering concepts and discovering solutions to those problems which serendipity has revealed... is the task of the professional minds at Martin-Denver. To individuals who possess this creative talent and who seek this stimulation, there is offered an opportunity for outstanding recognition. To participate in this program, inquire immediately of N. M. Pagan, Director of Technical and Scientific Staffing, The Martin Company, P. O. Box 179, (Dept. G-5), Denver 1, Colorado.

MARTIN
DENVER DIVISION



Frontiers are extended by the practical visionary

It is the practical visionary who has given us much of what we enjoy today. And it will be the visionary—the man with ability to seek concepts beyond the existing limitations of science—who will guide our developments of tomorrow.

The Applied Physics Laboratory (APL) of The Johns Hopkins University seeks men who will be engaged in advanced research problems—who will find solutions to problems yet to be posed. Their findings will provide guidelines for the space and missile hardware research of the future.

Your endeavors will be heightened by the professional atmosphere of APL. This atmosphere, created by men dedicated to the furtherance of science, has earned APL a reputation as a leader in programs vital to the national security.

Appointments at APL offer exceptional opportunities. For detailed information, address your inquiry to:
Professional Staff Appointments

The Johns Hopkins University Applied Physics Laboratory

8641 Georgia Avenue, Silver Spring, Maryland

with being very middle-class in his moral attitudes." No libertine in his personal life, Freud assumed that the entry of sexual impulses into consciousness would not lead to an "unrealistic" disregard for social convention. Perhaps it is legitimate to say that Freud loved sex less than he hated the hypocrisy that denies sex while claiming for itself the supposedly civilized virtues.

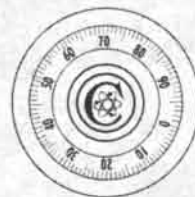
We arrive, then, at the heart of Freud's ethical imperative. The good is somehow identified with honesty—with the opposite of "civilized" self-deception—and thus with the untrammelled functioning of the ego, which is responsible for knowing about reality, both external and internal. Just as the cure of the patient means a strengthening of the ego, so the good life for all men means being free from illusions about oneself and the world. Freud once asked how people would behave "if their flight into illness is barred by the indiscreet revelations of psychoanalysis." His answer, says Rieff, "hints another kind of civilization, one that is not built on reticence or hypocrisy: they will have to confess to the instincts that are at work in them, face the conflict, fight for what they want, or go without it." This is Freud's definition of normality, but normality for him was a rare thing, difficult to achieve—an exacting ethical ideal. The deep strain of pessimism that many people have felt in his doctrines lies partly here: The rational, realistic ego is our only hope, but the ego is weak amidst the forces surrounding it, and there is only an outside chance that it will really prevail.

Freud's contribution as a moralist thus consists of what Rieff calls "the ethic of honesty." "This honesty Freud would have us achieve by working through the layers of falsehood and fantasy within us to a superior accommodation to reality." The new conscience demands a special candor and disenchantment, "a more accurate and yet more scrupulous self-centeredness." The ideal image created by the ethic is that of "psychological man," seen by Rieff as the natural successor of economic man, who has been our most recent dominant moral type. "Once again," says Rieff with something of a flourish, "history has produced a type specially adapted to endure his own period: the trained egoist, the private man, who turns away from the arenas of public failure to re-examine himself and his own emotions." And he points out an astounding irony, that psychological man "has espoused the Oriental ideal of salvation through self-contemplative ma-

nipulation just at the historic moment when the Orient, whose westernmost outpost is Russia, has adopted the Occidental ideal of saving activity in the world." But perhaps our author has gone too far when he finds something Oriental about an ethic that actually arose as a protest against upper-middle-class Viennese society in the late 19th century. As he points out elsewhere, Freud's ego is a brisk managerial agency: rational, prudent, with a gift for compromise, by no means disposed to turn its back on everyday realities or to court unnecessary friction with existing conventions. Psychological man may look within, but he is very much of this world.

The current appeal of Freud's ethical message is a powerful one in intellectual circles. He speaks to those who have become disillusioned about consoling beliefs and public enthusiasms, telling them that life should be led without such beliefs and enthusiasms. But Rieff does not allow potential converts to overlook the disturbing consequences of being a psychological man, consequences that may have arisen from Freud's own complete isolation from public affairs and from the fact that, thinking of himself as a neutral scientist, he never brought to his own consciousness the moral implications of his ideas. There is, according to Rieff, a "fatal lack of commitment about Freud's ideal type." The ego-directed, uninhibited person will be "busy, spirited, and self-confident," but this goal "will inspire only those who have resigned the ghosts of older and nobler inspirations." Rieff further points out that Freud "never understood the ethic of self-sacrifice," and that on this account his doctrine offers no real opposition to quite sinister possibilities. "Being honest, admitting one's nature, does not resolve specific issues of choice. . . . Freud gives no reason why unblinking honesty with oneself should inhibit unblinking evil." Psychological man thus proves in the end to be not a whole man. If he finds ways to affirm his membership in society, if he becomes a participant in cooperative endeavors to improve the conditions of life, he will be acting on some moral behest that was foreign to the founder of psychoanalysis.

Much as we owe to Rieff for his extraordinary analysis of the moral implications of Freud's doctrines, it is perhaps necessary to keep reminding ourselves that Freud did not strictly intend to be a moralist. And those who find him a hero perhaps similarly do not intend to take him as a complete moral guide. But this whole question has been



THE COMBINATION TO NATURE'S SECRETS



YBERNETICS
of CREATION

The book that defines the forces of Nature and how they integrate to form matter.

First by forming electrons; then how electrons unite to form the atoms of each element.

Then how atoms of various elements unite to form an infinite variety of molecules, and how molecules unite to form matter of all conceivable characteristics.

The description of these processes involve explanations of the entire spectrum of radiation and its reactions at various frequencies that produce Nature's other forces, including electricity, gravitation, heat, light, sight and color.

In other words, how and why we see, and why sight seems to be instantaneous whereas radiation travels at definite speeds.

Why and how all substances whether inorganic, organic or vital, grow by integration of lesser units of energy.

In short, the processes of creation, which every researcher must clearly understand to effectively pursue his avocation.

THE GREAT GIVE AWAY

With each book we give a copy of the PRICELESS CHART OF NUCLIDES produced by the General Electric Co. at the Knolls Atomic Power Laboratory. The modern bible of physicists, chemists, electronic engineers. It tabulates known characteristics of atoms of all elements and 1300 isotopes. Costing the Atomic Energy Commission millions of dollars to produce, it made possible the atom and hydrogen bombs and nuclear energy. With it chemists design new formulas and physicists can unravel the geometry of association of atomic structures.

Please Mail This Coupon

Send me on approval copies @ \$5.95 of Cybernetics of Creation with the chart of Nuclides.

Name _____

Address _____

City _____ Zone _____ State _____

TECHNIBOOK, INC.
P.O. Box 2 • Newport Beach • Calif.

THE PHYSICAL THEORY OF NEUTRON CHAIN REACTORS

by Alvin M. Weinberg
and Eugene P. Wigner

The only comprehensive and up-to-date study of the entire field of nuclear reactor physics. The stress is practical — and theory has been compared with the results of experiment at every stage. For clarity, scholarship, and scope there is no comparable book in existence.
\$15.00

NUCLEAR PHYSICS

A course given by Enrico Fermi
at the University of Chicago
by Enrico Fermi

A stimulating, engrossing survey — by the man who has been called “the architect of the atomic age.”
Paper \$3.50

ATOMS IN THE FAMILY

My Life with Enrico Fermi
by Laura Fermi

A remarkable narrative not only of the Fermis, but of the behind-the-scenes events that led to the first self-sustaining chain reaction.
\$4.75

ATOMS FOR THE WORLD

by Laura Fermi

An intimate and informative account of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1955.
\$3.75

Through your bookseller
UNIVERSITY OF CHICAGO PRESS
5750 Ellis Avenue, Chicago 37, Illinois
IN CANADA: The University of
Toronto Press, Toronto 5, Ontario

shrouded in an obscurity which Rieff has now gone far to dispel.

Short Reviews

THE ART OF NAVIGATION IN ENGLAND IN ELIZABETHAN AND EARLY STUART TIMES, by D. W. Waters. Yale University Press (\$12.50). This massive, attractively illustrated book is a thorough and scholarly history of the development of navigation during a period of dramatic advance, from 1550 to 1630. A new age of exploration, colonization and merchant enterprise demanded improvements in the mariner's art, which in the mid-16th century consisted mainly of the individual pilot's skill aided by hand-written records of traditional knowledge. Pilotage, or coasting, as described by a 16th-century French writer, meant “knowing perfectly by sight all the capes, ports and rivers met with, how they rise up and how they appear from the sea, and what distance lies between them, and what route or course, or rather bearing, they have one from another; also in knowing on what rhumb (bearing) of the moon high and low tides occur and the ebb and flow of the waters; and in knowing the depth and nature of the bottoms.” Oceanic navigation—*la navigation grande*—was a more formidable profession: the navigator had not only to be a well-tryed pilot, but had to know how to direct the ship's course in the absence of landmarks, to fix the ship's position by instrumental observation of heavenly bodies and mathematical calculation. The 80 years covered by Commander Waters's monograph saw much progress in chart-making, position-finding, the preparation of reliable tables, the construction of globes, compasses, astrolabes and other instruments, ship design and the training of navigators. Until the latter half of the 16th century an English shipmaster was still typified by Chaucer's “shipman” who had:

... to rekene wel his tydes,
His stremes and his daungers him
bisydes,
His herberwe and his mone, his
lodemenage ...
Hardy he was, and wys to undertake;
With many a tempest hadde his berd
been shake.

But little more than half a century later the master's beard had not only to withstand the tempest, but the rigors of trigonometry, of arithmetical and logarithmical navigation, of new learning—and its application—in astronomy, math-

A stimulating
exploration of
exciting new
concepts
in modern
mathematics,
what they mean, how they
are applied to practical
problems, and how they
are changing our life today.



THE NEW WORLD OF MATH

By GEORGE A. W. BOEHM
and the Editors of FORTUNE
\$2.50, now at your bookstore
THE DIAL PRESS

“The most
comprehensive
study of space
technology
ever prepared
in a form usable
by laymen.”

—The House Committee on Astro-
navitics and Space Exploration



SPACE HANDBOOK
Prepared by THE RAND CORPORATION
\$3.95, now at your bookstore. RANDOM HOUSE



ematics and hydrography. Waters's fact-filled, graphic story, which will give pleasure to readers of many different interests, has an extensive bibliography, a superb index (which merits special mention), 87 plates and 43 figures.

TRIGONOMETRIC SERIES, by A. Zygmund. Cambridge University Press (\$27.50). The first edition of this work, published in Warsaw in 1935 and later translated into English, was at once accepted as the best study of its kind. In the last quarter-century the theory of trigonometric series, as the author points out, has undergone considerable change. Its notions and methods now appear in abstract form, in distant fields such as the theory of groups, algebra and the theory of numbers. Zygmund has taken account of progress in this much-enlarged and revised edition. The first volume of this two-volume work contains the rewritten material of the original book; the second volume covers much material that has not been previously published in book form, including trigonometric interpolation, differentiation of series, complex methods, Fourier integrals, convergence and summability.

THE GOLD OF TROY, by Robert Payne. Funk & Wagnalls Company (\$3.95). A biography of the legendary Heinrich Schliemann, trader, plunger, banker, antiquarian, historian, philologist, archaeologist, who uncovered the buried cities of ancient Greece. Schliemann was born in 1822 in the parsonage of an obscure village in Mecklenburg-Schwerin, not far from the Polish frontier. His formal schooling ended when he was 13, and thereafter he had to fend for himself. His first job was as a grocer's assistant, but before he was 30 he had made a fortune as an indigo merchant in St. Petersburg and as a buyer of gold dust in Sacramento. He was an extraordinarily complex and gifted man who did not know what he wanted, could not fail at what he undertook and was unable to enjoy what he achieved. Self-taught, he mastered some 12 or 13 languages within a few years, learned the *Iliad* and the *Odyssey* by heart, studied philology at the Sorbonne, was cultivated and well-mannered, and lived like a prince. But the image he showed to the world bore little resemblance to the inward man. The years of privation, wretchedness and frustration had scarred him. He was restless, driven, suspicious, contemptuous, deceitful and vainglorious. No matter how his wealth multiplied—on top of what he already had he made millions profiting in the Crimean War—he




PARAMETERS

Yesterday's limitations on logic design are broken through today. Our capabilities in this field contribute to the advanced design of the airborne computers used in our Inertial Guidance systems. If the new parameters in logic design challenge you, perhaps you'd like to work with us. Write to Mr. C. T. Petrie.



LITTON INDUSTRIES Electronic Equipments Division
Beverly Hills, California



Pocket Size—Loose Leaf

LEFAX

TECHNICAL DATA BOOKS

\$125

Printed on loose leaf, 6 hole, 6 3/4" x 3 3/4" bond paper, each book contains about 140 pages of technical data, condensed, accurate, essential for engineer, technical worker, student, business man.

<ul style="list-style-type: none"> Architecture Electrician's Data Builder's Data Air Conditioning Building Constr. Surveying Surveying Tables Highway Eng'g General Math Math Tables Physics Trig-Log Tables Gen'l Chemistry Chemical Tables Analytic Chem. 	<ul style="list-style-type: none"> Mech'l Drawing Machine Design Mech. of Materials Pwr. Trans. Mach. Thermo. Tbls. & Charts Phys. & Thermo. Data Metals Metallurgy Hydraulics Radio Television & FM AC Motors & Gen'trs Transformers, Relays & Meters
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Write for **FREE** catalog (2000 listings). See how helpful **LEFAX** can be to you. Send \$1.25 book, or \$6 for any five books to **LEFAX**.

ENGINEERING FORMULAS & TABLES: Contains 396 pages of basic formulas, design data and tables, for the 3 branches of engineering—civil, mechanical, electrical. Condensed, indexed, accurate. In Sim. leather cover loose leaf Binder, \$4.75.

LEFAX PUBLISHERS

DEPT. SA-99,
PHILADELPHIA 7, PA.

FUNK & WAGNALLS 1959

New Language Phone Method

• **FRENCH**

• **SPANISH**

• **GERMAN**

• **ITALIAN**

The famous "Listen-See-Learn" method used by schools and colleges throughout the country is now available to you.

With Funk & Wagnalls *new* Language Phone Method, native-born teachers at leading universities come right into your home on high-fidelity recordings and bring you the thrill of speaking a foreign language fluently and correctly. With their expert help in pronunciation, usage, and conversation, supplemented by synchronized word-for-word manuals and a modern textbook, you learn the language of your choice easily, inexpensively, and in an amazingly short time.

Find out how easily and quickly you can now learn a foreign language. Send today for our **FREE** booklet.

There's no obligation and no salesman will call. Just mail the coupon below.

MAIL THIS COUPON

Funk and Wagnalls, Dept. SA-959
153 East 24 Street, New York 10

Please send me the **FREE** booklet telling all about the **NEW LANGUAGE PHONE METHOD** way of learning French, German, Spanish or Italian.

Name.....
Address.....
City.....Zone.....State.....

ELECTRONIC AND ELECTRO- MECHANICAL ENGINEERS

The varied programs of Bell's *Avionics Division* can be your springboard to a rewarding future. Opportunities now open for you in:

**INERTIAL INSTRUMENTATION
AUTOMATIC LANDING SYSTEMS
FLIGHT CONTROL SYSTEMS
VISUAL SURVEILLANCE SYSTEMS**

KEY POSITIONS ENTAILING:

- Evaluation of digital velocity meters and low drift gyros.
- Instrumentation electronics development.
- Instrumentation electro-mechanical
- Testing of inertial gyroscopes.
- Development and tie-in of transistorized digital logic circuitry.
- Analysis and development of automatic throttle control loops.

Openings at all levels from \$7,000 to \$15,000 yearly.

The industry's best retirement and group insurance plans... company paid tuition assistance... ideal family living in Western New York's vacationland.

For further information and to arrange a personal interview write or phone today.

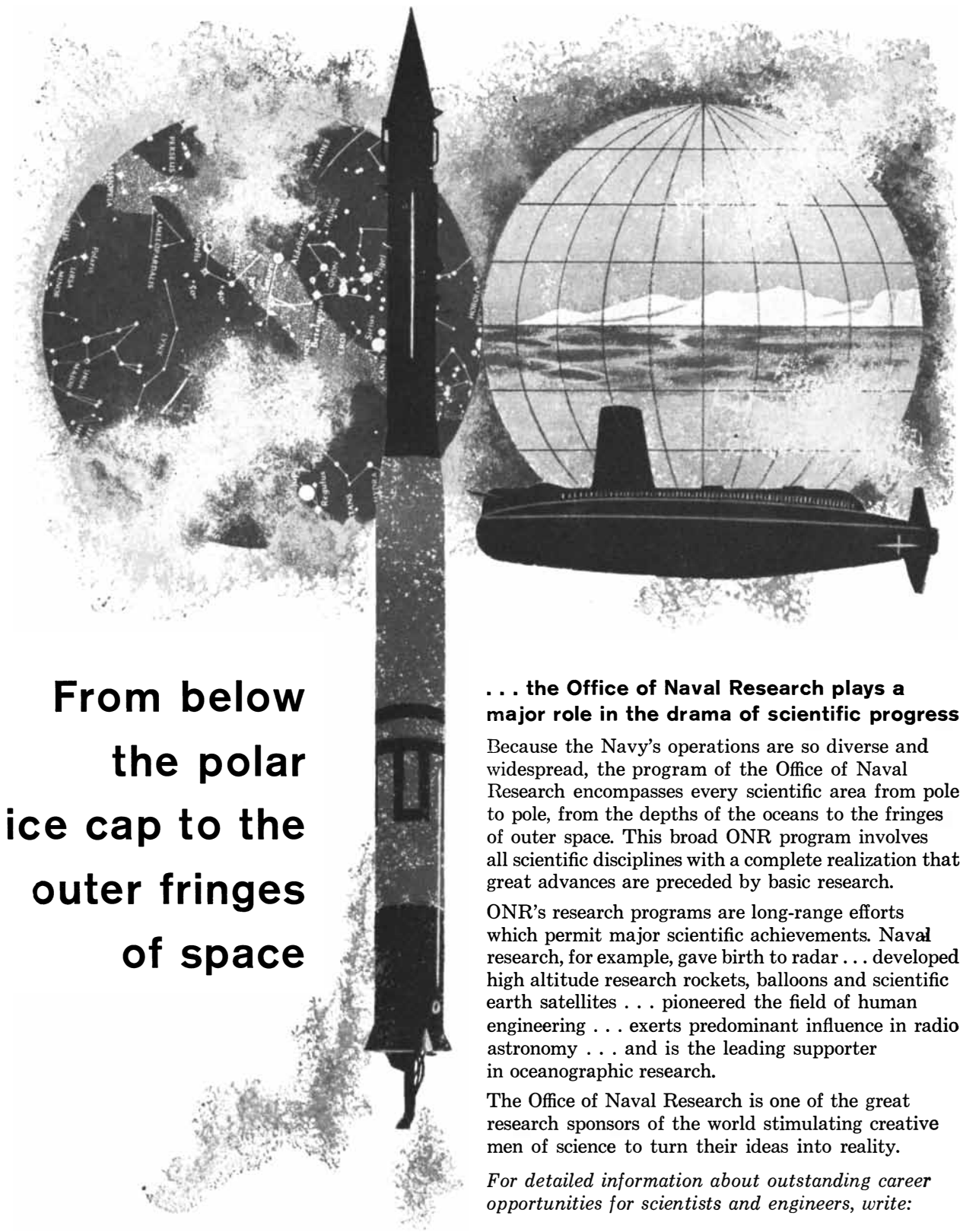
**SUPERVISOR
ENGINEERING EMPLOYMENT
BELL AIRCRAFT
CORPORATION
BUFFALO 5, NEW YORK**

was constantly in hysterical fear of ruin. "Fires blazed in him and sexual passion drove him almost insane. Above all he wanted a wife and children and with all the women in Russia to choose from, he had to choose a cold virago who married him only for his money, refused to share his bed, taunted him continuously, and lived out her life as though she were waiting for him to die so that she could inherit his fortune." By this woman he had three children, having "stolen" two of them from her, as he wrote brutally. Finally he divorced her in Indianapolis (he had become an U. S. citizen for the purpose), and soon afterward in Athens married a lovely 17-year-old Greek girl, a third his age, picked out for him by a friend pursuant to specifications and approved by Schliemann from a photograph. The marriage marked a turning point. With adventures, travels and successes behind him enough to fill a dozen lives, Schliemann at last found the clue to himself and began the career for which he is remembered. His grand and passionate aim was to unearth the buried city of Troy, and to that end he began a series of extensive excavations. He was surely the most erratic, impulsive and unscientific of archaeologists; he was also self-seeking, dishonest, greedy for the treasure he hoped to find, more interested in gold than in knowledge. Yet there was a genuine urge to uncover the past, a last desperate hope for self-fulfillment in making contact with the remains of the Greek heroes whose deeds had haunted and fascinated him since childhood. He dug like a madman, recklessly destroying whatever blocked his path to treasure; he uncovered walls and palaces and cities and enough antiquities (most of which he stole for himself) to fill a museum. His grandiose notions of the places he located—Hissarlik, for example, his greatest excavation, he believed to be the ancient citadel of Homer's Troy—were completely wrong; he had touched Troy but failed to recognize it "because he worked with such astonishing speed and because he was tempted to remove everything that was not Homeric from his path." The world he thought he had found probably never even existed; in his mania he created it because it was so much more beautiful than the world he knew. Still, through a blend of flaming imagination, high skill and incredible perseverance, he did a giant's work and, as Payne says, in the roll call of those who have brought the Homeric age to life Schliemann was the boldest and saw the farthest. An absorbing, fast-moving story, written in Payne's practiced, light-

ning-quick style. It is inexcusable, however, that the book has no index.

THE CROSSING OF ANTARCTICA, by Sir Vivian Fuchs and Sir Edmund Hillary. Little, Brown and Company (\$7.50). The story of the Commonwealth Trans-Antarctic Expedition 1955-1958, told by its leaders. In November, 1957, after two years of intensive preparations and reconnaissance, Fuchs and 11 of his men set out on a tractor-and-sledge journey across the Antarctic continent, from Shackleton Base, which they had established on the Weddell Sea, over the Pole to Scott Base on the Ross Sea. The 2,500-mile journey took 99 days. Earlier Hillary had traveled from Scott Base to the Pole, marking a trail and setting up supply depots that facilitated Fuchs's traverse. The achievement itself is not as dramatic as the polar expeditions of a hardier day: the mechanized equipment, radio communications and aircraft support inevitably dull the edge of the adventure. Still it was an exciting feat, here very ably reported and holding one's attention throughout. The weather was mostly frightful, as Antarctic weather usually is; the repeated white-outs were formidably dangerous; the Sno-Cats and Weasels kept falling into treacherous crevasses (though miraculously no one was injured and no tractor was lost). There were innumerable mechanical difficulties, and although extensive repairs—some requiring complete rebuilding of engines and tracks—had to be made in portable tent-workshops at 10,000 feet altitude in 35-below-zero weather, with a 30- or 40-knot "breeze" blowing, the engineer crew managed to keep every vehicle rolling as long as it was needed. Scientific observations were made along the way, including geological surveys, seismic soundings of ice depth, mapping, collection of meteorological data, glacier studies, physiological research. But for most of the participants it was the journey itself, rather than its scientific fruits, that justified the undertaking. G. L. Mallory's oft-quoted epigram that men climb mountains "because they are there" does not really hit the mark; they climb them, as they explore deserts and polar wastes, because of the danger, the satisfactions of shared privation, the beauty of silence and lovely places. Excellent illustrations.

THE WORLD OF INSECTS, by Paul Peterson. McGraw-Hill Book Company, Inc. (\$15). A translation from the French, by R. B. Freeman, of a lavishly illustrated popular survey of insects: their history and evolution, respiration,



**From below
the polar
ice cap to the
outer fringes
of space**

... the Office of Naval Research plays a major role in the drama of scientific progress

Because the Navy's operations are so diverse and widespread, the program of the Office of Naval Research encompasses every scientific area from pole to pole, from the depths of the oceans to the fringes of outer space. This broad ONR program involves all scientific disciplines with a complete realization that great advances are preceded by basic research.

ONR's research programs are long-range efforts which permit major scientific achievements. Naval research, for example, gave birth to radar . . . developed high altitude research rockets, balloons and scientific earth satellites . . . pioneered the field of human engineering . . . exerts predominant influence in radio astronomy . . . and is the leading supporter in oceanographic research.

The Office of Naval Research is one of the great research sponsors of the world stimulating creative men of science to turn their ideas into reality.

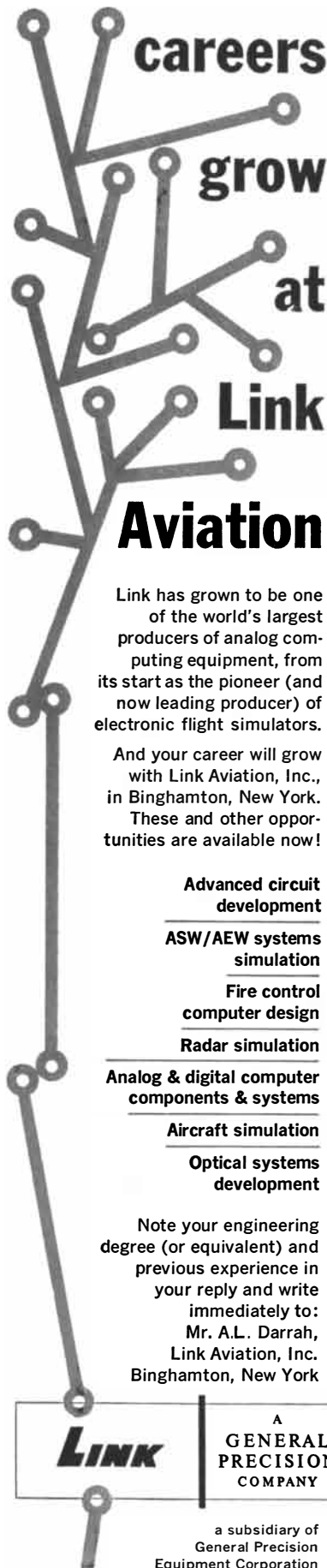
For detailed information about outstanding career opportunities for scientists and engineers, write:

Chief of Naval Research
Attention: Mr. Edward McCrensky



Office of Naval Research
Washington 25, D. C.

Naval Research Laboratory • Naval Training Device Center • Navy Underwater Sound Reference Laboratory
BRANCH OFFICES: BOSTON, NEW YORK, CHICAGO, SAN FRANCISCO, PASADENA, AND LONDON, ENGLAND



Link has grown to be one of the world's largest producers of analog computing equipment, from its start as the pioneer (and now leading producer) of electronic flight simulators.

And your career will grow with Link Aviation, Inc., in Binghamton, New York. These and other opportunities are available now!

Advanced circuit development

ASW/AEW systems simulation

Fire control computer design

Radar simulation

Analog & digital computer components & systems

Aircraft simulation

Optical systems development

Note your engineering degree (or equivalent) and previous experience in your reply and write immediately to:
Mr. A.L. Darrah,
 Link Aviation, Inc.
 Binghamton, New York

LINK

A
**GENERAL
 PRECISION
 COMPANY**

a subsidiary of
 General Precision
 Equipment Corporation

conservation of water, reproduction, embryology and development, sense organs and behavior, relation to climate and man. Insects, as the author clearly shows, are the most effective of living forms, and if man should succeed in exterminating himself, they will very properly inherit the earth. There are 225 photographs (some are marvelous), 52 in color. The color pictures are not of exceptional quality.

THE GULF STREAM: A PHYSICAL AND DYNAMICAL DESCRIPTION, by Henry Stommel. University of California Press (\$6). A technical monograph by a physical oceanographer who has spent some years in specialized study of the subject. The book discusses the history of ideas about the Gulf Stream, the instruments used to observe and measure its behavior, the balance of forces in the Stream, its hydrography, the wind system over the North Atlantic, linear and nonlinear theories of the Gulf Stream, meanders in the Stream, fluctuations in the current, the role of the thermohaline circulation. The author's general conclusions run along these lines: The central North Atlantic is covered to a depth of about 700 meters with a layer of warm water, slowly drifting toward the southwest under the combined influence of the wind and the earth's rotation. This is the fabled Sargasso Sea. It does not reach the eastern coast of North America but is bounded some distance offshore by the Gulf Stream, which "acts as a kind of dynamic barrier" or dam, which by virtue of the Coriolis force restrains the Sargasso Sea from overflowing the colder northern water of the North Atlantic. The water in the Stream is not much different in temperature from that in the Sargasso; the Gulf Stream, in short, "is not an ocean river of hot water," as is commonly supposed. Thus the popular and long-established belief that the Gulf Stream keeps the European climate warm is open to question. It is unlikely that the Stream itself has a direct climatological influence; more probably its effects are indirect, in determining the northern boundaries and average-temperature structure of the large mass of warm water on its eastern flank. Because of the many complex factors that must be taken into account, including the transport of the Stream, the physical relations between the Stream and the density and thermal structure of the water on either side, the thermocline of the Sargasso, the radial shrinking of the current system, the rates of the formation of water masses, the effects of wind on ocean currents and vice versa, oceanog-

raphers have not thus far succeeded in framing a comprehensive, testable theory of the Gulf Stream. A great deal of work must still be done before we can hope to understand the physical processes involved.

THE FOSSIL BOOK, by Carroll Lane Fenton and Mildred Adams Fenton. Doubleday and Company, Inc. (\$12.50). Fossils are remains or traces of organisms that lived during ancient geologic times and were buried in rocks. Ancient geologic times is a loose expression covering an enormous span from 1.5 billion years ago to the beginning of the present ice age; and the word rocks is not confined to its common usage but may mean gravel, clay, permafrost, paraffin beds, asphalt, amber or any other substance that registers and preserves traces of organic matter. In these traces the long story of life on our planet has been written, the story of our antediluvian ancestors and relatives, of the unceasing change that led "from jelly-like blobs to oaks and redwoods, from very simple wormlike creatures to snails, elephants and dinosaurs." The Fentons present an excellent account in text and pictures of the evolutionary parade. Their book explains how fossils have been preserved by freezing, drying, simple burial, fixing in wax and asphalt, carbonization, petrification, the formation of casts and molds, the solidification of tracks, trails and burrows. In some cases the complete organism has been almost perfectly preserved, but in most instances mere fragments are the basis of reconstruction of past life. From footprints men have learned where dinosaurs walked, ran and rested; from furrows, the trail of trilobites and snails; from bones, the nature of the soft anatomy and mental and sensory equipment of many fossil vertebrates; from fossil spores, the chromosome structure of plants; from bone lesions and scars, the diseases (*e.g.*, rheumatism, arthritis, tumors, abscesses) of ancient vertebrates; from the shapes and positions of shells, the habits of invertebrates. In 1950 Harold C. Urey analyzed a Jurassic belemnite roughly 150 million years old, and from the isotopes of oxygen present in the fossil he was able to show that the animal hatched in the summer, lived almost four years and died in the spring; that during its life summer temperatures ranged from 68 to 70 degrees Fahrenheit and winter temperatures from 59 to 64 degrees. The Fentons' book has hundreds of drawings and photographs, eight color-plates that show both actual fossils and restorations of

'HUMAN FACTORS is a rapidly growing professional specialty making contributions in personnel, training, human engineering, and all those areas where there is man-machine interaction. The rapid acceptance of system concepts has made the "human part" of any system a focal point for system planning. Wherever a system is required to collect and input information, process this information, display data for action or decision-making—at such places humans will be involved and human factors knowledge and techniques can make significant contributions to system design.

SDC is the world's largest private employer of human factors scientists. In conjunction with computer programmers, design and computer engineers and operations research specialists, human factors personnel at SDC are playing key roles in the development of several of the nation's largest data processing and control systems. SDC's development of the System Training Program for both the manual and SAGE air defense crews is well known. More recently this training has been expanded to include battle staff training and decision-making at the highest echelons. Simultaneously SDC has been diversifying its human factors work so that at the present time over a third of our human factors professional employees are working on design of advanced new systems, on human engineering, and on broad research problems.

If you have training and experience in the human factors area, and especially if your background is in human engineering or experimental psychology, we would be very pleased to discuss available positions in our expanding facilities at Santa Monica, California, Lodi, New Jersey and throughout the country and Alaska. Please address inquiries to Dr. E. H. Porter, Jr., Assistant Director of Human Factors for Personnel, at 2420 Colorado Avenue, Santa Monica, California."

Launor F. Carter

LAUNOR F. CARTER, DIRECTOR OF HUMAN FACTORS
AND GENERAL MANAGER OF SYSTEM TRAINING

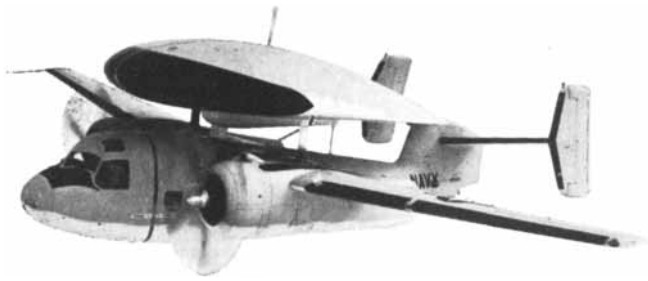


LAUNOR F. CARTER



SYSTEM DEVELOPMENT CORPORATION

SANTA MONICA, CALIFORNIA • LODI, NEW JERSEY •



OPPORTUNITIES IN ELECTRONICS

The Grumman WF2 Early Warning airplane is only one of the products which is a prime concern of our Electronics Engineers. Other Grumman programs involving large scale applications of electronics are Attack, Reconnaissance and Anti-Submarine Warfare Weapons Systems.

These programs and additional classified projects, drawing heavily on the ability of the Electronics Engineer, have created the following professional positions:

Radar Systems Engineer. EE or Physics degree with a minimum of 5 years' experience in the design, development or analysis of advanced radar systems. Work will consist of the analysis, preparation of specifications; vendor liaison; test and evaluation; flight development of the latest airborne radar equipment and systems. Responsibilities include the development of support equipment for these systems.

Digital Computer Engineer. EE or Physics degree with a minimum of 3 years' experience in the design and development of airborne digital computers. Work will involve the establishment of test point requirements and test logic for military automatic line test devices and automatic and manual military shop test equipment.

Automatic Flight Control Systems Engineers. EE or Physics degree with a minimum of 5 years' experience in the design and development of autopilot and flight simulators. Work will involve the development of airborne flight control systems and the establishment of military automatic test equipment requirements.

Communications Equipment Engineer. EE with a minimum of 5 years' experience with thorough knowledge of single sideband theory and its application. Should possess a complete understanding of AM, FM, PM, and single sideband modulation processes and their application as well as techniques. Must have experience in analyzing and testing communication receivers and transmitters and should be thoroughly familiar with HF and UHF antennas and associated propagation problems. A background in digital equipment; encoder, decoder and magnetic storage devices is an important consideration.

Antenna Design Engineer. EE, Physics or Math degree with experience in airborne antennas and/or radomes. Work to consist of antenna and radome analysis, synthesis, design and research in a modern, professional atmosphere, supported by the finest of facilities in a new Avionics Laboratory. U.S. Citizenship Required.

You are invited to send your résumé to Mr. A. Wilder, Engineering Personnel Director, Dept. Gr-23, who will arrange an interview at your convenience.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION
Bethpage • Long Island • New York

plants and animals, a glossary, a bibliography, and directions on how to collect fossils.

HISTORY OF AMERICAN STEAM NAVIGATION, by John H. Morrison. Stephen Daye Press (\$10). Reissue of a noted history first published in 1903. Morrison's book is a mine of important as well as marvelously trivial information about steamships and steamboats of the century following Fulton's *Clermont*. It covers the experimental period, the vessels of the Hudson and Delaware rivers, western-river navigation, coastal traffic, the lines plying Long Island Sound, Lake Erie and Lake Ontario, Maine and Boston shipping, ocean lines and liners, steam ferries and tugs, lighthouses, the deepening of New York City's Hell Gate. There is even a section on the steam calliope. Fifty quaint pen-and-ink drawings by Samuel Ward Stanton and a few photographs illustrate this volume, which will delight the antiquarian and inform the student of technology.

Notes

BIOLOGICAL AND BIOCHEMICAL BASIS OF BEHAVIOR, edited by Harry F. Harlow and Clinton N. Woolsey. The University of Wisconsin Press (\$8). Papers presented at a symposium at the University of Wisconsin, attempting to correlate studies in progress in anatomy, physiology, biochemistry and behavior.

PSYCHOPHARMACOLOGY FRONTIERS, edited by Nathan S. Kline. Little, Brown and Company (\$10). Proceedings of the Psychopharmacology Symposium of the Second International Congress of Psychiatry, with papers by many different specialists on the general problems of psychopharmacology, clinical observations and descriptions of the action of various drugs, and studies on the mode of action of psychotherapeutic drugs.

DICTIONARY OF PHYSICS AND ALLIED SCIENCES; VOL. I, GERMAN-ENGLISH, edited by Charles J. Hyman. Frederick Ungar Publishing Co., Inc. (\$9). The first bilingual dictionary primarily devoted to physics, with some coverage of related sciences such as mathematics, astronomy, chemistry, mineralogy, geology, geophysics, meteorology and technology.

THE NEW SCIENCE, by Max Planck. Meridian Books, Inc. (\$5). Three complete works of Planck are collected in this attractive volume: "Where is Science Going?", "The Universe in the

PHYSICISTS — NUCLEAR ENGINEERS

5 areas where the physicist may act to advance



THEORETICAL and APPLIED nucleonics

AT GENERAL ELECTRIC'S AIRCRAFT NUCLEAR PROPULSION DEPT.

The problems of developing nuclear propulsion for aircraft and missiles impinge upon many areas of theoretical and applied physics—and must be carried on at a high level.

Assignments of unusual scientific interest are now open at General Electric in:

THEORETICAL INVESTIGATIONS

Conduct theoretical investigations into areas of solid state physics with emphasis on effects of neutrons and photons on matter. (PhD)

RADIATION HAZARD STUDIES

Develop experimental and theoretical approaches to evaluation and limitation of radiation hazard for personnel. (PhD or MS, BS with 5 years experience Health Physics)

INTEGRATION of NUCLEAR THEORY and EXPERIMENTAL TECHNIQUES

Develop improvements in reactor theory and methods of reactor analysis. Combine advances in nuclear physics, transport theory and handling of large numerical problems on digital computers. (PhD, MS)

ADVANCED and PRELIMINARY DESIGN STUDIES of HIGH PERFORMANCE REACTORS

To identify and evaluate reactor types and configurations for future requirements. Also REACTOR ANALYSIS and critical evaluation of existing and proposed reactor designs. Interpret results of mockup critical experiments. (PhD, MS, BS)

NUCLEAR SHIELD PHYSICS

A broad program requiring physicists and nuclear engineers, BS to PhD levels
... shield physics experiments to develop fundamental data
... shield design and analysis for both present and future nuclear propulsion systems
... planning, design and analysis of shield tests of both partial and full-scale mockup configurations

ENGINEERS and
SCIENTISTS
who value
the opportunity
to do original work,
are invited to inquire
about positions
at the right.
Please include
salary requirements
with resume.

Write to: Mr. P. W. Christos, Div. 59-MI

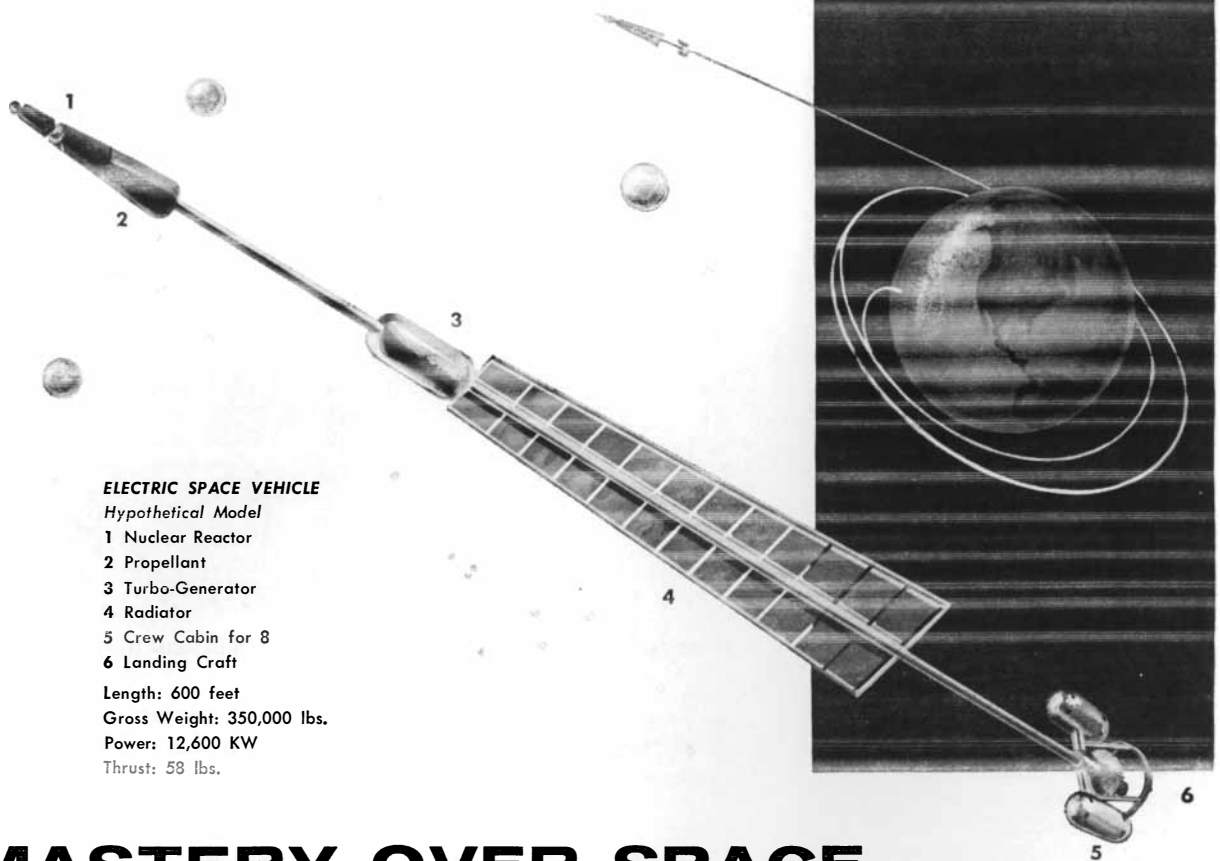
AIRCRAFT NUCLEAR PROPULSION DEPARTMENT

GENERAL  ELECTRIC

P. O. Box 132

Cincinnati 15, Ohio

All scientists have the advantage of large-scale computing equipment *at the site*, as well as supporting programming personnel.



ELECTRIC SPACE VEHICLE

Hypothetical Model

- 1 Nuclear Reactor
- 2 Propellant
- 3 Turbo-Generator
- 4 Radiator
- 5 Crew Cabin for 8
- 6 Landing Craft

Length: 600 feet

Gross Weight: 350,000 lbs.

Power: 12,600 KW

Thrust: 58 lbs.

MASTERY OVER SPACE

NASA's space efforts are directed toward two specific objectives. First, to make it possible for man to achieve the same mastery over space he has already secured in every other region he has attempted to make his own . . . on the surface of the earth, under it, or in the air above it.

Second, to free man from one additional element of intellectual bondage—that is, to gain for all mankind additional knowledge about the cosmos.

To accomplish these objectives NASA's broadly conceived programs encompass intensive work in the following areas:

Scientific investigations in space by means of sounding rockets, scientific satellites, lunar probes, deep space probes.

Research and development of spacecraft, missiles and aircraft.

Meteorological and communications satellite systems.

Space operations technology — Project Mercury and space rendezvous techniques.

Space propulsion research, including solid propellant rockets, high energy propellant rockets, 1½-million-pound-thrust single-chamber rocket engine, nuclear and electric rocket engines.

Orbiting space laboratories.

Scientists and Engineers:

Career opportunities for graduates at NASA are as unlimited as the scope of our organization.

Please address your inquiry to the Personnel Director of any of the following NASA research centers:

- Langley Research Center
Hampton, Virginia
- Ames Research Center
Mountain View, California
- Lewis Research Center
Cleveland, Ohio
- High-Speed Flight Station
Edwards, California
- Goddard Space Flight Center
4555 Overlook Avenue, S.W.
Washington 25, D. C.

NASA

National Aeronautics and Space Administration

Light of Modern Physics" and "The Philosophy of Physics." There is also a brief prefatory essay by Albert Einstein and a biographical introduction by James Franck. A fine package.

INTRODUCTION TO SYMBOLIC LOGIC AND ITS APPLICATIONS, by Rudolf Carnap. Dover Publications, Inc. (\$1.85). First English translation of a text by an outstanding authority, covering the elementary and advanced portions of the theory of symbolic logic and treating its applications.

THINKING TO SOME PURPOSE, by L. Susan Stebbing. Penguin Books (95 cents). A reissue of Miss Stebbing's manual of first aid to clear thinking, which exposes the assorted stupidities, illogicalities, canned ideas, frauds and chicaneries by which politicians succeeded in bamboozling not only us but themselves. This book was pointed to the world problems of 1939 but was never more needed than today.

THE NEW CAMBRIDGE MODERN HISTORY: VOL. II, THE REFORMATION, 1520-59, edited by G. R. Elton. Cambridge University Press (\$7.50). The second volume in this new series which succeeds, without necessarily supplanting, the first *Cambridge Modern History* of 50 years ago, describes the open conflicts of the Reformation "from Luther's first challenge to the uneasy peace of the early 1560's." The chapter on intellectual tendencies has a section on science written by A. R. Hall.

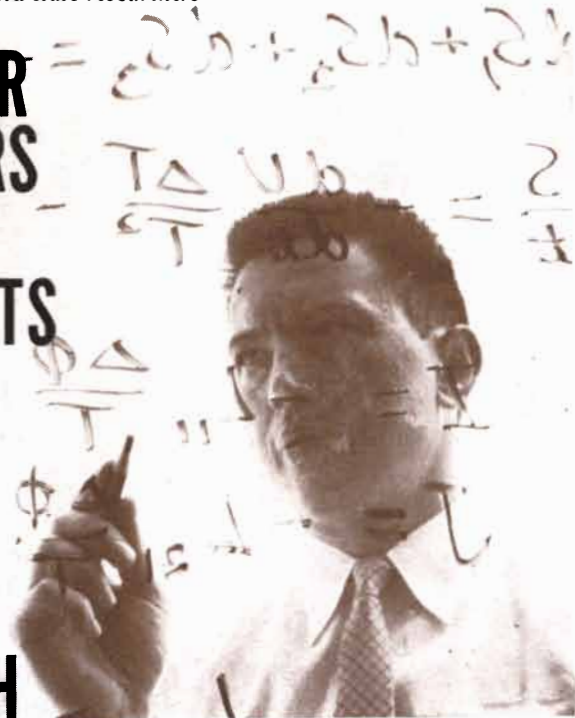
PHYSICAL LAWS AND EFFECTS, by C. Frank Hix, Jr., and Robert P. Alley. John Wiley & Sons, Inc. (\$7.95). A compilation for engineers of major physical laws and effects from absorption and Ampère's law to Wien's displacement law and the Zeeman effect. Descriptions and examples are given in clear language, and references to the literature. A quite useful book but overpriced.

A SHORT ACCOUNT OF EARLY MUSLIM ARCHITECTURE, by K. A. C. Creswell. Penguin Books (\$1.95). This book, based on the author's well-known larger work, explains how Muslim architecture was born and describes the cultural influences that helped to mold it. Seventy-two plates and numerous text figures.

THE THEORY OF ELEMENTARY PARTICLES, by J. Hamilton. Oxford University Press (\$12). An account of the basic mathematical methods used in investigating elementary particles.

solid opportunity for solid state researchers in southern california

COMPUTER ENGINEERS AND PHYSICISTS FOR ALL LEVELS OF RESEARCH



Here's an excellent opportunity to explore unknown horizons in the solid state computer field. NCR now has open 12 choice positions, including three senior ones for superior engineers and physicists. SENIOR RESEARCH ENGINEER OR SPECIALIST with an MS or Ph. D. and strong experience in transistor circuits is needed for magnetics research.

SENIOR RESEARCH ENGINEER OR SPECIALIST, (EE or physicist) with an MS or Ph. D. and broad research background including system experience, is needed for research analysis.

SENIOR PHYSICIST, MS or Ph. D., with semiconductor experience, is needed for solid state thermoelectrics research.

NINE EE's AND PHYSICISTS are needed for magneto-optics, direct character recognition, a parametron project, and a solid state project. Experience range: from junior to senior level. One of the following backgrounds required: transistor circuits, logical design, digital systems, magnetics, electron and physical optics, electro-chemistry, physical chemistry or chemical engineering, evaporated films, microminiature circuits or components.

At NCR Electronics Division, located in California's Riviera-like Southland, you will have a free rein to formulate and develop ideas in exciting new phases of solid state computers. You'll be part of the team that developed the *magnetic Rod memory* with a 4-millimicrosecond switching speed; the *photochromic memory*, based on the microencapsulation technique; *inhibit-core logic*, using ferrite cores or Rods for greater reliability; and the *NCR 304*, the first wholly business-designed large-scale computer having all-solid state circuitry.

What's more your future is assured — you'll be working for one of the best known and best financed companies in the world.

Please contact D. P. Gillespie, director of industrial relations. All replies held in strict confidence.

*National**

The National Cash Register Company
ELECTRONICS DIVISION

1401 East El Segundo Boulevard, Hawthorne, California

*Trade Mark Reg. U. S. Pat. Off.

INDEX OF

SEPTEMBER,

ACME ELECTRIC CORPORATION..... 58	BULOVA WATCH COMPANY, INDUSTRIAL AND DEFENSE SALES..... 213	GENERAL ELECTRIC CO., KNOLLS ATOMIC POWER LABORATORY..... 261
Agency: Scheel Advertising Agency, Incorporated	Agency: Duncan-Brooks Inc.	Agency: Deutsch & Shea, Inc.
AERO SERVICE CORPORATION..... 102	BURGESS BATTERY COMPANY..... 176	GENERAL ELECTRIC CO., LIGHT MILITARY ELECTRONICS DEPARTMENT..... 1
Agency: The Aitkin-Kynett Co., Inc.	Agency: Kane Advertising	Agency: De Garmo Incorporated
AEROJET-GENERAL CORPORATION, A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY..... 263	BURNDY CORPORATION, OMATON DIVISION 131	GENERAL ELECTRIC COMPANY, X-RAY DEPARTMENT..... 26, 27
Agency: D'Arcy Advertising Company	Agency: Ted Gravenson, Inc.	Agency: Klan-Van Pietersom-Dunlap, Inc.
AERONCA MANUFACTURING CORPORATION..... 12	CELANESE CORPORATION OF AMERICA, CHEMICAL DIVISION..... 114, 115	GENERAL MOTORS CORPORATION, ALLISON DIVISION..... 237
Agency: Penn and Hamaker, Inc.	Agency: Ellington & Company, Inc.	Agency: Kudner Agency, Inc.
ALLIED RADIO CORP..... 132	CELANESE CORPORATION OF AMERICA, PLASTICS DIVISION..... 211	GLOBE INDUSTRIES, INC..... 69
Agency: George Brodsky Advertising, Inc.	Agency: Ellington & Company, Inc.	Agency: Odiorne Industrial Advertising, Inc.
ALLIED RESEARCH ASSOCIATES, INC., A SUBSIDIARY OF VERTOL AIRCRAFT CORPORATION..... 116	CHICAGO RAWHIDE MANUFACTURING COMPANY, SIRVENE DIVISION..... 161	GOODYEAR AIRCRAFT CORPORATION, A SUBSIDIARY OF THE GOODYEAR TIRE & RUBBER CO..... 254
Agency: Gaynor & Ducas, Inc.	Agency: Aves, Shaw & Ring, Inc.	GOODYEAR TIRE & RUBBER CO., CHEMICAL DIVISION..... Inside Front Cover
ALPHA CORPORATION, A SUBSIDIARY OF COLLINS RADIO COMPANY..... 35	CONVAIR-FORT WORTH, A DIVISION OF GENERAL DYNAMICS CORPORATION..... 257	Agency: Kudner Agency, Inc.
Agency: Don L. Baxter, Inc.	Agency: Glenn Advertising, Inc.	GOVERNMENT PRODUCTS GROUP, AMERICAN MACHINE & FOUNDRY COMPANY..... 67
ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION..... 193	COOPER ALLOY CORPORATION..... 111	Agency: Cunningham & Walsh Inc.
Agency: Ketchum, MacLeod & Grove, Inc.	Agency: Adams & Keyes, Inc.	GRAPHIC SYSTEMS..... 258
AMCO ENGINEERING CO..... 185	CORNING GLASS WORKS..... 9	Agency: Diener & Dorskind Incorporated
Agency: Buti-Roberts	Agency: The Rumrill Company Inc.	GRUMMAN AIRCRAFT ENGINEERING CORPORATION..... 64, 65, 282
AMERICAN BOSCH ARMA CORPORATION, ARMA DIVISION..... 25	COX & COMPANY, INC..... 40	Agency: Fuller & Smith & Ross Inc.
Agency: Doyle, Kitchen & McCormick, Inc.	Agency: Donaldson Associates Inc.	GURLEY, W. & L. E..... 62
AMERICAN BRASS COMPANY, THE..... 30, 31	CURTISS-WRIGHT CORPORATION..... 198	Agency: Fred Wittner Company
Agency: Kenyon & Eckhardt Inc.	Agency: Adams & Keyes, Inc.	HAYDON, A. W., COMPANY, THE..... 173
AMERICAN EDELSTAAL, INC., UNIMAT DIV. 149	DAGE TELEVISION DIVISION, THOMPSON RAMO WOOLDRIDGE INC..... 158	Agency: Cory Snow, Inc.
Agency: Harold J. Siesel Company	Agency: Lampert, Fox, Prell & Dolk Inc.	HAYES, C. I., INC..... 210
AMERICAN FELT COMPANY..... 18	DEARBORN CHEMICAL COMPANY..... 108	Agency: Horton, Church & Goff Inc.
Agency: Kelly, Nason, Incorporated	Agency: Adams & Keyes, Inc.	HAYNES STELLITE COMPANY, DIVISION OF UNION CARBIDE CORPORATION..... 43
AMERICAN MACHINE & FOUNDRY COMPANY, GOVERNMENT PRODUCTS GROUP..... 67	DIAL PRESS, THE..... 276	Agency: J. M. Mathes Incorporated
Agency: Cunningham & Walsh Inc.	Agency: Sussman & Sugar, Inc.	HERCULES POWDER COMPANY, INCORPORATED..... 23
AMERICAN OPTICAL COMPANY, INSTRUMENT DIVISION..... 104	DOUBLEDAY & COMPANY, INC..... 269	Agency: Fuller & Smith & Ross Inc.
Agency: J. G. Kelly Co., Inc.	Agency: Franklin Spier, Inc.	HIGH VOLTAGE ENGINEERING CORPORATION..... 36
AMERICAN SMELTING AND REFINING COMPANY..... 215	DOUGLAS AIRCRAFT COMPANY, INC..... 245	Agency: Engineered Advertising
Agency: Needham, Louis and Brorby, Inc.	Agency: J. Walter Thompson Company	HOOKER CHEMICAL CORPORATION, DUREZ PLASTICS DIVISION..... 218
AMERICAN-STANDARD, MILITARY PRODUCTS DEPT..... 226	DOW CHEMICAL COMPANY, THE..... 6, 7, 178, 179	Agency: The Rumrill Company Inc.
Agency: S. Gunnar Myrbeck & Company, Inc.	Agency: MacManus, John & Adams, Inc.	HUGHES AIRCRAFT COMPANY..... 246, 247
AMPEREX ELECTRONIC CORP., SEMI-CONDUCTOR AND SPECIAL PURPOSE TUBE DIVISION..... 113	DOW CORNING CORPORATION..... 57	Agency: Footc. Cone & Belding
Agency: Sam Groden, Incorporated	Agency: Church & Guisewite Advertising, Inc.	ITT LABORATORIES, A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORP..... 255
ANACONDA COMPANY, THE..... 30, 31	DOW METAL PRODUCTS COMPANY, THE, DIVISION OF THE DOW CHEMICAL COMPANY..... 145	Agency: Carpenter-Proctor, Inc.
Agency: Kenyon & Eckhardt Inc.	Agency: MacManus, John & Adams, Inc.	INDUSTRIAL TECTONICS, INC..... 21
APPLIED PHYSICS CORPORATION..... 160	DU PONT DE NEMOURS, E. I., & CO., INC., FILM DEPT..... 24	Agency: Carl Connable Advertising
Agency: Clyde D. Graham Advertising	Agency: Batten, Barton, Durstine & Osborn, Inc.	INSTRUMENTS FOR INDUSTRY, INC..... 11
ARGONNE NATIONAL LABORATORY..... 291	DU PONT DE NEMOURS, E. I., & CO., INC., POLYCHEMICALS DEPARTMENT..... 17	Agency: McClellan Advertising, Inc.
Agency: Grant-Jacoby Studios, Inc.	Agency: Batten, Barton, Durstine & Osborn, Inc.	INTERNATIONAL BUSINESS MACHINES CORPORATION..... 110, 239
ARNOLD ENGINEERING COMPANY, THE..... 203	DU PONT DE NEMOURS, E. I., & CO., INC., TEXTILE FIBERS DEPARTMENT..... 136, 137	Agency: Benton & Bowles, Inc.
Agency: Erwin Wasey, Rutherford & Ryan, Inc.	Agency: Batten, Barton, Durstine & Osborn, Inc.	INTERNATIONAL MINERALS & CHEMICAL CORP..... 125
ARRIFLEX CORPORATION OF AMERICA..... 183	DUREZ PLASTICS DIVISION, HOOKER CHEMICAL CORPORATION..... 218	Agency: Klan-Van Pietersom-Dunlap, Inc.
Agency: Advertising Aides	Agency: The Rumrill Company Inc.	INTERNATIONAL NICKEL COMPANY, INC., THE, PLATINUM METALS DIVISION..... 44, 45
AUTOMATIC ELECTRIC COMPANY, SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS CORP..... 148	EASTMAN CHEMICAL PRODUCTS, INC., SUBSIDIARY OF EASTMAN KODAK COMPANY..... 146, 147	Agency: Marschalk and Pratt Div. of McCann-Erickson, Inc.
Agency: Kudner Agency, Inc.	Agency: Fred Wittner Company	INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION..... 135
AUTONETICS, A DIVISION OF NORTH AMERICAN AVIATION, INC..... 123	EASTMAN CHEMICAL PRODUCTS, INC., SUBSIDIARY OF EASTMAN KODAK COMPANY, CHEMICALS DIV..... 186	Agency: J. M. Mathes Incorporated
Agency: Batten, Barton, Durstine & Osborn, Inc.	Agency: Fred Wittner Company	INTERNATIONAL TELEPHONE AND TELEGRAPH CORP., INDUSTRIAL PRODUCTS DIVISION..... 56
AVCO CORPORATION..... 133	EASTMAN KODAK COMPANY..... 101	Agency: Darwin H. Clark Co.
Agency: Benton & Bowles, Inc.	Agency: The Rumrill Company Inc.	IRISH EXPORT PROMOTION BOARD..... 233
AVCO CORPORATION, AVCO RESEARCH AND ADVANCED DEVELOPMENT DIVISION..... 259	EDMUND SCIENTIFIC CO..... 251	Agency: Weiner & Gossage, Inc.
Agency: Benton & Bowles, Inc.	Agency: Walter S. Chittick Company	JAEGERS, A..... 258
BARNEBEY-CHENEY COMPANY..... 202	ERCO, DIVISION OF ACF INDUSTRIES, INC. 68	Agency: Carol Advertising Agency
Agency: Odiorne Industrial Advertising, Inc.	Agency: Conti Advertising Agency, Inc.	JANITROL AIRCRAFT DIVISION, SURFACE COMBUSTION CORPORATION..... 141
BATTELLE MEMORIAL INSTITUTE..... 262	FADEX COMMERCIAL CORP..... 158	Agency: Odiorne Industrial Advertising, Inc.
Agency: Byer & Bowman Advertising Agency	Agency: Gore Smith Greenland Inc.	JOHNS HOPKINS UNIVERSITY, THE, APPLIED PHYSICS LABORATORY..... 274
BAUSCH & LOMB OPTICAL CO..... 130, 196	FAFNIR BEARING COMPANY, THE..... 20	Agency: M. Belmont Ver Standig, Inc.
Agency: Wolff Associates, Inc.	Agency: Noyes & Company, Incorporated	KELSEY-HAYES COMPANY..... 34
BELL AIRCRAFT CORPORATION..... 278	FERSON OPTICAL COMPANY, INC..... 254	Agency: Zimmer, Keller & Calvert Inc.
Agency: The Rumrill Company Inc.	Agency: Godwin Advertising Agency	KENNAMETAL INC..... 212
BELL TELEPHONE LABORATORIES..... 37	FISCHER & PORTER CO..... 240	Agency: Ketchum, MacLeod & Grove, Inc.
Agency: N. W. Ayer & Son, Incorporated	Agency: The Harry P. Bridge Company	KNOWLTON BROTHERS INCORPORATED..... 225
BENDIX AVIATION CORPORATION..... 33	FUNK & WAGNALLS COMPANY..... 277	Agency: Barlow Advertising Agency, Inc.
Agency: MacManus, John & Adams, Inc.	Agency: Albert Frank-Guenther Law, Inc.	
BENDIX AVIATION CORPORATION, SYSTEMS DIVISION..... 107	GAERTNER SCIENTIFIC CORPORATION..... 4	
Agency: MacManus, John & Adams, Inc.	Agency: Sidney Clayton & Associates	
BENDIX COMPUTER DIVISION OF BENDIX AVIATION CORPORATION..... 207	GARFIELD, OLIVER, CO., INC..... 256	
Agency: Shaw Advertising, Inc.	Agency: Daniel & Charles, Inc.	
BESELER, CHARLES, COMPANY..... 173	GARRETT CORPORATION, THE, AIRESEARCH MANUFACTURING DIVISIONS..... 109	
Agency: Marwel Advertising, Inc.	Agency: J. Walter Thompson Company	
BLISS, E. W., COMPANY..... 50	GENERAL DYNAMICS CORPORATION..... Back Cover	
Agency: Feeley Advertising Agency, Inc.	Agency: D'Arcy Advertising Company	
BRITISH INDUSTRIES CORPORATION..... 132	GENERAL ELECTRIC CO., AIRCRAFT NUCLEAR PROPULSION DEPARTMENT..... 283	
Agency: The Zlowe Company Inc.	Agency: Deutsch & Shea, Inc.	
BROOKS & PERKINS, INC..... 176	GENERAL ELECTRIC COMPANY, DEFENSE SYSTEMS DEPARTMENT..... 216, 217	
Agency: Holden Chapin Larue Inc.	Agency: G. M. Basford Company	
BRUSH BERYLLIUM COMPANY, THE..... 5		
Agency: The Ken Fox Company		
BUD RADIO CORP..... 134		
Agency: Allied Advertising Agency, Inc.		
BUDD COMPANY, THE, NUCLEAR SYSTEMS DIVISION..... 175		
Agency: Lewis & Gilman, Incorporated		

ADVERTISERS

959

KOLLMORGEN OPTICAL CORPORATION.....	224	Agency: Wilson, Haight, Welch & Grover, Inc.
LABORATORY EQUIPMENT CORP.....	191	Agency: Jones & Taylor, Inc.
LAFAYETTE RADIO.....	191	Agency: Friend-Reiss Advertising, Inc.
LEEDS & NORTHRUP COMPANY.....	205	Agency: Harris D. McKinney Incorporated
LEFAX PUBLISHERS.....	277	Agency: H. Lesseraux
LIBRARY OF SCIENCE, THE.....	266	Agency: Wunderman, Ricotta & Kline, Inc.
LIBRASCOP, INCORPORATED, A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION.....	29	Agency: Compton Advertising, Inc.
LINDE COMPANY, DIVISION OF UNION CARBIDE CORPORATION.....	63	Agency: J. M. Mathes Incorporated
LINK AVIATION, INC., A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION.....	280	Agency: Gaynor & Ducas, Inc.
LITTLE, ARTHUR D., INC.....	177	Agency: Henry A. Loudon, Advertising, Inc.
LITTON INDUSTRIES, INC., ELECTRONIC EQUIPMENTS DIVISION.....	277	Agency: Fletcher Richards, Calkins & Holden, Inc.
LOCKHEED AIRCRAFT CORPORATION, GEORGIA DIVISION.....	46	Agency: Donahue & Coe, Inc.
LOCKHEED MISSILES AND SPACE DIVISION, LOCKHEED AIRCRAFT CORPORATION.....	234, 235	Agency: Hal Stebbins, Inc.
LORAL ELECTRONICS CORPORATION, SYSTEMS DIVISION.....	39	Agency: Smith, Winters Mabuchi, Inc.
LOS ALAMOS SCIENTIFIC LABORATORY OF THE UNIVERSITY OF CALIFORNIA.....	221	Agency: Ward Hicks Advertising
LUDWIG, F. C., INC.....	132	Agency: Moore & Company, Inc.
MALAYAN TIN BUREAU, THE.....	225	Agency: Gray & Rogers
MALLINCKRODT NUCLEAR CORPORATION.....	48, 49	Agency: H. George Bloch Inc.
MARCHANT CALCULATORS, DIVISION OF SMITH-CORONA MARCHANT INC.....	194	Agency: Foote, Cone & Belding
MARQUARDT AIRCRAFT CO.....	70, 71	Agency: Grant Advertising, Inc.
MARTIN COMPANY, THE.....	60, 61	Agency: VanSant, Dugdale & Co., Inc.
MARTIN COMPANY, THE, DENVER DIVISION.....	273	Agency: E. M. Halvorson Co.
M. I. T. LINCOLN LABORATORY.....	290	Agency: Randolph Associates
MELPAR, INC., A SUBSIDIARY OF WESTINGHOUSE AIR BRAKE COMPANY.....	187	Agency: Larrabee Associates Advertising
MERCK & CO., INC., CHEMICAL DIVISION.....	47	Agency: Charles W. Hoyt Company, Inc.
METAL & THERMIT CORPORATION, COMMERCIAL DEVELOPMENT DIVISION.....	51	Agency: Marsteller, Rickard, Gebhardt and Reed, Inc.
MINIATURE PRECISION BEARINGS, INC.....	192, 232	Agency: James Thomas Chirurg Company
MINNEAPOLIS-HONEYWELL.....	52, 53, 152	Agency: The Aitkin-Kynett Co., Inc.
MINNEAPOLIS-HONEYWELL, AERONAUTICAL DIVISION.....	288	Agency: Kerker Peterson Hixon Hayes, Inc.
MINNEAPOLIS-HONEYWELL, HEILAND DIVISION.....	153	Agency: Tool and Armstrong Advertising
MINNESOTA MINING AND MANUFACTURING COMPANY, CHEMICAL DIVISION.....	150, 151	Agency: MacManus, John & Adams, Inc.
MINNESOTA MINING AND MANUFACTURING COMPANY, MAGNETIC PRODUCTS DIVISION.....	8	Agency: MacManus, John & Adams, Inc.
MITRE CORPORATION, THE.....	227	Agency: Deutsch & Shea, Inc.
MODERNOPHONE, INC.....	256	Agency: The Kaplan Agency, Inc., Div. of Mogul Lewin Williams & Saylor, Inc.
NARDA ULTRASONICS CORPORATION, THE, SUBSIDIARY OF THE NARDA MICRO-WAVE CORPORATION.....	54	Agency: John Mather Lupton Company Inc.
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.....	284	Agency: M. Belmont Ver Standig, Inc.
NATIONAL CASH REGISTER COMPANY, THE, ELECTRONICS DIVISION.....	285	Agency: Allen, Dorsey & Hatfield, Inc.
NATIONAL COMPANY, INC.....	167	Agency: Burton Browne Advertising
NEW DEPARTMENT DIVISION OF GENERAL MOTORS CORPORATION.....	41	Agency: D. P. Brother & Company
NON-LINEAR SYSTEMS, INC.....	121	Agency: Barnes Chase Company
NORTON COMPANY, ELECTRO-CHEMICAL DIVISION.....	171	Agency: James Thomas Chirurg Company
NUCLEAR-CHICAGO CORPORATION.....	159	Agency: Don Colvin & Company, Inc.
OAK RIDGE NATIONAL LABORATORIES—ISOTOPES DIVISION (UNION CARBIDE CORPORATION).....	252	Agency: J. M. Mathes Incorporated
OFFICE OF NAVAL RESEARCH, DEPARTMENT OF THE NAVY.....	279	Agency: M. Belmont Ver Standig, Inc.
OPERATIONS RESEARCH OFFICE, THE, JOHNS HOPKINS UNIVERSITY.....	260	Agency: M. Belmont Ver Standig, Inc.
OXFORD UNIVERSITY PRESS, INC.....	268	Agency: Denhard & Stewart, Inc.
PAILLARD INCORPORATED.....	242	Agency: Fuller & Smith & Ross Inc.
PERGAMON PRESS, INC.....	270	Agency: Jon-Bruce Associates
PERKIN-ELMER CORPORATION.....	32	Agency: G. M. Basford Company
PHILCO CORPORATION, GOVERNMENT AND INDUSTRIAL DIVISION.....	169	Agency: Maxwell Associates, Inc.
PHOTO MECHANISMS, INC.....	128	Agency: Fred Wittner Company
PICKER X-RAY CORPORATION.....	15	Agency: Gotham-Vladimir Advertising, Inc.
POTTER & BRUMFIELD INC., DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY.....	28	Agency: Fletcher Richards, Calkins & Holden, Inc.
RADIATION DYNAMICS, INC.....	13	Agency: Conti Advertising Agency, Inc.
RADIATION ENGINEERED SERVICES.....	176	Agency: Al Paul Lefton Company, Inc.
RADIO CORPORATION OF AMERICA, DEFENSE ELECTRONIC PRODUCTS.....	55	Agency: Al Paul Lefton Company, Inc.
RADIO CORPORATION OF AMERICA, ELECTRON TUBE DIVISION.....	156, 157, 241	Agency: Al Paul Lefton Company, New York Division Inc.
RADIO CORPORATION OF AMERICA, INDUSTRIAL ELECTRONIC PRODUCTS.....	209	Agency: Al Paul Lefton Company, Inc.
RADIO ENGINEERING LABORATORIES, INC.....	129	Agency: Thomas Franklin Burroughs Co.
RAND CORPORATION, THE.....	2	Agency: Fletcher Richards, Calkins & Holden, Inc.
RANDOM HOUSE.....	276	Agency: Sussman & Sugar, Inc.
RANSBURG ELECTRO-COATING CORP.....	208	Agency: H. L. Ross, Advertising
RAYTHEON COMPANY.....	105	Agency: Donahue & Coe, Inc.
RAYTHEON COMPANY, GOVERNMENT EQUIPMENT DIVISION.....	264, 265	Agency: Hoag & Provandie, Inc.
RAYTHEON COMPANY, MISSILE SYSTEMS DIVISION.....	244	Agency: James Thomas Chirurg Company
REEVES INSTRUMENT CORPORATION, A SUBSIDIARY OF DYNAMICS CORPORATION OF AMERICA.....	199	Agency: Edward W. Robotham Co.
REMINGTON RAND UNIVAC DIVISION OF SPERRY RAND CORPORATION.....	243	Agency: Mullen and Associates, Inc.
REPUBLIC AVIATION CORPORATION.....	19	Agency: De Garmo Incorporated
RINEHART & COMPANY.....	272	Agency: Franklin Spier, Inc.
ROYAL PRECISION CORPORATION.....	143	Agency: C. J. LaRoche and Company, Inc.
SKF INDUSTRIES, INC.....	112	Agency: G. M. Basford Company
SCIACKY BROS., INC.....	106	Agency: Russell T. Gray, Inc.
SERVO CORPORATION OF AMERICA.....	119	Agency: Smith, Winters Mabuchi, Inc.
SIGMA INSTRUMENTS, INC.....	189	Agency: Culver Advertising, Inc.
SILICONES DIVISION, UNION CARBIDE CORPORATION.....	126	Agency: J. M. Mathes Incorporated
SOLAR AIRCRAFT COMPANY.....	Inside Back Cover	Agency: The Phillips-Ramsey Company
SPACE TECHNOLOGY LABORATORIES, INC.....	253	Agency: Gaynor & Ducas, Inc.
SPERRY ELECTRONIC TUBE DIVISION, SPERRY RAND CORPORATION.....	14	Agency: Reach, McClinton & Co., Incorporated
STOKES, F. J., CORPORATION, VACUUM METALLURGICAL DIVISION.....	103	Agency: The Aitkin-Kynett Co., Inc.
STROMBERG-CARLSON, A DIVISION OF GENERAL DYNAMICS CORPORATION.....	228, 229	Agency: The Rumrill Company Inc.
SUPERIOR TUBE COMPANY.....	38	Agency: Gray & Rogers
SYLVANIA ELECTRIC PRODUCTS, INC., SYLVANIA ELECTRONIC SYSTEMS DIVISION.....	42	Agency: J. Walter Thompson Company
SYLVANIA ELECTRONIC SYSTEMS, A DIVISION OF SYLVANIA ELECTRIC PRODUCTS INC.....	292	Agency: Deutsch & Shea, Inc.
SYSTEM DEVELOPMENT CORPORATION.....	281	Agency: Stromberger, LaVene, McKenzie: Advertising
TECHNIBOOK, INC.....	275	Agency: Dawson MacLeod & Stivers
TECHNICAL OPERATIONS, INCORPORATED.....	289	Agency: Instruments Incorporated
TEXAS INSTRUMENTS INCORPORATED.....	127, 183, 185	Agency: Don L. Baxter, Inc.
THIOKOL CHEMICAL CORPORATION.....	59	Agency: Brown & Butcher, Inc.
THOMPSON, H. I., FIBER GLASS CO.....	191	Agency: Van der Boom, Hunt, McNaughton, Inc.
THOMPSON RAMO WOOLDRIDGE INC.....	248	Agency: The McCarty Co.
THOMPSON RAMO WOOLDRIDGE INC., TAPCO GROUP.....	230, 231	Agency: Meldrum & Fewsmith, Inc.
UNION CARBIDE CORPORATION, HAYNES STELLITE DIVISION.....	43	Agency: J. M. Mathes Incorporated
UNION CARBIDE CORPORATION, LINDE DIVISION.....	63	Agency: J. M. Mathes Incorporated
UNION CARBIDE CORPORATION, OAK RIDGE NATIONAL LABORATORY—ISOTOPES DIVISION.....	252	Agency: J. M. Mathes Incorporated
UNION CARBIDE CORPORATION, SILICONES DIVISION.....	126	Agency: J. M. Mathes Incorporated
UNION CARBIDE METALS COMPANY, DIVISION OF UNION CARBIDE CORPORATION.....	195	Agency: J. M. Mathes Incorporated
UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO.....	250	Agency: Larcom Randall Advertising, Inc.
UNIVERSITY OF CHICAGO PRESS.....	276	Agency: Franklin Spier, Inc.
UNIVERSITY OF CHICAGO, THE, RESEARCH INSTITUTES.....	183	Agency: William Douglas McAdams, Inc.
UPJOHN COMPANY, THE.....	10	Agency: William Douglas McAdams, Inc.
VAN NOSTRAND, D., COMPANY, INC.....	270	Agency: R. W. Westervelt & Company
VARIAN ASSOCIATES.....	66, 197	Agency: Boland Associates
VEECO VACUUM CORP.....	16	Agency: Duncan-Brooks, Inc.
VELSICOL CHEMICAL CORPORATION.....	128	Agency: Sander Allen, Inc.
VITRO CORPORATION OF AMERICA.....	22	Agency: Molesworth Associates
WEIGHING AND CONTROL COMPONENTS, INC.....	185	Agency: Thomas R. Sundheim Incorporated
WESTINGHOUSE ELECTRIC CORPORATION, ATOMIC POWER DEPARTMENT.....	214	Agency: Groody Advertising Co.
WESTINGHOUSE ELECTRIC CORPORATION, DEFENSE PRODUCTS GROUP.....	162, 163	Agency: Ketchum, MacLeod & Grove, Inc.
WESTINGHOUSE ELECTRIC CORPORATION, SEMICONDUCTOR DEPARTMENT.....	223	Agency: McCann-Erickson, Incorporated
WILD HEERBRUGG INSTRUMENTS, INC.....	155	Agency: Duncan-Brooks, Inc.
WILEY, JOHN, & SONS, INC.....	271	Agency: Needham & Grohmann, Inc.
WOLLENSAK OPTICAL COMPANY.....	134	Agency: Wolf Associates, Inc.



Hugo Schuck, Director of Research
Honeywell Aeronautical Division

“Research Engineers, here are opportunities to join a group probing advanced concepts in space controls”

“A unique feature of man’s explorations in space is his utter dependence on automatic controls. Flight controls, environment controls, instrumentation and data processing, inertial guidance and navigation . . . these are the work areas of Honeywell Aero, a division of the world’s largest producer of automatic controls.

“Our group at Honeywell conducts research in these advanced control fields. Now we must expand 100% in the next three years to maintain our leadership—currently evidenced by our demonstration of electrically suspended gyro concepts and by the flight-tested “Adaptive” autopilot. Opportunities exist in seven areas: computer systems, infrared, inertial sensors, human factors, systems analysis, instrumentation, and automatic controls.

“If you are a qualified research engineer interested in a rewarding career in these areas, I’d like to hear from you. Drop me a line—including information on your background, interests, and accomplishments.”

Write: Hugo Schuck, Dept. 854A

MINNEAPOLIS
Honeywell
AERONAUTICAL DIVISION



2600 Ridgway, Minneapolis 13, Minnesota

Fine opportunities also exist in other Honeywell development and manufacturing facilities in the Boston area, the Philadelphia area, the Los Angeles area, Minneapolis, Seattle, St. Petersburg, Chicago and Freeport, Illinois, Denver, and the Washington D.C. area. Send resumé to H. D. Eckstrom, Director of Employment, Dept. 854A, Minneapolis Honeywell, Minneapolis 8, Minnesota.

BIBLIOGRAPHY

Readers interested in further reading on the subjects covered by articles in this issue may find the lists below helpful.

WHAT IS IONIZING RADIATION?

PRINCIPLES OF RADIOLOGICAL PHYSICS. Ugo Fano in *Radiation Biology*, Vol. I, Part 1, pages 1-44. McGraw-Hill Book Company, Inc., 1954.

THE CIRCULATION OF RADIOACTIVE ISOTOPES

RADIOACTIVITY IN GEOLOGY AND COSMOLOGY. T. P. Kohman and N. Saito in *Annual Review of Nuclear Science*, Vol. 4, pages 401-446; 1954.

THE RADIOACTIVITY OF THE ATMOSPHERE AND HYDROSPHERE. Hans E. Suess in *Annual Reviews of Nuclear Science*, Vol. 8, pages 243-256; 1958.

IONIZING RADIATION AND THE LIVING CELL

ACTIONS OF RADIATIONS ON LIVING CELLS. Douglas Edward Lea. Cambridge University Press, 1955.

ATOMIC RADIATIONS AND LIFE. Peter Alexander. Pelican Books, 1957.

IONIZING RADIATION AND THE CELL. Edited by Roy Waldo Miner. *Annals of the New York Academy of Sciences*, Vol. 59, Art. 4, pages 467-664; February 3, 1955.

RADIATION BIOLOGY. Edited by Alexander Hollaender, with the cooperation of Austin M. Brues, Berwind P. Kaufmann, Hermann J. Muller and Lauriston S. Taylor. McGraw-Hill Book Company, Inc., 1954.

IONIZING RADIATION AND THE WHOLE ANIMAL

EVIDENCE FOR A HUMORAL FACTOR (OR FACTORS) CONCERNED IN RECOVERY FROM RADIATION INJURY: A REVIEW. Leon O. Jacobson in *Cancer Research*, Vol. 12, pages 315-325; 1952.

THE RELATIONSHIP OF X-RAY DOSE TO THE TIME OF DEVELOPMENT OF RADIATION SICKNESS FOLLOWING EXPOSURE TO A SINGLE DOSE OF X-RAYS. W. M. Court Brown and John D. Abbatt in *British Journal of Radiology*, Vol. 28, pages 153-158; 1955.

REPORT OF THE UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION. General Assem-



Silence deep as death

● “There was silence deep as death, and the boldest held his breath, for a time.” Thomas Campbell was describing the Battle of the Baltic, in 1801. But many a submariner will recognize the moment in modern underwater combat, when complete silence is the only way to survival.

Modern submarines make the problem of silence tougher, for in these modern boats, some machinery must always be running. This is why *tech/ops* is probing, for the Navy's Bureau of Ships, the transmission of noise through water pipe lines through structure and into the sea . . . to be picked up by enemy ears. And *tech/ops* has found *new* ways of testing for such noise . . . methods that light the way toward “silence deep as death” for our Navy's pigboats.

Another typical break-through in *tech/ops'* broad scientific research and development for business, industry and government.

personnel requirements

at Washington, D. C.: Unusual opportunities for qualified scientists interested in more sophisticated disciplines related to mathematics, digital computer programming, operations analysis, statistical mathematics.
at Burlington, Massachusetts: Scientists and engineers with experience in simulation techniques, programming research, operations research, systems analysis, mathematical statistics, for long-term program to provide integrated weather observing, forecasting, data handling and transmission system.

at Fort Monroe, Virginia, Research Office: Experienced computer programmer; statistician interested in development and use of operational simulations; senior scientist experienced in Army weapons and support assistance.

at Monterey, California, and Honolulu, Hawaii, Research Offices: Senior mathematician-programmer for program integration including large file maintenance and informal retrieval problems; operations analyst to develop operational simulations and subsequent programming; junior programmer with large computer experience.

address: Robert L. Koller

Technical Operations, Incorporated

Central Research Laboratories, South Avenue / Burlington, Massachusetts

• WASHINGTON, D. C. • MONTEREY, CALIFORNIA • FORT MONROE, VIRGINIA





LINCOLN LABORATORY

invites inquiries from persons
with superior qualifications.

SOLID STATE Physics, Chemistry, and Metallurgy

RADIO PHYSICS and **ASTRONOMY**

NEW RADAR TECHNIQUES

COMMUNICATIONS:

Techniques

Psychology

Theory

INFORMATION PROCESSING

SYSTEMS:

Space Surveillance

ICBM Detection and Tracking

Strategic Communications

Integrated Data Networks

SYSTEM ANALYSIS

Research and Development

**M. I. T. LINCOLN
LABORATORY**

BOX 18

LEXINGTON 73, MASSACHUSETTS



bly Official Records: Thirteenth Ses-
sion. Supplement No. 17, 1958.

IONIZING RADIATION AND EVOLUTION

THE CAUSES OF EVOLUTION. J. B. S.
Haldane. Harper & Brothers, 1932.

THE DARWINIAN AND MODERN CONCEPTIONS OF NATURAL SELECTION. H. J. Muller in *Proceedings of the American Philosophical Society*, Vol. 93, No. 6, pages 459-479; December 29, 1949.

EVOLUTION, GENETICS AND MAN. Theodosius Dobzhansky. John Wiley & Sons, Inc., 1955.

GENETICS, PALEONTOLOGY AND EVOLUTION. Edited by Glenn L. Jepsen, Ernst Mayr and George Gaylord Simpson. Princeton University Press, 1949.

RADIATION AND THE ORIGIN OF THE GENE. Carl Sagan in *Evolution*, Vol. 11, No. 1, pages 40-55; March, 1957.

IONIZING RADIATION AND MEDICINE

DR. W. C. RÖNTGEN. Otto Glasser. Charles C. Thomas, 1945.

A MANUAL OF ARTIFICIAL RADIOISOTOPE THERAPY. Edited by Paul F. Hahn. Academic Press, 1951.

A PRACTICAL MANUAL ON THE MEDICAL AND DENTAL USE OF X-RAYS WITH CONTROL OF RADIATION HAZARDS. American College of Radiology, 1958.

RADIATION DOSIMETRY. Edited by Gerald J. Hine and Gordon L. Brownell. Academic Press, 1956.

RADIATION HAZARDS AND WHAT IS BEING DONE ABOUT THEM: A SYMPOSIUM. *The American Journal of Roentgenology, Radium Therapy and Nuclear Medicine*, Vol. 78, No. 6, pages 944-1,002; December, 1957.

RADIATION HYGIENE HANDBOOK. Edited by Hanson Blatz. McGraw-Hill Book Company, Inc., 1959.

IONIZING RADIATION AND ORGANIC CHEMISTRY

THE EFFECTS OF IONIZING RADIATION ON NATURAL AND SYNTHETIC HIGH POLYMERS. Frank Alden Bovey. Interscience Publishers, Inc., 1958.

THE EFFECTS OF RADIATION ON MATERIALS. Edited by J. J. Harwood, Henry H. Hausner, J. G. Morse and W. G. Rauch. Reinhold Publishing Corporation, 1958.

THE PHYSICS OF RUBBER ELASTICITY. L. R. G. Treloar. Oxford University Press, 1949.

PRINCIPLES OF POLYMER CHEMISTRY.

MESONS—ANTINUCLEONS—HYPERONS

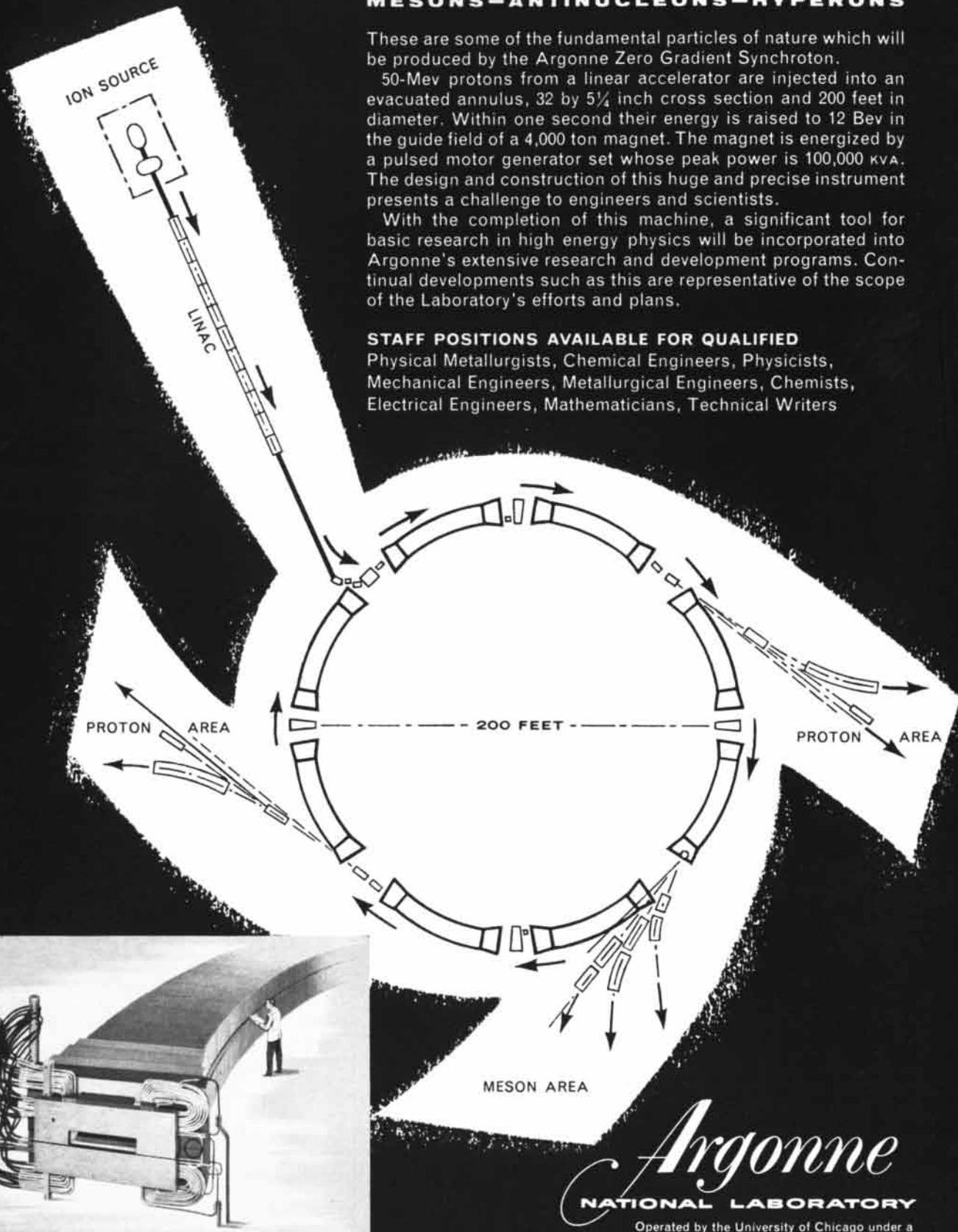
These are some of the fundamental particles of nature which will be produced by the Argonne Zero Gradient Synchrotron.

50-Mev protons from a linear accelerator are injected into an evacuated annulus, 32 by 5¼ inch cross section and 200 feet in diameter. Within one second their energy is raised to 12 Bev in the guide field of a 4,000 ton magnet. The magnet is energized by a pulsed motor generator set whose peak power is 100,000 kva. The design and construction of this huge and precise instrument presents a challenge to engineers and scientists.

With the completion of this machine, a significant tool for basic research in high energy physics will be incorporated into Argonne's extensive research and development programs. Continual developments such as this are representative of the scope of the Laboratory's efforts and plans.

STAFF POSITIONS AVAILABLE FOR QUALIFIED

Physical Metallurgists, Chemical Engineers, Physicists, Mechanical Engineers, Metallurgical Engineers, Chemists, Electrical Engineers, Mathematicians, Technical Writers



A magnet octant will weigh 500 tons and will produce a magnetic field of 21.5 kg.

Argonne
NATIONAL LABORATORY

Operated by the University of Chicago under a contract with the United States Atomic Energy Commission

Direct Inquiries To:
DR. LOUIS A. TURNER, DEPUTY DIRECTOR
P.O. BOX 299-R5 • LEMONT, ILLINOIS



LAST OF A SERIES

Data Systems and Techniques to Expand Man's Scientific Knowledge

...THE CONTINUING OBJECTIVE OF IMAGINATIVE MINDS
AT SYLVANIA'S DATA SYSTEMS OPERATIONS

Data processing, frequently regarded as a recent development, is as old as mankind. When we witness a person counting on his fingers, we are watching the world's oldest — and simplest — digital computer in operation. With man's constant search for faster, more efficient ways of processing and reducing data came the development of devices such as the abacus, straightedge-and-compass, slide rule, astrolabe, nomogram, planimeter and integrator. Each of these inventions brought measurable advances in engineering and the physical sciences.



Today, the world has entered the scientific age in which the bold dreams of yesterday are becoming realities. At Sylvania's Data Systems Operations far-ranging programs in data systems are directed toward expanding man's scientific knowledge and developing new technologies. Typical of these projects are MOBIDIC, the first mobile, transistorized, large-scale computer and the data processing phase of BMEWS, the USAF's Ballistic Missile Early Warning System.

■ **MECHANICAL ENGINEER** Senior positions in product engineering & design of data processing systems. Areas: (1) packaging design of digital & analog circuits with emphasis on modularity & standardization; (2) structural design of cabinets, racks, chassis & other modular packaging; (3) environmental control, testing & analysis; (4) design of operator's consoles & displays; (5) design of electronic test equipment; (6) systems integration.

■ **SENIOR SYSTEMS ENGINEERS** To work on digital data systems. Past experience (5-10 years) as Systems Designers or Project Leaders. Also openings for JR. SYSTEMS ENGINEERS with 1-5 years experience.

■ **SENIOR ENGINEER** BS/EE; at least 2 years recent experience in transistor circuit design; 5 years total experience in diversified circuit work, particularly digital computer circuits. Design & supervise development of transistor circuits to operate over wide temperature range. Select & specify components, packaging layout & interconnecting cables for pulse & switching circuits, high gain linear amplifiers & selection matrices.

Please send resume to J. B. Dewing

Data Systems Operations / SYLVANIA ELECTRONIC SYSTEMS

A Division of

SYLVANIA

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS



189 B Street — Needham 94, Massachusetts

Paul J. Flory. Cornell University Press, 1953.

IONIZING RADIATION AND METALS

CHEMISTRY OF THE SOLID STATE. Edited by William Edward Garner. Butterworths Scientific Publications, 1955.

DISPLACEMENT OF ATOMS DURING IRRADIATION. Frederick Seitz and J. S. Koehler in *Solid State Physics*, edited by Frederick Seitz and David Turnbull. Academic Press Inc., 1956.

RADIATION EFFECTS IN SOLIDS. G. J. Dienes and G. H. Vineyard. Interscience Publishers, Inc., 1957.

VACANCIES AND OTHER POINT DEFECTS IN METALS AND ALLOYS. The Institute of Metals, 1958.

IONIZING RADIATION AND THE CITIZEN

THE ABC OF NUCLEAR WEAPONS. H. W. B. Skinner in *The New Scientist*, Vol. 5, No. 119, pages 473-475; February 26, 1959.

THE BIOLOGICAL EFFECTS OF ATOMIC RADIATION. National Academy of Sciences, 1956.

GENETIC AND SOMATIC EFFECTS OF CARBON-14. Linus Pauling in *Science*, Vol. 128, pages 1,183-1,186; November 14, 1958.

GENETICS IN THE ATOMIC AGE. Charlotte Auerbach. Oliver and Boyd, 1956.

RECOMMENDATIONS OF THE INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. *British Journal of Radiology*, Supplement No. 6; 1955.

WORLD-WIDE CAPABILITIES FOR PRODUCTION AND CONTROL OF NUCLEAR WEAPONS. Howard Simons in *Daedalus*, Vol. 88, No. 3, pages 385-409; Summer, 1959.

MATHEMATICAL GAMES

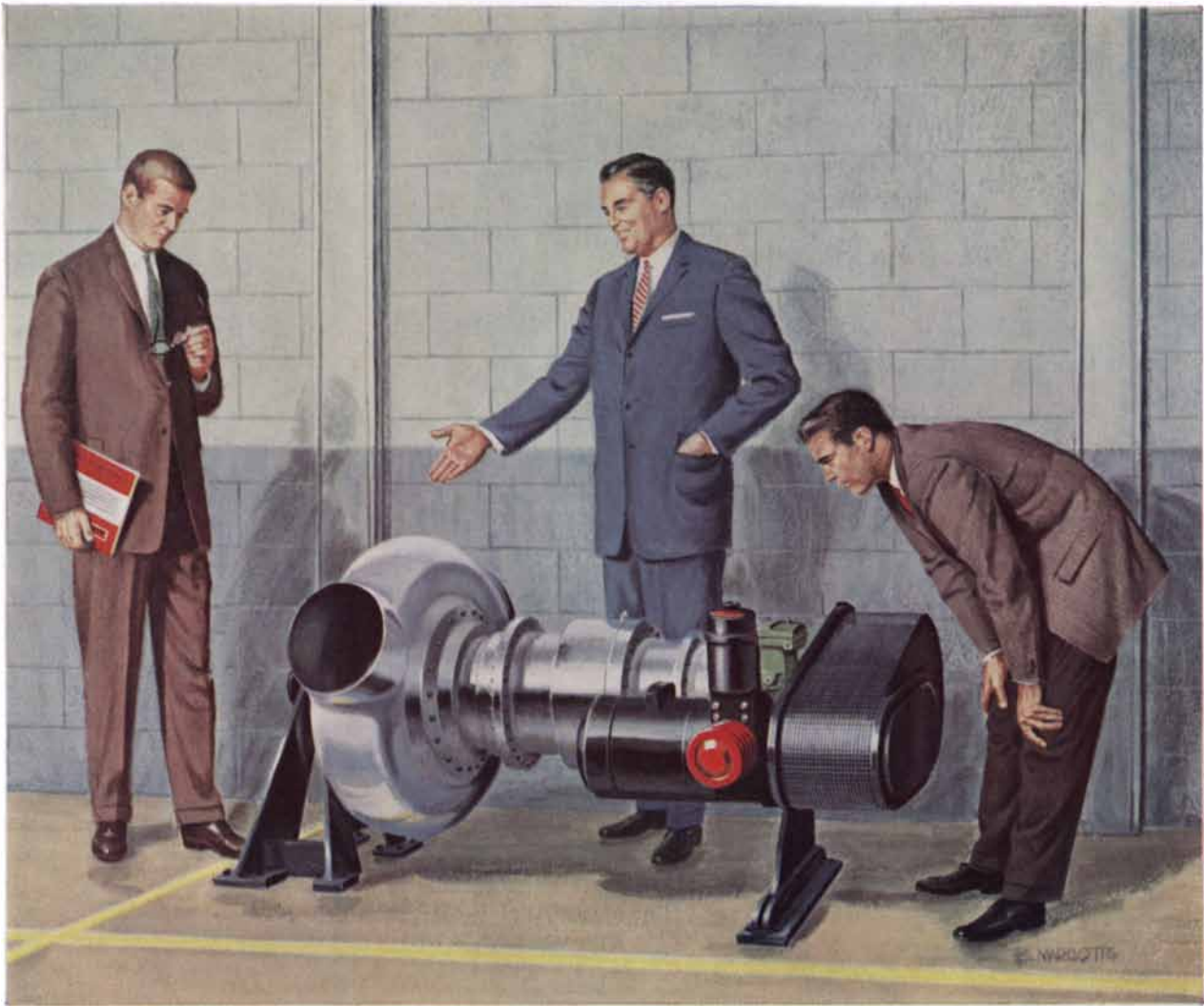
100 PUZZLES: HOW TO MAKE AND HOW TO SOLVE THEM. Anthony S. Filipiak. A. S. Barnes and Company, 1942.

PUZZLES OLD AND NEW. Professor Hoffmann (pseudonym of Angelo Lewis). Frederick Warne and Company, 1893.

A THEOREM ON THE TANGRAM. Fu Traing Wang and Chuan-Chih Hsiung in *The American Mathematical Monthly*, Vol. 49, No. 9, pages 596-599; November, 1942.

THE AMATEUR SCIENTIST

THE NEW PSYCHIATRIC DRUGS. Harold E. Himwich in *Scientific American*; October, 1955.



1100 HP!

*New Solar gas turbine offers small size,
light weight, greater fuel efficiency*

SOLAR'S REMARKABLE NEW 1100 hp *Saturn* gas turbine represents an important forward step in gas turbine fuel efficiency—requiring only .63 pounds of fuel per hp hour. The engine is extremely lightweight, averaging less than 1/10th the weight of conventional engines of similar hp; it occupies only about 51 cubic feet; it starts instantly and takes full load without laboring in

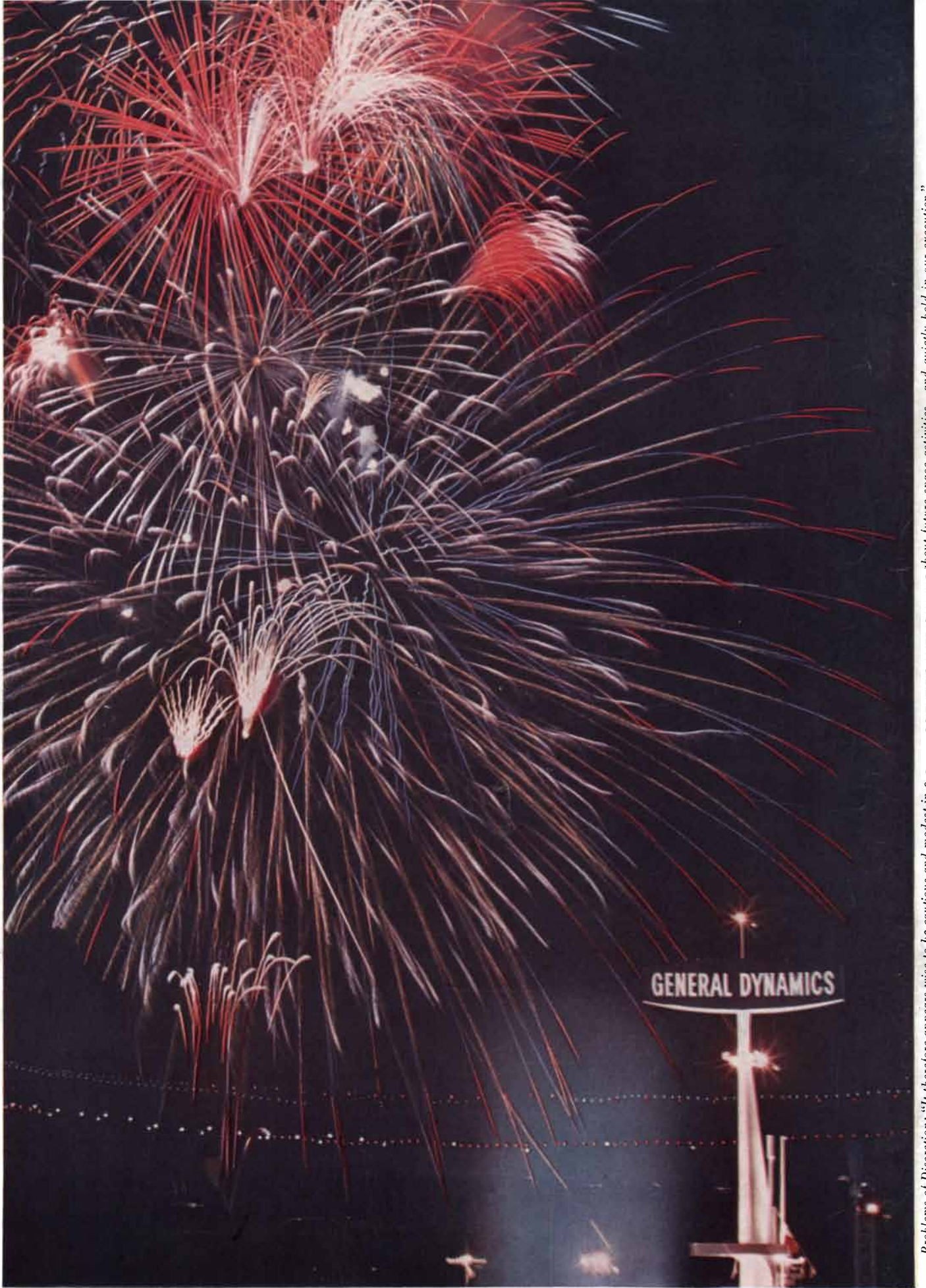
temperatures from -65°F to 130°F , even after long periods of standby service. And the new Solar *Saturn* engine will operate on a wide variety of fuels.

Today, proven-in-service Solar gas turbines—ranging from 50 to 1100 hp—are creating new standards of performance and reliability. As propulsion units for boats, as a dependable power source for electric generators, as high-

efficiency pumps and in other applications...Solar gas turbines are saving time and money for hundreds of satisfied users. For a new gas turbine brochure, write to Dept. G-135, Solar Aircraft Company, San Diego 12, Calif.

ENGINEERS WANTED! *Challenging projects, unlimited opportunities with Solar. Write today!*





Problems of Discretion: "It therefore appears wise to be cautious and modest in o. © 1959 SCIENTIFIC AMERICAN, INC about future space activities — and quietly bold in our execution."