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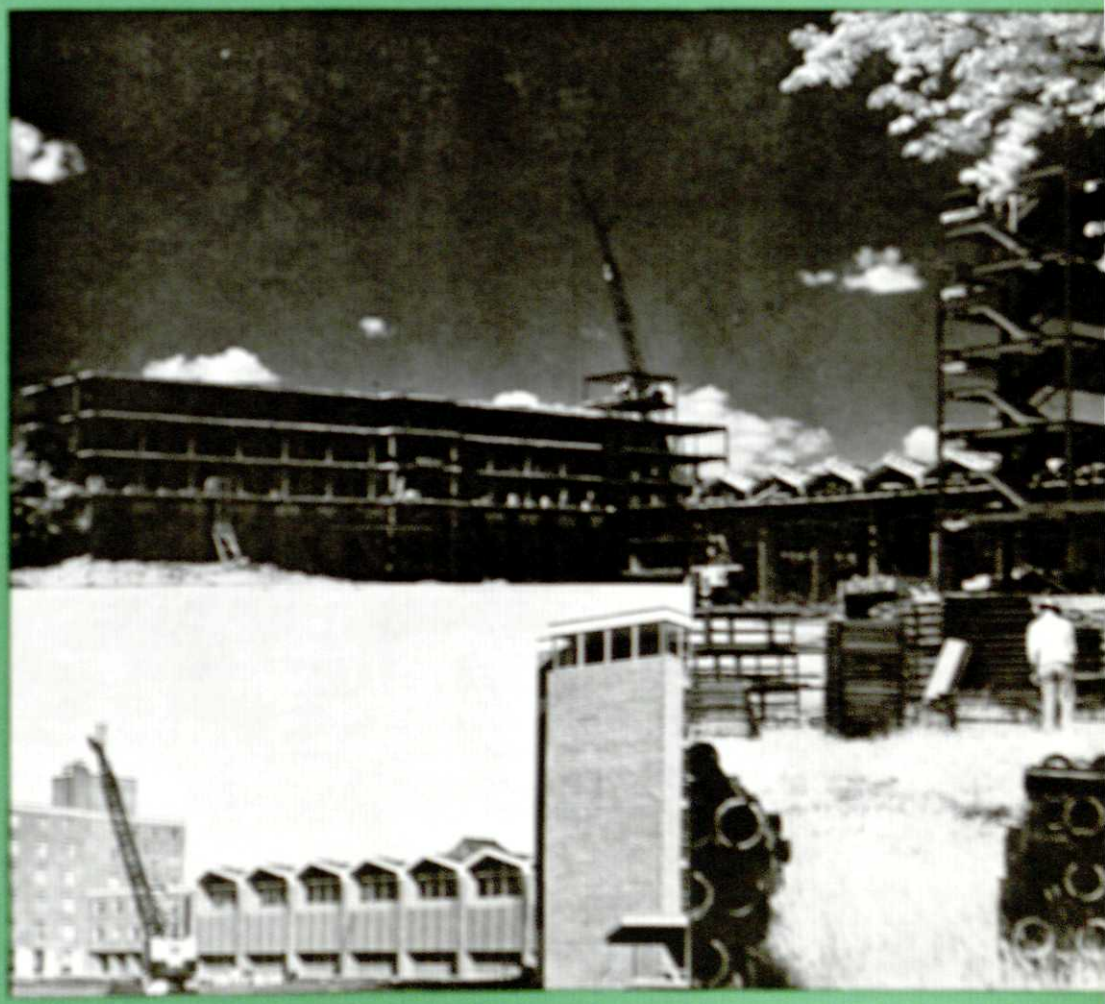
ENGINEER

november 1962



Super magnets may help harness the power of the H-bomb

If the energy that makes an H-bomb could be released in a controlled flow, man would have an almost limitless source of electric power. But the "if" is a big one. It means, among other things, building a container to hold 100-million degree temperatures . . . hot enough to vaporize any known material. Theoretically, this container problem could be solved by holding the hydrogen reaction inside a powerful magnetic field, a sort of "magnetic bottle." But such a magnetic bottle would require a series of huge costly magnets consuming a powerhouse full of electricity. However, Westinghouse is already marketing a fist-sized super conducting magnet that runs on virtually no power, yet produces a field twice as intense as a conventional magnet weighing 20 tons. Scientists believe that future developments of these super magnets may provide the answer to the problem of harnessing the energy of a hydrogen reaction. Perhaps you would be interested in helping to develop this and many other challenging projects at Westinghouse, an equal opportunity employer. For more information, see our representative when he visits your campus, or write to L. H. Noggle, Westinghouse Educational Center, Pittsburgh 21, Pennsylvania.

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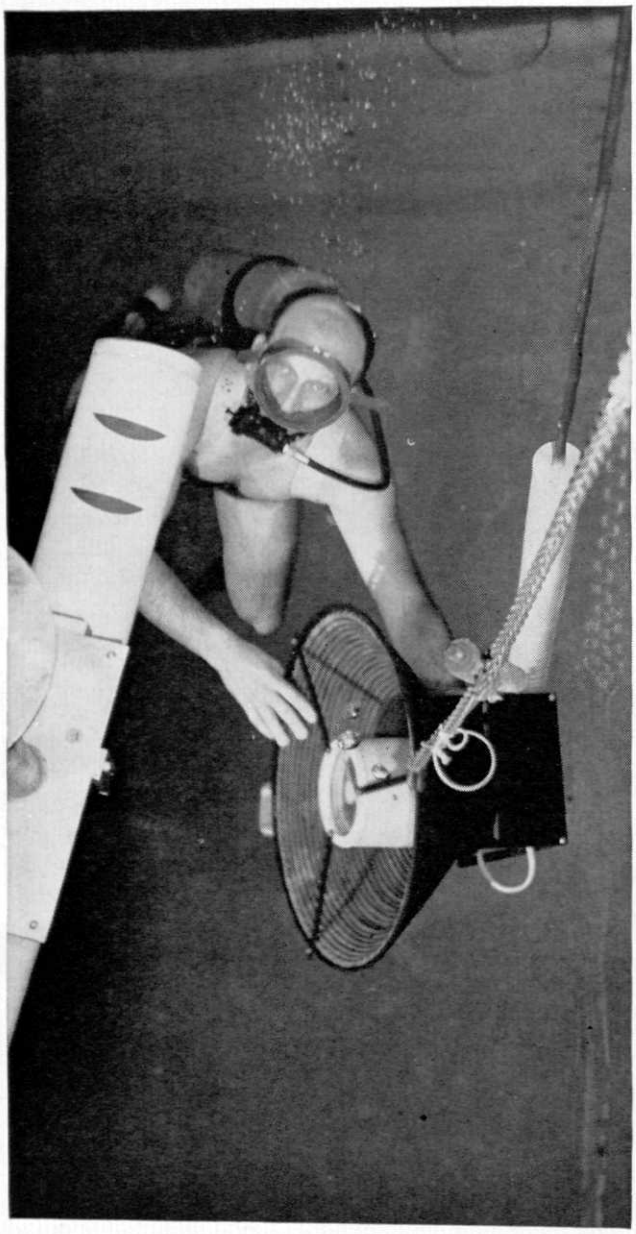

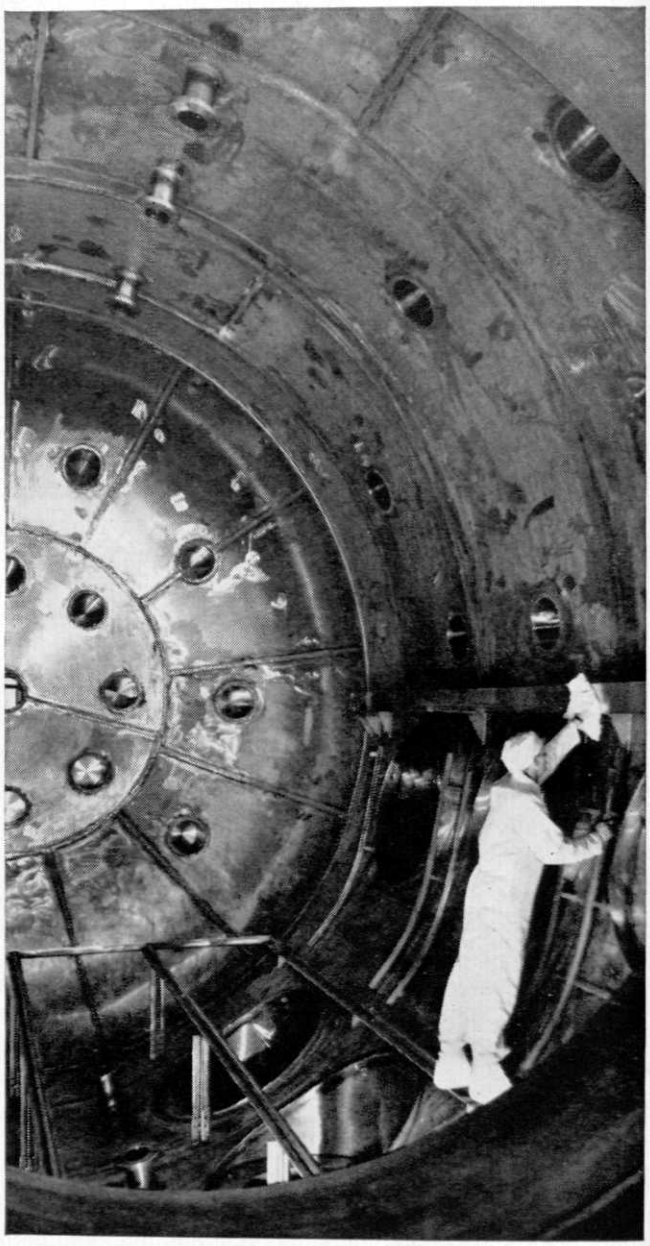

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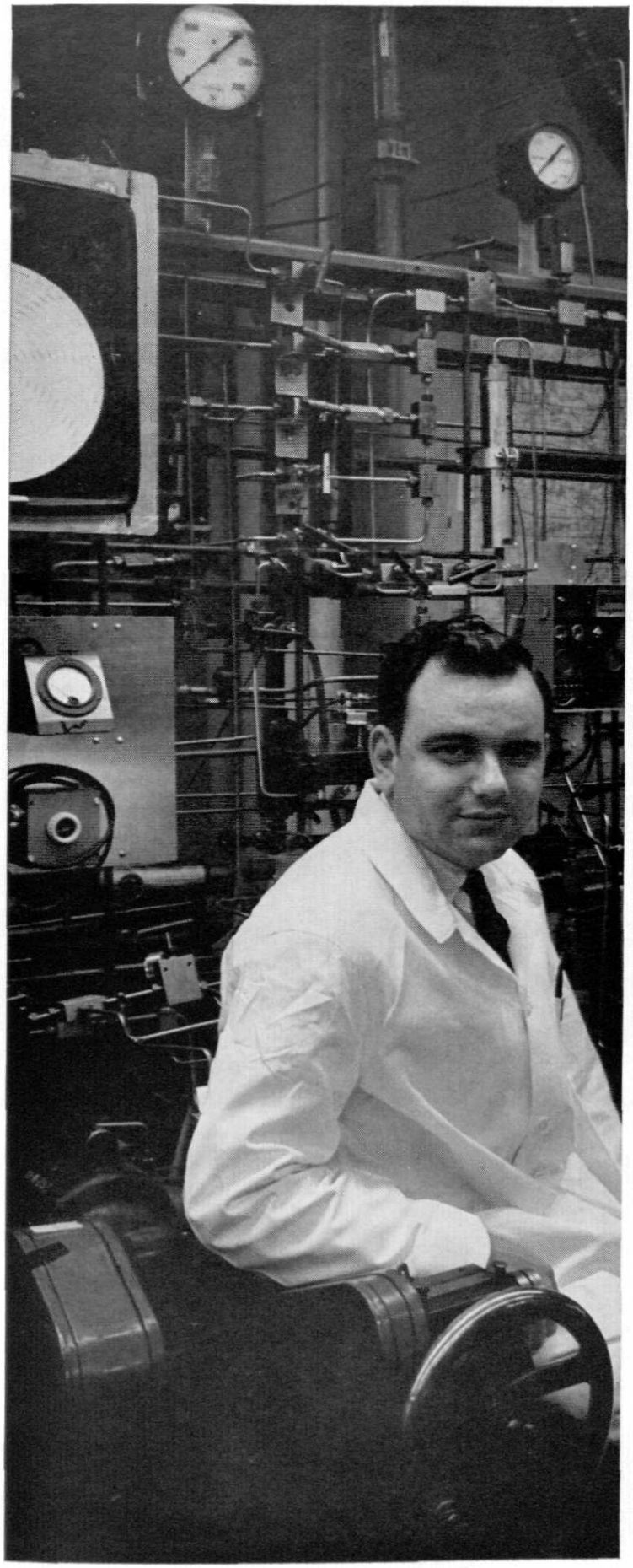

Variety: the spice of life at American Oil

by Jim Koller

"When I was first interviewed by American Oil representatives I was told I'd be given a free hand in guiding a wide variety of projects. This promise has certainly been kept!"

Jim Koller, 25 years old, came to American Oil right out of the University of Wisconsin where he earned his Bachelor of Science degree in Chemical Engineering. An Evans Scholar at Wisconsin, Jim describes his job at American Oil this way: "I work on basic chemical engineering problems, specializing in reactor design and process development problems. Before a process can go commercial, it must be tested in pilot plants. That's where I come in." Jim wants to stay in the technical research area, and plans to enroll in the Illinois Institute of Technology night school for courses in advanced mathematics.

The fact that many gifted and earnest young men like Jim Koller are finding challenging careers at American Oil could have special meaning for you. American Oil offers a wide range of new research opportunities for: Chemists—analytical, electrochemical, inorganic, physical, polymer, organic, and agricultural; Engineers—chemical, mechanical, metallurgical, and plastics; Masters in Business Administration with an engineering (preferably chemical) or science background; Mathematicians; Physicists.

For complete information about interesting careers in the Research and Development Department, write: D. G. Schroeter, American Oil Company, P.O. Box 431, Whiting, Indiana.

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STANDARD

STANDARD OIL DIVISION
AMERICAN OIL COMPANY

Spartan Engineer

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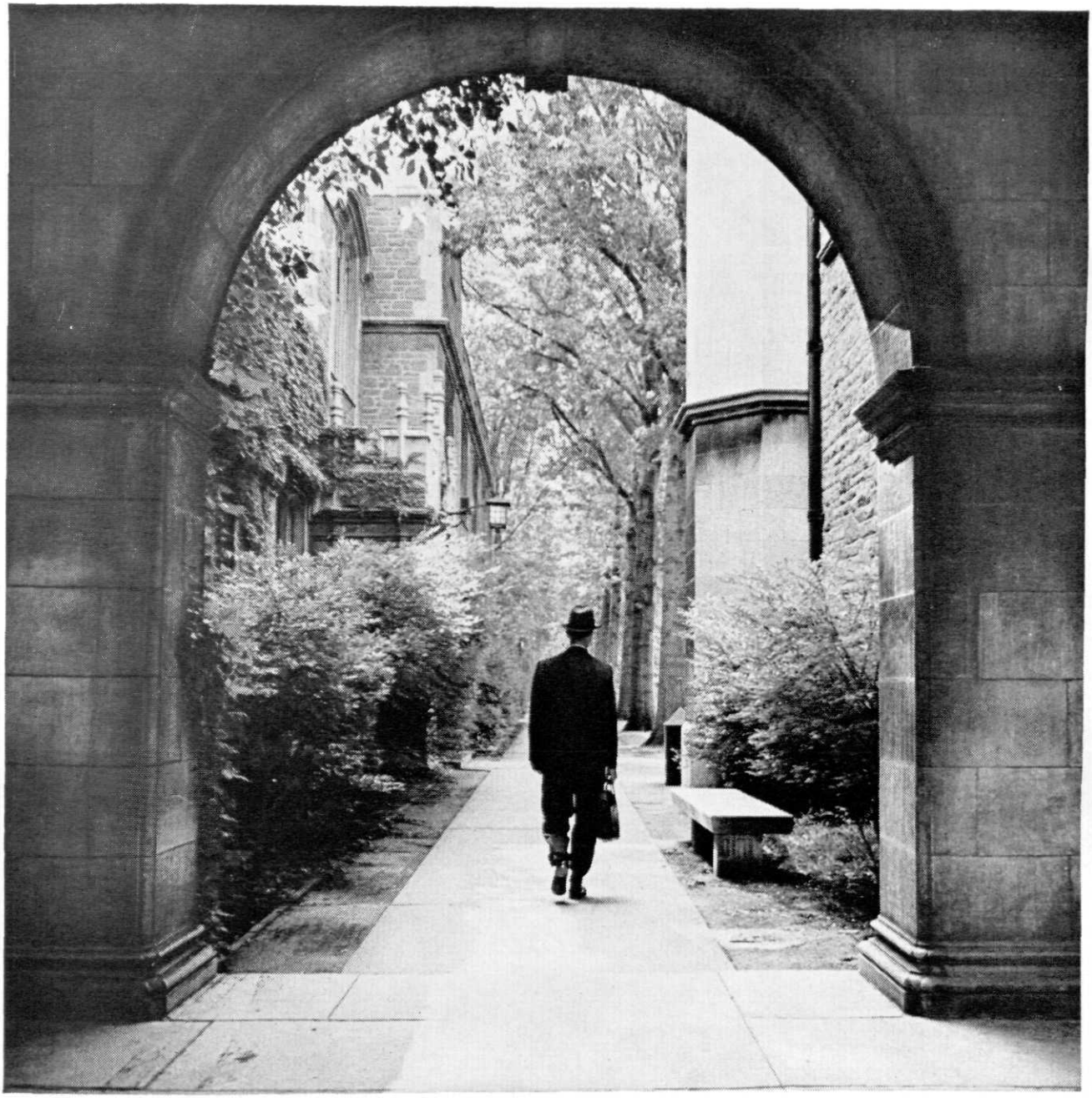

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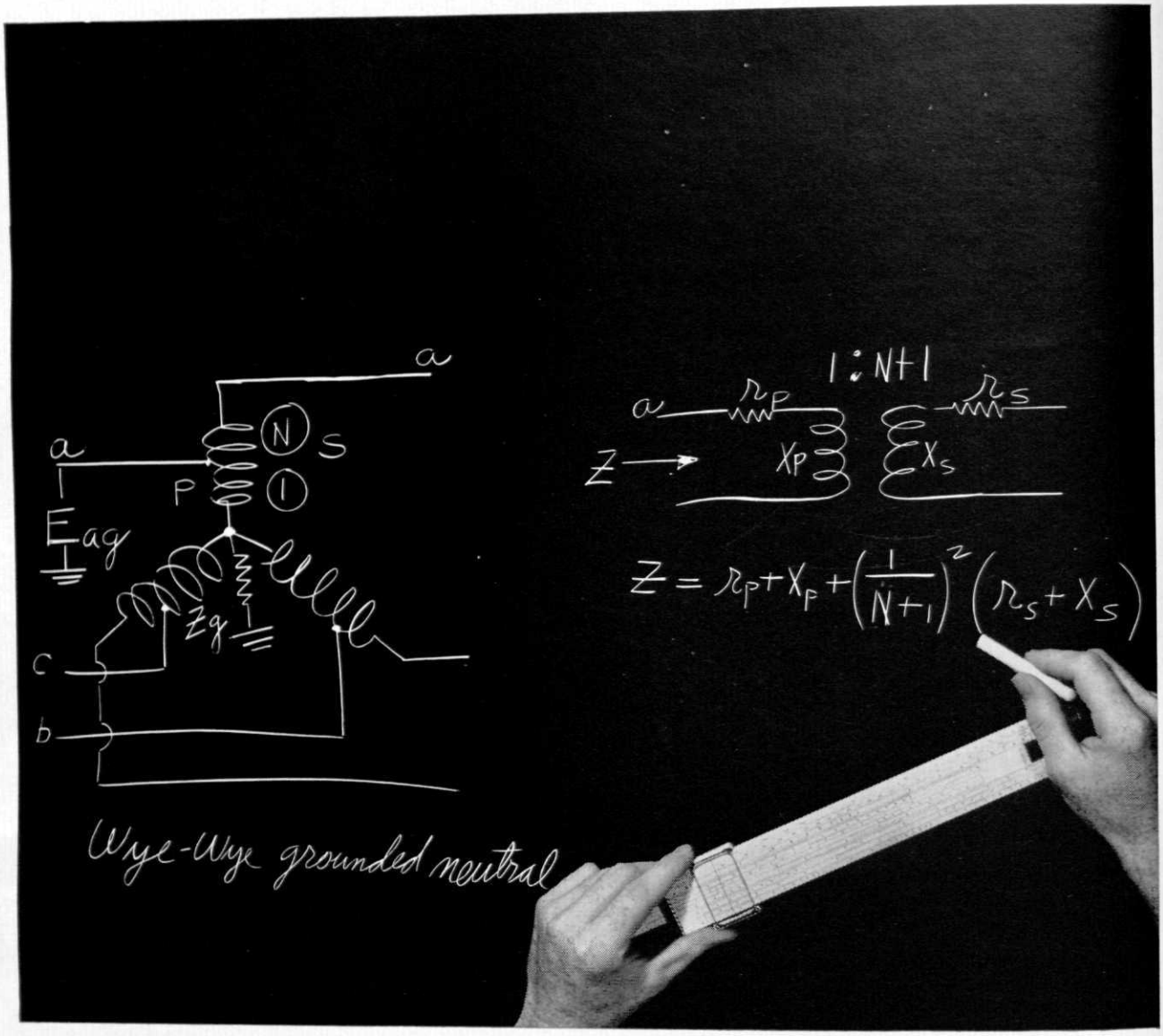

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An engineer knows no greater satisfaction than putting his training, his ideas and energy to work. At Detroit Edison, engineering talent finds rewarding opportunities for expression and professional advancement in this great and growing industrial center of Southeastern Michigan.

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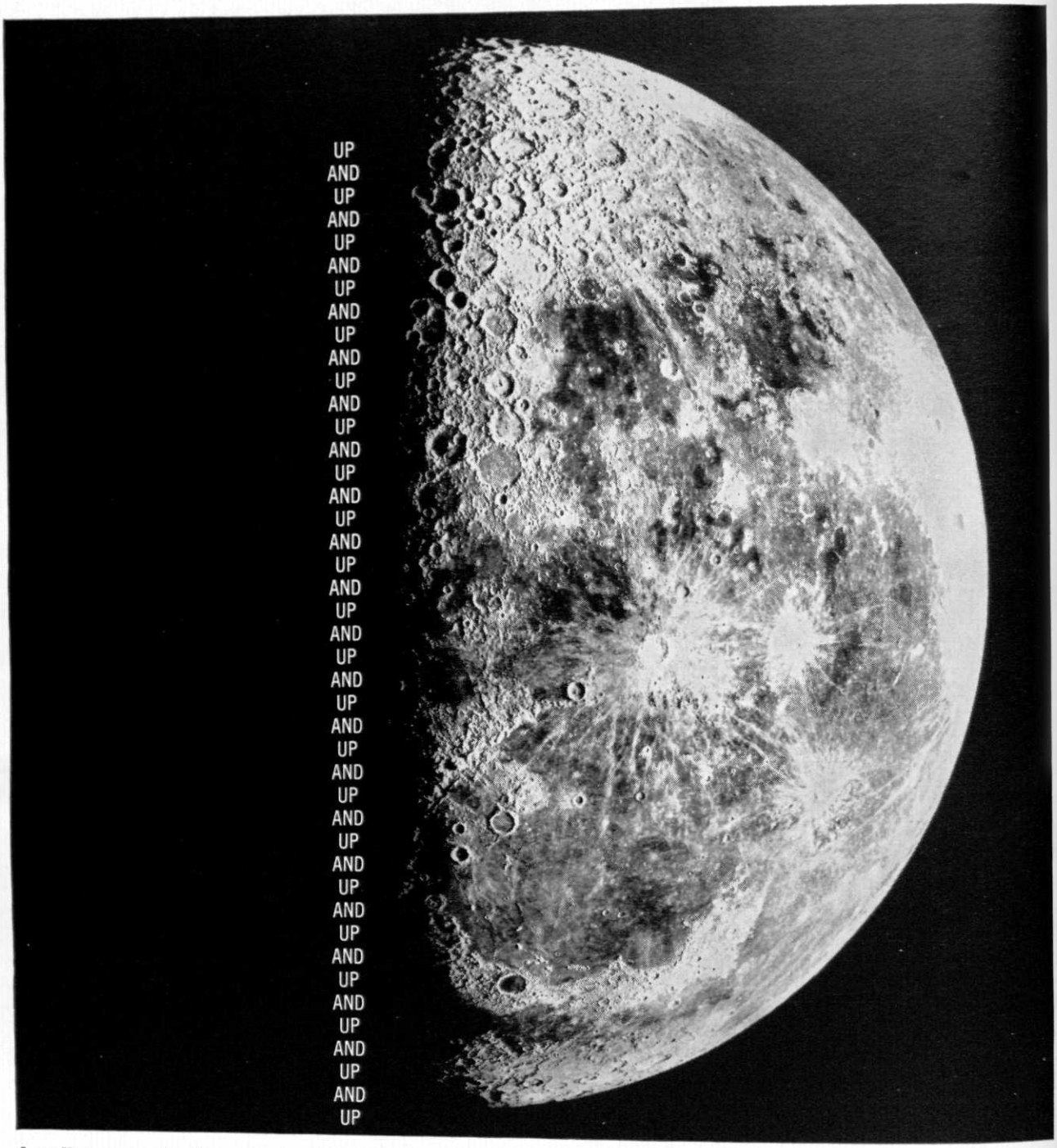
...suddenly, new hope in life

A man lies on the operating table, crippled with the exhausting tremors of Parkinson's disease. The surgeon guides a slender tube deep inside the patient's brain until it reaches the target area. Then liquid nitrogen, at 320 degrees below zero F., is fed to the end of the tube. Suddenly the trembling stops. The unearthly cold kills the diseased cells . . . and a once desperate human being has been given a new chance in life. ▶ Medical reports have indicated that not only Parkinson's disease but also other disorders causing tremor or rigidity have responded to this new technique in brain surgery. The operation has been described as easier on the patients than previous surgery, and they have been able to leave the hospital in a surprisingly short time. Also, encouraging results are reported on the use of cryosurgery, as it is called, to destroy diseased cells in other parts of the body. ▶ Through its division, Linde Company, Union Carbide was called upon by medical scientists for help in designing and making equipment to deliver and control the critical cold required in this new surgery. This dramatic use of cryogenics, the science of cold, is an example of how research by the people of Union Carbide helps lead to a better tomorrow.

A HAND IN THINGS TO COME

UNION CARBIDE

For information describing the work in cryosurgery done at the Neurosurgical Department of St. Barnabas Hospital, New York, write to: Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.



Leading organization seeks brilliant executives-in-the-making

The organization: perhaps the most important in the world today...186,000,000 shareholders in this country alone...an area of distribution extending millions of miles upward and outward.

The immediate business at hand: protecting and sustaining the peace—our very survival. There are some who would describe this organization as non-profit. And there are others, who would more thoughtfully deem its investments, dividends, and assets nothing less than priceless.

Today, thousands of selected young college graduates are joining that organization in responsible executive positions. They join to serve as officers in the United States Air Force.

The resources at hand for the career development of these applicants are matchless. They are participating in the world's most advanced research and development programs. Engineering, science, administration—each career field calls for the services of forward-looking graduates who will assume vital responsibilities. The start of an outstanding career awaits you in this organization where success is more than a corporate objective—because if it doesn't happen here, it won't happen anywhere.

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Dean's Letter

This seems a year of culmination for much of our planning, a new building and programs, both designed to orient our engineering graduate toward the needs of tomorrow's world. Our facilities visibly reflect that the engineering successes in jet and rocket propulsion, new energy conversion methods, new alloys and semiconductors from the solid-state field, and the complexity of today's engineering systems absolutely require a change in the preparation of the engineer.

There are also changes in engineering methods, less visible, but perhaps more profound in making tomorrow's engineer more an innovator, an analyzer, a planner, and less of a doer than has been true in the past. Among these changes in thought and method are:

1. Acceptance of research as a normal engineering duty.
2. Employment of the mathematical method as the usual approach to problem solution.
3. Appreciation of the computer as a necessary engineering tool.
4. Study of the *system* in contrast to concentration on the components.

These changes are in the nature of concepts or philosophies—more difficult to appreciate because of their abstract nature. With most of the new devices one can at least "see" something; a concept must be passed from mind to mind.

By keying our programs to these new concepts and to the problems of tomorrow's world we hope to provide you with the fundamental knowledge in an atmosphere of intellectual inquiry and technical curiosity, and of dissatisfaction with things as they are—to make you capable of attacking tomorrow's challenging problems, and of reaping the large rewards for their solution.

J. D. RYDER, *Dean*

Coed Dorm Constructed by Lift Slab

Case floors are poured and ready for lifting. (photo by Tom Crockett)

by Sharyn Smith

THE CASE FOR LIFT SLAB

Case Hall, Michigan State's first coed dorm was built by the new lift slab construction method employed by the Great Lakes Lift Slab Company of Chicago.

Designed by Louis J. Sarvis of Battle Creek, the $5 million structure houses 1,040 students and has facilities for eight classrooms and 16 offices. Christman Company of Lansing was the contractor.

Lift slab was used to build Case because the growing enrollment at MSU called for an inexpensive method of filling the space gap fast. Lift slab appeared to be the answer because it not only was less expensive than regular construction, in some instances by more than 30 per cent of structural costs, but due to the unique building process, work could continue throughout the winter months.

The following is simply a generalized view of lift slab construction, only applying to Case Hall when specifically stated.

BASIC LIFT SLAB COMPONENTS

The name "lift slab" describes the floor construction of buildings created in this manner. The floors are all slabs of concrete that are lifted as structure by hydraulic jacks from the ground floor level.

Each slab used in the building is pre-cast of 2,000 psi concrete mixed at the site. Ordinary concrete is mixed with pea-sized aggregate (with a maximum diameter of ¼ in.) for a lightweight mix to facilitate lifting.

Circular cans or cardboard tubing with reinforcing rods are cast into the slab to create openings for pipes, more strength to bending moment and cleared chambers for air-conditioning ducts and utilities. Incidentally the resulting hollowness provides sound-proofing between floors in the finished building.

The poured slabs must set from two to four days before lifting.

Since the underside of each slab forms the ceiling of the floor below, it is imperative that no form marks show. Therefore each slab is cast on the machine-troweled top of the lower slab.

With the resulting smooth ceiling, ceilings do not need to be plastered, merely painted.

COLUMNS

Columns used in lift slab construction are either of pre-cast 5,000 psi concrete or of steel. The addition of calcium chloride to the concrete strengthens its development so that columns can be picked up in three days.

Columns higher than 30 feet need steel reinforcement. During most of the lifting process, the weight of two or more slabs is carried by these columns unsupported except at the ends. The greatest intensity of stress occurs when the roof slab is in position and the next group of slabs is being lifted clear of the stacks on the ground.

The columns are usually braced against lateral loads by a reinforced concrete shear-wall with diagonal bracing on all sides.

At the top of the column is a steel cap plate used to support the hydraulic jacks used for lifting.

Concrete columns are preferred over steel by some builders because of the extra rigidity they provide and because they need not be fire-proofed.

COLUMN COLLARS

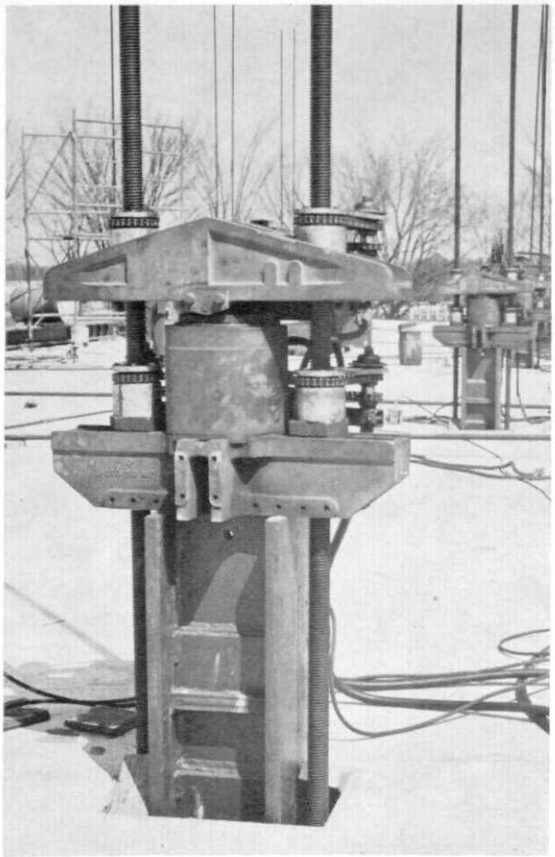
Lifting collars are usually of structural steel or cast steel. Two steel collar bands are incorporated in each column and welded to the slab collars.

These collars are angles forming hollow boxes which slide vertically up the columns with a minimum clearance on both sides. The horizontal legs point outward and are reinforced with steel plate gussets. The other legs are drilled with holes under which the bushings of the lifting rods engage.

Threaded inserts cast into the columns for lifting eyes can take the place of the collars.

(Continued on Page 28)

Workers smooth surface of ground floor. **(MSU Information photo)**



Jacks with cables set in place for lifting of slabs.

RAUDALES DAM

by Felipe Jarequi

Raudales Dam, a panoramic view showing four of the five tunnels constructed. Flood control will be made by a controlled crest spillway and floodgates.

Ever since Mother Ceres invented the art of husbandry, men of all races, climates, creeds and cultures have subsisted largely through the practice of this art. The ancient tribes which settled in the Valley of Mexico centuries ago were no exception to this rule, for they left traces that clearly attest their knowledge of land cultivation as well as a civilization and theology based on this knowledge.

The Toltecs, the Mayas, and later the Aztecs, depended principally on maize for their sustenance. Therefore, this gramineous plant, whose first fruits these indigenous people of Mexico dedicated to a protective deity, not only represented their daily bread but also signified the source of religious worship. And though the great changes of six centuries separate these primitive Mexicans from those of today, maize is still this country's staff of life.

Mexico, like many other countries of Latin America, is still trudging towards the goal of agricultural self-sufficiency. While undergoing during the past three decades a rapid process of industrialization, this country has been striving to carry out a wide construction program consisting of major

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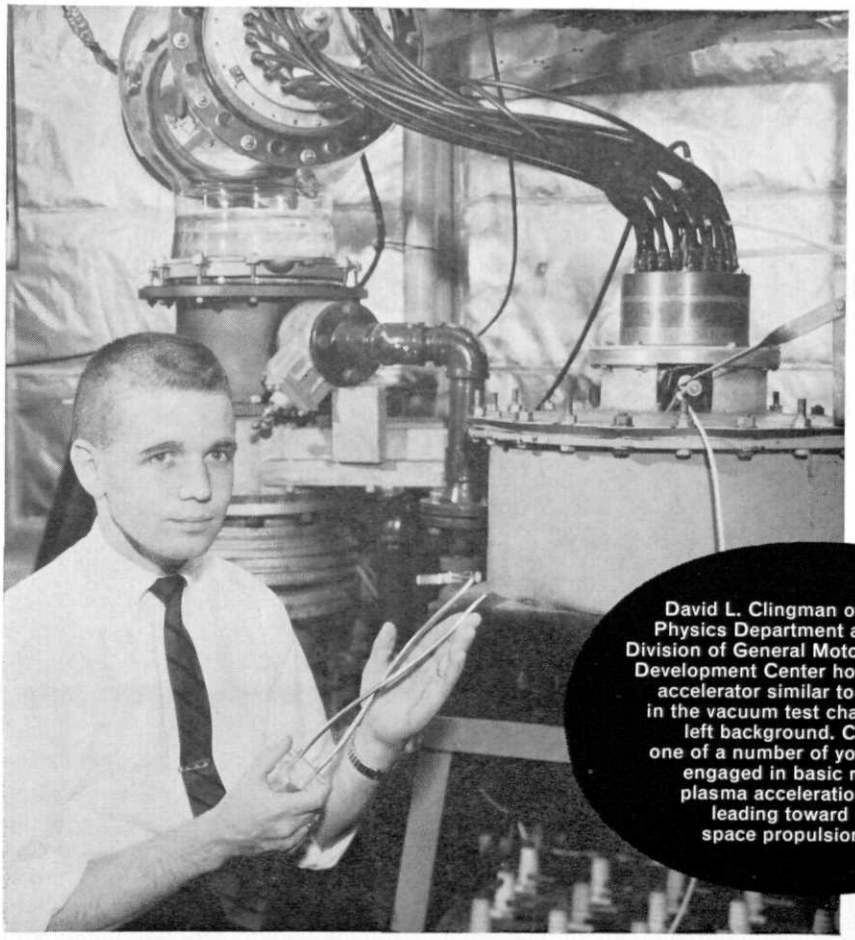


David L. Clingman of the Plasma Physics Department at the Allison Division of General Motors Research and Development Center holds a helical rail accelerator similar to one installed in the vacuum test chamber in upper left background. Clingman is one of a number of young scientists engaged in basic research in plasma acceleration programs leading toward primary space propulsion systems.

• **ENERGY CONVERSION IS OUR BUSINESS**—Admittedly, a broad and far-reaching theme, but then, so are the scientific investigations now underway at Allison Division of General Motors.

Within our 217-acre R&D Center in Indianapolis, Scientists and Engineers consider all aspects of energy conversion—utilizing nuclear/solar as well as chemical forms of energy.

Allison—long a leader in advanced types of aircraft engines—now is extending capabilities of turboprops to meet urgent, new military needs generated by current limited warfare requirements. There's emphasis on new engines for V/STOL applications, incorporating BLC (Boundary Layer Control), and programs to maximize fuel economy and range through high temperature regenerative cycles.

In the nuclear energy conversion area, Allison is prime contractor for development of MCR (Military Compact Reactor)—a highly mobile, completely self-contained nuclear fission power system—to provide electric power in remote areas.

First and second stage rocket engine cases designed and produced by Allison for Minuteman have achieved a 100 per cent reliability record. Allison's steadily growing competence in the field is reflected in the forward strides made in titanium and glass filament-wound ICBM cases. Also, in the missile field, Allison has developed a highly efficient regenerative liquid metal cell that may point the way to a powerful yet compact electrical system for space-age applications.

That's a small sample of the broad diversification of our activity today.

Perhaps there's a challenging opportunity for you in the creative environment at Allison. Talk to our representative when he visits your campus. Let him tell you first-hand what it's like at Allison where

"Energy Conversion Is Our Business."

WHAT ARE YOU WORTH?

by Morris Reason

Last spring, the AIEE-IRE conducted a study among graduating seniors to correlate their starting salaries in industry with two major factors: (1) the student's grade point average; and (2) his background, including extra-curricular activities, marital status, military service and previous experience with industry (summer employment, etc.).

The results of similar surveys were published periodically in trade journals but were nationwide in scope and applied to industry in general, not to a particular school.

We are interested in these factors as they relate specifically to Michigan State University electrical engineering students. This information will serve as a guide in helping students of future graduation classes determine what they might expect for a starting salary with industry upon graduation.

As more information is obtained from future graduation classes by their AIEE-IRE organization and added to the accumulated data, the correlations will become more accurate.

The idea of such a correlation study and of the analysis techniques used can be applied not only to electrical engineering students but also to students in every college of every university in the United States.

Interest in conducting such a study stems from the desire of most people for equal compensation for doing the same job, especially if their backgrounds are parallel in nature. As de Tocqueville implied, we would rather have equality in slavery than freedom, if the choice had to be made.

This is also the first time many students have had any direct contact with big industry. Most find themselves so inadequately informed that they don't know what to expect or where they stand until they have groped through several interviews. Taking a first job after college is one of the biggest steps taken in life, so the decision must be a carefully weighed and intelligent one. This article is an attempt to give a reference point for making an intelligent evaluation of prospects; it's at least a starting point.

Below is the questionnaire each senior was given to complete.

If we conducted this study again, we would ask two additional questions: (1) Have you published any articles, including newspaper and magazine articles, especially any AIEE-IRE Student Contest Papers? Indicate nature of article and any awards received; (2) Did you enter a project in the MSU Engineering Exposition? Indicate nature of project and any awards received.

From a graduation class of 86 seniors, 80 responded. We divided the class into four major groups, the first two groups are of primary interest and

AIEE-IRE
Joint Student Branch
Michigan State University

SENIOR CORRELATION STUDY

INDICATE WHERE YOU WILL MOST LIKELY BE LOCATED NEXT YEAR

☐ Industry Name of Company _____
☐ Graduate Starting Salary _____
School Address _____
Name of School _____
Address _____

I AM A MEMBER OF
☐ AIEE ☐ IRE ☐ Neither

AGE _____

GRADE POINT AVERAGE _____

EXTRA CURRICULAR ACTIVITIES (underline those in which you held office)
Organizations _____
_____
Honorary Societies and/or other honors received _____
_____
Other activities _____
_____

ARE YOU A MEMBER OF A SOCIAL FRATERNITY? (if so, list offices held) _____
_____

MARITAL STATUS:
Single _____
Married _____ How Long? _____ No. of Children _____

MILITARY SERVICE:
Months of Service _____
Branch _____
Brief description of duties: _____

HAVE YOU HAD ANY PREVIOUS EXPERIENCE WITH INDUSTRY (include summer employment)
Name of Company _____
Length of employment _____
Salary _____
Description of duties _____
_____

will be discussed at considerable length; the last two groups are of minor importance and will be mentioned briefly. The numbers in parenthesis throughout this article designate the number of students represented by the percentage figure.

Group I—52% went directly to work with industry (47).

Group II—28.75% were planning on taking graduate work (31).

Category 1—12.5% will be coming to MSU (10).

Category 2—10% will be going to various other schools (8).

Category 3—6.25% will take graduate work through some company-sponsored program (5).

Group III—2.5% are going directly into service (2).

Group IV—10% were of no help because they failed to indicate either their grade point average (gpa), their initial pay, or both; or they were not in class the day the study was made.

Group I

Table 1 is a complete summary of the questionnaire of the 47 students who went directly into industry. Starting salaries are listed in order of magnitude, ranging from a low of $530 to a high of $735 per month. The information in any one row represents the pertinent factors of the person whose salary is to the left of that row. The columns headed "S.S.," "Age," "G.P.A.," "Marital Status," and "Previous Experience" are self-explanatory. The uncircled numbers in the "Organizations" column under "Extra Curricular Activities" indicates the number of organizations in which the student held membership. The circled numbers represent the number of these organizations in which he held an office. For example, student No. 37 was a member of six organizations; of these, he was an officer of two. The figures in the AIEE-IRE column are already included in the "Organizations" column and the 1 or 2 indicates whether he was a member of one or both EE organizations. The same method was used in the "Honoraries," "Fraternities" and "Other Activities" columns. Under "Branch of Military Service," R.O., A.F., A., N. and M. stand for R.O.T.C., Air Force, Army, Navy and Marines, respectively.

These various factors can be correlated until a pattern becomes apparent

S.S.	AIEE IRE	AGE	G.P.A.	Extra Curricular Activities				Marital Status		Military Service		Previous Experience	
				Organizations	Honoraries	Fraternity	Other Activities	No. of years	no. of Children	Months of service	Branch	Months of employment	Salary per month
$530		21	2.5			1	2						
550		23	2.8		1								
560	1	22	2.9	1									
560	1	21	2.3	①			2						
560	1	22	2.7	3 ①			1	2½	2	1	RO	6	$258
565	1	21	2.2	1		1							
570	1	25	2.33	4 ①	1	①				42	AF		
570		23	2.53										
575		22	2.7	①	①			3	1			6	300
577	1	26	2.7	3 ①						46	AF	3	355
576		22	3.75		2								
580	1	22	2.4	1				3	1				
585	2	25	2.77	2	1			3½		43	AF		
585	2	22	2.44	2			1	4	3			18	430
585	1	23	2.3	1								6	375
585		25	2.9				1	1	1			9	472
585	1	26	2.54	2 ①	1			5	1	24	A	12	418
585	1	22	2.7	1									
590	1	22	2.4	1									
590	2	22	2.2	4									
590	1	26	2.65							45	N		
593		22	2.5			①						15	300
595		22	2.7										
596	1	22	2.93	1			1	2	1				
600	1	23	2.5	1				4	2			12	345
600	1	30	3.0	1	1			8	2	24	A	60	425
600		21	2.3	1								2	388
600		23	2.94				1					6	322
602		22	2.4		1	1							
602	1	22	2.52	1		①							
602		21	2.58										
610	1	22	2.53	3									
610		21	3.52		3	1	1						
610	1	21	2.9	2 ①	2	①						3	337
616		22	2.9			1						4	402
620	1	26	3.2	2 ①	2								
620	2	27	2.56	6 ②				4		45	AF	24	353
628	1	27	3.1	2 ①	1			8	3	43	N	48	?
650	1	26	2.56	2			1	6½	3	46	N		
650	1	23	3.5	2	2	1						3	452
655		25	2.98					3	2	35	M		
660		28	2.34				1	6	2	36	A	29	460
684		27	2.7					5	2	24	A	84	485
684	2	26	2.45	2				7½	2	48	AF	?	?
700		25	3.15	2 ①	5	①				46	N	6	430
713	1	41	3.28		1			16	1	240	N		
735	1	26	3.16	1			4	1	1			18	350
												36	600
												3	550

Table I

for the predictability of a possible individual starting salary.

The average salary was $606.12 per month, or $7,340 per year. To find the "median" salary, divide the 47 students by 2 giving 23 students. Count down the right column to the twenty-third student. The median salary was $596 per month. The "modal" salary was $585. Since more students received this amount than any others, this is probably the most accurate of the three.

Grouping these starting salaries, we see that students fall within a certain salary range.

Seventy percent of the students received from $575 to $625, only a $50 spread. The "Average G.P.A." column indicates the average grade points of those students in that particular range. It appears that the higher the G.P.A., the higher the starting salary should be. However, this is not the case, due partly to the fact that in some salary ranges only a very few students were sampled; this hardly justifies making a generalization about all similar groups. Nevertheless, students with gpa's in the mid 2.7 range may optimistically conclude that they will receive a starting salary of at least $575 to $625. No one else, at this point anyway, may conclude anything about their starting salaries from their gpa because there are too many other factors (to be discussed) which affect it.

Compare the starting salary vs gpa of students 4 and 5 and also 15 and 16. Students 4 and 5 got the same salary, but look at the difference in their gpa. The same is apparent with 15 and 16. Now compare students 4 and 15. They have the same gpa, but

(Continued on Page 16)

$25 per month difference in their salary. These disparities could be due to (1) the first impression they made during the interview, (2) the various purposes for which they were being hired, (3) the type of industry they went with and (4) differences in background.

The interview is a very important factor in determining starting salary and must be ranked almost equally with gpa and the total background. Personal appearance, poise, self-confidence, sincerity and good command of the English language all go into making an employer's first impression. Whether it is a good, fair or poor impression will make a difference in salary.

As for the various purposes for which one may be hired, a person going to work on a drafting board with a 2.7 gpa would probably get less than another who is going to be a field representative with only a 2.3 gpa.

A 2.3 student might receive a higher salary from an electronic and government contract oriented company than a 2.7 student from an electrical power company. In other words, the starting salary is also a function of the comparative types of industries.

Now consider how a student's starting salary is affected by his background, i.e., extra curricular activities, marital status, military service and previous experience. Call these four factors a, b, c and d. In Table III all those students who have no background factors are listed in one group, as are those with one, two, three, and all four background factors. Details of each factor are not specific but only a correlation of the number of factors they possessed with their salaries.

It might reasonably be expected that the broader a student's background, i.e., the more factors he has, the greater his salary should be. This indeed seems to be the case as Table IV shows (except for no factors and four factors, due to the lack of a large enough sampling of students in these categories). If the average starting salary of those possessing four factors were extropolated, assuming an ample sampling, it might be around $650.

Naturally, the older he gets, the more factors a student has; however, there seems to be no clear cut correlation between gpa and the number of factors.

No. of background factors possessed	Salary			Ave. G.P.A.	Ave. age	% of Students in this Category
	low	average	high			
0	$570	$589	$602	2.6	22	6.4
1	530	583	620	2.76	22.3	32
2	570	605	655	2.72	22.6	23
3	575	635	735	2.8	26.1	23
4	460	620	684	2.67	26.5	15

Table IV

87% (41) are in extra curricular activities

40% (19) are married

34% (16) had some military experience

47% (22) had related previous experience with industry.

Remember, when considering any one factor in Table IV, assume all other factors as being equal (which they are not, but without some simplifying assumption we could conclude nothing at all). As before the number in parenthesis is the actual number of students represented by the percentage.

79% belong to "organizations," an average of two each

They earned an average of $584 (30)

Those who were officers earned an average of $600 (11)

Those who did not belong earned an average of $607 (17).

It would appear as though it doesn't pay to belong to organizations, but this assumption is certainly not well founded. However, it does seem logical, as the figures show, that organizational officers should earn more for starting salary, all other things being equal.

32% belong to honoraries

Belongers average $613 (15)

Officers average $575 (1)

Non-honoraries average $585 (32)

Again, it seems only right that honorary society members should be worth more than non-honoraries. Also, officers should earn even more, but this is not obvious from a sampling of only one officer.

23.3% belong to fraternities

Members average $604 (11)

Officers average $615 (5)

Non-members average $606 (36)

Officers get more than members. Non-members get more than members! Don't forget the number sampled.

40% are married, average gpa—2.4

Marrieds average $625 (19)

Non-marrieds average $593 (28)

Logically, married students get more than single students. Married students have more responsibilities than single students and hense are generally more stable and of less risk to a company which spends a lot of money training a new engineering employee and expects its investment to be a lasting one.

34% are veterans, average gpa: 2.77

Veterans average $629 (16)

Non-veterans average $594 (31)

Naturally. Non-vets usually have their military obligation yet to fulfill and are therefore a greater "training investment" risk than a vet, who won't be leaving the company right away for this purpose.

26% are both vets and married, average gpa: 3.05

Average of married vets: $635 (12)

Average of those who are either vets or married, but not both: $608 (11)

Again, more stable, more responsible, more experienced.

Note the average gpa's of the last three groups: the marrieds, the vets, and those who are both veterans and married.

The service has a more maturing effect on an individual than just marriage; but a married veteran is considered highest in maturity by employers.

47% had previous experience in industry

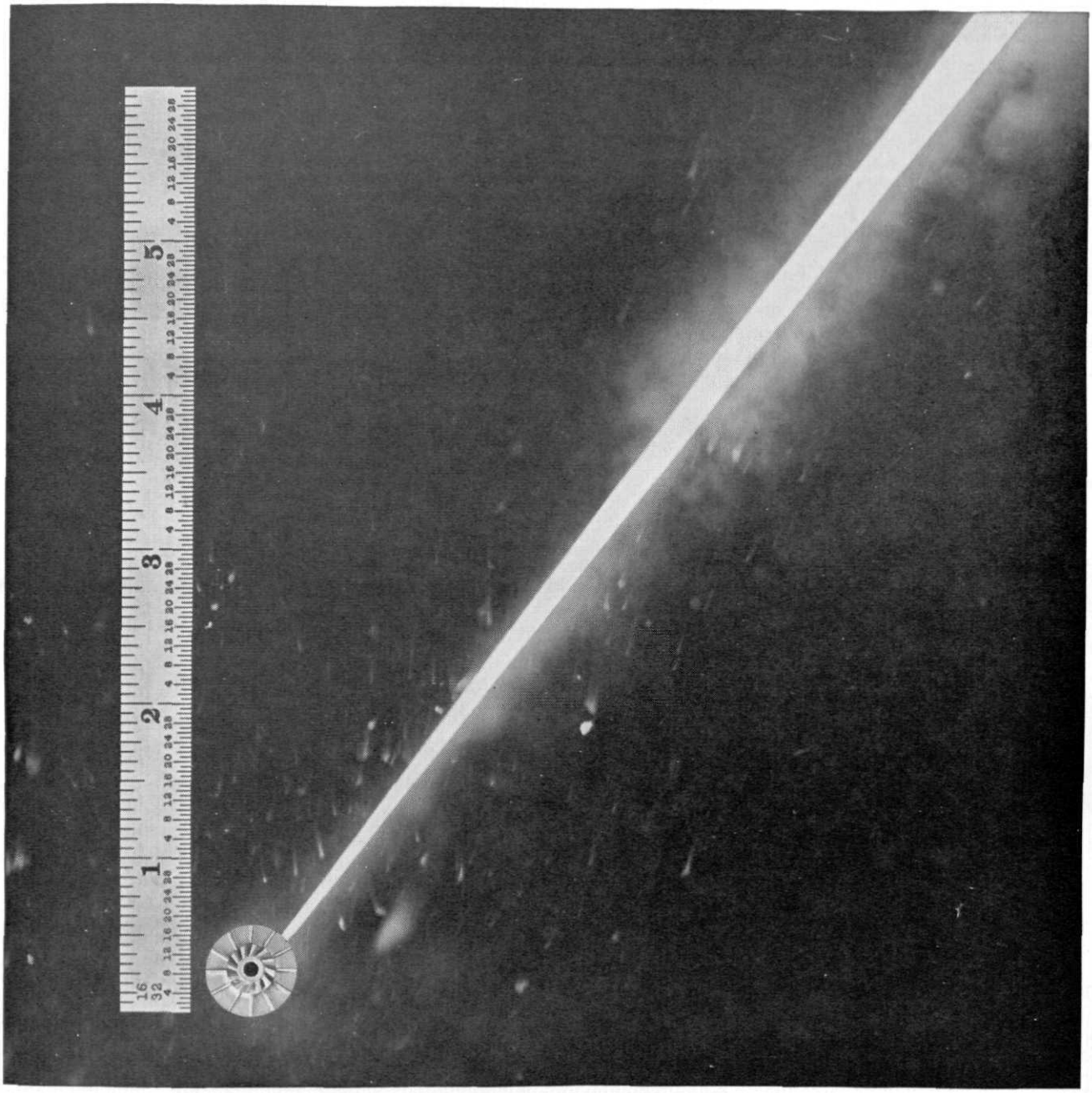
Previous experience average: $622 (22)

No previous experience average: $594 (25)

The average monthly "previous experience" salary was $400 per month.

Some companies allow a definite, but variable, starting salary increase for such factors as military service, previous experience, being married, etc. With military service the increase varies with the length of enlistment and how the service job is related to the job sought. Previous experience depends on how related and how pro-

(Continued on Page 38)



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For information about other interesting projects and the many career opportunities with The Garrett Corporation, write to Mr. G. D. Bradley in Los Angeles.

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The Last Frontier and . . . .

THE SUBMERSIBLE

by Paul Adams

The last earthly frontier is said to be the ocean's floor. In the great depths of the seas, vast areas are still unexplored and almost unknown to man. The little that is known was learned almost entirely from instruments or from a very few dives made by adventurous men.

The continental shelves are known to be rich in fishes and minerals. The floor in the pelagic deeps holds mysteries greater than any terrestrial wilderness. The scanty facts collected indicate that man's future may be intimately tied to the seas.

Mystery is sufficient reason for the adventurer to probe the unkown. Of course, there are military reasons sufficient in themselves for knowing about the ocean depths. But the greatest impetus to exploration comes from the knowledge that man is likely to outgrow his present food supplies and known mineral resources in an uncomfortably short period of time.

The annual harvest from the seas increases each year. New methods of taking the resources are developed more rapidly as the need arises and the interest and knowledge of seas accumulate.

There are several attempts at "wet ranching." Off the coast of Monaco, the waters are fertilized to produce abundant fish foods and a corresponding increase in the number and growth rates of the fishes. The California wet rancher merely provides cover for the fish he hopes to harvest in greater numbers. It is well known among commercial fishermen that the fish tend to concentrate around sunken vessels because of the protection afforded by the hulk. The rancher has achieved similar concentrations by dumping streetcars, old automobiles and anything else into the water that will give the fish protection from their predatory associates. Oyster farming is carried on in the French coastal waters by men in Aqua-lungs.

Petroleum and sulphur wells tap the mineral deposits off both the Atlantic and Pacific coasts in the United States. There is also considerable interest in the magnesium nodules that can be found on the ocean floor.

Jacques-Yves Cousteau, the inventor of the Aqua-lung, says that these are the formative years of the submarine industries. He says that the present efforts to utilize the sea's resources are the first timid steps in the development of under-water agriculture, mining and possible transportation.

Captain Cousteau, Auguste Piccard, and his son Jacques are pioneering in the development of the submersible—an underwater craft capable of diving to the floor of the sea at great depths and yet operating independently of the surface.

One of the first submersibles was the FNRS2 designed and built by the Piccards in 1948. This craft was tested off the coast of Dakar in that year and dived unmanned to a depth of 4500 feet. It also dove to 80 feet with a crew aboard. The FNRS2 was damaged while in tow and further testing at this time was impossible. However, the tests had proved the principles involved in the construction. The craft was given to the French Navy who have operated it successfully since then.

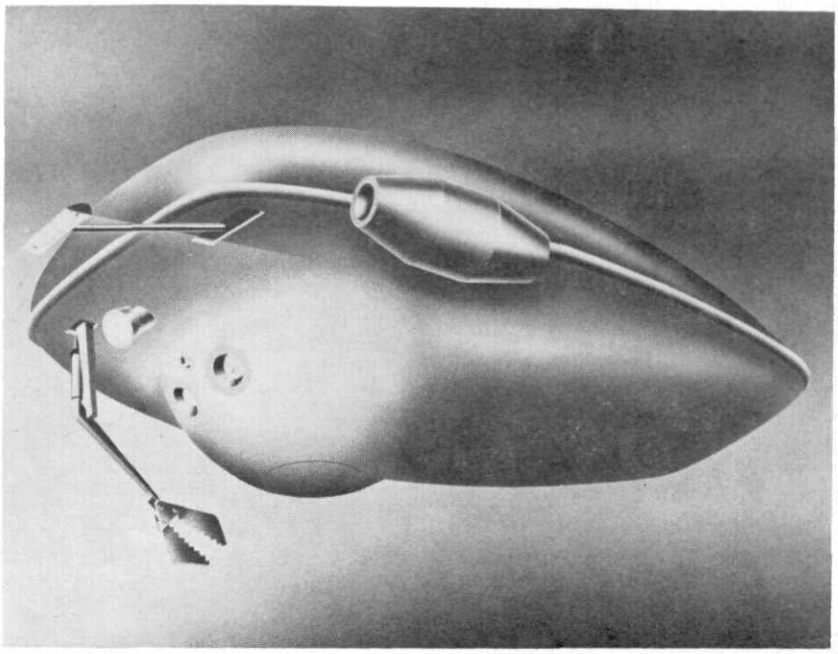
In 1952 the Piccards designed the "Trieste," a craft able to function safely at 12,000 feet.

Captain Cousteau has designed a diving saucer, which is capable of operating at a depth of 1,000 feet.

"The diving saucer has been proven in 65 successful dives and is the ideal tool for the exploration of the continental shelf," Cousteau said. It has been used in Puerto Rico, Guadeloupe Islands, and the Western Basin of the Mediterranean. Soon it will be used under the Arctic ice cap.

The latest submersible, also designed by Captain Cousteau, is the "Deepstar." This ship will be built in the United States by the Westinghouse Company. It is a commercial model which can be purchased or leased by anyone interested in the bottom of the ocean.

The "Deepstar" is basically spherical. The one and one-half-inch shell of high grade steel is about six feet in diameter and weighs seven tons. This spherical cabin has two plexiglass windows four inches thick. A three man crew can view the surrounding area and observe the operation of the two remote controlled arms. The arms will place sensitive oceanographic instruments precisely, something which has seldom, if ever, been done in deep



"Deepstar," Westinghouse's new submersible will have a range of 20 nautical miles and will be handled by a "mother" ship that will take it to the diving area. (Westinghouse photo)

waters, or will pick up samples and otherwise function as extensions of the operator's arms.

The craft will be propelled by two special electric motors, exposed to the sea but sealed in low viscosity liquid dielectric imiscible with sea water. The shaftless propellers will be integral parts of the motors which will eliminate the necessity of shaft logs, bearings and seals. Twin screws will make the "Deepstar" highly maneuverable.

In operation the "Deepstar" will be neutrally bouyant and will climb or dive by changing its attitude in the water. Mercury will be pumped fore and aft between tanks to cause the craft to head up or down as desired. In order to make the most of the maximum allowable time below, the craft will rise and descend in a vertical attitude. Average speed will be about three and one-half miles per hour.

The oxygen system will enable the "Deepstar" to stay under water for 48 hours; however, the battery life will limit the effective time to 24 hours.

All of the necessary equipment is included to make the "Deepstar's" excursions onto the ocean floor as scientifically profitable as possible. Cameras, floor lighting, radio, sonar and such safety equipment as smoke and light flares have been provided.

Most of the equipment—the motors, cameras, lights, balancing system and arms—will be covered or attached to a hydrodynamically shaped surface of the sphere.

In an emergency the ship can be given positive bouyancy by dumping ballast or in extreme situations, by dumping equipment.

The vehicle will have a range of about 20 nautical miles and will be handled by a "mother ship" that will take it to the area of the dive.

Mr. John Clotworthy, manager of the Ordinance Division of the Westinghouse Defense Center, is responsible for the construction of the "Deepstar." Mr. Clotworthy said, "Westinghouse will build the 'Deepstar' as its own laboratory facility to test oceanographic instrumentation, develop new detection techniques and generally study the marine environment.

"We will also lease the 'Deepstar' to organizations which need such a special-purpose vehicle for deep sea research," he said, "and we will build similar vehicles for sale to organizations which may want this kind of mobile facility on a full-time basis."

The future will bring other submersibles which will perform more efficiently at great depths.

Auguste Piccard and son suggest an underwater helicopter that will propel itself to the bottom with two counter rotating screws. The cabin will be made entirely of plexiglass and be positively buoyant. In the event of power failure the craft will float to the surface like a six-foot bubble.

Jacques Piccard believes it possible to produce a ship which can adjust its shape automatically, as a dolphin does, to prevent turbulence in the water next to its skin. The ship might have a rubber skin equipped with manometers to detect early formation of turbulence. An impulse transmitted to the central electronic system and relayed to magnets would attract pieces of iron glued to the skin, producing a craft nearly hydrodynamically perfect at all times. Such a vessel would require much less power than conventional ships.

The oceanographers have many questions, more will develop as investigations proceed.

Charles Darwin is said to have solved the riddle of the coral reef with a lead line and a vaulting pole. With such equipment as the "Deepstar," the "Trieste" and other submersibles as they are developed, an investigator today must make some truly startling discoveries.

Russian Dancing: This consists of folding one's arms over the chest and running while sitting down.

* * *

I shot a missile in the air,
It fell to earth, I knew not where,
Until next day, with rage profound,
The man it fell on came around.
In less time than it takes to tell,
He showed me where that missile fell;
And now I do not greatly care
To shoot more missiles in the air.

* * *

Pappa Bear: "Who's been drinking my beer?"
Mama Bear: "Who's been drinking my beer?"
Baby Bear: "Barf."

* * *

Famous last words: "Hell, he won't ask us that."

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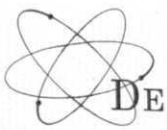

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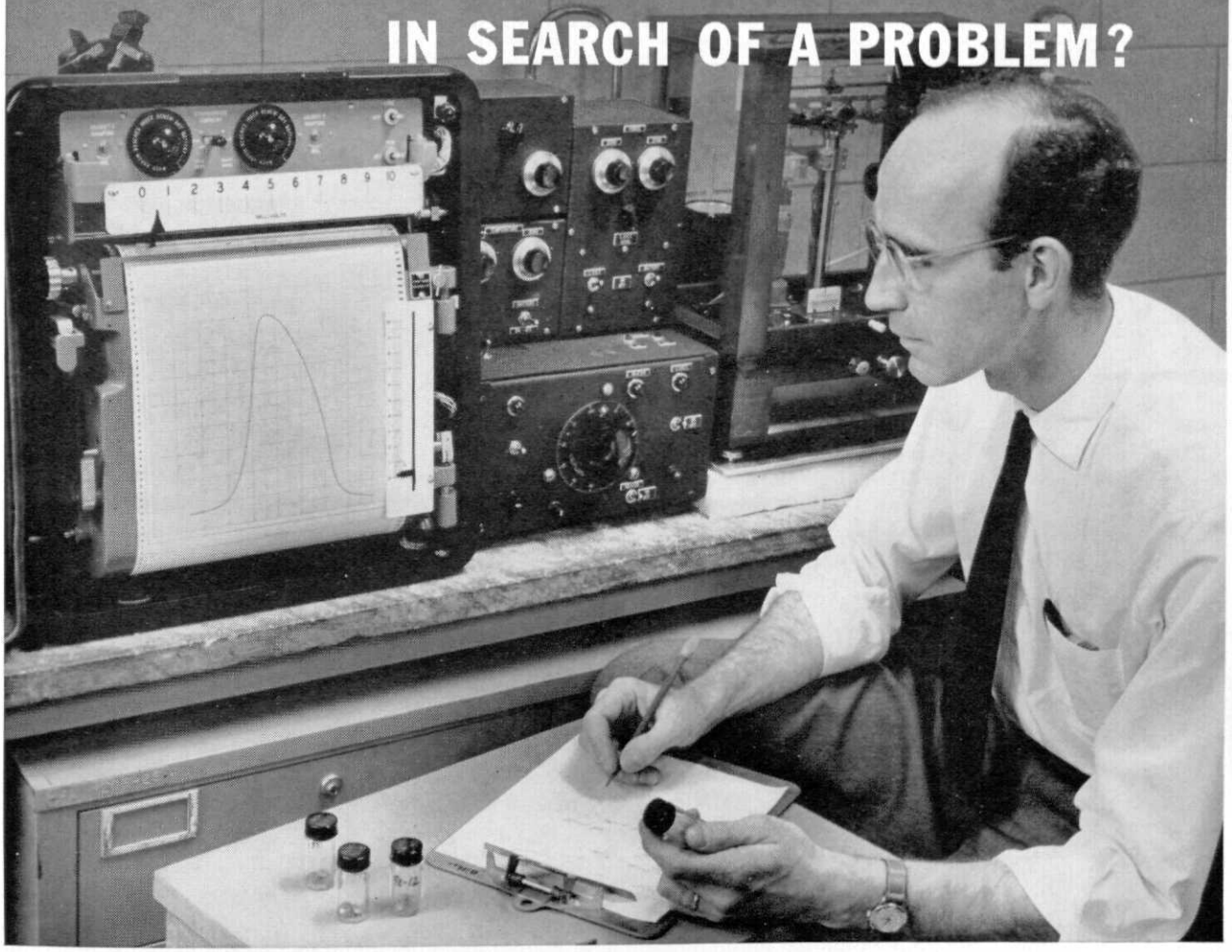
Opportunities at Du Pont for technical graduates—first of a series

EVER HEAR OF A SOLUTION IN SEARCH OF A PROBLEM?



It happens at Du Pont. Frequently. That's because 1350 technically trained employees are engaged solely in pioneering research. They're in the business of discovery, development and follow-through. Sometimes the newly discovered chemical poses the question, what to do with it?

For instance, Dr. Thomas J. Swoboda, a member of the Central Research Department staff, and his associates recently discovered a new family of metallic compounds, chromium manganese antimonides. They're unusual materials. Over a specific temperature range they are magnetic. As temperature drops, the magnetism does too.

The chart, pictured with Dr. Swoboda, shows the sharp magnetic transition. To the right, the material is ferri-magnetic, to the left (at low temperatures), anti-ferromagnetic.

So we have a solution. Now to find the problem it will solve. This situation was largely true when nylon was discovered. Only later did we find the many problems which its unique characteristics would solve—from cord for airplane tires to plastics for gears.

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a message to graduating engineers and scientists

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The glamour and excitement of space age programs often obscure a fundamental fact. It is simply that farsightedness must be coupled with sound, practical, down-to-earth engineering if goals are to be attained. This is the philosophy upon which Pratt & Whitney Aircraft's position as a world leader in flight propulsion systems has been built.

Almost four decades of solid engineering achievement at Pratt & Whitney Aircraft can be credited to management's conviction that basic and applied research is essential to healthy progress. In addition to concentrated research and development efforts on advanced gas turbine and rocket engines, new and exciting effects are being explored in every field of aerospace, marine and industrial power application.

The challenge of the future is indicated by current programs. Presently Pratt & Whitney Aircraft is exploring the areas of technical knowledge in *magnetohydrodynamics . . . thermionic and thermoelectric conversions . . . hypersonic propulsion . . . fuel cells* and *nuclear power.*

If you have interests in common with us, if you look to the future but desire to take a down-to-earth approach to get there, investigate career opportunities at Pratt & Whitney Aircraft.

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From Phend

ARE YOU ON THE ROAD TO GRADUATE SCHOOL?

Graduation from the College of Engineering at Michigan State University is an important crossroad in the life of the young engineer. The number of directions you can go after graduation approaches infinity, and the choice you make will affect you the rest of your life.

For simplicity, let's put the possible roads after graduation into two main groups—employment in industry or government, and graduate study. Some may take other paths, but these are relatively few. Some may have military service coming up, but usually this is an interlude before returning to their career in engineering.

The choice is an individual one. Find out what you can, evaluate this in terms of your own desires, needs and abilities and make your own decision. It isn't an easy one, and you should consider it carefully. You will need detailed information. To have time to gather this information, you should begin considering your decision in your junior year, or no later than the beginning of your senior year. Don't wait until you have to make this decision with insufficient data.

Why Graduate School?

Graduate work is absorbing and stimulating to the young engineer. He is interested in his profession and enjoys working hard at learning more in depth about it.

Many professional goals require the advanced training of graduate study. If you are considering teaching or research, for example, advanced degrees are practically essential. As a matter of fact, for most engineering careers, graduate study will be a real advantage. Additional points of view on the value of graduate work in your area of interest may be obtained from professors, advisors and industrial personnel.

An important point to keep in mind is the value of resident graduate work. On the campus, you have the association of faculty and students who share your interests. There are adequate libraries, laboratories, and other facilities for scholarly pursuit. You are, essentially, in a "learning" atmosphere. Graduate study is not just the accumulation of academic credits. It requires an atmosphere of inquiry, concentration, and study that cannot readily be achieved when you divide your attention between part-time study and full-time work in industry.

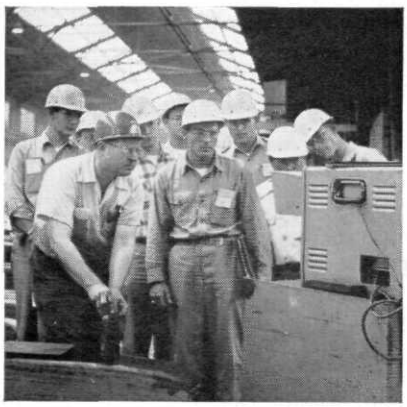
Which road are you going to take?

Harold W. Phend is assistant to the dean of Engineering. He is one of the Spartan Engineer faculty advisors. Watch for an article on Phend's Fiends in the next issue.

Opportunities are better than ever at Bethlehem Steel!

The Bethlehem Loop Course

. . . and how it works



The Loop Course is our continuing program for selecting and training qualified college graduates for careers with Bethlehem Steel. It was established some forty years ago. Its unusual name comes from the fact that from the very beginning, the course has included an observational circuit (or "loop") of a steel plant.

Promotion from Within

The Loop Course provides management personnel. Since it is our policy to promote from within, it is vital that competent men, well-grounded in our practices and policies, be available to fill management openings as they occur. And, due to Bethlehem's steady and continuing growth, there has been no lack of opportunities to advance.

The Basic Course

Every looper attends the initial five-week course held at our home office in Bethlehem, Pa., beginning early in July. He attends orientation talks, listens to discussions by management men on all phases of company operations, and makes daily trips through the local steel plant. At the end of this period he has a sound knowledge of the overall Bethlehem organization.

Their First Assignments

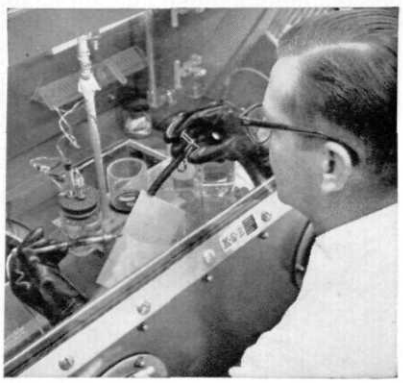
At the end of the basic course, loopers receive their first assignments. Ordinarily a large majority report to our steelmaking plants, where they attend orientation programs much like the initial one at Bethlehem. During this period, plant management closely observes each looper's aptitudes and interests, with the objective of giving him an assignment for which he appears to be best fitted, and corresponding as closely as possible to his interests, educational background, and work preferences. Loopers selected for sales, research, fabricated steel construction, mining, shipbuilding, and the company's administrative departments, proceed from the basic course to specialized training programs.

Preparing for Advancement

As the looper gains in ability, experience, and knowledge, and as openings occur, he is moved into positions of increasingly greater responsibility. The company expects and encourages the looper to produce . . . to make steady progress. Regular reports on his work and progress are made to department heads—and annual reports to divisional vice-presidents—throughout his career.

Emphasis on Technical Degrees

Because of the nature of Bethlehem's activities, the greatest demand is for men with technical degrees, especially those in chemical, civil, electrical, industrial, mechanical, metallurgical, mining, and naval architecture and marine engineering.



Read Our Booklet

The eligibility requirements for the Loop Course, as well as how it operates, are more fully covered in our booklet, "Careers with Bethlehem Steel and the Loop Course." Copies are available in most college placement offices, or may be obtained by writing to Manager of Personnel, Bethlehem Steel Company, Bethlehem, Pa.

An equal opportunity employer

Steel

BETHLEHEM STEEL

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The Case for Lift Slab

(Continued from Page 11)

JACKS AND JACK RODS

Hydraulically powered jacks are placed over each column top to do the lifting. Oil pressure is furnished by a six-cylinder diesel-driven pump with a capacity of 35 g.p.m. under a lifting pressure of 200 psi.

Thirty-six jacks can lift 12 tons.

Twelve jacks operate simultaneously from a control table that feeds fluid to all the jacks at the same time or to each jack independently.

In older equipment, each set of hydraulic lines leading into each jack terminates at the control in a revolution-counter indicator which gives the operator a measure of the amount of lift. The operator at the console can control the rate of lift for each jack by a series of hand-operated valves. Newer equipment performs this task automatically.

Such a control system for transmitting hydraulic material to the jacks insures uniform lifting.

From the jack on each column, two threaded lifting rods reach down to the collar of the slab. The jack pulls up the lifting rods in the threaded openings of the collar which are embedded in concrete.

Steel hoisting towers may be used in conjunction with the jacks to speed lifting time.

CONSTRUCTION PROCESS

FRAME WORK

The top of one slab is the only form needed to construct the next slab except for a small amount of perimeter work.

The basement floor is cast on the ground to serve as a casting bed for future slabs. Each floor is cast directly on the basement floor which is machine-troweled to a smooth surface.

Either the surface of the basement floor is wax-dusted with a foundry dusting powder, painted with a coat of curing compound followed by two additional coats, or sprayed with two applications of colorless sealing compound after it has taken initial set. These prevent bonding between the slabs and are repeated before each slab is poured on the underlying slab.

COLUMN ERECTION

For any structure, columns must have adequate foundation and be firmly anchored.

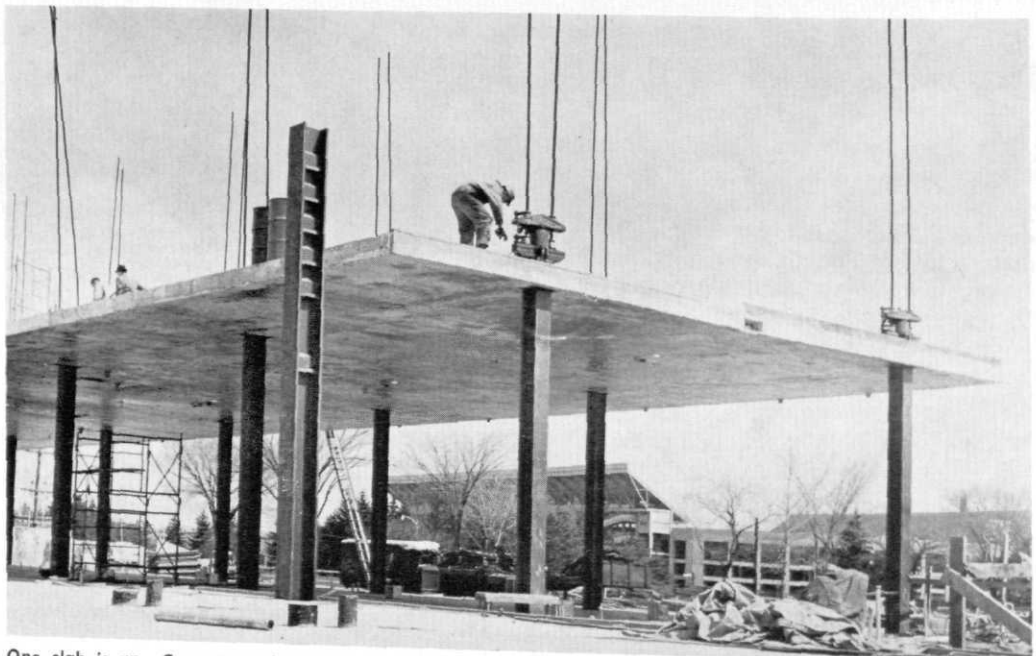
Anchor bolts one-foot, six inches long and four and 7/8 inches in diameter are adequate to hold the columns. There is little worry of bending moment in the bases since the dead weight of the structure eliminates almost completely any requirements of tensile stresses due to bending.

The last step before pouring the first slab is to slip lifting rings or collars around each column. Threaded holes on either side of the collar are where the lift bar sets. The upper ends of the lift bar are attached to hydraulic jacks set over the columns.

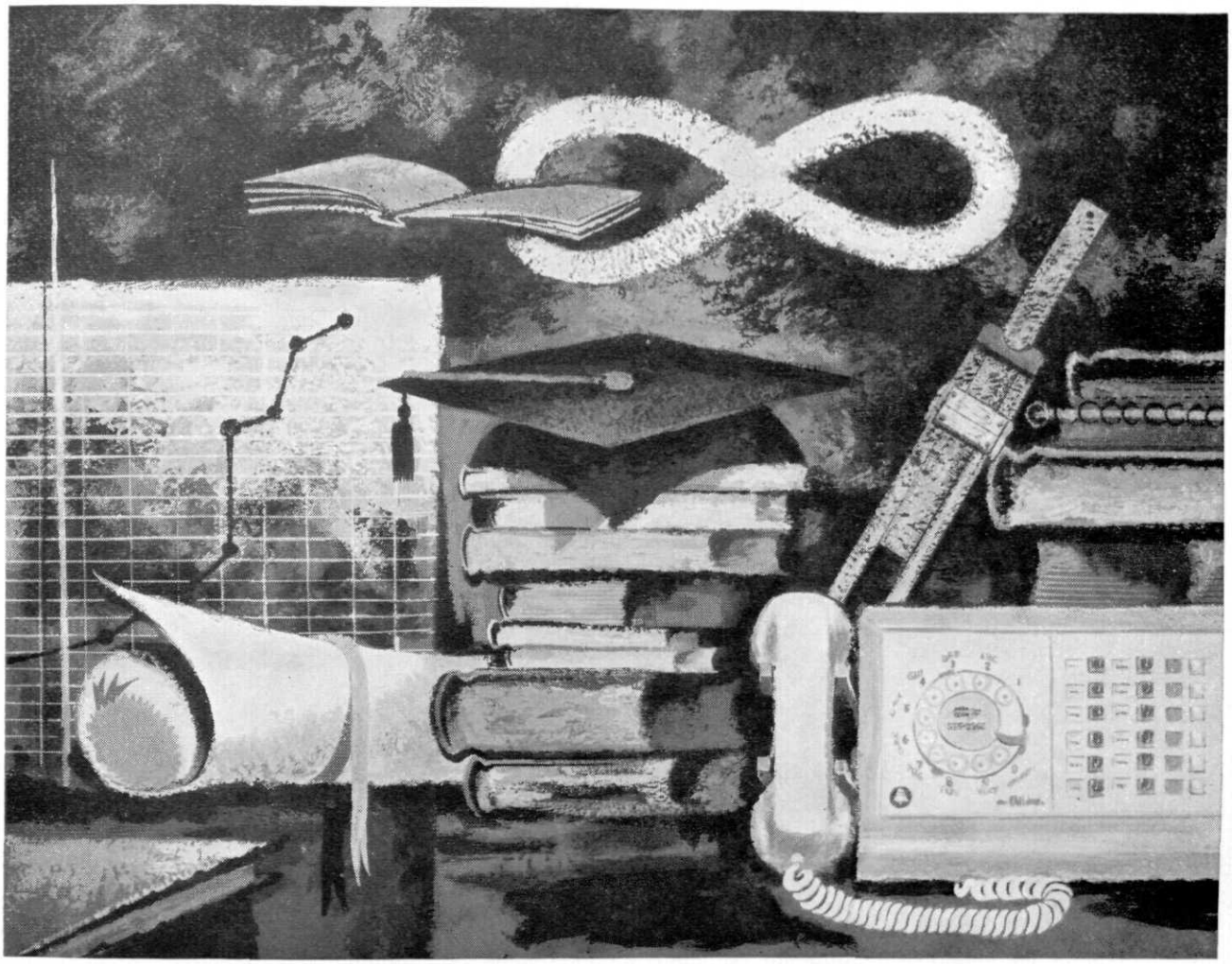
POURING

After the columns have been erected, the ground floor is poured around them leaving a clearance around the columns. Each floor is dusted as previously mentioned. All castings are done at two- to four-day intervals and given ten days for the roof slab to cure before lifting begins.

(Continued on Page 30)



One slab is up. Concrete at bottom of photo is the next floor ready to go up. Note the circular cans set in the slab to create openings for pipes.
(MSU Information photo)



Learning never stops for engineers at Western Electric

There's no place at Western Electric for engineers who feel that college diplomas signify the end of their education. However, if a man can meet our quality standards and feels that he is really just beginning to learn . . . and if he is ready to launch his career where learning is an important part of the job and where graduate-level training on and off the job is encouraged — we want and need him.

At Western Electric, in addition to the normal learning-while-doing, engineers are encouraged to move ahead in their fields by several types of educational programs. Western maintains its own full-time graduate engineering training program, seven formal management courses, and a tuition refund plan for out-of-hours college study.

This learning atmosphere is just one reason why a career at Western Electric is so stimulating. Of equal importance, however, is the nature of the work we do. Our new engineers are taking part in projects that implement the whole art of modern telephony from high-speed sound transmission and solar cells, to electronic telephone offices and computer-controlled production techniques.

Should you join us now, you will be coming to Western Electric at one of the best times in the company's history. In the management area alone, several thousand supervisory jobs are expected to open up to W.E. people within the next 10 years. And our work of building communications equipment and systems becomes increasingly challenging and important as the communications needs of our nation and the world continue to increase.

Challenging opportunities exist now at Western Electric for electrical, mechanical, industrial, and chemical engineers, as well as physical science, liberal arts, and business majors. All qualified applicants will receive careful consideration for employment without regard to race, creed, color or national origin. For more information about Western Electric, write College Relations, Western Electric Company, Room 6205, 222 Broadway, New York 38, New York. And be sure to arrange for a Western Electric interview when our college representatives visit your campus.

Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

Principal manufacturing locations at Chicago, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Winston-Salem, N. C.; Buffalo, N. Y.; North Andover, Mass.; Omaha, Neb.; Kansas City, Mo.; Columbus, Ohio; Oklahoma City, Okla. Engineering Research Center, Princeton, N. J. Teletype Corporation, Skokie, Ill., and Little Rock, Ark. Also Western Electric distribution centers in 33 cities and installation headquarters in 16 cities. General headquarters: 195 Broadway, New York 7, N. Y.

The Case for Lift Slab

(Continued from Page 28)

LIFTING

Before any slab is lifted clear of the stack it is cast on, the corner jacks are operated alone, without the interior jacks, so that each corner is pealed (i.e. raised 1/8 to 1/4 inch) to allow air to break the suction bond between the slabs and the stack.

Before the roof slabs are lifted, all roofing material is placed on them for lifting at the same time.

The sequence of lifting is the most fundamental and important item in lift slab. The sequence desired rests on these points:

1) the point at which the columns may be conveniently reduced to size;
2) the height at which the Euler load is best dealt with;
3) the height required to fix finally as many of the lower slabs as possible to stack temporarily the upper slabs conviently for the next lift, and
4) the length of the lifting rods.

Slabs are lifted at speeds of six to eight feet an hour in series of two to four slabs at a time.

The usual procedure is a 45-foot first lift with succeeding lifts shorter and shorter as column size reduces. Building specifications often limit the maximum difference in the amounts lifted between columns that are grouped together to 1/4 inch.

Dials on the jack console panel indicate how each jack is operating.

Careful control makes sure that the free-standing columns do not drift off line towards the vertical. Two plumb-bobs, six-inch diameter steel cylinders filled with concrete, dangle from the ends of the structure and are watched carefully.

Of course, transit and level observations are also considered.

Each floor is braced in place as it reaches its final position.

SECURING SLABS

When all slabs are lifted to the top of the first column length, the second section of the column is secured and slabs are lifted to this level and welded in place. The columns are held rigid during lifting by guy wires anchored to concrete deadmen.

The ground floor slabs are attached to the basement walls. Other slabs are connected directly to the columns.

The two collar bands incorporated in the column are welded to the vertical reinforcement steel of the slab collars with electrodes of low hydrogen iron powder. This welding equipment is because of the high carbon content of the reinforcing steel. The lifting collars are also guyed in place.

On some construction jobs, specially cast shear-heads are field-welded to the wide-flange columns and to bearing plates set in the concrete ribs.

Slabs can also be connected to the column by load wedges placed between the bottom of the cast steel lifting collars embedded in the slabs. Shear plates are shop-welded to the columns. After positioning the slabs, wedges are welded to both the collar and column.

ADVANTAGE OF LIFT SLAB CONSTRUCTION

ECONOMIC

More than 30 per cent of the cost for structural work can be saved by the lift slab method of construction.

Cost savings are attributed to three factors:

1) elimination of slab forms;
2) concreting of slabs by grade;
3) erection speed.

The elimination of slab forms saves about $0.50 per square foot. The lifting charge is $0.30 per square foot. A net savings of $0.20 per square foot can be realized (.50 − .30 = .20).

The concreting of the slabs entirely by grade instead of by hoist and in the air can result in a net savings of $0.10 to $0.30 per square foot.

Erection speeds save an amount dependent on the value of the actual time saved.

In addition to these major saving factors, the total savings in structure can be blown up by other factors.

The winter protection costs which are either reduced or avoided can add up to $1.00 per square foot savings. Floors can be cast in the winter at 30 degrees Farenheit with heating confined to an area of the ground where the slabs are cast.

The elimination of plaster ceilings can save $0.30 per square foot. Reduced floor to floor height saves volume in the building which for most structures costs a minimum $1.00 per cubic foot.

With savings like this, it is no wonder that more domestic, commercial and industrial lift slab construction is the current trend.

TIME SAVINGS

In addition to economic savings, lift slab saves time.

The speeds of erection are considerable. Two slabs can be lifted to their correct level daily with final fixing to follow. Each slab is cast into place in two to four days.

Form work is almost entirely eliminated deleting the time normally consumed in building and demolishing a wooden superstructure.

Finishing the structure takes less time, too, because the lower surfaces of each slab are as smooth as the machinne-troweled polished surface of the floor on the lower slab. They need only be painted with plastic paint because no plaster is needed. Also, all heating and electrical work is incorporated in the slabs on the ground.

The architect has more freedom in internal arrangements also. This is a result of the almost entire elimination of beams in the structure.

The advantages of life slab construction can be called the three C's.

CONVENIENCE

COST-CUTTING

CELERITY.

Front view of North Case Hall. Dorm capacity is 1,040 students.

EDITORS NOTE:

The Spartan Engineer has started the new year with a new staff and new ideas. The new staff was rounded up rather hastily and this issue completed in a mad scramble to the deadline. There is nothing quite like pressure to whip a staff into shape.

Our new ideas are quite frankly a different viewpoint. Every editor sees his magazine and its objectives differently than any previous editor.

In reading through the past issues of the Spartan Engineer we have found high standards continuous throughout the years. It is the intent of this editor and his staff to maintain this standard. The excellent papers from the broad field of engineering, papers covering new developments in industry, research and engineering education will remain the backbone of the magazine. We are particularly interested in what the MSU engineer is doing, and who he is. This, is our different viewpoint.

There are some interesting people in the Engineering College; students and staff members both. These people are doing some interesting things, and we are going to tell you about them.

We need some help. We can't meet everybody nor read everything. We're going to miss much that should be told. Collectively you know everything that happens in engineering, so . . . what is your special project? What's your roommates'? Who has a study that we ought to know about?

Tell us about it, or better yet, write it up and we'll see that the other engineers know about it too.

Calendar Girls

Miss November is Cindy Hicks, a 5′ 2″ East Lansing freshman. Cindy, an English education major, plans to teach secondary English. Meanwhile she models at local clothing stores.

Nickie Richmond, related to the Jolly Saint in name and disposition only, is Miss December. Nickie, a 5′ 2″ sophomore from Lincoln Park, is majoring in psychology. She plans to enter guidance and counseling after getting a master's degree.

Photos by Tom Crockett

1962 NOVEMBER 1962

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Raudales Dam

(Continued from Page 12)

and minor irrigation systems whereby to intensify the cultivation of extensive areas that were hitherto unused, and thereby to achieve an agricultural abundance.

This work, entrusted to the Ministry of Hydraulic Resources, has been going on as fast as available means have permitted, and its aim has been to catch up with the ever increasing needs of a population that has grown in the past 30 years at an inordinate rate.

Furthermore, the application of the Agrarian Reform has been seriously hampered on the one hand by lack of water, fertile lands, modern mechanical equipment, as well as of adequate financial credits, and on the other by an excess of farmers, or because the families of those who have been allotted in past years parcels of land have increased to six or more members, whose males have usually followed the father's occupation in husbandry. Thus, the problem of accommodating the surplus rural population must be solved by increasing the country's area of tillable soil.

Up to 1926, practically no major irrigation projects had been developed in Mexico. But beginning that year, when the government created the National Irrigation Commission, the country entered upon a new era. In 1948 this Commission was elevated to the status of a Ministry, titled Secretariat of Hydraulic Resources, maintained directly by appropriations from the federal budget.

Today, the federal appropriation for the Secretariat of Hydraulic Resources, amounting to 779,630,000 pesos, stands next to that of the Secretariat of Public Education, which is foremost in government expenditures and is almost at par with that granted the Secretariat of Communications and Transports.

Since its foundation, the Secretariat has built numerous irrigation projects in different regions of Mexico, as well as potable water and drainage systems in cities, towns and villages. The great increase in the volume of Mexico's agricultural production during the past 30 years has been largely the result of irrigation systems built by this Secretariat. Most of these systems, however, have been built in the central, northeastern and northwestern regions, which have the densest populations.

Therefore, the program formulated by this Secretariat is now mainly directed to the southeast, which is Mexico's most promising region for agricultural development. This region comprises the states of Tabasco, Chiapas, Campeche and Oaxaca. Grijalba and Usumacinta are the two main rivers whose flow must be harnessed to benefit this region. Their watersheds cover an extensive area and constitute a hydrographic system with thirty percent of the country's hydraulic resources. At the hydrometric station called Penitas the mean run-off of the Grijalba has been registered at 19 billion cubic meters annually. During the months of September and October the maximum flow of the two rivers has shown 6,220 cubic meters per second respectively, while the capacity of their beds is only 3,500 cubic meters per second.

The potential wealth of this region, capable of supplying raw materials for the development of important industries is immense. The forest-covered terrain is a store of timber species where mahogany, rosewood, ebony and cedar abound. The higher slopes are rich with colder climate varieties of pine, fir and oak. Its wild-life fauna includes deer, tapir, wild boar, jaguar, manatee and other species.

The area has vast regions suitable for cattle raising and for almost every form of agriculture. It also has great reserves of mineral wealth, mainly that of oil, particularly in the state of Tabsco. Nature indeed endowed Mexico's Southeast with an incalculable store of unexploited riches, which will be open to exploitation when the program of the Ministry of Hydraulic Resources is completed.

While this program consists of various projects, that of the Raudales dam, at the confluence of the Grijalba and La Venta rivers, in the state of Chiapas, is already under construction. (1) The benefits that will be derived from this dam can be listed as follows: prevention of disastrous floods over the communities in the region called Olla de Chontalpa, as well as over approximately 100,000 hectares under cultivation; the reclamation of 350,000 hectares of excellent land, with the probability of additional 200,000 hectares in the future. This in itself would fully justify the money invested in the project. Furthermore, electric power can be generated by this dam in the amount of 425,000 KW, and 2,490 million KWH yearly which will suffice to insure industrial development throughout the region and provide a surplus to be distributed to other regions.

In order to begin the construction of the Raudales dam it was necessary to deflect the river through five tunnels 14 meters in diameter, excavated in rock. These tunnels are being concrete lined and are soon to be completed. Two of these tunnels, on the left bank of the river are to feed the hydroelectric plant and at the same time will make possible discharges when such are needed; the other three on the right bank will also take care of outflows from controlling works.

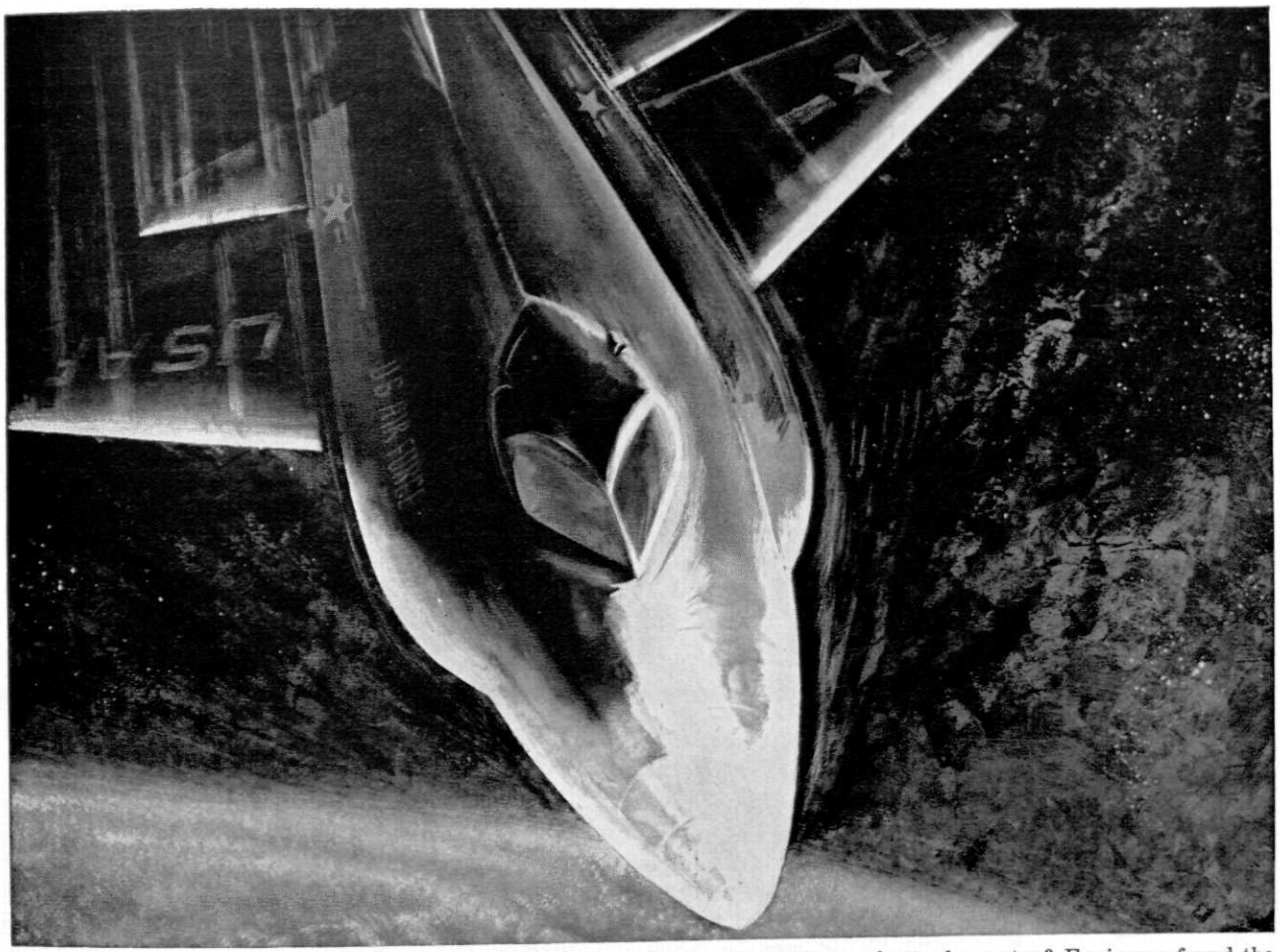
The intake works at the Raudales dam will be located on the left bank of the river, using tunnels number One and Two that feed the hydroelectric turbine.

This dam is rock fill with impervious core of compressed clay, gravel and sand filters. Its crest will be 20 meters wide, 450 meters long, and 130 meters high. The total capacity of the Raudales dam is 12,500 million cubic meters, which makes it the largest in Latin America. The artificial lake formed by the reservoir will cover an area of 29,000 hectares.

The filling in of land depression with silt carried by the river is an additional feature of the Grijalba project. The drainage method is to be utilized in the formation of soil. Past experience, that at the Don Martin dam in the state of Coahuila, shows that while from 1931 to 1938 its system worked normally, by the end of 1938 the reservoir went completely dry, indicating that silt deposited along the far end right to the wall of the dam not only preserved the bed of the Salado river, but also the grass that had grown in it. Something similar was observed in 1953 in the Marte R. Gomez dam after ten years in operation. Such eventualities are being prevented in the construction of the Raudales dam.

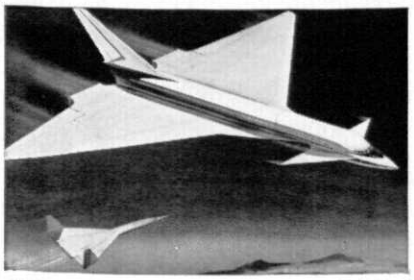
To form the reservoir of this dam it was necessary to close three openings by means of section dikes similar to those of the dam in which 17 mil-

(Continued on Page 36)

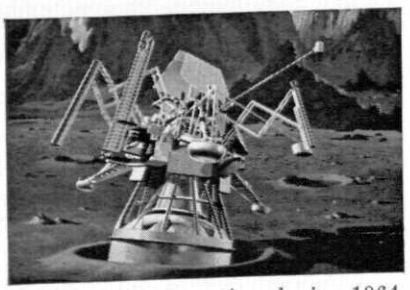


X-15—the famed research rocket plane that has reached speeds over 4000 mph and altitudes of 314,000 ft. Re-entering the atmosphere on the way back home, friction can make it glow like a red hot poker. The intense heat on the surface of the ship would soften and weaken materials normally used in aircraft construction. What kind of metal can be counted on to stay strong at the red heat of re-entry? Engineers found the answer to this difficult problem in a Nickel-containing alloy strong enough to resist sizzling temperatures of 1000 degrees, and more.

How Inco Nickel helps engineers make new designs possible and practical



2000 mph airliner—a supersonic jet that will fly from New York to London in just over 2 hours at speeds of 2000 mph, and at 70,000 ft. altitudes. What will hold her skin together? Logical choice: a brazing alloy containing palladium (one of the 14 elements produced by International Nickel), providing great strength at high temperatures—up to 630° F—caused by supersonic speeds.



Moon crawler. Sometime during 1964, this spider-like object—the "Surveyor"—is expected to land on the moon's surface and transmit information to earth on what the moon looks like and what it is made of. What metal will this machine need to withstand the extreme cold? Most likely a Nickel-containing alloy to provide toughness at sub-zero temperatures.

Today's engineer is aware of the advantages of Nickel-containing metals. He knows that Nickel, or one of its alloys, can make hundreds of new designs – from the strong, heat-resistant skin of a research rocket plane, to the complex parts of a moon surveyor—perform better and last longer.

You'll find Inco's List "A" helpful and informative. It has descriptions of 200 publications, covering applications and properties of Nickel and its alloys. Write: Educational Services,

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lion square meters of materials were utilized. Flood control will be made by two structures (1) a controlled crest spillway and floodgates and (2) a floodgate structure capable of regularizing the maximum current flow of 8,500 cubic meters per second to 3,500. In case of an extraordinary flow of 20,000 cubic meters per second, which is considered improbable, the two structures can discharge 16,000 cubic meters per second or enough to regularize said flow.

While the entire project will require several years for its completion, the construction of the Raudales dam is going ahead at a speedy pace and should be in operation by the end of 1964. Along the course of the Grijalba river, all the way from this dam to its outlet into the Gulf of Mexico at the port of Frontera, Tabasco, navigation shall foster trade and the establishment of new industries. The irrigation of several hundred thousand hectares of land in the Chontalpa region will provide opportunities for settlement of large contingents of landless farmers, and will greatly increase the state's agricultural product.

Comprising the initial phase of a comprehensive long-range government program which will materially transform Mexico's southeastern region, and thus extend its benefits to the entire country, the "Raudales" dam, an admirable feat of engineering, is an undertaking of signal importance.

Acknowledgements

The technical data contained in this article has been obtained from papers from Mr. Alfredo Varela E. Colin, civil engineer, and Under-Secretary of the Secretariat of Hydraulic Resources, and Mr. Jorge L. Pedrero, civil engineer.

MSU NEWS NOTES

What noise grabs a person's attention best?

Dr. Herbert J. Oyer, professor of speech at Michigan State University, plans to find out.

Working through a $42,780 grant from the Office of Civil Defense, Dr. Oyer will attempt to determine what sound or combination of sounds would be the optimum warning signal in event of an attack on the United States.

What qualities would the optimum signal have in addition to being easily audible? Dr. Oyer, who has just started on the project, is not sure at this point.

"Offhand, however," he said, "I can think of several probable requisites.

"The sound should be of a disturbing nature. Perhaps it should be a sound that suggests danger to a person.

"It should be a sound that would not be confused with some other, something different from the telephone bell or a fire engine which people are used to hearing. It ought to arouse a person from sleep as well as compete with the noises of his regular environment."

The sound could resemble a human or animal sound, Dr. Oyer observed. Also, he added, several attention-getting noises could be combined into one signal.

One sound Dr. Oyer wants to try is "white noise." This is a blend of several frequencies (pitches) just as white light is a blend of several colors of the spectrum.

"White noise makes a sort of hissing sound, like a steam clothing presser," Dr. Oyer said. Slight variations in the blend, he added, produce other sounds.

The MSU researcher pointed out that frequency (pitch), intensity (loudness) and other properties of sound can be regulated to produce sounds of any given specifications, natural or unnatural. Sound waves can be clipped off and regulated in other unusual ways.

"We can do all kinds of things with sound," Dr. Oyer said, "but what is ultimately the best warning signal remains to be determined."

After a thorough review of past research related to this project, Dr. Oyer plans to conduct laboratory experiments and actual field trials to determine the relative warning values of various sounds.

—MSU Information Services

The need for ICBM nose cones that are invisible to enemy radar was listed as a requirement of the Space Age by the chairman of mechanical engineering at Michigan State University.

Dr. Charles R. St. Clair, who was engaged in missile research for Avco Corp. before coming to MSU last April, noted that such a missile would be highly invulnerable to antimissile missiles.

Known interception techniques, he explained in an address to the MSU Men's Club, depend upon being able to detect and track an oncoming missile on radar.

Space scientists investigating the problem of undetectable missiles think the solution could be a matter of shape or material, or both, Dr. St. Clair said.

The MSU engineer pointed out that a missile nose cone, the part which carries the payload, is shielded from the heat of re-entry by an ablating material.

"This material," he said, "can be made of plastics and silica. It has to have low heat conductivity and burn away during re-entry, much like a piece of wood.

"When the nose cone re-enters the atmosphere, the material is chemically decomposed and vaporized by the intense heating, but only part of it is destroyed before the nose cone is slowed and the heating decreases. The rest of the vehicle is protected."

While use of the ablating material has solved the basic problem of re-entry heating, several improvements are needed, he continued.

Among them, he said, is the need to develop materials or designs which will permit constant radio communication with the ground. At present, there is a temporary "blackout" as re-entry forces create a sheath of charged particles around the cone.

Before space scientists decided on ablation-type nose cones, Dr. St. Clair said, designs called for cones constructed of solid copper with a mirror-like surface.

"The objective," he said, "was to absorb the heat from the gases flowing over the surface and conduct it away from the surface rapidly enough to prevent surface melting . . . It probably was capable of operating successfully but it was exceedingly heavy."

As associate manager of the physics research department at Avco, Dr. St. Clair was involved in the design of nose cones for the Minuteman and Titan missiles.

—MSU Information Services

HOW CUTLER-HAMMER CREATIVE ENGINEERING HELPS INDUSTRY REACH ITS AUTOMATION GOALS

Ralph Millermaster, vice president, engineering and development, answers the questions most frequently asked by students regarding Cutler-Hammer's role in industrial automation

Q. How long has Cutler-Hammer been in Automation?

A. Long before the word "automation" was coined.

Many company historians view the installation of the first electric turret-turning control for battleships as our original "automatic system" achievement. In 1904, trials aboard the U.S.S. INDIANA so improved rapid-fire and gunnery-control scoring that identical systems were installed on sister ships.

Q. How does your Automation—or "System Control"—effort differ from your other control business?

A. We work in two areas of control. One involves research, development and manufacture of standardized electric control components and apparatus. Here the customer orders from us through a bill of material.

The automation customer is different. He has no bill of material—he has a problem. He needs to improve production or quality, or to reduce his unit costs. He isn't buying "hardware," he's seeking a creative solution to a challenging problem . . . and that's what our engineers provide.

Q. Assuming I decide to work for a control manufacturer, why Cutler-Hammer?

A. The most compelling reason is our continuing interest and extensive experience in "System Control." This is the life of our company and distinct career advantages result from this concern.

Our engineers are forced to apply a combination of advanced electronic and electrical engineering know-how to solve a customer's manufacturing problem. They start with a thorough grounding in the customer's products—how he moves and works the materials he manufactures. Then they apply their technical knowledge to create a practical solution. We have a Materials Handling group, a Metal Processing group, and many other industry groups composed of young, creative-minded engineers.

And, we don't "stock-pile" our engineering talent. Every engineer we hire is expected to contribute quickly and directly to the team effort.

Q. How does Cutler-Hammer approach an automation job?

A. We have learned that a sizable system needs painstaking coordination between many groups—project teams, engineering, maintenance and purchasing personnel at the customer factory and headquarters locations . . . machinery builders, motor manufacturers, contractors and many more.

We view this coordination as one of our primary functions, and fulfill it by furnishing all responsible groups and individuals the information they want and need to guarantee an efficient dovetailing of effort.

We organize a coordinating task force for each project, headed by a lead engineer and staffed by engineers representing every necessary technical discipline. That task force is charged with three duties:

1. Create a system that will solve the problem.
2. Design the system within the time allotted.
3. Install the system at a cost which pays its way for the customer and provides us a fair profit.

Task forces work together in a modern 500,000 square foot plant specifically designed to house every activity involved in the evolution of the complete system. Every possible step has been taken to provide a climate that is conducive to creative planning and development.

This approach has paid off! Long recognized as a leader in standardized motor control, Cutler-Hammer is more and more being regarded as a major contributor in industrial automation. Our automation credentials include innovations in every industrial field from continuous process lines to newspaper mail rooms.

Q. How do I learn more about Cutler-Hammer's automation capability and the career opportunities for engineers?

A. By visiting your Placement Office . . . picking up the Cutler-Hammer literature on the rack, and talking to your Placement Director. Or, you can write direct to T. B. Jochem, Cutler-Hammer, Milwaukee, Wisconsin, for a complete kit of information. And, I hope that you will plan to meet with our representative when he visits your campus.

WHAT'S NEW FOR YOU? ASK...

CUTLER-HAMMER

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CONTROL

WHAT ARE YOU WORTH?

(Continued from Page 16)

gressive the experience was. If you worked four years but were only repeating six months experience eight times over, you are not as valuable as you would be if all four years had been progressive experience.

Other companies, after asking what other offers were made, will simply make an offer of whatever the budget of the department chosen can stand, regardless of any background factors.

This is an example of starting salary calculation. A list of the pertinent factors are:

Age: 26
G.P.A.: 2.56
Extra-curricular Activities:
- Organizations: 4, 2
- Honoraries: None
- Fraternities: None
- Other: None
- Marital Status: Married, 2 children
- Military Service: 48 months, Navy, AT2
- Previous Experience: 18 months, Wedemeyer's Electronic Supply Co. and Lear-Siegler Inc.

Estimate a salary between $575 and $625 since 70% of the 1962 class made this. From Table III, under four Background Factors in age and gpa, average the three salaries and set this average aside for later use.

$ 585
620
624
$1889

$629
3/1889

$629

Set the extrapolated figure of $650 from Table IV aside. Because of membership in four organizations and holding office in two, set aside $600. A married veteran should use the figure $635. Because of employment by Lear-Siegler last summer and 15 months by Wedemeyer's add $622 to the list. Now find the average of these figures:

$ 629 analogous to other students
650 extrapolated average
600 officer of an "Organization"
635 "Married Veteran"
622 "Previous Experience"
$3136

$627
5/3136

$627

Therefore, the predicted average of all offers received for permanent employment this year will be approximately $627 per month or $7,524 per year, $884.83 of which will go for Federal income tax leaving a net salary of $6637.17.

If the employee is single, tax on his $7,524 per year salary will be $1,415.

Now that you think you know what you're worth, don't walk into an interview with your mental calculator going, trying to figure out how large a salary you can wring out of the employer.

Seniors last year, for example, did not all accept the highest starting salary which they were offered. Most people would rather be doing a job they enjoy, with less salary, than one which is a high paying headache.

There are other important considerations to be made before a graduate chooses the company to work for: (1) what is the company's growth potential over the next few decades; (2) what kind of a story does the company's annual report tell; (3) what are chances for advancement; (4) what opportunities are offered for further education; (5) what percentage of their business is tied up in government contracts, i.e., how diversified are they in their interests; (6) company location; (7) the city; (8) recreational facilities, company and city; (9) taxes, state, county, city, school and property; (10) housing availability and comparative cost; (11) is the company growing or dying; (12) how much

No Background Factors	a	b	c	d	G.P.A.	Age
$570					2.53	23
595					2.7	22
602					2.58	21
1 Background Factor	**a**	**b**	**c**	**d**	**G.P.A.**	**Age**
$530	x				2.5	21
550	x				2.8	23
560	x				2.9	22
560	x				2.3	21
565	x				2.2	21
576	x				3.75	22
585	x				2.7	22
590	x				2.4	22
590	x				2.2	22
590			x		2.65	26
602	x				2.4	22
602	x				2.52	22
610	x				2.53	22
610	x				3.52	21
620	x				3.2	26
2 Background Factors	**a**	**b**	**c**	**d**	**G.P.A.**	**Age**
$570	x		x		2.33	25
580	x	x			2.4	22
585	x			x	2.3	23
593	x			x	2.5	22
596	x	x			2.93	22
600	x			x	2.3	21
600	x			x	2.94	23
610	x			x	2.9	21
616	x			x	2.9	22
650	x			x	3.5	23
655		x	x		2.98	25
3 Background Factors	**a**	**b**	**c**	**d**	**G.P.A.**	**Age**
$575	x	x		x	2.7	22
575	x		x	x	2.7	26
585	x	x	x		2.77	25
585	x	x		x	2.44	22
585	x	x		x	2.9	25
600	x	x		x	2.5	23
650	x	x	x		2.56	26
684		x	x	x	2.7	27
700	x		x	x	3.15	25
713	x	x	x		3.28	41
735	x	x		x	3.16	26
4 Background Factors	**a**	**b**	**c**	**d**	**G.P.A.**	**Age**
$560	x	x	x	x	2.7	22
585	x	x	x	x	2.54	26
600	x	x	x	x	3.0	30
620	x	x	x	x	2.56	27
628	x	x	x	x	3.1	27
660	x	x	x	x	2.34	28
684	x	x	x	x	2.45	26

Table III

stress is placed on R & D; (13) what is the nature of the training program; (14) is the job description informative enough; (15) what are the ages of the men in management; (16) what are the records of past graduates of MSU whom they have hired?

The interview should bring out the answers to many of these and any other questions a prospective employee has.

Listed in Table V are the companies who hired last year's seniors and the breakdown by numbers.

Table VII was set up to correlate starting salary and gpa with the amount of previous experience a person had. The "Previous Experience" salary is listed in order of magnitude. A close correlation exists between the number of months of previous experience and salary; the more experience, the more a prospect is valued. However, Table VI shows no correlation between gpa and length of previous experience.

The correlation becomes clearer when certain groups are averaged together as in Table II.

Those so dedicated to a field of interest in engineering that the starting salary is immaterial should find useful information in Group II.

Under Category 1, no one is going to graduate school this year with less than a 2.9 average.

Months Experience	S.S.		G.P.A.	
2	$600		2.3	
3	650		3.5	
3	577	612	2.7	3.0
3	610		2.9	
4	616		2.9	
6	560		2.7	
6	575		2.7	
6	585	604	2.44	2.78
6	600		2.94	
6	700		3.15	
9	585		2.9	
12	585		2.54	
12	600	592	2.5	2.52
15	593		2.5	
18	585		2.3	
24	620		2.56	
29	660		2.34	
57	735		3.16	
60	600		3.0	
84	684		2.7	

Table VII

Under Category 2, one student is being admitted to graduate school with only a 2.65 average; he is not taking advanced engineering work. In general, with a low gpa, a graduate can still obtain admission to do graduate work in another college, such as law, business, accounting, etc.

Among those taking graduate work is a conspicious lack of married students and/or veterans compared with those students who went directly into industry. Those vets who went into industry probably went into the service directly out of high school for several reasons, (1) financially unable to start right in with college directly out of high school, (2) emotionally unprepared for the rigor of collegiate academic study, (3) not sure where they were headed or what they wanted out of life. Many found themselves ready for college on all accounts after a maturing tour of duty in the service. Most veterans are also married (70%). Hence, from their maturing look at the outside world while in the service, and their responsibilities as a bread winner, they have acquired the drive or ambition to make the grade, if only by sheer determination.

On the other hand, those going to school for graduate work (1) were in the top 10% of their high school graduating class, (2) wasted little time on social events (they could have participated in extra curricular activities without "wasting" any of their time), (3) are very dedicated to their studies, (4) and don't have the responsibilities of a family man.

Company	Number Employed
I.B.M.	9
Hughes	6
Douglas	5
N.A.A.	4
Nortronics	3
G.E.	3
A.C. Spark Plug	2
Autonetics	2
Bendix	2
Lockheed	2
Western Electric	2
Boeing	1
Borg-Warner	1
Control Data	1
Lear-Siegler	1
R.C.A.	1
Raytheon	1
Sylvania	1

Table V

Previous Experience Salary	Months	S.S.	G.P.A.	Factors a	b	c	d
$258	6	$560	2.7	x	x	x	x
300	6	575	2.7	x	x		x
300	15	593	2.5	x			x
322	6	600	2.94	x			x
337	3	610	2.9	x			x
345	12	600	2.5	x	x		x
353	24	620	2.56	x	x	x	x
355	3	577	2.7	x		x	x
375	6	585	2.55	x	x		x
388	2	600	2.3	x			x
402	4	616	2.9	x			x
418	12	585	2.54	x	x	x	x
425	60	600	3.0	x	x	x	x
430	18	585	2.3	x			x
430	6	700	3.15	x		x	x
452	3	650	3.5	x			x
460	29	660	2.34		x	x	x
472	9	585	2.9	x	x		x
485	84	684	2.7		x	x	x
500	57	735	3.16	x	x		x

Table VI

On the other hand, those going to school for graduate work (1) were in the top 10% of their high school graduating class, (2) wasted little time on social events (they could have participated in extra curricular activities without "wasting" any of their time), (3) are very dedicated to their studies, (4) and don't have the responsibilities of a family man.

A Word From The Author

I hope you'll now be in a better position to make an intelligent decision about this major step in your life.

(Continued on Page 40)

GROUP II

Category 1: Graduate School, M.S.U.

G.P.A.	Extra Curricular Activities				Married		Military Service		Previous Experience		Factors				Name of School
	O	H	F	Ot	No. of years	No. of children	Mons.	Branch	Months	$/Mon.	a	b	c	d	
3.5		2									x				
3.42	2 ①	4 ②	1		2		48	N	3	458	x	x	x	x	
3.4	1	3							9	375	x			x	
3.65	1	2							3	400	x			x	
3.26	2	4 ①							3	360	x			x	
3.1		1	1								x				
3.0		1	2								x				
2.9	2	1	1						6	475	x			x	
3.18	1	6 ②	1						3	280					
3.94	④	7	1	3					6	400	x			x	
Category 2: Graduate School, elsewhere															
3.45		4			7	3			36	?	x	x		x	?
2.8	3 ②①								3½	200	x			x	?
2.95	1		1						3	408	x			x	Ohio State
2.98	2			1							x				Purdue
3.65	1	2			2	1					x	x			U of M
3.0	③	2	①						6	400	x			x	Harvard Business School
2.65		1			3	2					x	x			Duquesne U
3.0				2					12	440					U of Penn.

Name of company Name of school	S.S.	G.P.A.	Extra Curricular Activities				Military Service		Previous Experience	
			O	H	F	Ot	Mons.	Branch	Months	$/Mon.
Bell Tel. Labs N.Y. University	?	3.3		3		3			3	?
Bell Tel. Labs N.Y. University	565	3.87	1	3						
Bell Tel. Labs N.Y. University	575	3.3	3	3	①				12	410
I.B.M. Syracuse U. N.Y.	585	2.8	3	0	1					
Square D Co.	585	3.3	5	④	2		36	A	5	412

(Continued from Page 39)

I enjoin next year's AIEE-IRE student officers to continue this survey to further validate or disprove the correlations I've made this year. I have made "cliff hangers" out of many correlations, i.e., the results are inconclusive due to the lack of an adequate sampling of students in each of the different categories.

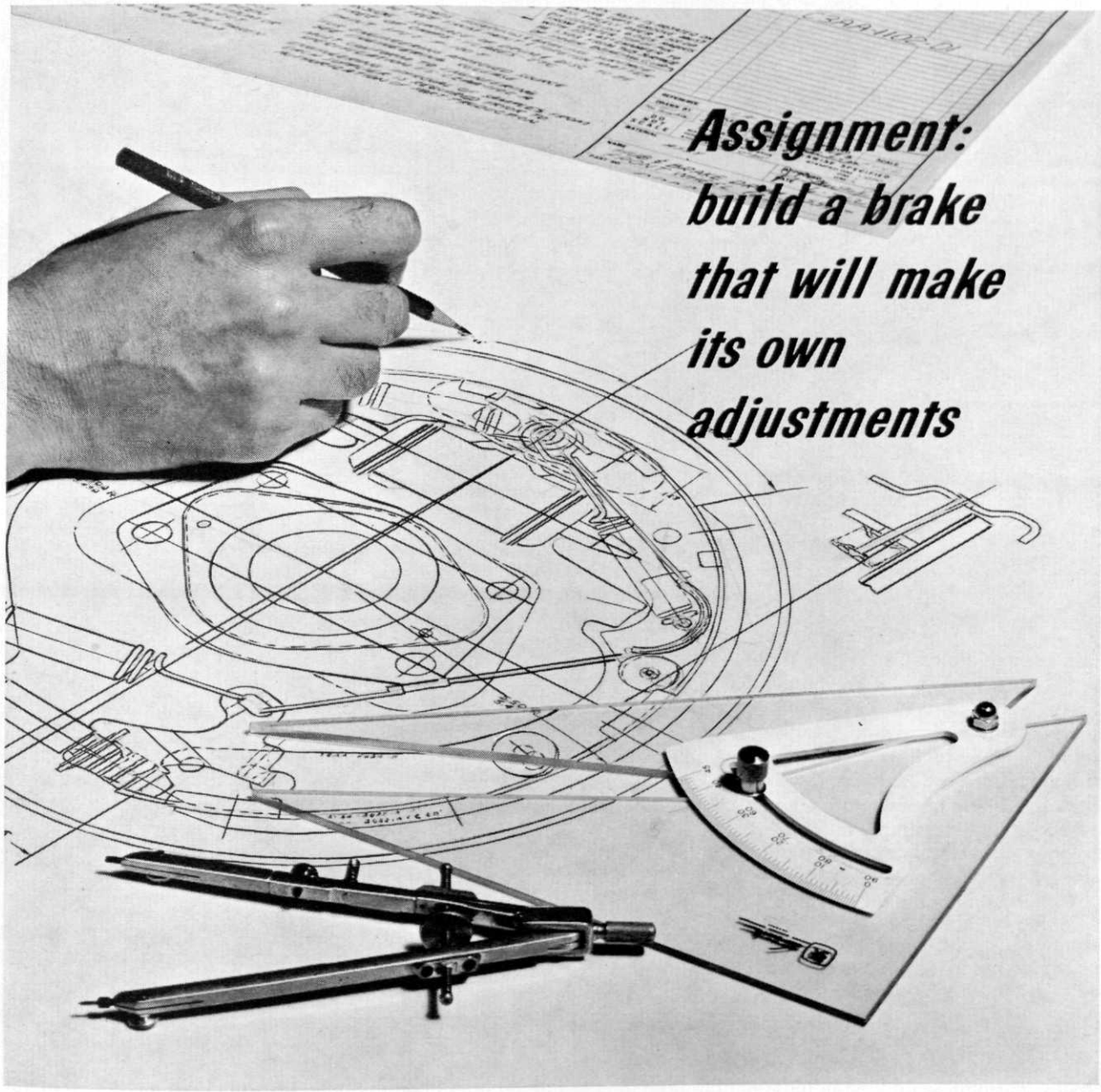
Good luck and good job hunting!

Salary Range	% of Students In This Range	Avg. G.P.A.
$525-549	2% (1)	2.5
550-574	15% (7)	2.53
575-599	34% (16)	2.78
600-624	36% (13)	2.76
625-649	2% (1)	3.1
650-674	8.5% (4)	2.84
675-699	4.2% (2)	2.57
700-724	4.2% (2)	3.21
725-749	2% (1)	3.16

Table II

Acknowledgements:

Thanks to the following people for their comments on the article: Dean Ryder, dean of the College of Engineering; Dr. L. W. Von Tersch, chairman of the Electrical Engineering Department; Mr. Fitzpatrick of the Placement Bureau; Professor Baccus, AIEE-IRE faculty advisor; Dr. Richard Reid, Electrical Engineering faculty member; Pete Stewart, chairman of the AIEE-IRE; Ron Reynolds, vice-chairman of the AIEE-IRE; and Vic Humm, former Spartan Engineer student editor.



It's now a fact: every Ford-built car in '63 has self-adjusting brakes

"Give us a brake," Ford Motor Company engineers were told, "that will automatically compensate for lining wear whenever an adjustment is needed—and make it work for the entire life of the lining."

Tough assignment—but not insurmountable. Today, not only does every Ford-built car boast self-adjusting brakes, but the design is so excellent that adjustments can be made more precisely than by hand.

This Ford-pioneered concept is not complex. Key to it is a simple mechanism which automatically maintains proper clearance between brake drum and lining.

Self-adjustment takes place when the brakes are applied while backing up. This adjustment normally occurs but once in several hundred miles of driving. The brake pedal stays up, providing full pedal reserve for braking.

Another assignment completed—and another example of how Ford Motor Company provides engineering leadership for the American Road.

Ford

MOTOR COMPANY

The American Road, Dearborn, Michigan

PRODUCTS FOR THE AMERICAN ROAD • THE HOME THE FARM • INDUSTRY • AND THE AGE OF SPACE

Finagle's Axioms and the Snafu Equation

EDITOR'S NOTE: We found this in the Missouri Shamrock—enjoyed it—thought you might too.

As Engineering students, it is important that we should know not only the goals and extent of engineering, but also the horizons and limitations. One of the primary differences between a scientist and an engineer is that whereas a scientist wants to know exactly what is happening inside a device, an engineer is satisfied if the device works well. True, theory is very important to an engineer, but let us not forget that our primary purpose is to apply the theory to some beneficial purpose.

In applying theories, it is often necessary, in the interest of labor-savings, to make "engineering approximations," some of which tend to leave Pure scientists and mathematicians white-faced and shuddering. As engineers, however, we merely shrug and proceed, often throwing caution to the winds.

Because of the many approximations and assumptions which are commonly used, there is usually some inconsistency in experimental work.

There are some twenty-nine axioms, known as Finagle's axioms, which should be known by every engineer who is concerned with experimentation, calculation, production or testing.

They are presented here in two sections, one concerned with experimentation and calculation, the other with production and testing. The axioms are arranged in semi-logical order, (i.e. as logically as possible), and are numbered separately in each section.

There is also an equation, called the general snafu equation, which relates actual experimental results with actual correct results. The equation, with its empirical proof is presented, in the form of a theorem, immediately following the list of axioms.

NOTE: This list of axioms may not be complete. If the reader is aware of any other axioms, please notify the author of them, c/o this publication. It will be greatly appreciated. cmp

Finagle's Axioms

On Experimentation & Calculations

1. In any calculation or experiment, any error which can creep in will do so.
2. Those factors which cannot go wrong, will probably go wrong anyway.
3. No matter what goes wrong, it will probably look right.
4. Any error will be in the direction of most harm.
5. Constants, especially those from engineering handbooks, must be treated as variables.
6. When an error has been found and corrected, it will be found to have been correct in the first place.
7. Any data, which, when included in a calculation, produces the desired result, are fair data for the calculation.
8. (Corollary to #7) If enough data is available, anything may be proven by statistical means.
9. Hell hath no fury like an unjustified assumption.

On Production & Testing

1. The most vital dimension on any plan or drawing stands the greatest chance of being omitted.
2. Major design changes will always arrive after construction is nearly complete.
3. Parts that positively cannot be assembled in improper order will be.
4. Interchangable parts won't.
5. A part requiring service or adjustment will be in the least accessable position.
6. Service conditions as given in specifications will be exceeded.
7. All delivery promises must be multiplied by a factor of 2.00.
8. Manufacturers specifications of performance must be multiplied by a factor of 0.50.
9. Salesmen's claims for performance must be multiplied by a factor of 0.25.
10. Installation and operating instructions will be promptly discarded by the shipping department.
11. The best approximation of service conditions in the lab will not begin to meet those conditions encountered in the field.
12. If only one bid can be secured on any project, the price will be unreasonable.
13. If a safety factor is set through service experience at a maximum value, someone will promptly devise a method to exceed said safety factor.

14. Identical units which test in identical fashion will behave dissimilarly in the field.

15. If a test installation functions perfectly, all subsequent production units will malfunction.

16. Warranty and guarantee clauses are voided by payment of the invoice.

The Snafu Equation

Theorem;

The results of an experiment performed under controlled laboratory conditions by competent personnel, using accurately calibrated equipment can be described by the following non-convergent infinite power series, whose coefficients are semi-random functions of space and time.

$$x^1 = K_1x + K_2x^2 + K_3x^3 + K_4x^4 + K_5x^5 + K_6x^6 + \ldots.$$

Where:

x^1 represents the correct results;

x represents the experimental results;

K_1 represents Finagle's constant (variable);

K_2 represents the fudge factor;

K_3 represents the Bugger variable (constancy);

K_4 represents the Diddle factor;

K_5, K_6, K_7, . . . are as yet unknown, although

K_5 is generally known as the tohellwithit factor.

NOTE: The proof is not rigorous, but empirical. In fact, no known rigorous proof exists, which bothers us not at all.

Suppose that a certain experiment, say Q, is performed under the specified conditions at some time t at the south end of a lab, say at position x_1, positive x being to the north. Suppose that Q is performed by a second similar group at the north end, say $x_1 + 30$, also at time t. It will soon be discovered that the conclusions of the two groups do not agree. If both groups repeat the experiment at some later time, say t^1, it will be seen that neither group can duplicate the previous data; i.e., there will be four sets of conclusions, no two of which are the same.

Further attempts at duplication will only produce more sets of inconsistent data. Thus, it is seen that the Snafu equation holds, although since the K's vary in semi-random fashion (i.e. sometimes random, sometimes not, thus preventing use of random number tables in the solution), it is of little practical use. This may, indeed, be the reason that K_5 appears to be the most commonly used term.

Michigan Geophysical Exploration by M.S.U.

Great reservoirs of oil hidden deep under Michigan in the limestone reefs of an ancient sea are being brought closer to discovery, reports a Michigan State University geophysicist.

For three years, Dr. William J. Hinze has led MSU student teams measuring gravity and magnetic force across most of Michigan, particularly the lower peninsula.

He and others have long suspected that valuable supplies of oil and other minerals are trapped under a mile-or-more-thick covering of sediment and glacial deposits from the ice ages.

"The results of our investigations," the associate professor of geology suggests, "should make it easier to locate this wealth by reducing the risks involved in deep-drilling and deep-mining operations.

"We cannot be certain that a particular venture will pay off but we can reduce the odds."

The extent to which the information is helpful, he points out, depends on how shrewdly it is interpreted. All geophysicists, however, need this kind of data to make reasonable predictions.

Geophysical techniques improve the oil drillers chances of striking it rich.

"The use of geophysics," Dr. Hinze points out, "cuts the risk in half."

To aid in interpretation, Dr. Hinze has made detailed gravitational, magnetic and seismic observations in Michigan oil-producing areas and is developing methods with his graduate students for using the MSU computer to determine when similar measurements from other areas signify the likely presence of oil.

The MSU scientist is certain that there is much more oil under Michigan than has been found so far. He also believes that more iron, copper and other mineral deposits will be discovered and worked.

At least a dozen oil and mining companies, including some of the biggest in the nation, have demonstrated strong interest in Dr. Hinze's work.

He estimates that they have donated or lent to MSU the use of about $100,000 worth of geophysical instruments and about $50,000 in direct grants and fellowships.

The National Science Foundation has also participated in underwriting the cost of research performed by undergraduates during extensive field trips throughout the state.

—*MSU Information Services*

SO WHAT ELSE IS NEW?

G-E Lightning

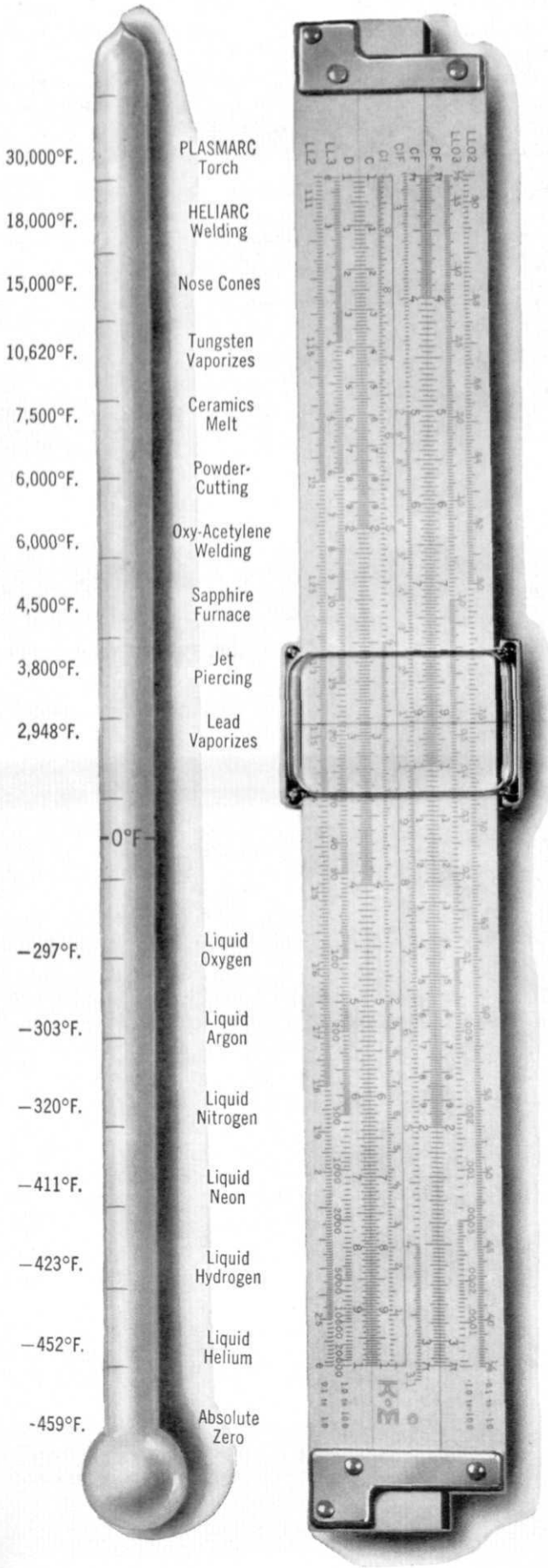
General Electric engineers have been assigned the task of measuring the effects of lightning strokes on missile sites.

Under a $400,000 contract from the Air Force's Special Weapons Center at Kirtland Air Force Base, New Mexico, G.E.'s Radiation Effects Operation will build instrumentation to measure lightning effects on missiles, missile pads, and associated electronic equipment.

In addition, the G-E group will conduct artificial lightning tests in conjunction with the Company's High Voltage Laboratory in Pittsfield, Mass., to initially check out the instrumentation and present lightning protection equipment.

Moreover, the Company's General Engineering Laboratory in Schenectady will provide one of the first histories of atmospheric behavior surrounding the time of a lightning stroke. Previ-

(Continued on Page 48)



A career at LINDE is a matter of degrees

Degrees—temperature as well as engineering—really matter at Linde Company.

LINDE, a leading commercial producer of industrial gases for over 50 years, is now engaged in many diverse industrial activities. Heat, cold, pressure, vacuum, and engineering talent are the basic creative tools used in continuing efforts to develop new products and advanced technological capabilities. Temperatures utilized may run as hot as 30,000°F., to as cold as −452°F. This work particularly requires the skills of Mechanical, Chemical, Metallurgical, Electrical, and Civil engineers.

There are excellent opportunities in programs in Cryogenics, Plasmas, Flame-Plating, Industrial Gases, Electronics, Molecular Sieves, Bio-Chemistry, Crystallography, and other technical areas.

You can look forward to a rewarding career in Research, Development, Design, Engineering, Production, Sales Engineering, Administration.

LINDE is a nationwide organization with offices, plants, factories and laboratories throughout the country. Where you work will largely depend upon the work you do.

Research and Development: LINDE has three technical centers at Buffalo, N. Y., Newark, N. J., and Indianapolis, Ind.

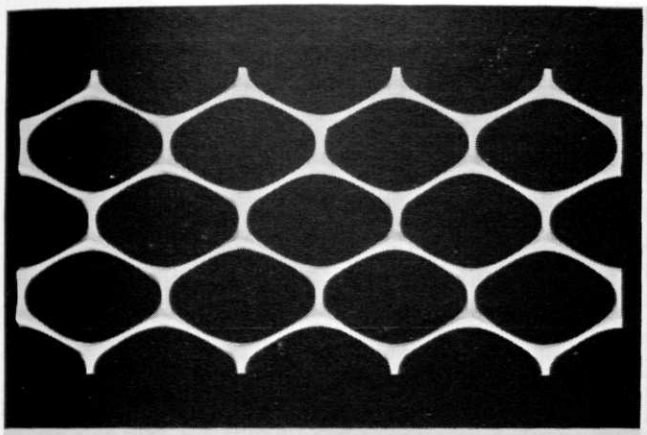
Production Facilities: LINDE operates production facilities in nearly every state of the Union.

General Offices and Sales Offices: LINDE's general offices are located in New York City; region sales offices are located in major cities throughout the country.

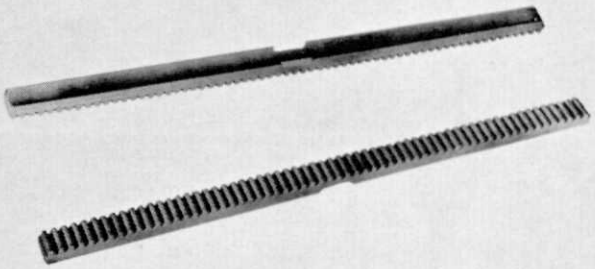
LINDE offers a progressive employment benefit program: relocation; Educational Refund Plan for advanced study in your field of interest. Promotion from within is a basic company policy. For further information, please contact Mr. E. R. Brown, Jr., Department 3742, Linde Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. All inquiries will receive prompt replies.

LINDE COMPANY UNION CARBIDE

AN EQUAL-OPPORTUNITY EMPLOYER

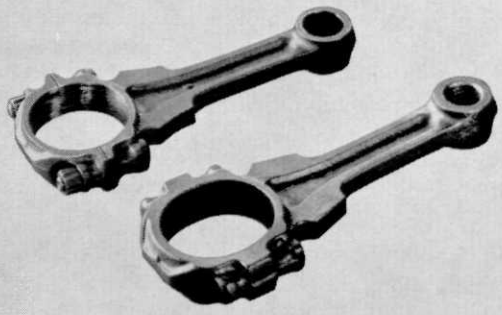


Pencil-Thin Treillage must be made of a metal that flows evenly and fully into every part of intricate molds. It must also resist corrosion and be able to absorb hard blows without breaking. Because Malleable iron has all these requisites, it is used for highest quality treillage in traditional and contemporary designs.



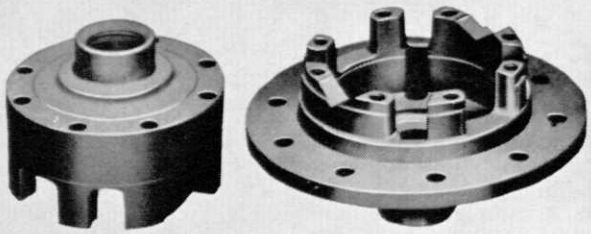
Two And One Half Foot Long Gear Racks for boat trailers look like costly machined bars. These racks are now Malleable iron castings, and are used without any finish machining. A concave impression running along the entire length underneath closely fits the pipe to which it is welded.

Which Would You Design As Malleable Castings?



Automotive Engine Connecting Rods are prime examples of highly stressed parts. Alternating tension and compression for millions of cycles demands high fatigue strength. Modern design, testing and production techniques have been combined to produce pearlitic Malleable connecting rods of superlative quality that are now being used in American cars.

Send for this 16 page "Malleable Engineering Data File." You will find this informative brochure is an excellent reference piece.



Limited-Slip Axle Differential Components of the design shown require high strength, hardenability and close tolerances. Expensive machining is eliminated by creating complicated interior details with shell molding. The use of pearlitic Malleable provides the desired combination of material and process for economical and reliable parts.

MALLEABLE FOUNDERS SOCIETY

Malleable Founders Society, Union Commerce Building, Cleveland 14, Ohio

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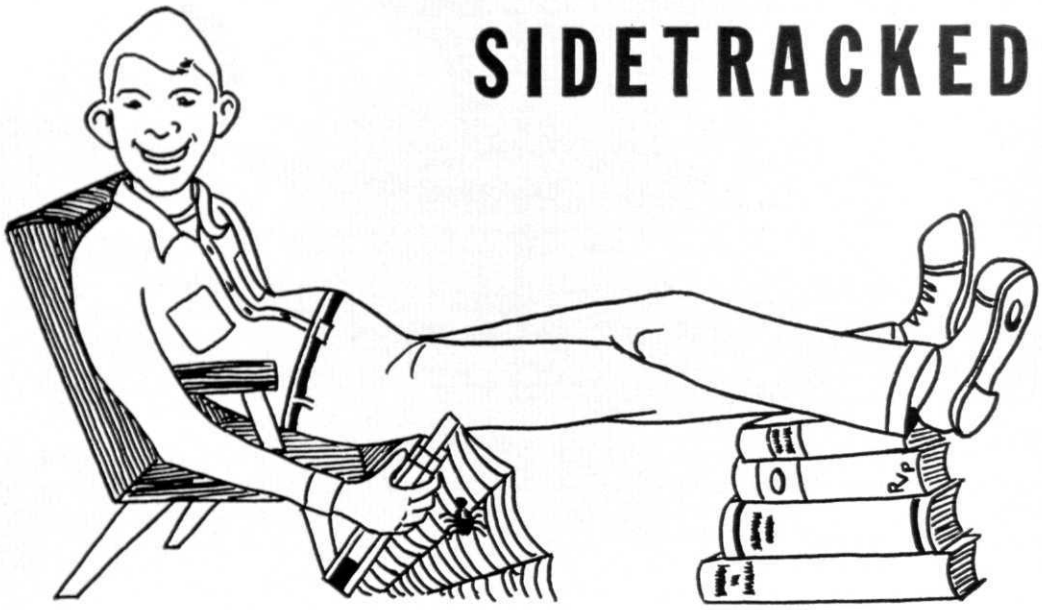


A young business man, a deacon in his local church, was going to New York on business and while there was to purchase a new sign to be hung in front of the church.

He copied the motto and dimensions, but when he got to New York discovered he had left the paper behind. He wired his wife: "Send motto and dimensions."

An hour later a message came over the wire, and the new lady clerk who had just come from lunch and who knew nothing of the previous message read it and fainted. When they looked at the message she had taken, it read: "Unto Us A Child Is Born. 6 feet long and 2 feet wide."

* * *

An old gent was passing an intersection when a large St. Bernard ran by and knocked him down.

A moment later, a Crosley car skidded around the corner and inflicted other damage. A bystander helped him to his feet, and someone asked him if the dog hurt him.

"Well," he answered, "the dog didn't hurt so much, but the tin can tied to his tail nearly killed me."

* * *

Late to bed

And early to rise.

Keeps your roommate

From wearing your ties.

The bright young high school graduate applied for his first full-time job. He read the application blank which asked:

"What machines can you operate?"

After a moment's thought he wrote:

"Slot and pinball."

* * *

A new inmate checked in at the local asylum. Whereas most of the new arrivals have a sullen attitude, this fellow was all smiles. In fact, he was laughing uproarously.

"Nearest kin?" asked the examining physician.

"Twin brother," responsed the fellow. "We were identical twins. Couldn't tell us apart. In school he'd throw a spitball and the teacher would blame me. Once he was arrested for speeding and the judge fined me. I had a girl. He ran off with her."

"Then why are you laughing?"

"Cuz last week I got even with him."

"What happened?"

"I died and they buried him."

* * *

A preacher at the close of his sermon discovered one of his deacons asleep. He said, "We will now have a few minutes of prayer. Deacon Brown, you lead!"

"Lead?" cried Deacon Brown, suddenly awakening, "I just dealt!"

The colonel was lecturing a class of ROTC students.

"A 40-foot flagpole has fallen down," he said. "You have a sargeant and a squad of men. How do you erect the flagpole again?"

The students thought, then made suggestions about block and tackle, derricks and so on.

"You're all wrong," said the colonel. "You'd say, 'Sergeant, get the flagpole up.' "

* * *

Seems that a wife, who was dearly loved by her husband, died. This devoted husband believed in cremation. After which he placed the ashes in a vase. Wishing to display his love for his departed mate by having her ashes near him, he placed the vase on his study desk.

After a while, as is the human habit, he more or less forgot her "presence" and became quite careless with his cigar ashes by using the vase for an ash tray.

One evening, a friend who knew the departed well, was visiting the widower, and casually glanced into the vase.

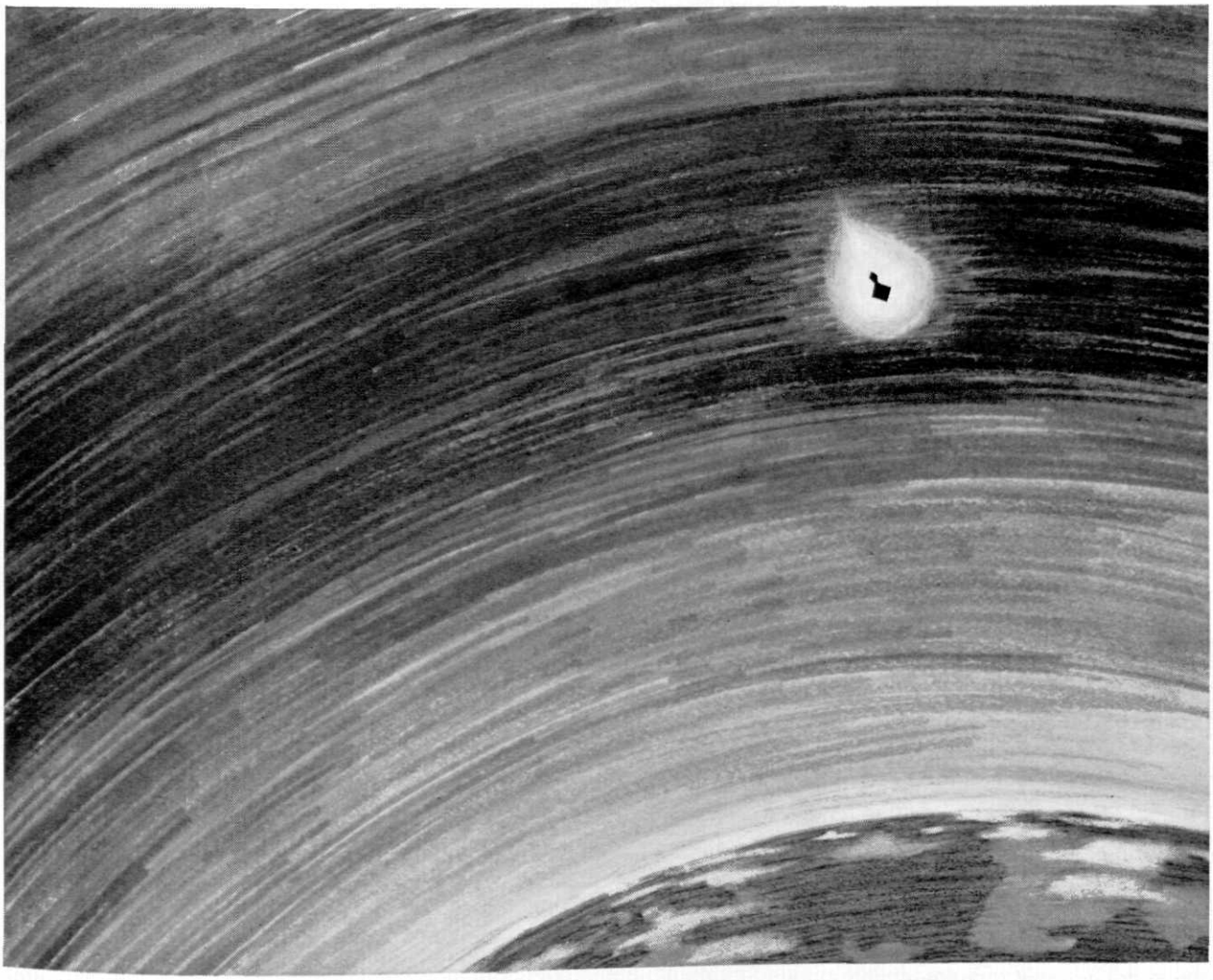
"Ah," he said, "I notice your wife has put on a little weight."

* * *

"Just because my eyes are red is no sign I'm drunk. For all you know I may be a white rabbit."

When a space vehicle slants back into the earth's atmosphere at mission's end, a curtain of silence lasting minutes closes between it and its tracking earth stations. A similar communications blackout occurs during the space firing of rocket engines. □ Villain is intense heat generated during re-entry and rocket firing which leads to ionization of atoms and disturbs or blots out radio frequencies. □ Because this phenomenon represents an obstacle to remote control of space vehicles, Douglas scientists are studying its exact causes. Work is in progress on methods of modulating or eliminating this interference.

ELECTRONIC BLACKOUT
...A STIMULATING AREA FOR CREATIVE ENGINEERS



The above is only one of hundreds of interesting assignment areas at Douglas. If you are seeking a stimulating career with an organization in the thick of the most vital programs of today and tomorrow, we invite you to contact us. Write to Mr. S. A. Amestoy, Douglas Aircraft Company, 3000 Ocean Park Boulevard, Santa Monica, California, Dept. 600-X.

DOUGLAS

THE ADVERTISER'S INDEX

So What Else Is New?

(Continued from Page 43)

ous work in this field has been limited to atmospheric measurements at chosen times during a storm. This work will give the Air Force increased scientific ability to predict strikes.

Later tests will be conducted at missile sites themselves where actual lightning will be experienced, and measurements of its effect will be made.

Lightning protection systems currently used at missile bases will be evaluated during these tests.

—Stroupp,
G.E. News Bureau

Elements Comp's Ampl.

Possibility of using cheap and abundant potassium nitrate for computer and amplifier elements is under study at General Motors Research Laboratories, Warren, Mich.

"For the first time," said John M. Campbell, GM Research scientific director, "a common, easily prepared polycrystalline, ferroelectric material has been found that exhibits much sought after low-energy electric capacitive memory properties at room temperature that are analogous to the well-known magnetic properties of ferromagnetic materials.

"This discovery of a material having nearly ideal electrical characteristics including apparent true 'coercivity,' in the language of the electrical engineer, is expected to stimulate new avenues of research leading to applications in compact electronic circuits of great interest to the computer, control and communications sciences."

Earlier experimenters had discovered a stable form of ferroelectric potassium nitrate only in the range of 110 to 125 degrees centigrade. Mr. Schubring and Mr. Nolta have now observed, however, that this range may be extended to include room temperature under certain conditions. Their present research is centered on determining the factors affecting the stability of the ferroelectric form of potassium nitrate at ordinary temperatures.

—GM Corp News

Gemini

A Gemini-type spacecraft is guided by a new orbital guidance system under development by General Electric. The spacecraft contains all the guidance equipment necessary to detect its deviation from its intended orbit.

The G-E orbital guidance system, made up of a radar altimeter and a simple digital computer, can continuously measure the spacecraft's altitude while passing over water—three-quarters of the time of a typical Earth orbit. These measurements establish the vehicle's radius from Earth's center of gravity. From the record of the vehicle's altitude during its first orbit compared with its intended orbit or trajectory, the system can determine the actual course of the vehicle for astronauts or Earth control centers.

The new G-E system can determine this information after one orbit with an accuracy now obtainable only after multiple orbits using ground tracking stations.

The entire system is self-contained for being carried in the space vehicle and weighs 20 to 30 pounds, depending upon application. It requires 30 to 40 watts of power to operate.

—J. B. Stroup, G.E.

Criticality Achieved in B&W

The world's first commercially operated pressurized water thorium converter reactor achieved criticality in August.

According to its designer and builder, The Babcock and Wilcox Company, the reactor will supply enough steam through fossil-fired superheaters to generate 275,000 KW of power, making Consolidated Edison's Indian Point station the largest electric generating station in the nation employing nuclear power.

The reactor is the world's first power generating reactor to use a combination of thorium and uranium as fuel, B&W added. Gross thermal output for the reactor is rated at 585 MW.

The reactor is a pressurized water thorium-uranium converter, and uses a basic fuel of highly enriched uranium 235 mixed with a fertile material, thorium 232. Additional fuel in the form of uranium 233 is obtained by conversion of fertile material within the reactor core.

—Babcock and Wilcox Co.

Kodak beyond the snapshot...

(random notes)

Resist education

A certain engineering college recently asked us for a contribution not of money but of a small object suitably symbolic to deposit in the cornerstone of a new building. After thinking about it a bit, we sent three intricately shaped bits of metal so small that one of them got lost and never found its way into the box that will be opened some day to show our descendants the topics that engineers in 1962 regarded as fresh and promising. Is it not true that the engineering mind today is much occupied with working metals and semiconductors in ways to get as much performance as possible from as little bulk as possible?

Doggone right. In addition to making deposits in cornerstones, we have been busy expanding the line of photosensitive resists on which this hot new art so strongly depends. Everybody in it should be delighted to learn of KOR, a new one that's 10 to 15 times as sensitive to arc light and 30 to 100 times as sensitive to tungsten light as Kodak's well-known resist, KPR. This opens up the possibility of exposing KOR by a projected image instead of by contact printing, but the photographic speed is still a little low for an ordinary enlarger. A high-intensity projection printer will turn the trick.

If you don't even know what we are talking about, you have a dangerous blind spot in your education which you could repair quickly by sending a buck to Eastman Kodak Company, Rochester 4, N.Y. for a copy of "Photosensitive Resists."

Cheaper than rubies maybe

We have entered the laser rod business. This decision looks logical enough. Lasers are a) very, very, very promising and b) connected by a strong thread to a technology about which we feel cocky —namely, non-silicate rare-earth glass, which we broke open commercially 25 years ago for photo lenses.

It was a thrill to hear that a rod of ours commenced action at a threshold of only 4 joules at room temperature. It emitted at 1.06μ by transition of Nd^{+++} from $4F_{3/2}$ to $4I_{11/2}$ (not down to ground state, which is $4I_{9/2}$). Its time to technological obsolescence will be inevitably and indubitably short.

Meanwhile, for the people busy feeling out the ground rules of laser engineering for machine tools, weapons, etc., our neodymium-boron-barium-lanthanum-thorium-strontium glass is a good first choice because 1) neodymium needs no refrigerants (fluorescence doesn't return Nd^{+++} to ground state); 2) 1.06μ is convenient to phototubes, phosphors, and photography; 3) threshold for laser action comes at ⅓ the energy input that Nd^{+++} needs in silicate glass.

You have heard of ruby lasers? They depend on Cr^{+++}. Cr^{+++} depends on the crystal field to define its energy levels. Rare earths don't need a crystal field because their 4f levels are shielded by 5s electrons. Therefore they can work in glass, which can come big and homogeneous. Already a 2" x ¼" rod with ends tuned to reflect ~100% and 98% at 1.06μ costs less than a decent used motorcycle.

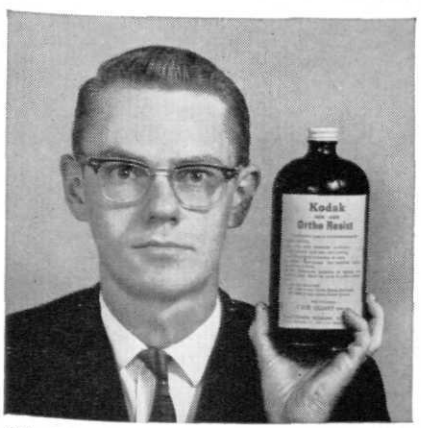
Adhesive findings

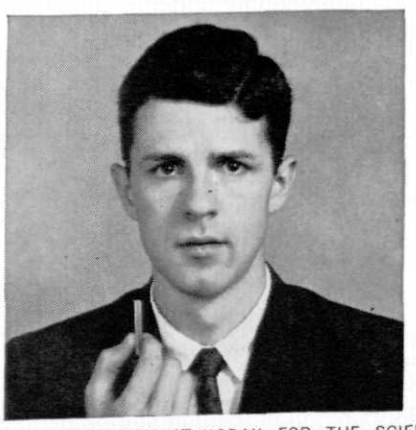
Mr. Guy V. Martin, 110 Yale Blvd., S.E., Albuquerque, N.M., has found EASTMAN 910 Adhesive vastly superior to soft solder for transmitting ultrasonic vibration. He has used up to 60 kc and electrical power inputs up to 200 watts at temperatures up to 200°F.

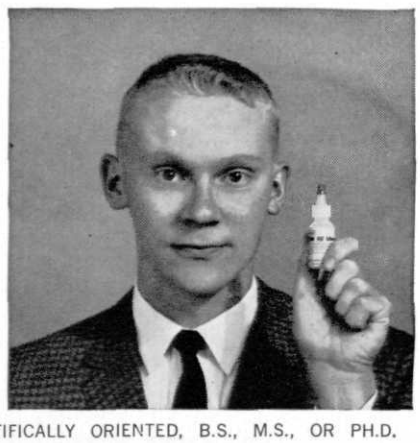
When he feeds energy like that through a solder bond from a transducer of laminated nickel sheets to an application tip, the solder deteriorates progressively and the transmission drops steadily. An EASTMAN 910 bond acts differently. Without apparent change, it transmits three to four times as long as solder takes to reach disintegration.

When the 910 bond finally snaps, it does so all at once with an audible snap. In the case of aluminum bonded to the nickel, rupture always takes place between the adhesive film and the aluminum. With other metals, plastics, ceramics, or glass bonded to the nickel, the rupture divides itself between one interface or the other and doesn't appear within the film.

Mr. Martin claims that for some 30 years Kodak has been very obliging in furnishing him helpful information from time to time. We claim that in volunteering his adhesive findings, he has now amply repaid us. We shall be very happy to furnish you, too, with helpful information for 30 years. EASTMAN 910 Adhesive is obtainable in a $5 sample kit from Eastman Chemical Products, Inc., Kingsport, Tenn. (Subsidiary of Eastman Kodak Co.). It develops great strength within seconds.





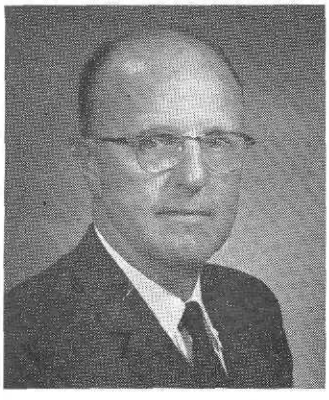


ALL SORTS OF PRODUCTS, ALL SORTS OF CAREER DEDICATION AT KODAK FOR THE SCIENTIFICALLY ORIENTED, B.S., M.S., OR PH.D.

EASTMAN KODAK COMPANY

Rochester 4, N.Y.

AN INTERVIEW WITH G.E.'s DR. GUY SUITS, VICE PRESIDENT AND DIRECTOR OF RESEARCH



Dr. Suits has managerial responsibility for the General Electric Research Laboratory and as a member of the Company's Executive Office he is directly concerned with G.E.'s over-all research programs and policies. He joined G.E. in 1930 as a physicist, and holds 76 patents, is Chairman of the Directors of Industrial Research, member of the National Academy of Science, Director of American Institute of Physics, previous Chairman of Naval Research Advisory Committee and Fellow of the AIEE, AAAS, and IRE, and has been Vice President and Director of Research since 1945.

For complete information about these General Electric training programs, and a copy of Dr. Suits paper "The New Engineer And His Scientific Resources," write to: Personalized Career Planning, General Electric Company, Section 699-05, Schenectady 5, New York.

How Scientists and Engineers Work Together in Industry

Q. Dr. Suits, I've heard a good deal about the scope of your programs. Is your research mostly in physics and electronics?

A. This is a common misconception. The work of the many laboratories of General Electric "covers the waterfront" in science and in advanced engineering technology. Some laboratories specialize in electronics research, others in atomic power, space technology, polymer chemistry, jet engine technology, and so forth. Actually, the largest single field represented by the more than 1000 Ph.D. researchers in General Electric is chemistry.

Q. Is this research performed principally by people with Ph.D. degrees in science?

A. General Electric research covers a broad spectrum of basic and applied work. At the Research Laboratory we focus largely on basic scientific investigations, much as in a university, and most of the researchers are Ph.D.'s. In other Company laboratories, where the focus is on applied science and advanced engineering, engineers and scientists with B.S. and M.S. degrees predominate. Formal college training is an important preparation for research, but research aptitudes, and especially creative abilities, are also very important qualities.

Q. What are the opportunities for engineers in industrial scientific research and how do scientists and engineers work together in General Electric?

A. Classically, engineers have been concerned with the problem "how," and scientists with the question "why." This is still true, in general, although in advanced development and in technological work scientists and engineers work hand-in-hand. Very close cooperation takes place, especially in the increasingly important fields of new materials, processes, and systems. Certainly in General Electric, a person's interest in particular kinds of problems and his ability to solve them are more important than the college degree that he holds.

Q. What does it mean to an engineer to have the support of a large scientific research effort?

A. It means that the engineer has ready access to the constant stream of new concepts, new materials, and new processes that originate in research, and which may aid his effort to solve practical problems. Contact with research thus provides a "window" on new scientific developments—world-wide.

Q. How does General Electric go about hiring engineers and scientists?

A. During each academic year, highly qualified technical people from General Electric make recruiting visits to most college campuses. These men represent more than 100 General Electric departments and can discuss the breadth of G.E.'s engineering and science opportunities with the students. They try to match the interests of students and the Company, and then arrange interview visits. The result of this system is a breadth of opportunity within one company which is remarkable.

Experienced technical people are always welcome, and they are usually put in contact with a specific Company group. Where no apparent match of interests exists, referrals are made throughout General Electric. In all cases, one finds technical men talking to technical men in a really professional atmosphere.

Q. Are there training programs in research for which engineering students might be qualified?

A. There certainly are. Our 2-year Research Training Program at the General Electric Research Laboratory gives young scientists a chance to work with experienced industrial research scientists before carrying out research and development on their own.

In addition, there are seven Company-wide training programs. Those that attract the largest number of technical graduates are the Engineering and Science, Technical Marketing, and Manufacturing Training Programs. Each includes on-the-job experience supplemented by a formal study curriculum.

Of course, not all graduates are hired for training programs. In many cases, individuals are placed directly into permanent positions for which they are suited by ability and interest.

GENERAL ELECTRIC