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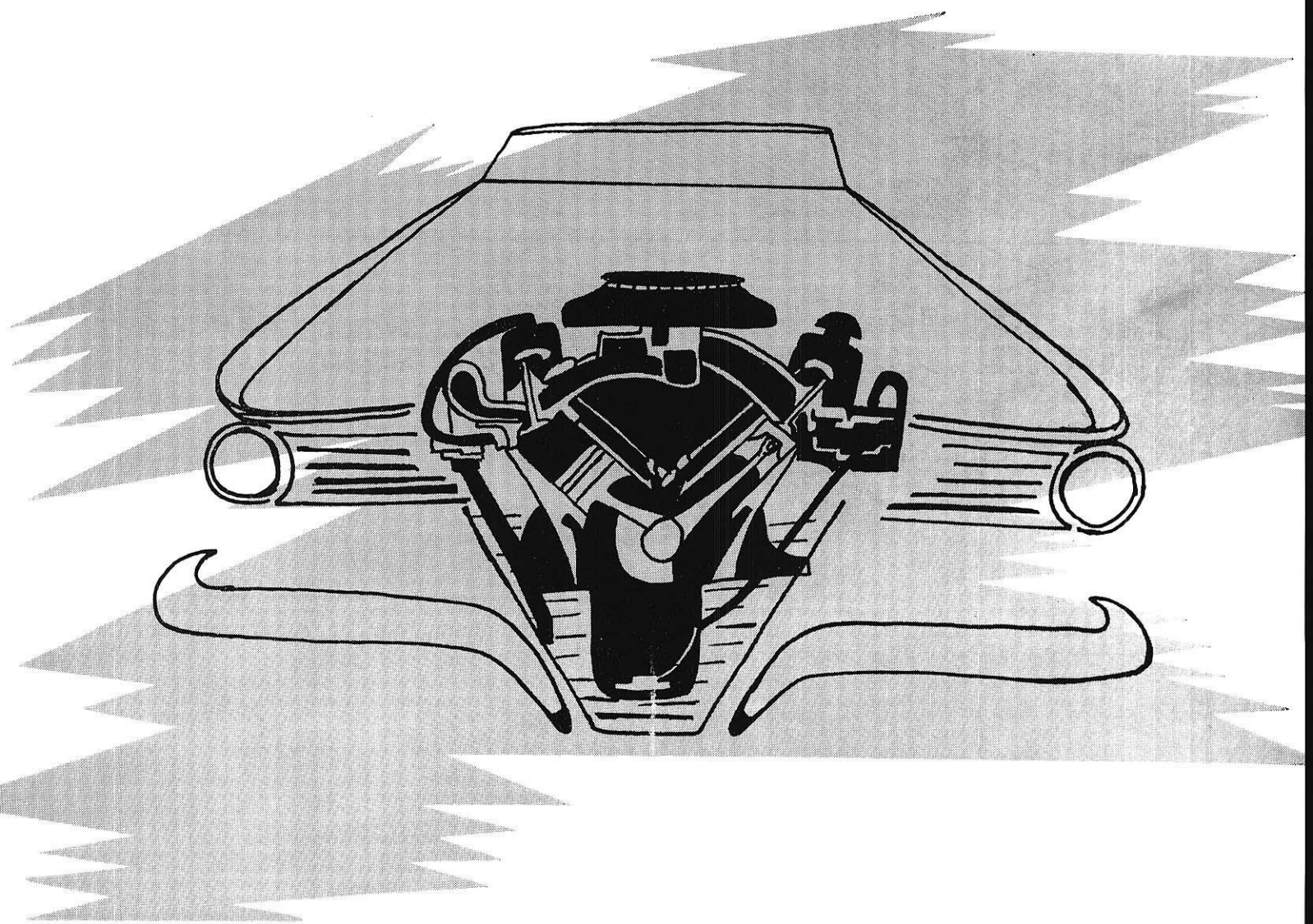
FEBRUARY
1959
The Wisconsin
25¢

engineer



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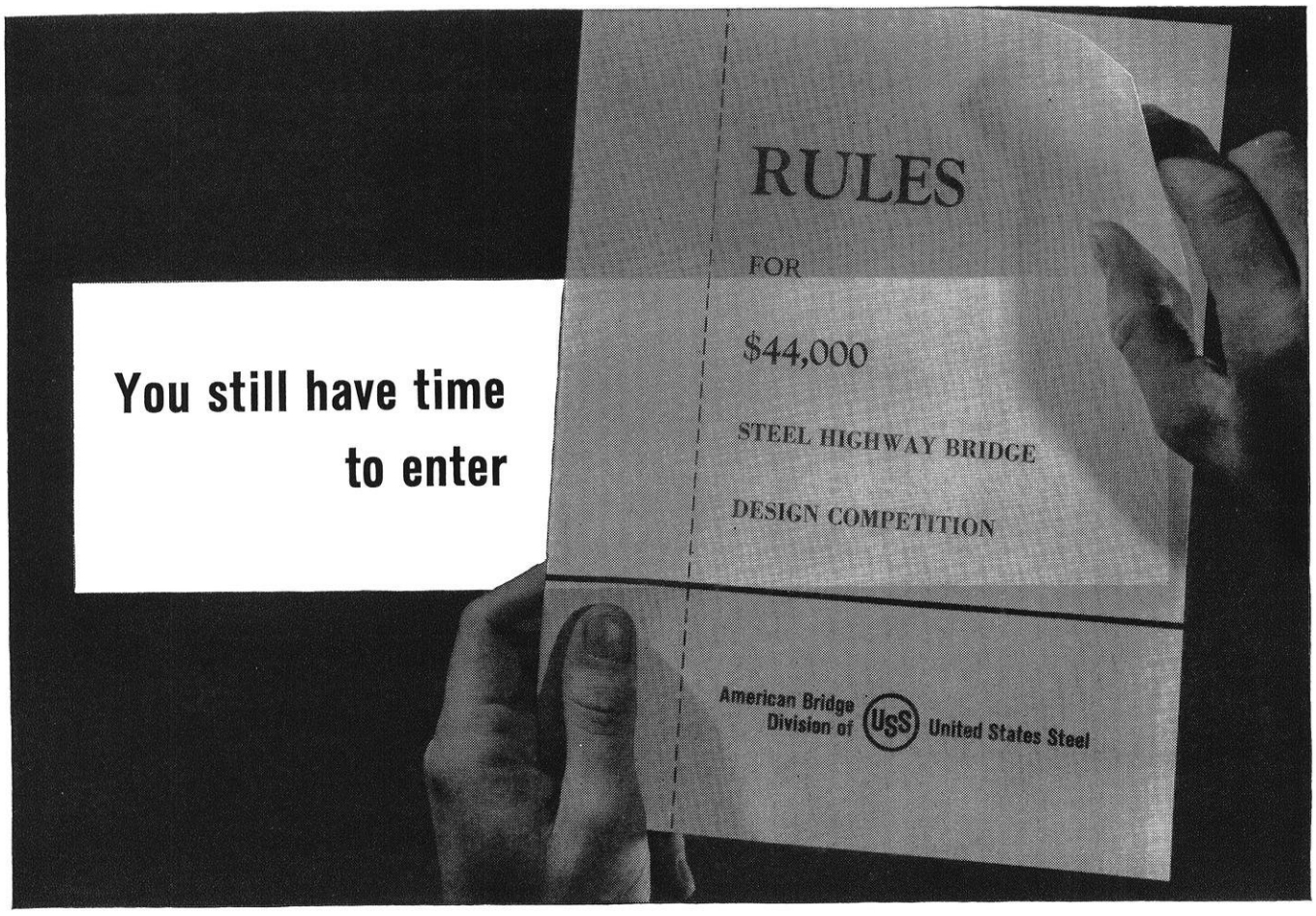

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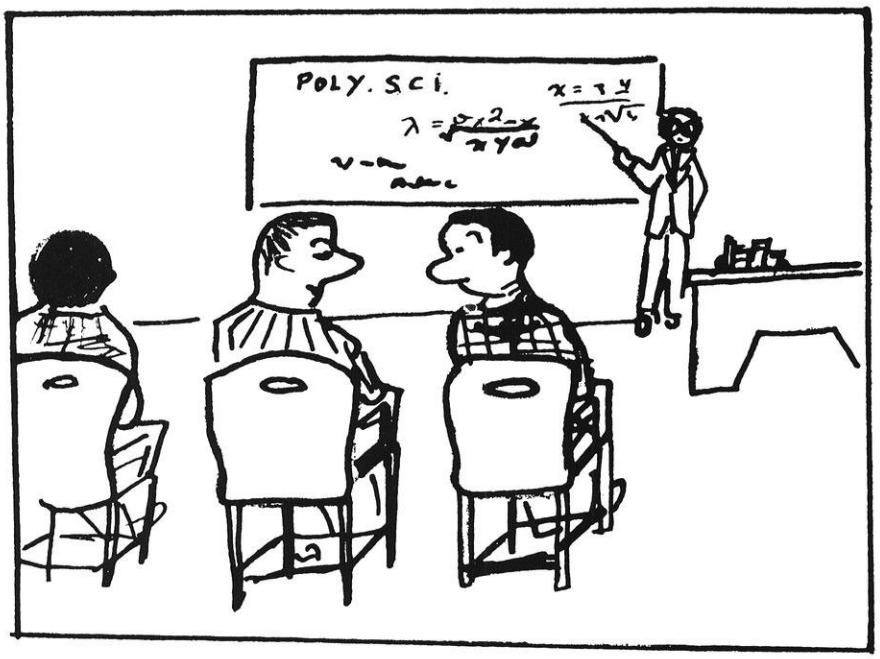
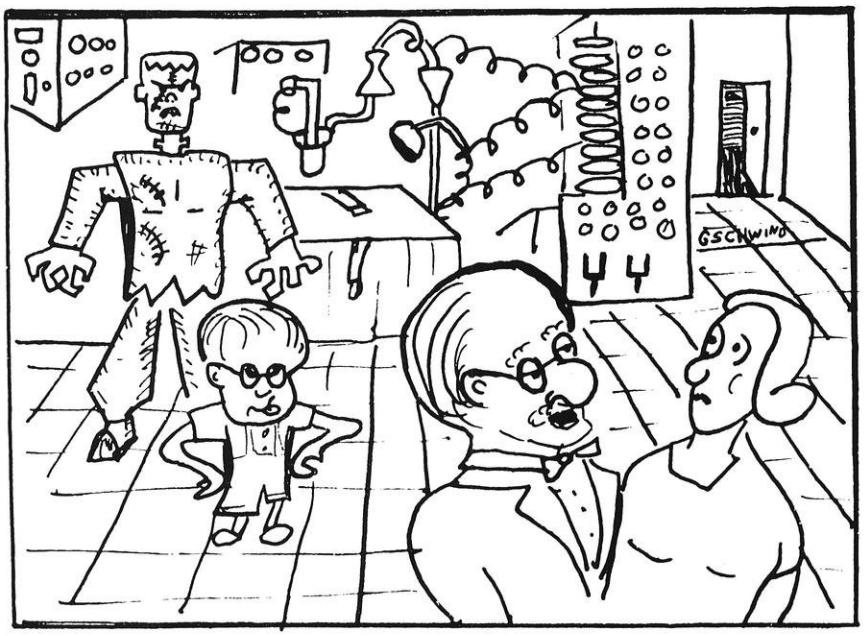
GENERAL MOTORS PERSONNEL STAFF DETROIT 2, MICH.



"This course isn't so hard; I never cracked a book in it last semester!

THE WISCONSIN ENGINEER??



"It's amazing what our students accomplish in lab. . ."

Volume 63 FEBRUARY 1959 Number 5

WISCONSIN ENGINEER

The Student Engineer's Magazine
FOUNDED 1896

Features

Departments

Cover

Cal Kreunen illustrates this month's cover with a section view of an automobile engine set in a body style of the future. For the article on new auto features see page 22.

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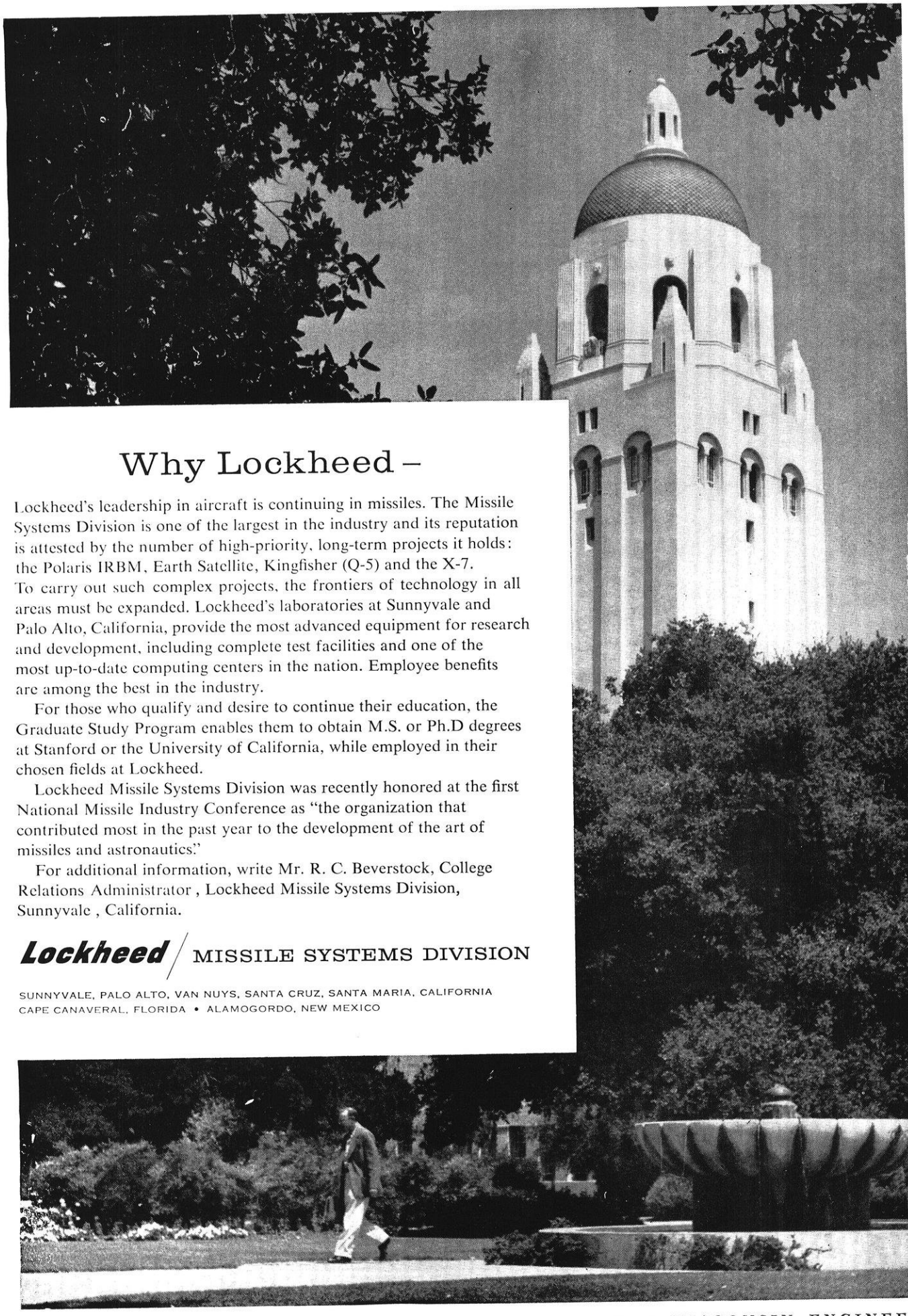

Why Lockheed –

Lockheed's leadership in aircraft is continuing in missiles. The Missile Systems Division is one of the largest in the industry and its reputation is attested by the number of high-priority, long-term projects it holds: the Polaris IRBM, Earth Satellite, Kingfisher (Q-5) and the X-7. To carry out such complex projects, the frontiers of technology in all areas must be expanded. Lockheed's laboratories at Sunnyvale and Palo Alto, California, provide the most advanced equipment for research and development, including complete test facilities and one of the most up-to-date computing centers in the nation. Employee benefits are among the best in the industry.

For those who qualify and desire to continue their education, the Graduate Study Program enables them to obtain M.S. or Ph.D degrees at Stanford or the University of California, while employed in their chosen fields at Lockheed.

Lockheed Missile Systems Division was recently honored at the first National Missile Industry Conference as "the organization that contributed most in the past year to the development of the art of missiles and astronautics."

For additional information, write Mr. R. C. Beverstock, College Relations Administrator , Lockheed Missile Systems Division, Sunnyvale , California.

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QUESTIONS WISCONSIN STUDENTS ASK MOST OFTEN

about today's opportunities at Alcoa

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2. Where will I be located if I am employed by Alcoa?

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6. How does Alcoa insure personal recognition for its people?

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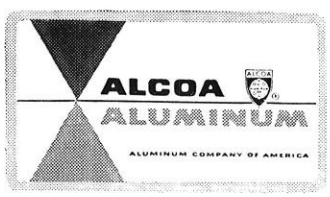
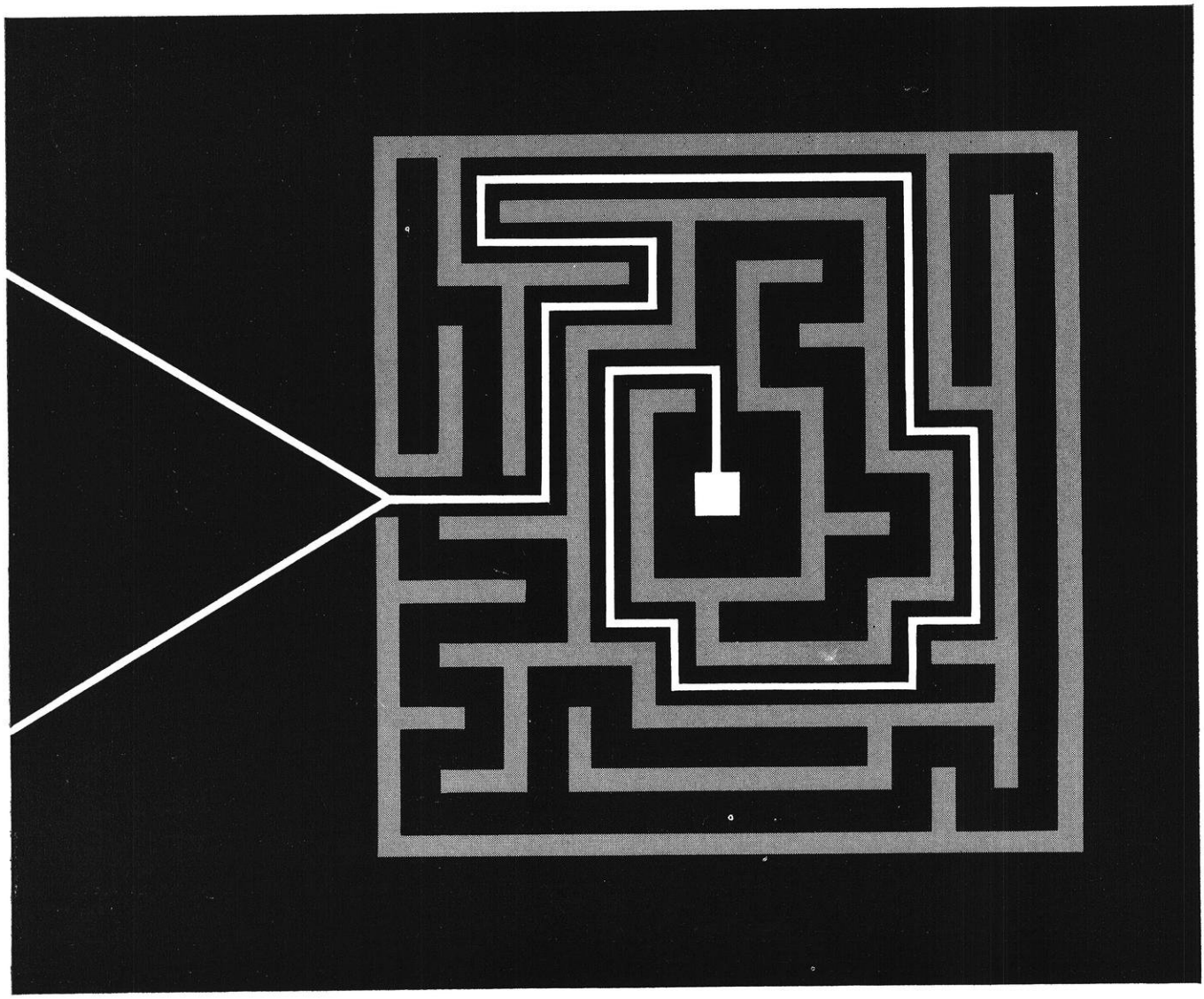
7. How do I apply for a position with Alcoa?

Contact your placement officer to arrange an interview. If you would like more details immediately, write Manager, College Recruitment, 809 Alcoa Building, Pittsburgh 19, Pa., for the newly revised booklet, *A Career For You With Alcoa.*



Your Guide to the Best in Aluminum Value



A RESUME IS A TWO-PARTY AFFAIR

Throughout your engineering career, the name of the first employer appearing on your resume can be as significant as your education. But, in selecting that first employer, you should also consider his resume.

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This is an all too brief resume. It would be hard to associate yourself with a company that offers the engineer greater choice of assignment. Write us about your interests — or see our representatives when they visit your campus.

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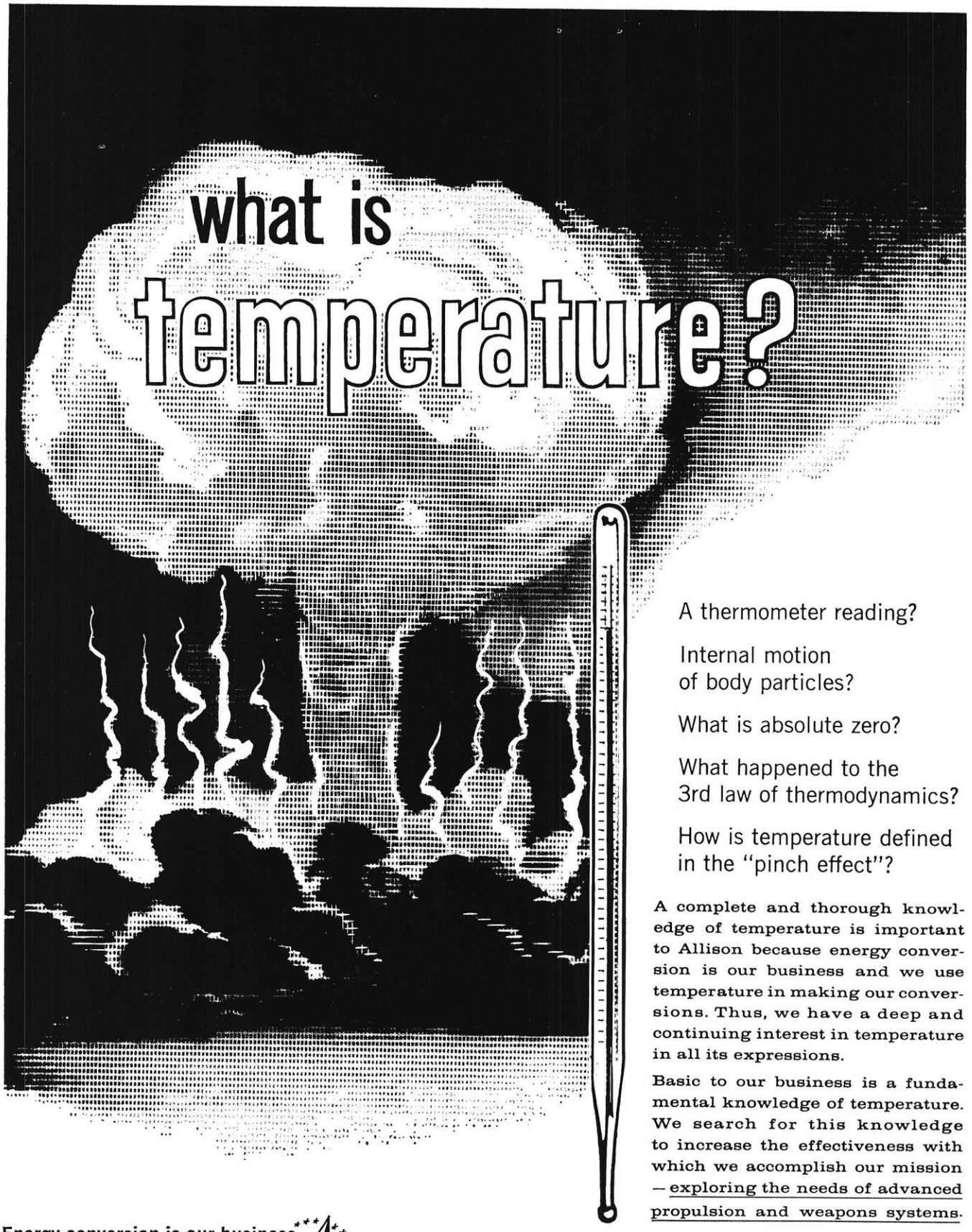

A thermometer reading?

Internal motion
of body particles?

What is absolute zero?

What happened to the
3rd law of thermodynamics?

How is temperature defined
in the "pinch effect"?

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Rambling WITH THE EDITOR

Don Olson, when he received the Outstanding Senior Engineering award recently, made a statement that many engineers evidently give little thought to. He said he felt it important not only to spend our time wisely, academically, but to participate as much as possible in extra-curricular activities also. For example, this senior in Electrical Engineering has been active in: Polygon Board (pres.), AIEE-IRE, Student Senate, Kappa Eta Kappa (Pres. and V-pres.), Senior Council, Union Council, Humorology promotions, Wisconsin Engineer article staff, Tau Beta Pi and Eta Kappa Nu (honorary engineering fraternities) while maintaining a 3.3 overall grade point average.

Perhaps freshmen and sophomores are frightened by the tales they have heard about the extremely difficult engineering curriculum. Perhaps this has kept them from taking part in societies, publications, or other activities. It goes without repeating that indeed the engineering courses are difficult—more difficult for some than for others. They require a lot of time—time that could be used for other things, perhaps.

But it has been my experience, as well as the experience of several others, that one's time is better utilized if he is involved in outside activities. Too often time is spent in loafing or just plain daydreaming when one doesn't have extra, interesting activities to occupy his time. This daydreaming can be (and often is) done even with the book open on the desk before us—even as we read over the page. It seems that having extra activities and, hence, extra responsibilities induce a more strict discipline upon our time. We know we have so much to do and so much time to do it. This knowledge is a strong force that brings about better concentration and efficiency in all our work.

Why is all this being presented here? There are many freshmen, sophomore, and junior engineering students on this campus that have the potential and the intelligence necessary to not only perform a valuable service to the campus but to receive a great deal of satisfaction for themselves by participating in some of the opportunities available to them each semester outside of the class room.

This individual reward referred to as self-satisfaction above comes in several forms, many of which may not seem apparent or outwardly recognizable. This extra work teaches one discipline of time, it provides added experience in other fields outside the class, it teaches one patience, especially when instructions must be passed on to others who may be following in the same position of responsibility, and, most valuable of all, it teaches one how to get along better with people—with other engineers. This last lesson (in group harmony and cooperation) is one engineers, who more and more are assuming positions of top management in industry, cannot learn from texts. Leaders in industry are encouraging engineers to better learn how to associate with people. The president of General Motors has said that the man who can manage to do these extra-curricular activities while he is in school "is not going to be the man who tells his employer that his home life keeps him from doing his assigned job—or who tells his wife and family that he is too busy with his job to pay attention to them. Nor will he refuse to assist his community on the grounds that he is too busy. He has proved that he is a whole man—not half a man."*

Perhaps this discussion would be more appropriate at the beginning of the year rather than now. However, now, within six or eight weeks, organizations will be determining their officers and staffs for next year. Therefore, now is just as good a time to become active in one or more of these activities.

During the first two weeks in March the Wisconsin Engineer will be making up its staff for next year. This staff will have the opportunity to work with the present staff in preparing the May issue of the magazine. There are several positions on the staff that need to be filled by competent and interested personnel. Some positions, naturally, require more experience than others, but there are several areas available that require little or no experience at all. Other staff members are always willing to help those who have questions about parts of the procedure necessary to publish an engineering magazine. If there are any freshmen, sophomore, or junior engineering students who have grade points of 2.5 or better and who are interested in this type of opportunity, by all means come into the office or contact the editor at AL-5-2075.

———

* From a talk by R. G. Tuttle of the General Motors Institute.

ANA TO AA TO EAL TO NAL—First of Ansett-ANA's two new Electras leaves production line of Lockheed's California Division, with 9th plane for American Airlines, 25th for Eastern Air Lines and first for National Air Lines following close behind. Ansett-ANA's 68-passenger ship will cover nearly 17,000 miles on unduplicated routes over Australia and Tasmania. Eastern, flying 12 of the new Lockheed prop-jets as of Jan. 20, inaugurated Electra service Jan. 12.

Adequate fertilizers used with good farming practices produce crops like these with increased yield and quality.

Fertilizers and Soil Fertility

by Paul Spangenberg che '59

Plants contain twenty essential elements which can not be maintained over a period of time in any soil. Fertilizers, along with crop rotation, help to replace the deficiencies that occur in the soil.

SOIL fertility may be defined as the reproductive capacity of the soil. Fertilizers are the best known means of maintaining the soil's reproductive capacity. A soil's fertility is not usually determined by the physical condition of the soil, but by the amount and availability of the mineral nutrients in the soil.

Sixty different elements have been found in plants and twenty of these are thought to be essential. These essential elements are usually divided into three groups.

The first group is called the primary essential elements. These are the elements found in the greatest amount in the plant. They are oxygen, carbon, hydrogen, nitrogen, phosphorus, and potassium. The first three of these make up an average of 95% by weight of the plant. They are acquired from air and water and are not apt to be deficient. The last three are minerals which must be gotten from the soil.

The next group is the secondary essential elements; sulphur, calcium, and magnesium. These minerals are all found in the soil.

The final group is called the rarer essential elements or trace elements. They are iron, manganese, boron, copper, zinc, and molybdenum. They are found in very minute quantities in the soil and in the plants.

Sodium, chlorine, and silicon are often considered essentials to plant growth, but they have not yet achieved full acceptance.

These elements are grouped by their relative abundance in the plant and soil, but this says nothing about their effect on plant growth. A plant can suffer just as much from lack of a minute amount of iron as it can from lack of a comparatively much larger amount of phosphorus. Furthermore, different types of plants need varying amounts of different nutrients.

A plant needs and uses mineral nutrients in the same way a human being does. Just as a child may get rickets from a lack of calcium in his diet, a plant may show poor development and drying of the feeding roots from lack of calcium. Some of the elements are important in the leaves, others in the seeds and fruits, and still others in the stems and roots, but the lack of any one nutrient can seriously affect the overall growth of the plant.

ORIGIN AND DEVELOPMENT OF USES OF COMMERCIAL FERTILIZERS

Archeological research has shown that cultivation of crops was begun about 10,000 years ago. The first use of fertilizers probably began shortly after this. Some of the first materials used for fertilizer were animal manures, bones, wood ashes, wood wastes, guano, fish, chalk, and marl.

One of the first investigations into plant nutrition was about 300 years ago, when an unknown person planted a willow weighing five pounds and fed it nothing but water until it weighed 164 pounds. He then decided that water was the basic nutrient of plants. In 1804, Nicholas de Saussure, after analyzing the ashes of plants, decided that the minerals in the plant ashes came from the soil. Justus von Liebig, a German chemist, was one of the first to emphasize the value of supplying phosphorus and potassium to plants. He also formulated his so-called toxic theory, which is the basis of crop rotation. He claimed that each plant gives off to the soil substances which are toxic to it. After these toxins build up in the soil, the plant can no longer be grown in that soil. However, these substances are not toxic to other plants; in fact, they were beneficial to them. Therefore, by changing the crops you could achieve increased yields.

During the nineteenth century the commercial fertilizer industry first began to develop, with ground bone being one of the first materials to be sold extensively for fertilizer. In 1822, Peruvian guana was first imported into England; and in 1830, the British started to develop the Peruvian, later Chilean, deposits of sodium nitrate. Potassium salts were first used in Germany about 1860, and by 1900, they had become an important commercial fertilizer. In 1868, phosphate rock was first mined for use as a fertilizer.

Today, there are between 800 and 900 companies in the United States producing and distributing fertilizers. It is estimated that fertilizers are responsible for from 50% to 100% in increased crop yields during this century. Today, the majority of the fertilizer used is applied to three crops: corn, cotton, and wheat. About one-half of fertilizer consumed in this country is applied in the Gulf and South Atlantic States.

TYPES AND USES OF MODERN FERTILIZERS

Nitrogeneous

The first main class of fertilizers is the nitrogeneous group. Although most of these fertilizers contain nitrogen in combination with some other element, their main purpose is the addition of available nitrogen to the soil, which is used chiefly in the making of proteins. A nitrogen deficiency will cause a small kernel or seed, an early shedding of the leaves, and at times, death of the lateral bud. Lack of nitrogen also appears to reduce the water content of the plant. Excess nitrogen may be just as injurious as a lack of nitrogen. The flavor of peaches deteriorates when excess nitrogen is present, and plants such as spinach may even have a bad effect on the consumer if they contain to much nitrogen. Because the nitrogen content of the plants is increased when abundant nitrogen is available, the protein content of a plant may be increased within certain limits. Nitrogen also appears to allow plants to make better use of the available phosphorus and potassium in the soil.

One of the main nitrogeneous fertilizers is sodium nitrate. About 10% of this fertilizer used in this country is from the Chilean deposits, while the rest is produced synthetically. Sodium nitrate is composed of from 16% to 26% nitrogen and contains small amounts of other minerals besides the large amount of sodium. Sodium nitrate, because of its solubility, is readily available to plants. However, this high solubility also makes it easily susceptible to leaching from the soil. Continuous use of sodium nitrate usually results in decreased permeability of the soil because of the breaking down of particles in the soil. Sodium nitrate can also reduce the acidity of soil and de-

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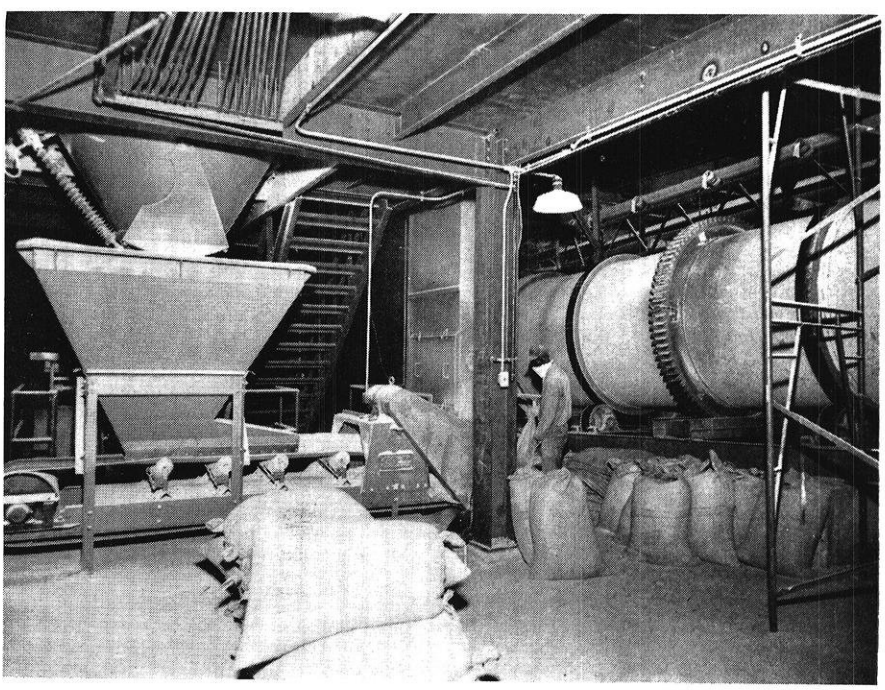


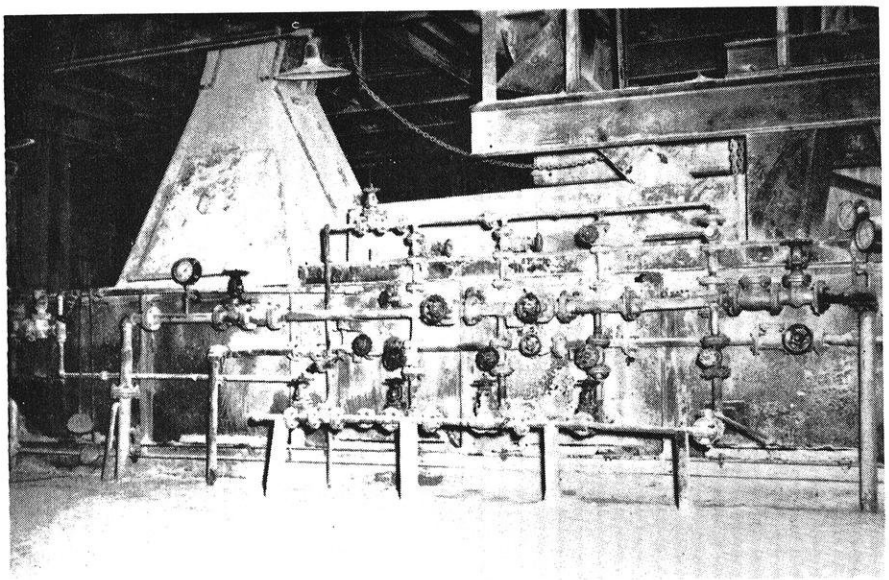
Shown here is part of the operations in the making of commercial fertilizer. In this phase of operation nitrogen is being added to fertilizer.

crease the loss of time. The sodium ion left in the soil after the absorption of the nitrate ion by the plants, appears to increase the availability of the potassium and phosphorus in the soil and at times it can be used to supplement potassium as a plant nutrient. Most field crops nearing maturity seem to utilize their nitrogen to the best advantage when it is in the nitrate form.

Ammonium sulfate is another important nitrogen liberator. It is produced as a by-product in the destructive distillation of coal and from synthetic ammonia. Because it is physiologically acid, it increases the acidity of the soil which, if allowed to go too far, can interfere with many soil processes. To prevent too great an increase in acidity it is usually applied with lime in ratios of from 1.5 to 2.0 tons of lime per ton of ammonium sulfate. Ammonium compounds are resistant to leaching and so ammonium sulfate is more suitable than nitrates for application at planting time when the young plants don't utilize much nitrogen from the soil.

Ammonium nitrate is another important fertilizer which is made by passing ammonia gas through nitric acid. It contains about 35% nitrogen of which one-half is in the ammoniacal form and the other in the nitrate form. It is entirely soluble in water and because of this it leaves no residue and is very quick acting. Also, because it has nitrogen in two forms it is well suited for grass and other crops that prefer nitrogen in both forms. Its nitrogen is also less susceptible to leaching than that from other fertilizers.

Synthetic nitrates are comparitively new and have the advantage of being able to give nitrogen in the ammoniacal, nitrate, or amide form. The main types are calcium nitrate, calcium cyanimide, potassium nitrate, and urea.



This intricate array of valves and gages show that the making of commercial fertilizers is no simple operation.

Phosphate Fertilizers

Phosphorus is one of the most important crop nutrients. Plants can only utilize it when it is combined with some other element found in the soil. Low crop yields are more often due to a lack of phosphorus than to any other cause. Phosphorus has been called the master key to agriculture and is involved in the production of nucleo-proteins in cell division. It also appears to have more influence on the seed and grain than either nitrogen or potassium. Furthermore, phosphorus has a marked influence on the time it takes a plant to reach maturity.

Calcium phosphate is one of the chief forms of phosphate fertilizers. This rock, after purification contains 30 to 40 percent phosphoric acid (13 to 17 percent phosphorus) and three to four percent flourine in addition to lime. The flourine greatly impedes the availability of the phosphorus while the fineness of the phosphate rock increases its availability. The smaller the particles are, the greater the area exposed to soil solvents. Phosphate rock is also made more available by acid soils which tend to dissolve the rock through a series of chemical changes. Organic matter also serves to increase the availability of the phosphorus, while liming seems to decrease its availability. Legumes and slow maturing plants are best able to obtain the phosphate from the rock.

Superphosphates is a term applied to phosphates, the phosphorus of which is in a form readily available to plants. These superphosphates are usually produced by acid treatment (usually with sulfuric acid) of the rock or by volatilizing the phosphorus in phosphate rock. Superphosphates are usually about four times as available as rock phosphates and are ordinarily used for the immediate crop. They appear to work better during wet years and on limed fields. Surface applications of the superphosphates are very prone to loss from erosion, but little is lost from leaching.

Potassium Fertilizers

Plants can only utilize potassium when combined with other elements. As far as is known plants do not build potassium into any of their parts, but it seems to be important in many plant processes. Potassium plays an important part in the oxidizing and reducing processes in the plant, and it is essential both for photosynthesis and the translocation of starch. Another marked influence of potassium on plants is in the development of the woody parts of the stems and the pulp of the fruits. There is also evidence that is essential for protein synthesis. Potassium also seems to minimize the effects of too much nitrogen or phosphorus.

Potash was one of the earliest fertilizers. It can be produced from such diverse things as potassium salt deposits, shales, industrial wastes, and seaweed. Potassium today is sold in the form of soluble salts of sulphur, chlorine, silica, and others. It is particularly effective on soils low in natural potassium such as muck and peat. Potassium fertilizers have little or no effect on the acidity of the soil. They are very

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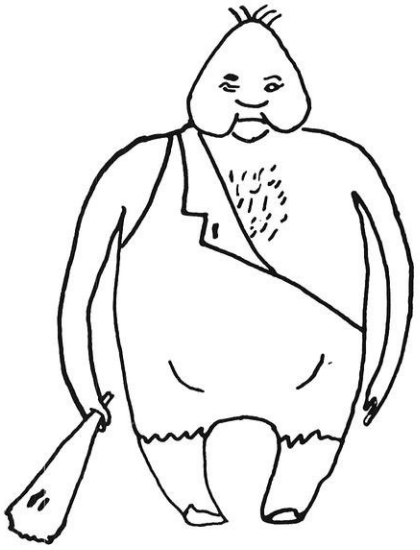


FRONT VIEW

Marvin Ook Discovers Gravity

by Charles H. Veen

THIS is the first in a series of discourses on the inventions and discoveries of the eminent scientist and engineer of the Cave Man Era, Marvin Ook, offered as a public service to clear up numerous misconceptions, of who invented what, which are prevalent in today's society.

As a child, Marvin Ook was familiar with the force of gravity. In his early life, it was a hinderance to him. However, by shrewd observation and application, he soon learned to use this force for his own benefit.

It was in his childhood that Marvin first realized the existence of gravity as a great potential force. After continuous attempts to climb a tree in order to secure apples, and, after continually falling out of the tree, Marvin realized that he always fell down, never up. Thus, his first deduction was that there existed an attraction between the earth and his body.

As years passed and he still fell out of trees, he noticed the force of impact on his head was increasing. His next deduction was that the attraction increased with the age of the person falling out of the tree. He soon found this to be incorrect after comparing lumps on the heads of people of varying ages. Thus, he conceived the idea that the attraction had something to do with weight, not age.

While proving his theory by throwing people of varying weights from the tops of trees, he noticed that the height of the trees was a factor in the differing indentations made in the ground. Thus, the idea stirred in his mind that the height of the tree had something to do with this attraction between the earth and the bodies of men.

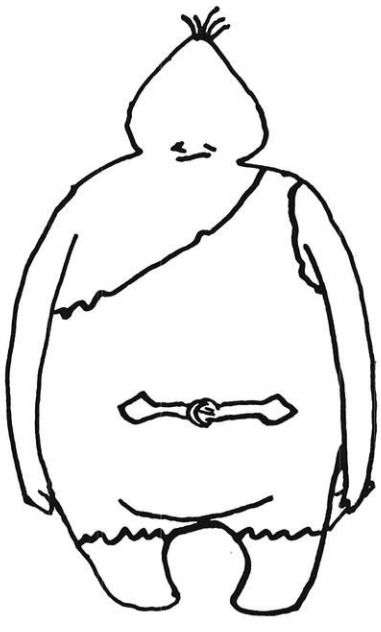
At this point in his experiments, Marvin ran into trouble. The local populace, adverse to the idea of being thrown from tree tops, arose in armed rebellion against Marvin. This was the first occasion on which Marvin made practical use of his discovery. Marvin combined his new discovery with the modern ideas of warfare—throwing stones —and came up with the idea of sitting in a tree and throwing the stones down at his tormentors. The idea was successful.

In fact, the idea was so successful that the League of Caves soon banned the use of Marvin's idea, as pertaining to warfare, and advised the people to leave Marvin alone lest he come up with something more devastating.

Marvin's experiments were abruptly stopped by a clause in the League of Caves decisions which stated that throwing people out of trees was to be banned.

This quirk of fate robbed Marvin Ook of the chance to complete his discovery of gravity. Instead, a Mr. Newton received the credit. Anyone can plainly see that Marvin pursued his theories concerning gravity with greater zeal and ingenuity than did Mr. Newton. It is obvious that deriving the concept of gravity cannot be done by merely watching apples fall out of trees. Marvin's concepts were pilfered by that lazy Mr. Newton, who spent his time lying under trees waiting for apples to fall instead of taking the initiative and going up after them.

THE END



REAR VIEW

Francis Bacon...on studies

"To spend too much time in studies is sloth; to use them too much for ornament is affectation; to make judgment wholly by their rules is the humor of a scholar. They perfect nature, and are perfected by experience, for natural abilities are like natural plants, that need pruning by study; and studies themselves do give forth directions too much at large, except they be bounded in by experience. Crafty men contemn studies, simple men admire them, and wise men use them, for they teach not their own use; but that is a wisdom without them, and above them, won by observation."

—*Essays 50. Of Studies, 1625.*

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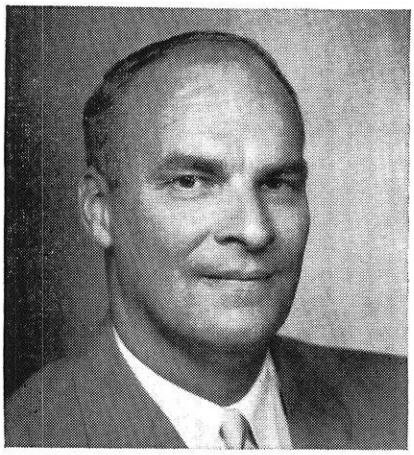
BENEFIT PROGRAM MEANS ADDED INCOME

by A. F. Hartford, Jr.
Du Pont personnel representative



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Product Certification Testing

by Charles Reynolds

Mr. Reynolds, supervisor of the qualification test group at Sundstrand Aviation, uses airborne component systems as examples to illustrate the various types and methods of certification testing.

AIRBORNE components, subsystems, and systems of today's aircraft and missiles are subjected to extensive product certification testing before their incorporation in a complete craft. The purpose of these "Qualification Tests" is to demonstrate that a component, subsystem, or system meets the design requirements of an appropriate specification.

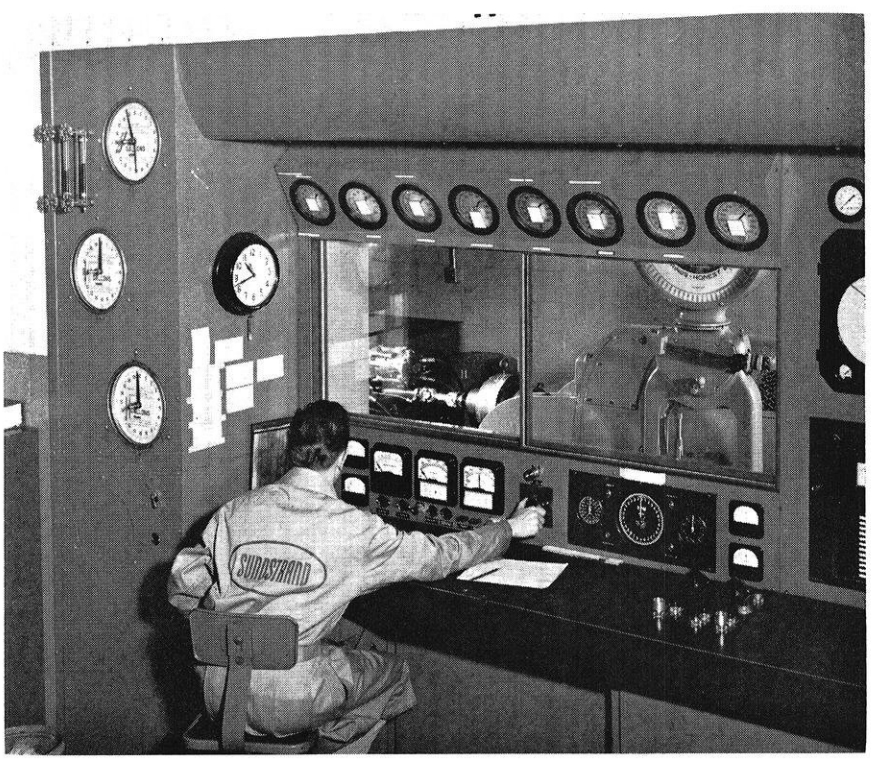
REASONS FOR PRODUCT CERTIFICATION TESTING

If an aircraft or missile were assembled with components and systems that had not been thoroughly tested, the problem of correcting faulty design and incompatibility of various components would be almost impossible. Therefore, each airborne component or system is thoroughly tested under simulated installation and environmental conditions to determine whether it will perform its intended function satisfactorily when incorporated in the craft.

When an aircraft or missile builder is designing a new vehicle, one of the first tasks is to prepare detailed specifications for equipment which will be purchased from subcontractors. These specifications incorporate the requirements for product certification tests to be performed on the equipment. Thus, when the subcontractor accepts the task of supplying that equipment, he also accepts the obligation to demonstrate that the equipment will comply with the specifications.

As was previously noted, product certification testing is normally referred to as qualification tests. This stems from terminology used by the Armed Forces. There are three types of product certification tests required by the government. These are known as "Qualification Tests." "Industry Developed Equipment Tests," and "Pre-Production Tests."

This article will merely attempt to acquaint the reader with the fact that there are three terms used by the government to define the tests and that only one of three is applicable for any one item or system. These tests and their associated approval procedures are one means by which the government monitors the quality of products it purchases for military aircraft and missiles.



Typical test stand for product certification tests of equipment requiring a prime mover or absorption dynamometer.

When airborne equipment is used in commercial applications, product certification testing is scrutinized by CAA in much the same manner as the government does on military applications.

There are several basic objectives of Product Certification Tests regardless of the product involved. These objectives are compatibility, reliability, safety, durability, and susceptibility.

TYPES OF TESTS AND METHODS

Although the basic objectives of any tests are the same for any product, the specific tests and methods involved are always based upon the product and its function. The following is a general discussion of a typical group of tests required for product certification of a constant speed hydraulic-mechanical transmission.

Endurance Test

This is a test in which the input to the equipment is varied over the normal range to simulate the actual operating conditions for the equipment. The time or duration of the test may be so many cycles or actuations or may be a time period of continuous operation. For example, the life requirement of an electrical switch might be 100,000 actuations of making and breaking the contacts, whereas the life requirement of a hydraulic pump might be 1000 hours of continuous operation.

The endurance test is normally run under standard laboratory conditions. The test setup and test equipment employed for an endurance test is similar to equipment used in production testing. Figure 1 is a photograph of a typical life test setup for a Constant Speed Drive System.

The primary objectives of endurance testing are to determine the extent of wear and the capability of the equipment to maintain its performance throughout the endurance test.

Endurance testing is one of the simpler tests to perform. However, particular care must be taken in design to achieve minimum weight and size while still obtaining sufficient life in the parts.

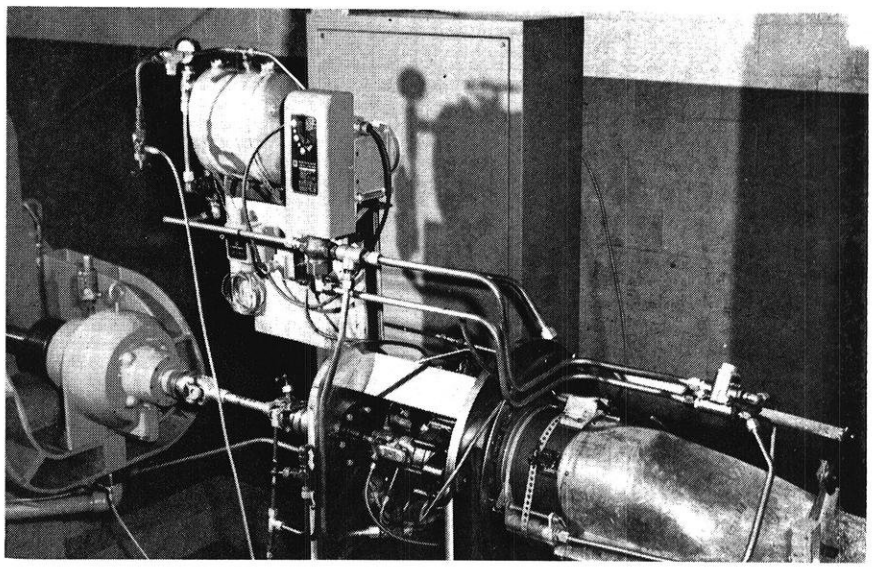


Fig. 1. Endurance test setup. In this setup the equipment and hydraulic circuit closely simulate the aircraft's system.

Performance Tests

These are tests to measure the operating characteristics of equipment under normal and extreme varying inputs to the equipment. The objectives in performance testing is to detect any adverse or undesirable characteristics of the equipment which might occur under any and all variable input conditions. These tests are often performed in conjunction with other equipment which can affect the performance of the specific equipment undergoing the test. This is often required in order to determine equipment compatibility.

This type of testing is normally done under standard laboratory conditions with much the same type of equipment and setup as required for endurance testing except the instrumentation employed is generally more elaborate.

The test stand console area where performance tests are performed on constant speed drive systems are set up for quick and convenient electrical circuit changes. The prime movers for these test stands are diesel engines which can provide the variable input speeds and horsepower necessary for performance tests of constant speed drive systems.

Performance tests cover a general group of tests. These include such tests as efficiency, fault condition, and operation of protective device.

When a specification is prepared, the performance characteristics of the equipment are established on the basis of the present state-of-the-art. Therefore, satisfactory results are usually achieved in the performance tests. However, careful attention must be given to the proper conducting of the tests and calibration of the instrumentation to complete the tests satisfactorily.

Environmental Tests

There are many types of environmental tests. For most aircraft equipment the environmental test conditions and procedures are those specified in MIL-E-5272. Most of the tests are conducted singly; i.e., only one extreme environmental condition is imposed at one time. The exceptions to this are the altitude and vibration tests where extreme temperature is also introduced as part of the environmental condition. Because most of the individual environmental tests require different equipment and methods, a discussion of each of the more commonly required environmental tests follows:

Low Temperature

All military aircraft must be capable of operating in an ambient temperature down to -65° F. Therefore, in product certification testing, all equipment is required to operate satisfactorily in an ambient temperature of -65° F. For

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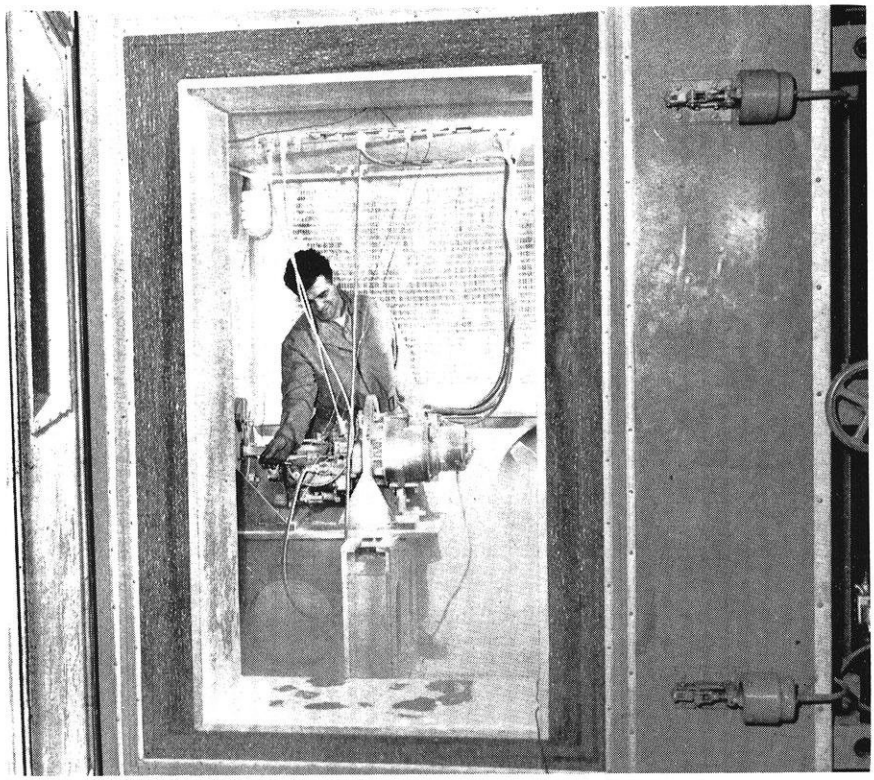


Fig. 2. Low temperature test in process with technician making adjustment.

most mechanical and hydraulic equipment the primary concern is the ability of the equipment to start at this low temperature, but because most such equipment is heat generating, continuous operation in a –65° F ambient is of less concern.

The test facility is normally an insulated chamber which can be cooled to and maintained at a temperature of –65° F. However, in one of the low temperature tests of MIL–E–5272 the chamber must be capable of maintaining a –80° F. Figure 2 illustrates the arrangement of a test setup within the low temperature chamber.

The test is conducted by reducing the internal temperature of the chamber to either –80° F for 48 hours followed by 24 hours at –65° F and then operating the equipment; or reducing the chamber temperature to –65° F and maintaining this for 24 hours and then operating the equipment.

Extreme care must be exercised in designing hydraulic and lubrication circuits if satisfactory results are to be obtained in the low temperature test.

High Temperature

The high temperature test simulates the operation of the equipment in a high ambient temperature. This condition occurs during flights in the vicinity of the engine nacelle, in areas heated by supersonic speeds, and during static conditions in unventilated areas exposed to the sun.

The equipment and facilities necessary for the high temperature test are in many cases the same equipment used for low temperature testing except that the chamber is equipped with heating elements which are capable of raising the air temperature within the environmental chamber. The heat source must be located so radiant heat does not fall directly on the equipment under test.

The test normally involves operating the equipment first under standard laboratory conditions and standard input conditions. Thus, equipment is then subjected to 50 hours at the high ambient temperature and is operated under the same standard input conditions. Thus the variation in performance due to the high ambient temperature is determined.

At the present time, most equipment can meet the high temperature requirements. However, because supersonic speeds have introduced extremely severe aerodynamic heating, it is anticipated that in the near future high temperature requirements will be the most difficult requirement for equipment to meet.

Altitude

The altitude test simulates the conditions associated with high altitude flying. These being low atmospheric pressures and low ambient temperatures. The primary concern in altitude testing for electrical equipment is to determine that the electrical equipment has sufficient air gaps between all connections so as to prevent flashovers due to low ambient air pressures. For hydraulic equipment the primary concern is to determine the effect of cavitation on pumps and low absolute pressure on oil supplies.

The test facility consists of a vacuum vessel and a means to refrigerate or heat the air within the vessel. Very frequently a single environmental chamber is used for the altitude, low temperature, and high temperature tests because all three environments can be obtained in one chamber specifically designed for that purpose. The environmental chamber is capable of providing all three environments; altitude with high or low temperature and high or low temperature individually.

The general method of performing the test involves operating the equipment under fixed input conditions while the temperature of the air within the chamber is cooled or heated as the specific test may require. Air pressure within the chamber is then reduced to simulate the specified altitude condition. The vacuum condition and temperature conditions are then maintained for a period of usually eight to ten hours while the equipment is operated at standard fixed input conditions.

This environmental test is seldom a problem in so far as the equipment meeting the requirements. The reason for this is that the environmental conditions are well understood from an engineering standpoint. Many times the test is difficult to perform because a vacuum condition is extremely difficult to maintain especially

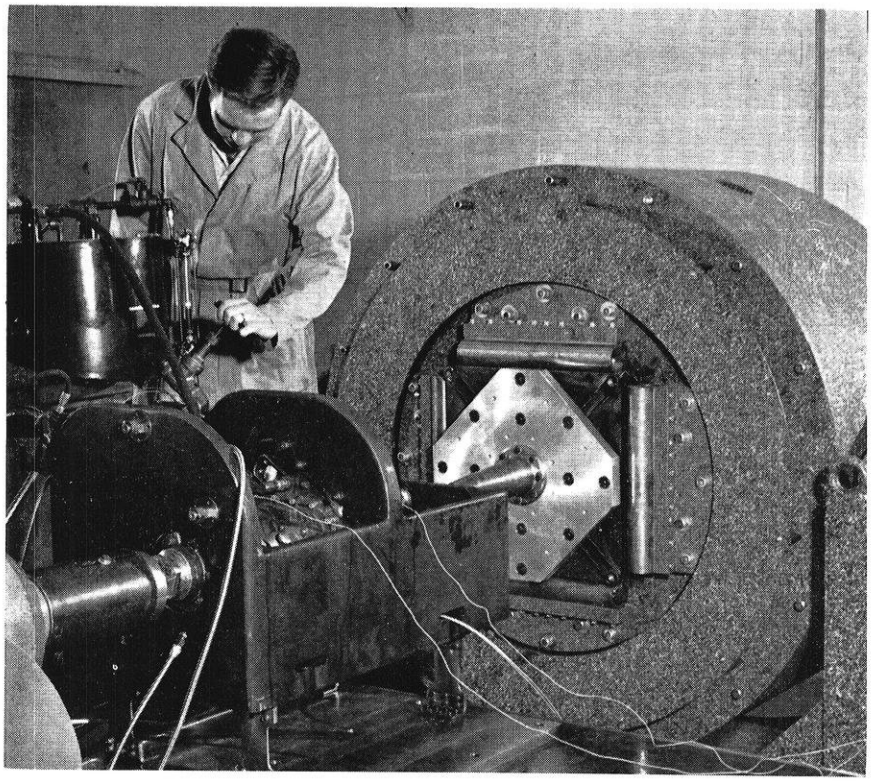


Fig. 3. Vibration test setup. Test unit is mounted in box-type bracket which is secured to a large concrete block by means of flexures (flat steep straps under bracket).

where it is necessary to have openings to provide hydraulic, electrical, and mechanical connections to the equipment under test.

Vibration

Vibration is produced by the engines, other mechanical equipment operating in the craft, and at times from turbulent air. Because of the devastating effects on equipment due to the normal vibration environment encountered in aircraft and missiles, it is essential and nearly always required, that airborne items are vibration tested during the qualification tests.

A special machine is required for vibration tests. There are three basic types of vibration machines—mechanical, hydro-mechanical, and electrical. The electrical vibrator is most commonly used because of its versatility and capabilities. The hydro-mechanical vibrator has only recently been developed and therefore is not as common. Other special equipment is often necessary in performing the vibration test. Figure 3 illustrates a test setup for vibration testing of a constant speed drive. Note that a special mounting fixture and drive mechanism is required to transmit the vibration from the shaker to the item being tested.

The procedure for vibration testing involves subjecting a unit to vibrations over a frequency range of five cps up to as high as 2000 cps with the vibrations applied in each of three mutually perpendicular axis separately. There are usually two types of vibration conditions imposed during any test. These are resonance vibration and cycling endurance vibration. Resonance tests involves the determining of the natural resonance frequencies of the equipment undergoing tests and maintaining these resonant frequency conditions for a specified period of time. In the cycling test, the vibration frequency is varied over the frequency range as defined by the applicable specification. The magnitude of vibration is usually ten g's over the majority of the frequency range being tested. During the vibration test the equipment is operated under steady state conditions or is not operated at all but checked functionally after a vibration test.

The primary purpose at the test is to demonstrate that the housings and mounting fixtures of the equipment have sufficient structural integrity. However, in vibration testing where operation is required simultaneously with the applied vibration, the test is also concerned with determining performance characteristics under the vibration environment.

Vibration testing is one of the more difficult tests to perform. The problem is producing and transmitting the required vibration. Also, where mechanical equipment is operating during the test, the self-induced vibration must be distinguished from the applied vibration.

Shock

The shock test is intended to simulate the effects of turbulent air on the aircraft and the effects of rough landings. These conditions are felt in every component of the aircraft. Therefore, most equipment is subjected to shock tests to determine its structural integrity under shock conditions.

There are several types of facilities used to produce the shock condition. One of the most widely used is what is known as the sand-drop tester. Figure 4 is a picture of this type of machine. This machine is merely a platform which can be raised and allowed to fall free into a box of sand. The shock intensity and duration are varied by the arrangement of the members beneath the platform and the distance which the platform is allowed to fall. Another shock machine is known as an impact shock tester. This machine employs a free-swinging arm which is allowed to strike a platform to which the equipment under test is fastened. The height from which the arm is allowed to fall and the material in the striking face are used to vary the intensity and duration of the shock.

The method of performing the shock test involves applying the shock in each of three major axis in each direction. The present procedure usually requires three shocks to be applied in each axis in each direction with a magnitude of 15 to 30 g's for a duration

(Continued on page 40)

The Vapor Lock Problem

by Richard Sholts, me'58

This article presents various causes of vapor lock in automotive engines and the corrections in design features which would eliminate this problem.

VAPOR lock, although reduced in the past few years, is still present in many motor vehicles. The problem is caused by the inability of the fuel pump to deliver enough liquid gasoline to the carburetor when large amounts of vapor are formed. This prevents the normal operation of the engine and many times the engine fails to run. When the engine fails to run the only practical way of eliminating vapor lock is to wait until the engine cools down.

OPERATING CONDITIONS FAVORABLE FOR VAPOR LOCK TO OCCUR

The vapor lock condition which develops in the fuel system is caused by liquid gasoline vaporizing before it reaches the carburetor. Since the fuel pump capacity is designed for liquid gasoline, trouble results when large amounts of vapor are mixed with the liquid. It is then impossible for the fuel pump to deliver enough fuel to the engine. Several of the operating conditions which may cause the gasoline to vaporize are discussed here in detail.

High Ambient Temperature Operation

Operation under these conditions of high surrounding temperatures is very favorable for vapor lock to occur because the vaporization of gasoline is a direct function of the temperature. A vehicle operated at temperatures above 90–100° F is highly susceptible to vapor lock unless preventative measures are taken. Although this is not an extremely high temperature, the gasoline tank temperature may become much higher than 100° F because heat from the exhaust system and heat radiated from the road are absorbed by the tank. If vapor lock occurs, it will generally be after two to three hours of operation under these conditions.

Vaporization generally takes place in the low pressure side of the fuel pump or in the fuel line from the gasoline tank. Rarely does vaporization take place in the fuel line between the fuel pump and the carburetor unless the line is located next to very hot parts. This is true because the fuel line from the fuel pump to the carburetor is under pressure while the line from the fuel tank to the fuel pump is under a partial vacuum. Gasoline at the lower pressure will vaporize much more readily; hence, the vapor lock problem here is in the low pressure lines.

The effect of the vaporization on the engine is a gradual starvation of fuel and eventual stoppage of the engine in severe cases.

High Altitude Operation

Vehicles are generally more susceptible to vapor lock at high altitudes than at low altitudes, operating at the same temperature. This is due to the atmospheric pressure being lower at high altitudes; thus, the vaporization temperature is lowered. This makes the fuel more volatile; therefore, more subject to vapor lock occurring after the operating temperature of the vehicle has been reached.

The effect of the vapor lock on the engine and where it takes place in the fuel system is about the same as operation at high temperatures.

During Stop Intervals After Full Throttle Operation

Ten to fifteen minutes after stopping an engine, which has been operated at full throttle, heat conditions surrounding the carburetor and fuel line leading to the carburetor are highly favorable for vapor lock to occur. The vaporization which takes place in the lower passages of the carburetor at this time is more correctly called percolation. This condition exists when the fuel vaporizes and causes a syphoning of fuel into the intake manifold. A very rich mixture results and, in extreme cases, the engine fails to start.

If the vaporization caused by the above conditions takes place in the fuel line from the pump to the carburetor, the engine may start and run normally if operated under light load conditions. However, if the engine is loaded excessively during a five to ten minute period after starting, it may eventually be starved of fuel and stop.

DESIGN FEATURES AFFECTING VAPOR LOCK

Location of Fuel System Components

Poor location of fuel system components is the major cause of vapor lock. Many times the components are located without regard to heat sources. Some of the more common causes of vapor lock are:

1. Fuel Filters.
2. Fuel Pumps.
3. Fuel Lines.

Fuel filters which are mounted in elevated positions under the hood are in the wrong location for two reasons. They are subject to much of the heat which rises off the engine, and more fuel line and fittings are required to mount the filter in this position. This extra line and fitting only serve to increase the restriction of flow of the gasoline. Thus, gasoline in filters in this position is at a high temperature and also at a low pressure. Both conditions being very favorable for vapor lock occurrence.

Most vehicle manufacturers use a mechanical linkage type pump which operates off the cam shaft of the engine. The location problem here lies in the fact that the cam shaft is generally on the same side of the engine as the exhaust manifold. To avoid any complicated linkages, the fuel pump is mounted on the side with the exhaust manifold and is therefore subject to very high temperatures. Many times the fuel pump is not shielded from this heat source and vapor lock occurs in the low pressure side of the pump.

Fuel lines are sometimes located next to very hot parts such as the engine block or exhaust manifold. Since it may be necessary to fasten the fuel line by some means to the engine block for rigidity, a type of bracket should be used in order that there will be a space for ventilation between the fuel line and the engine block.

Fuel lines which are located on the inside of the vehicle frame are also in a poor location from the standpoint of ventilation and cooling. However, they are afforded more protection in that position. Therefore, some sacrifice must be made by the designers to get the best combination of protection and ventilation.

Capacity of Fuel Pump

In many instances, vapor lock occurs because the capacity of the fuel pump is too small. When small amounts of vapor are mixed with the liquid fuel, the fuel pump fails to deliver enough fuel to the carburetor. Of course, this cause could be contributed only to the less severe cases of vapor lock without exceeding the normal capacity of the pump too greatly.

Type of Lines and Fittings

The size of fuel lines have a great effect on flow restriction and are reflected in a pressure drop in the lines.

Another item closely related to lines is the connecting fittings and elbows. Excessive use of either or both cause an extra pressure drop in the line. Many times an elbow is substituted for a bend in the pipe. This is not only more expensive, but is of poor design in preventing vapor lock.

The correct installation of fuel lines and fittings is very important. Too often in service garages a flexible line is replaced with a line which has a smaller inside diameter than the main line. Sometimes the flexible line is twisted while being replaced and this further reduces the inside diameter. One other common fault in the replacement and repair of fuel lines is the failure of the mechanic to ream the inside diameter of the tubing after being cut off by a rotary tool. All of these installation errors increase pressure drops and are caused by reducing the effective diameter of the fuel line.

Under-Hood Ventilation

Designers are faced with the problem of providing adequate ventilation when the vehicle is not in motion during hot weather and also the desirable retention of heat under the hood for quick warm-up during cold weather. The ventilation is also dependent on the body style and design. Because body style is a large determining factor in selling cars, many times no regard is given to the good under-hood ventilation. The stack action of hot under-hood air which may be used to draw in cooler air is not always utilized when the vehicle is stopped. Heat shields to deflect air from fan toward fuel pump also aids in preventing vapor lock.

The latest development on automobiles which has an effect on vapor lock is the under-hood air conditioning unit. At present, all the heat removed from the interior of the car is dumped under the hood. Many times this excess heat will raise the temperature of gasoline in fuel lines and pump enough so that vapor lock can occur.

FUEL CHARACTERISTICS AFFECTING VAPOR LOCK

High Volatility and The Reid Vapor Pressure

The resistance of a gasoline to vapor lock is made by a laboratory determination of the volume/liquid ratio to temperature. In the United States, the Co-ordinating Research committee's apparatus is used to determine this ratio which is called the Reid Vapor Pressure (R v p). This R v p is largely dependent on the volatility of the fuel. The higher the volatility, the

(Continued on page 46)

New Auto Engine Features

by Clifford Toraason

The author presents some original ideas on possible design changes in the block, cylinders, combustion chamber and valve train.

THE search for better automobile engine designs is continually being carried on. As everyone knows, the automobile is a very important item in modern life; and its success or failure depends largely on its power-plant.

Each new design attempts to encompass more and better features than the last. The problem of developing a satisfactory design is made more difficult by the fact that many desirable points such as performance and fuel economy tend only to be achieved at the expense of one another. The degree of desirability that each engine has is measured by how well its fulfills its purpose.

I have designed an engine which I think combines many desirable features to a high degree through the use of novel construction features. In this article I have attempted to describe this engine in nontechnical language for the interested layman.

Block Design

The block of my proposed engine is unique in many ways, but mainly because it is made of aluminum rather than the more usual cast iron. The reasons for this are:

1. The use of aluminum makes the machining of the block much easier.
2. The high thermal conductivity of aluminum dissipates the heat of the engine better.
3. The lower melting point of aluminum makes the use of permanent molds possible in casting. These molds would mean lower unit costs in volume production and they would produce better tolerances. Since permanent molds limit the degree of intricacy of the casting, perhaps the block would have to be cast in pieces and later welded together.

Aluminum is more expensive than cast iron, but the savings made possible by permanent mold casting should more than offset the higher cost of aluminum.

An additional difference in the block is that wet cylinder sleeves are used. These make casting much easier because intricate internal passages within the block are eliminated.

Cylinder Design

The cylinder design of this engine differs in two respects from the conventional engine; namely, it uses wet cylinder sleeves, and it has no head gaskets as they are ordinarily thought of.

The reasons for using cylinder liners are:

1. Because of the aluminum block, they are needed to provide a good wearing surface for the pistions.
2. The wet sleeve design greatly simplifies the block design and, at the same time, provides excellent heat transfer to the coolant.
3. Removable sleeves simplify production, because the bulky block does not have to be positioned for boring operations.
4. Maintenance is simplified because, with cheap replaceable sleeves, cylinder honing and reboring operations are eliminated.

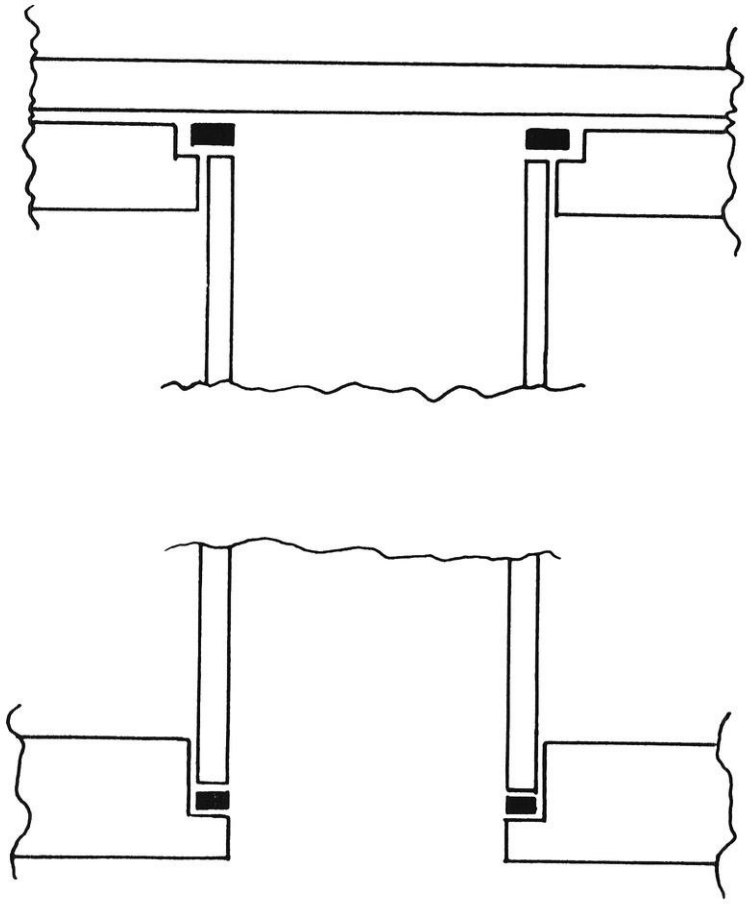


Fig. 1.
Cylinder Liner Detail

5. Engine life is longer because of constant temperatures maintained by sleeves of uniform wall thickness surrounded by equal volumes of coolant. Being machined, the sleeves are not subject to casting errors.

There is to be no head gasket to speak of in this new design. The cylinder liners rest on small shoulders machined into the block. A small ring gasket seals the liner at the top, and a similar gasket between the liner and the shoulder at the bottom prevents coolant leaks into the crankcase.

The two small gaskets provide a small amount of movement of the cylinder liner to compensate for the different expansion rates of the metals used. Also, the gaskets will be virtually blowproof as they are exposed to the combustion chamber pressures on one side only and are surrounded by metal on the other three sides. A further advantage is that the compression of the gaskets is controlled only by the size of the recesses in which they fit and is not subject to the torque on the headbolts.

The absence of a head gasket allows excellent heat transfer from the head to the block, as the two are in intimate contact with no insulator separating them. Because of this, and the fact that aluminum is to be used for the head as well as the block, it may prove feasible to use a head that is not cored for coolant flow. The good heat conductivity of aluminum, coupled with the good heat flow to the block, might prove to be all that is needed to dissipate the engine's heat.

Combustion Chamber Design

The engine has machined hemispherical domes in the head with no provision made for a chamber. The reasons for this design are:

1. The machining of the head:
   (a) Provides a smooth surface for better combustion.
   (b) Makes sure that each dome will be exactly the right size which might not be possible by casting.
2. The hemispherical shape allows for the use of the largest possible valves. The only limiting factor is the size of the bore.

The actual combustion chamber is cast into the top of each piston.

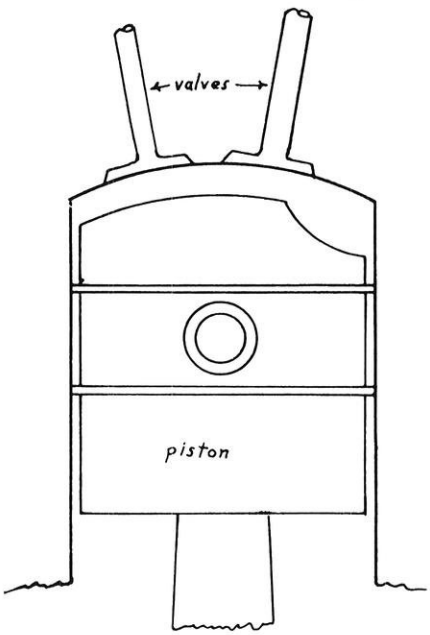


Fig. 2. Combustion Chamber Design

It resembles a small pocket or indentation in the head of each piston.

The reasons for putting the combustion chamber in the piston rather than in the head are:

1. More precise control may be had over the size and shape of the chamber.
2. Because the piston is a cheaper and more easily replaced part than the head, a more intensive and easier testing program may be undertaken to find the ideal design. This same reasoning would also facilitate altering compression ratios and providing subsequent model improvements.
3. By using this design in conjunction with the domed head, the desirable low-volume "squish areas" are included, increasing turbulence without making any reduction in valve size or inconvenient valve location necessary.

(Continued on next page)

4. The spark plug is located in the most desirable position and still does not interfere with the valves, nor is it in a position where cooling would be insufficient.

A possible disadvantage may arise because of the greater complexity of the piston and also because of its greater reciprocating weight.

Accessory Systems

The fuel system follows more conventional lines; but there are important improvements.

1. The manifold is not provided with a hot spot to aid in vaporizing the fuel-air mixture. Rather, the entire manifold is water jacketed. This will:
   (a) Provide a denser fuel-air mixture.
   (b) Prevent the carburetor from overheating with the subsequent boiling of fuel in it when the engine is shut down.
   (c) Provide for a quick warm-up of the manifold when the engine is cold.
2. The function formerly performed by the "hot spot" is now performed by a small stove around the exhaust manifold that heats the air before it is fed into the carburetor. Such a system is now in use on Lincoln and Mercury engines. Since most of the vaporizing of the fuel is done in the carburetor, it seems reasonable to aid the vaporization here rather than heating the air-fuel mixture with the hope of doing what the carburetor failed to do, namely vaporize the fuel completely.

Valve Train Design

The most unique area of this engine is the valve train. An attempt was made to use the largest possible valves in the most advantageous locations and, at the same time, employ a linkage that would be very light so the valve action would be positive at high speeds. Also, the design is very simple, which should greatly facilitate production and maintenance. There are none of the usual rocker arms, pushrods, tappets, valve lifters, etc.; therefore,

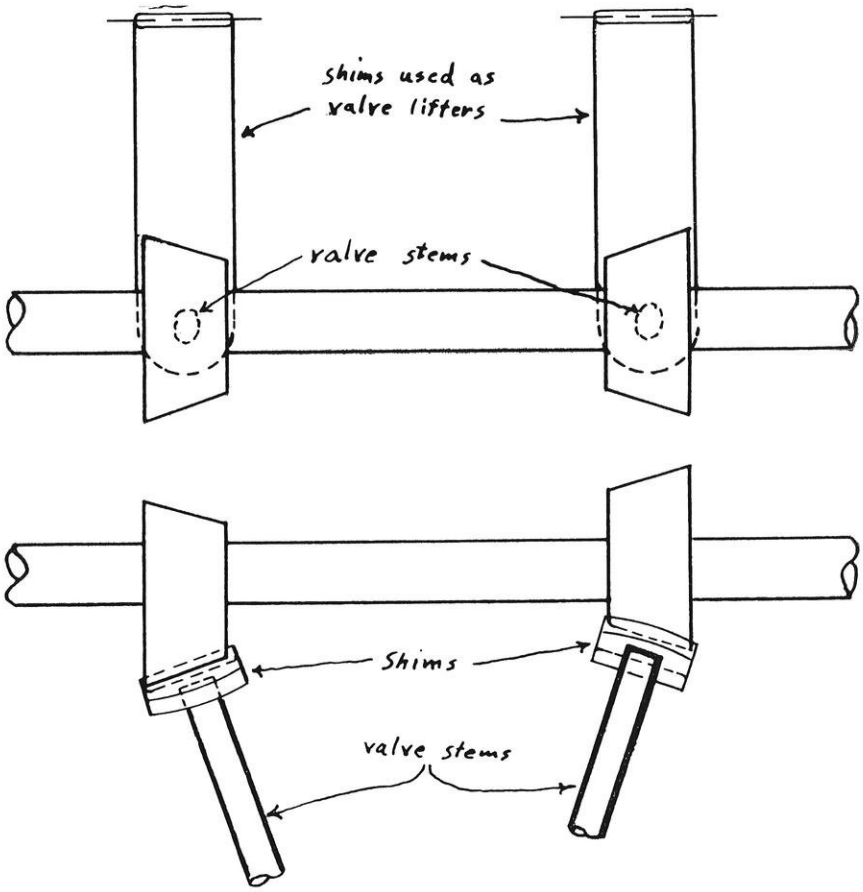


Fig. 3 - Valve Train Design

the problems that go with the afore mentioned do not occur in this engine. No provision is made for adjustment of the valve train in any way. This, of course, eases maintenance and prevents trouble caused by incorrect adjustment. This lack of need for adjustment is possible because the linkage has so few wearing points that the clearances involved should remain within satisfactory tolerances for the life of the engine.

The characteristics of the system are:

1. Two valves are used per cylinder, and they are inclined at some angle less than 90 degrees.
2. All the valves lie in a plane that contains the crankshaft. This is where this design differs from any other system using inclined valves.
3. A single overhead camshaft is used on each bank of cylinders. The shaft bears directly on a member in contact with the valve stem, thereby eliminating the usual array of linkage.

The camshaft is driven by means of a shaft with a helical gear on each end that engages a similar gear on the camshaft and a gear half its size on the crankshaft.

Valve Lifters

A system that could be used in lieu of the steel strips between the camshaft and valve stems would be large cup-type valve lifters. These lifters would be shaped like inverted water tumblers. They would be placed over the valve stem and spring. The outside machined surface would slide in a similarly machined recess in the head. The purpose of the lifter is to absorb the side thrust of the cam and to keep it from reaching the valve stem.

Variable Valve Timing

A high performance engine is usually a high speed engine. At these high speeds, an engine needs advanced valve timing and considerable valve overlap. The same characteristics that help the high speed operation have bad effects

(Continued on page 47)

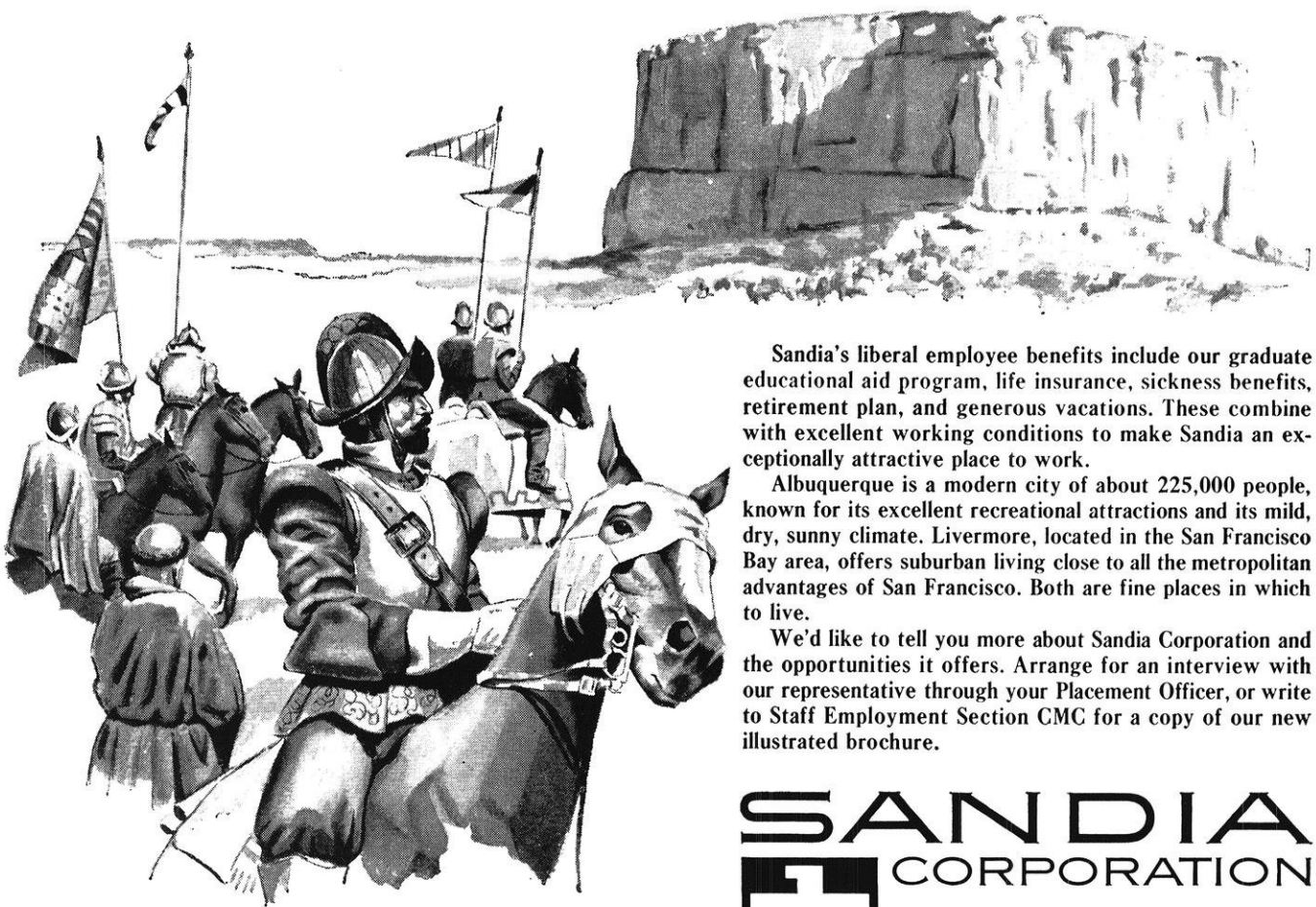
the challenge of new frontiers

Here in the West, where sweeping plains and towering mountains once challenged the conquistadores of New Spain, Sandia Laboratory now explores new frontiers of science and engineering—seeking the answers to vital questions in many areas of knowledge.

Sandia Corporation was established in 1949 to perform research and development in the ordnance phases of nuclear weapons for the Atomic Energy Commission. This is still our main task, but in doing it we have learned much in the way of theory and advanced technique that has application outside the field of weaponry. For example, Sandia Corporation, working in support of the AEC's nuclear physics laboratories, is currently studying problems concerned with the non-military uses of nuclear energy and with techniques involved in the control of thermonuclear reactions.

We employ over 7,500 people, of whom 1,800 are engineers and scientists, at our laboratories in Albuquerque, New Mexico, and Livermore, California. These laboratories are modern in design and equipment, with permanent facilities valued at $65,000,000. Equipment available, or in the process of installation, includes an electron and positive ion Van de Graff accelerator, a 5-megawatt tank-type heterogeneous nuclear reactor, a wind tunnel operating in subsonic through hypersonic ranges, digital and analogue computers, and various devices developed for specialized uses — as well as general laboratory equipment. Extensive test facilities are available to the research and development engineer for proving design theories and concepts.

If you are a graduating engineer, mathematician, or physicist, Sandia offers exceptional opportunities in the fields of fundamental and applied research; design and development; aeronautical, manufacturing, reliability, and test engineering; and quality assurance.



Sandia's liberal employee benefits include our graduate educational aid program, life insurance, sickness benefits, retirement plan, and generous vacations. These combine with excellent working conditions to make Sandia an exceptionally attractive place to work.

Albuquerque is a modern city of about 225,000 people, known for its excellent recreational attractions and its mild, dry, sunny climate. Livermore, located in the San Francisco Bay area, offers suburban living close to all the metropolitan advantages of San Francisco. Both are fine places in which to live.

We'd like to tell you more about Sandia Corporation and the opportunities it offers. Arrange for an interview with our representative through your Placement Officer, or write to Staff Employment Section CMC for a copy of our new illustrated brochure.

SANDIA CORPORATION

ALBUQUERQUE, NEW MEXICO

SANDIA LABORATORY RECRUITS WITH THE BELL SYSTEM TEAM

SCIENCE HIGHLIGHTS

Jim Mueller me'59

A NEW INTEGRATED TYPE
Helicopter Plant

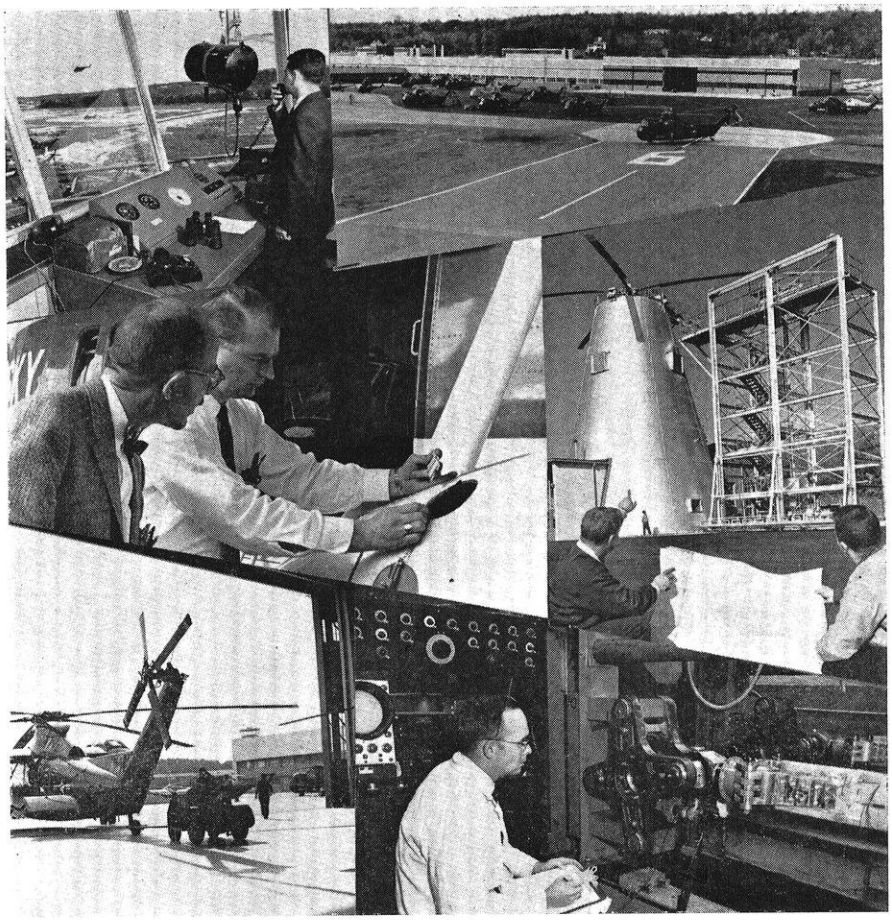
A design theme that reverses a modern trend in the aviation industry features a new 500,000 square foot engineering wing built by Sikorsky Aircraft, division of United Aircraft Corporation, at Stratford, Conn.

Through centralization and integration of the various engineering and production facilities, Sikorsky's engineers work in close proximity to their product from drawing board to flight field.

As the aviation industry has grown in size, it has tended to force engineers, particularly design people, further from the aircraft and flight field. In many cases, they don't even see aircraft. Some companies have located their engineers in localities separate from their experimental work. Sikorsky endeavors to have every engineer within convenient distance of his hardware.

The new wing, which is devoted chiefly to engineering and experimental work, is situated at the northwest corner of Sikorsky's 830,000 square foot plant so that it adjoins the flight field. The engineering wing brings together in one area the design people, test laboratories, experimental production department and flight test; i.e., the four most important elements in creating new aircraft.

Engineers can look out the windows and see helicopters on the ground and in flight. Windows on certain inside walls look out over the experimental production hangar and the experimental flight test hangar.



Views of the 500,000 square foot engineering Wing of Sikorsky Aircraft are shown from the flight field side (top right panel). Also in the right panel engineers check construction of Sikorsky's whirl test stand, largest in the world, and note results of blade fatigue test. In the left panel, control tower operator at Sikorsky flight field clears engineering helicopter for landing; test equipment engineers check installation on an aircraft; and Sikorsky S-56, world's largest production helicopter, is wheeled out of engineering hangar.

The integration idea has been carried out still further in the construction of a unique "peninsula," a three-story rectangular structure jutting out into the center of the huge hangar area. The peninsula is surrounded by the flight hangar, experimental production facilities, and laboratories. The peninsula contains people who support these operations. Located on its first level are hydraulic, electrical equipment, personnel, and hangar supervisors. The second level contains offices for pilots, flight engineers, and project engineers. On the third level are conference rooms. In building new aircraft for the mili-

tary, numerous conferences have to be held with government representatives. Many other engineering and administrative conferences also are required. The conference rooms are equipped with windows which look out over the experimental area.

The new wing includes expanded laboratory facilities, with provisions being made for static testing on a scale believed without equal in the helicopter industry. These facilities can test complete aircraft or any of its components.

The enlarged quarters also are enabling Sikorsky to pioneer in the aircraft industry a more rapid and economical method of reproducing engineering drawings. More than 8,000 individual drawings are required to build a new rotary-wing aircraft, and from 50 to 100 copies of each drawing have to be made for various phases of the design, manufacturing, and contract processes. In the past, all copies were made in a paper-to-paper process from the original drawing.

With the new process, the drawings are photographed with a three-ton camera, the impression transferred to a sensitized metal, and reproduced on a flat bed, offset proof press. The press is one of the largest of its kind in the country.

The entire engineering wing has been designed so that it can accommodate future growth in both aircraft size and production volume. Hanging points in the flight hangar, for instance, can pick up 80,000 pounds, nearly three times the weight of a fully-loaded Sikorsky S-56, which is the biggest production helicopter in the world.

In addition to providing for the entire engineering department, the wing houses the service department, production control, personnel, employment office, the photo department, a basement storage area, a cafeteria for 750 persons, an executive dining room, a main reception lobby, and escalators which carry several thousand persons daily from the main floor to the second floor where the bulk of the engineering department is located.

SOLAR 'SAIL' PROPULSION FOR SPACE TRAVEL

The cheapest, simplest, and lightest means of propulsion for man's exploration of space may involve a device he has used on earth for at least 3500 years. The device: A Sail. Not a wind-powered sail, but a "solar sail" made of aluminum foil or lightweight plastic material no more than one-thousandth of an inch thick which will use the energy of the sun to propel the space craft.

The performance of the solar sail on trips to nearby planets will be better than that of a chemical rocket. The theory that light exerts a small but definite pressure on a body when it shines on it was first made 85 years ago, but recent calculations have pointed out advantages a space sailboat would have over space propulsion equipment proposed during the past few years.

The solar sailboat would have to be launched from the earth by conventional means of rocket power. However, once in orbit, the rocket would be discarded and a huge, parachute-shaped sail could be unfurled and attached by shroud lines to a gondola carrying the payload and crew.

If the payload is 1000 pounds, calculations show that the required sail diameter would have to be 1600 feet, an area somewhat larger than the Pentagon building. Fortunately, there is not a lack of room in space. The very large sail can also be used as an excellent long-range radar antenna or as a radiation sweeper to remove the radioactive materials now known to exist in space.

There will be significant and substantial advantages to the use of the solar sail even before the space vehicle leaves its launching pad on the earth.

For example, to send a one-ton load to Mars by chemical rocket, nine tons of payload and fuel must first be shot to a satellite station. Choosing to sail, it is only necessary to shoot up one ton because the solar sail needs to carry no rocket fuel. So long as the sun shines, it has a power source. Calculations for a round trip with the same payload show that a chemical rocket would have to weigh 73 tons while the solar sail would still weigh only one ton.

The solar sail would be cheaper to build than any other means of propulsion that has been proposed. It can also be realized sooner since the necessary basic information is already at hand and no extensive research is required.

In operation, the space ship using a solar sail would work like this:

The ship would first be shot up from the surface of the earth by conventional rocket to an altitude of about 1000 miles where it would circle the earth in a satellite orbit. The sail would then be opened to receive the sun's energy. This energy causes the orbit to become larger and larger until the space ship escapes the earth's gravitational grip to become a solar satellite spiraling around the sun.

While this process of breaking free from the earth's gravitation may take several weeks, the orbit-to-orbit travel time via solar sailboat would be less than half the time required for a conventional rocket to reach orbital position around Mars; 118 days by sail as compared with 260 days by rocket.

Although a rocket would become a solar satellite much faster than a space ship using a solar sail, the rocket would have to go into an elliptical trajectory after burnout and would travel to the far side of the sun before intersecting the orbit of Mars. The solar sail, on the other hand, would be constantly under power. Therefore, it would be able to travel on a different trajectory and could take a "short cut." With a chemical rocket, you get a large force for a short time. Here, a small force is gotten for a long time; the solar sail will not run out of fuel so long as the sun shines.

By turning the mainsail, or possibly hoisting an auxiliary sail, this constant source of power can be used to control easily the direction of the space vehicle and thus reduce the serious problem of guidance in space. Space guidance would be a particular problem for rocket powered vessels which would have to use up precious fuel in order to be at an exact point in space at a precise time. But, if the

(Continued on next page)

solar ship by miscalculation should miss Venus on the first try, the sail will always provide the necessary propulsive force to turn back for another try. The ship could always return to the earth, even if many errors in navigation are committed.

INSULATION FOR 'RED HOT' ELECTRIC MOTOR

An electric motor which operates continuously over extended periods of time while completely immersed in temperatures of nearly 1000 degrees Fahrenheit has been developed by scientists of the Westinghouse Electric Corporation. The more than 100 hours while seated have operated in the thousand-degree range for any appreciable length of time without some form of artificial cooling. It has run for more than 100 hours while sealed inside an oven at 950 degrees Fahrenheit.

The motor was designed to test, in as severe a practical application as possible, the performance of a new system of electrical insulation for motors, transformers, relays, and other electrical equipment required to operate at very high temperatures, such as those encountered in the supersonic flight of jet planes, missiles, rockets, and other high-speed aircraft.

The new electrical insulation is described as a new system of insulation differing from any now in use. The system is composed entirely of inorganic materials, including inorganic binders to bond the insulation permanently to the wire it protects. No plastics, cloth, or other organic substances are employed.

It is a familiar fact that inorganic materials, typified by such substances as sand and clay, can withstand higher temperatures without deterioration than can organic materials. The problem is to find an inorganic material which has suitable insulating properties and at the same time is flexible enough to be placed around an electrical conductor.

An inorganic material with these "built-in" characteristics has been found. This means that full advantage can be taken of its natural resistance to physical and chemical deterioration at high temperatures. The temperatures at which it operates are well above the stability of any known organic system.

The new insulation has been tested for performance on a series of experimental motors. First tests were conducted on a five-horsepower motor operating at 110 volts. To raise the motor's temperature high enough to challange the insulation, heating strips were placed around the motor frame. The whole motor then was covered with a thick coating of asbestos to keep the heat from radiating away. In this early version the motor bearings were exposed to the air and were cooled by forcing additional air through them.

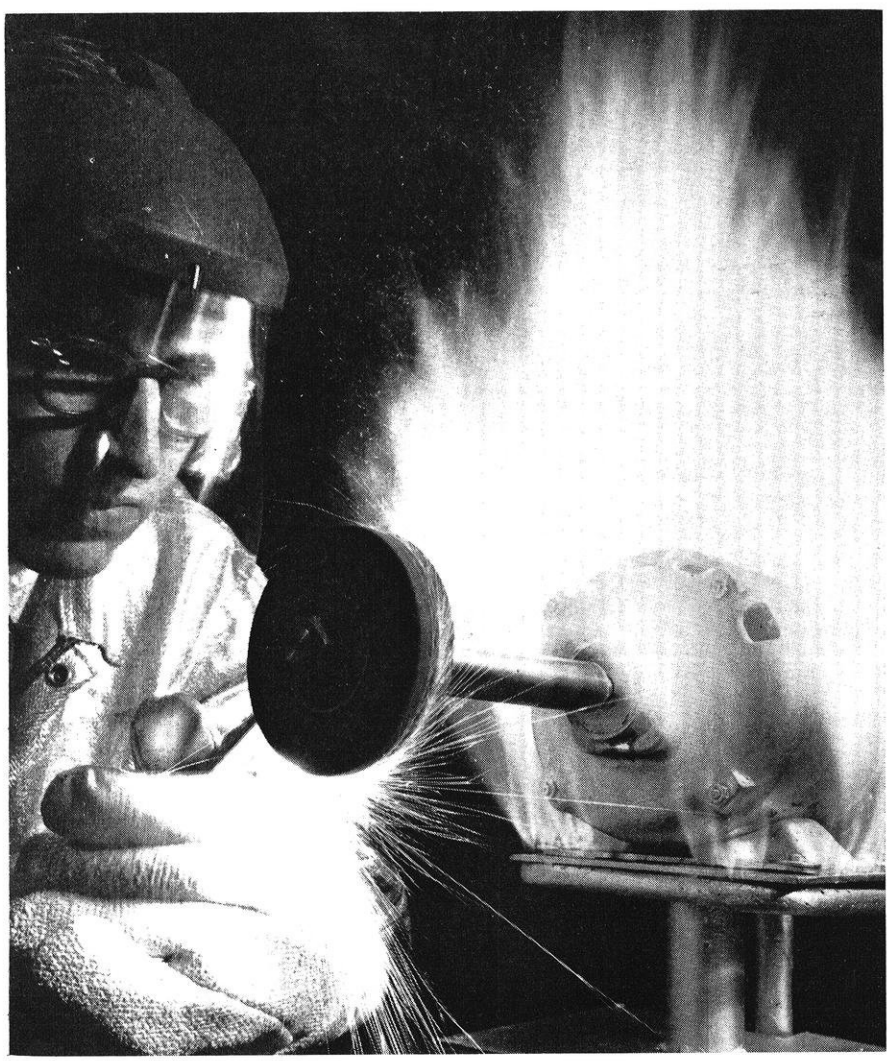
The motor ran at full speed under no-load conditions for more than 1000 hours at temperatures well above the melting point of metals such as lead and zinc. After the tests were stopped and the motor was torn down for inspection, no deterioration of the insulation could be found.

Following these initial tests, several versions of a motor were constructed that could operate while it was at red heat. These were smaller in size and used standard motor frames. Special high-temperature bearings allowed the motors, including their bearings, to operate continuously in the nearly 1000 degree heat.

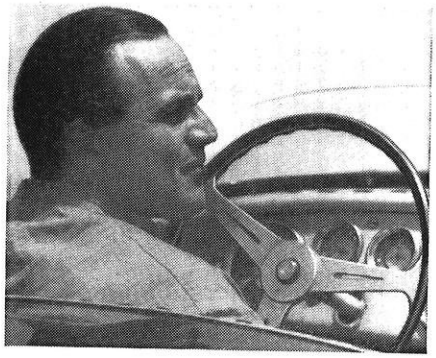
Copper wire could not be used to wind these experimental motors. At such temperatures, the metal soon oxidizes and becomes useless as a conductor of electricity. Among the most successful motors were those wound with wire of pure silver. The insulation also has been tested in solenoid coils, in small transformers, and in other devices.

The Westinghouse scientists reported that the new inorganic in-

(Continued on page 48)



This motor is operating under severe temperatures of nearly 1000°F. over long periods of time and still give satisfactory performance.



S. H. ARNOLT, *designer and builder of the Arnolt-Bristol sports car, and internationally known Indiana sportsman.*

"We design and build Arnolt-Bristols, and drive many of them ourselves in world-famous road races, at Sebring, Le Mans, and other courses. These road races are grueling tests of machinery. For Arnolt-Bristol cars, we use *forged* parts liberally, because *forged* parts are dependable when the going is tough. To win, to win safely, we depend on dependable parts, like forgings."

FORGED Parts are Dependable

when the going is tough

POSTSCRIPT: THE PRODUCTS OF THE FORGING INDUSTRY ARE FOUND AT VITAL POINTS OF MODERN CONVEYANCES AND MACHINES...LEVERS, STRUTS, CRANKSHAFTS, GEARS. THE FORGING PROCESS IS UNLIKE ANY OTHER. *FORGED* PARTS START WITH REFINED METALS—METALS ALREADY TRIED AND PROVED. THESE METALS ARE GIVEN ALMOST ANY DESIRED FORM OR SHAPE BETWEEN IMPRESSION DIES, UNDER ENORMOUS PRESSURE OR BY CONSECUTIVE BLOWS FROM POWERFUL HAMMERS. THE RESULT IS ADDED STRENGTH AND TOUGHNESS...WHICH PERMITS WEIGHT-SAVING DESIGNS, CUTS SERVICE COSTS, HELPS PROVIDE SAFETY IN A HIGH-SPEED WORLD.

DROP FORGING ASSOCIATION

55 Public Square Cleveland 13, Ohio

COMPOSED OF THE INDEPENDENT COMPANIES PRODUCING THE MAJOR SHARE OF COMMERCIAL FORGINGS IN THE UNITED STATES & CANADA

ENGINE EARS

by Tom Corth, ee'60

U.W. GETS $150,000 CHRISTMAS PRESENT

The University of Wisconsin's major Christmas gift, a $150,000 grant from the Atomic Energy Commission (AEC) which will provide a nuclear reactor for education in the peaceful uses of atomic energy, arrived in the form of a Christmas-eve telegram.

University regents are expected to consider accepting the grant at their next meeting. The grant was among only a half dozen given to leading American universities to aid the nation's atomic energy education program and the training of personnel in the rapidly expanding nuclear engineering field.

Dean Kurt F. Wendt of the UW College of Engineering said that the grant will provide the college with a nuclear reactor which will develop ten kilowatts of power plus other pieces of equipment, all to be used in the University's nuclear engineering program.

The nuclear reactor and other equipment will be installed by the University in a nuclear engineering laboratory in an existing engineering building on the Madison campus.

The nuclear engineering program was inaugurated in the UW College of Engineering in the fall of 1957. The program was developed and is administered by a Nuclear Engineering Committee comprised of faculty representatives from each department of engineering and from the departments of chemistry and physics.

The program was inaugurated because the rapid increase in the industrial applications of nuclear technology has created an urgent need for engineers having specific training in the nuclear sciences and related engineering applications, the committee pointed out when the program was started.

Under the UW program designed to aid in filling this need, the College of Engineering offers engineering training in nuclear energy through a master's degree program of study and research leading to the degree of master of science in nuclear engineering. The UW nuclear engineering program also provides opportunity to obtain a Ph.D. in this field.

Because some students taking the usual undegraduate engineering curricula are not sufficiently trained in physics, chemistry, and mathematics to start on the required M.S. study program, any student seeking his M.S. in the field is required to take certain undergraduate prerequisites. These can be obtained by enrollment in a "Nuclear Engineering Option" within the framework of the existing curriculum of any department in the UW College of Engineering, under the UW nuclear engineering program.

The College of Engineering added a new full time professor, Dr. Max W. Carbon, to its staff this year to take charge of the nuclear engineering study and research program. Dr. Carbon received his engineering degrees from Purdue University. He served in U.S. Army Ordnance during World War II. After receiving his Ph.D. in engineering from Purdue in 1949, he joined the nuclear engineering staff of General Electric Co., at its Richland, Wash., plant, where he served as thermodynamics specialist, pile engineer, chief of the heat transfer unit, and chief of the contact engineering unit during 1950–55. He came to the UW from the Avco Manufacturing Corp., research and advanced development division, at Lawrence, Mass.

The University's Nuclear Engineering Committee which developed the nuclear engineering program on the UW campus over a two-year period, included Prof. W. Robert Marshall, Jr., chemical engineering and associate dean of the College of Engineering, chairman; and Profs. Philip C. Rosenthal, mining and metallurgical engineering; R. Byron Bird, chemical engineering; Thomas J. Higgins, electrical engineering; Raymond J. Roark, engineering mechanics; Gerald A. Rohlich, civil engineering; Otto A. Uyehara, mechanical engineering; John C. Weber, electrical engineering; Robert G. Sachs,

physics; and Prof. John E. Willard, chemistry and dean of the Graduate School. Dr. Carbon is currently chairman of this Committee which now administers the program.

FELLOWSHIPS IN TECHNICAL WRITING

Rensselaer Polytechnic Institute is offering a graduate course in technical writing and editing leading to the Master of Science degree. The program gives the student intensive instruction and practice in technical writing in preparation for a career as a technical writer or editor in industry, government, or the technical publishing business. The curriculum encompasses courses in professional writing, literary research, and experimental research.

The major courses of study are offered by the Department of Language and Literature, but the student is required to include in his work advanced courses in science or engineering. Only applicants having appropriate background and experience in science or engineering will be admitted as candidates for this degree.

A number of fellowships and graduate scholarships are available at the Institute. Fellowships provide fees for tuition and a cash stipend. Scholarships provide fees for tuition only. All correspondence concerning admission to graduate study and fellowship and scholarship aid, including requests for catalogues and application forms, should be addressed to the Director of Admissions, Graduate School, Rensselaer Polytechnic Institute, Troy, New York.

MINING AND METALLURY CLUB NEWS

New officers for the Mining and Metallurgy Club were elected at the club's January meeting. They include:

Thomas Roth, *President*
Vladimir Petrovich, *Vice President*
Robert Sexton, *Secretary*
David Nelson, *Treasurer*

Thomas Mueller was also selected to represent the mining and metallurgical engineers on Polygon Board.

Following the elections, Thomas Pitterle, General Chairman of the Engineering Exposition, discussed aspects of the exposition and presented a film from the 1956 exposition.

COMING—WISCONSIN'S ENGINEERING EXPOSITION

Wisconsin's mammoth triennial Engineering Exposition will be held at the University of Wisconsin College of Engineering for three days next spring. The exposition, designed to give the general public inside information on the important part science, engineering, and industry play in their daily lives in the atomic-satellite age, will be held April 10, 11, and 12.

Biggest engineering project of its kind in the state, the exposition is such a huge undertaking that it is held only once every three years on the UW campus. The last one, viewed by thousands of Wisconsin citizens, was held in 1956. The 1959 exposition will be so large that exhibits and displays will be housed in all four of the big engineering buildings on the Wisconsin campus.

Early requests for show space already reveal that the huge exposition will have more than fifty displays by the state's and nation's largest industries. Along with the industrial displays, about 100 student displays have been planned for. Many students and student groups have already entered displays, but there is a need for many more. A few exhibits already entered and under construction by organizations are the Pi Tau Pi Sigma display featuring four voices on one radio channel for military communications, and the A. S. C. F. entry showing a highway in progressive stages of construction. Student exhibits feature a color organ by Charles McChure, and hi-fi in a coffee table by William Steil.

Remember! cash prizes are to be awarded to students and student groups for exhibits of high quality and original design. The deadline for entries is March 15. Any exhibits showing early progress will be used for newspaper and television publicity. For details on entering contact Ken Lewandowski, Student Exhibits Chairman, phone AL 5–0585.

WINNERS CHOSEN IN BUTTON DESIGN CONTEST

The winners in the 1959 Engineering Exposition button design contest are: First Place, Stephen Pech, EE–4, $10 and one ticket to the Exposition; Second Place, James Bartz, CiE–4, $5 and one Exposition ticket; and Third Place, Raymond Meyer, ME–2, one ticket to the Exposition. In addition to the excellent job done by the three winners, all forty entries showed much work and top-notch creative thinking.

EXPOSITION POSTER CONTEST

A poster contest is being held in conjunction with the coming 1959 Engineering Exposition. The theme of the Exposition is "Working For You" and will appear as a title on all posters along with the dates April 10, 11, and 12. Except for these requirements, the contest is open to any and all designs and ideas. Awards will be as follows: First Place, $10 and one ticket to the Exposition; Second Place, $5 and one Exposition ticket; and Third Place, one Exposition ticket. A thousand posters, all of the same design, will be distributed on campus and in and around Madison. The closing date for entries is February 27.

ASME NATIONAL MEETINGS AND CONFERENCES

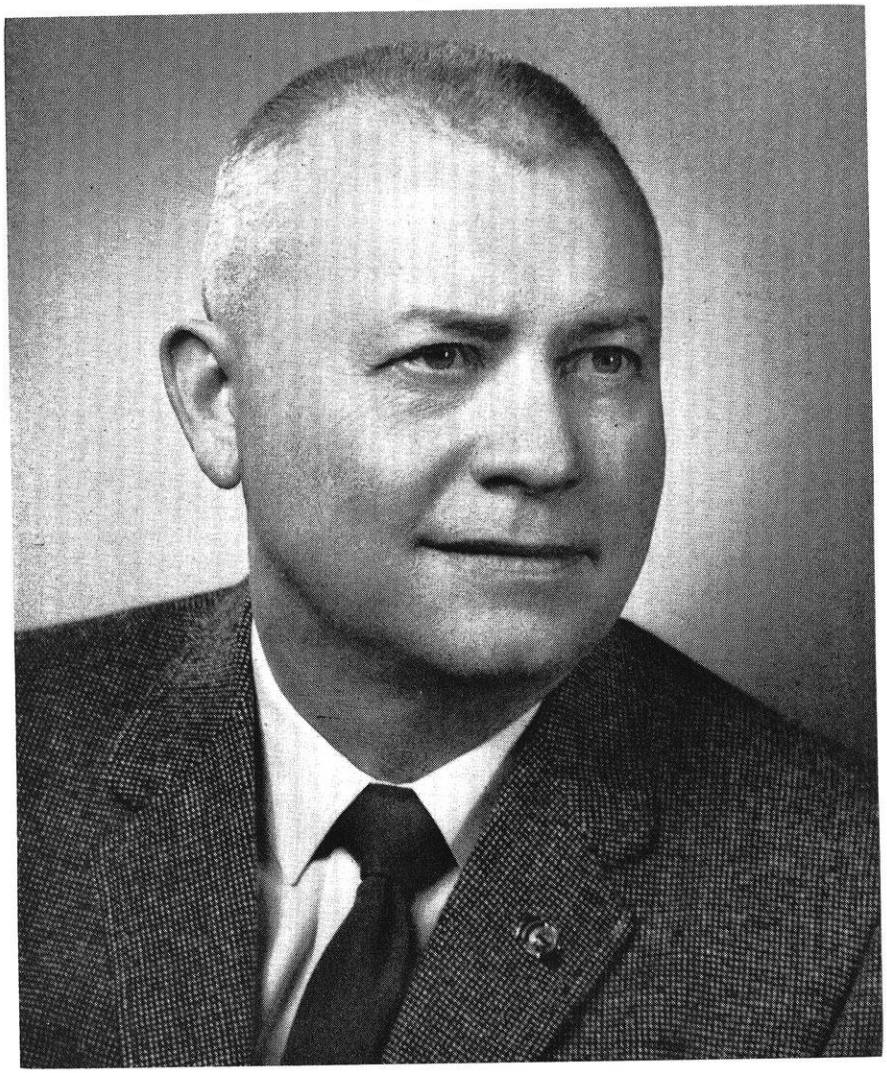
A record number of national meetings and conferences will be sponsored by The American Society of Mechanical Engineers during 1959, it was announced today. Twenty-eight major events are scheduled for the year, including ten which will be co-sponsored by other engineering groups.

Expected to attract the largest attendance are the Society's Annual Meeting in November, at Atlantic City, the Semi-Annual Meeting in St. Louis, in June, and the multi-society Nuclear Congress in April, at Cleveland.

The full schedule follows:

(Continued on page 49)

Meet the President



Benjamin C. Seal

Benjamin C. Seal, President of the Southeast Chapter of W.S.P.E. was born at Dewitt, Illinois, on April 1, 1905. He attended the University of Illinois, receiving the degree of Bachelor of Science in Civil Engineering at the University.

Mr. Seal has had the advantage of a varied work experience having been with the Corps of Engineers in the Mississippi River Area from 1928 to 1936; the City of Detroit, Michigan, from 1936 to 1938; Consoer, Townsend and Associates, Consulting Engineers from 1938 to 1940; the U. S. Army Corps of Engineers from 1940 to 1945; Warren and Van Praag Consulting Engineers from 1945 to 1948; and with Stone and Webster from 1948 to 1951. From 1951 to 1954, he served as City Engineer of Sheboygan, Wisconsin; and, in 1954, he assumed his present position as City Engineer of Kenosha, Wisconsin.

He has been active in both the Illinois and Wisconsin Societies of Professional Engineers. In 1946 and 1947, he served on the Publicity and Membership Committees of the Central Illinois Section of I.S.P.E. Since joining the Southeast Chapter of W.S.P.E., he has served as a Chapter Director, Vice President, and now President. Mr. Seal is also an Associate Member of A.S.C.E. and a member of the Kenosha Toastmasters Club.

Married to Lucille Tomiskey on June 9, 1934, he is the father of three children, Kathryn, Marilyn, and Stephen. His hobbies include golf, bridge, and the finishing and repairing of antique furniture.

Wisconsin Society of Professional Engineers

CAA NEEDS ELECTRONICS ENGINEERS IN ALASKA

The Civil Aeronautics Administration is recruiting electronic engineers for duty in Alaska, "where hunting and fishing are nearly perfect," and where, incidentally, a twenty-five per cent cost of living allowance is added.

College graduates hired at Grade 7 by the Federal Government will have to wait at least a year before promotion to Grade 9. Only "quality" graduates in engineering, science, and a few other professions will be hired at Grade 7 for the time being.

STATE HIGHWAY SALARIES UP

Salaries of state highway engineers have risen an average of 16 per cent in the last two years, the American Road Builders' Association reports. At the same time salaries in most states are still lagging behind the minimums recommended by the American Association of State Highway Officials.

The ARBA's fifth survey of state highway engineers' salaries is a comprehensive study of salary ranges for all grades of state highway engineers throughout the United States. As of the past summer, the averages include the following: chief engineer, $11,687–$14,045; bridge engineer, $9,370–$11,287; design engineer, $9,190–$11,121; district engineer, $8,832–$10,686. The report covers 21 job categories for each state. The full report is available from ARBA, World Center Bldg., Washington 6, D. C.

ACS SURVEY SHOWS 35% INCREASE IN SIX YEARS

Chemists and chemical engineers in 1958 are being paid an average of 35 per cent more in starting salaries than they were in 1952. Chemists' earning power increased about 32 per cent, and that for chemical engineers increased about 37 per cent during this six year period. These are among the major findings in the latest economic survey of the American Chemical Society.

Generally, the gains were not as great in 1958 as they were a year ago. The 1958 median starting salary for inexperienced B.S. chemists was $430 a month compared to $435 in 1957, but M.S. chemical engineers' salaries rose from $525 in 1957 to $541 in 1958. There was relatively little variation by geographic area—for B.S. chemical engineers West North Central was high with $480 and New England and Pacific were low with $470.

(Continued on page 51)

ENGINEERS' CREED

As a professional engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare.

I PLEDGE

To give the utmost of performance, to participate in none but honest enterprise, to live and work according to the laws of and the highest standards of professional conduct. To place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations. In humility and with need for Divine Guidance, I make this pledge.

Highlights from the November Milwaukee Chapter WSPE meeting featuring the presentation of P.E. and EIT certificates: Left to Right (1) Chas. A. Negel, President Milwaukee Chapter. (2) Frank R. Grabarezyk, recipient P.E. certificate. (3) Ralph D. Culbertson, State Engineer presenting certificates. (4) Frederick L. Plautz, recipient P.E. certificate. (5) Robert C. Johnson, President Siesel Construction Co. Mr. Culbertson and Mr. Johnson are members of the Registration Board.

George A. Sievers, Engineer of the Month

In the early post World War I years, a 21-year-old German lad, educated at Heidelberg in arts and sciences and seeking escape from the economic chaos then ravaging his homeland, sought new horizons. He visited relatives in Eau Claire, Wis., on his way to China; liked the forthright way of the American citizen; decided that this, not China, was his new horizon; stayed to apply for American citizenship, and shortly afterwards sent for Florence Thoelke, lifelong sweetheart, and destined to be his bride.

George A. Sievers, son of a German postal clerk, trained in philosophy, psychology, mathematics and languages in his homeland, liked people. He saw opportunities in the industrial growth of twentieth century America: large factories, production machinery, expanding labor-management problems. To train himself for his present avocation, he worked with his hands, as night foreman, shop superintendent, and chief engineer.

Through his employment in such companies as Hamilton Standard Propellor Corporation, Harnischfeger Corporation, the Falk Corporation, Line Material Co., and Galland-Henning Mfg. Co., George Sievers (now Dr. George A. Sievers, M.Ps., Ph.D., P.E.) had one goal in mind: to complete his studies in human behavior both of labor and of problems that motivate executives at work. He studied personnel problems, administrative and public relation problems, finance, labor, law, and economics. He received a diploma in electrical engineering at the University of Chicago and since has taken many special courses at the University of Wisconsin, Milwaukee Institute of Technology, and other schools in engineering, law, and accounting.

His industrial internship completed, Dr. Sievers founded the Industrial Engineering Institute in 1947 and has been in private practice ever since.

He serves industry and business as consulting psychologist and vocational counselor to young people and executives alike.

As president of the Industrial Engineering Institute, Inc., Dr. Sievers provides professional engineering services to industry.

The Bureau for Professional Employment, Ltd., was a natural outgrowth of these services. A licensed Wisconsin agency, the bureau places and procures professional people and executives with emphasis on engineering positions. Son, John W., was the director of this activity until his untimely death in June, 1958.

Dr. Sievers is a faculty member of the University of Wisconsin, Madison.

Dr. Siever's technical society affiliations are myriad:

AIEE, SAME, WSPE, NSPE, ASEE, and ESM.

He was president of the Milwaukee chapter of WSPE in 1954–55, and served as director of the state society from 1951 to 1953. Chairman of the State Ethics and Practice Committee during 1949–53, he has been chairman of the State Board of Ethics and Practice since 1950.

He has been Fellow and National Director of the SAM since 1952. He is a member of the American Ordnance Assn., American Society for Public Administration, Industrial Relations Assn. of Wis. and the Milwaukee County Society for Mental Health.

Dr. Sievers has authored many articles on professional development, engineering ethics, and training. He is lecturer and writer (Columbia and Marquette Universities, the University of Illinois and University of Wisconsin).

Dr. Sievers is active in the Milwaukee Kiwanis and Athletic Clubs and is a member of the Milwaukee Association of Commerce. He is a Mason and belongs to Shrine Temple.

The Doctor was active in squash and fencing at college. He likes to work out at the club, fishes when he finds time. In June, 1958, the Doctor was honored by membership in the National Association of Accredited Psychologists (Houston, Texas). "Who's Who" has listed him in the last two volumes. The University of London, England, deemed his thesis *cum laude* and conferred upon him the honor of Fellowship in January, 1958.

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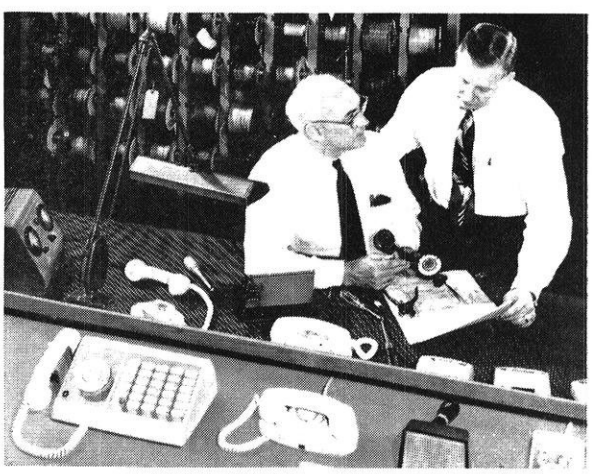

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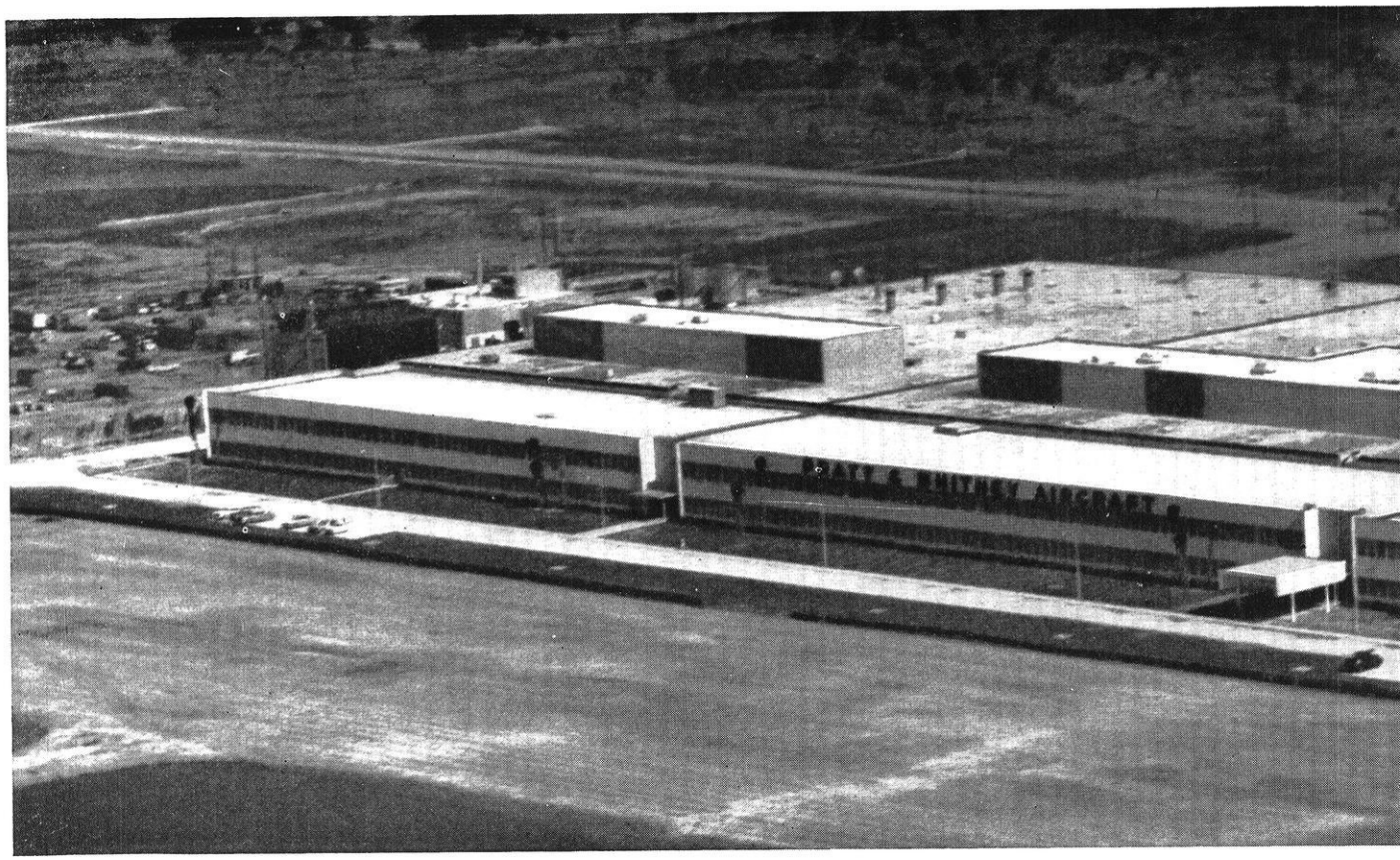
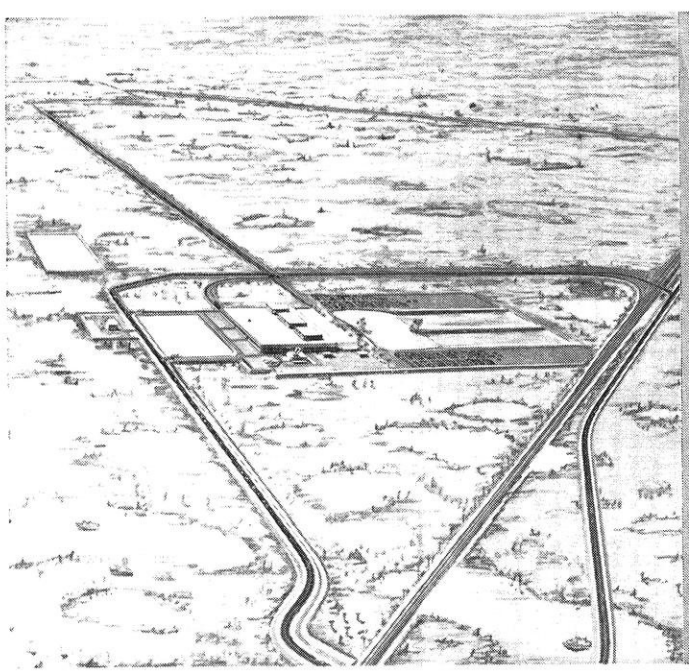
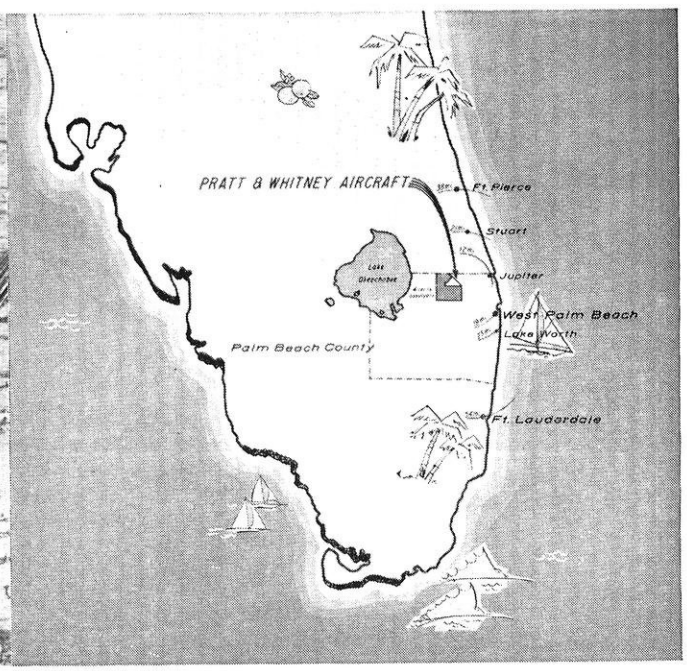


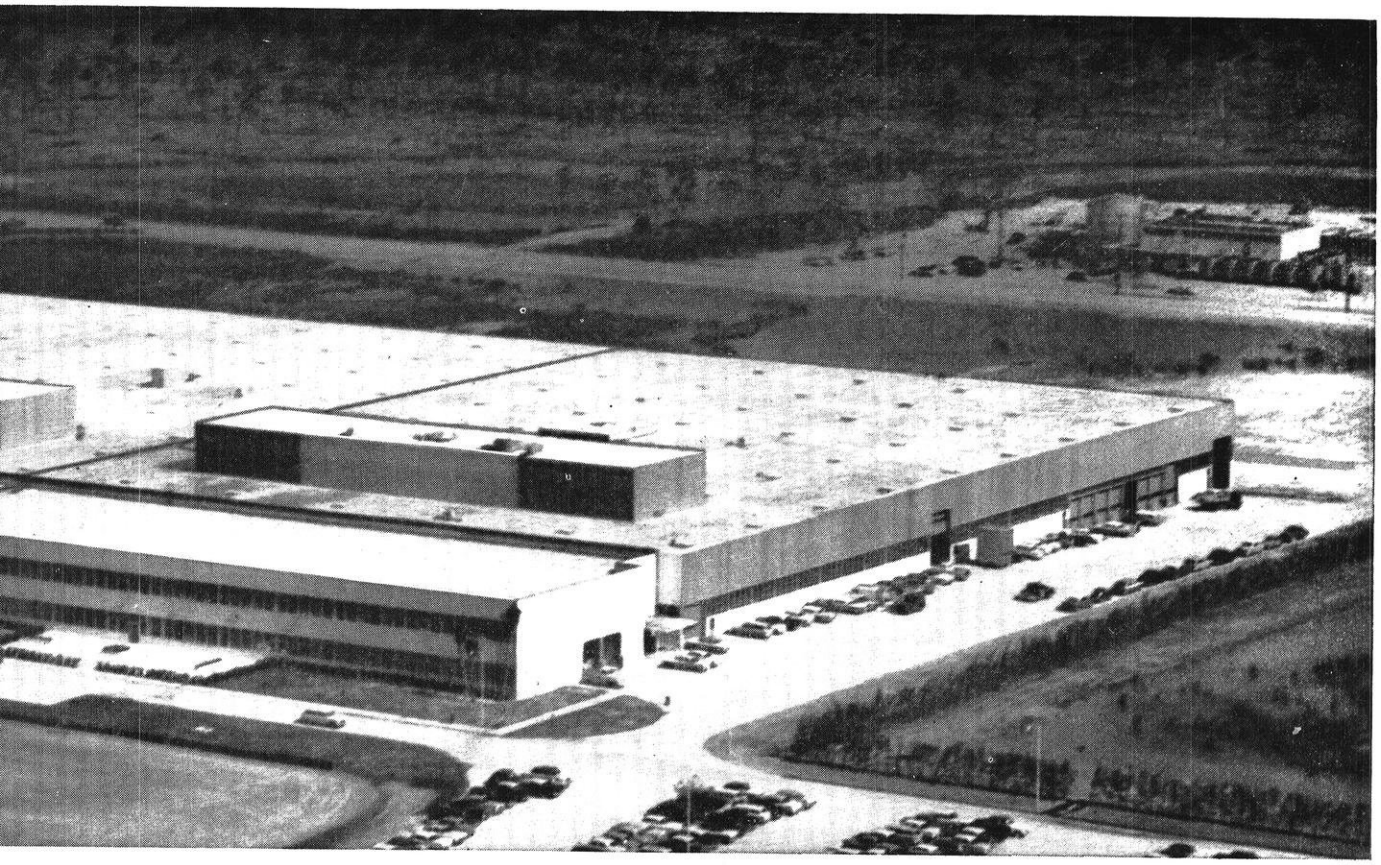
FLORIDA RESEARCH AND





ISOLATION—Ten square miles comprise the site of Pratt & Whitney Aircraft's new Florida Research and Development Center. Experimental shops and offices covering some 17 acres are in the foreground, while the tests areas, barely visible in upper left, lie four miles in the background.

LOCATION—The new Center is located at United, Florida, midway between West Palm Beach and Lake Okeechobee, in the upper Everglades area. It is almost surrounded by a wildlife sanctuary. Most employees live in the cities and towns along the east coast of Florida, driving to the Center on excellent new highways.



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Of the many people employed at the Center today, about half are scientists, engineers and highly trained technicians. By late next year, the total number is expected to be almost doubled.

The new Florida Research and Development Center is one more reason why Pratt & Whitney Aircraft is able to continue producing the world's best aircraft propulsion systems . . . in whatever form they take.

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FLORIDA RESEARCH AND DEVELOPMENT CENTER — United, Florida

Fertilizers

(Continued from page 12)

soluble so they are readily available, but also because of their solubility they are subject to loss by leaching.

Sulphur

Sulphur is a constituent of proteins and of glutathione (a compound supposed to take part in plant respiration), and is required by the plant in synthesizing essential oils. In some plants, such as legumes, the suphur content is greater than that of potassium. The necessity of applying sulphur depends on the local situation, but in general enough is already present and available because of compounds added during precipitation or from other fertilizers such as superphosphate. It is sometimes used in its elemental form to produce acidity or reclaim alkaline land. Sulphurous fertilizers are particularly successful when used on legumes.

Calcium

Calcium exists only in combination with other elements. It is generally believed that calcium has an influence on the translocation of carbohydrates. Plants suffering from a deficiency of calcium often show poor development and in many cases the terminal bud may die. The greatest use of lime is to neutralize the soil and to precipitate soluble toxins. The quantity of calcium present in most soils is so large that no more is needed to supply the needs of non-legumeous plants. The availability of calcium to plants is greatly decreased in an acid soil because of the inability of the plants to absorb it. Calcium is usually applied to the soil in the form of agricultural lime (ground limestone, oyster shells, etc.) and is also present in many other fertilizers.

Magnesium

Magnesium deficiency effects a larger area of the United States than any other deficiency. Magnesium is a key constituent of chlorophyll and may also help in the translocation of starch. Magnesium deficiency will result in such things as bronzing and reddening of the leaves, in chlorosis, and in some cases in a premature defoliage. Magnesium may be applied to the soil in a number of materials. The principal ones used are dolomitic limestone, potassium magnesium sulfate, and magnesium sulfate. Magnesium sulfates are very soluble while carbonates are only slightly soluble in the soil solution.

Rarer Essential Elements

The rarer essential elements (iron, manganese, boron, copper, zinc, and molybdenum) are those found in minute quantities in the plants or in both the plants and the soil. The response of plants to the presence of these elements varies with different plants and with different soil environment. Their uses are varied. They may be essential to plant growth; they may serve as substitutes; they may help form enzymes. An excess of as little as 2 parts per million of these elements may be toxic to plants.

Iron has long been known as an essential element. It appears to catalyze the production of chlorophyll, and its absence causes chlorosis. Most soils contain an abundance of iron, but a few acid soils and many alkaline soils have been reported deficient. Some of the heavier metals such as zinc and copper appear to make the iron in the soil unavailable. Iron is usually applied as ferrous sulfate, ferric oxide, or other soluble salts. Ten pounds of ferrous sulfate per acre are usually sufficient for the most iron deficient soils.

Manganese is particularly useful to legumes though essential in all plants. Many investigators concur that manganese tends to accumulate in the leaves and there is some proof that it can replace iron as a nutrient. Lack of manganese, therefore is obviously most noticeable in the leaves. Its availability is affected by its degree of oxidation, and it may also be limited by the relative acidity or alkalinity of the soil. It is usually applied as manganese sulfate in quantities of 25 to 100 pounds per acre.

Boron's exact role in plant growth is still unknown, although its function seems to be closely related to that of calcium. An increased absorption of boron does seem to increase the absorption of the other nutrients to an extent of several hundred percent. The availability of boron is hindered by an over abundance of lime. It is usually applied as boric acid or borax, and the quantity must be carefuly the quantity must be carefully are toxic.

Copper has recently been accepted as an essential nutrient. The exact function of copper is unknown, but it has been suggested that it plays a role in the synthesis of chlorophyll. Copper deficiency seems to affect most plants in the leaves as they are sometimes stunted or are lacking in solidity. Copper is applied as copper sulfate alone or in combination with other fertilizers.

Zinc is particularly important in the citrus industry. It appears to be necessary for normal chlorophyll production and growth and deficiency may lead to such things as the *mottle leaf* of citrus and *white bud* of corn. Its availability seems to be affected by intense summer light and high temperatures, as zinc deficiency diseases are generally found in this type of climate. Zinc is usually applied as a soluble salt such as zinc sulfate, which is frequently used in solution for spraying trees.

Molybdenum, of all the rare elements, seems to be taken up in the smallest amounts. Molybdenum nutrition in the higher plants appears to be associated with the nitrogen cycle. Deficiencies frequently result in the mottling of the lower leaves and the curling of the edges of the leaves. Molybdenum's availability is impaired in soils of a pH less than 5.3. It is applied as sodium or ammonium molybdate in amounts of from two ounces to one pound per acre. Molybdenum also appears as an impurity in superphosphates and this alone may be enough to eliminate a deficiency.

A balance of all these elements is essential for good plant growth. The amount of each nutrient needed may vary from situation to situation, but all of them are necessary in some amount. This amount can be decided only by a consideration of the individual situation. A wise use of fertilizers can lead to an increase of yield up to 100% and also a continuation of this higher production.

THE END

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Amazing textile fibers spun out of natural gas . . . wonder drugs squeezed from coal . . . shining stainless steel forged from drab, brownish earth. These man-made marvels were born in the minds and hands of research scientists.

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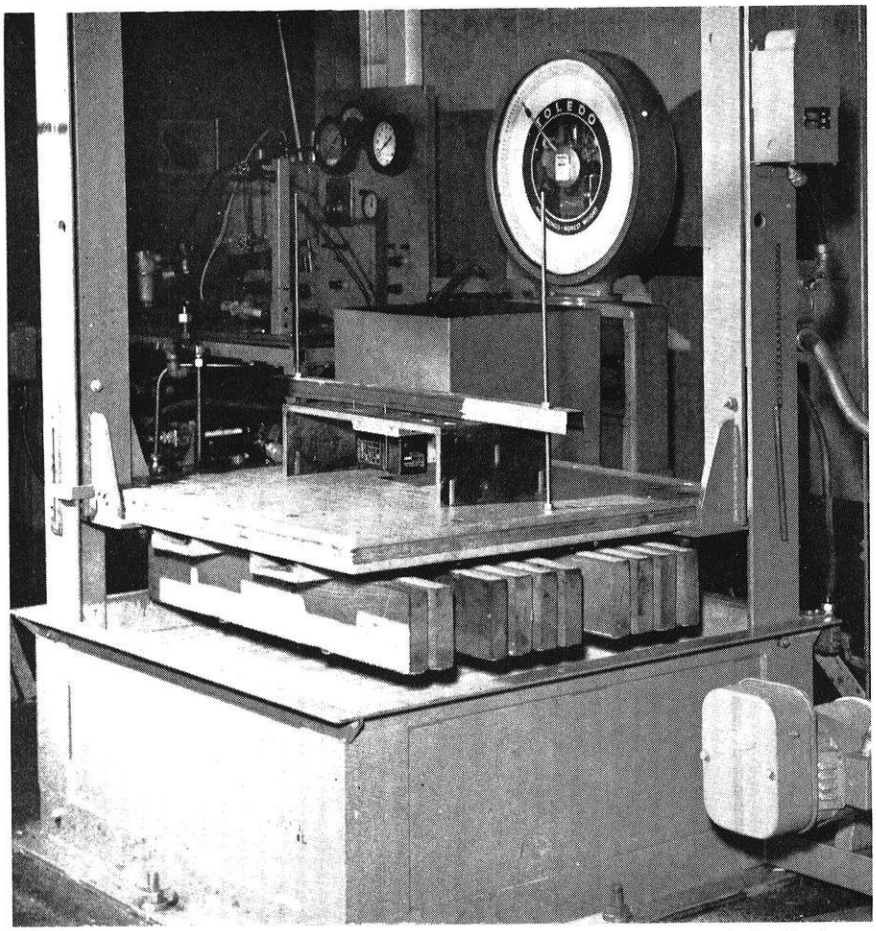


Fig. 4. Shock test machine. Platform raise 4 inches above sand for 15 9's shock and 10 beams under platform for 11 millisecond shock duration.

Product Testing

(Continued from page 19)

of eleven milliseconds. As a rule, most of the equipment is not operated during the shock test but is checked functionally after words to determine if the shock has produced any permanent failures.

Most equipment can be designed to withstand any specified shock conditions. Therefore, it is seldom difficult to achieve satisfactory results and is a relatively simple test to perform. Where delicate equipment such as instruments or radio gear must withstand high level shock conditions this equipment is normally mounted on what is called shock-mounted panels. These panels are isolated from the frame of the air craft by various shock-absorbing mounts which prevent high intensity shock and vibration from being transmitted into the delicate equipment.

Acceleration

This test is intended to determine the structural integrity and performance characteristics of equipment when subjected to acceleration forces produced by severe maneuvers of the craft. The forces produced within an aircraft maneuvering at very high speeds can be as high as 15 times gravity; therefore, to determine the effects of these conditions on equipment, it is necessary to produce them artificially on the equipment in the laboratory.

To produce these conditions in the laboratory a large centrifuge is required. The centrifuge is normally a long arm mounted to a rotating shaft so the arm can be rotated in a horizontal plant. The equipment under test is secured to the arm at the extreme and where it will be subjected to the greatest number of g's from the minimum number of revolutions of the arm. Figure 5 illustrates an acceleration machine equipped with special equipment for testing missile components and systems.

The test procedure is similar to the shock test in that the accelerations are applied in each direction of the three major perpendicular axis. The specified acceleration value is maintained for about one minute. When operation of the equipment during the acceleration is required, the test becomes much more difficult to perform. The reason for this is that all input power to the equipment must be transmitted through slip-joints and slip-rings at the shaft of the acceleration machine. Likewise, all outputs to be monitored must be transmitted out through slip rings; or continuous recording equipment must be located on the arm to record the phenomena while the acceleration is applied.

Humidity

Because of the high cost of aircraft it is necessary that they remain in service for a long period of time. Therefore, equipment and components incorporated in aircraft must be highly resistant to the effects of humidity so that there is a minimum amount of maintenance and repair.

Equipment required to perform this test is an insulated stainless steel-lined chamber which is equipped to vary the temperature and humidity content of the air. Humidity chambers are equipped with automatic control and recording equipment to maintain and record the environmental conditions within the chamber.

The test involves checking the equipment prior to subjecting it to the humidity test to determine its level of performance and then placing it into the humidity chamber for several days at a high humidity level. Operation is seldom required during or while the equipment is in the chamber, but the equipment must meet some standard of performance immediately subsequent to the test. The reason for this is that most performance deficiencies resulting from the humidity are permanent and can, therefore, be detected subsequent to removing equipment from the chamber.

The purpose of the humidity test is to determine that high humidity does not have a harmful effect on performance. The most difficult requirement is that the humidity condition does not create excessive corrosion or breakdown of the protective treatment with which the equipment is preserved. Mechani-

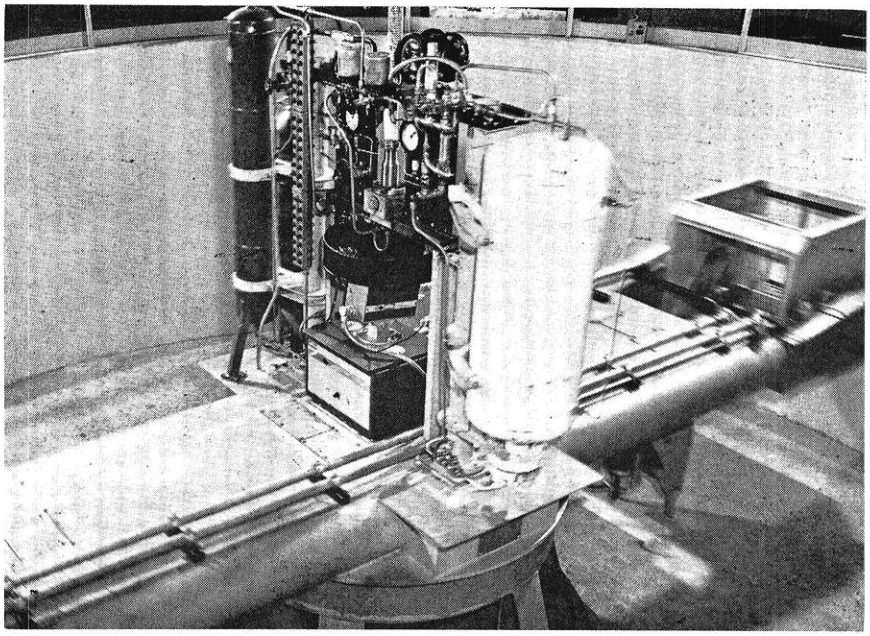


Fig. 5. Acceleration machine. This machine is mounted in a concrete pit for safety.

cal and hydraulic equipment usually offer less problems than electrical equipment in meeting the humidity requirements.

Sand and Dust

This test is intended to simulate the effects that dirt and contamination which the air might have on equipment performance and protective treatment of housings and cases. Because an aircraft may be in Alaska one day and in the Sahara Desert the next day, permanent protection must be incorporated in equipment against the adverse effects of airborne sand and dust particles.

The facility for performing the sand and dust test is somewhat similar but much smaller than a wind tunnel. Equipment is mounted within the chamber so that air can be circulated around all sides of it. The chamber is constructed so that circulating air carries the sand and dust across the equipment under test.

The procedure involved in running the test is very similar to the humidity test in that the equipment is not operated during the sand and dust conditions. The equipment is set up in the chamber and the sand and dust conditions are maintained for about eight hours after which the equipment is removed from the chamber, functionally checked and/or visually examined for any detrimental effects.

Fungus

The resistance of materials to support fungus growth seems at first insignificant. But experience during World War II showed that much military equipment was destroyed or made useless because it was not resistant to fungus growth. This is particularly true of equipment which will be used in tropical areas.

The facility used for performing a fungus test is the same as that used in humidity testing. The equipment is maintained in a warm, humid condition which is conducive to the growth of fungus.

The method of performing the test involves setting the equipment within the chamber and contaminating it with a variety of fungi. (The specific types of fungii being specified in MIL–E–5272.) The equipment is then maintained under warm, humid conditions for a period of 28 days. At the end of this time, the equipment is removed from the chamber and visually examined for any live fungus. It is then decontaminated to prevent undesirable contamination to humans and other objects.

There is considerable controversy over the criterion of this conditions of the test have a cortest. The reason being that the conditions of the test have a corrosive effect due to the high humidity required as part of the test conditions. Thus, much equipment fails this test because of effects of humidity rather than those of the fungus growth. It is, however, usually considered that if the materials with which the equipment is constructed have not supported the growth of fungus during the 28-day period the equipment has met the requirements of the test.

Salt Spray

A salt spray environment is encountered in coastal areas where the atmosphere contains salt-laden moisture. The effects of this environment can be extremely devestating, particularly to equipment composed of dissimilar metals where salt deposits on the equipment set up electrolytic action.

The salt chamber is usually a neoprene-lined box with provisions for atomizing and spraying a salt solution. The chamber is usually equipped with automatic controls and recorders to provide a record of the test conditions.

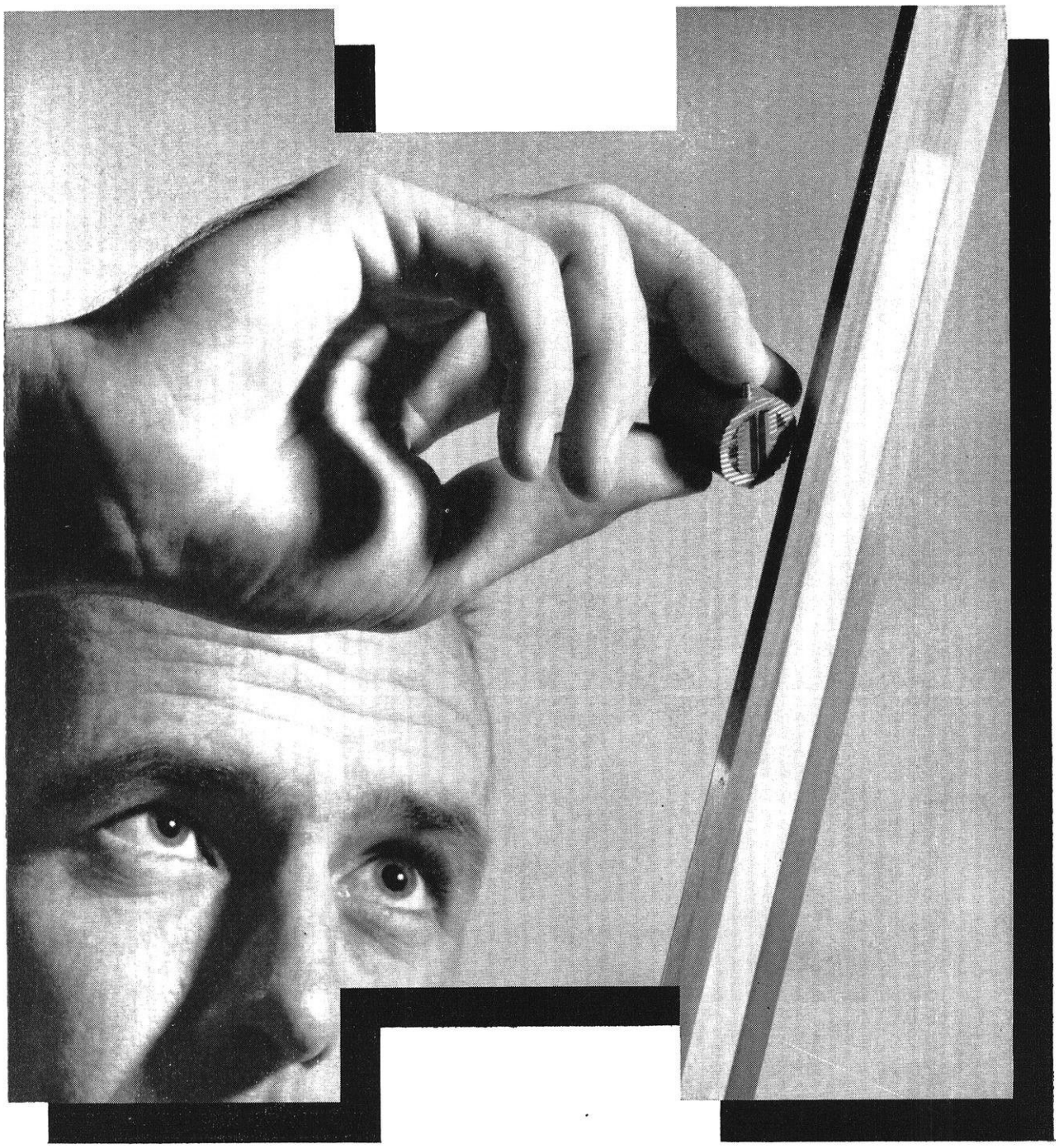
The general procedure follows that of the humidity test in that the equipment is initially checked prior to being subjected to salt spray test. It is then set up in the salt spray chamber and subjected to the salt spray for 50 hours. Following this, the equipment is removed from the chamber again, functionally tested and visually examined for deterioration and corrosion resulting from the salt spray. When one test item is used for a series of tests, the salt spray test is usually the last one to be performed. The reason for this is that it is almost impossible to remove all of the salt spray deposits left on the test specimen. When fungus testing is performed on the same specimen as salt spray, the fungus test must always precede the salt spray because the fungus will not survive on any materials contaminated with salts.

The main criterion in the test is that the protective treatments employed prevent excessive corrosion by the salt and that the equipment's performance is not affected.

The above environmental tests are representative of those tests required for most airborne equip-

(Continued on page 59)

Measuring progress with an



electronic yardstick

This etched metal bar *(at left)* directs the electromechanical positioning of cutting edges in the first all electronically-controlled machine tool line.

Developed by Hughes Products, the commercial activity of Hughes, this unique control system integrates any desired number of machine tools into one production line. Milling, drilling, tapping, boring and reaming operations are performed automatically to precise tolerances. Other commercial activities at Hughes Products center around the research, development and production of semiconductor devices, specialized electron tubes, and other advanced electronics systems and components.

The wide range of interest present in the commercial area of Hughes is also typical of other Hughes activities. The Research and Development Laboratories are conducting investigations into Advanced Airborne Electronics Systems, Plastics, Guided Missiles, Space Vehicles, Subsurface Electronics Systems, Global and Spatial Communications Systems...and many more. Hughes in Fullerton is developing radar systems which position beams in space by electronic rather than mechanical means. Complete modern manufacturing facilities are maintained at El Segundo (advanced armament control systems), Fullerton (3-D radar systems), and Tucson, Arizona (Falcon IR and Radar guided missiles).

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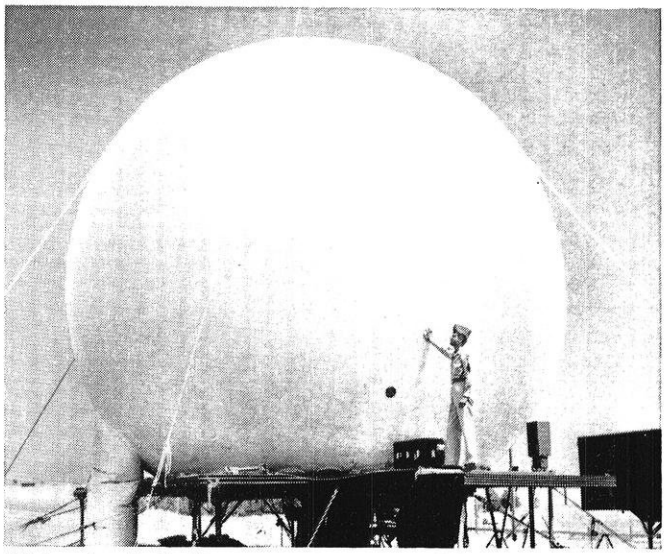
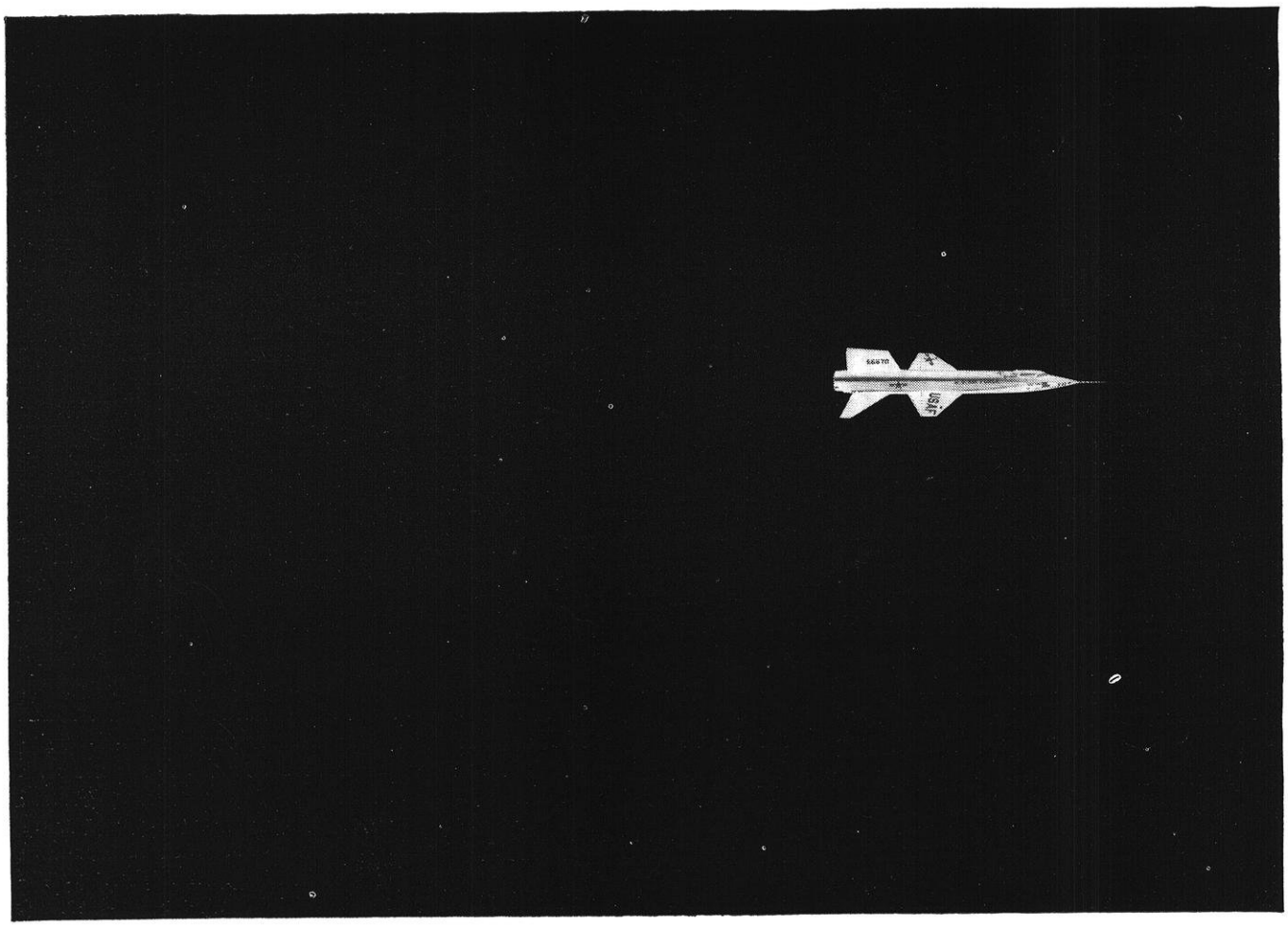


This plastic balloon, *resting on a mobile trailer unit like a golf ball on a tee, protects the new Hughes Frescanar three-dimensional radar antenna.*

Falcon air-to-air *guided missiles with both radar and infra-red guidance systems are being developed and produced by Hughes engineers in Tucson, Arizona.*



PPG glass will be there at...

mach 5+!

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The windshield of this rocket-like aircraft is double-glazed installations of glass by Pittsburgh Plate. The outer glass is tempered Herculite® heat-resisting glass; the inner is laminated safety glass with a Silicone interlayer. These specially fabricated X-15 windshields were made to resist terrific temperatures and to meet all other loads to which they will be subjected in this high performance, pressurized aircraft.

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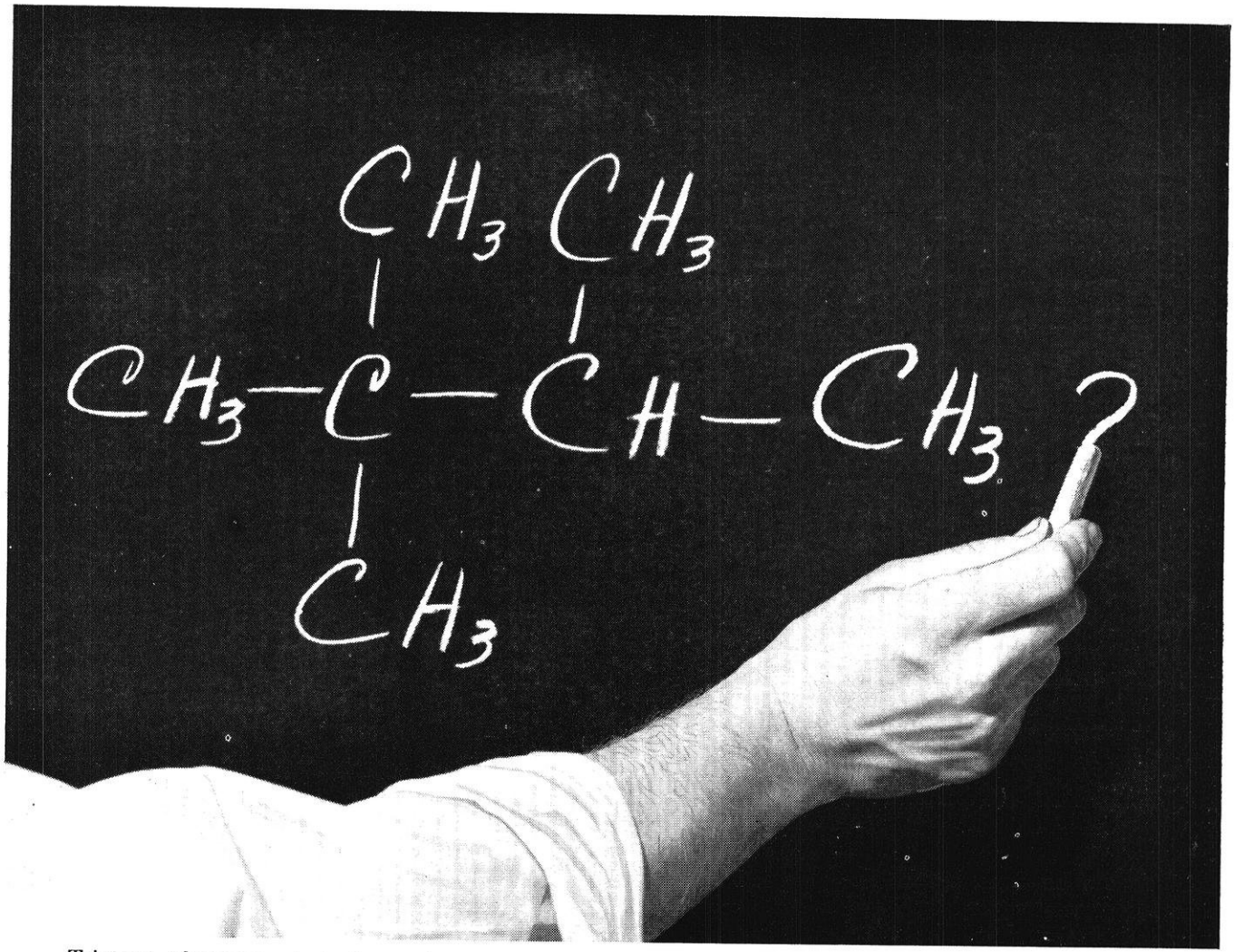

Triptane, whose formula is shown above, represents one of the most important challenges in petroleum research. Although oil companies have been working with this valuable gasoline anti-knock component for 15 years, no method for low-cost commercial production has yet been developed.

We don't have all the answers...yet!

We already know quite a bit about triptane, whose formula is shown in the picture. It is a branched heptane. Scientists at Standard Oil's laboratories can tell you that its octane number is 113. It is one of the best gasoline ingredients ever discovered.

As far back as 15 years ago, triptane could be produced in tank truck quantities. But no one has yet developed a large volume commercial method of making this valuable material.

Triptane represents but one of the creative research challenges that exist in the oil industry. A commercial way to make cyclopentane, another anti-knock material, ranks high on the list of unsolved problems. The same is true of certain hydrogenated polymethyl naphthalenes; their high energy content and low pour-point make them ideal for jet fuel.

At Standard Oil, young scientists and engineers have the opportunity to help solve important problems such as these. Here they can use their skills and knowledge to build satisfying, lifetime careers.

STANDARD OIL COMPANY

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STANDARD

THE SIGN OF PROGRESS...
THROUGH RESEARCH

Vapor Lock

(Continued from page 21)

higher the R v p, and the greater the tendency for vapor lock.

The gasoline industry is faced with the problem of providing a gasoline with high R v p during the winter for good starting and a gasoline with a low R v p during the summer for freedom from vapor lock. In addition to this, new crude oil reserves are of higher volatilities and in the event of a war, civilian gasoline would be of a higher R v p.

At present, the general public is paying for a gasoline that gives satisfactory results in freedom from vapor lock in most makes of cars. If the fuel industry should alter the R v p so that no cars would have vapor lock, then only those cars prone to vapor lock would be receiving their money's worth. Thus, it is best to try to redesign the cars having a vapor lock tendency.

CORRECTIVE ACTION TO ELIMINATE VAPOR LOCK

Much can be done by the designer to prevent vapor lock. Foremost in his mind should be a fuel system to handle gasoline with a minimum temperature rise. He should also build a fuel system requiring a minimum pumping effort and of an adequate capacity.

The gasoline industry is limited in changing their gasoline to prevent vapor lock. They are faced with large surpluses of highly volatile gasolines. These are the ones which have a vapor lock tendency. If the petroleum industry can devise a method of using these gasolines without vapor lock occuring, the price of gasoline would probably decrease.

Correction in Design

The first thing to be considered in a corrective design is the relocation of fuel system components. It has been proven that most ideal locations for fuel lines from the tank to the pump are on the outside of the frame with a slight upgrade. This upward slope causes any vapor in the line to naturally flow to the highest point. Thus it eliminates a trap for the vapor to collect.

Fuel filters, which are not an integral part of the fuel pump, should be located at a level approximately the same as the fuel pump. It should not be mounted in an elevated position.

Components which cannot be relocated, such as the carburetor and fuel pump, should be protected from sources of heat by shields and/or insulation.

A design feature which will greatly reduce vapor lock is the elimination of fuel line restrictions. This can be partially accomplished by using large enough lines to reduce the effect of fluid friction. Another aid in this respect is the minimum use of fittings and elbows and a design which avoids sharp bends in the line.

To combat the vapor lock problem in low pressure lines, automotive engineers recommend the use of an electric pusher type of pump mounted at or in the gas tank. The tank pump has several advantages:

1. It eliminates the suction line.
2. No filter loss.
3. Positive head at the pump.
4. Fuel under a non-pulsating pressure.
5. Pump is located away from heat zone of engine and exhaust.

Desert tests have shown that even though the gasoline in the fuel tank was boiling, the pusher type pump delivered gasoline to the carburetor. It is because of these advantages that many trucks and bus fleets have converted to the use of electric fuel pumps; thus, eliminating vapor locking tendencies.

Alteration of Fuels

The petroleum industry at this time is attempting to produce gasolines with higher volatilities but with about the same or lower R v p. To produce a gasoline of this type, petroleum engineers are working closely with automotive engineers. By proper blending of different types of gasolines and the use of additives, the engineers hope to accomplish their goal. But until that goal is reached, the petroleum industry must continue to control the R v p by the method now in use.

For the past twenty to twenty-five years, the petroleum industry conformed to the season of the year. During the winter, a gasoline with a high R v p is used, and during the summer, a gasoline with a low R v p is used. This method of combating vapor lock works out satisfactorily unless an unseasonably warm day comes while winter stocks of gasoline are still on hand.

SUMMARY

It may be stated that most vehicle manufacturers of today are very concerned about vapor lock and test their vehicles extensively. But the R v p of gasoline has been increasing slightly every year; thus, placing cars made a few years ago into a vapor lock classification.

Action to take in eliminating vapor locking tendencies in vehicles must be restricted to redesign of the fuel system. Four main points to remember in redesign are:

1. Handle fuel with a minimum of temperature rise.
2. Keep pumping effort to a minimum in delivering fuel from the tank to the carburetor.
3. Keep changes in cross-section and elevation of fuel lines to a minimum.
4. Have an adequate pumping capacity to insure sufficient liquid fuel to the carburetor when relatively large amounts of vapor are formed.

In conforming with the above four points, many times the cost of the revised fuel system is less expensive than the original system. In addition to this saving in cost, gas mileage may also be increased by reducing the carburetor bowl temperature. These two incentives alone should cause the manufacturers of vehicles prone to vapor lock to investigate a method of reducing it. **THE END**

* * *

Sheriff: "I'll have to swear you in as a deputy, Deadeye, in this emergency . . . But are you sure you can handle a couple of thirty-eights?"

Deadeye: "I certainly can. And I could do all right with a couple of skinny gals, too!"

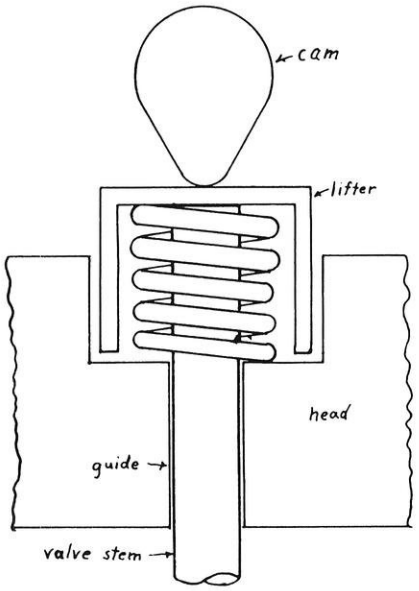


Fig. 4.
Cup Type
Valve Lifters

Auto Design

(Continued from page 24)

at lower speeds. Low speed torque, idling, and fuel economy all suffer.

What I propose is some device in the camshaft drive that will cause the camshaft to run slightly "ahead" or "behind" its normal compromise position. This would have the effect of changing the valve timing with different speeds to get the best efficiency. Only two positions would be needed, one for high speed and the other for low speed operation. If the camshaft were chain driven, a set of idler sprockets could maintain the proper chain tension and, at the same time, vary the length of chain on each side of the drive to produce the desired results.

Of course, the amount of valve duration and overlap must be seriously compromised between high and low speed performance. Unfortunately, these characteristics are built into the cam, and the system which I propose would do nothing to correct this. However, if two camshafts were used, one for the exhaust valves and the other for the intake valves, the valve overlap could be controlled by my method.

A simple vacuum or electrical device, dependent upon either engine load or speed, could be used to activate the system between its two positions.

This engine differs radically from present designs in many respects. I believe that sound reasoning is behind these hypothetical changes and that they produce advantages that make them worthwhile. The major differences from the conventional engine are:

1. Use of aluminum instead of cast iron in the cylinder block.
2. Use of wet cylinder sleeves with the coolant in direct contact with the sleeves.
3. Absence of head gaskets.
4. Incorporation of the combustion chamber in the crown of the piston rather than in the head.
5. Water cooling the intake manifold rather than using a hot spot for vaporizing the fuel.
6. Use of overhead camshaft without rocker arms or valve lifters.

Some of the advantages that these construction features make possible are:

1. Easy manufacturing processes because of absence of blind internal passages in the block and use of wet sleeves.

(Continued on page 59)

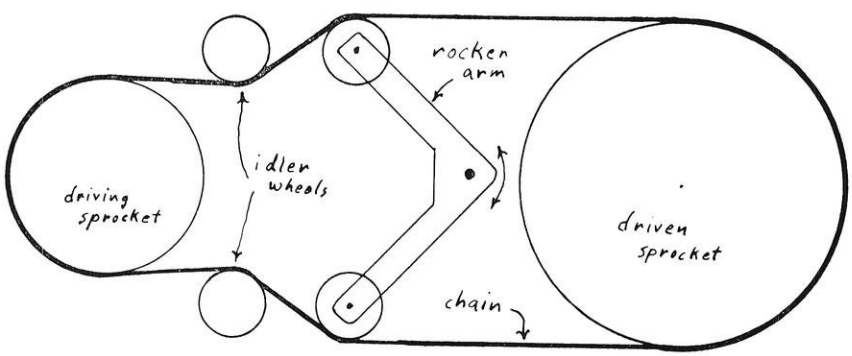


Fig. 5. - Camshaft Drive
for Variable Valve Timing

Science Highlights

(Continued from page 28)

sulation has been prepared experimentally in a number of forms suitable for a wide variety of uses. These include: insulated wire, flexible sheet insulation, and laminated materials. They also reported that these insulating materials are easily prepared on conventional equipment with low-cost raw materials. Only minor changes from conventional methods are necessary for processing of the components into the complete insulation system. The thermal life of all the insulating materials up to temperatures of 950 degree Fahrenheit is considered almost indefinite.

While there are still some problems to be solved in perfecting these new insulating materials and in adapting them to practical use, the major problems in designing a very high temperature inorganic insulation largely have been solved. Such insulation is of particular interest because of its potential applications in the 'red-hot' electrical equipment demanded by supersonic flight.

'SHAKING' OF ATOMS SHOWS STRUCTURE OF MATTER

Scientists have discovered a new way to probe into the complicated interior structure of matter by vibrating its atoms back and forth up to twenty-million times a second. The technique, known as "nuclear magnetic resonance acoustic absorption," is viewed as a major advance in methods for studying the structure of crystalline matter. It opens up a whole new field of research by permitting studies on crystals which have not been possible up to now.

Nuclear magnetic resonance acoustic absorption (NMRAA) takes advantage of the fact that the nuclei of atoms resemble tiny spinning magnets. These nuclear magnets have north and south magnetic poles, comparable to the poles of a compass needle, which tend to line up parallel with one another when placed between the poles of a magnet.

The vibrating supplies enough energy to affect the spinning nuclear magnets, thereby upsetting the atoms' magnetic balance. The unbalance is detected through tiny, tell-tale electrical signals that show the interaction between the atomic nuclei and the electrons swarming around them. This electronic "look" inside the atoms of crystalline matter reveals the crystal's internal structure and allows the scientist to better understand the forces holding the crystal together.

Nuclear magnetic resonance (NMR) has been known for more than a decade and within the past few years it has been turned into one of the most valuable tools of modern physics and chemistry. NMR is used to study the structure of molecules, to make chemical analyses, even of complex organic compounds, to study chemical processes, and to obtain basic scientific data on certain types of crystals. However, as with most techniques in science, NMR has limitations. It cannot supply this same sort of information about materials that conduct electricity, such as metals and semiconductors, which are certainly two of the most important classes of materials man has at his command.

This limitation on the usefulness of standard nuclear magnetic resonance is inherent in the technique itself.

The nuclei of all atoms have an over-all electric charge and a net motion, or spin. Any electric charge in motion creates a magnetic field, and so, in effect, the nucleus behaves as a tiny magnet with north and south magnetic poles.

These tiny nuclear magnets can be aligned by a steady magnetic field, much as compass needles are swung into line by a magnet. But when this is done, the nuclear magnets start to wobble, or precess, somewhat as the compass needles will oscillate back and forth when a strong magnetic field is first applied.

In ordinary nuclear magnetic resonance, a second magnetic field, this one pulsating instead of steady, is applied at right angles to the steady field and is adjusted in frequency until it matches exactly the rate at which the tiny nuclear magnets wobble. When so adjusted, the nuclear magnets absorb energy. This action provides the electrical signals used to "see" the internal structure of the substance under study.

But this technique does not work for metal and semiconductor crystals simply because the pulsating magnetic field cannot penetrate these materials and tip over their nuclei. These substances act as a shield against the pulsating magnetic field, just as a steel building cuts radio reception by shielding a radio receiver from radio waves.

Fortunately, there is a way to penetrate this shield. If a crystal is set into rapid vibration, magnetic and electric fields are created inside it. These internal fields interact with the nuclei in much the same manner as an externally applied field. When the motion matches exactly the frequency of wobble of the nuclear magnets, the nuclei behave exactly as they do when a pulsating external magnetic field is applied to them.

This nuclear shaking is done with sound waves, but by no means ordinary sound waves, those used vibrate up to twenty-million times per second. The sound waves used in the experiments came from a vibrating quartz crystal bonded to the crystal under study.

The objective in these experiments simply was to experimentally verify a theory which predicted this acoustic resonance in nuclei. It was not intended specifically to develop a new tool of significant practical value. However, from the results so far obtained, it appears that this new technique does indeed provide such a tool. It has performed successfully with semiconductors and the belief is it can be applied to similar research with metals. It should be a great help in reaching a better understanding of these two important classes of matter.

"H–IRON" BLAST FURNACE

The familiar blast furnace which produces metallic iron by reacting iron ore and coke may someday be replaced by units which use iron ore and hydrogen gas. This, in turn, may well lead to a decentralized iron and steel industry.

Recent developments have radically changed the picture which, until recently, has made the blast furnace unchallengeable under

American economic conditions. These developments include increasing capital cost of the blast furnace which is pricing itself out of the market while advances in natural gas and petroleum technology provide basis for a new iron ore reduction process of both excellent fuel efficiency and high unit capacity.

In a blast furnace, carbon from the coke combines with oxygen from iron oxide to leave metallic iron. In the "H-iron" process, the carbon would be replaced by hydrogen.

Adoption of the new process would mean lower capital construction costs for steel plants. Operating costs in the northeastern United States would be comparable for the new and old processes, but operating costs for steelmaking in Texas or other natural gas producing states are appreciably lower for the "H–iron" electric furnace route.

This development is of interest to the oil and gas industry since it provides a potential outlet for petroleum products and may permit refiners to find more economic uses for gases and heavy residues from crude oil processing.

The "H-iron" process, besides reducing costs, will free the steel industry from the necessity of locating plants where coke is available. With oil and natural gas serving as sources of the reducing hydrogen, being widely distributed and readily transportable even to remote locations, the "H–iron" process greatly multiples the number of locations where steelmaking is economical.

No one imagines that existing blast furnaces will be abandoned for many years to come, but the steel industry must give serious consideration to the combination of "H-iron" and electric furnaces for future expansion of steelmaking capacity. Several steel companies are already studying this combination for expansion of steelmaking activities in areas where natural gas is available.

Diversion of existing coke supplies from blast furnaces to hot-blast cupolas melting "H–iron" also presents attractive possibilities, in this way, a threefold expansion of hot-metal capacity can be secured without construction of new coke ovens. If the "H–iron" process succeeds in capturing most new iron-making capacity, use of hydrogen for "H–iron" manufacture may approach present hydrogen consumption in ammonia manufacture within ten years.

THE END

Engine Ears

(Continued from page 31)

ADVANCE SCHEDULE OF MEETINGS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS 1959

Symposium on Thermophysical Properties—Purdue University, Lafayette, Indiana—Feb. 23–26

ASME Gas Turbine Power Conference and Exhibit—Netherlands–Hilton Hotel, Cincinnati, Ohio—March 8–11

ASME Aviation Division Conference—Statler–Hilton Hotel, Los Angeles, Calif.—March 9–12

ASME Textile Engineering Conference—Clemson College, Clemson, S. C.—March 12–13

ASME Instruments & Regulators Division Conference—Case Institute of Technology, Cleveland, Ohio—March 29–April 2

American Power Conference (in which ASME and other Engineering Societies will take part)—March 31–April 2

Nuclear Congress (sponsored by Engineers Joint Council)—Cleveland Auditorium, Cleveland, Ohio—April 5–10

ASME–AIEE Railroad Conference—Sheraton Hotel, Chicago, Illinois—April 8–9

ASME Hydraulic Division Conference—University of Michigan, Ann Arbor, Mich.—April 13–15

ASME Oil & Gas Power Division Conference & Exhibit—Shamrock–Hilton Hotel, Houston, Texas—April 19–23

ASME–SAM Management Conference—Statler–Hilton Hotel, New York, N.Y.—April 23–24

ASME Metals Engineering Division Conference—Sheraton–Ten Eyck Hotel, Albany, N.Y.—April 29–May 3

ASME Maintenance & Plant Engineering Div. Conference—Edgewater Beach Hotel, Chicago, Illinois—May 4–5

ASME Production Engineering Division Conference—Statler–Hilton Hotel, Detroit, Mich.—May 12–14

AIEE Conference on Automatic Techniques (in which ASME will take part)—Chicago, Illinois—May 11–13

ASME Design Engineering Conference—Philadelphia Convention Hall, Phila., Pa.—May 25–28

ASME Semi-Annual Meeting—Chase–Park Plaza Hotels, St. Louis, Mo.—June 14–18

ASME Applied Mechanics Division Conference—Virginia Polytechnic Institute, Blacksburg, Va.—June 18–20

ASME–AICE Heat Transfer Conference—University of Connecticut, Storrs, Conn.—Aug. 9–12

ASME Wood Industries Conference—Multnomah Hotel, Portland, Oregon—Sept. 10–11

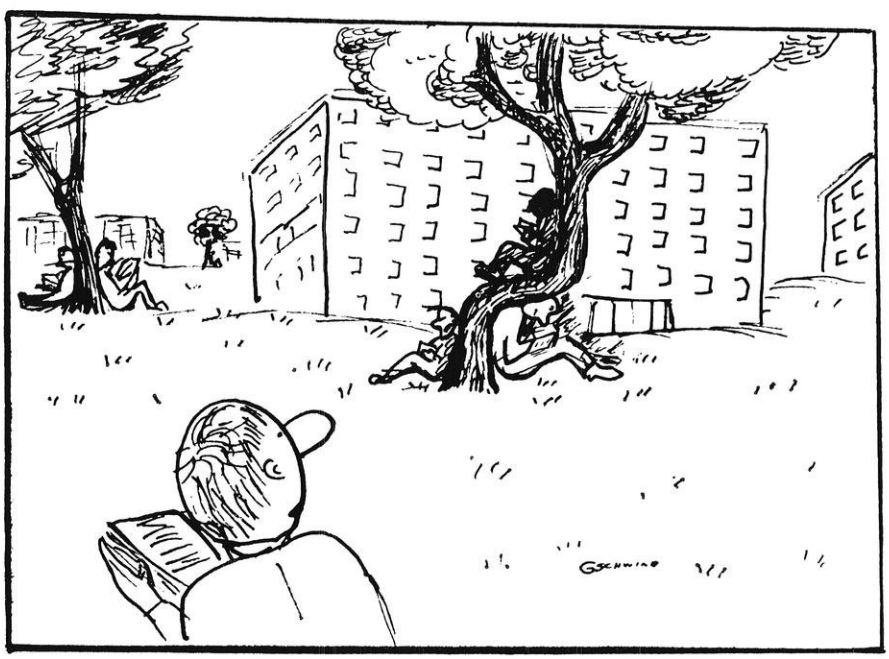
ASME Engineering Management Conference—Statler–Hilton Hotel, Los Angeles, Calif.—Sept. 17–18

ASME Petroleum Mechanical Engineering Conference—Rice Hotel, Houston, Texas—Sept. 20–23

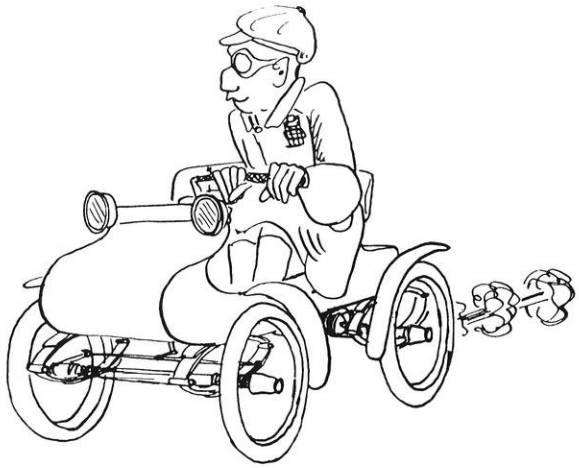
National Power Conference co-sponsored by ASME & AIEE—Muehlebach Hotel, Kansas City, Mo.—Sept. 28–Oct. 1

ASME–ASLE Lubrication Conference—Sheraton–McAlpin Hotel, New York, N.Y.—Oct. 20–22

(Continued on page 60)



Professional Students.



THE ENGINEER OF YESTERYEAR

by John Nichols ee'60

HEADLIGHTS FOR LOCOMOTIVES

December, 1912

DURING the earlier period of railroading in this country, no attempt was made to run trains except during the daylight hours, except in cases of emergency or delay. Because of the rapidly increasing traffic and the transportation of mail, it became necessary to establish night runs, which required some method of illuminating the track. One of the first devices was a fire basket, or a fire built on a platform in front of the locomotive. A more satisfactory illuminant became necessary as night runs became longer and more frequent, resulting in the development of a headlight fitted with a reflector. It is probable that lard or whale oil was used in the lamps of the earlier headlights. A short time after the introduction of headlights, considerable use was made of an oil distilled from coal, known as "coal oil," a term which persisted in 1912 as a popular name for kerosene. The term kerosene was originally a name for a particular brand of coal oil.

As the speed of trains increased a brighter illumination of the track was demanded in order to avoid accidents. Under normal conditions, a heavy train at sixty mile per hour may be brought to a stop in about 2,000 feet. This distance is much greater that the oil headlight is able to illuminate. Therefore the oil headlight is of no value in showing obstructions ahead. Its value is only that of a signal light to an approaching train and as a spreading light which gives the engineer some indication of his position by showing land marks on or close to the right of way. An oil headlight was developed in 1912 which had a silvered glass reflector and front lens giving better illumination along the track than the old design, but the beam was of small diameter and outside its range the illumination was not as good as with the older type.

In 1912, efforts were made to devise a type of electric arc light which would be efficient for use on locomotives. A satisfactory arrangement consisting of a small turbo-generator set was finally developed to give power to the lamp. The lamp itself consisted of a carbon rod for the positive terminal and copper for the negative terminal. Thus, automatic feed was required only for the carbon. This light was of sufficient quality to give good illumination of the right of way far enough ahead to prevent damage from obstructions, to give warning of an approaching train, and to give light bright enough to enable the engineer to see the semaphore signal blades. However, this light also had some severe drawbacks. An engineer looking into the field of this light developed temporary color blindness within two hours time. Classification lights were practically obliterated on a locomotive carrying this light. And it was nearly impossible for an observer to estimate the distance and speed of an approaching locomotive.

WOODEN PIPES

February, 1913

Lead was the first type of pipe used. It was used by the Romans for distributing water to their Thermae baths, fountains, and reservoirs. The introduction of wooden pipe in comparatively modern times marks the first move toward sanitary development. In the seventeenth century, some of London's water supply was distributed through wooden pipes. It was in 1800 that a great advance was made, one London company alone having nearly 400 miles of pipe. As many as ten lines were laid side by side to form a single main.

In 1865, public water supplies were generally introduced, and by 1913, most civilized countries had developed a general system of water supply. Wooden pipe was used in the United States as early as 1755. In 1800, Philadelphia installed wooden pipes, which being dug up in 1913, were found to be well preserved.

The wire-wound type pipe was usually made in convenient lengths of eight to sixteen feet. Each joint was a butt joint, enclosed in a sleeve or coupling made to a high pressure fit. The pipe was made of selected, kiln-dried Douglas fir. The staves were milled to true radial lines and assembled in forms and clamped. The pipe was then placed on a winding machine were wire was wrapped around it as it was rotated.

Wood when kept continously saturated with water was practically indestructable. The life of wooden pipe left continuously saturated was limited only by the life of the metal wrapping.

Wooden pipe did not burst when frozen. The reason being that the expansion was taken up by the wooden staves, the wire imbedding itself slightly more in the wood.

AIR CONDITIONING

March, 1913

Air conditioning realized its birth in applications in the textile industry and in the manufacture of pig iron.

In the textile industry, prior to the adoption of artificial methods, one of the main reasons for the American mills not successfully completing with European mills was largely due to the atmospheric conditions within the American mill centers. English manufacturers, ignorant of the principles of hygrometry and the mechanics of air and water, found that certain districts possessed climatic characteristics which fitted them for textile manufacturing. These districts were well sheltered vales with many cloudy days anda fairly constant humidity.

Modern high speed spinning machines cause a static charge of electricity to be set up in the fibers of cotton and cause them to stand out radially. It is necessary to produce atmospheric conditions of correct humidity and temperature to kill the electricity. Various methods were employed to obtain the conditions. At the outset, the floor was sprinkled and the evaporation of the water was supposed to increase the humidity. This crude method was replaced by channels, lined with porous brick which absorbed the water from the channels and gave it up to the air. Later, mechanical devices called humidifiers were employed. These humidifiers were classified as spray and evaporative types. The spray type introduced a finely divided spray directly into the room, while the evaporative type introduced only the water vapor. The amount of moisture was controlled automatically by devices similar to thermostats.

W.S.P.E.

(Continued from page 33)

Education Lags; Engineers Lead Chemists

The report summary shows that industry continues to pay recent graduates considerably more than academic institutions, and that chemical engineers do better than chemists. During 1958 there was a significant increase (52%) in the number of chemists and chemical engineers working for advanced degrees on graduate assistantships. There appears to be no significant dearth of jobs in chemistry or chemical engineering at the present time. The dollar value of advanced degrees is shown among industrial employers by starting salaries for chemists of $450 for B.S., $525 for M.S., and $700 for doctorates. By industry classification, the highest rate for B.S. chemical engineers was in metals (including steel) at $486, followed by chemical at $480.

The full report is contained in the October 20, 1958, issue of *Chemical and Engineering News* (1155 Sixteenth St., N. W., Washington 6, D. C.)

Eleven-School Survey of Starting Pay

A starting salary survey of eleven engineering schools, conducted by the editors of *Machine Design*, finds an increase of five per cent for 1958, compared to a yearly increase of five per cent for 1958, compared to a yearly increase of ten per cent in both 1956 and 1957. Averages were reported in the range of $475 to $515. Again in 1958, electrical engineers were at the top—from $480 to $535.

For the full report see: *Machine Design*, August 7, 1958 (Penton Bldg., Cleveland 13, Ohio).

APPLICATIONS FOR MEMBER AND AFFILIATE MEMBER—DECEMBER 6, 1958

Name and Position	Address	Reg. No.	Sponsor
FOX RIVER VALLEY			
Robert L. Van Hagan, P.E. Chief Engineer Central States Engr. Inc.	1000 W. College Ave. Appleton, Wis.	E-938	W. A. Mitchell, P.E.
Kenneth A. McLyman, E.T. Project Engineer Four Wheel Drive Co.	Green Tree Road Box 117 Clintonville, Wis.	ET-336	M. J. Bauer, P.E.
MILWAUKEE			
Frank A. Grabarczyk, P.E. Machine Design Engineer Allen Bradley Co.	1578 S 37th St. Milwaukee 15, Wis.	E-6713	J. R. Meyer, P.E.
Norman T. Kohlhardt, P.E. Field Supervisor General Electric Co.	940 W. St. Paul Ave. Milwaukee 3, Wis.	E-6149	C. T. Nauman, P.E.
Richard D. Pelton, E.T. Structural Engineer Lakeside Bridge & Steel Co.	4457A N. Hopkins Milwaukee, 9, Wis.	ET-2047	W. C. Dries, E.T.
NORTHWEST			
Werner J. Dicke, P.E. Plant Dept. Wis. Telephone Co.	R.F.D. 1 Eau Claire, Wis.	E-2605	T. A. Gustafson, P.E.
SOUTHWEST			
Donald P. Ryan, P.E. Partner Ryan Brothers Co.	P.O. Box 206 Janesville, Wis.	E-6734	R. P. Jahnke, P.E.
David W. Treadwell, E.T. Research Assistant University of Wis.	46 Breeze Terrace Madison 5, Wis.	ET-1931	Ed Busby, P.E.
Gerald X. Diamond, P.E. Metallurgical Engr. Private Practice	P. O. Box 1207 Madison 1, Wis.	24168 (Temp. permit for Wis.)	Transferred from Ohio
Paul T. Spelman, P.E. Engineer—Director Wis. Concrete Pipe Association	1033 Fiedler Lane Madison, Wis.	E-5666	Transferred from Mich.
Kenneth G. Carlson, E.T. Civil Engineer Mid-State Engr. Co.	127-10th Ave. Baraboo, Wis.	ET-1396	H. A. Kallsen, P.E.
WAUKESHA			
Gary K. Coates, E.T. Civil Engineer I City of Waukesha	328 W. Newhall, Apt. 4 Waukesha, Wis.	ET-1564	R. Vanden Noven, E.T.
Wm. B. N. Schultz, E.T. Ass't City Engineer City of Ft. Atkinson	9 S 4th St. West Ft. Atkinson, Wis.	ET-1929	R. P. Jahnke, P.E.

THE END

STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

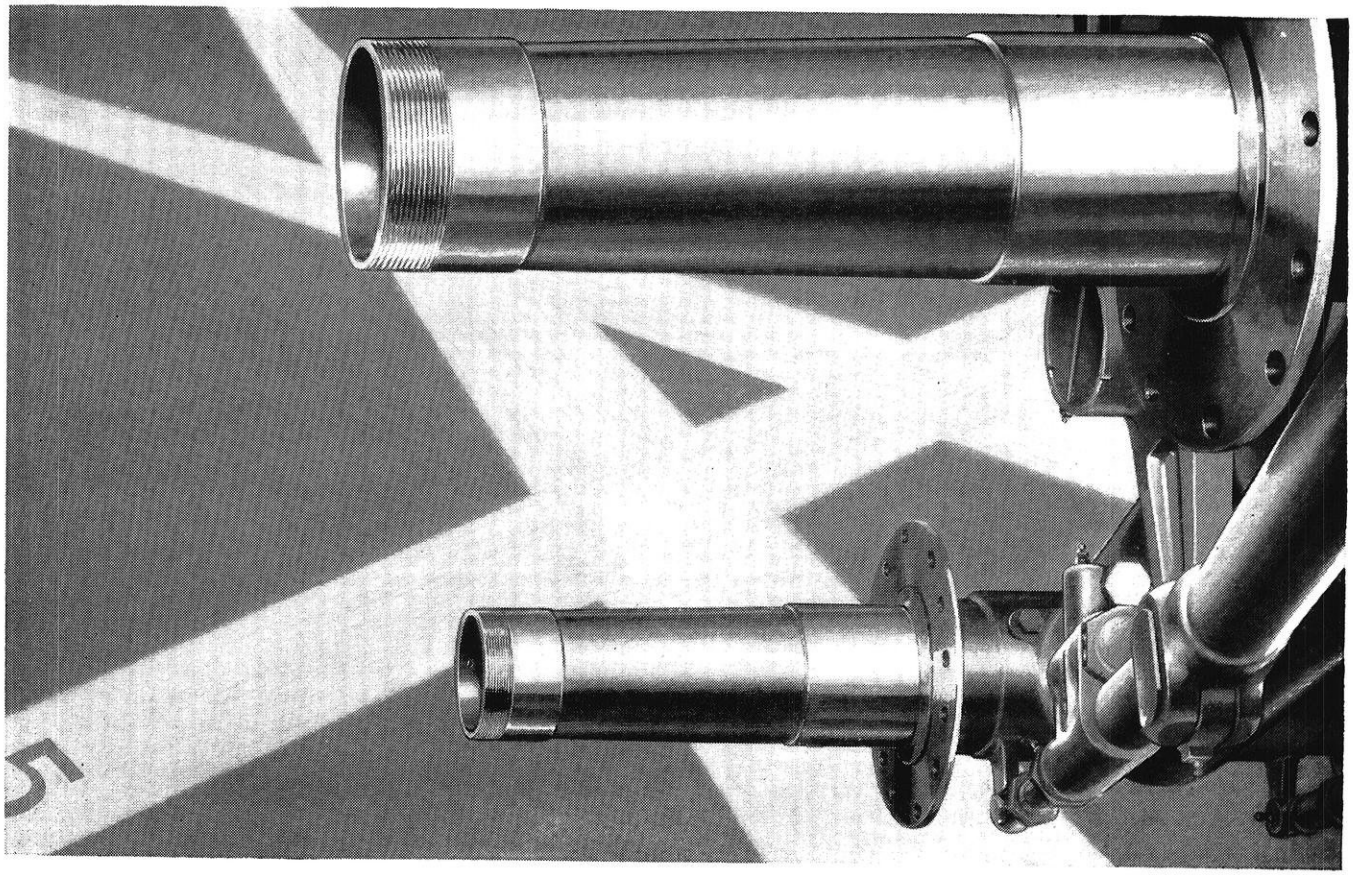
You may wonder what the future holds for the engineer who decides to build his career in the aircraft/missile industry.

In terms of permanent demand, this industry probably requires a greater proportion of engineers to total personnel than any other. Here at Douglas we are now employing more engineers than we did during World War II.

In regard to professional standing, the aircraft/missile industry deals always with the latest state of the art in every engineering and scientific specialty involved. Its engineers are in one of the best informed and highest prestige fields in their profession.

Whatever your present activity, if you decide to move into aircraft, missile and space technology, we would like to hear from you.

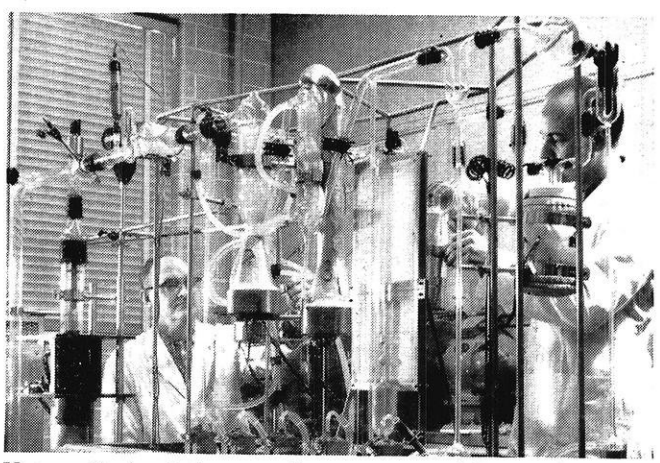
Please write to Mr. C. C. LaVene,
Douglas Aircraft Company, Box P-600,
Santa Monica, California



How to get steel tough enough to land America's first jet airliner

YOU see above the axles of the Boeing 707—America's first jet airliner. They have to be tough. A cross-wind landing could put the whole landing impact of this 122-ton plane on one wheel—instead of eight. And these axles have to be light. Manufacturers of the 707's landing gear had built landing gears for dozens of other models using an analysis of seamless steel tubing specially developed by the Timken Company. But to be strong enough for the much heavier 707, the steel would have to be cleaner. Any impurities in the finished part would cause its rejection. Timken Company metallurgists said the steel *could* be made clean enough for the 707. And it was—met highest specifications, stood up to the terrific landing impacts.

Timken steels have solved the toughest steel problems. Problems that you may face in your future job in industry. Our metallurgists will be ready to help you. And if you're interested in a rewarding career with the leader in specialty steels . . . with the world's largest maker of tapered roller bearings and removable rock bits . . . send for free booklet, "Better-ness and your Career at the Timken Company". Write Mr. Russ Proffitt, The Timken Roller Bearing Company, Canton 6, Ohio.

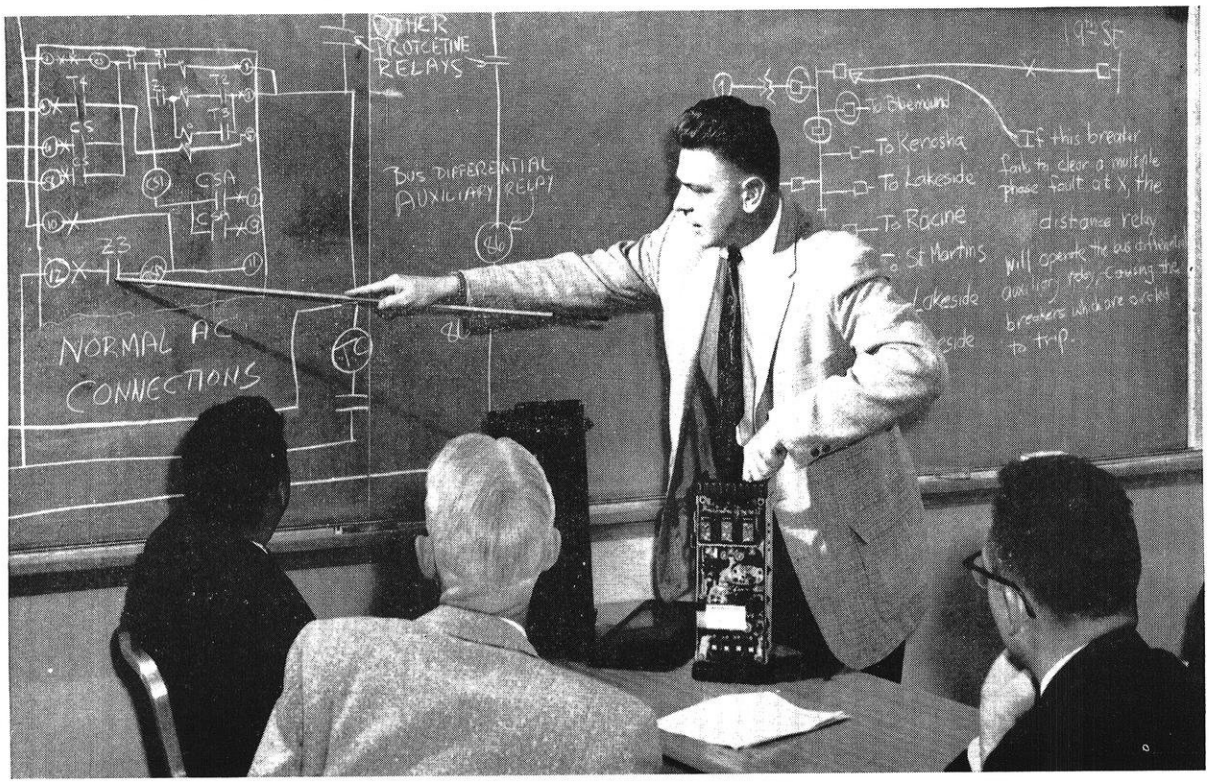


Vacuum Fusion Laboratory in our new steel Research Center, where small samples of new steels are analyzed—steels to answer today's problems, tomorrow's needs.

TIMKEN® *Fine Alloy* STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

It takes judgment...



It takes *engineering judgment* to plan for the immediate and future needs of a changing system. This quality has special importance in planning system protection schemes because of potential damage to equipment and the vital need to maintain service. Above, a relay engineer instructs operating supervisors in a modification in design and utilization of an impedance relay. This modification provides for maximum segmentalization of substation bus in case of faults on the 138 kv or 230 kv feeders from that bus. This special application of "zonal" relaying principles gives secondary protection at a minimum cost and is one phase of a continuing program of analysis and improvement of operations.

We're looking for men with qualities like these!

Even with skill, foresight, imagination and judgment, a person must find a receptive environment to enable him to exercise and develop these qualities. At Wisconsin Electric Power Company you will find such an environment. You will have a chance to use your engineering skills in a wide variety of fields — electrical, mechanical, civil, chemical, statistical, research, sales, administrative, etc.

Demands for our services are so great that our current expansion program anticipates the doubling of our facilities within a 10 year period. We invite you to grow with us!

WISCONSIN ELECTRIC POWER COMPANY SYSTEM

Wisconsin Electric Power Co.
Milwaukee, Wis.

Wisconsin Michigan Power Co.
Appleton, Wis.

Wisconsin Natural Gas Co.
Racine, Wis.

Landmark on The American Road

FORD *Motor Company Central Office Building*

950,000 square feet of ultra-modern office facilities for 3,500 employees, including a cafeteria seating 638 and auditorium for 500.

Architects: SKIDMORE, OWINGS & MERRILL, NEW YORK
General Contractor: BRYANT & DETWILER

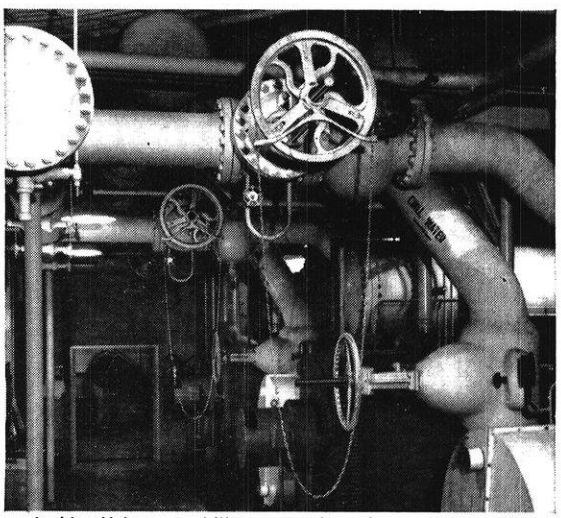
equipped with

JENKINS VALVES

because efficiency is a part of the over-all design

Beauty, comfort, efficiency — Keynote in the planning of Ford cars, this combination also was sought and clearly achieved in the Central Office Building of Ford Motor Company, Dearborn, Michigan.

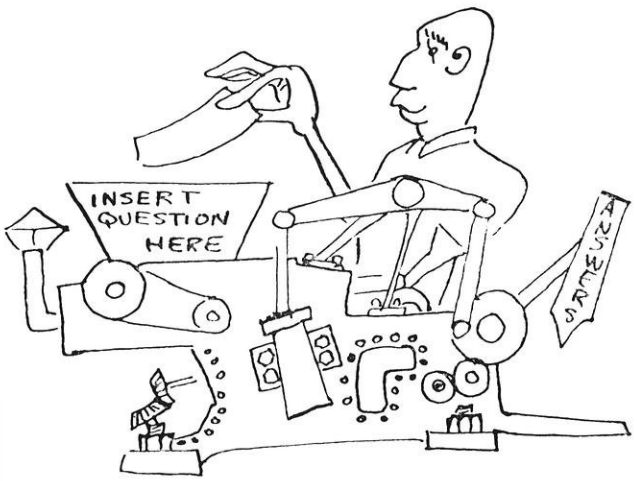
With efficiency a part of the over-all design it is not surprising to see Jenkins Valves on the plumbing, heating and air conditioning pipelines in this superb building. For almost a century the name JENKINS has meant reliability . . . valves with the enduring quality to last the life of a building. It will pay you to have this important assurance when you specify or install valves, especially since Jenkins Valves cost no more. Jenkins Bros., 100 Park Ave., N.Y.17.



Jenkins Valves on chill water and condenser lines serving Ford building's 2,200-ton air-conditioning system.

Sold Through Leading Distributors Everywhere

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
JENKINS SINCE 1864
Jenkins Bros

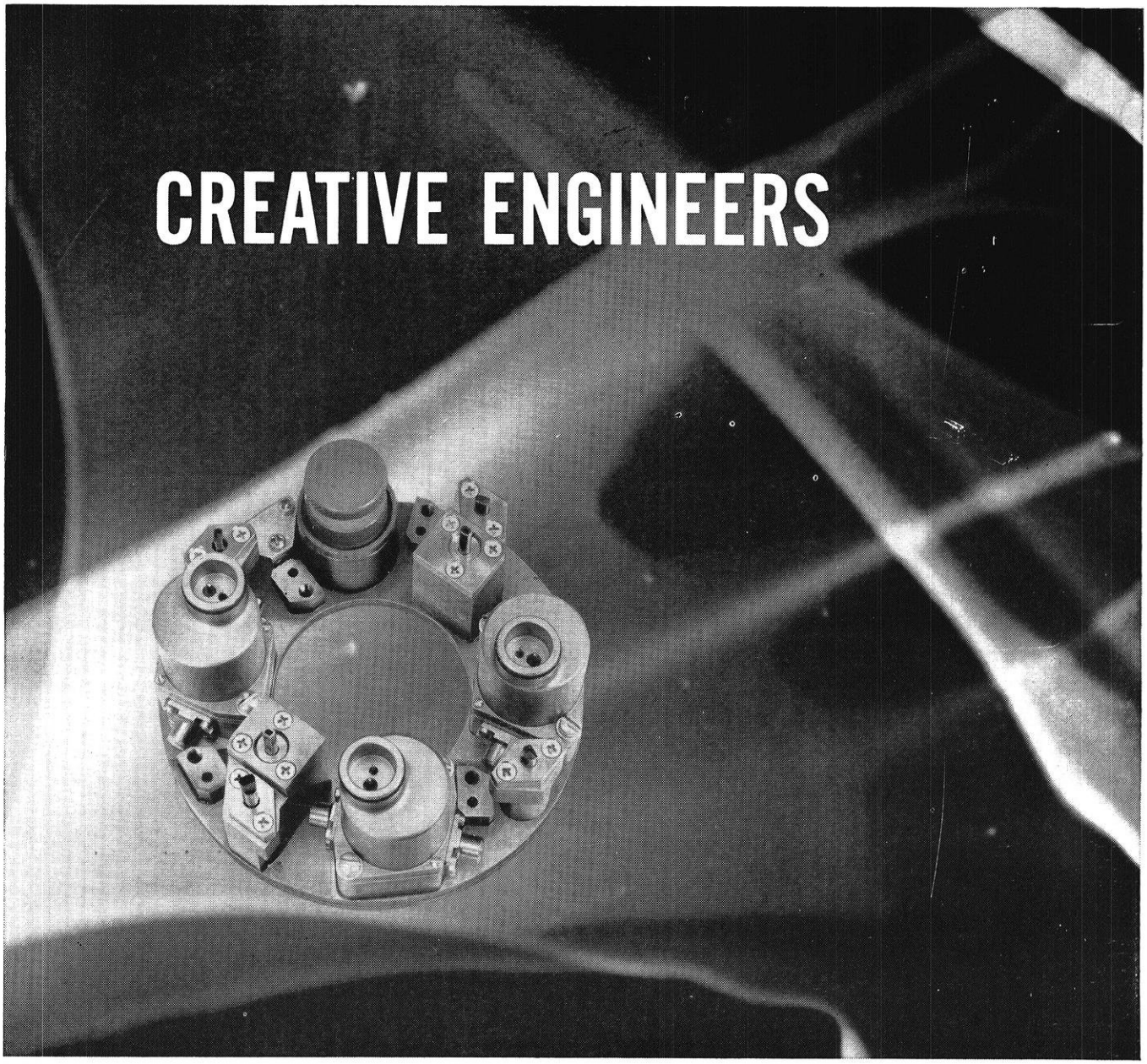


FINAGLE FACTORS

Some of you missed the A-H portion of the finagle factors in the December issue. Well, here they are.

Abamperes	10	amperes
Abamperes	$3x10^{10}$	statamperes
abamperes per sq cm	64.52	amperes per sq inch
abampere-turns	10	ampere-turns
abampere-turns	12.57	gilberts
abampere-turns per cm	25.40	ampere-turns per inch
abcoulombs	10	coulombs
abcoulombs	$3x10^{10}$	statcoulombs
abcoulombs per sq cm	64.52	coulombs per sq in
abfarads	10^9	farads
abfarads	10^{15}	microfarads
abfarads	$9x10^{20}$	statfarads
abhenries	10^{-9}	henries
abhenries	10^{-6}	millihenries
abhenries	$1/9x10^{-20}$	stathenries
abmhos per cm cube	$1.662x10^2$	mhos per mil foot
abmhos per cm cube	10^3	megmhos per cm cube
abohms	10^{-15}	megohms
abohms	10^{-3}	microhoms
abohms	10^{-9}	ohms
abohms	$1/9x10^{-20}$	statohms
abohms per cm cube	10^{-3}	microhms per cm cube
abohms per cm cube	$6.015x10^{-2}$	ohms per mil foot
abvolts	$1/3x10^{-10}$	statvolts
abvolts	10^{-8}	volts
acres	43.560	square feet
acres	4047	square meters
acres	$1.562x10^{-3}$	square miles
acres	5645.38	square yards
acres	4840	square varas
acre-feet	43.560	cubic feet
acre-feet	$3.259x10^6$	gallons
amperes	1/10	abamperes
amperes	$3x10^9$	statamperes
amperes per sq cm	6.453	amperes per sq inch
amperes per sq inch	0.01550	abamperes per sq cm
amperes per sq inch	0.1550	amperes per sq cm
amperes per sq inch	$4.650x10^8$	statamperes per sq cm
ampere-turns	1/10	abampere-turns
ampere-turns	1.257	gilberts
ampere-turns per cm	2.540	ampere-turns per in
ampere-turns per inch	0.03937	abampere-turns per cm
ampere-turns per inch	0.3937	ampere-turns per cm
ampere-turns per inch	0.4950	gilberts per cm
ares	0.02471	acres
ares	100	square meters
atmospheres	76.0	cms of mercury
atmospheres	29.92	inches of mercury
atmospheres	33.90	feet of water
atmospheres	10,333	kg per sq meter
atmospheres	14.70	pounds per sq inch
atmospheres	1.058	tons per sq foot
Bars	$9.870x10^{-7}$	atmospheres
Bars	1	dynes per sq cm
Bars	0.01020	kg per square meter
Bars	$2.089x10^{-3}$	pounds per sq foot
Bars	$1.450x10^{-5}$	pounds per sq inch
board-feet	144	cubic inches
British thermal units	0.2530	kilogram-calories
British thermal units	777.5	foot-pounds
British thermal units	$3.927x10^{-4}$	harsepower-hours
British thermal units	1054	joules
British thermal units	107.5	kilogram-meters
British thermal units	$2.928x10^{-4}$	kilowatt-hours
Btu per min	12.96	foot-pounds per sec
Btu per min	0.02356	horsepower
Btu per min	0.01757	kilowatts
Btu per min	17.57	watts
Btu per sq ft per min	0.1220	watts per square inch
bushels	1.244	cubic feet
bushels	2150	cubic inches
bushels	0.03524	cubic meters
bushels	4	pecks
bushels	64	pints (dry)
bushels	32	quarts (dry)
Centares	1	square meters
centigrams	0.01	grams
centiliters	0.01	liters

centimeters	0.3937	inches
centimeters	0.01	meters
centimeters	393.7	mils
centimeters	10	millimeters
centimeter-dynes	$1.020x10^{-3}$	centimeter-grams
centimeter-dynes	$1.020x10^{-8}$	meter-kilograms
centimeter-dynes	$7.376x10^{-8}$	pound-feet
centimeter-grams	980.7	centimeter-dynes
centimeter-grams	10^{-6}	meter-kilograms
centimeter-grams	$7.233x10^{-5}$	pound-feet
centimeters of mercury	0.01316	atmospheres
centimeters of mercury	0.4461	feet of water
centimeters of mercury	136.0	kg per square meter
centimeters of mercury	27.85	pounds per sq foot
centimeters of mercury	0.1934	pounds per sq inch
centimeters per second	1.969	feet per minute
centimeters per second	0.03281	feet per second
centimeters per second	0.036	kilometers per hour
centimeters per second	0.6	meters per minute
centimeters per second	0.02237	miles per hour
centimeters per second	$3.728x10^{-4}$	miles per minute
cm per sec per sec	0.03281	feet per sec per sec
cm per sec per sec	0.036	km per hour per sec
cm per sec per sec	0.02237	miles per hour per sec
circular mils	$5.067x10^{-6}$	square centimeters
circular mils	$7.854x10^{-7}$	square inches
circular mils	0.7854	square mils
cords	128	cubic feet
coulombs	1/10	abcoulombs
coulombs	$3x10^9$	statcoulombs
coulombs per sq inch	0.01550	abcoulombs per sq cm
coulombs per sq inch	0.1550	coulombs per sq cm
coulombs per sq inch	$4.650x10^8$	statcoulombs per sq cm
coulombs per sq inch	$3.531x10^{-5}$	cubic feet
cubic centimeters	$6.10x10^{-2}$	cubic inches
cubic centimeters	10^{-6}	cubic meters
cubic centimeters	$1.308x10^{-6}$	cubic yards
cubic centimeters	$2.642x10^{-4}$	gallons
cubic centimeters	10^{-3}	liters
cubic centimeters	$2.113x10^{-3}$	pints (liq)
cubic centimeters	$1.057x10^{-3}$	quarts (liq)
cubic feet	$2.832x10^4$	cubic cms
cubic feet	1728	cubic inches
cubic feet	0.02832	cubic meters
cubic feet	0.03704	cubic yards
cubic feet	7.481	gallons
cubic feet	28.32	liters
cubic feet	59.84	pints (liq)
cubic feet	29.92	quarts (liq)
cubic feet per minute	472.0	cubic cm per sec
cubic feet per minute	0.1247	gallons per sec
cubic feet per minute	0.4720	liters per second
cubic feet per minute	62.4	lb of water per min
cubic inches	16.39	cubic centimeters
cubic inches	$5.787x10^{-4}$	cubic feet
cubic inches	$1.639x10^{-5}$	cubic meters
cubic inches	$2.143x10^{-5}$	cubic yards
cubic inches	$4.329x10^{-3}$	gallons
cubic inches	$1.639x10^{-2}$	liters
cubic inches	0.03463	pints (liq)
cubic inches	0.01732	quarts (liq)
cubic meters	10^6	cubic centimeter
cubic meters	35.31	cubic feet
cubic meters	61.023	cubic inches
cubic meters	1.308	cubic yards
cubic meters	264.2	gallons
cubic meters	10^3	liters
cubic meters	2113	pints (liq)
cubic meters	1057	quarts (liq)
cubic yards	$7.646x10^5$	cubic centimeters
cubic yards	27	cubic feet
cubic yards	46,656	cubic inches
cubic yards	0.7646	cubic meters
cubic yards	202.0	gallons
cubic yards	764.6	liters
cubic yards	1616	pints (liq)
cubic yards	807.9	quarts (liq)
cubic yards per minute	0.45	cubic feet per second
cubic yards per minute	3.367	gallons per second
cubic yards per minute	12.74	liters per second



AiResearch engineered and produced this electro-hydraulic servo system—the most reliable and responsive steering control system for missiles yet produced. Extremely lightweight, it consists of three control valves and six actuators.

This unique system represents but a part of the challenging, important work under way at AiResearch in missile, electronic, nuclear, aircraft and industrial fields.

Specific opportunities exist in system electronics and servo control units; computers and flight instruments; missile auxiliary power units; gas turbine engines and turbine and air motors; cryogenic and nuclear systems; pneumatic valves; industrial turbochargers; air conditioning and pressurization; and heat transfer, including electronic cooling and nuclear applications.

Intensified engineering is conducted by small groups where individual effort and accomplishment are quickly recognized, providing opportunity for rapid growth and advancement. An eight-month orientation program is offered prior to permanent assignment to help determine your placement from a variety of analytical or development projects.

Advanced education is available through company financial assistance at outstanding nearby universities.

• *For full information write to Mr. G. D. Bradley*

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Product Testing

(Continued from page 41)

ment. There are many others, of course, such as sunshine resistance, rain, and ice but these are less frequently required. There are also many special tests devised for particular situations and special equipment which have unusual requirements. Some of these are attitude, radio noise, dielectric strength, and burst pressure. These special tests often require special test facilities such as the all-attitude test fixture.

PREDICTIONS FOR THE FUTURE

As previously noted, the present method used for product certification provide little data on the predicted reliability of equipment. This stems from the fact that today the design of an item is determined to be satisfactory on the basis of testing only a few representative samples of the design.

To overcome this fault, reliability programs are being developed. Through these programs it will be possible to determine the reliability and failure rates of equipment by accumulating data from testing and field service.

The future requirements for product certification will certainly increase in quantity and complexity. Furthermore, it is felt that some merger between the existing methods of product certification and the newly formed reliability programs will more fully satisfy the objectives of compatibility, reliability, safety, durability, and susceptibility. It is also expected that endurance and performance tests will be conducted under natural combinations of extreme environmental conditions.

Auto Design

(Continued from page 47)

2. High performance because of the large valves and domed heads.
3. Low maintenance because of the simplicity of the design.

Some possible difficulties encountered with the design are:

(Continued on next page)

1. The camshaft may be difficult to make because of the special shape of the lobes.
2. The differing rates of expansion between the iron and aluminum in the engine may cause difficulty. This would especially be serious in the areas of the cylinder liners and the headbolts.
3. Considerable testing would be necessary to prove the worth of the unique combustion chamber. It also may prove a problem to arrive at the final shape.
4. The drive to the overhead camshaft may be impractical. Very little lash caused by wear can be permitted here.

This article is merely intended to present some new ideas that appear to have merit. It would not be necessary to incorporate them all in a single engine. After further investigation some of them may prove to have more worth than others. THE END

Engine Ears

(Continued from page 49)

ASME–AIME Solid Fuels Conference—Cincinnati, Ohio—Oct. 7–9

Automation Show & Conference on Materials Handling—New York Trade Show Bldg., New York, N.Y.—Nov. 16–20

International Rubber Technology Conference (in which ASME, ACS, & ASTM will participate)—Shoreham & Park Plaza Hotels, Washington, D.C.—Nov. 8–13

ASME Annual Meeting—Chalfonte Haddon Hall, Atlantic City, N.J.—Nov. 29–Dec. 4

For further information, write to:

Meetings Department ASME, 29 West 39th Street, New York 18, New York.

MICROMETEOROLOGY AT WISCONSIN

University of Wisconsin scientists are literally "getting off the ground" in their attempt to understand the total picture of how the sun, the atmosphere, and the earth work together to produce our widely different climatic conditions.

A U.S. Army-backed project in micrometeorology calls for instrumentation of a light, twin-engined plane for studying solar radiation and energy exchange over the largest possible variety of climatic conditions and terrain.

Micrometeorology like all branches of meteorology deals with time-space variations of weather elements such as air density, temperature, and wind. Its distinguishing characteristic is emphasis on the interaction between air and ground.

Previous investigation indicates that the cause of micrometeorological differences is a complex interaction of a great variety of physical factors. Most prominent of these are the transmission, absorption, and scattering of solar radiation, and factors such as topography, vegetation, and soil type.

This project under the UW department of meteorology is headed by Prof. Heinz H. Lettau, who came to the University last year after serving as meteorologist at the Air Force Cambridge Research Center.

Dr. Lettau is professor of meteorology and civil engineering at Wisconsin. His primary interest is fluid mechanics, although he has published papers in general and applied meteorology, climatology, earth magnetism and tides, and atmospheric turbulence dynamics.

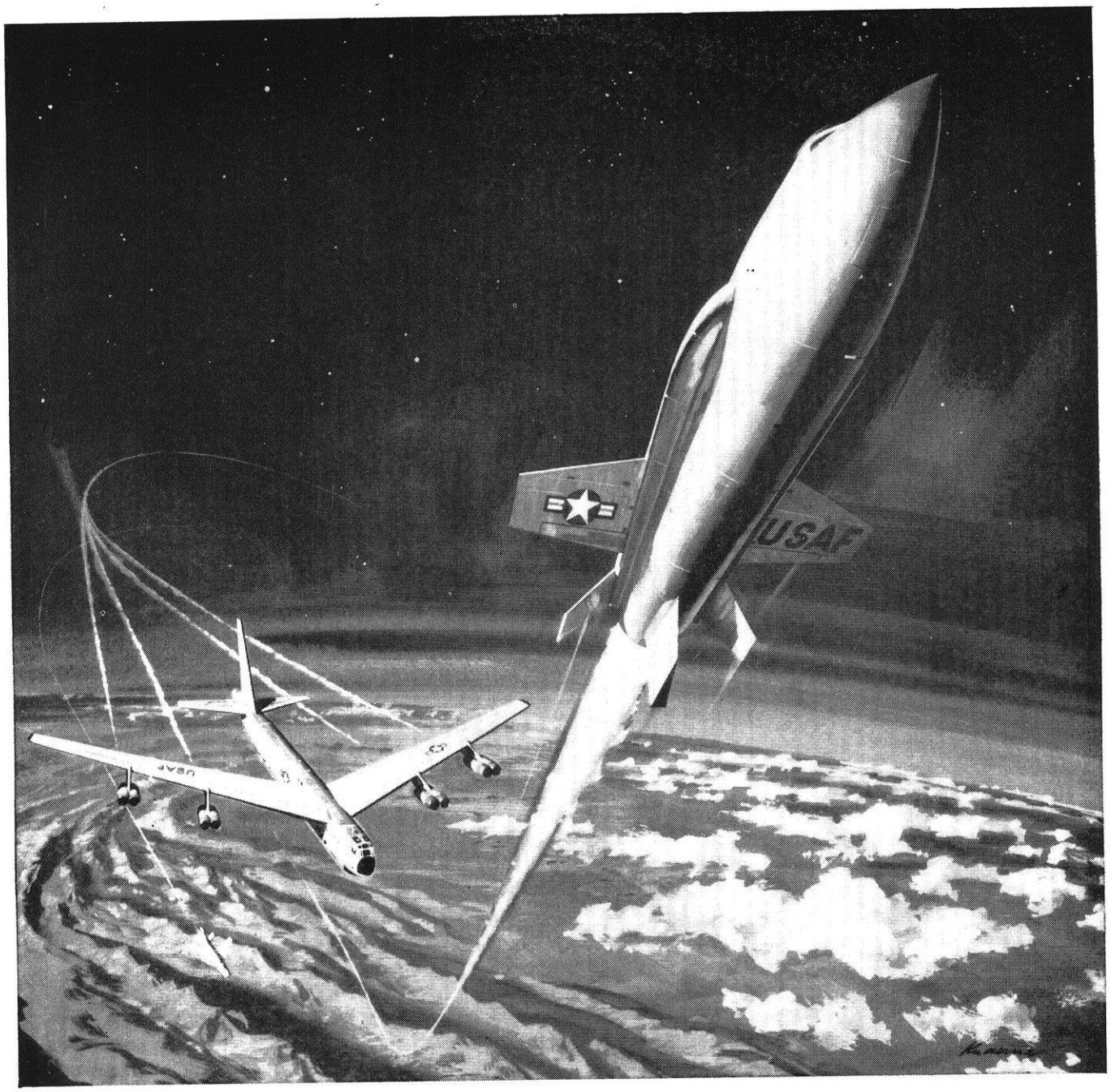
One phase of the study will consider the relationship of vegetation to both radiation and atmospheric circulation patterns found throughout the hemisphere. It will explore the feasibility of using meteorological variables and plant communities as mutual predictors.

At present the group is awaiting the arrival of needed instruments. The final instrument "package" will be fastened to the belly of a twin-engine Cessna 310. John Dutton, Madison graduate student in meteorology, will pilot the plane.

Six instrument groups will be included in the "package." The first is the normal set of flight indicators whose readings will be recorded on a 16-mm lapse time movie camera. The second component is geared to measure radiation.

Group three is comprised of aerial cameras loaded with black and white, color, and infra-red film

(Continued on page 63)



X-15 AWAY

. . . TARGET: 100 MILES UP! On a day surprisingly soon 45,000 feet above Wendover, Utah, North American's rocket-powered X-15 research plane will be released from a modified B-52 to take man 100 miles into outer space. Throughout the flight trajectory, radio contact between the X-15, the mother ship, chase planes and the ground will be maintained by custom-designed units from a Collins CNI (communication, navigation, identification) system, similar to the electronic packages Collins is providing for the new military jet aircraft.

At Collins you receive professional recognition, unlimited opportunity, the most completely equipped research and development facilities, the opportunity to work on the most challenging developments in electronics. Your placement office will tell you when a representative will be on campus. Or write for illustrated brochure "Career with Collins."

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COLLINS

Engine Ears

(Continued from page 61)

which will operate simultaneously to permit detailed analysis of ground surface data. Group four will measure mean temperatures and humidity at various flight levels.

Air turbulence will be recorded by fast operating wind directional vanes, variometers and thermometers. Finally, lapse time movie cameras in the airplane's nose and other locations, will be utilized for study of atmospheric and cloud structure.

Tornado and lake investigations conducted previously from the air have given the Wisconsin meteorologists enough experience with instrumentation of light aircraft to indicate that the "package" plan is feasible.

TWO WISCONSIN STUDENTS RECEIVE SCHOLARSHIPS

Among the recipients of the fifty four graduate fellowships assigned to twenty six educational institutions by the General Electric Educational and Charitable Fund were two Wisconsin students. **Gordon G. Hammes,** Fond du Lac, Wisconsin, and **David W. Olive,** Weeping Water, Nebraska were picked to receive grants of from $1750 to $2500 for the academic year 1958–1959.

These fellowships have been granted to students in the fields of engineering, the physical sciences, psychology, mathematics, economics, finance, and political science. The students are selected by the engineering schools and universities to which the Fund assigned the fellowships. In addition to the grant mentioned above all tuition and fees are paid for the student and the school which he is attending receives an unrestricted grant of $1000.

INDUSTRIAL SCHOLARSHIPS TO U W STUDENTS

Twenty-five students who have been awarded scholarships by American industry and engineering foundations to help them continue their engineering education at the University of Wisconsin during the 1958–59 school year were named

(Continued on next page)

today by UW College of Engineering officials.

Of the scholarships, 12 are given to the University by the Foundry Educational Foundation, four by Ladish Co., two by Pelton Steel Casting Co., two by International Nickel Co., two by American Smelting and Refining Co., and one each by American Society for Metals, Institute of Scrap Iron and Steel, and Kennecott Copper Co.

The scholarships are awarded by the UW College of Engineering faculty on the basis of the students' scholarship and need, and their interest in the mining and metallurgical, mechanical, and electrical engineering industries, Prof. Phillip C. Rosenthal, chairman of the mining and metallurgy department, said. Scholarships range from $250 to $1,000.

"These scholarships are of invaluable aid to our students, many of whom are in need of some financial help during their University careers," Prof. Rosenthal said. "At the same time these scholarships reward those students who do promising work in their studies and

training for engineering jobs in American industry, which needs well-trained engineers now more than ever in our history."

Scholarships and their recipients for the current school year are:

Foundry Educational Foundation ($365 to $450)—Thomas J. Bosworth (109 S. Randall Ave.), William F. Shaw, (1901 Vilas Ave.), LeRoy E. Abrahamson (622 Gately Ter.), John E. Hansen (215 N. Mills St.), and Peter H. Meyst (2122 E. Dayton St.) all of Madison; J. Edward Cantwell, Delavan; Alexander H. Meyers (9015 N. Rexleigh Dr.), Milwaukee; Andrew C. Mueller, Waukesha; James R. Widmeyer, La Crosse; David H. Eber, Racine; George H. Kerckhove, Bloomer; and John P. Tralmer, Chicago.

Pelton Steel Casting Co. ($500 to $600)—Eugene M. Pilerski, West Allis; and James Waldenberger, Onalaska.

Ladish Co. ($300)—Kenneth R. Olen, Cudahy; Orville Moody, Jr., Belmont; Thomas A. Pitterle (3056 N. 28th St.), Milwaukee; and Thomas A. Roth, DePere.

American Society For Metals ($500)—Richard J. Steuber, Juneau.

International Nickel Co. ($500)—David R. Nelson, La Crosse; and John M. Svobeda (2904 N. 51st St.), Milwaukee.

American Smelting and Refining Co. ($500)—Henry J. Brown, Oshkosh; and Thomas W. Mueller, Wausau.

Institute of Scrap Iron & Steel ($250)—Roger R. Matarrese, Kenosha.

Kennecott Copper Co. ($1,000)—John W. Nichols, Reedsburg.

THE END

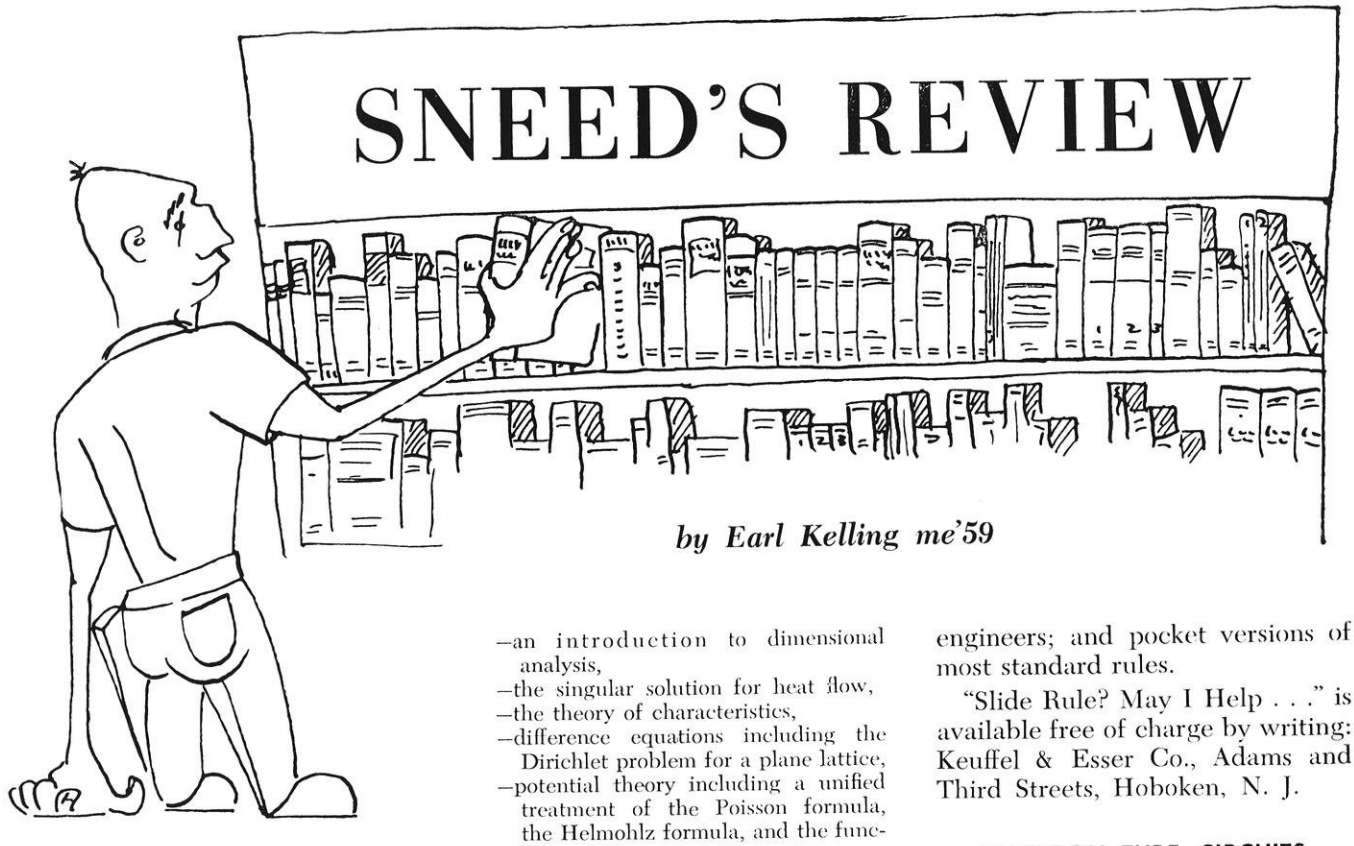
* * *

An engineering prof was lecturing his 8:50 class on the virtues of being wide awake.

"I've found that the best way to start a day is to exercise for five minutes after arising, breathe deeply, and finish with a cold shower. Then I feel rosy all over.

Interested voice from back of room: "Tell us more about Rosy."

SNEED'S REVIEW



by Earl Kelling me'59

MATHEMATICS OF PHYSICS AND MODERN ENGINEERING

By Ivan S. Sokolnikoff and R. M. Redheffer
810 pages, $9.50

The basic objective of this book is to provide a stimulating and palatable presentation of mathematical analysis as a living and vigorously-developing discipline essential to the scientific and technological well-being of the nation.

The approach develops a critical attitude towards analytic procedures. It stresses those aspects which make mathematics a living and developing discipline, as contrasted with a congealed structure consisting of sets of rules, formulas, and receipts for dealing with concrete problems. A sensible level of logical rigor is maintained . . . stressing its need by carefully motivated examples and counter-examples. Illustrative material, examples, and problems are chosen for their value in emphasizing the underlying principles.

The book features a great number and variety of topics not found in other texts of this kind.

The topics include:

- —the comparison theorems for first order differential equations,
- —mean and ordinary convergence of Fourier series,
- —calculus of variations,
- —an introduction to dimensional analysis,
- —the singular solution for heat flow,
- —the theory of characteristics,
- —difference equations including the Dirichlet problem for a plane lattice,
- —potential theory including a unified treatment of the Poisson formula, the Helmohlz formula, and the functions of Green and Neumann,
- —a systematic treatment of definite integrals,
- —full discussion of the relation of probability and relative frequency,
- —a correct treatment of the Gauss error law, and
- —examples illustrating fundamental statistical problems, such as testing a hypothesis and estimating a parameter.

SLIDE RULE? MAY I HELP . . .

By Don Herold
24 pages. Free

A new and readable booklet telling the story of how to select a slide rule has recently been released by Keuffel & Esser Co.

Titled "Slide Rule? May I help . . .," and written and illustrated by Don Herold, the 24-page offering is a guide for the student or professional about to buy a rule. The two-color pamphlet describes slide rule scale designs and arrangements, the fine woods, glass, and synthetic materials used in rule construction, and teaching aids and accessories for the slide rule.

The pamphlet also describes a wide variety of K&E rules. Included are: the Log Log Duplex Decitrig (the standard slide rule most widely used by engineers); the Polyphase and Mannheim types; special purpose models for businessmen, surveyors, and radio engineers; and pocket versions of most standard rules.

"Slide Rule? May I Help . . ." is available free of charge by writing: Keuffel & Esser Co., Adams and Third Streets, Hoboken, N. J.

ELECTRON–TUBE CIRCUITS

By Samuel Seeley
693 pages, $10.50

Electron-Tube Circuits begins by introducing the fundamental properties of electronic devices and their basic circuit applications. Then follows a discussion of a variety of untuned amplifiers, with and without feedback. Next, the book considers amplifiers having resonant circuits and studies tuned potential and turned power amplifiers. The final, and major sections, contain comprehensive treatments of amplitude modulation and demodulation and frequency modulation and detection.

Wherever possible, the analysis proceeds in two stages. An effort is first made to present a physical explanation of the operation of the circuits. If feasible, a mathematical analysis of the operation of the circuit is then given.

Extensively rewritten, this second edition has been strengthened with new material to make a more complete presentation. These new materials include: analysis of RC feedback amplifiers; f-m discriminators; electronic computing circuits and devices; and theory of clamping. The treatment of the principles of feedback has been greatly expanded and there is new

material on solid state electronics, the transistor, and the theory of transistor circuits of various types has been included. New problems have been added throughout.

PRINCIPLES OF THE PROPERTIES OF MATERIALS

By Jacob Porter Frankel
240 pages, $6.00

"Materials go in and out of fashion," the author says, "but they are always replaced by those designed on the basis of required properties." Consequently, in this book he has departed radically from the traditional approach and places emphasis on properties of materials rather than specific materials. His purpose is to present the subject in such a way that the student is prepared to solve not only advancing technology, but also those of the future.

The current trend in engineering schools is to treat the subject of materials from the viewpoint of structure rather than from the conventional approach of engineering usage. *Principles of the Properties of Materials* is the first text specifically written to fit this new course.

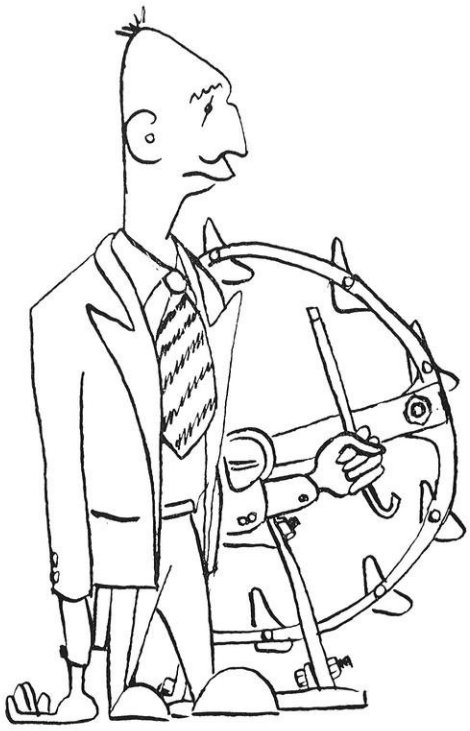
Emphasis is on mastering the fundamentals, heretofore available only in scattered form in advanced texts and published papers; consequently only the most important properties are considered.

The underlying principles of physics of matter are presented in such a way as to stimulate natural progress to more advanced work and actual practice.

A physical metallurgist, the author intentionally restricts the book to "principles;" the relationships of properties to atomic and crystalline structure of the material.

The introduction covers material on: materials and applied mechanics, properties, and mechanical and thermodynamic analysis.

The remainder of the book is divided into two parts; physicochemical foundations, covering: atoms, equilibrium, structure, cohesion, and metals; and properties, covering: conductivity, heating, diffusivity, electrochemitsry, elasticity, plasticity, fracture, viscosity, general considerations, and looking ahead.



THE FERROUS WHEEL

by Joe Coel

It was Sunday morning. He slipped on his wife's robe and went downstairs to answer the doorbell. As he opened the door the ice man kissed him. After giving due thought to this strange occurrence, he has come to the conclusion that the ice man's wife must have a similar robe.

* * *

A sweet old lady, always eager to help the needy, spied a particularly sad-looking old man standing on a street corner. She walked over to him, pressed a dollar into his hand and said, "Chin up."

The next day, on the same corner, the sad old man shuffled up to the lady and slipped ten dollars into her hand.

"Nice picking," he said in a low voice. "He paid nine to one."

* * *

"More people are caused by accidents than any other way."—From a speech on safety given in New York.

* * *

Recent tests in the physics department prove that grasshoppers hear through their legs. When a tuning fork was placed near a grasshopper, it was found that in all cases the insect would hop. There was no reaction to this stimulus, however, when the insects' legs were removed.

A young minister was trying to convince an old drunkard that he should drink something of a milder nature. Said the minister, "Why don't you drink 'Canada Dry' instead?"

The only reply he got was "What in—hic—the doose you think I been trying to do for the past twenty years."

* * *

Victims of an accident in Scotland were still lying on the road. Along came a native and said to a man lying on his back: "Has the insurance man been 'roon yet?"

"No," was the reply.

"Ah, well," said the Scot, "I'll just lie doon aside ye."

* * *

A castaway on a desert island pulled ashore a girl clinging to a barrel.

"How long have you been here?" asked the girl.

"Thirteen years," replied the castaway.

"Then you're going to get something you haven't had for thirteen year," said the girl.

"You don't mean to tell me there's beer in that barrel!"

* * *

Father: "What do you mean bringing my daughter in this late?"

Engineer: "Have to be in class by eight in the morning."

His letter from Italy read: "Am enjoying Florence immensely."

His wife wrote back: "You can stay in Europe. I am having a good time with Oscar."

* * *

A canny Scot was engaged in an argument with the conductor as to whether the fare was to be five or ten cents. Finally the disgusted conductor picked up the Scot's suitcase and tossed it off the train just as they were crossing a long bridge. It landed with a mighty splash.

"Haot man," screamed the Scot, "first you try to rob me, and now you've drowned my little boy."

* * *

"I want you to do just as I tell you," said the doctor to the young lady patient.

"That's what my boy friend said," replied the girl. "That's why I'm here."

* * *

An old man heard about some pills that would restore his youth. He bought a box, but instead of taking one every day, he swallowed the whole boxful in a single dose the next night.

When morning came, the family had great difficulty waking the old man. At last he rolled over, rubbed his eyes, and said, "All right, all right, I'll get up, but I'm not going to school!"

The Indispensable Man

SOMETIME WHEN YOU'RE FEELING IMPORTANT
SOMETIME WHEN YOUR EGO'S IN BLOOM

SOMETIME WHEN YOU TAKE IT FOR GRANTED
YOU'RE THE BEST QUALIFIED IN THE ROOM

SOMETIME WHEN YOU FEEL THAT YOUR GOING
WOULD LEAVE AN INFALLIBLE HOLE

JUST FOLLOW THESE SIMPLE INSTRUCTIONS
AND SEE HOW IT HUMBLES YOUR SOUL

TAKE A BUCKET AND FILL IT WITH WATER
PUT YOUR HANDS IN UP TO YOUR WRISTS

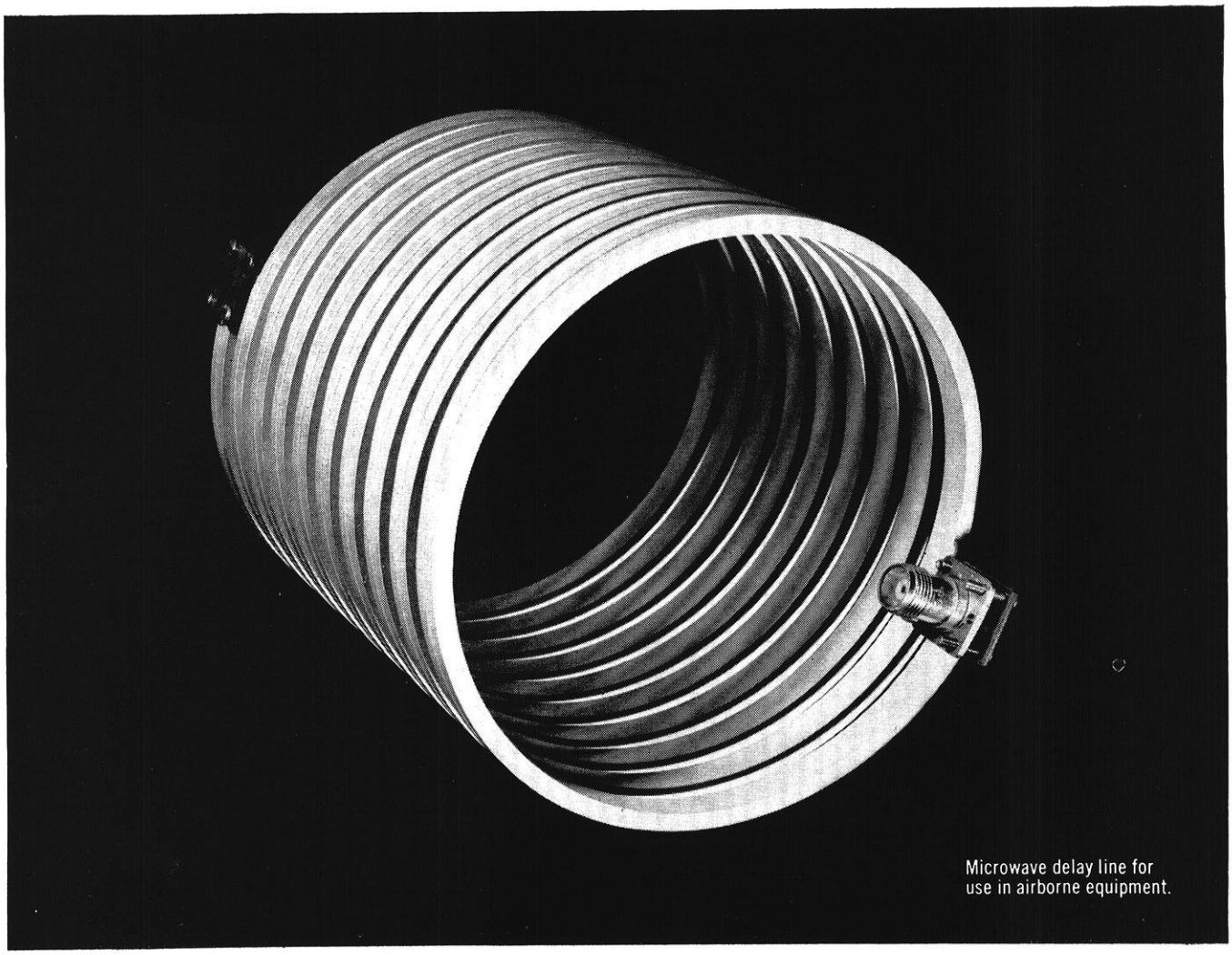
PULL THEM OUT AND THE HOLE THAT REMAINS
IS A MEASURE OF HOW YOU'LL BE MISSED

YOU MAY SPLASH ALL YOU PLEASE WHEN YOU ENTER
YOU MAY STIR UP THE WATER GALORE

BUT STOP AND YOU'LL FIND IN A MINUTE
THAT IT LOOKS JUST THE SAME AS BEFORE

THE MORAL OF THIS IS QUITE SIMPLE
DO JUST THE BEST THAT YOU CAN

BE PROUD OF YOURSELF BUT REMEMBER
THERE IS NO INDISPENSABLE MAN!



Microwave delay line for use in airborne equipment.

MICROWAVE RESEARCH

The expanding role of electronic equipment in modern military operations has given high priority to microwave research. No field today offers greater challenge to the scientist and engineer.

In support of current electronic countermeasures programs and in anticipation of future systems requirements, Ramo-Wooldridge Division is engaged in microwave research to develop new techniques and to refine conventional components.

Research is under way at Ramo-Wooldridge for new methods and new designs to reduce substantially the over-all size, weight and complexity of electronic equipment for both airborne and ground-based uses.

For example, the low-loss delay line in the photograph above was designed, developed and manufactured by Ramo-Wooldridge for use in airborne equipment. Packaged for use in the system for which it was designed, this miniature ceramic unit weighs less than two pounds. It replaces a component which weighed more than twenty pounds and occupied more than five times as much volume.

Special opportunities exist for those with qualified experience in microwave research—in technique evaluation, component development, and design of such systems equipment—at Ramo-Wooldridge.

Engineers and scientists are invited to explore openings at Ramo-Wooldridge in:

Electronic Reconnaissance and Countermeasure Systems
Infrared Systems
Analog and Digital Computers
Air Navigation and Traffic Control
Antisubmarine Warfare
Electronic Language Translation
Information Processing Systems
Advanced Radio and Wireline Communications
Missile Electronics Systems

RAMO-WOOLDRIDGE

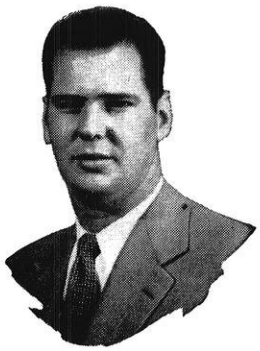
P. O. BOX 90534 AIRPORT STATION • LOS ANGELES 45, CALIFORNIA

a division of ***Thompson Ramo Wooldridge Inc.***

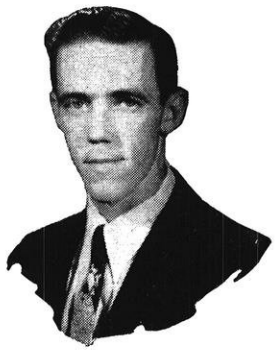
Allis-Chalmers offers training course

In nucleonics, Andrew Selep, Brooklyn Polytechnic Institute, BME '53, is working on the problem of reactor safeguards.

Special engineering by Paul W. Clark, Iowa State College, EE '49, is of large job involving combined electrical equipment.



Sales manager, Robert Horn, Marquette University, EE '51, heads sales of voltage regulators used on power lines.



Electronics man, William E. Martin, Alabama Polytechnic Institute, BSEE '53, engineers applications of induction heaters.

plus wide choice of type and fields of

Design of generators for steam turbines is directed by G. W. Staats, Illinois Institute of Technology, Ph. D. '56.

Field sales of America's widest range of industrial equipment is career of Carl E. Hellerich, U. of Nebraska, ME '49.

Promotion man, Robert I. Carlson, Worcester Polytechnic Institute, ME '50, directs promotion of switchgear, and substations.

Application and sales of steam condensers for power plants are handled by William E. Ellingen, U. of Wisconsin, ChE '49.

work on equipment for many industries

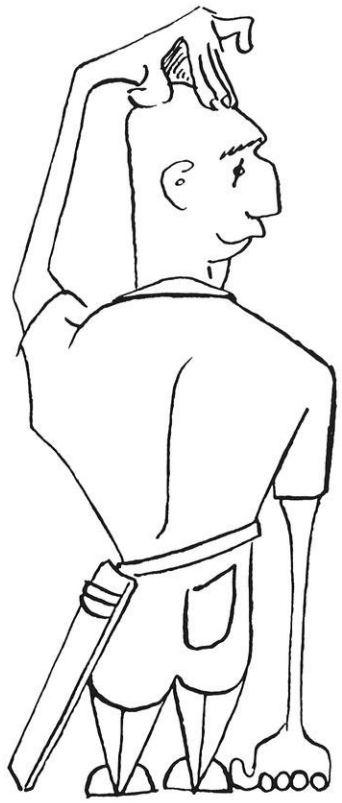
THE outstanding training course started by Allis-Chalmers has proved a springboard to many worthwhile careers In fact, most of the A-C management team has stemmed from its ranks.

Up to two years of theoretical and practical training are offered. This experience leads to jobs in research, design, manufacturing, application and sales.

Even though you may not know exactly what you wish to do, the Allis-Chalmers training course is designed to help you find the type of work and the field to which you are best suited.

ALLIS-CHALMERS

A-5600



So You Think You're SMART!

by Sneedly bs'60

RECENTLY Sneedly enjoyed a very marvelous week in the twin cities of Minnesota. While staying at the KHK EE fraternity he had the opportunity to visit the Engineering campus of the University of Minnesota. The fact that *The Wisconsin Engineer* is regarded very highly there pleased him very much.

At one of the discussions concerning the publication of engineering magazines, Sneedly had the brilliant idea (at least he thinks it is brilliant) of adding more culture to the magazine. What better way is there than to publish poetry?

However Sneedly does not want to publish poetry which can already be found in books. He therefore asks that those who like to write, send him some of their gems. The poems need not be of any specified form nor length, and they can cover any topic. However, they must be originals since the purpose of this new influx of culture is to acquaint the reader with the poets of our time.

Sneedly again has three problems which are worth ten dollars to the earliest postmarked correct solutions. To be more "cultural" one of the problems is in the form of a poem. So, send in your solutions and poems right away.

Here are this month's hair-raisers:

LADY ELFI AND HER LINGERIE

Lady Elfi was lovely with glamour galore.
She led him one day to a lingerie store.
A dozen of these and two dozen of those
Transparently feminine silk so-and-so's
Would cost him, they said, six bucks less if you please,
Than a dozen of those and two dozen of these.
Such extravagence, though, was way out of his reach.
He'd only ten bucks, which just bought one of each.
Ignoring the frowns and tut-tuts of the grundies,
Just figure the price of each item of undies.

* * *

Farmer Brown had five trusses of hay which he told his man Ed to weigh before delivering to the customer. The stupid fellow weighed them two at a time in all possible ways and informed his master that the weights in all possible combinations in pounds were 110, 112, 113, 114, 115, 116, 117, 118, 120, and 121.

What are the five correct weights of the trusses?

Five figures of the multiplication sum are shown, and the rest are indicated by x's. No seven appears in the calculation.

```
      2 X X
      3 X X
      -----
      5 X X
    X 4 X
  X X 3
  ---------
  X X X X X
```

Find the final result.

* * *

The answers to last month's problems follow:

The average speed of the vehicle constructed by the ME is 12mph and not 12.5 mph as some of you had thought.

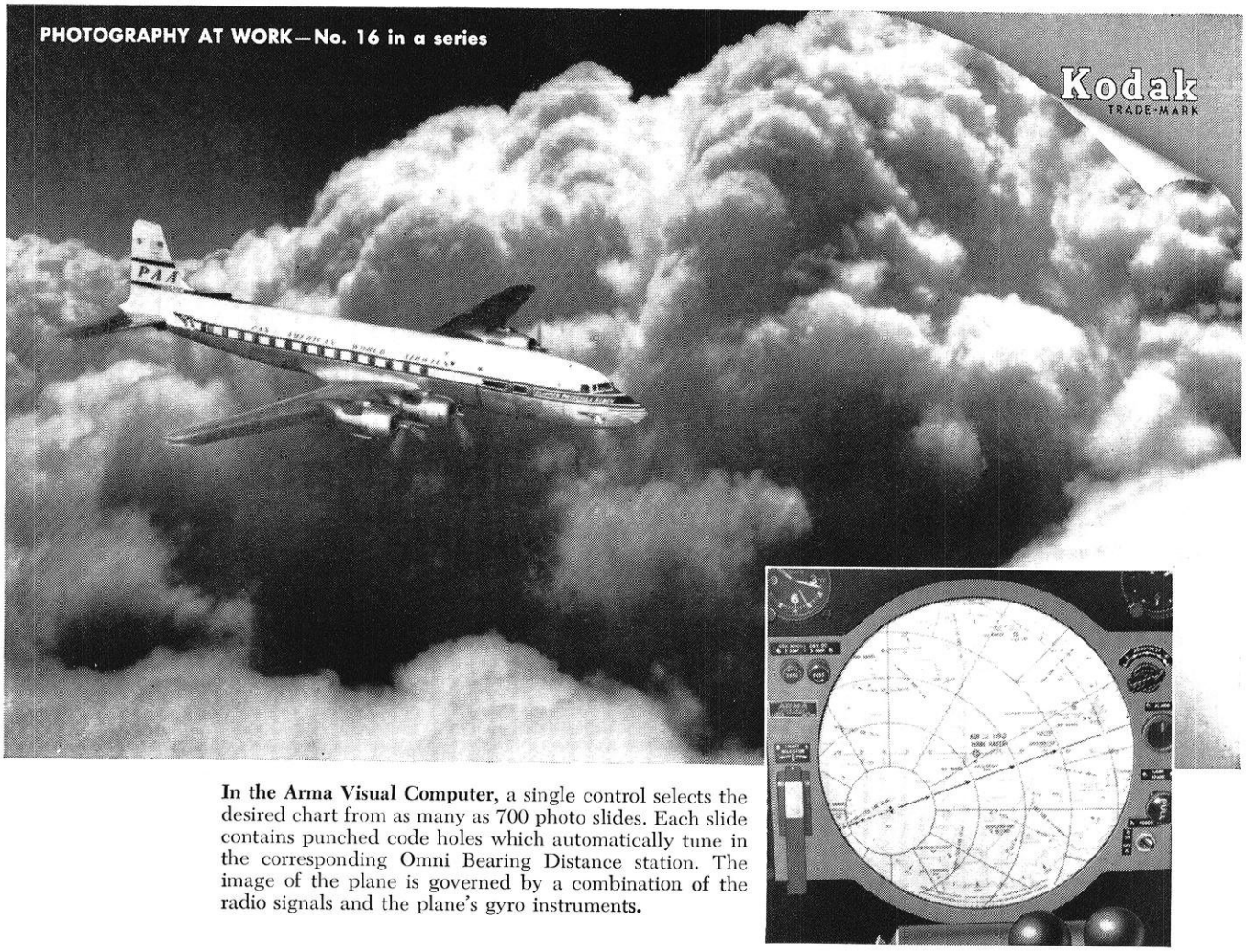
The other combinations of numbers in the square are such that the top line is 192, 219, 273, and 327.

The professor must have started the game with thirteen dollars; Mr. Mueller, with four dollars; and Mrs. Mueller, with seven dollars.

John Rivard, I suggest that with your ability you apply for a scholarship at M.I.T. Nice going John, this is your second ten dollars this school year.

* * *

Send this month's solutions to
SNEEDLY
c/o The Wisconsin Engineer
Mechanical Engineering Bldg.
Madison, Wisconsin



In the Arma Visual Computer, a single control selects the desired chart from as many as 700 photo slides. Each slide contains punched code holes which automatically tune in the corresponding Omni Bearing Distance station. The image of the plane is governed by a combination of the radio signals and the plane's gyro instruments.

Photography teams with electronics and adds new certainty to flight

Now a visual computer pictures a plane's precise position and heading on projected photos of aeronautical maps.

Arma Division, American Bosch Arma Corp., working with the Air Navigation Development Board and C.A.A., has developed a valuable new aid in air navigation using photography.

With it the pilot, high above the weather, flicks a switch and before him appears a map of the area he's over. On the screen a tiny shadow of a plane moves and shows exactly where he is, where he's heading and whether he's on course.

This spells added certainty. Even more! It can mean savings in time and money, too. For the flight can proceed by plan rather than by dog-legs on the beams.

So again we see photography at work helping to improve operations—doing it for commercial aviation just as it does for manufacturing and distribution.

Photography works in many ways for all kinds of business, large and small. It is saving time, saving money, bettering methods.

CAREERS WITH KODAK

With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design and production.

If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Eastman Kodak Company, Rochester 4, N. Y.

One of a series

General Electric interviews Dr. Richard Folsom, President of Rensselaer Polytechnic Institute, to explore . . .

Teaching— A Career Opportunity For the Engineer

Leading educators, statesmen and industrialists throughout the country are greatly concerned with the current shortage of high-caliber graduates who are seriously considering a career in the field of science or engineering education. Consequently, General Electric has taken this opportunity to explore, with one of America's eminent educators, the opportunities and rewards teaching offers the scientific or engineering student.

Q. Is there in fact a current and continuing need for educators in technical colleges and universities?

A. Colleges and universities providing scientific and engineering educational opportunities are hard pressed at the present moment to obtain the services of a sufficient number of well-qualified teachers to adequately carry out their programs. Projected statistical studies show that this critical need could extend over the next 15 or 20 years.

Q. Why is this need not being met?

A. There are probably three main reasons. These might be classed under conditions of financial return, prestige associated with the position, and lack of knowledge and understanding on the part of the college student of the advantages and rewards teaching as a career can afford.

Q. What steps have been taken to make education a more attractive field to engineering students?

A. Steps are being taken in all areas. For example, we have seen a great deal in the newspapers relating educators' salaries to the importance of the job they are doing. Indications are that these efforts are beginning to bear fruit. Greater professional stature is being achieved as the general public understands that the youth of our nation is the most valuable natural resource that we possess . . . and that those associated with the education of this youth have one of the most important assignments in our country today.

Q. Aside from salary, what rewards can a career in education offer as opposed to careers in government or industry?

A. The principal rewards might be freedom to pursue your own ideas within the general framework of the school, in teaching, research and consulting activities. As colleges and universities are normally organized, a man has three months in the summer time to engage in activities of his own choice. In addition, the educator is in direct contact with students and he has the satisfaction of seeing these students develop under his direction . . . to see them take important positions in local and national affairs.

Q. What preparation should an engineering student undertake for a teaching career?

A. In college, the engineering student should obtain a basic understanding of science, engineering science, humanities and social sciences with some applications in one or more professional engineering areas. He should have frequent career discussions with faculty members and his dean. During graduate work, a desirable activity, the student should have an opportunity to do some teaching.

Q. Must an engineering student obtain advanced degrees before he can teach?

A. It is not absolutely necessary. On the other hand, without advanced degrees, advancement in the academic world would be extremely difficult.

Q. How valuable do you feel industrial experience is to an engineering or scientific educator?

A. Industrial experience for a science educator is desirable; however, with a senior engineering educator, industrial experience is a "must". An ideal engineering educator should have had enough industrial experience so that he understands the problems and responsibilities in carrying a project from its formative stages to successful completion, including not only the technical aspects, but the economic and personal relationships also.

Q. What do you consider to be the optimum method by which an educator can obtain industrial experience?

A. There are many methods. After completion of graduate school, perhaps the most beneficial is a limited but intensive work period in industry. Consulting during an academic year or summer is a helpful activity and is desirable for older members of the staff. Younger educators usually need experience in "living with the job" rather than providing consultant's advice to the responsible individual.

Q. Based on your experience, what personal characteristics are possessed by successful professors?

A. Primarily, successful professors have an excellent and growing knowledge of their subjects, are interested in people, and transmit enthusiasm. They have an ability to explain and impart information with ease. They generate ideas and carry them out because they are devoted to developing their fields of knowledge. They desire personal freedom and action.

For further information on challenging career opportunities in the field of science and engineering education, write to: Mr. W. Leighton Collins, Secretary, American Society for Engineering Education, University of Illinois, Urbana, Ill.

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