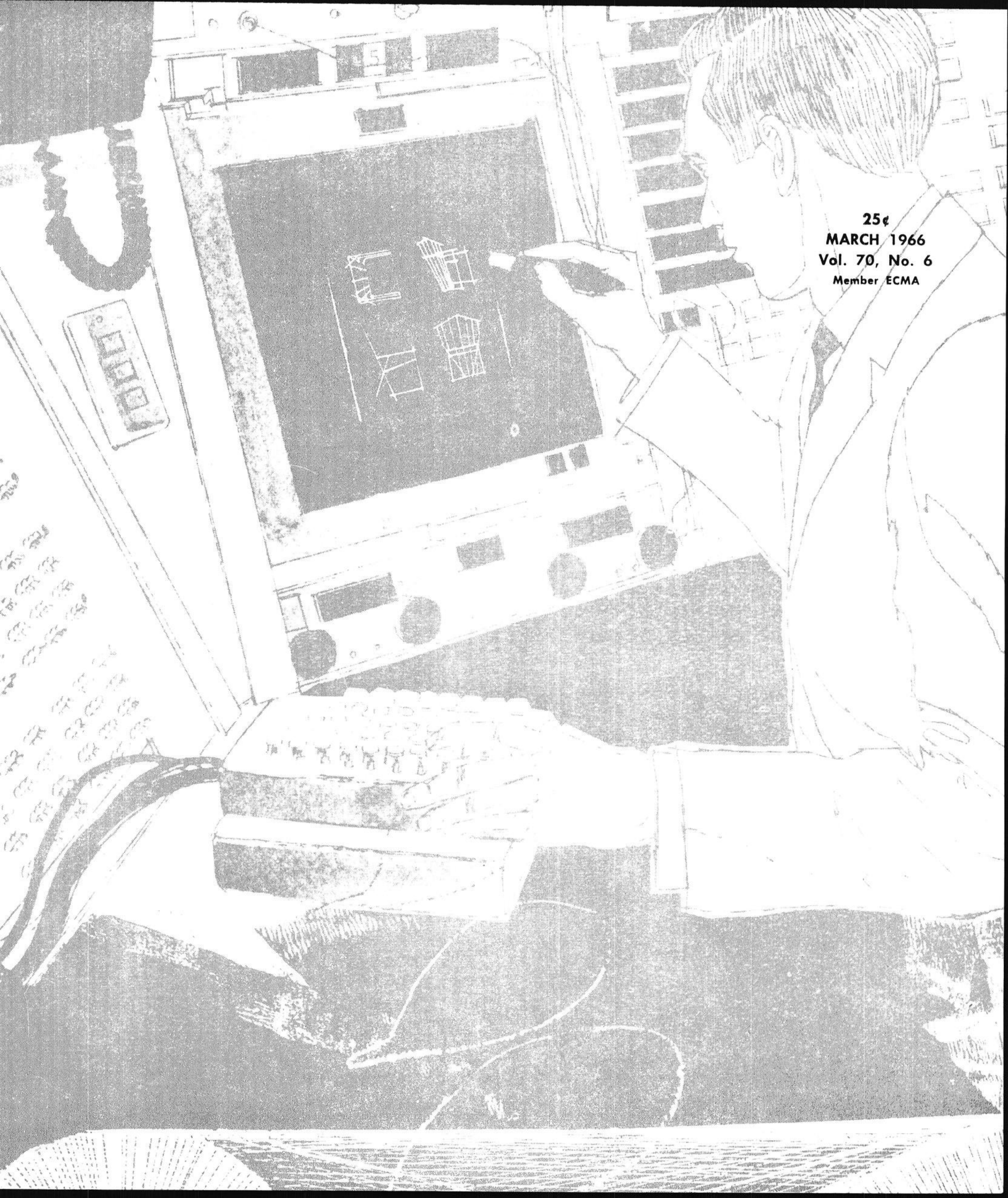
The Wisconsin engineer. Vol. 70, No. 6 March 1966

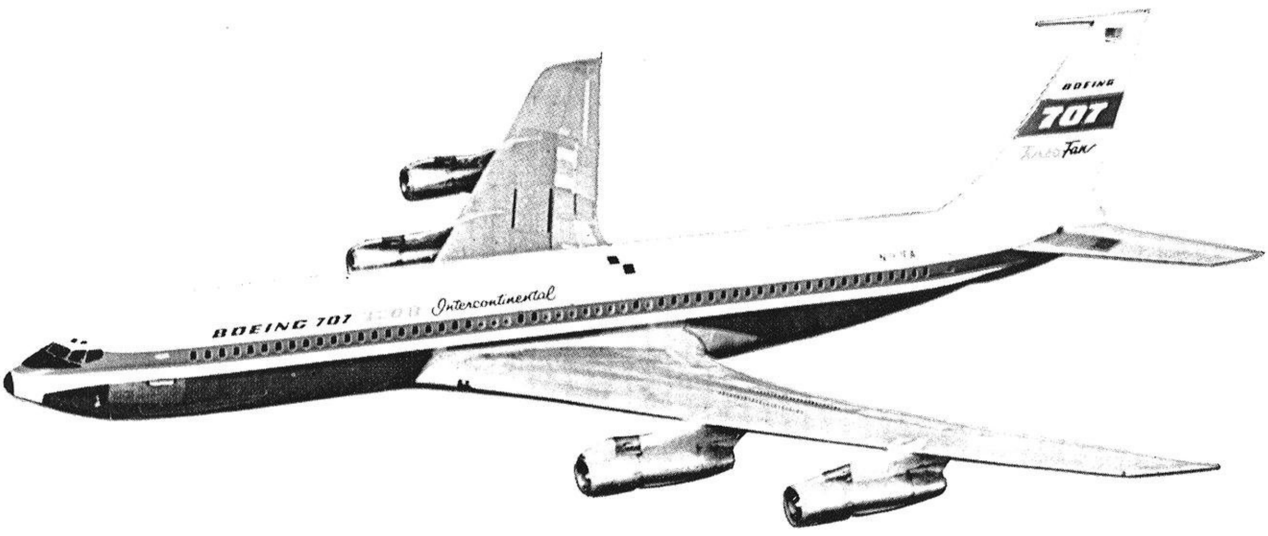
Madison, Wisconsin: Wisconsin Engineering Journal Association, [s.d.]

https://digital.library.wisc.edu/1711.dl/7P3DBZ6M5SIJV8I

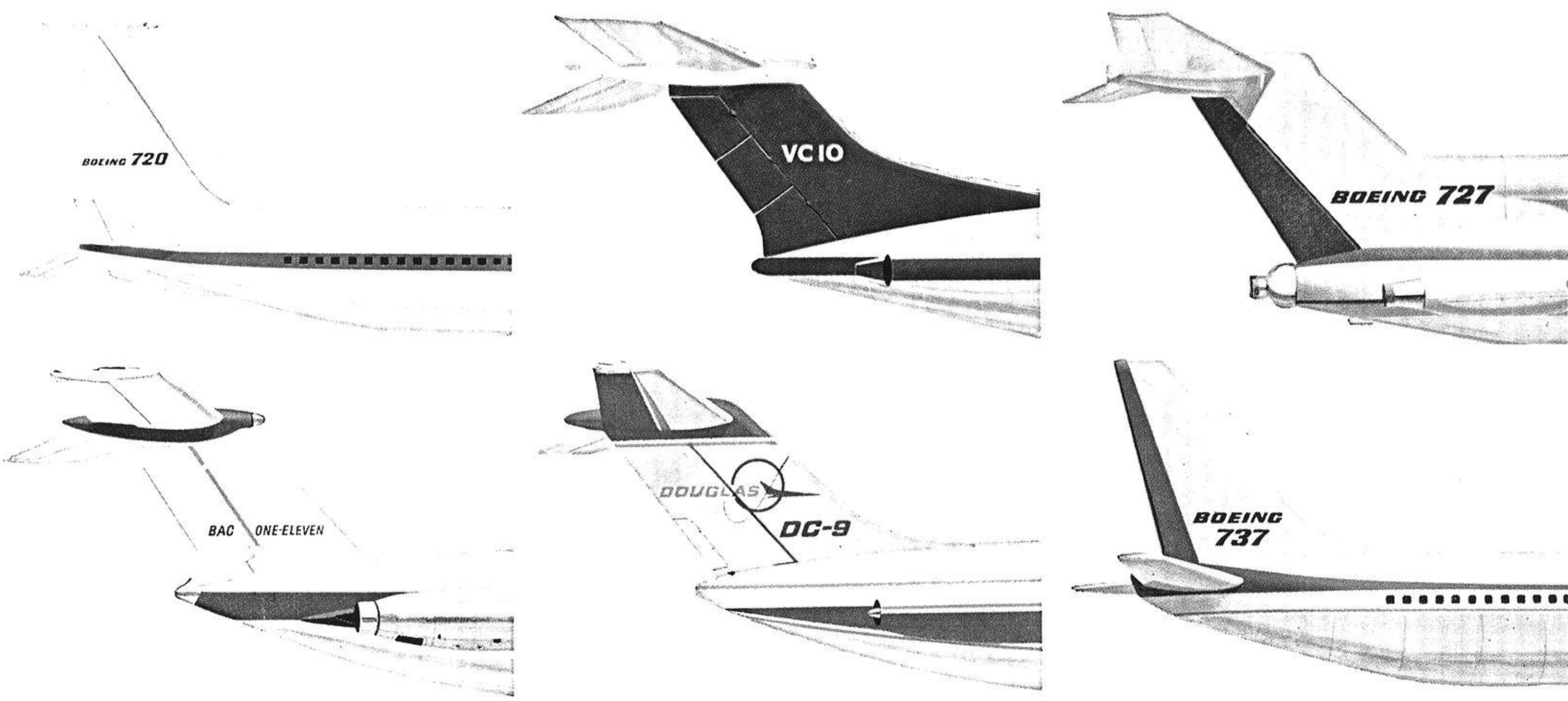
THE WISCONSIN ENGINEER



25¢
MARCH 1966
Vol. 70, No. 6
Member ECMA



Westinghouse electrical systems for jet aircraft are so reliable



they are now standard equipment on all these commercial jets

Westinghouse electrical systems supply the electric power for most of the commercial jet aircraft in the free world.

This is because Westinghouse systems are so reliable.

They have to be. Passenger safety and comfort depend on them.

Westinghouse systems supply the electric power required for flight control of the aircraft and for other vital things like fuel pumps, navigational gear, warning and indicating systems, deicing equipment and radar.

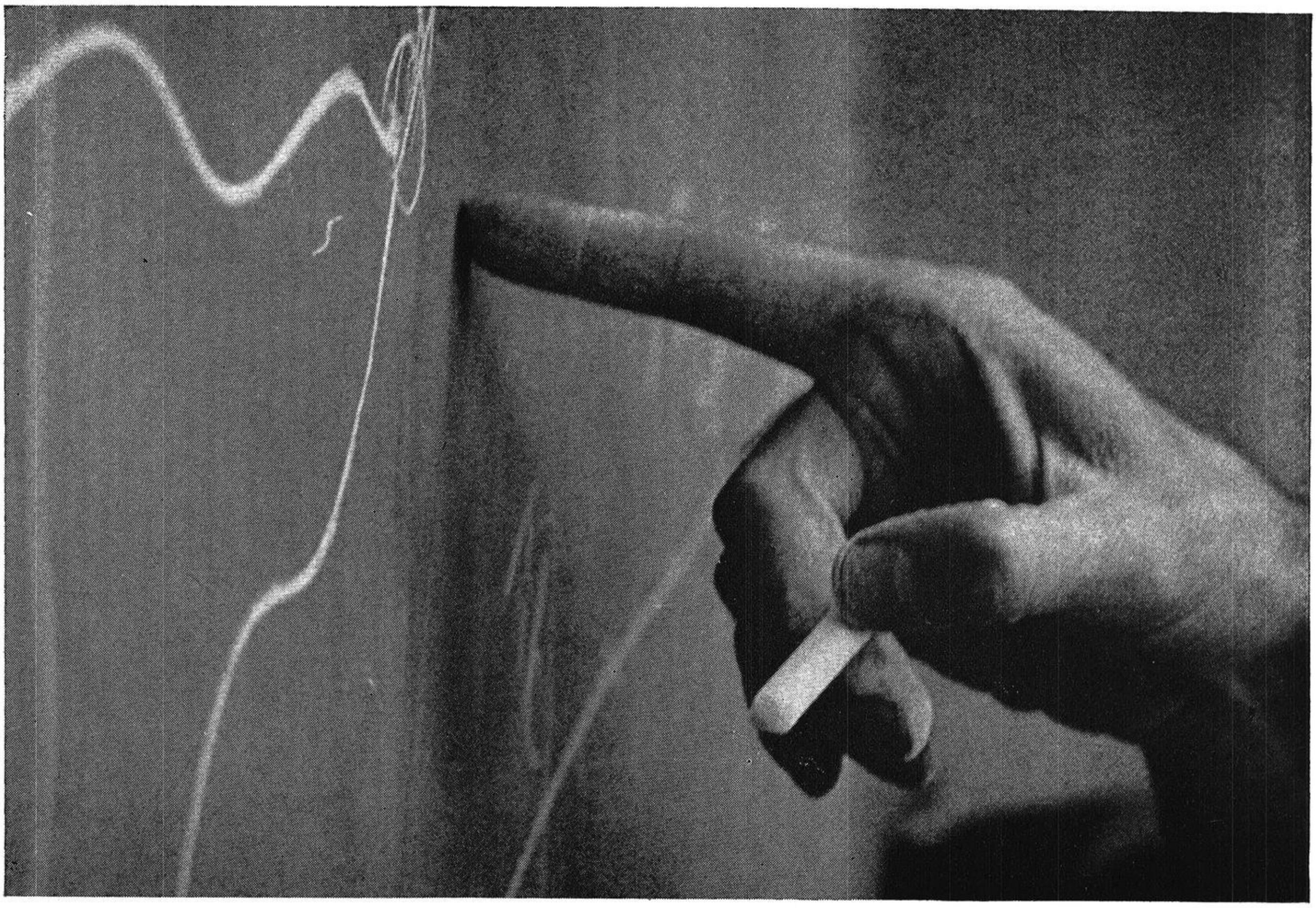
Westinghouse reliability has cut electrical system maintenance costs 50% in the last five years.

Westinghouse believes that reliability—especially in aircraft electrical systems—is something you can never get enough of.

You can be sure if it's Westinghouse

For information on a career at Westinghouse, an equal opportunity employer, write L. H. Noggle, Westinghouse Educational Department, Pittsburgh, Pa. 15221.

Dr. C. A. Wentz, Project Development Engineer, International Department.



MEMBER OF ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman: PROF. J. R. BISSETT, Dept. of Civil Engineering, University of Arkansas, Fayetteville, Arkansas 72701.

Publishers Representatives: LITTELL–MURRAY–BARNHILL, INC., 369 Lexington Avenue, New York, New York 10017.

Second Class Postage Paid at Madison, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at a special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized Oct. 21, 1918.

Published monthly from October to May inclusive by the Wisconsin Engineering Journal Association, 333 Mechanical Engineering Building, Madison, Wisconsin 53705. Editorial Office Hours 10:00–1:00 Tuesday and by appointment. Office Phone (608) 262–3494.

VOLUME 70, NUMBER 6 MARCH 1966

ARTICLES

THE WISCONSIN ENGINEER

The Student Engineer's Magazine Founded in 1896

FEATURES

THIS MONTH'S COVER

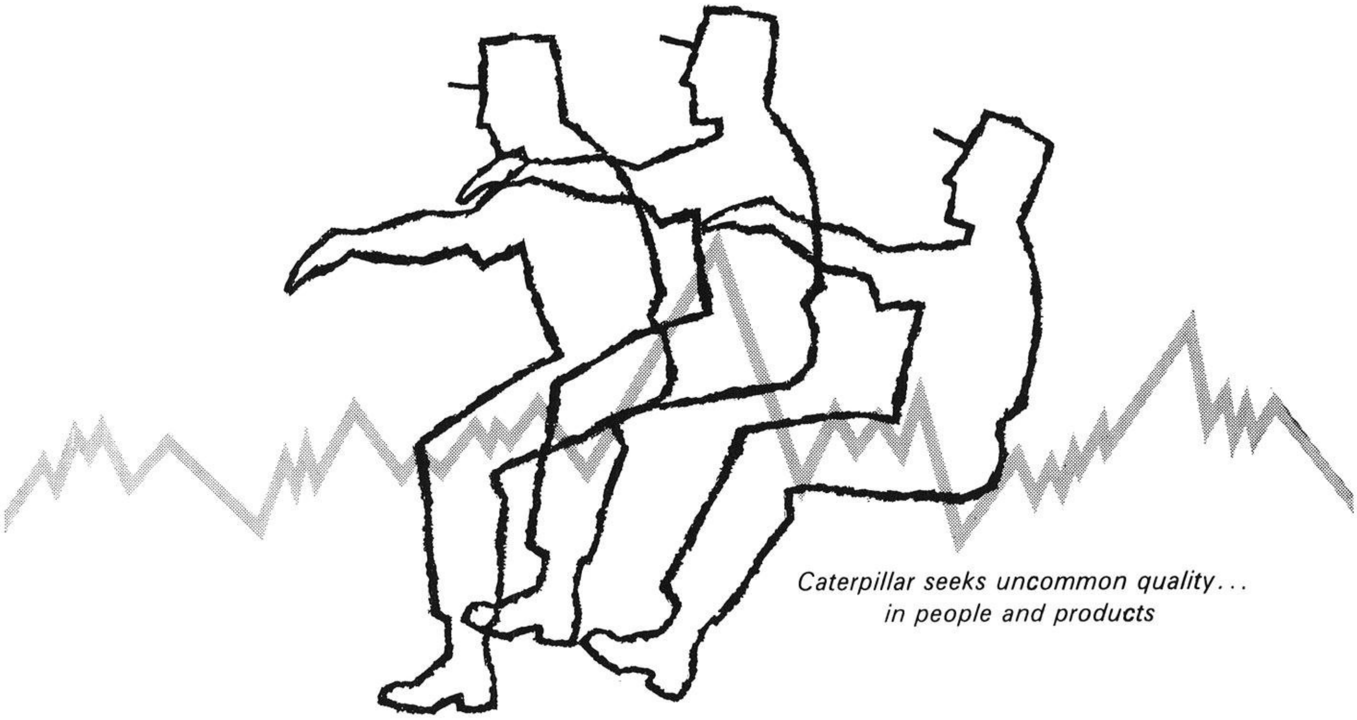
This month's cover is reprinted by special permission from McGraw–Hill Yearbook Science and Technology, *Copyright © 1965 McGraw–Hill Book Company, Inc. It appeared in an article entitled* Computer-Aided Design, *by R. W. Mann and S. A. Coons of MIT. It is an abstraction of the SKETCHPAD console on the TX-2 computer at Lincoln Laboratory, MIT.*

SUBSCRIPTION PRICE

$4.00 FOR FOUR YEARS $1.25 FOR ONE YEAR

SINGLE COPY 25¢


JOHN



Cat research and engineering led the way to "Instant Evaluation" of Vehicles

Test drivers could bounce across the field. But they couldn't remember every bounce. Precise data was needed, on motion, vibration, balance, noise and seat position. Cat engineers found a way.

First they had to develop instrumentation for recording all those effects on vehicle operators.

Then they developed a testing method that would duplicate identical conditions in a controlled lab environment. The Cat Ride Simulator. It has a ride platform with seat and controls. A servo drive mechanism which controls the platform. And an analog computer which directs the servo drive.

That wasn't bad. They could tape vertical acceleration measurements of a vehicle in the field. Then recreate them on the ride platform. That let them study effects closely. And judge two versions of a vehicle in fast sequence—no human memory involved.

But these were Cat engineers. They went after the next step: evaluating prototypes with pre-hardware paper testing. If this could be done, vehicle development could really be speeded up. Why build a vehicle, test it outside and make changes . . . if the concepted vehicle could be made to travel a "taped terrain"?

They used the analog computer, simulated a mathematical model and used a taped road profile as input data to the model—with the computer output actuating the ride simulator. Now, design modifications are pinpointed at once. Evaluations are made in moments, instead of days.

That's another example of what we mean by new frontiers. If you'd like to help us push back the boundaries of knowledge, we need you. In research, development, design, manufacture, sales. Here and overseas, opportunities for Cat engineers—all fields—are endless.

Contact your placement office. We'll be interviewing on your campus soon. Or write: College Recruiting, Personnel Development Dept. B, Caterpillar Tractor Co., Peoria, Ill.

CATERPILLAR

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

"An Equal Opportunity Employer"

Caterpillar Tractor Co., General Offices, Peoria, Illinois • Caterpillar Americas Co., Peoria, Illinois • Caterpillar Overseas S.A., Geneva • Caterpillar of Australia Pty. Ltd., Melbourne • Caterpillar Brasil S.A., Sao Paulo • Caterpillar Tractor Co., Ltd. Glasgow • Caterpillar of Canada Ltd., Toronto • Caterpillar France S.A., Grenoble • Caterpillar (Africa) (Pty.) Ltd., Johannesburg • Caterpillar Mexicana S.A. de C.V., Monterrey • Caterpillar Mitsubishi Ltd., Tokyo, Japan • Tractor Engineers Ltd., Bombay, India

Rambling with the Editor

LT or PFC?

Today's college men have another excuse for their insecurity as for the first time in recent years the threat of losing a handy-dandy II-S Selective Service Classification looms overhead.

Engineering students are generally no different than other students when the local draft board is making a decision. How many of you stand to join the ranks of the draftee when you graduate this June? We think that too many of you devote too much time thinking of ways and means to avoid your military obligation rather than investigating worthwhile ways to fulfill it.

As graduating engineers you are in demand —by industry, government, and your draft board. Perhaps you have serious plans for graduate study, or a job in a "critical" industry, or a family of four at home—this is all well and good, but the exception rather than the rule.

But what about those of you who may well become classified I-A and shortly thereafter attain the rank of Private, U.S. Army? It need not happen my friends, for there are numerous opportunities for you to serve your country in a position of esteem while practicing your engineering skills.

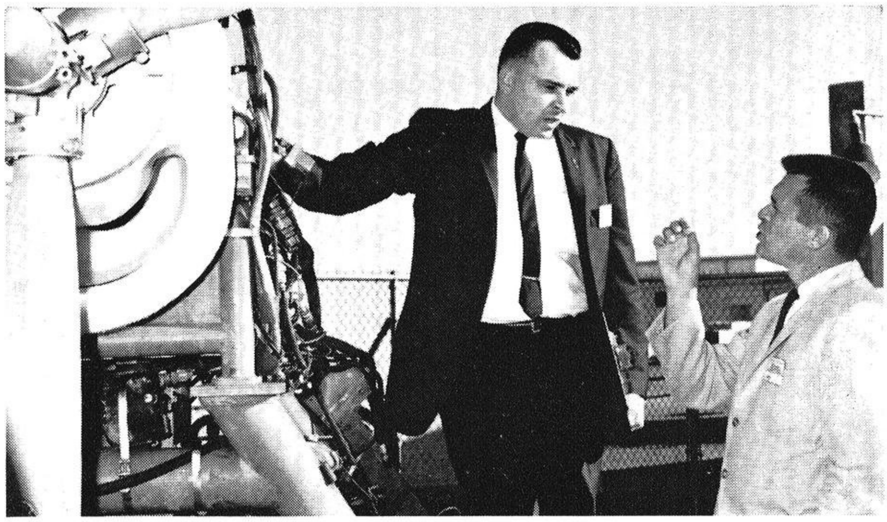
Today's armed services operate with the technology that has developed while you've been in school. Gone are the days of mis-matching men and jobs. There is a place for you in the officer corps of our Navy, Marine Corps, Army or Air Force. Sophisticated electronics systems, 21st century ordnance, nuclear reactors, millions of dollars of construction—all these and many more are the things that you can become involved with as a junior officer. Research and development work, along with graduate study at the best schools in the nation, is available. Not even the sky is the limit as our officers orbit the earth in Gemini spacecraft.

While the starting pay may not be quite what the headhunters offer, there are ample fringe benefits and tremendous opportunities for advancement. You aren't going to be wasting your time, for the experience you gain is looked upon favorably by prospective employers, and often counts for professional registration besides. We feel that the military service as a starting point for your career certainly deserves your honest and careful consideration.

—R. J. Smith

POSTSCRIPT: To recapitulate on this and *previous* editorials, we present a "Wish we'd said that" from our counterpart at The Ohio State University, Dennis Hurley: "No American citizen can expect to enjoy the rights and freedom that are his without contributing to the preservation of these rights. (Blood drives for the Viet Cong and other acts which either actively aid the enemy or decrease the morale of our troops can hardly be construed to be acts of preservation of civil liberties. Nor can they even be considered within the realm of the freedoms we enjoy.)"

What kind of engineer will you be... preliminary design, design, development? At AiResearch Phoenix, you work as all three before you decide.



Your future as an engineer is strongly influenced by your first assignment. What that assignment will be, should be, is an important decision.

At Garrett you control that decision. During an eight-month orientation program, you work with experienced engineers on a variety of assignments in different areas. Your permanent assignment depends on your own aptitude and interest.

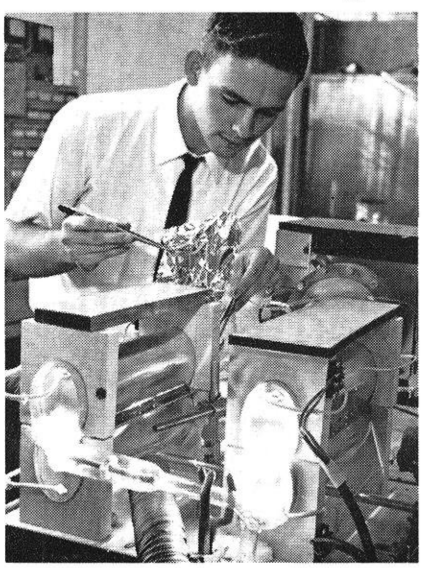
In preliminary design you may work on gas turbine engines, jet engine starters, or advanced power systems for space vehicles. Analysis is the key—and the emphasis is on thermodynamics, fluids, vibration, heat transfer, and math to solve today's problems.

As a *design engineer*, you see your solution to a product design problem take shape on the drawing board and in fabrication. You

may work on controls systems for turbine drives, engine fuel systems, or a laboratory test system. Mechanics is the theme—statics and dynamics, materials and processes, and graphics are your tools.

In *development*, you'll test designs before they go into production. Manufacturing processes are examined and production techniques are explored. Everything from nuts and bolts to complete power systems are tested, and your lab work and practical judgement will pay off in this area.

Your career at AiResearch Phoenix can be stimulating and



rewarding. You can work in all three important areas of engineering on diverse aerospace products. You can use your total education, learn more on top of it, and take part in a wide variety of advanced engineering.

At AiResearch Phoenix, the product lines include gas turbines for auxiliary power, turboprop engines for business and military aircraft, secondary power equipment for aircraft, advanced space vehicle nuclear power systems, pneumatic and hydraulic control systems, as well as a variety of related equipment for aerospace, ground, and undersea applications.

Find out the whole story in our new booklet, Your Future at Garrett. Get it from your campus placement office, or write AiResearch Manufacturing Division, 402 South 36th Street, Phoenix, Arizona 85034.

AiResearch *is* challenge

GARRETT

An equal opportunity employer.

Los Angeles • Phoenix

COOKING
by the
SCIENTIFIC METHOD

By JOHN FREE, ME4

EVER since man has existed, he has had to eat to survive. However, it wasn't until the Paleolithic, or Old Stone Age, that man started to cook his foods with fire. As time went on, man learned to cook more foods in many new ways. Today we have hundreds, if not thousands, of different kinds of foods. Most of these foods are cooked in some manner during their preparation.

As in any job or action, there are efficient and inefficient methods of doing or completing the job or action. This idea of efficiency or inefficiency also applies to the "art" or "science" of cooking. This article presents various methods of cooking basic foods in a minimum of time. The basic foods considered in this report are cuts of beef, potatoes, turkey, pork, sausages, fish, and other similar foods. Sauces, complicated mixes, and other non-basic foods were not considered.

Since cooking is directly dependent upon heat energy and the speed with which the heat energy is conveyed to and through the food, basic knowledge of heat transfer theory is necessary.

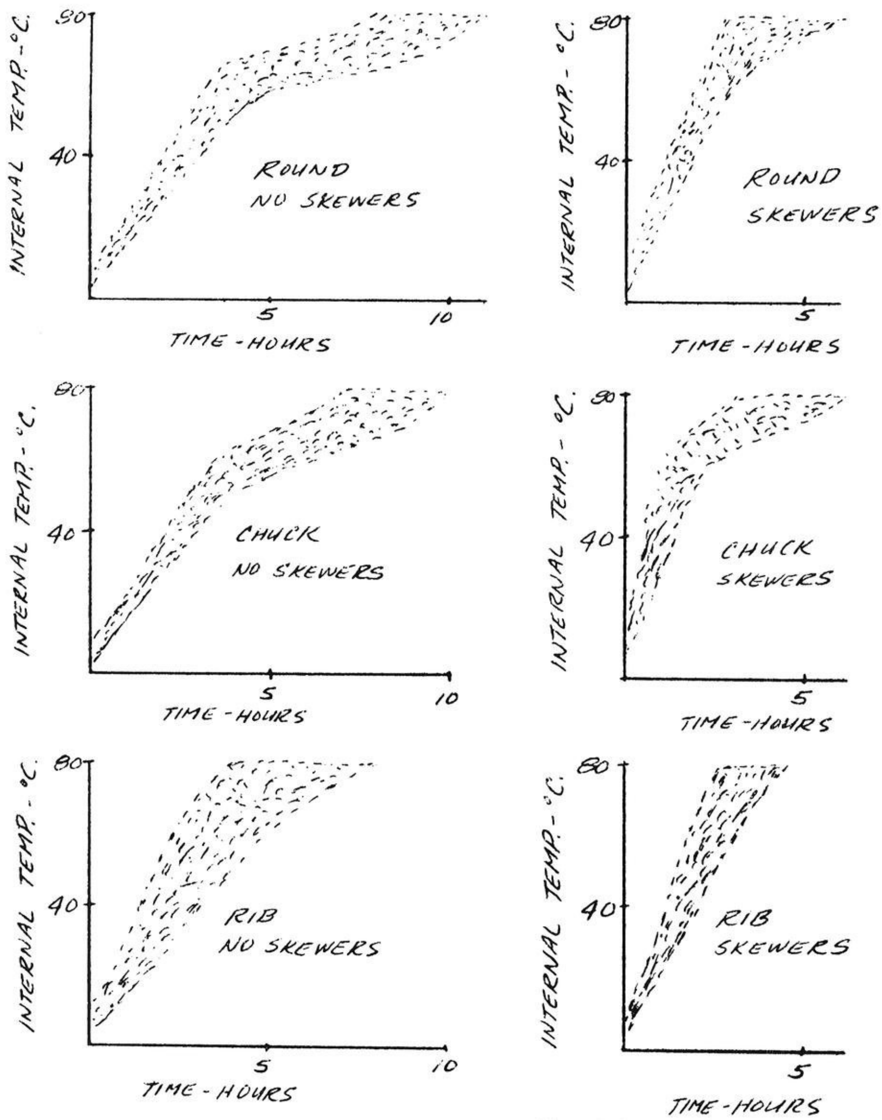
THEORY AND EXPLANATION OF HEAT TRANSFER

Heat transfer is that science which seeks to predict the energy transfer which may take place between material bodies as a result of a temperature difference. The energy transfer is heat, which is solely responsible for cooking. Thermal propagation does not merely explain how heat energy is moved, but it also predicts the rate at which the exchange of heat takes place. This rate of thermal energy exchange is in most instances directly proportional to the cooking time of most foods. Heat transfer occurs through three general methods, or a combination of the three methods: Conduction, Convection, and Radiation.

Conduction

The first method is conduction. Conduction is thermal motion of heat energy which is passed along from one molecule to the next, in a body, as a result of a temperature difference from one part to some other part of the body. An example would be a beef roast with an outside temperature of 250°F. and an internal center temperature of 140°F. Since the outside of the roast is hotter than the inside, heat energy will be moving from molecule to molecule of the roast from the higher to the lower temperature. This same thermal motion of heat energy occurs in all foods.

John Free, an ME4 is from Milwaukee. He has had considerable industrial experience with several large Milwaukee firms. John lives at the Regent. He is a member of SAE, ASME, and the Wolf River Conservation Club.



Adapted from *Food Research* (1941)

Fig. 1—Time-Temperature Histories of Skewered and Unskewered Roasts with an Oven Temperature of 125°C.

Convection

The second method of heat transfer is convection. Convection is the transfer of heat energy from one place to another by the actual motion of hot material, such as a fluid. An example of convection applied to cooking is the transfer of heat energy from hot air passing some food which is at a lower temperature. The motion of the hot material may be the result of differences in density resulting from temperature differences within the hot material itself. As the material is heated, its density decreases with respect to the cooler material. Therefore, the warmer material rises, since it is the more buoyant. This motion process is called natural convection. Air moving above a hot surface, such as a gas burner or an electric heating element in an oven, is the process of Natural Convection. The motion of the hot material may also be produced by some mechanical method. The mechanical process of moving the hot material is called Forced Convection. An example of Forced Convection is the movement of hot air from one place to another by the action of a fan or blower.

Radiation

The third mode of heat transfer is radiation. More specifically, as applied to heat transfer, thermal radiation is that electromagnetic radiation emitted by a body as a result of its temperature. Radiant heat waves cause heating by the absorption of energy; while in convection and conduction, molecular collisions accomplish energy transfer. Radiation is propagated at the speed of light. In cooking, two areas of Radiation have their greatest application. These areas are microwave radiation and infrared radiation. They are denoted by their frequencies. The complete spectrum of electromagnetic waves varies from the lowest frequency waves, radio waves, to the higher frequency waves, which, in increasing order of frequency, are respectively microwaves, infrared, visible, ultraviolet, X-rays, gamma, and cosmic waves. Microwaves are between radio waves and infrared waves. Microwave frequencies which are used in cooking are:

1. 915 megacycles per second
2. 2,450 megacycles per second
3. 5,800 megacycles per second
4. 21,125 magacycles per second

Because of complete penetration, microwaves cook food evenly. The inside cooks at the same rate and time as the outside of the roast. Therefore, microwave cooking is extremely fast. Electronic apparatus is used to produce microwaves. Infrared waves have higher frequencies than microwaves and lie between microwaves and visible waves in the electromagnetic spectrum. Infrared waves heat superficially and seldom penetrate the food being cooked. Infrared waves can be produced in several ways. Most often, the infrared waves are produced by a special heating element.

Conduction, Convection, and Radiation are singly or in combination, needed to cook foods.

EXAMPLES OF COOKING SOME BASIC FOODS

Examples of cooking foods will demonstrate how Conduction, Convection, and Radiation are needed for the cooking process.

Beef

A number of experiments have been run concerning the cooking of several cuts of beef. Cooking times, meat losses, and tenderness were considered in these experiments.

In the experiments conducted concerning several beef cuts, two methods of cooking were used and

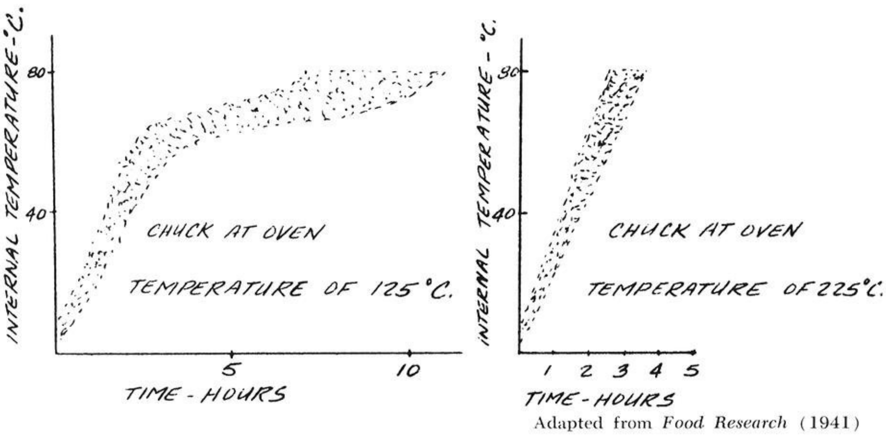


Fig. 2—Time-Temperature Histories of Unskewered Roasts with an Oven Temperature of 125°C. and 225°C.

compared as to the amount of cooking time necessary to reach a predetermined internal temperature. The first method was to cook the beef as is; that is, without any physical changes. The second method employed was to put metal skewers into the beef, which was of similar type, size, and shape as that beef in method one. In Experiment No. 1, paired roasts from right and left sides of the same beef carcass were cooked well done to an internal temperature of 80°C. at the same oven temperature of 125°C., one without metal skewers, and one with skewers. The skewers were 6 in. long and $\frac{3}{16}$ in. in diameter and were made of nickel-plated copper. Copper was used since it conducts heat better than most other materials. Nickel-plating was used because copper is somewhat toxic when used in cooking. Nickel also conducts heat quite well. Six of the skewers were placed in a circular fashion around the center of the roast. Round, arm-bone chuck, and standing rib were tested. The results of the cooking times were unanimous. The skewers decreased cooking time in all of the roasts. Below are six time-temperature histories of the three kinds of paired roasts. The statement of shorter cooking (roasting) times with skewers is easily verified by the curves in Figure 1. In general, when the oven temperature was increased, the slopes increased very rapidly on the time-temperature histories of the paired, unskewered roasts. See Figure 2.

In Experiment No. 2[2], the procedure was similar to that of Experiment No. 1. A thermometer was inserted into the center of the meat to record interior temperature and, therefore, the rate of cooking. Two rib-standing beef roasts, uniform in size and shape, were weighed and were measured for surface area. The roasts were then placed on the rack of an open or covered pan and cooked. After a desired inner temperature was reached, the roasts were removed from the oven. Since rapid cooking of meat depends upon the rate at which heat is conducted from the surface to the interior, metal skewers were used. The skewers conducted the heat at a much faster rate than the meat did to the interior of the roast. Nickel-plated copper skewers were chosen as in Experiment No. 1. The skewers were $\frac{3}{16}$ in. in diameter and 12 in. long. One-half of the skewer was straight, while the other half was coiled. The coil was used since it increased the weight of conductive metal exposed to the oven heat. This coil provided a means of getting more heat to the interior of the roast in a shorter time than if not used. Six skewers per roast were used. The average decrease in cooking time was 6.6 min./lb., or about 30%. The extent of shortening the cooking process was apparently directly proportional to the weight of copper used in the skewers. The maximum of shortening the cooking process was not obtained in this experiment. The economy of cooking with skewers is quite evident, since fuel is saved. Two tables follow which show the relative differences in cooking the roasts with and without skewers. Generally, the times from Table 2 are less than the times from Table 1 for similar roasts, and other similar environmental conditions.

Surface area variation of the roasts caused changes in cooking times. The length of the roasting period per square inch of surface, and per pound of weight, decreased with increased size when skewers were used. The reverse of this condition was true for unskewered roasts. The decreasing surface area per unit of cubical contents in the heavier roasts probably accounted for the above mentioned condition in the unskewered roasts. As a result of both experiments, skewers did reduce cooking time considerably in beef roasts. Fuel and time were also saved.

Skewers Reduce Losses

Despite the economic saving of fuel when using skewers, tenderness and losses from the roasts in the above mentioned experiments are also important to the consumer. Therefore, data follows concerning the relative tenderness and losses of skewered and unskewered roasts. From Experiment No. 1, the shorter cooking time (skewers used) of the roasts led to less tender meat. When the cooking time difference between the skewered and unskewered roasts was largest, the tenderness of the skewered roast was the least. However, when the cooking time difference was smallest, the tenderness of the skewered roast approached the tenderness of the unskewered roasts. The data from Experiment No. 2 tended to contradict the data from Experiment No. 1. The products obtained using skewers were very similar in appearance, flavor, and juiciness to the products not using skewers. A further conclusion of Experiment No. 2 was that the meat of the skewered roasts was more juicy, more appetising in appearance, and more tender than the meat of the unskewered roasts. This contradiction of whether skewered or unskewered roasts were more tender was the direct result of human testing, which was much less objective than more scientific means of testing. The personal tastes of the consumer would dictate, in the end, whether or not skewered roasts were more tender than unskewered roasts. Losses, moisture and fat, were less in both experiments when skewers were used. The decrease in losses, when using skewers, may have been the result of shorter cooking time.

Turkey

Here, as in the beef experiments, skewers, as an aid to faster cooking, were used in a similar experiment using turkey meat.[3] Turkey rolls ranging from 8.8 to 10.8 lbs. were cooked with several variations. Tests were run at several temperatures, without skewers, with aluminum and copper skewers, and utilizing two cooking methods, roasting and braising. Four skewers were used per turkey roll. The skewers were 8 in. long by 0.5 in. wide with a 1/8 in. beveled edge along each side. The copper skewers each weighed 55 gms. The aluminum skewers each weighed 20 gms. The skewers were effective in reducing cooking time and total losses. Roasting was more effective than braising when skewers were used. There was a tendency for roasted rolls with skewers to be more juicy. The differences in using copper or aluminum skewers were negligible.

Potatoes

As with the previous sections, I considered potatoes as one of the basic foods. Since no data existed on the use of skewers in baking potatoes, I ran my own experiment to see whether or not skewers would aid in shortening the baking time. I chose Idaho potatoes of similar shape, size, and weight. One potato was baked with the

Table 1. Length of Roasting Period and Loss in Weight of Unskewered Roasts
Adapted from *Journal of Home Economics* (1926)

No. of Roast	Weight of Raw Roast Gms.	Interior Temperature		Time of Roasting		Loss of Weight in Roasting		Kind of Pan O—Open C—Closed
		On Removal °C.	Max. °C.	Total Min.	Per Pound Min.	Total %	Fat %	
1	967	70	70	65	30.5			O
18	1446	70	74.5	74	23.2	39.9	13.2	C
17	1453	70	72	60	18.4	30.3	10.4	C
7	1625	70	76	68	18.9	29.0	8.8	C
16	1767	70	77	80	20.5	33.9	8.4	O
13	1811	51	57	46	11.5			O
15	1830	51	67	63	15.6	26.0		O
6	1839	70	74.5	87	21.4	35.3	12.3	O
10	1885	70	78.5	92	22.1			C
11	1894	70	77	98	23.5	38.3		C
2	1909	70	73	110	26.1			C
14	2258	51	61	60	12.0	25.4	6.5	C
8	3589	70	78	125	15.5	28.2	4.5	C
24	4305	69	73	200	21.0	33.2		O
					20.0	31.3	91	

Table 2. Length of Roasting Period and Loss in Weight of Skewered Roasts
Adapted from *Journal of Home Economics* (1926)

No. of Roast	Weight of Raw Roast Gms.	Interior Temperature		Time of Roasting		Loss of Weight in Roasting		Weight of Skewers Gms.	Kind of Pan O—Open C—Closed
		On Removal °C.	Max. °C.	Total Min.	Per Pound Min.	Total %	Fat %		
22	1440	60	72	43	13.5	23.8	3.4	264	O
3	1545	70	73	45	13.2			264	C
21	1744	60	73	50	13.0	28.0	6.0	264	C
5	1842	75	75	39	9.6	22.0	6.3	264	O
4	1935	70	70	33	7.7	19.1		264	O
23	4304	70	74	80	8.4	24.6		264	O
12	1542	60	60	46	1.35			175	O
19	1797	60	70	65	16.4	31.9	13.0	175	O
20	1846	60	73	64	15.7	29.3	8.9	175	C
25	4960	70	78	145	13.1	32.5		175	O
Average of All Roasts					12.2	26.4	7.5 (5)		
Average of Roasts w 264 Gm. Skewers					10.9	23.4	5.2 (3)		
Average of Roasts w 175 Gm. Skewers					14.7	31.2	10.9 (2)		

skewers, the other without. The skewers were actually three aluminum nails approximately 3/16 in. in diameter and 4 in. long. The skewers were placed equidistant distances apart around the potato in the same plane. The center temperature of the potatoes were measured by a glass meat thermometer. The oven temperature was set and kept constant for both potatoes at 450°F. Figure 5 shows the results in the way of a time-temperature history for both potatoes. Speed, using skewers, was increased approximately 15%. Here, as in the other food experiments, there was a saving of both time and fuel when skewers were used. The potatoes tasted the same. Since there are other means of cooking potatoes, and the experiment covered only baking of potatoes, the theory behind boiling potatoes will be considered next.

Besides taste, size, and intended use, the reason for boiling potatoes is primarily that of saving time. Where it may take one hour to bake a large potato at 300°F., it will be cooked quicker when boiled at 212°F. The reason for the increased speed is because water has a higher coefficient of heat transfer at 212°F. than hot air (as in an oven) has at 300°F. This means that heat can be convected to the potato much quicker. The increased speed of being heated quickly causes a shorter cooking time.

COOKING SUGGESTIONS

From the previous experimental data of the three basic foods considered I should like to, at this point in the article, make several suggestions in the use of metal skewers when cooking.

Cooking Beef with Metal Skewers

When roasting beef roasts at least three lbs. or more, I suggest that metal skewers (at least four)

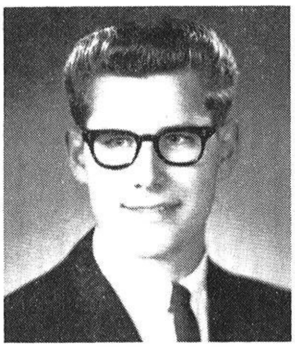
(Continued on page 32)

[1] Sylvia Cover, "Effect of Metal Skewers on Cooking Time and Tenderness of Beef," *Food Research*, Vol. 6 (1941), pp. 233–238.

[2] A. Morgan and P. Nelson, "A Study of Certain Factors Affecting Shrinkage and Speed in the Roasting of Meat," *Journal of Home Economics*, Vol. 18 (1926), pp. 371–378.

[3] J. R. Bowers, G. E. Goertz, and J. L. Fry; "Effect of Cooking Method and Skewers on Quality of Turkey Rolls," *Poultry Science*, Vol. 44, No. 3 (May, 1965), pp. 789–793.

The Use of SOIL-CEMENT for AIRPORT RUNWAYS



Greg Rinehardt is a Junior in Civil Engineering from Monticello, Wisconsin. Since he is a licensed pilot, the subject of runways is rather important to him. Greg lives in Turner House and has worked for the Green County Highway Department.

By GREG RINEHARDT, CIE3

THE tremendous increase in air traffic in the past years has brought about the development of a relatively new engineering field—the design and construction of airports and landing facilities.

One of the new developments which has been brought about by this demand for airports is the use of soil-cement for airport runways. Because of their economy, ease of construction, and strength, the use of soil-cement runways has increased greatly.

WHAT SOIL-CEMENT IS

Soil-cement is a highly compacted mixture of soil, portland cement, and water. The addition of cement greatly stabilizes the soil, which makes it capable of supporting a greater bearing force and more resistant to water and other deteriorating agents.

The percentages of soil, portland cement, and water vary with such factors as the type of soil used, type of cement used, and the purpose for which the soil-cement surface is intended. The percentages of cement, soil, and water, and also the density to which the soil-cement mixture is to be compacted are determined by various tests.

Material for Soil-Cement

The only materials required for soil-cement are portland cement, water, and soil.

Portland Cement—Any type of cement which complies with the latest ASTM (American Society for Testing and Materials), AASHO (American Association of State Highway Officials), or federal specifications can be used.

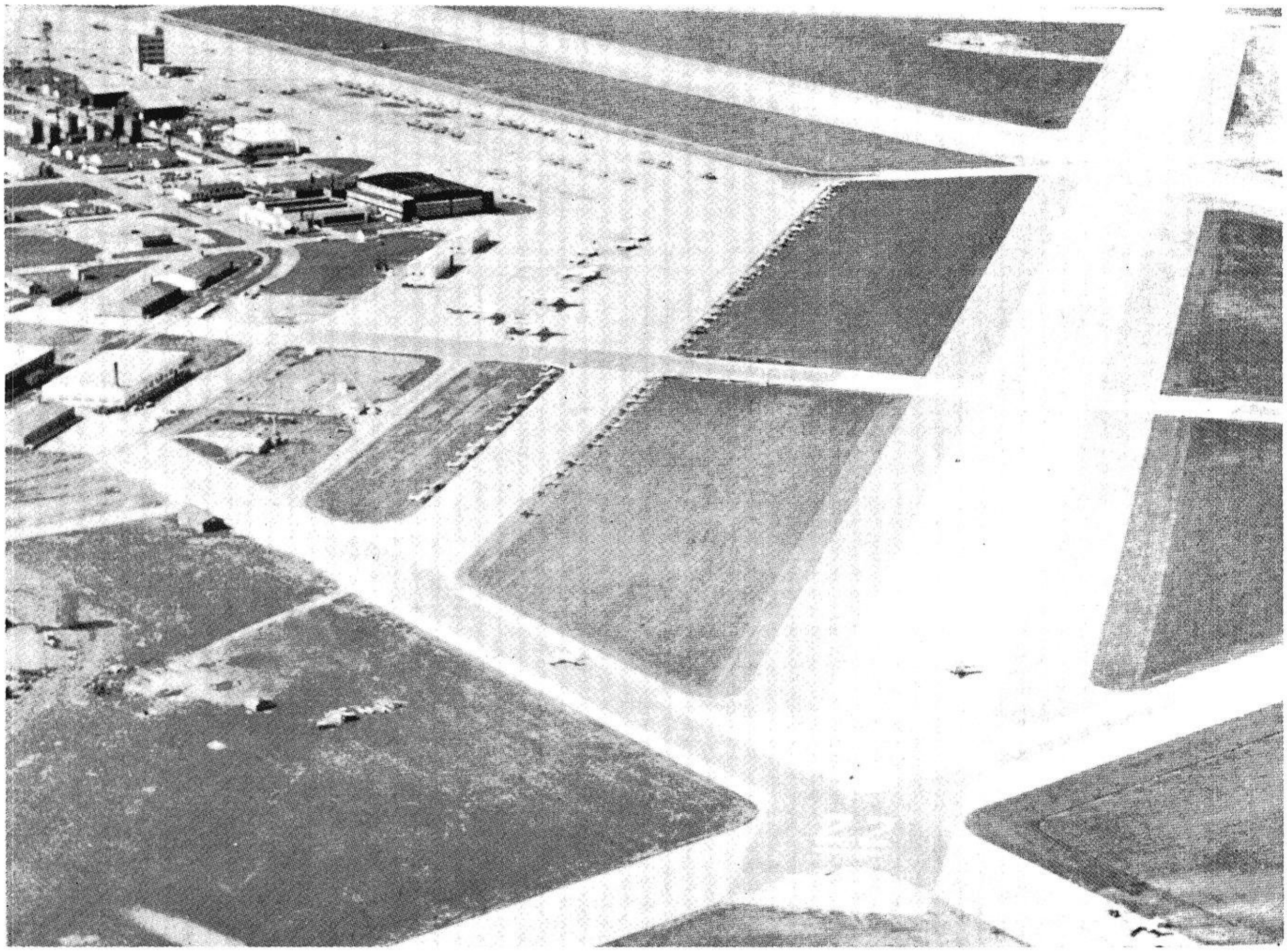
Water—The only requirements for the water used in soil-cement are that it be relatively clean and free from harmful amounts of alkalies, acids, and organic materials. Water which is pure enough to drink is suitable, but even sea water has been used with satisfactory results when fresh water was not available

Water has a dual purpose, it lubricates the soil particles so that they can be compacted, and it is necessary for the hydration of the cement.

Soil—Practically any type of soil can be used for soil-cement. The word soil is not used in its usual sense. The definition of soil is a well-graded aggregate of weathered rock which is capable of supporting plant life. In the case of soil-cement, soil refers to almost any mixture of gravel, sand, silt, and clay. Even waste materials such as cinders, caliche, and shale may be used. In cases were aggregate base courses of gravel or some other material were first used and proved unsatisfactory, the base-course material can be salvaged by using it as the "soil" for a soil-cement mixture. This old flexible base-course material forms very good soil-cement.

Types of Soil-Cement

There are three principal types of soil-cement:



Sioux City Municipal Airport—a modern facility constructed with soil-cement

Cement-Modfied Soil—This is an unhardened mixture of cement and soil. Cement and water are added to the soil in amounts which will change the properties of the soil a desired amount, but will not result in a rigid material. Chemical and physical properties of the soil are thus improved by the addition of cement. The cement increases the bearing capacity of the soil and reduces its plasticity and water holding capacity.

Plastic Soil-Cement—Plastic soil-cement is a mixture of cement, soil, and water which at the time of placing contains sufficient water and cement to produce a consistency about the same as plastering mortar. It hardens to a rigid surface, and its principal use is to pave steep or confined areas.

Compacted Soil-Cement—Compacted soil-cement is the most commonly used type. It contains enough cement to produce a hardened surface, and sufficient water to hydrate the cement and allow the mixture to be easily compacted. Hereafter, the term soil-cement will refer to compacted soil-cement.

EFFECTS OF SOIL PROFILES AND SOIL TYPES

When considering the use of native or residual soils in a soil-cement, one must carefully consider the soil type present and what part of the soil horizon will be used. The soil profiles and soil types are important factors when determining the amount of cement and water necessary to get the best possible results.

Soil Profiles

A soil profile is a vertical cross-section of the soil in a certain area which shows the transition of the soil from unweathered bedrock to the plant bearing soil at the surface. The soil profile is usually divided into three horizons (see Fig. 1); however, not all three horizons are always present in a particular soil profile.

In some areas, such as farmlands with rich, black soil, the A-horizon might be unsuitable for soil-cement because it contains large amounts of organic matter. The presence of this organic matter might make the use of native soils economically unreasonable because of the high cement content necessary for hardening of such soils. In these cases, the use of borrow soils might be more economical.

The B and C-horizons are better suited for soil-cement; however, the content of the C-horizon may very greatly, and this would make it necessary to vary the amount of cement used in the mixture.

It has been found that a soil formed from similar parent rock and under similiar conditions will have the same soil profile wherever it is found; therefore, the same amount of cement will be necessary for a soil-cement mixture. A good soil map (available for most areas from USDA) is extremely helpful in determining soil profiles and soil types for a certain area.

Fig. 1—Shows A, B and C horizons of a soil profile (from Soil–Cement Handbook)

Soil Types

Soils can be roughly classified into three broad divisions:

Sandy Soils—Sandy and gravelly soils are best suited for soil-cement and require the least amount of cement for hardening. The amount of fines (pass a No. 4 sieve) contained in this type of soil is a very important factor in how well the soil conforms to use in soil-cement. If at least 55 percent of the soil will pass a No. 4 sieve, it is well suited for soil-cement. Sand soils which lack the required amount of fines require more cement, but they still work well.

Silty and Clayey Soils—These soils can be successfully used in soil-cement; however, they require more cement than sandy soils. It is sometimes found that using borrow soil would be more practical. In general, when these soils require cement contents of 16 percent or more, one should consider the construction costs of the native soils as compared to those of borrow soils and decide which is more economical. Another unfavorable characteristic of silty or clayey soils is that they can be extremely hard to pulverize. As a rule of thumb, if it is possible to pulverize a soil of this type, then the soil is suitable for use in soil-cement. Construction with silty and clayey soils is also more dependent on the weather, as large amounts of moisture in these soils makes construction difficult.

Organic Soils—As mentioned before, organic soil is usually unsuitable for soil-cement because of the large amount of cement required for hardening. Borrow soil is usually used in areas were this type of soil is predominate.

TESTS FOR SOILS AND SOIL-CEMENT MIXTURES

For an effective and efficient soil-cement, various tests should be performed. The objective of these tests is to determine:

1. How much portland cement is needed to harden the soil adequately.
2. How much water should be added.
3. To what density the soil-cement should be compacted.

The number of tests required and their thoroughness vary greatly with the type of job. For a major project, very thorough soil sampling and identification tests would be conducted, and detailed tests on the soil-cement mixture itself would be carried out. In this major project, it would be desirable to determine the minimum cement content which could be used, for the savings due to the lower cement requirements would far outweigh the costs of the tests. But for a small project, the primary concern would be to determine a suitable, but not necessarily minimum, cement content which could be used. The time and cost of the tests involved would not be compensated by the small savings in the amount of cement used.

The primary objectives of the various tests performed on both soils and soil-cement mixtures will be discussed; however, a complete detailed coverage of the procedures involved is beyond the scope of this report. The Portland Cement Association's publication, "Soil-Cement Laboratory Handbook", thoroughly covers the details and methods of soil-cement testing, and should be consulted for further information.

Preliminary Soil Tests

The primary soil work is identifying the soil type and collecting suitable samples for use in soil-cement mixture tests.

Soil Sampling—Getting accurate soil samples is of the utmost importance. If the sample obtained is not a true representation of the soil which will be used in the soil-cement, all the tests performed on the sample will be worthless and will give misleading results. These results will cause problems when contruction begins.

A 75 pound sample is usually a sufficient quantity for laboratory tests. If the sample is to be taken from a runway subgrade which has been graded, it is usually taken by digging a trench from the centerline to the edge of the runway, and to the same depth as the proposed soil cement base. When taking samples from a runway which has not yet been graded, they are usually taken at exposed cuts or from the surface with an auger. A sample should be taken so that only the soil horizon which is to be processed is represented.

On small projects, where the principal concern is finding an adequate, rather than minimum, cement content, a sample is often taken of only the poorest soil on the site. The cement content found for this soil is used throughout.

Soil Identification—The soil samples taken are then identified and the group or series to which they belong are determined. There are two principal systems of soil classification the AASHO classification and the U.S. Department of Agriculture classification.

The primary objectives of the soil identification tests are the determination of:

1. Grain size
2. Liquid limit
3. Plastic limit

Accurate soil identification is important because it can be used to determine the cement content requirements for a particular soil. Soils of the same soil series and horizons have been found to require the same cement content for hardening wherever they are found. Therefore, the engineer can determine the cement content required for a certain job from the soil identification, and considerable laboratory testing can be avoided.

Soil-Cement Mixture Tests

Project size has more influence on soil-cement mixture than it has on soil tests. The treatment of soil-cement mixture tests will be divided into those for large and small projects. Fig. 2 shows the outline of tests performed for both large and small projects.

As stated, the primary objectives of these tests are the determination of:

1. Proper cement content
2. Proper moisture content
3. Proper compaction density

Cement content is determined by selecting a value from Table 1 for the given AASHO soil group. A sample with this cement content is then subjected to the moisture density test. If the sample passes this test, the cement content chosen is verified correct. This procedure is used for both large and small projects.

Proper moisture content and compaction density are then determined by the tests which follow.

Table 1—Cement requirements of AASHO soil groups

AASHO SOIL GROUP	Per cent by vol.	Per cent by wt.
A-1-a	5–7	3–5
A-1-b	7–9	5–8
A-2-4, A-2-5, A-2-6, A-2-7	7–10	5–9
A-3	8–12	7–11
A-4	8–12	7–12
A-5	8–12	8–13
A-6	10–14	9–15
A-7	10–14	10–16

Large Projects

As stated before, because of the economic importance of determining the minimum cement requirements in large projects, the tests are more numerous and detailed than for small projects. A cement content is taken from Table 1 and the test samples are prepared. In general, three principal tests are then performed on them:

1. Moisture-density test-AASHO designation: T134
2. Wetting and drying test-AASHO designation; T135
3. Freezing and thawing test-AASHO designation: T136

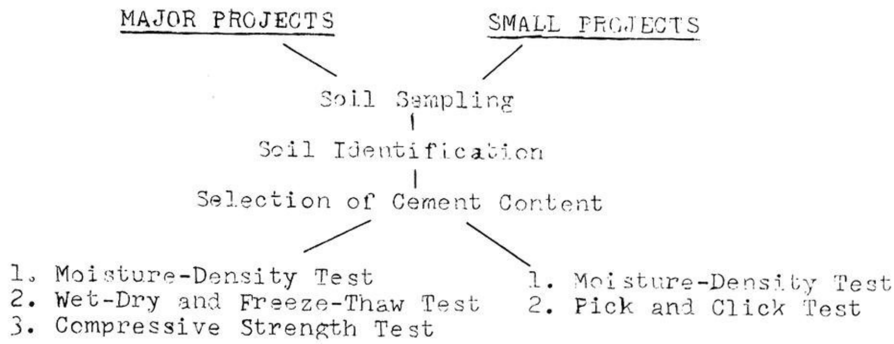


Fig. 2—An outline of soil-cement tests by project size

In addition, compressive-strength tests are usually made. A brief summary of the objective of each test is given.

1. *Moisture-density test*—This is used to determine the amount of water which should be added to the mixture and the density to which it should be compacted. The amount of water which should be added is called the optimum moisture content. The density to which the material should be compacted is known as the maximum density.

If the test specimen passes the moisture-density test, the cement content chosen is verified correct, and the values of cement content, optimum moisture content, and maximum density obtained are used in the field during construction.

2. *Wetting and drying test*—This test is used to determine whether the soil-cement mixture will soften when exposed to severe moisture variation.

3. *Freezing and thawing test*—This test shows how the soil-cement reacts to alternate freezing and thawing, and whether the cement has actually hardened the soil.

4. *Compressive-strength test*—This test is conducted by subjecting the test specimens to compressive forces and breaking them when they are 2, 7, and 28 days old. The results of this test are not used for design purposes, but to determine the rate of hardening of the soil-cement.

Small Projects

In small projects the primary concern is determing a satisfactory cement content. As Fig. 2 shows, the procedure is to first select the cement content from Table 1. The moisture-density test is performed, and positive results indicate that the choice of cement content was correct. Besides the moisture-density test, there are two other simple tests made.

1. *"Pick" test*—This test consists of taking a specimen and jabbing it with a sharp-pointed instrument such as an ice pick, as illustrated in Figure 3. Specimens that are hardened satisfactorily and have a suitable cement content will resist the penetration of the pick. To pass this test, a specimen, which is not over seven days old, should be penetrated only about one-eighth to one-quarter of an inch when struck with considerable force.

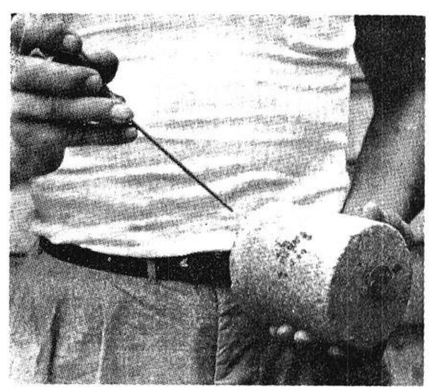


Fig. 3—The "Pick" Test

2. *"Click" test*—This test is made by taking a specimen in each hand and striking them together from about four inches apart. If the specimens are hardened satisfactorily, they will click together with a ringing or solid tone. Those specimens which are not hardened, will have a dull sound and will usually break after several clicks.

Although these tests seem rather vague, there is a distinct difference between satisfactorily hardened and unsatisfactorily hardened soil-cement. Even an inexperienced tester can distinguish them and determine a safe cement content.

SOIL-CEMENT CONSTRUCTION

After we have carried out the various laboratory tests and have determined the cement content, optimum moisture content, and maximum density, we have the required information to begin construction. The principal use of soil-cement on airport runways is as a base material; however, it is also used extensively as a surface material for small runways, shoulders, and taxiways. Construction procedures will be discussed as applied to the base material case because this is the most frequent use.

Fig. 4—Grading a runway to crown and grade after pulverization (from PCA)

Initial Preparation

Initial preparation refers to the construction work which is done prior to application of the cement. The runway subgrade is graded to the required crown and slope as shown in Fig. 4. If the soil is clayey or silty and will not readily mix with the cement when it is added, it is sometimes necessary to pulverize the soil. Soils which are difficult to pulverize when dry can be pulverized easier if they are prewet. After the soil has been pulverized, it is again graded to crown and grade.

Processing

The next three basic steps in the soil-cement construction are: cement spreading, mixing, and compaction. There are a great variety of methods and equipment for accomplishing these three operations. They range in simplicity from hand methods to traveling trains which perform all three operations in one pass.

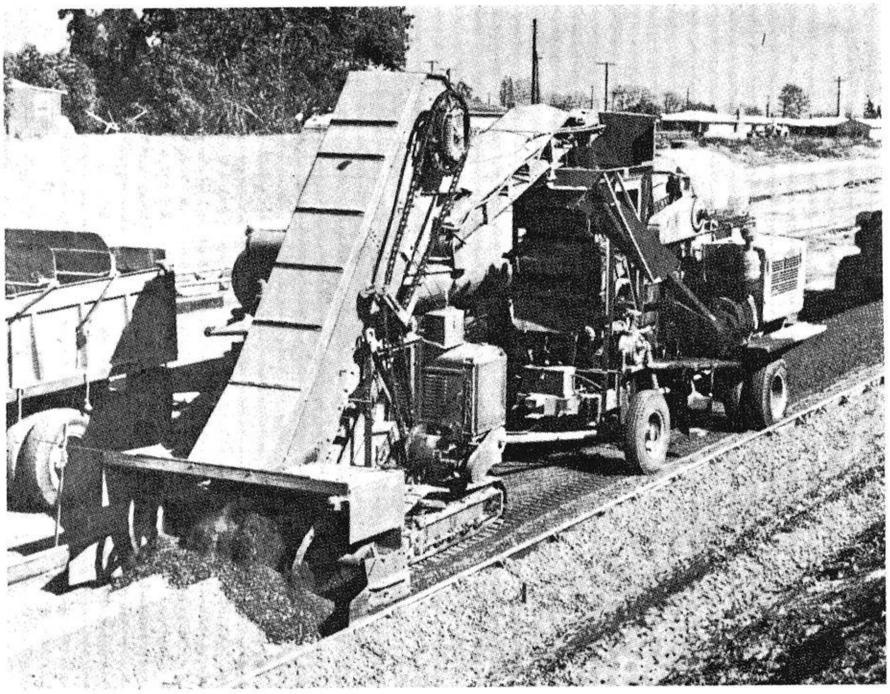


Fig. 6—Windrow type traveling mixer (from PCA)

Mixing. The simplest method of spreading the cement is by placing the bags of cement on the graded runway as shown in Fig. 5. The spacing of the bags should be at regular intervals both longitudinally and transversly with the spacing determined by the amount of cement required. The bags are then dumped by hand so as to form uniform windrows across the runway. A drag is then used to spread the cement uniformly over the runway. The cement and soil are then mixed by a cultivator or a rotary mixer. The next step is to spread the required amount of water with a distributor and immediately mix the cement, soil, and water thoroughly with rotary mixers.

The above operations of spreading the cement, adding water, and mixing the soil-cement mixture can all be accomplished in one operation with the use of traveling mixing machines. The three types of traveling mixing machines are:

1. *Windrow Type* (Fig. 6)—With this type of mixer, the soil is first bladed into uniform windrows with a blade grader. The cement is then deposited uniformly over the top of the soil windrows by a spreader (see Fig. 7) or by hand. The mixing machine, which travels along the windrows, mixes the cement and soil thoroughly and at the same time adds the required amount of water to the mixture.

2. *Flat Type* (Fig. 8—Preliminary pulverization is usually unnecessary with this type of mixer because it contains a high-speed pulverizing rotor. Therefore, the only initial preparation needed is to shape the runway subgrade to the proper grade and crown. The cement is spread in front of the mixer either by hand or by mechanical spreader. The machine first pulverizes the soil, then dry mixes it with the cement, and finally adds the correct amount of water. The remaining rotors mix the cement, soil, and water and spreads the soil-cement uniformly.

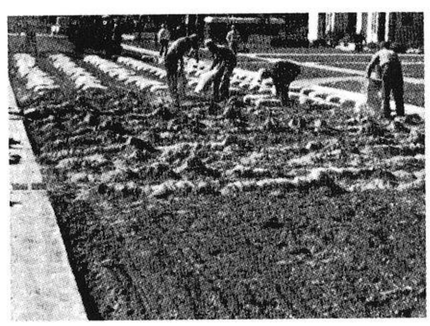


Fig. 5—Spreading cement in bags by hand (from PCA)

3. *Multiple-Pass Rotary Mixer* (Fig. 9)—This mixer, as the name implies, differs from the preceding two in that several passes of the mixer are required. The cement is

Fig. 7—Mechanical spreader for bulk cement (from PCA)

spread on the pulverized runway by mechanical spreader or by hand. The rotary mixer is then passed over it to mix the cement and soil. Water is then added by a distributor or a spray bar on the rotary mixer as it makes its next pass. The water is added slowly and several passes are necessary before the water content is up to optimum moisture. Several more passes are then made with the rotary mixer until the soil-cement is thoroughly mixed to the full depth of processing.

Fig. 8—Flat type traveling mixer

Compaction

When the soil, cement, and water have been mixed and spread uniformly over the runway, either by the hand method or by traveling mixer, the soil-cement should be compacted to maximum density immediately. Compaction of most soil-cement is accomplished with sheepsfoot rollers such as the one shown in Fig. 10. Some soils require special compaction equipment such as plate vibratory compactors or heavy pneumatic-tired rollers.

If the surface shows a graying appearance during compaction, water should be lightly applied.

Finishing

Methods of finishing the soil-cement surface vary with the type

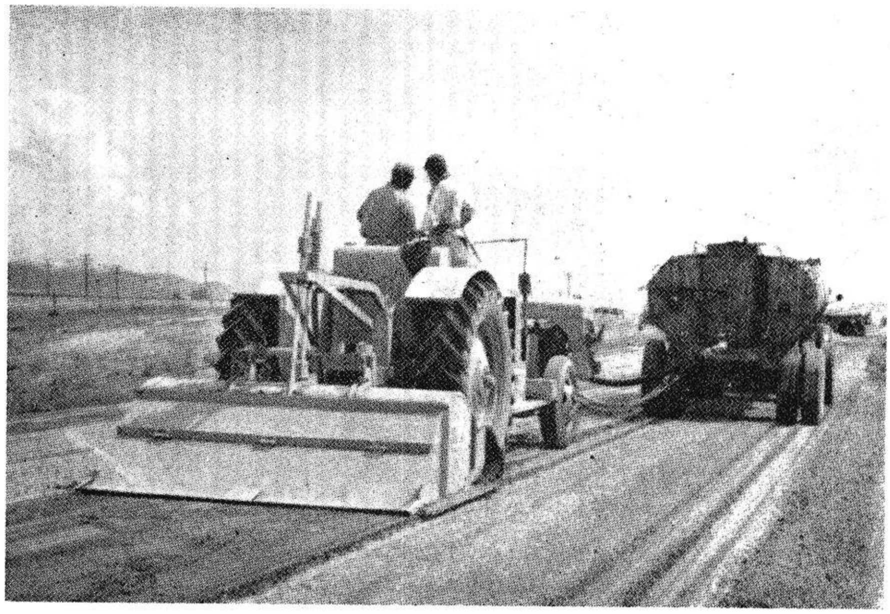


Fig. 9—Multiple-pass rotary mixer (from PCA)

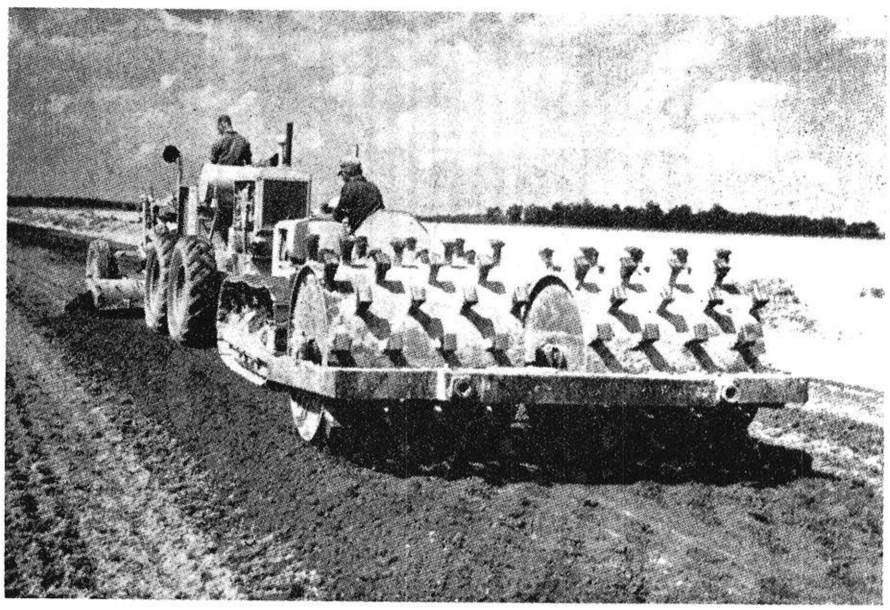


Fig. 10—Compaction with a sheepsfoot roller (from PCA)

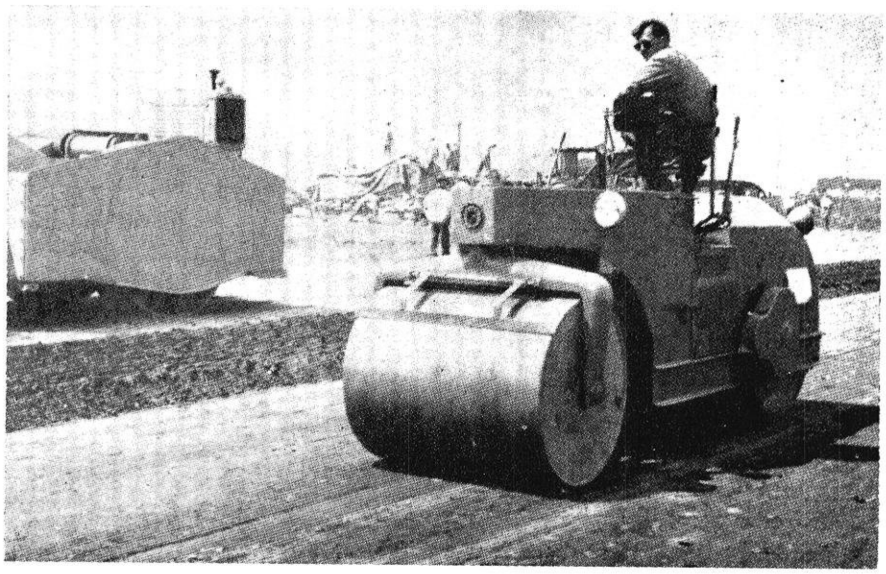
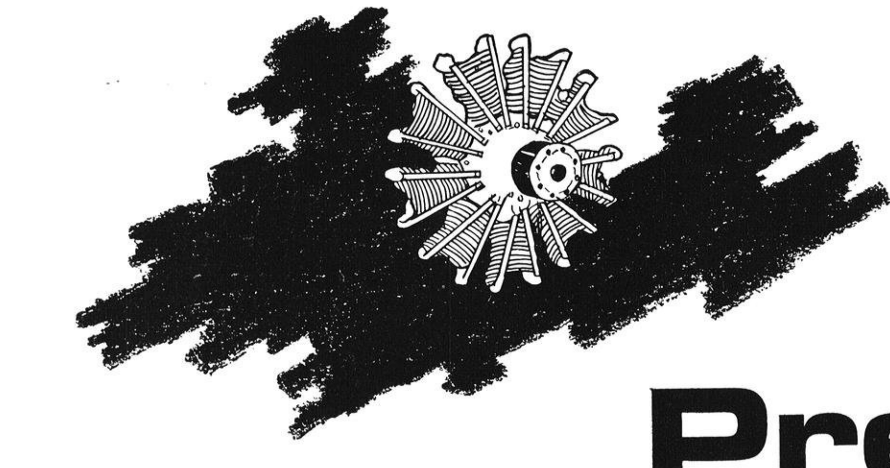


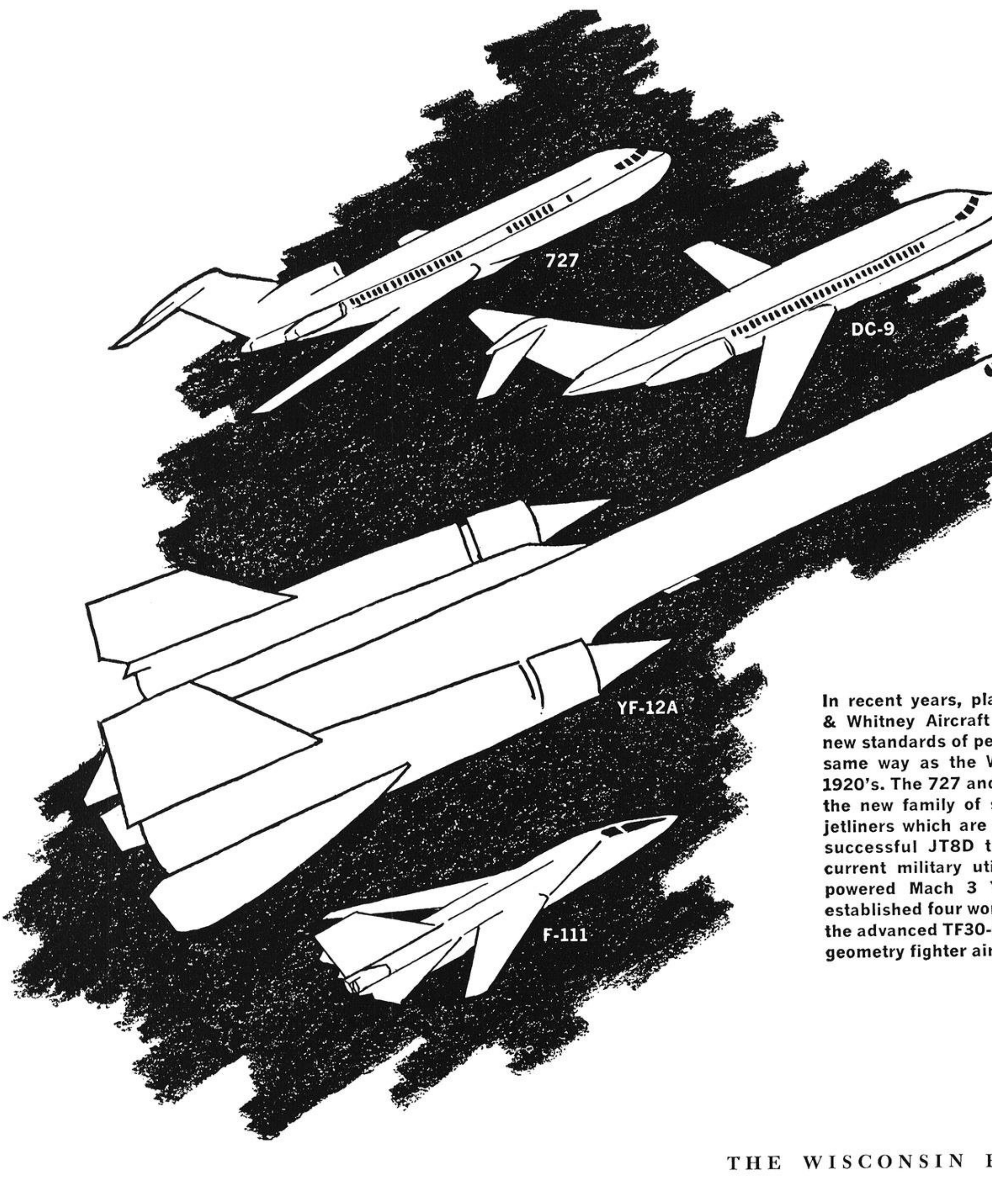
Fig. 11—Steel-wheel roller (from PCA)

Past



The Company's first engine, the Wasp, took to the air on May 5, 1926. Within a year the Wasp set its first world record and went on to smash existing records and set standards for both land and seaplanes for years to come, carrying airframes and pilots higher, farther, and faster than they had ever gone before.

Present



In recent years, planes powered by Pratt & Whitney Aircraft have gone on to set new standards of performance in much the same way as the Wasp had done in the 1920's. The 727 and DC-9 are indicative of the new family of short-to-medium range jetliners which are powered by the highly successful JT8D turbofan. Examples of current military utilizations are the J58-powered Mach 3 YF-12A which recently established four world aviation records and the advanced TF30-powered F-111 variable-geometry fighter aircraft.

Soil-Cement Runways

(*Continued from page 23*)

of job, soil characteristics, etc. The general procedure is to shape the surface of the soil-cement with a blade grader, and then lightly drag it with a nail or broom drag. The dragging removes small ridges caused by compaction and shaping. The surface is then rolled with a steel-wheel roller, then a light treatment of water is applied and the surface is rolled to a smooth finish with a pneumatic-tired roller.

Fig. 12—Pneumatic-tired roller (from PCA)

Curing

After compaction and finishing, the soil-cement should be allowed to cure. A moisture-retaining cover is placed over the surface to retain the moisture needed for hydration of the cement. Materials such as waterproof paper, or moist straw and dirt can be used satisfactorily; however, today a film of bituminous material is usually sprayed on the surface as a moisture-retaining cover. (see Fig. 13) The runway surface should be relatively clean and free of loose material when this bituminous material is applied.

Cracks will begin to appear in the soil-cement several days after completion. These cracks indicate that the cement is hydrating and the soil-cement is hardening.

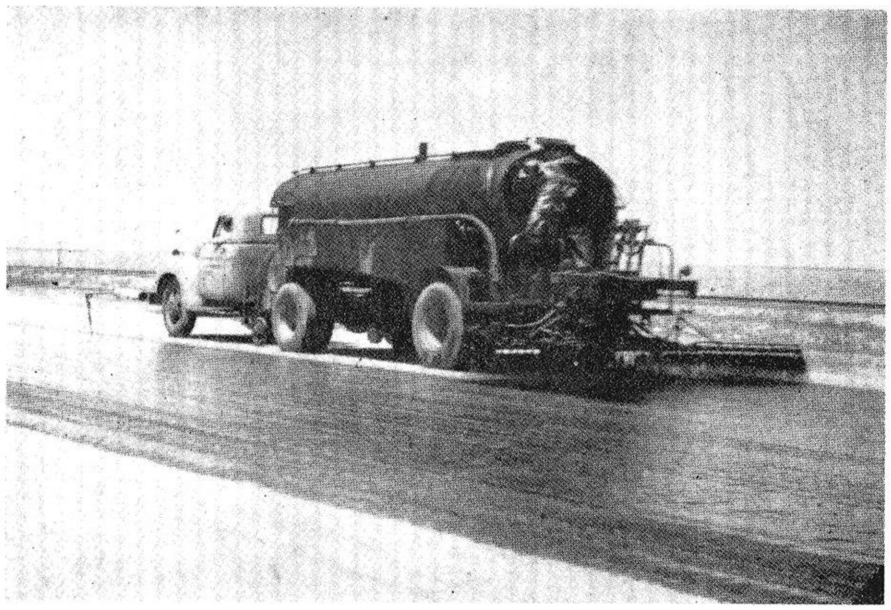


Fig. 13—A distributor applying a bituminous surface coating (from PCA)

Bituminous Surface

A bituminous surface layer is then applied to the soil-cement surface as soon as possible. The type and thickness of the surface layer will vary with the traffic handled, but a 1½ inch layer of plant mix is frequently used on runways which receive fairly heavy traffic. In general, thinner bituminous surfaces can be used on soil-cement bases than can be used on granular bases of the same thickness.

USE OF SOIL-CEMENT IN THE FUTURE

The use of soil-cement for airport runways is greatly expanding. The ever increasing demands of both commercial and private aviation will create a large future need for airport facilities. Soil-cement, because of its strength, ease of construction, and low cost, will be used extensively to meet the demands of the future.

END

REFERENCES

Andrews, W. P. *Concrete and Soil-Cement Roads*. London, Contractors Record Limited, 1960. p. 123.

Sharp, H. O. *Airport Engineering*. New York, Wiley and Sons, 1944. p. 104.

"Soil-Cement Construction Handbook". Published by the Portland Cement Association. Chicago, 1956. pp. 7, 8.

"Soil-Cement for Airports". Published by the Portland Cement Association.

"Soil-Cement Laboratory Handbook". Published by the Portland Cement Association. Chicago, 1959. p. 8.

"Soil-Cement Stabilization—A Committee Report". Published by American Road Builder's Association. Technical Bulletin No. 191, 1953. p. 7.

Soils Concrete and Bituminous Materials. London, 1946. p. 139.

The Numerically Controlled Drafting Machine

By JAMES I. PETERSEN, CIE3

THE tee-square, triangle, and scale, tools of the engineer and draftsman, have basically remained unchanged through the centuries. So have the time consuming and complex rituals of the drafting process. Development of the numerically controlled drafting machine has changed this, placing drafting among the accomplishments of the computer age.

This article is written to inform interested engineers and draftsmen about the numerically controlled drafting machine, its characteristics, method of operation, and uses. A brief look at the numerical drafting system as a whole is made, followed by a more detailed look at the numerically controlled drafting machine itself.

Source reference numbers such as "(3)", appearing in the report, refer to sources itemized in the list of references. The term "numerical control" is abbreviated "N/C" for convenience, since it is used frequently.

James Peterson is married and lives in McFarland. His home town is Kenosha, Wisconsin. Jim, a Junior in Civil Engineering (Structures), works part-time in the engineering department of Oscar Mayer Company here in Madison. He is a former cheerleader for our Fightin' Badgers and served one season as Bucky Badger at football games.

COMPONENTS OF THE NUMERICALLY CONTROLLED DRAFTING SYSTEM

The computer has brought many changes to industry, taking an important part in production design, manufacturing, production control, and quality control. Recently it has entered the process of drafting through numerical control. That is, a system which regulates the action of one or more machines by automatic interpretation of instructions which are expressed in the form of numerals. Interpretation refers to the conversion from numerals to distances, angles, and auxiliary commands such as "drawing pen up".

Computer

The mind and memory of the N/C drafting system is the computer. It is linked to the drafting machine by N/C. Geometric shapes, equations, and instructions are fed into the computer as input. Computer output is in the form of magnetic tape, punched paper or mylar tape, or punched cards which contain all the information necessary for making a drawing, including auxiliary commands such as "pen down".

Numerical Control Director

The director is the interpreter between computer and N/C drafting machine. It contains the necessary electrical system and controls to convert computer output into a form which will direct the N/C drafting machine. It has a readout which gives the exact location of the pen by coordinates.

Using a photoelectric tape reader, the director is able to accept and read computer punched tapes up to the rate of 400 characters per minute. It may also accept as input, punched cards, magnetic tape, or information from its manual keyboard. Its output is in the form of electrical impulses to the N/C drafting machine.

Figure 1 pictures a director. Note the coordinate readout at the

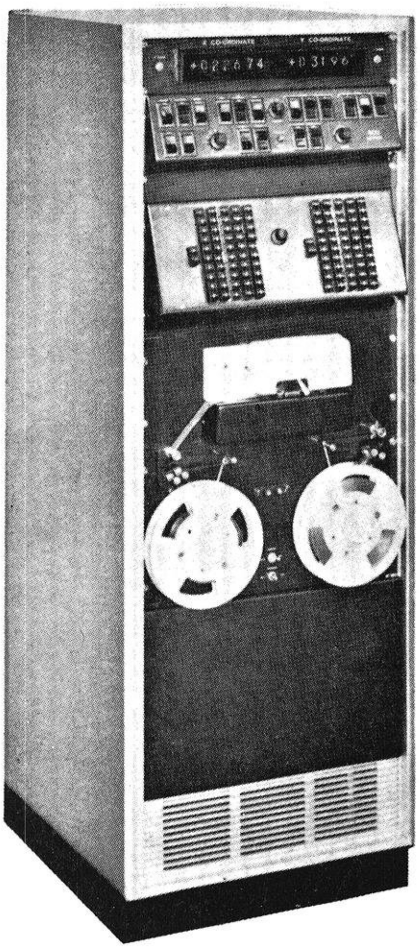


Fig. 1—N/C Director (3)

top; the manual keyboard in the center; and the tape reader at the bottom.

Numerically Controlled Drafting Machine

The N/C drafting machine is similar in appearance to an automatic drafting table mounted with a track type manual drafting machine. It is an appendage to the computer, just as the hand is to the mind. The N/C machine does as instructed by the director, accurately and rapidly. Electrical impulses activate its drive motors. The result is a graphic display or drawing in the conventional forms such as pencil on vellum.

Figure 2 pictures a N/C drafting machine.

Principal Parts and Their Operation. The N/C drafting table is a rigid structure, usually of aluminum, ranging in size from 50 inches by 60 inches to 5 feet by 20 feet. It may be designed to operate: in only a horizontal position; in only a vertical position; or adjustable from 0 degrees to 90 degrees by an electric tilting device. The type of table to be used depends upon the application and accuracies required. The most accurate N/C machines use horizontal only tables.

The bottom two rows of Table 1 indicate one manufacturer's series of N/C drafting system table types and sizes.

Floor to table top distance adjustment ranges from about 37 inches to 46 inches. The plotting surfaces can accommodate sheet or rolled plotting materials. Some tables are equipped with a vacuum chuck to hold the medium flat.

As indicated in Figure 3, the drawing head assembly consists of the turret and turret carriage; the bridge and bridge carriages; and two rails.

The turret holds instruments which make lines upon the drawing surface. A typical turret has six positions, holding any combination of pencils, diamond scriber, ink cartridges, and pens for several ink colors and line widths. The turret is rotated and the instruments raised or lowered by tape command, director controls, or manual movement.

Movement is accomplished by carriages. The turret is mounted on the turret carriage. This carriage travels along a bridge (the Y-coordinate axis) which spans the width of the table. The bridge in

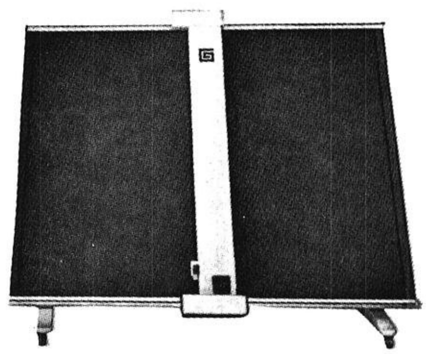


Fig. 2—N/C Drafting Machine (5)

turn travels on carriages along longitudinal rails (the X-coordinate axis), Squareness is maintained by synchronization of the two bridge carriages.

Vertical or horizontal straight lines are produced by carriage movement along either the X axis or the Y axis only, with pen down. Angular straight lines of curved lines are produced by the pen when the turret and bridge carriages move simultaneously.

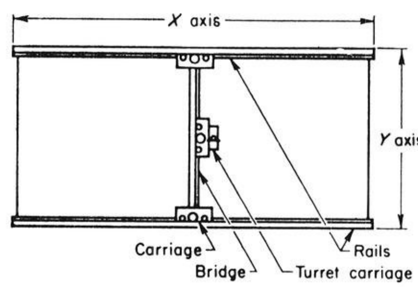


Fig. 3—Drawing Head Assembly (7)

Drive power is furnished by digital step motors which are mounted on the carriages and accept digital pulses from the director. Signals are transmitted to the carriages by sliding carriage contacts and conductors which are mounted under bridge and rail beams. Power is transmitted through rack and pinion drives.

(3) See list of references, p. 40, for footnote source.

Table 1. (4) Operating Characteristics

	1000.5	1001	1002	1032–1	1032–2	1072	1075–1	1075–2
Speed	100 ipm	150 ipm	240 ipm	60 ipm	100 ipm	300 ipm	200 ipm	250 ipm
Accuracy	±.003	±.005	±.005	±.001	±.0025	±.010	±.005	±.006
Repeatability	±.001	±.002	±.002	±.0005	±.0015	±.004	±.002	±.003
Resolution	.0005	.001	.002	.0002	.0004	.002	.001	.002
Table Position	Horizontal or Vertical	Horizontal or Vertical	Horizontal or Vertical	Horizontal	Horizontal	Electric Tilting	Electric Tilting	Electric Tilting
Table Size	5′ x 5′ to 5′ x 20′	5′ x 5′ to 5′ x 20′	5′ x 5′ to 5′ x 20′	4′ x 5′	4′ x 5′	5′ x 5′ to 5′ x 20′	5′ x 5′ to 5′ x 20′	5′ x 5′ to 5′ x 20′

The racks are mounted on machined bridge and rail surfaces. Each of the three carriages ride on ball bearing rollers which fit into bridge and rail tracks.

The bridge and rails are hollow tube extrusions with internal cross ribs for stiffness and light weight. The table, rails, bridge, and carriages are of the same material, usually aluminum, to avoid different coefficients of expansion with their resulting problems and inaccuracies.

Operating Characteristics. Pen speeds of up to 500 inches per minute are possible. The desired speed is prescribed by controls on the director. Accuracy can be to within ∓ .001 inches, while repeatability, the ability to repeatedly place the pen down on the same coordinate point, can be to within ∓ .0005 inches. Resolution, the smallest motion of the pen which can be programmed, is possible to ∓ .0002 inches. Table 1 gives the speed, accuracy, repeatability, and resolution of particular N/C drafting systems. It is interesting to note that limits of accuracy, repeatability, and resolution increase as the speed increases, and vary from model to model. N/C drafting systems are chosen on the basis of specific needs.

Tapes can be programmed containing three-dimensional information. The machine operator may take his choice of X-Y, X-Z, or Y-Z views by using the proper director controls. Also, if a figure is symmetrical it is sometimes practical to program only one half or one quarter of the figure and have the operator use symmetry buttons to direct the machine in drawing the full figure.

Output Medias

The N/C drafting machine requires no new drafting materials, for it uses all of the usual ones. The turret can be fitted with wet ink pens, ball point ink pens, graphite or plastic lead pencils, a diamond scriber, and routing heads for template and pattern preparation. Sheets or rolls of vellum, cloth, mylar, and sensitized sheet metal may be marked upon.

Operating Techniques

The operator can position the pen to the starting position, or any other point, through the use of a "floating zero". Floating zero is a neutral state in which the machine offers no resistance to manual movement. An image of a crosshair is superimposed upon the drawing. The carriages are moved until the crosshair is centered on the required reference point. Director coordinate readout and directional buttons may also be used to position the pen.

An operator can also manually add left off lines, or change lines with the use of the director's digital readout and direction controls. Solid, center, and dashed lines are programmed on the tape or cards, but may be altered at the director, changing line widths, dash lengths, and dash spaces. Several tapes can be combined to produce an assembly drawing. That is, tapes of component parts, each in a different scale, can be combined to make a single composite drawing in one scale.

Uses

The N/C drafting machine can be used to make all types of drawings, from preliminary design and elevations to production drawings and templates. Any figure or drawing that man can make can be made by N/C drafting machines. Fig. 4 represents an example of a drawing made by a N/C drafting machine.

The N/C drafting system can also work in reverse. By replacing the turret with a television optical signal or an automatic curve following device, data from drawings, graphs, and maps can be visually read, or recorded on punched cards or tape, or magnetic tape. This data can then be put into the computer for storage and the tabulation of data displays. The process just described is called digitizing. The digital reading system which accomplishes this is called a Coordinate Digitizer.

The process of N/C is becoming widely used in industry to direct the cutter paths of machine tools. These same tapes can be used to direct the N/C drafting machine, giving a graphic interpretation of the cutter path. This enables verification of such tapes and saves machine tool time.

The machine is also able to create mathematical models of equations. Designers are thus given visual proof of the accuracy of can be formed and compared. their mathematical definitions. They are also abl e to see if an equation gives them what they really want.

Another very important use is allowing designers to select the best possible design from a series of rapidly made drawings. By using different valves for variables in equations, slightly different lines can be formed and compared. Therefore it is possible to produce a series of drawings which differ from each other by related amounts.

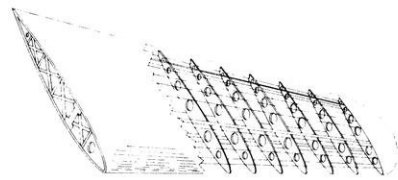


Fig. 4—N/C Drafting Machine Drawing (4)

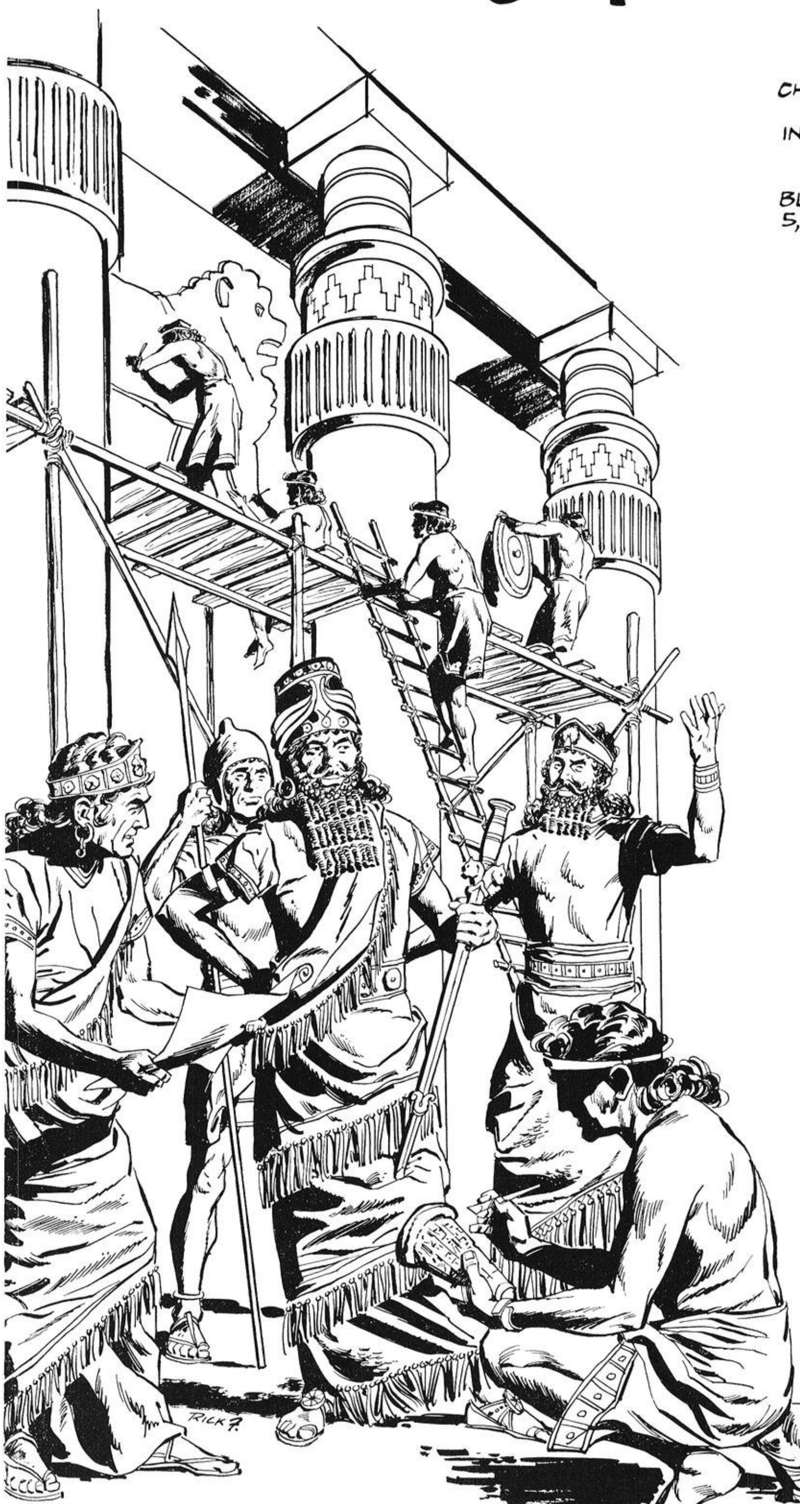
Advantages

Estimates made under actual operating conditions indicate that drafting jobs are handled about forty times faster than they are by manual drafting methods (8). N/C machine drawings are more accurate than manually made drawings. This is especially true on large size drawings which tend to compound human errors and make accurate drawing of long parallel lines very hard. The machine's accuracy, is dependable, i.e., it is a factor which is always present, but in a known quantity; whereas human accuracy varies greatly and is unpredictable. The N/C drafting machine eliminates the human error factor. Also, the machine's uniformity of line width, spacing, and density is superior to that of man's.

Because drawings can accurately be produced at a high rate of speed, engineering department output can be increased with a corresponding reduction in manhours and an increase in quality of work. An added benefit here is the speed with which quality originals can be made. Present

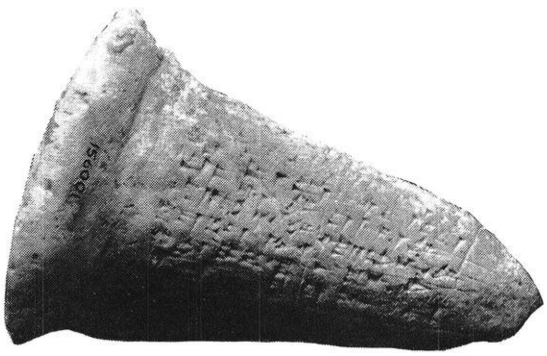
(Continued on page 32)

Construction by Lipit-Ishtar -2092 B.C.



CHURCHES ARE NOT, AS A RULE, EMBLAZONED WITH THE NAMES OF THE BUILDERS. INSTEAD, THE ARCHITECT, THE CONTRACTOR, AND THE CONGREGATION TAKE THEIR SATISFACTION FROM THE COMPLETED BUILDING. IT MUST HAVE BEEN THE SAME 5,000 YEARS AGO— BUT WITH A DIFFERENCE.

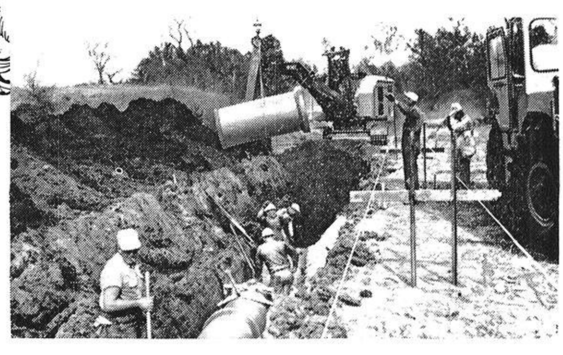
HOW DO WE KNOW THIS— BY THE CLAY WALL PEG SHOWN HERE.....



These pegs were embedded in the walls of an Iraqian temple dedicated to the Gods Enlil and Ninlil, built between 2102-2092 by Lipit-Ishtar, King of the Isin Dynasty. To tell future generations of his part in the construction, he inscribed his name and deeds on these pegs, then placed them in the walls. Centuries ago, the temple was just a memory. But the clay pegs are as good as the day they were inscribed.

Proof again of the amazing permanence of clay.

Dickey Perma-Line Clay Pipe is permanent, too. It's immune to the most corrosive wastes. It cannot disintegrate. It's exceptionally strong, too. Strength is built right in. Nothing can take it away. The pipe body is so dense, there is strength to spare in all sizes, 4-inch through 36-inch diameters. The pipe is glazed, too. Makes it as smooth as glass...self-scouring. And the patented Dickey Coupling on this pipe is made of the finest material...urethane. There's no gamble with Dickey Perma-Line Coupling Pipe.



Dickey sanitary glazed clay pipe

If it's made of clay it's good . . . if it's made by Dickey it's better

W. S. DICKEY CLAY MFG. CO. Birmingham, Alabama • Ft. Dodge, Iowa • Kansas City, Missouri
Meridian, Mississippi • St. Louis, Missouri • San Antonio, Texas • Texarkana, Texas-Arkansas

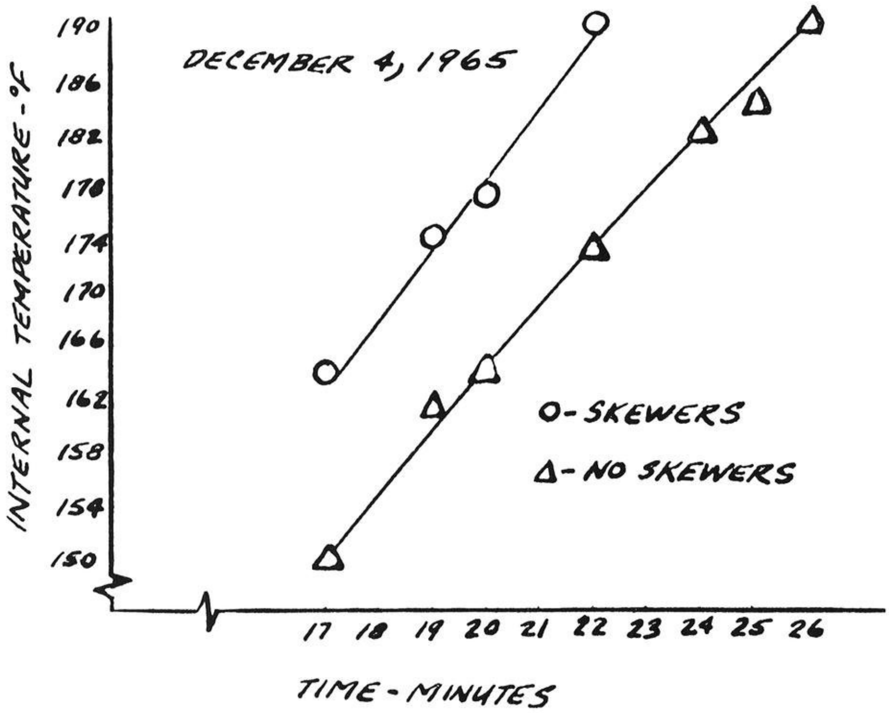


Fig. 5—Time-Temperature Histories of Baking Idaho Potatoes

Cooking

(*Continued from page 17*)

be used. The skewers should be either plated copper or aluminum and of similar size as used in the experiments. The reader, alone, will have to make his own opinions as to the tenderness of the meat.

Cooking Baked Potatoes with Metal Skewers

Here, as with beef, I suggest that skewers be used. Aluminum nails, which are inexpensive, work extremely well. As with the beef, the reader will have to determine which potato (with or without skewers) tastes better. The skewers can be used whether the potatoes are baked in an oven, baked over an open campfire, or baked on a barbecue grill.

Cooking Others Meats and Fish

Skewers can also be used with other meats. Pork roasts would cook faster with the use of metal skewers. The same skewers that are used in beef could be used with the pork. Large sausages would cook quicker with the use of metal skewers. Application of skewers to other meats should certainly be considered. When baking large pieces of fish, skewers would definitely speed the cooking time.

Although only six basic foods were considered in this report, there are many foods and combinations of foods where improved cooking methods (such as skewers) could be utilized. Very little research has been done in this area. It is, therefore, up to the individual to do his own experimentation. Whether or not the results of the cooking experiments would be successful, the experience could prove to be a delicious one.

END

REFERENCES

Bowers, J. R.; Goertz, G. E.; and Fry, J. L. "Effect of Cooking Methods and Skewers on Quality of Turkey Rolls." *Poultry Science,* 44 (May, 1965), 789–793.

Cover, Sylvia. "Effect of Metal Skewers on Cooking Time and Temperature of Beef." *Food Research,* 6 (1941), 233–238.

Holman, J. P. *Heat Transfer.* New York: McGraw–Hill Book Co., 1963.

Morgan, A. and Nelson P. "A Study of Certain Factors Affecting Skrinkage and Speed in the Roasting of Meat." *Journal of Home Economics,* 18 (1926), 371–378+.

Sears, Francis Weston and Zemansky, Mark W. *University PHYSICS.* Massachusetts: Addison–Wesley Publishing Co., Inc., 1957.

N/C Drafting

(*Continued from page 30*)

drawing reproduction techniques (ammonia vapor, wet developer, etc.) produce, at best, second rate reproducible prints (the intermediate prints known as "sepias" or "brown-lines"). Once a N/C tape is made, it can be used to make an almost endless number of identical drawings or patterns. To make more than one original by hand for the sake of good prints would be a tedious waste of valuable time.

Other Advantages

Another advantage of the N/C drafting machine lies in print transmission. Costly time delays resulting from the shipment of prints by mail can be eliminated. This can be done by having data from the original N/C drawing tape transmitted over teletype or data phone to a N/C drafting machine at the receiving end, which will make the drawing.

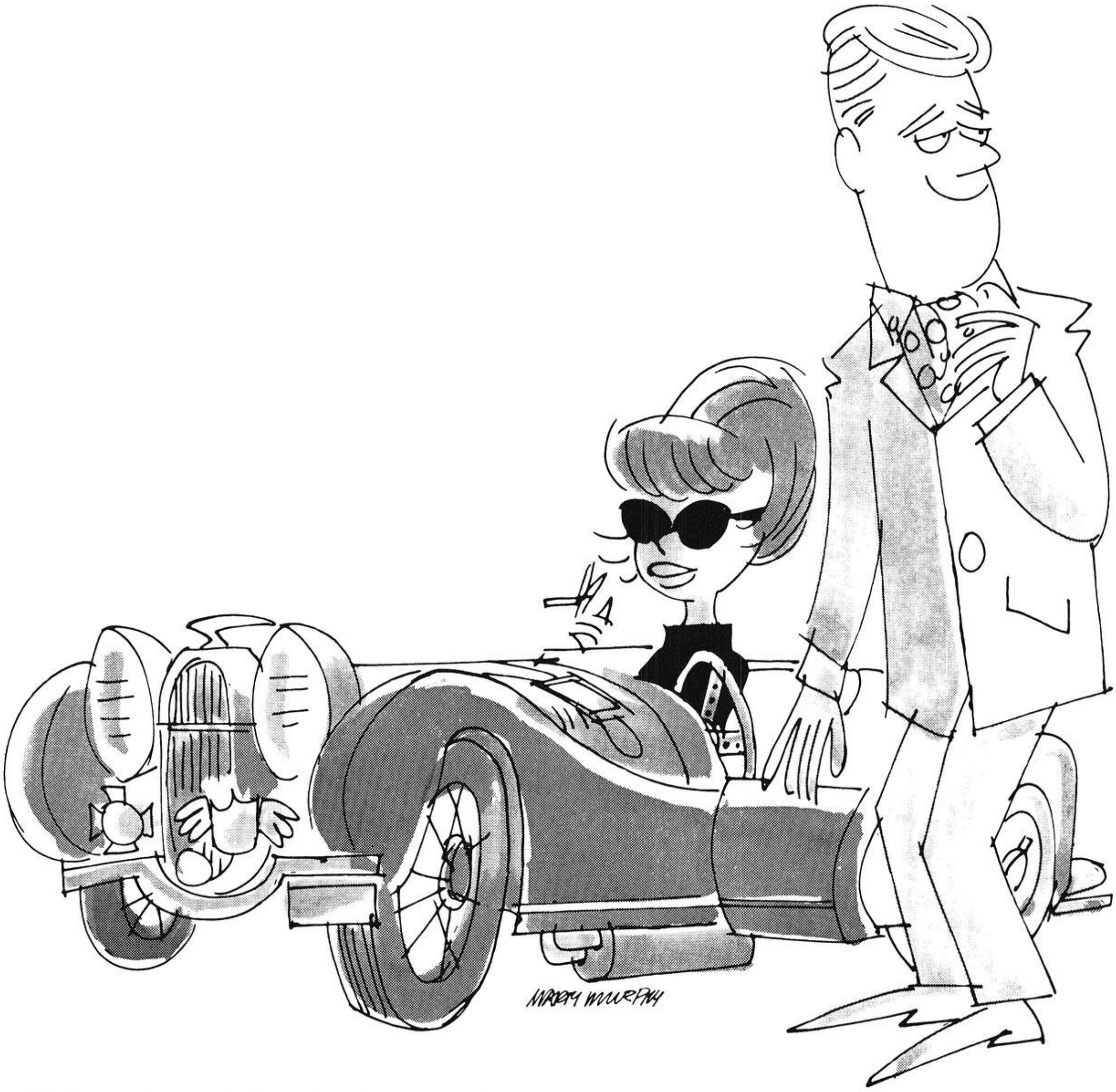
Large amounts of information can be recalled, changed, or updated at will with a minimum amount of effort. This combination of memory and the N/C drafting machine is one of the system's biggest assets. Once a tape has been programmed it can always be used in the production of related drawings. If changes are to be made, the old drawing can be run, leaving off the lines to be changed. New lines can then be added either manually with director controls or by new tape programming. Existing views and scales can also be altered to meet new requirements.

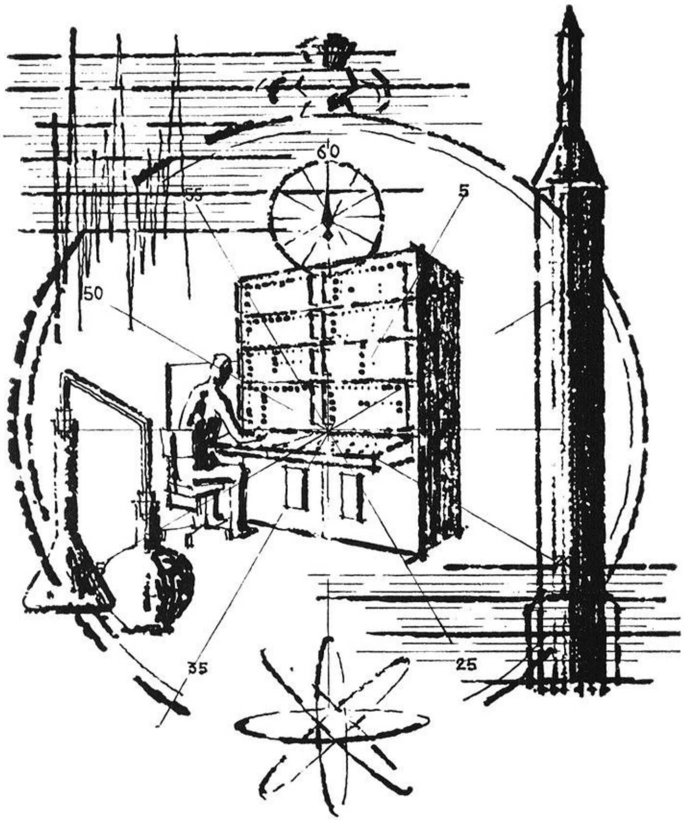
POTENTIAL SAVINGS

The N/C drafting system has an enormous savings potential. Drafting time can be cut to a small fraction of the present time which manual drafting processes consume. Resulting savings are not only in manhours. Increased speed along with improved accuracy and quality means faster production design, increased production, and improved product quality.

N/C drafting systems are available for under $20,000 (2), a cost which is justified when compared to the accomplishments and sav-

(*Continued on page 40*)





SCIENCE HIGHLIGHTS

A brief resume of new developments in government and industry, compiled by the *Wisconsin Engineer* staff

NUCLEAR FUEL PREPARATION COSTS ARE REDUCED

A New York firm has developed a way to cut the cost of preparing recycle fuel for nuclear reactors.

Recycle fuel is prepared by recovering fissionable materials from fuels which have been used in a reactor and combining them with fresh fuels.

According to scientists at Bobcook & Wilcox's Nuclear Development Center in Lynchburg, Va., the ability to use recycle fuel will be vital to the expansion of nuclear power generation and could result in conservation of nuclear fuel supplies.

Until now, costly shielding and remote operation to protect against radiation has been needed when fabricating elements using recycle fuel. B&W has solved the protection problem by stripping feed material of bulk radioactivity, rapid fuel rod fabriaction, and underwater assembly of fuel bundles, with a minimum of handling.

In the new method, fuel material is prepared quickly. The fuel rods are rapidly filled with fuel, compacted, capped, inspected and decontaminated while inside protective chambers called "glove boxes". They are then stored in racks and lowered into a deep pool of water. When enough rods are accumulated, a machine assembles them into a fuel element frame. Completed assemblies are stored underwater until shipment.

Assembling units in clear pools of water is easier, more economical, and as safe as assembling them with manipulators in heavily shielded "hot" rooms. This was demonstrated recently at Lynchburg. Specialists utilized fuel (U 233) for the thorium cycle in the demonstrations, but expect their refabrication method will be equally applicable to the plutonium cycle. Experiments on the use of plutonium fuels are being made at Lynchburg.

Nuclear scientists expect that all reactors using plutonium or thorium-uranium fuel will require recycle fuel to decrease power costs and conserve fuel supplies. Present power stations use cores of enriched uranium which has not been recycled and presents no radiation hazard during fabrication.

FROST IS FINGERPRINTED

Graphic "fingerprints" of water frost and of carbon dioxide "frost" have been obtained in recent measurements at the NBS Institute for Basic Standards. The work was undertaken to aid studies of the Venus cloud cover, which may be composed of crystals of one or of both of these substances. The Advanced Research Projects Agency of the Department of Defense and the Goddard Space Flight Center

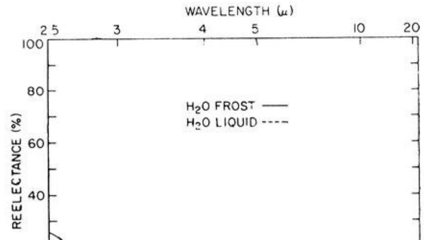


Fig. 1—Infrared spectral reflectance (2.5 to 22.2 microns) of water frost (solid curve) at the boiling point of nitrogen (—196°C) obtained in recent NBS experiments. Also shown (dotted line) is the reflectance of distilled water at room temperature.

of the National Aeronautics and Space Administration sponsored the research.

The fingerprints—clear patterns of the light-reflecting and absorbing properties of the two types of frost at wavelengths in the infrared spectra to be obtained from Venus in future space probes. They may also aid in climatic studies of the planet. For example, it is not now known why the clouds surrounding Venus apparently remain at the same temperature, both on the bright side of the cloud cover reflecting the sun's rays, and on the dark side away from these rays.

To achieve accurate measurements, the investigators used a special reflectance attachment on a high-resolution spectrophotometer. The attachment excluded the radiant energy emitted by the specimens. The inclusion of such emission, which only affects spectrophotometric measurements in the infrared, would have distorted experimental results.

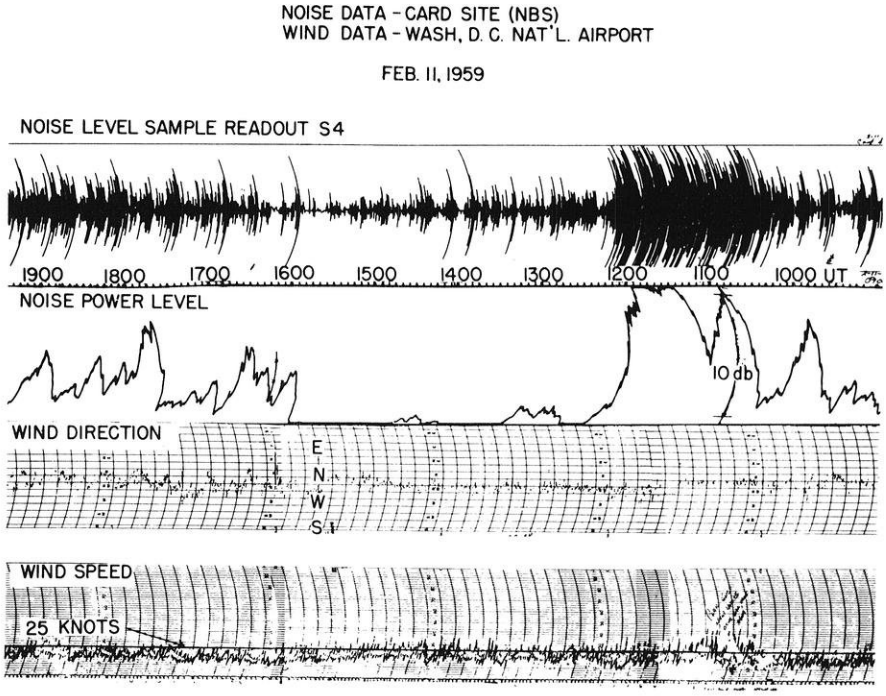


Fig. 1—Infrasonic noise data obtained locally by NBS over a period of nine hours are compared with U. S. Weather Bureau wind data derived for the same period. The comparison shows that noise power levels, obtained by a technique devised by the NBS staff, and wind velocities rise simultaneously.

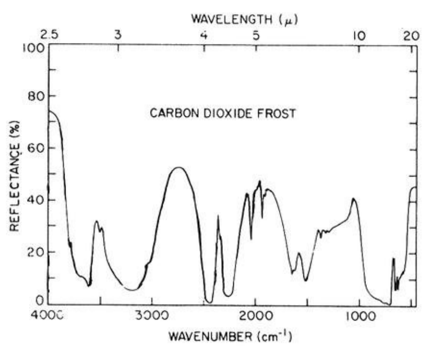


Fig. 2—Infrared spectral reflectance of carbon dioxide frost obtained at NBS, also at a temperature of —196°C.

Four types of specimens were investigated: (1) frost collected from atmospheric water vapor on a super-cooled base; (2) water at room temperature—for comparison purposes; (3) carbon dioxide frost formed on a super-cooled base in a closed container of evaporating solid carbon dioxide; and (4) crushed commercial "dry ice," i.e., solid carbon dioxide.

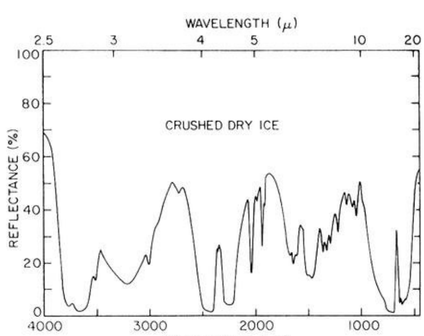


Fig. 3—Infrared spectral reflectance of crushed "dry ice" obtained at a temperature of —78°C (the sublimation temperature of carbon dioxide).

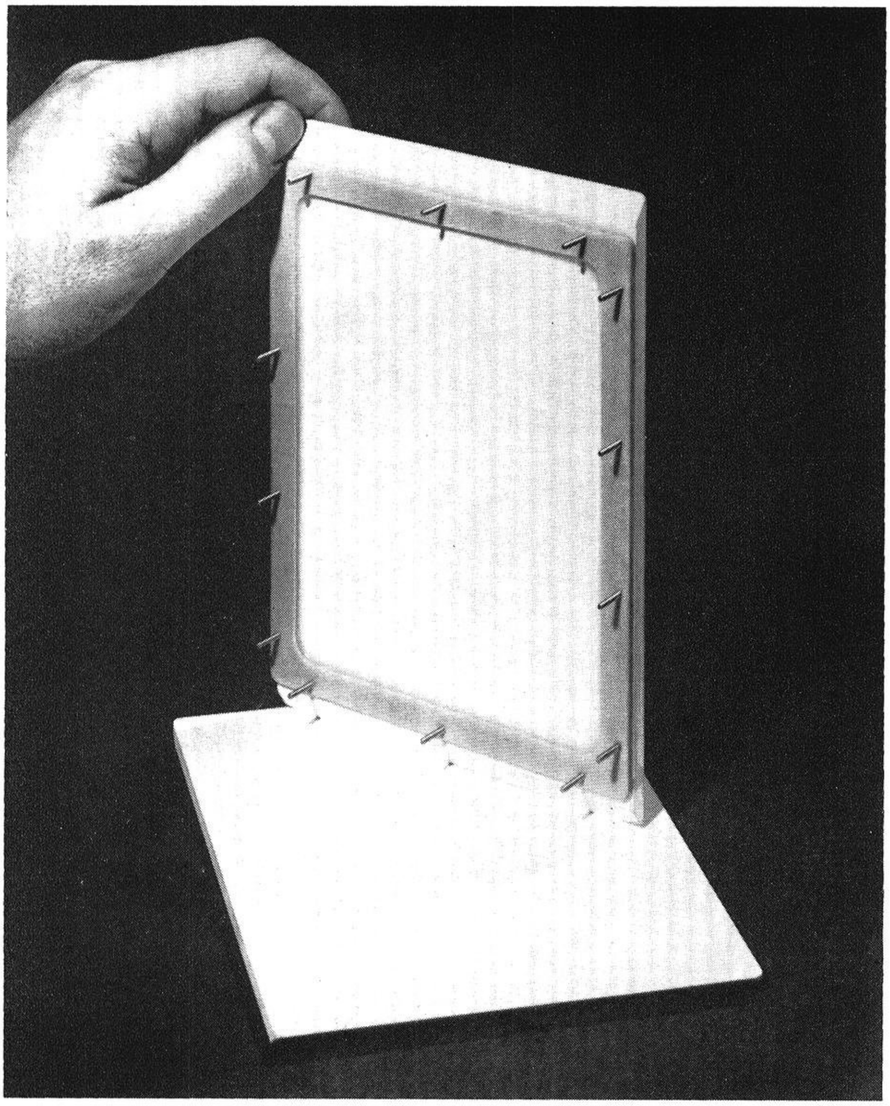
The method of specimen preparation did not rule out contamination of the water frost with the carbon dioxide frost, and vice versa; however, no common features were found in the resulting spectra of the various types of specimens. It therefore appears that the samples were essentially uncontaminated. Moreover, the spectra of both the carbon dioxide frost and of the crushed dry ice were strikingly similar at all significant wavelengths.

The study was carried out for Prof. John D. Strong of the Johns Hopkins University's astrophysics laboratory. Prof. Strong recently reported on measurements of the spectral reflectance of Venus obtained across part of the infrared from balloon-telescope flights in 1964. He applied laboratory corrections for absorption by residual water and carbon dioxide vapor in the upper atmosphere of Venus to these measurements. From the results, he concludes that the planet's clouds are composed of ice crystals.

Water frost data obtained in the present study confirm Prof. Strong's laboratory findings, although not in complete detail. The NBS measurements, however, on both water frost and solid carbon dioxide were made over a much larger infrared region than were Prof. Strong's measurements. They therefore supply a basis for more extended checks of the composition of the Venus cloud cover in future probes.

WINDS ARE NOISY . . .
in the Inaudible Range

A direct relation between high-velocity winds and infrasonic noise in the atmosphere has been found at the National Bureau of Standards Institute for Basic Standards. In this work, the NBS acoustics laboratory compared local wind velocities measured by the U.S. Weather Bureau with infrasonic noise measurements made at NBS over the same time intervals. The comparisons showed that large changes in wind direction or peak wind gusts accompanied high infrasonic noise levels, thus indicating noisy winds even in the inaudible range.



Porous glass water separator plates help keep the fuel cells functioning aboard the Gemini spacecraft. The fuel cells generate electricity by combining hydrogen and oxygen. Unless the by-product water is removed, the cells will drown themselves and cease to operate. A unique porous glass is used to separate gas and water in the water collection system.

These results are of particular interest to investigators studying the origin and direction of travel of low-frequency infrasonic signals as they are propagated through the earth's atmosphere. Such signals, generated by natural phenomena like volcanoes and earthquakes, are detected on sensitive instruments located vast distances away from the origin of the phenomena. Background noise, however, apparently caused by local disturbances, sometimes distorts or interferes with the measurements thus obtained.

The present study shows that this background noise is due to highvelocity winds in the vicinity of the measurement equipment. Hence, areas having a low probability of high winds should be designated for future infrasonic experimental sites. The study also demonstrates the need for improved wind filters on present infrasonic instruments to eliminate wind noise when high winds do occur.

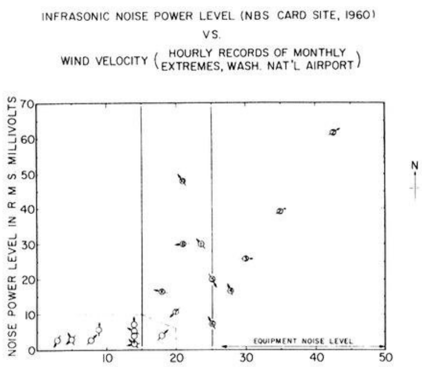


Fig. 2—This diagram shows infrasonic noise power levels as a function of extremes of wind velocities for several months. The numbers inside the circles correspond to the months, and the arrows show wind direction. Data inside the dashed lines are associated with velocities. The vertical lines encompass minimum noise power levels and wind a region of poorly correlated data. Above 25 knots, however, the data show a linear relationship.

POROUS GLASS PLATES EXTRACT WATER FROM GEMINI SPACECRAFT FUEL CELLS

Water separator plates made of porous glass have played a key role in the fuel cells aboard the Gemini spacecraft.

Fuel cells aboard each spacecraft combine hydrogen and oxygen to generate electricity. A byproduct of the chemical reaction is water—about a pint per kilowatt-hour. Unless the water is removed, the cells will drown themselves and cease to operate.

A unique porous glass, developed by Corning Glass Works, is used to separate gas and water in fuel cells made by the General Electric Company for the Gemini program.

Moisture-absorbing wicks collect the water formed on the oxygen side of the fuel cell and channel it to the inside surface of the glass water separator plates. The porous glass absorbs water rapidly from the wicks.

The water passes through the glass plates and is stored outside the fuel cell. But the plates will not permit oxygen to enter the water system. A positive pressure differential inside the cell prevents water from being re-absorbed and re-entering the cell.

Each cell uses three water separator plates approximately $5\frac{1}{4} \times 7\frac{1}{4}$ inches. Plate thickness is about $\frac{1}{4}$-inch. Pore size is approximately $5\frac{1}{2}$ microns.

For other applications this porous material can be fabricated in various flat shapes or as tubing, and pore size can be varied from about 1 to 200 microns.

grant. He was presented with the University's William H. Kiekhofer Award of $1,000 for excellence in teaching in 1964. Besides his teaching-research duties in mechanical engineering, he is also assistant director of the University-Industry Research Program, in charge of liaison for development of closer relationships between industry and the faculty in engineering and the physical sciences.

JOE COLLINS GETS A+ IN SPEECH

Joseph Collins, a senior in the Department of Mechanical Engineering at the University of Wisconsin, won first place in the American Society of Mechanical Engineers' speech contest held during the 1965 Winter Annual Meeting of the Society. Early in the year, Mr. Collins won the local contest staged by the campus student chapter of ASME and went on to win the semi-finals at the Midwestern Regional Contest held at St. Cloud, Minnesota, in April, 1965. At the national finals held in Chicago last night, Mr. Collins carried off top honors with his speech on the topic, "Electrolytic Machining—The Fundamentals". Mr. Collins was instrumental in starting a small electrochemical milling machine for use here at the University of Wisconsin. Some of his prize-winning speech centered around the machine being built here, and the rest of the discourse was a general, overall view of what can be done with this new process.

Mr. Collins came to The University of Wisconsin from the Illinois Institute of Technology in September, 1962 and will complete his work for the BS degree in January, 1966. He is married and lives with his wife and infant son at 2541 Fairfield Place, Madison.

PROF. BOLLINGER WINS PI TAU SIGMA GOLD MEDAL

A young faculty member of the University of Wisconsin College of Engineering at Madison has received the 1965 Pi Tau Sigma Gold Medal Award of the American Society of Mechanical Engineers.

Prof. John G. Bollinger of the University's department of mechanical engineering received the award at the annual fall-winter meeting of the national society held in Chicago. The annual award recognizes an outstanding young mechanical engineer.

This is the second professional award presented to Prof. Bollinger this year. Last August he received the 1965 Donald P. Eckman Award of the American Automatic Control Council for outstanding contributions in the field of automatic controls by a person under 30 years of age.

Bollinger joined the Wisconsin engineering faculty in 1961 when he received his Ph.D. degree from the University. He received his bachelor's degree in mechanical engineering from Wisconsin in 1957, and his master's degree from Cornell University in 1958.

He studied at the Technical University of Aachen in Germany during 1962–63 under a Fulbright grant.

FOUR $2,500 FELLOWSHIPS ARE ANNOUNCED BY AISC

Four $2,500 research fellowships will be awarded this year by the American Institute of Steel Construction, national association of the structural steel fabricating industry. The grants will be awarded to graduate civil engineering students pursuing advanced degrees and who intend to undertake specific research projects involving fabricated structural steel.

Announcement of the availability of the fellowships was made by Albert O. Wilson, Jr., Chairman, Committee for Education of the Institute, and president of A. O. Wilson Structural Co., Inc., Cambridge, Mass.

"We are continuously exploring ways to improve our product through research and technology," Mr. Wilson said. "This program represents one way of encouraging young graduate engineering students to set their fertile minds on new ideas which may be of benefit not only to our own industry but to the whole construction industry. Research fellows and their colleges or universities are free to publish the results of the research projects," he pointed out.

To be eligible for the fellowship awards, applicants must be currently enrolled as seniors in an undergraduate civil engineering program or have been graduated with a degree in civil engineering.

In addition, fellowships will be awarded on the basis of the applicants' choice of research project, undergraduate performance, and the recommendation of college authorities. The AISC Committee for Education plans to select the award winners but reserves the right to delegate the choice to an impartial jury comprised of engineers or educators not connected with AISC.

UW TO HAVE ELECTRON MICROSCOPE LABORATORY

A two-year experimental program that is basic to the design of possibly the world's most powerful electron microscope has been initiated by The University of Wisconsin in cooperation with Argonne National Laboratory and Associated Midwest Universities (AMU).

The research will be conducted at the Wisconsin campus in Madison as part of a joint electron microscope project sponsored by AMU and Argonne. The aim of this project is to construct at the Argonne site southwest of Chicago a radically new type of electron microscope laboratory. This installation may consist of several different types of electron microscopes all operated with the same power supply, an electron accelerator in the one-to-five-million-volt range.

AMU is a non-profit corporation of 32 major universities and research institutions organized for promoting research and education in all branches of science and to develop programs involving the use of Argonne facilities and those of other laboratories. Argonne National Laboratory is operated by The University of Chicago for the U.S. Atomic Energy Commission.

The scientists in Madison will build an experimental million-volt electrostatic electron accelerator, a high-vacuum beam tube, and an electrostatic analyzer for controlling the energy of the beam and measuring its stability. With this apparatus they will obtain information on achieving a well-focused beam of high-energy electrons of nearly the same energy. This information is vital to electron microscope design because the quality of the electron beam determines the quality of the magnified image.

The University of Wisconsin investigation will be carried out in the Nuclear Engineering Department laboratories of the Engineering Experiment Station in Madison. The accelerator and analyzer will be installed in Building T-23 on the Engineering Campus. The electron beam generator will be housed in a stainless steel tank about 2½ feet in diameter and 5 feet in length. A beam tube from the accelerator will be maintained at a very high vacuum (10^{-10} torr, or less than one seven-trillionth of atmospheric pressure). The electrostatic analyzer will deflect the electron beam with a highly stabilized voltage so that its energy can be precisely measured and controlled.

Two University of Wisconsin scientists will work full time on the project, which will be guided by Dr. Raymond G. Herb, Professor of Physics. The scientists are John M. Donhowe, an expert in the mathematical analysis of accelerator beams and in the experimental measurement and control of beam voltages, and Earl Meyers, a specialist in high vacuum techniques. Professor Max Carbon, Chairman of the Nuclear Engineering Department at Wisconsin, will provide administrative supervision of the project.

Investigations leading to the development of a Midwest electron microscope laboratory at Argonne began two and one-half years ago after the project was suggested by Dr. William R. Marshall, Associate

(Continued on page 40)

For Your Personal Library . . .

The Programmer's Fortran II and IV: A Complete Reference by Charles P. Lecht, Director, Advanced Computer Techniques Corporation. 162 pages; 8½ x 11; McGraw-Hill; $7.95. Publication date: February, 1966.

The Programmer's Fortran II and IV, a complete detailed reference source on the FORTRAN II and IV languages, is the only reference source incorporating both languages in such a way as to define each independently and indicate those characteristics which are different between them. In great detail, the author shows clearly and completely the full extent, meaning, and limitation of each type of statement in FORTRAN II and FORTRAN IV. The book is organized in a simple, easily read format which makes the differences between the two FORTRAN languages easily discernible.

Designed specifically as a working reference, the book contains examples within the explanation of each FORTRAN instruction, as well as in the glossary of terms (Appendix I), and it is arranged alphabetically to facilitate reference. Statements within the FORTRAN language which have never before been described in such detail are included. The book is an invaluable aid to all programmers, engineers, and scientists who are familiar with the FORTRAN language but have difficulty applying it to a specific programming task.

In addition to the glossary, *The Programmer's Fortran II and IV* contains two other appendixes—FORTRAN Built-in Functions and Library Functions, and FORTRAN Symbols with Equivalent Codes.

Charles P. Lecht, founder of Advanced Computer Techniques, began his career in the computer field as a programmer for IBM. Later he joined the Massachusetts Institute of Technology Lincoln Laboratory as a technical Staff Member, where he worked on the systems design, analysis, and programming of the SAGE data reduction effort. He has taught at Purdue and Cooper Union, and he taught in IBM's education program at M.I.T. Mr. Lecht has delivered lectures on computer technology in the United States and Europe.

How to Become a Professional Engineer, 2/e, by John D. Constance, P. E., Engineering Registration Consultant. 286 pages plus index; 37 illustrations; 5⅜ x 8; McGraw-Hill; $7.50. Publication date: January, 1966.

How to Become a Professional Engineer, 2/e, has been completely revised and updated to reflect the thinking of and experience sought by all state boards of examiners in licensing professional engineers. The book provides scope, orientation, and direction for engineers who seek registration, it brings together all information that the applicant can use to prepare his application record, and it explains the pitfalls he should avoid when sitting for the written examination. New material has been added to the appendix for those Canadian and foreign engineers who seek licensure in the United States.

The book, replete with illustrative material, provides various checklists, the bar chart of state examination dates, state-by-state variations in qualification requirements and examination procedures, the historical evolution of the engineers' licensing system and the variations in examination emphasis from EIT to the recognized eminence category. Interwoven with technical requirements for licensure is a clear and convincing presentation of the ethical attributes that complement the professional engineer.

The chapter topics of *How to Become a Professional Engineer* are: Developing a Professional Career; Why Engineers' Registration; What is Professional Engineering; Summary of State Registration Laws; Engineer-in-Training Program; Requirements for Registration; What is Qualifying Experience; Criteria for Evaluating Experience; Writing up Your Experience Record; The Written Examination; How to Prepare for the Written Examination; What to Look for in Refresher Courses; Multiple Registration; Eminence—Open Door to Registration; Oral Examination; The Engineer's Seal.

The Appendix includes updated addresses of state boards of examiners and addresses of their Canadian counterparts; current lists of ECPD and New York State Board accredited engineering schools; recommended reference texts and special study aids; and samples of experience records credited by boards of examiners.

John D. Constance, P.E., has been preparing engineers for licensure in the various states for over 20 years. He is associated with refresher courses and orientation work of ASME, IEEE, and ASCE and has conducted refresher courses for these societies as well as for many industrial organizations. Constance, a recognized authority and guidance counselor in this field, has written many articles and books on the subject. He is a graduate chemical engineer (New York University) with many years of industrial experience in design and operation.

Further information on both of the above books may be obtained from the McGraw-Hill Book Information Service, 327 West 41st Street, New York, New York 10036.

N/C Drafting Machine

(Continued from page 32)

ings which the system is capable of.

The coming of N/C to drafting brings with it freedom for technical personnel. Engineers are freed from tedious drafting jobs. They are able to concentrate their efforts on the process of engineering.

REFERENCES

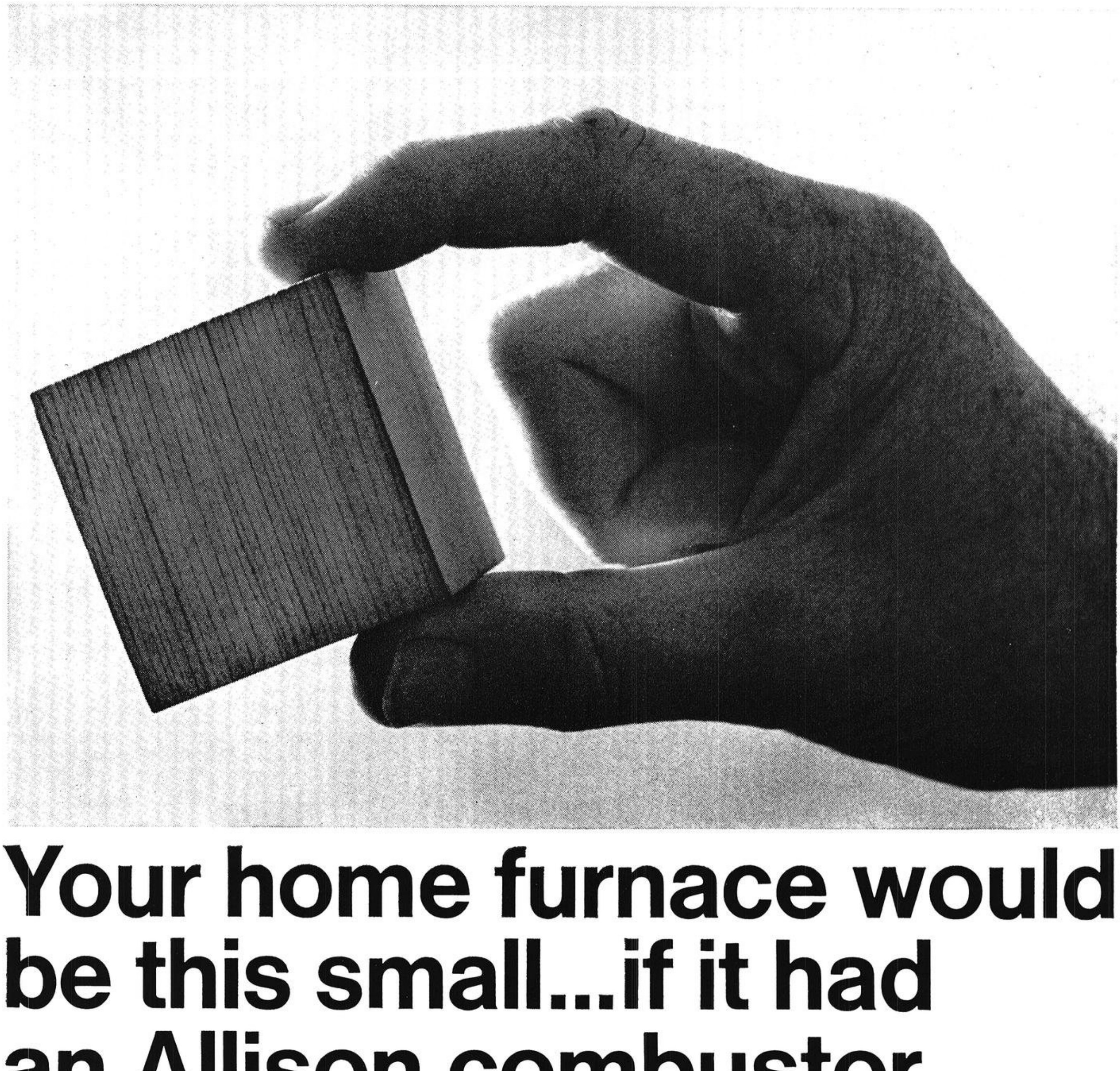
1. "Automatic Drafting and Plotting Units Produce Drawings from Digital Information." *Iron and Steel Engineer*, 41 (April, 1964), 166.
2. The Gerber Scientific Instrument Company. "Automatic Drafting on Low-Cost Unit." *Iron Age*, 193 (March 12, 1964), 148.
3. The Gerber Scientific Instrument Company. *Comprehensive Automatic Drafting Systems/Series 600.* 1964.
4. The Gerber Scientific Instrument Company. *Comprehensive Automatic Drafting Systems/Series 1000.* 1964.
5. The Gerber Scientific Instrument Company. *A Short Form Catalog of Graphic Data Reduction, Film Reduction, and Plotting.* 1964.
6. Hoydle, C. W. *Design by Numerical Control.* Technical Paper 581. ASTME Creative Manufacturing Seminars, 1964.
7. Johnson, W. B. "Automatic Drafting." *Tool and Manufacturing Engineering*, 51 (July, 1963), 47–49.
8. Wilson, Frank W. NUMERICAL CONTROL IN MANUFACTURING. McGraw-Hill, Inc., 1963.

Campus News

(Continued from page 39)

Dean of the College of Engineering at Wisconsin. Work on the project was started at Argonne in the summer of 1964 with Dr. Ernest D. Klema, Chairman of the Department of Engineering Sciences at Northwestern University, serving as coordinator.

The AMU-Argonne high voltage electron microscope laboratory, as proposed, would be the first large scale undertaking to be planned jointly from its earliest stages by a group of participating universities and Argonne. The installation would be used primarily for biological and metallurgical research and for electron microscope development. Design and construction costs of the entire facility, which has not yet been formally authorized, would be approximately $5,000,000.



Your home furnace would be this small...if it had an Allison combustor.

Or... in aircraft terminology: the new Allison Combustor turns out four times the heat release of combustors in production engines. Yet a combustor for a 10,000 lb. thrust engine can be held in one hand.

It's an Allison breakthrough in lightweight engine technology. Immediate application: Allison Lift engines. Designed to propel tomorrow's jet aircraft straight up.

So far, Allison Lift engines have attained thrust/weight ratios over four times those of production engines.

Other factors have contributed: Like new compressor blades that raise pressure 50%.

Advanced turbine cooling techniques allow higher inlet temperatures. Greater power. Lower blade temperatures.

Even greater advances are on the way—for turbojet and turbofan engines. With 30:1 thrust/weight ratios forecast. Shorter compressors. More efficient combustors. For lift or cruise engines.

Advanced lightweight technology is another demonstration of Allison's broad capabilities in research, engineering, and production. Capabilities that help keep defense, aerospace and nuclear projects *on target.**

Zero defects . . . a way of life at

Allison GM

The Energy Conversion Division of General Motors, Indianapolis, Indiana.

*Want to know about opportunities here in the creative climate at Allison for the young, graduate engineer? Talk to our representative when he visits your campus. Or, send for our brochure describing the opportunities: Mr. R. C. Martz, Personnel Director, Allison Division, General Motors, Indianapolis, Indiana. An equal opportunity employer.

Alumni News

LLOYD J. SEVERSON mme'36 WITH USS IN PITTSBURGH

Mr. Lloyd J. Severson has been appointed Director—International Raw Materials Investigations of United States Steel Corporation effective January 1, 1965, it was announced today by Mr. Robert M. Lloyd, administrative vice-president—International. Mr. Severson will be based in Pittsburgh, Pa.

In his new responsibility, Mr. Severson will investigate raw materials sources throughout the world, seeking new mineral deposits that warrant development. His broad background in this field, much of it in foreign areas, extends to 1936, when he was graduated from the **University of Wisconsin.** He was associated with the U.S. Government's Foreign and Economic Administration from 1942 through 1944 in connection with stategic mineral supplies for World War II.

Prior to assuming the presidency of Quebec Cartier in 1957, he was vice-president—mineral development of the Oliver Iron Mining Division of U.S. Steel, with headquarters in Duluth, Minn. He headed the investigational work which discovered the present mineral areas of Quebec Cartier Mining Company and became president of that company when it was formed in 1957.

The development of these properties and the construction program at Quebec Cartier has been one of the larger developments in iron ore mining to be completed in recent years. It involved the planning, scheduling and contracting of a large deep-draft harbor, nearly 200 miles of railroad through undeveloped country, and the establishment of one of the world's largest mining and concentrator operations.

Mr. Severson was active in the Canadian Institute of Mining and Metallurgical Engineers, the Corporation of Engineers of Quebec, and was a member of the Honorary Board of Governors of the Canadian Association for Retarded Children.

DR. C. R. ADLER APPOINTED AT KODAK

Dr. Charles R. Adler has been appointed manager of product planning for the business systems markets division of Eastman Kodak Company, James M. Arnold, general manager of the division, has announced.

Dr. Adler began his career with the company in 1950 in the manufacturing experiments division at Kodak Park Works, Rochester, N.Y. He became a senior development engineer in 1955.

From 1959 to 1960 he held an Alfred P. Sloan Fellowship at Massachusetts Institute of Technology, where he received an M.S. degree in management.

He was made a technical associate with Kodak in 1961 and the following year transferred to Kodak office where he joined the general management staff as an administrative assistant.

A native of Illinois, Dr. Adler received a B.S. degree in chemical engineering from the Illinois Institute of Technoloy and **M.S.** and **Ph.D.** degrees in **Chemical Engineering** from the **University of Wisconsin.**

He holds membership in Phi Lambda Upsilon, chemical honorary fraternity; Alpha Chi Sigma, chemical professional fraternity; and Sigma Xi, research honorary fraternity. He is a member of the American Institute of Chemical Engineers, the Society of Sloan Fellows, the Rochester Chamber of Commerce, and the Rochester Society of Photographic Scientists and Engineers. He is also a member of the board of directors for the Rochester area Council of Churches.

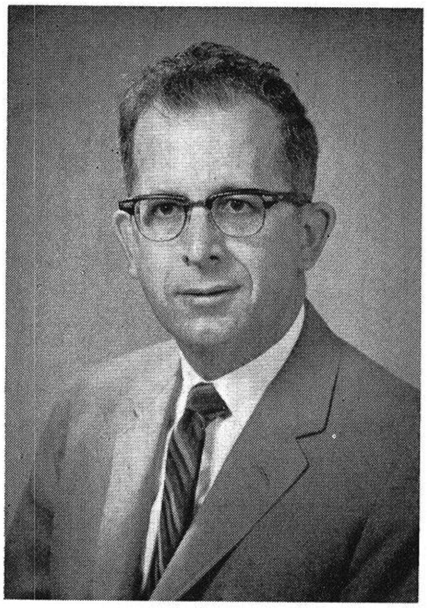
He has written articles on chemical engineering and has received two U.S. patents.

Dr. Adler resides with his wife, Carol, and their three children, at 170 Danbury Circle South, Brighton, N.Y.

THE WISCONSIN ENGINEER APPRECIATES ALUMNI NEWS FROM FIRMS AND INDIVIDUALS.

PLEASE INCLUDE YEAR OF GRADUATION, MAJOR, AND A GLOSSY PHOTO, IF POSSIBLE.

or: Badgers Make Good



V. E. HERZFELD VP OF UNIVAC

Four top Twin Cities executives of the Sperry Rand Corporation's UNIVAC Division received promotions last year in the company's Defense Systems and Data Processing Divisions. All four are newly created positions.

Dr. V. E. Herzfeld was named as a new vice president.

He has been director of Engineering for the Data Processing Division and was elevated to the new post of vice president of Engineering for the division.

Dr. Herzfeld, 1041 Douglas Road, Mendota Heights, joined UNIVAC here in 1953 after receiving his doctorate (1953) in **Electrical engineering** from the **University of Wisconsin.** He received bachelor's (1949) and master's (1951) degrees from the same university. He is a native of Weyauwega, Wis.

Dr. Hersfeld has served as a project engineer, supervising engineer, department manager and director of Commercial Engineering with UNIVAC.

R. S. PERRY WILL MANAGE ENGINEERING AT TUBE TURNS

Russell S. Perry has been named manager of engineering for Tube Turns division of Chemetron Corporation, it is announced by John A. Henby, vice president of operations.

Tube Turns is a major producer of welding fittings and flanges, bellows expansion joints, other industrial piping components and custom forgings.

Perry joins Tube Turns after 15 years with another major Louisville firm where he served as chief engineer.

He is a registered professional engineer in Kentucky and a member of the American Society of Mechanical Engineers, American Standards Association and the American Petroleum Institute.

Perry holds a **Bachelor of Science** degree in **Mechanical Engineering** from the **University of Wisconsin at Madison** and has studied at Indiana University and the University of Louisville.

He is married to the former Sue White of Peoria, Ill. They have two children and live at 117 Pawnee Drive, Jeffersonville, Ind.

P. J. SCHMITZ, EE'56 SIGNETICS MANAGER

Patrick J. Schmitz, 36, has been named manufacturing manager of Signetics Corp., it was announced here today by J. F. Riley, president of the Corning Glass Works integrated circuits subsidiary.

Schmitz comes to Signetics from the Centralab Division of Globe-Union Corp., Milwaukee, where he had been product manager for the past year. Earlier he had been manufacturing manager of Continental Device Corp., and operations manager of Transitron.

At the same time, Riley announced that Donald Liddie has been named manufacturing service manager of the company. Mr. Liddie has served in several manufacturing and administrative positions at Signetics and will now be responsible for all manufacturing support activities.

Schmitz, a native of Milwaukee, received his **B.S.E.E.** from the **University of Wisconsin** in 1956. The same year he joined Hughes Aircraft in Los Angeles and was general superintendent of diode and transistor manufacturing in 1960 when he left to become manufacturing manager of Continental Device Corp.

ASCE

SAE

ANS

IEEE

ASME

AIChE

Polygon Board

READ ABOUT

THESE AND OTHER

UW ENGINEERING ORGANIZATIONS

IN FORTHCOMING ISSUES

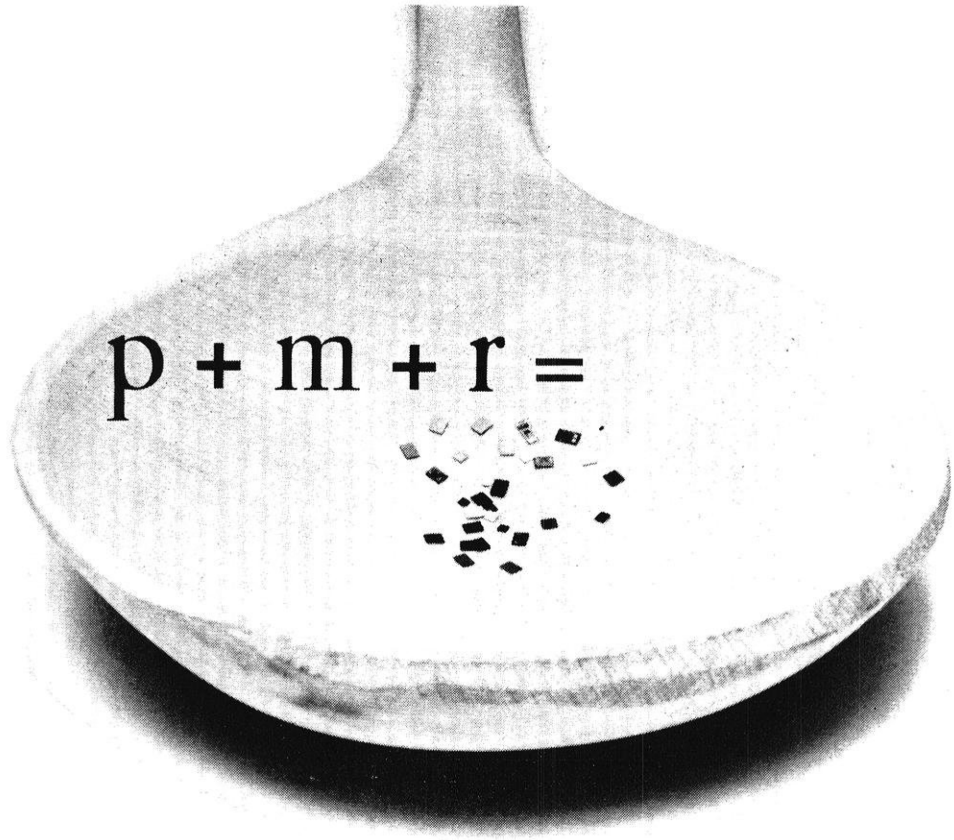
Society correspondents are reminded to have schedules and news copy in 1 month prior to desired publication date.

MAKE YOUR FREE TIME COUNT

Applications are now being taken for trainees for most staff positions. Those students accepted will be in line for promotions as vacancies exist. This is considered excellent journalism experience and will be an asset to your record.

To learn more about the opportunities, stop in or call our office, 333 Mechanical Engineering, Phone 262–3494. Office hours are 10:00 a.m.–1:00 p.m., Tuesdays and by appointment.

CONSUMER PRODUCTS * COMMUNICATIONS * SEMICONDUCTOR PRODUCTS * MILITARY ELECTRONICS * AUTOMOTIVE PRODUCTS * CONTROL SYSTEMS



Ten years ago we were making only a handful of relatively simple semiconductor devices for a limited number of applications. Today, with highly advanced and exotic processes, we are producing hundreds of different and sophisticated semiconductors — for thousands of applications. Our technicians can now control material composition down to the molecules with precise regulation of impurity levels — and on a daily production line basis.

This we call PERFORMANCE.

Five years ago we produced semiconductor packages the size of a pencil eraser that replaced the big glass vacuum tubes in your radio. Today we're making sophisticated semiconductors that perform giant-sized tasks — yet fit on a soupspoon like grains of rice.

We call this MINIATURIZATION.

Drop the old time vacuum tube and it would smash. Its parts wore out pretty regularly too. Shake it or shock it beyond relatively modest limits and you were in trouble. Now you can launch a space vehicle with thousands of semiconductor components to go all the way to the moon and back . . . and make it go back around all over again. And a couple of times more after that.

That's RELIABILITY.

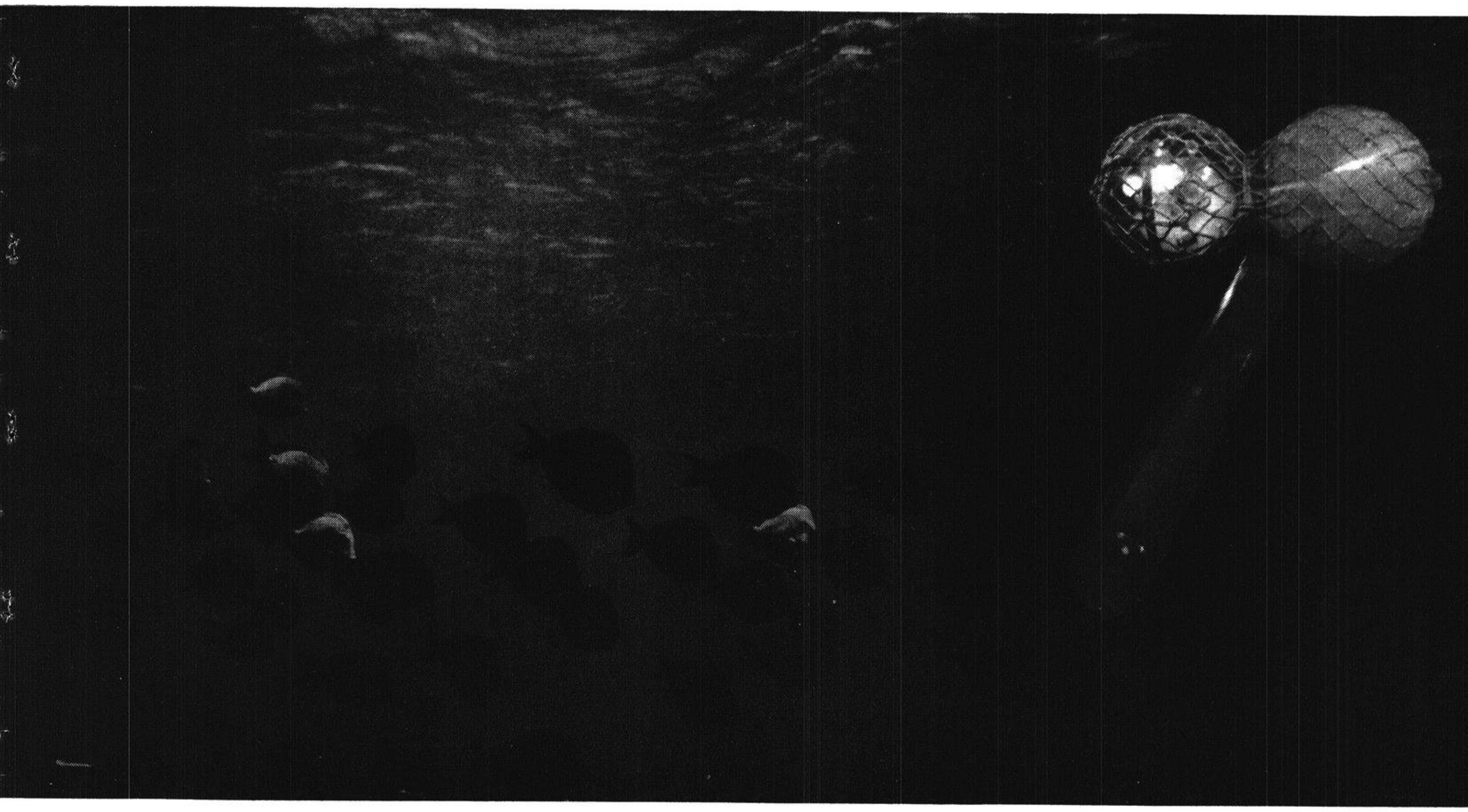
Shake 'em, shock 'em, squeeze 'em or freeze 'em — today's electronic devices have got to be able to take it . . . and perform. Motorola makes them as though they're a matter of life or death.

Sometimes they are.

TRUST THIS EMSIGNIA WHEREVER YOU FIND IT

MOTOROLA

If you still think glass is just glass,



ask Woods Hole.

Now glass can do what metals can—and more. Much more. Ask Woods Hole Oceanographic Institution.

For years, the only way to get a sample of the ocean's floor was to lower what they call a "bottom corer" on a wire and then laboriously haul it up again. Not any more. Now a "Boomerang Corer"—made for Woods Hole by Benthos, Inc.—is simply tossed overboard and allowed to plunge freely. When it slams into the ocean floor, it drives a sample of sediment into a hollow tube inside the corer.

The impact releases two glass spheres that can do what most hollow metals can't: withstand the tremendous pressures at the bottom of the ocean. They tug the tube loose and float it to the surface. A flashing beacon inside one of the spheres pinpoints its location for the waiting ship.

Today glass can be made to maintain constant electrical properties at missile speeds. Be a heat exchanger in a gas turbine engine. Save weight without sacrificing strength. Conduct or insulate. Bend. Not bend. Break. Not break. Melt. Not melt. Do whatever you want it to. It is *the* most versatile basic engineering material.

For solutions to their problems, industry and government are coming to Corning. Because Corning is *the* glass-master. We are widely diversified, internationally based, and have one of the most daring, expert and imaginative engineering staffs. Plus, a marketing principle that concentrates on developing products only in areas where a need exists and no product does.

Young engineers seeking challenge, opportunity, and advancement are invited to write to Career Development Manager, Corning Glass Works, Corning, New York.

CORNING
CORNING GLASS WORKS
AN EQUAL-OPPORTUNITY EMPLOYER

BARREL THE OF BOTTOM

If all the junior engineers who sleep through the thermo lecture were placed end to end they would be more comfortable.

* * *

What makes people walk in their sleep?
Twin beds.

* * *

Federal aid is like giving yourself a blood transfusion in your left arm, drawing from your right arm and spilling 90 per cent of it on the way across.

* * *

St. Peter was questioning them as he left them in.
St. Pete: "Who are you?"
Stude: "A student from Minn."
Pete: "Enter my son."
Pete: "Who are you?"
Stude: "A student from Ohio."
Pete: "Enter my son."
Pete: "Who are you?"
Stude: "A student from Wis."
Pete: "Let's see your fee card."

* * *

A fool and his money are soon popular.

A bachelor friend of ours reminds us that sometimes a girl can attract a man with her mind, but it's easier to attract him with what she doesn't mind.

* * *

The house guests were assembled with their hosts in the living room after dinner, chatting pleasantly, when the five-year-old daughter of the host appeared suddenly in the room, her clothes dripping with water. She could scarcely articulate, so great was her emotion, and her parents rose in consternation as she entered:

"You—you," the little girl babbled, pointing to the male of the house guests, "You're the one who left the seat up."

* * *

Ole and Olga had just been married, and at the reception one of the guests said to Olga laughingly, "Olga, I think you have a little Swede in you!"

Olga said in return, "Ya! Ole, he yust couldn't vait!"

These days, too many beautiful women are spoiling their attractiveness by using four-letter words —like don't and can't and won't.

* * *

Tourist Guide: "We are now passing the largest brewery in the United States!"
CE: "Why?"

* * *

The young Georgia miss came to the hospital for a checkup.

"Have you been X-Rayed?" asked the doctor.

"Nope," she said, "but ah've been ultraviolated."

* * *

A little bear went tripping through the woods one spring morning singing, "I'm a ready teddy, I'm a ready teddy," and gently swaying her graceful body in time with the tune. Suddenly from behind a big tree came big, hairy arms.

Some time later she continued on her way singing, "I'm a ruined bruin, I'm a ruined bruin."

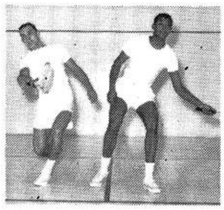
* * *

Many a go-getter is afterwards sorry that he gotter.

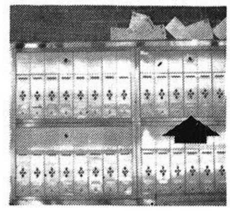
Invitation from Kodak to

We need the new ways of technical thinking, fresh from a good campus.


CLASS OF '66

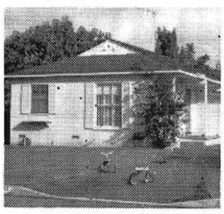

CLASS OF '65


CLASS OF '64


CLASS OF '63

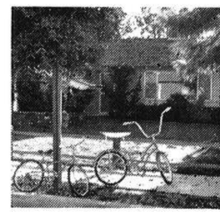

CLASS OF '62

CLASS OF '61


CLASS OF '60


CLASS OF '59


CLASS OF '58


CLASS OF '57

If it has been necessary to pick up some instructive experience before selecting a long-haul employer, that's fine.

The box below permits a chemical engineer, just for kicks, to test himself for possible interest in our kind of problems. Bright M.E.s, E.E.s, and other engineers will pick up enough of the general idea to transpose the test to their own fields of competence. The next step would be to drop us a line about yourself and your ambitions. If mutuality of interest develops and if the mundane matter of compensation should come up, we feel that now and far into the foreseeable future we can afford the best.

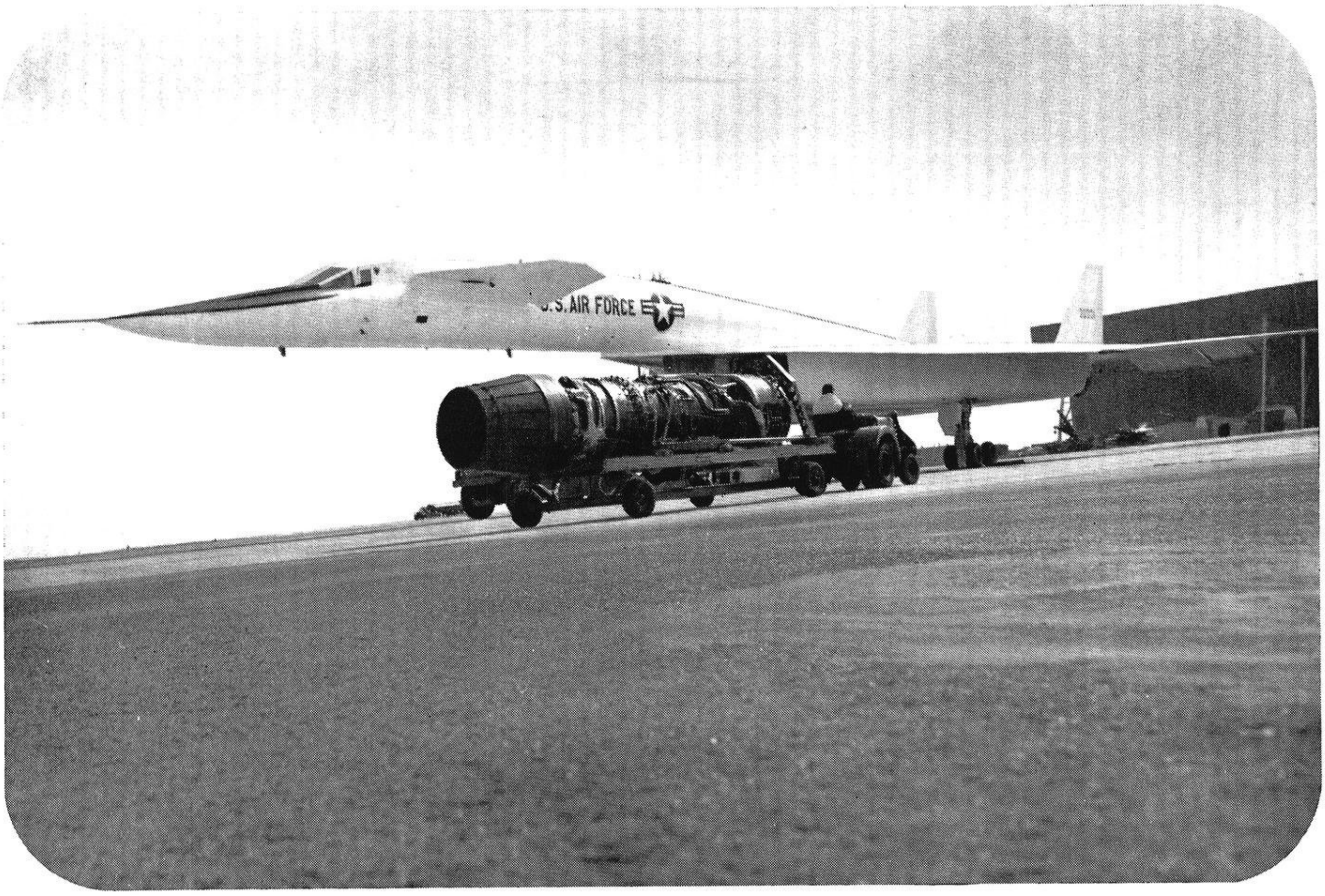
EASTMAN KODAK COMPANY, Business and Technical Personnel Dept.
Rochester, N.Y. 14650

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

We can react diketene and tert.-butyl alcohol to tert.-butyl acetoacetate [$CH_3COCH_2COOC(CH_3)_3$] by methods that bring the price down to $3.50 a pound—about one-sixth the prevailing research-quantity price—with the usual prospect for a substantial further plunge as volume develops. A plunge to reach the price level of methyl acetoacetate and ethyl acetoacetate, two currently large-volume acetoacetic esters of ours, is unlikely. The tert.-butyl ester, however, has an advantage over the other two. When alkylated to $CH_3COCHRCOOC(CH_3)_3$, mere heating with a trace of acid catalyst drives off first $(CH_3)_2C{=}CH_2$ and then CO_2, leaving CH_3COCH_2R. With the cheaper acetoacetate esters for making ketones, there is no such neat cleavage. There the ethyl or methyl group has to be hydrolyzed off, and if R happens to be hydrolysis-sensitive itself, poof goes the yield. This same readiness of α-alkylated tert.-butyl acetoacetic esters to split out isobutylene and then decarboxylate opens up promising routes also to carboxylic acids, pyrroles, pyrazalones, uracils, and coumarins.

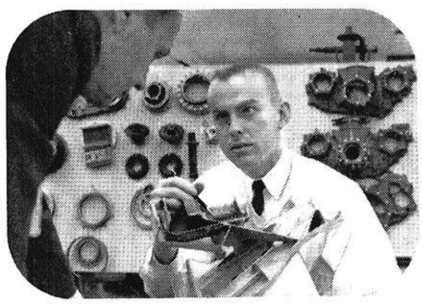
Now assume we have large supplies of diketene and tert.-butyl alcohol, as indeed we do.

The problem: multiply their combined economic value to many times the sum of their separate values.

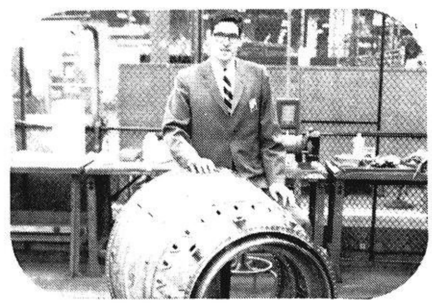


SIX G-E J93 ENGINES push USAF XB-70 to MACH 3.

JACK WADDEY, Auburn U., 1965, translates customer requirements into aircraft electrical systems on a Technical Marketing Program assignment at Specialty Control Dept.



PAUL HENRY is assigned to design and analysis of compressor components for G.E.'s Large Jet Engine Dept. He holds a BSME from the University of Cincinnati, 1964.



ANDY O'KEEFE, Villanova U., BSEE, 1965, Manufacturing Training Program, works on fabrications for large jet engines at LJED, Evendale, Ohio.

A PREVIEW OF YOUR CAREER AT GENERAL ELECTRIC

Achieving Thrust for Mach 3

When the North American Aviation XB-70 established a milestone by achieving Mach 3 flight, it was powered by six General Electric J93 jet engines. That flight was the high point of two decades of G-E leadership in jet power that began when America's first jet plane was flown in 1942. In addition to the 30,000-pound thrust J93's, the XB-70 carries a unique, 240-kva electrical system that supplies all on-board power needs—designed by G-E engineers. The challenge of advanced flight propulsion promises even more opportunity at G.E. GETF39 engines will help the new USAF C-5A fly more payload than any other aircraft in the world; the Mach 3 GE4/J5 is designed to deliver 50,000-pound thrust for a U.S. Supersonic Transport (SST). General Electric's involvement in jet power since the beginning of propellerless flight has made us one of the world's leading suppliers of these prime movers. This is typical of the fast-paced technical challenge you'll find in any of G.E.'s 120 decentralized product operations. To define your career interest at General Electric, talk with your placement officer, or write us now. Section 699-16, Schenectady, N.Y. 12305. An Equal Opportunity Employer.

Progress Is Our Most Important Product

GENERAL ELECTRIC