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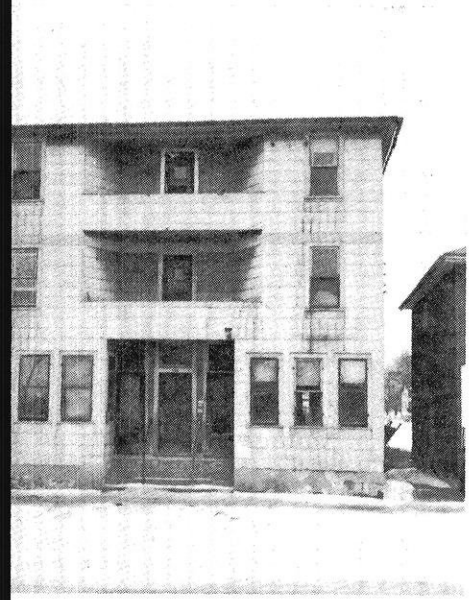
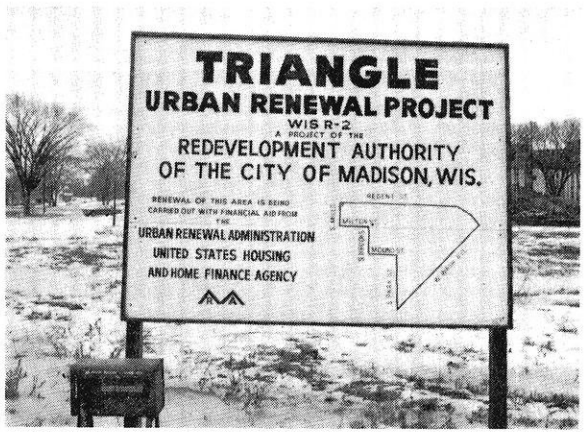
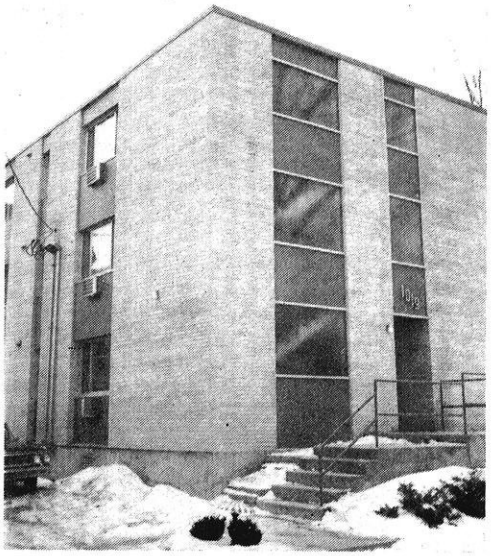
# THE WISCONSIN
# ENGINEER

FEBRUARY 1965 • 25 CENTS
MEMBER E. C. M. A.



**URBAN RENEWAL: PROS & CONS . . . See Page 12**

*To Meet UW's 'Impr*

# Renew[al] Study Group
# A[sks] Wider Area Look

Wisconsin State Journal

T. AEHL [for st[udy] [primarily by federal money; the] study of "zoning, land use, traf[fic]

# Wis 10-Story A[part]ment Backed

THE CAPITAL TIMES

## Downtown Study Plan Is Held Up

[a] [mit]tee rec[om]mendations [neigh]borhood (NRP) study area. The university expansion area is in the GNRP.

The neighborhoods proposed [as] "residence" section roughly east [and] no

Exac[t] borhood[s] would [be] partme[nt] studies

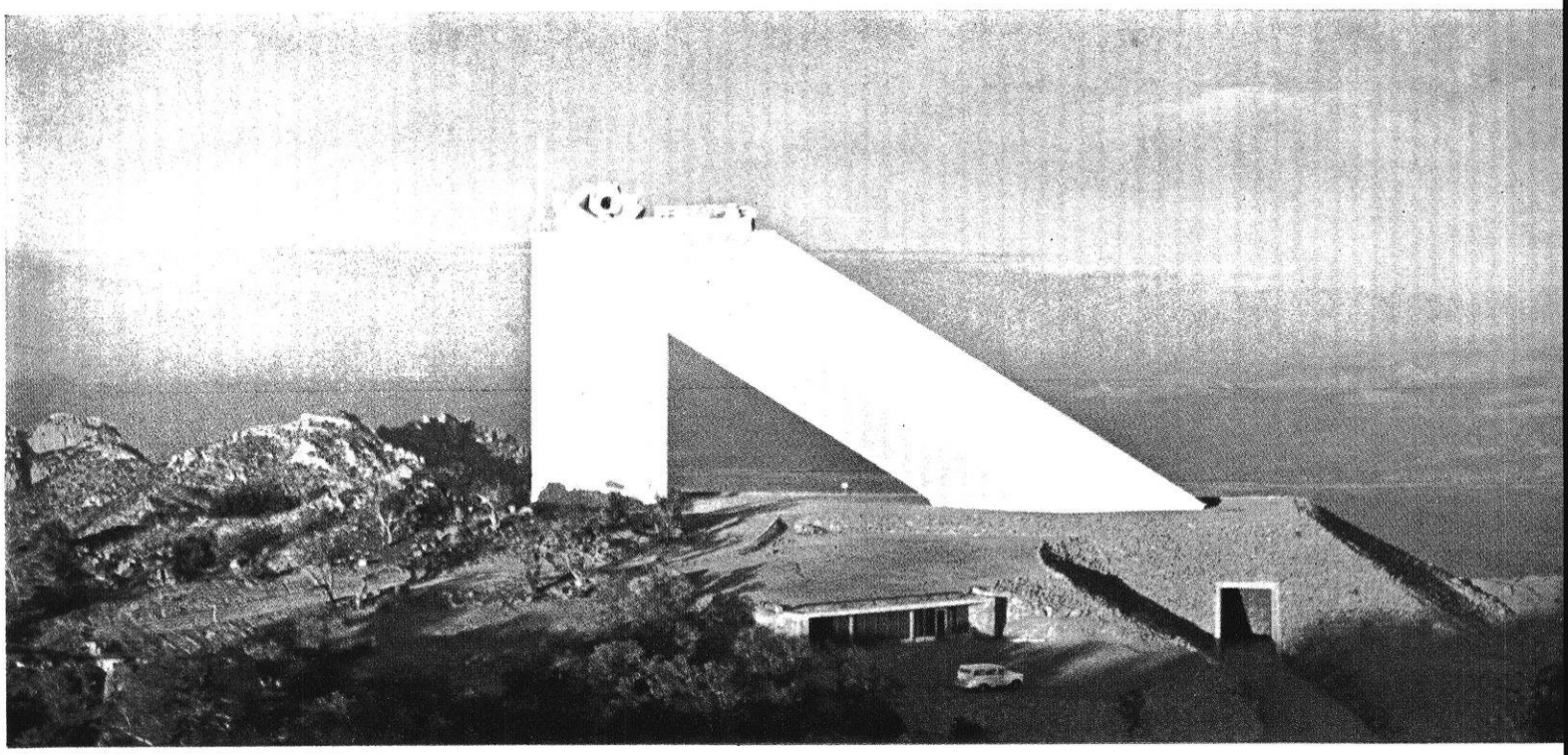
The GNRP and any urban renewal projects which might arise from the study would be financed

[ing] area were appare[nt]

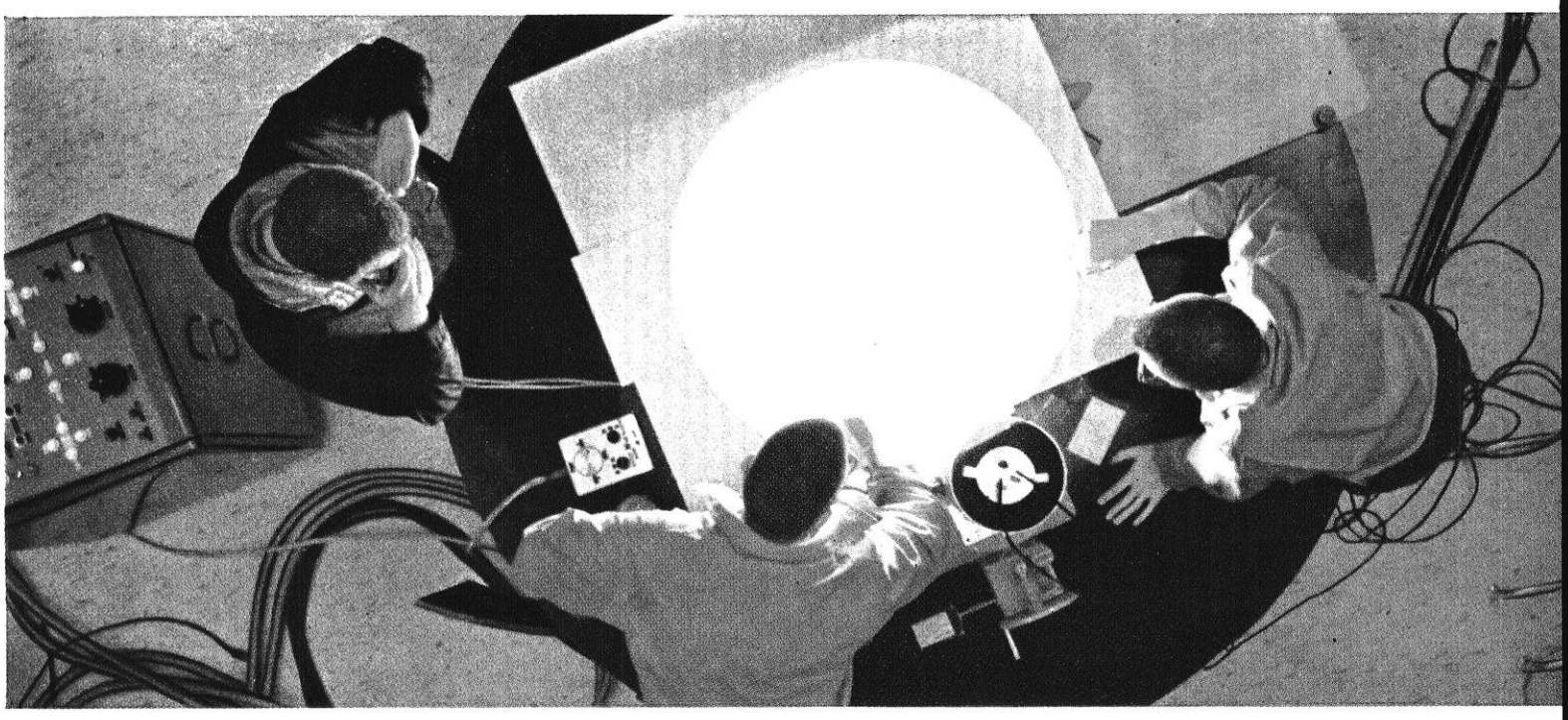
[di]-

## Mayor's Veto of MRA [Plan] Should Be Sustained

The committee said that because of expansion impact, a [Madison Redevelopment Authority (MRA)] listed that a much of the area outside the smaller GNRP would not have [been eligible for]



## On top of Kitt Peak, the world's largest solar telescope



## gives scientists the largest image of the sun man has ever had

At the top of the gleaming white tower in the upper picture is a 60-inch quartz mirror which precisely tracks the sun all day in the clear, dry air above the Arizona desert.

It is cradled in a carriage called a heliostat, built by Westinghouse.

Part of this telescope is tunneled out of the flank of the mountain. Sunlight is reflected 480 feet down this tunnel and back up 280 feet into a dark viewing room by means of two other mirrors, also on Westinghouse mountings.

By studying the sun's image here, scientists hope to learn more about the sun's magnetic field and how sunspots affect our weather and communications.

The 60-ton heliostat at the Kitt Peak National Observatory is designed to track the daily motion of the sun to an accuracy of 1/1000 of an inch.

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# February in Brief

Here it is February already; the ground hog has seen his shadow so we can all settle down for six weeks of cold weather and six weeks exams. Relax group, it's second semester and that means another school year is waning. For many of you this means graduation, while for others it may mean a summer job that helps you fill your pockets with coins. Anyway, our advice is to hit the books extra hard now, when the weather isn't always perfect. Then, when spring comes (it really does you know) you can spend more time at Vilas, on the piers, at Picnic Point, or what have you.

## THIS MONTH . . .

Our cover story, "The Pros and Cons of Urban Renewal," begins on page 12. This is intended to give you politicians some fuel for a bull session, now that this topic has become a big election issue in Madison. For the scoop on the successes and failures of urban renewal, this article shouldn't be overlooked.

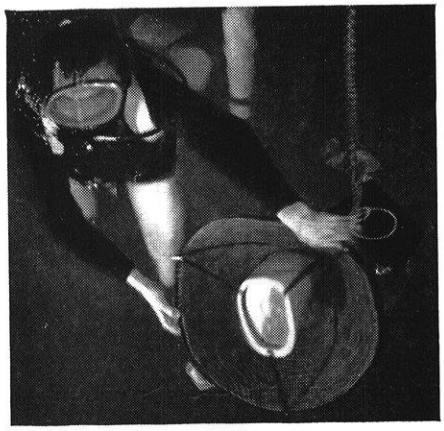
A current report on a future giant among engines begins on page 16. From engineering details, to research, to predicted potential use, Glen Scharpf's "The Wankel Rotary Engine" is intriguing and interesting.

As a followup to our articles of March 1964 (Critical Path and MAPI) we present "PERT: A Management Tool." Jim Horton's article is current and thorough. Maybe you can use PERT to help you with your homework.

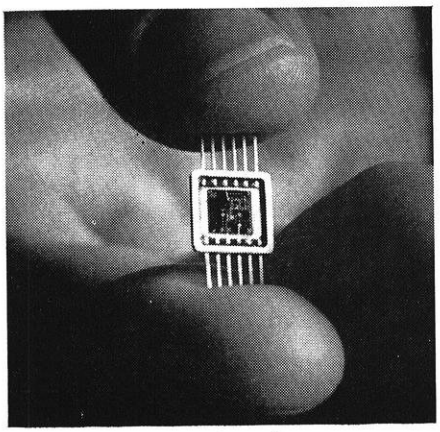
Messrs. Fonstad and Weber and some anonymous joke editor have their usual contributions, on pages 44, 36, and 39 respectively.

We do owe you an apology for not printing the 2nd semester interview schedule as promised, but it just couldn't be fit in this month. The Placement Office has the current schedule posted, along with some additions and corrections, so check with them if you're job-hunting.

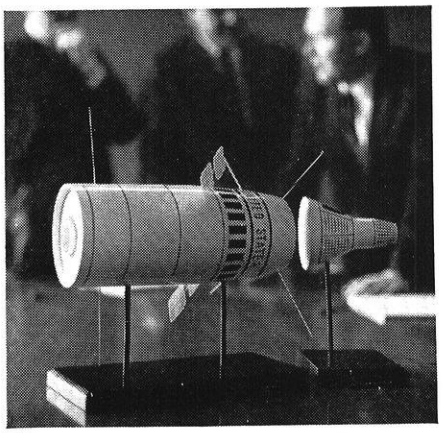
Happy exams, etc.



We do research on oceanics,

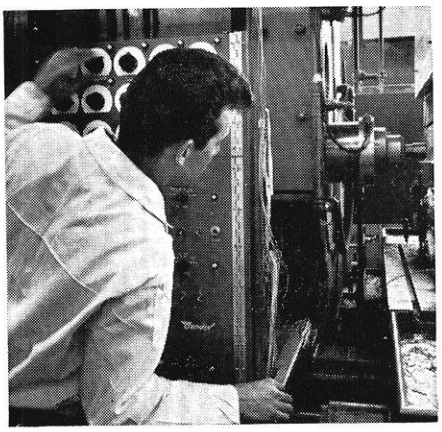


microcircuitry,

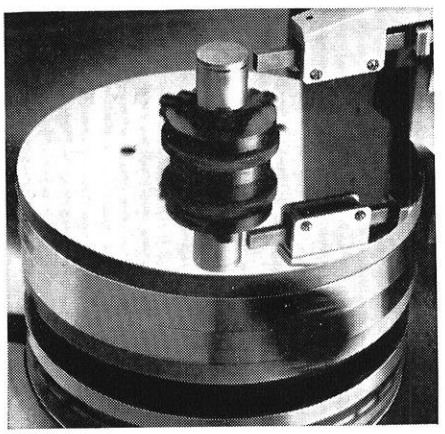


controls for space stations,

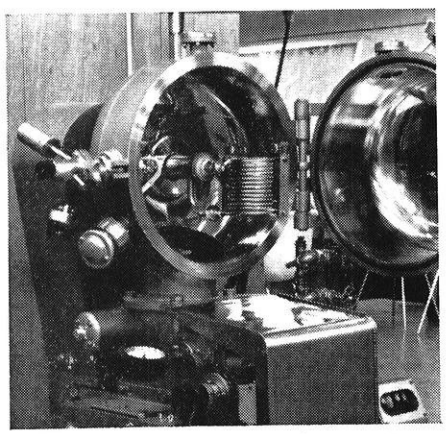
all-weather landing systems,



self-adaptive machines,

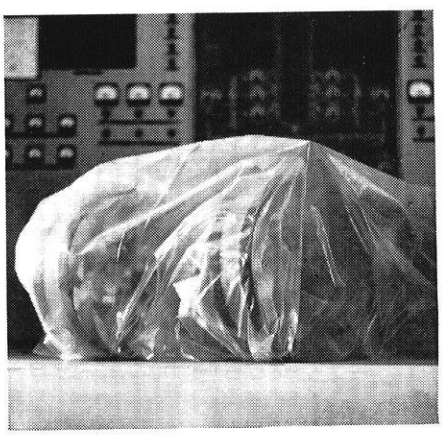


noncontact measuring gages,



high vacuum equipment,


automotive brakes,



and lots of secret stuff.

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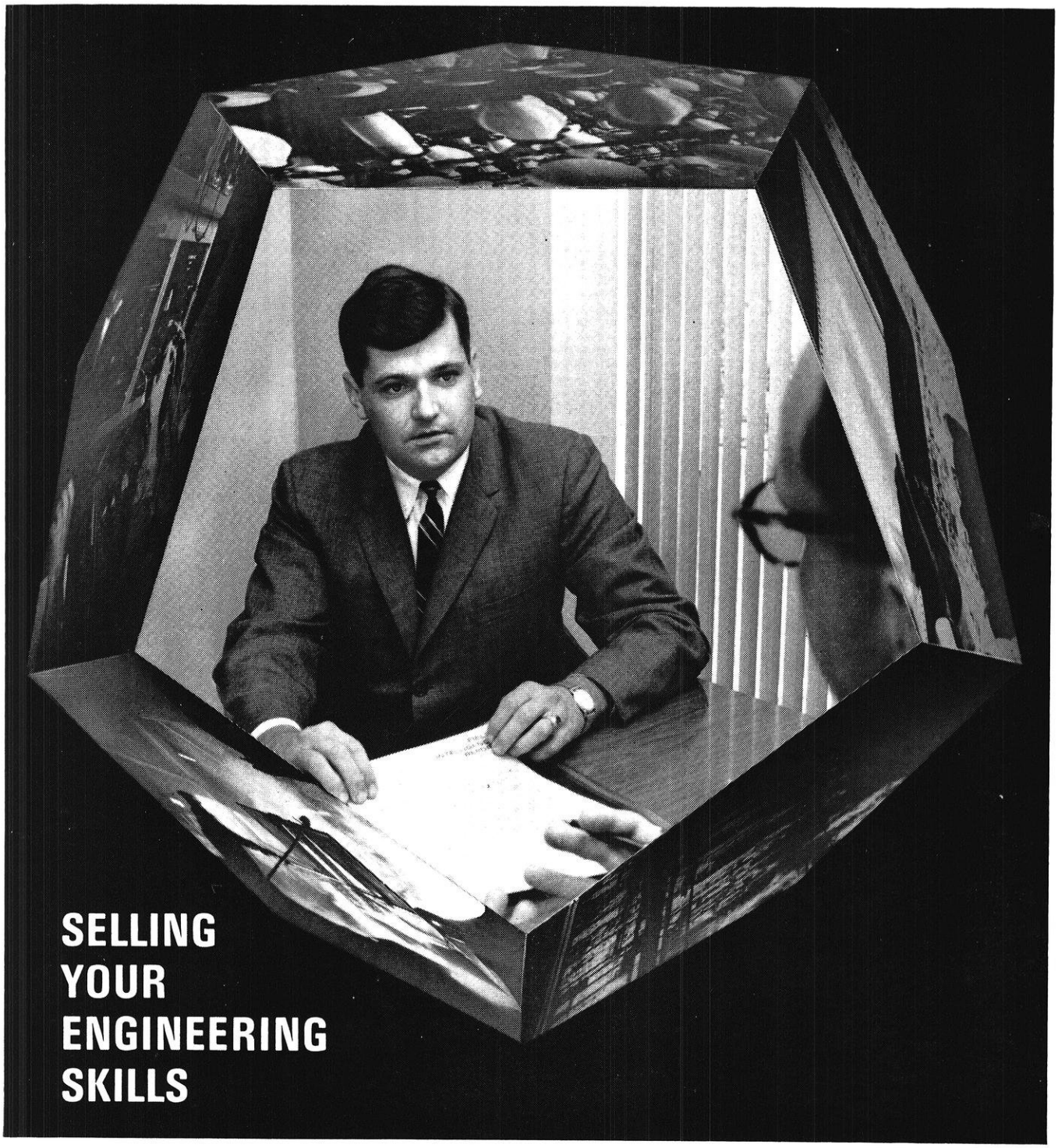


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# TOPPED OUT

A little of this kind of "devil may care" goes a long way with most of us. Not to mention that the work is quite specialized and tends to be repetitive.

These workmen are perched atop a new 550 foot stack at our Oak Creek power plant site.

However, many challenging engineering applications are incorporated into the 310 mw generating unit which this stack will serve. These include direct firing of pulverized coal instead of a bin storage system, solid state electronic combustion control instead of pneumatic control, and the use of a digital computer for start-up and shut-down as well as for other functions.

To prevent our power engineers from becoming "topped out" in one specialized field, we offer varied assignments and lateral transfers to provide experience vital to the successful handling of higher responsibilities.

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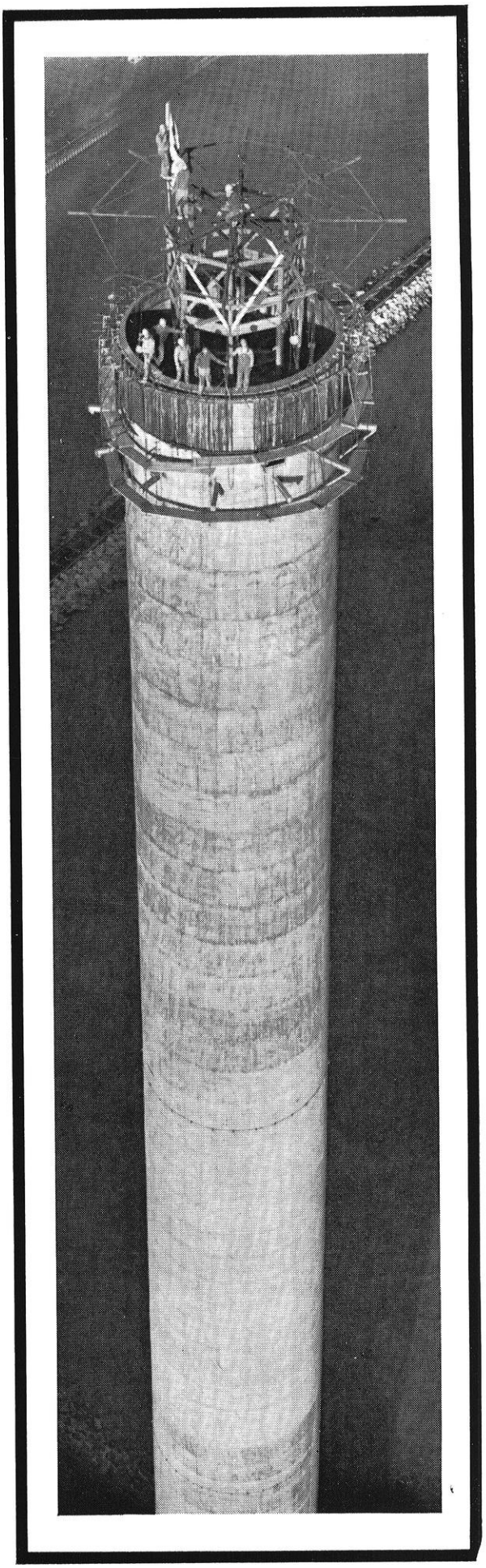
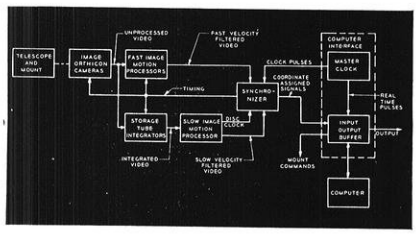


# Engineering and Science at RCA

## Ground Detection of Space Objects in the Night Sky

RCA has designed and installed for the Air Force a new optical satellite surveillance system that utilizes advanced techniques in several fields including physics, electronics, mathematics and astronomy. Starting in the laboratory with a bread-board experiment to prove the feasibility of using image orthicon tubes as detectors of moving targets among the




millions of stars in the night skies, a team of scientists and engineers carried the project through systems and design analysis, and produced the requisite equipment even to building an observatory on a mountain top in New Mexico. The system is now being evaluated under actual operating conditions. While performance data are security classified it can be said that the system is designed to detect, without a priori information, very dim satellites in real time, far beyond normal radar ranges.

Optical physics and engineering of the highest order were required to produce an eleven-ton, 27 inch f/1 telescope that uses 6 million optical fibers to present images to 12 orthicon cameras. Image motion processing necessary to find a tiny satellite moving slowly through a star field as dense as the Milky Way is accomplished by entirely automatic electronic signal integration, star cancellation and data association and reporting. The very latest techniques of electronic engineering have produced highly sophisticated equipment for control, data gathering and analysis of results.

System design, performance evaluation and computer programming have involved rigorous mathematical analyses applied to new combinations of scientific disciplines. Proof of the deductions are just beginning to emerge from the observatory, and much will be learned about applied astronomy as the system is used.

*Reference—J. A. Hynek and J. R. Dunlap, "Image Orthicon Astronomy," Sky and Telescope, Vol. 28, No. 3, p. 130, Sept., 1964.*

## Color TV Receiver Automatic Degaussing

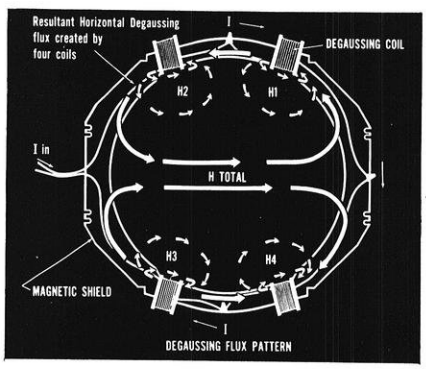
Even the comparatively small magnetic fields exhibited by the earth can cause visible errors in color television reception. To give picture tube output proper color alignment, while the TV receiver is in any desired location, an effective magnetic shield is required. But before a practical magnetic shield can perform its function, the shield must be degaussed in the specific magnetic field to be shielded.

Degaussing enables the metal in the shield to "forget" its previous magnetic orientation and to magnetically realign to counteract any new position. Degaussing affects the metal in the picture tube's shadow mask in the same manner.

Usually, a color television receiver is degaussed by driving a solenoid wound coil with 120 volt AC line voltage and moving the coil around the front of the tube . . . then slowly drawing the coil away. This operation usually is required every time the position of the color receiver, with respect to the earth's magnetic field, is changed.

Recently, RCA introduced *automatic degaussing*. This gives the color instrument freedom of movement, regardless of the earth's magnetic field. Automatic degaussing also protects the receiver from magnetic fields generated by nearby vacuum cleaners and other electrical appliances.

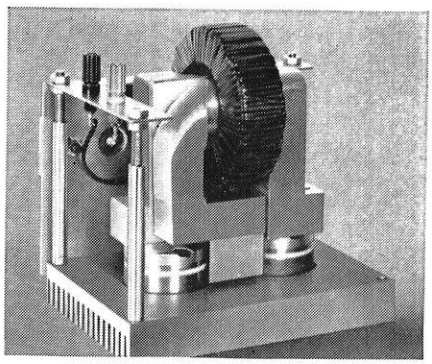
An RCA innovation, automatic degaussing is accomplished during initial warm-up—each time the color receiver is turned on from a cold start. The surge currents charging the electrolytic capacitors of the B+ supply start from a high value and decrease exponentially during the charging time. A thermistor in series with this charging current starts at approximately 110 ohms and decreases to 4 ohms as the current's heating effect changes the resistance.




A voltage-dependent resistor, in series with the degaussing coils (wound on the picture tube shield), acts as a switch to connect the coils across the thermistor only during the warm-up of the receiver. Thus, the slow drawing away of the coil in manual degaussing is simulated automatically.

## Energy Conversion

One of the most attractive new methods for the direct conversion of heat to electricity is the thermionic generator. In many applications, however, the efficient use of a thermionic generator requires some form of low voltage DC to AC inversion. Such generators developed at RCA are capable of several hundred watts output at efficiencies of 20%. Because this power is generated at only 0.5 volts, techniques were needed to step up output to practical voltage levels. Under Navy and Air Force sponsorship, RCA has now developed a tunnel diode inverter system capable of inverting the output of thermionic generators and other low voltage power sources to any AC voltage desired, with efficiencies up to 80%. This is believed to be the first time that usable power has been developed from a thermionic generator.



The new system employs the use of gallium arsenide, a semiconductor material which provides larger bandgaps and hence higher efficiencies and temperature capabilities. The tunnel diode inverter system has the advantage over previous designs in the following areas:

*Radiation resistance*—operable at radiation levels of $10^{17}$ nvt with only small decreases in efficiency. *Temperature*—GaAs tunnel diodes have been operated successfully at 200°C. *Circuit simplicity*—An extremely simple circuit is required consisting of only one transformer and two tunnel diodes, while the more conventional type of transistor inverter requires several transformers, resistors, diodes and transistors. *Cost-Weight-Volume*—Due largely to their simplicity, these advantages are obvious over other circuits of comparable performance.

These advanced engineering achievements represent a real breakthrough in energy conversion that is extremely important to our defense and space efforts.

These recent achievements are indicative of the great range of activities in research, applied research, advanced development, design and development engineering at RCA. To learn more about the many scientific challenges awaiting bachelor and advanced degree candidates in Electrical or Mechanical Engineering, Physics, Chemistry or Mathematics, write: College Relations, Radio Corporation of America, Cherry Hill, New Jersey.

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Name(s) .....

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1. Individual Student
2. Student Organization
3. Grad Student
4. Student Group (Two or more students)
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Title of exhibit .....

General description of exhibit (include any special exhaust or power requirements)

Place this form in the Engineering Exposition mailbox in the M.E. lobby.

If you have any questions contact Dean Taylor, 257–4901 or Chuck Scalia, 255–3581.

***NOTE:** No company may be given credit, in the form of a courtesy or otherwise, in any student classified exhibit. If it is necessary to give credit before the company will consent to lend materials, the materials can not be used and the exhibit will not be allowed to set up.*




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VOLUME 69, NUMBER 5 FEBRUARY 1965

ARTICLES



# THE WISCONSIN ENGINEER

*The Student Engineer's Magazine Founded in 1896*

FEATURES



THIS MONTH'S COVER

*With Madison mayoralty elections approaching, Urban Renewal is making the headlines daily. For a dicussion of MRA, and the pros and cons of the subject of Urban Renewal, see page 12.*

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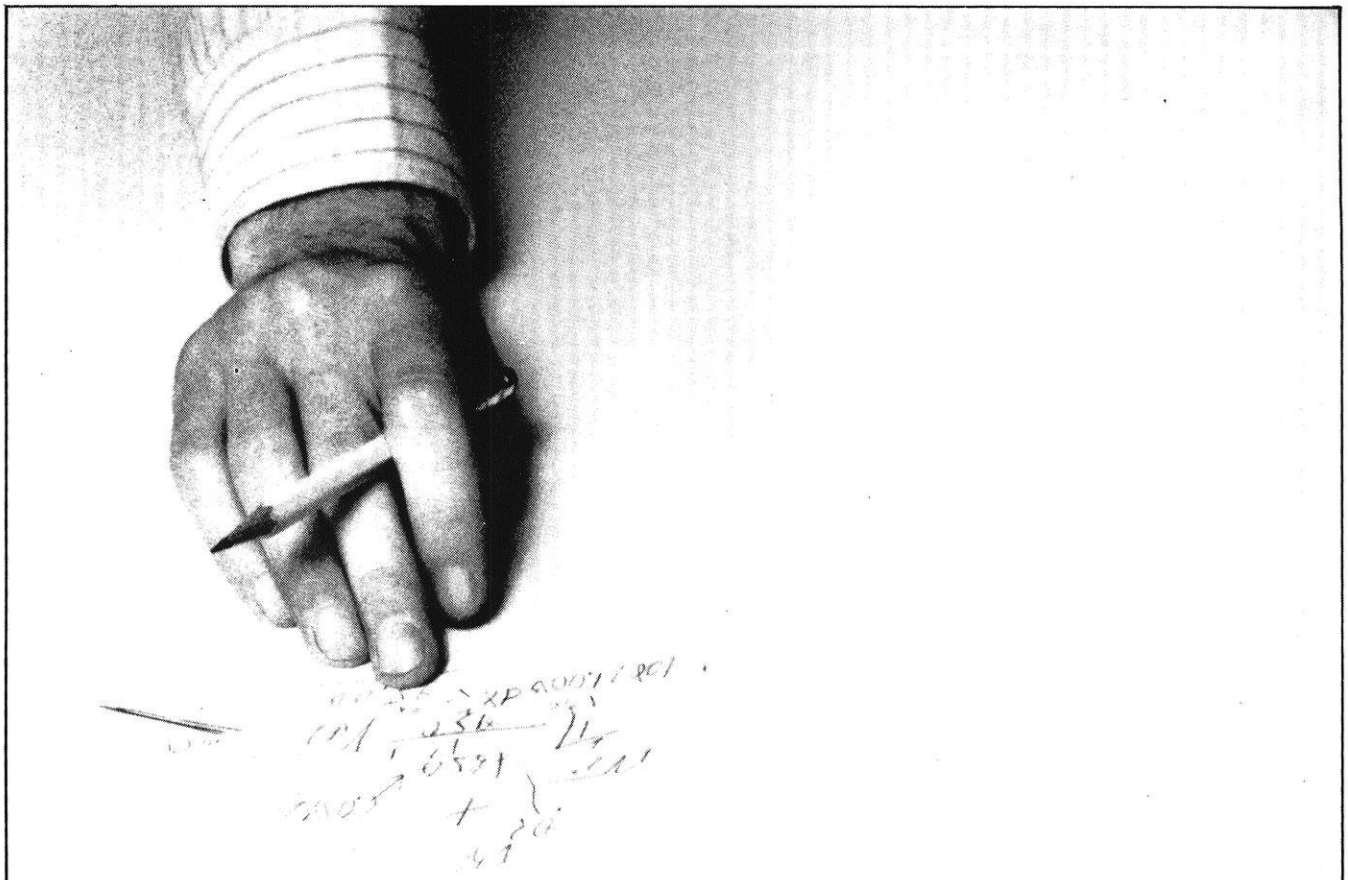
# What is a chemical engineer doing at NCR?



Lots of things. With a BS, MS or Ph.D. in chemical engineering, he may be working with plastics, polymers, inks, paper, metals, foods or pharmaceuticals.

In NCR's Finishes Control Laboratory, his assignment might deal with new process design for electro or electroless plating. Or with new etching techniques for printed-thru-hole circuit boards.

In Chemical Development, he might be working with special paper products for business systems (such as carbonless transfer and thermocopy paper, punched cards, and tape). He might be developing new media storage by changing materials and coating techniques.

In the Plastics Laboratory, you may find him evaluating new materials, determining new methods of production, developing new processes or improving old ones.

Capsular Research and Product Development would involve him in NCR's unique microencapsulation process which locks up a material in a microscopic capsule for subsequent release. This has applications in such fields as pharmaceuticals, foods and adhesives.

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# Across the Editor's Desk

## COMPLAINT DEPARTMENT

If we had an aggravation award, we certainly could have many deserving recipients in mind. By presenting it to this month's candidate, we could do a service to the City of Madison and the University of Wisconsin. Perhaps a bit of verbal lambasting will suffice.

Just to make it a little more interesting, let's make it a game—we'll give you some clues, and you give yourself one point for each one you have to use until you get the right answer:

1. The recipient is not a person but a corporation.
2. The corporation operates wheeled vehicles in the campus area.
3. The wheeled vehicles are big and ugly.
4. They roll on steel at a snail's pace.
5. They make us late for classes.
6. They make it difficult to get to the H-T.
7. They succeed in backing up traffic on three of Madison's busiest arterial streets for block after infinite block.

Scoring: 1—you cheated, 2—you're a junior or senior, 3 or more—you don't drive or walk around much.

Admittedly, it's the nature of these freight trains of the Milwaukee Road to lumber along in an endless queue. They have to do it. But, we plead, do they have to get in the way at the hours of peak traffic flow on Johnson Street, University Avenue, and Dayton Street? Isn't the traffic problem severe enough without a steel barrier during the morning and afternoon rush hours?

### CASH FOR YOUR TALENTS . . .

We invited your attention to the Student Exhibits division of the 1965 Engineering Exposition. Information is available on bulletin boards, departmental offices or at the *Engineer* office, 333 ME. There's an application and entry form on page 6. We hope that you clip it out and use it.

R. J. SMITH

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# "we explore freely . . .

***and no restrictions are set upon our imagination."***

The speaker was a brilliant young Navy scientist discussing his work, and he might well have been referring to the Naval Ordance Laboratory at White Oak, Maryland, where technological explorations are pursued to the ultimate advantage of the nation's posture of defense.

Who would have thought, especially before the advent of POLARIS, that a submarine could someday fire what appears to be an ordinary torpedo which would, a few seconds later, take off upwards into a ballistics trajectory . . . drop its rocket motor somewhere down-range . . . re-enter the water intact at supersonic speed . . . automatically arm itself . . . and let loose a nuclear blast that will decimate any number of submerged hostiles?

Today, SUBROC promises to be the deadliest anti-submarine warfare weapon ever devised, but when it was first dreamed up by NOL scientists back in 1957 it presented the thorniest set of problems yet to face the still-young missile age. That SUBROC itself, together with its sonar detection system and special digital computer fire control system, are almost ready for fleet use is a real tribute to NOL's creativity, technical direction, and test & evaluation capabilities.

But SUBROC—although an undertaking of incredible proportions—is just one in a long series of NOL projects in anti-submarine warfare, air and surface weaponry, aeroballistics, chemistry, explosives, and materials research. Many such dreams have become reality at NOL—seven new magnetic materials that have sharply upgraded magnetic amplifiers, magnetometers, and electromagnetic transducers . . . new ways to measure drag, stability, and heating effects of missiles traveling in excess of Mach 10 . . . the arming and fuzing devices for POLARIS . . . a new data reduction method for underwater acoustics that opens the door to *passive* sonar ranging . . . two new nuclear depth bombs . . . and literally hundreds more.

There are more than 1,000 graduate professionals at NOL-White Oak today, but the Laboratory is always interested in talented explorers—especially those delving into aero and electro technologies. And, to help you explore more freely (and productively), NOL offers:

- assignments of national importance
- the finest equipment and facilities to be had (900 acres of them)
- several programs for advance degrees in cooperation with Washington-area universities. The University of Maryland even holds some courses on NOL premises which you may attend during working hours. (NOL has always been fertile ground for PhD theses.)
- the stimulus of working with top people in their specialties, many of whom are staff members and lecturers at colleges and universities.
- the added stimulus offered by the Washington environment, now one of the top four R & D centers—private as well as government—in the country.

The same young Navy scientist we quoted earlier also remarked: ". . . *if a scientist wants the freedom to satisfy his intellectual hunger and open doors now closed to him, his best bet is to work for the Government.*"

**NOL**

Check your College Placement Office for news of NOL interviews on campus, or write Lee E. Probst, Professional Recruitment Division, **Naval Ordnance Laboratory**—White Oak, Silver Spring, Maryland, for more details. The Navy is an equal opportunity employer.

*Lajos Wernigg, a Junior in civil engineering is married and the father of two children. An interest in city planning was the inspiration for this article. Lajos immigrated to the United States from Budapest, Hungary after the revolution there in 1956, and studied English at Georgetown University prior to entering UW.*

# The Pros and Cons of Urban Renewal

By LAJOS M. WERNIGG

## INTRODUCTION

WHY should a plan to clear our slums in this United States be a controversial matter? Why should building new apartment houses with bathrooms, running water, and furnaces to replace unkept and substandard housing cause opposition from so many people? It is an established fact that urban renewal is a necessity for present day cities. Why, then, do attempts at these projects often appear to many people as failures?

The problem of urban renewal is an old one. For many years people in large cities have attempted to clear their slums. Today with our increasing population, this problem has become very real to the average citizen. In our city of Madison, Wisconsin, we voted on a referendum in the spring of 1964 on whether to dissolve Madison Redevelopment Authority (MRA). Many of us also were asked to sign petitions to save our houses from being torn down. I believe every citizen should be informed of the advantages and the pitfalls of urban renewal. He then will be able to make an intelligent decision when asked to vote on this issue.

## SHORT HISTORY OF URBAN RENEWAL

The seeds of city planning were planted in the United States when the World Fair, called the Columbian Exposition, opened its gates in Chicago in 1893. In the Nineteenth century, industrialization brought more and more people into the cities, which were full of smoke and soot and the cities became cramped, monotonous and ugly—while the fair was big, broad and beautiful. The people were awakened by this contrast and the movement of "classic revival" was launched. Every large city strived to become the "City Beautiful". At first, monumental plans were made without paying attention to economics and usefulness. Then came the practical men, free of dreams, and city planning became an engineering process.

The necessity for governmental guidance and assistance was recognized, as it became apparent that private enterprise alone was not able to stop the physical decay that had eaten deeply into the urban community. The blight has been found everywhere: in the business and industrial districts, downtown, and in the outskirts of the city. It undermines civic pride, and breeds crime and delinquency. It causes municipal bankruptcy, traffic deaths and injury. It was found in a survey of cities that only six per cent of the cities' revenue came from slums, but these areas cost forty-five per cent of the total expenditures for urban services.

"The legitimate object of government", said Abraham Lincoln, "is to do for a community of people whatever they need to have done but can not do at all or can not do so well for themselves in their separate and individual capacities."[1] As this need for government assistance became clearer, bills were introduced in Congress concerning urban redevelopment. The Housing Act of 1949 was passed by the 81st Congress and became a law.

The Housing Act of 1954 extended the role of the federal government from simple redevelopment to urban renewal after it was found in 1953 that the slums were still growing faster than they were being cleared. This Act was further implemented in 1956, 1959, and 1960.

As urban renewal stands now, it is a joint venture by local and federal governments with private enterprise. The rules are set up by Congress, but the initiative and hard work to make it a success rests with the citizens of the community.

One of the most successful urban renewal projects ever undertaken, is the Rockefeller Center (See Figure 1). This unique 15-building development on Manhattan Island is the world's largest privately owned business and entertainment center. It occupies approximately 12.5 acres on a piece of land that previously had more than 200 obsolete structures.

## INEFFICIENT PLANNING AND QUESTIONABLE PROCEDURE

In our cities, congestion created high land values that were augmented by the lack of regulations limiting land use. This situation very often touched off unlimited speculation in real estate.

Laws for urban renewal provide for the sale or lease of cleared land to a private redeveloper. This

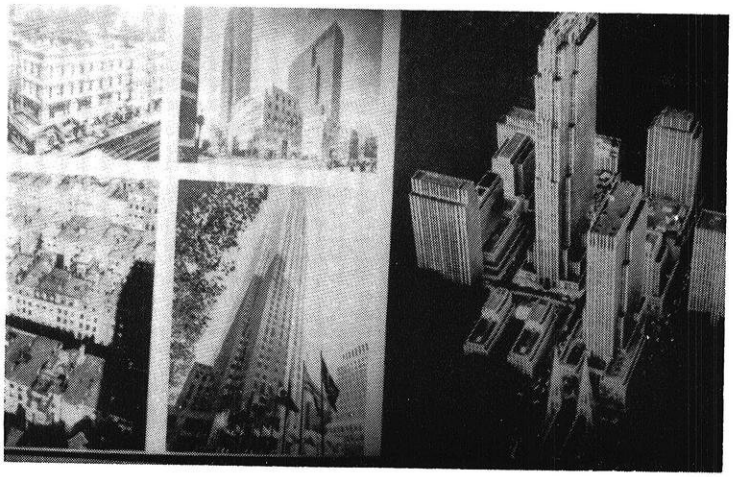


Figure 1.—The old (left) and new (center and right) in Mid-Manhattan, New York City.

raises the question as to the advisability of this procedure. The price received for these parcels is always much less than the cost of buying and clearing the areas. The United States Housing Home Finance Agency (HHFA) absorbs two-thirds of the resulting loss. Why are the taxpayers required to pay for this, when the land is then handed back to the same abuses that have made urban renewal necessary? The public interest is served by bringing the land price down to an economic value for redevelopment, but this subsidized price is an inducement to engage in urban redevelopment for profit. This is a distortion of the purpose for which urban renewal was designed.

One example of this was seen in Washington, D. C. The city's redevelopment agency paid the Washington, D. C. Transit System, of which O. Roy Chalk is president, $1,266,065 for some real estate. They later leased it back to his company, Chalk House West, Inc., for 99 years at a bargain rental price.

We have had frequent controversies over renewal here in Madison, Wisconsin. Many citizens resent the way the Madison Redevelopment Authority handled the local urban renewal project. The Authority sold part of the cleared land to a redeveloper, who was the only one interested in buying that property. The rental units built by the redeveloper (see Figures 2 and 3) were too expensive for the people who were displaced from the area. Large families who had lived in a two-or three-bedroom apartment, or house, could now rent only a small one-bedroom apartment in the new buildings, with the same amount of money. As Professor Bruce Davidson has said, anyone who used to rent a room now can rent only a bathtub to sleep in.

The price of low-rent housing was already inflated in Madison, Wisconsin because of the inadequate supply, and the large demand by low-income families anl University students. After the urban renewal project was implemented, the shortage of low-cost units became more acute. This helped to maintain high prices on the still-available "low cost" and substandard housing.

This is in contrast to the national goal under President Johnson's Administration, which is for the elimination of poverty in America. The kind of urban renewal that I have described above helps the slum landlords get richer, instead of helping the poor tenants.

## POLITICS IN URBAN RENEWAL

### Madison Redevelopment Authority

One of the major obstacles in the path of urban renewal is politics. Many of those who make the decisions of urban renewal are more interested in re-election than in their peoples' interests.

One of the hottest political issues in the last election in Madison, Wisconsin, was urban renewal. (See cover). It all started with the Triangle Renewal Project. Many people resented the relocation of Negro families to white neighborhoods. These people brought pressure on their aldermen to work against urban renewal. Other aldermen were unseated by opponents in the last election, because they favored urban renewal. The combination of political pressure and new aldermen brought about a majority of opposing votes to urban renewal.

The action of the Madison, Wisconsin City Council the last few weeks shows the results of this public pressure. The resignation of the director of MRA, Mr. Roger Rupnow, exemplifies the effects of this pressure. He resigned after criticisms from the City Council because of his buying property in an area near the University of Wisconsin, which is to be studied for a possible urban renewal project. A short time after Mr. Rupnow's

Figure 2.—Madison, Wis., rental units.

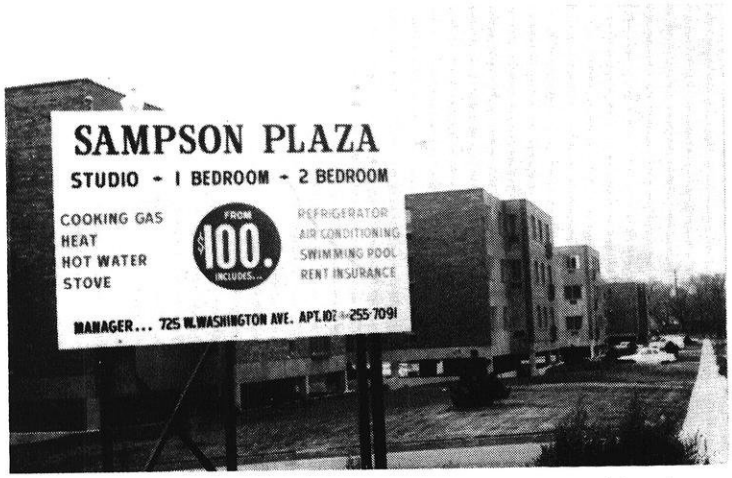



Figure 3.—The sign explains the terms of the renewal units.

resignation, the aldermen voted to stop all possible urban renewal projects in Madison for one year, with the exception of those already in progress.

### Political Machine in Control of Local Government

One of the suggested ways of solving the spread of blight in the cities is the municipal ownership of the land, as in many cities in Europe. However, there are several drawbacks to this type of solution. One of them is found in the control of local government by a political machine, an unfortunate situation prevalent in many metropolitan areas. Lands held by such municipalities can be the source of graft and corruption. Serious problems in the areas of housing and redevelopment have been exposed from time to time, and there is no reason to expect that some individuals will stop trying to have public officials turn public assets over to them for little or nothing. This political favoritism and corruption exists now in urban renewal, because some public officials can be tempted to allot choice parcels of land to friendly individuals, or to an inner ring of political professionals.

### Code Enforcement

The government has power to stop the development and growth of blight in urban areas. Codes and code enforcement are important tools for municipalities in this respect:

1. The purpose of zoning codes is to regulate land use, the location and height of buildings, type and architectural design, and density of land occupancy.
2. Building codes set standards for materials to be used for construction, and detail the requirements for walls, partitions, and similar components.
3. The health codes require regular inspections to check over-crowding, sanitation facilities, and preparation, service, and storage of food.
4. Fire prevention codes are concerned with such things as storage of wastes and flammable materials, proper insulation of walls, and sufficient exits.

Strict code is contrary to the interest of the man who runs for public office and is not concerned with the public interest, but simply with winning an election. The money for his campaign support does not come from the unfortunates who live in the slums or those displaced by urban renewal, but from those who make money from the unfortunates' miseries. His concern is to carry out the wishes of his contributors, and not to interfere with property owners, and to give a free hand to developers of cleared land in urban renewal areas.

The question arises about zoning procedures of the Madison Triangle and Brittingham Park urban renewal projects, in Madison, Wisconsin. As shown in Figures 2 and 3, the developer was allowed to build multi-family apartment houses with relatively high rent, when there was a great need for housing for low-income families. This action necessitates the construction of subsidized public housing by the Madison Housing Authority (MHA). This means that additional public funds have to be spent.

There are other enforcement problems due to an insufficient number of inspectors, corruption of inspection officials, complaints that the courts tend to favor property owners rather than enforcement officials in code-enforcement cases, and habitual code violators.

### "The Sad Little Story of Wink"

The urban renewal in the village of Wink, Texas, can serve as a good example of the results of political favors, lack of foresight in plannig, and extravagant financing.

The last census gave Wink a population of 1863. It was a town of 15,000 at one time, but after the collapse of the local oil boom, the people moved away. Wink started to become a "ghost town" when they heard about urban renewal. They voted to try for some Federal Funds for an urban renewal project.

The Urban Renewal Administration encouraged them to "think big". When the project temporarily seemed to get stuck in Washington, D. C., a Wink booster appealed to Vice-president L. B. Johnson, a fellow Texan. Soon "a Santa Claus came to Wink", a visiting newspaper man wrote. The town received $891,868 as a grant and $1,034,758 as a loan. That amounted to $1,034 per capita. If renewal funds were given on the same basis per capita as in Wink, to some other metropolitan areas, the approximate figures would be fantastic:

| | |
|---|---|
| Houston | $ 969,000,000 |
| Milwaukee | 1,240,000,000 |
| Chicago | 6,600,000,000 |
| New York | 9,600,000,000 |

Because of lack of opportunities in the city, some local residents predicted that the money they received would be the "get-away" money for many, and Wink would be a well-laid-out city with no people.

These predictions seemed to be right. Since the renewal started, the population declined by about 300. Many left-over businesses have moved away. There are acres of paved surfaces, streets and parking lots left from the never-materialized projected "great shopping center". There are "For Sale" signs on many of the better houses.

## THE ESSENCE OF URBAN RENEWAL IS PEOPLE

As urban renewal progresses, we can see evidences of improvement in the bulldozers clearing the slums and later the building of new modern apartment houses. But what becomes of the people for whom these projects are intended? Very often as the urban renewal program moves ahead, the underlying purpose is forgotten: "re-creation of an urban environment in which the functions of the contemporary city can be performed with order." We may also be guided by Aristotle's advice: "A city should be built to give its inhabitants security and happiness."[1]

### The Right to Own Property

There seems to be no limit to the power of a city government if it chooses to condemn an existing building. In the name of urban renewal, well-kept, neat and clean houses may be doomed if they fail to meet some modern standards set up. "What if its owners liked it that way?" said E. Barrett Prettyman, a well-known Washington, D. C. judge. "The poor, the slow, the old, the small in ambition have no less right to property than the quick, the young, the aggressive. Are such questions to be decided by the government?"

The handling of Erieview Project No. 1 in Cleveland, Ohio, touched off much furor. When the project was proposed, almost everybody in Cleveland thought it would benefit their city greatly. There was one problem, however. Urban renewal regulations state that federal aid in demolition jobs can be given only to areas not worth saving. Before the project was planned, most of the 118 buildings were judged sound by Cleveland housing inspectors. In order to get federal aid, they arbitrarily reclassified 84 buildings as "substandard", and scheduled for demolition. One of these was valued at $660,000 and lacked only self-closing devices on some doors and the cellar needed cleaning. A 12-year old building valued at $80,000 met the same fate when the only violations were in the "pointing of the chimney and venting of the toilets."

Some stunned property owners went to court. The judge ruled that since the city council had approved the Erieview plan, there was nothing they could do. The Ohio Supreme Court refused to hear their cases because there was "no debatable constitutional question".

### Relocation Problems

When an area is cleared in order to make way for new apartment buildings during renewal, what happens to the families whose homes are torn down? They must move, to be sure. This imposes an inconvenience to most and a real catastrophe to some.

In the case of old people, this uprooting is most painful. The reasons for difficulty in relocation may be:

1. They have emotional attachments to their home.
2. They live in a close-knit neighborhood where the people speak their native tongue; and have real difficulty communicating in English.
3. On their limited income from social security or retirement, they are unable to make monthly payments on a home. The money they received from their old home is not enough to buy a new home.
4. They are unable to adjust to apartment-living (no yard nor garden, and noisy, close neighbors).

An example occurred in Madison, Wisconsin, which shows what can happen. A seventy-year-old lady had a house in which she rented a room to a student to supplement her limited income from Social Security. She was a diabetic and needed the services of a Visiting Nurse daily. According to her income, the fee for the nurse was regulated at 25¢ per day. When the renewal program went into effect, her house, although it was sturdy and clean, was torn down. She received a generous sum for her house, but this was not enough to buy a new home. Because of her increased income from the sale of her house, the Visiting Nurse Service increased their fee to $4 per day. This lady was unable to rent an apartment for less than $80 per month.

It can be seen that she will eventually run out of funds, and will be forced to live on welfare. This is emotionally upsetting for a proud old lady who has always paid her own way.

Young people do no find it so difficult to make changes in their living quarters, or friends. However, if they have a limited income, they may have a great deal of trouble finding an apartment with rent they can afford.

In some cities, urban renewal has essentially meant "Negro removal". When low-income Negroes are forced to move into a non-white section, this probably means that they will congregate in an area which nearest resembles the slum from which they were removed. Because of the habits of these Negroes who have lived all their lives in a slum district, the new area will rapidly deteriorate and be the city's new slum.

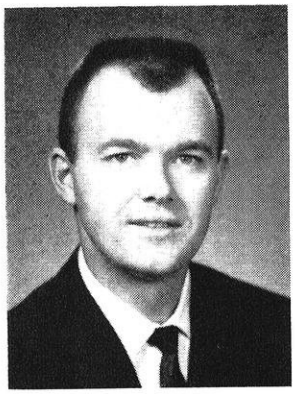
## CONCLUSIONS AND RECOMMENDATIONS

Hearing and reading about the difficulties with urban renewal makes people think: is it worth while to continue? We cannot deny that there are many problems, but the picture is not as black as many think.

Because of the policy of the news media that bad news is the only good news, the general public often does not know about the progress that has been made in urban renewal. What they read in newspapers and magazine articles is just one side of the story, especially when the articles are politically motivated.

What can hurt urban renewal also has other effects in our society.

*(Continued on page 27)*



*Jim Horton is a Milwaukee native in his last semester of mechanical engineering. A member of the Hoofer's Ski Club and Sailing Club, and the AIIE, Jim plans on being employed as an industrial engineer after graduation. Interest in the idea of an organized means of analyzing a complex situation inspired Jim to write this article.*

# PERT: A Management Tool

By R. JAMES HORTON

PERT is a management tool which provides its user with a means of evaluating progress and knowledge which will aid him in the effective allocation of manpower, materials, and equipment.

PERT forces the user to plan in advance every move he will make. This is done by means of a network which graphically displays the individual tasks to be performed and their relationship to each other and the ultimate goal.

Prior to the introduction of PERT in the mid-1950's, it was virtually impossible to plan and organize the many tasks which make up a large project into one integrated whole. The human mind is unable to cope with the complexity involved with organizing many inter-related tasks. As a result management has often been ineffective and inefficient.

PERT has been so successful in overcoming the uncertainties and complexities associated with large-scale management and planning that it is now realistic to speak in terms of an overall "Master Plan."

## INTRODUCTION

Today's manager must effectively control the use of manpower, material, and facilities. To aid him in this task, many techniques, such as Gantt charts and milestone charts have been developed. One of the more recently developed of these techniques is PERT (Program Evaluation and Review Technique).

## PERT AND ITS ORGANIZATION

### What is "PERT"

PERT is a pictorial representation of the chronological relationship between the events and activities that make up a large project. The large project may be as complex as the Manhattan Project of World War II or as simple as a man working at a machine.

### Activities and Events

In PERT the large, total, overall project is represented by a spidery network of lines which connect a number of nodes (see Figure 4). The network is then made up of smaller time consuming elements called activities. The activities are represented by lines with arrow heads at their tips. An event represents a milestone or point in time but is not time consuming. It is designated by a circle. Activities always take place between two events. For example, the activity "unpack and install equipment" could come between the events "equipment arrived" and "equipment installed." Figure 1 shows how this would be represented in the PERT network.

### Multiple Activities and Events

Figure 1 shows the simplest type of relationship in the PERT network; one activity follows an event and the second event occurs after the completion of only one activity. The more usual situation would be one in which an event was followed by more than one activity, or one in which more than one activity preceded an event. As an example of multiple activities following an event, the event "production approval" could be followed by the activities "market study" and "acquire production equipment." This configuration is illustrated in Figure 2.

As an example of multiple activities preceding an event, the event "begin production" might be preceded by the activities "hire production personnel" and "acquire raw materials." This configuration is illustrated in Figure 3.

### Principle of Concurrency and Dependency

In all cases the overriding principle involved is that all activities preceding an event must be completed before any activity following


**Figure 1.—PERT Representation of Event; Activity-Event.**

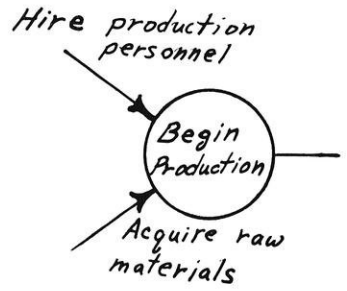



Figure 2.—Multiple activities following an event.

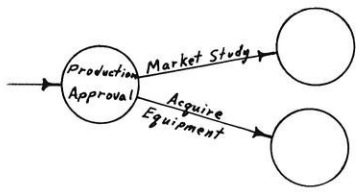



Figure 3.—Multiple activities preceding an event.

that event can be started. With the principle set down we are now in a position to understand that activities may take place concurrently or dependently. When the activities take place concurrently as do "hire production personnel" and "acquire raw materials" in Figure 3, they may both be in progress at the same time. Again in Figure 3, the activity following the event "begin production" may not proceed until both activities preceding the event have been completed. This activity is dependent on the event "begin production" which in turn is dependent on the two preceding activities.

### Activity Times

Each PERT network is drawn for a specific project and a specific level of management. The group that participates in the network contsruction should be limited to around five people and should contain the person directly responsible for the end result of the project. When the network has been completed, each of the individuals who will be responsible for a specific activity will be asked to submit three estimates of the time that will be required to complete that activity. These three time estimates will be:

1. to: Optomistic time—time required under unusually good conditions (approximate probability of realization = .01).
2. tm: Most likely time—time required under average conditions.
3. tp: Pessimistic time—time required under unusually poor conditions (approximate probability of realization = .01).

The above definitions for each time value should be used by the estimator only as an aid to understanding. From the three estimated times the expected time (te) is calculated from formula 1:

$$te = \frac{to + 4m + tp}{6} . \qquad (1)$$

There is a 50% statistical probability that the activity will be completed by the expected time, te. Each activity in a network has the four previously mentioned times-associated with it. Hereafter, any activity time referred to will be the expected time unless otherwise stated.

## EVENT TIME CALCULATIONS

Figure 4 is an example of a PERT network. This network will be used in the discussion that follows. In this network the events are numbered beginning with one and ending with eight, and the expected times are printed above the activities.

### Using A Pert Worksheet

Table 1 illustrates an orderly manner for carrying out PERT calculations.

Start by listing the final event in the successor event column. Next, in the predecessor event column, list all the preceding events, each on a separate line. When this is completed, proceed to the next numerically largest event and list it in the successor event column. In the predecessor event column list all the preceding events. Continue this procedure until all events are listed in the successor event column. The first event will not be a successor event and will not appear in this column. The four activity times for the activity between the successor and predecessor event will be listed on the line containing the predecessor event. With the material so arranged the calculations for TE, TL, and slack are much simpler.

### Earliest Expected Time

The first computation we will be concerned with in respect to the PERT network is the earliest expected time, TE. (Notice that event times are represented by capital letters, whereas activity times are represented with lower case letters.) TE is the earliest time after the start of the project that an event may be expected to be completed. This is the accumulation of all the preceding activity times along the longest path from the beginning of the project to the event in question. It may at first seem contradictory that the longest path should be the earliest expected time. However, the reader should remember that an activity following an event cannot begin until all preceding activities have been completed. It is therefore the longest path through the network to an event that will determine the earliest time an event can be expected to be completed. Each event will have an earliest expected time.

TABLE 1.—PERT WORKSHEET

| Successor Event | Predecessor Event | tp | tm | to | te | TE | TL | Slack |
|---|---|---|---|---|---|---|---|---|
| 8 | 7 | 5 | 3 | 1 | 3 | 12 | 12 | 0 |
| | 6 | 7 | 6 | 5 | 6 | | | |
| | 3 | 6 | 4 | 2 | 4 | | | |
| 7 | 5 | 5 | 3 | 1 | 3 | 9 | 9 | 0 |
| | 4 | 4 | 3 | 2 | 4 | | | |
| 6 | 2 | 3 | 2 | 1 | 2 | 4 | 6 | 2 |
| 5 | 2 | 6 | 4 | 2 | 4 | 6 | 6 | 0 |
| 4 | 2 | 3 | 2 | 1 | 2 | 4 | 5 | 1 |
| 3 | 2 | 5 | 3 | 1 | 3 | 5 | 8 | 3 |
| 2 | 2 | 3 | 2 | 1 | 2 | 2 | 2 | 0 |

The TE for an event can be determined by adding to the preceding TE the activity time between the two events. See Formula 2. TE for Event 1 is zero.

$$\text{TE (successor event)} = \text{TE (predecessor event)} + \text{te (activity)}. \quad (2)$$

When an event is preceded by more than one activity, more than one TE will be calculated. In this case the largest will be used and the others discarded. For example, in Figure 4, TE for Event 7 will be nine time units. This is the sum of activity times along path 1–2–5–7. While the sums of the activity times along path 1–2–4–7 can be completed in eight time units, this cannot be considered the earliest expected time, since the activity following Event 7 cannot be started until all preceding activities have been completed. This requires nine time units. The earliest expected time for Event 8, the end of the project, is 12 time units and follows path 1–2–5–7–8. This is also the critical path, which will be discussed in more detail later.

## LATEST ALLOWABLE TIME

Looking at the PERT network from another point of view, we might ask ourselves, what is the latest time after the beginning of the project that a particular event can be completed without affecting the schedule completion time of the project? This is called the latest allowable time, TL. TL is the difference between the scheduled completion time and the accumulation of activity times along the longest path backward from the final event to the event in question. The TL for the final event will be, by definition, the scheduled completion time. If there is no scheduled completion time, the TL for the final event will be set equal to the TE for the final event. Beginning at the final event, TL for the preceding event will be TL for the succeeding event less the intervening activity time. See Formula 3.

$$\text{TL (predecessor event)} = \text{TL (successor event)} - \text{te (activity time)}. \quad (3)$$

When an event is succeeded by more than one activity, more than one TL will be calculated. In this case the smallest will be used and the others discarded. (Also see Table 1.) For example, in Figure 4 the latest allowable time for Event 2 is two time units after the start: latest allowable times for Event 2, figured backward along paths 8–3–2, 8–7–4–2, 8–7–5–2, and 8–6–2, give TL's of 5, 3, 2, and 4 respectively, and 2, the smallest, is the one which is used.

### Slack

Slack is the difference between the time an event can be completed and the time it must be completed if the project is to meet the scheduled completion time. Slack = TL (event) — TE (event). The event slack may be positive, negative, or zero, depending upon whether the project's scheduled completion time is greater than, less than, or equal to the project's TE. Positive slack indicates time to spare, negative slack indicates that time must be made up. If there is zero slack, the project must run as it is set up, in order that it be finished by the scheduled completion time. For example, in Figure 4, Event 3 has a slack of three time units. We may expect that Event 3 may be completed in five time units. However, as long as it is completed by the eighth time unit, there will be sufficient time to complete the remaining activities by the twelfth, time unit, the scheduled completion time for the project. Event 3 has 8 — 5 = 3 time units of slack. Slack affects the entire path, not just one activity. Therefore, all events on the same path will have the same slack.

### Critical Path

The critical path will be that sequence of events and activities that requires the longest time to complete. The critical path is easily traced through a network by means of a comparison of slack times. The value of slack for all events on the critical path is equal and is the smallest positive or largest negative value. For example, the critical path in Figure 4 is 1–2–5–7–8. This is easily verified, since the slack for these events is zero and the slack for all other events is positive.

### Probability of Meeting Schedule

With the data at hand, it is a relatively easy matter to determine the probability of completing the project by the scheduled completion date. The first step is to calculate the value Z.

$$Z = \frac{TS - TE}{\sum\left(\frac{t_p - t_o}{6}\right)}.$$

1. TS = scheduled completion time
2. TE = earliest expected time for the final event
3. $\sum\left(\frac{t_p - t_o}{6}\right)^2$ is evaluated by following steps

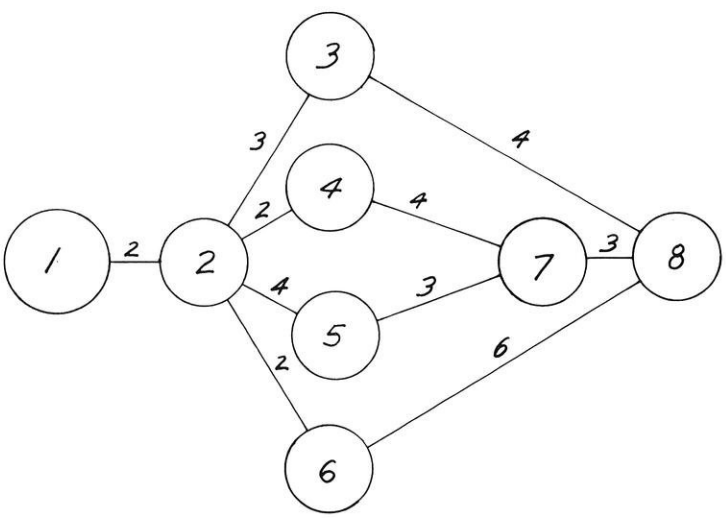



Figure 4.—A complete PERT weekend with numbered events and with expected times printed above the activities.

*a* through *e*. (Also see example in Table 2.)

a. Pessimitic time minus optomistic time.
b. Divide quantity *a* by 6.
c. Square quantity *b*.
d. Repeat *a*, *b*, and *c* for all activities on the critical path.
e. Add all the results of *c* together.

The second step is to look up the calculated value of Z in Table 3 and read off the corresponding probability. For example, if TS = 12.36, TE = 12, and $\Sigma = 1.443$ are substituted, then Z is +.03 and the probability of completion by the scheduled completion date will be 62%. This says that if this project were performed one hundred times, it would be completed on schedule sixty-two times. It should be noted that if the scheduled completion date is the same as the earliest expected time, the numerator of the value Z will be zero and the denominator need not be calculated. In this case Z is zero and, as can be seen from the table, there is a 50% probability that the project will be completed on schedule.

**TABLE 3.—PROBABILITIES CORRESPONDING**

| Z | Probability of Completion | Z | Probability of Completion |
|---|---|---|---|
| 0.0 | .50 | 0.0 | .50 |
| —0.1 | .46 | 0.1 | .54 |
| —0.2 | .42 | 0.2 | .58 |
| —0.3 | .38 | 0.3 | .62 |
| —0.4 | .34 | 0.4 | .66 |
| —0.5 | .31 | 0.5 | .69 |
| —0.6 | .27 | 0.6 | .73 |
| —0.7 | .24 | 0.7 | .76 |
| —0.8 | .21 | 0.8 | .79 |
| —0.9 | .18 | 0.9 | .82 |
| —1.0 | .16 | 1.0 | .84 |
| —1.1 | .14 | 1.1 | .86 |
| —1.2 | .12 | 1.2 | .88 |
| —1.3 | .10 | 1.3 | .90 |
| —1.4 | .08 | 1.4 | .92 |
| —1.5 | .07 | 1.5 | .93 |
| —1.6 | .05 | 1.6 | .95 |
| —1.7 | .04 | 1.7 | .96 |
| —1.8 | .04 | 1.8 | .96 |
| —1.9 | .03 | 1.9 | .97 |
| —2.0 | .02 | 2.0 | .98 |
| —2.1 | .02 | 2.1 | .98 |
| —2.2 | .01 | 2.2 | .99 |
| —2.3 | .01 | 2.3 | .99 |
| —2.4 | .01 | 2.4 | .99 |
| —2.5 | .01 | 2.5 | .99 |

*Adapted from the normal distribution.

## CONCLUDING REMARKS

### Brief Summary

PERT can be a valuable tool to a wise manager. It will give him a picture of the inter-relatedness of the activities for which he is responsible. This picture will be physical in one sense, because he has the network to look at, but it will also give him another view. He will be able to see the interrelatedness of times. This is because each event will have associated with it a starting time and a completion time. Because he knows the slack of events, he will know whether he can postpone a starting or completion time and if so, by how much. The manager also has before him the critical path. He knows that any lengthening or shortening of activities along the critical path will lengthen or shorten the entire project. If the project must be completed two weeks ahead of schedule, the extra effort must be concentrated on the critical path. Extra effort applied elsewhere will not reduce the overall project time. If a key man should become incapacitated for a short time, a quick look at the network will tell the manager if someone must be brought in to complete the activity or if this part of the project has enough slack so that the delay will not affect the scheduled completion time.

**TABLE 2.—CRITICAL PATH ACTIVITIES**

| Successor Event | Predecessor Event | tp | to | Step a and b (tp-to)/6 | Step c ((tp-to)/6)² |
|---|---|---|---|---|---|
| 8 | 7 | 5 | 1 | .666 | .444 |
| 7 | 5 | 5 | 1 | .665 | .444 |
| 5 | 2 | 6 | 2 | .666 | .444 |
| 2 | 1 | 3 | 1 | .333 | .111 |
| | | | | | Total = 1.443 (Step d) |

### Critical Path Method

In a situation which is nonrepetitive, such as research or development, it is difficult or impossible to estimate cost. Also, estimates of the time required for activities can be no more than guesses. In such situations PERT finds its main application. However, when cost data are available and activity times can be estimated quite closely, it would seem desirable to have a means for evaluating a project on a cost-time basis rather than a time basis alone. The Critical Path Method is similar to PERT and has the advantage of being able to evaluate a project on a cost-time basis. Once PERT has been learned, it will require only a little more effort to acquire the additional concepts necessary to use CPM. If the reader intends further study, he should plan to investigate both methods.

### Conclusions

In conclusion, three strong points of PERT are:

1. PERT forces complete, logical planning.
2. PERT provides a means of progress evaluation.
3. PERT provides knowledge necessary for effective allocation of manpower, material, and equipment.

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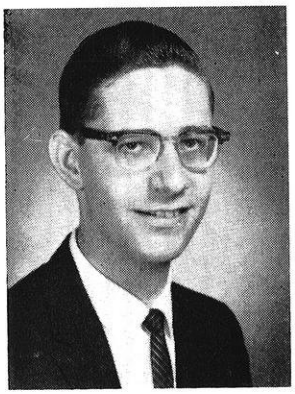


*Glen Scharpf received his BSME last June and is now working on his Master's. A bachelor from Milwaukee, Glen is interested in internal combustion engines and new developments in the field. Automotive or rocket propulsion is the field that this member of Pi Tau Sigma and SAE would like to work in eventually.*

# Power for Tomorrow: The Wankel Engine

By GLEN SCHARPF

## INTRODUCTION

THE purpose of this article is to describe the newest development in the field of internal combustion (IC) engines, the Wankel rotary combustion engine. This engine has attracted much attention among engineers in both the automotive and aircraft industries because it is a successful attempt to replace the present reciprocating masses in IC engines with inherently smoother rotating masses. Therefore, the engine could become an important factor in the future development of all sizes of IC engines.

The article is intended to acquaint the reader with the principles of operation of the Wankel engine and the development work performed by NSU Motorenwerke A.G. in West Germany and Curtis-Wright Corporation in the United States. Included also are descriptions of various applications of this new engine design.

## HISTORICAL BACKGROUND

A practical rotary engine has long been the dream of many pioneers of engine design. Several forms have been proposed, the most popular of which is the rotating internal combustion type. This design has either the piston or both the piston and cylinder housing rotating. The other basic design has a rotating shaft connected to reciprocating pistons, not unlike the modern-day automobile engine, but with a more unorthodox piston arrangement.

### Rotary Engine Designs

The development of the first rotary engines began as soon as the steam engine had become successful as a source of power. Work was being done on both rotary and reciprocating forms, with the rotary design having the advantages of continually rotating parts and consequently providing a smoother source of power. However, the design involving the reciprocating principle was found to be easier to develop and gained wider acceptance, because of the fewer problems involved in the sealing of high pressures and with the operating cycle itself. Through the years, however, many designs have been developed and patents issued for rotary combustion engines.

Where sealing is not a critical problem, as in compressors and pumps, the rotary design has proved superior over conventional reciprocating types. Today many pumps use the rotating principle.

Several developments have occurred within the last forty years to stimulate engineering interest in the rotary engine. In 1923, the Michael engine was developed, followed in 1939 by the Redrup engine. Both are similar, having rotating shafts connected to reciprocating pistons through swash plates fixed to the shafts. In 1961, the Selwood engine was announced. This is a twelve cylinder, two-cycle type having twelve pistons in a round rotating block. Ignition is by twelve spark plugs mounted in the block using slip rings to transmit the current. Announced in the Fall of 1963 was the Renault-Rambler rotary engine, a four-stroke cycle design with five combustion chambers located in a circle with the crankshaft at the center. A four-lobed rotor within the housing produces a changing cylinder volume.

### The Work of Felix Wankel

The German engineer, Felix Wankel, first became interested in rotary engines in 1926, opening an institute in that year to study the problems involved. By 1936, he was working on sealing arrangements for disc valves in rotary-valve engines. This project evolved into a rotary-piston pump used as a supercharger on motorcycles. In 1951, Wankel entered into a joint research agreement with the NSU Motorenwerke A.G. of West Germany.

Wankel had determined that the problems involved in designing a rotary engine were: (1) too many possible arrangements and configurations for the design, (2) difficulty in sealing the high pressures, and (3) problems in determining the correct thermodynamic and gas

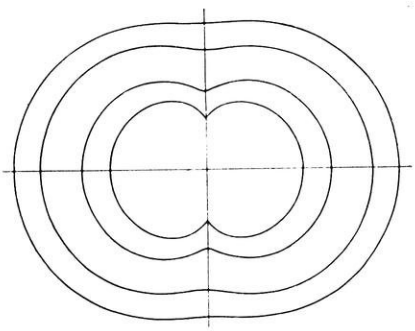


Figure 1.—Epitrochoids.

## ENGINE GEOMETRY

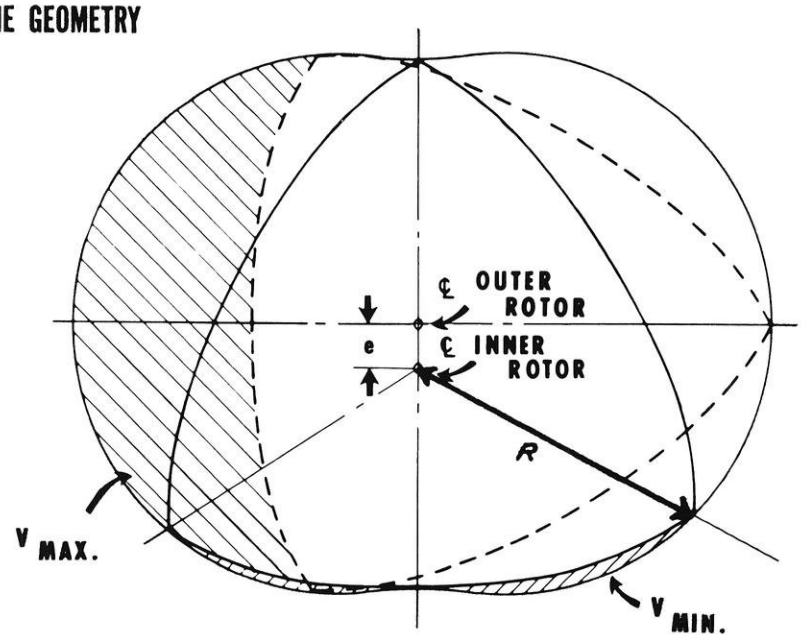



Figure 2.—The geometry of the Wankel engine.

cycles to be used. Overcoming these problems, the first engine was constructed in 1954, producing 32 hp at 17,000 rpm from 125 cu. cm.

### DESIGN CONSIDERATIONS OF THE WANKEL ENGINE

The Wankel engine is not based on any new theories in design. It is new only in its general conception and in its detail design. The basis for the engine design is an epicyclic curve known as the epitrochoid. This curve represents the path traced by a point on the radius of a circle, rolling without sliding on the outer circumference of another circle. The shape of the curve is determined by the ratio of eccentricity e, to the length of the generating radius. When the ratio $X - R:e = \infty$, a circle is formed. When R:e is less than infinity, an elliptic is generated with the waist of the epitrochoid becoming more pronounced as the ratio decreases. A family of basic epitrochoids is shown in Figure 1. The maximum theoretical compression ratio is also determined by this ratio of R to e, the optimum being at approximately six or seven.

#### The Principles of Operation

The Wankel engine has only two major parts, an outer and an inner rotor. As shown in Figure 2, the inner surface of the center housing is in the shape of an epitrochoid. Within this housing is a three-lobed rotor in basically triangular form. The outer surface of this rotor approximates the inner envelope of the epitrochoid when the two rotors rotate relative to each other.

The rotors are mounted with their axes parallel but spaced apart to produce the required eccentricity of the epitrochoid. Two versions of this arrangement are possible. With one, both the inner and outer rotors rotate, producing a specified relative motion. The other arrangement produces this motion by having the inner rotor rotate within a stationary outer rotor.

The actual processes in the combustion cycle are illustrated in Figure 3. The figure shows the three overlapping cycles that exist during one reveloution of the rotor, the single spark plug firing three times to produce three power strokes per revolution. The power is transmitted to the driveshaft through a sun-gear arrangement with the rotor rotating at two-thirds of the output shaft speed. The combustion chamber is formed by the lobes of the faces of the rotor, seen as dotted lines in Figure 3.

Once the basic design of the engine was decided upon, in conjunction with NSU, Wankel focused his attention on the problems of ignition, cooling, and sealing.

#### The Ignition System

The ignition system developed is basically the same as that currently being used in the automotive field. The primary difference is that a transistorized power supply is used to charge the condensor. The condensor then discharges to ground producing a surge of current through the coil primary, generating a secondary voltage which fires the spark plug. In order to reduce erosion and sensitivity to fouling deposits on the spark plugs, the rate of voltage rise from the condensor is four times that used in automotive systems.

To increase the durability of the spark plugs, a cold design is used. Furthermore, to produce a higher compression ratio, the plugs are mounted in the leading part of the combustion chamber. For medium and low ratios, they are positioned in the trailing portion of the chamber.

Using this system, starting has not been a problem with the Wankel engine. In fact, engines up to 45 hp in size have been easily started using a rope and pully arrangement similar to that on outboard motors.

#### The Cooling System

The Wankel engine, because of its unusual design, has in some respects a unique cooling system.

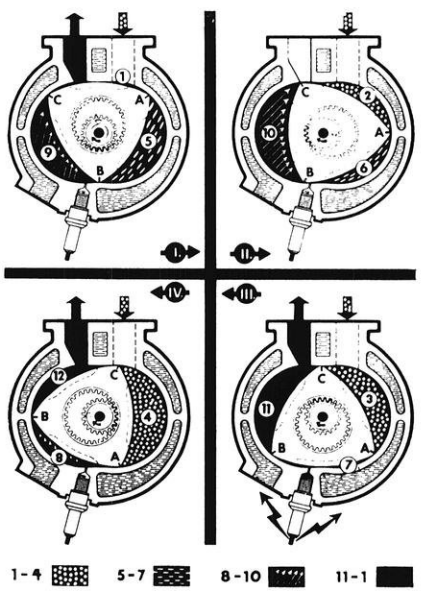
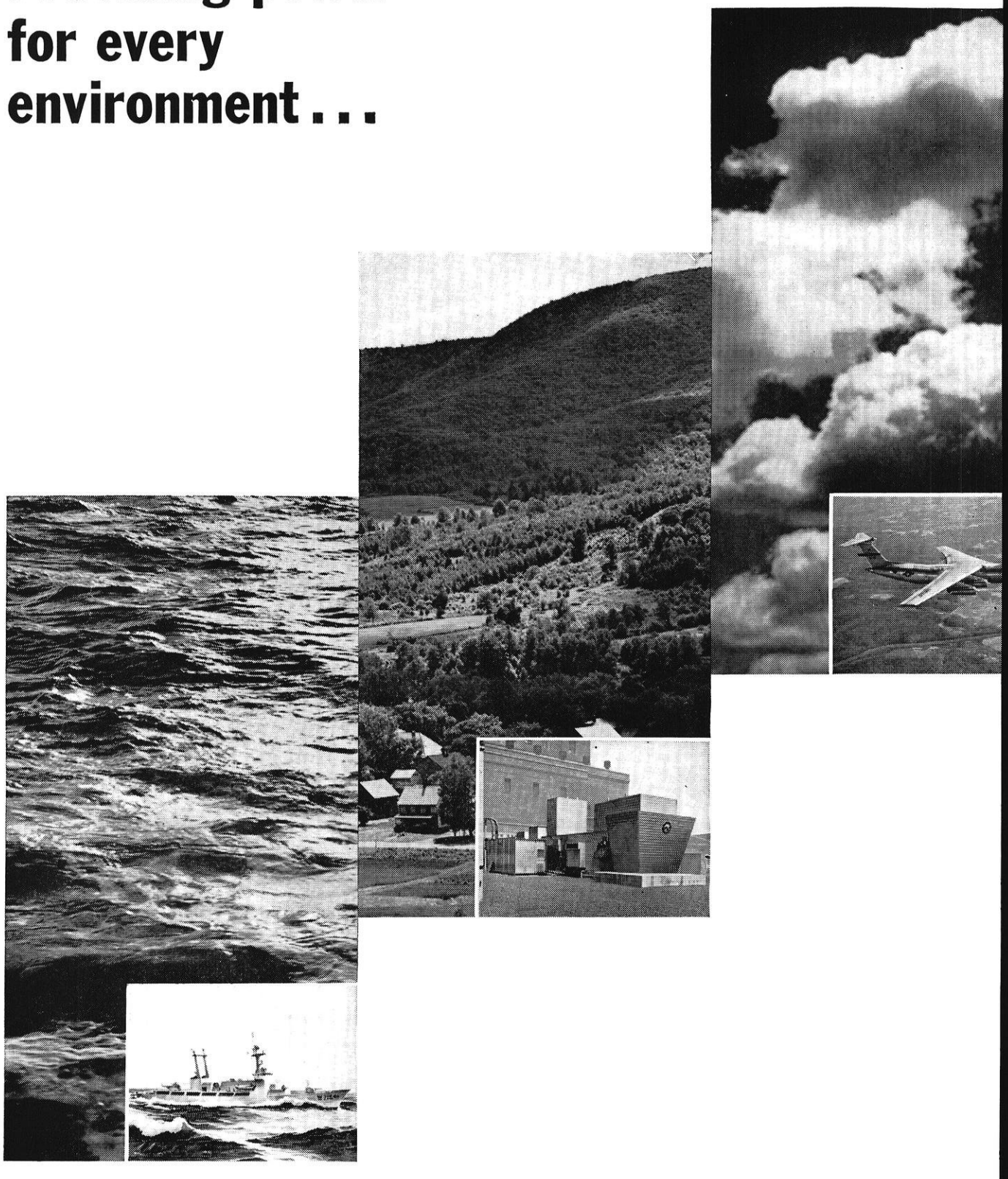
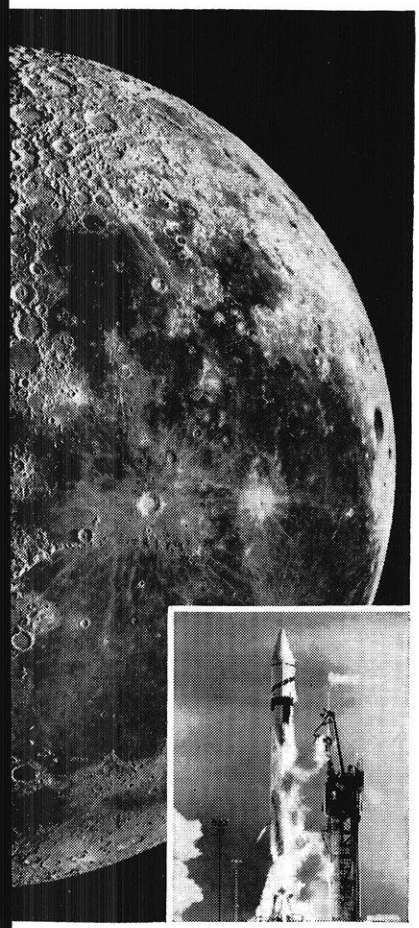



Figure 3.
1–4 Intake.
5–7 Compression.
8–10 Combustion.
11–1 Exhaust.

# Providing power for every environment . . .





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The housing is water cooled. However, the same housing locations are always exposed to the same part of the engine cycle creating a temperature distribution pattern which does not vary. This fixed pattern causes certain portions of the housing to absorb more heat than others. The uneven temperature distribution therefore requires a multi-pass forced-flow cooling system with the size of the water passages varying with the temperatures. The passages run parallel to the engine axis with the water being redirected in the end housings through the use of internal ribbing. The typical water flow is approximately ten gallons per minute. Air cooling the housing has also been tried and proven to be quite effective for the smaller engine sizes. Along with the internal passages, external fins are used to dissipate the heat.

The rotor, because it is rotating within the housing, necessitates a new form of cooling system using oil as the coolant. The oil also serves as a lubricant for the main bearing. To increase the transfer of heat, the rotor is made of cast aluminum having both a low weight and a high thermal conductivity. The oil is fed through the hollow shaft to the rotor bearing where it emerges through radial holes in the eccentric center plane. At this point the oil flow divides, half going to lubricate the bearing, and the rest for cooling the rotor. Because of the natural circulation of the oil in the rotating rotor, neither a scavenge pump nor a pressure feed are required to cause the oil to flow to and from the rotor. A flow of one gallon per minute has proven sufficient for both cooling and lubricating purposes.

### The Sealing Mechanism

The design of an adequate sealing mechanism has caused the most trouble in the development of the Wankel engine and is the major factor in keeping it out of production. The difficulty lies in the manner in which the three chambers of the engine must be kept sealed from each other. The apex seals, the sealing elements, are located in the rotor tips and as they rotate, are in continual contact with the inner wall of the housing. The non-uniform gas pressures and varying velocities of the seals due to the eccentricity of the rotor produce a gradual breakdown in the seal material and subsequent leaking.

The difficulties have been generally overcome through the testing of different types of apex seals, one of which is illustrated in Figure 4. Among the various materials tested, a high-duty cast iron used in piston rings was found to work best in the rotor sides and tips. The strips are held in place and preloaded toward the surrounding walls by wave springs. The design is such that the main sealing force is produced by the gas pressure. This action produces a variable force during the relative movement of the rotor increasing the seal life.

As might be expected, the wear rate of both the apex seals and of the inner surface of the housing depend upon the combination of materials used for the seals and the cylinder. Testing has shown that wear in the radial direction of the seal is not critical. However, wear at the end faces does cause a drop in the power output because of the change in the seal cross-section from a rectangular to a trapezoidal shape allowing leakage between combustion chambers.

The arrangement of sealing as presently developed meets several basic requirements, as determined by Wankel.

1. The sliding velocities of the apex seals against the surrounding housing are of reasonably low values.
2. There is a continuous metal-to-metal line of contact between the sealing elements and the housing, providing good sealing ability.
3. The parts carrying the sealing components are shaped in such a way as to permit the locating of cooling passages close to the seal grooves.
4. The total length of the sealing line is approximately the same as that of a piston engine, when the length around the valve seats of the piston engine is included.

With these requirements met, most criticisms of the sealing ability of the engine can be answered satisfactorily. With further development work, the sealing mechanism will be improved.

### DEVELOPMENT WORK BY NSU

Since the first work by Felix Wankel with the rotary engine and his subsequent joining with NSU, many other companies around the world have become interested in his rotary design. NSU has granted development rights to several firms, including Daimler-Benz, Fichtel and Sachs, Yanmar Diesel, and Toyo Kogyo. In the United States the Curtis-Wright Corporation has the sole rights to the manufacture of the Wankel engine, granted them by NSU in 1958. These two companies are doing the major development work, with

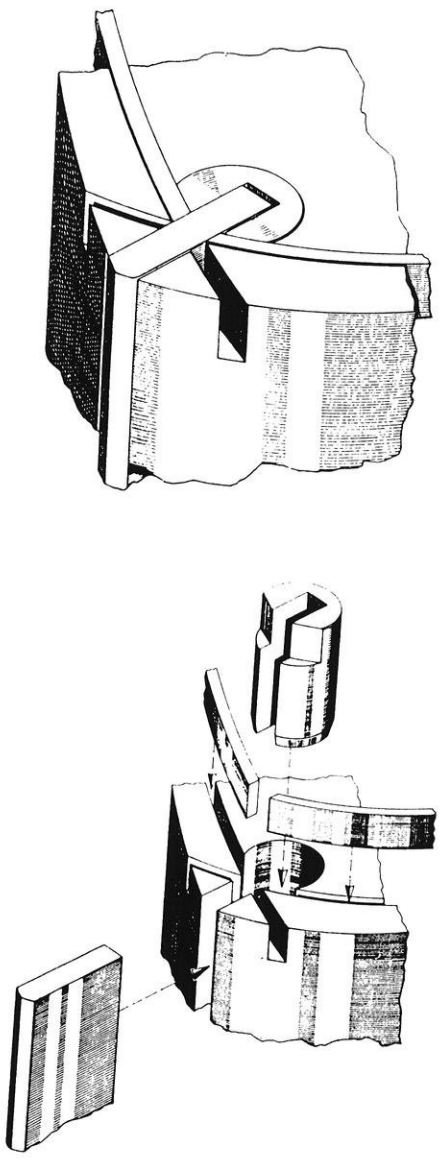

**Figure 4.—The Apex seal, one of several methods tried.**

Curtis-Wright working on high horsepower designs and NSU on engines in the low horsepower range.

As first conceived by Wankel, the engine had a rotor and housing that both rotated in the same direction, but at different speeds. Known as the DKM, this was a complicated and expensive design with the one advantage that it was naturally in balance. When NSU began their work, the DKM design was disgarded in favor of the KKM, a design first thought of by Dr. Walter Froede, Chief of Research with NSU. This engine is the kinematic inversion of the DKM and has a stationary outer rotor (the housing) and a rotating inner rotor. It has the disadvantage of being out of balance because, though the rotor is balanced about its own center, it is mounted eccentrically to the output shaft. This condition is corrected by using balancing weights mounted on the output shaft.

### The KKM 125

The KKM 125, so named because it has a displacement of 125 cu cm, was the first engine developed by NSU in conjunction with Wankel, following his work on the DKM 125. Weighing 24.2 lb., it develops 29 hp. from a package 7.7 in. in diameter and 5.9 in. in length. Tests have shown that the fuel consumption for this engine is comparable to that for the Volkswagen automobile.

### The KKM 60

To test an alternate means of cooling the housing, a 60 cu. cm. air-cooled engine was developed. It produces 5 hp. at 6,000 rpm. and weighs only 16.54 lb. One version was installed in a rotary lawn mower and operated satisfactorily for two summers without any problems occurring.

### The KKM 150

This slightly larger engine than the KKM 125, weighing 14.73 lb., puts out 24 hp. at 8,000 rpm. Two versions have been constructed, the KKM 150W, a water-cooled design, and the KKM 150L. The latter uses air cooling and produces 12 hp. With some modifications, the water-cooled engine has been used as an outboard motor. It is also being used in a small water-skiing tug, which is operated by the skier, that is capable of speeds up to 25 miles per hour.

### The KKM 250

The KKM 250 was developed specifically for use in the NSU Prinz, a German compact automobile. It develops 20 hp. at 8,000 rpm. and 30 lb.-ft. maximum torque at 5,500 rpm., from a unit 9 in. in diameter and 7 in. in length. The high rpm. required by the engine is not harmful because the rotor itself is only turning at one-third the speed of the output shaft. This same requirement, though, necessitates more gear changes and produces an engine that is not very flexible. However, there is immediate throttle response and good engine braking with fuel consumption comparable to that of a conventional automobile.

### The KKM 400

The KKM 400 is an improved version of the KKM 250 developed for the NSU Sport Prinz automobile. The 400 cu. cm. engine produces 57 hp. at 6,000 rpm. and drives the car through a Volkswagen transmission. Top speed is approximately 100 miles per hour. The lubrication required besides the oil used in the rotor is a 50 to 1 mixture of gasoline and oil for new engines changing to a 200 to 1 ratio for engines that have been broken in. Eventually, NSU hopes to eliminate mixing any oil with the gasoline. These automobiles have been test driven for over 621,400 miles.

In another application, the KKM 400 has been mounted as an inboard-outboard drive on a 14 foot boat and is able to drive it at speeds of 28 to 31 miles per hour. The KKM 400 has also been used as the basis for the first NSU twin-rotor engine in which two rotors are mounted on one shaft within one housing. This design, known as the KKM 3x300, has a power output of 60 hp. at 5,000 rpm. and is the forerunner of other multi-rotor powerplants.

### The KKM 500

The KKM 500 is the first rotary combustion engine to go into actual production and is being used in the NSU Spider, a two-seat sports car. This is the first automobile ever to be sold equipped with a rotary engine as standard equipment. The KKM 500 was developed for a high torque output at low speeds, required of an automotive engine. Having an 8.5 to 1 compression ratio, the engine, seen in Figure 5, puts out 54 hp. at 6,000 rpm and 57 lb.-ft. torque at 3,500 rpm.

The 500 cu. cm. design has the center housing cast from tempered silumin, an aluminum-silicon alloy, and the end housings from cast iron. The rotor uses malleable cast iron as its basic material. The oil sealing is accomplished through a combination of oil scraper rings and centrifugal discs mounted to the eccentric. The engine, mounted in the rear of the automobile, drives through a four-speed transmission and differential unit.

## DEVELOPMENT WORK BY CURTIS-WRIGHT

Since 1958, the Curtis-Wright Corporation has done much work in adapting the Wankel rotary combustion engine design to larger sizes with outputs over one hundred horsepower. The sealing mechanism for these engines is basically the NSU-Wankel design but more ruggedly constructed to withstand the higher gas pressures. Testing performed at Curtis-Wright has shown that the best indicator of engine performance is the mean apex velocity, the apex being the point of the rotor in contact with the housing wall. Supercharging with carburetion has proven to give a thirty percent greater power output. Work with the larger sizes has shown that the friction losses increase as the displacement decreases, thereby making the larger engines more efficient.

### The Air-Cooled Engine

Along with NSU, Curtis-Wright also constructed a small engine to determine the feasibility of air cooling. The output varies from 1 to 3.5 hp. at 1,600 to 4,000 rpm. The cooling is provided by a centrifugal fan mounted on the crankshaft. Furthermore, "heavy" finning

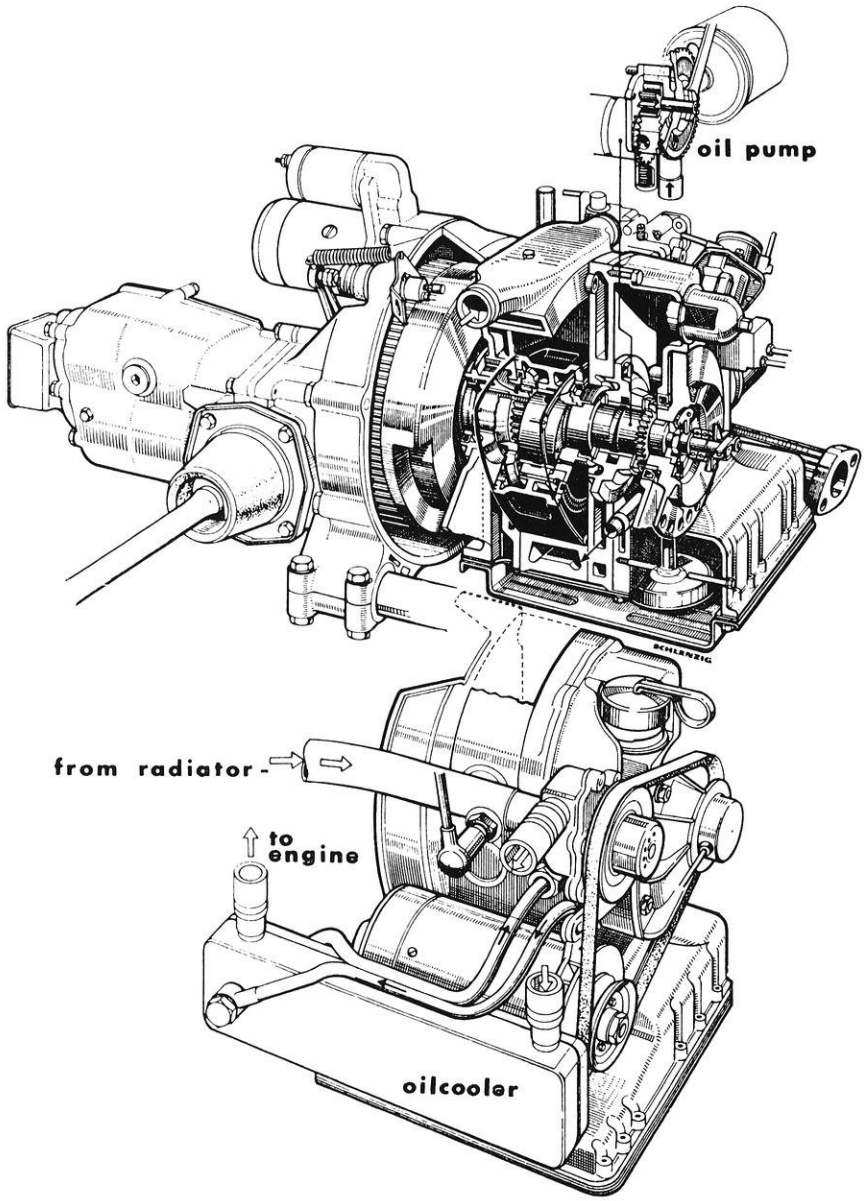


Figure 5.—The KKM 500 NSU—Wankel engine. It is standard equipment in the NSU Spider.

is used in areas having a high temperature distribution pattern such as around the combustion and exhaust port zones.

### The RC6

The RC6, shown in Figure 6, is the first engine constructed by Curtis-Wright and is based completely on the NSU-Wankel design except for increased dimensions. The cooling system uses the multipass forced-flow design for cooling the housing. Water is the coolant. This system keeps temperature variations to a minimum. The forged aluminum rotor has a forced circulation of oil for both lubrication and cooling purposes.

The 60 cu. in. engine has been developed in two versions. The first has side intake ports and develops 100 hp. at 5,500 rpm. or 1.67 hp. per cu. in.; the other uses peripheral intake ports and produces 124 hp. at 6,500 rpm. or 2.05 hp. per cu. in. Both engines put out their highest torque at lower speeds. They have been successfully run using many different kinds of fuel, including regular automotive gasoline, non-leaded high octaine fuel, leaded fuels. and aviation gasoline.

### The 4RC6

A method of mounting two or more rotors on the same shaft to make a larger and more powerful engine was developed using the RC6 as a basis. The first engine of this type was of a twin-rotor design which approximately doubled the performance of the RC6, producing 215 hp. at 5,000 rpm. The second type, the 4RC6, uses four RC6 rotors and was designed for a small diameter and short length. It develops 425 hp. at 6,500 rpm and 400 lb.-ft. torque at 4,000 rpm.

The 4RC6 has the rotors mounted on the one-piece crankshaft. The housing sections are mounted in an in-line arrangement of their major trochoid axes. For this reason, the intake and exhaust ports and spark plugs are also in an in-line pattern creating a clean engine design. To develop good breathing, two carburetors and dual side ports are used on the engine. The coolant and lubricant flow in parallel through all of the sections. Because the power cycles are at 90° intervals, a small couple is produced which is compensated for by balance weights mounted at either end of the crankshaft.

### The RC19

The RC19 was developed to test the performance of extremely large rotary combustion engines. It uses the same configeration as the RC6 but has its dimensions enlarged approximately three times to produce an engine having a 1,920 cu. in. displacement. Developing 782 hp. at 1,525 rpm., the RC19 has shown a good power potential. One drawback that has turned up in tests so far is its susceptibility to detonation on standard fuels. This problem can probably be overcome through further work with the engine.

## THE FUTURE OF THE WANKEL ENGINE

What will the future hold for the Wankel rotary combustion engine? Considering how much the development of this engine has covered in only a few years, the possibilities seem almost unlimited. At this time there are several companies conducting experiments to improve the design details and ease of manufacture. Curtis-Wright Corporation is developing an ap-

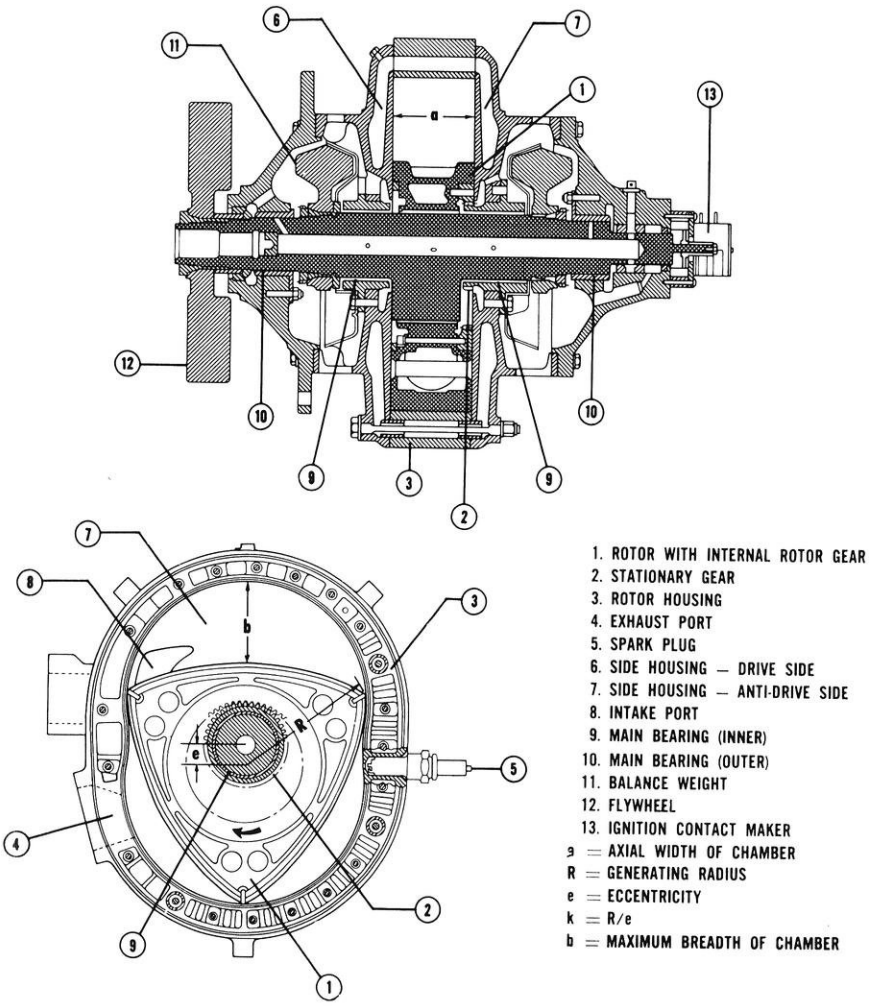


**Figure 6.—The RC6, which was the first engine built by Curtis–Wright. Water is the coolant.**

plication to aircraft use based on the RC6. They have decided a four rotor version with air cooling to be the best design, considering the weight and volume requirements of an aircraft engine. Cooling would be accomplished by having a blower force air through passages parallel to the axis.

The rotary engine has several advantages over gas turbines making it suitable for airplanes. Being competitive in size, weight, and fuel consumpion, it does not require exotic materials or a complicated design. This results in reduced manufacturing costs. The powerplant's vibration-free operation and good power-to-weight ratio make it practical for many other applications. Also, a wide range of horsepower ratings can be easily gotten from a single design by mounting combinations of rotors on the eccentrics of one crankshaft.

In the way of future applications for The Wankel engine, may soon be seen in the industrial and marine fields where limited power requirements and speed variations exist. The automotive possibilities are also very appealing, especially where the flat torque curves over a wide rpm range would make this a practical engine for the small car. NSU has already demonstrated this in their production version used in the NSU Spider sports car. Future designs may even incorporate small engines driving each wheel. Also to be investigated is the possibility of basing the design on the Diesel cycle instead of the present Otto cycle used by modern-day engines.

## Urban Renewal

*(Continued from page 15)*

The "I could care less" attitude and "I don't want to get involved", are some of the worse ones. Many people can recall the murder case in the well-to-do suburb of New York City. A girl was stabbed to death while dozens of people were watching from their windows. When the police department investigated, and asked these people why they didn't go to the aid of the girl, or call the police department, most of them answered: "I didn't want to get involved."

"Democracy is the recurrent suspicion that more than half of the people are right most of the time," said E. B. White. If more than half of our people are apathetic about, or afraid to become involved in their government, there can be no true democracy. If people do not take part in local affairs, and specifically in city policy, it is an easy matter for graft and corruption to take a hold.

What can be done to have an effective renewal program? All of us can help by:

1. Becoming better informed.
2. Voting.
3. Electing honest, civic-minded officials.
4. Strict enforcement of zoning and not code standards.

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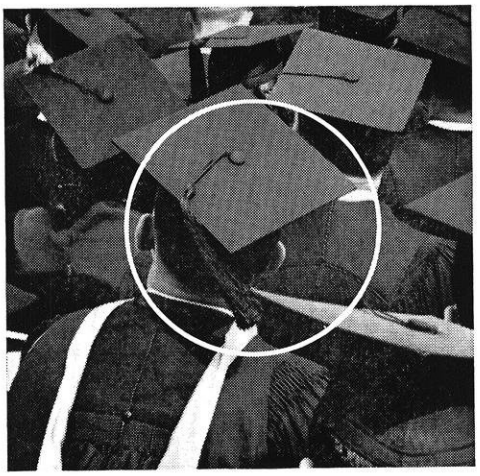

# John Lauritzen wanted further knowledge

# He's finding it at Western Electric

When the University of Nevada awarded John Lauritzen his B.S.E.E. in 1961, it was only the first big step in the learning program he envisions for himself. This led him to Western Electric. For WE agrees that ever-increasing knowledge is essential to the development of its engineers—and is helping John in furthering his education.

John attended one of Western Electric's three Graduate Engineering Training Centers and graduated with honors. Now, through the Company-paid Tuition Refund Plan, John is working toward his Master's in Industrial Management at Brooklyn Polytechnic Institute. He is currently a planning engineer developing test equipment for the Bell System's revolutionary electronic telephone switching system.

If you set high standards for yourself, educationally and professionally, let's talk. Western Electric's vast communications job as manufacturing unit of the Bell System provides many opportunities for fast-moving careers for electrical, mechanical and industrial engineers, as well as for physical science, liberal arts and business majors. Get your copy of the Western Electric Career Opportunities booklet from your Placement Officer. And be sure to arrange for an interview when the Bell System recruiting team visits your campus.

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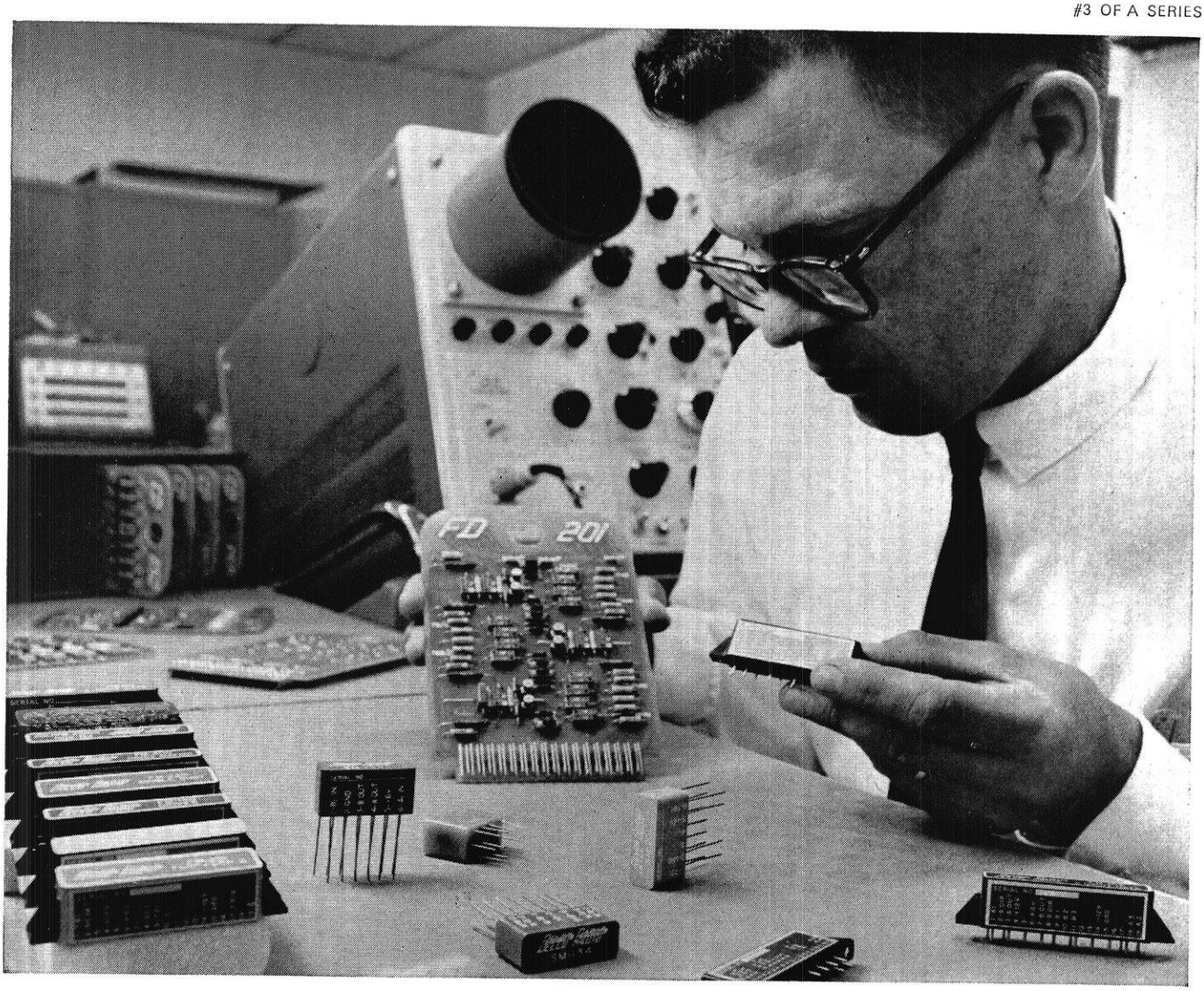
#3 OF A SERIES



# FROM CAMPUS TO CAREER WITH DELCO RADIO

Dewey Nelson came to Delco Radio Division of General Motors in 1958 with a BSEE from Iowa State University. Today, as a project engineer at Delco, Dewey helps design the building blocks for digital control systems—such as the logic cards and modules pictured above. He also assists in designing complete digital systems using these parts.

Like other talented young engineers at Delco, Dewey can enjoy the prospects of a longtime, satisfying career with this stable electronics division of General Motors. He can look forward to a happy future for his family in the friendly, growing environment of Kokomo, Indiana where schooling is tops . . . desirable new homes and apartments plentiful . . . cultural and recreational attractions nearly endless. And both Purdue and Indiana Universities offer undergraduate and graduate work locally.

As a young graduate engineer you, too, might soon be on your way to a challenging and rewarding career with Delco Radio. You'll find abundant opportunities in such areas as silicon and germanium device development, ferrites, solid state diffusion, creative packaging of semiconductor products, development of laboratory equipment, reliability techniques, and applications and manufacturing engineering.

Our brochure detailing the opportunities to share in forging the future of electronics with this outstanding Delco-GM team is yours for the asking. Watch for Delco Radio interview dates on your campus, or write to Mr. C. D. Longshore, Dept. CR, Delco Radio Division, General Motors Corporation, Kokomo, Indiana

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solid state electronics

DELCO RADIO DIVISION
OF GENERAL MOTORS
Kokomo, Indiana


# YOU CAN SHARE IN A GROWTH LIKE THIS

**Whose growth?** Fisher Governor Company, manufacturer of automatic controls for any and all fluids, gases or air that flow through pipe. We are the leader in our growing industry. Our sales have shown a relatively steady rise during the past decade (from 18-million to 41.5-million—a 130% increase in just ten years). See chart above. Our products—control valves, pressure regulators, liquid level controls and instruments—are key elements in industrial automation.

**Location:** Fisher is basically an "Engineering" company with 1,500 employees located in a pleasant Iowa community of 22,000. It's less than 10 minutes to the modern Fisher plant and engineering facilities from any home in Marshalltown. The community has an outstanding cultural and educational environment.

**Type of work:** Fisher offers a rewarding challenge to the graduate engineer (BS and MS) who is interested in design and development, research and test, sales or manufacturing.

**Advancement:** Coupled with Fisher's policy to promote from within, advancement opportunities reflect a growing company within a growing industry.

If a growing company like ours appeals to you, consult your placement office or write directly to Mr. John Mullen, Employee Relations Manager, FISHER GOVERNOR COMPANY, Marshalltown, Iowa.

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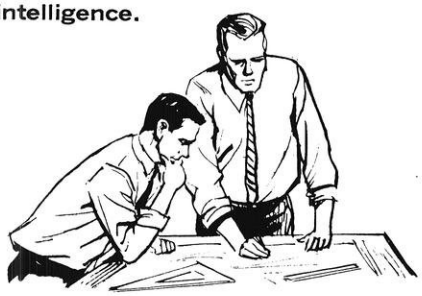
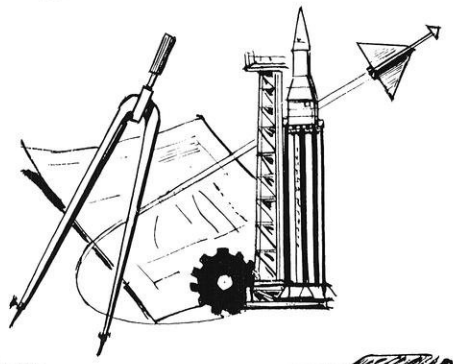
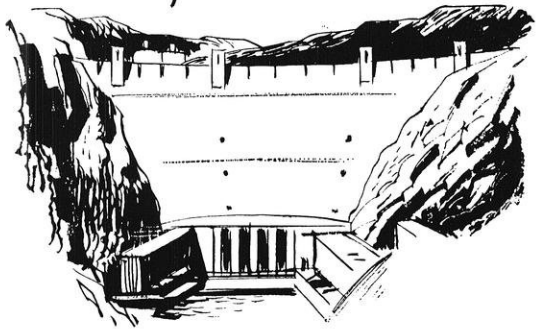
■ The world's foremost and largest engineering organization in the construction field, pioneering new and advanced engineering practices and concepts.

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







■ An organization that recognizes each engineer as an individual, providing well-rounded career development programs with on-the-job training; courses at government expense in colleges, universities, and seminars as necessary to assure steady progression to top professional and managerial levels; encouragement and assistance in attaining professional registration and recognition; and an opportunity to win national and international awards.

■ An organization with offices and projects in nearly every one of the 50 States and in many foreign countries that encourages employees to further their development by accepting new and challenging assignments.

■ An organization which provides excellent rates of pay with liberal fringe benefits, including generous retirement annuity, complete health and life insurance coverage, paid vacation leave, military training leave with pay, generous sick leave; and special pay awards for outstanding performance and suggestions that improve operating efficiency.

If you're thinking this is all too good to be true, you're wrong! All of the above is available to you in a civilian engineer career with the U. S. Army Corps of Engineers. If you are interested, you can get further information from the Chief of Engineers, Department of the Army, Washington, D.C. 20315.

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# 1965

# UW Engineering Exposition

## April 1, 2, 3 and 4, 1965

*Student Exhibits in These Categories*

1. Individual Student
2. Student Organizations
3. Graduate Students
4. Student Group (two or more)
5. Craftsmanship (something made, but not specifically for the Exposition)

★

Cash Awards and Trophies for Best Exhibits

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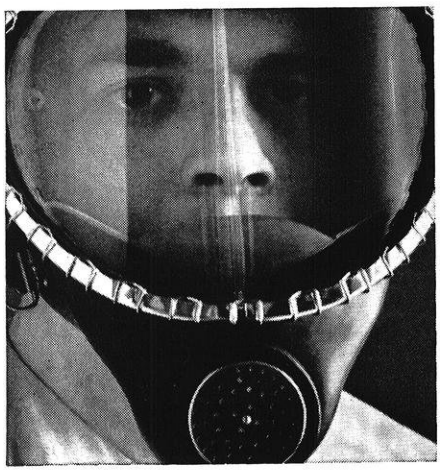
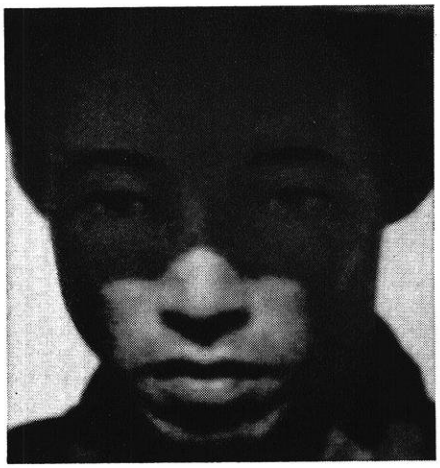
# MAKE YOUR FREE TIME COUNT

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. Regular office hours are 2:30–4:30 p.m., Monday, Wednesday and Friday.





# They're on the job for Olin.

Want to join them?

Take the masked man on the left, for instance. He's actually a pharmacologist on the job in one of our Squibb Division labs, testing out some pungent material behind a sniff-proof mask. Take a job with us doing biochemical research and you'll join him. You might even *be* him; behind those masks, who can tell?

The man in the middle? He's Nai Charden, a loyal, worthy and trusty fertilizer tester for our International Division. He works in the rice paddies around Nongkam (Thailand), helping Olin men check out the effectiveness of various grades of Ammo-Phos® fertilizer.

And then there's Casper. (One of our Winchester boys gave him the name during the last 20 seconds of his [Casper's] life.) Casper is (was) on the job for Olin, too, although he wasn't actually on the payroll. Unwittingly, he helped an Olin team in darkest Africa to test out the new line of sporting arms from our Winchester-Western Division.

Sounds interesting?

Well, there's a hedge, of course.

We can't promise, for example, that the minute you're off campus you'll be on safari. And we're not saying you'll walk out of your dorms and into the jungle.

What we are offering is a unique chance to pick your career out of an incredibly wide spectrum of opportunities in specialized fields: engineering, science, liberal arts, business administration—you name it.

And we are definitely offering you a chance to train and work with some of the sharpest people in your field (native scouts and target lions notwithstanding). You will pick up right where you leave off at graduation and, with crack specialists, start probing the intricacies of your special area. Most important, you will learn by *doing*. (At Olin, a guy is always learning because he is always doing, always looking for new ways to do new things. Which is one way of saying there's no end of opportunity at Olin.)

Interesting people are on the job for Olin, all over the world. And they're doing interesting things.

Want to join them?

There's no hedge on this score; no gimmick, either.

In fact, all you have to do is get in touch with Mr. M. H. Jacoby (he's our College Relations Officer) at Olin, 460 Park Avenue, New York, N.Y. 10022. He'll answer any questions you might have, and if he can't answer them he'll send you to the fellow who can. And if you've got a healthy curiosity (and what graduate worth his salt hasn't?) you'll find that's just the beginning.

Start out talking to Mr. Jacoby and there's no telling where you'll wind up. (You may have shouldered a .22, but we'll give odds you've never wielded a machete.)

**Olin**

(An equal opportunity employer)

■ One of the many rewarding advantages of an engineering career at Allison is the association—in a creative environment—with outstanding scientists and engineers in their respective fields.

Dr. Y. S. Tang, Group Project Engineer in the Heat Transfer and Fluid Dynamics Section, is the calibre of man we believe you'd like to be associated with when you embark on your professional career.

Dr. Tang was graduated from Chinese National Central University in 1944. He received his M.S.M.E. from the University of Wisconsin four years later, and in 1952, received his Ph.D.C.E. from the University of Florida.

Joining Allison in 1959, he is currently responsible for research in fluid dynamics and heat transfer devices for auxiliary power generation for space, under sea and terrestrial power plants. In the course of this work, he also carries out studies in boiling and condensing liquid metals, radiant heat transfer and phase separation in aerosols.

Let us tell you about your career opportunity at Allison, where "Energy Conversion Is Our Business." Talk to our representative when he visits your campus. Or, write now for a copy of our brochure which tells how the young graduate engineer can advance his professional career at Allison.

Send your request to: Allison Division, General Motors Corporation, Indianapolis, Indiana 46206, Att: Professional and Scientific Placement.

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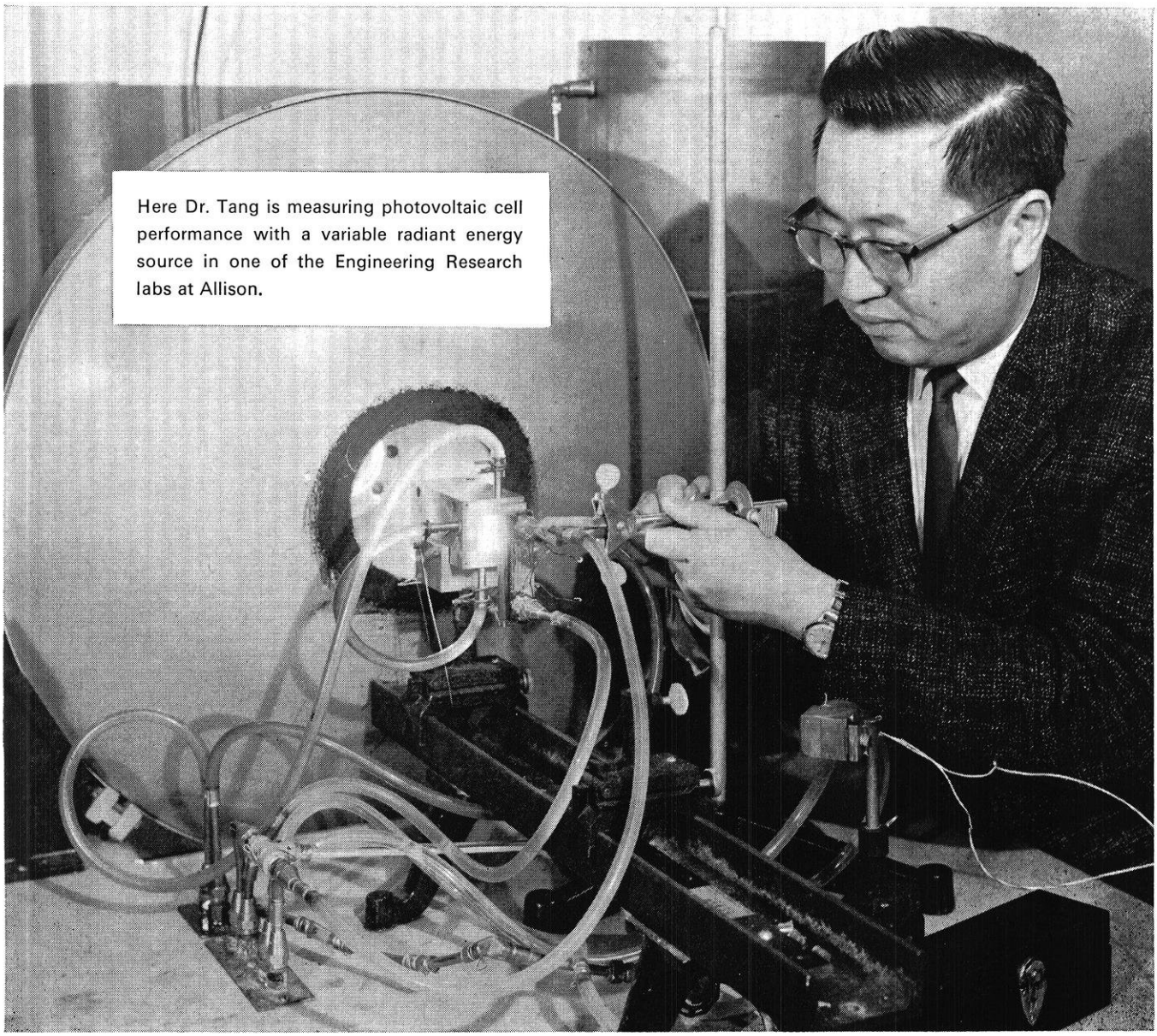
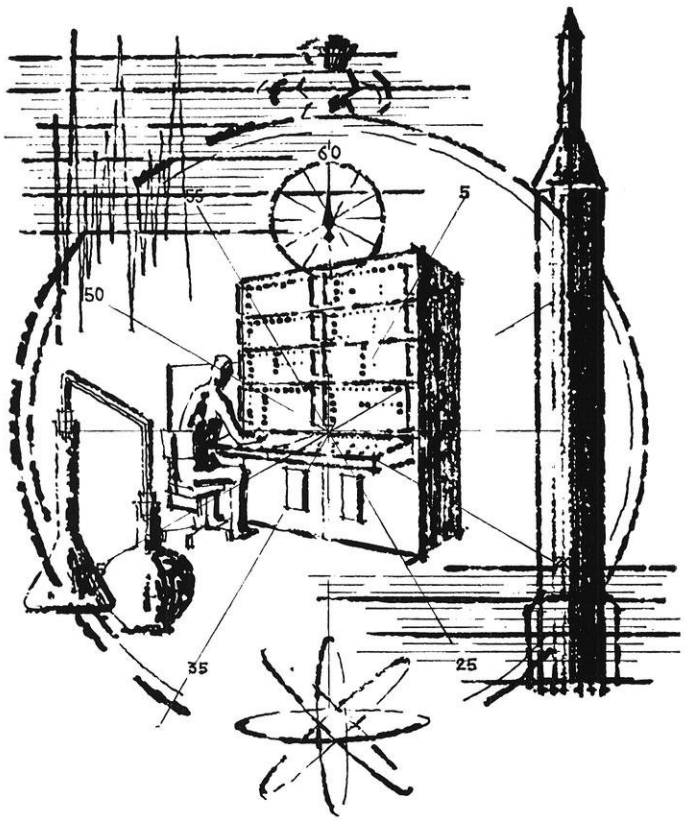
Allison GM
THE ENERGY CONVERSION DIVISION OF GENERAL MOTORS, INDIANAPOLIS, INDIANA
General Motors



Here Dr. Tang is measuring photovoltaic cell performance with a variable radiant energy source in one of the Engineering Research labs at Allison.




# SCIENCE HIGHLIGHTS

By HAROLD WEBER, me4

## NEW SYSTEM DETECTS AND RECORDS DISTANT EARTHQUAKES' GROUND AND AIR WAVES

A system so sensitive it can detect the drop in atmospheric pressure of a one-quarter inch rise in elevation graphically recorded both the ground wave and subsequent air pressure wave here from an earthquake 1,960 miles distant.

Developed by P. G. Davey of the Lawrence Radiation Laboratory, and Walter C. Marion, seismography engineer at the University of California's Seismographic Station, the "Davey-Marion microbaragraph" is coupled with a Varian model G-10 strip chart recorder at the university's Byerly Seismographic Station. A discussion of the graphic record it made of this spring's Good Friday earthquake centered at Prince William Sound, Alaska, has been made in the scientific magazine "Nature" by Professor Bolt, Director of the Seismographic Station.

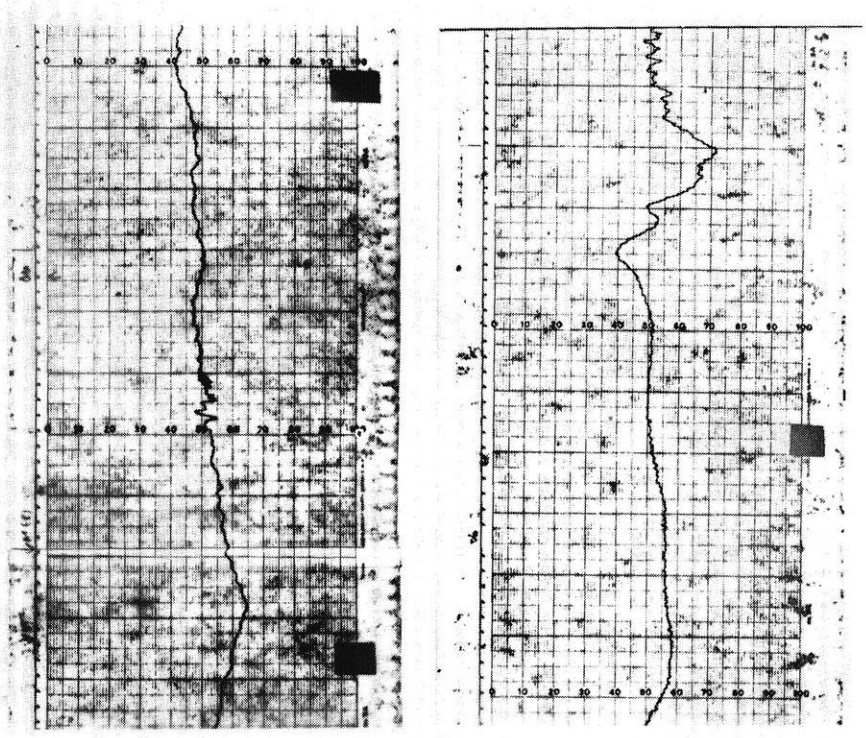
When the earthquake struck Alaska, the time in Berkeley was 8:36 p.m., Friday, March 27, 1964, Pacific Standard Time. The ground wave took a little less than 14 minutes to travel the 1,960 miles from the epicenter to the University of California. The earth under Berkeley rose and fell one-quarter inch.

As the accompanying photograph taken from the Varian recorder's chart of that day shows, the changes in atmospheric pressure accompanying the motion are well within the range of the microbarograph. Two hours and forty minutes after the ground shock recorded by the microbarograph, the air pressure wave reached the instrument.

The microbarograph consists primarily of two large, empty wine demijohns donated by a graduate student who had found them in the basement of his grandparents' home. The demijohns are open to outside air pressure, with a thermistor bridge circuit located in a tube leading to the demijohns. The bridge circuit is connected to a highly sensitive rate-of-climb indicator built in England for sailplane gliders. In the bridge circuitry, current is applied only through the center thermistor, causing heat.

With an increase in atmosphere pressure, air enters the opening to equalize the pressure inside the demijohns. Passing over the bridge circuit, the air transfers heat from the center thermistor to the thermistor nearest the demijohns, unbalancing the bridge, and causing a difference in potential across the circuit. The voltage change is sensed by the rate-of-climb indicator, which is connected to the input of a Varian Associates Model G-10 strip-chart recorder, deflecting the pen.

When atmospheric pressure decreases, the higher pressure inside the demijohns results in unbalancing the bridge circuit in the reverse direction. And again, this difference in voltage-drop across the



Right chart shows measurement of ground wave that reached Berkeley 14 minutes after Alaska earthquake. Left chart shows air pressure wave that arrived 2 hours and 40 minutes later.

bridge is recorded by the Varian G-10 recorder through the rate-of-climb meter.

Short-duration fluctations in atmospheric pressure have been prevented from reducing the instrument's sensitivity by adding a small chamber to the input tube containing the thermistor bridge circuit. The chamber has a small opening to restrict air drafts. In effect, the small chamber acts as an RC (resistive-capacitive) network which filters out high frequencies, allowing the instrument to make full use of its low-frequency sensitivity. Marion calibrates the instrument by raising it in two-inch steps on styrofoam pads.

The output from the microbarograph is connected only to a single Varian G-10 strip-chart recorder with no secondary, back-up recorder.

### IOBBM—NEW SPACE-AGE MATERIAL

A sheet of it will take 1400°F. without wilting. Pound for pound, it's nearly as strong as steel. It can be machined or molded. A piece only 1/32-inch thick will block an electrical surge of 45,000 volts. It's not measurably affected by a radiation attack nearly 2 million times stronger than would kill a man.

It's the newest General Electric insulating material: inorganic bonded mica mat (IOBBM).

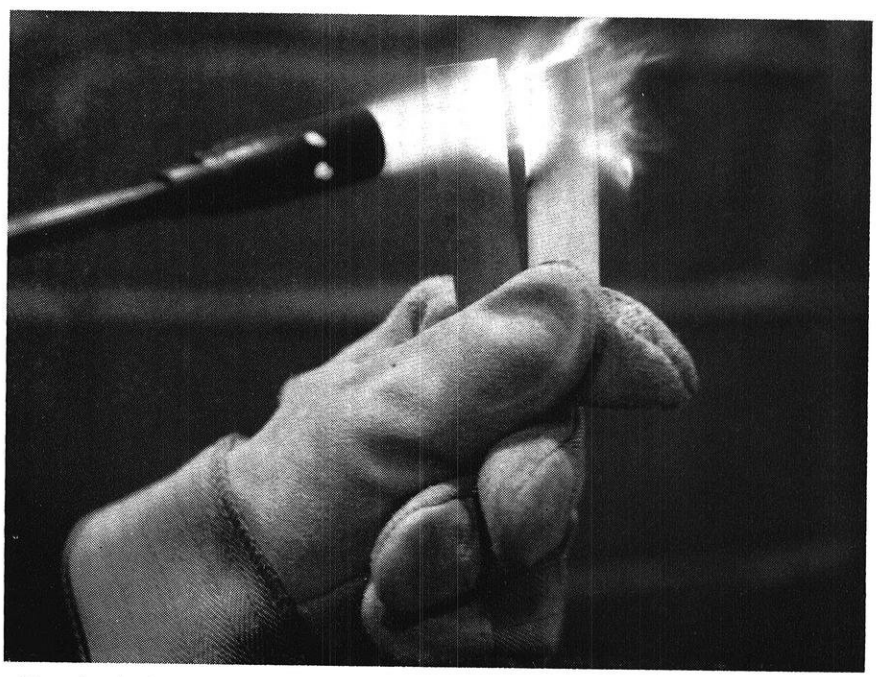
Mica has long been used as an electrical and thermal insulator, of course, but it's impossible to obtain large enough pieces in nature to fabricate into uniform segments. GE's solution was to reconstruct the mica into wafer-thin sheets and laminate them to uniform thickness using an inorganic bonding material.

The bonding material has effectively added some 900 degrees to the temperature threshold of mica, giving IOBBM significant advantages over ceramics in the 500 to 1400 degree range. One advantage is weight: IOBBM has a specific gravity of only 2.1 compared to ceramics' 3 to 4. And sheets of mica laminate can be drilled, milled, molded, punched, cut or filed with little or no waste.

Applications of this new material are limited only by the imagination unique combination of electrical and thermal properties makes it ideal for key structural components which are subject to severe environments.

### LARGE-SCALE LOW-COST ELECTRICAL WATER DESALTING PLANT PROPOSED

A five to ten million gallon per day water desalting plant, based on the electrodialysis process, was proposed for the State of California's saline water program, in testimony delivered before the Subcommittee on Saline Conversion and Nuclear Energy of the California Legislature, by Russell



New insulation material from G.E. will not wilt from blast of acetylene torch. Beside it, insulating glass fiber bursts into flame.

L. Haden, Jr., President, Ionics, Incorporated, Cambridge, Massachusetts.

Haden stated that desalination by electrodialysis of highly-mineralized ("brackish") water which is available in plentiful supplies in California, deserves an important place in the State's program. It offers a valuable third alternative source of new fresh water, supplementing presently proposed projects for nuclear desalting of sea water and long-distance transmission from the north. Haden also noted that although the presently proposed nuclear demonstration plant leading to even larger plants is worthwhile, the major need will be for smaller municipal plants.

Where suitable brackish waters are available, Haden predicted that conversion by electrodialysis would have total costs of between 9 and 16 cents per thousand gallons for a plant equal in size (50,000,000 gallons per day) to the proposed nuclear sea water distillation dual-purpose plant for Southern California. These costs favorably compare with the 46 cents he estimated for the nuclear project. For a typical small electrodialysis plant with capacity of between 5 and 10 million gallons per day the costs would be between 13 and 24 cents.

In the electrodialysis process, salts and minerals are removed by electric current. More than 120 water desalting plants with capacities ranging from a few thousand to 650,000 gallons per day have been installed throughout the world by Ionics. The Ionics plant at Coalinga California, in continuous operation for over five years, was the first U. S. municipal desalting plant. The installation serving Buckeye, Arizona, since 1962, is the first saline water converter of any type to demineralize the entire water supply of a U. S. municipality and is the lowest-cost saline water conversion plant currently in operation.

### WORK-MEASUREMENT MACHINE STUDIES MAN IN "SPACE"

Dr. Irving Streimer of Boeing has developed a human work-measurement machine—named an anthropometric-ergometric facility. The Streimer machine simulates the weightlessness of a spaceman by floating him on a perfectly balanced, ball-bearing-mounted chair. While he sits in the chair, the subject is presented with a variety of levers, cranks, and wheels to push, pull or twist. Since he has no way to brace himself to do this work, the psuedo spaceman can produce only one-fourth normal earthman torque, or turning force, with considerably more exertion. A typical work effort test on the Streimer chair might seek to determine the force a man can apply to a wheel. This force would then be compared with the effort the subject could exert if he were braced. An important part of the facility is a pair of high-speed moving cameras. Located above and in front of the panel, they record the paths of small lights attached to the subject. In this way they present a three dimensional record of the man's movements, and further indicate the area or "work envelope" required to carry out each task most efficiently. The Streimer chair is only one research tool for studying space man's weightless environment. But it is valuable because of its speed, ease of measurement and relatively low cost.

# "PRINTABLES"

Two aggies were sitting in the library when a young coed walked by.

"Her neck's dirty," said one.

"Her do?"

* * *

**A Texas oil man was visiting New York. His city friend showed him all the sights including the Empire State building.**

**"Isn't that a magnificent structure?" asked his friend.**

**"Nothin," said the Texan. "I got an outhouse bigger'n that."**

**The New Yorker looked him over. "You need it!" he retorted.**

* * *

"Thish match won't light."

"Washa matter with it?"

"Idunno—it lit all right a minute ago."

**A draftee after his first night in an Army barracks was shaken by his platoon sergeant.**

**"It's four-thirty," bellowed the Sgt.**

**"Four-thirty!" gasped the draftee. "Man you better get to bed. We got a big day tomorrow."**

* * *

Lecturer: If I talk too long, it's because I forgot my watch and there's no clock in this hall.

Voice from the audience: There's a calendar behind you.

* * *

**Someone asked the C.E. why he always closed his eyes when he took a drink.**

**"Well, fella," he said, "the sight of good liquor makes my mouth water and I wouldn't want to dilute my drink."**

A comely young coed stepped on the drugstore scales after devouring a giant sundae and was shocked at what she read. Promptly she slipped off her coat and tried again. The result was still unflattering, so she slid off her shoes. Then she discovered she was out of pennies. Without a moment's hesitation the boy behind the soda fountain stepped forward.

"Don't stop now," he volunteered, "I've got a whole handful of pennies and they're all yours."

* * *

**The automobile motor began to pound, and it finally stopped. The worried guy turned to his companion, "I wonder what that knock can be?"**

**"Maybe," said the blond, "it's opportunity."**

# Why become an engineer at Garrett-AiResearch? You'll have to work harder and use more of your knowledge than engineers at most other companies.

If you're our kind of engineer, you have some very definite ideas about your career.

For example:

You've worked hard to get a good education. Now you want to put it to work in the best way possible.

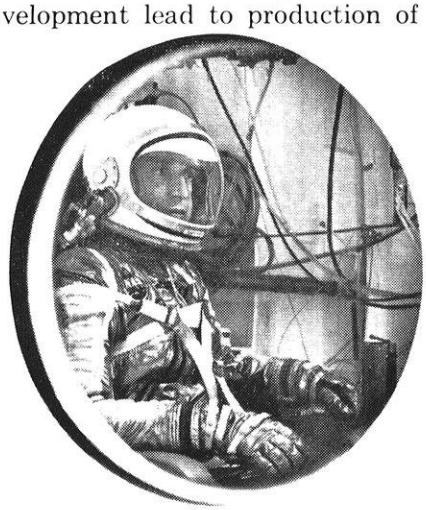
You will never be satisfied with run-of-the-mill assignments. You demand exciting, challenging projects.

You not only accept individual responsibility – you insist upon it.

Does that sound like you? Then AiResearch is your cup of tea.

Our business is mainly in sophisticated aerospace systems and subsystems.

Here, research, design, and development lead to production of actual hardware. That means you have the opportunity to start with a customer's problem and see it through to a system that will get the job done.



The product lines at AiResearch, Los Angeles Division, are environmental systems, flight information and controls systems, heat transfer systems, secondary power generator systems for missiles and space, electrical systems, and specialized industrial systems.

In the Phoenix Division there are gas turbines for propulsion and secondary power, valves and control systems, air turbine starters and motors, solar and nuclear power systems.

In each category AiResearch employs three kinds of engineers.

Preliminary design engineers do the analytical and theoretical work, then write proposals.

Design engineers do the layouts; turn an idea into a product.

Developmental engineers are responsible for making hardware out of concepts.

Whichever field fits you best, we can guarantee you this: you can go as far and fast as your talents can carry you. You can make as much money as any engineer in a comparable spot – *anywhere*. And of course, at AiResearch, you'll get all the plus benefits a top company offers.

Our engineering staff is smaller than comparable companies. This spells opportunity. It gives a man who wants to make a mark plenty of elbow room to expand. And while he's doing it he's working with, and learning from, some of the real pros in the field.

If the AiResearch story sounds like opportunity speaking to you—don't fail to contact AiResearch, Los Angeles, or Phoenix, or see our representative when he comes to your campus.

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## AiResearch *is* challenge

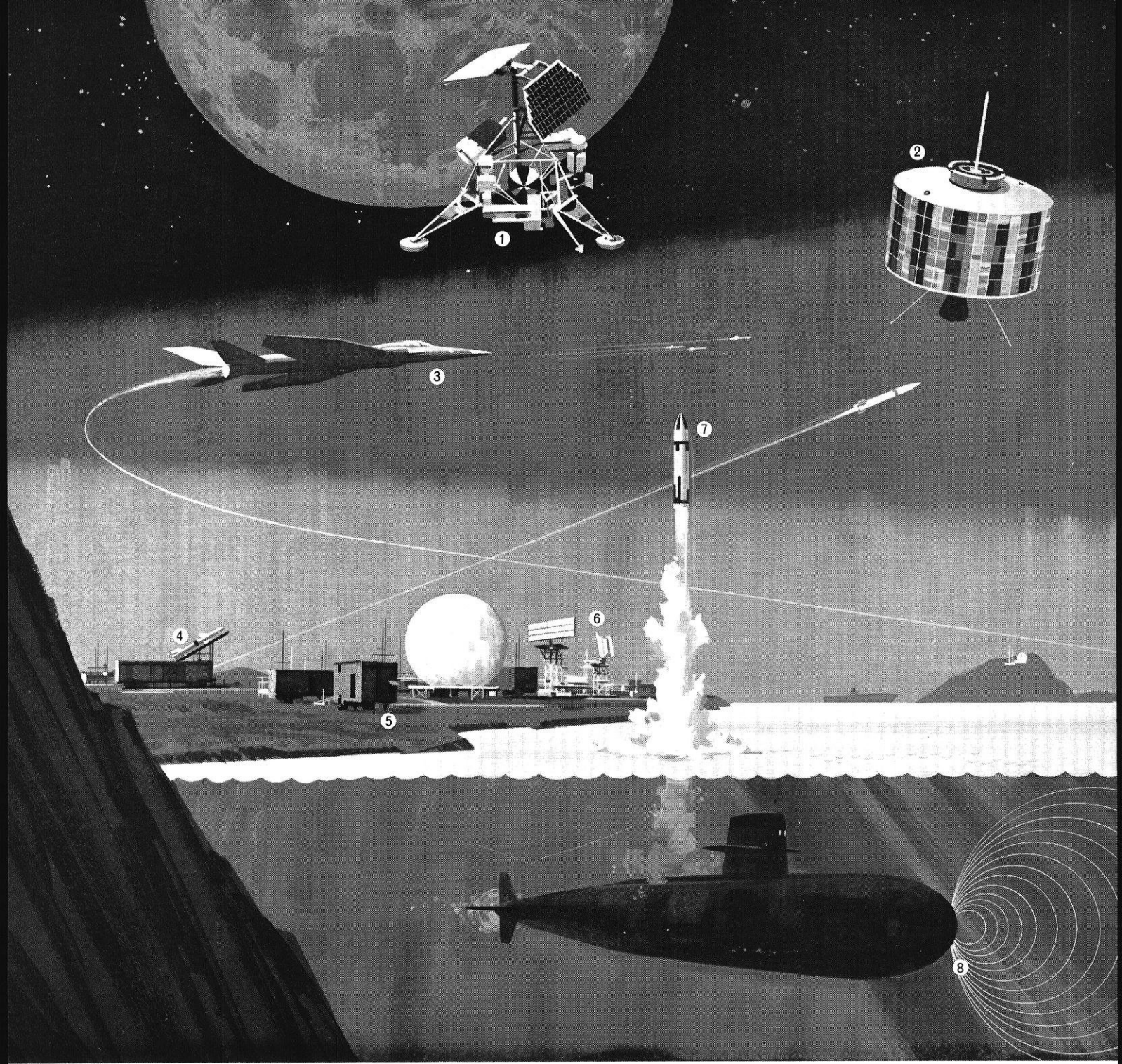
GARRETT

*Los Angeles • Phoenix*

# IN YOUR FIRST JOB WILL YOU BE HEADING HELLBENT FOR OBLIVION?

The accelerated pace at which technology is advancing may mean that the wrong decision for your first job may cause you to slip into the abyss of obsolescence. Engineers and engineering management at Hamilton Standard have already confronted and successfully overcome this bleak problem. ☐ In the early 1950's, while continuing an undisputed position in the propeller business, management initiated a swift, sound product diversification program. By judiciously applying the valued skills and capabilities that HSD engineers acquired as the world's foremost developers and manufacturers of propellers, the switch to new product opportunities in the then-new jet market was orderly and highly successful. Hamilton Standard rode the wave of aviation progress to leadership in the jet aircraft and aerospace equipment field as they already held in the field of propellers. Engineers with heavy experience in hydromechanical control devices for propellers turned their skills to metering fuel flows in engine controls; the aerodynamics of air conditioning systems proved a natural field for engineers who had moved masses of air with propellers. From air conditioning the field was broadened to include jet engine controls and pneumatic valves, beginning with analytical feasibility studies through preliminary design and prototype development. ☐ Since early 1960 this same determination and mobility has been applied to adapting engineers' skills to obtaining a share of the new missile, rocket and space vehicle opportunities. Company state-of-the-art advances have led to receipt of contracts to provide the environmental control for the lunar excursion module, and space suits. Studies have been completed on one-man propulsion units to be used by astronauts during orbital rendezvous and on the moon's surface. ☐ The company's continued expanding probe into the fields of electronics, ground support, electron beam technology and industrial valves, among others, is sustained by an organization of almost one thousand graduate engineers and technicians with a wide variety of complementary engineering and manufacturing skills. Supporting these technical/production teams, in turn, are some of the most extensive privately-owned experimental and manufacturing facilities in the United States. Without such support, theory holds sway, new products rarely mature, and obsolescence of both company and personnel set in. Hamilton recognizes that its ability to produce a workable article is measured by two basic criteria: its **people,** and the **tools** at their immediate disposal. ☐ Such diversification has brought Hamilton into the areas of engineering and scientific disciplines including aerodynamics, compressible flow, control dynamics, digital computation, analog computation, electronics, electron optics, fluid dynamics, heat transfer, hydraulics, instrumentation, internal aerodynamics, kinematics, magnetic circuitry, mechanical metallurgy mechanics, metallurgy, physical chemistry, physics, quality control, reliability, servo-mechanisms, statistical analysis, structures, systems analysis, thermodynamics, thermoelectricity, tool engineering, transistor circuitry, vehicular dynamics and vibrations. ☐ Hamilton Standard's successful diversification also hinged on another hedge against engineering obsolescence . . . the obsolescence associated with the inability of the individual to keep up with new developments in his field. Management recognized and met this problem early, by setting up programs of continuing education. United Aircraft Corporation sponsors a Graduate Education Program offering part-time, tuition-paid advanced study at Trinity College, University of Connecticut, and Rensselaer Polytechnic Institute of Connecticut. There is also a regular schedule of technical and non-technical courses at company facilities, plus seminars and short courses at colleges and universities. ☐ Are you faced with the task of selecting a company that will keep you up-to-date in **your profession?** Explore career opportunities with Hamilton Standard — an equal opportunity employer — write to Mr. Timothy K. Bye, Supervisor of College Relations, Windsor Locks, Connecticut or see you Placement Office for an appointment with our representative when he visits your campus. ☐

**Hamilton Standard** DIVISION OF **United Aircraft**




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

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

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

**Other responsible assignments include:** ATS (advanced technological satellites), TOW (wire-guided, anti-tank missile system), VATE (automatic checkout equipment), advanced infrared systems, electronic signal processing, space communications, parametric amplifiers, airborne radar systems, reconnaissance systems, aerospace vehicle development, missile/spacecraft power & propulsion systems...and others.

**B.S., M.S. and Ph.D. Candidates**

## CAMPUS INTERVIEWS

## March 15, 1965

Learn more about opportunities at Hughes, our educational programs, and the extra benefits Southern California living offers. **For additional information and literature, consult your College Placement Director.** *Or write:*

*Mr. A. J. Simone*
*Hughes Field Service & Support*
*P.O. Box 90515*
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**HUGHES**

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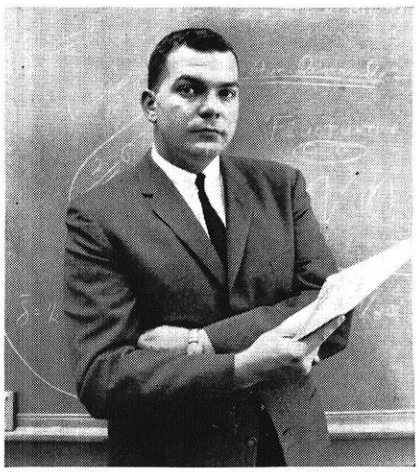
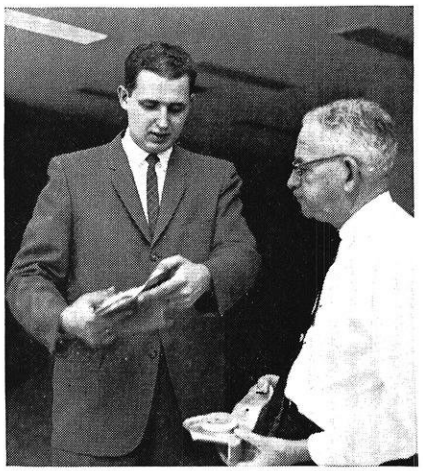
# *Men on the move at Bethlehem Steel*

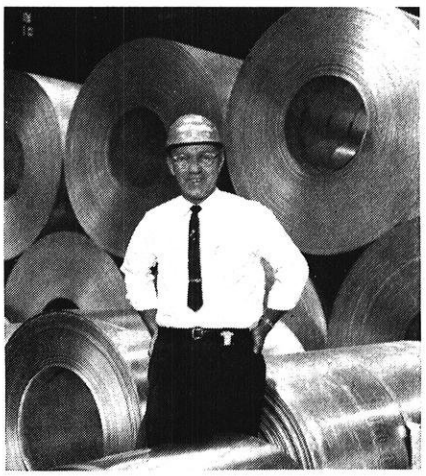
BETHLEHEM STEEL



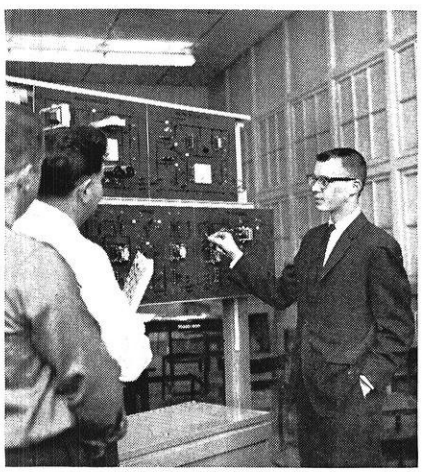
**JIM ANTHONY, I.E., JOHNS HOPKINS '60**—An operations research man at our Sparrows Point, Md., Plant, Jim applies techniques such as linear programming, regression analysis, exponential smoothing, CPM, and PERT to complex production problems.



**TOM FREE, MET.E., CASE INSTITUTE '60**—After experience in both mills and laboratories, Tom became a Lackawanna Plant metallurgical service engineer. His job is to solve problems in customers' plants.

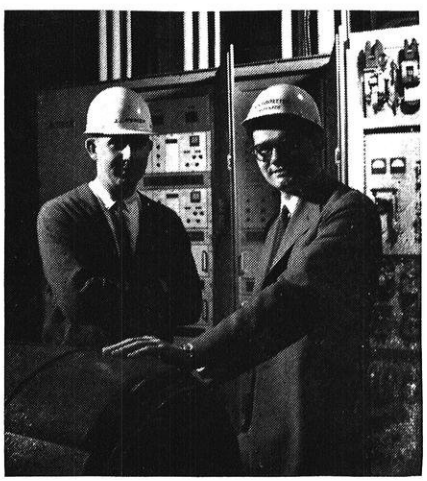


**DICK PEOPLES, C.E., NORTHEASTERN '60**—Dick helped build our new, $20-million continuous galvanizing mill at the Lackawanna Plant, near Buffalo, N.Y. Now he's foreman of the mill's production line.



**JIM BULLOCK, E.E., BROWN '58**—Jim is an electrical engineer at our Bethlehem, Pa., Plant. His broad-ranging duties include instructing technicians in the intricacies of electronics.

**SAM COLEMAN '62, DOUG HATCHER '61, BOTH M.E., SOUTH CAROLINA**—Sam and Doug are salesmen in our Atlanta District. Their technical training is a valuable asset in selling steel products.



**JOHN O'BRIEN, CH.E., NOTRE DAME '60, AND DICK HOSTETTER, M.E., PENN STATE '58**—Production engineer O'Brien and research engineer Hostetter worked together on an automatic gage-control system for a mill at our Sparrows Point, Md., Plant.

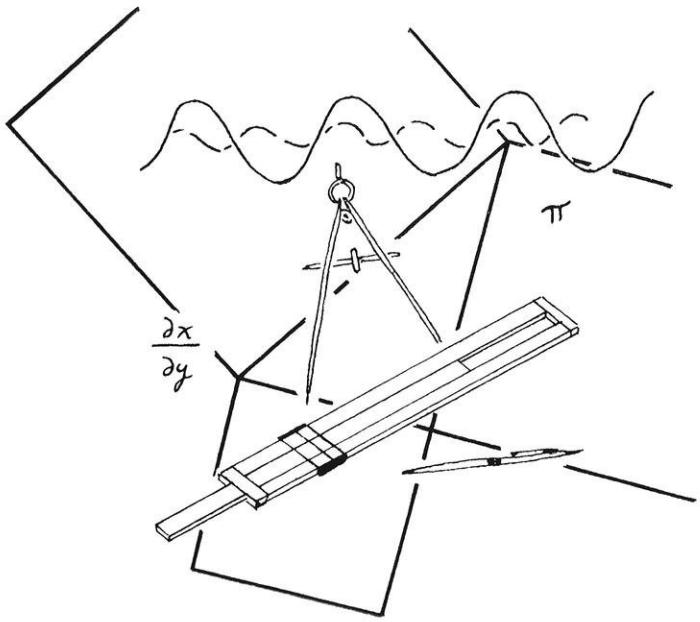
These alert young men are a few of the many recent graduates who joined the Bethlehem Loop Course, one of industry's best-known management development programs. Want more information? We suggest you read our booklet, "Careers with Bethlehem Steel and the Loop Course." Pick up a copy at your Placement Office, or write to our Manager of Personnel, Bethlehem, Pa.

*An equal opportunity employer*

THE

# MENTAL MAZE

By CLIFTON FONSTAD, JR. ee4




LET'S get started immediately on the first puzzle—the first turn in this month's Mental Maze.

1. To start with try a geometric problem. What is the largest number of spots that can be painted on a sphere in such a way that every spot is exactly the same distance from every spot ("Distance" here is distance measured along the surface of the sphere)?

2. If you have ever played with squares you might have noticed certain interesting sums:

$$3^2 + 4^2 = 5^2$$
$$10^2 + 11^2 + 12^2 = 13^2 + 14^2$$

There is a rule, Hoppenot's Rule, which generates such sums of consecutive squares. It begins: "The sum of the squares of n + 1 consecutive integers, of which the greatest is 2n (n + 1), equals the sum of . . . ."

Can you finish it?

3. Now it is time for our monthly probability problem.

Two identical packs of cards are shuffled thoroughly. One card is drawn from pack A and shuffled with pack B. Then the top card of pack A is turned up. If this card is the queen of hearts what is the chance that the top card of pack B will be the king of hearts?

4. A fellow engineering student was telling of his trip home between semesters and came up with quite a problem.

The road between his home and Madison is all Interstate highway so he maintained a constant speed all the way. He said he drove as many miles as the number of minutes he'd have taken to drive two-thirds the distance if he'd driven ten miles an hour faster than he'd have had to drive to drive the distance he did in ten minutes less than he took, but if he'd driven half as fast again for ten minutes longer than he did drive, he'd have driven sixteen miles more than he did.

How fast did he drive?

5. The next puzzle in this month's Maze is a bit shorter. It's a gift for the chemical engineers.

One pipe can fill a vat of GL-70 in 3 hours, while another can fill it in 2 hours, and a third can drain it in 4 hours. How long will it take to fill the tank half-way when all three pipes are working?

6. The final puzzle is a tale from Tiola Tech. It seems that during on particularly dry class, Engr. 671, most of the students spend their time looking out the window. Fortunately the view through the window is good; from it you can see two bell towers, 200 yards away, and 240 yards apart. There is also a wall between the towers 150 yards from each. The problem is how far is the well from the 671 classroom window?

ANSWERS

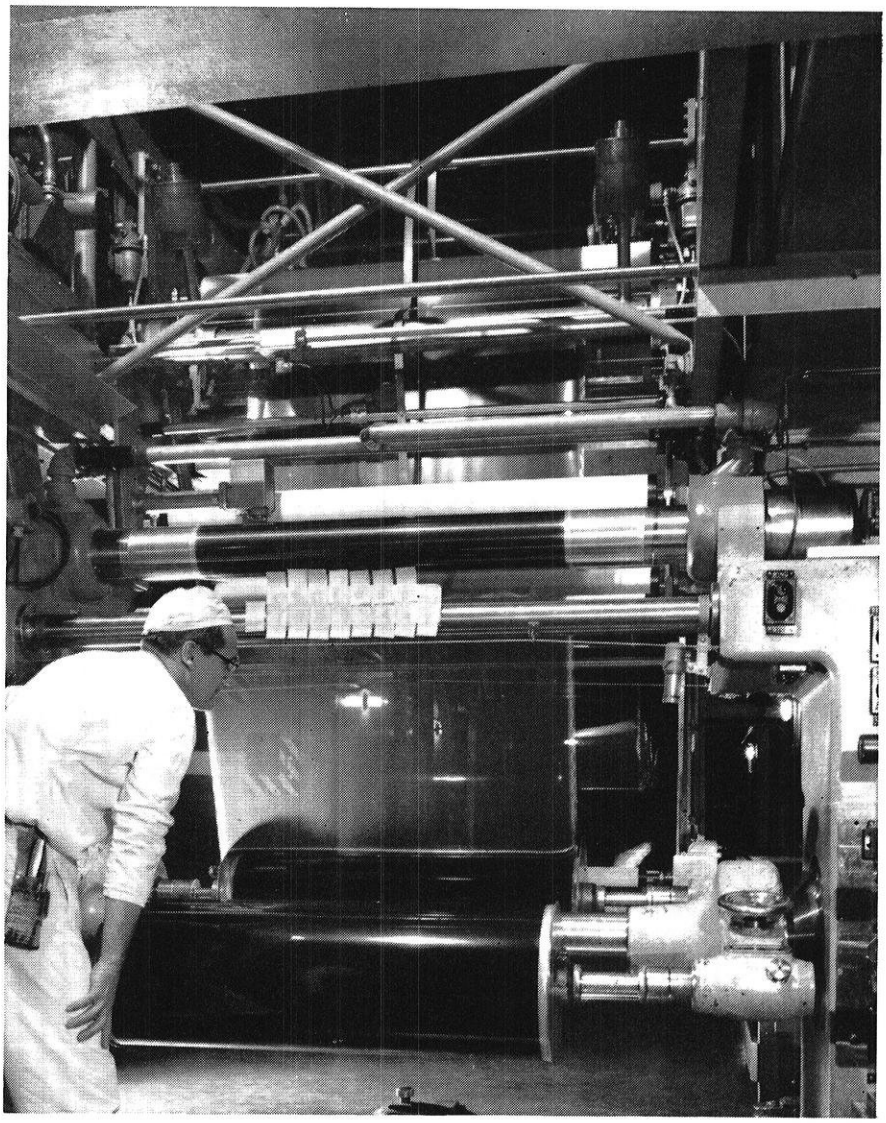
The answers to last month's Mental Maze are:

1. 5.5 feet.
2. 11 sec. Then miles per hour equals 10 × the number of clicks in 11 sec.
3. 14.
4. 7.
5. Connect the two palms with a rope—call this length 2L. The treasure lies at a point L units inland along the perpendicular bisector of the rope.

We're still giving five dollars for the first set of correct solutions sent to Mental Maze, % Clifton Fonstad, Wisconsin Engineer, Rm 333, Mechnical Engineering Bldg., U. of W., Madison, Wisconsin, so hurry and write.

We have several Maze Masters to announce: November's was R. K. Gupta of Madison, an M.E. graduate student and December's was Curtis Shawkey of Madison.

# Design a better one and call it chemical engineering



We understand as well as the next company the difference between, let us say, a chemical equipment design engineer and an electro-mechanical development engineer. To turn out the volume we intend of such a fantastically demanding cross-product of chemical and mechanical engineering as a KODAPAK Cartridge of KODACHROME-X Film, we have to interest fresh graduates answering to both these job descriptions and many, many others.

In talking to shoppers from the campus, we find it wise to be very specific about job descriptions. We would create the wrong impression at the interview by referring to the job available as "professional engineer."

The young man is winding up four or five years of building himself into a good all-around engineer. Now comes the time to get specific. He is smart enough to know that the demand by strong organizations for all-around engineers under 25 can be expected to remain slack. He is right. The projects awaiting engineers are terribly specific. But if he has picked the right employer, he will find that with each project brought off well the walls between the compartments of engineering get a little softer.

By the time he discovers he has been transformed into that vague "professional engineer," he is having too much fun fighting our competitors by the boldness of his concepts to care what specialty he promised to devote his career to.

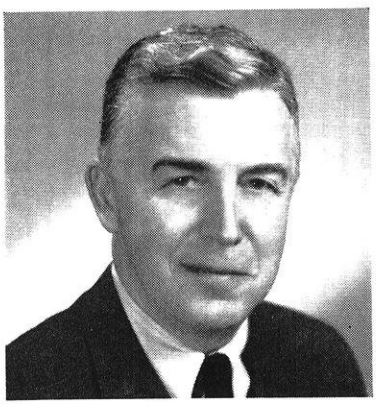
On the chance that we might be the right employer, drop us a line.

**EASTMAN KODAK COMPANY,**
Business and Technical Personnel Department, Rochester, N.Y. 14650
An equal-opportunity employer offering a choice of three communities:
Rochester, N.Y., Kingsport, Tenn., and Longview, Tex.

**Kodak**

# Should You Work for a Big Company?

An interview with General Electric's S. W. Corbin, Vice President and General Manager, Industrial Sales Division.



S. W. CORBIN

■ Wells Corbin heads what is probably the world's largest industrial sales organization, employing more than 8000 persons and selling hundreds of thousands of diverse products. He joined General Electric in 1930 as a student engineer after graduation from Union College with a BSEE. After moving through several assignments in industrial engineering and sales management, he assumed his present position in 1960. He was elected a General Electric vice president in 1963.

Q. **Mr. Corbin, why should I work for a big company? Are there some special advantages?**

A. Just for a minute, consider what the scope of product mix often found in a big company means to you. A broad range of products and services gives you a variety of starting places now. It widens tremendously your opportunity for growth. Engineers and scientists at General Electric research, design, manufacture and sell thousands of products from microminiature electronic components and computer-controlled steel-mill systems for industry; to the world's largest turbine-generators for utilities; to radios, TV sets and appliances for consumers; to satellites and other complex systems for aerospace and defense.

Q. **How about attaining positions of responsibility?**

A. How much responsibility do you want? If you'd like to contribute to the design of tomorrow's atomic reactors—or work on the installation of complex industrial systems—or take part in supervising the manufacture of exotic machine-tool controls—or design new hardware or software for G-E computers—or direct a million dollars in annual sales through distributors—you can do it, in a big company like General Electric, if you show you have the ability. There's no limit to responsibility . . . except your own talent and desire.

Q. **Can big companies offer advantages in training and career development programs?**

A. Yes. We employ large numbers of people each year so we can often set up specialized training programs that are hard to duplicate elsewhere. Our Technical Marketing Program, for example, has specialized assignments both for initial training and career development that vary depending on whether you want a future in sales, application engineering or installation and service engineering. In the Manufacturing Program, assignments are given in manufacturing engineering, factory supervision, quality control, materials management or plant engineering. Other specialized programs exist, like the Product Engineering Program for you prospective creative design engineers, and the highly selective Research Training Program.

Q. **Doesn't that mean there will be more competition for the top jobs?**

A. You'll always find competition for a good job, no matter where you go! But in a company like G.E. where there are 150 product operations, with broad research and sales organizations to back them up, you'll have less chance for your ambition to be stalemated. Why? Simply because there are more top jobs to compete for.

Q. **How can a big company help me fight technological obsolescence?**

A. Wherever you are in General Electric, you'll be helping create a rapid pace of product development to serve highly competitive markets. As a member of the G-E team, you'll be on the leading edge of the wave of advancement—by adapting new research findings to product designs, by keeping your customers informed of new product developments that can improve or even revolutionize their operations, and by developing new machines, processes and methods to manufacture these new products. And there will be classwork too. There's too much to be done to let you get out of date!

FOR MORE INFORMATION on careers for engineers and scientists at General Electric, write Personalized Career Planning, General Electric, Section 699-12, Schenectady, N. Y. 12305

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