The Wisconsin engineer. Vol. 70, No. 4 January 1966

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

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THE WISCONSIN ENGINEER

JANUARY, 1966
VOL. 70, NO. 4
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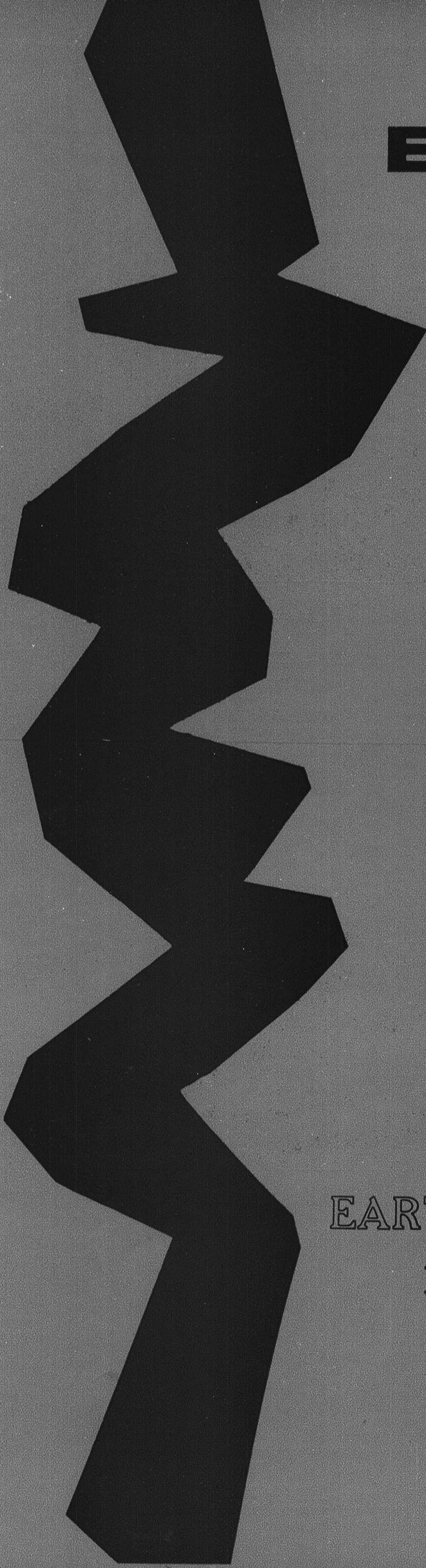
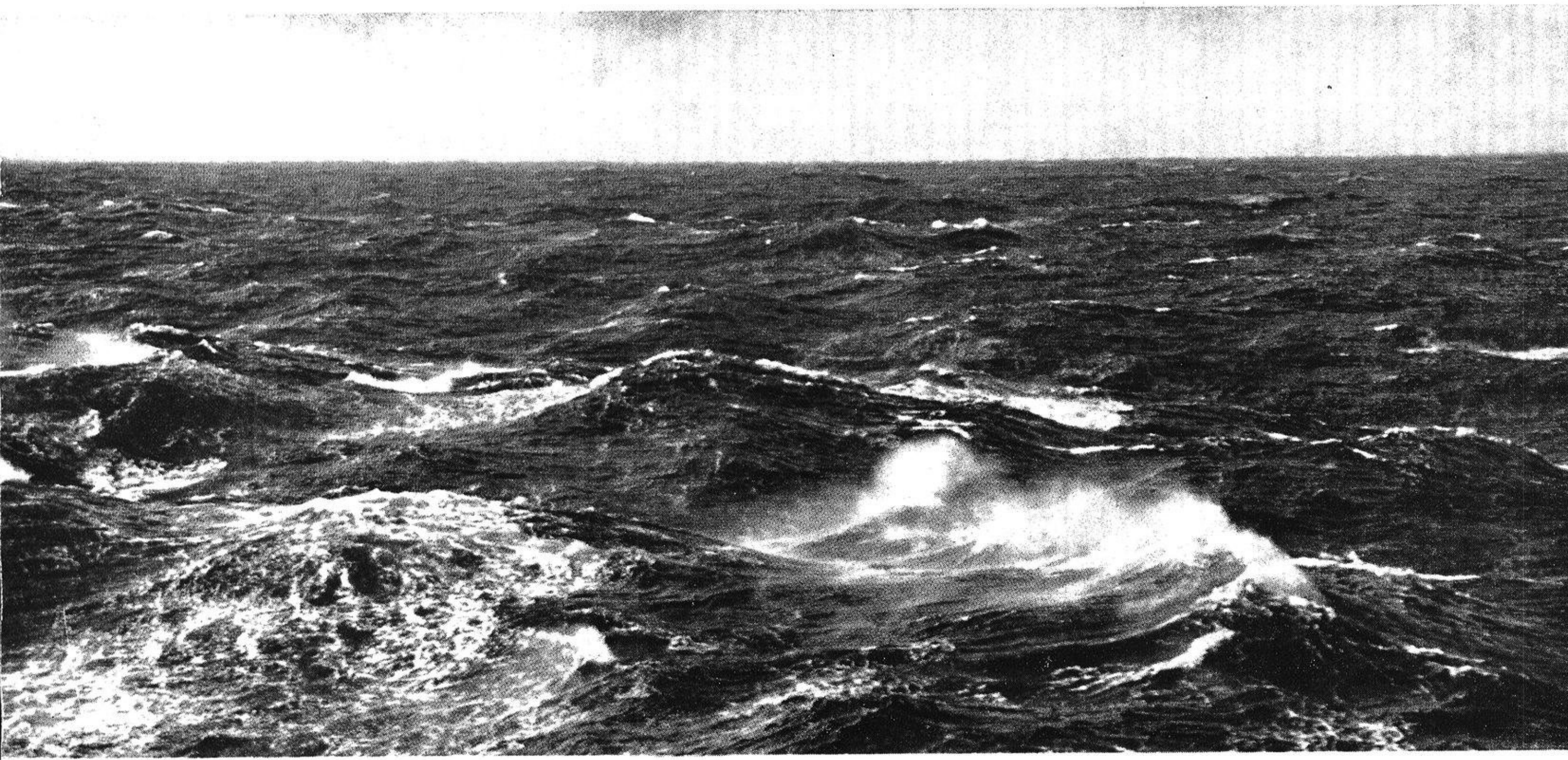
Member E. C. M. A.



EARTHQUAKES
page 14



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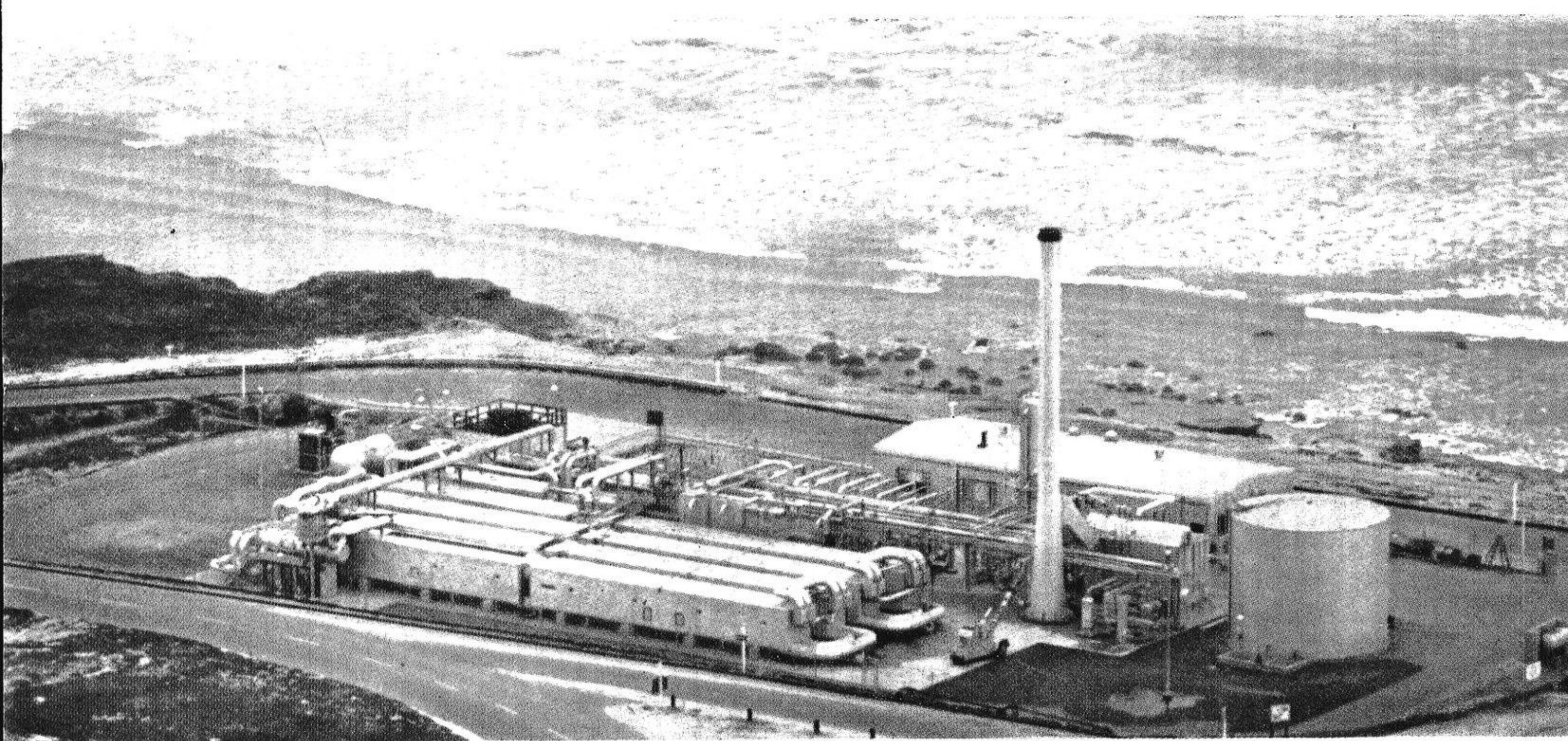

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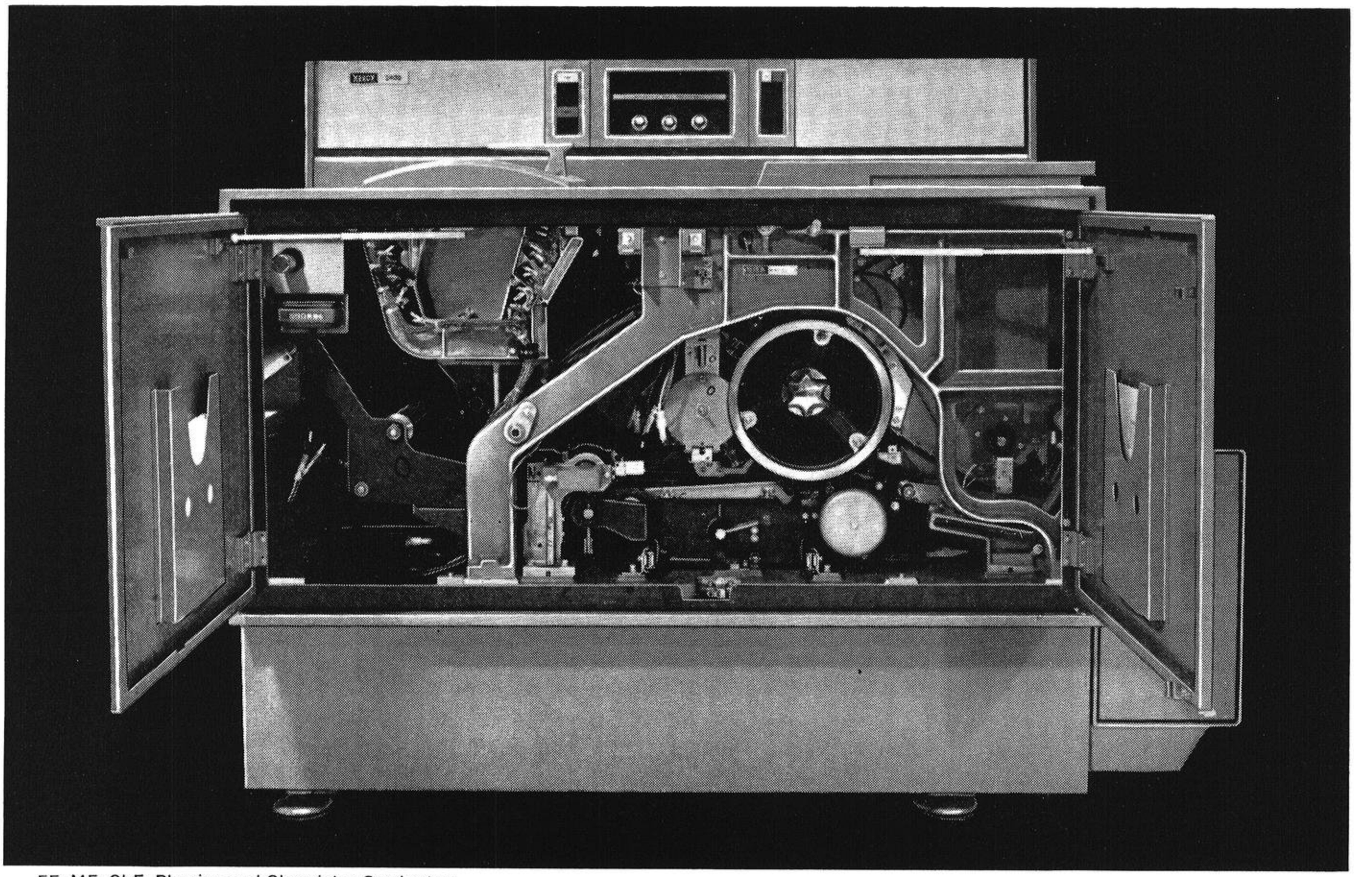

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Second Class Postage Paid at Madison, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at a special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized Oct. 21, 1918.

Published monthly from October to May inclusive by the Wisconsin Engineering Journal Association, 333 Mechanical Engineering Building, Madison, Wisconsin 53705. Editorial Office Hours 3:30–4:30 Monday, Wednesday and Friday. Office Phone (608) 262-3494.

VOLUME 70, NUMBER 4 JANUARY 1966

ARTICLES

THE WISCONSIN ENGINEER

The Student Engineer's Magazine Founded in 1896

FEATURES

THIS MONTH'S COVER

Our January cover really isn't splitting apart—Earthquakes don't really look this way either. For the real story, see the article beginning on page 14.

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Rambling with the Editor

"TWO PRECIOUS DAYS"

During this January Final Examination period, we will be able to observe the effects, if any, of an innovation in the semester calendar.

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The advantages are patent and significant. An extra two days after the last day of classes is about the best thing that could happen for many of us. Everyone has been plagued at least once, we're sure, with a full day of classes on a Thursday and one or two final exams on Friday. No matter how diligent and studious one has been during the semester, one evening does not give adequate time for a review of a semester's material.

Naturally, a desirable thing can be abused and the opportunities for abuse of the study period are obvious too. Students may not utilize the period and thus indicate to the administration and faculty that extra time for review is unnecessary. And the faculty, too, may make the open period undesirable by assigning additional homework, "since students will have more time."

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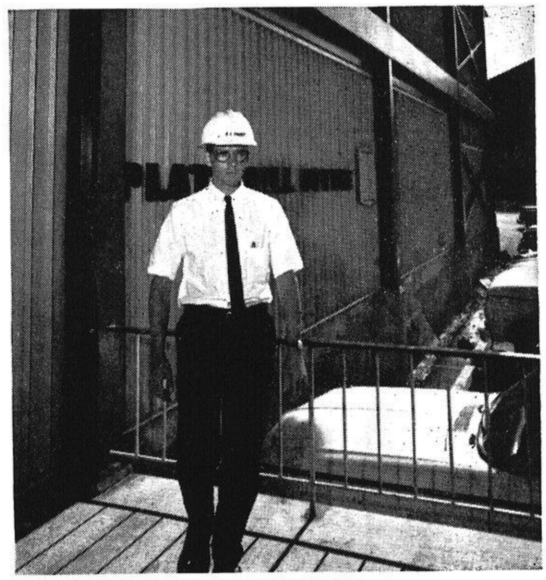

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Men on the move at Bethlehem Steel

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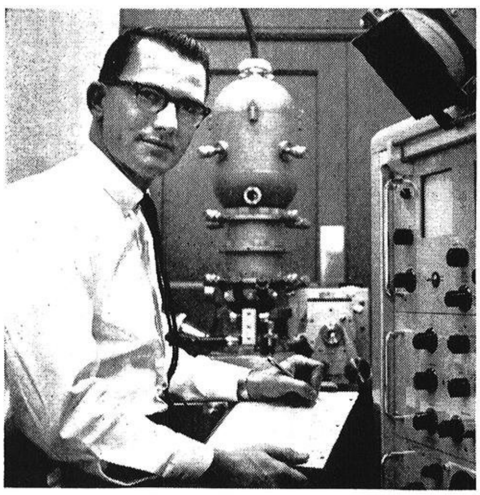

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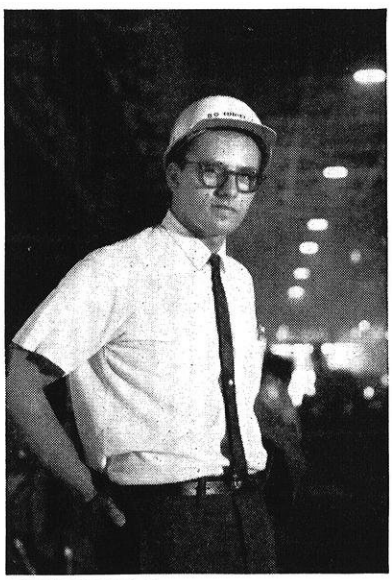

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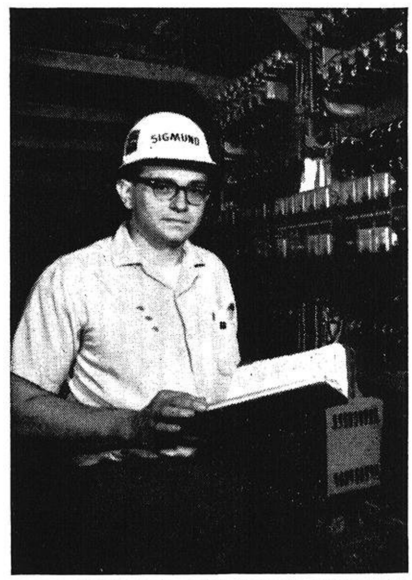

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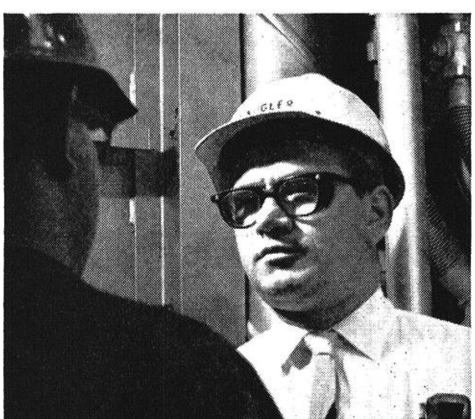

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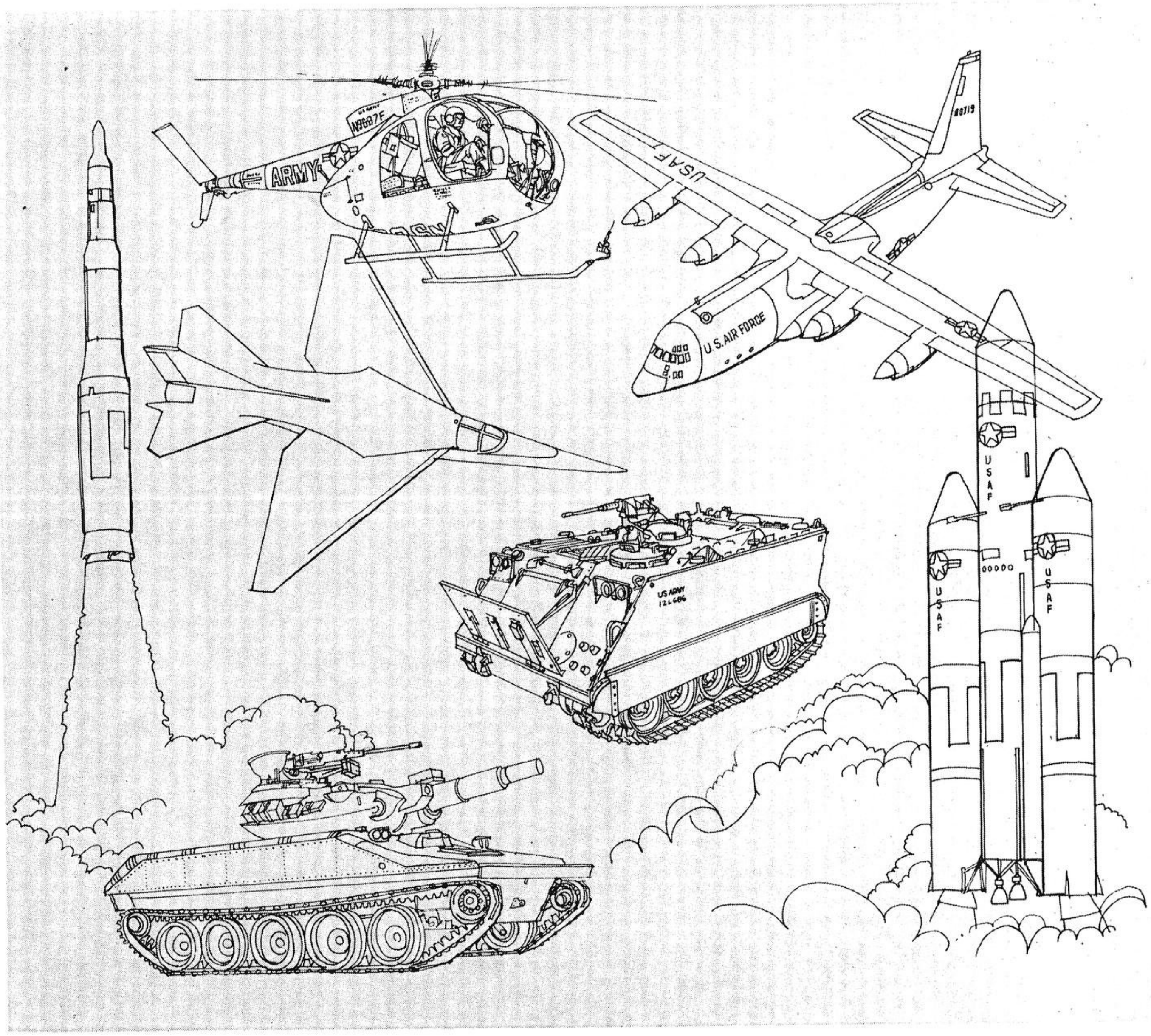

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Aftermath of Alaskan Earthquake of 1964.

EARTHQUAKES!

Their causes and characteristics

by

Larry Jost, cie4

EARTHQUAKES have been in existence for as long as the world itself, according to radioactive dating and other methods. Theories on the cause of earthquakes have ranged from giant monsters, to the wrath of God, to such sophisticated theories as radioactive discharge. One thing that everyone agrees on, however, is the vast amount of destruction that is incurred by an earthquake of high magnitude.

This article will give a brief resumé of the causes and common characteristics of earthquakes.

EARLY THEORIES OF EARTHQUAKE

The earliest mention of earthquakes on record is in the sixtieth Psalm in the Bible: "Thou hast made the earth to tremble; thou hast broken it; heal the breaches thereof; for it shaketh." At the time that the sixtieth Psalm was written, it was the common belief that earthquakes were God's way of saying that He was displeased with the actions of His people. This theory died when scientific methods of analysis were introduced, but it was again revived when, in 1857, following the great Italian earthquake, the Pope proclaimed that it was God's revenge for the sins of the people. This theory was quickly refuted by the people and particularly by Robert Mallet, who had just finished extensive tests with the effects of high explosives. He postulated that an earthquake was the result of large explosions in a focal cavity deep within the earth.

Some of the more interesting theories have been handed down to us through mythology from different nations. The Japanese believed that earthquakes were the result of the writhing of a giant catfish that lived beneath the crust of the earth. The peoples of South America believed that it was a whale instead of a catfish and the North American Indians believed that a giant tortoise was responsible for the wild contortions of the earth.

There were many minor hypotheses that followed, such as the belief that earth movements were due to atmospheric disturbances, electrical discharges, or chemical changes in the earth. Certain of these are still believed to play a very small role in the triggering of earthquakes.

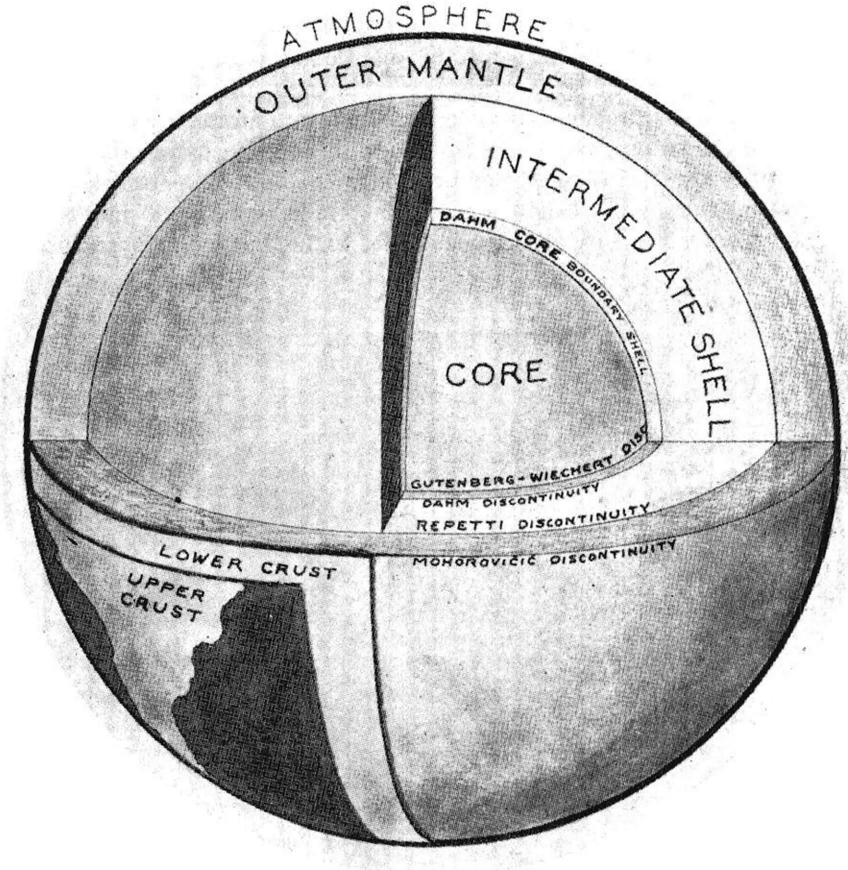
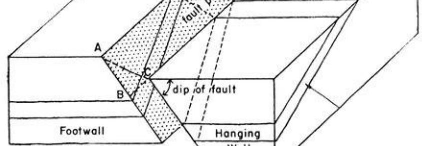


Figure 2.—The interior of the earth.

FAULTS IN THE EARTH

Before the causes of earthquakes can be completely or even partially understood, it is necessary to be familiar with certain basic concepts and definitions of geology. Faults are fractures in the earth along which formerly continuous beds of rock have been dislocated in a direction parallel to the fault surface. This means that a fault is really just a discontinuity in the earth's interior or crust. There are two basic types of faults which occur: 1. the strike-slip fault which occurs when the two sides of the fault move in horizontal directions, and 2. the vertical fault in which the walls move in vertical directions. The two types of vertical faults are: A. the normal fault in which the upper or hanging wall moves down in relation to the footwall, and whose members are in tension; and B. the reverse fault in which the opposite occurs—the hanging wall moves up relative to the footwall, and its members are in compression. (See Fig. 1.)



—Courtesy of Macelwane

Figure 1.—A typical fault showing the hanging wall and the footwall.

This leads to another definition or description which can be best understood by the use of Fig. 2. The earth is made up of the upper and lower crusts which together are between four and fifty miles thick. The mantle and intermediate shell together extend about 1800 miles down. The mantle is almost entirely made of solid rock whose true identity is not entirely The core is divided into two layers known. The core is divided into two layers (not shown in Fig. 2). The outer core, which is metallic liquid, goes down about 1000 miles more, from the mantle to the inner core. Unlike the outer core, the inner core appears to consist entirely of metal in the solid state. Most faults occur within the mantle, while a few occur in the crust.

MODERN THEORIES OF EARTHQUAKES

Since the beginning of the 20th century and slightly before there has been only one main theory, with a sub-theory and several subordinate theories, on the cause of earth tremors. The most easily accepted is the **elastic rebound theory.** Very briefly defined, this theory states that when the stresses on the alls are built up, reach a limit, the surfaces of the fault will suddenly snap, slide relative to each other, and release tremendous amounts of energy.

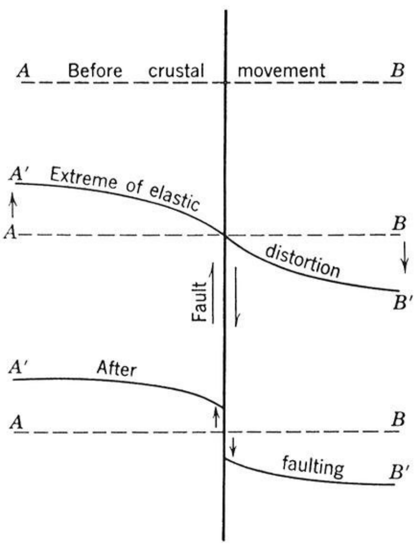


Figure 3.—Elastic rebound along a fault.

Fig. 3 illustrates this principle. The sides of the fault are held together in static equilibrium. As the stresses on the wall are built up, the surfaces start to deform until the maximum stress point is reached and the whole thing releases. This theory could be compared to getting your foot stuck in the mud. You pull and pull and finally your foot releases and you fly backwards due to the elastic rebound.

A second hypothesis which has been discarded by most geologists is the **regional force theory.** It is closely associated with the elastic rebound theory except it postulates that the forces set up by heat and compression in a small regional core are suddenly released in all directions much like a firecracker.

THEORIES OF EARTH FAILURE

The causes of faulting, like so many other phenomena of nature, are hard to explain, but there are many theories that try. The first popular theory is the **contraction** hypothesis. This is the oldest of the modern theories and it assumes that the earth is cooling in the region between 80 and 600 miles deep. This cooling causes the earth's surface, which is not cooling, to pull together and form cracks or faults. This theory could also be used to explain the elastic rebound theory which says that when the distorting forces reach a magnitude which exceeds the frictional resistance of the fault surface, the elastically stored energy is suddenly released. There have been numerous attempts to discover exactly where the forces that cause the distortion come from. This could be a possible solution.

The **convection current** hypothesis assumes that heat is being generated by radioactive disintegration. This heat slowly builds up and is then carried to the surface by gigantic convection currents within the mantle. Because of their tremendous size these currents have the power to distort the features of the earth (See Fig. 4) The currents supposedly move with a velocity of about one and one half feet per century.

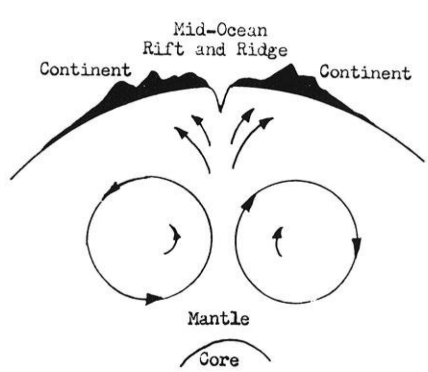


Figure 4.—Convection currents.

The **continental drift** theory postulates that all the land of the world was once one continent situated in the middle of what is now the Atlantic ocean. There is a ridge in the mid-Atlantic that seems to substantiate this theory. Also the bulge on the west coast of Africa would fit very nicely into the Caribbean area and the bulge of Brazil would fit into the dip in the southwest coast of Africa. There are also new methods of confirming this theory by the study of magnetism which has been in the earth since its formation. The pulling apart of the continents supposedly caused crevasses and faults, and may still be causing the stresses which are needed for the formation of earthquakes.

The **expanding earth** hypothesis states that the earth started out as a very small solid ball of material, but due to an increase in gravity and internal pressures the earth is gradually expanding in size. The expansion sets up forces similar to those necessary for the formation of earthquakes. The expansion also creates great fissures which spew forth molten rock in the form of volcanoes. The molten rock is formed by the heat created by the internal pressures.

The theory of **isostasy** (equal standing) refers to the changes in the surface of the earth due to the low densities of features such as mountains, and the high densities of plain areas. Because gravity is a function of density and mass, the high densities of the plains tend to buoy up the low density mountains thereby equalizing the gravitational attraction of each. These forces are supposedly at work at all times equalizing the heights of the crust and the mantle. If this theory, which has been proven and disproven by many people, is true, then it too could explain the forces that act on faults to form earthquakes.

These five theories go a long way toward explaining the extremely large stresses necessary to activate an earthquake of high magnitude.

Because we do not know exactly how the earth was formed, whether it was formed by the condensation of hot gas, or the accretion of cold particles, it cannot be determined whether the earth is still heating up or cooling off. If it is really heating up, then the contraction theory has to be thrown out. If it is cooling off then the expansion hypothesis must be dropped.

One of the few weaknesses in the faulting theory of earthquake causation is the observation that relatively few earthquakes have been accompanied by surface faults. It is usually just assumed that the slipping occurred at depth with no surface rupture.

CAUSES OF SUBORDINATE EARTHQUAKES

There are four basic causes of earthquakes of a lesser nature. All of them have been generally accepted so it will not be necessary to discuss their merits to any great length.

Collapse earthquakes are caused by the failure of large caverns, usually in and area where large limestone caves are numerous. The collapse of the walls and roof is enough to cause a slight jar in the immediate area. It had been thought once that these collapses were the cause of all earthquakes, but this can be easily disproven by comparison of the amount of energy released by collapse and the amount necessary for a large quake.

Small earthquakes may sometimes be caused by the **impact of meteors** with the earth. The only recorded instance of a tremor caused by meteors was in Siberia on June 30, 1908. Huge craters covering an area of 15 to 20 miles in diameter were found. Despite the fact that this is the largest meteor shower known, it just barely caused enough movement to be recorded by geologists.

Much has been written about and much faith has been placed in the connection of earthquakes and **volcanoes.** The idea that both are due to pressures operating in great reservoirs of molten rock at considerable depth has long been abandoned. It is a well established fact that this is the cause of volcanoes, but any earthquakes associated with volcanoes are caused by side effects such as the great stress and thrusts that are produced in a volcanic eruption. Slight tremors are often felt before and after volcanic eruptions but they are not caused directly by the pressures of the molten gases.

Last and by far least, are **rockbursts**. These occur in mines due to failure of rock under stress resulting from removal of material. Rockbursts afford opportunity for special seismological investigations but they contribute little to the overall effect of earthquakes.

There are other isolated pockets of earthquakes that may be the result of local geophysical action. The earthquakes of the New England and St. Lawrence region are thought to be the result of isostatic readjustments of the earth's crust incident to the retreat of the ice sheet which covered much of the northern United States and just about all of Canada.

SOME CHARACTERISTICS OF EARTHQUAKES

There are basically three things to be studied when dealing with earthquakes:

1. Causes leading up to earthquakes.
2. Motion produced by earthquakes in the earth.
3. The effects of this motion on humanity.

The first portion of this article was designed to explain the causes. This second part is intended to group motions and effects under one broad haading-characteristics.

The exact center of an earthquake is called the focus, which is generally deep in the earth but may be anywhere from the surface down to about 400 miles. The more destructive earthquakes generally have their foci near the surface, thereby causing much greater agitation of the crustal area.

Classification

Earthquakes are classified according to several different methods, one of which is depth. Shallow quakes are those whose focus is less than 80 miles deep. Those in the range from 80 to 300 miles are considered intermediate, with the deep being those greater in depth than 300 miles.

Another method of classification is by the use of scales which are based on human judgement. One of the most popular of these scales is the Modified Mercalli Scale, shown in the box on page 18.

The scales of this type are basically measuring the intensity of the earthquake. With uniform surface conditions, the Mercalli scale will drop one grade each time the distance from the epicenter, which is the point on the earth's surface directly above the focus, is doubled.

MAGNITUDE

The other main way of classifying earthquakes is by magnitude, which is a measure of the energy released. To find the energy of an earthquake, the amplitude (c-d of Fig. 5 and period (a-b of Fig. 5) of the waves produced by the earthquakes must be known, the distance between the epicenter and the recording must be found, and a correction factor for the particular station where recordings are being made must be introduced. The correction factor takes into account local geologic conditions and the individual characteristic of the recorder.

The energy released by a shock of great magnitude is of the order of 10^{25}ergs, which is equal to approximately one trillion foot-pounds! The energy released is of two types:

1. Heat energy, which is dissipated within the earth and
2. Elastic wave energy which is dissipated as the waves spend themselves.

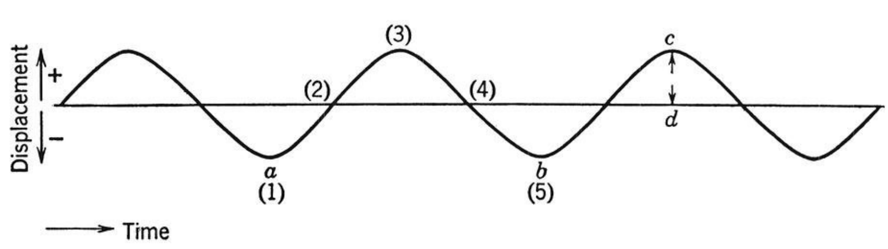


Figure 5.—Simple harmonic motion.

Modified Mercalli Scale (after Hodgson)

I. Not felt except by a very few under especially favorable circumstances.

II. Felt by only a few persons at rest, especially on upper floors of buildings. Delicate suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of building, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing truck. Duration estimated.

IV. During the day felt indoors by many, outdoor by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V. Felt by nearly everyone: Many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable object overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks say stop.

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars.

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls, heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbs persons in motor cars.

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in sub-substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed over banks.

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward in the air.

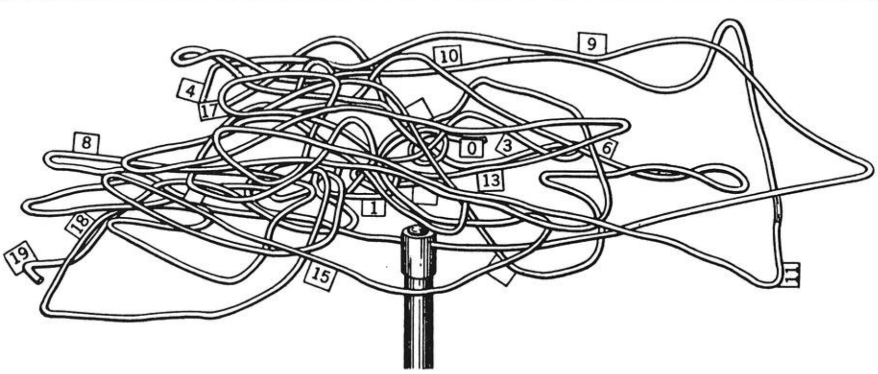


Figure 6.—Model of ground motion during the first 20 seconds of the Japanese earthquake of February 15, 1887. The model is greatly enlarged.

Distribution and Frequency

There are four main belts of earthquakes around the earth:

1. The circum-Pacific belt with many branches.
2. Mediterranean and trans-Asiatic belt.
3. Narrow belts through the Arutic and Atlantic oceans and East-African underwater valleys.
4. Scattered belts of only local significance.

It is estimated that over one million earthquakes occur annually with the majority of them occurring in one of these four regions. In Hawaii alone in the months of September and October of 1959 over 22,000 earthquakes were recorded. Most of them were too small to be felt but were recorded with sensitive instruments.

Strong-Motion Instruments

There are many types of instruments that are used in the detection and classification of earthquakes. Possibly one of the most interesting of these is the strong-motion instrument. Designed by the United States Coast and Geodetic Survey, it records ground acceleration and the ground displacement on a sheet of photographic paper. The actual displacement of the ground is small and seldom exceeds a fraction of an inch but it can leave some wierd patterns as illustrated by Fig. 6.

CONCLUSION

The study of earthquakes is based on a progression of theories. The elastic rebound theory is supported by the earth failure theories, which are based on the theory of how the earth was formed. From this it can be seen that there is really no firm foundation for the study of earthquakes, even though there has been much work done in this field.

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The Role of CLIMATE in SOIL GENISIS

by

Edward E. Bellin, meag4

SOIL, like faith, is the substance of things hoped for, the evidence of things not seen. It is the starting point for all the living things which inhibit the earth. The flowers that grow in the garden, the trees that tower in the woods and forests, and the grains and grasses that flourish in the fields, as well as the animals that consume them—all owe their existence to the soil. Man himself, by way of all the food he eats, is a product of the soil.

Soil is what is left of the rocks that originally covered the face of the earth after such weathering forces as rain, sunshine, frost, and wind have broken them to pieces. Soil also contains the remains of many generations of plants and animals that have lived on the earth.

Soil must be considered in relation to its environment. Soil, climate, and vegetation are all so closely related that if one knows the facts about any two of these, he can deduce the facts about the third.

CLIMATE

Soil-forming processes are directly affected by climate. Climate determines the kind of vegetation predominating in any region. It affects the percolation rate in the soil by the amount of precipitation, the relative humidity, the temperature, and the length of the frost-free period.

Some of the direct effects of climate on soil formation include:

1. A shallow accumulation of lime in areas of low rainfall.
2. Acid soils in humid areas due to intense leaching.
3. Thin soils on steep hillsides because of the quantity and intensity of rain producing erosion.
4. Deposition of soil material downstream.
5. More intense erosion in warm regions where the soil does not freeze.

Soils come from rocks. The rocks will weather to form the parent material of the soil. The parent material will weather to form the soil itself. Some of the weathering forces are: rain, sunshine, frost, and wind. Water, wind, gravity, and ice will transport the soil. The parent material of the corn-belt was deposited by the wind. The parent material in the northern part of the United States and the marine sediments along the Gulf and Atlantic coasts were deposited by glaciers. Therefore, weathering is another way to express the climatic effects on the soil. There are essentially two types of weathering; namely, physical or mechanical weathering, and chemical weathering.

Physical Weathering

Temperature. The most universal type of physical weathering is that which is produced by changes in temperature. Expansion and contraction in the superficial layer of the rocks, when of sufficient magnitude and suddenness, can result in strains leading to shattering. This type of weathering occurs mostly in dry climates where great changes in temperature occur at sunrise and sunset. Changes in temperature from day to night and from season to season tend to break the rocks into large-scale pieces. In cool climates with greater rainfall, the effects of freezing and thawing are often important in the breaking apart of rocks, depending on the number of joints and interstices which become filled with water in winter. The screes of our mountain valleys are examples of the disruptive action of alternating frost and thaw.

Rivers, moving ice in glaciers, wave action, and the blast of sand grains in the wind are all agents of physical weathering. Desert soils and the soils of the arctic and alpine regions result primarily from physical weathering. These soils are termed "skeletal" and are characterized by the presence of large proportions of coarse material.

Temperature governs the speed of chemical and biological reactions. It decreases the effectiveness of rainfall by increasing the evaporation in warmer climates. Higher temperatures are generally associated with increased clay content in the profile. Organic matter accumulation increases with decreasing mean temperature and increasing precipitation.

Precipitation. Precipitation affects the soil moisture content, aeration, and leaching. Rainwater tends to dissolve some of the limestone and other parts of the rock. Wetting and drying cause expansions and contractions of the loosened limestone particles, breaks them apart, and finally leaches them out of the soil.

Low rainfall, low relative humidity, and severe wind or water erosion of the soil material are factors retarding soil-profile development. Some of the physical and chemical characteristics of soils developing under conditions of limited rainfall are:

1. The colloid is dominated by bases—primarily calcium.
2. The soil reaction is near or above neutral in most horizons with slight acidity often characterizing the surface horizons.
3. The chemical and mineralogical makeup of the colloid fraction is relatively uniform throughout the profile, except where variations in the composition of the soil-forming material prevent this. Movement of colloids by percolating water is limited, probably because of the high state of aggregation due to the abundance of calcium ions.
4. A zone of calcium-carbonate and magnesium-carbonate frequently develops. This zone is thought to coincide with the depth to which percolating water most frequently penetrates.
5. Soil organic matter accumulates throughout virtually the entire profile.

Below is a generalized map of the annual precipitation in the United States.

Temperature and Precipitation Versus Aggregation. It is interesttion with the soil-forming climatic tion with the soilforming climatic factors of rainfall and temperature. The finer-textured soils have more silt and clay to aggregate than do the coarse-textured soils. Aggregate analyses are available for a number of different soils which have yielded sufficient data for a correlation between climate and aggregation. The results show the formulation of several tendencies. Some of these tendencies can be seen from the curves on page.

The percentage of aggregates is low in desert soils because of a low clay content. This is due to slow chemical weathering under arid conditions. As rainfall increases, the clay formation increases. The increase in clay content continues until the rainfall becomes great enough to eluviate the clay from the top layer of the soil down to the next layer. This decrease in clay content in the top layer decreases the possibilities for aggregate formation. The layer percentage of aggregation of silt and clay in regions of decreasing rainfall is due to the amount of organic matter present.

When rainfall is constant and temperature increases, the percentage of aggregation of silt and clay is affected differently in humid and semi-arid regions. The percent of aggregation of silt and clay decreases from Canada to Texas. This decrease in aggregation is due to the lowering of organic matter content with the increasing temperature. The aggregation of these soils varies from 75 per-cent in Canada to 25 per-cent in Texas. The "S"-shaped curve which correlates the aggregation of silt and clay in humid soils with temperature is due to the differences in factors contributing to the building of secondary particles. These tendencies indicate that the soil-forming climatic factors of rainfall and temperatures are expressed in the structure of the major soil groups.

Chemical Weathering

Chemical weathering processes depend on the decomposing action of water, the presence of dissolved carbon dioxide, and, in some cases, the organic acids formed from the decay of plant residues. Chemical

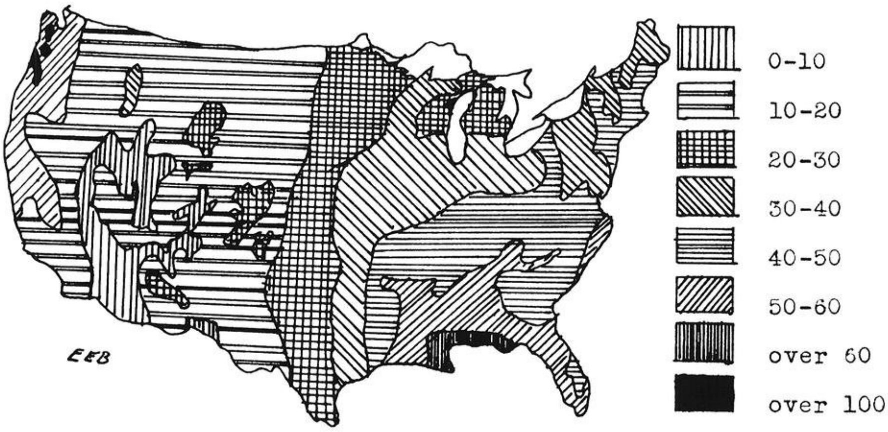


Figure 1.—Generalized map of annual precipitation.

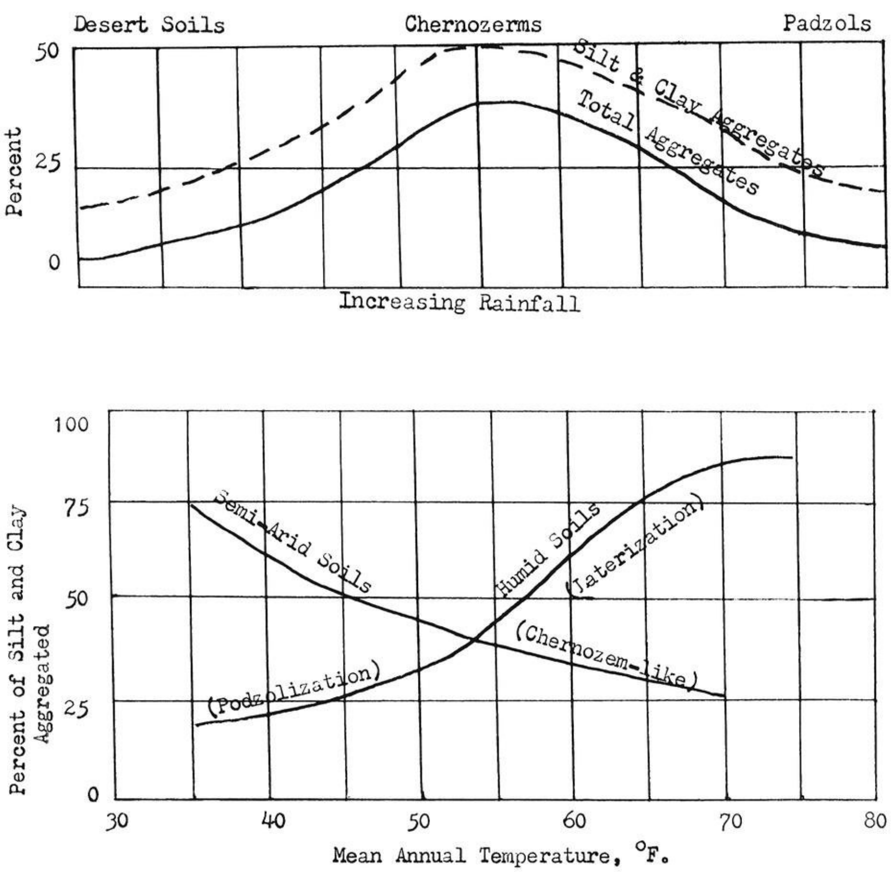


Figure 2.—The climatic aspect of soil aggregation.

weathering becomes more intense on the surface of rocks where physical weathering has already taken place; however, chemical weathering alone is capable of disintegrating.

Chemical weathering involves two phases; namely, (a) the disappearance of certain minerals and (b) the formation of secondary products. Secondary products may originate by precipitation from solutions containing the soluble products of weathering. The mineral silicates such as the felspars, micas, and ferromagnesian minerals are principally affected by chemical weathering. Certain minerals are practically unaffected by chemical weathering and persist unaltered in the soil.

In areas of cold temperature and/or low rainfall, chemical weathering is relatively slow. It is at a minimum under desert conditions since it is quite dependent on the presence of water. Increased temperatures will speed up chemical reactions and decomposition of organic matter.

Chemical weathering is speeded up with increased rainfall and temperatures. The amount of leaching of base elements in the soil is another direct effect of climate. High rainfall will cause greater washing-out of calcium, potassium, and magnesium. Many soils rich in limestone long ago are now strongly acid in the surface. As rainfall decreases, the lime accumulation layer tends to be nearer to the surface.

VEGETATION

The vegetation growing on any given area of soil in its virgin state provides a clue not only to the nature of the climate, but also to the nature of the underlying soil as well. Climate influences soil formation indirectly, largely through its action on vegetation. For example, grasses can get along with less water than trees. Drought tends to stop plant growth and eventually kill the plant. Rain provides conditions for reseeding. Trees do not reestablish themselves so easily. That is why the dry Great Plains are a natural grassland and trees are the dominant vegetation in the humid climates.

Influence of Natural Vegetation on Soil Formation

The character of natural vegetation really expresses the sum of all the climatic factors under which it grows. Its influences on soil formation is brought about mostly by the kind, amount, and distribution of the organic matter which they add.

The kind of soil material influences the trees that will grow on it. These trees in turn influence the soil-forming processes. For example, pine trees will grow on a more acid soil than will beech, maple, or basswood. The pine needles are lower in calcium, potassium, and magnesium than the leaves of these other trees. The leaching water through decaying pine needles is therefore more acid. This means that there will be a greater leaching effect on the surface soil.

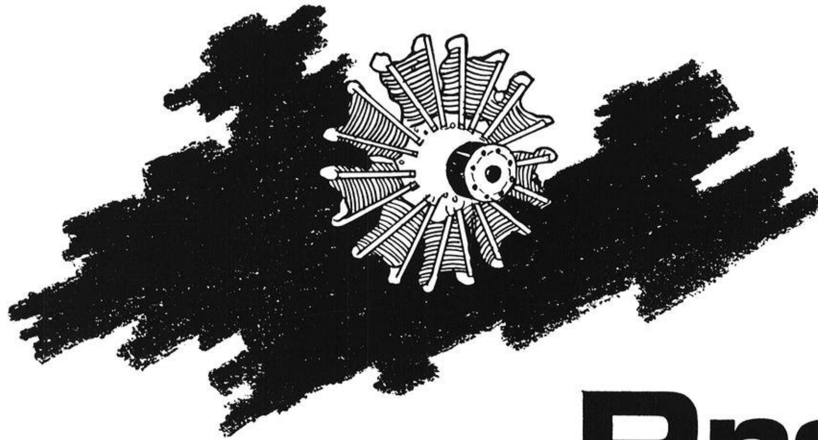
The transition zone between vegetation types shows the effect of soil conditions the greatest. In the northern coniferous forests there is little ground vegetation. The main source of soil organic matter is leaf fall which tends to form a superficial layer of acid peaty humus. The leaves are naturally poor in mineral substances. The leaf fall is richer in mineral constituents under deciduous forests.

Forests grow best under humid conditions while extreme humidity leads to bog or moor. We have already noted that the rainfall decreases as you cross the Great Plains from east to west. The native vegetative cover changes from trees or tall thick grass to short or bunch grass as shown in Figure 3.

Ground vegetation also provides for a considerable amount of organic matter; in fact, even more so than the forests do. The organic matter under the tall grasses extends 15 to 30 inches in depth while the organic matter under short grasses extends only six to eight inches in depth. The higher organic matter content of grasslands as compared to forest soils is due to a number of circumstances:

1. Accumulation of organic matter under forest conditions

Past



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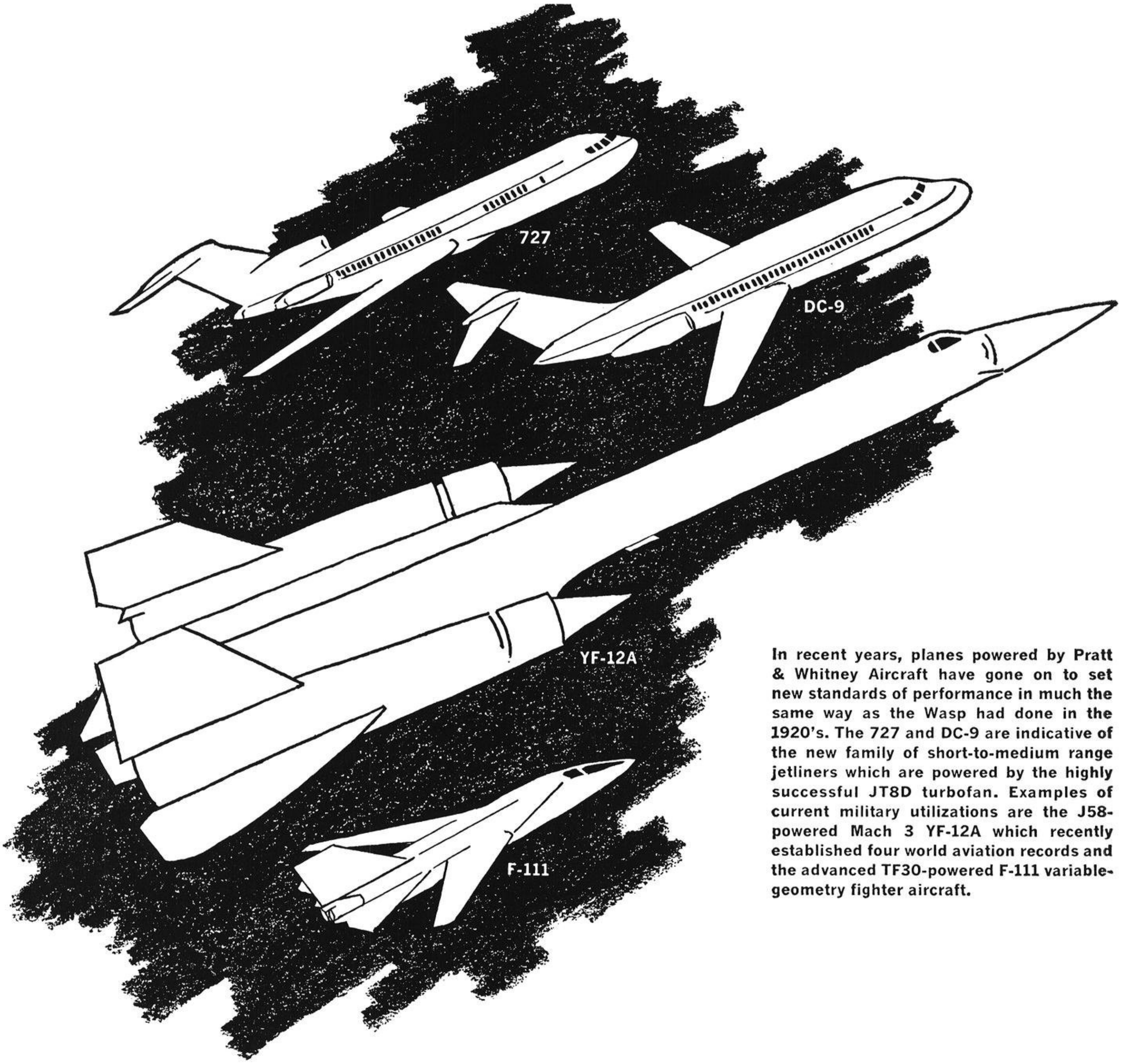

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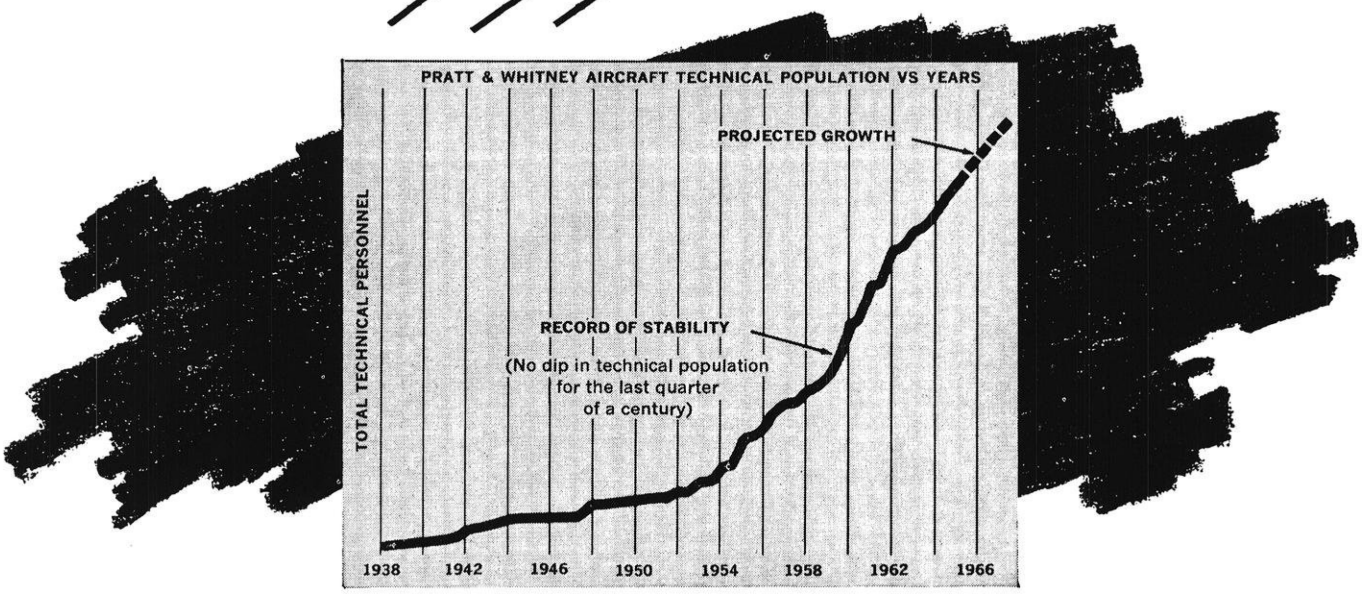

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comes from leaf-fall which is exposed to serious losses by oxidative decomposition occurring on the surface. Plant residues under grassland conditions are added both within the soil from dead plant roots and at the surface from the remains of leaves and stems of dead plants.

2. The activity of earth-worms and other burrowing animals is greater under grasslands than under forests. Therefore there is a more rapid and thorough incorporation of residues throughout the profile.
3. Biological decomposition is more restricted due to summer drought under grassland conditions than under the humid forest conditions.

Major Effects of Vegetation

Vegetation is the source of organic matter in soils. Soil development in the portion of the soil profile in which there is a noticeable influence of organic materials on the changes in the physical and chemical properties of the mineral constituents. Grasses and trees are the two most important single groups of plants which synthesize organic matter. Their relationship to climate in soil development is seen in Figure 4.

Canopy Protection. The aboveground portion of plants is very effective in preserving the content of large pores in the soil. Raindrop impact deteriorates the structure of the soil by decreasing the volume percentage of large pores more than the total porosity. In 1874 Wollny observed that peas, rye, and vetch protected the soil from raindrops to such an extent that the non-capillary porosity of the protected soil was 34 to 53 percent higher than the adjacent unprotected soil. As the number of plants per unit surface area increases, there is a reduction in the magnitude of the soil volume increase. A certain number of fertilized plants are about as effective as twice as many unfertilized plants. Structural changes are due to the dispersion of aggregates in the soil surface and the movement of silt and clay into larger pores. This increases compaction and de-

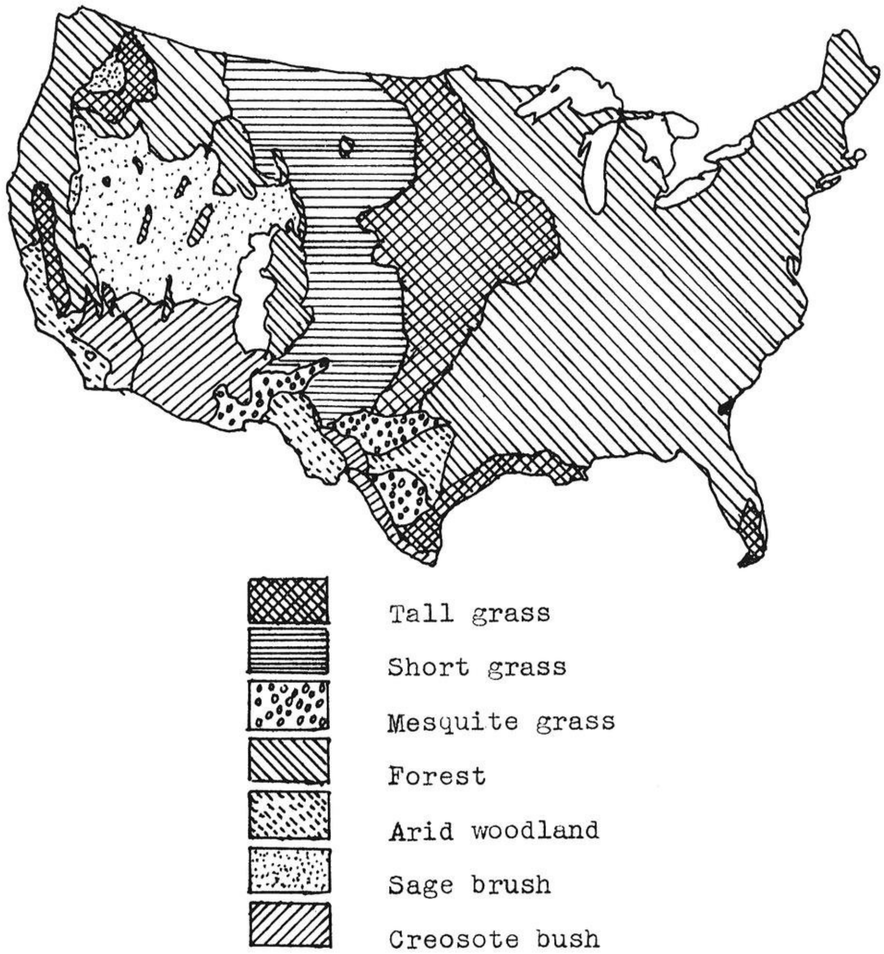

Figure 3.—Map showing the native plant cover in the United States. This map does not show the small areas of tall-grass prairie in Indiana, Michigan, Ohio, and Wisconsin.

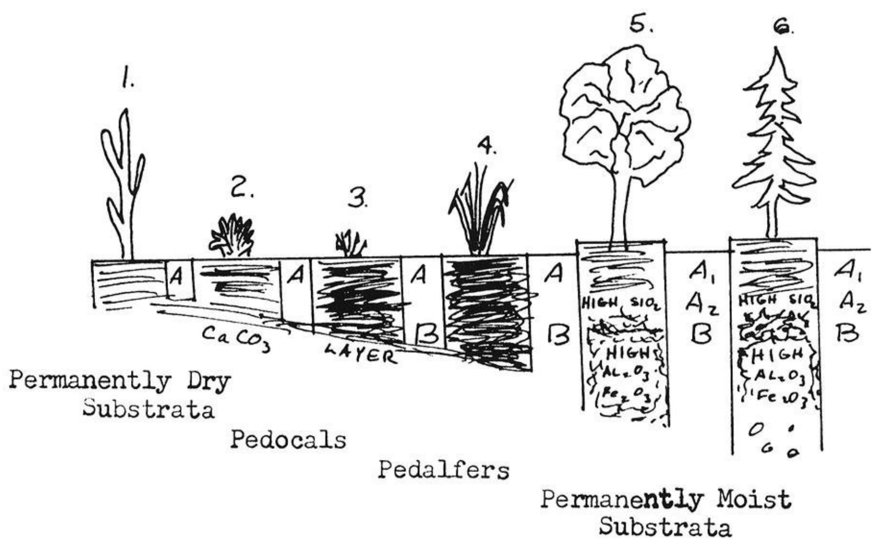

Figure 4.—Schematic diagram showing relation of climate and vegetation to soil development.

1. Cactus—arid—high evaporation
2. Sage brush—semi-arid
3. Short grass—sub-humid
4. Tall grass—humid
5. Hardwoods
6. Conifers—humid—low evaporation

creases the amount or soil content of large pores.

Plants provide shade which reduces evaporation of water and thereby increases the effectiveness of natural precipitation. Wollny also showed that the denser the plant cover, the less will be the change in porosity of the soil during the growing season. He found that only 45 to 88 per-cent of total rainfall reached the land surface directly depending on the type of crop and the number of plants per unit area.

Any vegetative cover impedes run-off. It not only slows the rate of water flow, but it also prevents a rapid concentration of the water. It therefore lessens the cutting action of the water. There is more time for infiltration when the rate of run-off is decreased by vegetation. A good grass sod resists the cutting action of water. The following table will show this fact.

TABLE 1.—THE EFFECT OF VEGETATION ON THE AMOUNT AND VELOCITY OF RUNOFF
(Norman and Smith—1937)

YEAR	NUMBER OF RAINS	CROP	MAXIMUM RATE OF RUNOFF, INCHES OF RAIN/HOUR	TOTAL RUNOFF, INCHES OF RAIN
1933-1936	50	Corn, Clover	0.67	0.57
		& Timothy	0.27	0.38
1933-1934	36	Corn	0.79	0.34
		Blue Grass	0.20	0.13
1935	19	Oats	1.23	0.52
		Blue Grass	0.53	0.50

Crop Effects. Crop effects hinge quite closely with the facts about canopy protection. The direct effects of growing crops on the structure of the soil may be divided into two categories: 1. the protection provided by the leaves and stems against the impact of raindrops which retards the deterioration of the soil structure and 2. the development of granulation and porosity through root activity which aids in the regeneration of the structure. The indirect effects are those changes in granulation that are caused by the organic matter produced by plant growth. The effect of plant cover on the interception of rainfall depends on the type of plant providing this cover. (See Table 2 below-.

Root Effects. Two facts are significant concerning the effect of the root system of vegetation on the genesis of the soil structure. First, there is a growing belief that plant roots are as important as any other factor in soil formation. Second, a complete picture of the nature of these beneficial root effects is unavailable.

Sod crops. Anyone who has spaded or worked with grass sods undoubtedly has been impressed by the granular nature of the soil among the roots. There are several explanations which may be offered for this type of granulation. The earliest explanation was based on the pressure exerted by the growing roots. This pressure tends to separate the particles adjacent to the roots and to press these particles into aggregates. One of the more recent explanations suggests that changes in moisture in the vicinity of the root system promotes granulation. This will produce localized dehydration. There may, however, be other influences which are equally important.

Something comes from the plant root which stabilizes any aggregation that is formed. It may be the organic colloids which are produced during root decomposition. Organic residues from plant roots may also have a considerable effect upon stabilizing the secondary particles.

When the plants and roots die and decompose, they promote the passage of air and water through the spaces and channels left by the decayed material. The ideal soil structure for cultivated crops can be produced in only one known way and this is through the compacting of a soil richly provided with actively decomposing humus and the breaking-up of the compacted soil into crumbs by the action of grass roots. Plant roots also help to hold the soil in place and to protect it from water and wind erosion.

The amount of organic material produced by the roots of a grass crop is very considerable and may amount to two tons per acre per year. Fine roots continually die off and are readily decomposed. Microbial development favors these conditions of the soil in the neighborhood of the plant roots.

Biological Influences. Soil fauna are most abundant where is ample vegetative cover. Earthworms, beetles, and other biotic life with their channels permeate the soils under thick forest litter. This makes the soils permeable to water. Further experiments conducted by Wollny show that channeled soils are about two and a half times more permeable to air than the unchanneled soils.

Transpiration Effects. Transpiration of vegetation removes the major portion of the water in the soil

TABLE 2.—THE EFFECT OF PLANT COVER ON THE INTERCEPTION OF RAINFALL

Percent of Total Rainfall Penetrating Vegetative Canopy
Woll, N.Y. (BAUER, 1938)

CROP	Number of Plants per Four Square Meters: 0	36	64	100	144
Corn	100	62.9	60.7	57.0	44.5
Soybeans	100	88.4	78.2	65.9	64.3
Oats	100	----	78.5	78.4	78.9
Vetch	100	----	----	78.1	----
Lupines	100	----	----	57.9	----
Peas	100	----	----	87.8	----
Red Clover	100	----	----	61.3	----
Alfalfa	---	----	----	----	----

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after the soil has drained to about its field capacity after a rain. Vegetation increases the storage capacity of the soil for rainfall. In the winter months, when the large areas of leaf surface are not present to intercept the raindrops and to transpire the water, vegetation's main function is to decrease the rate of run-off. It may also protect the soil from freezing and thereby maintain a fairly good infitration rate for the soil in question.

Equilibrium Level of Soil Fertility

Vegetation itself does not influence the soil-forming processes independently. Nutrients extracted from the subsoil are returned to the soil surface by growing plants. Vegetation is therefore the ultimate source of the organic carbon in the soil in the form of humus. Carbon, through photosynthesis in the leaves of living plants, is obtained from atmospheric carbon dioxide. When the plants die, they return to the soil to form humus after undergoing processes of decomposition and resynthesis. Plants which absorb many nutrients and borrow from the soil's fertility "reserves" also tend to maintain soil fertility in active circulation if their residues return to the soil. Plants, like pine trees, make only small demands on soil fertility and tend to exhaust the soil of its fertility.

Plants requiring many nutrients will naturally grow on soils which can provide the nutrients and vice versa. Also, plants making the biggest demand on soil fertility will make the biggest contributions to soil fertility. Therefore an equilibrium level of soil fertility is set up depending on the soil-forming factors. Under natural conditions, the balance is automatically maintained; but under agriculture, the balance is unavoidably upset. The art and science of soil management tries to maintain the fertility balance by soil recompensation in such ways as the application of fertilizer.

THE SOIL-FORMING PROCESSES DUE TO CLIMATE AND VEGETATION

A certain characteristic set of soil-forming processes usually pre dominates under a particular type of climate and vegetation. There are three major types of soil-forming processes which have been given a specific designation; namely, podzolization, calcification, and laterization. These processes give rise to the podzols, the chernozems, and the laterites, respectively. (See Fig. 5).

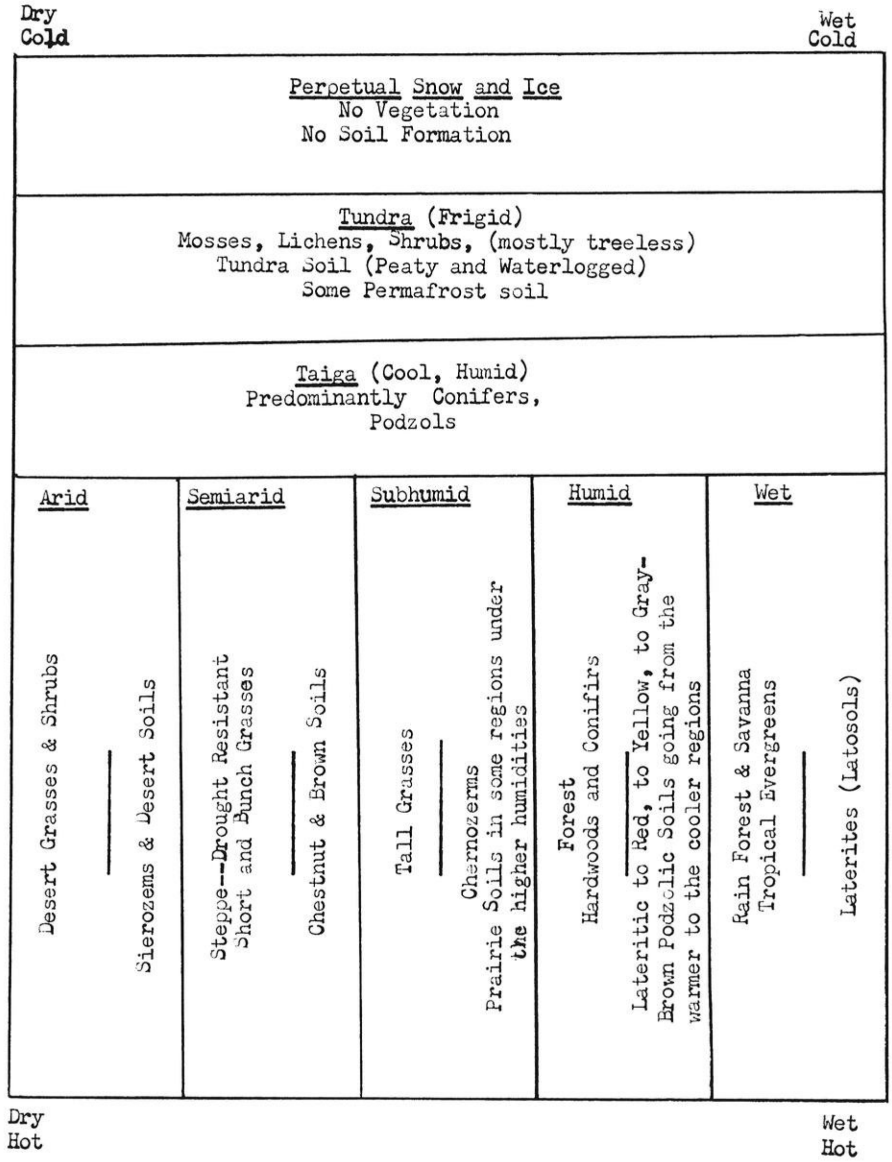

Figure 5.—Diagram illustrating the distribution and relationships of climate, vegetation, and soils.

Podzolization

Podzolization comes from the Russian term podzol, meaning ash-like. Podzolization is the soil-forming process characterized by the translocation of iron and other base-forming elements and clay from the A-horizon to the B-horizon. This will produce an acid A-horizon and a compact and rather impervious B-horizon.

Podzolization prevails where the climate is cool and moist, and where coniferous trees such as the pines, the spruce, and the hemlock predominate. A milder form of podzolization occurs over extensive areas where hardwoods prevail. Because of severe leaching, the A-horizon of podzols are comparatively infertile. Strongly podzolized soils are therefore not favorable to the growth of most crops. Podzols occur in the cool, humid regions throughout northeastern North America.

Calcification

Calcification is the soil-forming process characterized by the deposition of calcium and magnesium carbonates to a depth approximating that to which most water percolates. This process occurs in regions of limited rainfall and where grass or brush vegetation is dominant. It is especially char-

acteristic of the grasslands of the arid, semiarid, and subhumid regions. Lack of water is the limiting factor for crop production on grassland soils.

Laterization

Laterization is the soil-forming process characterized by the accumulation of iron in the form of reddish ferric oxide and usually lesser amounts of aluminum oxide, and the relatively rapid removal of silica by leaching. Periods of heavy rainfall, followed by periods of drought so as to restrict vegetative growth, will cause severe leaching and still have a marked lack of accumulation of organic matter. Laterization appears to be favored by three conditions:

1. Periods of heavy rainfall which alternate with periods of drought.
2. High temperatures during all or most of the year.
3. Parent rock material in which the silica exists largely in the combined form and is thus liberated upon weathering in colloidal form which is readily dispersible and soluble in water. Basic igneous rocks provide these conditions.

Laterization is in a sense a process of parent-material formation rather than one of soil development. The red, clayey product produced often occurs as deep uniform deposits without horizon differentiation. The lateritic deposits often have an excellent physical condition and are therefore very productive when properly fertilized.

CONCLUSION

Climate and vegetation, therefore, have a great effect on the formation of soils. Through various changes in temperature and rainfall, many different states of the soil can be produced. Some are profitable for economic purposes such as agriculture, while others are virtually useless.

Vegetation adds to and subtracts from the properties of the soil. Together with changes in temperature and rainfall, vegetation can also form many different kinds of soils.

Climate and vegetation are only two of the five soil-forming factors, but they are the most important after the parent material of the soil. The other two soil-forming factors are time and topography. Further study can be made as to their effect on soil genesis.

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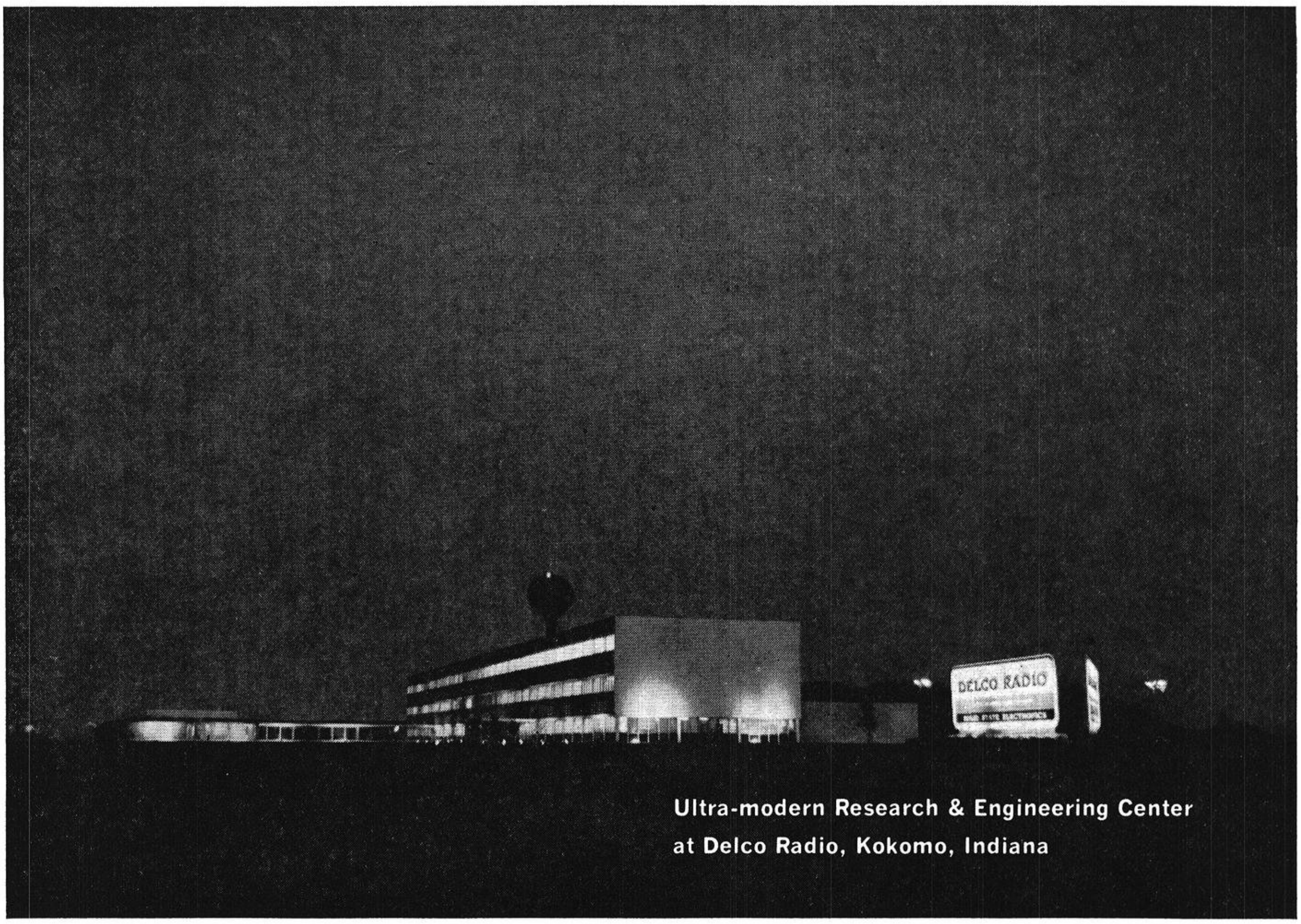

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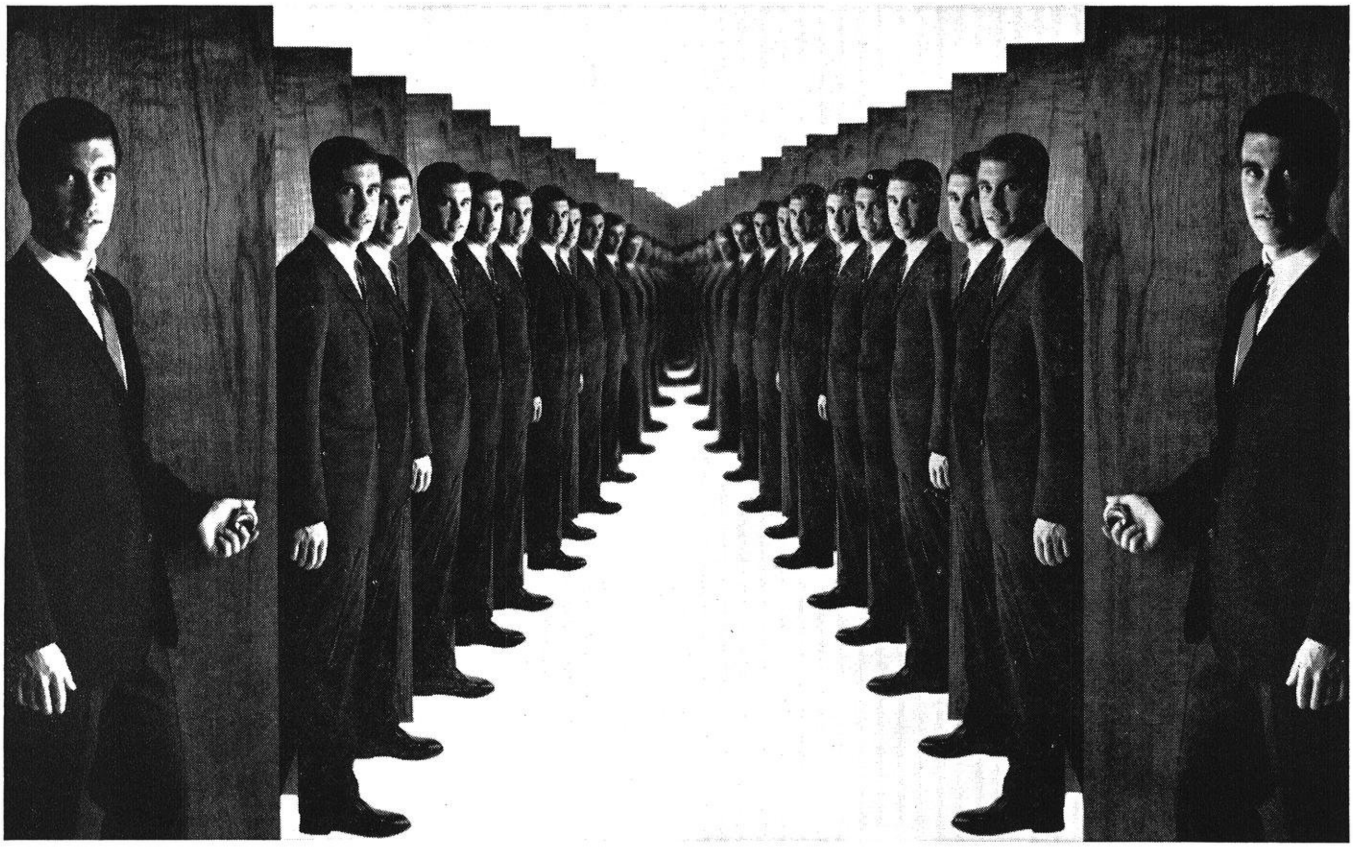

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Such product diversity means not only many jobs, but many kinds of jobs to suit your talents and inclinations. It means more top jobs, and more chances for advancement. It's one of the important things to look for when you're choosing a company.

Allied Chemical is directly involved with today's most significant areas: agriculture, space, and nuclear energy. Some of its products are basic—many are new. Products introduced since World War II now account for a quarter of sales. There's tremendous variety: Building materials. Fashion fibers. Rocket fuels. Dyes. Fertilizers. Plastics. Petroleum products.

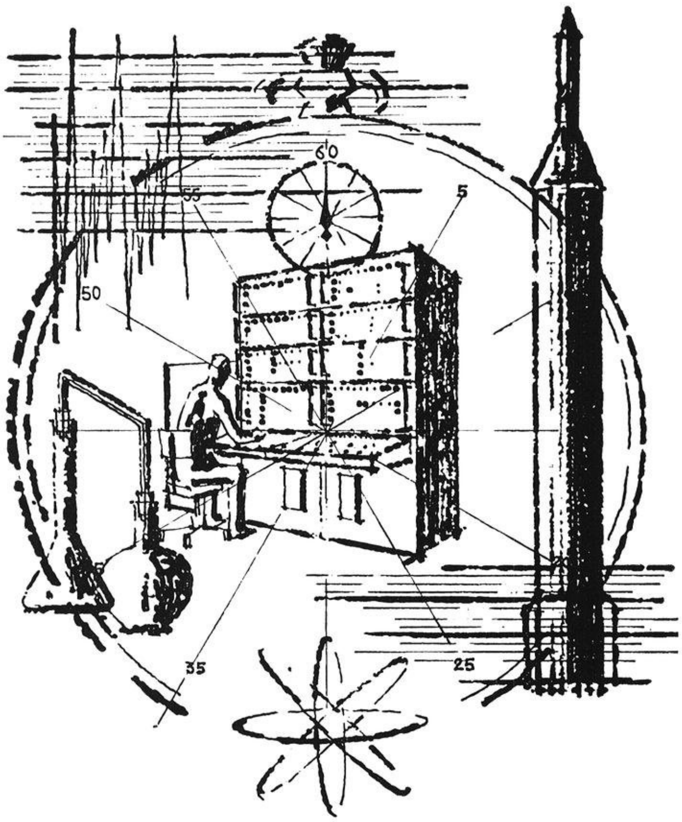
Over 35,000 people work in Allied Chemical's 10 divisions—at more than 100 plants and research centers—at scores of sales offices throughout the country.

It's a big company with big opportunities—and a good one for you to know more about before making a career decision. Ask your placement office when our interviewer will be on campus.

Allied Chemical

An equal opportunity employer

Divisions: Barrett • Fibers • General Chemical • International • National Aniline • Nitrogen • Plastics • Semet-Solvay • Solvay Process • Union Texas Petroleum



SCIENCE HIGHLIGHTS

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

POWER SYSTEMS ENGINEERING FELLOWSHIPS AVAILABLE

The American Electric Power System has announced a program of sponsorship of four fellowships yearly to spur graduate study in power systems engineering.

President Donald C. Cook, in announcing the program, said, "We hope the fellowships will make it possible for some worthy students to continue their advanced education and, hopefully, their interest in power engineering. We also trust that the program will serve as an incentive to the schools concerned to expand their curricula in power engineering."

College engineering graduates selected for the fellowship program will be able to pursue advanced studies at six schools: Cornell University, University of Michigan, Northeastern University, Purdue University, Rensselaer Polytechnic Institute and **University of Wisconsin.**

Candidates for the fellowships must satisfy the scholastic requirements of the participating universities. Preferred candidates must also have worked for a power company for at least one summer in a significant training program. The AEP System offers summer work experience that can lead to preferred-candidate status.

While fellowship funds will be separately determined for each student, the program allows as much as $200 per month for one academic year for preferred candidates, plus full payment of tuition, registration and laboratory fees. Married students will receive $400 for each of their dependents for the duration of the fellowship.

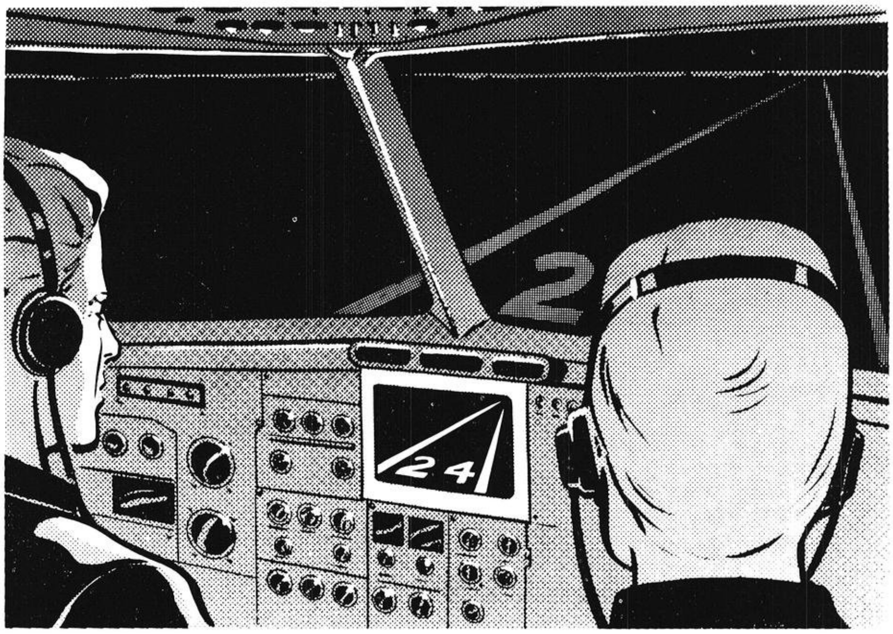
The fellowship program is the most recent instance of support of education by the seven-state AEP System to assure a continuing supply of competent power engineers. Other activities in support of education include the establishment of professorial chairs, scholarships, educational assistance to employes, summer and cooperative education programs for students and faculty members, and education awards to employes' children.

LASER TV SYSTEM REQUIRES NO LIGHTS

The laboratory development of a laser television system which needs no studio lights or other external sources of illumination was announced recently. Scanned by rapidly moving narrow lines of red laser light, subjects even in complete darkness appear on the TV screen as if in daylight brightness. Picture quality is exceptionally sharp and clear.

Unlike conventional TV cameras the laser system uses no image orthicon tube. The system is unique in that it uses a laser light transmitter and a reflected-energy receiver, both of which are contained in a single unit. Intensity of the laser beam is well below the level which might endanger the vision of human subjects.

Although the present system is operable under conditions of low light or complete darkness, the technique could also be used in bright light with some modification of equipment.



Perkin–Elmer Laser TV would prove useful as a pilot's direct vision landing aid effective from a few hundred feet altitude until after touchdown. The use of special retro-reflective runway markings results in energy returns several hundred times greater than normal materials.

While the device may have specialized use in commercial TV studios, this application remains to be evaluated by industry experts. Because the light emitted from the laser TV camera comes from a single source, the lighting effects are similar to those of a photo taken with a flashbulb; the effect of many light sources from different angles is not possible with the presently developed system. Laser scans from several different points are conceivable but might prove impractical from the standpoint of cost. Single-source illumination, however, may prove completely adequate for some uses such as "spot" TV news reporting.

Another potential use is that of an all-weather landing aid for aircraft. The device could be used as a direct vision video "radar" effective from an altitude of several hundred feet. Runways or helicopter landing spots can be readily marked off with reflective paints or tapes. These would give energy returns to the laser receiver with several hundred times the intensity of the surrounding terrain. Such a landing aid would be especially valuable in remote military bases as in jungle or other dense areas. For helicopter landings, landing sites could be quickly indicated by ground crews using portable makers.

An operational landing aid system would employ a relatively powerful continuous beam laser and a "tracking aperture" receiver.

Laser TV has potential as a means of covert surveillance for law enforcement agencies. As used in the present system, the laser beam's fast scan speed and low intensity combine to make it virtually invisible, so that dark areas such as doorways could be scanned at night without the knowledge of those observed. With a properly tailored system it would be possible to observe persons at distances in excess of a mile.

In the field of science, a number of applications such as studies of the nocturnal habits of animals may be feasible.

In the present system red light emitted by a helium-neon gas laser is used to scan the subject through a pair of rotating, diamond-faceted mirrors. The fast line sweep of the transmitted laser beam is synchronized with the electron beam of a standard television picture receiver, and laser light energy reflected from the subject is sensed by a self-contained receiver. The energy returned from the subject controls the intensity of the electron beam of the TV monitor's picture tube, forming the image. The very low useful energy emission of about one milliwatt from the demonstrator unit has proved adequate for imaging objects about 30 feet distant.

Performance and range capability of all forms of this system could be tremendously enhanced by utilizing the new argon green-beam lasers, which provide output powers of several watts. Other laser wavelengths also could be employed.

Versions of this type of system also could have application as a lunar or planetary landing aid for spacecraft. For close-range use the simpler helium-neon lasers are preferred.

Lasers, first developed in 1961, are a source of brilliant, pure, coherent and monochromatic light. The name laser is the acronym for Light Amplification by Stimulated Emission of Radiation. Lasers of various types have been developed, some of intense power which virtually emit "bullets" of light which have a life of only a fraction of a second. The gas laser used in the present TV system is of far lower power but emits its pure light beam continuously.

SUSPENSION BRIDGES IN HALF THE TIME

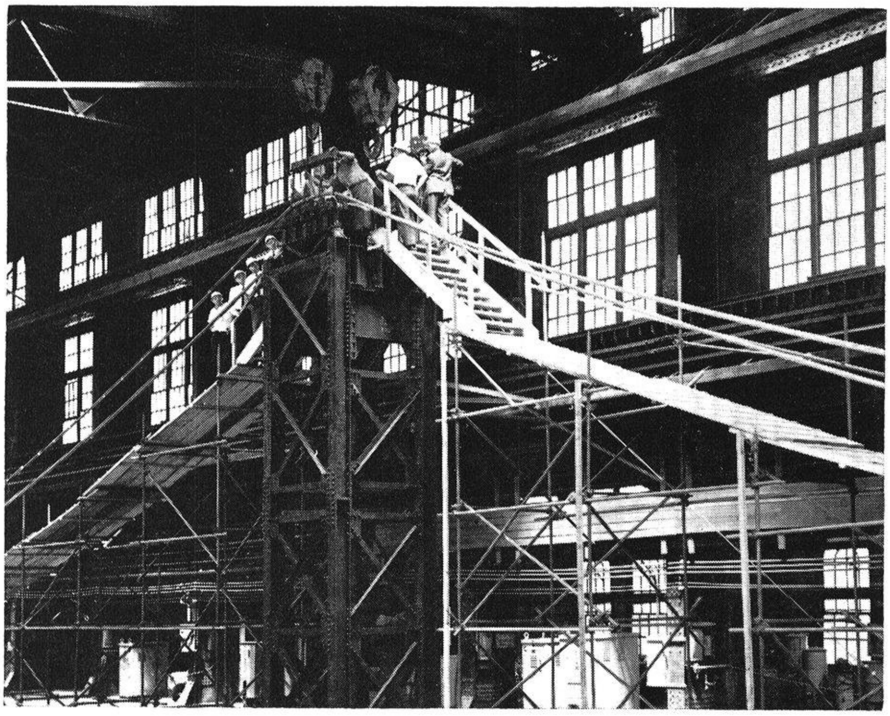
Bethlehem Steel Corporation recently announced it has developed a method for the fabrication of suspension bridge cables which will speed erection of these structures and outmode the present time-consuming practice of "spinning" these cables wire-by-wire.

The newly-perfected process makes possible manufacture and socketing of brridge strands having parallel wires within the manufacturer's plant, and the transportation of these prefabricated strands on reels to the bridge site for relatively speedy erection.

Engineers claim that the new development will "significantly reduce" the construction time required for major suspension bridges, with important financial advantages to the bridge owner in terms of reduced debt interest charges and earlier toll collections.

Time and money savings, they point out, will depend upon a num-

SCIENCE HIGHLIGHTS



Parallel-wire bridge strands are erected atop tower of a model suspension bridge test span as engineers observe strand placement in simulated saddle. The new prefabricated strand promises to speed suspension bridge cable construction and outmode present time-consuming practice of "spinning" suspension bridge cables in the field.

ber of factors, including the size of the bridge, its location, climate, and construction schedule.

The "aerial spinning" method of suspension-bridge cable erection was originated by French engineers in the 1820's and developed into a production process in the United States. It was first applied in substantially its present form in the construction of the famous 821-foot-span Niagara Suspension Bridge, completed in 1855 (and dismantled in 1897). Since then, cable-erection procedure for large suspension bridges has changed only slightly.

In the "cable spinning" method endless loops of individual wires of about 3/16-inch diameter are strung in place over the tower tops and attached to the bridge anchorages. Each wire must be adjusted individually to the correct sag in each span. When the desired number of wires are in place, they are bundled together to form a "stand." When all the strands are completed, they are compacted to form a cylindrical parallel-wire cable. The largest bridge cables built to date—those on Golden Gate Bridge, George Washington Bridge, and Verrazano-Narrows Bridge—contain over 25,000 wires and are about three feet in diameter.

The "spinning" procedure is complex, costly, and time-consuming. It requires setting up and using a large amount of specialized, complicated equipment; it necessitates considerable manpower; it calls for the closest coordination of the work force; it demands individual length adjustment of each wire in each span; and it can be affected severely by wind conditions.

On large suspension bridges, for instance, it may take four months simply to set up the cable-spinning equipment, and six months to spin the cables wire-by-wire. The new construction method may reduce this equipment set-up time since considerably less equipment is required. It will also slash cable-erection time by 50 per cent or more.

For some decades, strands of shop-fabricated *helical*-pattern wires have been used to construct cables of small suspension bridges. However, these helical-wire strands are uneconomical for large suspension bridges because they have a lower strength to weight ratio and reduced modulus-of-elasticity as compared to parallel wires.

The idea of shop fabrication of *parallel*-wire bridge strand is not new, but until active development of this process by Bethlehem this method was not considered to be technically feasible.

The parallel-wire strand is practical and economical for use both in small and large suspension bridge cables. The new process makes possible the fabrication, socketing and reeling of long lengths of bridge-cable strand, each composed of many individual parallel wires, under closely controlled conditions in the manufacturer's plant.

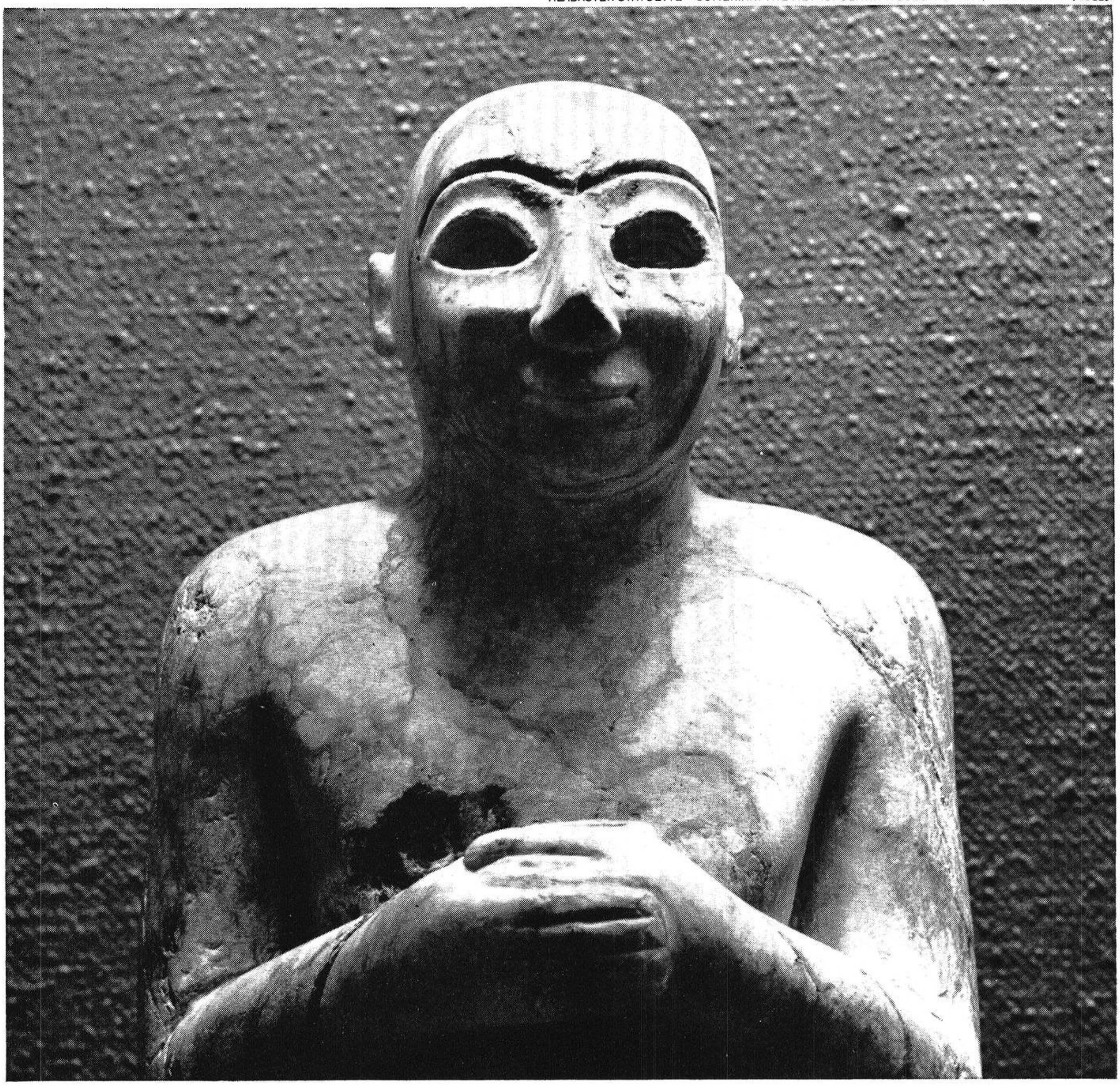
The reels are then transported to the bridge site, and each parallel-wire strand is erected by pulling the socketed end off the reel and across the bridge spans by means of a towing rope.

Strands under tow are carried on rollers, which in turn are supported by aerial working platforms known as "footbridges." The strands are then placed in suspension by pulling the sockets into the anchorages and attaching them.

Finally, the whole bundle of strand wires is adjusted to the correct sag in each span *at one time*. Individual wire adjustments, required in the old "spinning method," are eliminated. Succeeding strands are erected in similar fashion until all strands are in place to form the complete cable. Compacting of the cable and application of the weather protection follow.

In releasing its announcement, Bethlehem also made available a just-completed 16-page engineering report which describes the new method and attests to its validity. Prepared by Steinman, Boynton, Gronquist & London, Consulting Engineers, New York, the report is entitled, "Proposed Use of Shop-Fabricated Parallel-Wire Strands for Construction of Main Cables of Suspension Bridges."

ALABASTER STATUETTE—SUMERIAN. THE METROPOLITAN MUSEUM OF ART, ROGERS FUND, 1950.



He was a great scientist in his day

This Sumerian was minding our business five thousand years ago.

Like Olin, he specialized in chemicals and metals. He smelted copper and tin to make bronze. He made an iron axle, put it between two wheels, and off he went.

Men have always been trying to find the answers to important problems. Today, Olin is at it, harder than ever.

Our pioneering research in liquid chlorine helped eradicate typhoid and other water-borne diseases.

Our anti-tubercular drug, NYDRAZID® is a major reason TB deaths decreased 60% in the last eight years.

Olin's ammonium phosphate fertilizer (Ammo-Phos®) makes it possible for farmers to grow more food than ever before.

And to prevent the tremendous waste in food spoilage, we're working on an antibiotic-coated plastic wrapping.

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Every division of Olin seeks the creative, scientific mind for the answers to the research problems of our day. If this is the kind of work that interests you, call Olin or write to M. H. Jacoby, College Relations Officer, Olin Mathieson Chemical Corporation, 460 Park Avenue, New York 22, N.Y.


MARTY MURPHY

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

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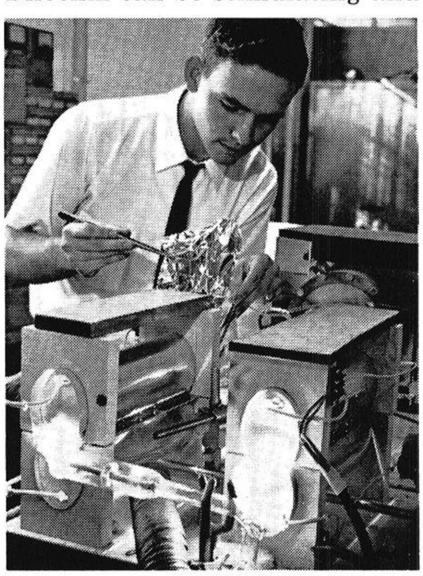
Your career at AiResearch Phoenix can be stimulating and rewarding. You can work in all three important areas of engineering on diverse aerospace products. You can use your total education, learn more on top of it, and take part in a wide variety of advanced engineering.



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

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

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BARREL THE OF BOTTOM

Doc: "Tell me, why do you have so many boy friends?"
She: "I give up."

* * *

**M.E.: "I'm grasping for words."
Coed: "I think you're looking in the wrong place."**

* * *

"What was the hardest thing you learned at college?" asked the M.E.'s proud father.
"How to open beer bottles with a quarter," replied the prodigal son.

* * *

Definition of a meteorologist: A guy who can look at a girl and tell whether.

* * *

EE: "Quick, give me a round trip ticket!"
Clerk: "Where to?"
EE: "Back here, you fool!"

**"It was terrible, roommate," complained the curvy coed. "I had to change my seat three times at the movies."
"Some man start bothering you?" asked her roommate.
"Yes," said the coed. "Finally."**

* * *

Then there was the porcupine who bent his quills trying to overpower a wire brush in a dark corner.

* * *

**When a man sits with a pretty girl for an hour, it seems like a minute. But let him sit on a hot stove for a minute—and it's longer than an hour. That's relativity.
—Albert Einstein**

* * *

Izzy: "I've had a hard life. At the age of eighteen I was left an orphan."
Dizzy: "What did you do with it?"

**An impatient old lady making a trip by bus became irritated at the many stops. "Such a slow bus," she snapped. "I believe we stop at every telephone pole."
"Why not, lady?" replied the driver. "This bus is a Greyhound."**

* * *

Ecstasy is something that happens between the scotch and soda and the bacon and eggs.

* * *

**Student: "I've added all these figures up eight times."
Prof: That's very good and thorough, young man."
Student: "Yeah, and here are the eight results."**

* * *

Doctor: "Lay off booze for a couple of weeks, and you'll be right as rain."
C.E.: "Are you sure there isn't a simpler way . . . like, say, an operation?"

Kodak

wants two kinds of mechanical engineers:

1. burning with ambition to reach manager's status as soon as possible

• College grade-point average on the high side in technical subjects

Secretly admitted to self at certain point in undergraduate career that the scholar's way of life is for other people *but smart enough to have kept secret from the professors who are, after all, scholars.* Diploma in, secret out.

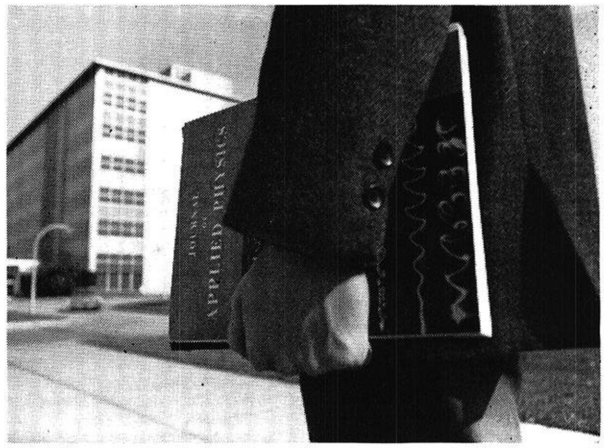
• Seeks prosperous, highly diversified employer

Competitive personality who wants to play on a strong, long-lasting team in the big leagues.

• Unafraid of choices and changes

With a mechanical engineering background, we might find him adept at keeping a troupe of welders happy on a new petrochemical project, or designing a new type of machine for the lithographic industry, or organizing a small laser-manufacturing department, or operating a large magnetic tape plant, or profitably piloting one of the world's major industrial corporations.

2. able to hold a manager's job in time but sure he wouldn't like it



• College grade-point average on the high side in technical subjects

Why not? The subjects were intrinsically interesting, and most of the professors proved to have a clear understanding of them.

• Seeks prosperous, highly diversified employer

To practice modern mechanical engineering—this is not 1936—one needs scope, contacts, and resources.

• Unafraid of choices and changes

With a mechanical engineering background, he might choose to take a high leap over the interdisciplinary wall into solid state physics, pull some excessively generalized equations out of a journal that others on the circulation list quickly glance at and pass along. Six months later he may have a new composition of matter on board a ship bucking the solar wind to Mars.

What is said here about mechanical engineers is equally applicable to chemical engineers and electrical engineers. Our expansion rate now demands technical people who, at the one extreme, are still fresh from the classroom with its benefits and, at the other, have had ten years of practice in their professions and are now ready to select a lifetime employer. We offer a choice of three communities: Rochester, N. Y., Kingsport, Tenn., and Longview, Tex. We earnestly solicit serious and honest self-descriptions addressed to:

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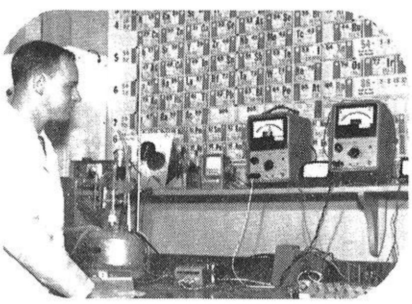
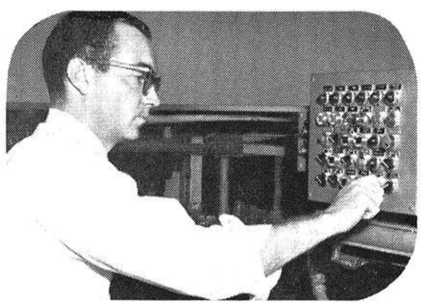


OUTPUT VOLTAGES from nickel-cadmium cells are examined by engineer John Bliven, BSEE, Union College '63 on assignment at G.E.'s Battery Business Section.



PRODUCT RELIABILITY of electric slicing knife components is the responsibility of Mike Reynolds, BSME, New Mexico State, a recent Manufacturing Training Program graduate.

PRICE AND DELIVERY information on nickel-cadmium batteries is supplied by Bob Cook, BSME, Univ. of Florida '65 on a Technical Marketing Program assignment in Gainesville.

A PREVIEW OF YOUR CAREER AT GENERAL ELECTRIC:

Creating New Growth Businesses

At our Brockport, N. Y., plant, the new business of manufacturing cordless slicing knives is **rush.** So is that of the rechargeable-battery supplier, our two-year-old plant at Gainesville, Fla., which has just doubled its working area. Its sealed, nickel-cadmium batteries, in hundreds of shapes, sizes and ratings, are meeting growing customer demands in the consumer, defense, and aerospace industries—with applications from power tools to satellites. At General Electric, new ventures are a way of life. In both their formative and growth stages, these ventures call on the skills and enthusiasms of experts in more than 120 product departments—in engineering, manufacturing and technical marketing. To define your career interest at General Electric, talk with your placement officer, or write us now. Section 699-15, Schenectady, N. Y. An Equal Opportunity Employer.

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