The Wisconsin engineer. Volume 67, Number 8 May 1963

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

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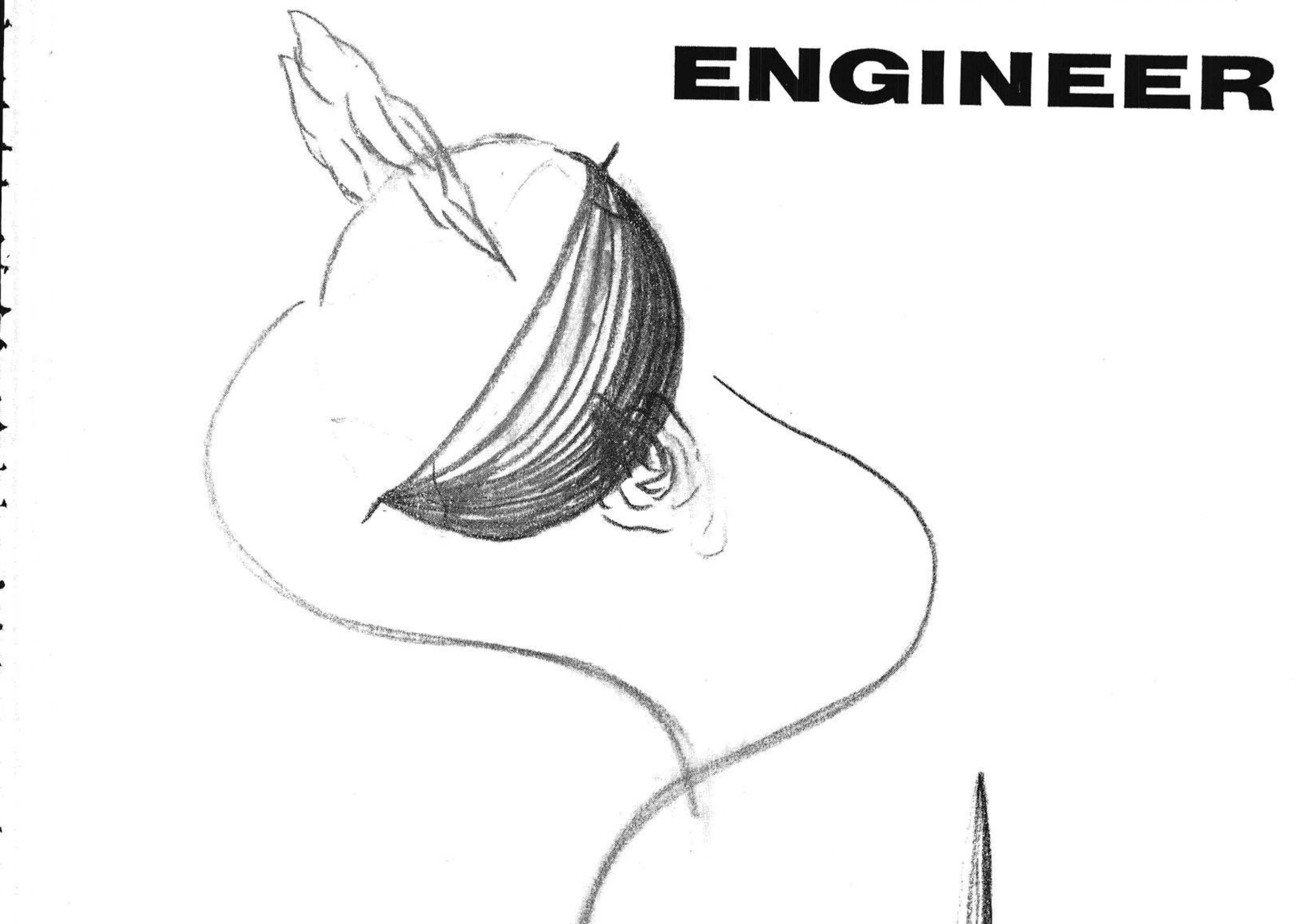
MEMBER E. C. M. A.

THE WISCONSIN ENGINEER



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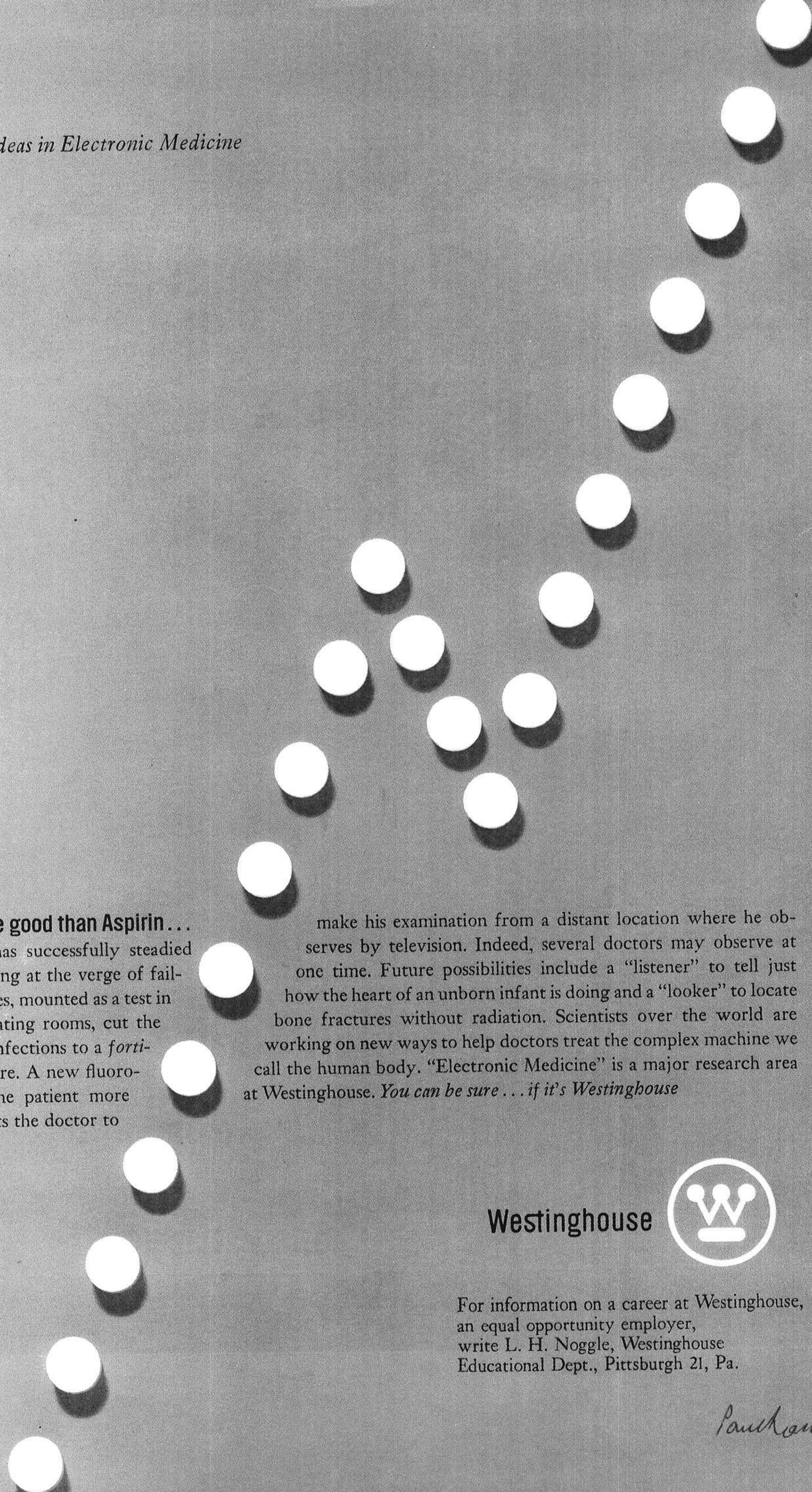

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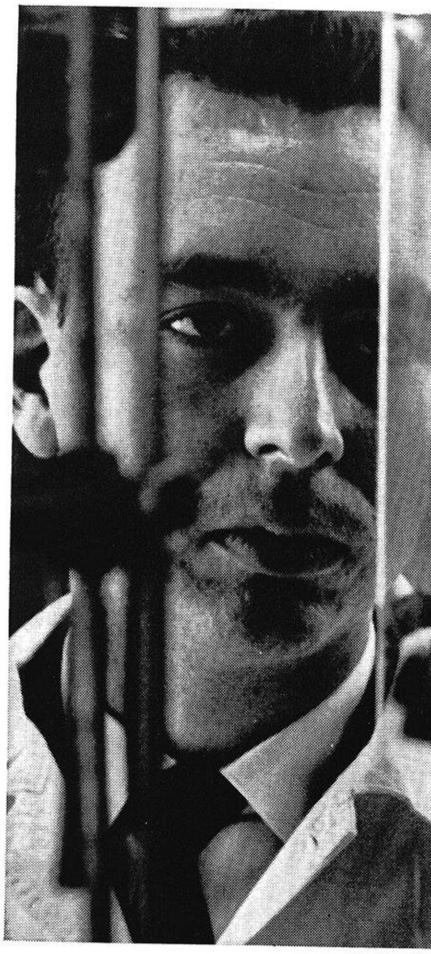

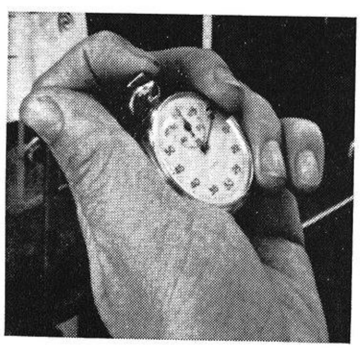

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Second Class Postage Paid at Madison, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at a special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized Oct. 21, 1918.

Published monthly from October to May inclusive by the Wisconsin Engineering Journal Association, 333 Mechanical Engineering Building, Madison 6, Wisconsin.

VOLUME 67, NUMBER 8 MAY 1963

ARTICLES

THE WISCONSIN ENGINEER

The Student Engineer's Magazine Founded in 1896

FEATURES

THIS MONTH'S COVER

This is a charcoal drawing done by Nancie Nelson, pertaining to the articles on the moon.

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Rambling With The Editor

TUITION HIKE

Lately there has been much talk in the legislature and on the campus about a tuition hike. When people talk about a tuition hike they should break their discussion into two different and completely distinct categories—tuition hikes for residents and tuition hikes for non-residents.

During the first week of May there was a bill passed in the State Assembly which would establish a fourth system of schools in the state for higher education. This bill, if passed by the Senate, will establish a school system much like the Junior College System in the State of California. The best argument that was put forth in support of this fourth school system was that it would provide a means for the people of Wisconsin to receive a good, inexpensive education. If the means to provide an inexpensive education for the citizens of Wisconsin is needed in the state, why should the cost of receiving a college education under the present system be raised for the resident who has already paid for much of his education through high taxes?

The student who comes to Wisconsin is actually considering the colleges in Wisconsin as private colleges. If he were to attend a good private college of comparable quality he would consider himself lucky to pay less than $1500 in tuition for the school year (compare this to the $750 paid by non-residents for tuition at the UW). It has been said that raising the tuition for out-of-state students would drive them away. Check around and see how many non-resident students would transfer if the tuition was raised to the suggested $1000 for a school year. You won't find very many.

R. N.

North American Aviation's XSM–64 NAVAHO guided missile, developed by the company's Missile Division in Downey, California, was used to gather high speed high altitude data for SAC's newest weapon, the B-70 Mach 3 intercontinental bomber. This program was known as project RISE (Research in Supersonic Environment).

Exploring the Moon: What and How?

By Roland Rucinski, ME-4

SINCE October, 1958, when the Russians orbitted the first of many Russian satellites, there has been much talk about manned orbits, space probes, and solar expeditions. Successful attempts at orbitting and returning manned capsules by both Russia and America have proven man has the means by which he can explore space, though it will be a matter of years before all the problems are solved. One of the first, if not the first, places man will attempt to explore is the Moon. What he will find there and how he will go about handling it is the subject of this report.

In order to fully appreciate why certain types of vehicles may be used, it is necessary to know the different types of surfaces man may encounter on the Moon. A discussion of these surfaces will lay the foundation for the discussion of the vehicles.

Almost everyone knows that man can and will go to the Moon, but few people know what he will do when he gets there. The purpose of this report is to explain what will be done and how it will be accomplished during the first manned landings on the Moon.

BACKGROUND

When man finally reaches the Moon, he will not land upon it as a person entering a dark room and striking matches to see what is there. Rather, he will be landing there knowing many definite facts about the Moon and trying to prove or disprove other theories based upon scientific observations and measurements.

Some of the facts already known about the Moon have been known for centuries while others have been discovered only recently. For instance, with the naked eye it can be seen that the same half of the Moon always faces the Earth. Actually, measurements have shown that a total of 59% of the surface is visible at one time or another. Day and night last two weeks of Earth time. From measuring the size and density, it was found that the Moon's gravitational force is only one-sixth that of the Earth's. Because of a lack of haze around the Moon, it is safe to say there is no atmosphere. This will be discussed in greater detail later. With no atmosphere there can be no wind, weather, or free water. The lack of an atmosphere also means the Moon's surface is not shielded from solar and cosmic radiation and is subjected to large temperature changes.

Since the environment is so hostile, one may ask, "Why does man want to go to the Moon?" The answer to this is that man can use these properties to his own advantage. For example, the lack of an atmosphere will enable him to perform high-vacuum experiments impossible to perform on Earth.

Besides using the Moon for scientific experiments, an important reason is to use it as a stepping stone for the exploration of other planets. It will be far more advantageous to launch spaceships from the Moon than from the Earth to make long-distance voyages.

The Moon may be used as an observation post as effectively as a launch pad. From it the Earth's weather could be predicted farther in advance and much more accurately. Other planets could be viewed more clearly because of the lack of a light diffusing atmosphere. If it must be, it can also be used as a military observation post, or even a "battle station" armed with rockets pointed to any place on Earth.

LUNAR SURFACE

Since its formation, the surface of the Moon has been changing continuously. As it cooled from a molten mass, it formed a crust much as the Earth did. Shrinking caused mountain ranges to be formed and volcanic eruptions of ths still molten center. Moonquakes caused cracks and crevasses. Even today the surface is being changed by the bombardment of meteors. This is probably the greatest single cause of changes in the Moon's surface since its formation.

Some of the common types of surfaces are:

1. Faults—fractures which occur on a vertical plane.
2. Drowned structures—walls or other formations covered with lava at a time later than their own formation.
3. Craters—walled plains, empty craters, or craters with central elevations.
4. Hills, valleys, and depressions.
5. Swellings—five to ten miles in diameter may have cavities underneath.
6. Mountain ranges.

Though the Moon may look very bright on a clear night it is known that the surface is fairly dark, because the measured reflected light is a small amount as compared to how much is directed to the surface. This is one of the reasons many scientists believe there is a layer of dust covering the Moon; however, there are many theories as to how thick this layer may be.

One piece of evidence supporting the theory that there is a layer of dust is the recorded temperature change during an eclipse. The change in temperature is so rapid it was concluded the material just below the surface is very cold and the high day-time temperatures apply only to the outer surface. This leads to the conclusion that the surface materials consist of insulating substances such as dust or porous lava.

However, as telescopes increased in power, it was seen that the lunar surface was rough. There were really no smooth areas visible. Also, the color of the surface was not uniform, as might be expected from a layer of dust. Therefore, the theory that the Moon is covered by a thick mantle of dust is probably incorrect.

Though the question of dust on the surface of the Moon may be unanswered, it is a fact that there are rocks and rock formations. Indeed, if the theory that the Moon was once a part of the Earth is true, these rocks may be exactly like those found on Earth, containing the same elements. Some terrestial igneous rocks contains as much as five percent by weight of water. Thus, if this is true on the Moon, water may be recovered during the extraction of minerals.

The water contained in the rocks of the Moon's crust will be the only water found on the Moon. There is no free water, because of the lack of an atmosphere. Calculations of the Moon's gravitational force and speed of rotation have shown that any gases originally present would have been "thrown from" the Moon by centrifugal force. The maximum amount of atmosphere that could be present is only 1/1,000,000,000,000 that of the Earth's. Any free water present at that pressure (approximately zero) would evaporate and also be "thrown from" the Moon.

On Earth, the insulating effect of the atmosphere allows the temperature to vary between about 150F. at the equator to —150F at the North or South Pole. Temperatures on the Moon, however, vary from 272F during lunar day to —243F during lunar night. To say the very least, man would find it very uncomfortable without heating or cooling facilities.

Just as man would find it unbearable to live without protection, it seems impossible for plant life to exist under these conditions. However, some astronomers say there is a mist during the lunar sunrise, but that it dissipates later. "Moreover, it has been suggested that definite cyclical changes which repeat at each lunation might be caused by the growth and decay of vegetation such as lichens or moss which has become adapted to complete its life cycle during the fourteen days of sunshine." Possibly, contrary to common belief, man will find life on the Moon.

PROPOSED VEHICLE DESIGNS

Whether or not man finds life on the Moon, he must have some means of transportation over the Moon's surface. He could, of course, use the means with which Nature has provided him, but walking has too many limitations. The distance he can travel and the supplies he can take with him are too small to be practical. Therefore, he must invent machines to carry him about as well as keep him alive. Necessity is the mother of Invention, so it must be known what is necessary in the design of a lunar surface vehicle.

Before venturing from the safety and security of their spaceship, the first astronauts to land on the Moon may send out an unmanned vehicle first. The operations this vehicle must be able to carry out are: surface exploration, evaluation of environment, atmosphere sampling, chemical and physical surface analyses, seismic experiments, gravitometric measurements, determination of a magnetic field. If facts from these operations allow, a one-man vehicle may be the next step. This would perform the same operations as the unmanned vehicle except with manned observation added. Eventually, three-man vehicles may emerge from the spaceship to explore the Moon more fully.

As manned operatione are expanded, the functions would be broader and would include: exploration; construction of a lunar base; personnel transfer; remote placements of instrumentation; equipment repair, servicing, and maintenance; remote emplacement of power plant; and connection of remote equipment to lunar base. Initially, a vehicle capable of traveling 50 miles and sustaining three men for 72 hours would be satisfactory. One of the major problems of design in that respect is the fact that the vehicle must be able to operate independently of any air supply, be lightweight, have low volume, require a minimum of fuel, and be extremely reliable. These provisions require materials having maximum strength at lowest weight and maximum load-carrying capacities.

The fact that it must have maximum strength to density ratios is not dictated by conditions on the Moon alone. Many of the limits of design are imposed by conditions on Earth. The high gravitational field of the Earth requires maximum strength to density ratios of materials. This is necessary to have the least amount of weight in the launch vehicles. Atmospheric friction requires the spaceship to be streamlined, which means anything inside should have low volume. Many other conditions on Earth will have a bearing on the design on lunar surface vehicles.

The type of material to be used in constructing a lunar surface vehicle will also be based on the temperature differences present on the Moon. Since metals expand at high temperatures and contract at low temperatures, the vehicles must be designed to take into account the high thermal stresses occurring during temperature changes. This does not apply only when the vehicle passes from lunar day to lunar night, but it also applies when the vehicle is in the light of the Sun for the four-

Roland is a senior, and expects to graduate in January, 1964. He is married and has no children. He is a member of ASME and wants to work in the aircraft industry after graduation.

teen Earth days of a lunar day. Part of the vehicle will be in direct sunlight and subject to high temperatures, and part of the vehicle will be in shadow and subject to low temperatures. The simultaneous expansion and contraction of different parts of the vehicle under these conditions must be taken into account to prevent failure or rupture of the vehicle's body.

Besides knowing the kind of material to use to build a lunar surface vehicle, the designer must know what and how much instrumentation should be incorporated into the vehicle. Wherever feasible, operations should be manual to conserve power and facilitate emergency operations. This was proven during the orbital flight of Commander Walter Schirra when he saved 60% of his fuel by switching off all automatic operations and controlling the capsule manually, rather than running out of fuel as Commander Scott Carpenter did when he let almost all operations be performed automatically. The amount of instrumentation should also be selected on the basis of weight and reliability. However, weight should not be conserved at the sacrifice of important instrumentation necessary to the successful completion of a lunar exploration.

Successful completion of a lunar exploration means, of course, that the men doing the exploring must be kept alive and in good physical and mental health. Life support systems must be incorporated into the design of lunar surface vehicles. The most important requirement for sustaining human life in the vehicles is that there must be an ample supply of food, water, and oxygen. Waste products must be removed, stored, or converted into usable products. There must be protection from the extremes of temperature. There must be protection from cosmic rays, ultraviolet rays, and other radiation. Micrometeorites which will cause atmospheric leakage must be guarded against. All these things are necessary to keep man alive.

Man performs best when the conditions around him are most favorable, rather than when he is just barely existing. Therefore, such factors as pressure and moisture content of the air inside of the vehicle, acceleration, noise, vibration, confinement, isolation, and detachment from the mother ship must be accounted for in the design of a lunar surface vehicle. In order to leave the vehicle for repairs or manual operations outside, the men must pass through airlocks, which are chambers that connect the inside quarters to the outside and are able to be filled with air or oxygen.

All the things mentioned above are essential requirements in any design of a lunar surface vehicle. Different designs handle these problems in different ways and may or may not have additional features. One design already proposed has a large, cylindrically shaped body with track wheels, capable of traversing flat or rough terrain, but not capable of crossing deep, wide crevasses or ridges. Attached to an arm extending from the main body is a smaller one-man capsule. The arm provides access to any point within a 40-foot radius of the vehicle. The capsule on the end of the arm has actuators provided with shoulder, elbow, wrist, and finger motions. Hand parts of the actuators have vise-like grips for holding and using special tools, such as hammers, wrenches and drills. The advantages of using a capsule in comparison to a spacesuit are many. Some of these are that it has greater reliability, less atmosphere loss, it is more economical of vehicle space, and there are no insecurities resulting from separation from the vehicle. However, suitable protection must be provided for bearings, joints, and other exposed components. It must be provided with controls for drives and safe-travel limits for shoulder, elbow, and other movements. High reliability in these controls is essential. Space suits should not be abandoned altogether, since some repairs or operations may call for work being done on the outside of the vehicles.

The entire vehicle is capable of sustaining three men for 72 hours. While one man is in the capsule, another is covering the controls, communications, and instrumentation, while the third is operating the vehicle.

Variations of this design may include a vehicle with low pressure tires similar to swamp-crossing vehicles of the southern states of America. Though there are no swamps on the Moon, these tires will be helpful in traversing areas thickly covered with dust, if there are any. Or the vehicle may have tracks in long, rigid sections which could cross crevasses. In this case, the vehicle itself would lay the tracks.

Another proposed design consists primarily of three airtight compartments, mounted by an external crane. It is 65 feet long, 16½ feet high, and has an internal diameter of 12 feet. The forward section contains the control room where the crew on duty works and where the vehicle driver crevasse bridging crane operator sits in a conning dome. The section also contains lunar suit stowage, lockers and work tables for the exploration team, five television relays, the galley, food store, and air conditioning equipment. Water and liquid oxygen are stored in a segment above the section.

The middle compartment contains beds for sleeping nine of a crew of twelve, since at least three men will be on duty at all times. Personal lockers are also provided in this section. The compartment contains washing and shower facilities and two toilets. Water and liquid oxygen are above the compartment, while silver-cadmium batteries are stored below. On either side are food stowage spaces and also light, rigid crevasse bridges. A second air conditioning unit is in this compartment.

The rear compartment contains photographic and observation equipment, the electronics cab containing monitoring equipment, a mechanical and electronic repair

(Continued on page 28)

The Tennessee Valley Authority

By Ronald L. Gratz

TVA IS NOT a very impressive name, but it represents the biggest development project in the history of the United States. To people throughout the world, the Tennessee Valley Authority represents the greatest achievement of American democracy.

The knowledge of what TVA is will help people to better understand the great achievements which can be made when people plan and work under a democratic form of government.

PROBLEMS

The Development of TVA was slowed by many obstacles. In a project which would develop an entire river valley spreading over 42,000 square miles, the problems are numerous, frequent and varied. The problems encountered in construction and planning alone were enough to stop most projects. In addition, political difficulties stalled the start of TVA for many years.

Political Problems

After General Jackson settled the issue of soverignty in that part of North America, the national government took more interest in the strategic Tennessee area. More than 120 years ago, the Treasury Department began the first big project at Muscle Shoals, where many problems would later occur.

The South was financially ruined by the Civil War and until the end of the century nobody was interested in financing Southern projects at the expense of the North. Before the twentieth century there was no thought of public ownership of large scale projects. It was assumed that the project would be exploited by private concerns.

Senator George Norris of Nebraska became interested in public control of the project. In 1922 he introduced his first bill for public development of the Tennessee Valley area. The bill did not pass Congress. Norris introduced similar bills in 1924, 1926, and 1927. None passed. In 1928 Norris introduced a sixth bill. The bill was passed by the Senate and by the House in 1931. President Hoover vetoed the bill. Again in 1932 the seventh Norris bill was introduced. Hearings were held on the bill but no action was taken. There appeared to be little hope for public development of the Tennessee Valley area.

At the time when prospects were looking worst for supporters of public control, a new administration came into power. The advent of the Roosevelt administration in 1933 gave the needed boost to get the project started.

Although the first large obstacle had been passed, the real problems of development were just beginning.

Planning Problems

The planners of the project found many problems in dealing with the people of the area. Many people, remembering the days of the CCC camps and the bad conditions accompaning some of the camps, were trying to prevent the construction of the dams and other structures. They did not want their quiet towns turned into construction camps.

The creation of about twenty lakes would require the relocation of not only many farm families but also entire villages. Numerous people lived in the same houses that their ancestors had lived in for several generations. They were not willing to leave the only homes they had ever known and move to a new location.

Some of the residents of the valley felt that the project and results of the development would attract too many tourists and interrupt their quiet lives.

Economical Problems

A project as vast as TVA has many economical problems. The first problem was finding funds to finance the development. It seemed almost impossible for any undertaking to justify the needed expenditure for developing an entire river valley.

Southern power companies argued that the cheap power produced would financially ruin them. Northern companies feared their markets in the South would be greatly damaged because of the new industries which would spring up there.

Much discussion arose about the value of existing facilities, such as those at Muscle Shoals. Needless to say, the owners of these facilities would require a purchase price greater than the actual value. When the government did pay the higher prices, opponents of the project made charges of graft. Similar problems were encountered with the prices to be paid for land.

Rates would have to be set on the prices of power sold to the existing power companies for distribution. Rates would also have to be set of the prices that the distributors could charge for the electricity.

Engineering Problems

Designing the Tennessee Valley project was one of the greatest engineering and architectural feats ever accomplished. The basic plans called for structures which would be both functional and pleasing to look at. It was no easy task to design the huge masses of steel and concrete so they would meet both requirements.

The location of the dams was

very much of a problem. The dams had to be designed and located to get the most value out of the reservoir behind them. They had to be located so the public could get the most value out of the lakes and recreational areas which the dams would create.

It is impossible to mention all the problems encountered in the construction of the various structures. Some of the dams were built during the war when some construction materials were unavailable. Structures were planned so they could utilize some of the materials which were close to the site. In an area which has 70–80 inches of rainfall per year, the problem of building dams is very big. Construction was stopped many times by floods and high water.

These and many other problems plagued the planners of The Tennessee Valley Authority. The important fact is that the problems were overcome and the dream of a Tenessee Valley Authority became a reality. Construction could now begin.

CONSTRUCTION

After the problems were settled and the project was ready to begin, the program was given a name. Tennessee Valley Authority was the name given to an organized plan which was composed of many smaller projects. All these projects were aimed at the development and improvement of the Tennessee Valley region. The construction in the region can be divided into four classifications: main river dams, storage dams, steam plants, and nonpower projects. Each of the divisions is discussed below.

General Layout

The main river has been changed into a series of huge lakes separated by nine dams. In the tributaries of the river, a total of 19 dams provide water storage and control. Each dam plays its own important part in the whole system.

Main River Dams

The main river dams have made the Tennessee River open to navigation from Knoxville to Paducah and have added 650 miles to the inland waterways of the United States. The Tennessee Valley is now joined by a cheap transportation route to the Great Lakes region, the Middle west, and the Gulf Coast. The nine foot channel created by the dams allows the large Mississippi River barges to travel safely on the Tennessee River.

Besides the added transportation route, the dams have provided flood control for the entire river valley. Floods which once caused millions of dollars of damage are now reduced to a slight increase in the water level of the lakes.

The dams making this navigation and flood control possible will be discussed and listed in order of construction.

Wilson Dam was authorized for construction in 1916 and started by the Corps of Engineers in 1918. After completion, the dam became a subject of national controversy until 1933 when Congress turned it over to TVA.

Although Wilson Dam was not constructed under TVA, it is still considered a part of the system. The contrast between the architecture of the Wilson dam and the other TVA dams is very striking. The classical revival of Wilson Dam seems to have no place among the other style of design. The newer dams are much more functional than Wilson Dam. The generators at Wilson produce about the same amount of power as each of the newer generators but they require twice as great a water head per kilowatt of electricity. The contrasts show what a difference is made in a well planned and well engineered project.

Wheeler Dam, the first of seven multipurpose dams, was built at Elk River Shoals, sixteen miles above Wilson Dam. Wheeler has the distinction of being the lowest dam on the main river. Unlike the other TVA dams, there is no generator room at Wheeler and the generators are built under exposed steel cowlings. A highway passes over the dam on an elevated roadbed.

Pickwick Landing followed Wheeler by a year and a half, and was located 52 miles below Wilson Dam. This dam, combined with Wilson, completed the task of covering the dangerous Muscle Shoals. The dam is constructed mainly of earth and rock. A natural inlet was developed just above one end of the dam to provide a recreation area with facilities for camping and boating. The construction camp contained many permanent buildings. The houses are now occupied by the families of the men who operate and maintain the dam. Pickwick is the only TVA dam designed with the switchyard (the area from which power lines lead) built above the powerhouse.

Guntersville Dam was the fourth built by TVA. It completely revitalized the town from which it took its name. The town of Guntersville, in Alabama, was a quiet, dusty little river town in 1935. Today it is an industrious, prosperous port and recreation center. The backwater from the dam almost surrounded the town. Anticipating this, the engineers built three causeways to connect the town with the major highways near by. Guntersville Dam is made of rock and earth over more than half its length. The capacity of the spillway is so great that no foreseeable flood could ever reach the top of the embankments.

Chickamauga Dam, started one month after Guntersville, is located ten miles northeast of Chattanooga, Tennessee. In 1936 Chattanooga was the most vulnerable to flood of any city in the Tennessee Valley. Had it not been for Chickamauga Dam and the rest of TVA above Chatanooga, a flood would have rolled over the city in 1957 which would have damages conservatively estimated at $66,000,000. The amount saved in just this one case was more than the cost of the dam. TVA designers made provisions for a bridge to be built across Chickamauga Dam and the State did the erecting.

Watts Bar Dam is located midway between Chattanooga and Knoxville. Original plans for the dam specified that two of the proposed generators should be postponed until the additional power was needed. Because of the war developing in Europe it was decided to install all five generators during the initial construction. A steam plant was also built a mile downstream from the dam. The state of Tennessee built a bridge over the dam.

Kentucky Dam, the greatest of all TVA dams—approximately 7 million cubic yards of concrete, earth, and rock—backs up water for 184 miles. The maximum storage capacity of the lake behind the dam is more than twice that of the next largest lake. The gantry crane is the largest ever built by TVA, and also one of the most attractive. Unlike any other TVA dam, Kentucky supports both a highway and a railroad. Recreation facilities provided are: a boat basin, a vistors building, and a picnic area.

An interesting object at Kentucky Dam is a floating guard wall. This guard wall is a long, cubical, hollow concrete beam which guides boats into the locks. Usually a solid pier type guard wall is used. The pier type wall is solidly anchored to the river bottom. The floating guard wall was less expensive than the pier type.

Fort Loudoun Dam was the last dam to be constructed on the Tennessee and is the farthest upstream. This dam is in most respects the most harmonious of all TVA multipurpose dams. Here the engineers and architects were able to assemble all their knowledge and skill from the past construction. Fort Loudoun, located a few miles from Lenoir City, Tennessee, is very popular with tourists. Guided tours of the dam can be arranged upon request.

Hales Bar Dam, built in 1905–1913, was completely remodeled after purchase by TVA in 1939. The dam was improved in many ways: the foundation water leaks were stopped; effective height of the spillway was increased; the navigation lock was improved; and two additional generators, each with a capacity equal to several of the existing ones, were installed. Hales Bar Dam is a very good example of the difference between old design of dams and the new designs adopted by TVA.

Storage Dams

The fact that the tributaries of the Tennessee River are not navigable results in a change of dams on these streams. The dams on the tributaries differ from those on the main river both in appearance and function. Navigation locks are not necessary. Since the tributaries are mainly in the eastern mountains, their banks rise sharply resulting in higher and more dramatic dams. Referred to as storage dams, their purpose is to control the flow of the Tennessee River. The storage dams hold back water during certain seasons and later release it as it is needed downstream.

The area around these dams receives more annual rainfall than any other part of the country except the Pacific Northwest.

Although **Apalacia** is only 150 ft. high, the water head at the powerhouse is 400 ft. The powerhouse is located eight miles downstream and the water is piped through 18 ft. diameter conduits.

An interesting aspect of **Hiwassee Dam** is a pump-turbine. It can be used to produce electricity and then be reversed during periods of low power consumption to pump water back into the reservoir to use for periods of high power consumption. Hiwassee is considered by many people to be the most beautiful dam built by TVA.

Chatuge is the only TVA-built dam made entirely of rolled earth. Studies showed that earth, faced with riprap on the upstream side, would make an adequate dam here.

Ocoee No. 3 is a sister project to Apalachia Dam. An extra 270 feet of head was gained by locating the powerhouse 2.5 miles downstream from the dam. Both the spillways and the powerhouse at Ocoee No. 3 are remotely controlled.

Nottely is the fifth and last dam to be built by TVA in the Hiwassee River Basin. A low bridge spans the crest of the spillway and a road crosses the full length of the dam.

Fontana is the most dramatic of all TVA dams and the highest dam

STATISTICS OF T.V.A. MAIN RIVER DAMS

Name	Length	Height	Generating Capacity	Cost
Wilson	4535'	137'	436,000 kw	$ 52,000,000
Wheeler	6342'	72'	259,200 kw	$ 48,000,000
Pickwick Landing	7715'	113'	216,000 kw	$ 74,000,000
Guntersville	3979'	94'	97,200 kw	$ 39,000,000
Chickamauga	5800'	120'	108,000 kw	$ 41,000,000
Watt's Bar	2960'	112'	150,000 kw	$ 35,600,000
Fort Loudoun	4190'	122'	128,000 kw	$ 43,000,000
Hales Bar	2315'	112'	99,700 kw	$ 35,000,000
Kentucky	8422'	206'	160,000 kw	$119,000,000

in the United States east of the Rocky Mountains. Fontana is a popular tourist resort and is visited by thousands of people every year. The rainfall on the Fontana watershed averages 75–80 inches each year.

In 1940 an order was given to begin a dam on the Holston River and to have it in operation in 21 months. This was the shortest construction schedule ever planned by TVA. In 16 months the gates of **Cherokee Dam** were closed and water started to back up behind it. Two weeks before the scheduled completion date, the first generator was producing power.

Douglas, a wartime project, was impounding water and producing power only 13.5 months after construction began—an incredible record of speed in such construction.

Boone was TVA's nineteenth dam in nineteen years of construction. As in most TVA projects, its beauty lies largely in its simplicity of form and detail.

Fort Patrick Henry Dam is like Boone Dam in many ways. It is remotely controlled from Boone.

South Holston is the fourth highest dam in the system. It has two means of discharging water: through the turbine, and through an underground spillway.

Watauga Dam was made by filling a deep, narrow mountain gorge with 3.5 million cubic yards of earth and rock. The layout here consists of three parts: the dam; the powerhouse and control building, located one mile below the dam; and the visitor's building, which is a few hundred yards above the dam. Watauga Lake is one of the most picturesque in the entire Tennessee Valley.

Wilbur Dam was one of several existing dams which were purchased by TVA. Remodeling consisted of: raising the height of the dam, increasing its generating capacity, and removing silt deposits from behind the dam.

Steam Plants

When TVA began producing power, back in 1933, few could imagine that someday the valley economy would require more power than the dams could produce. Today the power generating capacity of the valley region is over ten million kilowatts, more than twelve times the 1933 capacity. This extra output is due to the construction of eight steam generating power plants.

One plant like Johnsonville can produce more power than the combined peak production of Hiwassee, Douglas, Cherokee, Norris, and Fontana dams.

The operation at the plants is basically the same for all plants: (1) coal is brought to the plant by barge, except at John Sevier, (2) a conveyor brings the crushed coal to the pulverizers, (3) from the pulverizers, the coal is blown into the boilers, (4) in the boilers water, heated by burning the coal, is turned into steam, (5) the steam drives turbines which turn a generator, (6) the generator produces power which is distributed to the consumers.

At the end of the last century, seven pounds of coal were required to produce one kilowatt-hour of electricity. Because of advanced engineering and planning, TVA's latest steam plants require only three-fourths of a pound per kilowatt-hour.

Kingston is the world's largest steam electric plant. It was originally planned with nine 150,000 kw generators, but during construction it was decided to make the last five generators 200,000 kw units.

The four units at the Colbert plant are only part of the ten units planned. If completed according to plans, Colbert would have had a total of at least 2 million kw. It is probable that units of 250,000 kw capacity could be used for the last six. This would bring the capacity to 2.3 million kw—by far the largest in the world.

The present generators at the Colbert plant each burn 76 tons of coal per hour. This fantastic flow of coal requires the most efficient methods of transporting the coal from the barges to the plant.

The John Sevier plant is unique in the respect that it receives no coal by barge. All of the coal is brought in by rail. TVA is making studies for transporting coal to the plant from Virginia. The coal would be piped to the plant in a mixture of coal and water.

The plants in the TVA system represent the largest and most advanced steam electric generating system in the world.

Nonpower Projects

The dams and steam plants represent the major achievement of TVA's construction program, but they do not represent the entire works by any means. The creation of many new lakes would change the valley. Many roads and highways; dozens of bridges and miles of railroads, telegraph, and telephone lines; even cemeteries would be under water. TVA had the responsibility of relocating all of these things.

The same designers and engineers who had planned and built the dams and steam plants also worked on the new roads and bridges. Like the great dams and steam plants, these projects were given very much planning. Many of the bridges represent the best in American bridge design.

BENEFITS

The realization that our democratic way of life can achieve goals such as those achieved through TVA can not be expressed in dollars and cents. In fact it is difficult to express such things in mere words. We can not know how other nations feel toward us and our success in such an undertaking. Dr. Julian Huxley, an Englishman, wrote, "In a way most significant of all, TVA has succeeded in demonstrating that there is no antithesis between democracy and planning, and that planning cannot only be reconciled with individual freedom and opportunity, but can be used to enhance and enlarge them." The Honourable John G. Winant, former Ambassador of the United States to the Court of St. James, described TVA as: "—an American democratic experiment that can be applied in many areas of the world and would add to the wealth of nations and the general welfare of the common man."

Economical Benefits

The TVA dam control system is able to reduce flood crests on the Mississippi by three to four feet. This results in a multi-million dollar saving annually due to flood

(Continued on page 20)

The Birth and Death of the Moon

By Neil E. Christensen

Neil is a senior in ME and lives in Green Bay, Wisconsin. He is planning to enter into research after graduation.

THE moon has been an object of wonderment and awe for man since the beginning of recorded history. Today the interest in the earth's only natural satellite is intensifying as, within the next decade, it promises to be the first heavenly body to be visited by man. A vast amount of knowledge will be gained when man succeeds in traveling the 238,000 miles to the earth's nearest neighbor, but one of the most important questions that may be answered is, where did the moon come from? When this question is resolved, man will take an important step towards discovering the origin of the earth, the solar system, our galaxy (the "Milky Way"), and the universe itself.

A BRIEF SURVEY OF THE FORMATION OF THE UNIVERSE

According to one of the most accepted theories based on present scientific knowledge, the solar system, our galaxy, and the universe were formed in spectacular fashion in the far, far distant past. At that time according to this theory, the whole universe, including the earth, the sun, and all of the stars, was condensed into one gigantic body referred to as the primary mass. When this mass became too dense and the pressures became too great, a fantastic explosion took place which vaporized some of the mass and completely shattered the rest, and sent vapor and firey particles flying in every direction from a common center. Eventually these particles and vapors recondensed to form stars which are still moving away from the common center. Some of these stars changed course due to the gravitational attraction of their neighbors, and one star passed so close to the star which we call our sun that it pulled a long trail of matter and gases from the sun which later condensed again into droplets and continued to rotate around the sun. These droplets are now the planets of our solar system.

All stars, and our solar system, are still moving in directions roughly away from a common center. If we accept the foregoing theory, sometime in the very distant future (a billion billion billion years hence), the stars through mutual gravitational attraction will again condense into a gigantic primary mass and the cycle will begin again.

How many cycles has this mass already gone through? There is no way of knowing. Does a theory such as this refute the existence of God? No, on the contrary, it helps to substantiate the existence of a Supreme Being, for if we go back in time far enough, to a point before the beginning of the first cycle, we reach a point where there was nothing but empty space. Where did the primary mass come from in the very beginning? In science there can be no answer, for it is impossible to obtain mass when there is nothing at all to start with, so we must rely on the existence of the Supreme Being, God.

THE FORMATION OF THE SATELLITES IN THE SOLAR SYSTEM

The foregoing theory has brought us to the time when the solar system was very young. In the ages that followed many of the planets captured satellite which revolved around their hosts as their hosts revolved around the sun.

Our moon is not unique as a satellite in the solar system. Starting with the planet nearest the sun and working outward, (Fig. 1), we find that Mercury and Venus have no satellites, probably due to their

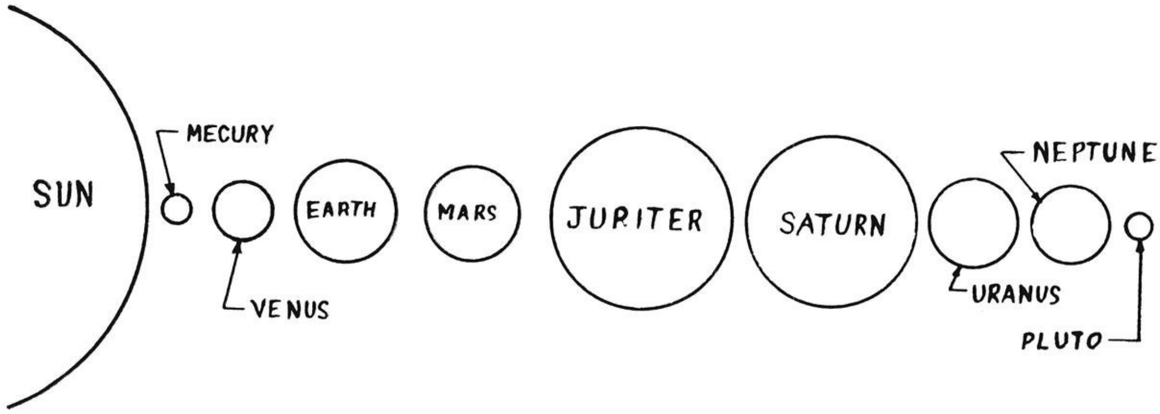


Fig. 1. The Planets of the Solar System

small size. Earth is the next planet and has one satellite, followed by Mars with two. Jupiter, the largest planet in our solar system, has nine satellites; Saturn has nine and three rings; Uranus has four; Neptune, one; and the last planet, Pluto, has none. These satellites, with the exception of our moon, have long been considered to be stray meteors or asteroids which were captured by their hosts when they wandered too close and fell under the influence of their host's gravitational field. This conclusion was arrived at from considerations of size, position with respect to their hosts, and orbits of the respective satellites.

The moon is, however, unique in the solar system in size with respect to its host, the earth. The moon has a 1:4 ratio of diameters with respect to the earth and a mass ratio of 1:81, while Titan, the largest of Saturn's satellites and the second largest satellite compared to its host, has a diameter ratio of 1:20 and a mass ratio of 1:4,700, both with respect to its host. This makes the moon way out of proportion compared to the other satellites in our solar system as can be seen clearly in Fig. 2.

It is highly unlikely that a body the size of the earth could possibly capture a body the size of the moon for a satellite. Another theory must therefore be developed for the formation of the moon.

THE FRACTURE THEORY OF THE FORMATION OF THE MOON

Origin of the Fracture Theory

The fracture theory of the formation of the moon (the theory that the moon was torn out of the surface of the earth) was first presented in the latter part of the 19th century by the English mathematician, G. H. Darwin. Since then the theory has been altered slightly by more recent research and many pieces of evidence have been found to both substantiate and refute the theory.

Tides Raised on the Earth's Surface

After the earth was pulled from the sun it remained in an extremely hot, plastic or semi-liquid condition for millions of years. During this time the earth was spinning very rapidly on its axis; at the approximate rate of one revolution in six hours instead of the one revolution in 24 hours which is its spin rate today. Since the earth was in a semi-liquid form, the gravita-

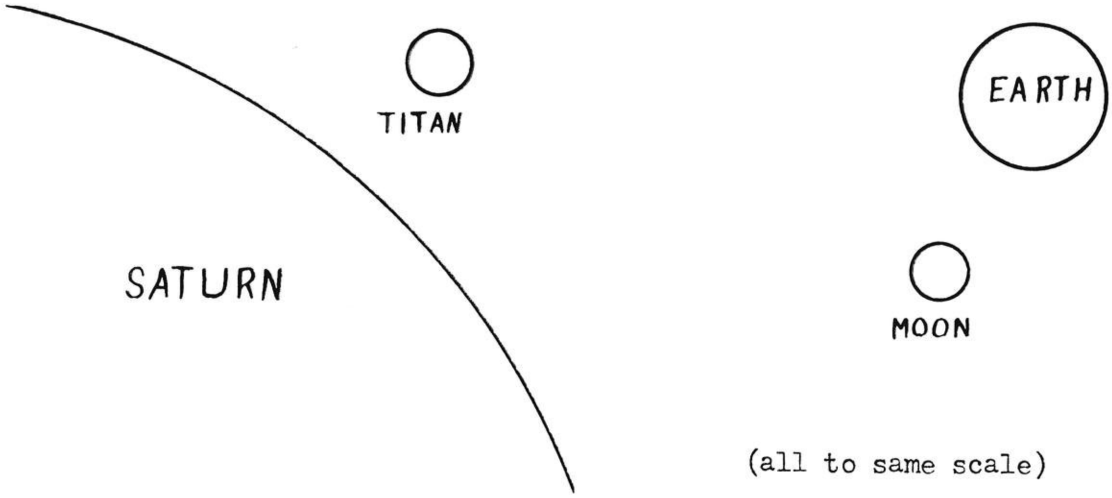


Fig. 2. Sizes of Titan and the Moon Compared to Their Hosts
The Moon, George Gamow, London: Abelard-Schuman, 1959

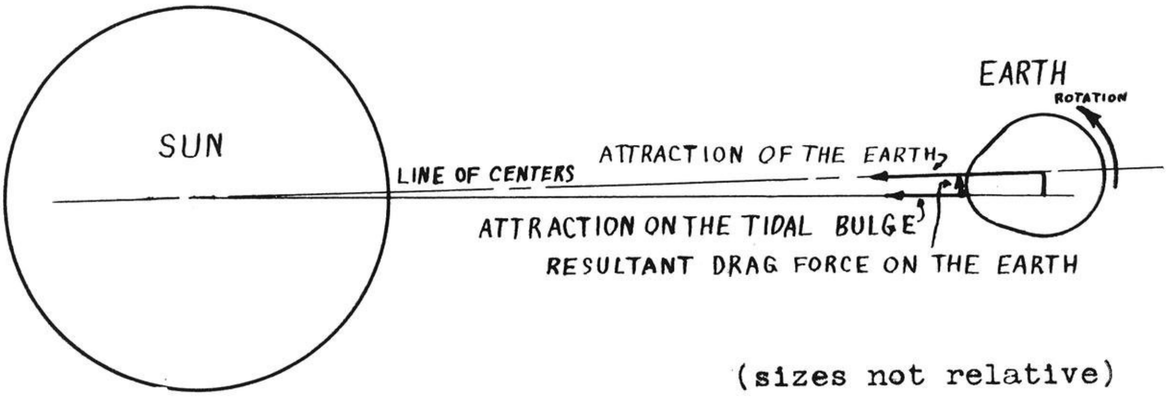


Fig. 3. The Sun's Braking Effect on the Earth

tional attraction of the sun raised huge tides on the surface in the same manner that tides are raised in the oceans by the gravitational effects of the sun and moon today. This tidal wave, the bulge on the earth's surface caused by the sun, (Fig. 3), was not obstructed by land masses as are the ocean tides of today, and was able to run clear around the earth unhindered, with the bulge always directed approximately toward the sun. Because of the rapid rotation of the earth and the viscous effects of the molten rock, the tidal bulge was dragged beyond a line drawn between the center of the earth and the center of the sun. The gravitation of the sun was trying to pull this bulge into a direct line between it and the center of the earth, while the earth, due to viscous forces, was trying to keep the bulge stationary on its rotating surface. The combined effect was to act as a brake and very slowly, slow down the rotation of the earth.

Resonance of the Gravitational and Rotational Forces

There was a second major force acting on the earth, besides the gravitational attraction of the sun, at this time. This force was the earth's own natural period of vibration (rotation). When the earth was spinning rapidly this second forced had little effect, but as the velocity of rotation slowly decreased, the natural period of vibration of the earth came closer to equalling the actual period of revolution. These two periods finally became equal and were in resonance. Now that the forces were in resonance they acted together, and the effect was a steadily increasing height of the tidal bulge as each rotation now added to the height of the bulge during the last rotation.

The reason for the increasing height of the tidal bulge when the forces came into resonance can be seen by comparing it to an event that we are familiar with, such as a car stuck in the snow. If the driver merely puts the car in gear and steps on the gas he may move forward slightly but he will probably remain stuck. If however, he alternates stepping on the gas and resting (letting the car rock back), in the right time sequence, which will be the natural period of vibration of the car, each rocking motion will build on the last and he will slowly move forward. This same effect is demonstrated by pushing a swing or throwing a heavy object. We can push it higher or throw it farther by using the right rhythm and swinging it back and forth, so that each push builds on the push before it.

The Moon Breaks Away from the Earth

This resonant effect of the tidal period and the natural period of vibration (rotation) of the earth, continued for several million years and slowly drew the earth into an

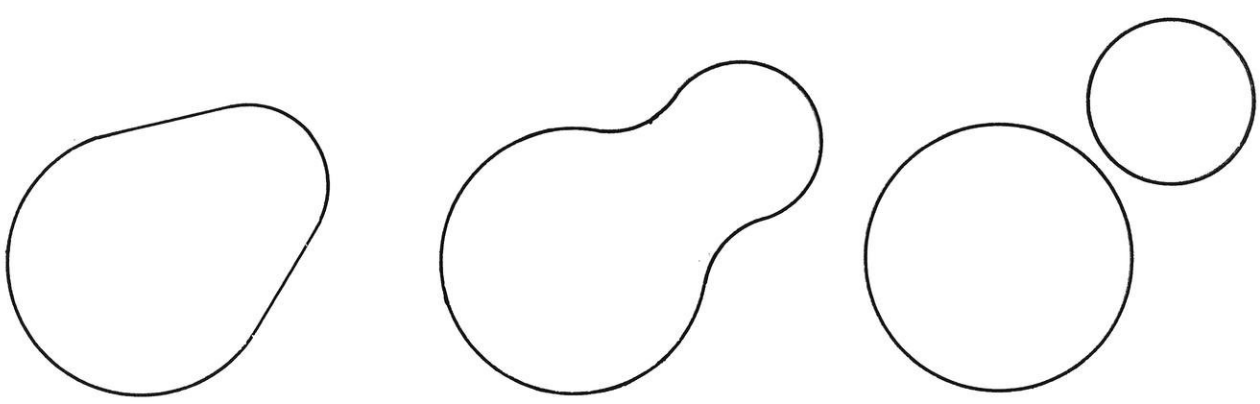


Fig.4. Steps in the Fracturing Off of the Moon from the Earth

elliptical shape. The ellipse drew into a dumb-bell shape with one end of the dumb-bell larger than the other as shown in Fig. 4. Finally the neck of the dumb-bell became stretched too far and broke. The moon was born.

The moon did not go hurdling off into space, but held its relative position with respect to the earth, and the semi-liquid neck slowly sank back into the masses of the earth and the moon. Because of the nearness of the earth and the moon, the tides of molten rock raised on the surfaces of both bodies were enormous. The forces due to the tides and the natural period of vibration of the earth were no longer in resonance however, because of the change in mass of the earth. Therefore there was no further "building" effect of the forces. The same mechanism that caused the sun to slow down the rotation of the earth in the past again came into play, but now between the earth and the moon, and the velocity of rotation of both bodies decreased slowly.

Conservation of Momentum in the Earth-Moon System

The earth and moon were the only cause of the significant forces acting to slow each others rotation. Therefore, if we consider the two bodies together, there was no significant outside force acting to decrease the momentum of this system. From physical laws, the momentum of a system with no external forces acting on it must remain constant, so the decrease in momentum due to slowing of the rotations must reappear at some other point or in some other form in the system. The only way that this could be accomplished was for the bodies to move farther apart, thereby increasing the length of the moment-arm between the two bodies and increasing the momentum of the moon circling the earth.

After a period of time, both bodies became essentially solid and the tides could no longer be raised to an extent great enough to cause an appreciable braking effect. However, the earth was massive enough to produce a bulge in the moon due to the earth's gravitational force as the moon was solidifying. This stationary bulge acted in the same way that the tides had to cause a braking action on the rotation of the moon. This braking action pushed the moon further away and eventualy slowed the rotation of the moon to zero with respect to the earth so that the same face of the moon would always face the earth. It is interesting to note that this condition still exists today: there is a sizeable bulge on the face of the moon facing toward the earth, and the moon still presents the same face to the earth at all times.

The moon's effect on the earth was slightly different after solidification took place. The moon was not massive enough to raise a bulge on the face of the earth to get a grip on, but the tides raised in the oceans had the same effect.

Tides are raised in the oceans by the moon and travel around the earth at the same relative speed that the moon travels around the earth. These tides do not flow unobstructed, however, and eventually hit land and are stopped. The stopping of these tides produces the force that is acting to slow down the rotation of the earth at the present time and the decrease in speed of rotation continues to push the moon further away in order to conserve the momentum in the earth-moon system.

PHYSICAL VERIFICATION OF THE FRACTURE THEORY

The Scar Left on the Face of the Earth

If this is the correct theory of the formation of the moon, we would expect to find some remains of a scar on the face of the earth that would have been left when the moon was torn away. We would expect this because the earth was in a plastic state at that time, with at least some crust already formed on the surface and further solidification taking place fairly rapidly. Such a scar is, in fact, visible.

In searching the features of the globe for such a possible scar we can see that *the Pacific Ocean basin is the only feasible answer.* Even the Pacific Ocean basin is not large enough to form the moon out of the surface material that could have been taken from the depression, so we must continue to search.

Another feature of the globe's surface that is evident is the similiarity in shape of the shorelines of the continents, especially the shorelines on the Atlantic Ocean. By using a little imagination, the continents can be pictured as pieces of a jig-saw puzzle. It is seen that North and South America could slide over to fit very neatly against Europe and Africa. Australia and Antartica can roughly fill in the Indian Ocean, and Greenland can slide between Russia and Canada to fill in the Arctic Ocean. This leaves us with a greatly enlarged, roughly circular Pacific Ocean basin that would be the size of all the present terrestrial oceans. In W. H. Pickering's *The Moon*, Professor Pickering states,

> "A body the size of the moon would equal a section of the earth's crust having an area equal to the terrestrial oceans, and a uniform depth of 35 miles."

This basin would be the approximate size that we are looking for.

Further verification of the Pacific Ocean being the scar left by the moon is the material that makes up the floor of the Pacific Ocean. The entire earth is covered with a layer of granite, with the exception of the the Pacific Ocean basin which does not have any granite but has a basalt floor. Over the rest of the globe, basalt rock protrudes to the surface in only isolated locations. Because of this we would expect the moon to have the approximate density of granite if it came from the Pacific Ocean basin. We find this to be true. The overall relative density of the earth is about 5.5 times the density of water, while the relative density of the moon is 3.3, which corresponds very closely to the density of granite.

Drifting of the Continents

The one problem that remains, if we are to accept the Pacific Ocean basin as the scar that we are looking for, is accounting for the movement or drifting of the continents. Is this drifting of the continents plausible? Professor W. H. Pickering pointed out in his book, *The Moon,* that the crust of the otherwise fluid earth must have been torn apart at the moon's birth leaving a huge hollow where the torn off mass had been. Moreover, he stated that the shock caused by the final fracture would have been violent enough to crack the crust in other places. This could have caused the cracks that allowed the continents to drift apart on a sea of molten basalt.

Evidence of the possibility that the continents had drifted in the past is derived from the fact that the continents that drifted, like North and South America, all have mountain ranges raised on their leading edges. These mountains are of the pressure or folded-crust variety (not volcanic mountains) that would have been caused by the resistance of the underlying rock, which was slowly solidifying, to the movement of the continents. Besides raising mountains on the leading edges of the continents, huge stresses were built up in the same places due to the movement and the building of mountains. These stresses are still present today and are being relieved by earthquakes and volcanoes.

Earthquakes and Volcanoes Act to Relieve the Stresses

The volcanoes appeared because of the heat built up by the stresses and the resulting cracks in the rock surfaces. These volcanoes built the land mass we now call Japan; the string of islands extending from Alaska far out into the Pacific Ocean known as the Aleutian Islands; the Cascade mountain range along the north western coast of the United States; and the volcanic mountains of the Andes mountain range of South Africa. During the time of the volcanic action and continuing today there were, and are, earthquakes along the perimeter of the Pacific which relieve the stresses and strains caused by the release of the moon and the cooling and contraction of the earth. Some of the most violent quakes of modern history have occured in this area, including the San Francisco earthquake of 1906, the Yellowstone quake of 1959, and the Chilian earthquake of 1960.

It is true that earthquakes and volcanoes occur in other parts of the world, but in no place do they occur as a definite concentration as they do along the shores of the Pacific Ocean. Other quakes and volcanoes are isolated events caused only by the slow cooling and contraction of the earth which cause stresses that become too large to be carried by the rock formations of the locality.

THE FATE OF THE MOON

We have reached the present in our theory. We will now look into the futuer and predict what the fate of the moon might be.

Future Movement of the Moon Relative to the Earth

Using modern methods of research it has been calculated that the earth's rotation is slowing down at the rate of one second in 100,000 years, that is, the length of the day in 100,000 years will be one second longer than it is today. According to these figures, every rotation of the earth takes .00000002 seconds longer than the previous rotation. In 100 years therefore, since the effect is accumulative, it can be calculated that we would be 14 seconds behind our present time. This difference shows up at present in the timing of eclipses of the sun and moon. Astronomers have been able to accurately predict the time of a future eclipse to the nearest second for over a century, and the present eclipses that were predicted a century ago are consistantly 14 seconds late as compared to their predicted time. This is conclusive evidence that the speed of rotation of the earth is decreasing.

Since the earth is slowing down with respect to its period of rotation, the moon must be moving farther away from the earth because of the conservation of momentum law. The days will continue to grow longer until they equal a month, in other words, the time it takes for the moon to rotate once around the earth will equal the time it takes for the earth to rotate once on its axis. At that time the month and the day will both equal 47 of our present days, compared to the present length of the month which equals twenty seven and one third days. At that time the moon will be 340,000 miles away from the earth compared to 238,000 miles at present, and it will be about the year 50 billion A. D.

The Future Effect of the Sun on the Earth-Moon System

Up to this point the effects of the sun on the rotation of the earth were neglected because they are very small compared to the effects of the moon. When the length of the day equals the length of the month however, the moon will be stationary with respect to the earth and therefore will have no effect on the rotation of the earth because the tide that it causes will be stationary on the face of the earth. Even though the tides caused by the moon will have ceased (the "tide" will now be just a bulge), there will still be tides due to the sun which will still further slow down the earth's rate of spin. The effect now however, will be to draw the moon closer to the earth.

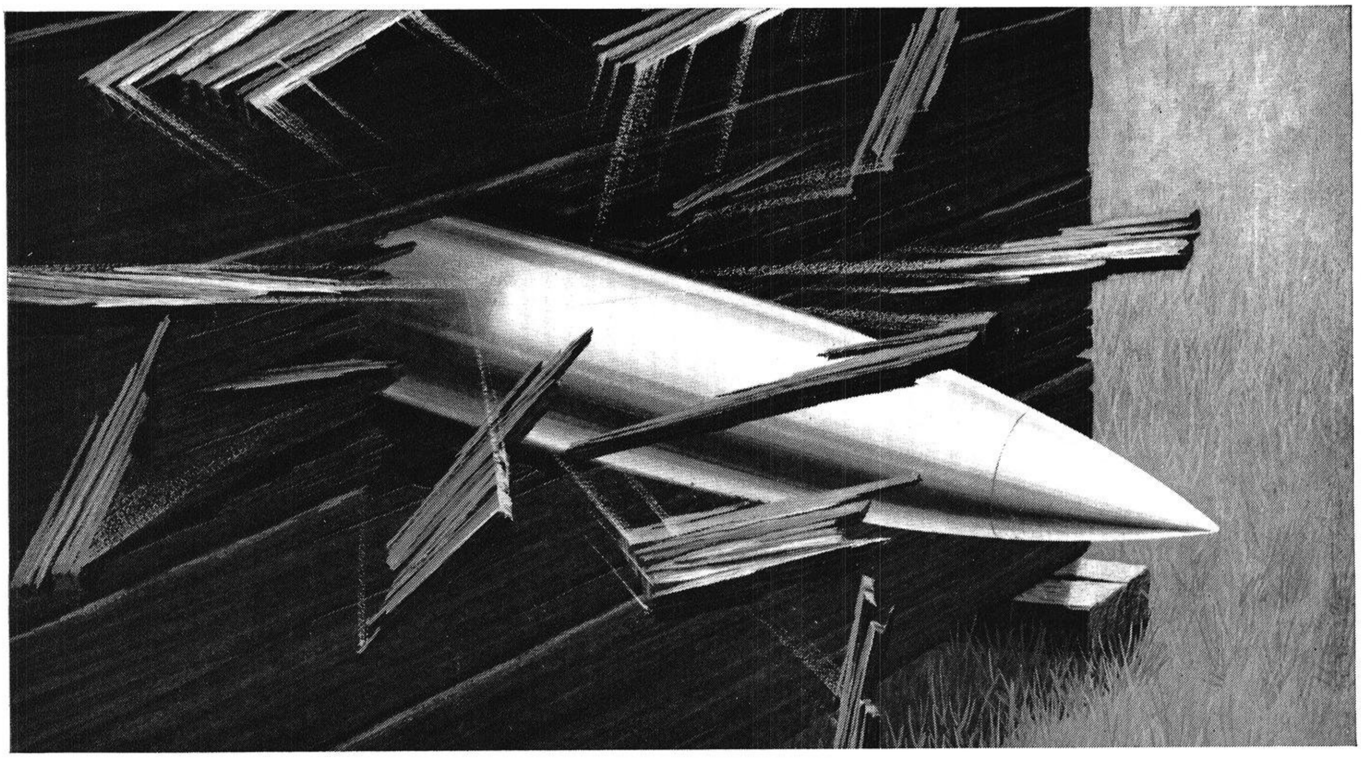
"A tidal bulge will thus be left a little behind the moon. The lunar pull on this will try to speed up the earth's rotation; the angular momentum due to the terrestrial rotation will therefore increase, and that due to the revolution of the moon will decrease. The result will be that the moon will gradually close in again."—PATRICK MOORE, *A Guide to the Moon,* New York: W. W. Norton & Company, 1953, p. 40.

The moon will continue to move closer to our planet until sometime in the very distant future the moon will approach so closely that a strange fate will overtake it. It will be broken up into fragments.

The "Roche Limit"

It may seem strange that the moon will shatter into fragments instead of hitting the earth like a giant meteor, but according to present scientific knowledge, this will be the case. The gravitational attraction between the earth and the moon is proportional to the combined masses and the square of the distance between them, therefore, this force will grow fantastically as the moon approaches the earth. The safety limit to which an object can approach the earth is dependent on the mass of the object, its density, and many other factors not yet entirely understood. This limit is called the "Roche Limit".

(Continued on page 30)



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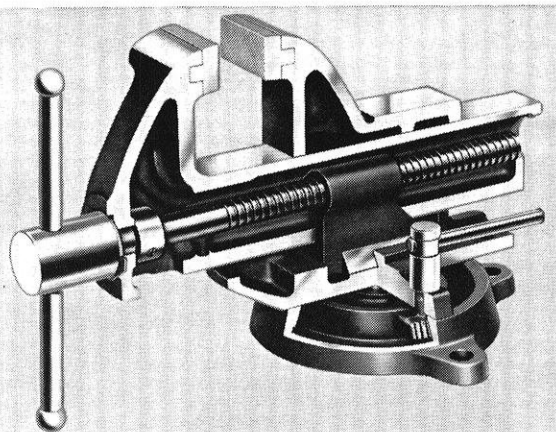

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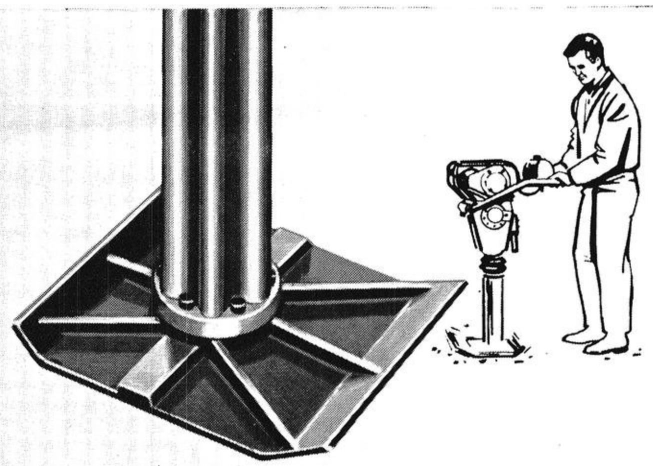

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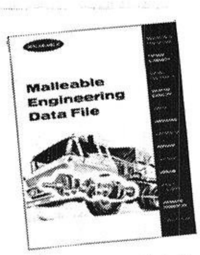

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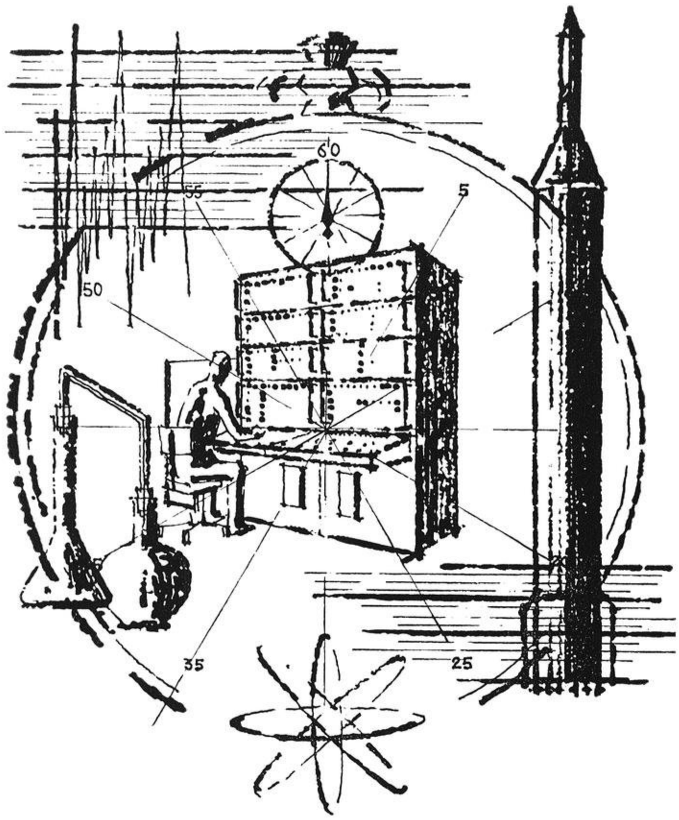


SCIENCE HIGHLIGHTS

By Patrick D. Meagher, EE '66

NEW COLOR PICTURE TUBE

A new color cathode ray tube for television sets, that can be produced for substantially less than present color television tubes, has been patented by D. M. Goodman of New York University. Mr. Goodman, a Senior Research Scientist at N.Y.U.'s Engineering Research Division, is entering the race with his revolutionary tube for the rapidly growing markets in data display and color television.

The tube employs a single electron gun instead of using three guns which is now standard practice in the industry. The new tube also dispenses with the mechanical "shadow mask", a selection device that substantially cuts down the brightness of the projected picture. The Goodman tube has a target screen consisting of repeating groups of vertical color strips and thin indexing strips, all deposited on the face of the tube. When bombarded by the scanning beam released from the single electron gun, the index strips give off short bursts of ultra-violet and x-ray index signals, which locate the position of the electron beam on the target screen. Attached to the electron gun are light pipes which pick up the index signals and send them through the neck of the tube to very rapid gating circuits. These circuits sample the different video color signals, and then control the modulation of the electron beam to insure registry of the different color signals on the target screen.

The new tube does not employ the wire grids and apertured masks used by the expensive color cathode ray tubes now in use. Instead, the Goodman tube provides a unitary, non-vibrating, sandwich assembly of index strips and color strips on the face plate of the tube. The index strips operate at the same voltage as the color strips, requiring no additional high voltage power at the target screen. Also, because the index signals are transmitted as electromagnetic radiation to the light pipe members, additional high voltage circuitry is not needed. This arrangement, which simplifies the target screen and index signal pick-up structures, makes the tube less expensive to produce. In addition, the new tube is better adapted to meet the broad range of environmental conditions likely to be imposed by industrial and military users.

Initial production plans are for a 600 color line tube, with a brightness capability of 75 foot-lamberts unmodulated, to be available for television receivers this autumn. The tube will be produced in the 21 inch–72° round envelope now available, and also in the 23 inch–90° rectangular envelope. Both tubes will be price about $40 each in quantity. The tube with the 90° deflection angle desirably will be much shorter in length.

TELSTAR REPORTS: HIGH RUSSIAN BLASTS CAUSE SURGE OF RADIATION IN SPACE

Telstar detected large increases of radiation in a particular region of space following the Russian high-altitude nuclear tests of October 22 and 28, a scientist of Bell Telephone Laboratories reported.

Two concentric belts of intense radiation, called the Van Allen belts, bulge upward from the earth's atmosphere for thousands of miles. Walter L. Brown, head of the semiconductor physics research department, told the annual meeting of the American Physical Society in New York that immediately after the blasts, the "gap" or "slot" between the two belts was nearly "filled up" with energetic electrons. There was less of an increase of electrons in the belts themselves than in the slot.

The number of electrons added by the blasts gradually diminished during succeeding weeks, but in the center of the slot the decrease was more rapid than it was on the sides of the belts and more rapid than would have been expected. Scientists do not yet know the reason for the existence of a natural gap in the intense radiation. That is, they don't know why the region of radiation is not one continuous belt.

Telstar showed that the October 22 blast nearly filled up the slot, increasing the number of electrons there a hundred to a thousand fold. The electrons then decreased in the center of the slot at the rate of 50 per cent per day, but much more slowly elsewhere. The October 28 blast again nearly filled up the slot, and again the number decayed at approximately the same rate as before.

Scientists are not agreed about the precise results of the U.S. nuclear test in space on July 9 (called Starfish) at altitudes above 600 miles because there were no radiation-measuring satellites in orbit that high at the time of the test.

UNISPHERE

United States Steel began the construction of the Unisphere, the permanent symbol which it is presenting to the 1964–1965 New York World's Fair.

Workmen for U. S. Steel's American Bridge Division, fabricator and erector of Unisphere, set in place the first 20-ton section of the tripodic-shaped base that will support the 12-story-high globe of the world.

The pedestal section was fabricated of U. S. Steel's rugged alloy steel, Cor-Ten, one of four major types of steel being used in the unique structure. Others are stainless-steel-clad structural members representing the latitudes and longitudes of the globe; rigidized stainless steel sheets, from which the land masses and mountain ranges have been fashioned; and USS "T-1" steel, a super-strength alloy steel, from which connecting bolts have been made.

To be surrounded by a reflecting pool, Unisphere will be one of the tallest buildings in the 1964–1965 Fair. With its stainless-steel surfaces designed to reflect both natural and artificial light, it will be one of the outstanding attractions at the Fair as well as its permanent symbol.

NEW NORELCO TV SYSTEM FOR VISUAL X-RAY INSPECTION ON THE PRODUCTION LINE

Designed originally for inspection of missile case wall materials and weldments in steel of one-eighth inch thickness or less, an image enlargement system has found many new industrial uses. It provides unique sesitivity for testing thin-gage foils and sheets (from 0.001 to 0.250 in.) for cracks and other discontinuities of the order of 0.001 inch in dimensions. Complex assemblies of thin materials such as brazed honeycomb stainless steel components, are revealed with extreme clarity, including all fillets and braze bonds. Brazed sandwich structures show clearly all braze alloy voids, down to 0.001 inch in size. Butt weldments, including electron beam welds in thin materials, can be examined for porosity, internal cracks, inclusions, and surface discontinuities. In materials of one-quarter to one-eighth inch thickness, for which standard penetrameters are available, the smallest penetrameter holes are shown.

SLIPPERY ALUMINUM

General Electric has developed new aluminum lubricants that have coefficients of friction about one-fifth those observed when conventional lubricating oils are used.

Investigations into the chemistry of "fresh" metal surfaces in ultra-high vacuum—approaching that encountered by Project Mercury spacecraft at the top of their orbits—led to the development of the new aluminum lubricants.

The chemical reactions which occur in a billionth of a second in ordinary atmosphere can be slowed down and watched for a period of hours using the space-vacuum method.

This led to the identification of a class of compounds which form a chemical attachment to the surface of aluminum. The "secret additives" form a wear-resistant film, and provide a coating for the tiny wear particles which otherwise damage the sliding surfaces.

(Continued on page 30)

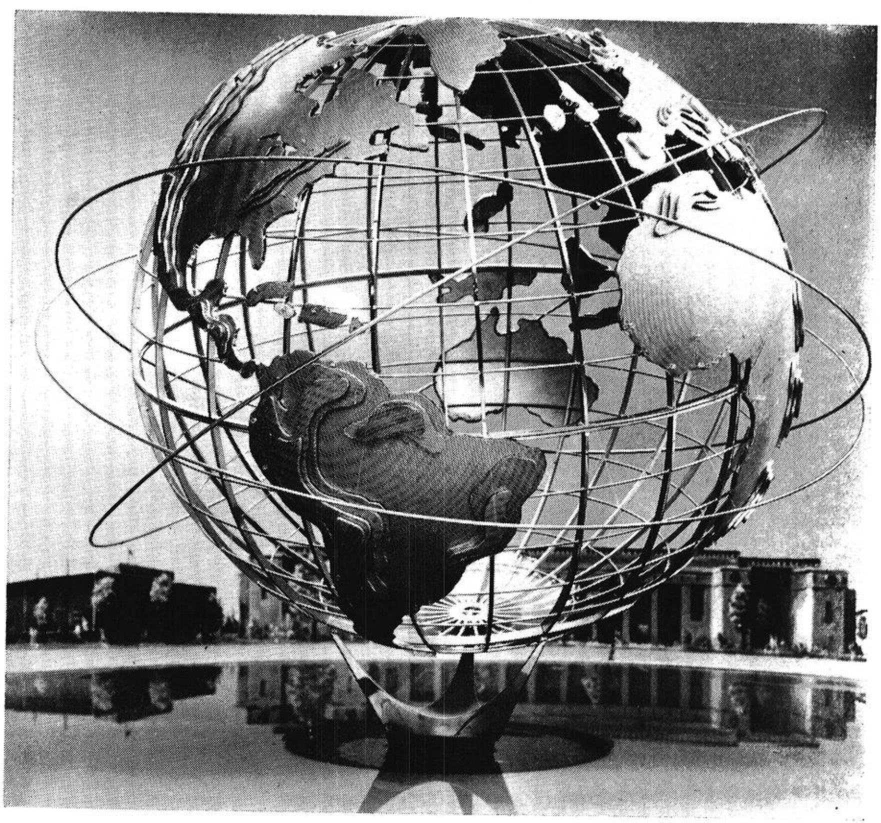
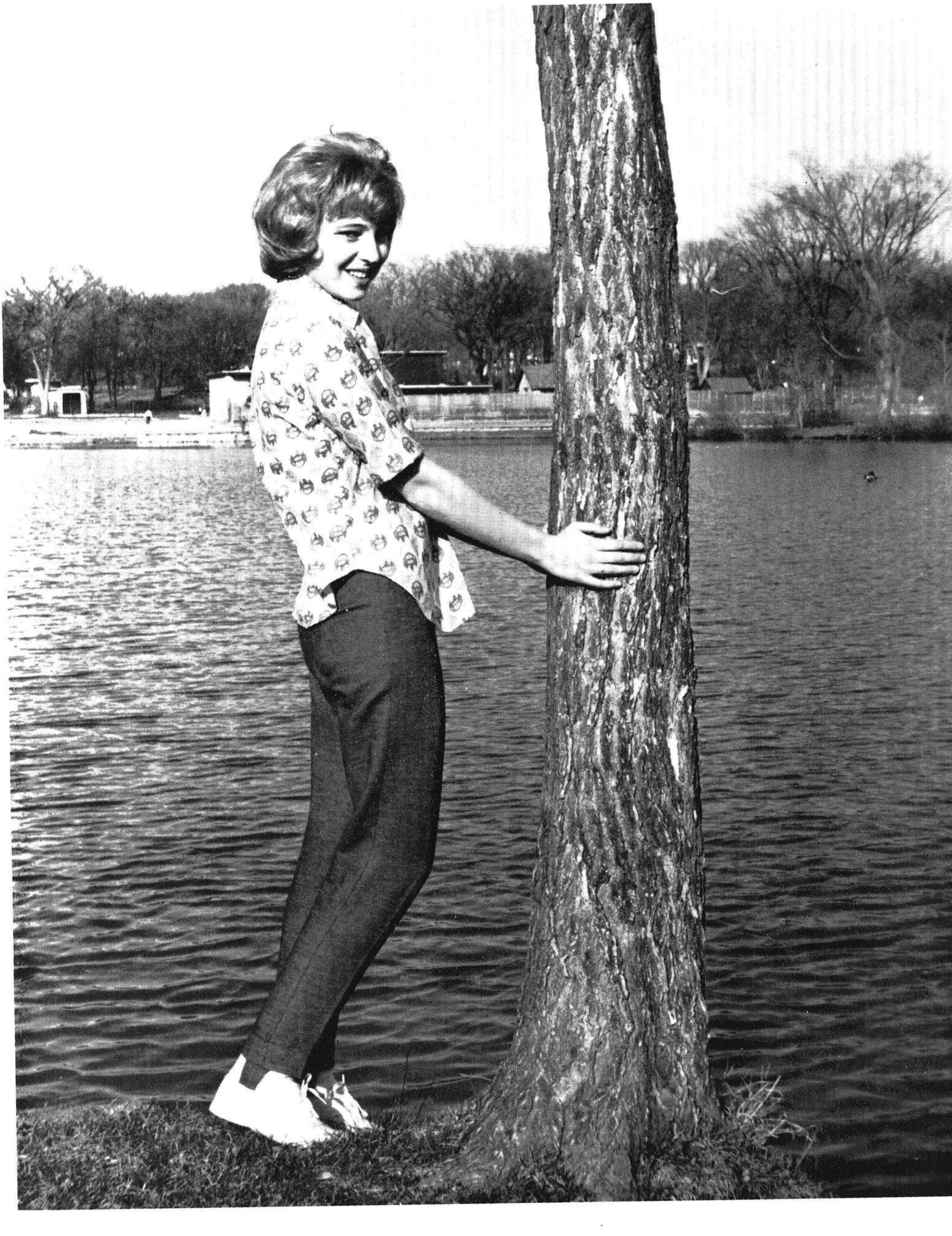


Photo of model of Unisphere, permanent symbol of 1964–1965 New York World's Fair.

ENGINEERS GIRL FRIEND

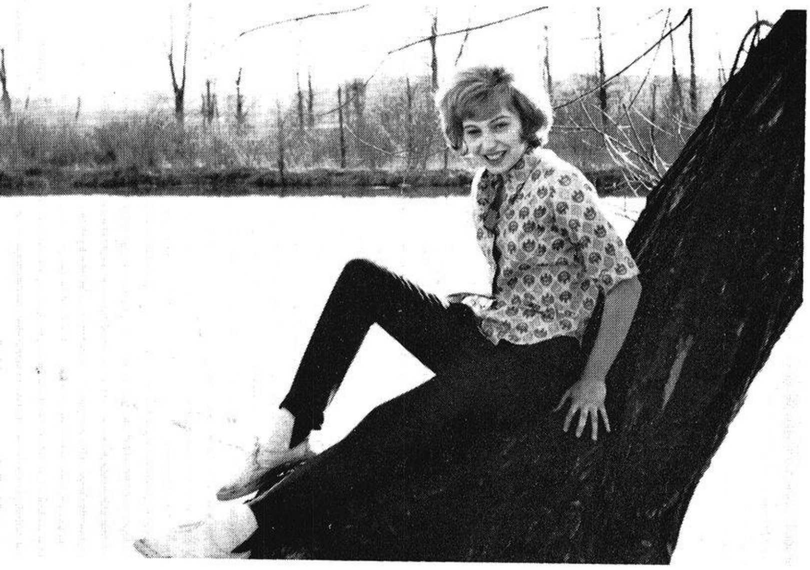


MISS MAY

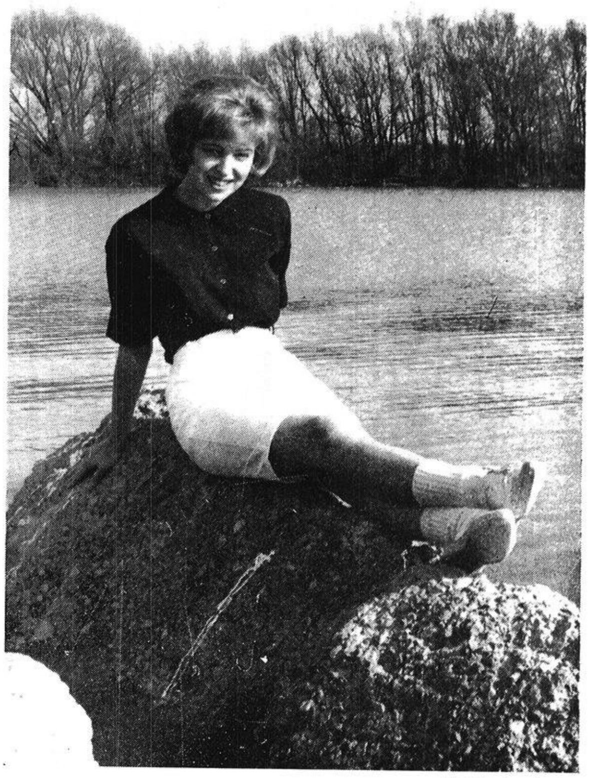
BILLIE JONES

Our blond Miss May, Billie Jones, is a native of Richland Center, Wisconsin. This 5′8″, 18 year old beauty resides at Elm Drive "A" while attending classes leading to a Psychology Major here at the University.

For those of you who might just happen to have a ranch or a hot S K class boat, Billie admits a love for horses and water skiing.



A refreshing sight at the lake shore, our Miss May basks in the Spring sun.



—Photos by jack

Exploring the Moon

(Continued from page 12)

bench, and a store of standardized spares. There is also lunar suit stowage and air conditioning equipment.

The entire unit is powered by a separate power generation trailer. It contains a thermionic converter for main supplies and a solar boiler for use in the event of failure of the converter.

Some other designs are more radical. One such design calls for a unipod stabilized by a large gyroscope, which would move on small tracks or wheels, and would be capable of jumping crevasses. Another is a walking-beam three-man vehicle which would be similar to an Army "Grasshopper" vehicle. Still another is a sphere which would roll over the Moon's surface. The quarters inside would remain upright at all times, stabilized by a gyroscope.

All of these designs may be built with double walls for the outer skin. The inner wall would be of a material having low thermal conductivity characteristics so as to insulate the interior of the vehicle. The double walls would also be some protection from micrometeorites. With a single wall, there would be dangerous losses of vehicle atmosphere when penetrated by a meteorite. Double walls would reduce the possibilities of rupture of the inner wall and would greatly facilitate repairs of either wall. If it is found that more insulation is needed than was put into the vehicle, it may be possible to further insulate the vehicle by covering it with dust.

The power plant of the vehicle is a very important feature. There are a number of possibilities. Hydrogen-peroxide or diesel-fuel-oxygen engines may be used. Their capabilities are known and are lightweight. One disadvantage is that they require a high fuel supply. Nuclear power plants can operate on a low fuel supply, but their weight would be excessive, because of the engine and shielding. Fuel cells or chemical batteries may be applicable if advanced in time. Still another possibility is the use of solar batteries, powered by the energy collected from the Sun.

STEPS TO ACHIEVE EXPLORATION OF THE MOON

Much work has already been done to solve all the problems arising from a proposed expedition to the Moon. The National Aeronautics and Space Administration has instituted Project Mercury. This project has orbitted man around the Earth and is laying the foundation for Projects Apollo and Gemini. These projects will include orbitting two men in a single capsule and, eventually, a trip to the Moon.

Instruments will be sent to the Moon to gather information before men will attempt a trip. These instruments will either be landed on the Moon or put into orbit around the Moon. The information they gather will be sent to Earth by radio and/or television.

Testing on Earth does not take advantage of the Moon's reduced gravitational field. Dynamic analyses will have to be modified for the reduced weight on the Moon. Power plants for surface vehicles are being designed and tested at the present time. Since they are such an important part of the vehicle, much time, money, and effort is being put into their development. Life support systems are also being researched. These include compression-distillation units for regenerating potable and utility water during normal operations, hydrogen-reduction electrolysis systems for regeneration of normal breathing oxygen, refrigeration systems for storing food and solid wastes, and food warming units. Experimentation with the foods themselves is also being carried on. Eventually all these problems will be solved and man will land on the Moon. The successful exploration of the Moon will be the end of the beginning.

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TVA

(*Continued from page 17*)

prevention. The construction of the Kentucky dam alone saved the Illinois Central and two smaller railroads ten million dollars just for the one reason that their tracks would not have to be raised out of flood danger.

The excellent transportation and sources of cheap and plentiful electricity attracted new industry to the valley. This created more and better jobs for the residents of the valley and raised their standard of living.

The beautiful lakes have attracted tourists to the valley. This tourist trade represents a new multi-million dollar income source for the people.

TVA has definitely proven that it can return manyfold the investments which the people of the United States trustingly made.

Conservational Benefits

With all the hard work that goes with such a project as TVA, there must also be provisions for recreation. TVA planners and the Government allowed for many recreation facilities in the development of the valley.

A major objective of TVA has been to check soil erosion and improve soil usage. Some of the steps in this project are: manufacture of fertilizers, turning lands unsuitable for crops onto grass or forest, building check-dams and planting shrubs and trees, contour farming, rotation of crops, and filling of gullies. More than 200 million seedlings have been planted in the valley. Reclaimed land amounts to over 200 square miles.

Farmers are given classes on how to get the best use out of their farm land. The Tennessee Valley has some of the most advanced farms in the United States.

The conservational benefits can be summed up in the words of Mr. David E. Lilienthal, a member of the TVA board of directors, "All over the Tennessee Valley region you can look upon land that eight years ago was too gullied and exhausted, declared too far destroyed for productive use; now it is restored and helping to support farm families. You can go into community after community and find farmers and whole communities alive with energy and renewed faith in themselves and their capacity to meet their responsibilities to their land and to their country."

Recreational Benefits

Over half a million acres of fishable waters have been created. Most of this water is also open to boating. On Norris Lake alone there are over 3,000 pleasure boats.

TVA made an agreement with the National Park Service to set up parks. Because of the lakes and these parks, the Tennessee Valley has become one of the major tourist centers in the United States. Tourists bring at least $150 million annually to the region.

These are a few of the benefits of TVA that we know of at the present. Undoubtedly, each year will bring new benefits to the Tennessee Valley and the rest of the United States of America.

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Birth and Death of the Moon

(Continued from page 22)

When the moon reaches this safety limit the acting forces will stretch the moon into a flattened elliptical shape, and as the moon continues to stretch in this manner the stresses and strains will build up until finally it will completely shatter into millions of tiny fragments. These fragments will spread out in the orbit which the moon occupied until there is a ring around the earth similar to the rings of Saturn. It is believed that the rings of Saturn were formed by one of its satellites which sometime in the distant past approached too close to its host.

A question arises with the discussion of the "Roche Limit". If the moon did come from the earth, it must have been inside of the "Roche Limit" at one time. If this is so, why didn't it shatter then instead of moving off into space? This is a serious flaw in the fracture theory. Two possible answers have been proposed however. One solution is that at the time of final break-off with the earth, the dumbbell shape was so elongated that the part that broke off to form the moon was already beyond the "Roche Limit". The second answer could be that the moon was still in such a plastic state that it could deform into a flat elliptical shape without a critical amount of stress while within the "Roche Limit", and after it receded past this limit it was free to congeal into a roughly spherical shape.

CONCLUDING REMARKS

Is this the correct theory of the moons formation? At present nobody can say for sure. Many scientists are waiting for the day when man reaches the moon and unlocks the secrets of its formation. Until that day man will use his knowledge and imagination to find new faults and proofs for this theory and other theories of the moon's formation, and perhaps derive entirely new theories.

Whether the fracture theory proves to be the correct theory or not it will remain a tribute to man's reasoning powers and imagination.

* * *

Science Highlight

(Continued from page 25)

It is now possible to lubricate aluminum to produce the low friction of the best babbitt bearings. Broad applications for the new lubricants are anticipated not only in bearing lubrication but also in aluminum fabrication methods such as die forming, roll forming, rolling, machining, extrusion, wire drawing, spinning, and die casting.

Fill in your Own Lines

By Rollo Everett, CHE '64

* * *

Tourist Guide: "We are passing the largest brewery in the United States."
C.E.: "Why?"

* * *

Two cannibals were in an asylum. One was tearing pictures of men, women and children out of a magazine and eating them.

"Tell me," said the other, "is that dehydrated stuff any good?"

* * *

Trying to rest after an exceedingly hard day at the office, poor father was being bedeviled by a stream of unanswerable questions from little Willie.

"What do you do down at the office?" Willie finally asked.

"Nothing," shouted the annoyed father.

After a thoughtful pause, Willie inquired: "Pop, how do you know when you're through?"

* * *

An engineer is said to be a man who knows a great deal about very little and who goes along knowing more and more about less and less until finally he knows practically everything about nothing, whereas,

A salesman, on the other hand, is a man who knows very little about a great deal, and keeps knowing less and less about more and more until he knows practically nothing about everything.

A purchasing agent starts out knowing practically everything about everything, but ends up knowing nothing about anything, due to his association with salesmen and engineers.

CRANIAL COMBAT

By Don Vande Yacht, ME '65

GOOD Luck with the last of this year's puzzles. Don't forget to stay in shape for next year's Cranial Combat!!

This little trick would be good to know, but don't try it in church.

1. How could you take a coin out of a plate without touching either?

2. A postage stamp is hanging by a short cotton thread, when someone sets fire to the thread. When it has all burned, the stamp remains hanging in the same position as before. Give an explanation of how this is possible.

Here is one that should be a soft touch for all E.E. majors.

If you screw an electric bulb in the socket by turning the bulb to the right with your right hand, which way would you turn the socket with your left hand to unscrew it while holding the bulb stationary?

A. To the right?
B. To the left?

Not overlooking the aeronautical engineers, I offer this one.

If an autogyro propeller revolves from left to right when driven by the motor to lift the machine into the air, will it revolve in the same or opposite direction if the motor is shut off when descending for a landing?

Describe four ways of turning a glass of water upside down without spilling the water. You must give four *different* ways of turning based upon different natural laws. There are at least six methods of doing this.

ANSWERS FOR THIS MONTH'S ISSUE

1. Blow it out.

* * *

2. The thread had been soaked in a saturated salt solution and then dried. Then this is repeated several times, the chain of salt crystals forms a little tube around the thread, and the tube will support a light weight after the thread has been burned.

* * *

3. *A.* To the right; and it makes no difference which hand you use.

* * *

4. In the same direction.

* * *

5. Six ways to choose from:

a. Covering it first with the palm of your other hand.
b. Placing a sheet of paper over it and letting atmospheric pressure do the rest.
c. Freezing it, so that a layer of ice holds it in.
d. Swinging it at arm's length over your head, so that the water is kept in by centrifugal force.
e. Inverting it over another glass of water; done by holding both glasses under water at once.
f. Lowering the glass into a basin of water and turning it upside down below the surface.

APRIL ANSWERS

(1) Under this system, the number of a male ancestor equals twice the number of his son or daughter; the number of a female ancestor equals twice the number plus 1. Therefore, we can write down 1 for the contemporary in New Orleans, 2 for his father, 5 for that man's mother, 11 for that woman's mother, 22 for that woman's father, 44 for that man's father, 89 for that man's mother, 179 for that woman's mother, and so on.

If you run the number scale backward, starting at 1,000, continually dividing by two and watching the remainders, you will find the following relationship for the obscure ancestor number 1,000: he is the father of the father of the father of the mother of the father of the mother of the mother of the mother of the mother of our contemporary. (These are the figures you will get by division, *r* meaning remainder: 1000, 500, 250, 125, *r*, 62, 31, *r*, 15, *r*, 15, *r*, 7, *r*, 3, *r*, 1.)

* * *

(2) Exactly 111 1/9 pounds.

* * *

(3) $\frac{1}{9^9}$

* * *

(4) The fractions are 16/64, 19/95, 49/98.