

# *INGENUSU*

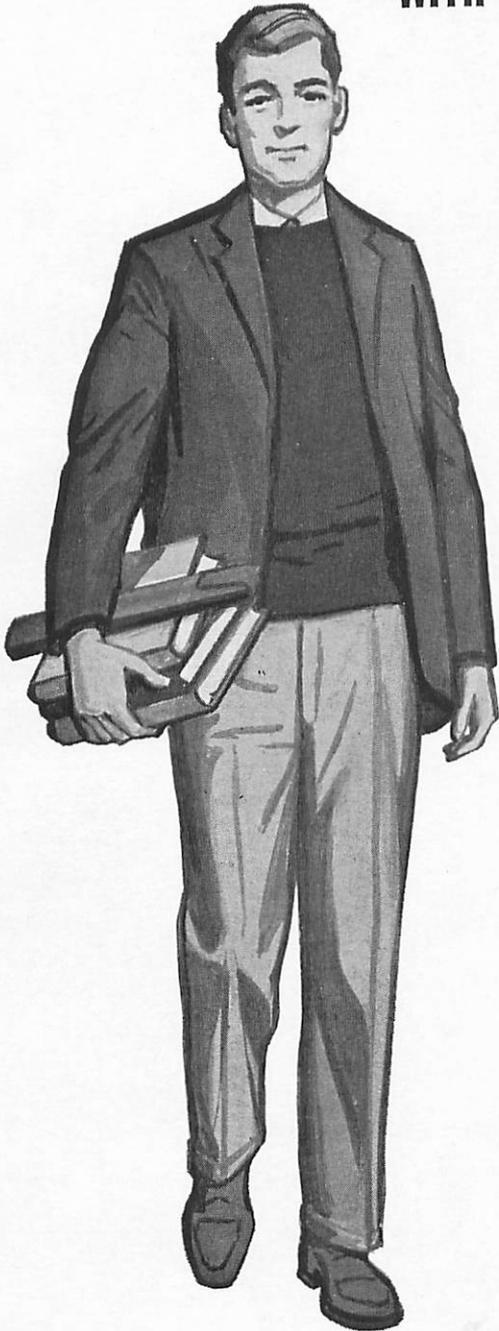
UTAH STATE UNIVERSITY  
LOGAN CAMPUS

ARE YOU INTERESTED IN...

**CONSTRUCTION...**

**WATER RESOURCES DEVELOPMENT...**

**IN THE GEOGRAPHICAL AREA OF YOUR CHOICE  
WITH THE CORPS OF ENGINEERS**



#### **DIVERSITY OF ACTIVITIES**

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

#### **OPPORTUNITY**

Opportunity is provided for progressive movement toward top positions for men with ability. You learn from top calibre professionals who have had many years of high quality experience.

#### **LOCATION**

Projects are located in every State and in many foreign countries.

#### **A CAREER NOT A JOB**

The Corps offers a well defined 18-month rotational training program for young graduate engineers covering all facets of the varied work program. This is followed by planned career development assignments. These assignments enable a young man to develop his special aptitudes in the engineering field. As he progresses, special attention is given to the development of managerial and executive abilities.

#### **ADVANCED EDUCATION AVAILABLE**

Attendance at special seminars, symposiums, and university courses and participation in professional societies and activities are encouraged, and sponsored when possible. Fellowships for advanced study and awards for outstanding achievement are also available.



**CORPS OF ENGINEERS  
DEPARTMENT OF ARMY**

AN EQUAL OPPORTUNITY EMPLOYER

FOR ADDITIONAL INFORMATION... and an illustrated brochure "Your Career", write to the Chief of Engineers, Department of the Army, Washington, D.C. 20315

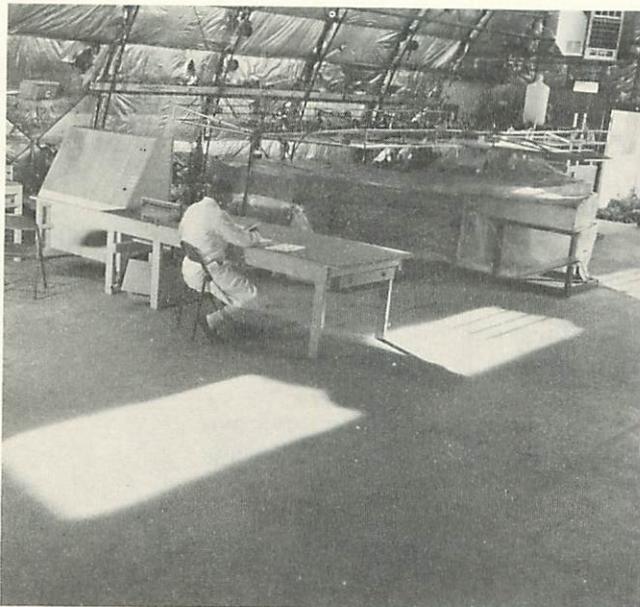
# Description of a Watershed Model and Rainfall Simulator

by D. L. Chery\*

Rainfall, runoff, streamflow, and infiltration are just a few phases of the hydrologic cycle which are very important to many people. With each passing day, water becomes more important and more effort is made to utilize it with more efficiency and to greater advantage. Optimum utilization requires a better understanding of the mechanisms relating runoff to the vagaries of precipitation. This understanding is especially essential for better utilization and increased water yields in arid and semiarid regions.

In the four states of Colorado, New Mexico, Arizona, and Utah, there are some 335,600 square miles of land or approximately 80 percent of the four-state area on which the weighted average rainfall never exceeds 18 inches per year. For this area the average rainfall is approximately 13 inches per year, which represents some 225,800,000 acre-feet of water supplied by precipitation to this arid area. However, the Soil Con-

\* D. L. Chery, Hydraulic Engineer, Southwest Branch, Soil and Water Conservation Research Division, Agricultural Research Service, U.S. Department of Agriculture, Logan, Utah.



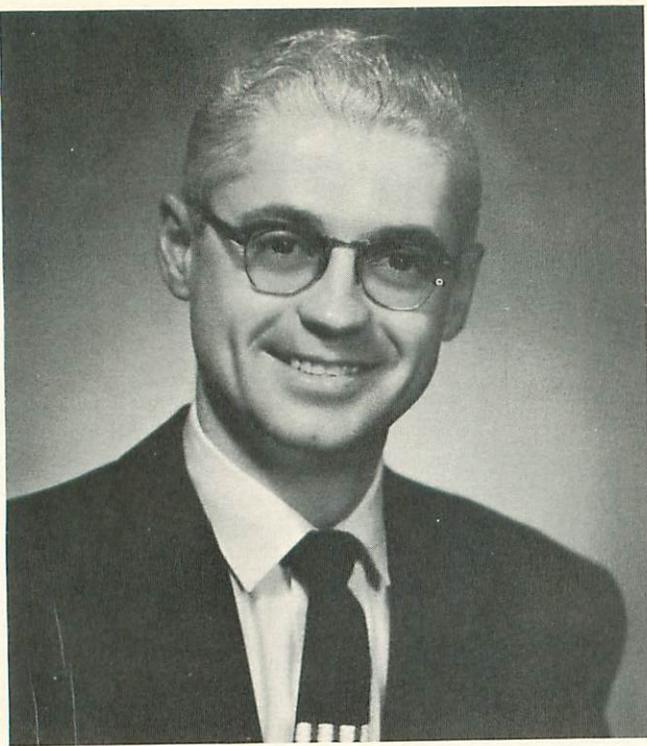
View of full model showing: timing instruments far left, storm programmer left center, topographical model with rainstorm simulator above in right portion of picture.

servation Service calculates that from this supply only a meager 5,200,000 acre-feet of water is available for other than natural watershed uses. This means that 220,600,000 acre-feet, or 98 percent of the rainfall, is consumed where it falls or is lost in transit to points of downstream use.<sup>1</sup> This is a dramatic statistic; but, because of the very nature of the sparse and sporadic rainfall in the arid region and the extremely high consumptive-use potentials, it becomes very difficult to divert more of the 225,800,000 acre-feet of supply for beneficial uses. Yet, with improved understanding of the rainfall-runoff relationship, significant amounts of this supply could be made available for man's use. By far the greatest portion of water used in this four-state arid zone comes from the humid regions and the mountain blocks that border or are located within the arid regions. Even in these regions of ample water, little is known about the relation between rainfall and runoff. Thus, as the demand for water increases, the understanding of hydrologic relations on a watershed becomes all the more imperative. This applies not only to the four states mentioned, but is true throughout the world.

Responding to this need for information, the problem is being investigated from many aspects. This paper describes an apparatus being developed to study the rainfall-runoff relationships by one approach — that of a physical model of a watershed. This model reproduces the topography of the actual watershed in miniature and has a rainfall simulator capable of duplicating various intensities, distributions, and paths of rainstorms on the model. This is the first model, known to the writer which is capable of simulating actual rainfall distributions. One other much smaller and simpler watershed model was constructed by J. P. Mamisao at Iowa State University. R. V. Keppel, Leader for the Agricultural Research Service's Southwest Watershed Research Center located at Tucson, Arizona, was familiar with Mamisao's work and suggested this present study. The project is being done under a Cooperative Agreement between the Agricultural Research Service and Utah State University. The author, a graduate student at Utah State University designed and is constructing the model, with Professor Jay M. Bagley of the Engineering Experiment Station as advisor.

As already mentioned, the model is composed of two major components — the topographical model and

<sup>1</sup> White, G. F., (ed.), *The Future of Arid Lands*, Amer. Assoc. of the Advancement of Science, Washington, D.C., 1956.



Dr. Bartel came to Utah State as Head of the Department of Industrial and Technical Education this year from Kansas State College, Pittsburg, Kansas. His responsibilities include that of administering the Department of Industrial and Technical Education, coordinating and conducting research activities, and teach-



ing professional education classes. Besides Dr. Bartel, three new staff members were added this year. It is anticipated that in the near future, great strides will be made not only in increasing enrollment for degree programs, but also in carrying out and conducting research in Industrial and Technical Education.

---

## What Type of Engineer Will YOU Be?

A list of the various disciplines embraced by the term "engineer" would include dozens of titles and hundreds of subject areas, but there's one type of engineer who is indispensable to all types of industry — the tool and manufacturing engineer.

Whether he's concerned with manufacturing automobiles in Michigan, plant layouts in Georgia or testing space missiles in California, the tool and manufacturing engineer is the hard-core man — the key man — in industry.

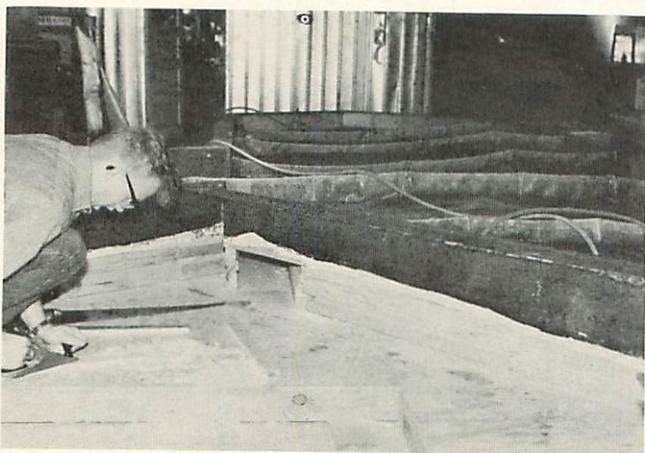
Students planning a technical career would do well to consider the advantages, the material rewards and the sheer creative joy offered by a career in tool and manufacturing engineering.

And the basis for taking the first steps toward such a career is available on the Utah State University campus, in the form of the USU Student Chapter of the American Society of Tool and Manufacturing Engineers. You can learn of the advantages of ASTME membership (as a student member or as a regular member after graduation) from Chapter Chairman, Reid L. Rice, 277 Lauralin Drive, Logan, Utah; or from Professor Frederick L. Preator in the Tool and Manufacturing Engineering Department, USU.

the rainfall simulator. First the topographical model will be described and then the rainfall simulator.

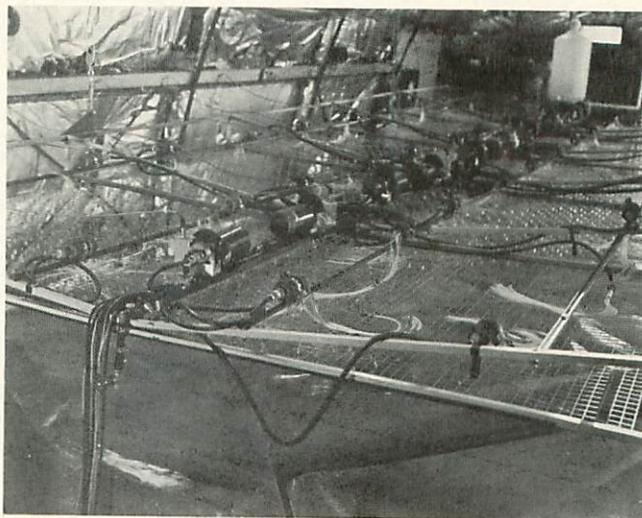
A small watershed near Albuquerque, New Mexico, was selected for modeling. It is a semiarid watershed of 97.2 acres, roughly "Y" shaped, about 3,600 feet long, and 1,500 feet wide. The parent material for the soil is sandstone and shale but what little soil has developed is now eroded. The land is described as rough, broken badland, 77 percent of which is barren. The watershed has interesting hydrologic features and more important has been instrumented for over twenty years, which is essential when comparisons are to be made between the model and the actual watershed.

Considering the laboratory facilities, a length-scale ratio in both the horizontal and vertical direction of 1:175 was selected. At this scale the completed model occupies roughly 220 square feet of floor space, or approximately a rectangle 22 feet by 10 feet. The topographical model was begun by making photographic slides of a 5-foot contour map of the watershed. These slides were projected onto sheets of plywood which had been sanded to the proper thickness to represent a 5-foot contour interval in the model. Each contour in the map was cut along this line and set in a box encompassing the boundaries of the watershed. This was the beginning of a negative mold of the model watershed. The contours in the mold were stacked in reverse order, the lowest point in the mold representing the highest portion of the watershed. Once the cut plywood sheets were positioned, the steps between the contours were



Topographical model ready to be removed from mold.

smoothed by filling the indentations with a prepared plaster mix. The plaster was sanded smooth and then painted and coated with a plastic resin to give it a glassy smooth surface. The prepared mold was coated with a bond-release to allow for easy separation of model from mold and then another coat of plastic resin applied over the bond-release. Fiberglass mat was laid over the mold and then saturated with resin, which, when it set, resulted in a stiff shell, with its outer surface modeling the shape of the New Mexico watershed. The process used is very similar to that used to con-



#### RAINSTORM SIMULATOR

Close-up of motor and pump supplying water to the extremely small plastic tube distributing water above the topo model.

struct fiberglass boats. When the casting had cured, it was broken from the mold, turned over and set on a frame elevating it about 2½ feet above the floor. Making the topographical model of fiberglass has at least three distinct advantages: (1) it is relatively easy to construct; (2) it gives a surface that is easily polished, roughened, or machined; and (3) it gives a thin light shell, about three-sixteenths of an inch thick, which can be moved and into which instrumentation can be easily placed.

Compared to the topographical model, the rainfall simulator is a much more complicated and expensive item. So that the simulator may be useful as a research tool, it is important that it have the capability of simulating actual storms. Most difficult to simulate are the wild and transient thunderstorms. These convective rainstorms are characterized by a great range in rainfall intensity, extreme variability in areal extent, and erratic occurrence with respect to time. Yet, it is just this type of storm that must be simulated because such are the storms that generally contribute significant runoff in arid watersheds, and in particular are the only source of runoff in the watershed being modeled.

In an attempt to model the very limited and changeable areal extent of the convective rainstorms, the simulator was divided into eleven similar modules, with approximately equal areal coverage. Each module can be operated independently of the other ten modules. The water used to simulate the rainstorm is distributed evenly over the area of each module by about 680 uniformly positioned, fine plastic tubes. These tubes are all

2 feet long and have an inside diameter of 0.011 inch. In each module these tubes emanate from four brass distribution heads, which are supplied water from a small gear pump. These gear pumps have positive displacement, which means there is a direct relationship between the amount of water they deliver and the speed at which they are turned. Each pump is driven at desired speeds by a one-twelfth horsepower, direct current motor. The speed of the motor is controlled by a motor controller such that different settings of a potentiometer correspond to different motor speeds. A storm programmer, designed for the model, automatically switches different potentiometer settings into the motor controllers, which in turn control the speed of motors as desired to simulate a particular rainstorm.

Events happen much faster in the model than they do in the natural watershed. By combining the length ratio of 1:175 and the dimensionless Froude relationship, a time-scale ratio can be derived. The time ratio

comes out to be 1:13.25, which means that one minute in nature corresponds to 4.54 seconds in the model. Thus, a storm that would last for one and one-half hours in New Mexico would be over in less than seven minutes on the model.

The runoff resulting from a simulated rainstorm applied to the model watershed is recorded at the model outlet by a continuously recording weighing platform. This record of the runoff from the model will then be compared to the record of the prototype until there is a verification between the output of the model and the events recorded in the field. Once the basic techniques for rainfall-runoff modeling are developed, it is intended that the model be used for studying many types of engineering problems, such as predicting flood flows for the design of spillways, or water yield for beneficial use. Most importantly, studies with the model are expected to contribute to better basic understanding of natural hydrologic phenomena.

---

## TRACKING CHARGED PARTICLES

A new investigative technique for nuclear research has been discovered by two physicists at the Research Laboratory. The fission of lead atoms in mica has been observed using the highly sensitive new technique, developed by Dr. P. Buford Price and Dr. Robert M. Walker, of the Metallurgy and Ceramics Research Department.

When a piece of material is exposed to radiation, the paths of charged particles moving through it can be made visible under an electron microscope by etching the substance with hydrofluoric acid, Price and Walker discovered. During the etching, the tracks are eaten away by the acid, so that they are transformed into ultra-fine holes, about ten atoms in diameter.

The etching procedure in many cases makes visible particle tracks that could not otherwise be seen. In one experiment, a sample of a mineral known as natural muscovite was irradiated with artificial "cosmic rays" (protons) at three billion electron volts in the "Cosmotron" accelerator at Brookhaven. No tracks were visible until the sample was etched. It was then possible to observe track densities of 70 million tracks per square centimeter.

The sensitivity of the technique makes it useful for studying nuclear reactions. Because the paths taken by atomic particles reveal much about what is happening to them, the ability to observe nuclear events at distances on a near-atomic scale makes it possible to observe some nuclear interactions in much greater detail

than has been possible up to the present time.

Measurements of track densities may also make it possible to study the histories of extra-terrestrial objects, such as meteorites, which have been exposed to natural cosmic rays, Price and Walker speculate. A meteorite, for example, exposed to primary cosmic rays for only 10,000 years, would have an easily detectable track density of about 30,000 tracks per square centimeter. The maximum track density that could be resolved with the electron microscope would correspond to an exposure to radiation equal to the lifetime of the universe, several billion years.

Walker and Price have also discovered that in at least one type of mica, the points where the tracks of the charged particles met the surface of the material served as the starting points for the growth of new phases. Square, plate-like shapes formed as the temperature was raised to the neighborhood of 800°C. These areas proved to be the phase of mica known as "forsterite." In mica that has not been irradiated, this phase does not begin to form until about 900°C. Although it has been suggested in the past that such transformations might occur, this represents the first direct observation of a phase transformation nucleated by radiation.

The research described above was sponsored in part by the Air Force Cambridge Research Laboratories, Office of Aerospace Research, under contract number AF 19(628)369.