studies of the earth's resources.

Not forgotten are the military uses of the system. For example, says Fletcher, "when something strange happens," the Air Force would be able to move into space to take a look—possibly with 48-hours notice. (Currently 3 to 4 months are needed to prepare an Apollo spacecraft for launch.) Such a quick reaction capability is said to be very appealing to the current Administration.

Another element high in the Administration's hopes for the shuttle is the inherent international possibilities. "The shuttle will encourage greater international participation in space flight," says Fletcher. The Europeans have been studying the shuttle now for several years and are reportedly interested in participation (SN: 8/29/70, p. 165). The shuttle would have a universal docking collar that would permit it to dock with Soviet spacecraft (SN: 9/11/71, p. 167). Other nations, according to George Low, associate administrator of NASA, will have one more year to decide what their level of participation in the development phase will be and at least five years to decide what payloads, experiments or astronauts they would like to fly. "Everyone in the world will have to come to us," boasts Fletcher of the potential prestige the shuttle would provide.

Still undecided are the location of shuttle ports—the launching and landing sites—and the booster design and type. Most likely Cape Kennedy would be the first port. But at a later time additional ports could be built elsewhere.

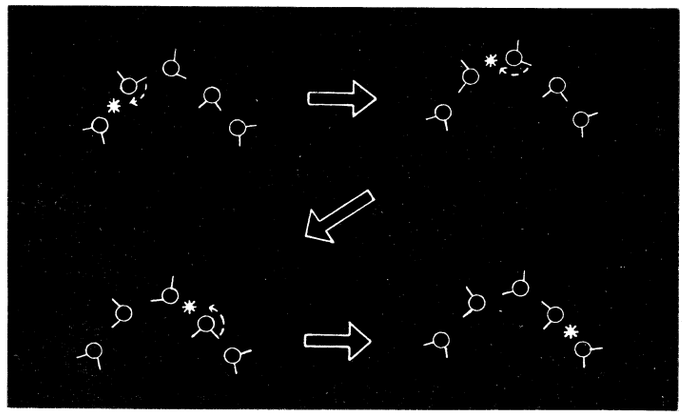
The shuttle that will eventually go into orbit in 1978 is not the one originaly planned by NASA. Because political priorities prohibited a $10 billion to $12 billion initial investment in a two-stage fully reusable shuttle, NASA decided on a "phased approach." Originally both the booster and the orbiter would have been launched vertically, then return to earth, land as an airplane and be reused (SN: 8/29/70, p. 178). The initial investment would have been twice the $5.5 billion now requested, but each launch would have cost less. The phased approach is a compromise to stay within NASA's current annual budget range of $3 billion to $4 billion. The "phased shuttle" will still have a reusable orbiter that looks like an airplane, but the booster will be similar to current boosters. The booster could be partially reused but would have to be recovered from the ocean to be refurbished. Only when and if the political support were found in the 1980's would the fully reusable booster be built.

Whether NASA can build a shuttle within the current budget restraints without hurting other scientific programs proposed for this decade (SN: 9/18/71, p. 187) is another question that the President's budget message late this month may answer. Scientists who tend to favor unmanned space science efforts over manned activities will be watching closely.

But whether the shuttle package is attractive enough to weather the Congressional storm is the major issue. President Nixon in his shuttle statement last week quoted Oliver Wendell Holmes: "We must sail sometimes with the wind and sometimes against it, but we must sail and not drift, nor lie at anchor." Then he added: "So with man's epic voyage into space—a voyage the United States of America has led and still shall lead."

NASA believes the only ship for the 1970's and beyond is the shuttle—and all of its hopes have been placed on deck. □

Explaining water: Focus on broken hydrogen bonds



Minton's water model: Asterisk locates the broken bond. As molecules rotate, it moves from one to another.

Minton/Nature

The bulk physical properties of liquid water depend on the molecular structure of the liquid and the interactions of molecules within the liquid. The bulk properties can be measured; the task for chemists and physicists interested in the subject is to devise models of the structure of water that will explain them.

The problem has been a fruitful source of controversy for years, and several schools of thought have grown up. Some models make the bulk properties depend on the physical states of the molecules within the water. One group, which can be designated mixture models, sees water as made up of clusters or groups of molecules in distinctly different physical states differentiated by some criterion that the modeler considers important. A single molecule is not bound in a given state but changes rapidly with time. The bulk properties arise from averaging the states contained in the model and change as the proportions of molecules in different states change. Opposed to this is the uniformist view, which says that the physical states of the molecules vary gradually and cannot be separated into sharply defined clusters.

The two approaches lead to differing views on the chemical bonding in water. The uniformists tend to believe that all the water molecules are bound to each other by hydrogen bonds, connections in which a hydrogen atom holds two molecules together by sharing its electron with them. In the mixture models the amount of hydrogen bonding varies, but is usually not complete.

In the Dec. 27 NATURE, Allen P. Minton of the National Institute of Arthritis and Metabolic Diseases at the National Institutes of Health presents a new model in which the bonding is more important than the states of the molecules. The important feature is a broken hydrogen bond that migrates through the liquid in the presence of a lot of unbroken ones. The model comes as an extension of yet a third school of thought, computer models. These models start out with individual water molecules interacting with each other according to some force between them. The computer follows their activity to see what sort of structure comes out of it and what bulk properties it leads to. Computer models have had a fair amount of success, says Minton, but "I thought these models didn't sufficiently account for the dielectric depolarization of water."

In water molecules, as in many others, electric charges are not symmetrically distributed. The asymmetry is called an electric dipole moment. If an electric field is imposed on a sample of water, there is a tendency, a very small one, for the dipole moments to orient themselves in line with it. This bias in the otherwise random orientation of the molecules causes a bulk dielectric polarization in the sample.

When the external field is turned off, the molecules tend to return to random orientation. The way this relaxation takes place and the time it takes are what Minton's model was first designed to explain. "I don't talk about states of molecules," he says. "I distinguish be-

tween presence or absence of hydrogen bonds." Most of the molecules will be hydrogen bonded to each other, but some few, because they are too far apart perhaps or because mutual orientation does not favor the formation of the bond, lack a bond. They have dangling hydroxyl groups.

As the molecules rotate under the influence of thermal energy they possess, the location of the broken bond shifts from molecule to molecule. The way the molecules reorient themselves and the way the broken bonds migrate can account for the way the dielectric depolarization takes place, Minton says.

Minton believes that his model, devised to explain one bulk property of water, can also account for others. He is now at work relating it to certain temperature-dependent properties such as density change with temperature or changes in the static dielectric constant with temperature. In mixture models these properties are supposed to result from the changing proportions of molecules in two different physical states, and it would be a great advantage for Minton's model to explain them without resorting to that. □

The planetesimal that formed Mare Imbrium

In its early years, according to theorists, the solar system contained large numbers of small bodies similar to the present asteroids and meteoroids. The cratered surface of the moon is supposed to be a witness to their existence. As time passed, objects with unstable orbits fell into the sun, and most of those with stable orbits were swept up by the larger planets. Again the moon is a witness to the activity.

The maria of the moon, and particularly Mare Imbrium, were supposed to have been dug by collisions of fairly sizable bodies. Now it seems that the Apollo 14 expedition brought back debris from the body that made Mare Imbrium.

The report, in the Jan. 7 NATURE, is by R. Ganapathy, J. C. Laul, J. W. Morgan and Edward Anders of the University of Chicago. The chemical composition of some of the Apollo 14 material leads them to suggest that it came from a planetesimal the size of the island of Cyprus that struck the moon.

The composition of the planetesimal does not represent that of any known class of meteorites, they say, though the class called group IV A irons comes close. It does not appear to have undergone the segregation of metals and silicates characteristic of planets, and thus it is apparently not matter thrown off by the earth or by the moon in the process of their formation.

The body appears to have struck the moon about 700 million years after the formation of the moon. Since its velocity of impact was very low, 2.4 to 6 kilometers per second, the question arises how a body with such a low velocity with respect to the moon could have survived for 700 million years without capture. The answer favored by the Chicago group is that it was also an earth satellite. Gradually, tidal forces would have changed the orbit of the smaller body until it crossed the moon's orbit. At this time, it could have been swept up by the moon. □

Seeding Stormfury's Ginger: Nothing definitive

Project Stormfury, though contributing much to theoretical understanding of hurricanes, has had singular bad luck in applying its models to hurricane modification in the field. After Hurricane Debbie of 1969, the next seedable hurricane to come along was Ginger last September (SN: 10/2/71, p. 226), and Ginger just barely qualified.

Ginger was seeded on Sept. 26 and 28. In a preliminary report on the results of these seedings, released last week, Stormfury director R. Cecil Gentry said effects of seeding on the hurricane's structure were much less spectacular than on Debbie. He emphasized, however, that the meteorologists had known beforehand that Ginger could not be dramatically altered. The potential for modification is greatest in storms with well-defined eyes, large convective clouds, lots of supercooled liquid water and sharp wind and pressure gradients. Ginger had none of these characteristics. She was so diffuse, in fact, that the scientists wonder what kept her running.

In spite of Ginger's drawbacks, the scientists decided to experiment. "After all," Gentry said, "Ginger was available and the project had had no storm on which to experiment in two years. Obviously, storms such as Ginger do occur in nature and the project would be well advised to take advantage of such an opportunity to learn as much as could be learned about this type of storm and to determine if, and under what conditions, such storms can be modified beneficially."

Lacking a well-defined eye, Ginger was unsuitable for the eyemod experiment used on Debbie, in which clouds surrounding the hurricane eye are seeded. Instead, the researchers for the first time attempted the rainsector experiment. In this procedure, the curved bands of clouds with heavy precipitation located 70 to 100 miles from the storm center are seeded in an attempt to draw off some of the energy flowing inward to the storm's center.

Seeding apparently produced some modification of clouds; seeded clouds became brighter and fuzzier. Wind speeds decreased following the seedings on the 28th. Because many more clouds were seeded on the 28th than on the 26th, Gentry says this result was encouraging. The radius of maximum winds increased following the seedings on both days. These wind changes, however, were no larger than typical natural variations, says Gentry, and there were natural forces present that could have caused the observed effects. He concludes that evidence at present is insufficient to justify saying that the seeding caused wind decreases, and that the experiment's major value was that it produced a wealth of data on a peculiar storm.

A legal challenge to AEC's dual roles

Atomic Energy Commission chairman James R. Schlesinger told electric utilities and the nuclear power industry last fall that the AEC is no longer in the business of promoting and protecting them (SN: 10/30/71, p. 290). Additionally, AEC has upgraded its environmental reviews of nuclear plants. Environmentalists are not satisfied. They feel that the Atomic Energy Act of 1954 places the AEC legally in the position of both regulating and promoting nuclear power—a position they regard as an untenable, and unconstitutional, conflict of interest.

Last week, a group of local environmental groups filed a complaint asking that the District of Columbia Federal Court set up a three-judge tribunal to hear their plea that the two AEC roles constitute a denial of due process to opponents of any given nuclear power plant. Joining in the suit are the Conservation Society of Southern Vermont, the Chesapeake Bay Foundation, the Lloyd Harbor Study Group of Long Island, Businessmen for the Public Interest of Chicago and the Cortlandt Conservation Association of New York. □