for tornado formation. As issued by the Weather Bureau, these usually cover an area of about 100 by 300 miles.

From then on, notes Dr. Edwin Kessler, director of the National Severe Storms Laboratory, Norman, Okla., the only way to tell if a tornado is forming is to watch the sky for a funnel cloud. When one is spotted, the Bureau issues a tornado warning which is broadcast by radio and television stations to the community. It is a signal to take cover immediately.

Last year, the Bureau catalogued 579 tornadoes that raked all but seven states of the Union, causing 100 deaths and a quarter of a billion dollars in damage.

There is plenty of general information on tornadoes, Dr. Kessler observes, but the sort of precise data needed for scientific study is just not available yet. Nonetheless, he believes meteorologists are beginning to develop an understanding of the storms.

This summer, researchers from the center plan to examine Oklahoma tornadoes with the help of two doppler radar units. They hope to zero in on the storms from different angles with the radars, then correlate data from each of them to yield more information on their activities and makeup than could be obtained from a single observation point.

It will be a long time before anyone can predict the point where a twister will form, Dr. Kessler cautions, and longer still before anyone can do anything about them.

"We don't exclude weather modification as an ultimate objective," he says, "but it's not around the corner." (See page 432)

Federov at WMC

An eminent Russian meteorologist foresees, in our time, a scientific victory as colossal as space flight and ocean exploitation: control of climate as well as weather.

Moreover, he warns that the world's scientists better start now to try for climate control. Else all the space, nuclear, and industrial activities—notably pollution—might set off a chain of events that could destroy our climate.

Prof. E. K. Federov, director of the Leningrad Institute for Experimental Meteorology, talked boldly of climate modification within 20 years at the Fifth World Meteorological Congress, which ended last week. As he outlined current Russian activity in his field, it sounded closely parallel to that of the United States (See page 243).

Soviet scientists in several experiments have dissipated clouds over areas of several thousand square kilometers, changing the state of the lower atmosphere, and raising daytime temperatures by 7 or 8 degrees (C). They have created a weak anti-cyclone, dispersing clouds.

The Russians also now have conducted many experiments to protect crops from hail by preventing the growth of large stones. They spray reagents from anti-aircraft shells and rockets in a cloud zone identified by specially designed radar sets. Last year, more than two and a half million acres were protected. The cost is 2 percent of the value of the crops saved.

On climate control, Federov spoke like a surgeon contemplating a patient. He urged global intervention in the process, suggesting several possible operations.

• Destruction of the Arctic Ice Cap: The Soviets believe that once destroyed, the ice cover would not reform. The changed pattern of the atmospheric circulation would keep the naked Arctic Ocean relatively warm, they suspect.

Tass/UPI
Twin cyclones from Russian satellite.

• Deflecting Ocean Currents: "A change lasting for some time in the temperature of the surface waters over a considerable part of the ocean could serve as the jolt needed to alter the circulation of the atmosphere," Federov says. "It will be possible to change this temperature by deflecting ocean currents."

• Altering Snow Cover: By speeding or slowing thawing or by creating snow artificially over large areas, meteorologists could influence the heat exchange between the atmosphere and the earth's surface, the Russian says.

• Interfering in Stratospheric Processes: Artificial changes in the upper layers of the atmosphere could change the activity below. Federov notes that there are only limited quantities of matter up there and small amounts of energy are transferred.

"But major changes in climate will be triggered only if the reactions cause a chain of events in a given direction, leading to planned modifications of the atmospheric circulation pattern," Federov emphasises. "This must be a stable modification, with no mistakes in forecasting it. Here, and not in the technical side of the matter of the expenditure of energy, lies the fundamental difficulty."

Meanwhile, he fears that "the rapid increases in the heating of the lower layer by industries and transport, the introduction of new ingredients, combustion products and industrial pollutants into the atmosphere, the change in moisture circulation due to land improvement and finally important changes in the composition of the upper layers by the rapid developments in space, all inevitably affect the complex of hydrometeorological processes which determine climate."

Deliberate intervention, he believes, will be a bulwark.

"The sooner we intervene deliberately . . . the better chance we have to avoid setting off chain reactions that might affect climate in an undesirable direction."

Pain

The experience of pain appears to be a high level mental affair, not a simple reflex action.

Feelings of pain have been found to be influenced by subjective states, such as expectation and attention. And there is no direct relationship between feeling pain and physiological reactions. In other words, the body may react to hurt while an individual does not feel it.

Moreover, through post-hypnotic suggestion, people can deaden pain from only one part of their body—a single hand for instance. Such discrimination implies a high level process.

Dr. Ernest Hilgard of Stanford University, well known for his work on hypnosis, told a National Academy of Sciences audience in Washington last week that about a tenth of the people he tested could block out pain with post-hypnotic suggestion. He believes others can be trained to do the same, with important implications for medicine. "It would be a great thing to have," he said.

Hypnosis has, in fact, been used to successfully anesthetize burned patients and women in childbirth. Clinics have a slightly higher rate of success than the 10 percent he found, said Dr. Hilgard, possibly because patient expectations are higher. His own subjects knew they were part of an experiment and may have thought they should feel the pain.

Dr. Hilgard had his subjects immerse their hands in a tub of ice water until they could no longer stand the cold. All had been previously tested for susceptibility to hypnosis and had been told they would not feel pain. Those who responded felt no more pain after 60 seconds than they had after the first five.

One girl was able to block pain on her own, by studying a spot on her skirt. She was, incidentally, not hypnotizable, but could redirect her attention and effectively prevent pain from reaching consciousness. Dr. Hilgard said that probably one in a hundred people are capable of this.

Just what the mental mechanism is for controlling pain remains a mystery, but Dr. Hilgard believes it is located in the higher neural centers concerned with attention and alterations in consciousness.

Helium Near Zero

The strange properties of liquid helium have fascinated and puzzled scientists and laymen alike for some 30 years. At temperatures near absolute zero, liquid helium becomes a superfluid—conducting heat with greater efficiency than metals, flowing up the sides of its container and seeping through holes smaller than the size of a helium atom.

Many, but not all, of the superfluid's properties are understood.

A way to explain one aspect of helium's behavior at temperatures below 2.17 degrees K. was reported to the American Physical Society meeting in Washington last week by Dr. Lyle B. Borst of the State University of New York in Buffalo. A cupful of liquid helium, he said, acts as if it consisted of a collection of constantly changing pairs of helium atoms. Their motion, can be described by the rules of quantum mechanics. As an analogy, he cited the following:

If Niagara Falls were helium, first, they would never freeze; helium freezes only under high pressure. The falls themselves would not be unusual, but strange things would happen at the Whirlpool below.

If the temperature dropped to just below 2.17 degrees absolute, the form of the whirlpool would not change. The liquid helium would form a vortex at the center. However, any person falling into the liquid would not be sucked under at the center, since the liquid would flow past him without effect.

Moreover, he would be unable to escape, because when he tried to swim his hands and feet would pass through the liquid equally without effect. This unusual behavior, called the Pellam paradox, shows clearly in photographs of an object inserted into the vortex of liquid helium in the laboratory—neither has any effect on the other. In ordinary liquids, the object would be caught and pulled down into the twisting vortex.

Dr. Borst believes the Pellam paradox and many other strange effects can be explained by considering liquid helium as a fluid whose atoms are paired in an endless exchange of partners. In a rotating liquid, the whirlpool of the analogy, a minuet takes place in which the atoms are always paired and always changing partners.

This condition can change only in jumps; an input of energy is required to produce any change at all. If the swimmer in the analogy were strong enough to change the whirlpool, he would immediately be caught by the moving liquid and sucked under.

At lower temperatures, within half a degree of absolute zero, Dr. Borst reports, the liquid can be described by a theory that requires no atomic structure at all. Helium, he says, then shows effects that are inconsistent with the presence of any atoms, a possible first exception to the atomic theory.

Nuclear Theory

A major theory about the structure of the atomic nucleus may have to be refined because of discrepancies in recent experiments. The discrepancies appeared in the observed and theoretical values of the magnetic forces in an isotope of antimony.

According to theory of the atomic nucleus—the so-called shell model—protons and neutrons are arranged in shells or rings. The number of shells depends on how many protons and neutrons it contains.

Various forces—electrical, magnetic, nuclear—act on the nuclear particles. The shell theory predicts how these forces act.

Recent experiments on magnetic forces in antimony, a metal used in many alloys, qualify the shell theory.

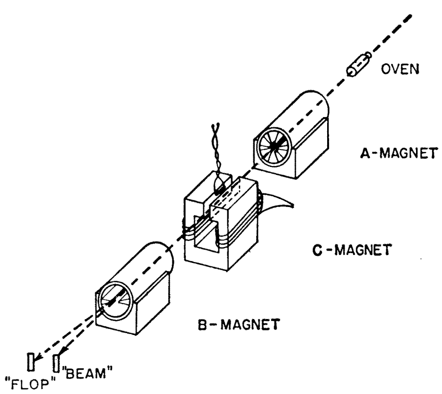
Reporting to the American Physical Society meeting in Washington, Geoffrey J. Garrett of the Palmer Physical Laboratories at Princeton University said values measured for three isotopes of antimony agreed with theoretical values. But for a fourth isotope, antimony 117, experimental values didn't match the theoretical.

Garrett said the reason for the discrepancy isn't understood yet. Either the theory will have to be revised or the experimental technique will have to be refined.

The four isotopes tested—antimony 117, 118, 119 and 120—were produced by bombarding tin with high-energy protons from the Princeton cyclotron.

The atoms were heated in an atomic oven to 1200 degrees C. At this temperature, they shot out of the oven through the fields of three test magnets.

The first magnet lined up the atoms so that all had a magnetic force pointed in the same direction. The second magnet had a variable field, and the frequency of the variation could be adjusted. At the right frequency, the magnetic force of the atom would flip to the opposite direction.



Garrett

Magnetic test setup flips antimony.

The third magnet sent the flipped atoms to one detector, and the unflipped atoms to another.

From the shell theory, it is possible to compute what frequency the variable magnetic field should have to flip the atoms of each isotope of antimony that was measured.

In three isotopes, the experimental frequency matched the computed value. But in antimony 117, the experimental value was off by more than 25 percent.

The calculated values depend on the magnetic properties of the neutrons and protons that make up the nucleus. According to the shell model, the magnetic effects of the protons and neu-