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"IN THE beginning, God created the heavens and the earth, and the earth was without form and void. And the Lord said, 'Let there be light,' and there was light."

This over-simplification from the first verse of Genesis describes quite well the beginning of this Earth and its complex atmosphere. As the molten mass of the new planet began to cool, vast rain clouds formed and enveloped it in tropical rains for maybe a million years. As the earth cooled further from the poles to the equator and the rains subsided, there must have been left a vast tropical rain garden into which Adam and Eve were first placed.

Although ancient man was affected and concerned about the weather around him, its vagaries eluded any attempt at scientific solution for a vast period of time. The earliest indications of scientific activity in the field of meteorology date back to at least the 5th century B.C. The first text, written by Aristotle in 350 B.C., was still being used by many colleges and universities until the Civil War.

The weather so confused early man that he scarcely made any attempt to make observations. Instead, he turned his efforts to recording information about the heavenly bodies. The weather seemed to follow no pattern and its changes and extremes were attributed to the disposition of various gods or demons.

Development of even the simplest tools to measure the various weather elements was slow. Wind vanes appeared on church steeples about the 9th century A.D. Galileo made a temperature indicator in 1597, but it was many years later before it became a measuring instrument through the addition of an arbitrary scale. Torricelli made the first barometer about fifty years later. Five years passed before Periers, following a suggestion by Pascal, Descartes and oth-

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ers, carried the instrument to the top of a mountain to prove that atmospheric pressure decreased with altitude. Benjamin Franklin made important contributions to meteorology through his famous experiment with the kite and the key.

It is interesting to note that the first weather map was probably constructed by Leverrier about 1854, and then more as a direct order from Napoleon III than from scientific inquisitiveness. History relates that during the Crimean War a strong and sudden storm hit the Black Sea inflicting great damage on the French fleet, particularly to the battleship "Henry IV." Shortly before this storm, the astronomer Leverrier had won world acclaim by forecasting the existence of a new planet in the heavens, using purely mathematical calculations. The planet was found and named Neptune. The French emperor apparently thought that if science could predict the whereabouts of hitherto unknown planets, it could certainly forecast weather and storms.

Thus, the French astronomer Leverrier became the first consulting meteorologist, conducting a "post mortem" on the Black Sea storm and arriving at the conclusion that if simultaneous weather observations could be made over a large area and transported to a central office with sufficient speed, one could plot and analyze weather maps and follow a storm from chart to chart and even extrapolate its future movement.

With interest in weather observations and forecasting increasing across Europe, the Americans were doing their share, too. Early weather records were being kept in Boston and the first weather observation network was established in 1814 as a function of the Army's medical department. However, it wasn't until 1870 that President Grant established the U.S. Weather Service. On the first day of November of that year, the Army Signal Service "observers" took and dispatched by telegraph this nation's first simultaneous weather observations at twenty-two cities from Cheyenne in the Wyoming Territory to Boston on the east coast and from Key West, Florida, to Duluth, Minnesota. Twenty years later, President Benjamin Harrison signed into law an act effectively transferring the weather services of the Army into an agency of the Department of Agriculture aptly called the "U.S. Weather Bureau."

Fundamentally, meteorology is a combination of physics, mathematics, mechanics, chemistry and electronics applied to the atmos-

phere. The development of meteorology as a science had to await developments in the other sciences. Collection and simultaneous transmission of weather observations had to necessarily await the invention of telegraphy and, finally, radio and the teletypewriter.

As is the case so frequently, advancements in science progress most rapidly during periods of war. Great strides were made during World War I as aviation came into being as an instrument of war. With the growth of post-war aviation in this country, the Weather Bureau was assigned weather responsibility for civilian aviation and the development of commercial aviation during the 30's and 40's was a major factor in the explosive expansion of the Weather Bureau, the military weather services and commercial weather studies.

The military requirements of World War II brought about revolutionary expansion of weather knowledge on a global scale and created three instruments of war that, converted to peace time use, has placed this nation into a position of world leadership in the field of meteorology. The first of these instruments was radar. The second was the high-flying rocket which was eventually to carry earth-orbiting weather satellites into space. The third was the high speed computer, long awaited by the meteorological community.

The gathering and distribution of meteorological information is today a vital service to all phases of American life and commerce. Such a task is primarily the responsibility of the National Weather Service, originally born as the U.S. Weather Bureau.

Today's complex weather services are interwoven into such agencies as the Atomic Energy Commission, the Department of Health, Education and Welfare's National Air Pollution Control Administration, and the National Aeronautics and Space Administration. The Department of the Interior's geological survey makes valuable contributions in the field of water resources, and the Bureau of Reclamation is actively pursuing weather modification and hail suppression programs. The Federal Aviation Administration, although basically interested in air traffic control, works closely with the National Weather Service in observing and disseminating weather information for pilots. The U.S. Coast Guard, an agency of the Department of Transportation and the U.S. Navy, inputs into the system regular and vital weather observations from the high seas. The Department of Agriculture's soil conservation service,

forest service and experiment stations all share an interest in providing the best service available to what is perhaps the most weather-sensitive industry in the world. The National Science Foundation, through its National Center for Atmospheric Research, supports a great deal of the research and development work carried out by a number of scientific agencies with weather-related programs on a worldwide basis.

The Department of Defense, through the Air Force, Army and Navy, provides weather support for military projects and operations on a global scale and contributes immeasurably to the public weather services of the nation. The best known of these contributions is the Hurricane Hunters, airborne reconnaissance by the U.S. Air Force and Navy that provide finite measurements and information on the location and intensity of dangerous tropical storms. The Air Force Air Weather Service provides a vital link in the communications field by supporting the rapid collection and dissemination of global weather information. Such a center is based in Fort Worth, Texas, at Carswell Air Force Base.

The American Meteorological Society, founded in 1920, is dedicated to "the development and dissemination of knowledge of meteorology in all its phases and applications, and the advancement of its professional ideals." The American Meteorological Society is the catalyst bringing together the research meteorologists from the nation's great universities, the government's various weather-related agencies, and the private and industrial communities.

ESSA, the Environmental Science Service Administration, created in 1965, serves as the focal point for Federal weather services to the general public. Within ESSA are the National Weather Service, the ESSA research laboratories, the National Environmental Satellite Center, the Coast and Geodetic Survey and, most importantly, the Environmental Data Service located in Ashville, North Carolina. Of primary interest to the legal profession is the National Climatic Center (NCC), a branch of the Environmental Data Service, for it is here that all weather records are kept and that certified copies of all weather information may be obtained. A valuable addition to any library is a publication available for one dollar from the Superintendent of Documents titled "Key to Meteorological Records Documentation #4.11—Selective Guide to Climatic Data Sources."

The only direct contact most Americans have with the National Weather Services is the little box in the upper left hand corner of the paper that says . . . "The Weather Today . . . Fair and Warmer," or the fellow on television with a bunch of maps describing the weather in Michigan and telling of the possibility of showers in the Metroplex on Friday. Television has had a profound effect on American life over the past quarter of a century, and education of the lay public to the vagaries of the weather has been perhaps one of the more beneficial by-products. More people know and understand cold fronts and thunderstorms and gusty winds and vertices than at any other time in our history. But few realize how much effort and scientific know-how is really involved in just these simple facts as explained on nightly television, or as printed in the morning paper.

All over this nation trained weather observers of the National Weather Service and the military services keep a continuous check on the weather, employing highly sophisticated instrumentation to measure the exact quantities of the weather. These observation points manned by National Weather Service personnel alone number in excess of three hundred in the continental United States, Alaska and Hawaii. Every hour on the hour these observers report the current state of the weather on a permanent record. These reports are sent to a central distribution point where each one is combined regionally with others and transmitted by high speed teletype to all of the using agencies throughout the United States. These reports constitute a source of extremely valuable information, not only for current dissemination to aviation interests and forecast centers, but as a source of data for very detailed and finite meteorological research. These observations are taken every hour on the hour and recorded on a form designed for this purpose and referred to as an hourly record of surface observations. Included is such information as the amount of the sky covered, the height of the bases of the clouds above the ground, their direction of movement and even their changing character. It includes a measurement of visibility and any restrictions to visibility such as rain, snow, dust, fog, etc. The time of onset of precipitation is noted and the time of ending is recorded along with a description of the intensity and character of the precipitation or restriction to visibility. In the case of thunderstorms, a description of the lightning is given by the trained

observer as a part of his duties. He measures the wind direction and speed with precision and accuracy, as well as the barometric pressure, the temperature and the dew point. He makes special note of such seemingly insignificant observations as pressure jump lines, rapidly changing pressures or wind shifts and maximum wind gusts. He measures the amount of precipitation that has fallen and the highest and lowest temperature during the twenty-four hour period. He comments on the direction of movement of thunderstorms and showers and knows the character and type of over one hundred cloud formations. The weather observer all but memorizes a publication titled "Federal Meteorological Handbook on Surface Observations" that is as thick as a metropolitan telephone book. When the weather is changing, he knows exactly when to report these changes and the proper procedure and criteria for handling them.

In addition to these professional weather observers, there exists an army of cooperative weather observers across the country that record daily rainfall and temperatures for the National Weather Service. Civil Defense works with the National Weather Service to provide additional eyes to warn of approaching storms and to spot isolated funnel clouds or tornadoes.

All of this information, as well as severe storm observations, is tabulated and published as a part of national weather records and is available upon request for a very small fee from the National Climatic Center.

Constant radar surveillance is maintained by National Weather Service trained operators at ninety-four locations across the nation. Fifty-one of these radar units are equipped with the S-band WSR-57 radar, the finest and most sophisticated weather detection radar unit in existence today. These radar units, located strategically across the country, continuously scan the skies for developing storm clouds but can perform fantastic feats of measurement. On these powerful radar units, a skilled operator can detect the freezing level within the cloud structure, he can measure the intensity of rainfall and determine areas of hail, severe turbulance, and at times, even tornadoes. He can measure the top of the echo, determine the speed and direction of movement, give much valuable information on the changing intensity and character of a given storm, and even detect new developments within a large storm system. All of this information, in so far as is possible within time limits, is recorded

manually on a prescribed form and transmitted to the various using agencies. Scope photography on 35mm film is standard procedure when storms or potential storms appear on the radar scope. This film is preserved and kept in the National Climatic Center at Asheville, North Carolina, along with the coded word description logs and is available for study and research upon application.

Nearly all of the surface observation stations keep a continuous recording of pressure and its changes and maintain a continuous recording rain guage from which the exact time of onset and ending of precipitation can be accurately determined along with the amount and the rate of fall and change. This, too, is available from the National Climatic Center upon request.

A constant check on the state of the atmosphere is maintained at 197 Upper Air Stations. Twice daily, large balloons are launched, carrying a small payload aloft, often to heights of 100,000 feet, transmitting back to earth, via radio signal, continuous readings of temperature and moisture and altitude information from a miniature barometer. Once this radiosonde unit has ascended to its optimum height, the balloon bursts and the payload descends on a small parachute. Highly accurate radio tracking devices measure the wind direction and velocity throughout the duration of the ascent.

This multitude of meteorological measurements and observations is transmitted to all aviation interests and forecast centers across the nation and overseas. More importantly, it is fed directly and continuously into banks of computers at the National Meteorological Center located at Suitland, Maryland, and the Air Force Global Weather Center in Omaha, Nebraska. These ultra high speed computers digest the information and through a most intricate programming technique spit out extremely complicated mathematical solutions in graphic form which are then transmitted via National Facsimile to all using agencies. Twenty-four hours a day, the endless parade of maps and charts rolls over the Facsimile network into the hands of the various government and private meteorological agencies. All of this information, too, is maintained as a permanent record at the National Climatic Center.

From this mountain of meteorological data cranked out every hour of every day, the logical question is asked, "Who uses it and for what purpose?" To adequately answer this question could be

the subject of an entire textbook. But, it is sufficient to say that the observational data is utilized by all aviation interests, the forecast centers of the National Weather Service, the consulting meteorologists and a host of commercial interests, not the least of which are public utilities, resort area operators, trucking and shipping interests, contractors, etc.

In their assigned professional tasks, the government meteorologists find uses for all of this information as do the professional consulting meteorologists as representatives of their clients. They work either full time or part-time for organizations having weather-related problems and apply professional knowledge at the problem level.

By law, the National Weather Service addresses itself to at least four major user groups: public, farmers, aviation, and marine interests. The fifth major user is the consulting meteorologist, who in most instances obtains the raw data in partially or completely unprocessed state and in turn prepares the output for his client in terms of the client's specific operational requirements.

More and more the legal profession is turning to the professional consulting meteorologist for assistance in securing needed documents and information and for his assistance in "reconstructing" the finite weather at a given point in time and space on a micro basis. Due to the complexity of the various calculations that must be made to produce even a "fair and warmer" forecast for the general public, the meteorologist compresses his decision time into a compact time span. In the preparations of such forecasts as might be necessary for tornado or severe storm warnings to protect life and property, he must make certain broad assumptions concerning the severity and spatial configuration of the system. Conversely, the research meteorologist can utilize the same data and extract much more exacting information of a finite nature, simply because he has generally unlimited time to search out the minute details that constitute the truth.

Since all weather information is prepared in a standard, coded form, the meteorologist can assist the legal profession by correctly interpreting the data and converting it into "plain language." He can take the time to study each radar frame to find the particular storm in a maze that might look to the layman like a bunch of grapes on a vine.

A forecast may outline in general terms an area covering sever-

al thousand square miles in which a "few tornadoes" will occur over a six-hour time span. Within the present state of the science, he cannot tell in advance which square city block or which building will be the selected target of the severe storm cell imbedded in a line that may be in excess of 100 miles long, nor can he tell precisely the time that the storm will strike, although from a forecasting standpoint, he may be able to more accurately estimate the time of onset than the location. The consulting or research meteorologists can, by examining the radar film and applying certain tests to the physical energy available within the atmosphere, advise if damage may have been caused by winds, or even a tornado, or whether water damage from excessive rains may have contributed. He can make decisive computations on wind velocity from the evidence and the data available that may be applied against known structural design capabilities, and thus provide valuable information for his client.

Given the time for adequate study, the consulting meteorologist can advise his lawyer client as to the extent of cloud cover and icing potential existing at the time of a fatal aircraft accident, or determine if, at the site of an accident, a severe storm may have been in progress at the time. By utilizing nothing more than the surface reports from the multitude of surface rainfall observers, he can reconstruct the path and estimate the intensity of a storm that may not have been detected by radar. The professional consulting meteorologist is only concerned with determining the truth, in learning exactly what happened, and why.

Your tax dollars help to support 430 National weather installations with a value of $60,000,000 to provide 5,200 full-time employees to make 3.5 million observations and 1.9 million forecasts and warnings at an annual cost of nearly $200,000,000. If you even remotely suspect that knowledge of weather might be helpful, utilize the information, and if you need further assistance, seek the help of a qualified graduate consulting meteorologist.