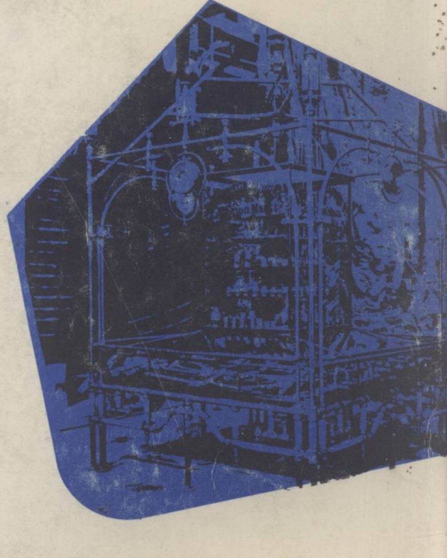
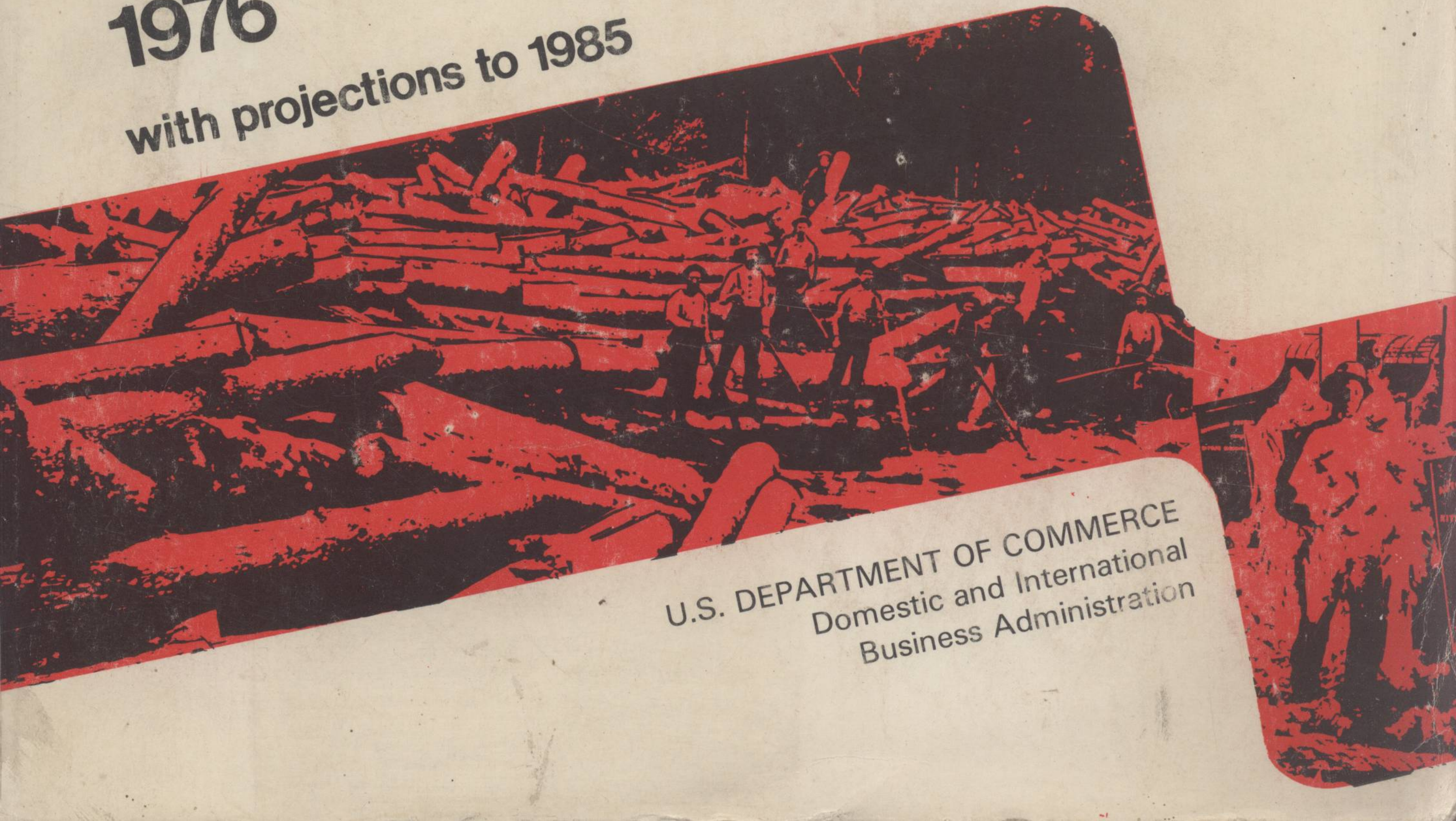


U.S. INDUSTRIAL OUTLOOK 1976

with projections to 1985



U.S. DEPARTMENT OF COMMERCE
Domestic and International
Business Administration

U.S. INDUSTRIAL OUTLOOK 1976

with projections to 1985

U.S. DEPARTMENT OF COMMERCE
Domestic and International Business Administration
Bureau of Domestic Commerce
January 1976

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Foreword

This 16th edition of the *U.S. Industrial Outlook* provides a compact and comprehensive review of U. S. industry, and is designed to serve as a valuable reference for businessmen, investors, planners, marketers, consumers, and educators.

In order to increase the timeliness and effectiveness of this edition, the production schedule was shortened by forty percent, and the publication date was moved from October to January to coincide with the start of the calendar year.

The *Outlook* presents an analytic review of major industry in the United States for 1975, and offers one year and ten-year economic projections. It covers 85 percent of the total value of U. S. manufacturing industry shipments. Industry analyses cover supply and demand, foreign trade, technological developments and employment. Capital, energy and anti-pollution requirements of the individual industries are discussed, where relevant.

The flavor of the nation's Bicentennial celebration is found in illustrations depicting the Nation's great industrial history. Two of the Commerce Department's oldest services and one of the newest are subjects of special articles that describe their response to today's challenge. The Patent Office, observing its bicentennial along with the nation, currently provides added incentive to innovators in the energy and environmental field. The National Weather Service, in its 105th year, is also strengthening its capability to respond to energy and environmental problems. The Economic Development Administration is experimenting with new approaches to increase productivity and to promote quality-of-work concepts that will generally enhance the national economy. Because the national energy situation impacts across the broad spectrum of industry, the Office of the Secretary of Commerce has provided a special energy update.

Publication of the *OUTLOOK* is a joint effort. The basic analyses and projections were prepared by industry specialists of the Office of Business Research and Analysis under the direction of Charley M. Denton. Overall editorial coordination and special features were provided by the Office of Ombudsman for Business, with the Office of Public Affairs handling final printing production. Special mention is given to Wesley H. Long, John J. Bistay, and William J. Bolce.

Recognition is extended to the other elements of the Department that cooperated in preparing this edition. Acknowledgement is made to the Office of the Assistant Secretary for Economic Affairs and to the authors of the feature articles.

The collection of economic information contained in this *Outlook* is designed to aid the Department of Commerce in fulfilling its charter to promote and foster the growth of U. S. commerce and industry. The effort to produce the edition in this Bicentennial year is dedicated to the economic well-being of U.S. citizens and to the improvement in the quality of life in America.

Your comments concerning the publication, and suggestions for its improvement will be appreciated.

Samuel B. Sherwin
Deputy Assistant Secretary
and Director
Bureau of Domestic Commerce

INTRODUCTION: THE GENERAL ECONOMIC OUTLOOK

U.S. Industrial Outlook 1976 presents a review of 1975's developments in more than 200 industries or industry groups—both manufacturing and nonmanufacturing—and projected activity levels in 1976 and to 1985 for selected industries. A list of the industries covered in this volume and ranked in descending order of projected growth in 1976 appears in the Appendix. Manufacturing and nonmanufacturing industries are ranked separately. Summaries of chapters contain projections to 1985 for industries covered.

Economic activity in 1976 will be shaped in large measure by the developments of 1974 and 1975. A review of recent economic trends is therefore essential to understanding the projections in this *Outlook* for 1976 and the years thereafter.

In the spring of 1975 the Nation's economy began to emerge from the most severe recession of the post-World War II period. The seeds of this recession were sown by an accelerated rate of inflation that began early in 1973 and persisted throughout 1974. The rate of inflation moderated substantially during the first half of 1975, and growth in real GNP was resumed in the second quarter, following five consecutive quarterly declines. As production and employment recovered in the early summer months, the unemployment rate began to decline.

Major sectors of the economy were affected by the recession at widely different times. Accordingly, the timing of the recoveries in those sectors varies considerably. Retail sales, in constant dollars, began to decline in the spring of 1973 and started to recover in late 1974. Recovery in consumer spending was reinforced by the Tax Reduction Act of 1975, which included rebates on 1974 income tax liabilities, lower tax withholding schedules, and special one-time payments to recipients of social security, railroad retirement, and supplemental security income. Residential construction also started to decline early in 1973 and did not begin to recover until the spring of 1975. The decline in real outlays for nonresidential fixed investment that began in the second half of 1974, showed signs of leveling off in late 1975.

Overall economic activity during 1975 was determined in large part by the behavior of inventories. A massive liquidation of inventories began early in the year, and was at or near an end in late 1975, setting the stage for a resumption of inventory accumulation. A sharply reduced rate of inventory liquidation in the second half of 1975 meant that production was raised closer to the level of real final sales. This caused a sharp rebound in real GNP during the second half of the year.

Near-Term Outlook.

Forces are set in motion for a continuation of the economic recovery in 1976. Growth in real GNP is expected to be in the range of 6 percent to 7 percent. This will represent an average to above-average economic expansion in comparison to equivalent periods of the preceding four recoveries. The sources of strength to the economic expansion in 1976 are expected to be continued strong growth in real consumer spending, further improvement in residential construction, rebuilding of business inventories, and a recovery in real capital spending.

Government purchases of goods and services, after allowance for inflation, are projected to increase moderately. The net export balance is projected to decline, reflecting a faster growth of imports than exports as the economic recovery proceeds more rapidly in the United States than in other industrialized nations.

By historical standards, the unemployment rate will remain high in 1976, but is expected to be declining throughout the year. A reduction to an average rate of $7^1/_2$ percent to $7^3/_4$ percent for the year as a whole is projected. The high rate of unemployment, the large margin of unused physical capacity in many industries, and the expected cyclical rise in productivity seem likely to contribute to further progress in reducing the rate of inflation. The consumer-price index is projected to rise about 6½ percent in 1976.

The Longer-Run Outlook.

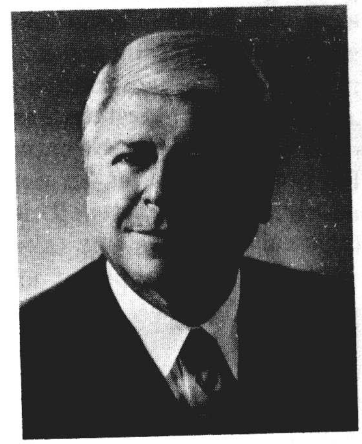
The projections from 1976 to 1985 are based on a large-scale econometric model indicating probable values for real output in various industries. After 1976, growth in real GNP is projected to subside to a more sustainable long-run rate. Industry projections were made within the framework of real GNP advancing, on the average, about 4½ percent per year. This implies continued improvement, albeit gradual, in the unemployment rate. The general price level is projected to rise about 4 percent per year, slightly above the postwar average of 3 percent.

The long-run projections show an above-average gain in investment, reflecting the need to develop the Nation's energy industries, deal with environmental problems, and expand industrial plant and equipment so that jobs can be provided for millions of new entrants into the labor force. As a share of GNP, non-residential fixed investment is projected to rise from the postwar average of about 10 percent to 11 percent by 1985. Personal consumption expenditures and Government purchases of goods and services, as shares of GNP, are projected to decline slightly between 1976 and 1985.

Users of *Industrial Outlook* should be aware that the current state of economic forecasting is such that long-run projections cannot be made with great precision. As a generalization, it is easier to forecast variables in real terms than in current dollar magnitudes—that is, it is more difficult to project the trend of prices. Long-run growth in real GNP is determined primarily by factors such as growth in the labor force and trends in the workweek and productivity. Reasonable projections of these variables indicate that real GNP is likely to grow at an above-average rate during the latter half of the 1970's, partly because of cyclical factors. A slowdown in the growth of the labor force beginning in the late 1970s is expected to result in below-average gains in real GNP during the first half of the 1980s.

Events of recent years have clearly demonstrated the need for major policy decisions to ensure stable and sustainable economic growth, to promote an increased share of investment, and to restore conditions of relatively full employment and stable prices.—*Office of the Assistant Secretary for Economic Affairs.*

Special Report



THE ENERGY OUTLOOK: Challenges and Responses

The Honorable Rogers C. B. Morton
Secretary of Commerce

When the nation was celebrating its 100th birthday in 1876, the city of Cleveland, Ohio, then the country's oil capital, observed the occasion by lighting a bonfire from 20 barrels of crude petroleum. Such an act would not be considered patriotic today. It would even be unthinkable.

If value is determined by scarcity, the materials that we now convert to energy must be among our most precious possessions. How much will they be worth by 1985? There is no way of predicting such worth, but we all know now, if we didn't before, the importance of the energy resources that are required to fuel the great engines of our economy.

Any energy equation should include the future factors that threaten its balance. Every moment delayed lets the crisis grow larger. The energy problem must be dealt with in broad, comprehensive strokes and at the same time swiftly, before the complexities defy solutions. The oil imports that cost less than $4.5 billion in 1972 cost over $25 billion in 1974. Unless the drift toward greater reliance on foreign oil is checked, these costs in 5 years will exceed $40 billion. Dollar drains of such magnitude cause capital shortages, weaken our economy, and contribute to unemployment. The Arab oil embargo of 1973-74 is estimated to have reduced our national Gross National Product—the total amount of goods and services we produced in one year—by $10 to $20 billion. Another such embargo could reduce our annual GNP by more than $30 billion for each million-barrel-per-day cut-off over a year's time. The effects on jobs, wages, and prices would, of course, be devastating.

Obviously, we cannot afford to let anything resembling this happen. But we are dealing with a situation in which finite resources are being depleted by an ever increasing rate of demand. Consider for a moment a mineral that would last a billion years at a given flat rate of consumption. Then, instead of keeping at this level, apply a growth rate of three percent a year. If so, the billion-year supply would run out in 582 years. The exponential growth becomes even more dramatic if you start with a two-billion-year supply because the second billion would be consumed in just another 23-and-a-half years.

In recent decades, the United States has been increasing its demand for energy not by three percent but by four and five percent a year. And we're far from having a one-billion-year supply of any fuel that we are presently capable of using. Estimates of our oil reserves are imprecise, but it appears that oil can serve as a heating and transportation fuel for only about 25 years more, and then as a feedstock or source of petrochemicals for the remaining 25 years. Thus we might see the end of the petroleum era in about 50 years.

Our natural gas situation is even more critical: production has exceeded discoveries each year since 1968. We have an 11-year supply left at current rates of demand, and, given the current rate of new discoveries and assuming no growth in demand, at most a 40-year overall supply of gas.

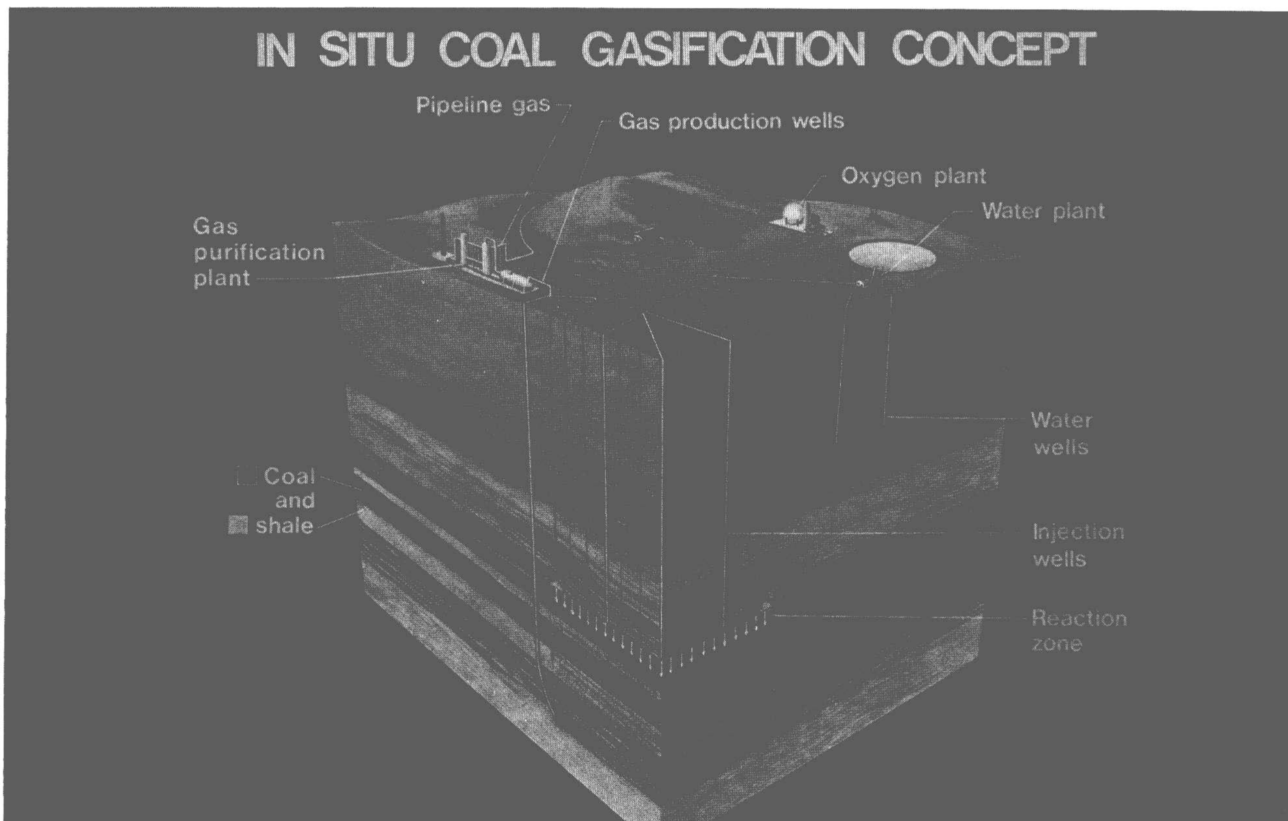
Moreover, because of the price fixed by the Federal Power Commission at the wellhead for gas moving in interstate commerce, a demand akin to past mad scrambles for gold has arisen. Unless new interstate gas is deregulated, there will be a migration of natural gas-using industries to producing states—a development that has already, indeed, started. This kind of trek is uneconomical and does not take into account the fact that the total supply of natural gas is limited or that gasified coal and other sources of energy will become available as they are developed.

Our states that are presently rich in gas stand in danger of becoming industrial graveyards, because the industries that migrate to them will have used up their prime energy resource. At the same time, the industries will have isolated themselves from the newly developed sources of energy.

Perhaps by the time this page appears in print, events may have permitted or mandated the decontrol of the price of natural gas. Meanwhile, in terms of energy equivalence gas sells at $3.30 while oil is selling for up to $14 a barrel. Decontrol may cause higher energy prices, but painful as they may be, they will bring supply and demand into balance in both the petroleum and natural gas fields: they will stimulate exploration for new deposits, and they will encourage conservation of existing resources as well as spur the development and use of alternative fuels.

We have to wring out all the waste we can and develop our domestic oil and gas resources to their full potential so that they provide an economic and national security cushion for us as we shift to domestic coal and nuclear power, and as we perform the research and development functions necessary to create a system of non-depletable energy resources.

The most promising near-term developments are the synthetic fuels that can supplement conventional supplies of oil and natural gas. An important advantage of synthetic fuels is their adaptability with very few if any modifications to our existing energy system. Technology is being rapidly developed to bring these fuels into prompt and economic commercial use, and there is a vast domestic supply of the raw materials from which these fuels can be produced.



Since World War II, technologies have been developed and refined for oil shale extraction, and for coal gasification and liquefaction. By 1985, I hope, we will have reached President Ford's production goal of one million barrels a day of synthetic fuels. Much of this activity has concentrated on finding ways to extract the estimated 80 billion barrels of recoverable shale oil. Another area of promise is in the tar sands; they hold a potential domestic yield of between 20 and 30 billion barrels of oil. The commercial feasibility of this technique has already been demonstrated at the Athabasca Tar Sands plant in Canada which is profitably producing 52,000 barrels of oil a day.

Solar energy technology is progressing along six different routes, and significant advances have already been made along three of these routes: (1) solar energy for heating and cooling; (2) wind energy conversion; and (3) bioconversion. If the present rate of advance continues, commercial applications of these technologies could occur in the near term. Solar, thermal, and ocean thermal conversion techniques are in the initial stages of development, but show promise of providing significant amounts of electric power by the turn of the century.

Geothermal energy—trapped in lava chambers of the earth—has the potential to provide a large part of the energy needs in the Western United States and Alaska. The geysers found in Northern California are a familiar example of geothermal energy. The Pacific Gas and Electric Company has already installed generators using conventional steam turbine technology to harness the geysers north of San Francisco to supply power to that city at competitive prices.

The successful development of nuclear fusion can furnish us with the reliable, economic, and safe production of electricity. Given the development and building of breeder reactors, our supplies of uranium and thorium could probably last 2,000 years.

But coal is the crucial element in our drive to energy independence. It is estimated that we have over four times more energy in coal than the entire Middle East has in oil. At present rates of consumption, we have reserves that will last 350 years. The nation's estimated three trillion tons of coal reserves constitutes about 80 percent of our entire stock of fossil fuel resources.

In 1900 coal supplied 90 percent of the nation's energy demand. The growing use of oil and gas dropped that figure to 38 percent by 1950; and today it is about 17 percent. Commercialization of the technologies to produce clean fuels from coal, and to improve the direct combustion of coal could supply a major share of U.S. energy demand. To point us in this direction President Ford has urged the doubling by 1985 of coal production to some 1.2 billion tons a year.

Commercial development and application of new ideas in energy conservation are as vital to achieving our goals of self-sufficiency as is energy-resource development. There is already some movement in this area worth mentioning. Domestic automobile manufacturers, for instance, have promised a 40 percent improvement in fuel efficiency on a weighted average for all new autos by the 1980 model year.

The country's largest energy-using industries have been applying various technological approaches as they strive to reduce their consumption of energy. The Commerce Department and the Federal Energy Administration have received pledges from the 10 most energy-intensive industries to improve their energy efficiency from 10 to 15 percent per unit of output by 1980. So far, the six largest energy users have already reported improvements in energy efficiency ranging from 1.7 to 7.8 percent. Progress in this endeavor is crucial, because business and industry consume two-thirds of all the energy used in the country.

President Ford's energy program has set a goal that—despite the growth in total energy consumption—we will be importing less than five million barrels of oil by 1985, and will have a strategic reserve of 1.3 billion barrels, thereby immunizing us from even a total petroleum embargo. And, unless we are willing to accept a drastic fundamental change in our economic system, private industry through private investment must be prominently involved in this development. As new energy systems become commercially feasible, the private sector must take over the final marketing, building, and operating stages.

The challenge of our energy future is one of unparalleled magnitude. The Commission on Critical Choices estimates that we will need a capital investment of $800 billion by 1985. The commission breaks down the investment needs into: $300 billion for oil and gas resources; $160 billion for new power plants; $100 billion for the introduction of new energy-saving devices; $40 billion for coal development; $50 billion for environmental controls; and $150 billion for investments that will produce energy after 1985.

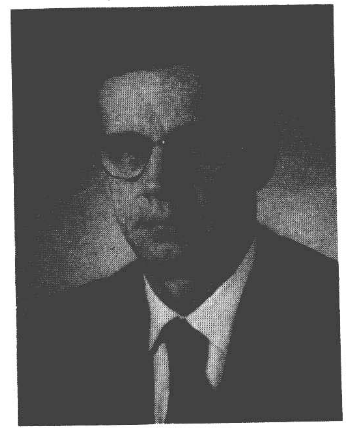
The business community of no other nation in the world could even dream of meeting such a challenge. No nation can determine its energy future as can the United States. We have the resources, the technological ability, and the kind and variety of capital financing needed to succeed. Only American business has the managerial skills and the organizational ability to assemble the scientific, manpower and material resources required for this massive undertaking.

It is an undertaking in which the very survival of this nation and its traditions are at stake. To assure our national independence we must regain our energy independence. Our energy independence is inextricably tied to national independence, to our ability as a world power to shape our own future and destiny in peace and harmony with others.

My confidence that we can meet this challenge—the greatest economic and technological undertaking in world history—has not wavered. Our 200 years of independence support that confidence and attest to our ability to overcome any and all obstacles now and in the future.

Special Report

THE U.S. WEATHER SERVICE



By Dr. George P. Cressman, Director, National Weather Service

Historic Importance to Industry

The Weather Service's history is closely linked to the economic history of the nation. In fact, the weather service was created to meet an urgent need of commerce. Ships on the Great Lakes were frequent victims of storms; in 1868 and 1869, more than 3,000 vessels were sunk or damaged at a cost of 530 lives.

At the urging of Increase Lapham, a Milwaukee weather observer, Representative H. E. Paine of Wisconsin introduced a Joint Congressional Resolution requiring the Secretary of War to provide for meteorological observations at military posts and to give notice by telegraph of the approach and strength of storms. The resolution was passed by Congress and signed into law by President Ulysses S. Grant on February 9, 1870. Command of the new service was assigned to Brig. Gen. Albert J. Meyer, Chief Signal Officer of the Army, who named it "the Division of Telegrams and Reports for the Benefit of Commerce."

Storm warnings for Great Lakes shipping helped to reduce losses dramatically. By the turn of the century, weather was causing less than 25 percent of the casualties on the Great Lakes, whereas, before 1870, it had caused 75 percent.

The Signal Service's field weather stations grew from 24 in 1870 to 284 by 1878. Three times a day each station telegraphed its observations to Washington, where predictions were made and telegraphed back to the observers. They also went to railroad stations and to the Associated Press. Although by charter the new agency was limited to the Great Lakes and seacoasts, the appropriation act of 1872 authorized weather reports throughout the nation for "commerce and agriculture." In 1873, midnight weather reports were sent to thousands of rural post offices for display as "Farmers' Bulletins."

An ocean meteorological network was begun in 1871, when General Myer asked merchant ships to log three weather observations a day, particularly when in coastal waters. Five years later naval vessels were asked to do the same. By 1885, U.S. weathermen, in cooperation with Britain, were issuing warnings for Atlantic storms. In 1873 a river stage and flood forecasting service was added by the Signal Service.

On Oct. 1, 1890, Congress transferred the Weather Service to the Department of Agriculture. The new United States Weather Bureau—a name it was to retain until Oct. 3, 1970—began on July 1, 1891, and it grew rapidly. By the turn of the century it was sending daily forecasts to about 80,000 recipients by telegraph, telephone, and mail. Weather maps and bulletins were posted in hotels, stores, office buildings, post offices, railway stations, and even trolley cars. In 1898 a hurricane warning service was established by President McKinley to protect American ships during the Spanish-American War. A hurricane forecasting center was first established in Jamaica, then moved to Cuba, and, in 1902, to Washington, D.C. Also, in 1901 and 1902 the U.S. Weather Bureau adopted wireless telegraphy, the first U.S. Government agency to do so, and conducted its first tests between stations at Hatteras and Roanoke Island, North Carolina.

Radio telephony or voice broadcasts appeared with the development of the vacuum tube in 1920. By 1923, there were 140 radio stations in 39 states broadcasting weather reports, crop information, and cold wave warnings.

During this period the airplane, too, came into its element and became another major stimulus to weather forecasting. By the end of 1918 the Weather Bureau was issuing special forecasts for domestic military training flights and for the Post Office's new airmail routes between Washington, D.C., New York, and Chicago. By 1920 there was a transcontinental mail route and the Weather Bureau established flight forecast centers at Washington, D.C., Chicago, and San Francisco.

The Air Commerce Act of 1926 assigned to the Weather Bureau the role of helping the development of commercial aviation in the United States. The Weather Bureau by 1930 had established 50 airport stations and 250 airway sites to provide weather observations. Radio broadcasts of weather data and forecasts were delivered every 30 minutes.

Service to the public was also expanded during this period. In 1939 the first automatic telephone answering service for weather forecasts was introduced in New York City. In less than a week it was handling 58,000 calls a day. Today's systems handle hundreds of millions of calls a year.

Modern Developments

Meanwhile the techniques of weather observing and forecasting were being refined.

The development of the radiosonde—a tiny radio transmitter carried aloft by a balloon—made today's forecasting system possible. The Weather Bureau began periodic radiosonde observations in 1937, and daily soundings a year later. Tracking of the radiosonde by radio and radar were added in World War II, to obtain wind direction and speed—rawinsondes.

Today, about 1,000 radiosondes are launched twice daily from 500 sites around the globe.

The radiosonde has given meteorologists an inexpensive way to sample the atmosphere to 100,000 feet and thereby make great improvements in forecasting.

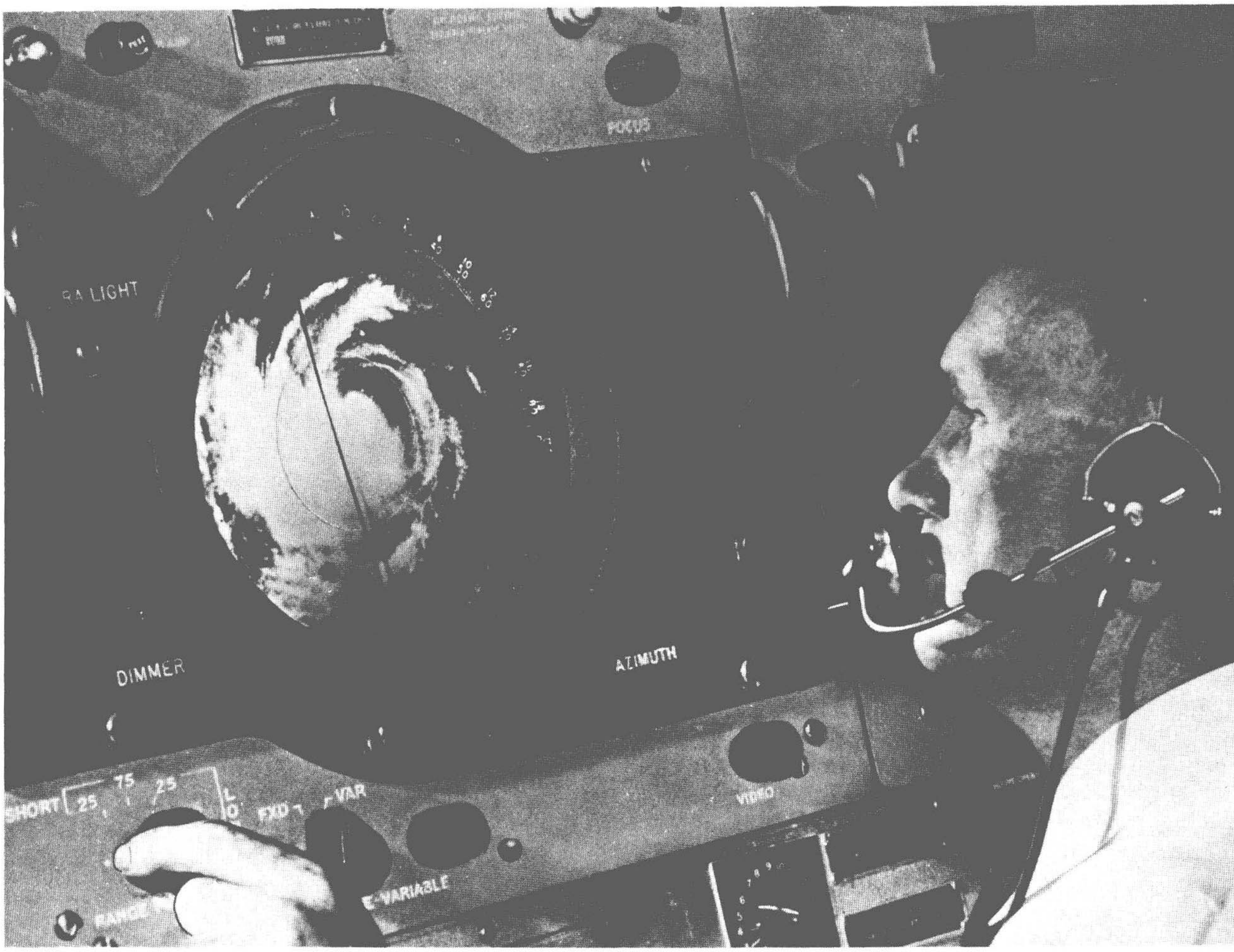
Because of the importance of the Weather Bureau's service to commercial aviation, it was transferred to the Department of Commerce on June 30, 1940. This transition, in effect, mirrored the country's transition from a rural to an industrial society.

World War II mushroomed the needs for meteorology. For example, in the summer of 1944, when the Air Weather Service reached peak strength, there were 19,000 officers and men manning some 900 stations, about 700 of them overseas. The Commerce Department's Weather Bureau provided more than 700 men to the Armed Services, and Bureau meteorologists instructed at civilian universities where meteorologist candidates were given crash courses in forecasting weather.

The war brought many demands for special forecasts for such things as military airfields, munitions plants, glider detachments, chemical warfare units, and proving grounds. The number of civilian and military flights grew tremendously. In 1943 the Weather Bureau established an experimental Flight Advisory Weather Service at New York's La Guardia Field to provide special service to flight controllers, and through them to pilots in flight. By August 1945, more than 26,000 clearances and flight plans were being handled a month.

The war provided valuable new tools for the meteorologist. Radar, for instance, enabled the forecaster to extend his range of vision across tens of thousands of square miles and to see weather at night. With radar he can even pierce clouds and fog and see one thunderstorm behind another.

In 1946 the Navy gave the Weather Bureau 25 surplus aircraft radars which Bureau technicians modified for use on the ground. So great were the benefits that the Weather Bureau developed its own weather radar in the 1950's and today's weather radar network consists of 56 operated by the National Weather Service and 15 by the Department of Defense. These 71 radars provide coverage of the weather in 39 states and partial coverage in 6 of the other 11. In addition, there are 22 Federal Aviation Administration air-traffic-control radars that provide weather surveillance for parts of western United States, and



a Commerce Department program placing 66 local warning radars in areas that are especially susceptible to severe weather.

Another new tool that evolved from World War II is the weather satellite. At the end of the war German V-2 rockets were brought to the Army Ordnance Proving Grounds at White Sands, New Mexico, and their warheads were replaced with instruments and cameras to be parachuted to earth. The panoramic cloud pictures produced by this means led to the development of today's meteorological satellites. Among the most recent and useful are three synchronous meteorological satellites launched within the past two years and now poised 22,300 miles above the Equator—SMS-1, SMS-2, and GOES-1. Every 30 minutes they provide visible light photos by day and infra-red photos by night of the entire western hemisphere. They are part of the Geostationary Operational Environmental Satellite (GOES) System operated by the Commerce Department. GOES satellites are particularly useful for locating and tracking hurricanes. They also help spot and track the towering thunderheads most likely to produce tornadoes, and act as radio relay stations for weather information from remote observing stations anywhere within their field of view.

By far the most important aid to forecasting in the postwar period has been the high-speed electronic computer. Although the complex equations to approximate atmospheric behavior had been worked out 25 years before the high-speed computers arrived, the computations could not be performed quickly enough to make forecasts. In April 1955, operational computer weather forecasts were begun, and the science of meteorology entered a new era. Computer forecasts now provide the local forecasters of the National Weather Service with the information on which they base their detailed weather predictions. This guidance has markedly improved the accuracy of forecasting in most communities.

Computers have also improved river and flood forecasting. Weather Service hydrologists have developed numerical models of river basins. These models are lodged in computers and are fed observations of the rain, snowfall, evaporation, and river stages. The computers then give back forecasts of river and flood stages, which are distributed to the Army Engineers, Civil Defense officials, public safety officials, and others as appropriate. The value of this service was demonstrated in the spring of 1969 when massive floods in the Midwest forced 25,000 people from their homes. Forecasts that were made earlier, when snow was still on the ground, aided in the saving of many lives and in preventing an estimated $250 million of potential property damage.

River stage forecasts are of great value to barge traffic. An inch or so of additional depth that may be safely navigated, if known in advance, allows barge operators to maximize the loading of their craft with a precision that over the long run saves many dollars.

Weather forecasting for maritime shipping has also been greatly strengthened in recent years. Forecasters on the Atlantic and Pacific coasts and in Hawaii issue weather and sea-state forecasts for large portions of both oceans. These are distributed by radio, teletypewriter, and facsimile to ships at sea. Storm warnings are issued at regular intervals over great distances as an add-on to the National Bureau of Standards time signals.

Marine weather units provide forecasts and warnings for fishing fleets that operate in the Atlantic, the Pacific, the Caribbean and the Gulf of Mexico. On the Great Lakes the service includes notices of the beginning and ending dates for ice blockages to navigation.

Forecast services to commercial aviation have continued to grow. Prior to 1940 there were two commercial transatlantic flights a week to Europe. Now, Weather Service offices help meet the needs of hundreds of flights a day for carriers of many countries. Airliners crossing the oceans use computer-generated flight plans based in part on computerized forecasts from the National Meteorological Center.

Domestic aviation needs are met by hundreds of Federal Aviation Administration (FAA) Flight Service Stations and Weather Service offices. Forecasts are delivered to aviators by automatic telephone recordings, at air terminals in preflight briefings, and in the air by radio.

ESSA, NOAA, and NWS

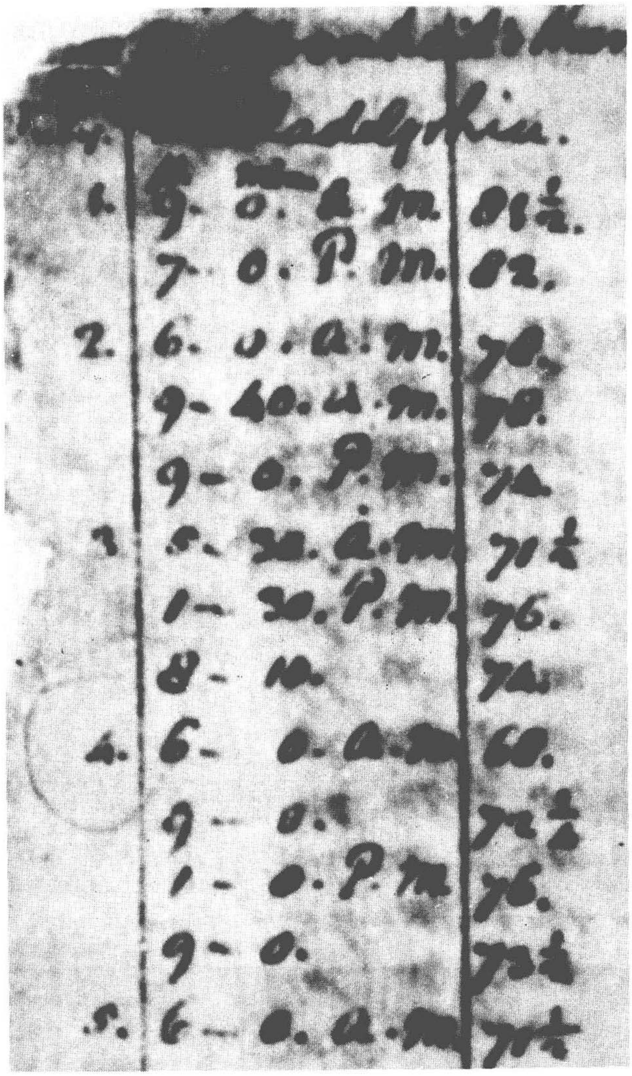
In 1965, President Johnson asked Congress to establish a new agency that would "provide a single national focus to describe, understand, and predict the state of the oceans, the....atmosphere and the size and shape of the Earth." The result was the Environmental Science Services Administration (ESSA), created that year and placed in the Department of Commerce.

ESSA included the Weather Bureau, the Coast and Geodetic Survey, and the Central Radio Propagation Laboratory of the Bureau of Standards, along with three newly created sister components: the National Environmental Satellite Center, the Environmental Data Service, and the Environmental Research Laboratories.

Five years later, October 3, 1970, ESSA was replaced by the National Oceanic and Atmospheric Administration (NOAA). NOAA constituted the merger of the former ESSA components with the Interior Department's Bureau of Commercial Fisheries, Marine Game Fish Program, and Marine Minerals Technology Center; the Navy's National Oceanographic Data Center and National Oceanographic Instrumentation Center; the Coast Guard's National Data Buoy Development Program; the National Science Foundation's National Sea Grant Program, and a part of the Army Corps of Engineers' Lake Survey.

The Weather Bureau was renamed the National Weather Service and retained its role as provider of the nation's basic weather services and warnings. Its climatology program was placed in the Environmental Data Service, which manages geophysical observations of many kinds, including the National Climatic Center, its largest data center. Holdings at the Center range from 300-year-old weather diaries to the 100 million weather observations received annually from around the earth. The Center makes available at cost a variety of publications, microfilms, magnetic tapes, and radar and satellite films.

To NOAA's Environmental Research Laboratories are assigned such functions as weather-modification experiments with snow, rain, hail, lightning, and hurricanes; studies of tornadoes; special samplings of air pollution to determine its effects at remote sites; examinations of the effect



A page from Thomas Jefferson's weather diary. The entries were made in Philadelphia in 1776 and include weather observations for July 4th.

of solar radiation on the atmosphere; and computer modeling of global atmospheric circulation.

The Forecast

Looking ahead, contributions of NOAA's and NWS's weathermen to the business community and the nation will include improved radar and satellite coverage, increased use of automatic weather stations, better detection of severe thunderstorms and tornadoes, and faster and more reliable dissemination of weather forecasts and warnings.

The prototype Automatic Meteorological Observing Station (AMOS), first produced in the 1950s, demonstrated that such stations could relieve human observers of the repetitive tasks of reading instruments and transmitting data. A total of 30 AMOS stations are in operation and 50 more are planned. A comparable system for remote unattended sites is called RAMOS. Several of these are being procured. They will provide data from hard-to-reach or harsh environments such as mountain tops, deserts, and polar wastes.

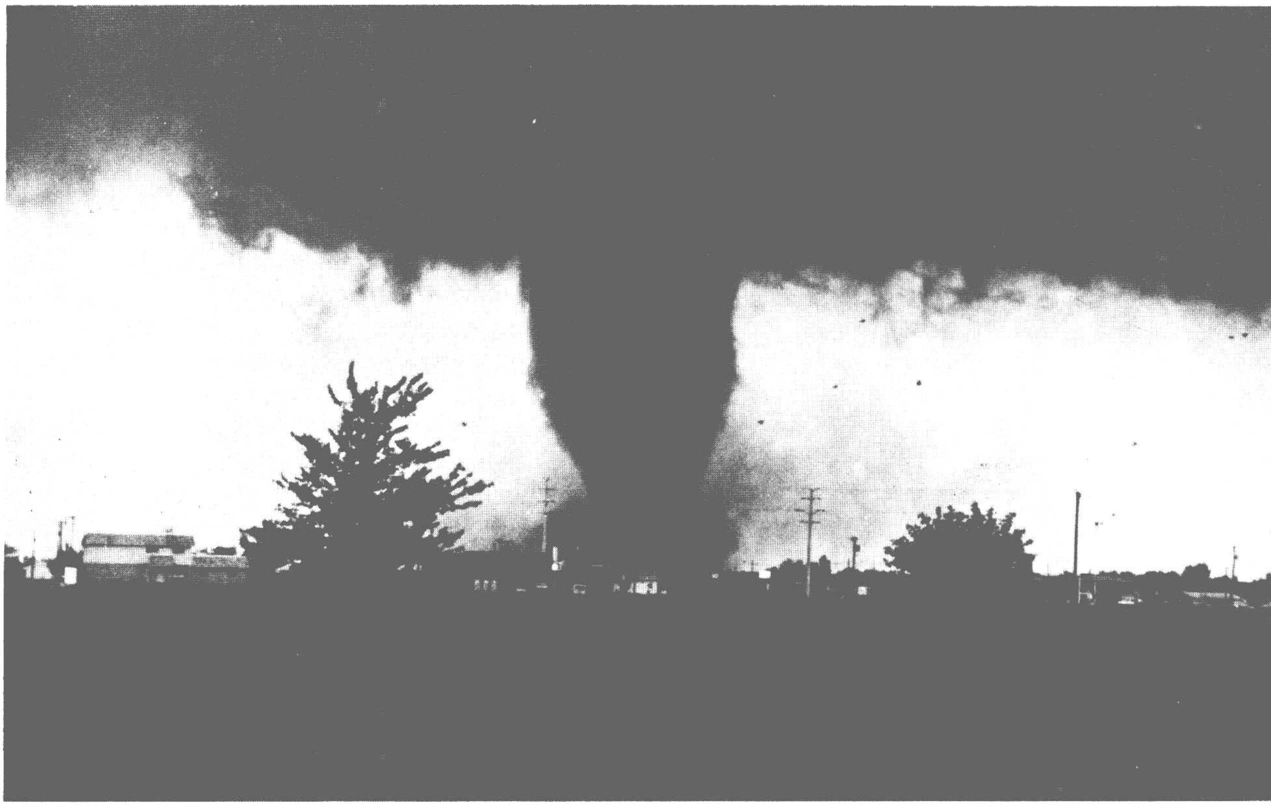
A tornadic-storm detection system, based on the burst rates of atmospheric electricity at certain frequencies, is being field tested. An infrared Doppler system is being developed to measure wind velocities in waterspouts and tornado funnels.

To help forecasters carry out routine tasks and still be ready to make the quick decisions needed for sudden weather events such as tornadoes; a highly automated high-speed weather service is becoming available, called AFOS—for Automation of Field Operations and Services. AFOS will provide on-site minicomputers and TV-type monitors at some 275 Weather Service offices and will replace by an all-electronic system the teletypewriters, facsimile machines, and the vast quantities of paper required for them. A National Distribution Circuit will deliver information from one station to any other station on the circuit within about 25 seconds. AFOS is slated for completion by 1980.

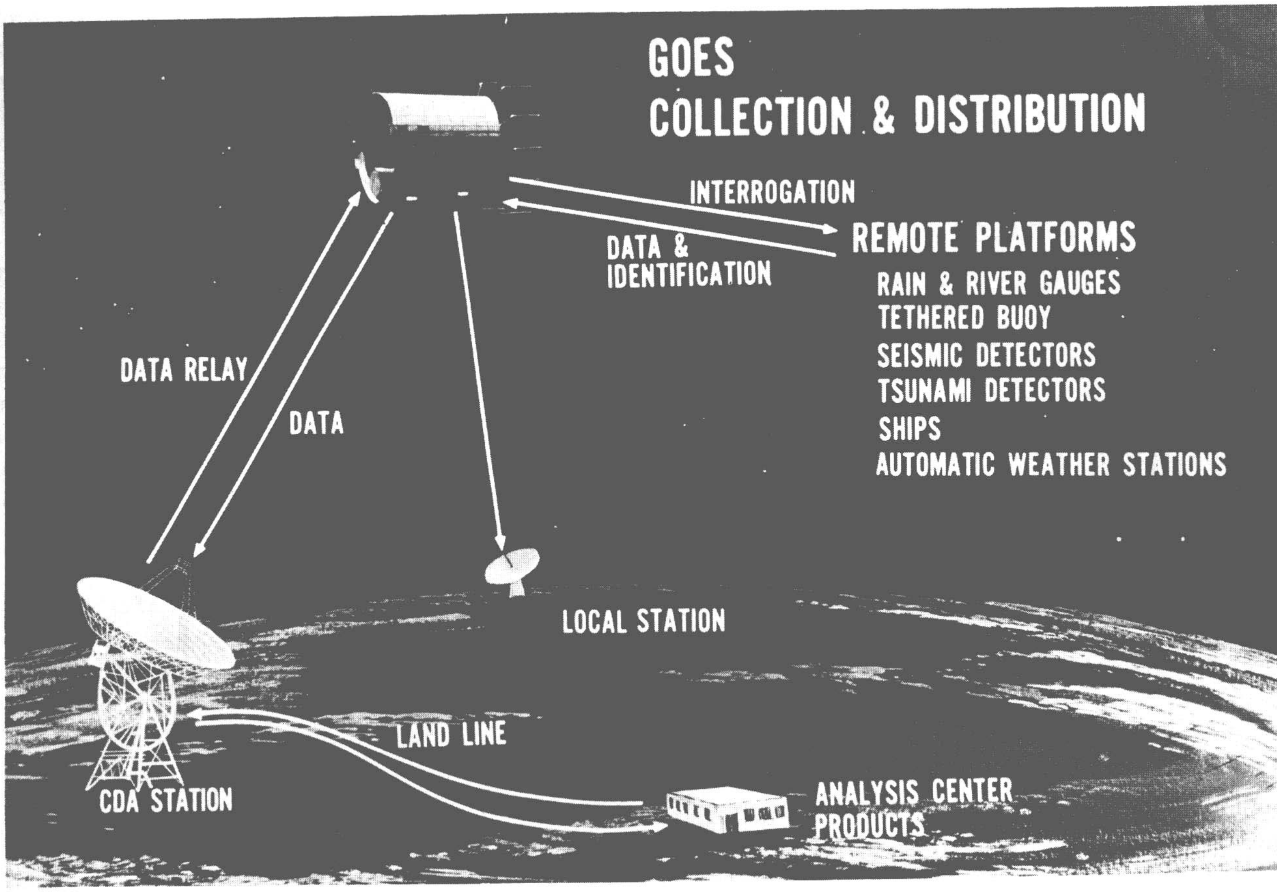
The NOAA Weather Wire Service, which provides teletype information from Weather Service offices to radio and TV stations, newspapers, and various other users, will soon be available in 48 states.

NOAA Weather Radio, a network of VHF-FM transmitters that provide continuous broadcasts of weather warnings and forecasts, is to be greatly expanded. This network, operated entirely by the Weather Service, has grown from four stations in 1965 to 77 in 1975. Plans call for the network to be expanded to 331 stations providing service for about 90 percent of the U.S. population within about four years.

As a valuable added feature of this service, special storm-warning receivers are now becoming available at moderate prices. These can be automatically turned on or made to sound an alarm by a tone signal activated in Weather Service offices, thus providing a positive and immediate notice of the threat of a tornado or flash flood. Such receivers are vital aids to schools, hospitals, nursing homes, factories, and mobile-home communities where there are large concentrations of people who are especially vulnerable



TORNADO



or who are unable to monitor the weather themselves.

It is clear that the forecaster of the future will have to respond to growing pressures on our natural resources. Movement and storage of heating fuels, for example, will lead to demands for forecasts of the weather for weeks and months ahead. There will be increased interest in ways to predict devastating droughts, floods and the more subtle long-term changes in climate.

Already, a systematic study of climate change is under way as part of the World Meteorological Organization's Global Atmospheric Research Program.

There will be growing pressure for short range and specialized forecasts. Agriculturists, seeking to maximize yields and minimize losses, will call for forecasts tailored to their needs, say, of 12 hours or so. Forest fire fighters will get quicker forecasts for very short periods at the scene of the action. The trend toward the concentrations of people living in exposed environments in mobile homes, so vulnerable to strong winds, will put increased emphasis on storm warnings on a minute-by-minute basis.

In short, as our society becomes increasingly sensitive to changes in weather; the need for appropriate response by forecasters will grow—and will be met.