PARTMENT OF COMMERCE
WEATHER BUREAU

THE INSTRUMENTAL PROGRAM OF THE U.S. WEATHER BUREAU

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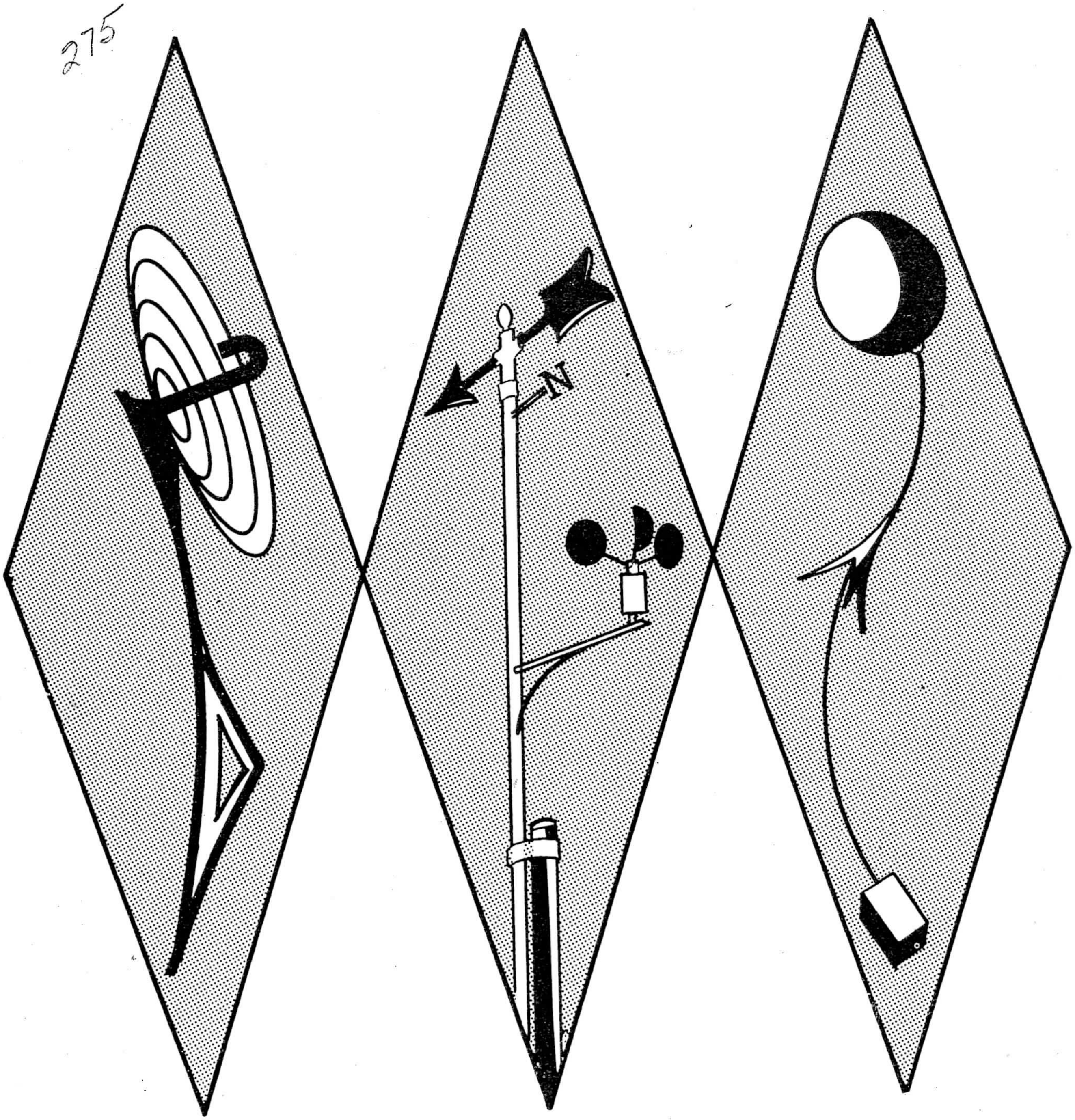


WASHINGTON, D. C.
December 1961

SURFACE WEATHER OBSERVATIONS

The U.S. Weather Bureau is well embarked on a program to modernize and standardize the surface aviation observational program. To further this concept, instruments important to flight safety have been and are continuing to be remoted to positions on the airport. The exposure of existing wind equipment is being standardized, and rotating-beam ceilometers, transmissometers, hygrothermometers and RVR are being installed as rapidly as possible.

Priority of end-of-runway installations is based on the number of instrument contacts at an airport. At many large airports, more than one instrument runway exists and in such cases multiple installations of EOR equipment are planned.

INSTALLATION PROGRAM

The program for installation of airport meteorological observational facilities consists of three equipment categories.

1. <u>"End-of-Runway" or EOR.</u>

   Set of equipment consisting of a transmissometer installed near the approach end of the instrument runway, and rotating-beam ceilometer installed near the middle marker of the Instrument Landing System (ILS).

2. <u>"Wind-Temperature."</u>

   Set of equipment consisting of a hygrothermometer, anemometer and wind vane. Sensing elements are normally installed at a representative exposure site on the airfield.

3. <u>"Runway Visual Range" or RVR.</u>

   Single piece of equipment which uses the output of the transmissometer for determination of RVR. Readouts are located in both WB and FAA facilities.

Eventually, the observing program at all airport stations will be modernized by the installation of transmissometers, rotating-beam ceilometers, hygrothermometers, and wind recorders. Initially, EOR and wind-temperature equipment is being installed on all ILS-equipped airports, but plans also exist for installation of modern equipment at other FAA or WB stations where non-standard or poorly exposed installations now exist.

WIND-TEMPERATURE

A. The F420 wind system (see Fig. 1) is a direct indicating system using a 3-cup rotor and spread tail vane. The wind speed transmitter, which is a permanent magnet d-c generator, generates a voltage which is indicated on a milliammeter calibrated in knots. The wind direction circuit uses a d-c synchro transmitter which operates a synchro type indicator graduated in degrees and compass points. The wind speed circuit requires no power source while the direction circuit requires a 12-volt d-c supply.

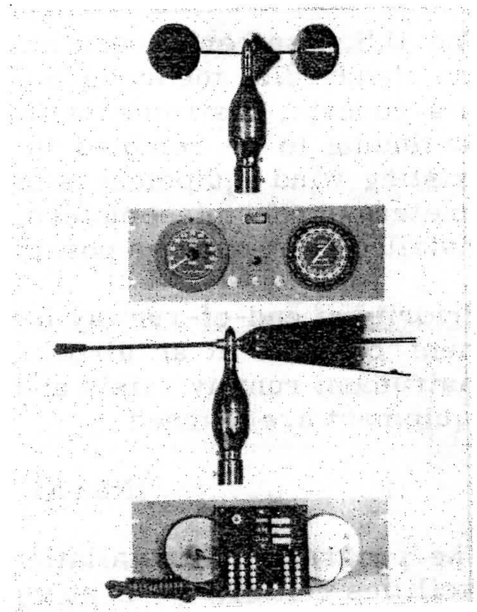


Fig. 1 Standard F420 Wind System

B. The hygrothermometer system (see Figs. 2 and 3) is designed for indicating or recording dew point and ambient air temperature through the use of remote registering thermometers.

At the exposure site the sensing thermometers are situated in a continuously aspirated thermal shield. The dew point thermometer is encased in a lithium chloride cell which is maintained at the lithium chloride "equilibrium temperature" by means of an automatic heating arrangement. Thermometers employed may be of the three-lead resistance type or the liquid-filled type, depending upon the telemetering system employed between thermometers and indicators.

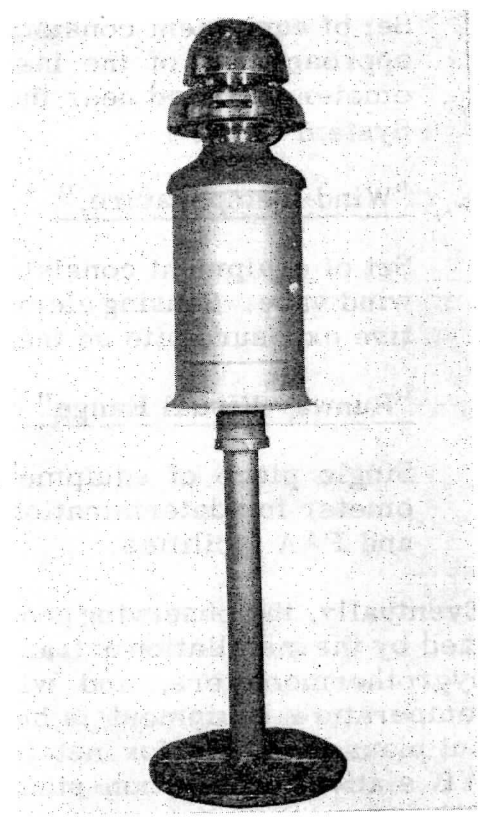


Fig. 2 Hygrothermometer System

For short distances, up to a few thousand feet, a self-balancing Wheatstone bridge arrangement is employed and the dew point and ambient temperatures are indicated at the observatory on wide angle scales by pointers operated from the servo motors of the self-balancing bridges. The dew point scale arrangement effects a conversion from lithium chloride equilibrium temperature to dew point over water. Moreover, slave hands on the ambient temperature indicator provide a means for obtaining maximum and minimum temperatures.

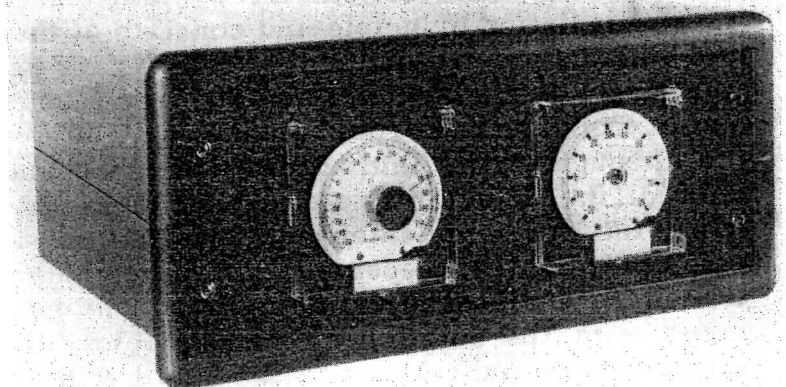


Fig. 3 Hygrothermometer Indicator

For longer distances, several miles or more, liquid-filled thermometers operate telemetering transmitters which transmit time impulses, the length of which are proportional to the thermometer readings. Indicators at the observatory decode the time impulse signals from the transmitter and register dew point temperature and air temperature on scales similar to those employed with the Wheatstone bridge system.

LOCATIONS

The hygrothermometer and wind system are located adjacent to each other at a representative location on the airport (see Fig. 4). The anemometer and wind vane are mounted on a 20 foot tower while the hygrothermometer is surface mounted.

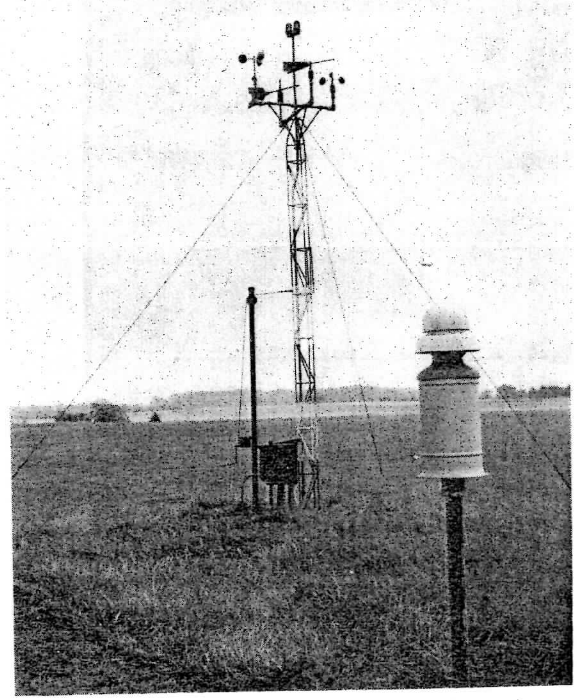


Fig. 4 Center-Field Wind-Temperature Installation

END-OF-RUNWAY (EOR)

A. Rotating-Beam Ceilometer (RBC).

The rotating-beam ceilometer system (see Figs. 5 - 7) works on the triangulation principle and consists of three major components: a projector, a detector, and an indicator or recorder. The beam of light from the projector is rotated continuously in a vertical plane and is modulated in order to make the light identifiable to the detector, through whose field of view the light beam passes. The field of view of the detector is toward the zenith and as the beam of light from the projector intersects the base of the cloud a part of the reflected light is received by the detector. In turn, the detector transmits a signal to the indicator. The indicator, being synchronized with the rotation of the projector, translates the received signal into an indication of the actual height of the cloud.

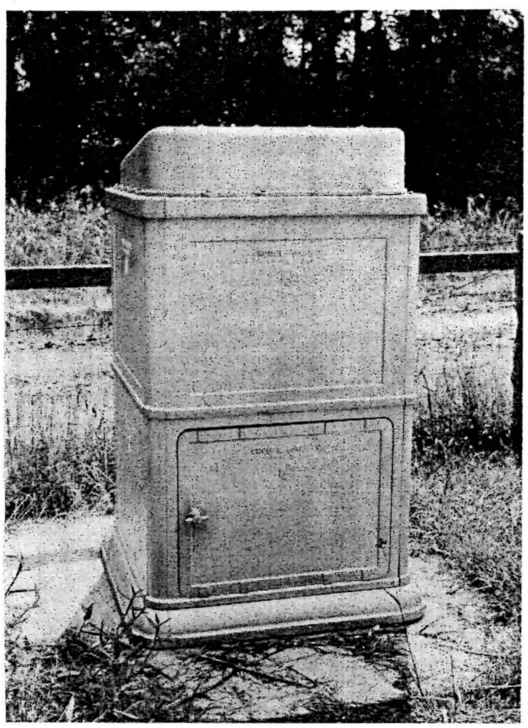


Fig. 5 Rotating-Beam Ceilometer Detector

Fig. 6 Rotating-Beam Ceilometer Projector

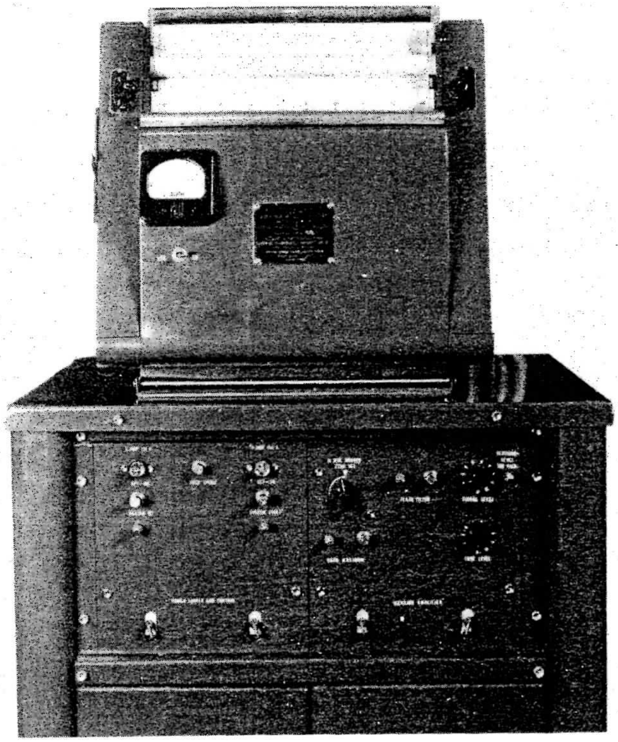


Fig. 7 Rotating-Beam Ceilometer Recorder

B. Transmissometer.

The transmissometer (see Figs. 8 and 9) is an instrumental system designed to measure visibility by giving a continuous indication of the transmissivity of the atmosphere over a selected line of sight. The system consists essentially of a sealed-reflector light projector and photoelectric receiver with indicator. In a typical installation, the projector and receiver are situated out-of-doors on a known baseline (usually 750 or 500 feet) with the indicator and a recorder indoors. The projector and

Fig. 8 Transmissometer Detector

Fig. 9 Transmissometer Projector

receiver are usually located near the approach end of the instrument runway to give the visibility near touchdown point.

LOCATIONS

The RBC is located 3500 feet off the approach end of the instrument runway at the site of the middle marker. The transmissometer is located on the airport near the approach end of the instrument runway.

C. Runway Visual Range (RVR).

Runway visual range is an instrumentally derived value, based on standard calibrations, that represents the horizontal distance a pilot will see down the runway from the approach end; it is based on the sighting of either high intensity runway lights or on the visual contrast of other targets--whichever yields the greater visual range.

A simple computer (see Fig. 10) stores six sets of presolved tables and converts the transmission received from the transmissometer into the visual range of an average pilot in the vicinity of the instrument runway. Six tables are required in order to have both day and night RVR values available for each of the three runway light settings used during conditions of poor visibility. The computer automatically selects the proper RVR value from the proper table at any given moment based on the high intensity runway light setting in use and the existence of day or night.

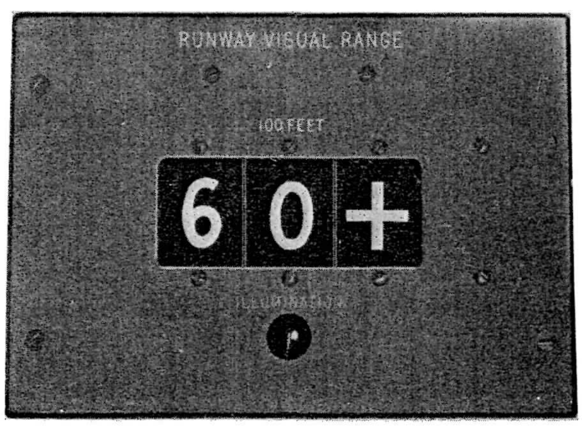


Fig. 10 Runway Visual Range Computer

RVR allows the pilot to take advantage of the increased guidance afforded by high intensity runway lights. For example, a light transmission condition equivalent to 1/4 mile (approx. 1300 feet) meteorological visibility yields an RVR (based on highest light setting) of 2,000 feet. Thus RVR permits landings and take-offs under conditions of lower meteorological visibility than allowable without the use of the high intensity lights. Because of this advantage, RVR is replacing runway visibility wherever runway instrumentation is suitable.

STATUS OF INSTALLATIONS

The "end-of-runway" equipment includes the rotating-beam ceilometer and the transmissometer. At the present time funds are available for 198 RBC's and all 198 have been delivered or are on order. Ninety-four have been installed, thirty-four are planned for fiscal year 1962, and seventy for FY63-64. Funds are available for 198 transmissometers of which 147 have been delivered or are on order. Ninety-three have been installed, thirty-four are planned for FY62 and seventy-one for FY63-64.

Center-field wind-temperature equipment includes the hygrothermometer and the F420 wind system. Funds are available for 289 hygrothermometers of which 229 have been delivered or are on order. One hundred fifty-one have been installed, twenty-two are planned for FY62 and one hundred sixteen for FY63-64. The F420 wind system is already standard equipment but unfortunately many installations are not standard with height above ground and exposure varying considerably. The wind systems are being relocated to center-field installations as rapidly as possible.

Runway visual range (RVR). Funds are available for 170 sets of RVR of which 14 have been delivered or are on order. Four have been installed, fourteen are planned for FY62 and one hundred fifty-six for FY63-64.

AMOS

The Automatic Meteorological Observing System, popularly known as AMOS, has been undergoing development for many years. At the present time 22 have been installed and are operating successfully throughout the country.

This equipment (see Fig. 11), when connected to the appropriate sensors, will automatically:

1. Collect and compute raw meteorological data.
2. Transmit digital readings over teletypewriter lines.
3. Make a printed record of the station's observations.

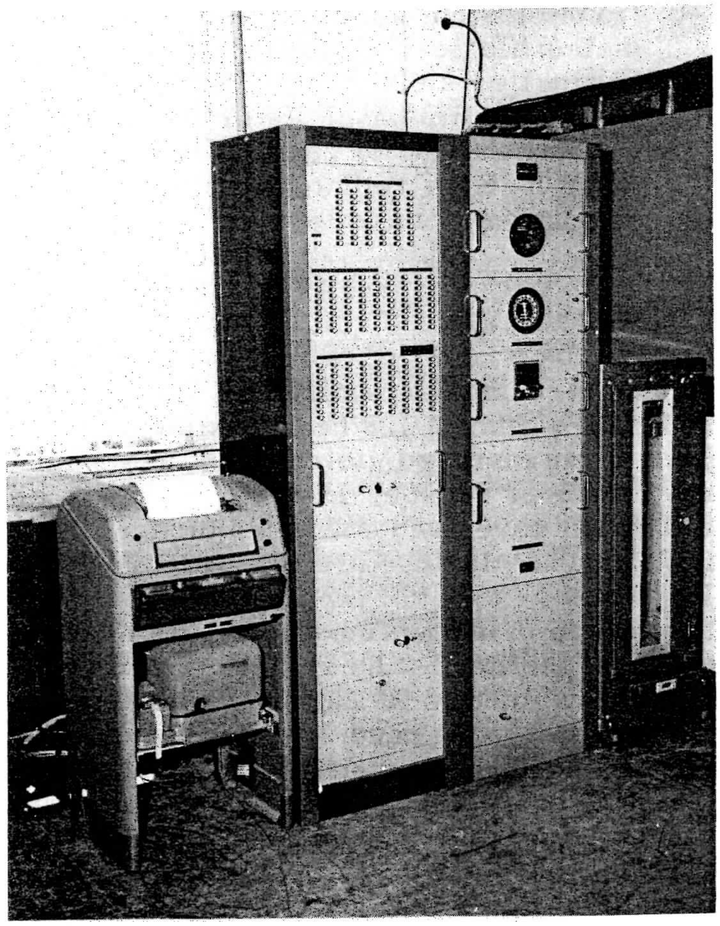


Fig. 11 AMOS III

4. Punch paper tape for preparation of punch cards.
5. Provide a continuous digital display of current weather information as required in weather offices, airport control towers and air traffic control centers.

At present, the following parameters are automatically processed.

1. Runway visibility or runway visual range.
2. Temperature
3. Dew Point

4. Wind direction and speed

5. Altimeter setting

6. Precipitation amount

7. Thunderstorms

Additional sensors under development include a sky cover detector and a weather element detector. The sky cover detector scans the celestial dome starting at the zenith until it has integrated the amount of sky cover down to an angle of 45°. The scanning system employes an infra red technique and is capable of giving a "yes-no" answer on the existence or nonexistence of clouds. The total sky cover is integrated, with the data being presented in terms of eighths of total sky cover. The weather element detector uses a series of sensors which enable the AMOS to sense and report any of a number of precipitation elements. The four sensors incorporated in this system are:

1. Rebound - capable of detecting hail or sleet.

2. Optical - capable of detecting snow.

3. Mass Accumulator - capable of detecting freezing precipitation.

4. Impact - capable of detecting intensities of precipitation.

The latest of the AMOS series has been termed AMOS IV (see Fig. 12). This AMOS contains a magnetic drum which is used to store data and perform simple calculations.

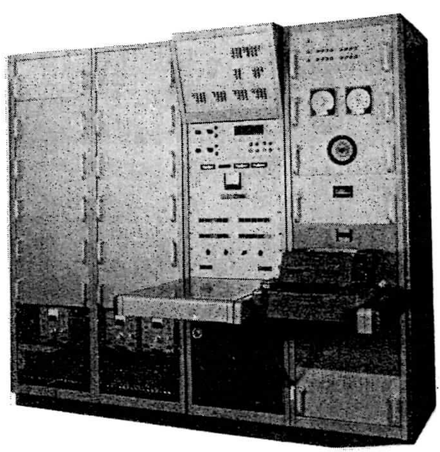


Fig. 12 AMOS IV

THE WSR-57 RADAR

The Weather Bureau's radar network has been greatly improved by the installation of a number of long range WSR-57 weather surveillance radars. Designed in 1957 specifically for the task of weather surveillance, the first WSR-57 was commissioned at Miami, Florida, on June 26, 1959. Twenty-nine of the thirty-one ordered by the Weather Bureau have been commissioned. These long range radars are distributed along the hurricane vulnerable Gulf and Atlantic Coasts, through "tornado alley" of the Midwest, and at other strategic points. (Figure 14.)

The WSR-57 radar observes precipitation areas and associated meteorological phenomena within a 250-nautical mile radius of a fixed site. It is designed and constructed to operate over extended periods of time in a wide variety of climatic conditions. The operating frequency is in the S-band, 2700 - 2900 mc. The design of the equipment is such that at a later date the frequency can be changed to C-band, 5600 - 5650 mc. or X-band, 9300 - 9500 mc. by changing the transmitter package on the antenna and the RF feed, but C and X-band packages are not yet on order. Peak power output is 500 kw. Thirty-nine sets of equipment have been manufactured by the Raytheon Corporation of Waltham, Massachusetts. Thirty-one are for the Weather Bureau and eight are for the Bureau of Aeronautics, U. S. Navy.

Other characteristics of the equipment are as follows: pulse length, 4 microseconds or 1/2 microsecond; pulse repetition frequency 164 pps or 658 pps; beam width 2°; minimum detectible signal -108 dbm. Provision is made on the RHI scope for measureing echo heights to 70,000 feet within 100-mile range. Antenna rotation rate is variable from 0 to 4 revolutions per minute, and the antenna can be tilted in elevation from minus 10 to plus 45 degrees.

The principal components of the radar are shown in Figure 15. In a "standard" installation, the antenna is installed on top of a 70-foot tower, and is covered by an 18-foot spherical radome. The purpose of the radome is to protect the equipment from the weather and to permit the antenna to be rotated regardless of wind speed. An air-conditioned building is located at the base of the tower, and the modulator and stand-by power supply as well as work space for the electronics technician are located in this building. The control console is located in the meteorological office, usually near the forecast and pilot briefing positions. The console is housed in a room where the level of illumination can be controlled. In many cases, special lighting is provided in the radar room. The photographic repeater is usually installed in the same room as the control console.

MISSOULA RADAR INSTALLATION

One of the most unusual and interesting WSR-57 radar installations was commissioned on November 1, 1961. The Weather Bureau has installed a WSR-57 radar (antenna and modulator) atop Point Six Mountain near the WBAS, Missoula, Montana. The console and photographic repeater are located in the WBAS, Missoula, twelve airline miles away. A two-way microwave system has been built to control the radar antenna and transmit the video information from Point Six to the Weather Bureau Airport Station. The purpose of this installation is to test the effectiveness of a weather surveillance radar located atop a mountain and to provide radar data to the Weather Bureau and other agencies in that area.

RADAR SITE AT SANTA CATALINA ISLAND

The Congress has appropriated funds to install a WSR-57 radar at Santa Catalina Island, California.

The Weather Bureau Office will be located at the Catalina Airport with the radar antenna installed on Black Jack Mountain which is approximately 8,000 feet away. To accommodate the installation of the radar antenna, a new road approximately one-half mile long will be built. The PPI display will be microwaved to WBAS, Los Angeles from the radar console site through the use of an intermediate relay station on San Pedro Hill.

In addition to the WSR-57 radar, associated instrumental facilities at Catalina Airport will include an AMOS-IV, rotating beam ceilometer and hygrothermometer, wind system, and transmissometer. Additionally, a transmissometer, ceilometer, and hygrothermometer will be located near the beach at the seaplane landing area, and another hygrothermometer on Black Jack Moutain. The three hygrothermometers will provide continuous measurement of temperature at 2,070 feet, 1,500 feet, and sea level for smog and stratus forecasting in the Los Angeles Basin. Present plans call for commissioning the radar on October 15, 1962, with all other equipment installed and commissioned by December 1, 1962.

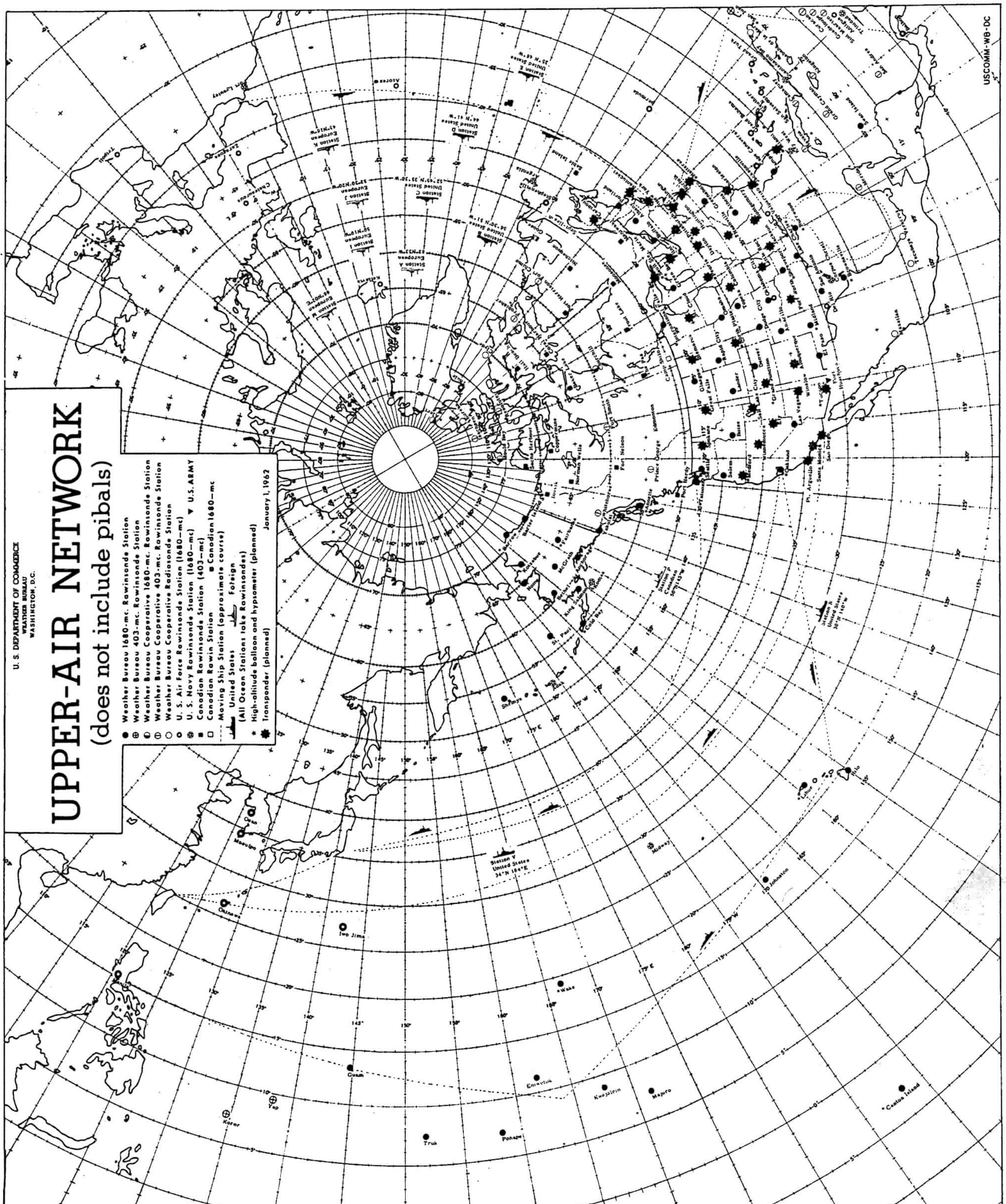
UPPER-AIR OBSERVATIONS

In Fiscal Year 1960, the Weather Bureau purchased an additional twenty-three sets of radiotheodolite equipment. When the last of these are installed and the relocation of the existing GMD-1 () sets are completed in early 1962, all rawinsonde stations operated by the Weather Bureau will have modern automatic-tracking rawin equipment of the GMD or WBRT type.

In Fiscal Year 1961, contracts were let for the manufacture of adjuncts so that the GMD or WBRT equipment at thirty-five stations can be modified for transponder-type operation. It is expected that delivery of the transponder adjuncts will begin during the first half of 1962 and that installation of the kits will be completed by the end of the year. These modifications, when used in conjunction with transponder-type radiosondes, will permit the direct measurement of the slant range distance between the tracking set and the balloon thereby appreciably improving the capability for measuring high-speeds winds aloft. We anticipate routine transponder-type observations to be under way by the end of 1962, and in future years as funds become available the transponder capability will be expanded to eventually include all stations in the network. Planned locations for the initial thirty-five sets of equipment are shown in Figure 16.

In Fiscal Year 1962, two new rawinsonde stations were added to the upper-air network; Winslow, Arizona and Huntington, West Virginia. Funds were also made available to provide high-altitude balloons and hypsometer-type radiosondes for routine use at thirty stations. This will provide the capability of obtaining upper-air data to 100,000 feet on a routine basis; this capability will be expanded to other stations in future years as funds become available. The location of the initial thirty high-altitude stations are shown in Figure 16. A graph showing the average altitudes attained in previous years using available radiosondes and balloons is shown in Figure 17.

With the advent of the transponder-type observation, it has become feasible to consider a degree of automation in the rawinsonde observation. Studies are now under way leading to the development of suitable electronic computing equipment to accomplish rapidly and automatically the data reduction in such observations. Output of the computer will be radiosonde and upper-wind data in a form suitable for immediate transmission to the forecast office and for entry into the climatological archives.


U. S. DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON, D.C.
UPPER-AIR NETWORK
(does not include pibals)
Weather Bureau 1680-mc. Rawinsonde Station
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Weather Bureau Cooperative 1680-mc. Rawinsonde Station
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Weather Bureau Cooperative Radiosonde Station
U. S. Air Force Rawinsonde Station (1680-mc)
U. S. Navy Rawinsonde Station (1680-mc)
U.S. ARMY
Canadian Rawinsonde Station (403-mc)
Canadian Rawin Station
Canadian 1680-mc
Moving Ship Station (approximate course)
United States
Foreign
(All Ocean Stations take Rawinsondes)
High-altitude balloon and hypsometer (planned)
Transponder (planned)
January 1, 1962
USCOMM-WB-DC

Figure 16

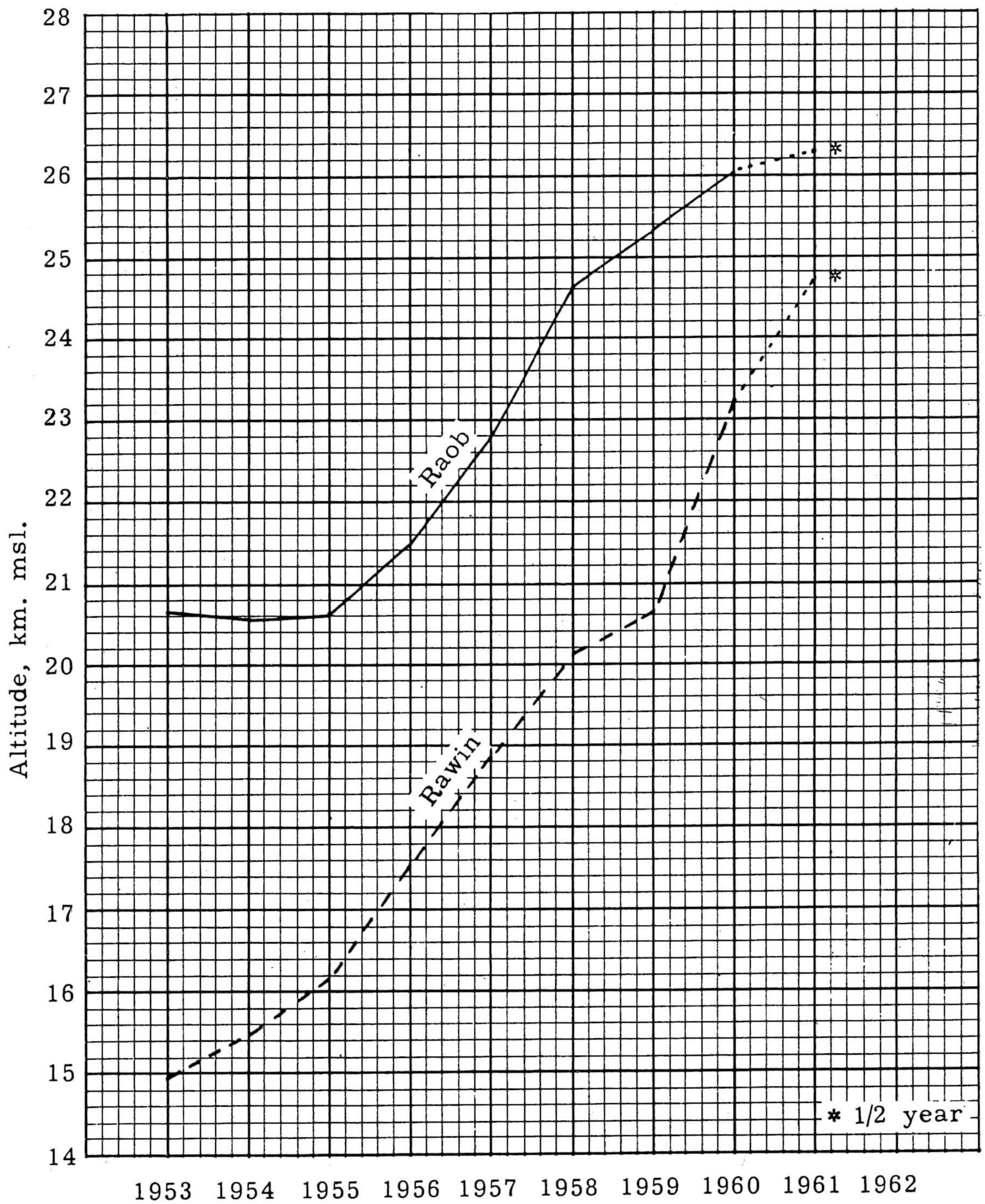

Fig. 17 Average Terminating Altitude for Rawinsonde Observations

Preliminary studies are under way leading to the development of equipment to provide an all-weather system for obtaining winds-aloft data for use at non-rawinsonde stations. The system envisioned would employ a balloon-borne target and a small automatic-tracking radar coupled to electronic computing equipment. Output would be winds-aloft data in a form suitable for immediate transmission to the forecast office and for entry into the climatological archives.

USCOMM-WB-DC

OBSERVATIONS FROM OCEAN AREAS

MAMOS, the Marine Automatic Meteorological Observing Station (or NOMAD-Navy Oceanographic Meteorological Automatic Device) was developed jointly by the U. S. Navy and National Bureau of Standards to serve as a platform for synoptic observations in remote ocean areas. It remains at sea unattended for periods of six months or more during which meteorological data are automatically transmitted by radio to shore stations. Power is provided by a rechargeable battery system capable of operating the station for extended periods.

Constructed primarily of aluminum, the hull is approximately twenty feet in length and ten feet abeam. Meteorological sensors, navigational aids and transmitting antenna are located topside; electronic gear and power supply are stored below deck in watertight compartments.

The unit pictured (see Fig. 13) has been anchored in approximately 2000 fathoms of water in the Gulf of Mexico at 25°N, 90°W. From this position MAMOS reported barometric pressure, air temperature, sea temperature and wind speed and direction during Hurricane CARLA. Some minor structural damage resulted from high winds and seas and several modifications are currently under test and development as a result of this encounter.

Networks of buoys similar to MAMOS are planned for the near future with the possibility of satellite interrogation for data collection as a longer range plan.

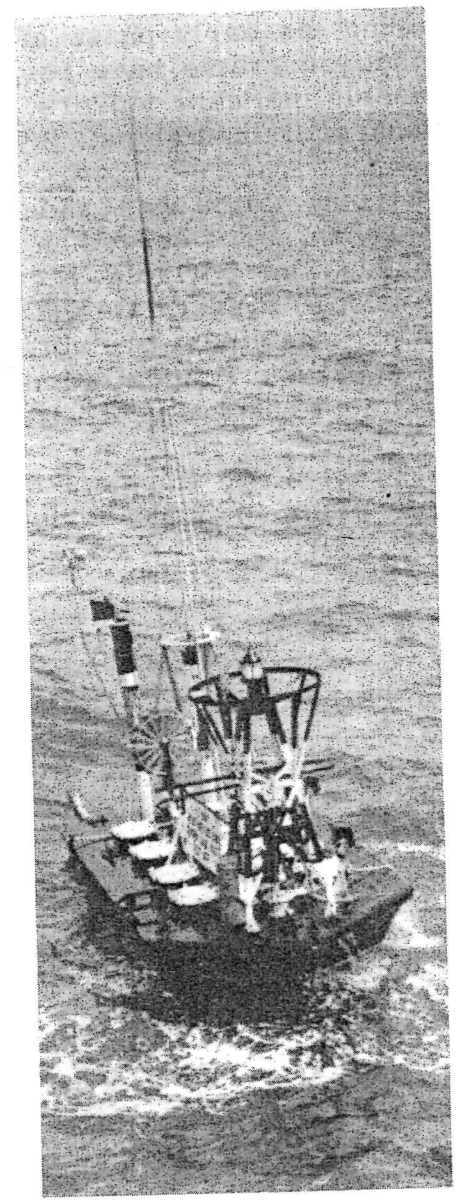

Fig. 13 MAMOS

MOBILE SHIP PROGRAM

Because of increased demands for meteorological data over the oceans, the Weather Bureau began planning for a marine observational network as early as 1950. The USNS GENERAL CALLAN made a successful pilot voyage with two observers aboard and, as a result, a fully operational mobile ship program was begun in 1955. Merchant ships plying between the U. S. East Coast and Puerto Rico made routine observations during the early phase of the program. Since then mobile ship radiosonde programs have been conducted aboard several different types of vessels including tankers, bulk carriers, research vessels and conventional merchant ships.

Instrumentation has undergone considerable changes since the first merchant ships served as observational platforms. Miniaturized radiosondes and portable receiving and recording equipment have been developed to facilitate the transfer of the observing station from ship to ship. Aluminum prefabricated shelters have been designed for easy removal and reinstallation on other ships should program requirements dictate a change.

At present two ships are operating in the Atlantic and six in the Pacific with plans to increase the total to fourteen moving stations within the next year.

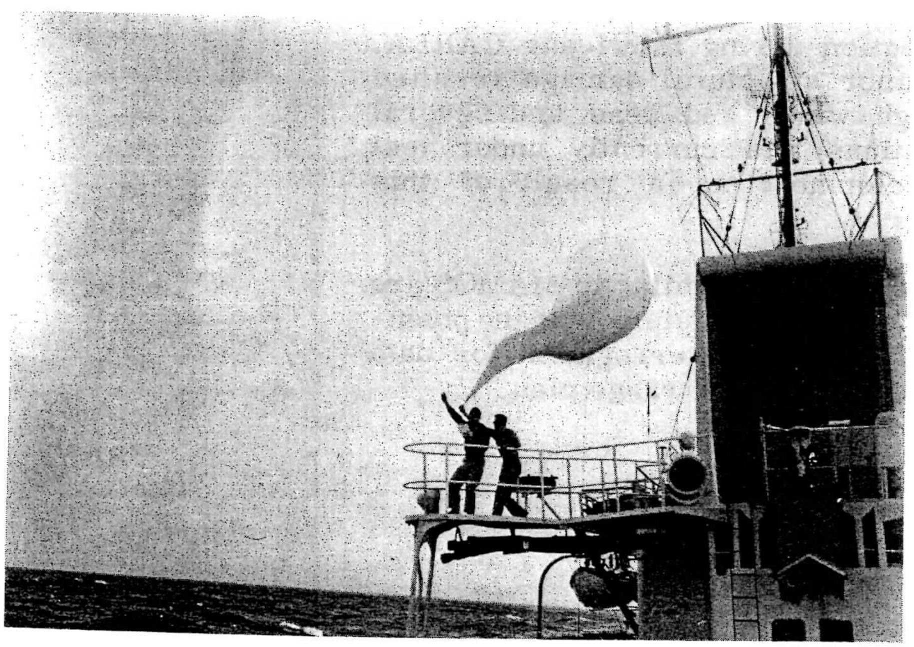

Fig. 18 Difficult radiosonde balloon releases at sea are routine.