WEATHER SERVICE
Bulletin

HEADQUARTERS AAF WEATHER SERVICE
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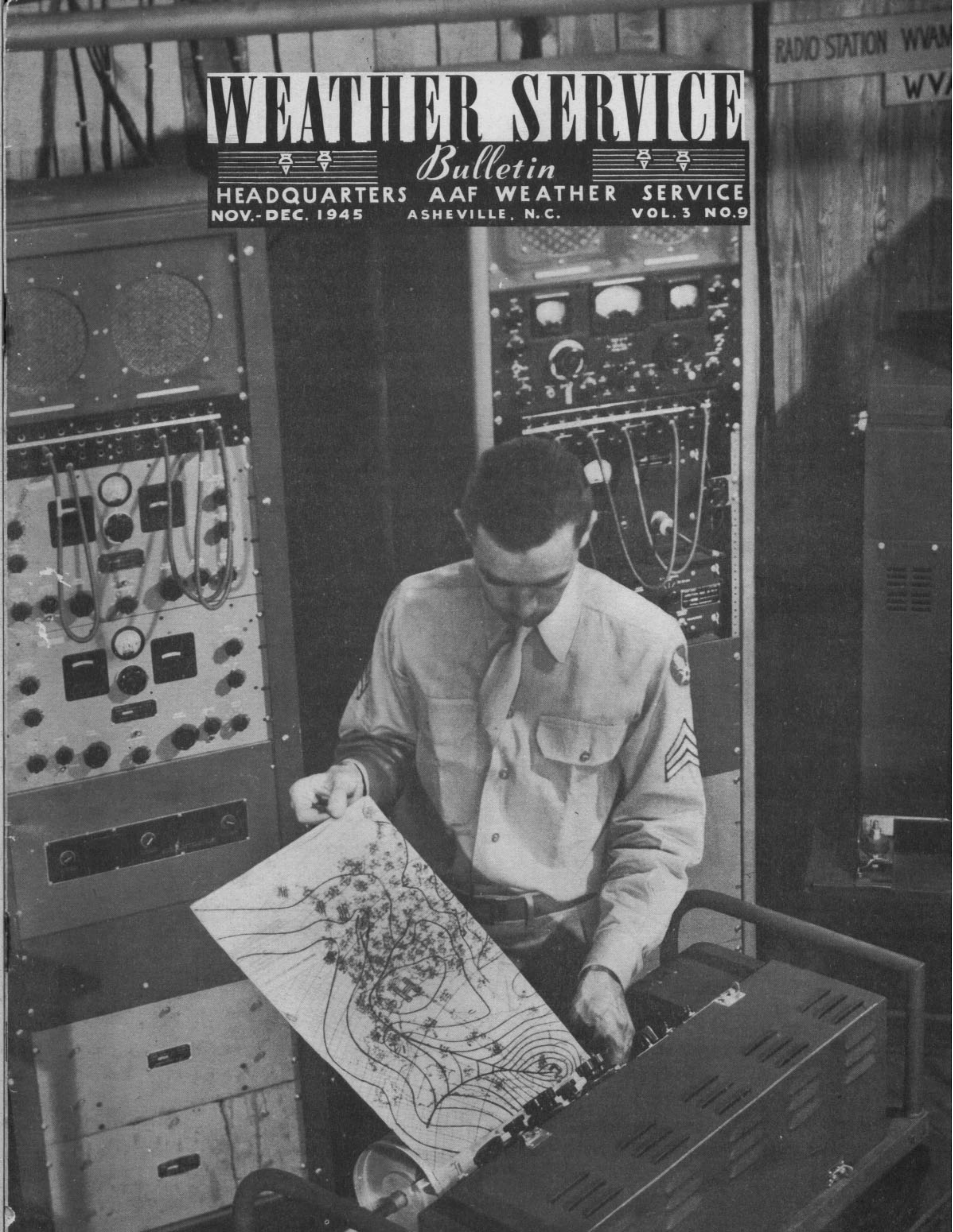

HEADQUARTERS, 12TH ARMY GROUP
APO 655

27 June 1945

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SUBJECT: Report on and Recommendations for Weather Service with the Ground Forces.

TO: Commanding General, European Theater of Operations, APO 887, U. S. Army

1. **General:** *The 12th Army Group, since the time of its organization, has been provided with a mobile weather service by the 21st Weather Squadron, Ninth Air Force. Close cooperation has been maintained between the ground forces and air forces personnel in an effort to develop a weather service that would be best adapted to meet the needs of the Ground Force units, and to utilize weather information in plans and operations to the fullest extent. It is felt by this headquarters that the weather service has been of considerable value, both in the planning and in the execution of operations. This report is submitted to (1) indicate the nature of the weather service that has been provided in this theater; (2) to point out its merits and deficiencies; (3) to make such recommendations concerning this weather service as are deemed helpful in guiding Ground Force units contemplating similar programs of coordination with the AAF Weather Service.*

2. **Organization:**

a. **Responsibility:** *The 21st Weather Squadron, Ninth AirForce was charged with the responsibility of providing a weather service to the Ground Forces in the European Theater of Operations. This weather squadron has provided the 12th Army Group with twelve mobile weather detachments, trained and equipped to operate with the armies and corps of this command.*

b. **Weather Detachments:** *Each of the weather detachments consisted of a mobile weather and communications unit, completely independent and able to serve under severe conditions. Five of them were equipped with radiosondes: these detachments were placed in such a manner as to provide the best possible ballistic weather information to the antiaircraft and field artillery units of the armies and corps of this command. Unfortunately, owing to the heavy demand placed upon the facilities of the weather squadron, certain corps of the 12th Army Group did not have weather detachments during their period of operations. These corps have received weather information and forecasts either from the detachments located at Army Headquarters or from neighboring corps weather detachments. This service has necessarily been less complete and less valuable than that which could have been provided by a weather detachment working directly with the unit.*

(continued on page 31)

The 12th Army Group, ***commanded by General Omar N. Bradley, consisted of the First, the Third, the Ninth, and the Fifteenth Armies. As the greatest military force in U.S. history, the 12th Army Group played a mighty part in dissolving the Wehrmacht during the Allies' sweeping march across France, Belgium, Holland, and Germany.***

MASTER FORECASTING PLAN

by Lt. Col. John M. Feeley, Jr.

The personnel shortage in domestic regions is being alleviated, by centralizing routine work to avoid duplication of effort.

In the spring of 1945, the 23d Weather Region submitted certain suggestions for post-war operations to the Chief of the AAF Weather Service. Included was a "master forecasting" plan, which promised that a high standard of weather service might be provided with half of the personnel previously considered necessary. A few central, outsized stations were to be staffed and equipped to analyze all desirable surface and upper-air charts and to prepare extensive forecasts, for transmission to subordinate stations over a special teletype network.

A few months later, when a critical shortage of weather manpower came to be felt in the United States, the plan was given a trial at six weather stations in Colorado. Peterson Field became the master station for Pueblo AAF, La Junta AAB, Lowry Field, Buckley Field, and the Denver Modification Center. The transmitted information was used as a *guide* in analysis and forecasting; thereby, the advantages of consultation were obtained without the sterilizing influence of an insistence upon strict uniformity. This arrangement has been so successful that it is being extended to other regions.

At present, the master station transmits by teletype chart analyses in Combined Analysis Code (see Figure 1), raob data in tabular form, and forecasts in words. From Peterson Field, the items transmitted are:

1. A surface chart analysis, four times daily, covering the North American continent and the ocean areas of WRC 4-4A.

2. A prognostic surface-chart analysis for a 24-hour period, twice daily; and prognostics for 48- and 72-hour periods, once a day.

3. Analyses of the 850, 700, and 500mb constant-pressure charts and of the 700mb prognostic chart, twice daily. When, in the usual case, these charts are used without modification, no plotting of winds or radiosonde data is required in the subordinate stations. Weather observers plot the points representing contours and isotherms; then forecasters complete the analysis by connecting the points in the sequence of transmission.

4. Data for the 700mb Theta-E Chart (values of Theta-E, mixing ratio, and lift for each radiosonde report), calculated at the master station and sent in tabular form.

5. A large number of radiosonde reports, each analyzed at the master weather station and teletyped in tabular form:

BJ	10	11	58	7	99
925	04	02	48	8	97
850	00	03	39	8	97
797	54	54	34	9	97
782	52	51	34	8	00
700	57	57	21	6	01
621	63	65	17	7	03
574	66	64	13	6	06
500	72	74	06	4	10
456	74	75	//	1	//
400	82	84	//	1	//
MPK					

This table is interpreted thuswise:

Column 1: Station call sign and pressure levels (surface press. omitted).
Column 2. Temperature in °C (50 added for negative values).
Column 3: Temperature 24 hours before (50 added for negative values).
Column 4: Mixing ratio in units and tenths (tens digit omitted).
Column 5: Coded relative humidity.
Column 6: Equivalent potential temperature (hundreds digit omitted).
At Bottom: Air mass classification. Overrunning and height may also be shown; for instance, with MT over MPK at 7000 ft, the classification would be given as MPK7MT.

From such a radiosonde report, the forecaster in a subordinate station can make a rapid, preliminary analysis for type of air mass, convective stability, frontal overrunning, humidity, cloudiness, and changes in air mass from the previous day. This is adequate in practice for most soundings, and where a sounding appears to be of particular interest, an adiabatic and a Rossby chart may be plotted from the tabular data in a very short time.

6. An upper-air synopsis in plain language, twice daily. It includes a description of the current upper-air situation at all levels; a discussion of the relationship between the upper-air charts and the surface chart; and a forecast, derived from the upper-air charts, of developments at sea level.

7. Area forecasts for a 24-hour period, in plain language, covering the Central and North Central U.S. These forecasts are issued merely for information to the weather stations: there is no requirement that the forecasts prepared at any station must conform to them.

In addition, certain stations on send-receive status prepare and transmit terminal forecasts for their own immediate vicinity (in U.S. Weather Bureau Terminal Forecast Form). These transmissions are sent in a sequence indicated by the manual of operations for the master station circuit.

Under the master forecasting plan, the surface (sea-level) chart is the only one which is analyzed regularly from raw data in the satellite stations. The sea-level analysis for ocean areas, upper-air analyses, prognostics for all levels, and auxiliary diagrams transmitted by the master station are used without modification *unless conflicting information is at hand.* The italicized clause is important. Weather Service authorities are agreed that the distribution of master analyses and forecasts does not relieve the field forecaster of any responsibility. If a forecaster has reason to disagree with master transmissions, he is required to correct them by reference to the raw synoptic data, which is still sent out for that purpose. The master station primarily seeks to perform for its satellites many routine tasks normally duplicated in each weather station, rather than to interfere with the independence of their analyses and forecasts.

In a time of critical personnel shortage, the master forecasting plan multiplies the forecasting aids available at understaffed weather stations. During the summer of 1945 in the 23d Region, a class "A" weather station often had only three forecasters and five observers. Though everyone worked overtime, it was impossible to prepare enough auxiliary charts, or even to use certain analytical procedures for the charts which were drawn. Once the master system was introduced, the desired auxiliary charts, prepared from the most complete data by specialists who were not pressed for time, were always at hand. Overtime for observers at the satellite stations was slashed. The forecasters, relieved of several routine duties, found more time to refine the analyses and forecasts of particular interest to their station.

In normal times, the plan will save man hours without sacrificing efficiency. Even though a master station requires an exceptionally large staff, the reduction in personnel over the network as a whole may be considerable. For example, a class "A" station acting as a satellite can provide a complete service with only four forecasters and six observers.

Synoptic analysis is rapidly becoming more complex, another trend which has created a demand for heavily-manned stations. On the other hand, it is unlikely that local forecasting will ever be eliminated. In view of manpower limitations, the master plan is a way to implement the extensions and refinements of analysis while leaving ample room for independent forecasting at many stations.

In master system practice, the teletype has not been ideal for transmitting chart analyses. Installation of a complete facsimile network would represent a definite improvement. Facsimile equipment today, however, is somewhat lacking in speed of transmission and detailed definition of the reproduced copy. In the future, improved facsimile (or television) probably will become available for use by the weather service. Then the master forecasting plan will offer even more attractive possibilities.

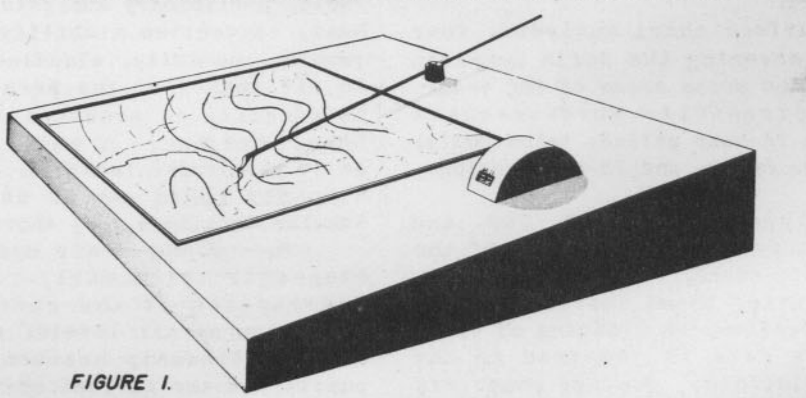
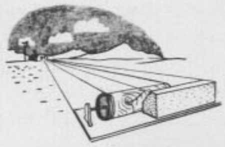


FIGURE I.

This ***Map Analysis Encoding Machine*** was developed by Sergeant Arthur C. Ganger for the master station at Peterson Field. When the pointer is placed on a weather map at a significant point, its latitude and longitude are given by the dials at the right.



THESE ARE THE FAX

by Captains Melvin Schlessinger and William Stokes

Several recommendations for achieving a greater unity, completeness, and precision in synoptic analysis have recently been opposed because they would require more man-hours than are available. The obvious answer, now that manpower deficits are pressing, is to increase the staffs and activities of certain weather stations at the expense of others. In consequence, it may seem that some installations must be closed---a step which would sacrifice some opportunities for a local approach to forecasting and for a man-to-man briefing. However, the transmission by facsimile of completed weather charts from a master station may permit field weather units to perform superior services with fewer personnel.

Seven facsimile networks currently are being operated by the Weather Service, within the United States and abroad, in modified versions of the Master Forecasting Plan (pages 1, 2). This use of facsimile ("fax" to the trade) avoids the teletype difficulty of coding, decoding, and replotting each weather analysis.

Fax transmissions provide directly all of the desirable charts, prepared at a master station which is staffed by specialists and is supplied with extensive data and facilities. With facsimile, a class "D" station can have analyzed charts and prognostics available for possible using agencies, even though it lacks the services of a forecaster. A class "C" station can have continuity maintained at night, ready for the forecaster when he comes on duty. At fully-manned class "A" stations, weathermen can refer to certain charts which they haven't been able to prepare (the isentropic chart, the θ_e-change charts, oceanic analyses, and so on). Stations which service mass flights can select a special facsimile reception, "Timefax", which produces directly a master copy for a ditto machine. And it is possible to receive photos of weather charts, as positives or as negatives which can be reproduced in a number of conventional prints. All of these advantages can be obtained for facsimile's insignificant cost in manpower.

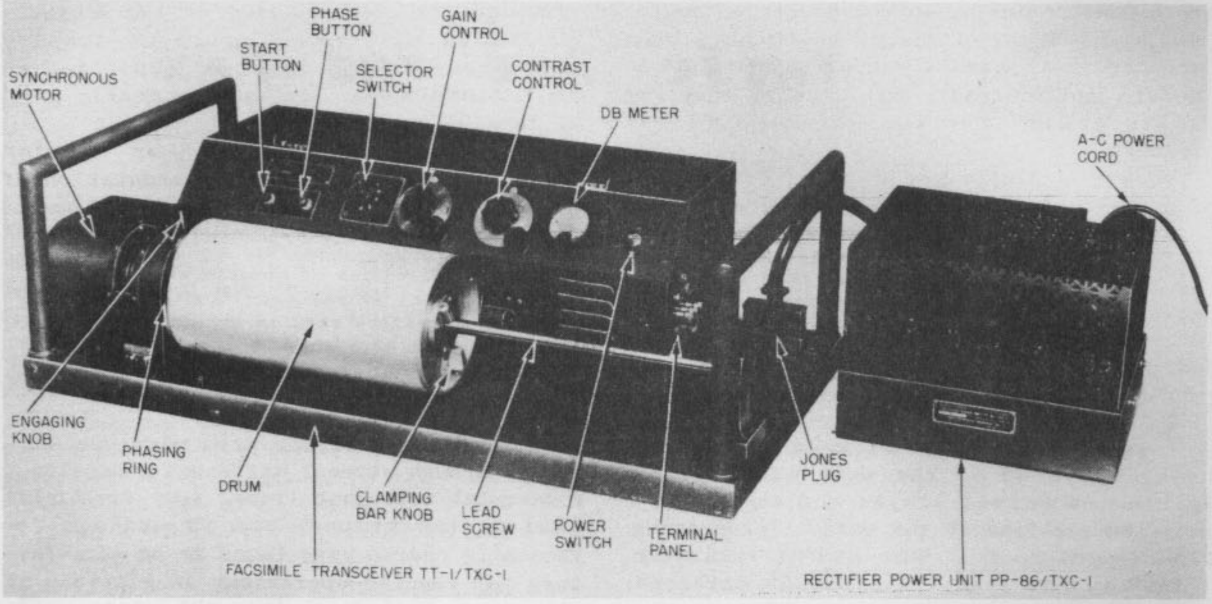
Extensive field tests have demonstrated the merits and the practicability of facsimile service in weather network operations. The first model rugged enough for Army duty was tested for six months in 1942 on a circuit from the Joint Weather Central in Washington, D. C., to Presque Isle, Maine. Four synoptic and several auxiliary charts each day were transmitted over the 700-mile circuit, with only two minor failures in half a year.

Later, the AAF Center tested facsimile's weather role. Over a five-station net, fax transmissions were made successfully through several different channels: commercial telephone lines, Army field wire laid on the ground, and FM radio. The facsimile charts were found to be satisfactory for regular operations in stations of all types, including class "D" mobile units, using either portable generator or commercial power. All fax equipment is essentially fragile, but the relative durability of *AN/TXC-1* was proven by its survival during test movements over Florida roads.

Facsimile weather transmission moved out of the experimental stage when it was established in the ETO. In the last days of Nazidom, a ten-station facsimile network was linking certain AAF headquarters in Britain, France, and Germany. The net operated continuously, transmitting 72 charts every 24 hours---analyses, prognostics, flight cross-sections, briefing charts, and so on. In fact, at some stations weathermen forecast for clearances on the basis of facsimile material alone. With an eye on the growth of commercial and private flying, the CAA already is installing facsimile nets in the United States to provide standard, inexpensive, and adequate weather service to a host of satellite fields.

Facsimile Set AN/TXC-1, which has been designed primarily for weather services, can be operated in the receiving station by unskilled personnel. Civilian girls performed the chore at Presque Isle. Nevertheless, a general view of facsimile from the technical side is both instructive and interesting.

Whole images cannot be sent instantaneously by facsimile. Instead, they must be divided into elemental areas, about .01 inch square, for each of which a characteristic impulse is transmitted in turn. This process, called scanning, is reversed at the receiving set. The smaller the elemental area, the more distinct the final image but the longer the time required.



For *Facsimile Set AN/TXC-1*, a balance is struck between speed and definition. A 12" x 18" weather chart is divided into 2,109,600 elemental areas and requires 19 minutes for complete transmission.

The chart to be sent is mounted on a drum (see photo above). During transmission, this drum spirals at a predetermined speed: it moves slowly from right to left, .01 inch per revolution, while it is revolving 60 times per minute. [The dimensions of the drum limit the size of the image which can be transmitted in one operation, 12" x 18" for the *AN/TXC-1*. Larger charts are sent in sections and are reassembled with transparent tape in the receiving station.]

Meanwhile, a light of constant intensity is focused onto the drum. Some of this light is reflected into a photoelectric cell, more from the bright areas of the image than from the shadows. The reflected light is transformed into electrical energy in the photocell, amplified, and transmitted as a sequence of continuously varying signals.

At the receiving end, the signal is again amplified. In one process it is passed through a tungsten stylus, then through *Teledeltos* recording paper wrapped on the moving drum, and thence to the ground. The Teledeltos paper has a metallic backing to insure good contact with the grounded drum, a middle layer of carbon, and a whitish top layer of cornstarch. A spark from stylus to drum burns the starch, exposing the carbon layer underneath according to the amplitude of the incoming signal. If the signal is strong (from a dark area of the original), the starch is completely burned off; if weak (from a light area on the original), the starch is not burned at all. Half tones are recorded by partial burning. Although the original may be colored, it is received only as black, gray, and white. Consequently, the various representations on charts to be received on Teledeltos paper should be symbolic and in black.

There is also a photographic process which can be used with *Facsimile Set AN/TXC-1*. In this case the signal current passes through a "crater" or recording lamp, which varies its light in response to changes in the signal. The beam from the lamp is focused on the revolving drum, wrapped this time with photographic film. The varied intensities of light produce a latent image, which is developed in a regular dark-room procedure.

Still a third medium for recording on *AN/TXC-1* is *Timefax* paper, on which a ditto inking system has been substituted for the carbon layer of Teledeltos. When the protective coating of starch has been burned off during reception, the Timefax can be used directly as a ditto master sheet to reproduce a number of copies.

Teledeltos reception avoids the darkroom complications of photography and is complete when the recording is finished: definition and contrast, however, are mediocre. Hence, the chart to be transmitted by this process should be plotted with oversized and uncrowded numbers. Although photo reception demands the extra facilities, precautions, and time (10 minutes) necessary to develop and dry the copy after recording, the contrast and detail of photo charts are very good.

Either negative or positive photos can be received, depending on the number of copies desired. Dittoed charts which have been produced from Timefax reception are poor in detail and contrast, but usually they are satisfactory for inclusion in flight folders.

The Facsimile Set *AN/TXC-1* consists of four major components:

The *Rectifier Power Unit PP-86/TXC-1*, which operates from any commercial source of 90 to 130 volts at 50 to 70 cycles of alternating current.

The *Facsimile Transceiver TT-1/TXC-1*, which contains electronic circuits, optical systems, drum, and lead screw.

Table MT-252/TXC-1, upon which the other equipment is placed when in use.

Photographic Equipment PH-549/TXC-1: bottles, chemicals, and photographic paper.

Normally, AACS operates and maintains the facsimile sets at master stations. Weather charts are given to AACS operators according to a pre-arranged schedule, for immediate transmission. In satellite weather stations, receiving sets are operated by weather personnel, but are maintained by AACS technicians from the nearest AACS station. These men work on a regular preventative maintenance schedule and are available for immediate call in case of emergency.

Without casting any reflection on the operational reliability of fax equipment, there are certain malfunctions which should be recognized. If the receiving drum rotates at a different speed from that of the transmitting drum, the picture received will be distorted. Such non-synchronous operation warps rectangles into parallelograms ("skew"). Synchronism in the *AN/TXC-1* is obtained to one part in 100,000 by tuning fork control of the motor speed at the transmitter and at the receiver.

If operation starts when the two drums are out of phase, the facsimile chart will be split into two halves, and the image of the clamping bar will appear somewhere on the recording paper. The receiving and transmitting machines are "in phase" when their respective clamping bars pass the optical systems at the same instant. Phasing is accomplished in the *AN/TXC-1* by a special circuit incorporated into the receiving machine to prevent rotation of the drum until a phasing pulse is received from the transmitter.

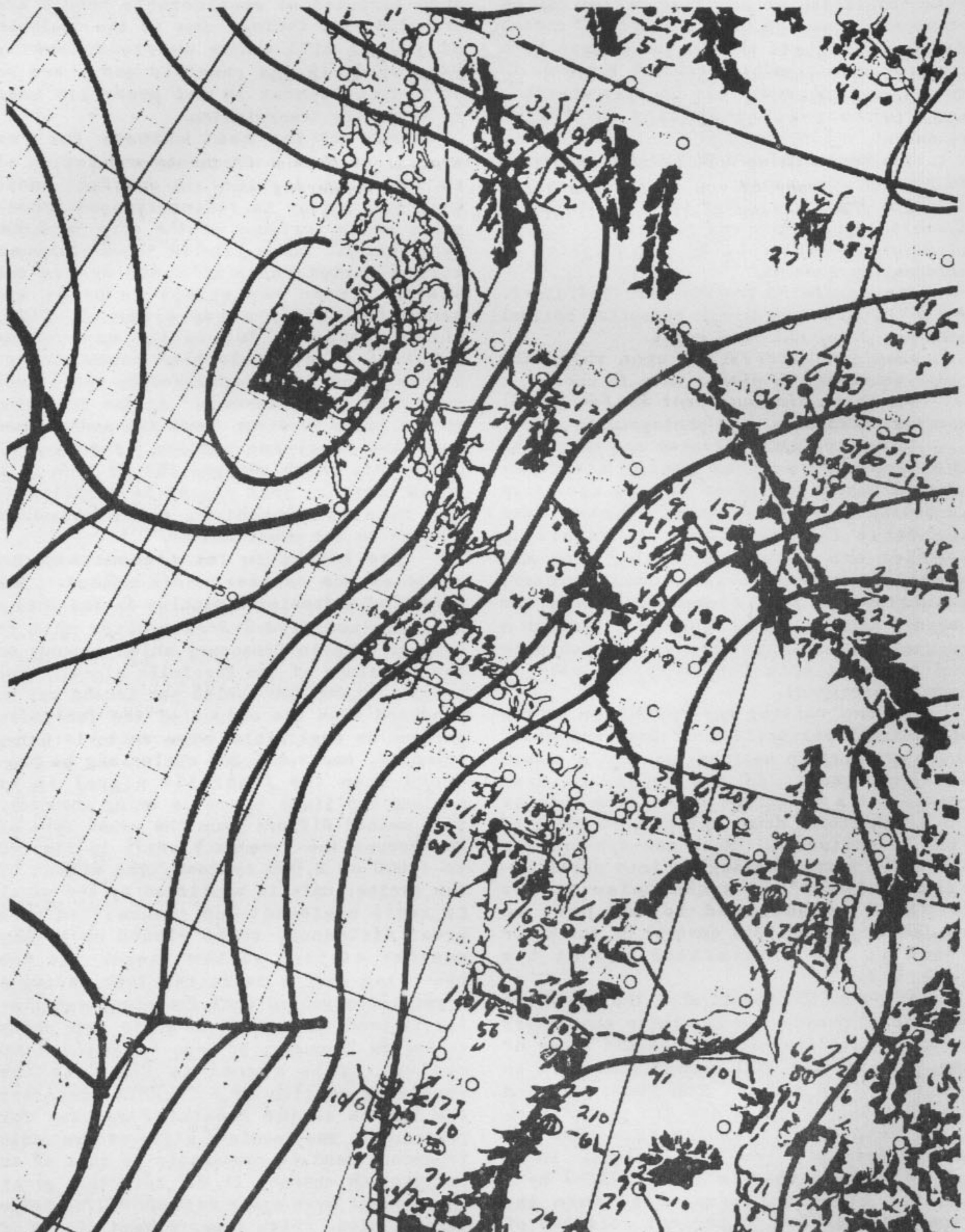
Facsimile signals may be conveyed from transmitter to receiver in several ways. A telephone channel normally is satisfactory. Transmission by amplitude-modulated radiotelephone is suitable, except that most such circuits of considerable length are troubled with fading. One or two decibels of fading will cause spurious density variations in the received copy, and so AM radiotelephone is not generally used in facsimile transmission.

One of the best methods for fax transmission is a frequency modulation of an audio sub-carrier. A constant audio tone emitted by AM radiotelephone represents white portions of the copy (a 3,000 cycle note). Lower pitched tones represent darker shades, down to 1,800 cycles for black. These variations in pitch are generated within a converter, *CV-2/TX*, whose output is fed to the microphone input of a radiotelephone transmitter. Transmission is accomplished by radio just as for any voice message. At the receiving end, a radio receiver feeds the audio tones into the receiving portion of a *CV-2/TX* converter, which changes the FM tone into an AM signal. This signal is supplied to the facsimile machine, which prints a picture in the usual manner.

The latest in fax transmission by radio is the *carrier shift* method. The output of a facsimile machine is fed into a slightly-modified *0-5/FR* exciter unit to produce a radio frequency which depends on the amplitude of the facsimile signal. For example, 2,000,000 cycles per second may be produced when the output of the facsimile machine is negligible (when white is being scanned), and 2,001,200 cycles may be produced when the facsimile signal is at maximum amplitude (black is being scanned). This method differs from the usual type of FM because the frequency shift is limited to 1,000 or 2,000 cycles. The output of the exciter unit is amplified by the usual CW radio equipment and transmitted over great distances, to be picked up by any weather station within range. At the receiving end, a radio receiver having a crystal-controlled beat frequency oscillator is used to produce an audio tone which varies in frequency between 1,800 and 3,000 cycles. This signal is fed into the receiving portion of a *CV-2/TX* converter and thence to the facsimile machine for recording. The required width of the radio frequency band is comparable to that of an ordinary CW channel (1,200 cycles), a great improvement over other methods of facsimile transmission, which require band widths of 5,400 to 6,000 cycles.

The problems which must be overcome in radio facsimile transmission are caused by fading, multipath, and noise. Fading is successfully eliminated by the limiting action of the *CV-2/TX* converter. Both

(concluded on page 25)



This is part of a surface chart received by the photographic facsimile method over a 500-mile circuit. The chart used for transmission was a conventional one, with colored fronts and pressure-center labels. Sometimes, however, in preparing the master chart for fax transmission it is advantageous to use black ink throughout, to cross-hatch areas customarily designated by colors, to use graphical symbols for colored lines, and to make all numbers somewhat bolder and larger than usual. Where the transmission channel is very poor, it may be desirable to overprint significant weather areas of the chart with written words of description.

Col. Yates is the Chief, AAF Weather Service

Our Future

by Colonel D.N. Yates

Now that the war is ended and reconversion to a peacetime organization is being accomplished as rapidly as possible throughout the Army and Navy, many of you in the Weather Service are wondering what the future offers in the field of military meteorology as well as in civil life. Although I am unable at present to state with certainty the answers to all of the inevitable questions, I am sure that a general review of the policies approved and proposed will be helpful. One thing we do know is what we would like our Weather Service of the future to look like, and I pass that picture on to you for what assistance it may be to you as individuals in making your own decisions.

There is no question but that a permanent military weather organization of several thousand must be maintained. Moreover, the officers of the AAF Weather Service should be primarily meteorologists. Provision must be made for advanced education and research leading toward masters' and doctors' degrees. Weather officers should also be permitted to attend military schools of the other branches and even serve limited tours of duty outside the Weather Service to familiarize themselves with the agencies which use weather information---thus to become well-rounded officers. All officers of the permanent Weather Service should be eligible for all command and staff positions commensurate with their grades, regardless of whether or not they are pilots. A limited number of rated officers will be trained and detailed to the Weather Service for periods not to exceed four years.

For our permanent weather officers I naturally look first to the present group of wartime meteorologists. Provision will be made for commissioning these officers in most grades over a three to five year period until a regular peacetime strength is reached. In addition, graduates of the U. S. Military Academy will be trained in limited numbers and will become eligible for assignment to the Weather Service. Finally, a course in meteorology for aviation cadets should be maintained to provide the very necessary reserve complement. Some of these reserve officers will be commissioned as regular second lieutenants in the AAF Weather Service, upon passing a qualifying examination. Graduates of recognized courses in meteorology at civil institutions who have completed a prescribed ROTC course should also receive reserve commissions.

There must be comparable opportunities for enlisted personnel. I am not convinced that our use of enlisted men in the Weather Service is entirely satisfactory. This problem will be thoroughly reviewed, and consideration will be given to opening all noncommissioned grades to weather observers and technicians. Utilization of enlisted men as forecasters probably will decrease, but in compensation more opportunities should be available for enlisted forecasters to win reserve and regular commissions.

Research and development in procedures and in equipment will receive top priority. Fortunately, opportunities will abound for our regular personnel to embark upon advanced study in meteorology and allied sciences. Problems involving the atmosphere are of supreme importance in nearly all Air Force projects. Unless we maintain a group of qualified scientists in all phases of atmospheric physics, we will be shirking our clear responsibility.

That is the generalized picture. The functions, actual and potential, of a military meteorological organization have only been touched upon during this war. I am confident that with a policy following the lines indicated here, the future of a meteorologist in the AAF Weather Service will be anything but dull.

THE NAVY WAY

by Lt. T. C. Hagins, Jr., USNR

This article is from a talk to the AAF weathermen in Asheville, N. C. As a preliminary, Lt. Hagins said, "This discussion has been prepared from my personal observations and from conversations with others. My remarks do not necessarily represent the official opinion or policy of the United States Navy.

In the Navy we never hear the word "meteorology"; it is always "aerology". Perhaps some admiral found the longer word a tongue-twister, perhaps it was the idea of saving time and space (but that doesn't sound like the Navy), or perhaps we just had to be different from the Army. Strictly speaking, aerology is that branch of meteorology concerned with conditions of the free atmosphere determined from direct observations. At any rate, our commissioned officers are called aerologists; our warrant officers, aerographers; and our enlisted men, aerographers' mates. Incidentally, only an aerologist does any forecasting.

Navy weather centrals have been set up in Norfolk, San Francisco, Balboa, Pearl Harbor, Guam, Manila, Chungking, and elsewhere. Each central collects the weather information pertaining to its assigned sector and broadcasts reports, forecasts, and canned analyses to ships and outlying stations.

The Navy Weather Central at Pearl Harbor, for example, gathers many hourly reports from significant land stations, from aircraft, from submarines, and from weather ships. The latter are small vessels (for example, a converted pre-war pleasure yacht), each of which has a specified position in the Pacific from where it transmits complete, six-hourly observations. All of the weather reports from the assigned area (except those from secret subs), Alaska and West Coast observations, map analyses, and area forecasts---all properly coded and enciphered---are broadcast on a regular schedule.

The Navy maintains some sort of weather office on nearly every ship afloat. The smaller and less important ships, such as an auxiliary oiler, may have only a few instruments in the care of a quartermaster. He is required to keep the skipper informed of the approximate weather and wind, and that's all. Next in size is the office aboard a seaplane tender, a repair ship, or an attack transport. The complement is one third-class AerM (comparable to a sergeant in the Army). Cruisers carry a second-class AerM (ranks with S/Sgt), and battleships carry a first-class, or perhaps a chief AerM (T/Sgt or M/Sgt). These men use weather central information to keep the captain and the navigator posted on weather conditions every day. Also, they furnish the gunnery officer with ballistic data for aiming the main batteries.

All carriers have rather complete aerological offices, for these are the ships which need and use weather information more than any other. The carrier is the brains of the task force, for in most cases the admiral makes his headquarters aboard a carrier. Rear Admiral Durgin, ComEsCarFor, has pointed out that in times of bad weather the carrier strike is superior to the land-based mission, for carriers can be moved out into zones of operational weather.

"Jeep" or escort carriers (the CVEs) usually have one officer, an ensign, plus three AerM's, and one seaman, a striker under instruction. It has a good-sized office on the main deck, immediately below the flight deck.

First-line carriers (the CVs) and medium-sized carriers (the CVLs) have a full weather staff: one lieutenant (a j.g. who usually receives his promotion to full lieutenant before completing his tour of sea duty), a chief, four other aerographers' mates, and two strikers.

On my carrier the weather office is located on the second deck of the superstructure. Two decks above us is the open bridge, hangout of the captain and the navigator. One deck above that is the admiral's station (the Flag Bridge), with his operations office (Flag Plot). I keep my weight down by dashing up the ladders with pertinent weather information for the admiral in person. Our office has voice box communication with all other units customarily using weather information, from the pilots in their briefing rooms, or "ready rooms", to the commander who directs air operations.

The aerologist aboard a carrier first

of all must determine what weather broadcasts are to be copied, and then prepare a schedule for the radio operator. Is he closer to the Pearl Harbor Weather Central or to the Guam outfit? How many of the Army broadcasts can be picked up? When can he intercept a broadcast from some island base which has its patrol planes sending in frequent weather observations? Where can he pick up an alternate broadcast when the original transmission from the weather central is garbled or blocked-out by static? Incidentally, I have found radiomen most cooperative, but the difficulties in reception are so numerous that there are times the aerologist would almost sell his soul for that wonderful gadget, the teletype.

The radio signals received must then be deciphered and decoded. The information from the weather central enables the aerologist or his chief to draw the standard four maps per day. The basis of all ocean analysis in shipboard aerological offices is the "canned map", which gives a clear picture of the over-all synoptic situation.

The broadcasts from weather central also supply us with regular forecasts by their best men for the sector in which we are operating. However, I for one have never been able to use this information to great advantage. In the first place, the forecasts are not detailed enough. And they are of necessity several hours old by the time they reach our office. But more important still, the weather central may be a thousand or more miles away. The greatest benefit we derive from these forecasts is to use them as a check on our own opinions and ideas.

The aerologist at sea must rely on his own observations. The scarcity of reports means that a complete and detailed synoptic picture is impossible to obtain. The aerologist spends time on the bridge or flight deck watching clouds move and develop, noticing any change of wind direction or intensity, and keeping an eye on rain squalls. In this way he is the first to detect weather changes, and also he gains a "feeling" for the weather---this last factor is not to be taken lightly, especially in the Pacific. Many a time I've heard Captain Lockhart, the Navy's senior man in Weather, tell his inexperienced ensigns to keep their eyes on the sky. He insists that accurate observation of clouds is of prime importance.

The aerographers' mates aboard a carrier make hourly observations 24 times a day. A unique problem is to compute the true surface wind from the apparent surface wind velocity and the ship's course and speed. Frequent and accurate determinations are necessary, because the entire fleet turns into the wind when the carriers are to launch or recover their aircraft. An unobserved wind shift or an error might require a complicated change in course by many great ships.

The winds aloft are determined several times a day, especially when aircraft are to be launched on a long-range mission. A 16-inch balloon with a 1,000-foot-per minute ascent rate is used, so that the balloon can be followed to high levels even when the ship is speeding up wind. A pibal sounding at sea is complicated by the fact that the ship's course and speed enter into the computation.

Radiosonde observations from shipboard have proved to be impractical because the reception of signals is poor. There is another reason which also discourages the use of radar for winds aloft observations: the location of the task force might be disclosed if the enemy should discover U.S. raob transmitters or radar reflectors floating in the sea. Many carriers were originally equipped with radiosonde receptors which now have been removed and installed on islands.

Another source of information, used often with good results on a carrier, is the report submitted by the weather conscious pilot upon his return from a mission, whether combat or patrol. However, neither these reports nor any other may be transmitted from a carrier because of the requirement for keeping radio silence. In any event, standard logs are kept and are submitted monthly to the Bureau of Aeronautics in Washington.

The main forecast is issued around mid-afternoon, based upon the synoptic chart, local observations, and pilot reports. Periods covered are "tonight" and "tomorrow". Distribution is made to high-ranking officers, bulletin boards, and briefing rooms. To the captain and to the admiral, the aerologist usually presents his ideas and charts in person. Incidentally, in carrier forecasting there is always the problem of determining where the ship will be 12 or 24 hours hence. The navigator is helpful, except for the many occasions when he himself has not the slightest idea of contemplated movement.

The aerologist also makes an early morning forecast. He must be on the job two or three hours before sunrise to evaluate last-minute reports and to verify his prognostication of the previous afternoon. He then issues a short, concise forecast for the next six or eight hours in which he strives for exactness and pinpoint accuracy rather than generalities. This forecast is especially valuable to pilots and to the Air Operations Officer in "Air Plot", the nerve center for flight operations. (That office always knows the location and condition of every plane, whether on hangar deck, flight deck, or in the air.) Weather information is relayed to the pilots through Air Plot, and it is the Air Operations Officer who briefs the pilots. He usually is a pretty good weatherman himself, as well as an experienced aviator.

The aerologist, in personal conference with the admiral, the captain, or the navigator, is sometimes asked to make important decisions; ne may even be asked to guide the ship and determine its future movement. The ship may need good weather and moderate winds for the launching and recovery of aircraft; or the exact opposite, a low overcast with rain squalls, for protection.

Most favorable for flight operations is a relative wind of 30 to 33 knots. With a true wind of 15 knots and the carrier steaming into it at 15 to 17 knots, conditions are about ideal. With a stronger true wind, the carrier must slow down, thus presenting a better target to the enemy. On the other hand, acceleration to a high speed is a slow process. With a light wind or no wind at all, the carrier must use all its boilers and consume fuel at a tremendous rate to add those last few knots of top speed. The small carriers (CVEs) simply cannot launch a loaded plane in a light wind, since the maximum speed of the CVE is only about 19 knots. Needless to say, a steady wind is much more to be desired than a gusty one.

An unrestricted visibility usually is preferable, but I've seen operations when it was only one mile in rain. Visibility is not so important in launching, but it certainly means a lot in the recovery of aircraft. A rain shower is dangerous; not only does it reduce visibility, but also it makes the flight deck slippery. We would always like to have a 4,000-foot ceiling, but 2,000 feet is not bad, 1,000 feet is not a serious handicap, and less than that is flyable. In fact, like visibility, you never know how little you can manage with until you have to try it. Waves produced by a moderate or even a fresh wind are of no concern, but a swell is a different proposition. A carrier is topheavy to begin with, and even a moderate swell from any direction is troublesome, more so for the large carrier than for the small one.

At this point I'd like to mention that radar has more than once been valuable in our weather work. Precipitation will return an impulse sent out by the radar gear, originating an echo which makes a scope image different from that produced by a land mass or another ship. Experienced operators can detect a storm many miles away, can determine its center of activity, and its approximate area and height. They can also see through a concentration of storms and tell us what is on the other side. There have been many occasions when my carrier, operating in a zone of squally weather and finding conditions dangerously close to unflyable, has been able to locate a nearby area where the clouds were fewer and the squalls more thinly scattered. With radar we could more or less play games with rain squalls. Radar Plot would pick out a well-defined squall, plot its successive positions, and determine its path of movement. Thus we dodged storms. On other occasions, finding ourselves in the midst of a widespread squall, we chose the easiest way out with the help of radar.

The aerologist frequently gets valuable help from climatological data. In addition to his own studies, he is furnished with papers from the Fleet Weather Central and has access to the secret operational plan of his own task force, which plan contains a section on expected weather conditions. Also, he has access to numerous Army phamplets and to some British publications.

After making his study and before arriving in the unfamiliar region, the aerologist confers with the ranking officers aboard and describes to them the weather most likely to be encountered. He then briefs the Air Groups and gives the pilots, in non-technical language, a picture of the weather they are to fly in. After an operation, the aerologist prepares a summary of the weather actually encountered by his ship and his planes. He lists specific data and shows how weather helped or hindered flight operations. This report is official and is made a part of the campaign history.

As you know, the Western Pacific in the latter half of the year presents one weather hazard which dwarfs all others by comparison, the typhoon. A typhoon warning service is now set up which should be adequate. All advisories and warnings are originated either by the Fleet Weather Central or the Army Weather Central, on Guam. Careful liaison is maintained by telephone and teletype between the two weather centrals to avoid broadcasting of conflicting forecasts. If agreement cannot be reached by routine means, then the matter is arbitrated, and a joint decision made which is used as the basic fact in all broadcasts.

Maximum effort is made to obtain adequate reports in the vicinity of a typhoon: Army weather reconnaissance squadrons and our Pacific Fleet search planes are used, surface craft in the vicinity send in reports, and special flights are made from island bases. An advisory is issued as soon as practicable after the disturbance has been located. Warnings are then issued every six hours subsequently, for positions plotted at standard map times. The delay is one hour, or two hours at the most. Fleet Weather Central is responsible for warning all ships of the Pacific Fleet, all merchant vessels in the area, and all Naval Commands shore-based in the Western Pacific theater.

At this point, let's turn from what the Navy can do and should do with its weather information to a few illustrations of weather influences on naval combat operations.

Weather was a vital factor in the Battle of the Coral Sea. Our task force of three carriers and many other vessels, after refueling at sea on May 6th 1942, proceeded northwesterly to encounter a cold front that night. In the cold air there was a stratocumulus overcast, studded with rain squalls. By daylight there were breaks in the overcast, and our carriers sent out scouts to search an area of a 250-mile radius. One scout turned back because of bad weather; and it so happened that two Jap carriers were hiding under the low clouds of his sector. However, another scout reported other enemy vessels in the clear. Our carriers then launched an attack group, which sank a large carrier plus a light crusier. The Japanese counter attack failed because our ships were hiding under the overcast.

That night, our ships steamed southeastward and out of the zone of bad weather. Early the next morning our scouts located the two large carriers missed on the previous day. An attack group was launched but had trouble finding the enemy carriers, which were under the front. Only one was sunk; the other, though damaged, got away in a large rain squall. Then land-based Japs came for us while we were sitting out in the clear. The mighty *Lexington*, a destroyer, and a tanker went down.

The Navy used weather information to better advantage in the Guadalcanal campaign. In the Southern Hemisphere's winter, cold fronts pass over the Solomons on the average of one per week. One was located over Australia on August 1st and was forecast to reach Guadalcanal on August 6th. Our task force, assembled in the Fijis, steamed westward, then northward, intending to rendezvous with the front and screen our approach under frontal weather. We met the cold front as scheduled on August 5th. The next day there was no U.S. air activity, but more important there also was no Jap reconnaissance. Then the cold front passed; the weather cleared; and our task force was able to get fixes, round the western end of Guadalcanal, and make landings at daybreak of August 7th on Guadalcanal and Tulagi. There was a calm sea with no surf or breakers on the island's lee side, where 10,000 men and supplies were quickly put ashore to effect a complete surprise.

Later on, however, the weather at Guadalcanal cost us a carrier. Torrential rains were bogging down the Henderson Field runways one day when a Jap fleet was approaching. The AAF's heavy bombers could not take off, so we had to send our surface ships alone to intercept the Japs. The battle of the Santa Cruz Islands resulted. Guadalcanal was saved but it was a costly victory: our task force was caught out in the clear and lost the *Hornet* plus several smaller ships.

The first carrier raids on Tokyo were made in February of 1945. For four days our carriers and screening ships were very near Japan, under a low overcast sky, but not one of our ships was attacked by Japanese. Either they could not find us, or else they were kept a little too busy on their home island. The carrier planes had found partly cloudy skies over Nippon with conditions favorable for action.

Some few days later the *Saratoga*, on which I spent quite a few months, was critically damaged off Iwo Jima. After two hours of concentrated attack by suicide dive bombers---with seven direct hits, with terrific damage by fires and explosions, with most of its guns knocked out, and with a dangerous list---she began a withdrawal to the south. Four hours later, the Japs came out for the kill, with twenty planes clearly visible on our radar. Extremely vulnerable and almost helpless, the gallant *Sara* was saved by an overcast of very low clouds. The Japs could not find her, even though they were practically overhead.

Yes, the Navy has from the beginning tried to use available weather information, both in planning and in operations. There have been mistakes, it is true, but on all occasions the weather has been given a prime consideration.

METRO ASPECTS OF BOMBING

by Lt. Morris Hendrickson

The following article is primarily a revision and an expansion of *Weather Division Report No. 922*, of the same title, which was written by Capt. R. A. Porter.

At present, the AAF in visual bombardment generally uses the "synchronous method" with an M-series bombsight. The course, the ground speed, and the altitude remain fixed during the bombing run. The bombardier feeds certain data (functions of air speed and absolute altitude) into his bombsight by adjusting several knobs. Then he peers into his telescope and "synchronizes" the bombsight, thereby accounting for the ballistic effect of the wind at flight altitude. At this point the bombsight takes over control: it keeps the telescope cross-hairs fixed on the target and releases the bombload at a computed time.

This automatic solution of the bombing problem can yield satisfactory results only when a number of conditions are fulfilled. The wind at flight altitude must represent the effective windflow in the whole column of air below the bomber. The atmospheric density at every level must correspond to a standard value. And correct values of altitude and air speed must be used. Table I describes the importance of deviations from these conditions by an example in which the altitude is 25,000 feet and the True Air Speed is 300mph.

Figure 1 illustrates a bombing run (here the wind is assumed to be along the course, in order to simplify the discussion by reducing it to two dimensions). A_1 is the position of the plane at any time prior to the bomb release, A_2 the position at the time of release, and A_3 the position at the time the bomb strikes the target; α is the "sighting angle," β the "dropping angle," and ϕ the "trail angle."

The functions of air speed and altitude which determine preliminary bombsight adjustments are the "disc speed" (5300/duration of bomb's flight) and the "trail ratio" (1000 tan ϕ). To obtain these values, the bombardier consults his bombing tables, which are tabulations of the disc speed and of the trail ratio for a given type of bomb dropped in the standard artillery atmosphere at various values of air speed and altitude.

From Figure 1, it can be seen that $\tan \alpha = X/Y$. Differentiating,

$$(1)\quad \frac{d}{dt}(\tan \alpha) = \frac{1}{Y}\frac{dx}{dt} = -\frac{G}{Y}$$

where G is the ground speed.

Since a constant ground speed, course, and altitude are maintained, $\frac{d}{dt}(\tan \alpha)$ is a constant: that is, the tangent of the sighting angle (α) changes at a uniform rate, $(-G/Y)$. When $\tan \alpha$ becomes equal to $\tan \beta$, the bombs are released automatically.

If t is the duration of the bomb's flight, then

$$(2)\quad R = tG - Y \tan \phi,$$

where R is the range of the bomb. From Figure 1, $\tan \beta = R/Y$. Then from (2),

$$(3)\quad \tan \beta = t\,G/Y - \tan \phi$$

Synchronization of the bombsight establishes the value of $(-G/Y)$, whereas t and $\tan \phi$ are accounted for by the disc speed and the trail ratio, respectively.

The equation (3) is the fundamental one in any discussion of bombing errors. Anything which causes the sight to compute an incorrect value of $\tan \beta$ will cause an error, as will anything which causes the flight of the bomb to be different from that assumed in preparation of the bombing tables.

The following remarks pertain to the sources of error which owe their origin to meteorological factors, in the method of bombing just discussed. Table I shows the comparative effects of the variables entering into the bombing procedure, for several different types of bombs dropped under the same conditions. In preparing this table it was assumed that no gross errors, such as incorrect use of the bombing tables, incorrect setting of the bombing table data into the bombsight, or failure to obtain complete synchronization were involved. The effects presented concern

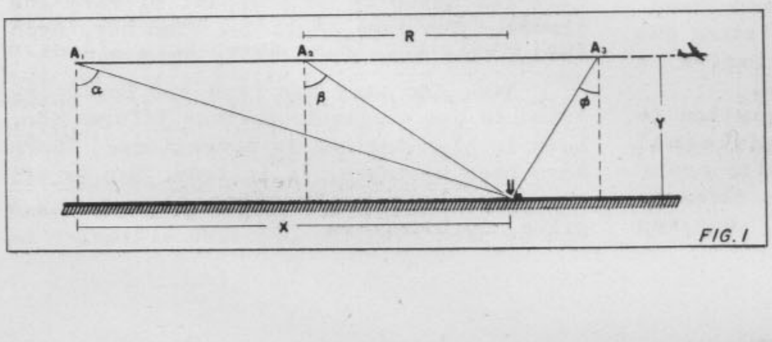


FIG. I

Type of Bomb	Altitude error of 100 feet	TAS error of 1mph	Deviation in density of 1% from standard	Differential Ballistic wind of 1mph
Cluster, Fragmentation 500 Lb., M26 (Immediate Separation)	48	30	30	30
100 Lb. G.P., AN-M30 or AN-M30A1	44	18	18	18
500 Lb. G.P., AN-M43, AN-M64 or AN-M65A1	44	10	10	10
1000 Lb. G.P., AN-M44, AN-M65, or AN-MK65A1	42	8	6	8
1600 Lb. A.P., AN-MK.1	37	4	5	4

Table I: The displacement in feet of the impact point for various bombs when there is a unit discrepancy in one of several bombing factors. Computed for a bombing altitude of 25,000 feet and a True Air Speed of 300mph, assuming no gross errors of a personal or mechanical nature.

the deviation from the aiming point of the center of impact of the bombs. The effect of an altitude error increases with decreasing altitude, becoming about twice as great at 5,000 feet as at 25,000 feet. The other effects decrease with decreasing altitude: they are about 25% of the values in Table I when the bomb is dropped from 5,000 feet.

The determination of each of the variables listed in Table I involves meteorological factors. They will be described in turn.

ALTITUDE ABOVE THE TARGET

The displacement of the impact point caused by an altitude error may be computed easily by use of equation (3). The altitude error does not affect the determination by the bombsight of G/Y, since that is done independently of any data set into the sight. This error does introduce false values of t and tan ϕ, which depend upon altitude. Let t and ϕ be the values of those variables for the true altitude, and t' and ϕ' the values set into the bombsight corresponding to the computed altitude. Then the correct dropping angle would be determined by the equation

$$\tan \beta = t . \frac{G}{Y} - \tan \phi$$

while the one computed by the bombsight would be

$$\tan \beta = t' . \frac{G}{Y} - \tan \phi'.$$

The range of the bomb would be

$$R = Y \tan \beta = t.G - Y \tan \phi,$$

yet it would be released a distance

$$R' = Y \tan \beta' = t'. G - Y \tan \phi'$$

ahead of the target. Hence, the error in its impact point would be

$$(4) \quad \Delta R = R - R' = G(t-t') - Y(\tan \phi - \tan \phi').$$

For the altitude errors normally encountered in practice, the term $Y(\tan \phi - \tan \phi')$ is extremely small, since tan ϕ is insensitive to changes in altitude. Therefore, to a high degree of approximation, the error caused by an altitude error, is simply $G . \Delta t$, where Δt is the time of flight error caused by entering the bombing table with an incorrect altitude. Equation (4) shows that if the computed altitude is too low, the bomb will hit beyond the target; while if it is too high, the bomb will hit short.

Determination of altitude above the target depends upon the relation between pressure-altitude and absolute altitude. The difference between these values may be quite large. For example, the mean value of absolute altitude minus pressure altitude at 25,000 feet over Tokyo in the month of July is about +1200 feet. In January, on the other hand, this same difference is about -200 feet. These differences are equal to the altimeter error if the altimeter is set at 29.92 inches. A considerable portion of the difference between the absolute altitude and the altimeter reading could often be eliminated by having the altimeter correctly set for the surface pressure at the target. In some cases, however, this procedure would lead to an even larger difference. For example, if the pressure at the surface were below standard while that at flight level were above standard (as in the case of a warm Low), using the correct altimeter setting for the target would result in a larger error than if 29.92 inches had been used.

A radio altimeter in a bomber which is approaching a coastal target from the ocean can be used with the pressure altimeter to find the pressure altitude over the target within approximately 100 feet. If the target is far inland, however, such a procedure is not feasible. In such cases, or in any case in which the airplane is not equipped with a radio altimeter, it is necessary to forecast the pressure altitudes over the target in order to avoid gross errors. No extensive tests of the absolute accuracy to which such forecasts can be made have ever been run. However, forecasts of this type were made for the VIIIth Bomber Command in the bombing of Germany, and proved to be much superior to the use of the C-2 Altitude Correction Computer alone. (For a discussion of the methods employed in such forecasts see Appendix III of *Weather Division Report No. 708, Revised)*. Although no exact figures are available, it is believed that such height forecasts are accurate to within about 1% of altitude. This represents an altitude error of only 250 feet in bombardment from 25,000 feet, whereas the error in an uncorrected altimeter reading might well be 1,200 feet or more.

TRUE AIR SPEED

(This section was written by Captain G. E. Forsythe. It is a revision of the corresponding material in *Weather Division Report #922.)*

When values of t and ϕ corresponding to an incorrect airspeed are set into the bombsight, the resulting displacement of the impact point may be computed by use of equation (3). By an argument like that used in discussing errors caused by an incorrect altitude, we find that

$$(4)\quad R = R - R' = G(t-t') - Y(\tan\phi - \tan\phi'),$$

where the notation is the same as before (i.e., t and ϕ correspond to the True Air Speed; while t' and ϕ' are the values corresponding to the computed air speed, which are set into the sight). In this case, however, the greater part of the error is found in the term $Y(\tan\phi - \tan\phi')$, which controls the sign of the error, because the time of flight is relatively insensitive to changes in air speed. If the air speed is computed too low, the bomb will fall short, while if it is computed too high, the bomb will fall beyond.

The standard method of determining True Air Speed (TAS) follows:

a. The Indicated Air Speed (IAS) is read from an indicator which essentially measures the difference between the pitot pressure and the static pressure.

b. The pressure-altitude is read from the pressure altimeter, which essentially indicates the static pressure.

c. The temperature is determined by use of the free-air thermometer.

d. The IAS, pressure-altitude, and temperature are set into an appropriate computer to determine the TAS.

Every one of these operations is subject to one or more errors. Each operation will be discussed in turn, using the same reference letters as above.

a. There are three possible sources of error in the IAS: the pitot pressure, the static pressure, and the air-speed indicator itself.

(1) Errors in pitot pressure are small and may be ignored.

(2) The static pressure is liable to errors resulting in errors up to 5mph in the IAS. These errors may be of either sign.

(3) The mechanical imperfections of the air-speed indicator may cause errors of either sign up to 2 or 3mph in the IAS. The errors (2) and (3) are not ordinarily distinguished from each other, and their sum is called the *position error* of the air-speed indicator. The magnitude of the position error can be determined by flying low over a fixed course, but this procedure is ignored all too frequently. The Calibrated Air Speed is the IAS corrected for position error.

b. The pressure-altitude is indicated by a pressure altimeter set to 29.92 inches. It is subject to two sources of error.

(1) Erroneous static pressure, associated with errors equivalent to 4mb in either direction.

(2) Mechanical imperfections in the pressure-altimeter, which may cause errors of up to 300 feet in the altimeter reading.

Fortunately, the effect on the computed TAS of errors in the pressure-altitude is relatively small, usually less than 2mph.

c. Accurate determination of the free-air temperature involves two considerations:

(1) Free-air thermometers vary in their instrumental accuracy, but bombardiers' thermometers are usually correct to within 2°C. However, in some B-29 aircraft the thermometer readings have been excessive by an average of 3 or 4°C, presumably due to cabin heat.

(2) Dynamic heating causes free air thermometers to read high by an amount proportional to the square of the TAS, amounting to over 7°C at a TAS of 300mph. Since a temperature error of 1°C causes the computed TAS to be in error by nearly 0.5mph, it is important to correct for dynamic heating.

d. The TAS scales on the *E-6B Computer* were designed for low-altitude, low-speed aircraft. The use of the *E-6B* (or of any method which does not allow for the compressibility of air) at higher altitudes and higher air speeds causes the computed TAS to be excessive. The error is about 5mph for an IAS of 200mph at 25,000 feet. Use of the *G-1* or the *D-4 Computer* eliminates all but about 2mph of this error.

For B-29 aircraft it happens that most of the various sources of air-speed error operate in the same direction; all but one cause the computed TAS to be higher than the actual value. For an IAS of 200mph at 25,000 feet (TAS about 300mph), the errors in TAS accrue more or less as follows (these figures are only rough estimates, and cannot be applied to a particular aircraft):

a.	Position error	5mph
b.	Effect of pressure-altitude error	-2mph
c.	Effect of dynamic heating	4mph
d.	Effect of thermometer error:	2mph
e.	Effect of using *E-6B Computer*	*5mph*
	TOTAL	14mph

It has been reported by some squadrons that the TAS computed during their operations have actually been somewhat consistently too high by approximately 17mph. Such an error would cause the 100 lb. General Purpose bomb to fall more than 300 feet beyond the target. However, remedies for all the sources of error are known, which if applied would reduce the TAS error to less than 5mph.

BALLISTIC DENSITY

Bombing tables are calculated on the assumption that a certain relationship exists between density and altitude above the target. Any deviation from this assumption causes a displacement of the impact point of the bomb, and requires a correction. For any given density profile in the atmosphere, a ballistics expert could compute the trajectory of the bomb and thus figure out what the displacement of the impact point would be. Such a procedure, worked in reverse, is used in computing bombing tables. This procedure is not feasible in actual operations, since it is very complicated and time-consuming. In order to make corrections for non-standard density conditions, the *ballistic density* is considered.

At each altitude above the target, the actual density is a certain percentage of the standard density for that altitude. It can be shown that if this percentage density is the same at all levels, the displacement of the impact point will be very nearly proportional to the deviation of the percentage density from 100%. The ballistic density is defined as a single number, expressed in percent, which is such that if a bomb falls through an atmosphere where the percentage density at all levels is equal to the ballistic density, the impact point will be displaced by the same amount as when the bomb falls through the actual atmosphere. The ballistic density is computed by taking an appropriately weighted average of the percentage densities at various levels. The weighting factors depend upon many variables, of which the air speed, the bombing altitude, and the type of bomb are most important.

Since standard densities are referred to height above the target while the actual densities depend primarily upon height above sea level, variations in ballistic density are large when the altitude of the target differs significantly from sea level. The bombing tables present the corrections to trail angle to be made when the target height differs from sea level. The increase of range caused by an increase of 100 feet in the target height for each of the bombs in the bombing problem presented in Table I are shown in the table below.

The value of the ballistic density depends upon the season and the synoptic situation, but these changes normally are not over 5% and reach a probable maximum of slightly more than 10%: they are small compared with the changes produced by appreciable variations in target height.

A ballistic density can be expressed as a fictitious target height. This height will be identical with the geometric target height in the special case in which the actual density equals the standard density at every height above sea level. If the fictitious target height is different from the geometric height, the bombing table which gives corrections to the trail angle for various heights of target may be entered to get a single correction for the effect of ballistic density variations caused by target height and all other factors combined. The fictitious target height is properly used only for computing the effects of density variations, and not

Type of Bomb	*Increase in range for every 100 feet of target height above sea level*
Cluster, Fragmentation 500 Lb., M26 (Immediate Separation)	9.5 ft.
100 Lb. G.P. AN-M30 or AN-M30A1	5.5 ft.
500 Lb. G.P., AN-M43 AN-M64, or AN-M65A1	3.0 ft.
1000 Lb. G.P., AN-M44, AN-M65, or AN-M65A.	2.0 ft.
1600 Lb. A.P., AN-Mk. 1	1.5 ft.

for computing height above the target.

There are smaller effects of density variations which would not be corrected for by the method outlined above. For example, a change in density alters the effect of winds on the bomb, so that wind corrections should depend upon ballistic density. Such effects are extremely small, however, and may be safely ignored, since the resulting displacement of the impact point is probably less than the normal dispersion of bombs of the same type dropped under identical conditions.

Fortunately, the effects of deviation of density from standard are small. Failure to account for the effect upon density of target height above sea level will usually result in bombing errors of less than 200 feet, except in mountainous country. The bombing error involved in other variations of density will almost always be less than 200 feet, and will seldom exceed 100 feet. If these errors are too great, forecasts of ballistic density for 18 hours in advance can be made to within approximately two percent (see Table I).

DIFFERENTIAL BALLISTIC WIND

The assumption implicit in the solution of the bombing problem by the bombsight is that the wind at flight altitude remains unchanged all the way to the ground. Such a condition is almost never encountered in practice, especially when the bombing altitude is high. The effects of winds on bombing are twofold. First, the winds at bombing altitude, through their effect on ground speed, give the bomb an initial impetus with respect to the ground, similar to the muzzle velocity of a projectile. Second, the winds between the ground and the bombing altitude blow the bomb off its still-air trajectory.

The winds of the vertical column of the atmosphere between the ground and the bombing altitude could be replaced by one fictitious, uniform *ballistic wind*. This wind would have the same effect on the displacement of the bomb's impact point as the variable winds actually encountered. The ballistic wind is computed as the vectorial sum of the winds at several levels, each multiplied by an appropriate scalar weighting factor. The *Differential Ballistic Wind* (DBW) is the result of the vectorial subtraction of the wind at flight altitude from the ballistic wind. It is the DBW which should be used in computing wind corrections by the synchronous method of bombing.

The effect of the DBW component along the course of the plane on the range of the bomb may be computed easily by use of equation 3. Imagine a plane flying in still air at altitude Y. Suppose that at all levels below the plane there is a constant headwind of speed w. If G is the ground speed of the airplane, it is also its air speed (since the plane is flying in still air). The bombardier would take from the bombing tables values of t and ϕ corresponding to the value G of the air speed. However, when the bomb leaves the plane, its air speed becomes $(G + w)$, so that values of t and ϕ corresponding to $(G + w)$ give the correct results in computing the impact point of the bomb. Hence, a DBW along the course of the plane is equivalent to an error in air speed of magnitude equal to that of the DBW. The effect of such an error may be computed by using equation (4), where t' and ϕ' correspond to the air speed G, while t and ϕ correspond to the air speed $(G + w)$. This fact explains why the effects given in Table I for air speed errors and DBW are the same in all cases.

The DBW at 25,000 feet over Tateno, Japan, averages about 25mph over the whole year. It is considerably higher in the fall and winter, lower in the spring and summer, and increase appreciably with increasing altitude. Differential Ballistic Winds as high as 100mph have occurred over Japan. Such a wind would produce an error of about 3,000 feet on a 500 lb. fragmentation cluster at one extreme, and 400 feet on a 1,600 lb., Armor-Piercing bomb at the other. Present bombing technique would ignore this error.

Unfortunately, the DBW cannot be forecast with any great degree of accuracy, as shown during an artillery-firing project at Pine Camp, N. Y. At that time winds up to 30,000 feet were forecast and then compared with radar wind observations for verification. The standard vector error of the DBW computed from a forecast wind was slightly over 31mph. This result is based on an analysis of only 18 runs, but it gives some idea of the magnitude of the errors to expect. A verification of forecast winds at 20,000 and 30,000 feet on other occasions gave standard vector errors ranging from 28 to 62mph. It seems clear then, that until wind forecasting techniques improve, some other method must be sought to cut down the errors caused by Differential Ballistic Winds.

The weighting factors used in computing ballistic winds give a great deal more weight to the winds in the upper levels than to those in the lower levels. For this reason, it usually happens that the ballistic wind is very nearly parallel to the wind at bombing altitude, except in those cases where the winds are very light and variable, and hence of little significance. This fact suggests that there should be a high degree of correlation between the ballistic wind and the wind at bombing altitude. Such an hypothesis was tested for climatological data from several localities. In *Weather Division Report No. 882*, for Tateno, Japan, the constants A and B were given for various altitudes, ground speeds, and seasons, such that if w is the speed of the wind at altitude, then $(AW + B)$ is the approximate speed of the ballistic wind. The direction of the ballistic wind was assumed to be the same as that of the wind at altitude. The standard vector errors of the ballistic winds computed by the above method varied from 3mph at 10,000 in summer to 15mph at 33,000 feet in winter.

It appears, then, that an accurately determined wind at flight altitude may be used to get a better estimate of the ballistic wind than can be forecast. However, the determination of the wind over the target poses several tactical and technical problems. Operational reports have shown differences of over 60 knots between winds determined by navigators in different aircraft at approximately the same altitude, time, and location. The various techniques which may be used for the purpose of wind determination in flight are as follows:

(1) *Visual Double Drift*. This technique requires a change of course, involving a loss of time which may be tactically prohibitive near the target. This technique can be accurate to within 5mph, and it is relatively insensitive to errors in True Air Speed (TAS). However, visual double drifts require fixed reference points which frequently are not available under conditions of cloudiness, poor visibility, or oceanic flights. It is also true that some drift meters are unsuited for use at high altitudes.

(2) *Radar Drift*. A "visual" double drift may be accomplished with radar "vision" to eliminate the obstructions of cloud cover and visibility. However, the reference point for radar must satisfy even more stringent requirements and longer flight legs are necessary. The wind can also be determined from a single drift reading and a knowledge of the ground speed, which can be measured by radar without changing course. Unfortunately, this method is fairly sensitive to errors in TAS.

(3) *Successive Fixes*. The method of successive fixes (the "Air Plot") can be employed in many cases where radar or visual drifts are impossible. In an area where Loran is available, the method can be used over water in any weather conditions. Fixes can be obtained by radar from identification of fixed targets as much as 50 miles distant. This method is quite sensitive to incorrect air speed determinations and to variations from constant heading and air speed, but it does not require changes of course.

(4) *D-System Drifts*. Radio-pressure altimetry can determine accurate drifts if comparatively long, straight legs are flown; but this method requires a great deal of time and a change of course. Furthermore, it is useful only over water.

(5) *Use of Bombsight*. The fact that the bombsight, when properly synchronized on a target, "knows" the ratio G/Y may be used to get G if the altitude, Y, is known. From G and the TAS, the wind may be computed. This method is sensitive to errors in both TAS and altitude, however.

All the above methods may be used with success at some distance from the target when there is no problem of avoiding anti-aircraft fire or hostile fighters. The errors of each method are sometimes reduced by having several navigators in a flight determine the wind independently and communicate with the lead ship, which then announces a value for the wind velocity.

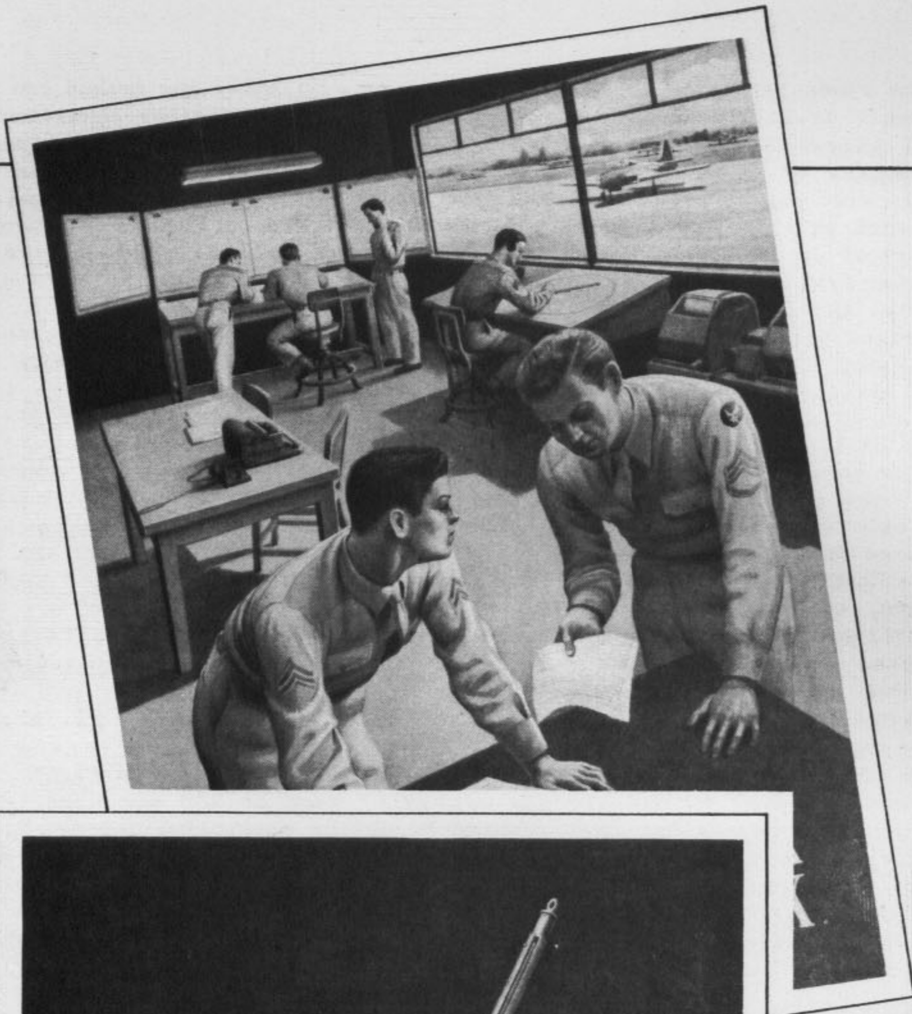
A very promising method of correcting for DBW's has recently been devised. The approximate ballistic wind is assumed to be parallel to the wind at flight altitude and to be of the magnitude given by the formula

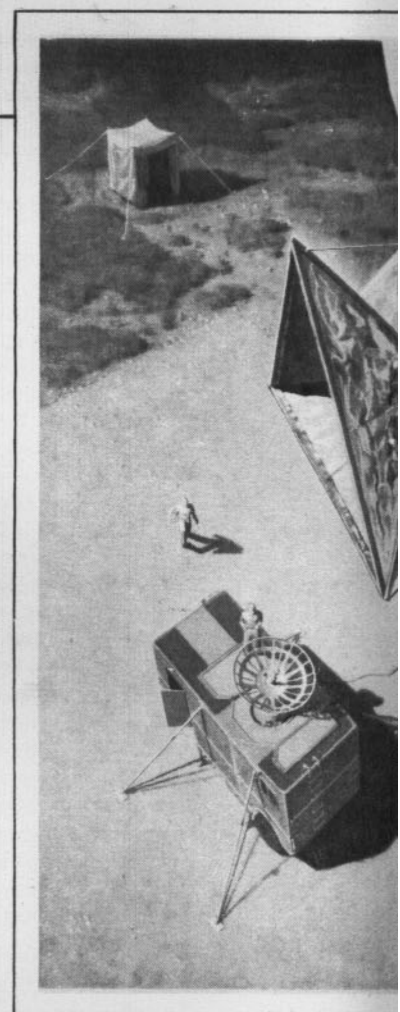
$$w_B = Aw + B,$$

where w_B is the speed of the ballistic wind and w is the speed of the wind at flight altitude. Then

$$\frac{w_B}{w} = A + \frac{B}{w}.$$

The constants A and B change only very slightly with ground speed (and hence with wind speed for a constant air speed), and the constant B is normally very small. Therefore, even a crude forecast or determination of w will give a very good value of w_B/w, especially since only errors in *speed* will affect the ratio. This ratio is used as one of the arguments in a revised type of bombing table, with which the bombardier can make allowances for the DBW by carrying out an equivalent to the present standard operating procedure. Then the DBW correction is performed by the bombsight during the usual synchronizing process. This procedure does not allow for the component of the differential wind at right angles to the wind at flight altitude, but that component is normally very small at high altitudes.

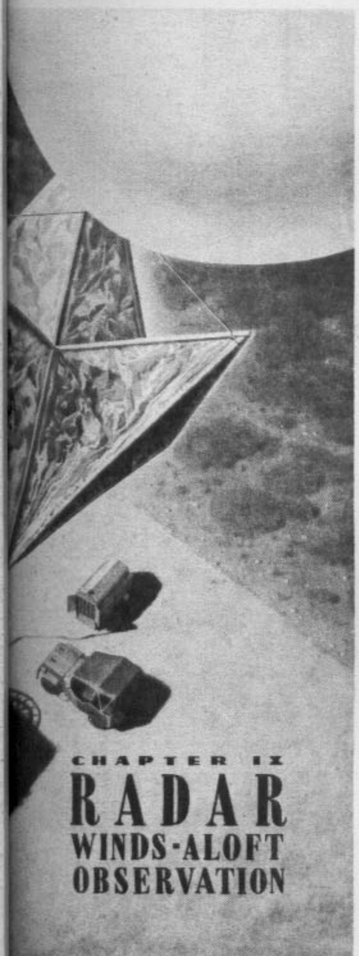


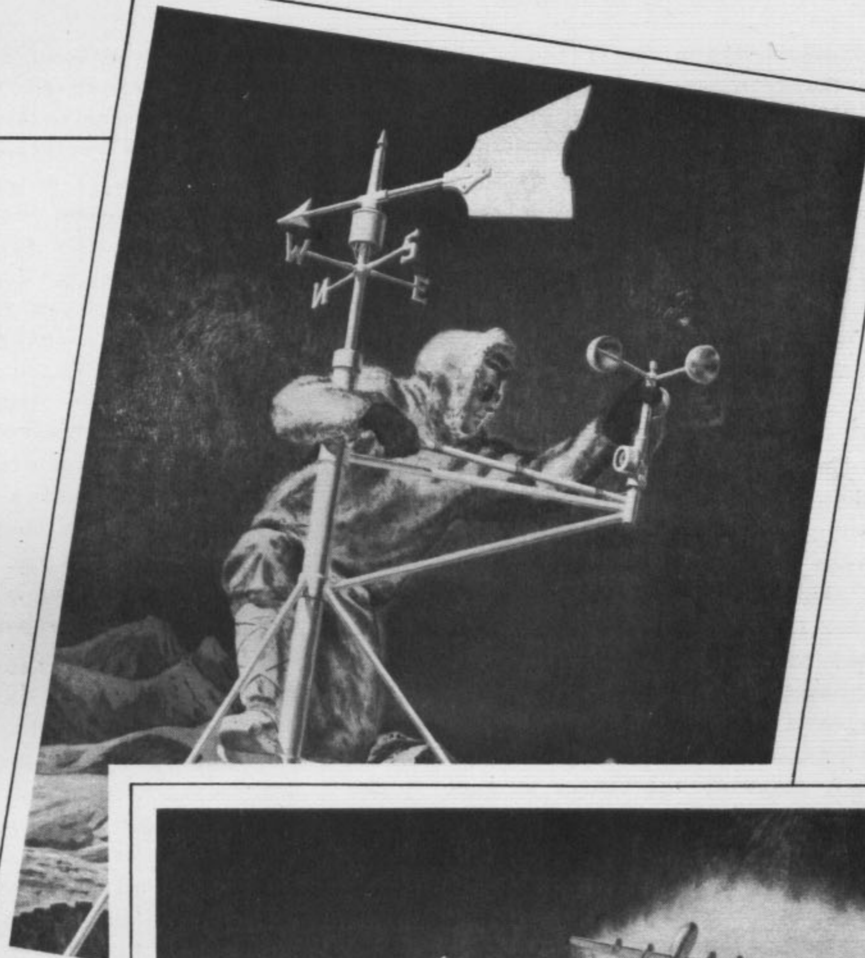


TM 1-235 Weather Stat for the Obse

The new TM 1-235, containin ing procedures than ever before distributed. Superseding the ou 1942 Supplement, the new TM has tables. The pages, bound by a contain double columns, and ar facilitate quick revision.

The manual has 11 chapters, first eight contain basic inform tion, winds-aloft, codes. forms





tion Handbook
rver

more up-to-date information on observ- mmassed in a single volume, is now being dated "Weather Observer" (1942) and its 910 pages, 479 illustrations, and 239 hard cover, are 8" x 10½" in size, e put together in loose-leaf form to

three more than the original book. The ation on instruments, surface observa- , synoptic charts, auxiliary charts, and communication facilities. The last three chapters are new: on radar, ballistics, and arctic observation. These chapters have been added to provide information for observers engaged in specialized work, or liaison work between the Weather Service and other arms. Three appendices cover an inclusive glossary, special tables, and a comprehensive bibliography.

The manual is organized for use both as a text and as an operational or reference guide. For use as a text, some phases of weather observing are repeated throughout the manual so that each chapter gives a complete coverage of its subject. For use as an operational guide, the manual contains a quick cross-reference index which tells the observer exactly where to look for information on a specific item. A special index for symbols is provided in the chapter on codes. Each chapter contains a table of contents and has its own consecutive numbering of pages, paragraphs, figures, and tables so that it can be separated from the manual and used with greater convenience.

Although the bulk of the manual's material has been retained, with numerous revisions, much of the information is new. In Chapter I, *Weather Instruments*, some of the more significant items that have been added, with first-rate illustrations, are aneroid barometers; schematic diagrams on leveling and orienting the theodolite; hydrogen generators; timing and telephone set; wind instruments; radiosonde equipment; mobile and automatic weather stations; and radio direction finding equipment.

The chapter on surface observation has been notably improved by the addition of a series of aerial views of cloud types and a number of unique, air-brushed illustrations on the determination of ceilings and sky conditions. Also new are the illustrations on visibility check points. The art work devoted to this chapter easily makes it one of the most impressive sections in the manual.

Winds-Aloft Observation, Chapter III, gains a number of illustrations on the preparation of balloons for observation; recording runs on plotting boards; use of scales in determining wind direction and speed; and an examination of the double theodolite method and tail method for obtaining winds-aloft data. The codes chapter has been entirely re-written on the basis of code revisions and additions, plus the inclusion of international codes. An innovation has been introduced in Chapter V, *Weather Forms*, by filling in the data on all form illustrations. WBAN Forms 10A, 20, 20A, and 22 are fully explained. The section *Synoptic Charts* has been brightened by the use of color in plotting examples. In the examples given on plotting, the chapter also stresses the placing of cumulative data around a station circle instead of utilizing the circle for just one entry, as was done in the old manual. Also introduced in the chapter is the method of plotting airplane reports and weather analysis transmissions.

A major addition to Chapter VII, *Auxiliary Charts*, is the information on upper air analysis: a discussion of the pressure change chart and the weather analysis transmissions in combined analysis code. This section also includes an explanation of the hodograph. All illustrations give plotted entries and among the new charts shown are ML-124A, 123E, and 123F. The last of the original chapters, on communication facilities, gives the most recent changes in teletype procedures and has been expanded to include other means of communication: i.e., radioteletype, telegraph, telephone and interphone, radio and radiotelephone, and finally, facsimile reproduction.

Certainly one of the prominent features of the new TM is the art work, and highlighting it are the full-page wash drawings that keynote each chapter. Most of these were done by Sgt William Bartell. The writing and editing of the entire manual were under the supervision of Major Elbert F. Corwin.

Revisions and additions to the manual will be made at regular intervals. Complete new pages, explicitly numbered, will be sent out to the field to replace obsolete pages. Some of the new material to be inserted in the near future are the Combined Aircraft Weather Code, the Combined Radiosonde Code, the WRC-8 series of winds-aloft charts, and constant pressure charts.

AIR SUPPORT WEATHER: II

by Corporal Irving Ripps

Part I of "Air Support Weather," published in last month's Bulletin, tells the story of the early experiences in the MTO of S/Sgt Philip L. Voland and other air support weathermen attached to Mobile Unit #2, 12th Weather Squadron. This unit, led by Major David M. Ludlum, was the first weather detachment to post observers with front line infantry divisions to obtain target weather conditions for air strikes. Part I followed these men through their training in Tunisia, their landing in Sicily, and their operation on the beaches of Salerno.

By September 1943, three American divisions in the interior sector had established command posts in the mountains around Presenzano. Fall's bad weather was rapidly moving in, and the air support weather observers became of increasing importance. Voland had replaced Craig with the 45th Division, Brechler was with the 36th, and Van Dyne, a new air support weatherman, joined the 34th Division which was busy on the 45th's right flank. The Nazis had only recently retreated from Presenzano and had taken along with them accurate surveys of such fixed objectives as road junctions and bridges. Every night these and other installations were subjected to precision shelling.

It rained almost daily, ceilings were generally lower than the surrounding mountain tops, and visibility was poor. The weathermen were constantly on the alert to report flyable weather. On several occasions General Clark gave the boys a sample of some vivid swearing while sweating out an L-5 for a 100-mile hop to Anzio (the landings on the Anzio beach had already been made). Once when all the Cubs were staked down and surrounded by a ring of two-and-a-half ton trucks in anticipation of heavy winds, the General, his patience at the breaking point, ordered his plane out and took off. Before long the three-starred L-5 came limping back, rebuffed by powerful headwinds.

Even when the weather did break, our planes still were not able to spot Jerry positions. German artillery was kept hidden in mountain caves during the daylight hours and was wheeled out for firing only at night. After a while the Nazis got a line on our divisional command posts, and air support parties spent many sleepless nights.

"It wasn't only the artillery," Voland says, "but Jerry patrols and snipers bothered us quite a bit, too. They knew all the little hiding places and took pot shots at us whenever they felt like it. Once we were coming back from a late chow when a sniper's bullet tore through the toe of my shoe. That was the closest I ever came to getting a pedicure.

"Even when we had a couple of hours to grab off a little sleep," continues Voland, "Jerry wouldn't let us use our sleeping bags---those mountains were pretty cold and damp. It takes even longer to crawl out of a sleeping bag than it does to crawl into one; and with the Germans sneaking in and out from behind the nearby rocks and bushes we never had time to fool with it. If we had it might have turned out to be our coffin."

Next came the historic siege of Cassino and its famous abbey. Operating in the valley below the city, the Allies were in an extremely vulnerable spot. Every Allied move was observed from the Nazi-held monastery and nullified by artillery fire. Although Allied strategy originally called for the capture of Cassino without damaging the abbey, this plan had to be discarded. Air support observers were posted with divisional parties overlooking Cassino and began sending up-to-the minute ciphered reports to Mobile Unit #2 for dispersal among fighter and light bomber bases in the Naples area. American artillery was called up and began laying down heavy barrages, and whenever the weather permitted, this was followed by dive-bombings. The roof and top story of the monastery crumbled, but that was all. The great stone structure remained immune to further attack.

It became apparent that if the Germans were going to be blasted out of Cassino and the hills beyond, the full weight of the Tactical and the Strategic Air Forces would have to be employed. Weather, never had a more prominent role to play in Italy than it now had at Cassino. The type of weather needed would have to prevail for approximately six hours, from early morning until noon, on the day selected for the operation. Brigadier General Gordon S. Saville, chief of XII Tactical Air Command, assigned the job of naming the day to Major Ludlum and his crew. The operation, in recognition of weather services to ground force tactics, was called "Operation Ludlum" by General Clark.

The weather angle was tough, something that would make any top-ranking forecaster in the SRV program squirm. It was then the middle of February, when the Italian climate offers little in the way of flying weather. Prolonged precipitation and greater than five-tenths cloud coverage could be expected almost daily---enough to seriously hamper air support operations. The stakes were high: on the day selected for the operation, the infantry around Cassino would be withdrawn to be out of range of the bombs, and if the weather should suddenly stall air activity, the Jerries would gain precious territory for which the Allies had fought bitterly.

For 30 consecutive days (contrary to *Time* and *Newsweek* versions), Major Ludlum sweated over the daily maps and charts while Generals Clark and Saville waited for his decision. On March 14, the major picked up the phone and spoke to General Saville. "We can promise you good operational weather for about six hours beginning early tomorrow morning."

The Germans will remember March 15 as the day when Cassino rocked under 3,000 tons of bombs dropped by 1,000 bombers. The infantry took up the march again. But not for long. Halfway up Montecassino they ran into an intense Nazi counteroffensive, which recaptured part of the town and isolated our troops on the mountainside. After holding out for almost a week, the pocketed troops were relieved by elements of the British 75th Division. At this time, if the Allies were considering the possibilities of attempting another drive, they changed their mind. With the onset of daily precipitation, and with the Nazis in possession of the only all-weather road, it would have been impossible to move heavy equipment without bogging down. Once again the battle for Cassino was stalemated.

Back in January, when the Allies had begun to realize that the job of driving the Nazis out of Cassino was not going to be a hands-down affair, strategy was mapped to outflank the enemy and make his position on Cassino untenable. Specifically, the plan called for amphibious landings at Anzio and Nettuno. The operation would require the use of two air support observers. Sgts Wolf and Hunt, both of Mobile Unit #2, volunteered for the job and left to join air support parties in the staging area with the 6th Corps and 3rd Division, respectively. Hunt was to operate from Nettuno, Wolf from Anzio. On D-day, January 22, the two men hit the beaches with the initial landings and in less than four hours the observers back at the mobile unit were breaking down weather reports from the beachhead.

At noon on January 24, a message was received at a fighter base located about 100 miles south of Anzio, requesting a strike over Anzio. The operations officer had a mild fit and strode over to see the weather officer. "What's the matter with that weather guy on Anzio?" he demanded. "His last report said an occluded front was moving in over there. Where's the sense?" The weather officer promised to look into the matter. He got in touch with the communications men and had the thing cleared up in a minute. What happened was that the clouds had suddenly broken up, the sky becoming scattered. Wolf informed the air support officer that the afternoon would be ideal for some light bombing and strafing. (It might well have been a matter of personal concern to Wolf. For the three days he had been on Anzio, he had been subjected to close to 30 German air raids.) The air support officer took a brief glance at the sky and agreed, instructing the communications men to contact the fighter base. But only part of the message got through---the part dealing with the request for air support. The communications equipment had suddenly broken down before the latest weather report could be transmitted.

One of the unfortunate things about the Anzio campaign from the point of view of air support was that bad weather hardly ever hindered Nazi air activity to the extent that it did Allied air operations. The German fighters were based much closer to the beach and could conduct raids almost at will.

"Wolf and Hunt counted 46 enemy fighter attacks during the first week following the Anzio landings," Voland says. "They practically lived with their heads in the dirt. Once a bomb exploded in Hunt's shelter, but he wasn't in it. During that same raid, two bombs landed 10 feet apart and split the trunk of a big tree clean down the middle. The concussion was so terrific it knocked a dozen men out cold."

The weather at Anzio would be so bad at times that communications would often break down and hold up reports for several hours. An example of this took place on the morning of January 26. It hailed, rained, and blew gusts over 40 miles an hour. At 1100 the sky suddenly cleared. The air support officer, upon consultation with Wolf, decided to put in a request to the 99th Fighter Squadron for planes. But the radio had gone dead and by the time it was fixed the sky was rapidly approaching a low, overcast condition. The request was cancelled.

On February 10, the two beachhead air support observers had a good day. Both had received forecasts from the mobile unit that they could expect rain that day. The morning, however, was bright and clear, and following reports to this effect by Wolf and Hunt, Allied fighters and bombers came out to make sweeps on German forward positions. The weather remained good, and air activity continued all that day. It wasn't until dusk that the weathermen noticed a bank of low clouds coming in from the west. By the time the beachhead observations were reporting a low cloud coverage of seven-tenths, the last American dive-bomber had turned home. The rain came at night.

The Russian High, sweeping the Mediterranean area in late fall and winter, was responsible for many a difficult forecast. Heavy rains would be followed by a frontal passage, with consequent clearing weather. Along would come the High to shove back the front, and the rains would resume. The mountainous terrain, battle dust, unpredictable valley fogs, smoke screens, smoke from burning targets, rapid variations in cloud systems often were imponderables. So, in the final analysis, on-the-spot observations from air support weathermen were vital to a true picture of target weather.

On February 15, Mobile Station #7, headed by Captain Valdo Moncada, arrived at Anzio to begin full-scale operation. Their job on Anzio done, Wolf and Hunt boarded an LST for Naples to rejoin M.U. #2. When they got back they found several of the men down with either jaundice or dysentery. Thomas was in the hospital with malaria, and every one else was taking his atabrine religiously. The problem of controlling the spread of intestinal diseases had been bothering the Allied medics since the fall of Naples, back in October. Just before the Nazis had evacuated Naples, they had blown up important installations, among which was the sewage system. The Neopolitans blamed it on the Allies, just as they were blaming the Allies for most of the wreckage strewn over the city, which they believed had been caused by the extensive American and British bombings. The people weren't cooperating with Allied efforts to straighten out the dislocated state of local affairs. Even the matter of disposal of garbage and human waste was being treated in a slip-shod manner.

"The Italians were really sore at us," Voland says. "They went so far as to take it out on the weather unit, too. The kids used the rain gauges for urinals."

In a small town between Naples and Caserta there was an epidemic of typhus. A group of medics went in with their DDT spray guns but were literally stoned out of town. They came back with MP's, who stood guard with rifles while the belligerent natives were subjected to the delousing process.

At the invitation of 5th Army Headquarters, Mobile Unit #2 took up residence on the grounds of a palace just outside of Naples. The palace belonged to a duchess. Evidently she was a pretty game old girl, because amid ack-ack flak and raids by enemy fighter craft, she resolutely refused to give up her wing of the palace. She vowed the army would vacate the grounds before she would, and by and by the army did vacate.

A couple of the boys from the mobile unit seriously thought about renting an apartment in the city. With real estate conditions the way they were, apartments could be obtained in Naples for $3 a year (the price equivalent of six eggs). The lads figured for as long as they'd be operating in that particular sector, an apartment would be a nice place to come home to following a field assignment. But as it turned out, the weathermen never got around to setting up house until after the invasion of southern France some months later.

The mobile men were now working on a new idea for getting front-line weather reports. They had got hold of a leaky, amphibious jeep, or "seep," and had installed in it a battery receiving set and a transmitter, converting the frequency to the one used by the mobile weather net. Assigned a crew of one weather observer and one radio operator, the jeep was to operate from forward positions under the station call letters of 66-JIG. The observer would make regular hourly observations and encipher them in converted Alaco for radio voice broadcasting to the mobile unit's radio truck. In this way, the need for using air support party communications would be eliminated.

The first team of "Jigs," consisting of Bohrer and Anderson, the latter handling radio, began operating in early May in Cassino. From Cassino to Rome, the jeep changed personnel at regular intervals.

Krasne (observer) and Edic (radio), who took over on May 25, established themselves at the astronomical observatory on Monte Mario, overlooking Rome. Here the weathermen found evidences of recent Nazi habitation: a torn shirt, empty food cans, and several German letters. A fireplace in the room had a stackful of kindling in it. Apparently Jerry didn't have much faith in the Americans' knowledge of booby-traps because when Krasne investigated the fireplace one nippy night, he found generous portions of dynamite sprinkled throughout the tinder.

Krasne and Edic were the only weather unit operating for the air forces that far north. With the coming of fair weather, front-line weather reports became of decreasing importance since conditions were generally favorable for air support missions. By mid-July, all Mobile Unit #2 personnel operating in the field pulled up stakes and returned south to Naples in preparation for the invasion of southern France.

"I was not in on the 7th Army's invasion of southern France," explains Voland, "because I got married at the time it took place. The lady was an American WAC stationed with the 5th Army in Naples. We were both given 10-day furloughs which we spent on Mt. Vesuvius. I went into France with the unit as part of the rear echelon." Voland was mindful of the fact that the volcano on Vesuvius had erupted back in March (pouring molten lava down to within 100 yards of Eremo, headquarters for the 12th Weather Region at the time), but he and his bride had no qualms about spending their honeymoon there.

On August 15, D-day, American infantrymen hit the French coast east of Marseilles at 0800. Opposition was practically nil. Bohrer was with the 3rd Division, Wolf with the 36th, and Cogswell with the 45th. The American landings turned into one of the greatest running engagements of modern warfare. On D plus three the infantry had already captured from the German 19th Army locations which, according to the Allied timetable, should have been taken on D plus 86.

"Our air support observers found it impossible to operate," Voland states. "They were trying continually to keep up with the air support communications parties who were chasing divisional command posts, who, in turn, were running after the regiments. But the lack of front-line reports didn't handicap air operations because the weather was almost always good.

"In their mad chase after the Jerries," continues Voland, "the forward units must have forgotten to clean up the mines on the beaches. When we landed a couple of days later, some infantrymen got hurt pretty badly. The Nazis had set up a lot of telephone poles to prevent Allied glider landings and had buried mines in the ground below the poles. The engineers almost had their heads blown off trying to remove them. I saw two men step on a mine. One of them got his foot blown off. I remember the way he looked. He kept watching for the blood, but it didn't come. The heat of the explosion must have sealed off the end of his leg. A minute later he passed out. The other fellow---its funny, but all he suffered were a few scratches around the eyes when his glasses smashed to the ground from the force of the explosion."

Air support fighters made history one day near the town of Montilimar, which is south of Lyons. The planes were out flying reconnaissance up and down the valley. A P-47 spotted a long, motorized convoy on the open highway. There were thousands of Jerry vehicles packed bumper to bumper, starting four miles south of Montilimar and extending through the town and beyond it for another three miles. The fighter bombers wasted no time. First, both ends of the convoy were knocked cold. The road block thus created, flight after flight strafed the hapless convoy from stem to stern, demolishing every bit of motorized equipment on the road. Not overlooked were several gigantic railroad guns sitting on an idle train which the planes sent up in flames. Part of the rubble was horse-drawn artillery, and the stink of dead horses in the area was still evident when Mobile Units #2 and #6 rolled by a week later.

From an old French castle, called the Chateau Bornell, Hunt and Van Dyne had been running a class D station for the 64th Fighter Wing, which was operating in the French sector near the Belfort Gap. They were recalled to M.U. #2 on December 12. At this time the unit was operating at Saverne, about 20 miles northwest of Strasbourg in the Rhine valley. The men were living in a house that had been occupied by some high German officers. It contained the finest furnishings the town had to offer. One night the house was buzzed by an ME-262, a twin-engine jet plane. The same thing happened the following two nights; but the Jerry pilot didn't use his guns. Then one morning he spotted a small convoy and began a strafing run. An M.P. in a jeep shot down the plane with machine gun fire, and the pilot, unharmed, was taken prisoner.

"For some reason," Voland says, "this prisoner was put up at our house for several days under special guard. He was wearing the Iron Cross and some other decorations. We found out from one of the M.P.'s that he was a Nazi big-shot and was being taken to London for interrogation. One of our boys tried to engage him in conversation, but Jerry gave him a quick brush-off."

On December 20, Hunt left the unit to join the air support party operating with the 3rd Division in Strasbourg. From here he reported weather conditions over Germany proper, on the opposite side of the Rhine. Then German patrols started crossing the river every night. The air support party pulled out and Hunt was recalled to the station. When he didn't report at about the time he was expected, it had the boys worried. Some said he might have been pulled into the infantry. This was at the time of the Ardennes offensive and the infantry was grabbing available men wherever it could. Somebody proposed the idea that Hunt had been wounded and was now sweating it out in an evacuation hospital. In this connection, there was a rumor that the infantry was picking up convalescent air force cases that hadn't been claimed at the hospital by their commanding officers. But Hunt finally showed up, and according to Voland he had this explanation to offer:

"I needed a haircut and when I got my orders to go back, I thought I'd get myself cleaned up a little first. So I went into town. I still had a couple of hours to catch my plane ride and decided to get a glass of wine. I was standing at the bar of the cafe when a bunch of German P.W.'s were hustled in by some French Goums. At the time I was wearing my new green field jacket. No stripes. It resembled the Jerry coat a lot. When I started to leave I was stopped at the door by one of the Goums. I couldn't speak French and he couldn't speak English. The upshot of it was I had to go along with the prisoners. It took me several days to prove my identity."

At the end of December, Mobile Unit #2 was recalled from the field. As far as Voland was concerned, his next job was to write the history of the unit. In summing up his experiences as an air support weatherman, this is what he says:

"Like most things in the army, our work had its good and bad points. The good things---well, offhand you might think there weren't very many. And maybe you'd be right. But the big thing was we could see the results of our work. Every time the planes came over we liked to feel that we had something to do with getting them up there. Another thing was being close to the battle zone. We got the feeling that we were part of it---that we had a tiny stake in the many little victories and defeats. We felt that way because we were close to the infantry and the artillery. When they moved up, so did we; when they got pushed back, we were right there with them.

"The bad points are a little more concrete. As weather work goes, our job was dangerous. The adventure was there, but it was the kind that gave you a nervous stomach. Then there were the little inconveniences of having to set up and tear down the station every time we made a move. We always had to worry about camouflaging equipment and setting up where we might have some protection. We never seemed to have enough tools for the maintenance of the generator, or the PE unit. Sometimes we'd work in mud so thick we'd have to tie a rope to the van in order not to spend half a day getting back to it. Our food and water were frequently flavored by dead rats and insects. In France we ate horsemeat. When we weren't on the move, we'd try organizing some softball or volley ball games. By the time we hacked out a spot to play in, we were ready to shove off again.

"But don't get me wrong," Voland concludes. "I'd pick the same job again if I had to, but I hope I never have to."

FAX (concluded from page 5)

multipath and noise are made negligible by use of directional antenna in conjunction with sufficiently high-powered transmitters.

Other facsimile sets than *AN/TXC-1* are available, but are not used to any great extent by the Air Corps.

The *RC 58* tape facsimile machine, designed primarily for the Armored Forces, transmits hand-written copy from a paper tape at the rate of 50 inches (or 22 words) per minute. Copy is reproduced at the receiving machine in ink on a 3/4" paper tape.

The TH tape facsimile sets are non standard machines, capable of sending and receiving typewritten material (100 words per minute) or the printing of a model 14 teletypewriter (68 words per minute) on a 3/8" white paper tape.

The *RC 120 A* and *B* are similar to the *AN/TXC-1*, except that they are equipped with a smaller drum and transmit smaller pictures (a 7x7½" page in 7 minutes: drum revolves at 90 rpm). They are standard machines, available through the Signal Corps and widely used by the Ground Forces. Although copy may be received either photographically or on Teledeltos paper, the drum is too small for weather charts.

TIDE PREDICTIONS

by Lieutenant V. J. O'Connor

Weathermen at stations near sea coasts have been required to predict tides for AAF supply and rescue boats, for bombers practicing on targets in the open sea, for stray seaplanes, and for a myriad of unconventional operations. Although the Navy provided oceanographic data for the initial landing phase of U.S. amphibious operations, the Army Engineers and the Weather Service, in cooperation, furnished tide information for the beach and harbor supply phase.

Tides, the alternate rising and falling of ocean waters in a period of 12 or 24 hours, are produced by the forces of the moon, the sun, and the weather.* Yet even when these forces are the same at two coastal stations, the tides there are not likely to be the same: differences in underwater terrain augment the tide at one place and diminish it at another. When all the tide-producing and tide-influencing forces are operating at a maximum, the difference between high tide and low tide (the tidal range) may approach 50 feet, as in the Bay of Fundy. For contrast, there are places where the range is less than a foot: at Tahiti, for instance.

At either extreme, the tides change from day to day and from week to week. Even the sea level varies, seasonally and annually. Nevertheless, the effects of climate, celestial bodies, and terrain at a station are computable; and they add up to a tide prediction which is close to the observed value, both in timing and magnitude. Forecasts of the time and height of tides at a given place and date---neglecting the influence of *daily* weather changes---are published yearly in tables compiled by the U. S. Coast and Geodetic Survey (Figure 1). The Survey first used a mechanical brain (Figure 2) for this job 35 years ago; ever since, tide forecasting has been a routine. The machine may require as many as 37 separate settings, but then a year of predictions for one station can be cranked out in a single day. Figure 3 compares the predicted tides with the actual tides in New York harbor. The

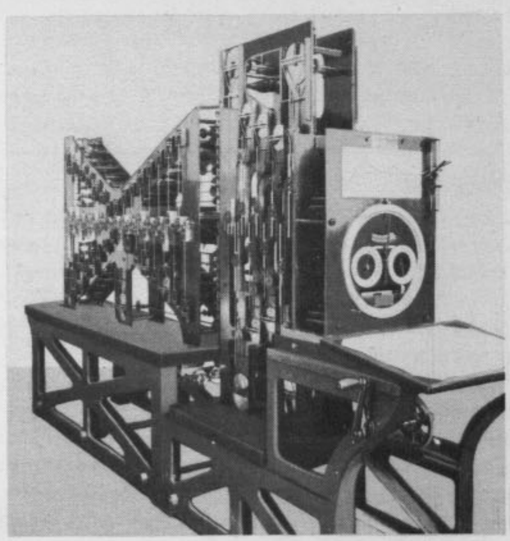
**Weather factors also produce short-term, non-tidal perturbations of the water level, with a period measured in seconds.*

MANILA, PHILIPPINE ISLANDS, 1946 — 21

OCTOBER					NOVEMBER					DECEMBER				
Day	High		Low		Day	High		Low		Day	High		Low	
	Time	Ht.	Time	Ht.		Time	Ht.	Time	Ht.		Time	Ht.	Time	Ht.
	h. m.	ft.	h. m.	ft.		h. m.	ft.	h. m.	ft.		h. m.	ft.	h. m.	ft.
1	0 34	3.4	8 51	0.6	1	0 55	3.6	10 48	0.0	1	1 24	3.4	11 03	-0.4
Tu	...	..	...	..	F	...	..	...	..	Su	...	..	...	..
2	0 58	3.5	10 02	0.6	2	1 45	3.5	11 54	0.0	2	2 21	3.2	11 46	-0.3
W	...	..	...	..	Sa	...	..	...	..	M	...	..	...	..
3	1 34	3.5	11 28	0.6	3	2 44	3.4	...	..	3	3 28	2.8	...	..
Th	...	..	...	..	Su	...	..	12 49	0.0	Tu	...	..	12 21	-0.1
4	2 25	3.5	...	..	4	4 01	3.2	...	..	4	4 49	2.5	...	..
F	...	..	12 52	0.5	M	...	..	13 31	0.1	W	19 47	1.8	12 48	0.1
5	3 31	3.5	...	..	5	5 27	3.1	...	..	5	6 19	2.1	0 54	1.3
Sa	...	..	13 53	0.4	Tu	...	..	14 04	0.1	Th	19 51	2.2	13 12	0.4
6	4 55	3.5	...	..	6	6 50	2.9	...	..	6	7 49	1.7	2 26	0.7
Su	...	..	14 35	0.3	W	20 58	2.0	14 31	0.3	F	20 08	2.8	13 29	0.7
7	6 14	3.6	...	..	7	8 01	2.7	1 59	1.3	7	9 18	1.4	3 34	0.1
M	...	..	15 08	0.3	Th	21 07	2.4	14 54	0.6	Sa	20 37	3.3	13 52	0.9
8	7 22	3.6	...	..	8	9 11	2.4	3.12	0.8	8	...	..	4 34	-0.5
Tu	22 06	1.8	15 37	0.3	F	21 24	2.8	15 12	0.8	Su	21 15	3.6	...	..
9	8 23	3.6	1 30	1.7	9	10 19	2.1	4 14	0.3	9	...	..	5 30	-1.0
W	22 05	2.0	16 02	0.4	Sa	21 48	3.3	15 25	1.1	M	21 50	4.2	...	..
10	9 20	3.5	2 45	1.4	10	11 34	1.8	5 15	-0.2	10	...	..	6 29	-1.3
Th	22 18	2.3	16 25	0.6	Su	22 19	3.8	15 38	1.3	Tu	22 34	4.4	...	..
11	10 15	3.2	3 50	1.0	11	...	..	6 15	-0.6	11	...	..	7 26	-1.4
F	22 36	2.7	16 47	0.9	M	22 55	4.1	...	..	W	23 22	4.5	...	..
12	11 15	2.8	4 52	0.7	12	...	..	7 18	-0.8	12	...	..	8 24	-1.4
Sa	22 59	3.1	17 02	1.2	Tu	23 34	4.3	...	..	Th	...	..	...	..
13	12 16	2.4	5 55	0.3	13	...	..	8 25	-0.9	13	0 11	4.3	9 23	-1.2
Su	23 28	3.5	17 08	1.5	W	...	..	...	..	F	...	..	...	..
14	...	..	7 00	0.1	14	0 20	4.4	9 36	-0.9	14	0 59	3.9	10 18	-0.9
M	13 26	1.9	17 05	1.6	Th	...	..	...	..	Sa	...	..	...	..
15	0 02	3.9	8 13	-0.1	15	1 05	4.2	10 48	-0.7	15	1 53	3.5	11 07	-0.6
Tu	...	..	...	..	F	...	..	...	..	Su	...	..	...	..
16	0 41	4.1	9 34	-0.2	16	2 02	3.9	11 55	-0.5	16	2 47	2.9	11 46	-0.2
W	...	..	...	..	Sa	...	..	...	..	M	...	..	...	..
17	1 25	4.2	11 03	-0.2	17	3 06	3.5	...	..	17	3 55	2.3	...	..
Th	...	..	...	..	Su	...	..	12 40	-0.3	Tu	19 36	1.7	12 13	0.1
18	2 17	4.1	...	..	18	4 28	3.0	...	..	18	5 22	1.7	0 55	1.3
F	...	..	12 27	-0.3	M	...	..	13 26	0.0	W	19 36	2.1	12 32	0.4
19	3 27	3.9	...	..	19	5 55	2.5	...	..	19	7 11	1.2	2 42	0.8
Sa	...	..	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12 52	0.3	Th	[illegible]	[illegible]	[illegible]	[illegible]

Figure 1: A portion of the Tide Prediction Table for Manila, 1946, which gives times and heights of daily high and low water for three months. Only one high and one low tide per day is the usual rule: there are exceptions, however.

Figure 2: *Tide prediction machine.*



Figures by courtesy of Lt. Comdr. C.E. Green, U.S. Coast & Geodetic Survey

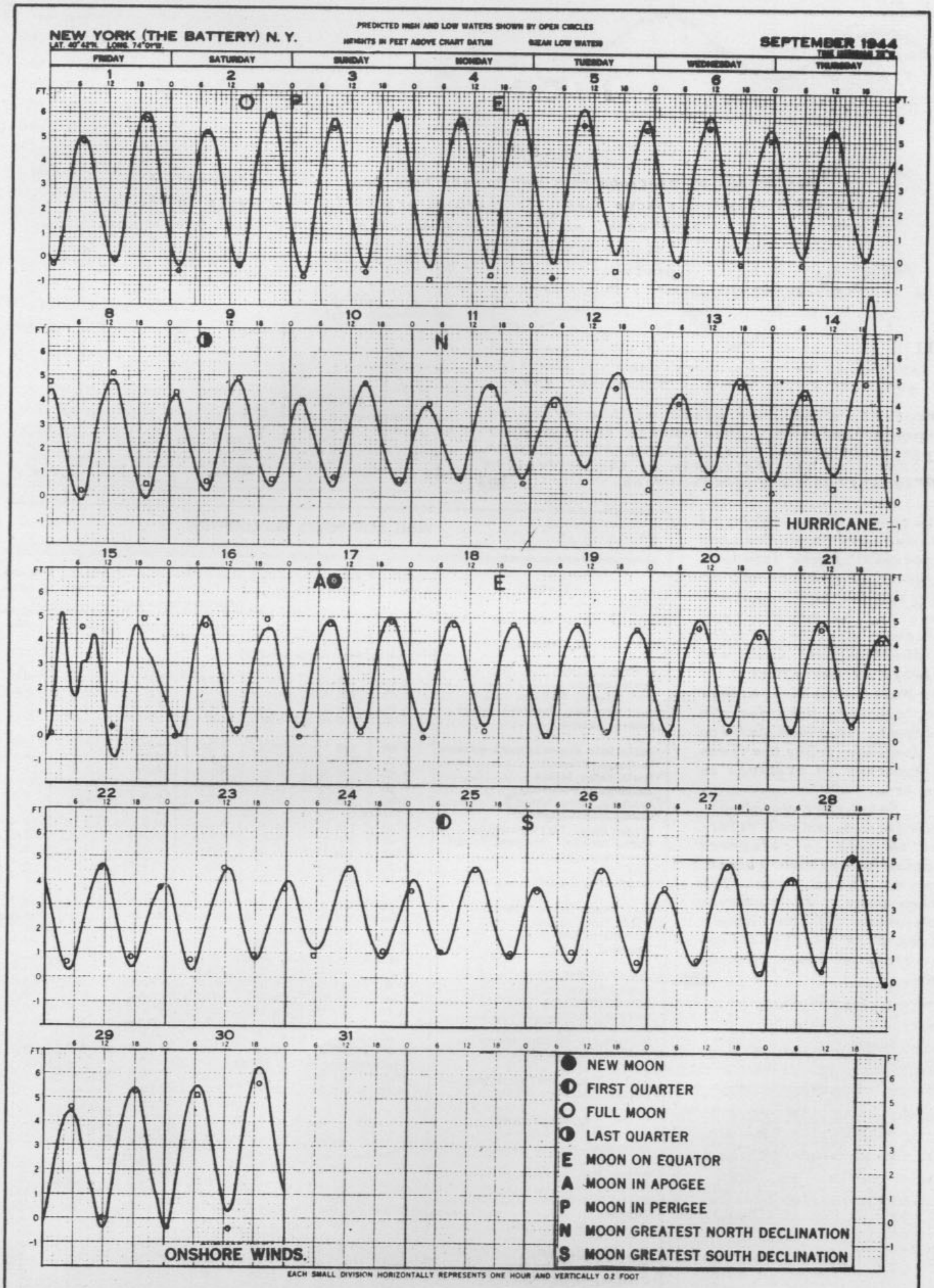


Figure 3: *A comparison of the tides predicted for New York Harbor (values given by the small, open circles) with the observed tides (continuous curve) for the month of September 1944. See text for explanation of lunar terms.*

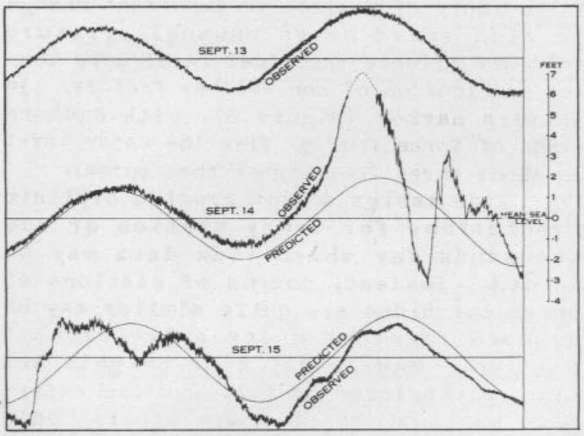


Figure 4: *Effect of a hurricane on the tide at Atlantic City, N. J., September 1944.*

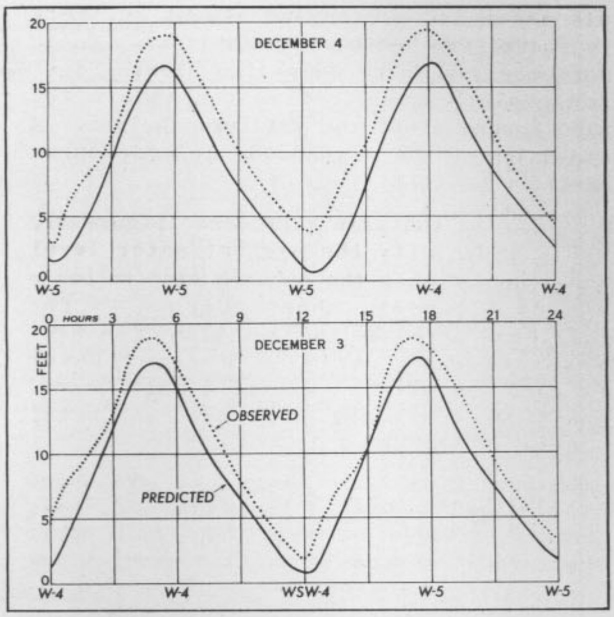


Figure 5: *Effect of winds on the tides at Antwerp, Belgium. This record is from Navy research data used to establish arbitrary rules for applying wind forecasts to the correction of tabulated tide predictions.*

Figure 6: *This table of "Tidal Differences and Constants" gives time and height ratios which can be applied to the complete data for an appropriate reference station in order to find the tidal times and heights at any station in the Philippines. In this way, complete data for six reference stations suffice to describe fully the tides at hundreds of stations in the area.*

Note that Maimbung, Jolo Island, is not referred to Jolo, a reference station on the same island, but to Davao, some 300 miles away. Tide curves have shown that Mainbung's tides more nearly follow the tides at Davao than at Jolo.

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TIDAL DIFFERENCES AND CONSTANTS

Station	Latitude	Longitude	Tidal difference: Time	Tidal difference: Height of High water	Tidal difference: Height of Low water	Mean range	Diurnal range
	° ' North	° ' East	h. m. Time meridian 120° E.	feet	feet	feet	feet
SULU ISLANDS							
Reference station, DAVAO							
Tumindao Island	4 47	119 25	+0 05	*0.7	*0.7	3.1	3.8
Sibutu Island	4 45	119 30	+0 35	*0.9	*0.9	3.5	5.0
Port Bongao, Tawitawi Island	5 02	119 46	+0 05	*0.7	*0.7	3.3	4.2
Batu Batu Bay, Tawitawi Island	5 04	119 53	-0 05	*0.8	*0.8	3.4	4.4
Banaran Island	5 02	120 06	-0 05	+0.3	-0.2	4.8	5.6
Gallo Malo Channel, south entrance	5 08	120 14	+0 20	+0.6	-0.2	5.1	5.9
Tandungan Channel	5 13	120 19	+0 20	*0.8	*0.8	3.4	4.4
South Ubian Island	5 12	120 30	-0 30	*0.6	*0.6	2.6	3.4
Tapul Island	5 42	120 53	+0 25	*0.5	*0.5	2.0	2.7
Maimbung, Jolo Island	5 55	121 01	+0 15	*0.7	*0.7	3.2	3.9
Reference station, JOLO							
Tataan Pass, Tawitawi Island	5 15	119 57	-0 30	*0.9	*0.9	--------	2.4
Basbas Channel, Tawitawi Island	5 21	120 13	-0 40	*0.9	*0.9	--------	2.5
Lahatlahat Island	5 39	120 17	-0 35	*0.9	*0.9	--------	2.6
Pearl Bank	5 51	119 44	+1 10	+0.6	0.0	--------	3.4
Pangutaran Island	6 15	120 30	+1 25	+0.7	0.0	--------	3.5
Port Siasi, Siasi Island	5 33	120 49	-1 35	+1.3	0.0	--------	4.1
JOLO, Jolo Island	6 04	121 00	See predictions			--------	2.8
Tulayan Island	6 01	121 19	-1 55	*0.9	*0.9	--------	2.4
Dassalan Island	6 44	121 28	+0 20	+0.5	0.0	--------	3.3
Reference station, DAVAO							
Capual Island	6 01	121 25	0 00	-0.6	-0.2	3.9	4.9
Simisa Island	5 58	121 34	-0 05	*0.8	*0.8	3.5	4.2
Bulan Island	6 09	121 50	-0 05	-0.5	-0.2	4.0	4.7
Linawan Island	6 19	121 56	-0 25	*0.8	*0.8	3.5	4.1
Balas, Basilan Island	6 41	122 08	+0 10	*0.8	*0.8	3.6	4.3
Bojelebung, Basilan Island	6 31	122 12	-0 05	+0.1	-0.1	4.5	5.2
Amoyloi, Basilan Island	6 26	122 08	+0 20	+0.8	-0.3	5.4	6.2
Reference station, JOLO							
Port Holland, Basilan Island	6 33	121 52	-1 50	+0.2	0.0	--------	3.0
Isabela, Basilan Island	6 42	121 58	0 00	*0.8	*0.8	--------	2.2
MINDANAO ISLAND							
Zamboanga	6 54	122 04	-1 55	+0.5	0.0	--------	3.3
Reference station, CEBU							
Sibuco Bay	7 19	122 04	-0 40	*0.8	*0.8	2.5	4.0
Panabutan Bay	7 35	122 08	-0 40	*0.8	*0.8	2.5	4.1
Port Santa Maria	7 46	122 07	-0 40	*0.8	*0.8	2.5	4.2
Dapitan	8 40	123 25	-0 40	*0.8	*0.8	2.6	4.4
Murcielagos Bay	8 38	123 34	-0 10	*0.8	*0.8	2.8	4.2
Plaridel (Langaran)	8 37	123 43	-0 25	*0.8	*0.8	2.6	4.1
Oroquieta, Iligan Bay	8 29	123 48	-0 15	*0.8	*0.8	2.7	4.0
Jimenez, Iligan Bay	8 20	123 51	-0 05	*0.8	*0.8	2.7	4.1
Misamis, Iligan Bay	8 09	123 51	0 00	*0.9	*0.9	2.9	4.4
Iligan, Iligan Bay	8 14	124 14	-0 10	*0.8	*0.8	2.6	4.2
Macabalan Point, Macajalar Bay	8 30	124 40	-0 15	*0.8	*0.8	2.7	4.2
Canauayor Anchorage	9 00	124 51	-0 15	*0.8	*0.8	2.6	4.1
Mambajao, Camiguin Island	9 15	124 43	-0 15	*0.8	*0.8	2.5	4.1
Nasipit Harbor, Butuan Bay	8 59	125 20	-0 15	*0.8	*0.8	2.8	4.1

discrepancies are caused almost entirely by short-term weather fluctuations. On 30 September, a force four wind blowing dow Long Island Sound raised the tide level nine inches above the predicted height. A major hurricane distorted the tide curve markedly on 14-15 September.

During the same hurricane (Figure 4), at Atlantic City the highest water level was recorded when the onshore wind velocity was at its peak, about 90mph. As the hurricane moved up the coast and the wind reversed completely, the water level dropped 11 feet in two and a half hours. The tides continued to be abnormal until the end of the third day.

Some tide-table users have evaluated statistically the local effect of daily weather on tides, so that they could apply short-range forecasts to tide prediction. In the Gulf of Mexico, an important change in wind speed or an unusual pressure tendency affects the tidal level more than any combination of non-weather factors. In Antwerp harbor (Figure 5), with onshore winds of force four or five the water level is about three feet higher than normal.

Tide tables do not provide explicit predictions for every station of the thousands for which tide data may be needed. Instead, dozens of stations at which the tides are quite similar may be grouped together under a "reference" station. Day-by-day tide heights and times are printed in full for the reference station; but for the others, only ratios to the reference station data are given, in a table called "Tidal Differences and Contestants" of which figure 6 is an example. Six reference stations are enough to define implicitly the tides

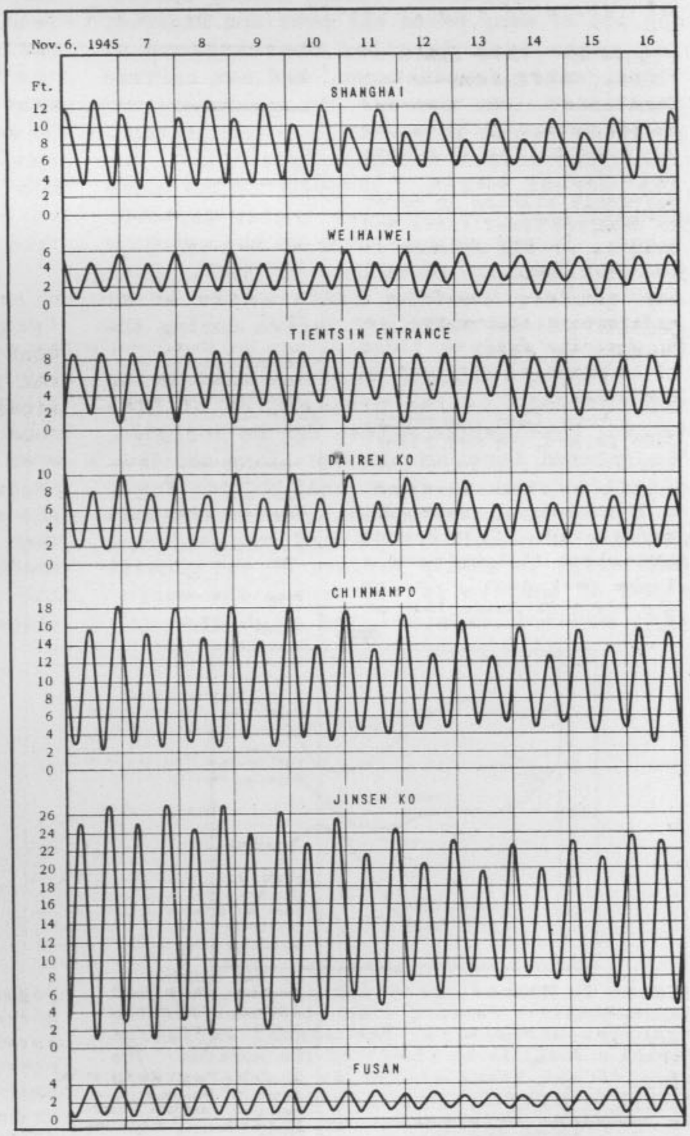


Figure 8: Typical tide curves for reference stations on the Yellow Sea. Although Jinsen Ko and Fusan are fairly close together on Chosen Peninsula, note the striking difference between the two curves.

Figure 7: Reference stations (black dots) for East Asia. This map is published in the front of the "Special Tide Tables for Japan and China."

at hundreds of places in the Philippine Islands.

Some reference stations are close together and some are far apart (Figure 7). They are not selected to cover the area evenly, but to be representative of a particular tidal pattern. There are no reference stations in the Sea of Japan, for instance. And stations all along the northwest coast of Honshu, Japan, are referred to Hong Kong, China, a thousand miles or more away. The Yellow Sea as a whole has two tides a day (Figure 8), but differences in inequalities and range require that it have a number of reference stations. Jinsen and Fusan are comparatively close together on Chosen Peninsula; yet at Jinsen the spring range is 26 feet and at Fusan it is only three feet.

American specialists know the tides of the Orient very well, thanks to the Japanese. Nipponese fishing boats, operating out of many ports all over the Pacific, for years took detailed observations of tides, water temperatures, and sea surface conditions. The pre-war Jap government was generous enough to publish this information.

Tide tables compiled by the U.S. for the Tarawa beaches proved to be more precise than the Japanese tables captured there. It was an ignorance of the synoptic weather factor, an offshore wind, that caused Navy landing craft boats to be impaled on the reefs off Tarawa during the assault in 1944.

While synoptic weather must be an imponderable in the preparation of tide tables, the climatic effect can be included. The general level of the sea along the U.S. Atlantic Coast is about half a foot lower in the early spring months than in the fall months, a regular seasonal phenomenon. Similarly, in Manila (Figure 9) the general stand of the sea is low during the northeast monsoon (winter) and high when the southwest monsoon (summer) prevails.

The tide in New York harbor (Figure 3) is of the "diurnal" type, in which each day has two high waters---a characteristic of the whole Atlantic Coast. (The tides in the Gulf of Mexico are "daily," with one high water each day. Those of the Pacific Coast are "mixed," with one high and one medium high tide each day.) The range of tide around the 3d and 4th of the month was more than six feet, while one week later the range was only half that amount. Significantly, the 3d and 4th of the month were days immediately following full moon (when earth, moon, and sun are in line), while the 9th and 10th followed a quarter phase of the moon (when the three bodies determine a 90° angle).

Celestial considerations are not involved in the use of tide tables, but they do provide some of the terminology. The large tides on the occasion of new and full moon are called *spring tides*, and the smaller tides occurring at the first and the third quarter of the moon are called *neap tides*. The spring range around the 3d was considerably larger than the spring range around the 17th because on the 3d the moon was nearest to the earth, in *perigee*, while on the 17th the moon was farthest from the earth, in *apogee*.

The declination of the moon had only a slight effect on the New York tides (Figure 3). When the moon was at the equator, on the 4th and again on the 18th, the range of the morning tide was practically the same as the range of the afternoon tide. But on the 11th and on the 26th, when the moon was at maximum north and at maximum south declination, respectively, the morning tide was noticeably smaller than the afternoon tide. In general, when there is a maximum declination of the moon, there is an inequality between the high tides.

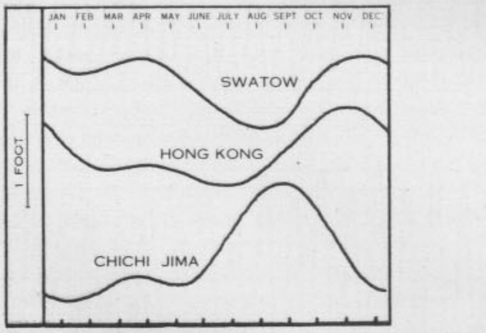


Figure 9: Annual variation in sea level at representative Pacific tide stations. In the examples shown here, the annual variation (about a foot) is an effect of the monsoon. The rate of sea level change is a forecastable result of seasonal changes; hence it is possible to consider this variation in the initial computation of tide tables.

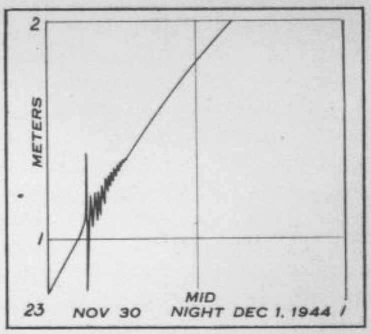


Figure 10: A section of the tide curve for Antwerp harbor, Belgium, last December. The curve was disturbed by the swell from a V-2 rocket explosion about 500 yards away. The amplitude shown is much too small, since tide gauges are designed to damp out all short-term disturbances.

c. *Position of the Weather Detachment within the Ground Force Organization:* Owing to the experimental nature of the weather program there has been some difference of opinion as to the most appropriate place for the weather detachment within the organization of the armies and corps. A small number of the units organized early in the program has been attached to the field artillery observation battalions, while the remainder has been placed with army and corps headquarters. The latter form of attachment has proven more satisfactory to the Ground Forces since it has enabled the weather detachments to properly serve the staff of the army or corps without detracting from the service provided to the antiaircraft and field artillery.

Two German paramines did this to a communications truck of the 21st Weather Squadron, near Omaha Beach, Normandy. The award of seven purple hearts was an aftermath of the blast.

d. *Control:* The weather detachments have been attached to units of the 12th Army Group for rations, quarters, and administration only. Duty and training have remained a function of the Ninth Air Force. This arrangement has proven to be a satisfactory one, since the weather detachment has been free to provide full service to the Ground Force unit, while the technical phases of its activities have remained under the control of the weather squadron, which is fully familiar with the problems.

e. *Coordination:* The Staff Weather Officer, Ninth Air Force, has acted in the capacity of Staff Weather Officer, 12th Army Group. In this dual position, he has been able to coordinate the weather needs of both the Ground Forces and the Air Forces, providing an adequate service to both with the existing personnel and facilities. Similarly, the commanders of the weather detachments serving this Army Group have acted unofficially as staff advisers to the Commanding Generals of their respective units.

f. *Communications:* The entire group of weather detachments working with the 12th Army Group has been organized into a radio net for the purpose of interchanging basic weather information with other portions of the weather squadron and with allied meteorological organizations. This radio net has been supplemented wherever practicable by weather teletype communications, the lines being provided by the Army or Corps and the equipment by the weather squadron. The latter is a more effective method of interchanging weather data, since more rapid transmission is possible, and is therefore preferred by the weather personnel. For distribution of weather information and forecasts to units of the Army, Corps, and Divisions, the weather detachments have utilized the communications facilities available within the Ground units. This arrangement has proven satisfactory for all needs except for the dissemination of meteorological messages for antiaircraft and field artillery battalions. In these instances, separate radio frequencies have been provided by the armies for the transmission of the needed data.

g. *Supply:* The weather squadron has maintained the responsibility for the supply of all technical equipment and peculiar expendable supplies necessary to the operation of the weather detachments. Common supply items have been provided to the detachments by the armies and corps to which the weather units have been attached. This system has operated effectively, except during periods in which rapid movement of the ground echelons has made distribution of peculiar supply items difficult for the weather squadron.

3. *Weather Services:* The weather units serving the 12th Army Group have provided a variety of services to the Army Group, Armies, and Corps to which they were attached. The 12th Army Group utilized the services of the weather detachment at the Advanced Headquarters, Ninth Air Force, while the Armies and Corps received service from the weather detachments attached directly to them. These services may be broken down into those which were primarily of value in the planning of ground operations, and those which were of direct use in tactical operations. In addition, the weather squadron cooperated in certain specific programs in which weather information played an important role.

a. *Service to the 12th Army Group Headquarters:* This headquarters set up a plan whereby weather information and forecasts were provided to all staff sections daily. One officer of the 21st Weather Squadron, using the facilities of the weather detachment located with the Advanced Headquarters, Ninth Air Force, prepared short and long range weather forecasts for the staff sections each morning. In addition, this officer conducted a weather briefing at the Commanding General's staff meeting daily, stressing particularly the expected effects of weather on air coordination and major Ground Force operations. He also served as weather liaison officer to the 12th Army Group staff, supervising the preparation of climatological and weather studies desired by the various sections.

b. *Services to Armies and Corps:*

(1) *Planning Services:* The weather detachments with the subordinate units of the 12th Army Group provided two basic types of weather information which were used in the planning of operations.

(a) *Climatological Information:* For direct use, the detachments provided climatological data including temperature, precipitation, soil conditions, snow cover, winds, and visibility; all factors which were of prime importance to mobile ground warfare. This material was distributed through all sections of the Ground Force Headquarters, and also to Division levels. In addition, the weather units provided studies of medium and heavy bomber, and fighter operational probabilities, which were used in the coordination of ground and air operations.

(b) *Long Range Weather Forecasts:* The weather detachments utilized long range weather forecasts prepared at higher air force headquarters to construct long range weather outlooks, interpreted in terms of their meanings for air support, aerial photography, soil trafficability, and chemical warfare operations. These forecasts were prepared daily and distributed to all staff sections and division headquarters. In many of these units, the outlooks were presented verbally in the daily staff meetings. This form of presentation has become increasingly popular with Army and Corps staffs, and is an excellent method of apprising all of the expected weather conditions and their meaning in terms of Ground Force operations.

(2) *Tactical Services:* The weather squadron has provided units of this command with a wide variety of weather services which have been valuable as direct aids to the operations of the Armies and Corps.

(a) *Meteorological Messages for Antiaircraft and Field Artillery:* The weather squadron developed a detailed method of preparing meteorological messages for the artillery from upper air observations available to its weather units. This method involved the computation of meteorological messages from known data, rather than using assumptions of upper level conditions as had been done previously by all antiaircraft and field artillery units. Further, weather squadron officers cooperated with this headquarters in the training of SCR-584 Radar crews in the procedure of tracking targets attached to free balloons to obtain measurements of the winds aloft. The combination of these two types of observations enabled the personnel of the weather units to prepare meteorological messages regardless of the time of day or weather conditions. These messages were prepared four times daily and were distributed to all field artillery and antiaircraft battalions in the unit served by the weather detachment. Distribution of these messages was made either by telephone or by special radio net, the frequency for which was set aside by the army involved. The messages prepared in this fashion are felt by artillery and antiaircraft personnel of this command to be superior to the older methods prescribed by TM 4-240, resulting in more accurate fire by both antiaircraft and field artillery pieces.

(b) *Chemical Warfare Forecasts:* The weather detachments offered detailed forecasts of weather conditions important to the use of chemical smokes. These predictions were not made as a daily routine, but were prepared whenever the Chemical Officer of the unit felt that conditions warranted a detailed forecast. This prediction was most valuable in operations involving detailed planning, such as crossing of the Rhine River.

(c) *Soil trafficability Forecasts:* A daily estimate of the suitability of the soils for the passage of wheeled and tracked vehicles was made by the weather units. Although this was merely an estimate of future conditions, necessarily not based on detailed technical information, the forecasts were useful, especially during the difficult soil conditions of the winter and early spring, 1944-45.

(d) *General Weather Forecasts:* Each of the weather units prepared a short range weather forecast twice daily for distribution to all sections of the Ground Force headquarters, and to division headquarters as well. These predictions comprised a detailed forecast of the weather conditions expected to occur during the next twenty-four hours plus an interpretation of the meaning of the weather conditions to ground and air operations. This information was most valuable when presented to staff officers in the form of daily briefings, since the weather factor was thus brought into direct contact with tactical planning.

c. *Special Projects:* The 21st Weather Squadron also participated in two special projects which were of importance to units of the 12th Army Group.

(1) *Operation of Omaha and Utah Beaches:* During the first four months after the invasion of Normandy, virtually all supplies for units of the 12th Army Group necessarily passed over Omaha and Utah beaches. In order to accomplish this mission successfully, it was necessary that the Engineer Units supervising and accomplishing the unloading have highly accurate predictions of the wave and swell conditions to be expected on the approaches to the beaches. The weather squadron provided two officers, and later a full detachment consisting of two officers and ten enlisted men to make these highly specialized predictions. These forecasts were accurate and very valuable to the success of the beach operations.

(2) *Rhine River Predictions:* In November 1944, it was felt at this headquarters that it would be necessary to have an accurate prediction of the flood stages of the Rhine River in order that the proper time for the crossing could be chosen, and also so that the safety of the temporary bridges erected after the crossing might be maintained. This headquarters initiated the formation of the Flood Prediction Section of the Intelligence Division, Office of the Chief Engineer, Communications Zone. Their problem, that of forecasting the stages of the Rhine River, was primarily an engineering one, but also hinged on weather factors to a large extent. Consequently, the Flood Prediction Section was placed with Headquarters, Ninth Air Force, where complete weather information was available, and where the radio and teletype nets of the weather squadron could be used to effect communications between the Flood Prediction Section and the Army Group and Army Headquarters.

4. *Recommendations:* In view of the experience of the 12th Army Group in the use of a weather service, as well as the problems involved in providing it, the following recommendations are made regarding weather services:

a. *Program of Weather for Ground Forces:*

(1) It is recommended that a weather service be provided to each Army Group, including its armies and corps, in operational theaters by the Air Force responsible for air coordination with that Army Group.

(2) That the designated Air Force provide an officer trained in meteorology to serve as the Staff Weather Officer of an Army Group.

(3) That this Staff Weather Officer be responsible for the supervision of the weather units attached to the Army Group, and that he be responsible to the senior weather officer of the theater for matters relating to technical operation of the weather service.

(4) That control of the technical weather matters remain with the Air Force and weather squadron providing the weather service to the Army Group.

(5) That technical advice and research facilities be made available by the Army Air Forces Weather Service to ground force units within the Zone of Interior to insure that the potentialities of weather information and forecasts are fully developed to meet the needs of the ground forces.

b. *Organization of the Weather Detachments within the Ground Forces:*

(1) That the commanding officer of each weather detachment serving an Army or Corps be given an official additional position on the staff of that unit in order that he may fulfill his mission to the best advantage.

(2) That the weather detachments attached to each Army and Corps be placed directly under the supervision of the G-3 Section of that headquarters, so that the weather service provided will be developed to the fullest extent.

(3) That the weather detachment serving each Army headquarters be made sufficiently strong in numbers of personnel and communications facilities to enable it to prepare all short range forecasts, long range forecasts, and climatological studies necessary for that Army and all its Corps.

(4) That the weather detachments serving the Corps be set up as interpretive weather units to receive most basic information from the Army Weather Detachment, and to be under the direct supervision of the officer commanding the Army Weather Detachment.

(5) That the weather detachments be given the fullest cooperation in matters of communication. This should include adequate teletype lines whenever possible for the sole purpose of collecting weather data from the Air Force Weather control to all Army and Corps weather detachments. These lines would also be

used to supply observations made by the ground force weather detachments to the detachments with the Air Force. Further, adequate frequencies for radio transmission of ballistic data should be allotted the weather detachments by Army antiaircraft and artillery sections. This will allow direct transmission of meteorological data to all artillery battalions within the Army and the Corps.

FOR THE ARMY GROUP COMMANDER:

s/s/ C. R. Landon
/t/ C. R. LANDON
Colonel, AGD
Adjutant General

"The most recent T/O&E 6-76, for Headquarters and Headquarters Battery, Field Artillery Observation Battalions, dated 20 February 1945, provides for inclusion of SCR 658, Radiosonde Receptor AN/FMQ-1, and associated metro station equipment in the organic equipment of these units. Steps were taken in ETO to provide for the proper integration of these metro stations with Air Force weather stations in computation and dissemination of weather data." --- CG, AGF.

Metro Musings

R. A. COMMISSIONS

If you are a wartime officer (with active or inactive status), the War Department invites you to submit a letter of application for a Regular Army commission. Although legislation governing the selection of R.A. officers has not yet been enacted, you can submit your letter now, in duplicate, to your immediate commanding officer, giving such particulars as choice of arm or service, educational and professional background, and record of military duty. Also required are the names of three former immediate commanding officers (preferably recent) from whom an officer evaluation report can be obtained. Included should be the grade and last known address of these officers and the dates you served under them. Your letter together with the accompanying evaluation report will be forwarded to the Adjutant General in Washington, D.C.

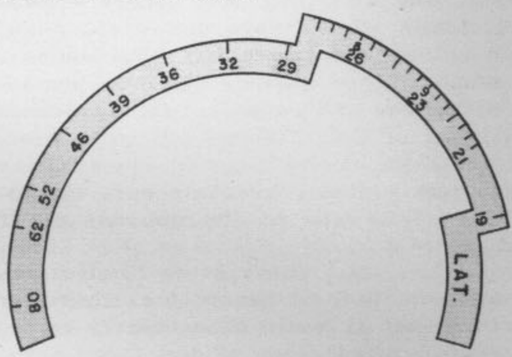
Officers and former officers, other than retired, who have served since 7 December 1941 and who have been relieved from active duty under honorable conditions may submit their letter directly to the Adjutant General, Washington 25, D.C.

The W.D. reminds you that you will not be appointed to a grade higher than that which you held in wartime. For further details read W.D. Circular 243.

MORE ABOUT THE E-6B

This is a latitude scale for the *E-6B Computer*, useful for the meteorological calculations described in "E-6B: A Weather Gadget," *Wea Svc Bul*, June 1945. The scale is drawn, cut out, and cemented to the Computer, with the bump surrounding the "for altitude computations" window. The small "8" and "9" on the latitude scale should be directly opposite the "48" and "54" on the minutes scale. Lt. Paul Dannenbaum, Newcastle AAB, submitted this note.

The illustrated device might be easier to use if it were labeled with familiar values of latitude.



FOR CANADIANS

The Canadian government is seeking experienced weathermen to staff its stations in the Northwest, reports the A.M.S. Canadian citizenship and civilian status are necessary qualifications. For information, write to:

Dr. J. Patterson, Controller
Air Services Meteorological Division
Department of Transport
315 Bloor St, West
Toronto 5, Ontario, Canada

SNAPPY SEQUENCES

"The station at Hill Field, Ogden, Utah, has added a labor-saving device to an already excellent weather sequence display arrangement. Two portable typewriters are mounted on ball-bearing-equipped frames that move along U-shaped rails running the entire length of the sequence display assemblies. This arrangement allows forecasters to move the typewriters to directly in front of the latest teletype sequence report, thus facilitating the completion of Forms 23. The set-up was designed by the StaWO, Major DeWitt Morgan."

---from an historical supplement, 24th Weather Squadron

INDEX FOR 1945

The Bulletin was published monthly in 1945 until July; bimonthly thereafter. The nine issues of the Bulletin in 1945 comprise Volume III, indexed below.

TWO YEARS BEFORE THE INKWELL

The Weather Service Bulletin *was conceived in the mid-summer of 1943, to act as an informal but authoritative forum which would spread news and technical developments to every AAF weather unit in the world. This plan, though ambitious, soon was dwarfed by events. Various liaison officers of Allied governments, having noticed the* Bulletin *in Washington weather offices, requested copies from Headquarters AAF. Shortly thereafter, these requests were multiplied and extended, so that this magazine came to be circulated in certain of the Allied metro services as far as the station level.*

Many U.S. military commands reacted similarly. At war's end, the Bulletin *had been requested for more than 125 schools of the AAF Training Command, for all of the AAF Flight Service Centers and Regions, for the Antiaircraft Sectionsof 41 Army commands, by more than 120 other Army and Navy headquarters, and by almost 500 staff weather officers in every theater. These requests were filled, under War Department authority. Official correspondence subsequently revealed that agencies which used the Weather Service often were informed thru the* Bulletin *of developments which interested them.*

In addition, the Bulletin *soon became more than a purely military publication. Many civilian agencies under contract to the Army successfully applied for receipt of the* Bulletin; *notably, certain U.S. airlines, universities with meteorological departments, and the U.S. Weather Bureau. Extraordinary requests were made for special issues: 600 for the April 1945 number, and 430 for the Sept-Oct number.*

The regular mailing list of the Bulletin *at present calls for 4,000 copies. Of this number, 2,800 go to Weather Service units, on the basis of one copy to every six weathermen at an installation. The influence of* Bulletin *articles has frequently been extended beyond its circulation. The Air Technical Service Command's* Technical Data Digest, *the AAF Training Command's* Training Intelligence Reports *and the RAAF's* Tropical Research Bulletin *have reprinted or abstracted a total of 34 articles which first appeared in the* Weather Service Bulletin. *The III Bomber Command reprinted the February 1945 issue to explain the principles of radar storm detection to all of its VHB bases. Furthermore, the AAF weather training centers at Chanute Field and at Goldsboro reported that they make extensive use of* Bulletin *articles in their programs.*

The first editor of the Weather Service Bulletin *was Major Wallace Howell, who directed the preparation of Volume I, Numbers 1 and 2. In February 1944 he was succeeded by Captain William Stokes, who still holds that position. Usually, the unsigned* Bulletin *articles are researched and written by the editor. Research assistants have been Lt. Orville Amidon, WOJG Carlyle Frarey, and Corporal Irving Ripps. The art staff of the magazine until September 1945 was headed by S/Sgt Thomas Miiius; for the current issue, by S/Sgt Fred Carl. Sgt. William Bartell and S/Sgt William Harris were art assistants.*

CONTENTS

The *Weather Service Bulletin* is published with the approval of the Director, Bureau of the Budget. It is reproduced by Headquarters AACS, Asheville, N. C.

CONTRIBUTORS

LT. COLONEL JOHN M. FEELEY, JR, will long remember his first day of foreign service. It was 7 December 1941 at Hickam Field. He stayed on in Hawaii as weather officer for the 38th Recon Squadron until 17 December 1942. Colonel Feeley is now assistant chief of staff for operations, Continental Weather Wing. He took his meteorological training at Cal Tech with the January 1941 class. A graduate of the Colorado School of Mines, he worked in civilian days as an engineer for various mining concerns in Nevada, Colorado, and Montana.

LT. THOMAS C. HAGINS, USNR, contributed his share to the Pacific war as the Aerologist aboard the *U.S.S. Sarotoga* until February 1945. He is now land-based, with the U.S. Naval Air Station at Jacksonville, Florida. Lt. Hagins graduated from the UCLA metro cadet course in December 1942. He describes his civilian occupation as that of "small town banker."

LT. V. J. O'CONNOR has stationed in the Operations and Training Division of the Weather Service Headquarters since September 1944. Before that he was a meteorological instructor at Randolph Field. A master of science from Michigan University, Lt. O'Connor used to teach school in Iowa and Michigan.

CAPTAIN MELVIN SCHLESSINGER's hobby has undoubtedly made him many friends. He spends his spare time repairing everything from clocks and radios to typewriters and automobiles. Following completion of the Chanute Field metro cadet course in November 1943, Captain Schlessinger was assigned to Hq. Weather Service and then to AACS. Now he is fax training officer at Sheppard Field, Texas.

The Bulletin Board

Graduates of the Grand Rapids-Chanute Field metro courses have asked about the amount of college credit they could expect for the various courses given to officers, cadets, and enlisted men. While the particular college involved always reserves the right to make this decision, it usually is guided by the recommendations of the American Council on Education. In ACE's "Guide to the Evaluation of Educational Experiences in the Armed Services," the following statements are found:

a. *Meteorological Training, Course* ---Chanute Field and Grand Rapids (Page M-38.87). "To higher institutions: Providing the work in meteorology covered by this course normally would be accepted in the student's proposed educational program, it is recommended that credit be allowed to a maximum of 30 semester hours in meteorology. This recommendation is based on the judgments of the five universities which are giving similar courses. While the sub-division of material into courses at Chanute Field is somewhat different from the course breakdown at the universities, each institution indicated that the Chanute Field course is similar to its own and that substantially equivalent credit would be given for its successful completion. The course material is at the advanced undergraduate or graduate level."

b. *Weather Forecaster, Enlisted* ---Chanute Field and Grand Rapids (Page W-31.36). "To higher institutions: Provided the work in weather forecasting covered in this course normally would be accepted in the student's proposed educational program, it is recommended that credit be allowed to a maximum of 17 semester hours in weather forecasting."

c. *Weather Observer, Enlisted* ---Chanute Field and Grand Rapids (Page W-31.61). "To higher institutions: It is recommended that 2 semester hours of credit in weather forecasting should be granted toward a baccalaureate degree."

The "Guide" recommends that no credit toward a baccalaureate degree be given for the refresher or for the radiosonde operator courses, but that terminal credit be granted by junior colleges. Courses not described in the "Guide," such as Micrometeorology and Tropical Meteorology, will be evaluated by A.C.E. upon request. To repeat, these recommendations are advisory and should not be construed as a guarantee that the indicated amount of credit will be granted by a given civilian school.

"The Weather Bureau needs a considerable number of meteorologists who have the equivalent of an advanced degree in modern statistical methods, especially with applications to climatology. They are also needed as forecasters who can, on their own initiative, develop objective methods of forecasting specific weather elements for designated locations. During the past year we have succeeded in developing simple, objective methods of forecasting that appear to be as accurate in the periods in which they have been tested as the forecasts made by experienced, well-trained meteorologists. Both the Bureau and the Department of Agriculture also need agricultural climatologists.

"The demand for competent, well trained statisticians could not be met before the war, and as a result of war experience the demand is greater than ever before. Since training in mathematical statistics was effectively stopped during the war, opportunities in this field are numerous and of many kinds. Army weather officers with undergraduate training in mathematics and/or engineering, also some with a background in agriculture, might well consider taking a year of training in modern statistical methods." ---C.F. Sarle, Executive Assistant, U.S. Weather Bureau.

Three schools now offering advanced degrees in statistics have instructors interested in the application of modern statistical methods to problems in weather, river forecasting, and climatology. The appropriate representatives are:

Miss Gertrude Cox, Director, Institute of Statistics, North Carolina State College, Raleigh, North Carolina.

Mr. H.C.S. Thom, Statistical Laboratory, Iowa State College, Ames, Iowa.

Dr. J. Neyman, Statistical Laboratory, Univ. of California, Berkeley, Cal.

Weathermen with agricultural backgrounds can apply for research assistantships at North Carolina State. In addition to funds they may receive under the G.I. Bill, a limited number of students will be paid $15 to $20 per week for 15 to 20 hours of research work in the statistics or the climatology of agriculture. Such students must carry at least 12 semester hours of courses, with statistics as a major. Three semesters or four quarters probably will be needed to obtain a Master's Degree in statistics unless the candidate has had that subject as an undergraduate.