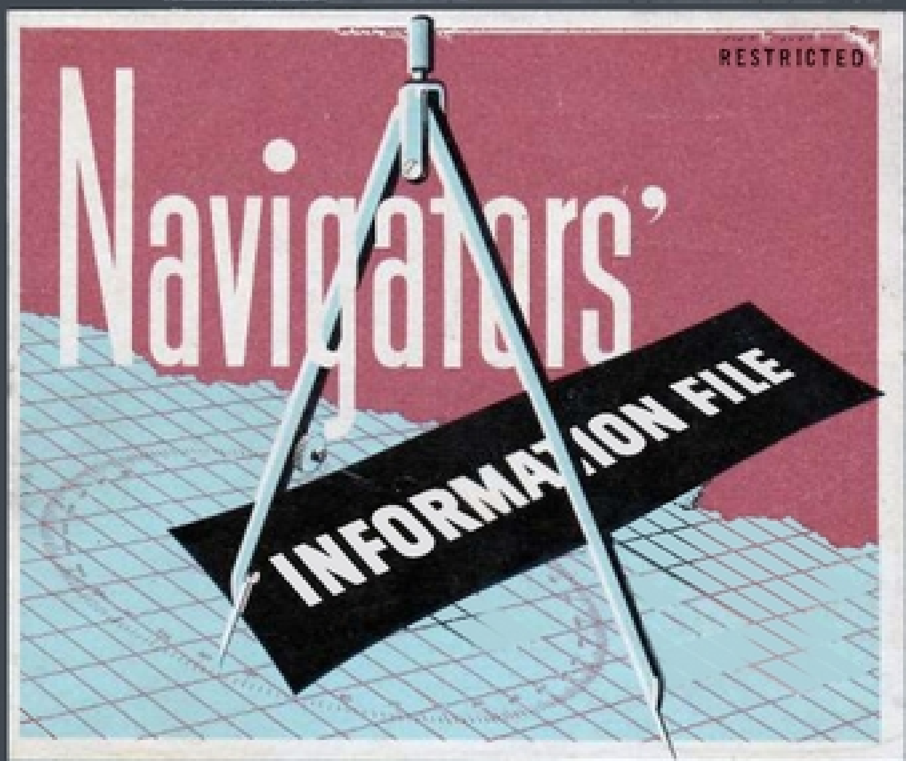

RESTRICTED
Navigators'
INFORMATION FILE

KEEP YOUR COPY OF NIF CURRENT

This copy of Navigator's Information File is from the original edition dated April, 1944. Revisions to the file will be released as new information and changes in procedures, techniques, and regulations become available.

NIF revisions may be obtained by you at any operations office, but preferably at your home station. Ask for them periodically to be certain that you have all the latest information in your file. When you receive a new revision put it in your copy of NIF immediately. Follow carefully the detailed instructions you will find on each NIF revision envelope. General instructions for revising this book are contained in NIF 1-5.

AS YOU REVISE NIF WRITE REVISION NUMBERS AND DATES IN THE SPACE PROVIDED BELOW

Revision Number	Date of Revision	Date received by you	Date Form 24NA certified
1	Oct., '44	Dec. 15	
2	APRIL, 1945	JUNE 28, 1945	

TAKE GOOD CARE OF YOUR COPY OF NIF

The supply of Navigator's Information Files is limited. Copies lost or damaged by misuse will be difficult to replace. Handle your copy of NIF carefully. When you are not using it put it away in a safe place so that it will not be lost or torn.

AAF REGULATION)
No. 62-15)
EXTRACT)

HEADQUARTERS, ARMY AIR FORCES
WASHINGTON, 24 NOVEMBER 1944

FLYING SAFETY

Information Files

(This Regulation supersedes AAF Regulation 62-15, 28 February 1944, and 62-15A, 1 May 1944.)

1. **General.** To promote safe flying and operational efficiency, AAF pilots, navigators, bombardiers, flight engineers, flight surgeons, aviation medical examiners and airborne radio operators who are on flying status must be familiar with many items of a general nature, with the results of current research, and with other instructions and information found in a variety of War Department, AAF, and other pertinent publications which are not always readily available to them. These items will be selected, organized, and presented in simple, non-technical form in loose-leaf books, to be designated as follows:

* * * * * *

b. For navigators: The "Navigators' Information File" (NIF).

* * * * * *

2. **Publication of PIF, NIF, and BIF.** The Office of Flying Safety will be responsible for the selection of items, the coordination of the material, the form and treatment of the subject material, the proper illustration of the text, and the publication of the Files. That office will be responsible for the publication of necessary revisions. It is authorized to deal directly with all AAF organizations and establishments in gathering and coordinating instructions and information for the Files. All AAF establishments will submit items which they desire to have included in the Files directly to Office of Flying Safety, Information Files Branch, Buhl Building, Detroit 26, Michigan.

3. * * * * * *

4. **Table of Contents.** A table of contents, listing, numbering, and dating all current subjects, will be published for each File. Each table of contents will be revised every three months. The use of the tables of contents is outlined in AAF Reg. 15-24.

5. **Distribution in Continental United States.** These Information Files and revisions thereto will be distributed by the Chief, Office of Flying Safety on the following basis:

* * * * * *

b. NIF: Through base operations officers, one copy to each AAF navigator in the domestic area, one copy to each aviation cadet in AAF Navigators' School. Two copies to each base operations office, group, and squadron. Copies as required to the regularly established files of AAF organizations and establishments. Copies to AAF schools and training establishments as necessary for the training program, and such copies as the Chief, Safety Education Division, Office of Flying Safety shall determine as necessary for the accomplishment of his basic directive.

* * * * * *

6. **Distribution in Overseas Theaters.** If commanding officers in overseas theaters and "alerted" areas so direct, PIF, NIF, BIF, ROIF, and revisions thereto will be procured by requisition to the Director, Air Technical Service Command, Wright Field, Dayton, Ohio, through Air Technical Service Command distribution centers located in the theaters concerned.

7. **Compliance.** Commanding officers will be responsible that personnel specified in paragraph 5 certify that they have read and understand all instructions and information contained in their respective Files; and that they place the revision sheets issued to them in their personal copies of the Files so that their Files are currently correct. Compliance with this directive will be recorded as follows:

* * * * * *

b. For navigators: Form 24N (the NIF table of contents) will be signed and used as a permanent record of compliance. When NIF and revisions thereto are distributed, they will be accompanied by compliance forms (AAF Form 24NA), which will provide temporary records of compliance. The use of AAF Forms 24N and 24NA is set forth in AAF Regulation 15-24.

* * * * * *

e. For all other personnel authorized to receive PIF, NIF, BIF or ROIF as set forth in paragraph 5 and for whom no Form 5 files are maintained, the record of compliance will be as directed by commanding officers.

8. **Retention of Permanent Forms.** Commanding officers will be responsible that permanent forms referred to in paragraph 7 are retained for record as directed in AAF Reg. 15-24.

9. **Familiarity with Instructions Regarding Equipment.** In addition to the provisions of this Regulation, commanding officers are responsible for insuring that pilots are thoroughly familiar with all instructions and information pertaining to equipment to be flown, as provided in AAF Reg. 50-16.

10. **Activities Exempt from These Provisions.** AAF activities operating in overseas theaters and AAF activities operating in domestic areas under "alert" orders will be exempt from the provisions outlined herein to the extent determined by the commanding officer concerned.

11. **Definitions.**

* * * * * *

b. The term "navigator" will be construed to mean any individual who holds a currently effective military aeronautical rating of aircraft observer (navigator) or aircraft observer (navigator-bombardier).

* * * * * *

By command of General ARNOLD:

OFFICIAL SEAL

HQ AAF

BARNEY M. GILES

Lieutenant General, United States Army
Deputy Commander, Army Air Forces and
Chief of Air Staff

Form 24NA for Navigators' Information File.

* * * * * *

Each such temporary certificate of compliance form consists of two sections: a small detachable bottom section, the use of which is described in sub-paragraph a, below, and a main upper section, the use of which is described in sub-paragraph b, below:

a. The detachable section at the bottom of each form is provided as a receipt for revision sheets (or for the complete volume of the pertinent Information File issued to any individual entitled to it). The individual receiving any Information File material will indicate by signature thereon that he has received it. Operations Officers will hold such receipts for their records until the compliance (main upper section of Form 24A, 24NA, 24BA or 24RA) is received. Whenever Information File material is issued to any individual entitled to it at any station other than his home base, his receipt (the lower detachable section) will be forwarded by the issuing agency to the base operations office of the recipient's home station.

b. The main (upper) section of Forms 24A, 24NA, 24BA and 24RA will list in red the revision number and the page numbers for which each is to serve as a temporary compliance certificate. When issued with the complete volume of the Information File, it will indicate that it applies to the complete volume of the pertinent Information File and indicate (in red) the revision numbers contained as an integral part of that edition of the Information File. Individual concerned will sign this portion of Form to certify that:

(1) He has read and understands the Information File material listed therein.

(2) He has **removed** from the Information File and **destroyed** all sheets that specific instructions printed on the envelope which contains the Information File material direct him to remove and destroy.

(3) He has placed each revision sheet listed in the compliance certificate in its proper place in the Information File.
When the individual concerned has complied with (1), (2), and (3) above, **(and not before)**, he will sign the compliance certificate (the upper section of Form 24A, 24NA, 24BA, or 24RA) and return it to the base operations officer at his home station.

5. Operations Officers will be responsible that the properly executed compliance certificate (upper section of Forms 24A, 24NA, 24BA, or 24RA) is returned within a reasonable time (but in no case longer than 30 days after receipt) and, in the case of personnel for whom Form 5 files are maintained, placed in the Form 5 file of the individual concerned. It will remain there until the individual has executed the next dated table of contents (Form 24, 24N, 24B, or 24R, whichever applies) and turned it in, when all previously dated compliance certificates (Forms 24A, 24NA, 24BA or 24RA) and the previous table of contents will be removed and destroyed. Compliance certificates for personnel for whom Form 5 files are not maintained will be retained for record as directed by commanding officers.

6. **Distribution.** AAF Forms 24A, 24NA, 24BA and 24RA will be published by the Chief, Office of Flying Safety and distributed:

a. Through Operations Officers, automatically inclosed with each set of revisions and each complete volume of any Information File.

b. Upon letter request from Operations Officers to: Office of Flying Safety, Information Files Branch, Buhl Building, Detroit 26, Michigan.

7. **Destruction of Unused Forms.**

a. Unused Forms 24, 24N, 24B and 24R become obsolete and will be destroyed six months after the date of issue.

b. Forms 24A, 24NA, 24BA and 24RA held in excess of the material to which they apply will be destroyed.

By command of General ARNOLD:

OFFICIAL SEAL

HQ AAF

BARNEY M. GILES

Lieutenant General, United States Army
Deputy Commander, Army Air Forces and
Chief of Air Staff

AAF REGULATION)
No. 15-24)
EXTRACT)

HEADQUARTERS, ARMY AIR FORCES
WASHINGTON, 23 NOVEMBER 1944

BLANK FORMS

AAF Form 24 .... PIF Table of Contents
AAF Form 24A .... Temporary Compliance Certificate for PIF
AAF Form 24N .... NIF Table of Contents
AAF Form 24NA .... Temporary Compliance Certificate for NIF
AAF Form 24B .... BIF Table of Contents
AAF Form 24BA .... Temporary Compliance Certificate for BIF
AAF Form 24R .... ROIF Table of Contents
AAF Form 24RA .... Temporary Compliance Certificate for ROIF

(This Regulation supersedes AAF Reg. 15-24, 28 Feb. 1944, and AAF Reg. 15-24A, 2 Aug. 1944.)

TABLES OF CONTENTS OF INFORMATION FILES

1. AAF Form 24N is the table of contents for the Navigators' Information File.

* * * * * *

Each has two uses:

a. As a part of the Information File for which it is the table of contents for a three-month period (until it is replaced by a revised current table of contents). Each will list, date, and number all current subjects in its pertinent Information File. An asterisk (*) prefixing any subject will indicate that the subject has been revised or added since the previous table of contents was issued.

b. As a compliance certificate for its pertinent Information File. Personnel specified in AAF Reg. 62-15 as being required to comply with pertinent information files and for whom a Form 5 file is maintained will sign the Form 24, 24N, 24B, or 24R (whichever applies). When a new table of contents is issued, it will replace the one in the Information File, and the replaced Form (24, 24N, 24B or 24R), properly signed, will be placed in the Form 5 file of the individual concerned, where it will remain as a record of compliance until the next issued Form (24, 24N, 24B or 24R) replaces it. Compliance records for personnel authorized to receive pertinent Information Files and for whom Form 5 files are not maintained will be kept as directed by Commanding Officers.

2. **Publication.** Under the authority contained in AAF Reg. 62-15, the Chief, Flying Safety will revise and publish AAF Form 24, 24N, 24B and 24R every three months. In order to facilitate identification of the date of issue, there will be a color band along one border of the respective Forms as follows:

* * * * * *

Form 24N Issue of 1 July (any year)—Blue
Issue of 1 October (any year)—Yellow
Issue of 1 January (any year)—Red
Issue of 1 April (any year)—Gray

* * * * * *

3. **Distribution.** AAF Form 24, 24N, 24B or 24R will be distributed by the Chief, Office of Flying Safety through Base Operations Officers:

a. As a part of every complete volume of the Information File for which it is the table of contents.

b. As one sheet of revisions to the Information File to which it belongs, issued as follows:

* * * * * *

Form 24N: NIF revisions dated 1 July, 1 October, 1 January, and 1 April.

* * * * * *

c. Upon letter request to: Office of Flying Safety, Information Files Branch,
Buhl Building, Detroit 26, Michigan.

TEMPORARY CERTIFICATES OF COMPLIANCE

4. Since Forms 24, 24N, 24B, and 24R are retained in their respective Information Files for the three-month period for which they are the current tables of contents, it is necessary to use temporary certificates of compliance for revisions which may be issued in the interim. Such temporary certificates will be issued as follows:

* * * * * *

Table of Contents . . . DATED JULY 1945

NAVIGATORS' INFORMATION FILE

IN accordance with the provisions of AAF Regulation 62-15, dated February 28, 1944, all AAF navigators in the United States will certify that they have read and understand all instructions and information contained in Navigators' Information File. They will do so by signing in the space provided at the end of the Table of Contents.

Check with operations offices regularly to be sure you have all current amendments to NIF and Table of Contents. The Table is revised quarterly and distributed on the same basis as the Navigators' Information File. Subjects preceded by an asterisk (*) have been revised or added to NIF since April 1945.

AUTHORITY FOR NIF-AAF REGULATION 62-15

TABLE OF CONTENTS-AAF FORM 24N

KEEP THIS FORM IN NIF DURING JULY, AUGUST, AND SEPTEMBER, 1945

KEEP THIS FORM IN NIF DURING JULY, AUGUST, AND SEPTEMBER, 1945

I CERTIFY THAT I HAVE READ AND UNDERSTAND ALL SUBJECTS IN THE NAVIGATORS' INFORMATION FILE LISTED IN FORM 24N, DATED JULY, 1945

When you receive your new Form 24N, dated October, 1945, remove this form, sign it, and give it to your Operations Officer to put in your Form 5 file.

SIGNED ______________________ ASN. ____________

RANK ______________________ CREW NO. ____________

ORGANIZATION ______________________

DATE ______________________

SECTION 1

GENERAL

IF YOU ARE A GOOD NAVIGATOR YOU ARE A SAFE NAVIGATOR. KNOW WHAT YOUR RESPONSIBILITIES ARE AND LIVE UP TO THEM. THE LIVES OF OTHER MEN ARE DEPENDENT UPON YOUR FINDING THE WAY.

NAVIGATOR'S RESPONSIBILITY

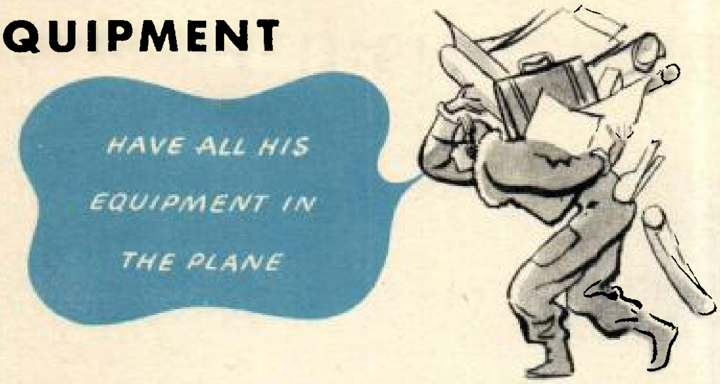
PLAN

- Distances
- Headings
- Altitudes
- Alternate Destinations
- Time of Departure
- Estimated Time of Arrival
- Methods of Navigation
- Precomputed Solutions
- Fuel Consumption

WEATHER

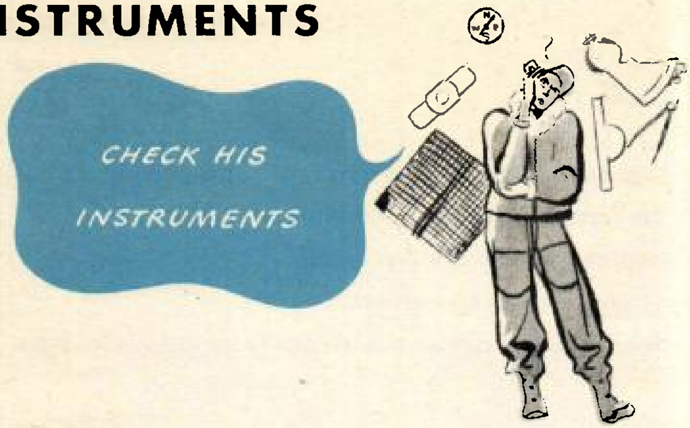
- Winds Aloft as Well as on the Ground
- Wind Trends
- Immediate and Forecast Conditions
- Position of Any Fronts
- Barometer Readings and Trends
- Dew Points
- Temperatures

EQUIPMENT



- Solution Books
- Log Forms
- Charts
- Flight Plan
- Precomputed Solutions
- Instruments and Tools

INSTRUMENTS



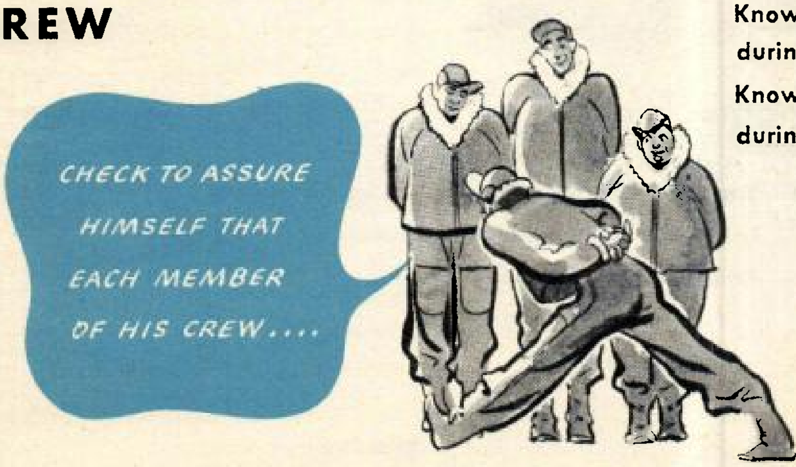
- Driftmeter Alignment
- Radio Circuits
- Compass
- Sextant
- Watch
- Turret Calibration
- Astro Mounts
- Instrument Panel
- Interphone

FUEL

"CHECK AND KNOW THE FUEL CONSUMPTION OF HIS PLANE"

Determine the exact amount of fuel in his tanks before each takeoff

CREW

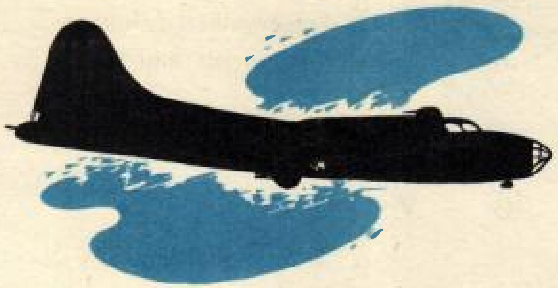


Knows his general navigation duties during flight

Knows his particular navigation duties during flight

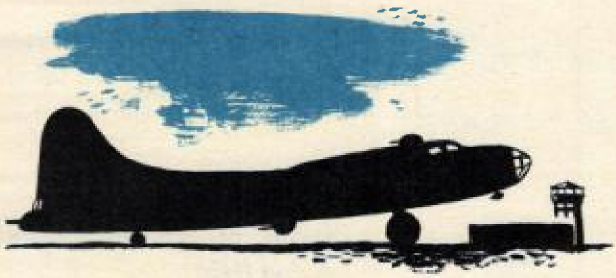
BE SURE THAT ALL ABOVE IS SATISFACTORY FOR THE FLIGHT PLANNED

NAVIGATOR'S RESPONSIBILITY



During flight the Navigator shall

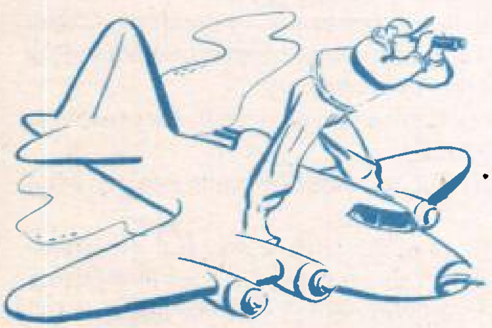
1. At all times use every means available of determining position
2. Check his compass on every heading
3. Give position reports upon request
4. Keep a complete log of events
5. Initiate requests for navigational aids from crew members



Upon landing the Navigator shall

1. Properly stow all equipment and instruments
2. Enter any instrument deficiencies in forms 1 and 1A
3. Analyze the completed mission
   - *(a)* Improper planning
   - *(b)* Errors made
   - *(c)* New situations
   - *(d)* Specific instrument flight errors
   - *(e)* Insufficient crew cooperation

FLYING SAFETY



UNSATISFACTORY NAVIGATION RESULTS FROM

Ignorance

Carelessness

Poor Physical Condition

Bad Judgment

Lack of Initiative

In the campaign to defeat these enemies of safety, proper authorities have prescribed navigation techniques, procedures and standard practices; but they can only point the way

SAFETY OF NAVIGATION DEPENDS UPON YOU

Keep yourself physically fit

Be proficient in every method of navigation

Keep your equipment in operating order

Check every result

Question everything you do in the light of good, hard common sense

Plan in advance for possible emergencies and work out in your own mind procedures you propose to follow for each

PLAN EVERY FLIGHT IN DETAIL

Be sure you know before you get off the ground, what your destination is, the weather you will probably encounter, the methods of navigation which will probably be most advantageous, and proper courses and distances.

If you don't have a planned attack for the mission and its individual problems, you won't solve them accurately in the air. Know what you are going to do—then do it.

CHECK YOUR EQUIPMENT

Be sure all of your equipment is in working order all of the time. Be sure the crew chief knows how to keep all of your equipment properly aligned and calibrated; but check it yourself and oversee every calibration—for you are going to use the equipment.

Be able to check the accuracy of your equipment in the few minutes before takeoff by sight alignment and calibration checks.

Establish and carry a check list at all times for use in gathering your equipment for each mission.

TAKE THE INITIATIVE

You are entrusted with the job of getting your airplane to its destination, so be sure you get it there—and on time.

Ask crew members to give you the help you need, when you need it, and be sure that your requests for information are understood. Check directly with the crew members to guarantee a proper understanding of terms and instructions you will use in the air.

Check all results at least twice, then ask yourself if the result is reasonable. Think out everything you do.

Know you are right, then be sure the pilot understands exactly what you want him to do.

Be sure your pilot is thoroughly familiar with terms and directions you will use in the air before you get off the ground. Go over everything that will improve your work together. When you're in the air, it is too late for groundschool classes.

Be so conscientious that your crew will always have confidence in your ability to find the way. Develop your technique to the point where even you have confidence in your work.

KEEP A COMPLETE LOG

Proper records of each flight are a must. Develop your own system of keeping the flight record, but be sure that it is adequate.

Do not hurry through an entry. Be sure the proper time, place and event is legibly and fully recorded.

Make enough entries to tell the full story. A complete log will absolutely reconstruct the flight for purposes of intelligence, observations, self-analysis, equipment flight errors, and general record. No mission is complete without a complete record.

ADMIT YOUR MISTAKES

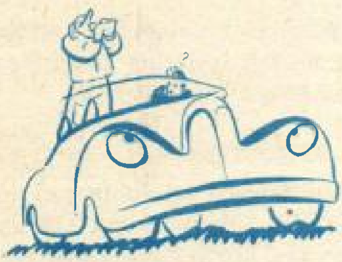
Be sure to analyze the results of every mission as soon as you get on the ground. Be honest with yourself.

If something has happened that you can't understand, find out why it happened. If you've made a mistake, decide why you made it. When you've found the reason behind poor results or unexpectedly good results, use this knowledge on all future missions.

When on a mission, keep the pilot fully informed of the progress you are making, without bothering him with every minor detail. He wants to know important things.

Don't get lost and keep that information to yourself until you run out of gas. If you let the pilot and crew know when things are going well, let them do some of your worrying when you are lost. Two heads are better than one when you're in a tight spot.

PRACTICE ALL METHODS OF NAVIGATION



No matter what type of navigation you are engaged in over a period of time, be sure to sustain your knowledge and skill in every form of navigation. You may have to use another type of navigation on your next mission.

You can retain your skill and knowledge only by sincere, conscientious endeavor. The knowledge of some minor navigational aid may mean the difference between life and death for you.

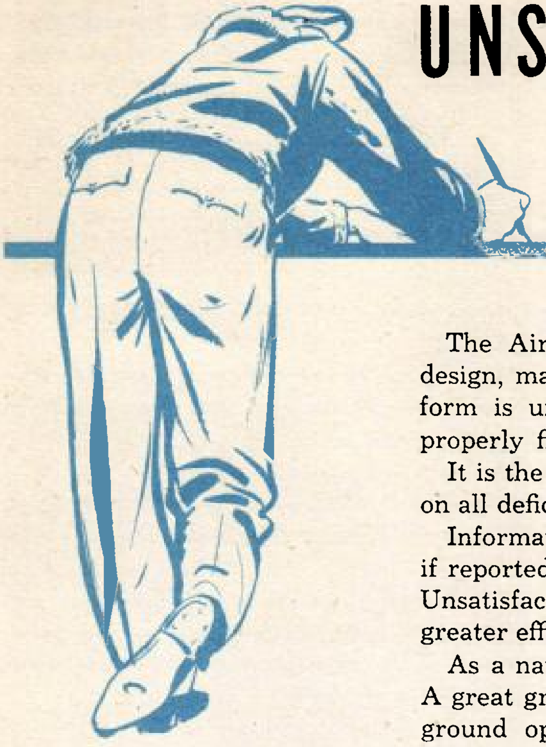
AT ALL TIMES, KEEP THINKING ABOUT NAVIGATION

KEEP PRACTICING NAVIGATION.

FINALLY:

Navigating is an exacting, serious business. It demands everything you have of knowledge, attention, effort, judgment, and skill. If you give it any less than your best, it exacts a high price for your mistakes.

UNSATISFACTORY REPORTS



The Air Technical Service Command wants to know what equipment, design, material, workmanship, maintenance or supply method, system, or form is unsatisfactory. AAF Form No. 54, Unsatisfactory Report, when properly filled out, gives the Command all the information it needs.

It is the responsibility of every navigator to file an Unsatisfactory Report on all deficiencies that affect the accuracy of his work.

Information concerning even the smallest failure may be of great value if reported to proper authorities in time. Everyone is encouraged to submit Unsatisfactory Reports whenever he sees an opportunity to contribute to greater efficiency by suggesting correction of faults.

As a navigator, you are in close touch with both methods and machines. A great ground organization is behind the men who fly. But both flying and ground operations always can be improved. Unsatisfactory Reports are designed to speed improvements and to permit the individual to present a maintenance problem and his suggested correction, through channels.

IMPORTANT

Unsatisfactory Reports are not restricted to faulty or unsatisfactory equipment. Use AAF Form No. 54 to report any of the following conditions:

1. **Failure of equipment.**
2. **Unsatisfactory equipment design.**
3. **Unsatisfactory aircraft design.**
4. **Defects caused by faulty material, workmanship, or inspection.**
5. **Unsatisfactory maintenance.**

How to Prepare a UR

Obtain AAF Form No. 54 from your Engineering Officer.

Each report must be a complete description of an individual case. It must explain the unsatisfactory condition, including all pertinent information, to enable investigation and correction of the trouble reported without the need for further requests for information. Include photographs and specific serial numbers of equipment. Unless you make the unsatisfactory condition clear you might as well not send in a UR. See AAF Regulation 15-54 for details about how to file different types of UR's.

Coordination

All Unsatisfactory Reports originating at a station are routed through the Engineering Officer, who investigates and enters his endorsement. He sends the UR to the Director, Air Technical Service Command at Wright Field, Dayton, Ohio.

Action

If you submit a UR don't expect an answer. Air Technical Service Command uses its personnel to correct deficiencies, not to answer mail. The U.R. Digest is published periodically and it reports on UR's received and action taken. Check this digest for a report on any UR's you have submitted.

An Unsatisfactory Report properly filled out is shown on the following page.

REMEMBER

AAF Form No. 54, Unsatisfactory Report, is designed to facilitate the correction of field problems. Minimize your problems by reporting all unsatisfactory conditions immediately.

WAR DEPARTMENT
AAF Form No. 54
(Revised 2-18-43)

WAR DEPARTMENT
ARMY AIR FORCES
UNSATISFACTORY REPORT
(See AAF Reg. 15-54 for Information on Proper Use of this Form)

TO BE FILLED IN BY STATION	
STATION SERIAL No.	DATE SUBMITTED
45-106	2-9-45

LEAVE BLANK		
A. S. C. SERIAL No.	REFER TO	CLASS

STATION: AAB, Westover Field, Mass.			ORGANIZATION: 112th AAF BU CCTS Bomb (H).			
SUBJECT OF REPORT	Property Class—Name: 05-A Aircraft Sextant, Type A-10		Manufacturer: Fairchild		AAF Order or Shipping No.:	
AIRCRAFT—Model & AAF Serial No.:		ENGINE—Model & AAF Serial No.:		UNIT OR ACCESSORY—Type, Model and Serial No.: Type A-10, all models		
AIRCRAFT REPORTS ONLY	LAST B. L. R.—Depot:		Date:	Flying Time Since:	Total Flying Time:	
ENGINE REPORTS ONLY	LAST OVERHAUL—Depot:	Hours Since:	Depots and Hours At Each Previous Overhaul:			
PART	Name: Bubble Chamber		Part Drawing, Serial and Specification No.: C320-389			
PART	Time in Use: Since Jan '43	Quantity on Hand: 120	Quantity Known Defective: 120	No. Previous Failures:	Manufacturer:	Inspector's No. or Identification:

Indicate by "X" Disposition of Exhibit: [X] Photographed and Prints Enclosed; [X] Held for Instructions; [ ] Sent Under Separate Cover; [ ] Sent in Attached Package; [ ] Repaired and Returned to Service; [ ] Disposed of (Explain Below.); [ ] To Overhaul Facility (INITIALS)

GIVE COMPLETE DETAILS, PROBABLE CAUSES AND RECOMMENDATIONS BELOW:
(Use Only Applicable Spaces Above—Avoid Unnecessary Repetition)

EXPEDITE

1. DESCRIPTION OF UNSATISFACTORY CONDITION:

The use of electrical illumination for the A-10 sextant bubble causes the field of vision to be filled with dim light which has been scattered from the periphery of the bubble, thereby reducing the visibility of stars.

2. HISTORICAL DATA:

Experiments conducted by the Standardization Board, this station, in conjunction with the physics department of Massachusetts State College, indicate positively that radium illumination of the bubble is possible.

3. ACTION TAKEN TO CORRECT UNSATISFACTORY CONDITION:

See Historical Data. Subject UR submitted.

4. RECOMMENDATIONS:

Paint with radium paint the following parts: (a) Ring, Bubble Chamber Light, Manufacturers' Drawing #B320-376; (b) Plate, Bubble Chamber Diffusion, Manufacturers' Drawing #B320-420. The recommended change will permit the elimination of the battery case with two batteries which is now used for internal illumination of the bubble.

5. DISPOSITION:

In use; held for instructions.

R. C. Kugel
R.C. KUGEL,
Lt. Col., A.C.,
Director for Maintenance & Supply.

ROUTING SEND ORIGINAL AND TWO COPIES DIRECT TO COMMANDING GENERAL, HQ. AIR SERVICE COMMAND, PATTERSON FIELD, FAIRFIELD, OHIO.

U. S. GOVERNMENT PRINTING OFFICE : 1943 16—34019-1

SAFEGUARDING CLASSIFIED MATERIAL

Military information and devices are classified as **top secret, secret, confidential,** or **restricted.** All classified material is clearly marked with its classification. If it is not so marked, it is unclassified. Treat all classified material as follows:

Top Secret

May be read or handled only by specifically designated persons. No one may have access to it merely because of his rank or office. Special procedures for handling top secret material are covered by letter instructions to the people concerned.

Secret

Only persons directly concerned should read it. It should be discussed only with those who may read it. It must be kept in a 3-combination safe when not in use. It must be mailed in two envelopes, an inner envelope addressed properly and marked or stamped **Secret**; an outer envelope addressed properly, **but with no marking to indicate its classification. Send it by registered mail.**

To destroy secret or confidential material, burn it, or use an approved shredding machine. Until you can do one or the other, tear it in small pieces and safeguard it as you would the original material.

Confidential

May be read only by persons in the military establishment and by civilians whose duties require that they read it. It may be discussed with those authorized to read it, **but never over the telephone.** Mail and guard it the same as secret material.

Restricted

May be read by, and discussed with anyone whose loyalty is unquestioned. It is never to be released for publication, or discussed with the general public. It is to be kept in a guarded area, behind locked doors, or in a safe.

Mail by first class mail unmarked.

To destroy, tear up the material before throwing it into a wastebasket.

Inspection

At every Headquarters an inspection will be made each day immediately before closing to insure that classified material is properly taken care of.

Classified Equipment

The regulations for safeguarding classified equipment are, so far as practicable, the same as those for written matter. In general the procedure for handling secret and confidential equipment is as follows:

When you land at an Army Air Field, either post an armed guard or remove the equipment and place it in a locked safe or vault.

When you land at any other field, be sure that an armed guard is continuously assigned to your airplane. **Locking the airplane is not a substitute for a guard.**

When you are forced down in or near enemy-held territory, destroy all secret and confidential equipment. If detonators are installed, use them. If not, destroy the equipment manually. Make certain that the essential parts of the equipment are destroyed beyond recognition.

Remember: You are directly responsible for the classified material in your possession. You may at any time become responsible for such material normally in the hands of others. You must **understand** these classifications in order to know what your responsibilities are in any given case. You must **observe** security regulations at all times or you will endanger yourself, your crew, and your mission.

REFERENCE: Army Regulation 380-5

HOW TO USE NIF

Your NIF Responsibility

When you receive NIF revisions you are required by AAF Regulations 62-15 and 15-24 to do the following:

1. Sign the receipt portion of Form 24NA (which is always enclosed as the first sheet of every revision). Hand this receipt at once to the operations office where you received the revision.
2. Read the directions on the envelope which contains the revision.
3. **Remove from your NIF and destroy** the pages which are listed on the envelope. Don't try to short-cut and place the revision pages in at the same time you remove the replaced pages. You are sure to make mistakes. Do it one step at a time. Go clear through your book and take **all** pages out that are listed on the envelope. **This is vital.**
4. Read and study the revision sheets until you understand them.
5. Place the revision sheets in **their proper places** in your copy of NIF.
6. When you have done all of the above, **and not until you have done it all properly,** sign the compliance section of Form 24NA and return it to your Operations Officer so that it may be placed in your Form 5 file.

You have 30 days (by AAF Regulation 15-24) in which to do all of the above. If you have neglected any of the steps above you have violated regulations and are subject to disciplinary action.

The duties outlined here require perhaps two hours a month. If you shirk or neglect these duties your NIF cannot be useful to you. It must be currently correct or you cannot add new revisions properly.

Navigators' Information File is your book. It was designed to save you many hours of work. You would have to search and read through thousands of pages of War Department, AAF, and miscellaneous publications to get the information which you have to have to keep up-to-date with your duties and responsibilities if it were not for NIF.

General

The Navigators' Information File is a manual of instructions and information with which all AAF navigators in the continental United States are required to comply, in accordance with the provisions of AAF Regulation 62-15.

NIF is designed to keep you informed of matters affecting flying safety and operational efficiency. It contains a review of basic material and attempts to keep abreast of changes in equipment and techniques. Check frequently to be sure that you have read and understand the information in NIF.

How Subjects Are Numbered

Each subject listing is numbered. **The first number** indicates the section. For example, 3, which is Celestial. **The second number** refers you to the subject. For example, 3-4, Aircraft Sextants. **The third number** lists the page. Thus, the third page of Aircraft Sextants is marked 3-4-3.

Revisions

Revised sheets bear a new date line in the upper right hand corner thus: REVISED APRIL, 1945. If the page is new and does not replace an old one, it bears a line thus: ADDED APRIL, 1945.

Often a whole subject is revised completely and the revised pages may number more or less than the pages they replace. In such a case all the pages merely bear the REVISED notation, with the date. So don't be confused if you have more or fewer pages than you have removed.

To Comply with Revisions

When you receive a set of revision sheets from your operations office, you find in the envelope a temporary certificate of compliance (Form 24NA).

Before you sign it to certify that you have read and understand all the revisions, be sure you have read and have complied with each item you are certifying to.

With each revision a page is supplied to explain the changes that were made. You will find that often only minor changes have been made on some pages.

Distribution of Revisions

Revisions are distributed to individual navigators by the Base Operations Officer, who receives revisions automatically from the publisher of the File.

If any Operations Officer does not receive the correct number of revisions (plus a 10% overage) he will communicate at once with: Office of Flying Safety, Information Files Branch, Buhl Building, Detroit 26, Michigan, stating number of revisions required at his station. He will also send letter request to the above for any copies he may need of the complete File.

Operations Officer will also report promptly on the activation or deactivation of any station.

The Table of Contents (Form 24N)

Every three months you will receive a new Table of Contents in the envelope with the revisions of that month. In order that you may identify it, and be sure that you have the current table in your NIF the following color key is used:

January : Red	April : Gray
July : Blue	October : Yellow

Subjects preceded by an asterisk (*) have material revised or new since the last Table of Contents.

You will find that all the pages of any one subject do not bear the same date. But the date following the subject listing in the Table of Contents is the **latest revision date for any of the pages included in that subject.**

When you replace the Table of Contents with a new one, **don't destroy the old one.** Sign it to show that you have read and understand all the subject matter it lists. Then turn it over to your Operations Officer to be placed in your Form 5 file.

Operations Officer's Responsibilities

An Operations Officer is responsible:

1. That every navigator attached to his base receives a copy of NIF and all revisions.
2. That every navigator on his base signs a compliance form certifying that he has read and understands all material contained in NIF and revisions.
3. That the compliance certificates (Form 24NA and Form 24N) are placed in the Form 5 files of the individuals concerned.

When navigators turn in their Forms 24N at the end of a three-months period, the Operations Officer will see that previously dated Forms 24N and 24NA in the Form 5 files are removed and destroyed.

WANTED: YOUR CRITICISMS OF NIF

May we call your attention to AAF Regulation 62-15, which directs all AAF establishments to submit, to the address given below, items they desire to have included. This also means any criticism of material already in NIF—corrections, questions of interpretation, and mistakes. Staff navigators of all commands in the domestic area meet every three months to advise the Editor, NIF, and review all suggestions and criticisms from the field. Our aim is to keep NIF accurate, current, and fully useful. If you can help us do that, we will appreciate it. Mail any comments, criticisms, or suggestions to: OFFICE OF FLYING SAFETY, Information Files Branch, Buhl Building, Detroit 26, Michigan.

NAVIGATION DIRECTIVES

The following Army Air Force Regulations, Memos, and Training Standards affect your status as a navigator and as a member of an aircrew. The directives referring to your navigation duties are classed as *primary*. Others are *general*. Training Standards are listed separately.

PRIMARY

Regulations

AAF Regs. 15-21 and 15-21A. Instructions for filling out AAF Form 21A, Navigator's Flight Log.

AAF Reg. 15-24. Use of Forms No. 24N and 24NA, certifying that Navigators' Information File has been read and is up-to-date.

AAF Regs. 50-7 and 50-7A. Training and other requirements necessary to attain navigator's rating.

AAF Reg. 55-17. Requires each station to have a properly installed master watch or clock, checked at least once each day against radio time signals. Also shows method of recording daily error.

AAF Reg. 55-18. Requires that flight crews be briefed thoroughly in operations, intelligence, weather, communications, and any other subjects necessary for the accomplishment of their missions. Covers the subjects in which the crews must be briefed.

AAF Reg. 60-17. Navigational training: correct navigational procedure; limitation of navigational methods, including pilotage, dead reckoning, radio navigation, and celestial navigation.

AAF Regs. 65-67 and 65-67A. Issue of kits: Permanent issues to authorized military personnel are made on shipping tickets. Temporary issues to nontactical organizations and to individuals are made on memorandum receipts.

Memos

AAF Memo. 35-12. Duties of staff navigation officers assigned to squadrons, groups, or wings. Training responsibilities of such officers are emphasized particularly.

GENERAL

Regulations

AAF Regs. 15-54 and 15-54A. Unsatisfactory reports. See NIF 1-3-1.

AAF Reg. 35-16. Suspension, removal, and reassignment of rated personnel on flying status.

AAF Reg. 35-47. This regulation contains descriptions of all the Army aviation badges, tells who may wear them, and prescribes that no one shall wear more than one at a time.

AAF Regs. 60-16, 60-16A, 60-16B, 60-16C, 60-16D, and 60-16E. Air traffic rules. These regulations also include a list of distress signals (Reg. 60-16, par. 13).

Memos

AAF Memo. 25-2. Effects of high altitude on flying personnel. Memo includes use of oxygen.

AAF Memo. 65-8. Common abuses to parachutes.

TRAINING STANDARDS

AAF Training Standard No. 20-1 (Special). For A-26 night bombardment crews.

AAF Training Standards Nos. 20-1 and 20-1A. For medium and light bombardment crews.

AAF Training Standards Nos. 20-2 and 20-2A. For heavy bombardment crews.

AAF Training Standard No. 20-3 (Special). For B-29 units and crews which operate stripped aircraft.

AAF Training Standards Nos. 20-3, 20-3A, and 20-3C. For very heavy bombardment crews.

AAF Training Standard No. 30-4. For night photo reconnaissance units and crews.

AAF Training Standard No. 30-6. For reconnaissance units and combat crews engaged in long-range photographic, weather, and radio-countermeasure missions.

AAF Training Standard No. 30-7. For reconnaissance units and combat crews (very long range photographic).

AAF Training Standard No. 80-970. For Link Celestial Navigational Trainer Operator (SSN 970). SSN means Specifications Serial Number.

AAF Training Standard No. 90-1034. Job description for the navigator.

AAF Training Standard No. 90-1036. Job description for the navigator-bombardier.

AAF Training Standard No. 120-2. Requirements and proficiencies to attain in the operational training of troop carrier groups, units, and combat crews.

AAF Training Standard 130-2. For emergency rescue units and crews (aircraft).

NAVIGATION INSTRUMENT TECH ORDERS

Air Position Indicator	05-35-34
Airspeed Meter	05-10-2
Airspeed Meter Calibration	05-20-8
Altimeter	05-30-1
Altimeter, Radio SCR-718	AN 08-40SCR718-2
Altimeter, Radio AN/APN-1	AN 08-10-186
Astrocompass	05-15-11
Chronometers and Navigation Watches	05-35A Series
Compass, Calibration and Swinging	05-15-3
Compass, Gyro-Stabilized Flux Gate	AN 05-15-16
Compass, Magnesyn	AN 05-15-5
Compass, Magnetic	05-15-2
Compass, Magnetic B-16	AN 05-15-17
Computer, C-2 Altitude	05-35-21
Computer, E-6B	05-35-9
Computer, G-1 True Airspeed	05-35-17
Directional Gyro	05-20-10
Driftmeter, B-2	05-25AA-1
Driftmeter, B-3	05-25DA-2
Driftmeter, B-5	05-35-20
Kits, Celestial Navigation	00-30-61-2
Loran AN/APN-4	AN 08-30APN4-2
Loran AN/APN-9	AN 08-30APN9-2
Radio Compass, AN/APN-7	AN 08-30APN7-2
Radio Compass, Model MN-31	08-10-85
Radio Compass, SCR-269-G	08-10-175
Radio Compass Calibration and Compensation	08-5-30
Radio Data and Radio Aids to Airways Flying	08-15-2
Sextants, A-5 and A-7	05-35-4
Sextants, A-6, A-6A, and A-8	05-35-7
Sextant, A-10	05-35-12
Sextant, A-10A	05-35-33
Sextant, A-12	05-35-15
Sextant, AN-5851	05-35-22
Sextant, AN-5854	05-35-27

UNSATISFACTORY NAVIGATION EQUIPMENT MUST BE REPORTED ON AN AAF FORM NO. 54, UNSATISFACTORY REPORT. YOU MUST GIVE THIS FORM TO YOUR SQUADRON AND GROUP NAVIGATOR AS WELL AS TO YOUR ENGINEERING OFFICER

SECTION 2

DEAD RECKONING • PILOTAGE • RADIO AIDS

YOUR ABILITY TO NAVIGATE STEMS FROM YOUR ABILITY TO DEAD RECKON ACCURATELY. LEARN EVERYTHING YOU CAN ABOUT DEAD RECKONING AND SUPPLEMENT THIS KNOWLEDGE WITH SOUND PRINCIPLES OF PILOTAGE AND RADIO AIDS.

NAVIGATIONAL TERMS

AAF publications for the most part agree in their definitions of navigational terms. In their use of these terms, however, AAF navigators sometimes depart from the meanings of the definitions. The following explanations may bring about more consistency between definitions and uses.

DEAD RECKONING

Dead reckoning, the basis of all navigation, is the use of information such as time, speed, and distance from a known position to find unknown data involving the same factors.

1. In **basic dead reckoning**, use groundspeed and track-made-good, established directly from two or more known positions.

2. In **precision dead reckoning**, use known position, true heading, true airspeed, and wind speed and direction.

   In **ground plot**, find the position of your airplane by plotting track-made-good (true heading with wind effect) and groundspeed (true airspeed with wind effect).

   In **air plot**, find the no-wind position of your airplane by plotting true heading and true airspeed.

3. In **follow-the-pilot**, continuously determine your position, using precision dead reckoning, without controlling the heading or airspeed of the airplane.

FIXES

A fix is the airplane's position determined by one or more navigational aids.

1. In **fix-to-fix** procedure, treat single fixes as actual positions.
2. In **average track** procedure, establish average track and groundspeed by interpreting a series of fixes.

DEAD RECKONING

Importance

The successful termination of any flight depends on dead reckoning. Navigators returning from all over the world—from the Aleutians, where weather is always a problem; from the Marianas, where long over-water flights are made constantly; from China, the land of no maps—stress this fact: **Dead reckoning is the basis of all navigation. Use it.**

Celestial, pilotage, radio, and Loran all are aids to dead reckoning. Use them only as aids.

Dead reckoning is based upon the solution of the time-speed-distance problem, and **you are primarily a dead-reckoning navigator.** Pilots dead reckon on every flight, though they are not always aware of this fact. Your work must be more exact, of course, than a pilot's mental calculations. And you must know and use every form of dead reckoning available to you on every flight you make.

If you make but one resolve as a navigator, it should be, "I'll dead reckon on every flight from the time we take off until the wheels are back on the ground." If you do less than this you are not doing your job—and that can easily prove fatal.

Computations

To do accurate work you must be able to recognize all possible errors in your computations and know how to compensate for them. Furthermore, you must understand the navigation problems you are likely to encounter and plan your solutions of them **before you leave the ground.** Constant air practice then gives you needed confidence.

Prepare adequately on the ground to make your work as easy as possible in the air. The distractions of flight conditions such as combat, weather, and lack of oxygen, and the inconveniences of fatigue and cramped quarters unavoidably complicate your job. Don't make it more difficult for yourself.

True Airspeed

An error that is not always recognized is the error in the free-air temperature gage. Although the free-air temperature gage is mechanically perfect, it measures only the temperature of the air immediately surrounding the airplane. Because of the effects of compressibility and friction, this air invariably is **warmer** than the free air. Obtain accurate free-air temperature by decreasing indicated temperatures by the following amounts:

TAS (knots)	Decrease (C°)	TAS (knots)	Decrease (C°)
60	0.4	260	7.2
80	0.7	280	8.3
100	1.1	300	9.5
120	1.5	320	10.9
140	2.1	340	12.3
160	2.7	360	13.7
180	3.4	380	15.3
200	4.2	400	17.0
220	5.1	420	18.7
240	6.1	440	20.5

1. Set indicated temperature and altitude on your computer and read approximate true airspeed above calibrated airspeed.
2. Enter the table with approximate true airspeed and find the temperature correction.
3. Use the corrected temperature and altitude to obtain accurate true airspeed.

Record corrected free-air temperatures on weather reports for Weather Intelligence, or note on the report that you have not made the correction.

REFERENCE: Technical Order 05-40-15.

Turns

Depending upon the type of operation and whether your airplane is flying alone or in a formation, it may be a good idea to calculate the distance you travel in a turn. That distance depends upon the rate of turn and the speed at which you are flying.

For example, a formation of B-17's (approximately 36 airplanes), indicating 150 mph, makes a 90° turn in this manner:

The lead airplane starts to turn one minute before the turning point and straightens out on course one minute past the turning point.

You can gain or lose time by increasing or decreasing the rate of turn.

WIND DETERMINATION

Track and Groundspeed

When you know true heading, true airspeed, track-made-good, and groundspeed you can obtain wind direction and speed on the E-6B computer as follows:

1. Obtain track-made-good and groundspeed by any method which is convenient, such as a pilotage or Loran fix.
2. Place the true heading of your airplane under the true index of your E-6B computer.
3. Place true airspeed under the grommet.
4. Mark the intersection of your groundspeed and drift line.
5. Place this mark on the center grid line under the grommet.

In combat, after assembling the formation, lead navigators fly a briefed true heading at a briefed indicated airspeed in order to check metro winds. They do this before crossing enemy territory.

Wing navigators also should know how to check metro winds; this is valuable information if they must abort or are separated from the formation for any reason. They should be told the best leg for checking winds, during briefing, and should use the following procedure:

1. Use the briefed true heading, even though your compass fluctuates around this heading.
2. Use the briefed indicated airspeed. The lead airplane flies at a constant airspeed in formation.
3. Apply free-air temperature and pressure altitude to the briefed indicated airspeed to find your true airspeed.
4. Obtain track-made-good and groundspeed by any convenient method.
5. Place these four factors, TH, TAS, GS, and TMG on your E-6B in the way explained previously.

If the flight plan is altered for any reason, all airplanes in the formation are notified.

Air Plot

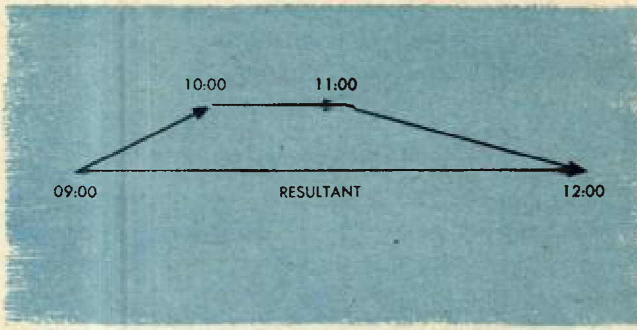
You can find an air position (no-wind position) for any given time in flight by using true heading and true airspeed as a basic plot. The vector between your air position and a pilotage point or fix is average wind effect from the beginning of the plot. Place this wind on your computer to obtain drift correction for altering your course into destination.

When using an air plot, you determine the wind once you have established a fix, even though you have flown several headings. After several hours of flight, however, this wind is not a reliable indication of the latest wind. It is an average wind effect.

Here is a suggested method of obtaining a reliable dead-reckoning position if your fixes are liable to be five miles or more in error. This is particularly applicable to a single airplane in over-water flying.

You must obtain at least one fix an hour to achieve good results.

1. Keep an air plot.
2. Use each fix to obtain a wind.
3. Keep a plot of the wind vectors obtained from each fix, with a record of the number of minutes that each represents.
4. Divide the resultant force by the total number of minutes represented. This gives you a wind force.
5. Using the average weighted direction, plot this wind force for the time of your desired dead-reckoning position. This gives you a weighted dead-reckoning position from which to turn into destination. It should be accurate within 10 miles even though your fixes are 10 miles in error in any direction and a 90° wind shift has occurred at some time during the flight.



AVERAGE WEIGHTED WIND

Example:

1. Departure 09:00.
2. Take a fix at 10:00. Wind which you obtain from the fix is 245°/20k.
3. Plot this vector.
4. Take another fix at 11:00. Wind which you obtain from this fix is 270°/17k.
5. Plot this vector from the end of the first vector.
6. Take another fix at 12:00. Wind which you obtain from this fix is 286°/34k.
7. Plot this vector from the end of the second vector.
8. Measure the direction and length of the resultant. 271°/67k.
9. Because the resultant is found from vectors totaling six hours, divide 67 by 6. The average weighted wind is 271°/11k.
10. You want a dead-reckoning position at 12:30 so you can alter course to destination. Plot a wind vector from your 12:30 air position equal to 271°/38½k (3:30 × 11k). The end of this vector is your weighted dead-reckoning position at 12:30.

Wind Pilotage

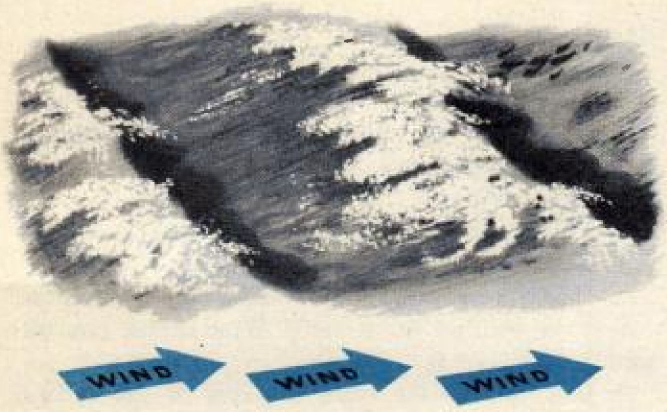
If you fly at an altitude of 2000 feet or less, with no cloud formations between your airplane and the surface of the water, you can estimate the direction and force of the wind. As a general rule, in the Northern Hemisphere wind direction at 1500 feet over the sea is about 10° greater than at the surface. Apply this tendency to veer (shift clockwise) pro rata for intermediate heights. It is too uncertain for extension much above 1500 feet. Westerly winds always veer in this manner; easterly winds sometimes veer, but not always. The direction of wind shift is reversed in the Southern Hemisphere.

Over inland waters the wind direction varies as much as 30° to 40° because contours along the shoreline affect wind direction.

The ability to estimate this wind is important, because 6- to 12-hour, low-altitude, over-water missions are not uncommon. Emphasis on Pacific operations makes this even more important.

Wind Direction

Crest lines of the smallest ripples on the sea surface are perpendicular to the direction of the wind. The foam or white caps that are formed on the water always appear to slide into the wind. This illusion is especially striking to an observer in an airplane.



What actually happens is that the foam is left on the water by the white caps, and as the waves advance the foam is left behind.

To judge wind direction:

1. Place true heading of the airplane on your E-6B computer.
2. Hold the computer with true index facing the nose of the airplane and the center grid line parallel to its longitudinal axis.
3. Lay your plotter across the computer, parallel to the crest line of the waves.
4. Read true bearing of the crest line and add or subtract 90° to obtain wind direction.

When there is no definite line of waves or ripples you can often see streaks on the water parallel to the wind direction. These streaks are called wind lanes. By aligning your plotter with these wind lanes you can obtain wind direction directly from your computer.

At the approach of a squall or a sudden summer shower a rapid wind shift of as much as 180° may be expected.

You can detect a wind shift by watching the surface of the sea. When the wind shifts, the waves at first appear to run together.

Watch the surface carefully when you see these indications of sudden shifts in the wind:

1. A sudden calm or glassy surface.
2. Curved wind streaks. Long, straight streaks indicate a steady wind.
3. A distant line appearing on the surface, as if caused by a rip tide.

Wind Force

The appearance and roughness of the sea depend upon a number of factors, and not solely on the strength of the wind locally. The length of time the wind has been blowing and the rate at which it is changing its direction and velocity are the more important influences. Make changes in the following guide as your experience dictates.

The force of the wind is divided into six phases:

1. **0-3 knots.** When there is no wind the sea is calm and the surface is glassy. You can observe ocean currents during a calm. If you are flying over an area in which there are currents, you find they look like long winding rivers on the surface of the sea, they stand out so prominently.

As the wind increases, the sea becomes rippled in patches. These patches stand out like green fields surrounded by brown foliage.

2. **4-6 knots.** The entire surface of the water is rippled. The sea is beginning to be disturbed.
3. **7-11 knots.** You can see a definite wave formation with scattered white caps making their first appearance. Some of these white caps appear to be longer than others. The height of the wave crest is from 3 to 5 feet. The white caps have grown large enough to make foam, which, as it slides into the trough, appears to slide into the wind.
4. **12-16 knots.** The surface of the sea becomes rough. The height of the wave crest is now 5 to 8 feet. This phase is characterized by numerous well-developed white caps, which give the ocean a spotted appearance. The foam that is made by the white caps now stays on the water for the first time.
5. **17-21 knots.** The difference between this phase and the preceding one is principally one of degree. For the first time, however, the foam that is formed is blown over the tip of the waves in the form of a spray. This spray is easy to see and it marks a definite phase in the force of the wind.

The height of the wave crest is now from 8 to 12 feet.

6. **Above 22 knots.** The sea becomes foamy and the spray gets thick. The height of the wave crest increases from 12 to 20 feet with a wind force of 25 knots. At 33 knots the waves increase to a height of 40 feet, at which time their forms become completely confused.

Important

Your estimation of windspeed is not as reliable as your estimation of wind direction. This is especially true when temperatures and pressures are lower than standard.

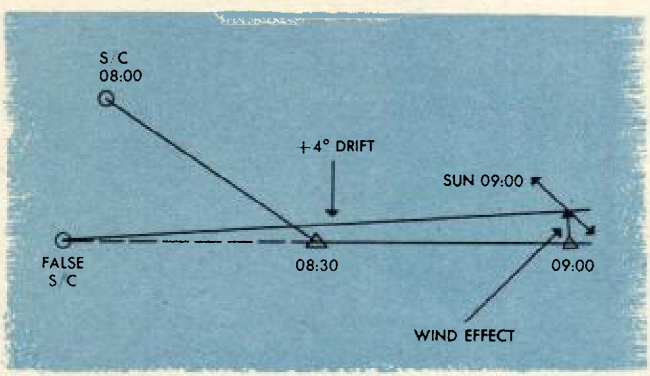
At all times remember you are using your own judgment of the wind. You will gain confidence in your judgment at first by estimating the wind, then checking it with a double drift. When you can estimate the drift on course to the degree, you can begin to have confidence in your ability to read drift from the appearance of the surface of the sea.

When you know wind direction, determine windspeed on the E-6B computer as follows:

1. Place the grommet over your true airspeed.
2. Draw a line down from the grommet, representing the direction of the wind.
3. Turn the scale to the direction of flight (true heading at true index).
4. Draw in the observed drift on course.
5. The intersection of these lines gives you windspeed as well as direction.

You can't check wind force in this manner when you have a direct headwind or tailwind because you don't observe any drift.

Drift and Position Line



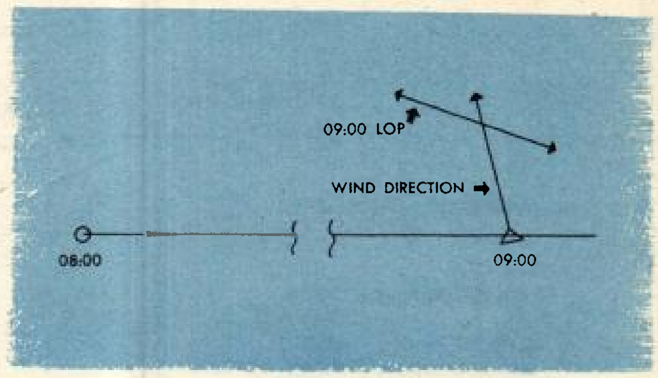
When you are flying at an altitude above 2000 feet and are unable to judge wind direction and speed from the water, use the following procedure:

1. Carry an air plot.
2. Read drift with your driftmeter.
3. Plot average drift (not drift correction). This line is your track-made-good.
4. Obtain a line of position, such as radio, celestial, or radar.
5. Draw a line from your air position to the intersection of your track-made-good and line of position. This is wind effect for the duration of the plot.
6. Convert this to an hourly wind.

To increase the accuracy of your wind finding, take two or more lines of position and average them.

If your air plot changes in true heading, lay off the length of the air plot to the turning point in a reciprocal direction from the turning point. This gives you another departure point. Proceed as indicated above.

Position Line and Wind Lane

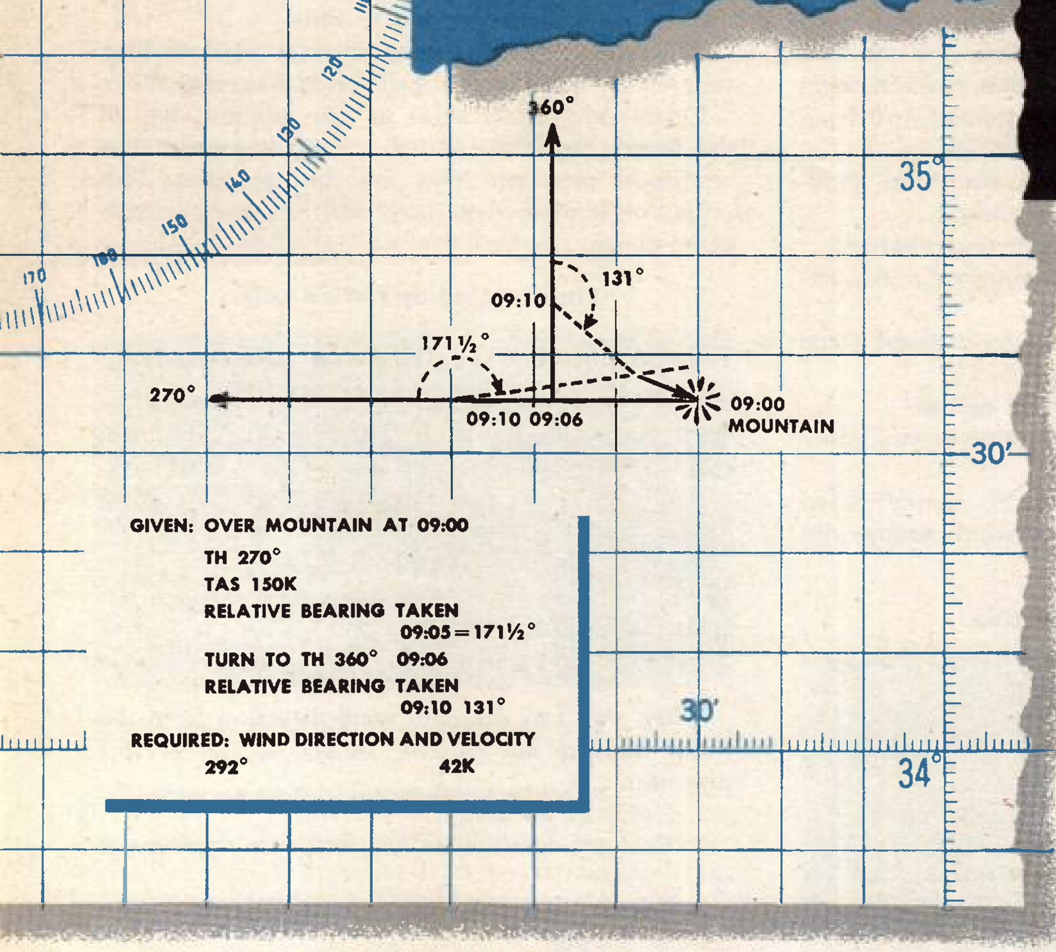


When you can estimate wind direction from the water but are not sure of windspeed, follow this procedure:

1. Carry an air plot.
2. Estimate wind direction from the appearance of the water.
3. Obtain an average line of position (two or more lines of position).
4. Plot wind direction for your air-plot position at the time of the line of position until it cuts the line of position. This vector is your wind effect.
5. Convert this to an hourly wind.

See the index for other wind subjects in NIF. Take special note of NIF 2-22, Most Probable Position.

WIND BY BEARINGS



Procedure

Fly the airplane over a definite object, and hold the heading constant for a definite length of time. Take a bearing on the object while on this heading by such means as are available: pelorus, astrocompass, driftmeter, or gun turret. Then take a new heading, preferably 90° to the first heading. Take a bearing on the object while on this heading.

For the time of the second bearing, establish the true air position along each heading by moving the first bearing up to the time of the second bearing along the original heading by use of true airspeed.

From this position on each heading, plot in the relative bearing found on that heading. From the intersection of the two bearings, draw a wind vector toward the object on which the bearings were taken. The direction of the wind is always toward the object. This represents the wind direction and velocity for the period of time that elapsed between first passing over the object, and the time of the second bearing.

Remember, convert the velocity to a full hour before using it on the computer.

IT'S AN ILL WIND THAT'S BLOWING, IF YOU DON'T KNOW WHERE IT'S GOING.

DRIFT BY TIMING

Here is another method of obtaining drift with limited facilities. Suppose you are flying over an overcast, with a mountain peak visible above it.

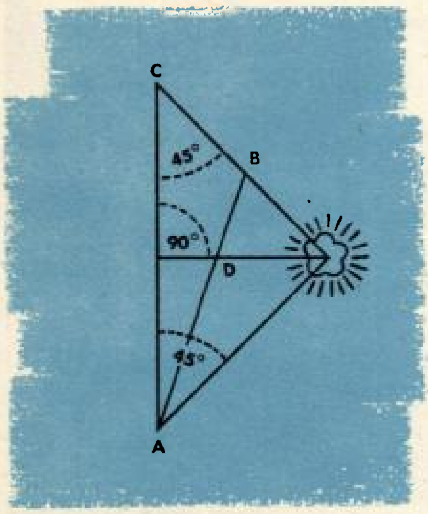
Your equipment includes a driftmeter, pelorus, astrocompass, or any other instrument with which you can take a relative bearing. Then approach and fly by the mountain. The relative bearings you take depend upon which side of the mountain you pass. For this problem the mountain is on your right.

The instrument you are using to take the bearing is set on a relative bearing of 45°. As the mountain comes into your line of vision, record the time.

Then set a relative bearing of 90° on your instrument, and the instant the mountain is again visible, record the time. Repeat this on a bearing of 135°, and record the time.

Divide the time interval between the taking of the second and third bearing by the time interval between the taking of the first and second bearing. The result is the factor with which you enter the table below.

If the object on which you took the bearing is to your right, the sign of the drift correction is as shown. If the object is to your left, reverse the sign.



VECTOR DIAGRAM SOLUTION

1. Construct a triangle on a Mercator chart consisting of the bearings to be taken, either 45°, 90°, 135°, or 315°, 270°, 225°.
2. Give time values to the markings on the edge of your plotter and construct line AB so that AD is equal to the time interval between the first and second bearings, and DB is equal to the time interval between the second and third bearings.
3. Angle CAB is your drift in degrees.
4. Drift is right if the first time interval is greater than the second.
5. Drift is left if the first time interval is less than the second.

DRIFT CORRECTION		FACTOR
PLUS	1	1.0355
	2	1.0724
	3	1.1106
	4	1.1504
	5	1.1918
	6	1.2349
	7	1.2799
	8	1.3270
	9	1.3764
PLUS	10	1.4281
	11	1.4826
	12	1.5399
	13	1.6003
	14	1.6643
	15	1.7321
	16	1.8040
	17	1.8807
	18	1.9626
	19	2.0503
PLUS	20	2.1445
	21	2.2560
	22	2.3559
	23	2.4751
	24	2.6051
	25	2.7475

DRIFT CORRECTION		FACTOR
MINUS	1	.9657
	2	.9325
	3	.9004
	4	.8693
	5	.8391
	6	.8098
	7	.7813
	8	.7536
	9	.7265
MINUS	10	.7002
	11	.6745
	12	.6494
	13	.6249
	14	.6009
	15	.5774
	16	.5543
	17	.5317
	18	.5095
	19	.4877
MINUS	20	.4663
	21	.4452
	22	.4245
	23	.4040
	24	.3839
	25	.3640

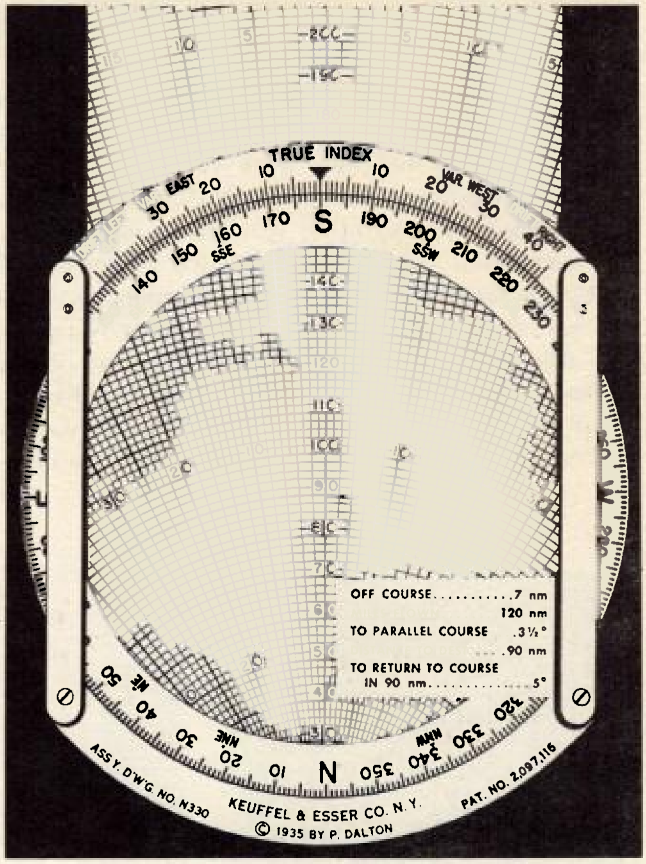
OFF COURSE CORRECTIONS

E-6B COMPUTER

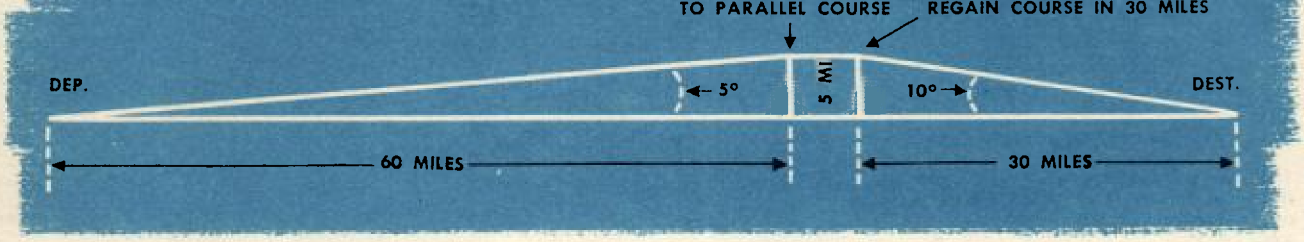
1. Place any heading at true index and any true airspeed figure under the grommet.
2. Draw a line representing the number of miles you are off course down from the grommet.
3. Rotate the compass rose 90°.
4. Place the grommet over the number of miles you have flown.
5. Read correction to parallel course off the end of the arrow.
6. Slide the card until the distance to return to course or destination is under the grommet.
7. Read the correction to return to course in the required distance from the end of the arrow.

Use this method of course correction under the following conditions only:

1. When you have a small correction angle.
2. When wind effect is the sole reason you are off course.



MERCATOR SOLUTION



Rule of Thumb

In traveling 60 miles, each mile off course is equal to a 1° correction. By correcting 1° for each mile off course, you parallel your intended course. By correcting 2° for each mile off course, you regain the intended course at the end of 60 miles.

If after traveling 30 miles you find you are 5 miles off course, remember—that is equivalent to 10 miles off course in 60 miles run. The correction is 10° to parallel your intended course.

Don't use this method of correcting course when you can measure wind, dead reckoning position, and directions on a Mercator chart accurately.

Accurate navigation comes before any rule of thumb you can improvise.

THIS IS ONLY AN EMERGENCY MEASURE, BUT KNOW IT FOR THAT EMERGENCY

GROUNDSPEED BY TIMING

WHENEVER PRACTICAL CHECK YOUR GROUNDSPEED BY TIMING

This isn't the easiest or most practical method of finding your groundspeed. Its accuracy, however, depends upon your exactness in measuring altitude and using your stop watch. Practice this method, and check results with known groundspeeds **until you know you can get an accurate groundspeed every time.**

Problem

Given: Absolute altitude 3000 ft.
0° to 50° trail angle spread
Time in seconds 18

Required: 1. Factor
2. Groundspeed

Solution

1. The intersection of 0° and 50° shows the factor to be .706.

2. Divide the altitude, 3000 ft., by time, 18 seconds, and multiply by the factor .706.

3. The groundspeed is 117 knots.

When using the trail angle, cage the gyro for the entire operation.

B-5 Driftmeter

The computer on the face of the B-5 driftmeter will solve for groundspeed in one application. Set the inner, second scale, opposite the absolute altitude on the outer scale; read groundspeed directly from the pointer. Absolute altitude is the height of the airplane above the terrain at any given instant.

Another Method of Obtaining Groundspeed

When flying near a coastline or islands, swing the driftmeter around to 90° or 270°. Use the trail angle to tell when you are abeam a prominent landmark, even though it be 30 or more miles to one side. Note the exact time you pass abeam of the object.

Take two such bearings, each on a different point. Then draw lines 90° to the course, and through the points on which the bearings were taken.

You know how far you travelled in a certain time, the distance and the time between these lines, so you know your groundspeed.

You can compute your wind from true heading, true airspeed, groundspeed, and drift.

FACTORS FOR GROUNDSPEED BY TIMING

$$\frac{\text{NAUTICAL MILES}}{\text{HOUR}} = \frac{\text{ALTITUDE (FEET)}}{\text{TIME (SECONDS)}} \times \text{FACTOR}$$

START / FINISH	*0°	10°	20°	30°	40°	50°
5°	.0518					
10°	.1043					
15°	.1587	.0543				
20°	.2155	.1112				
25°	.2761	.1717	.0605			
30°	.3419	.2375	.1264			
35°	.4146	.3102	.1990	.0727		
40°	.4968	.3924	.2813	.1549		
45°	.5921	.4877	.3765	.2502	.0953	
*50°	.7057	.6013	.4901	.3638	.2089	
55°	.8456	.7412	.6300	.5037	.3487	.140
60°	1.026	.9222	.8100	.6837	.5287	.320
65°	1.270	1.165	1.054	.9275	.7729	.564
*70.9°	1.706	1.602	1.490	1.364	1.209	1.000

*B-3 Driftmeter Has Detents At These Angles

FACTORS FOR GROUNDSPEED BY TIMING

$$\frac{\text{STATUTE MILES}}{\text{HOUR}} = \frac{\text{ALTITUDE (FEET)}}{\text{TIME (SECONDS)}} \times \text{FACTOR}$$

START / FINISH	*0°	10°	20°	30°	40°	50°
5°	.0596					
10°	.1202					
15°	.1827	.0625				
20°	.2482	.1280				
25°	.3179	.1977	.0697			
30°	.3937	.2735	.1455			
35°	.4774	.3572	.2292	.0837		
40°	.5721	.4519	.3239	.1784		
45°	.6818	.5616	.4336	.2881	.1097	
*50°	.8126	.6924	.5644	.4189	.2405	
55°	.9737	.8535	.7255	.5800	.4016	.161
60°	1.181	1.062	.9328	.7873	.6088	.369
65°	1.462	1.342	1.214	1.068	.8900	.650
*70.9°	1.965	1.846	1.716	1.571	1.393	1.152

*B-3 Driftmeter Has Detents At These Angles

AB COMPUTER

The automatic bombing computer is used with the M-series bombsight. When you set up the computer and lock the compass rose and wind gear to the directional gyro, the compass rose, wind gear, and wind disc are held in a fixed position in space. When the vector triangle has been set up for one heading, the computer automatically determines drift, groundspeed, and the tangent of the dropping angle for any heading that the airplane flies.

Zeroing

If the dots on the idler gear do not match the dots on the wind gear and wind disc, remove the wind gear by unscrewing the compass rose lock and replace it so that all dots match.

When you set wind on the windspeed scale and set the drift pointer at 0°, be sure the lubber line is opposite the point, or tail, of the wind arrow. If it is not, adjust the lubber line until it is.

Wind by Bombsight and AB Computer

1. The airplane is flown manually or by autopilot on any constant heading, at an altitude equal to bombing altitude (BA), and at an airspeed at which the bombing run is to be made.
2. Set proper trail, disc speed, and small sighting angle into bombsight for BA, TAS, and type of bomb.
3. Uncage gyro and swing bombsight as driftmeter to determine drift.
4. Synchronize for rate to find the tangent of the dropping angle.
5. Attach tangent scale to AB computer for BA, TAS, and type of bomb.
6. Loosen all 4 locks.
7. Set and lock TAS on true airspeed scale.
8. Set and lock TH on compass rose under the lubber line.
9. Turn wind arrow to approximate direction of the wind.
10. Set drift pointer at drift angle found from bombsight.
11. Hold drift pointer there and rotate wind gear to place groundspeed indicator at the tangent of the dropping angle found from bombsight.
12. Lock windspeed lock and wind gear lock.

Complete this entire operation before turning off the heading on which you determined the wind.

The true direction and speed of the wind are now set on the AB computer. Find the true direction of the wind at the tail of the wind arrow. Find the windspeed at indicator on the windspeed scale.

(If you are using MH, winds found are from a magnetic direction.)

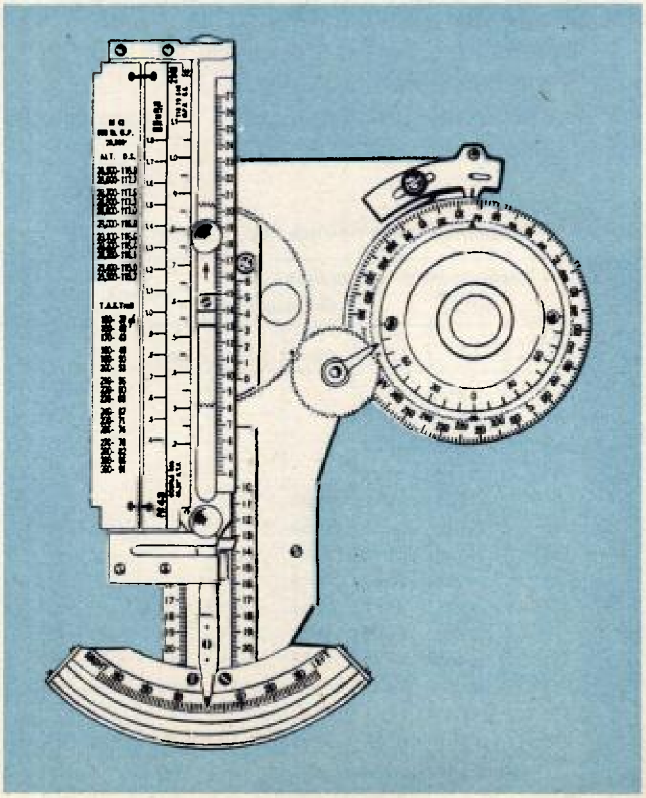
Correction for Precession

The directional gyro precesses about 10° for every 360° turn in the same direction. This gives an incorrect TH on the compass rose of the AB computer. Unless you make an adjustment, the AB computer indicates incorrect drift and tangent of the dropping angle for the TH of the airplane.

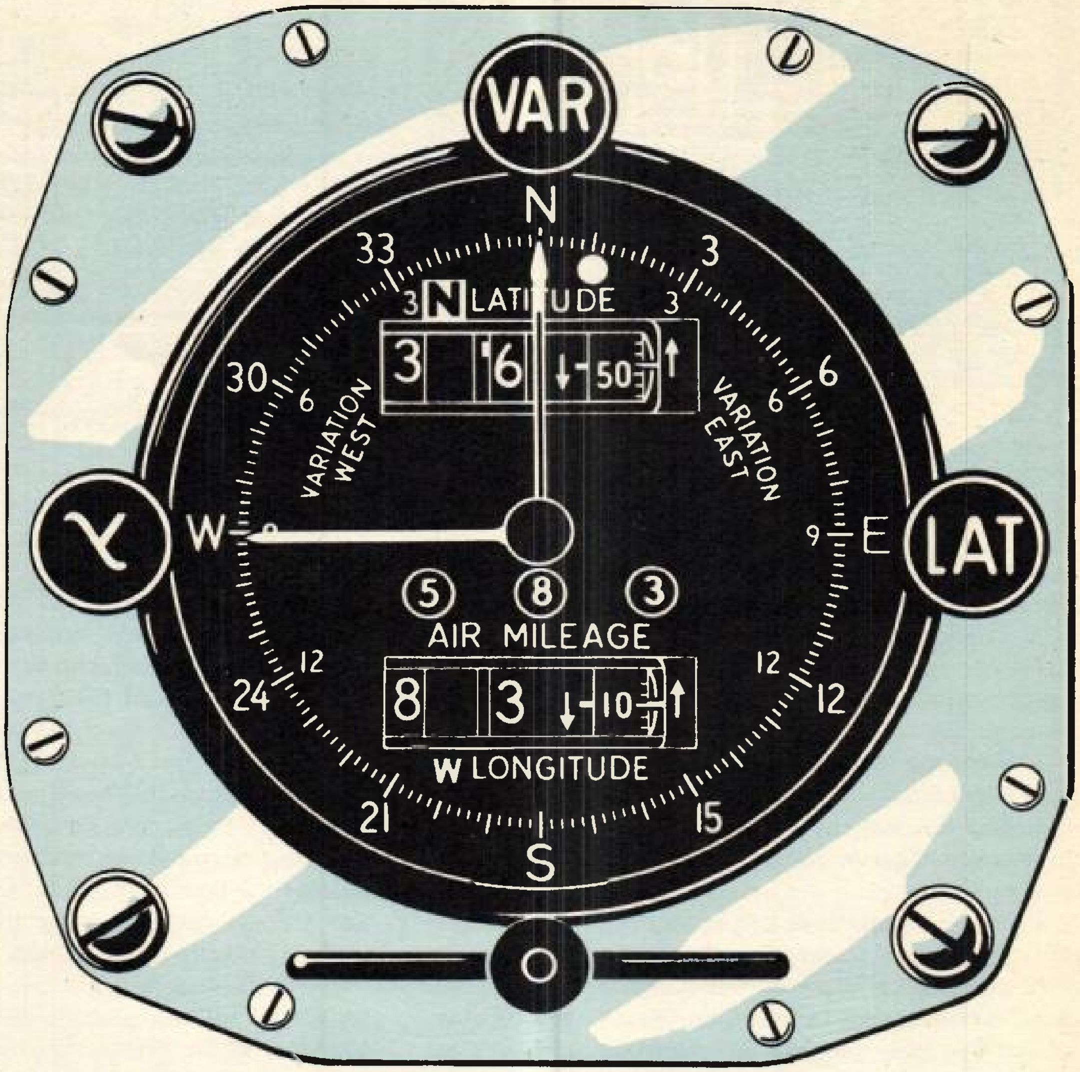
To correct for this precession, first loosen compass rose lock. Then set the TH of the airplane on compass rose under lubber line and lock again. Do this shortly before using the computer.

When TAS Exceeds 210 MPH

When TAS is more than 210 mph you must use a special tangent scale. It is marked DOUBLE TAS and is graduated to give correct tangent readings when using ½ settings of TAS, windspeed, and groundspeed. **Do not double tangent values given on this scale.** Set the true airspeed indicator at ½ the TAS. Also set the windspeed indicator at ½ the actual windspeed. Now, if you read groundspeed from the computer, double the indicated values.



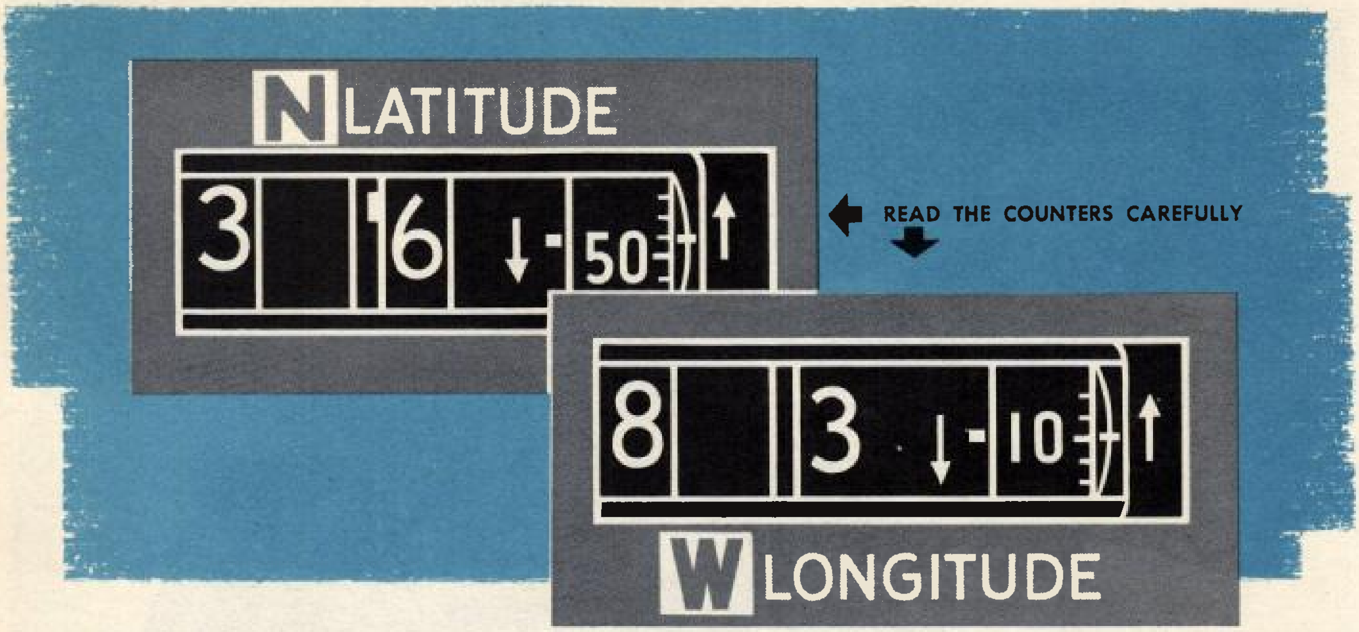
AIR POSITION INDICATOR



The air position indicator gives you a continuous indication of true heading, air miles flown, and the latitude and longitude of your position. It maintains a continuous mechanical air plot. You must apply the wind vector to the air position obtained in this manner to get your ground position.

The system consists of four units:

1. The amplifier, which distributes the necessary power to the other component units.
2. The controller, which is essentially a switch to actuate the pump.
3. The pump, which provides air pressure to the controller unit and also rotates a flexible shaft connected to the computer at a speed proportional to the true airspeed.
4. The computer, which receives a signal from the flux gate or magnesyn compass system and registers it as true heading, converts the rotation of the pump into air mileage flown, and converts both the direction and air mileage into the latitude and longitude of the air position. The computer face contains all the controls you will operate.



Before Takeoff

1. Set the proper latitude indication on the shutter (counter shield) by use of the right shutter lever.
2. Check the telltale dot latitude indicator; white for north, red for south. If the dot does not show the proper color, reset it by turning the latitude knob through the equator until the proper color appears.
3. Turn the latitude knob until the latitude of the field appears on the latitude counters.
4. Flip the left shutter lever so the proper longitude name, East or West, appears on the longitude counters.
5. Turn the longitude setting knob until the longitude of the field appears on the longitude counters.
6. Set zero variation on the computer dial and set local variation (not average) on the master indicator of the flux gate compass. An alternate method is to set zero variation on the flux gate and set local variation on the computer, **but do not set variation in both places.** If using a magnesyn compass, set local variation on the computer dial.
7. Turn on the power switches to both the compass system and to the API.

After Takeoff

After the airplane has reached an IAS of 90 mph, check the following:

1. See that the heading pointer hunts through about ±3°.
2. Be sure that variation is not set on both the computer and the master indicator.
3. See that the computer dial heading pointer agrees with the master indicator heading pointer.

Operation

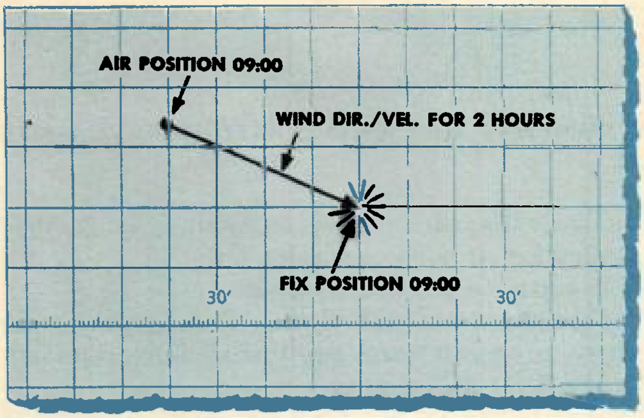
At departure point begin to use the API. Reset the counters to conform to the coordinates of departure, and record the reading of the air mileage unit. You cannot reset the air mileage unit, so be sure to have the initial reading in your log.

During flight the heading pointer indicates true heading. Take a visual average, because the pointer oscillates through approximately ±3°. Be sure to change the variation when necessary. Obtain average true airspeed for any period by dividing the elapsed air mileage by the elapsed time.

The counters indicate your air position all the time. Plot this air position on your chart and apply the wind effect for the time elapsed since the counters were reset. This gives you your DR position.

When reading counters, be careful to note direction of increasing values as indicated by the arrows. Always read minutes dials of both latitude and longitude and air mileage counter first, then read the tens and units digits. Do this because the minutes dials are moving continuously and you must read them as nearly simultaneously as possible. When minutes dials read between 50′ and 10′, be careful not to read the units dials incorrectly.

To find wind from a fix, plot the fix and the coordinates of the air position for the same time. Because it is difficult to read the indicator and obtain a fix at the same instant, it is good practice to obtain



a fix first, then read the indicator. Move the fix up to the time the indicator reading was recorded. The vector from the air position to the fix is the wind effect for the time elapsed since the counters were reset. Reduce the length of the wind arrow to one hour to determine the velocity.

Whenever you have determined a good fix, reset the counters. Do not do this for too short a period of time, however, because winds determined over a short interval are not accurate. Once every hour is a good average. When a fix is not available, reset the counters to your dead reckoning position at least once every two hours. This will keep the air position reasonably close to your dead reckoning position. Winds determined from an air position carried over several hours represent the average wind, and not necessarily the existing wind at the time of the fix.

Compensation

Compensation of this unit is much like that of the flux gate compass. You must compensate the true heading pointer accurately to obtain good results.

Magnesyn Compass System

When compensating an API that is connected to a magnesyn compass system, you must first compensate the compass system. The compass must be located in its permanent position in the airplane.

1. Turn off the power.
2. Connect a C-1 Test Set to the pitot static tube to obtain pump rotation similar to that obtained under actual flight conditions. Set the pitot pressure at 150 mph airspeed. If you do not have a C-1 Test Set, ground the cable from the amplifier to the control unit, at the control unit end. This ground should be opened for two seconds and then closed for two seconds, intermittently.
3. Remove the computer from the mounting panel. If you have to disconnect the flexible transmission shaft, reinstall it before proceeding. Remove the small cover plate which is directly over the compensating cam at the rear of the computer.
4. Set the variation pointer at 0°.
5. Turn on the power.
6. Use a compass rose or a turntable to swing the airplane so as to obtain accurate magnetic headings every 15° through 360°.
7. Adjust the compensating cam of the computer at each 30° test point (15° on earlier models). Energize the pump with the C-1 Test Set or by grounding. Use a screw driver to turn the appropriate adjustment screw of the compensating mechanism until the reading of the computer agrees with the airplane's heading. An index marker on the hub of the cam follows the computer pointer and indicates the set screw corresponding to the particular reading to be compensated. Rotate the spider covering so that the index marker and its adjacent set screws are accessible for adjustment.

Important: Correction adjustments must be distributed on adjacent compensating set screws to provide a smooth correction curve and to avoid straining the compensating cam. When the corrections are large, swing the airplane through 360° twice, removing half of the error on each swing.

8. Make a check swing and then turn off the power. Reinstall the cover plate and remount the computer after connecting all of the cables. It is now ready to operate.

Gyro Flux Gate Compass

The master indicator on this system can be compensated either before or after the API compensation. Make certain that the master indicator pointer and the computer pointer agree, however.

1. Connect a gyro flux gate compass test transmitter into the flux gate circuit.
2. Connect a C-1 Test Set to the pitot static tube or ground the control unit cable intermittently to energize the pump.
3. Set variation on both the computer and the master indicator to 0°.
4. Operate the test transmitter so as to rotate the master indicator pointer in 30° steps, and make the computer pointer indicate the same reading by adjusting the compensating screws.

If a flux gate test transmitter is not available, rotate the pointer by hand as explained under Gyro Flux Gate Compass, NIF 2-9-3. **Be sure to disconnect the cable from the transmitter to the flux gate amplifier at the amplifier and turn the power on.**

INSTRUMENT CALIBRATION

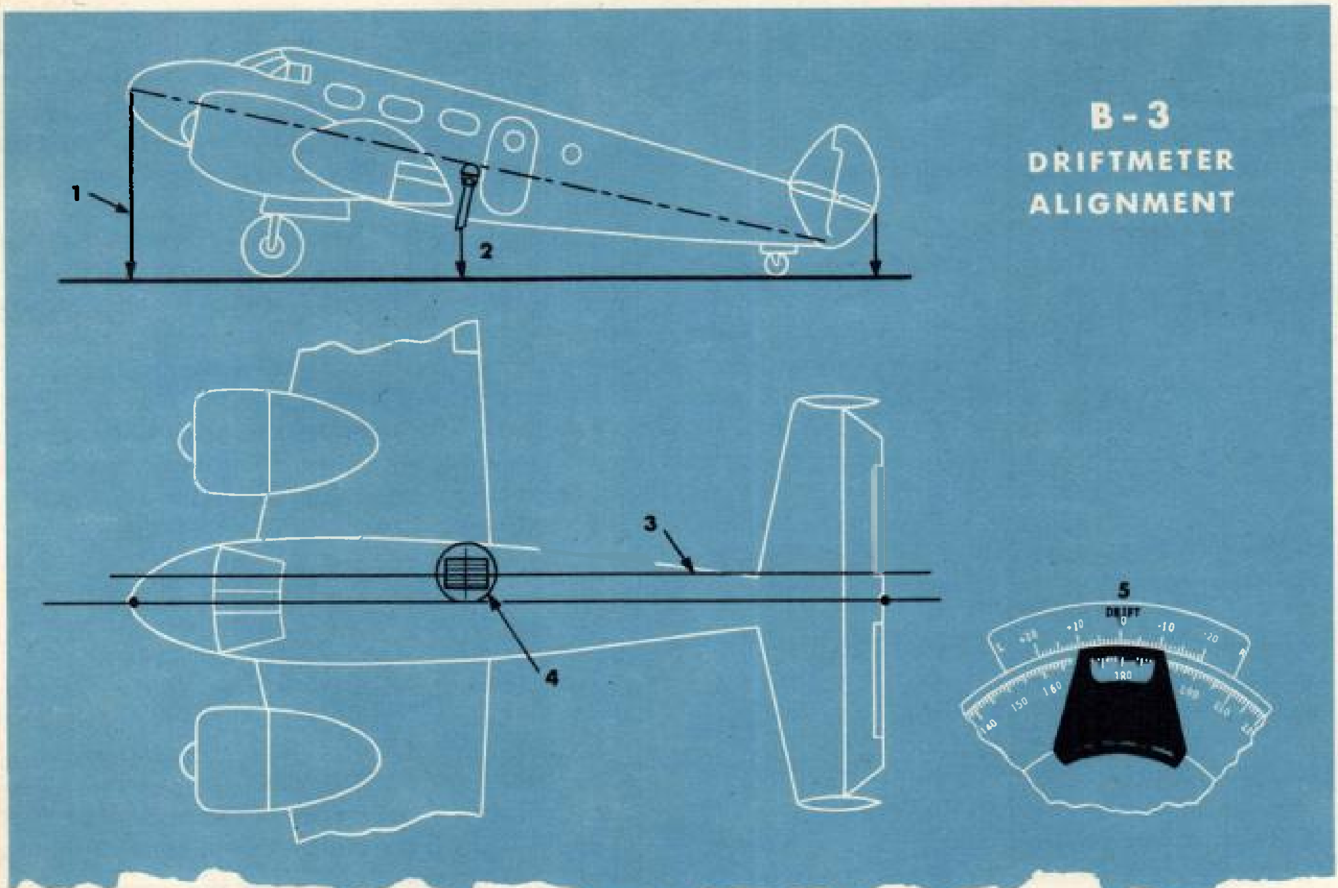
BE SURE THAT ALL INSTRUMENTS ARE CALIBRATED AT ALL TIMES

Calibrate all instruments at least every thirty days. When a new engine is installed, you must recalibrate and check your instruments.

All calibrations must be marked prominently; show calibration, number of ship, name of supervising officer, and date accomplished. You must calibrate the radio compass as carefully as all other equipment. It is an important aid.

Study gas consumption curves.

Navigators are held directly responsible for the entry in aircraft Form No. 1 of all defects in navigation flight instruments.



B-3 DRIFTMETER (ALIGNMENT)

1. Establish the longitudinal axis of the airplane by dropping plumb-bobs from center of the tail section, and the nose. A line between these two points represents the longitudinal axis of the airplane.
2. Drop a plumb-bob from center of driftmeter.
3. Through this last point draw a line parallel to the first line. This line is then parallel with the longitudinal axis of the airplane.
4. With the driftmeter in its normal position, turn the trail angle through 85° and note whether the line on the ground appears to follow down the **center grid line.** If it does not, rotate the grid lines until the line on the ground does parallel the center grid line.
5. Adjust the grid scale to read zero.

Zeroing the Trail Angle

Do not try to zero the trail angle. The driftmeter is designed so that the line of sight and the center line do not coincide. The center of the grid lines describes an arc or circle on the ground when the driftmeter is properly installed. The error is negligible so do not try to change or adjust the installation to correct it.

When you are assigned to one particular airplane, align the driftmeter; immediately after alignment turn the trail angle to 85° and then rotate the driftmeter until center grid line is lined up with some protruding part of the undercarriage, such as the pitot-tube, or lower antenna. Note the angle you then read on the azimuth scale. Place this reading in some convenient location so you can check the alignment of the driftmeter quickly before going on a mission. Always check the driftmeter before takeoff. Be sure that it is functioning properly.

Be sure that the B-3 driftmeter is caged during violent maneuvers. It is a gyro instrument and cannot stand rough treatment. Parts and instrument experts are hard to get.

B-5 DRIFTMETER

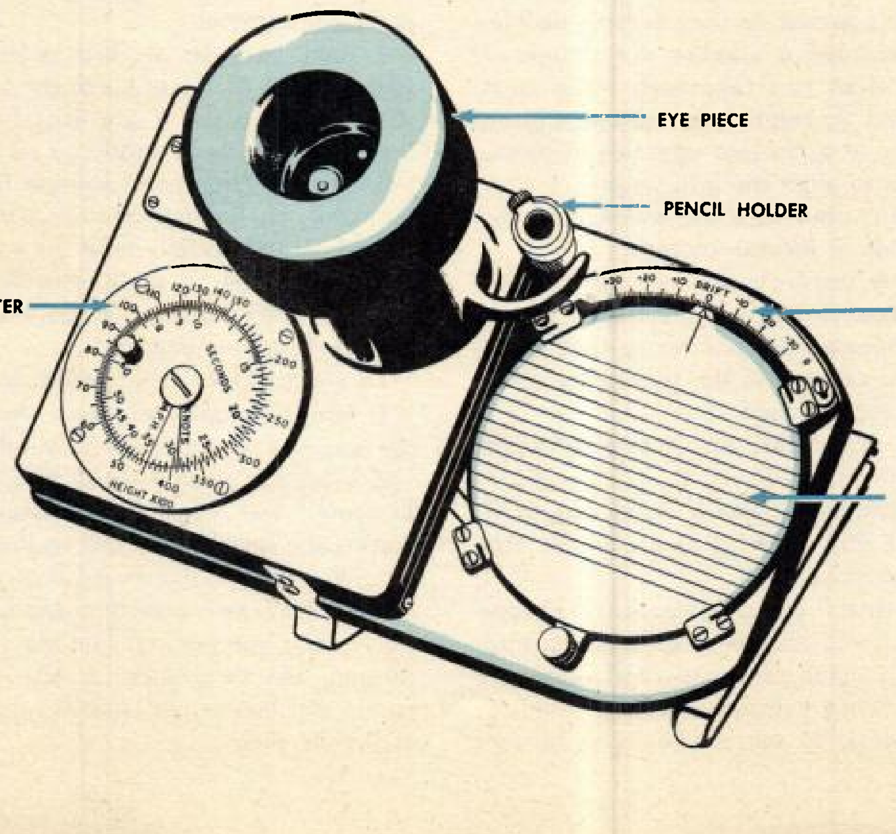
Many tactical airplanes have B-5 driftmeters as standard equipment. It isn't easy to read drift accurately with this sight, however, and it will take time and patience to gain confidence in its use. But —proper operation is a must.

When placing the driftmeter in its bracket, depress the tension spring in the end of each channel rail with your fingers. Slide the driftmeter on rails provided in the aircraft structure. The detent (guidepin) in the center of each rail drops into an alignment hole when the meter is correctly positioned. Position it carefully.

To Obtain Drift

1. Move the pencil to draw a track on the glass plate, so that the pointer follows the movement of an object on the ground across the field of view of the instrument. Repeat with other objects. Two or three tracks should be enough in fairly steady conditions and at heights above 2,000 feet. At lower altitudes and in bumpy weather you will have to average several tracks.

Drift tracks must be distributed on both sides of the center to avoid the slight error which arises if



the tracks were mainly on one side of the center. If the aircraft hull restricts the field on one side of center, use tracks as close as possible to the center.

2. Push pencil holder over the clip beside the eye-piece and bring the grid card into alignment with the average direction of the recorded tracks.

3. Read off the drift angle on the scale.

4. At night, you see the pointer silhouetted against the ground if you can distinguish any ground contours. For use with ground lights which may come within the field of view, the end of the pointer is made luminous.

You can also read drift with the B-5 driftmeter just as you would with a B-3 driftmeter with the gyro caged. Adjust the grid lines until objects on the ground pass through the line of vision, parallel to the grid lines. Then read drift on the drift scale.

To Measure Groundspeed

1. While grid card remains in alignment with the recorded drift tracks, use a stop watch to time passage of an object between the two timing lines.

2. On the circular computer set time in seconds on inner scale against the ascertained absolute altitude on the outer scale. Read off on the outer scale the groundspeed in knots or mph.

A Few Suggestions

When flying over broken clouds, record the tracks of any objects as soon as they become visible, until you have recorded a number of portions of tracks. Remember that you take each track on a different object, and therefore you must not place the grid card lines so as to join any two of them. The best method is to align the grid with each portion of track in turn and take the average of the indicated drifts. Take a mental average.

When flying over territory that has no well-defined objects or over a calm sea, you can obtain track records by moving the pointer so that it remains stationary in relation to the texture or color variations of the ground or sea.

To remove the driftmeter, lift it by the inner edges and pull it toward you.

If you need a new pencil, use a 3-inch length of hard pencil (about 2H). Insert it in the holder and lock it with the set screw.

Before taking drifts or groundspeeds, always warn the pilot that you are about to begin so that he will maintain a constant course and airspeed. Then tell the pilot when you have finished.

Before using, check to see whether the instrument is calibrated for **drift angle or drift correction.**

British-manufactured instruments carry the former calibration, and you must reverse the sign before using. **Starboard is right, port is left.**

Alignment

The following method is suggested for accurate alignment of the B-5 driftmeter in all types of aircraft under all field conditions.

1. Open the face of the driftmeter and make an internal check as follows:

a. Lay a plotter or straight edge on the ground-glass face, parallel to the black lines. If it doesn't parallel the reticle lines, the instrument itself is out of alignment.

b. Lay a plotter so that it connects the pantograph joint and the pencil point. The tip of the needle should just touch the plotter midway between the pencil and the joint. If the needle is out of line, bend it slightly to correct its position.

2. With the driftmeter eye-piece raised so that the reticle is exposed, use a pair of dividers to locate the center point of the inner and outer grid lines. A line drawn between these two points is perpendicular to the longitudinal axis of the airplane when the driftmeter is aligned.

3. Mark this perpendicular to the longitudinal axis by placing a small piece of masking tape on the reticle or scratching the paint from the grid lines at the center point.

4. Sight through the driftmeter and have an assistant move the tip of his finger on the ground until it is in the center of the drift lines as marked by the masking tape or scratches on the grid lines.

5. Through this point draw a line on the ground perpendicular to the longitudinal axis of the airplane.

6. Rotate the reticle until the edge of the masking tape is parallel to the perpendicular line on the ground. Then adjust the driftmeter scale to read 0° drift. It is then aligned.

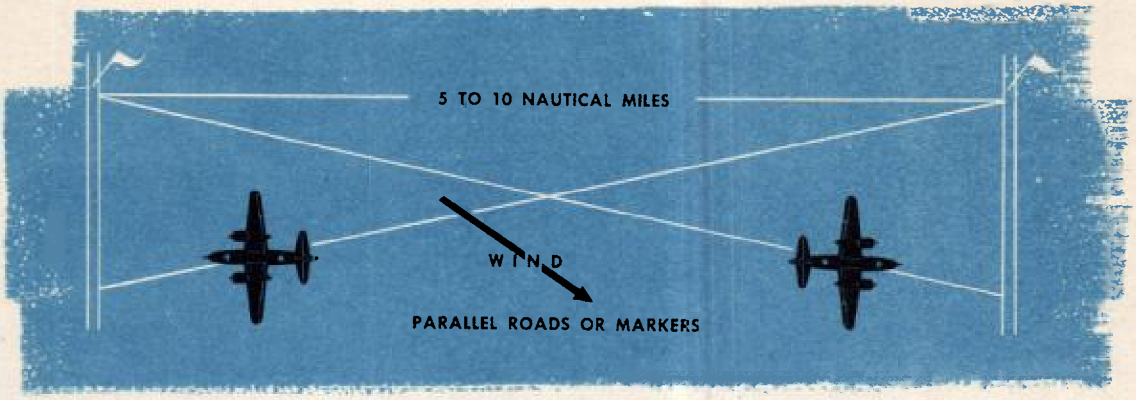
To construct a perpendicular line on the ground:

1. Drop a plumb-bob from the nose and tail of the airplane to establish its longitudinal axis.

2. With the point located through the driftmeter as center, and any fixed radius, describe two arcs cutting the longitudinal line on the ground.

3. With these points as centers and any fixed radius, draw two arcs intersecting on the opposite side of the longitudinal line from the point located through the driftmeter. A line joining these two points will be at right angles to the longitudinal axis of the aircraft.

CALIBRATION OF AIRSPEED INDICATOR



In heavy bombardment aircraft it is necessary to make a separate calibration of the airspeed indicator for empty bomb bay flights, and loaded bomb bay flights, because of difference in gross weights.

The simplest method of calibration is to time each run made on upwind and downwind flights over the exactly-known distance between two parallel roads.

Instruct the pilot to keep the same airspeed and altitude on both upwind and downwind runs. Make runs enough to cover your complete airspeed range. The pilot must not crab into the wind. Make a run both upwind, then downwind at the same IAS.

Check the pitot tube frequently to make sure that it is not dented, bent, or clogged, since such defects cause tremendous errors in calibration.

When the airplane is on the ground always cover the pitot tube with a cloth protector to keep out sand, dust, or dirt.

Procedure for Obtaining Data

1. Remove the pitot cover before leaving the ground and check the tube for dents and clogged openings.
2. Make sure the altimeter reads the correct pressure altitude. Set 29.92 in the window.
3. Make a pair of runs over the course for each throttle setting, one run in each direction. The pilot must hold heading, altitude, and airspeed as nearly constant as possible.
4. Record readings of the indicated airspeed, temperature, and pressure altitude as well as the time over the course. Use the driftmeter to determine when the airplane is directly over the end of the course. Check the time with a stop watch to the nearest tenth of a second.
5. Make the first pair of runs at the maximum speed of the airplane and then reduce speed by 15 or 20 mph for each subsequent pair.

Preparation of Data

1. The data you obtain from flight is recorded on Form No. 21F: Pressure altitude for each run in column 2, average indicated airspeed in column 3, time upwind and downwind in columns 4 and 5, and free-air temperature in column 9.
2. Determine the speed upwind (column 6) and downwind (column 7) from the formula:

$$\frac{\text{Speed in knots}}{3600} = \frac{\text{Distance in nautical miles}}{\text{Time in seconds}}$$

Be sure the distance is in nautical miles before using the formula. Use the E-6B computer as illustrated on the next page.

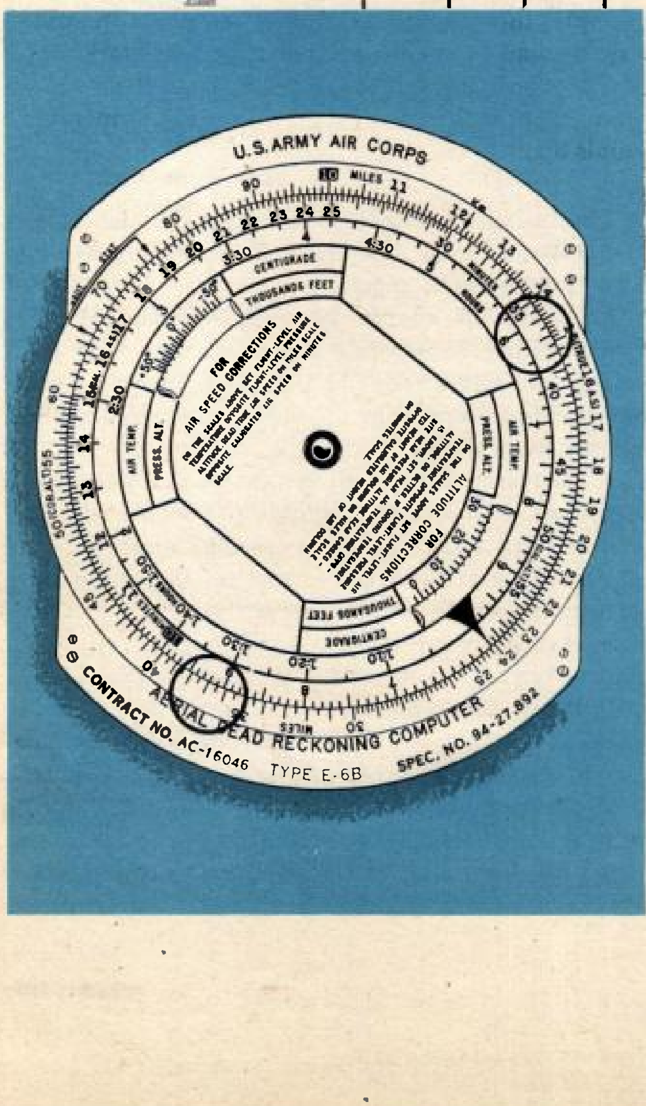
3. Divide the course distance, 3.7 nautical miles by the time in seconds both with the wind and against the wind. Place 92.2 beneath 3.7 on the computer. Find the answer on the outer scale, above 10 on the inner scale.
4. Convert nautical miles per second to nautical miles per hour by multiplying the above answer by 3600. Leave the computer with 92.2 under 3.7 and read the speed over the course on the outer scale directly above 36 on the inner scale.
5. Average your speed over the course with wind, and against wind, to obtain an average speed.
6. Place the temperature of plus 20° C. above pressure altitude of 610 feet. Directly below true airspeed of 146.25 find calibrated airspeed, 143 knots.
7. Make a graph of calibrated airspeed (column 11) against indicated airspeed (column 3) (the average from both runs of the pair) and draw the best representative straight line.

WAR DEPARTMENT
Air Corps
Form No. 21F
Approved Feb. 6, 1937

CALIBRATION OF AIRSPEED INDICATOR

Place: Parallel Roads Of Darby
Airplane: 43-27654
Date: 5-2-44
Altimeter: Navigator's
Pilot: Jones, E.E.
Airspeed: Navigator's
Observer: Walker, J.M.
Thermometer: Navigator's
Length of course: 3.7 Nautical Miles
Pitot-static tube: Navigator's

1	2	3	4	5	6	7	8	9	10	11	12
Run	Press. Alt.	Aver. A. S. R'D'G.	Time over Course: Against Wind	Time over Course: With Wind	Speed over Course: Against Wind	Speed over Course: With Wind	Aver. Speed	Air Temp.	$\sqrt{\frac{\rho_o}{\rho}}$	Cal. Speed V_c	Remarks
1	610	140	92.2		144.25						
		140		89.9		148.25	146.25	+20°		143	



8. From the data of the curve, complete calibration card. Draw lines representing even 10 knot increments of indicated airspeed opposite proper calibrated airspeed which you read from the graph. Subdivide the intervals to make interpolation easier. Place the card in the airplane near airspeed indicator. Note: When the airspeed indicator is not functioning properly, check the installation for:

1. **Water in the connection tubes.** Disconnect both the static and pitot lines of the instrument, open the drain plugs and blow out the lines with air.

Caution: Be sure that both lines are disconnected. Then blow the lines from the inside.

2. **Damaged pitot tubes.** Check the alignment of the pitot tube to see that it is in the line of flight. If the pitot or static openings are damaged, replace the pitot-static tube.

3. **Leaks in connecting lines.** Put a rubber tube over the pitot opening of the pitot-static tube and close the drain holes. Apply sufficient pressure to give an indicator reading of 150 mph and pinch the tube. The indicator should hold steady. If the indicator returns to 0, check the connections for leaks. If connections are tight, the leak is probably around the cover glass of one of the instruments.

Do not attempt to calibrate the airspeed meter with a C-1 Test Set.

Trailing Static Tube

In some theaters of operations it is impossible to lay out an accurate course for airspeed calibration. This is especially true in wild and sparsely settled regions covered with dense jungle growth. The trailing static tube has proven useful under such circumstances and when, for any reason, calibration by the method explained above is not advisable.

If, for purposes of study, you want to read a full explanation of the use of the trailing static tube, turn for reference to T.O. 05-20-8.

ALTIMETER

The altimeter, an air pressure instrument, tells you how high you are. The pressure of surrounding air activates the mechanics of the dial. Always remember, however, to correct indicated altitude for pressures and temperatures which differ from the arbitrary standard by which the altimeter is calibrated.

Instrument Error

Instrument error is usually very small and is rather difficult to determine. But you can check the altimeter at a position where you know the barometric pressure accurately. Set altimeter setting in the window of the instrument, and read the elevation of the field plus 10 feet. If the instrument does not read within 30 feet of the correct altitude of the field, check and tighten all connections. If the instrument still does not read within this allowable tolerance you can adjust it as follows, provided the error does not exceed 50 feet:

1. Set the counter to read 29.92.
2. Remove the soft wax in the screw hole at the left of the adjusting knob.
3. Loosen counter reset screw at least four turns.
4. By turning the counter reset knob, set the hands to read the altitude corresponding to the reading taken from a standard mercury barometer.
5. Tighten the counter reset screw to engage the counter, and fill the hole with soft wax.

If the altimeter does not react correctly, check the static lines for accumulation of dirt and water. Disconnect the lines from the instrument and blow them out with moderate air pressure.

Be sure that the lines are disconnected and that you blow them from the inside out.

Another Method

You can also determine the altimeter setting error by using the master altimeter in the C-1 Test Set. Set the reference marks to 0 (or 29.92) on the master altimeter, vibrate the instrument, and note the pressure altitude. If there is a scale error, apply it to this reading. Compare this reading with the pressure altitude on the airplane's altimeter.

If the two readings are not the same, set the pointers of the airplane's altimeter to the correct reading. Loosen the adjusting screw to the left of the knob and displace it to the left. Pull out on the knob and adjust the pressure scale to read 29.92. Move the screw back to the right and tighten.

Foreign Planes

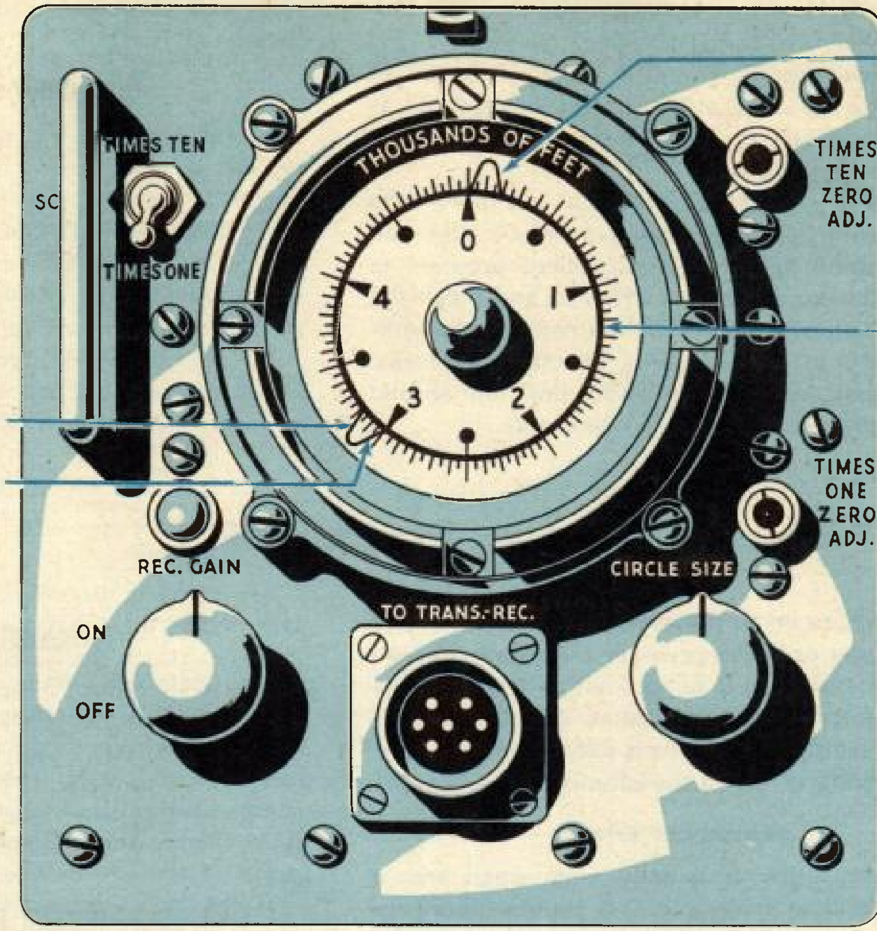
In altimeters of some foreign planes, British for example, the window may show pressure in millibars instead of inches of mercury. Standard pressure for those instruments is 1013.2 millibars, which equals 29.92 inches of mercury. One inch of mercury equals approximately 34 millibars.

Low Pressure Areas—Danger

It is important to remember that if your altimeter is not properly set, low pressure areas mean you are lower than the altimeter indicates. **Low pressure areas mean danger.**

Always know your true altitude when flying in mountainous country. True altitude is your actual altitude above sea level.

Be sure to give yourself plenty of terrain clearance at all times.



SCR-718 HIGH-ALTITUDE ALTIMETER

SCR-718C

The 718 altimeter gives you the absolute altitude of your airplane. It is primarily an aid to pilotage and high-level precision bombing. It does not warn you of obstructions to your flight, such as mountains.

The altimeter indicates altitudes from 0 to 40,000 feet. When it is properly adjusted, it deviates approximately 50 feet from exact height above ground or water. The pulse is constantly in motion and the 50-foot error is partly a result of the fact that it is difficult to read the indicator accurately. With practice, however, you can minimize this reading error. Always read the dial carefully.

Operation

The controls and the indicator are on the same panel.

To turn ON:

1. Rotate the REC GAIN control clockwise one-half turn. The red pilot lamp should light. If it is inoperative, check the ACTIVE FUSE on the panel of the transmitter-receiver unit, BC-788.

2. Allow the equipment to warm up for five minutes. A green trace then appears on the indicator.

3. If the green trace is not visible, adjust the CIRCLE SIZE control until the trace appears.

4. Rotate control until the circle is just barely

visible as a luminous ring at the outer edge of the black calibrated scale. Be sure the SCALE switch is at X1 (times one).

5. Adjust REC GAIN until a pulse ¼ inch high appears on the circle trace near 0 on the dial. This is called the **reflection pulse.**

Adjustments

At takeoff:

Just before the wheels leave the ground, or when the airplane has leveled off, rotate the X1 ZERO ADJ control until the counter-clockwise edge of the reflection pulse is exactly at 0.

In flight:

As you gain altitude, the reflection pulse rotates clockwise around the circle and decreases in height. The position of the counter-clockwise edge of the pulse indicates your altitude. To get accurate readings, maintain the height of the pulse at ¼ inch by adjusting REC GAIN. After you rotate this control halfway through its path, a second pulse appears near the 0 mark. This second pulse is called the **reference pulse** because its counter-clockwise edge is used as a reference line. **Do not re-set reference pulse to 0 in the air if you require extreme accuracy at low altitudes.**

For other than low-altitude measurements, you can adjust the reference pulse to 0 with the X1 ZERO ADJ control. You can do this at any time during flight, without affecting the accuracy of the equipment materially. Then read altitude directly from the reflection pulse. The error resulting from this adjustment is approximately 20 to 30 feet.

Reading Altitude

The scale on the indicator is calibrated every 50 feet, from 0 to 5000 feet. Read the altitude at the leading or counter-clockwise edge of the pulse, where it intersects the green circle.

On the indicator shown, the reference pulse is at 0 and the reflection pulse is at 3000. The altitude is 3000 feet (read from the counter-clockwise edge of the reflection pulse). Remember, the SCALE switch is still at X1.

Above 5000 Feet

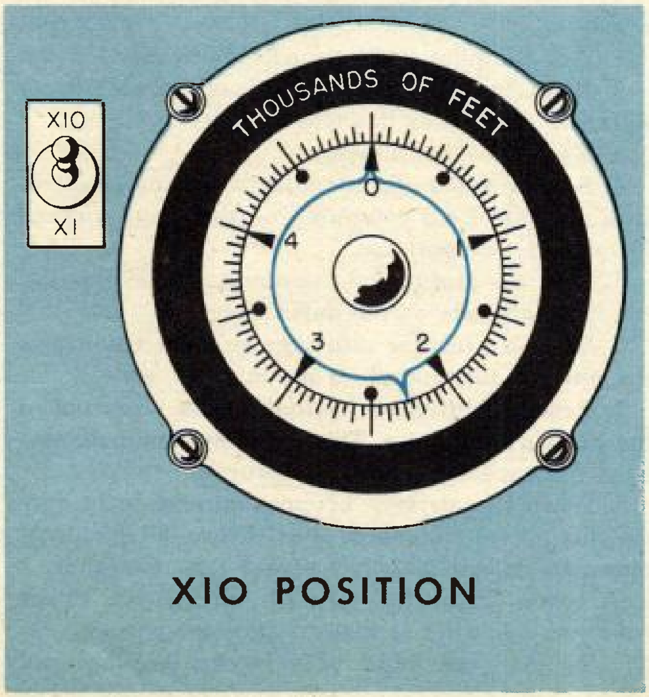
When you reach an altitude of 5000 feet, the reflection pulse has made one complete clockwise rotation and is directly behind the reference pulse. This occurs for every multiple of 5000 feet.

Do not rotate the X1 ZERO ADJ control when the two pulses overlap. It causes inaccuracies.

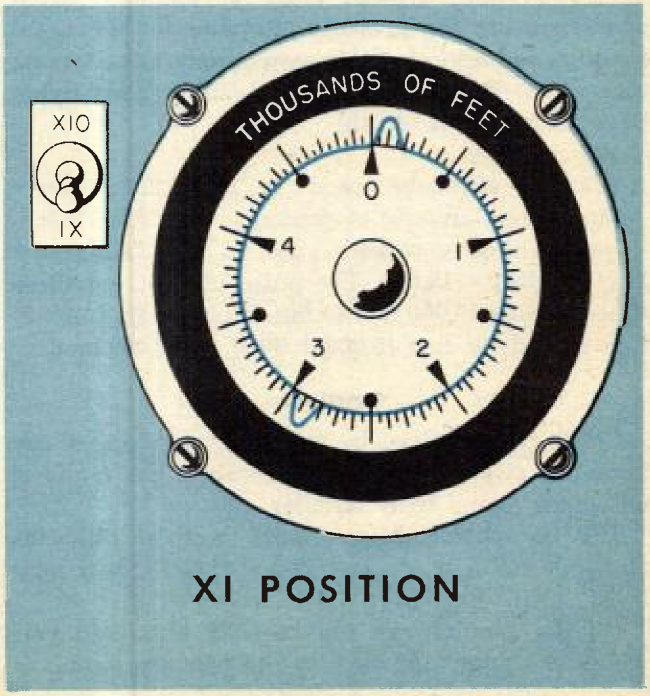
To read altitudes above 5000 feet:

1. Place SCALE switch at X10. The green trace becomes smaller. With the SCALE switch at X10 the scale of the dial is increased 10 times. Each dot and arrowhead is equal to 5000 feet instead of 500 feet.

2. Read the reflected pulse position on the trace to the next lower 5000-foot mark.



XIO POSITION



XI POSITION

3. Place SCALE switch at X1.

4. Read altitude as described under the topic heading, Reading Altitude.

5. Combine the readings obtained in steps 2 and 4.

With SCALE switch at X10, the altimeter reads 20,000 feet (the next lower 5000-foot mark).

With SCALE switch at X1, the altimeter reads 2750 feet.

20,000 feet + 2750 feet = 22,750 feet

When SCALE switch is at X10 the green trace should be approximately ¼ inch inside the black calibrated scale. This prevents you from using the X10 scale for accurate readings at low altitudes.

SCR-718B

The SCR-718B altimeter operates exactly like the 718C, but it has been produced in limited quantities only. The only real difference between the two altimeters is that the I-152B indicator does not have a pilot light.

SCR-718A and SCR-718AM

These two sets operate like the 718C and 718B, with but one exception. They have no X10 SCALE switch.

Because there is no X10 SCALE switch on the A and AM models you can read altitude to the closest 5000 feet only. After one revolution of the reflection pulse you must add 5000 feet to each reading. For each additional revolution, you must add another 5000 feet. There is no indication of the number of revolutions the reflection pulse has made. To avoid confusion, use the pressure altimeter for a general reading, and a topographic map to determine terrain clearances. Do not attempt a reading while flying over mountainous terrain.

For example:

Pressure altimeter reads ....23,000 feet
Map shows altitude of terrain ...... 3,500 feet
Radio altimeter reads .... 3,000 feet

23,000 − 3500 = 19,500. The pulse has rotated three times, adding 15,000 feet to the direct reading. Absolute altitude is then 15,000 + 3000, or 18,000 feet.

Cautions

Check irregularities by watching the shape of the luminous circle. Inaccuracies result if the circle is off center or not truly circular.

The equipment doesn't work well at altitudes above 40,000 feet; if used above 45,000 feet it may break down altogether.

On the ground, ask the crew chief to tell you where the pilot light fuse in the primary circuit is located. Be sure all connecting cords and plugs are firmly tightened. Then, in the air, if the pilot light doesn't operate, check the fuse.

If the reference pulse and the reflection pulse are not the same size:

1. Turn REC GAIN control until the reference pulse is ¼ inch high, without regard to the size of the reflection pulse.

2. Adjust the reference pulse to 0.

3. Adjust REC GAIN control until the reflection pulse is ¼ inch high.

4. Take your readings.

Indicators and transmitters are interchangeable, but never use the X10 scale when you use indicators I-152B or I-152C with transmitter-receiver units BC-788A or BC-788AM. If you have such a combination, be sure to safety-wire the SCALE switch at X1.

This equipment is accurate to within 500 feet of the ground at all times. You can rely upon it below 500 feet if your antenna system is in good condition, but **don't use it as a landing aid.**

Use

The 718 altimeter is a valuable navigation instrument. Use it with the pressure altimeter as an aid in finding approximate sea-level pressure; in finding approximate drift, even while flying blind; and in pilotage.

Sea-Level Pressure

To obtain approximate sea-level pressure over the ocean:

1. Ask the pilot to fly straight and level.

2. Read free-air temperature and correct it for dynamic heating, as described in NIF 2-1-1.

3. Read the 718 altimeter.

4. Set the radio altitude against the air temperature on your E-6B computer, on the scales marked for altitude computation.

5. Find the altitude on the minutes scale opposite the radio altitude on the miles scale.

6. Set the pressure altimeter so that it indicates the altitude just found on the minutes scale.

7. Read the altimeter setting on the inset dial of the pressure altimeter. This is the approximate sea-level pressure in inches of mercury.

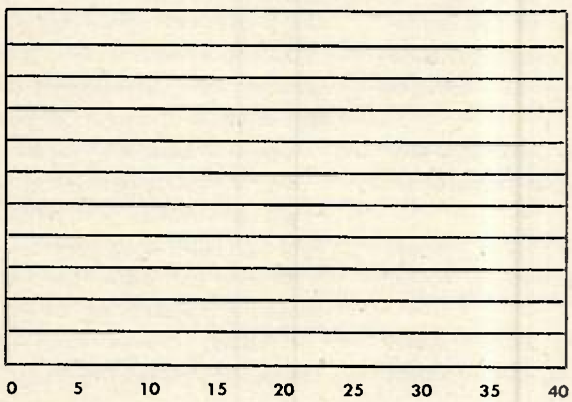
8. When the airplane bounces up and down during this operation, repeat steps 3 through 7 several times. In smooth weather repeat this operation at least twice. Your first readings enable you to set your computer and pressure altimeter approximately. You then can make your second readings and

FORM FOR COMPUTING NORMAL WIND COMPONENT FROM RADIO ALTIMETER RUN

Date____________GCT Time____________GCT Lat.____________ Long.____________

TIME	RADIO ALTITUDE	PRESSURE ALTIMETER READING (UNCORRECTED)	$Z - Z_p$ (SUBTRACT ALGEBRAICALLY)
T	**Z**	**Z_p**	**D**

LAT.	K
10°	123
15°	83
20°	63
25°	51
30°	43
35°	37
40°	33
45°	30
50°	28
60°	25
70°	23
80°	22



Plot points on graph, writing in an appropriate scale of values for D. Draw a *straight* line best fitting the points. Take values of ΔT and ΔD off straight line. ΔD is the change of D (in feet) during a time interval of ΔT (in minutes).

$\Delta T =$__________minutes; True airspeed $v =$__________knots.

$x = \frac{v \cdot \Delta T}{60} =$__________naut. miles; $\Delta D =$__________feet.

$K =$__________(see table); $H = K \cdot \Delta D =$__________.

$C_n = H/x =$__________knots (crosswind component).

IN NORTHERN HEMISPHERE:
Drift is to LEFT if D increases algebraically.
Drift is to RIGHT if D decreases algebraically.

IN SOUTHERN HEMISPHERE:
Drift is to RIGHT if D increases algebraically.
Drift is to LEFT if D decreases algebraically.

calculations more rapidly because there are only minor adjustments. This gives you the best possible sea-level pressure.

Use of Sea-Level Pressure

1. Watch the change in altimeter setting. It indicates weather conditions along your flight path.
2. Transmit this information or carry it to a weather officer at a coastal base. He can make valuable use of it for weather forecasts.

Drift

To obtain drift you must keep the pressure altitude constant to within ± 200 feet.

Use the following method of obtaining drift over oceans or large lakes when overcasts above and below the airplane prevent you from finding drift. You must be at least 10° north or south of the equator.

1. Ask the pilot to keep heading, altitude, and airspeed constant. It is hard to read altitudes at exact multiples of 5000 feet because the two pulses are superimposed. Because of this, fly at altitudes other than 5000, 10,000, 15,000 feet, etc.
2. Set the pressure altimeter at 29.92.
3. After five minutes of even flight, take an average reading of both altimeters **at the same time.** This requires some care. Record these readings and the time on the first line of the table in the form. Be sure the pilot is holding the pressure altitude constant to within ± 200 feet. If he is not, correct him before you take your readings.
4. Subtract the pressure altitude algebraically from the radio altitude, to obtain the first value of D. Record this in the last column.
5. Repeat steps 3 and 4 every 15 minutes. When you become experienced in this operation, make readings every 30 minutes only.
6. Continue these readings as long as the flight altitude is unchanged. If you change to a new flight altitude, start a new series of readings.
7. To compute the drift, first examine the values of D made at one flight altitude. Throw out any values that do not appear to follow the general trend, which should be fairly consistently increasing, decreasing, or constant.
8. Take two readings of D which were made at least 30 minutes apart. Record the time interval (ΔT) and the algebraic change of D (ΔD) between these readings. (Watch the sign: the change of D from −60 to +50 is +110, not 10.)
9. Fill out the bottom four lines of the form; ignore the graph. The symbol x stands for the no-wind distance traveled during the time-interval ΔT. K is a constant which depends on the latitude and is tabulated on the form. K and H have no significance outside the computation itself.
10. Cn is the wind-component perpendicular to your heading, averaged over the time-interval selected. Combine it with estimated groundspeed on your computer to get approximate drift. (If the groundspeed is unknown, use true airspeed.) Determine drift by the rule at the bottom of the form.
11. Find true wind direction and velocity by repeating this procedure on two different headings. Be sure that your change of heading is at least 60°.
12. Because of the time required, use this blind double drift only near a point where your flight plan calls for a large change in heading. (See T. O. AN 08-40 SCR-718-2.)
13. At low latitudes take longer time intervals (60 to 90 minutes) for the computations; at high latitudes, 15 minutes is sufficient, especially in high winds. Examine the trend of D or your data sheet to see how reliable the computed wind is going to be.
14. If the values of D do not follow a trend you are probably not reading the altimeter carefully enough. You can still use the data, though, as follows:

Write a suitable scale for D on the graph, and plot each value of D against time.

Draw a straight line which comes closest to fitting the points you have plotted.

Select a convenient point near each end of this straight line, and record the time interval (ΔT) and the change of D (ΔD) between the points selected.

Use Δ T and Δ D as in steps 9 and 10 above.

15. If you have a set of tables for computing crosswind and drift, you can enter these tables with x and ΔD, and determine Cn without computation. You also can enter the tables with Cn and the estimated groundspeed, to get the drift angle.

Caution: Never turn ZERO ADJ control while taking drift with the SCR-718.

Pilotage

Over water you receive a steady pulse. Over mountainous terrain the pulse fluctuates and increases in size. It may spread as much as 2000 feet. (Remember, always read altitude at the counterclockwise edge of the pulse.)

By carefully studying your map in close relation to reading the altimeter you can learn to determine the type of terrain below you even when you are flying above an overcast. Practice this on clear days when you can fix your position by visual reference to the ground.

COMPASS AND COMPASS SWING

APERIODIC COMPASS

Engine changes and/or installation of driftmeters affect the deviation of your compass, as do various loads and various armament. Installation of radar equipment creates deviations as high as 20°. Electrically-heated flying suits also may affect your compass. Move the magnetic compass as far from such equipment as is practicable, and then check it with electrical equipment both on and off.

Compensation by Coefficients

Coefficient A is commonly known as lubber-line error. It is the algebraic sum of deviations on north, south, east, and west headings, divided by 4. Failure to correct it causes no harm, but correction minimizes the deviations tabulated on the compass card and the amount of compensation for coefficients B and C.

Correction:

1. If A is positive, rotate the compass clockwise.
2. If A is negative, rotate it counter-clockwise.

Example:

North −3° deviation
East +4° deviation
South +3° deviation
West −2° deviation

Sum = +2°
+2° ÷ 4 = +½° (Coefficient A to the nearest ½°.)

Rotate the compass clockwise ½°.

Coefficient B determines the correction necessary to compensate for the fore-and-aft horizontal component of the airplane's hard iron. It is equal to deviation on the west heading subtracted algebraically from deviation on the east heading, divided by 2.

Correction:

1. Add the value of B algebraically to the compass reading when the airplane is headed east.
2. Adjust the east-west compensating screw, or insert magnets in the longitudinal chamber of the compensating drawer, until the compass indicates the corrected reading.

Example:

East +4° deviation
West −2° deviation

Difference = +6°
+6° ÷ 2 = +3° (Coefficient B)

Head the airplane east. The compass reading is 86°. 86° + 3° = 89°. Adjust the compass until it indicates 89°.

Coefficient C is similar to B, but it determines the correction to compensate for the lateral horizontal component of the airplane's hard iron.

It is equal to deviation on the south heading subtracted algebraically from deviation on the north heading, divided by 2.

Correction:

1. Add the value of C algebraically to the compass reading when the airplane is headed north.
2. Adjust the north-south compensating screw, or insert magnets in the lateral chamber of the compensating drawer, until the compass indicates the corrected reading.

Example:

North −3° deviation
South +3° deviation

Difference = −6°
−6° ÷ 2 = −3° (Coefficient C)

Head the airplane north. The compass reading is 003°. 003° −3° = 360°. Adjust the compass until it indicates 360°.

Do not make any corrections for coefficients D and E. When the compass is installed in a satisfactory position, coefficients D and E are negligible.

Compass Swing

After compensation, swing the compass by any one of the following methods:

B-16 Swinging Compass

1. See T.O. 05-15-3 for checking the accuracy of the swinging compass.
2. Hold the swinging compass in cupped hands or on a suitable non-magnetic support at a comfortable reading distance from your eye. **Don't tilt the compass.** If you are holding it, brace your elbows against your body.

3. Stand at least 50 feet from the airplane and align yourself with its longitudinal or transverse axis. Don't align yourself with the vertical fin because it is not necessarily on the longitudinal axis of the airplane.

4. Align the compass visually with the longitudinal axis of the airplane and take a reading. This is the magnetic heading of the airplane or its reciprocal, depending upon your position.

Directional Gyro Swing

Select a day when the wind is less than 10 mph, in order to avoid errors in reading heading.

1. Set a magnetic bearing on your directional gyro 90° from that of the road, railway, or runway.

2. Have the pilot fly across the road, the bombardier correcting him until the airplane's transverse axis is parallel to the road.

3. Uncage the gyro. (Gyro now reads magnetic heading of the airplane.) Note your compass heading.

4. Turn to the left and fly either 8 headings, 45° apart, or 12 headings, 30° apart, completing a circle. Read the directional gyro and compare it with your magnetic compass (using an average of three or more readings) on each heading. The difference in readings between the directional gyro and the magnetic compass is deviation.

5. Check precession of the directional gyro by flying the original compass heading.

6. If it has precessed, distribute the precession error over the headings flown.

After completing the swing, determine the deviation on each heading by comparing the magnetic heading of the airplane with the compass heading. Plot the deviations against magnetic heading on a graph and draw a smooth curve through the points. Record the deviations for every 15° of magnetic heading on a compass correction card and post near your desk in the airplane.

Astrocompass

Use the astrocompass to aid your directional gyro swing. Head to magnetic north by astrocompass and set the directional gyro at 0°. Then follow the procedure outlined under Directional Gyro Swing, checking precession with your astrocompass.

Independent Directional Gyro Swing

See T.O. 05-15-16 for a description of swinging the compass in the air without reference to the ground or heavenly bodies.

Continue to check deviations on course.

Pilot's B-16 Compass

Be sure that you swing the pilot's compass regularly. You may have to depend upon it in an emergency. It is essentially the same kind of instrument as your aperiodic desk compass and you use the same procedure to swing it and compensate it.

GYRO FLUX GATE COMPASS

The gyro flux gate compass system is a remote indicating compass that is stabilized by an electrically driven gyroscope. The magnetic element, or flux gate, is placed in the airplane where it is least affected by the magnetic field of the airplane itself and therefore has small deviations. By stabilizing the magnetic element in a horizontal plane, all turning errors set up by the vertical component of the earth's magnetic field are eliminated.

The master indicator has a large compass face graduated in degrees. An indicator gives the corrected reading, and a small cut-out gives the uncorrected reading or compass heading. By using the variation knob, offset the outer dial so that it reads true heading instead of magnetic heading.

Operation

1. The airplane's electrical system supplies the necessary power for the compass system through an inverter. On the older models, wire the amplifier switch in the ON position.

2. Leave the gyroscope in the uncaged position all the time, except when going through the cage-uncage cycle. Do not touch the remote caging device until after the gyroscope has been running for at least five minutes.

3. Erect the gyroscope after it is running at high speed by running through the cage-uncage cycle. On the older models turn the caging switch to CAGE for 45 seconds, then return it to UNCAGE. On the newer models, hold down the caging button until a red signal lights, then release and the cycle is automatically completed.

4. Set the gain control on the amplifier at the highest position in which it does not produce oscillation of the indicators.

5. Offset the outer dial by means of the variation knob and read true heading on the master indicator and secondary indicators or repeaters.

Compensation

Compensation of the flux gate compass means aligning the transmitter and correcting the master indicator. Corrections applied to the master indicator do not affect the transmitter. The transmitter is the heart of the system.

When you are assigned a new airplane or are unfamiliar with the care given your flux gate compass, use the following procedure:

1. Zero the master indicator. In other words, merely make the uncorrected reading and the pointer reading agree by taking all pressure off the compensating cam. Consult your instrument man. Remember, the master indicator is part of a precision instrument and should be treated as such.

2. Remove the lubber-line error.

Find coefficient A and remove this error by aligning the transmitter correctly. If coefficient A is positive, rotate the transmitter in a clockwise direction. If coefficient A is negative, rotate the transmitter counter-clockwise.

You must check the exact number of degrees and direction of rotation by watching the master indicator. The instrument man turns the transmitter and locks it in position after aligning it.

3. Complete the compensation.

Where it is possible to set the airplane accurately on 15° headings, and when you have followed steps 1 and 2, it isn't necessary to plot a curve. Find the magnetic heading of the airplane and make the pointer agree with this heading. The uncorrected reading won't change. This uncorrected reading is the compass heading of the airplane. Therefore the corrections made are always evident and can be checked easily during flight or in later check swings.

If you use the curve method, remove the lubber-line error, then swing the airplane on at least 12 equidistant headings. Record the magnetic headings and the uncorrected headings. Plot a curve from these readings and, from the curve, make the necessary corrections to the indicator.

There are three well-known methods of moving the pointer and the UNCORRECTED dial while you are compensating the compass:

1. Swing the airplane with the electrical system turned on.

2. Turn the shaft of the induction motor by hand.

3. Use the test transmitter either with engines running or with auxiliary power.

The first method is cumbersome in that it requires two swings of the airplane to complete the compensation. The second method is not advisable because it is sometimes necessary to remove the indicator cover.

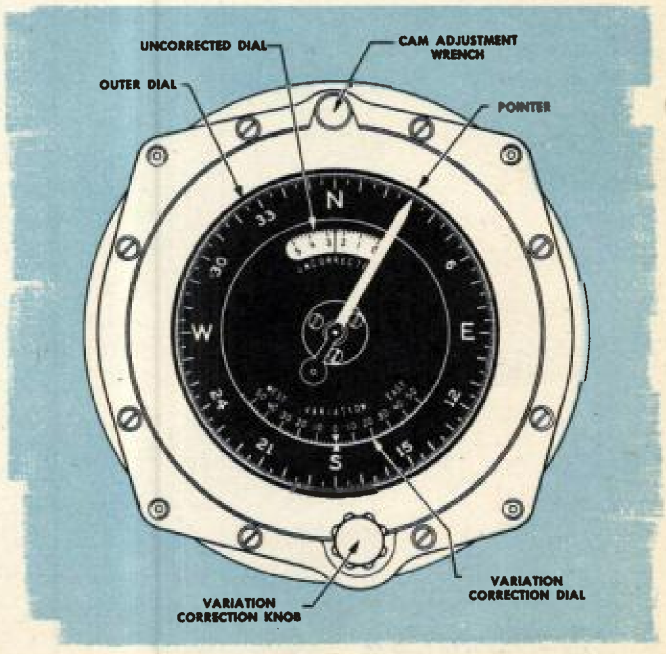
Here is the simplest method:

1. Remove the cable connecting the master indicator to the amplifier. The plug of the test transmitter connects with the amplifier and the cable from the master indicator connects with the receptacle of the test transmitter.

2. Turn the electrical system on, using either engine power or auxiliary power to maintain battery strength.

3. Turn the knob of the test transmitter to rotate the master indicator pointer and the uncorrected reading card. Place the desired uncorrected reading in the window of the stationary dial and introduce the necessary corrections to the pointer with the cam adjustment wrench. Complete this procedure through 360°.

With the master indicator zeroed and the lubber-line error removed, average corrections do not exceed 2° and further adjustment is unnecessary. It is a good idea, however, to check the corrections taken from the curve against the differences between the pointer readings and the uncorrected readings. You have in effect transferred the plotted curve to the indicator. Check deviation any time by comparing the pointer readings with uncorrected readings.



MASTER INDICATOR, GYRO-STABILIZED FLUX GATE COMPASS

Cautions:

1. Always set the variation at 0° before swinging.
2. Consult T.O.'s and instrument men on how to compensate and operate the flux gate compass.
3. Keep a record of your compass, the corrections, date of compensation, etc.
4. Always have the pilot take down the readings of his magnetic compass and his flux gate repeater when you swing and compensate the flux gate.
5. If a part, such as a transmitter, is exchanged for a new one, you must repeat the compensation.
6. Check your compass whenever possible.
7. If the system is not getting power, check:
   The fuse in the amplifier.
   The fuse in the copilot's fuse box.

Test Transmitter

The preferred way to compensate the flux gate compass is to use the Pioneer 13256-1 test transmitter. The test transmitter allows the master indicator to operate independent of the rest of the compass system.

Since test transmitters are scarce, a substitute has been devised. It is suggested that service groups manufacture locally one such unit per squadron.

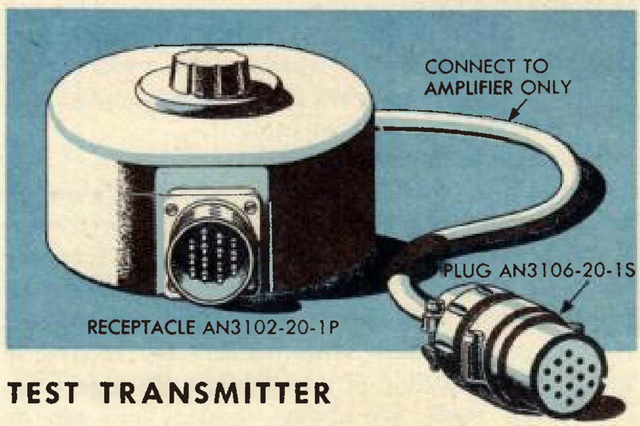
The main units required are:

1. Autosyn motor, AY-5, salvaged from dual indicator, Pioneer 6007-7A.
2. Plug Spec. AN3106-20-1s.
3. Receptacle Spec. AN3102-20-IP.
4. 100,000-ohm carbon resistor, about 1/10 watt.

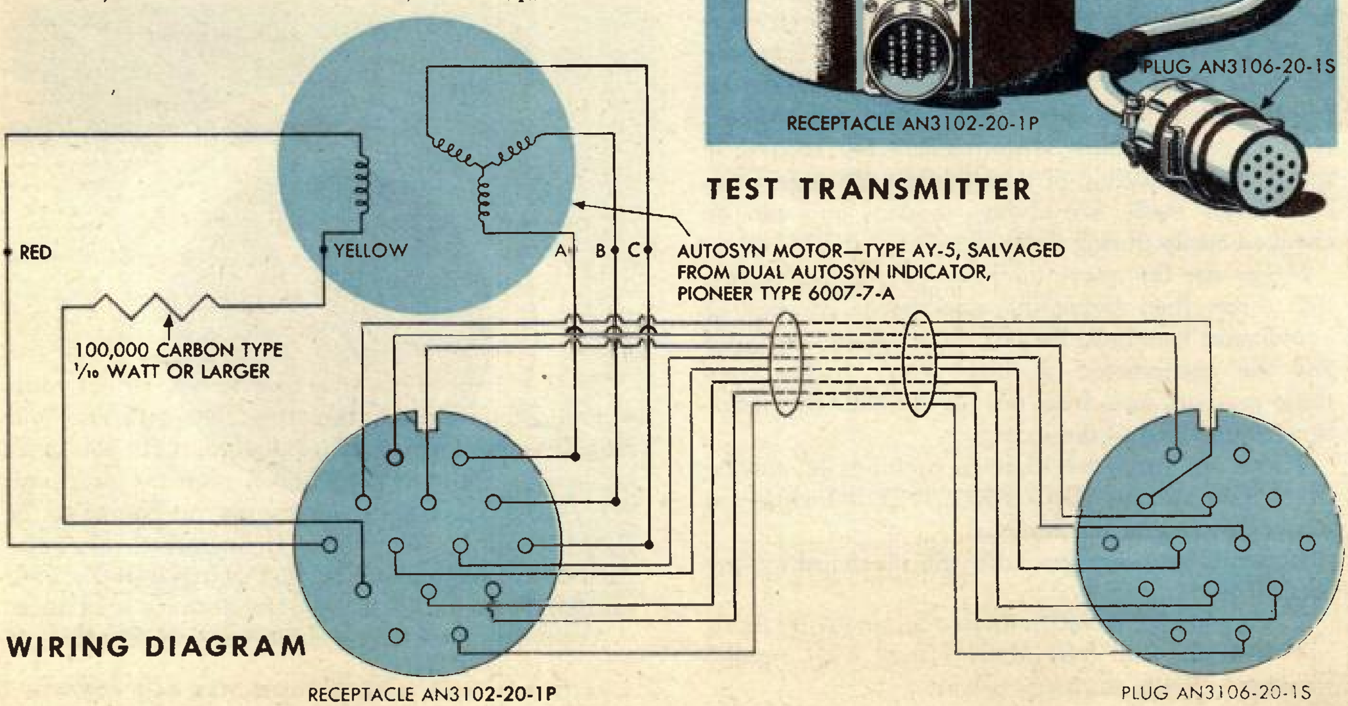
Assembly

1. Mount the autosyn motor (AY-5), with screws through its flange, in any suitable case, so that the shaft of the motor extends outside the case.
2. Fix the receptacle (AN3102-20-IP) to the case at a convenient position on the side opposite that from which the shaft extends.
3. Attach eight wires, of any size between 18 and 22 A.W.G., and approximately two feet long, to the plug (AN3106-20-1s) as shown below.
4. Lead these wires or cables to a hole made in the side of the case, and pass them through a rubber grommet to the inside of the case, where they are connected to their positions on the receptacle.
5. Connect the wires from the autosyn motor to their positions on the receptacle.
6. Mount a suitable turning knob on the protruding motor shaft to complete the assembly.

To use the test transmitter to correct the master indicator, remove, at the amplifier, the cable which connects the master indicator to the amplifier, and insert the transmitter between them. For compensation instructions see NIF 2-9-3, or T.O. 05-15-16.



TEST TRANSMITTER



WIRING DIAGRAM

DIRECTIONAL GYRO

KNOW WHAT IT MEANS AND WHAT IT WILL DO FOR YOU

The object of the directional gyro indicator is to help you maintain flight direction. The relative movement of the airplane in azimuth is shown on a circular card graduated in degrees, and the gyro indicator neither lags, swings, nor oscillates. It is an accurate indicator of direction and turn.

Handle it with care

You must handle it with care, for it cannot be repaired easily. Do not cage the gyro on takeoffs and landings, but be sure to cage it whenever the airplane is engaged in maneuvers that exceed its operating limit of 65° from the vertical. When caging or uncaging the gyro, operate the caging knob with a firm but gentle motion, in or out.

Precession

The gyro will not hold its position absolutely, but will drift or precess slightly. The average drift should not be more than 2½° in 15 minutes. A drift of 4° is permissible on one heading provided the average on the four cardinal headings does not exceed 2½°.

For accurate navigation work, determine the drift for each of the directional gyros installed in your airplane. You can do this on any flight by merely having the pilot fly a steady course by the directional gyro and noting the change in the magnetic heading. The flight should be long enough to obtain a good average, and the result expressed as the number of degrees of drift, or precession, per minute.

Operation

After the airplane is on a steady heading, turn the knob on the indicator until the desired heading is shown. Then pull the knob straight out, taking care not to turn the card away from the desired reading. The gyro will then continue to indicate the heading (within the allowance for drift), no matter how rough the air is.

The gyro indicator is especially useful in evasive action. For best results set the indicator to true heading and keep an air plot. Then no matter how much the airplane turns, you will read true heading from the indicator.

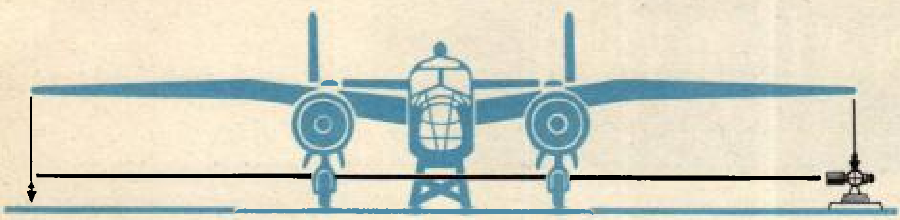
You can also use the gyro to check deviation on a new heading. Merely determine the magnetic heading of the airplane before turning and set it on the gyro indicator. Then after the turn is made the directional gyro indicates the new magnetic heading. Compare this with the new compass heading. The difference will be deviation.

Remote Control Unit, Auto-Pilot

Airplanes equipped with an auto-pilot may have a remote control feature so that either you or the bombardier can control the direction of flight directly. This assembly consists of a control unit and flexible coupling. The control unit is conveniently located and the control cable is connected to the rudder control of the automatic pilot. To alter course, turn the control knob in the proper direction until you reach the desired heading. Since this control operates through the automatic pilot you must apply the correction slowly and it must be slight. The pilot must disengage the auto-pilot and place the airplane on the new heading manually if the correction is large.

Let it do your work for you!

CALIBRATION OF TURRET OR ASTRODOME



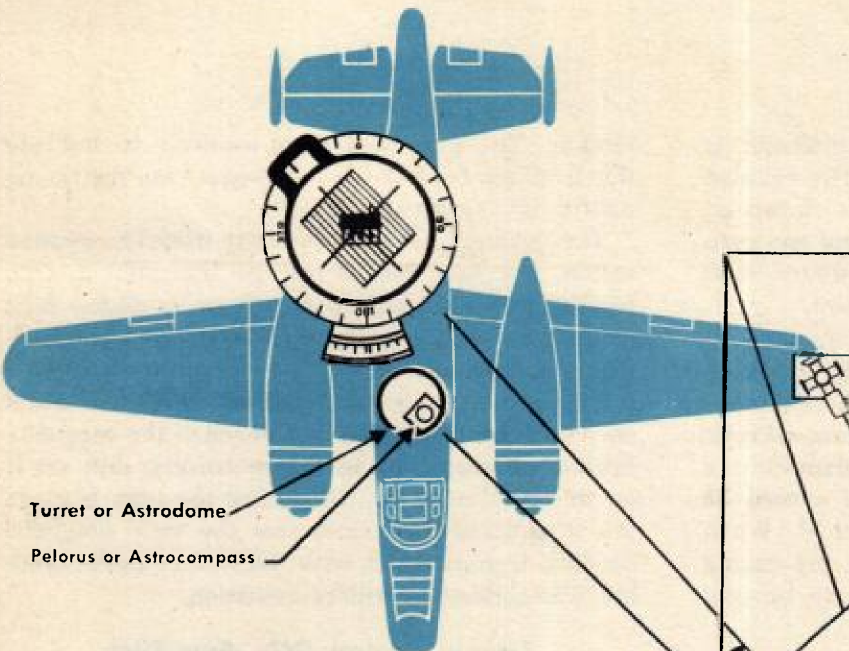
Use a surveyor's transit or your B-3 driftmeter to find the relative bearing of an object at least two miles away. Place the airplane in a position as close to flight attitude as possible

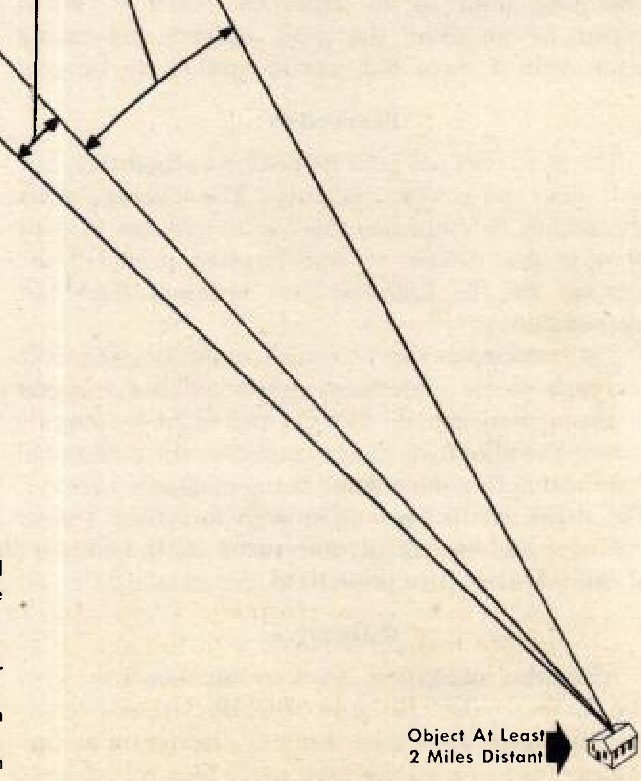
USE A SURVEYOR'S TRANSIT TO ESTABLISH THE RELATIVE BEARING

a. Drop plumb-bobs from each wing tip of your airplane.
b. Center and level a transit under the plumb-bob on the left wing tip.
c. Sight plumb-bob on right wing tip, and set the lower scale of the transit on 90°. (Use 270° if transit is under right wing tip.)
d. Sight an object at least two miles away, and read the relative bearing of the object from the upper scale of the transit.

ERROR ANGLES

There is an error of less than 0° 11′ in the relative bearing of an object two miles away, with a perpendicular distance of 33 feet 9 inches between lines of sight (½ wing spread of a B-25).





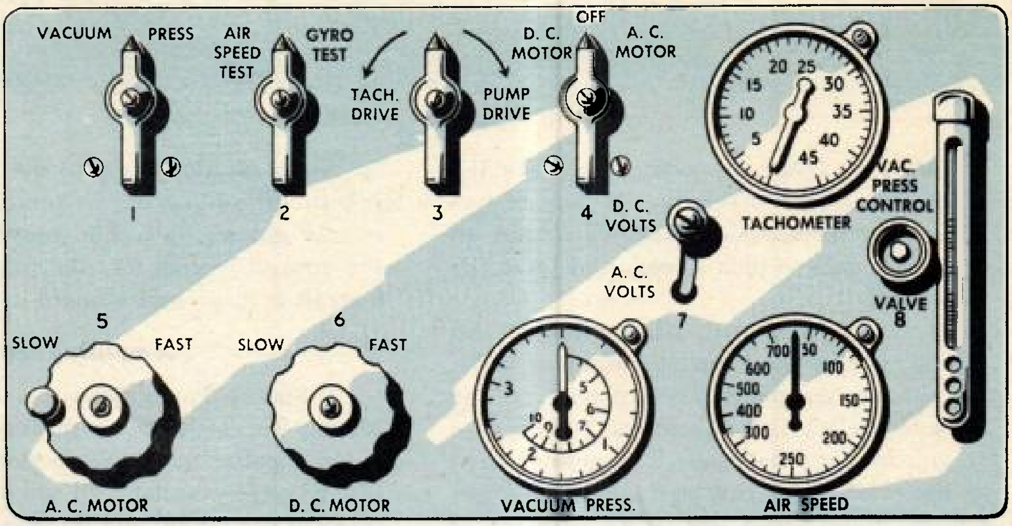
USE A B-3 DRIFTMETER TO ESTABLISH THE RELATIVE BEARING

a. Cage the gyro on the B-3 driftmeter.
b. Use full trail angle, and sight an object at least two miles away.
c. Read the relative bearing of the object from the azimuth scale.

CALIBRATE THE TURRET WITH AN ASTROCOMPASS

a. Make sure the astrocompass is aligned.
b. Set the latitude scale at 90°.
c. Set the relative bearing you obtained from the transit or B-3 driftmeter reading at the true bearing index and level the instrument.
d. Sight the object in the sighting notch.
e. Read the turret calibration for that position at the true course lubber line.
f. Repeat this procedure for each position of the turret or astrodome.
g. Stencil the calibration numbers beneath the instrument position.

C-1 TEST SET



The C-1 Test Set is a portable unit. Use it to make scale error tests and other tests on airplane instruments to determine serviceability and insure correct and accurate operation of the instruments in the air. It will not check installation errors.

The set is equipped to make many checks. For your work use it to check the airspeed meter and altimeter cases for leaks, to check the pitot-static lines for leaks, and to check the altimeter for any zero-setting error.

Operation

Operate the set with either direct or alternating current. Use alternating current when available. Otherwise use a portable electric power plant to supply the current.

Before applying the current, check the set:

1. Set switch No. 4 to the "OFF" position.
2. Set control knob No. 7 to the appropriate position, that is, either "DC" volts or "AC" volts, then No. 4 can only be turned to that source of current indicated by control knob No. 7.
3. Set control valve No. 8 to the closed position. This may require several turns. **This is a needle valve. Do not turn it too tight.**
4. Set the motor speed control to "FAST" position. Use the one that corresponds with the kind of current being used; that is, either No. 5 or 6.
5. Set control No. 3 to "PUMP DRIVE."

To check the airspeed meter diaphragm and pitot lines for leaks, connect the small hose to the ¼-inch outlet on the rear side of the test set. Connect the hose to the fixture which fits over the pitot tube.

1. Set control knob No. 1 on "PRESSURE."
2. Set control knob No. 2 on "AIRSPEED TEST."
3. Apply current to the motor set with control No. 4.
4. Open control knob No. 2 slowly and check readings of airspeed meter with the master gage.
5. Turn control knob No. 8 closed. If there are no leaks in the pitot line or airspeed meter, the master gage should not fall off more than 10 mph per 10 seconds. Watch the gage closely.

To check the airspeed meter case and static lines for leaks, connect the small hose to the ¼-inch outlet on the rear side of the set. Use the fixture on the static tube and connect the hose to it.

1. Set control knob No. 1 on "VACUUM."
2. Set control knob No. 2 on "AIRSPEED TEST."
3. Apply current with control No. 4.
4. Open control knob No. 8 slowly and check readings of the airspeed meter with the master gage (the altimeter will also function).
5. Turn control knob No. 8 closed. If there are no leaks in the static lines of attached instruments, the master airspeed meter should not fall off more than 10 mph per 10 seconds and the airplane's altimeter should not drop more than 150 feet per 10 seconds.

The procedure for using the master altimeter included in the Test Set to determine the zero-setting error is explained in NIF 2-8 under Altimeter.

Power Turret Calibration

By calibrating certain turrets you can have the gunners help you find the relative bearing of terrestrial objects and celestial bodies. **You need all the help you can get, so plan ahead, and have the turrets calibrated.**

Once the turret is calibrated, call the gunner and ask him for a bearing on a certain object or body. When the gunner has his sights centered on the object, have him click the interphone switch as a signal for you to hack the time. The gunner then gives you the relative bearing as read on the turret calibration. Repeat this procedure as often as you think necessary for an average.

The procedure for establishing longitudinal axis of the aircraft and calibration of given stations follows the principles used in calibration of turret or astro-hatch. You must establish the entire 360° of the azimuth circle, however, for this calibration.

First, establish stations at each 45° of azimuth. Then divide these arcs mathematically or geometrically. All the present models of turrets have azimuth rings of approximately 40 inches diameter. One degree then subtends approximately .35 inches.

On a plane having a single vertical stabilizer and rudder (B-17, B-26, B-29), the 180° station may be established by sighting the center of the tail. Most ships have some object forward of the gun turret on the longitudinal axis of the ship that will establish the 0° station of the turret. Be sure the plane is in flight attitude. The position of the turret in the aircraft is such that the turret is level when the aircraft is in normal straight and level flight.

Computing Sights

All Sperry Turrets and the very latest models of Martin Turret have computing sights. These sights automatically make corrections, allowances, and predictions for bullet trail, windage, and the relative speed of the target, and introduce excessive errors if you use them to take relative bearings. Make a sight from stiff wire or a small piece of metal and attach it in a convenient place on or near the computing sight to be used only for taking relative bearings. Make a sight check for the improvised sight by establishing a marked point on the plane structure and noting its relative bearing. Check the accuracy of this sight before every mission.

Calibration Markings

The actual marking of the calibration scale is a matter of the materials at hand and the particular turret model involved. The numbers and markings may be painted, stenciled, scratched, or put on pieces of paper and glued into place.

MARTIN UPPER TURRET

Models 250C-2, 2A, 3, 3A, 4, 5, 7, (B-24, B-26). Sights N-3A, N-6. (Latest models may have computing sights) Az. 360° Elev. –6½° to 85° T.O. 11-45B-1.

The Martin Upper Local Turret is suspended in a stationary outer ring in the top of the airplane fuselage. This ring supports the entire weight of the turret, gunner, ammunition, etc., by a system of rollers attached to the turntable, which roll in a race in the outer ring

The outer ring is so constructed as to have a lower gear rack extending around the entire circumference of the lower edge. The turret is turned in azimuth by a spur gear on the azimuthal motor shaft running in the lower gear rack of the outer ring. The lower edge of the outer ring and the gear rack protrude below the turntable apron approximately ⅜″ opposite the gunner's shoulders. This ledge makes an ideal surface for the calibration, using the pointer on the turntable casting as a reference.

The outer ring gear rack has 484 teeth. Therefore if you determine 45° stations (45°, 90°, 135°, 180°, 225°, 270°, 315°, 360°), 45°=60½ teeth (484 ÷ 8 =60½). Since the degree marks will be approximately .3″ apart, the error is only a minor one if you assume the 45° arc to have only 60 teeth. 1°=1⅓ teeth in the gear rack. The odd ½° is spread over several degrees.

There are fire interrupter cams near the 0° and 180° stations on the narrow ledge mentioned above. Take care in keeping the numbers and marks legible by placing them above or below as the cams allow. If you put marks on the fire interrupter cams, tie the cam followers in against their cases until the paint or stencil marks are dry.

BENDIX UPPER TURRET

> Model N. (B-25) Sights No. 80400 (80400 has 40 mile speed ring and dot. Computing sights have a crosshair reticle) Az. 360°. Elev. 0° to 90° T.O. 11-45A-3.

The weight of the Bendix Upper Turret and gunner is supported by a full length column and base, attached to the floor of the airplane. The turret proper is steadied and guided by a bearing race directly below the canopy assembly and approximately level with the fuselage.

This race serves as a guide for the two sets of adjustable rollers attached to the box casting. The rollers follow the upper two-thirds of the bearing race proper. The inside surface of the lower one-third provides an ideal surface for calibration. You can place the reference mark on the box casting.

The inside diameter of the bearing race is machined to 40″, therefore 1° equals .35″. Break up the calibration process into 45° or 90° stations, and calibrate the lower edge of the inner surface of the bearing race, geometrically.

SPERRY UPPER LOCAL TURRET

> Model K-3 (B-17) Sights Sperry K-3 Computing Sight Az. 360° Elev. 0° to 85° T.O. 11-45C-1.

The Sperry Upper Local Turret is supported by a base on the floor of the plane. Approximately 11″ above the floor of the plane is a gunner's platform upon which the gunner stands. The outside edge of this gunner's platform makes an ideal calibration surface. The outside diameter of the platform is 25″, therefore 1°=7/32″.

You can make a reference mark by attaching a wire pointer to the floor so that it will overlap the outside surface of the platform, yet be out of the way so it won't get bent.

To determine the calibration marks find the center of the platform and use a protractor or plotter after you have established 45° or 90° stations. You can calibrate the rim geometrically by making each degree 7/32″ apart.

Miscellaneous Turrets

There are other power gun turrets in common use. Their positions in the plane, however, do not allow you to use them for taking relative bearings. They are: Consolidated Tail and Nose (B-24), Bendix Lower (B-25), Sperry Lower Remote (B-17), Sperry Lower Ball (B-17).

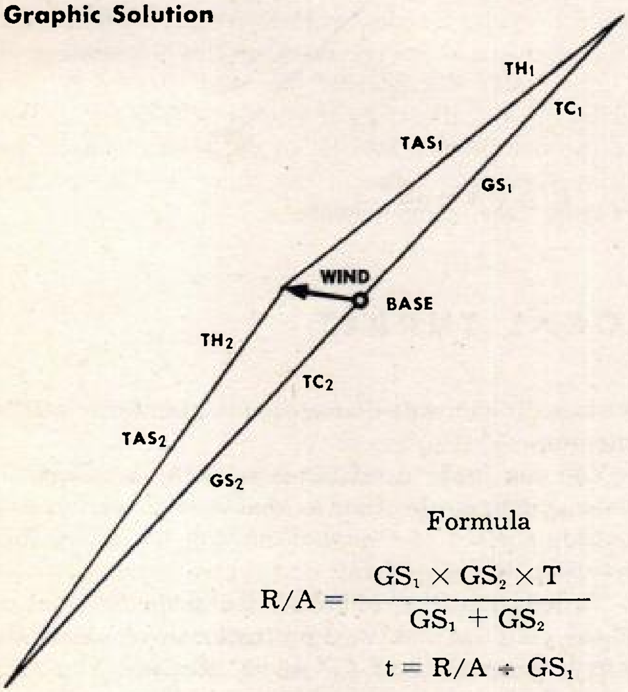
RADIUS OF ACTION

Know both graphic and computer solution

RADIUS OF ACTION SAME BASE

You are trying to find the maximum distance you can fly along a given course and still return to your base with a reserve of fuel.

Graphic Solution



Formula

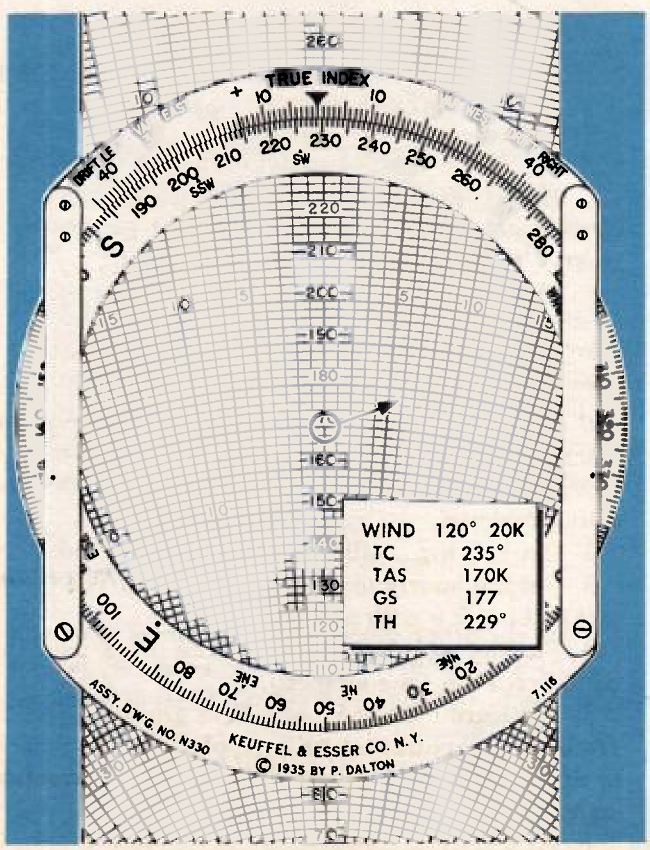
$$R/A = \frac{GS_1 \times GS_2 \times T}{GS_1 + GS_2}$$

$$t = R/A \div GS_1$$

R/A is the distance on the course out, T is total fuel hours available less 25%, t is time on course out, and GS_1 and GS_2 are groundspeeds on the course out and the course back respectively.

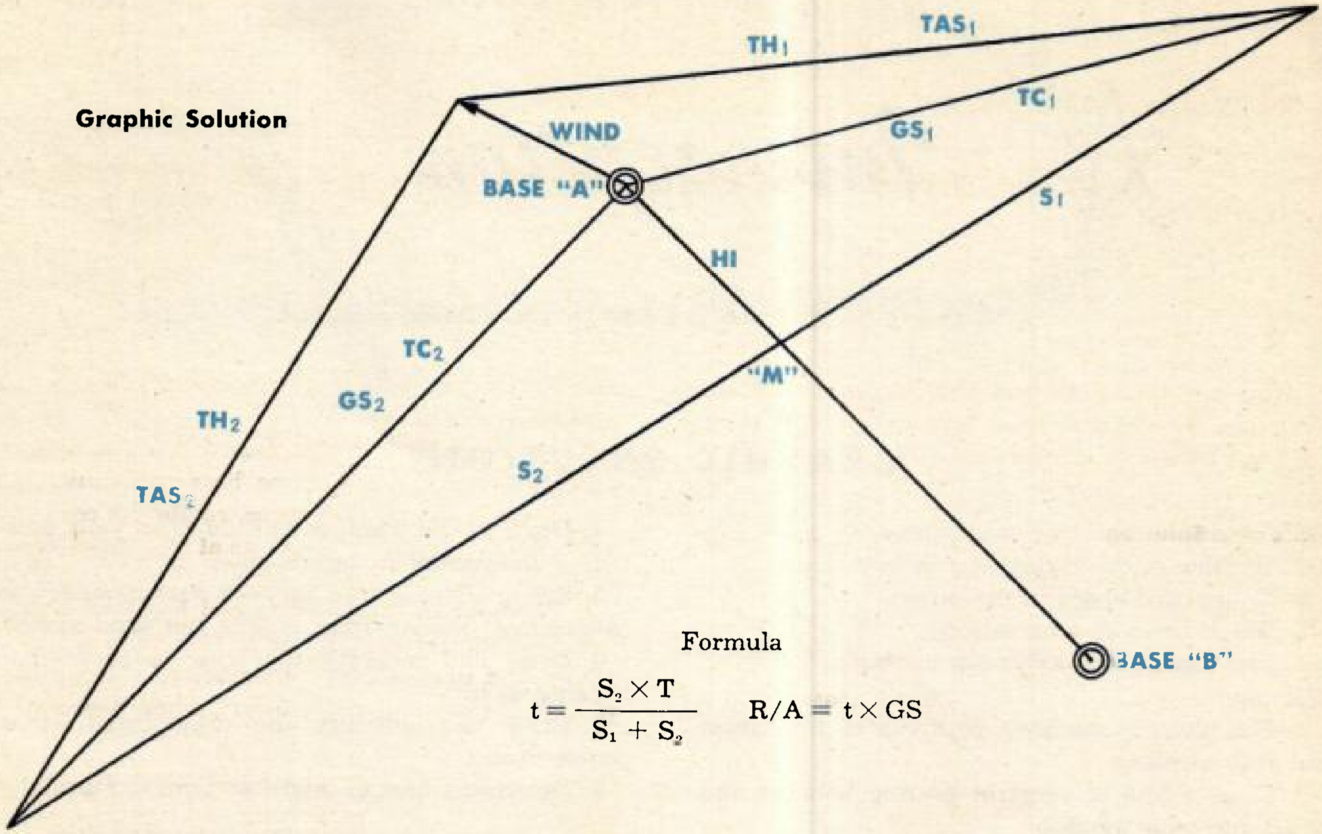
Computer Solution

1. Place the wind on the computer in the usual manner, down from the grommet.
2. Place the grommet on true airspeed.
3. Place patrol course at true index, and adjust or juggle your computer to obtain true heading.
4. Knowing true heading, true airspeed, and intended course, obtain groundspeed. This is the groundspeed out.
5. Knowing that if you depart from a base, in order to return to the same base you must fly a reciprocal of the patrol course, rotate the computer 180°. With the reciprocal course at true index adjust or juggle for true heading back.
6. Now obtain the groundspeed back.
7. Use the formula above to find your radius of action, and time out on course before turning back to base. If the winds change work a new problem.



RADIUS OF ACTION ALTERNATE BASE

Graphic Solution



Formula

$$t = \frac{S_2 \times T}{S_1 + S_2} \qquad R/A = t \times GS$$

The solution to this problem tells the following:

1. Maximum distance you can patrol a given course and still return to an alternate base with a reserve of fuel.
2. Time to turn on heading for alternate base.

Computer Solution

1. Since in this solution you read groundspeed and track on the center vector, place the wind on your computer down to the grommet instead of down from the grommet as you do when solving drift problems.
2. Put bearing of alternate base at true index.
3. Put the hourly increment down from the grommet and mark it with an "X".
4. Put the true course under true index with the wind arrow on true airspeed.
5. Read groundspeed under the grommet and S_1 (rate of departure) at "X". Apply drift correction to determine true heading. Reverse drift correction signs for use in this problem.
6. At this same setting draw in the vector passing through "X". Draw this vector along the vertical drift correction line at "X".
7. Turn the computer face until this vector is parallel to the drift correction lines on the opposite side of the center line.
8. Set the end of the wind arrow on true airspeed.
9. Read S_2 (rate of return) at "X", GS_2 under the grommet, and TC_2 at the true index. Determine TH_2 from the drift correction. Remember: reverse drift correction signs for this problem.
10. Determine t (time out on course) and radius of action from the formula.

This method of solution is not intended to replace the Mercator or graphic solution. It is to be used as a quick and rapid check once you have completed the graphic solution.

Remember:

If you ever operate from an aircraft carrier, remember the carrier is moving from departure to the position designated as alternate base. You can turn to TH_2 at any time before your radius of action is completed, and you will intercept the carrier.

Interception

GRAPHIC SOLUTION

Four quantities that you must know:

1. Position of the target at a definite time.
2. Course and speed of the target.
3. Wind direction and velocity.
4. The true airspeed you can maintain.

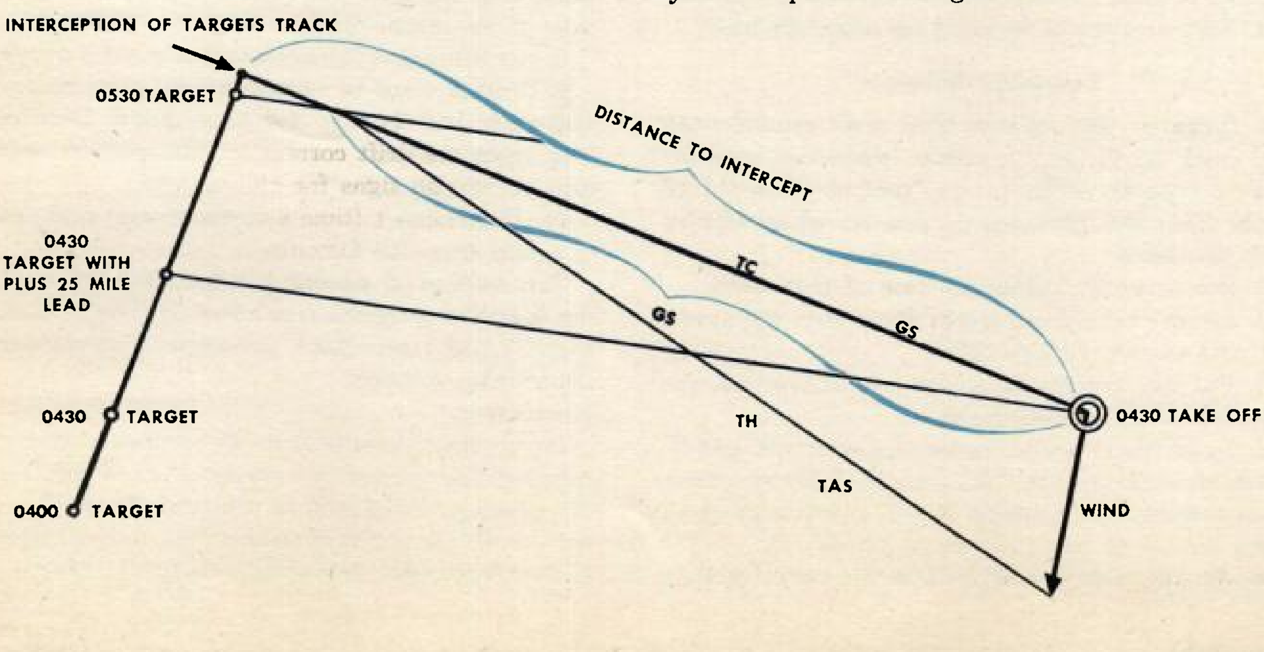
Solution:

1. Plot the simultaneous positions of the target and your airplane.
2. Draw a line of constant bearing between the target and your position.
3. Draw a parallel line of constant bearing through the position of the target at the end of one hour. Draw this line parallel to the first line.
4. Draw in the wind, downwind from your position, at the start of the interception.
5. Swing off your true airspeed onto parallel line of constant bearing from end of the wind vector.
6. Draw and measure the true airspeed – true heading vector.
7. Draw and measure the groundspeed – true course vector.
8. Determine time to intercept from the formula:

$$t = \frac{\text{distance to intercept}}{\text{groundspeed}} = \frac{\text{distance to close}}{\text{rate of closure}}$$

Remember:

The target may be the ship or it may be a point ahead or behind the ship, depending upon whether you use a positive or negative lead.

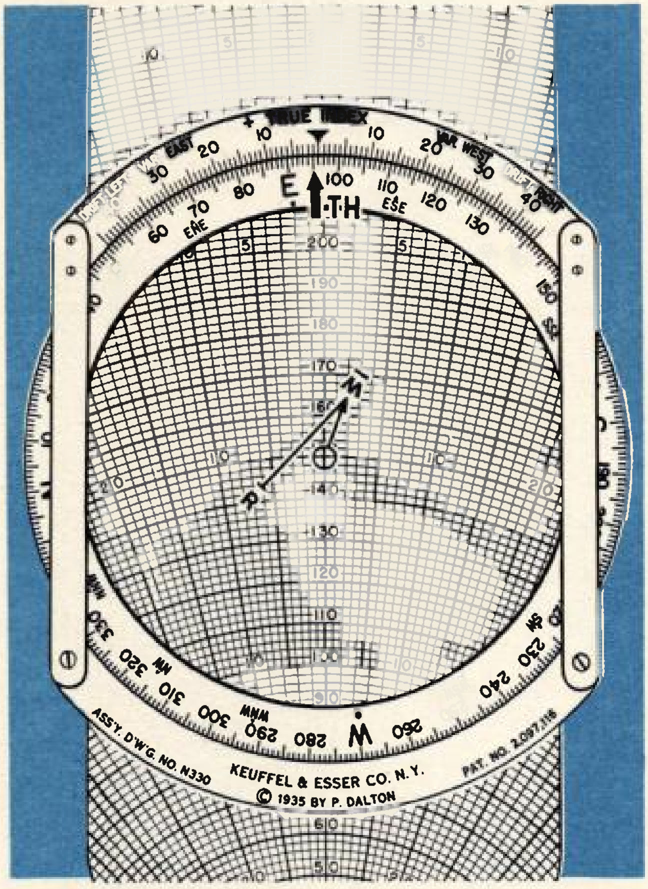


A COMPUTER CHECK ON YOUR GRAPHIC SOLUTION

To work this problem on your computer you must know angle of constant bearing (true bearing of the target from the airplane) and distance separating the target and plane. You must know wind, your true airspeed, and the ship's speed and course.

1. Lay off the wind vector down from the grommet. Mark a "W" at end of the wind arrow.
2. Turn the slide of the computer over so that the parallel grid lines are visible in the transparent face of the computer.
3. Set the ship's course under true index.
4. Move slide so that the arrow end of wind vector "W" just touches the zero line of the grid.
5. Draw a line downward equivalent to the ship's speed. Mark the end of this line "R".
6. Turn the slide over.
7. Place the grommet on your true airspeed.
8. Place the constant bearing of the ship under true index.
9. Adjust the face of the computer so that the drift indicated on the slide (at the end of "R") is the same as the drift indicated on the scale above the constant bearing of the ship.
10. Read true heading to intercept at true index, rate of closure at R, drift angle at W, and groundspeed at W.
11. Determine time to intercept from the formula:

$$t = \frac{\text{distance to close}}{\text{rate of closure}} = \frac{\text{distance to intercept}}{\text{groundspeed}}$$



PROBLEM

Given:

Angle of constant bearing 90°
Distance to close 100 n.m.
Wind 300° 15 knots
TAS 150 knots
Ship's speed 30 knots
Ship's course 140°

Required:

TC = 98°
TH = 96°
Rate of closure = 143
GS = 164 knots
Time of interception = :42

Place 143 under 100 on the E-6B computer and read the time of interception above the black hour pointer.

One thing you must check: Is your answer reasonable? After deciding that the answer is reasonable, check your work for minor errors such as might occur from measuring or computer inaccuracies.

SEARCH AND RESCUE

Responsibility

Surface craft cannot search any given area as effectively as aircraft because their visibility is restricted. They do, however, perform the actual rescue operation once they are directed to the scene of the accident or the location of survivors. On occasions when fast crash boats are available and can be dispatched to the scene of the ditching or crash immediately they can supplement the air search materially. They are also effective at night when they can use their searchlights.

However, it is the basic responsibility of air units to find the survivors.

Where trained search controllers are directing the search, your responsibility is to cover designated areas accurately. When a search controller is not available the navigation officer must plan the search.

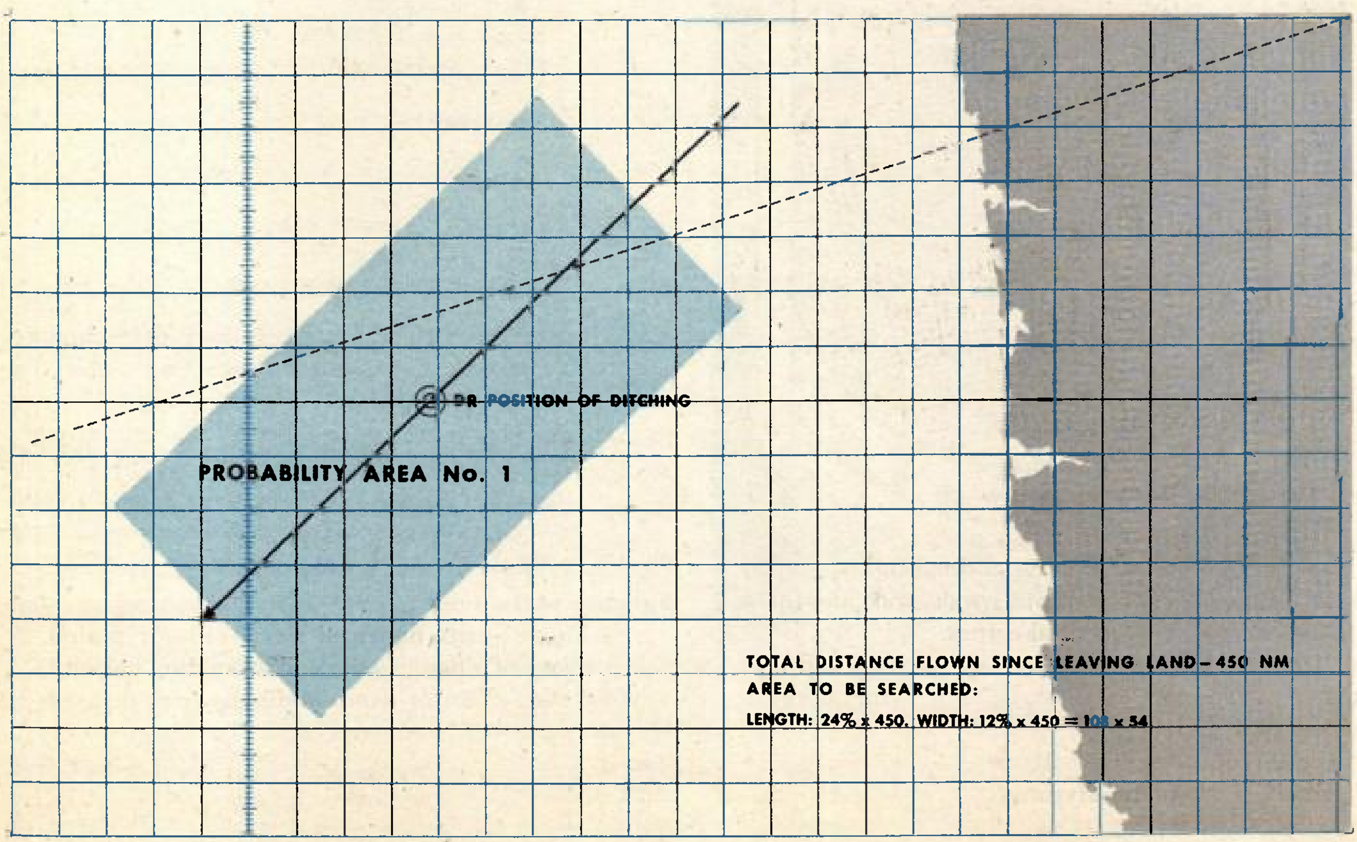
The search doctrine outlined below is the result of years of experience by the Army Air Force, Royal Air Force, and Royal Canadian Air Force. You must know this information to fulfill your responsibilities.

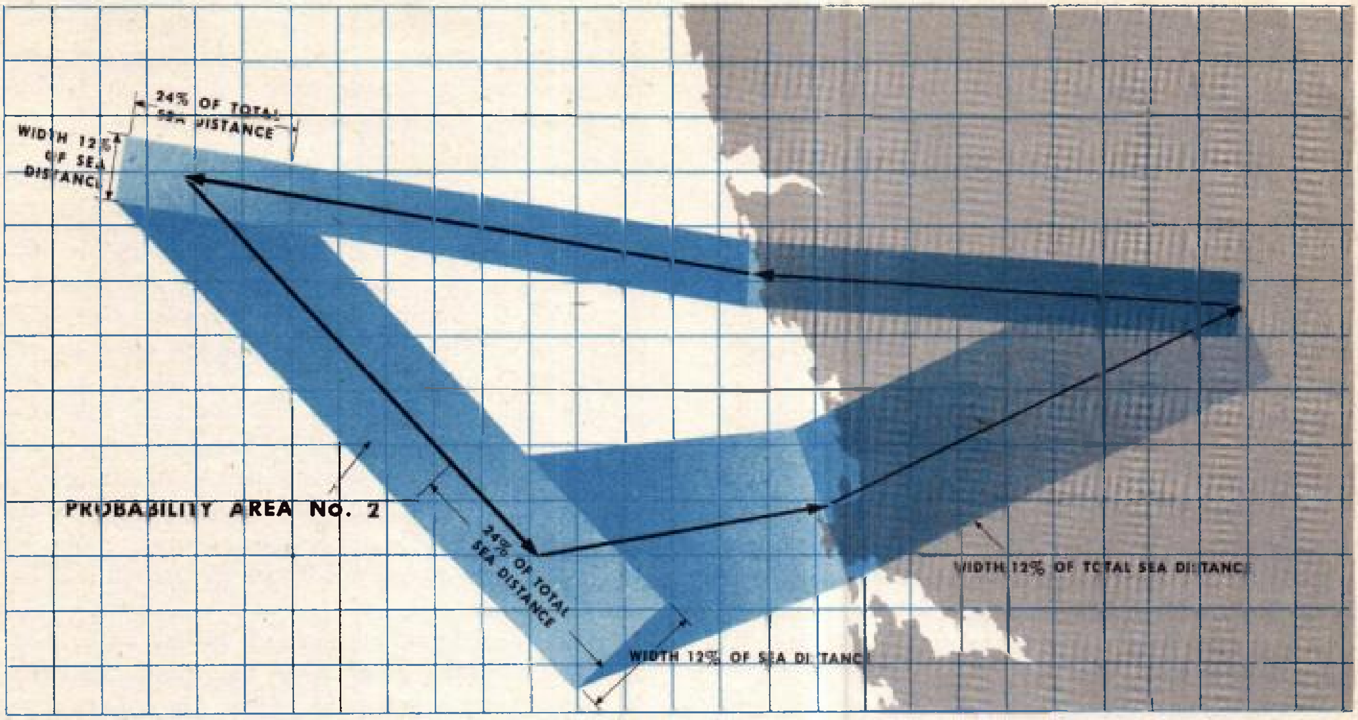
Planning a Search Mission

Use the last reliable fix on the missing airplane as the position about which to search. This is the datum point. If you don't know the ditching position, use the last reported land position from which to compute the DR track of the airplane. If the time of ditching is known, estimate the DR position and use it as a center of search.

Eliminate errors in determining the search area by outlining a rectangle 24% above estimated distance out from land along intended course and 12% perpendicular to intended course.

There are three probability areas that you can search. They depend upon the information available. When ditching position or time of ditching is known, the area outlined by the 24%-12% rectangle is the immediate search area. Designate this area as Probability Area No. 1. If the search becomes prolonged over 12 hours you must progressively change this area to allow for the effect of winds, tides, and currents upon the dinghy.





When no specific ditching position or time is available, search a strip of progressively increasing width equal at any point of the track to 12% of the distance flown from land. Designate this area as Probability Area No. 2. Use this type of search for aircraft reported overdue at destination.

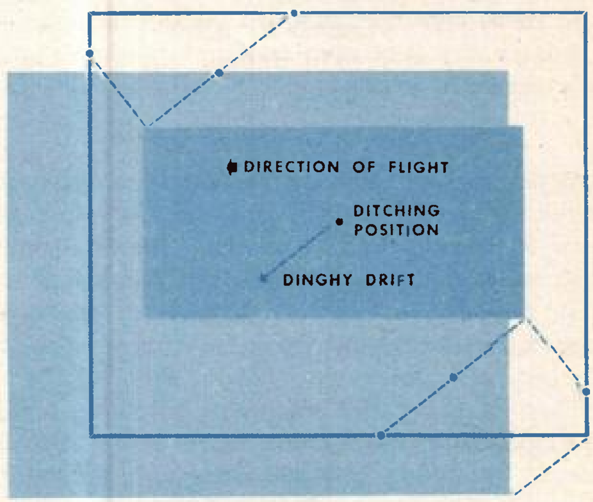
If you search the original Probability Areas, No. 1 and No. 2, without result, extend your search to other logical areas. Each of these other areas comprises a Probability Area No. 3.

Because you cannot always rely upon the accuracy of reported ditching positions, compute the probable position from any information you can find in the flight plan of the missing airplane. If this area does not coincide reasonably well with the reported ditching position, use it as a further search area when search of the reported ditching area proves fruitless.

Prolonged Search

If search aircraft arrive at the ditching coordinates even one hour after the time of ditching they must allow for the effect of currents, winds, and tides upon the dinghy, and navigational errors.

Current: Obtain a chart giving the direction and drift of the currents in the area which you intend to search. The most reliable and detailed information on the direction and velocity of ocean currents can be obtained from the Hydrographic Office publication No. 14, Pilot Chart, which is issued monthly.



Extend the boundaries of the search area by twice the amount of the average, or mean, drift in the direction of the current and by the amount of the mean drift at right angles to the current. Then shift the whole area by the amount of the drift in the direction of the average or mean current.

The dinghy drift figure is for a 24-hour period. For portions of a day use the corresponding velocity.

Wind: The effect of wind on dinghy drift depends on the force of the wind and the state of the sea. If the search is continued beyond a few hours, shift the search area again for movement of the dinghy from the action of the wind. If you have any doubts as to actual wind velocity in the search area, enlarge the area to encompass the possible extremes of wind velocity.

The average drift of a flat-bottomed rubber raft of existing design, without keel, sail, or sea anchor, expressed as a percentage of wind velocity is:

In winds up to 6 knots..........11 to 14%
In winds 6 to 12 knots.......... 8 to 11%
In winds 12 to 18 knots.......... 5 to 8%

If an effective drogue or sea anchor is used, the drift averages about 4% for lighter winds and about 2½% for winds up to 18 knots.

A drogue is highly effective in minimizing the effect of wind, and drift then becomes more dependent on the direction and velocity of ocean currents. A good drogue also helps greatly to keep the raft bow-on to the wind and to increase its seaworthiness.

Briefing for over-water flights should always include instructions on whether a drogue should be used so that those planning rescue operations will know how to plan the search.

Tides: If the search area is 50 miles or more from shore, disregard the effects of tide. Within 50 miles from shore you must take tides into consideration.

Enlarge the area even farther to allow for possible navigational errors.

Cumulative Record of Search

Re-plot the search area every 12 hours to keep the search up-to-date with the winds and currents. Because of the uncertainties of weather, serviceability of aircraft, and lack of a sufficient number of aircraft, you will not always be able to cover the desired area completely on the first day or even on subsequent days.

When planning the search on subsequent days you must take into account the searching that has already been done, both as to area covered and the adequacy of the cover. Three-eighths mile visibility is the maximum to insure the picking up of a dinghy. An area covered with that visibility is 100% covered. On the other hand, an area covered with a visibility of 1½ miles is only 25% covered. Dinghies can drift as much as 40 miles in a day, so an area that has been covered one day still needs to be covered on the following days.

An area 25% covered on each of two successive days is 50% covered. But because of drift the search on the second day covers a different area so far as the finding of the dinghy is concerned. You still have only a 25% chance of finding the dinghy if it happens to be in the area covered.

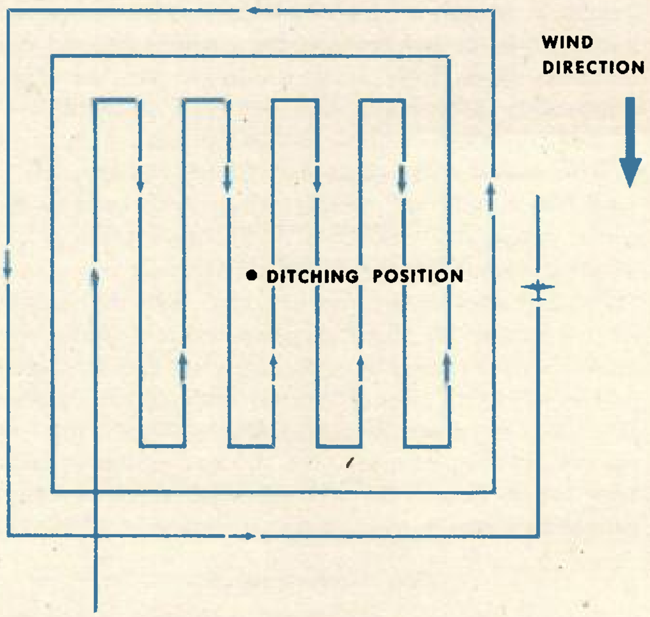
Keep a daily record of the areas searched, by percentage of cover. Do this by evaluating the reports of the searching aircraft and keeping the percentage figures on the appropriate section of the chart, or by crosshatching the areas covered.

Search Procedure

Whenever possible fly 500 feet above the water on any search mission. Altitudes above or below 500 feet decrease your chance of spotting an object in the water. If you fly below 500 feet, you pass small objects so rapidly that you have great difficulty in identifying them readily. Fly the search at the slowest indicated airspeed permitted by the airplane's stalling speed.

Unless restricted by the number of searching aircraft, search with ⅜ mile visibility on either side of the airplane. This alone provides adequate cover. If you relax these patrol conditions the search will be less effective.

Always coordinate your search pattern with wind direction as nearly as possible. This eliminates drift on half of your headings and gives you a more constant drift on the others.



Where an unusually precise ditching position is known it is good practice immediately to carry out a parallel search in a 10-mile square about the reported position, then continue with an expanding square.

A dinghy can sometimes be seen 10 miles away after it has been pointed out to you and you train your glasses on the object, but for practical search the altitude of 500 feet with ⅜ mile visibility on either side of your airplane is the only sure way of finding the dinghy.

Search into the wind. You may go over the same area twice but you will do a thorough job.

Navigation accuracy is extremely important. You must be able to calculate the distance it takes to make a turn.

A needle-width 180° turn takes 1 minute. At 180 mph you travel approximately 2 miles from your original course during the turn. To keep your parallel tracks ¾ mile apart you must make a 180° turn in approximately 22 seconds. These figures do not take into account the effect of a crosswind. This may be beyond the capabilities of some aircraft. If you can't make the necessary turns, be sure to take this into account when reporting coverage of an area.

Use this table to time your turns:

Distance Traveled Perpendicular to Track
In 180° Turn

MPH	One Minute	MPH	One Minute
300	3.18 miles	200	2.12 miles
280	2.97 miles	180	1.91 miles
260	2.76 miles	160	1.75 miles
240	2.55 miles	140	1.49 miles
220	2.33 miles	120	1.27 miles

A 2-minute 180° turn will double the figures given in the table. A ½-minute 180° turn will halve them.

Check driftmeter recordings against observations of wave formations to obtain accurate drift (See NIF 2-22). Check winds carefully.

Report surface winds to Operations so the drift of the search area can be calculated accurately.

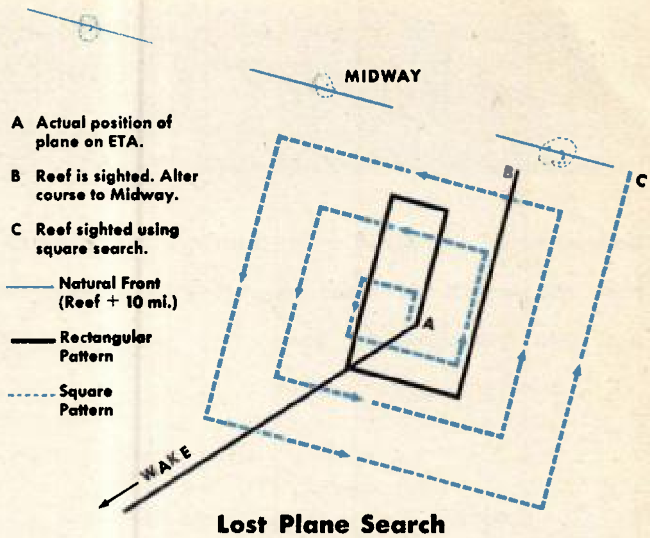
Land Search

Over rough country use the following procedure: Divide the area being searched into rectangles of 10 miles by 20 miles and assign aircraft to these rectangles with orders to carry out a full contact search of each. A full contact search means searching the area while using minimum altitude and visibility. Use large scale charts. If weather conditions make certain areas inaccessible, leave them blank on your chart and search these areas at a later date. Shade in all areas as they are searched.

Signals

You must transmit information regarding your search to Operations upon every sortie. This enables the search to proceed methodically. The signal covering the day's search by any airplane must include:

1. Coordinates of the area covered.
2. Time spent in covering the area designated.
3. Type of search (expanding square, etc.).
4. Patrol height and visibility used.
5. Meteorological visibility.



Lost Plane Search

Before your ETA runs out decide what you will do if you don't sight destination. Consider possible hazards to flying, visibility, and fuel remaining. Then design a pattern which gives you the best chance of picking up a check point. No hard and fast rules can be set. You must use your own judgment.

The illustration above does not necessarily represent the best solution but it illustrates the problem involved and one possible solution.

A plane returning to Midway from a raid on Wake has lost one engine and is flying beneath an overcast. Visibility is about 10 miles. Radio equipment is completely inoperative.

When the ETA runs out, only open water can be seen. To take advantage of the natural front of the Kuri-Midway-Pearl and Hermes archipelagoes, the navigator flies an expanding rectangular pattern, aligned across the front. Note that if he had flown a square search pattern he would have run out of fuel before sighting a reef.

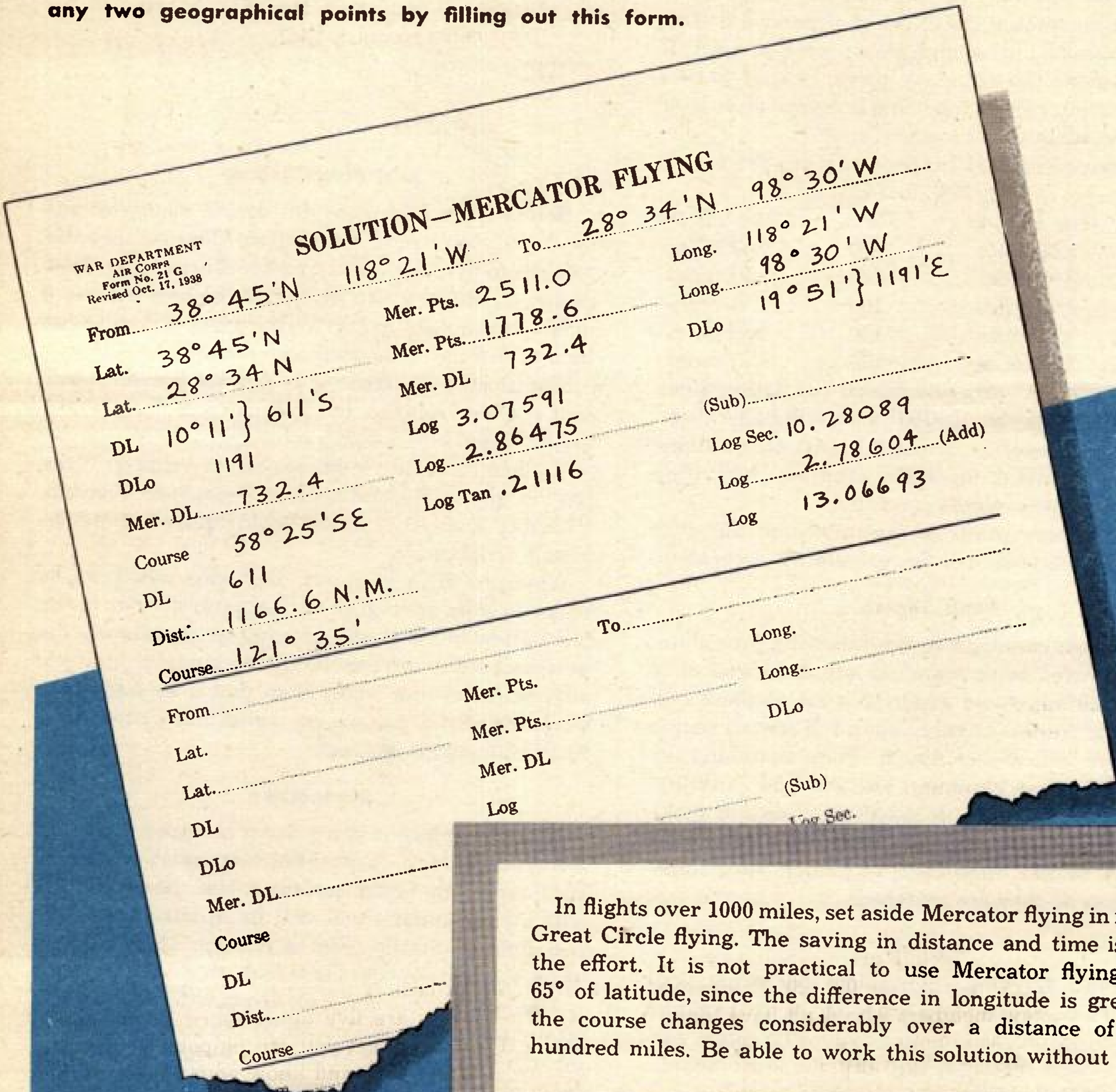
Remember

If your airplane is going down be sure to transmit a correct position. A good position report will speed your rescue by hours and days. Use the position at which you estimate you will be in the water. This will differ radically from a position at 10,000 feet when the decision was made to ditch.

The precise position of an airplane forced down is vitally important. If you are at the scene of a ditching, circle the spot until you are certain that ground radio facilities have received your message and surface craft are on the way. Then continue to circle the dinghies until rescue craft have arrived or your fuel reserve is exhausted and you are forced to return to your base.

MERCATOR FLYING

Be thoroughly familiar with your meridional parts table. Find the exact Mercator course and distance between any two geographical points by filling out this form.



WAR DEPARTMENT
AIR CORPS
Form No. 21 G
Revised Oct. 17, 1938

SOLUTION—MERCATOR FLYING

From 38° 45'N 118° 21' W To 28° 34' N 98° 30' W

Lat. 38° 45' N Mer. Pts. 2511.0 Long. 118° 21' W

Lat. 28° 34 N Mer. Pts. 1778.6 Long. 98° 30' W

DL 10° 11' } 611'S Mer. DL 732.4 DLo 19° 51' } 1191'E

DLo 1191 Log 3.07591 (Sub)

Mer. DL 732.4 Log 2.86475 Log Sec. 10.28089

Course 58° 25' SE Log Tan .21116 Log 2.78604 (Add)

DL 611 Log 13.06693

Dist. 1166.6 N.M.

Course 121° 35'

From To

Lat. Mer. Pts. Long.

Lat. Mer. Pts. Long.

DL Mer. DL DLo

DLo Log (Sub)

Mer. DL Log Sec.

Course

DL

Dist.

Course

In flights over 1000 miles, set aside Mercator flying in favor of Great Circle flying. The saving in distance and time is worth the effort. It is not practical to use Mercator flying above 65° of latitude, since the difference in longitude is great, and the course changes considerably over a distance of a few hundred miles. Be able to work this solution without a form.

GREAT CIRCLE FLYING

BE SURE TO FIND THE SAVING IN DISTANCE ON ANY LONG FLIGHT

If you wanted to fly a true great circle course, you would have to change course continually. To get around this, fly rhumb line chords or tangents to the great circle. The saving in distance outweighs the disadvantages of computing the chords and changing true course.

Solution by Great Circle or Gnomonic Chart

1. Plot the coordinates of departure and destination on the Gnomonic chart and draw a straight line connecting them.
2. Transfer the coordinates of the intermediate positions along the route to a Mercator chart.
3. Connect these points by rhumb lines.
4. Measure the true courses and distances along these rhumb lines.

Solution by Lambert Conformal Chart

You can get a close approximation to the Great Circle course by drawing a straight line between departure and destination on a Lambert Conformal chart. You can measure the coordinates of intermediate points, true courses, and distances more easily on this chart than on the Gnomonic chart.

Solution by HO 211 (Ageton)

Use HO 211 to compute not only the initial course and distance, but to solve for the coordinates of intermediate points along the route.

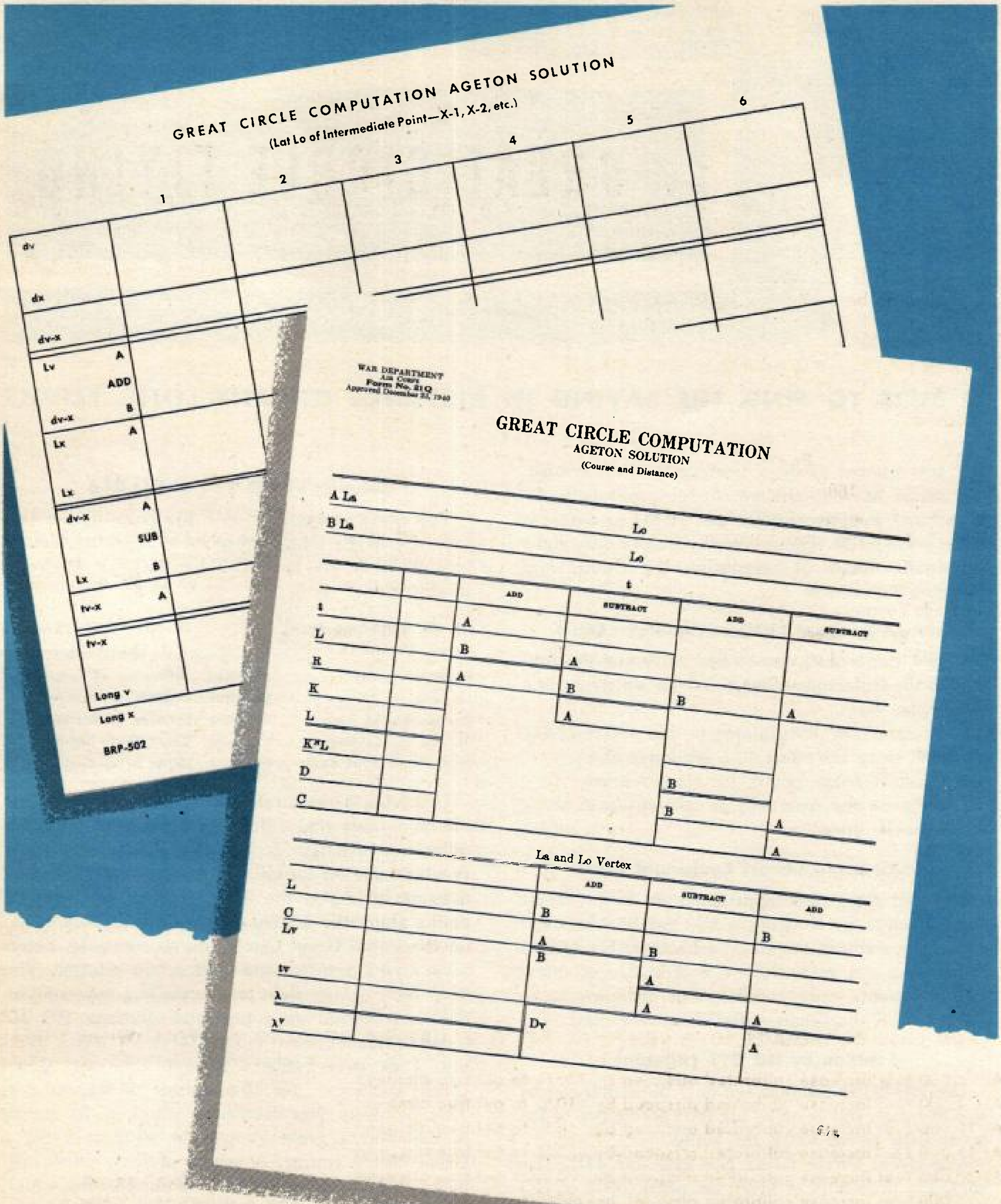
Use Great Circle forms No. 21Q and 21R. The complete procedure is given on pages 10-13 of HO 211. Pay special attention to the rules at the bottom of page 11. Follow the signposts.

Solution by HO 214 or HO 218

You must be familiar with the parts of the terrestrial triangle that correspond to the astronomical triangle when you use HO 214 or HO 218. The relationships are:

IN THE ASTRONOMICAL TRIANGLE		IN THE TERRESTRIAL TRIANGLE
Local Hour Angle	becomes	Difference of Longitude
Latitude of Observer	becomes	Latitude of Departure
Declination of Body	becomes	Latitude of Destination
90°-Hc, or Co-altitude	becomes	Great Circle Distance
True Azimuth of Body	becomes	Initial Great Circle Course

In solving Great Circle solutions by HO 214 or HO 218 you must make three interpolations. One for difference of longitude, one for latitude of destination, and one for latitude of departure. This method does not give you the coordinates of intermediate points along the course. You can dead reckon out on the initial Great Circle course, however, determine a new position, and work a new solution. You don't have to stay right on course, as a new solution does not depend upon previous solutions. HO 218 incorporates a special table (Table V) which gives the "Difference between Rhumb Line and Great Circle Distances" for the latitude of the volume. This will help you determine whether the saving in distance is great enough to warrant flying a Great Circle course. A saving of forty miles may mean the difference between landing in the water, or at your destination. A land plane won't do anyone any good in six fathoms of water.


GREAT CIRCLE COMPUTATION AGETON SOLUTION
(Lat Lo of Intermediate Point—X-1, X-2, etc.)
1
2
3
4
5
6
dv
dx
dv-x
Lv
A
ADD
dv-x
B
Lx
A
Lx
dv-x
A
SUB
Lx
B
tv-x
A
tv-x
Long v
Long x
BRP-502
WAR DEPARTMENT
Air Corps
Form No. 21Q
Approved December 23, 1940
GREAT CIRCLE COMPUTATION
AGETON SOLUTION
(Course and Distance)
A La
B La
Lo
Lo
t
ADD
SUBTRACT
ADD
SUBTRACT
t
L
R
K
L
K"L
D
C
La and Lo Vertex
ADD
SUBTRACT
ADD
L
C
Lv
tv
λ
λv
Dv

CONTROLLED ETA

On tactical missions you must arrive at the rendezvous point on time. Depending upon the conditions of the flight, control your estimated time of arrival by changing indicated airspeed or cutting corners to gain time, overshooting a turning point to lose time, essing on course, or even making a complete 360° turn to lose time.

No rules can be made. This is air sense and timing that you must develop through experience.

CONTROLLED GROUNDSPEED

An easy way to control ETA is to control your groundspeed.

Problem

Given: Wind 160° 20 knots
True airspeed 150 knots
Pressure altitude 20,000
Temperature −15° C.
True course 20°

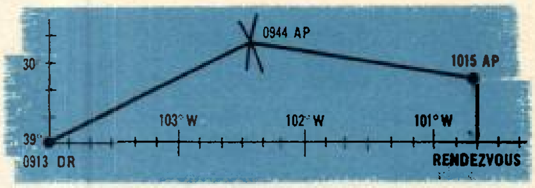
Required: To indicate an airspeed that will give a groundspeed of 180 knots.

1. Place the wind on the computer (160° 20 knots).
2. Place true course at true index (20°).
3. Put the end of the wind vector at the groundspeed desired (180 knots), rotating the disk until true heading corresponds with the drift correction indicated. True heading 24½°.
4. Read true airspeed from the grommet (165).
5. Turn the computer over and place temperature (−15° C) above pressure altitude (20,000 ft).
6. Read the calibrated airspeed (118 knots) directly below the outer true airspeed scale (165).
7. Find indicated airspeed on the airspeed calibration card opposite calibrated airspeed (118 knots).
8. Instruct your pilot to hold the desired indicated airspeed. Then check it to see that he does.

FORMATION FLYING

In formation flying the pilot must fly according to Standard Operating Procedure (SOP). A change in throttle settings will disrupt a formation.

To control your ETA, plan your course to the rendezvous point in the form of a dog-leg based upon the forecast winds and flight conditions. If you see that you will arrive late, turn earlier than you had planned. If you are arriving early, turn later than planned.



Example

The flight plan calls for a flight to 39°45′N, 102° 20′W, and then a turn to a rendezvous point at 39° 00′N, 100°40′W.

Dead reckoning position at 09:13 39° 00′N, 104° 00′W.

Wind 360°/25k
True airspeed 160k
ETA to rendezvous point 10:25 ½
Rendezvous is at 10:15

1. Plot wind effect for 62 minutes (26k) from the rendezvous point to determine your air position for 10:15.
2. With your dead reckoning position and this air position as centers, draw two arcs with a radius equal to 31 minutes of true airspeed, or 82½ nm. Intersection of these arcs is your air position for turning at 09:44.
3. Measure the true heading of each leg with your computer.

IF YOU LOSE OR DAMAGE YOUR COMPUTER, GET TRUE AIRSPEED BY USING THE FOLLOWING TABLE

At 5,000 feet increase calibrated airspeed by	7½%	to get true airspeed
At 7,500 feet increase calibrated airspeed by	10%	to get true airspeed
At 10,000 feet increase calibrated airspeed by	15%	to get true airspeed
At 15,000 feet increase calibrated airspeed by	25%	to get true airspeed
At 20,000 feet increase calibrated airspeed by	35%	to get true airspeed
At 25,000 feet increase calibrated airspeed by	50%	to get true airspeed
At 30,000 feet increase calibrated airspeed by	65%	to get true airspeed
At 35,000 feet increase calibrated airspeed by	80%	to get true airspeed

TRUE AIRSPEED

TO GET CALIBRATED AIRSPEED FROM A KNOWN TRUE AIRSPEED, DIVIDE TRUE AIRSPEED BY 1.075, 1.10, 1.15, 1.25, ETC.

AIRCRAFT RADIOS

Besides the radio compass there are three other radio sets in tactical aircraft with which you must become familiar.

1. Command set
2. Interphone system
3. Liaison set

Know where this equipment is located in your airplane. Know how to operate it. Most important of all, know which set to use for any given situation.

Command Set

The command radio set is controlled from the pilot's compartment. Use it for communication from plane-to-plane or from plane-to-ground over limited distances. It consists of three receivers which operate on 3 to 6 megacycles, 6 to 9.1 megacycles and 190 to 550 kilocycles respectively. To obtain clear definition of range signals, place the switch of the radio range filter in the pilot's compartment to "RANGE." With the switch in this position, voice reception is nearly eliminated. With the switch on "VOICE," the range signals give way to clear voice reception. Place the switch on "BOTH" to hear both range and voice signals at the same time.

Two to four transmitters are included which allow you to operate on predetermined frequencies. You can operate on only one transmitter at a time. Select the transmitter you want by turning on the proper switch.

To transmit code signals place the "TONE-CW-VOICE" switch on either "TONE" or "CW." Use either the microphone button, a standard transmitting key, or a key located on the top of the transmitter control box.

Interphone System

Use the interphone system to carry on communication with the crew members in the airplane. The jackbox of the interphone system also provides means of switching your microphone and headset to the input and output circuits of other radio equipment in the airplane such as; Radio Compass, Liaison or VHF radio set and Command radio set.

To call another crew member on the interphone hold the jackbox switch in "CALL" position and simultaneously depress the microphone switch while talking. After calling, return the switch to "INTER" position and wait for an answer. To answer, the called party switches to "INTER".

To use the interphone most efficiently, hold the microphone directly in front of your mouth, lips lightly touching the center of the mouthpiece. When you use the throat microphone, have the buttons face in against the sides of your Adam's apple. Speak slowly and distinctly in a moderate voice.

Have the openings in the earphones directly over your ears and adjust the earphones so that the cups fit firmly and evenly to seal out noise.

Do not hold the microphone switch depressed when listening, for this affects transmission.

Liaison Set

The liaison radio set is capable of transmitting and receiving over a wide range of frequencies. Use it for long distance air-to-ground communication.

The receiver unit is capable of Voice or Code (CW) reception on frequency bands ranging from 200 to 300 kilocycles, 1.5 to 3.5 megacycles, 3.5 to 6 megacycles, 6 to 9.5 megacycles, 9.5 to 13.5 megacycles and 13.5 to 18 megacycles. You can pick up the Bureau of Standards Time Signal from Station WWV on this set at either 5, 10, or 15 megacycles. See Time Signals, NIF 2-25-1.

To receive voice signals:

1. Turn "AVC-OFF-MVC" switch to "AVC."
2. Turn the volume control clockwise until you get a signal that you can hear easily.
3. Select frequency band desired by turning the band switch.
4. Adjust to the exact frequency by turning the tuning crank. Rock the crank back and forth slightly to obtain best definition of the signal.

To receive code signals:

1. Turn "AVC-OFF-MVC" switch to "MVC."
2. Place "CW-OSC" switch to "ON" position.
3. Turn "CRYSTAL IN-OUT" switch to "IN" position after "CW" signal has been tuned in.
4. Adjust "BEAT FREQ" control to obtain a tone that is pleasing to your ear.

To listen to the "LIAISON" radio set, place the selector switch on the jackbox at "LIAISON".

Transmission over the liaison set is the radio operator's duty so only attempt it after he has given you proper instruction.

Know the operation, capacities, and limitations of each piece of equipment.

PILOTAGE

Orientation

It is good practice to turn your map so that you can view it in the same direction you are flying.

If you have been flying over an undercast, keep an accurate record of your dead-reckoning position. Study the map area around that position. Pick out the most distinctive features it contains, and then search the ground around you to try to find them. Draw a circle around your dead-reckoning position. The radius of the circle should be about 10% of the distance flown since you last had a reliable check on your position. There is no need to draw the circle on your map. Just project it mentally. Keep up with your dead-reckoning position by advancing your position, and the circle, every few minutes.

Don't be a wishful thinker. Wishful thinking is a real danger to the map reader. Check individual landmarks, but be sure the individual items fit into the correct pattern. You can make a mistake on an individual check point much easier than you can on a general pattern.

Always work from the map to the ground. Some features on the ground are not shown on the map, but most features on the map appear on the ground.

Crew Cooperation

Before a mission, discuss the route in detail with the pilot and crew members. Be sure to have all watches synchronized. Give the crew the expected times of coast crossings, the time of expected enemy action, both flak and fighters, and the time you expect to pass prominent landmarks. Describe these landmarks so they'll know what to look for. They can help you find check points that may not be visible from your compartment.

If you have time, prepare a small-scale map with the course and appropriate ETA's for the pilot. It will keep him oriented during the flight. Always give position by reference to a prominent landmark. Latitude 48° 45′ N, Longitude 02° 20′ E, doesn't mean much to crew members who don't have maps.

Memory Pilotage

Your knowledge of the country over which you are operating may easily mean the difference between getting home and getting lost.

Commit to memory the section of the country over which you are operating. Be sure you know the relief, culture, and water features, including all landing strips and enemy installations, and their relationship to one another.

Check your skill by drawing this map repeatedly until you have confidence that it is impossible for you to get lost in this area. Then constantly check your observations from the air.

By knowing your operating territory:

1. You can check all other methods of navigation by ground reference.

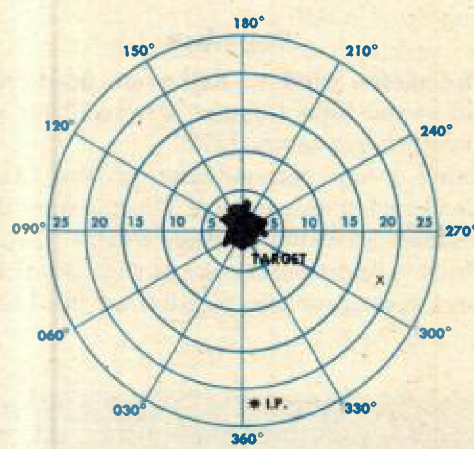
2. You can recognize landmarks from occasional glimpses of the terrain.

3. You can orient yourself if you are forced down in enemy territory.

Important

Practice pinpoint pilotage from high altitude at every opportunity. It is used extensively in the ETO.

In preparation for combat missions always memorize the target area. At times you may approach a target from zero altitude and will be unable to use maps or charts of any kind. You must know the target area from any angle of approach and be able to recognize every prominent landmark instantly. This takes concentration, but the success of the mission depends upon your work at this crucial moment. Be sure that your memory is dependable by practicing this aid to navigation at every opportunity.



Use an inverted compass rose to help orient yourself when approaching the target. Draw this on your map. The circles are five miles apart. If you don't see the IP or the target you can pinpoint your position in the target area and know your course to the target instantly. Remember, the compass rose is inverted. For example: You find yourself at X. Your heading to the target is 290°; the distance is 19 miles.

At any time when you give position, heading, or ETA to your pilot, be specific.

MOST PROBABLE POSITION

The most-probable-position technique was developed for use on long over-water flights. It consists of finding your most probable position on an LOP, at least once an hour, from a dead-reckoning position determined at the same time. It is of particular value when you are flying over an overcast and have only forecast winds and sun lines with which to navigate. This technique enables you to find wind direction and force and recognize wind shifts as they occur. Your sun lines must be within reasonable limits of accuracy. It is suggested that you take several LOP's and average them. This has proven to be more accurate than relying on a single LOP.

Procedure

1. Use metro wind to find your dead-reckoning position at the time (assume it was 10:00) you observed your first average LOP.

2. Draw a line perpendicular to the LOP from your dead-reckoning position. This point on the LOP is your most probable position (MPP).

3. Draw a line connecting your air position (AP) and your most probable position on the LOP. This vector is the most probable wind effect (MPW).

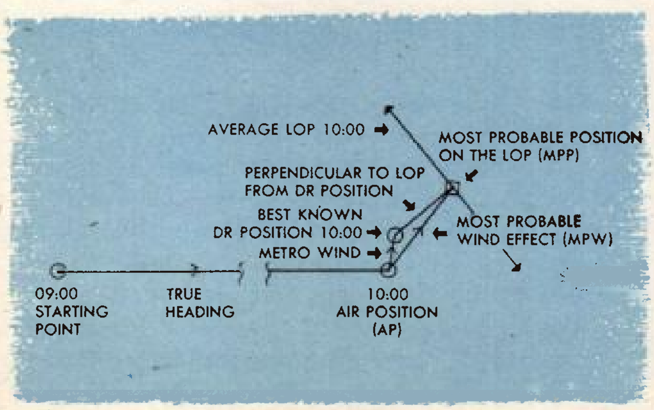
4. Convert this wind effect into wind.

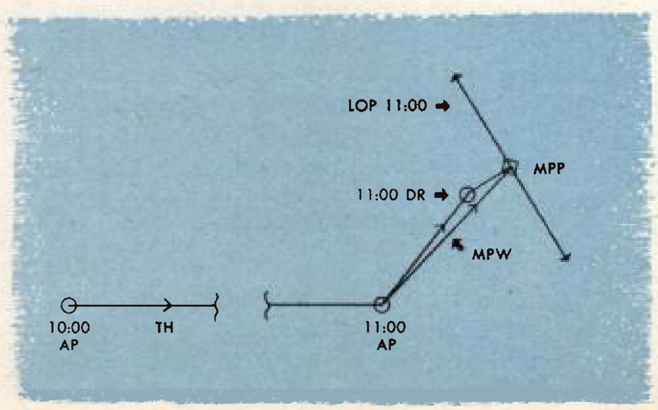
5. Observe another average LOP at 11:00.

6. Find your 11:00 dead-reckoning position, using the most probable wind found at 10:00.

7. Draw the perpendicular to the LOP from this 11:00 dead-reckoning position.

8. Connect your AP and your MPP on the LOP. This vector is your most probable wind effect.

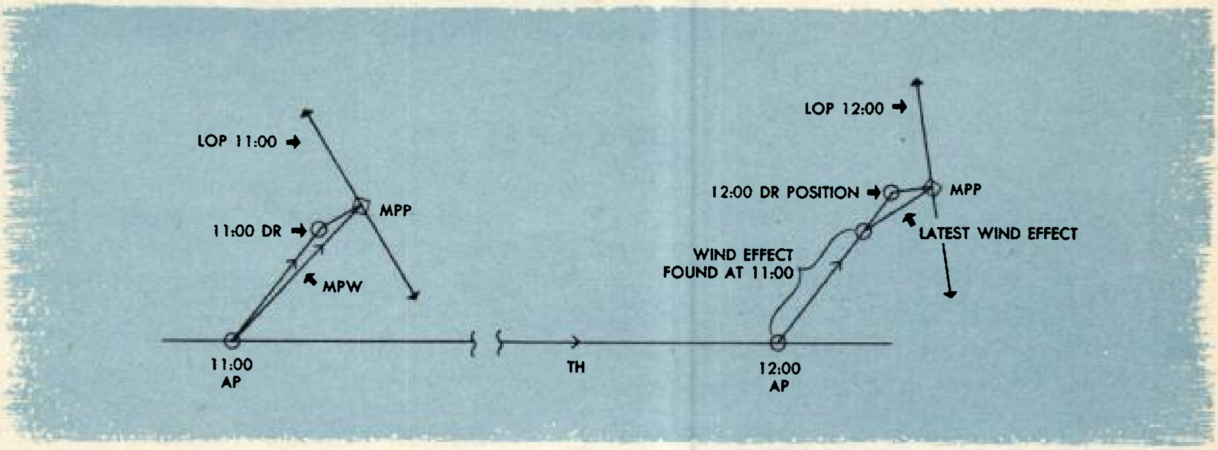




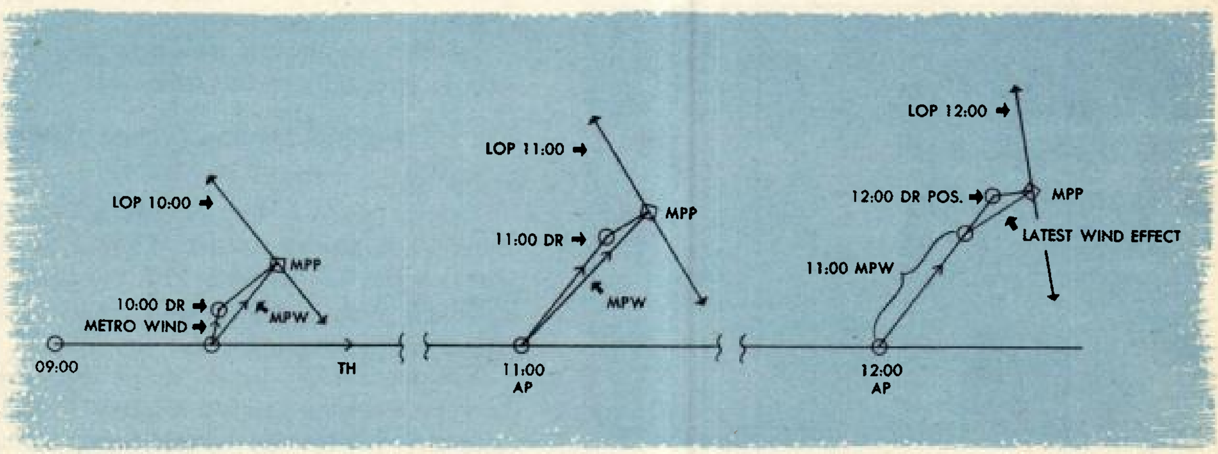
9. Convert the wind effect into wind.

Follow this procedure until you are ready to turn into destination. Obtain the latest most probable wind effect as follows:

1. Observe an average LOP at, for example, 12:00.
2. Find your 12:00 dead-reckoning position, using the most probable wind found at 11:00.
3. Find your most probable position on the LOP by drawing a line perpendicular to the LOP from your dead-reckoning position.
4. Measure off the total wind effect, found at 11:00, on the wind vector you used to plot your 12:00 dead-reckoning position.
5. Draw a line from the end of the 11:00 wind effect line to your most probable position on the LOP. This vector is the wind effect for the period between 11:00 and 12:00 and is your latest wind.
6. Use this wind to alter course into destination.



Your most probable position and most probable wind become more accurate as the flight progresses. Your dead-reckoning position continues to approach your most probable position so long as the wind is constant and your work is accurate.



If your dead-reckoning position and most probable position suddenly fall farther apart, this indicates a wind shift. Use this new wind effect as the basis from which to find a more accurate most probable position Use this wind effect as you used the metro wind at the start of the flight.

A wind shift is always readily apparent if your work is accurate.

RADIO COMPASS RECEIVING SET

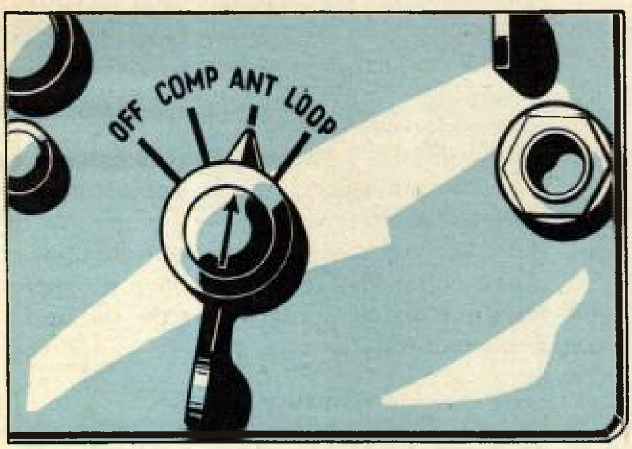
OPERATION

Set the interphone switch to "COMP".

Set the radio control switch to "COMP" or "ANT" position.

Push "CONTROL" switch to operate green light (hold switch in for two or three seconds if necessary). When the green light comes on, your set has control of the radio compass.

Adjust the "AUDIO" or interphone control to a satisfactory headset level. To get better reception of radio range signals (between 200 and 420 kc), set the interphone control fully clockwise, and adjust the "AUDIO" knob to the lowest usable headset volume.



Always tune in a station on "ANT" first, then switch to "COMP" or "LOOP." Do this to get better reception. When you have the station tuned in and properly identified, turn to "COMP".

If you tune a station in on "COMP," reception will not be clear, and wear and tear on the compass and compass indicator will materially increase.

If reception is noisy because of precipitation static, use loop reception for better results. Turn the function switch to "LOOP" and use "L-R" knob to rotate loop until you get maximum volume.

Homing

Turn the "VAR" knob on your indicator until the azimuth zero is at the index.

Switch to "COMP".

Turn the airplane in the direction shown by the indicator, until it reaches zero.

When the indicator is at zero, you are headed toward the radio station.

If the indicator is to the right or left of zero, the station is respectively to the right or left of the heading of the airplane.

It is not practical to home on a radio range course and fly it aurally at the same time.

Position Finding (Visual Method)

Switch to "COMP".

Before making fix determinations, locate the stations on the map, tune them in, identify them, and log the dial reading with the time.

This procedure will prevent delay and error when you are obtaining a fix.

Use the "VAR" knob to set the azimuth scale to zero in order to read relative bearing. Set the azimuth scale at the true heading of the airplane to read true bearing.

To obtain a fix, take bearings on three or more stations when available, 30° or more apart, obtain the true bearings and plot them in from the stations.

Have the pilot hold the airplane on a steady heading when you are taking bearings. Bearings are not accurate if the heading of the airplane is constantly changing.

Position Finding (Aural Null Method)

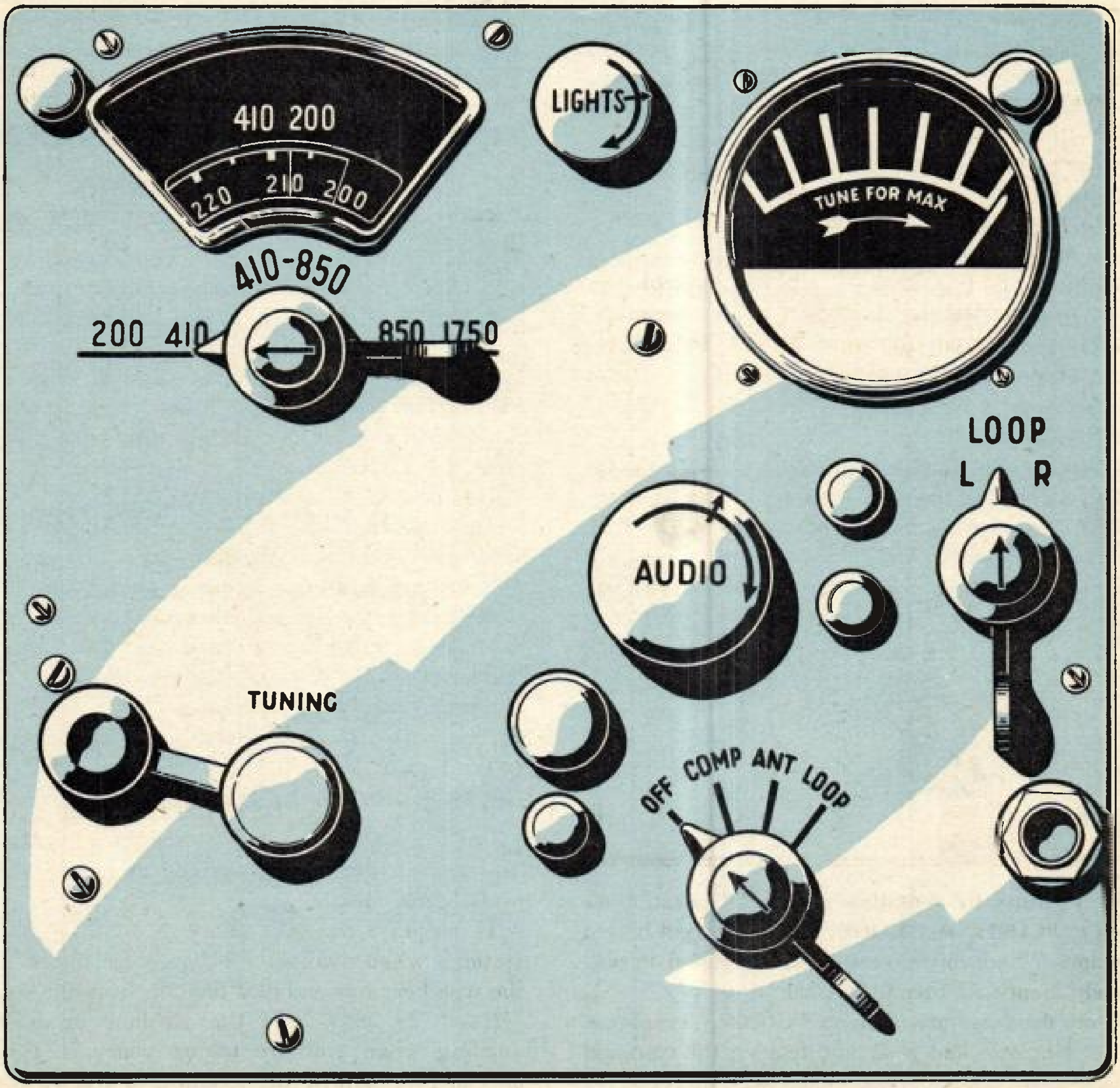
Switch to "LOOP".

Use "LOOP L-R" switch to rotate the loop for minimum headset volume, then read the bearing indicator. To rotate the loop more rapidly, depress "LOOP L-R" knob when turning it to the left or to the right. If the signal null exists over too wide an angle, obtain greater accuracy by rotating "AUDIO" fully clockwise and locating the null either by listening for the disappearance of the signal or by noting the dip in the tuning meter deflection.

Use the "CW-VOICE" switch in the "CW" position to decrease the apparent width of the null. In Radio Compass SCR-269-G installations this switch is located on the front panel of Radio Compass Unit BC-433-G. In Radio Compass Type AN/ARN-7 installations this switch is located on the lower side of Radio Control Box Type C-4/ARN-7.

You can obtain a fix by the aural null method, but be sure to watch for 180° ambiguity in bearings.

In poor weather and in storm conditions when the needle is unreliable for visual indications, use the aural null method for best results.



RADIO COMPASS CONTROL BOX

Enemy Action

Jamming

When the enemy transmits on the same frequency as a beacon, it is jammed. You can detect this easily because the jamming note (this is sometimes actually a four-tone musical note, at other times just hash) will be heard above the beacon, and the compass indicator needle will search frantically.

Meaconing

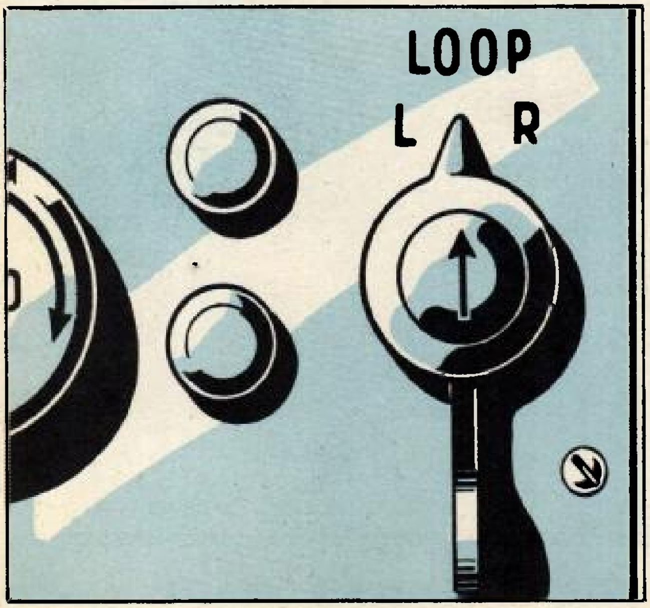
This condition is usually more dangerous and harder to detect than jamming. Meaconing takes place when the enemy keys a transmitter on the same frequency and in step with one of our beacons. No extraneous signal is heard on the earphones, and if the meaconing signal is strong enough, you may actually home on the wrong signal.

The effects of meaconing are much like those of night effect. The indications are as follows:

1. Fading of signals.
2. Widening of null.
3. Displacement of null.
4. Swinging of null.
5. Duplication of null.

The best test is for the duplication of the null. Do this as you obtain the first bearing.

1. Put the compass in loop position.
2. Use the "LEFT-RIGHT" switch to rotate the loop through 180 degrees. If you find three minima or nulls, the beacon is meaconed.



Another good check is to switch quickly to another frequency from that same splasher site. (A splasher site is a transmitting unit.) If its bearing agrees with the first, this is a good sign the beacon is not being interfered with.

In the UK, splashers are monitored, and when meaconing is apparent, the beacon signal is mutilated by sending a series of dots on the same frequency. **This service is available with splasher systems only.** Multi-beacons are also subject to meaconing.

POLARIZATION ERRORS

The radio compass is designed to serve primarily as a navigational aid in flying. As long as you use it in this capacity and recognize its limitations, it is a useful and valuable device. Unfortunately, in actual flight there are certain periods when the indications are not correct because of radio wave polarization errors. Failure to recognize these errors can throw you far off course, and make you mistrust the compass.

The principal polarization error is **night effect.** Other cases of faulty bearings are **mountain effect, shore-line effect,** and **magnetic disturbances,** such as those found in auroral zones of polar regions.

Ordinarily, for homing, the radio compass receiver depends on reception of vertically polarized radio waves. When these waves are reflected from the sky, however, they may change polarity and become horizontally polarized. These horizontally polarized waves conflict with the vertically polarized waves and cause fluctuations in the reading of the radio compass indicator.

Night Effect

Since radio waves are reflected in greater strength by night than by day, the opposition of horizontally opposed waves is stronger at night. Errors caused by this phenomenon are called night effect.

Polarization errors may flare up for a few seconds at intervals through the day and cause the needle to hunt about the bearing. Real night effect causes hunting of more than 30 seconds duration. Variations in the intensity of this hunting may be classified into two types.

1. In less severe form the indicator hunts over a total angle of 15° or less around the true bearing; and you can often take a bearing with an accuracy of 5° by computing a mean reading.

2. **In more severe cases** the indicator moves constantly, usually through a wide angle and not around the proper bearing. An average reading is not possible under these circumstances. You sometimes encounter short periods of nearly normal operation during these periods of extreme instability.

The times at which night effect begins, vary considerably, even on the same station. Usually the first and last disturbances appear during the periods just before sunset and just after sunrise. The errors increase with an increase in frequency, or with an increase in the distance of the airplane from the transmitting station.

Remedies

Night effect recurs frequently. There are definite steps you can take to combat it, however. First, recognize it by remembering that a period of fluctuation in the bearing indications lasting more than 30 seconds is a sure sign. Then try the following:

1. **Use other methods of navigation to check the bearings.**
2. **Increase altitude.**
3. **Average the fluctuations if possible.**
4. **Select a station of lower frequency.**
5. **Remember that comparatively large errors are tolerable for purposes of homing, since accuracy increases as the distance diminishes.**

Other Effects

You may notice fluctuations when flying across coast lines when the radio waves cross the coast at acute angles. Errors may occur, also, when you are flying over certain mountainous regions, and to a limited extent, through cold fronts.

FIRST ECHELON MAINTENANCE

1. With equipment completely inoperative, check fuses.
   a. One 5 Amp and one 10 Amp fuse located on face of BK-22.
   b. One 50 Amp fuse located in inverter junction box, on top of inverter.
   c. One 40 Amp fuse located in co-pilot's fuse box.
2. If receiver is excessively noisy, check Threshold Sensitivity control on face of receiver. Proper adjustment procedure is outlined in T. O. 08-10-175.
3. If reception of signals is intermittent, check positioning of tubes, grid clips and grid shields.
4. If receiver operation is dead or intermittent, check plug connections for poor contact.
5. If signals are weak, check antenna ground connections.
6. If modulated signals are distorted, check "CW-VOICE" switch for "VOICE" position.

Radio Compass Compensation

The radio compasses that are installed in most combat airplanes are corrected according to standard deviation curves for the type of airplane and the location of the antennas. This is done in accordance with T.O. 01-1-152. Do not attempt to change the compensation that is set in the loop compensator. The corrections that are set in following the T.O. will not ordinarily make the deviation zero on all indicated bearings. For accurate work swing the radio compass and construct a deviation curve for the residual deviation present. This curve will probably be very irregular and should not have a very large spread. Post the curve near your desk in the airplane for accurate airwork.

Radio Compass Swinging

To swing the radio compass to determine the residual deviation, select a medium or high-powered station about 100 miles from the place you want to conduct the swing. Since the deviation changes somewhat with frequency, the frequency of the station should be between 200 and 800 kilocycles. Select a day when the wind is less than 8 mph to avoid excessive drift and do not perform the calibration during the time polarization errors are prevalent, just before sunset and just after sunrise, when large fluctuations of bearings are noted.

Set the "VAR" knob on the indicator so that the index is opposite zero. Find a reference point, such as a tower or a prominent building, and determine the true bearing of the radio station from that point.

Since power lines or railroads on or adjacent to the landmark may distort the radio bearing, make a check to determine whether or not there is distortion. You can do this by crossing the reference point at various angles while maintaining a fixed heading by means of the directional gyro. If the bearings change rapidly as you approach the point, distortion is present. Eliminate it by flying at a greater altitude or by selecting a new reference point for the swing.

Fly three small circles around this point, the pilot using his directional gyro and decreasing the heading each time by 45°. The ninth and seventeenth headings are only 30° smaller. For Example:

360	015	030
315	330	345
270	285	300
225	240	255
180	195	210
135	150	165
090	105	120
045	060	075

On each leg determine the true heading by astro-compass and the indicated bearing from the radio compass. Then as the true bearing and the true heading are known, determine the correct relative bearing as follows: True Bearing − True Heading = Relative Bearing. Find residual correction as follows: Relative Bearing − Indicated Bearing = Correction.

Plot these corrections through the indicated bearing and draw a smooth curve through the points. Post this graph near your desk in the airplane. Be sure to use the graph on all bearings.

RADIO NAVIGATION AIDS

Taking Bearings

On most combat missions the range is usually too great for radio bearings with the home stations. You can frequently obtain bearings on enemy stations of known position. Because of the ease of moving transmitting stations, however, you can't exercise too much caution in using these bearings.

Do not consider the position of any enemy transmitters known, unless the Intelligence Officer definitely makes a statement to that effect immediately before the flight. You can't be too careful.

Be sure to evaluate every bearing taken intelligently. When using the radio compass, note the distance the airplane is from the transmitting station, the probable terrain effect, and the possibility of the transmitter being moved.

Conversion of Bearings

As radio bearings are actually great circle bearings, you cannot plot them directly on the Mercator chart. Use the following table to convert bearings

CORRECTION REQUIRED TO CONVERT A RADIO GREAT CIRCLE BEARING TO MERCATORIAL BEARING

MIDDLE LATITUDE	DIFFERENCE OF LONGITUDE OF SHIP AND RADIO STATION														
	2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
66	0.9	1.8	2.8	3.7	4.6	5.5	6.4	7.3	8.2	9.1	10.0	11.0	11.9	12.8	13.7
63	0.9	1.8	2.7	3.6	4.5	5.4	6.3	7.1	8.0	8.9	9.8	10.7	11.6	12.5	13.3
60	0.9	1.7	2.6	3.5	4.3	5.2	6.1	6.9	7.8	8.6	9.5	10.4	11.2	12.1	12.9
57	0.8	1.7	2.5	3.4	4.2	5.0	5.9	6.7	7.5	8.4	9.2	10.0	10.9	11.7	12.5
54	0.8	1.6	2.4	3.3	4.1	4.9	5.7	6.5	7.3	8.1	8.9	9.7	10.5	11.3	12.1
51	0.8	1.6	2.3	3.1	3.9	4.7	5.5	6.2	7.0	7.8	8.5	9.3	10.1	10.8	11.6
48	0.8	1.5	2.2	3.0	3.7	4.5	5.2	5.9	6.7	7.4	8.2	8.9	9.6	10.4	11.1
45	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.6	6.3	7.1	7.8	8.5	9.2	9.9	10.6
42	0.7	1.4	2.0	2.7	3.4	4.0	4.7	5.4	6.0	6.7	7.4	8.0	8.7	9.4	10.0
39	0.6	1.3	1.9	2.5	3.2	3.8	4.4	5.0	5.7	6.3	6.9	7.5	8.1	8.8	9.4
36	0.6	1.2	1.8	2.4	3.0	3.5	4.1	4.7	5.3	5.9	6.4	7.0	7.6	8.2	8.7
33	0.5	1.1	1.6	2.2	2.7	3.3	3.8	4.4	4.9	5.4	6.0	6.5	7.1	7.6	8.1
30	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.4
27	0.5	0.9	1.4	1.8	2.3	2.7	3.2	3.6	4.1	4.5	5.0	5.4	5.9	6.3	6.8
24	0.4	0.8	1.2	1.6	2.1	2.4	2.9	3.3	3.6	4.0	4.4	4.8	5.2	5.6	6.0
21	0.3	0.7	1.1	1.4	1.8	2.2	2.5	2.9	3.2	3.6	3.9	4.3	4.6	5.0	5.3
18	0.3	0.6	0.9	1.2	1.6	1.9	2.2	2.5	2.8	3.1	3.4	3.7	4.0	4.3	4.6
15	0.3	0.5	0.8	1.0	1.3	1.6	1.8	2.1	2.3	2.6	2.8	3.1	3.3	3.6	3.8
12	0.2	0.4	0.6	0.8	1.0	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1
9	0.2	0.3	0.5	0.6	0.8	1.0	1.1	1.2	1.4	1.6	1.7	1.9	2.0	2.2	2.3
6	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.6
3	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8

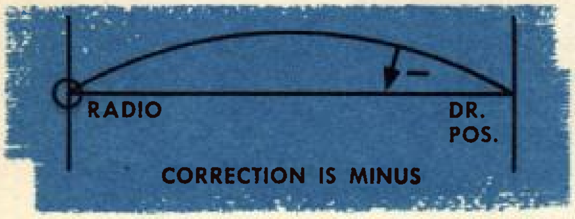
before using them on a Mercator chart.

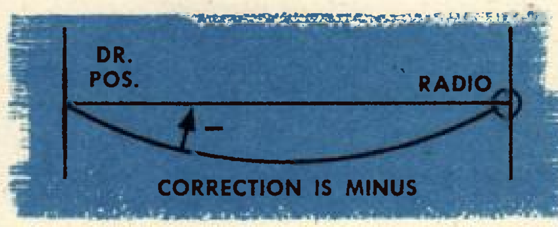
To determine whether the conversion angle is to be added to or subtracted from the Great Circle bearing, remember that the Great Circle always lies on the polar side of the rhumb line connecting the station and plane; that is, toward the elevated pole.

The four diagrams shown here illustrate the corrections you must apply.

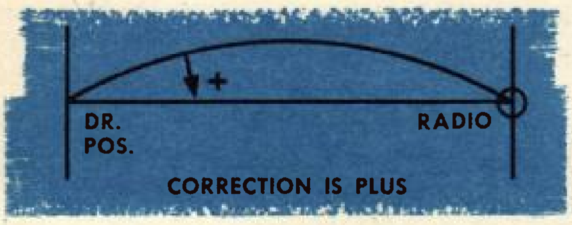
North Latitudes | **South Latitudes**

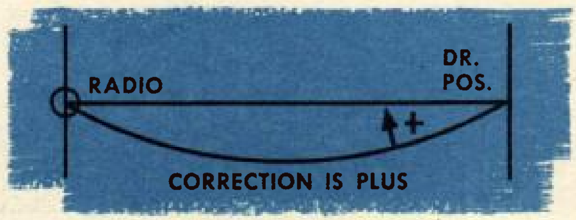
Plane East of Station





Plane West of Station





Reverse the sign of the correction when the bearings are taken on your airplane by a DF station.

BEACONS

The beacon lights on the main airways are numbered from 1 to 10, and coded as shown here, to aid you in flying light lines in this country.

1 • ▬ ▬ When

2 • • ▬ Undertaking

3 • • • ▬ Very

4 • • • • Hard

5 • ▬ • Routes

6 ▬ • ▬ Keep

7 ▬ • • Direction

8 ▬ • • • By

9 ▬ ▬ • Good

10 ▬ ▬ Methods

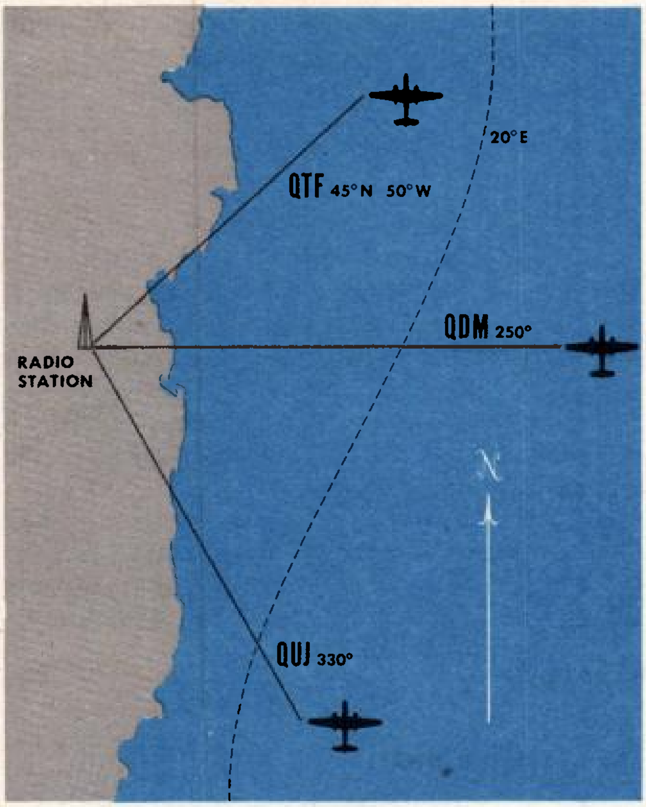
The code flashes in the direction of the airways, six times per minute. The code in red means no night landing facilities. The code in green designates night landing facilities. You can read the code by flying parallel and close to or across the light line.

COURSES AND POSITIONS

The three important radio navigation signals for aircraft are QUJ, QDM, and QTF. Direction Finding stations will give you this information upon request. Use these signals at any time when radio silence is not enforced.

It is a good idea to practice using these signals at every opportunity so you will be familiar with them when they are needed.

Because direction finding is an excellent emergency procedure, the frequencies must be cleared for aircraft in distress. If you are on a practice mission you can use the direction-finding facilities, but always inform the station that you are practicing. In this way the station, without endangering your airplane, can divert attention to any urgent calls from other aircraft during your mission.



When a D/F station gives you a QUJ, QDM, or QTF the time of the signal is contained in the message. If for any reason a station other than the transmitting station has provided the data the message will contain the call sign of this station.

Class of course and fix (position) is designated in the message by a letter which tells you the relative accuracy of the data.

Class A course....... Accurate within 2°
Class B course....... Accurate within 5°
Class C course....... An error of over 5°

Class A fix .... Accurate within 5 miles
Class B fix .... Accurate within 20 miles
Class C fix .... An error of over 20 miles

If a Class C fix is in error over 50 miles, this will be indicated in the message.

MESSAGE DESCRIPTION

473	RQW	QTF	45°N, 50° W	A	1630Z
Aircraft call letters	D/F station	Type of signal	Fix or course	Class	Time

Because of the possibility of reciprocal error, QTE is not requested normally.

FM 24-13 and AAF Letter 100-17 must be carried aboard your airplane.

One-Station Fix

You can obtain a fix by using your radio compass on one station as follows:

1. Take a relative bearing on a station.
2. After a few minutes take another relative bearing on the same station.
3. Enter the table to obtain the factor.
4. Compute the distance between the first and second bearings, using your best known groundspeed.
5. Multiply the factor you obtained from the table by the distance between the bearings to obtain your distance from the station.
6. Knowing your distance from the station and your bearing from the station, you have fixed your position.

QUJ When you ask for a QUJ you receive the true course to steer to reach the transmitting station.

QDM When you ask for a QDM you receive the magnetic course to steer to reach the transmitting station.

QTF When you ask for a QTF you receive the coordinates of your position according to the bearings taken by the transmitting station.

INITIAL BEARING	SECOND BEARING												
	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°
20°	1.97	1.00	0.68	0.53	0.45	0.39	0.36	0.35	0.34	0.35	0.36	0.39	0.45
30°		2.88	1.46	1.00	0.78	0.65	0.58	0.53	0.51	0.50	0.51	0.53	0.58
40°			3.70	1.88	1.29	1.00	0.84	0.74	0.68	0.65	0.64	0.65	0.68
50°				4.41	2.24	1.53	1.19	1.00	0.88	0.82	0.78	0.77	0.78
60°					4.99	2.53	1.73	1.35	1.13	1.00	0.92	0.88	0.87
70°						5.41	2.75	1.88	1.46	1.23	1.09	1.00	0.95
80°							5.67	2.88	1.97	1.53	1.29	1.14	1.05
90°								5.76	2.92	2.00	1.56	1.31	1.15
100°									5.67	2.88	1.97	1.53	1.29
110°										5.41	2.75	1.88	1.46
120°											4.99	2.53	1.73
130°												4.41	2.24
140°													3.70
150°													0.00

EXAMPLE

You obtain a relative bearing of 30° from a station at 09:05. On the same heading you obtain a relative bearing of 40° at 09:08.

Enter the table at initial bearing of 30° and go across to 40° for the second bearing. At this intersection obtain the factor 2.88.

Groundspeed is 180k. Time between bearings is 3 minutes. You have traveled 9 nm between bearings. 9 x 2.88 = 25.92.

At 09:08 the station was at a relative bearing of 40° and you were approximately 26 nm from the station.

RADIO RANGES

Your radio can be used for orientation in ways other than taking bearings. It is to your advantage to understand its every use. Commercial airlines navigate by radio almost exclusively.

Radio procedures require a thorough knowledge of signal tone structures. The best way to obtain practice in recognizing signal tones and flying radio ranges is voluntarily to take some instruction in the Link trainer. After a few hours' instruction you will be familiar with the range system of orientation. For further reference, study T.O. 30-100B-1, Instrument Flying, Advanced. You can always find a copy at Base Operations or in the base technical library.

By means of this study you will be able to orient yourself with the range stations as follows:

1. Tune in two or more stations and fix your general position by reference to the signals received from each station. Then pinpoint your position by pilotage.

2. You can use the one-station fix procedure outlined above to establish the number of miles you are away from the station.

3. When you cross the beam of a radio range station you can pinpoint your position by pilotage because the "on-course" signal width is but 3°.

4. Use the automatic radio compass to find your approximate position by following this procedure:

a. Tune the compass to a station you are passing.

b. Wait until the station is at a relative bearing of 90°.

c. Check the time and wait for 2 minutes.

d. At the end of 2 minutes check the relative bearing of the same station.

e. Divide the number of seconds that have elapsed by the number of degrees change in relative bearing.

f. This is the number of minutes you are from the station and you obtain the bearing of the station direct from the radio compass.

Example

At 09:03 the relative bearing of station RQ is 90°.
At 09:05 the relative bearing of station RQ is 100°.

120 ÷ 10 = 12 minutes.

At a groundspeed of 180k you are 36 nm from the station and the station bears 100° from your heading.

5. You can home on a station by using the automatic radio compass and keeping the relative bearing at 0°.

6. You can check the quadrant of a station by flying an average bisector of the quadrant and listening for the build or fade of the signal.

Time Signals

YOUR RADIO OPERATOR CAN GET YOU TIME TICKS BY USING THESE SIGNALS, FREQUENCIES, AND TIMES.

1. Set to MVC
2. CW Oscillator ON
3. Crystal on IN

The United States Naval Observatory at Washington, D. C. is the origin of all government time signals broadcast in the United States and its possessions excepting the Philippine Islands. During the transmission of the time signal, the radio stations at Arlington and Annapolis are automatically controlled by wire from the Naval Observatory transmitting device. The San Francisco signals are controlled by a similar device located at the Mare Island Navy Yard.

The transmission of signals begins at 55 minutes 0 seconds of some hour, and continues for 5 minutes. Signals are transmitted on every second during that time, except that there is no signal on the 29th second of any minute, nor on certain seconds at the ends of the minutes, as shown on the following diagram:

SECONDS

MINUTES	50	51	52	53	54	55	56	57	58	59	60	
55	—		—	—	—	—					—	56
56	—	—		—	—	—					—	57
57	—	—	—		—	—					—	58
58	—	—	—	—		—					—	59
59	—										—	60

UNITED STATES TIME SIGNALS

The dashes in the above diagram indicate seconds on which signals are transmitted. The seconds marked "60" are the zero seconds of the following minutes. All seconds from 0 to 50 inclusive are transmitted, except the 29th second as explained above. The dash on the beginning of the hour (shown as 59 minutes 60 seconds above) is much longer than the others (1.3 seconds).

In all cases the beginnings of the dashes indicate the beginnings of the seconds, and the ends of the dashes are without significance.

The number of dashes sounded in the group at the end of any minute indicates the number of minutes of the signal yet to be sent.

Repetitions. In case of the failure of a signal, it is repeated one hour later.

For ordinary commercial and navigational purposes the time signals are sufficiently accurate as broadcast.

UNITED STATES—ATLANTIC COAST

Washington, D. C. (NSS) broadcasts time signals at the times and wave lengths given below. Times are in GCT.

03:55 to 04:00.........113 kc, 4390 kc, 9425 kc, 12,630 kc.
09:55 to 10:00.........113 kc, 4390 kc, 9425 kc, 12,630 kc.
15:55 to 16:00.........113 kc, 4390 kc, 9425 kc, 12,630 kc.
21:55 to 22:00.........113 kc, 4390 kc, 9425 kc, 12,630 kc.

The time given is the start of the 5 minute period.

System: United States system. **Accuracy:** Average error .02 second.
Source: Naval Observatory, Washington, D. C.

UNITED STATES—PACIFIC COAST

San Francisco (Mare Island), Calif. (NPG) broadcasts time signals at the times and wave lengths given below. Times are in GCT.

02:55 to 03:00.........115 kc (2609 m), 9090 kc (33 m), 12,540 kc (23.9 m); A1.
07:55 to 08:00.........115 kc (2609 m); A1.
14:55 to 15:00.........115 kc (2609 m), 9090 kc (33 m), 12,540 kc (23.9 m); A1.
16:55 to 17:00.........115 kc (2609 m); A1.
19:55 to 20:00.........115 kc (2609 m); A1.
23:55 to 24:00.........115 kc (2609 m); A1.

System: United States system.
Accuracy: Normally correct to less than 0.1 second, except the 08:00, 17:00, 20:00, and 24:00 signals, which are normally correct to less than 0.5 second.
Source: Crystal clock synchronized with the Naval Observatory, Washington, D. C.

SPECIAL TIME SIGNALS

These are transmitted at 08:00, 17:00, 20:00 and 24:00 on a frequency of 42.8 kc (7005 m) and 115 kc (2609 m), and are not preceded by the special one-minute time tick from Washington, D. C.

HAWAIIAN ISLANDS

Oahu (Honolulu) (NPM). Times are in GCT.

03:55 to 04:00.........113 kc (2653 m), 9090 kc (33 m), 12,540 kc (23.9 m); A1.
15:55 to 16:00.........113 kc (2653 m), 4390 kc, 9090 kc (33 m), 12,540 kc (23.9 m); A1.
19:55 to 20:00.........113 kc (2653 m), 9090 kc (33 m); A1.

System: United States system. **Accuracy:** Normally correct to less than 0.1 second.
Source: Rebroadcast of the San Francisco (NPG) time signal by automatic relay.

PANAMA CANAL ZONE

Balboa (Summit) (NBA). Times are in GCT.

04:55 to 05:00.........148 kc (2027 m), 2716 kc, 5540 kc (54.12 m), and 11,080 kc (27.06 m); A1.
16:55 to 17:00.........148 kc (2027 m), 2716 kc, 5540 kc (54.12 m), and 11,080 kc (27.06 m); A1.

System: United States system. **Accuracy:** Normally correct to less than 0.1 second.
Source: Rebroadcast of the Washington-Arlington time signal by automatic relay.

GREAT BRITAIN AND IRELAND

British Broadcasting Company

The BBC time signal consists of the automatic transmission by the standard clock at Greenwich Observatory of 6 dots (· · · · · ·), one for each of the last 6 seconds of each minute, thus:

Seconds:	55th,	56th,	57th,	58th,	59th,	60th.
Dots:	●	●	●	●	●	●

The final dot is the time signal. **Accuracy:** Normal error 0.1 second.

The time signals are transmitted as follows:

BBC HOME SERVICE

Wave: 6180 kc (48.54 m), 1474 kc (203.5 m), 767 kc (391.1 m), 668 kc (449.1 m)
Time: 07:00, 09:15, 12:00, 16:00, 17:00, 23:00. (Sundays: 08:00, 12:00, 16:00, 17:00, 23:00)

BBC FORCES SERVICE

Wave: 1013 kc (296.15 m), 877 kc (342.1 m)
Time: Hourly from 06:00 to 20:00, except 10:00

BBC OVERSEAS SERVICE

Thirteen of the stations listed below are included in the service performed by the Daventry station, located at 1° 08′ W, 52° 15′ N. The locations of the remaining stations are listed only in classified documents.

	kc		kc		kc
Wave: (GRB)	6010	Wave: (GRU)	9455	Wave: (GSH)	21,470
(GRC)	2880	(GRV)	12,040	(GSI)	15,260
(GRD)	15,450	(GRW)	6150	(GSL)	6110
(GRF)	12,095	(GRX)	9690	(GSN)	11,820
(GRG)	11,680	(GRY)	9600	(GSO)	15,180
(GRH)	9825	(GSB)	9510	(GSP)	15,310
(GRJ)	7320	(GSC)	9580	(GSU)	7260
(GRM)	7120	(GSD)	11,750	(GSV)	17,810
(GRP)	17,870	(GSE)	11,860	(GSW)	7230
(GRS)	7065	(GSF)	15,140		

Time: Every hour except 10:00 and 21:00; on Saturdays only at 12:30 by (GSP). Signals are transmitted on groups of frequencies selected from the above list.

BBC VARIOUS SERVICES

In addition to the times listed under BBC OVERSEAS SERVICE, signals are transmitted from (GRN) on 6195 kc from 01:00 to 24:00, and on 583 kc from 05:00 to 22:00.

FOREIGN TIME SIGNALS

The following radio time signals are those most commonly used by stations in foreign countries.

International (ONOGO) System

This system was adopted at the Conference Internationale de l'Heure, 1912. It is better known as the ONOGO system because of the sequence of the Morse letters used in the time code. The transmission of the actual time signals lasts for three minutes. As transmitted by the majority of stations the signals proper are preceded by preparatory signals designating the respective stations.

The signal proper lasts three minutes and is sent as follows:

SIGNAL	TIMES (m. s. to m. s.)	DIAGRAM		
Series of X's sent every 5 seconds	57 00 to 57 49	—··—	—··—	etc.
Letter O	57 55 to 58 00	55—56	57—58	59—60
Letter N	58 08 to 58 10	08—09	.10	
Letter N	58 18 to 58 20	18—19	.20	
Letter N	58 28 to 58 30	28—29	.30	
Letter N	58 38 to 58 40	38—39	.40	
Letter N	58 48 to 58 50	48—49	.50	
Letter O	58 55 to 59 00	55—56	57—58	59—60
Letter G	59 06 to 59 10	06—07	08—09	.10
Letter G	59 16 to 59 20	16—17	18—19	.20
Letter G	59 26 to 59 30	26—27	28—29	.30
Letter G	59 36 to 59 40	36—37	38—39	.40
Letter G	59 46 to 59 50	46—47	48—49	.50
Letter O	59 55 to 00 00	55—56	57—58	59—60

In the transmission of the signals ONOGO, each dash (—) = 1 second, and each dot (.) = 0.25 second. The end of the final dash in the letter O (---) represents an even minute and is taken as the time signal.

New International System (Modified ONOGO)

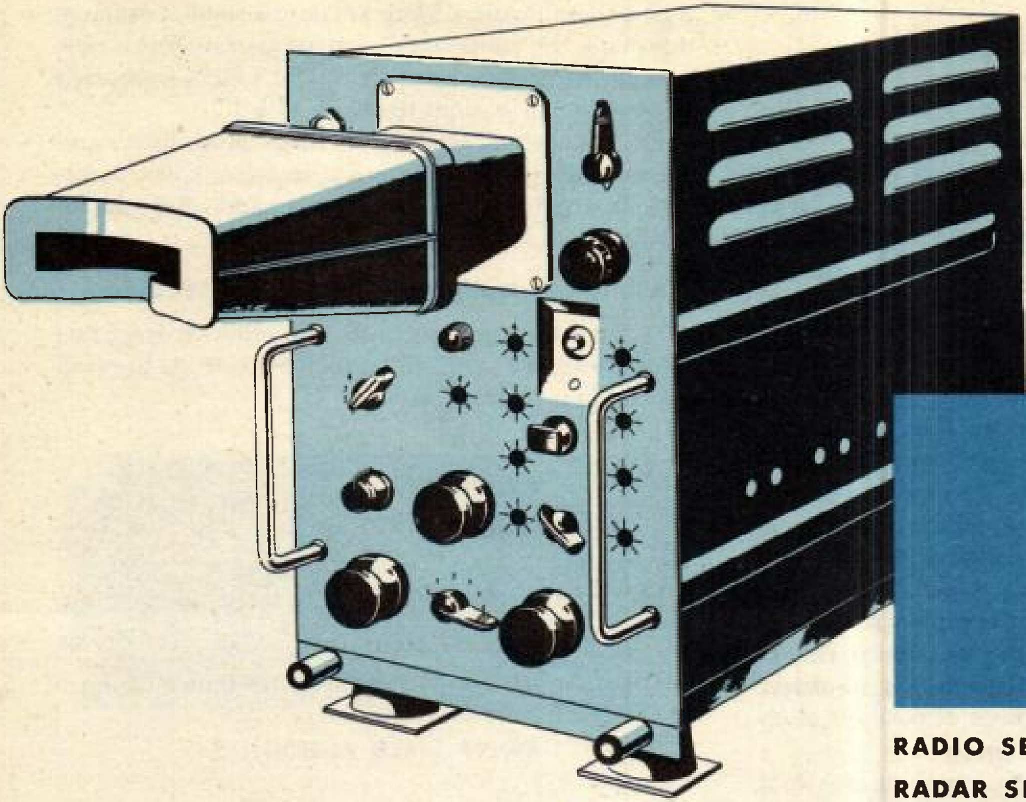
The International Time Commission, July, 1925, recommended that the International (ONOGO) System of radio time signals be amended, by the substitution of 6 dots (•) sent at the 55th, 56th, 57th, 58th, 59th, and 60th seconds of each minute, instead of the 3 one-second dashes that commence at the 55th, 57th, and 59th seconds of the last 3 minutes, and which constitute the time signals. Dots are easier to read than the beginnings and ends of dashes.

This merely means that dots replace the 3 dashes at the 58th, 59th, and 60th minutes.

Rhythmic System

This is the New International System of rhythmic wireless time signals.

From the 55th minute of the hour to the hour, a series of dots are transmitted, 60 dots per minute. At the end of each minute, there is a dash of 0.4 second duration. The beginnings of the dashes must be used, not their endings.



RADAR SET AN/APN-9

LORAN

RADIO SET AN/APN-4 AND RADAR SET AN/APN-9

Loran is long-range navigational equipment used to determine the exact geographic location of an airplane in flight. Radio signals consisting of short pulses are broadcast from pairs of special shore-based transmitting stations. The airborne Loran receiver intercepts these signals and its indicator measures the difference in their time of arrival, to an accuracy of two microseconds (millionth of a second). You refer this measured time difference to a Loran chart showing numbered lines of position. Cross two lines of position, determined from two pairs of transmitting stations, to obtain a fix.

Loran lines are fixed with respect to the surface of the earth.

Radio Set AN/APN-4 consists of Indicator ID-6/APN-4, Receiver R-9/APN-4, and Group A parts for installation. Total weight installed is approximately 70 pounds and power requirement is approximately 265 va.

Radar Set AN/APN-9 differs from Radio Set AN/APN-4 in these respects:

Both the indicator and receiver are in one container (Receiver-Indicator R-65/APN-9).

The sweep on the cathode ray tube is logarithmic rather than linear.

It has a three-inch cathode ray tube with a magnifying lens, instead of a five-inch tube, but the presentation is similar.

Total weight installed is approximately 35 pounds and power requirement is approximately 190 va.

Range

The maximum range using ground waves is obtained during the day over water, but is reduced at night when the atmospheric noise increases. Over land the range of the ground waves is greatly reduced at the surface. A slight increase is obtained at altitudes exceeding 3000 feet. You obtain no appreciable change in signal strength over the sea by increasing your altitude.

Accuracy

The accuracy of Loran positions is ordinarily greater than that obtained by celestial navigation. You can expect errors of less than one-half mile in favorable locations under good conditions. In unfavorable locations under poor conditions, errors range from five to 10 miles.

The accuracy of a Loran line of position depends on the following:

1. Synchronization of the transmitting stations.
2. Accuracy of matching and reading the signals

on the receiver-indicator.

3. Your position relative to the stations.

4. Accuracy of sky-wave corrections.

5. Sweep-speed calibration and station-selector calibration.

If the error of synchronization exceeds the tolerable limit, usually set at plus or minus 2 microseconds, one or both stations blink their signals. There are two types of blinking: The signals either go off and on, or they jump back and forth by 1000 microseconds every few seconds.

Cautions:

Do not attempt to read a signal that is blinking.

The accuracy of your readings of the receiver-indicator depends largely upon care and judgment.

The separation of Loran lines, which governs the accuracy of the system, is a function of distance and direction from the transmitting stations. The relative accuracy of Loran over the coverage area is apparent from the spacing of the lines on the charts.

The most favorable position, in seeking to obtain minimum separation between lines of position, is on the base line between transmitters.

When you take a reading by matching the first sky wave from each station of a pair, you must correct the reading to the equivalent ground-wave reading. Sky-wave corrections, in microseconds, are tabulated on the charts for each pair of stations, at points separated by whole degrees of latitude and longitude.

Identification

You identify station pairs by the radio-frequency channel and pulse-recurrence rate (PRR). A number of pairs of Loran stations operate on the same radio frequency, but each pair operates at a different PRR. You can select a particular pair of stations by switching to its PRR, which makes the indicator sweep-recurrence rate the same as that of the received signals.

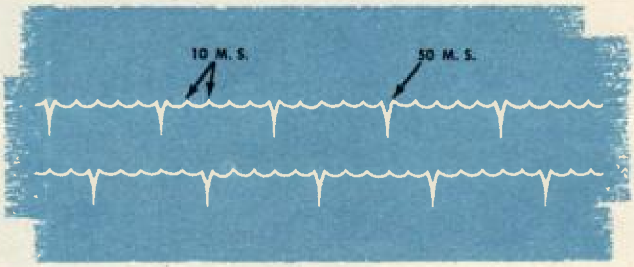
Loran receivers have four fixed, tuned channels; two basic pulse-recurrence rates (high and low); and a station-selector switch which selects the specific recurrence rate.

Each station pair has a three-character identification symbol by which you identify LOP's on your Loran chart. For example, 2L5-4039 indicates LOP 4039 (absolute time difference of 4039 microseconds), obtained from a pair of stations operating on channel 2 with basic recurrence rate L (low) and specific recurrence rate 5. By changing the specific recurrence rate you obtain another pair of stations and a new identification. They are on the same frequency and have the same basic recurrence rate but a new specific recurrence rate. Cross the LOP's from each of two pairs of stations to obtain a fix.

For operation, pulse-matching procedure, and measuring time difference, see Handbook of Operating Instructions, 08-30APN4-2, and AN 08-30-APN9-2.

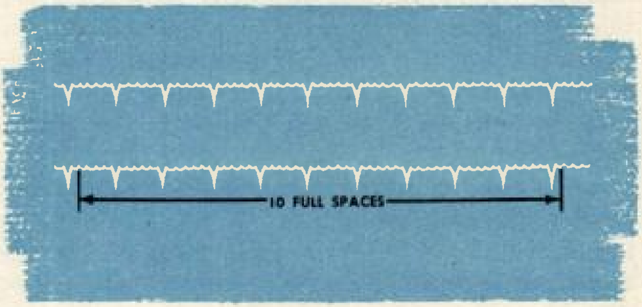
AN/APN-4 Operational Alignment Procedure

1. Turn the equipment on, and allow at least five minutes for the tubes and associated circuits to reach operating temperature.



SWEEP SPEED POSITION 5

2. Turn the STATION switch to 0 and the SWEEP SPEED switch to position 5. With a screwdriver, turn the screw marked A on the front panel of the indicator. It is adjusted when there are five 10-microsecond spaces between each pair of 50-microsecond markers. By turning screw A, you can reduce this number to four spaces or increase it to six spaces. Position the screw in the middle of the region within which the proper value remains unchanged on the trace.

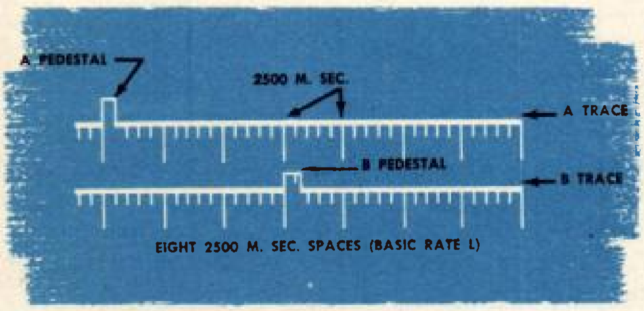


SWEEP SPEED POSITION 6

3. Turn the SWEEP SPEED switch to position 6. Turn the FINE control until two 500-microsecond markers are visible on the B (bottom) trace. With a screwdriver, adjust the screw marked B on the front panel of the indicator. It is adjusted when

there are ten 50-microsecond spaces between 500-microsecond markers. Position the screw in the middle of the region within which the proper value remains unchanged on the trace.

Note that the 50-microsecond markers do not coincide exactly with the 500-microsecond markers. This is normal and does not affect the reading of time difference. Count the incomplete 50-microsecond space at the left as a complete space.



SWEEP SPEED POSITION 7

4. Turn the SWEEP SPEED switch to position 7. With a screwdriver, adjust the screw marked C on the front panel of the indicator. It is adjusted when there are five 500-microsecond spaces between 2500-microsecond markers. Center the screw in the region where this condition remains unchanged.

5. With the SWEEP SPEED switch at position 7, adjust the screw marked D until you find the proper number of 2500-microsecond spaces. For basic rate L (25 per second), there should always be eight 2500-microsecond spaces. For basic rate H (33⅓ per second) there should be six 2500-microsecond spaces. Center the screw in the region within which the proper value remains unchanged on the trace.

6. Return the SWEEP SPEED switch successively through positions 7, 6, and 5, noting the appearance of the markers in each case. You may find it necessary to readjust the screws slightly to insure that each is in the middle of the range over which you found proper adjustment.

7. Return the SWEEP SPEED switch to position 7. Note the position of the A pedestal. The left-hand edge of the A pedestal should be directly on the first 2500-microsecond marker from the left-hand end of the A trace. If the A pedestal is not in this position, adjust the A delay screw on the right side of the indicator through the hole nearest the front panel. The position on the A pedestal rarely, if ever, requires adjustment in routine operation. Ordinarily this adjustment is made by the maintenance mechanic during bench tests of the equipment.

8. Turn the SWEEP SPEED switch to position 6. Turn the COARSE and FINE controls to the left index marks. Adjust the screw marked ADJ. 200 until four 50-microsecond spaces appear between the first 500-microsecond marker on the B trace and the first 500-microsecond marker on the A trace.

9. Turn the FINE control to its right index mark. This should add 500-microseconds. Adjust the screw marked ADJ. 700 until four 50-microsecond spaces appear between a 500-microsecond marker on the B trace and the 500-microsecond marker to its right on the A trace.

10. Turn SWEEP SPEED switch to position 7. Turn the COARSE and FINE controls to the left index marks. Adjust the screw marked ADJ. 0 until the B pedestal is under and slightly to the right of the A pedestal.

11. Turn the COARSE control to the right index mark. Turn the screw ADJ. 10,000 until the left edge of the B pedestal is slightly more than 10,000 microseconds to the right of the left edge of the A pedestal.

There is a considerable interlocking between ADJ. 0 and ADJ. 10,000, as well as between ADJ. 200 and ADJ. 700. You will probably have to repeat the adjustment successively in each pair to obtain the final settings.

Summary: Steps 8, 9, and 10 are made merely to assure that the COARSE and FINE controls have their proper ranges of adjustment. Improper setting of these controls does not affect the accuracy of reading, but may affect the ability of the equipment to match pulses when the time differences are at the extremes of the range of measurement.

12. Then check the settings of the STATION switch. This is an important step, because improper setting of this control may result in mistaking the specific rate of a particular pair of stations, with consequent error in plotting the corresponding line of position. Set SWEEP SPEED switch to position 8. Set the STATION switch to position 0. A pattern of dots appears on the face of the scope.

13. Turn the STATION switch to position 1. One dot in one of the vertical columns of dots disappears. This dot is the second dot from the bottom in that particular vertical column. If this dot does not disappear or if two dots disappear, turn screw marked E until just one dot disappears. Leave the screw in the center of the range within which this condition remains on the trace.

Note that you can move the position of the column of dots by turning the COARSE control. Center the significant column on the face of the scope.

14. Turn the STATION switch to position 2. Adjust screw marked F until a second dot disappears just above space vacated by the spot in step 13. Leave the screw in the center of the range within which this condition remains unchanged on the trace.

15. Repeat the same procedure with the STATION switch successively in positions 3, 4, 5, 6, and 7. The dot pattern respectively should show rows 3, 4, 5, 6, and 7 missing. On STATION switch 7 one dot remains at the bottom of the column and two dots at the top.

16. Then return the STATION switch through all positions (0 through 7) and observe the dot pattern to be sure that the proper number of dots is omitted in each case.

See T. O. 08-30APN4-2.

RADAR SET AN/APN-9

You must become thoroughly familiar with the counter indications so that you will notice any deviations while the set is operating. Operating results are correct only if the counter and station rates are adjusted correctly. If you cannot synchronize them, results are too inaccurate to use.

Check the counter and station rates as follows:

1. Turn the FUNCTION switch to position 4.
2. Turn the PRR switch to position H.
3. Count three 5000-microsecond intervals between the extreme right and left ends of the trace.
4. Count five 1000-microsecond intervals between the 5000-microsecond markers.
5. Turn the PRR switch to position L.
6. Count four 5000-microsecond intervals between the extreme right and left ends of the trace.
7. Count five 1000-microsecond intervals between the 5000-microsecond markers.
8. Turn the FUNCTION switch to position 5.
9. Count five 10-microsecond intervals between the 50-microsecond markers on the lower trace.
10. Count two 50-microsecond intervals between the 100-microsecond markers on the upper trace.
11. Count five 100-microsecond intervals between the 500-microsecond markers on the upper trace.
12. Count two 500-microsecond intervals between the 1000-microsecond markers on the upper trace.
13. Observe the STATION rate markers on the lower trace. Set the STATION switch at 0 and count the number of 50-microsecond intervals between the crosshair and the first STATION rate marker. Repeat this operation for STATION rate settings 1 through 7. The count must agree with the table below:

STATION SWITCH SETTING	50-MICROSECOND INTERVALS
0	8
1	7
2	6
3	5
4	4
5	3
6	2
7	1

14. With the STATION switch set at position 4, move the RIGHT-LEFT switch to RIGHT and count the two 50-microsecond intervals between the crosshair and the first STATION rate marker.
15. Repeat the last two steps with the PRR switch set at H and L positions.

You can make adjustments in flight if these indications show a faulty count or station rate adjustment. Procedure is outlined in Section IV, paragraph 2, of AN08-30APN9-2, Handbook of Operating Instructions.

The set should be realigned in a maintenance shop as soon as possible after any adjustments have been made.

Special Uses of Loran

Homing or following a particular LOP is a technique especially adaptable to Loran:

1. Select from your charts a Loran line which passes through your objective.
2. Determine its reading and station pair.
3. Set up reading and station pair characteristics (channel, basic, and specific recurrence rates).
4. Set a course to cross this line, and when the pulses appear matched on the indicator you have crossed the desired LOP.
5. Change heading to keep the pulses superimposed. This holds you on a course along the desired LOP. Take fixes by readings from another pair of stations, until you reach your objective.

Another application is SS (sky-wave synchronization) Loran, wherein you maintain synchronization between the ground stations by sky waves and extend the distance between transmitting stations. Operation of SS Loran is restricted to night flights, when you can obtain sky waves consistently. SS Loran gives increased range and coverage and you can arrange the stations to give larger angles of crossing for LOP's.

SECTION 3

CELESTIAL

REMEMBER—THE PROPER EXECUTION OF CELESTIAL NAVIGATION DEPENDS MORE UPON THE SKILL OF THE NAVIGATOR THAN ANY OTHER FORM OF NAVIGATION.

MOTIONS OF HEAVENLY BODIES

Solar System

The whole solar system is moving through space as a unit. While this motion is rapid as compared with the individual motions of the earth and other planets, it is slow in relation to the great distance from the solar system to the stars.

Although the stars have motion in relation to each other, they are at such great distances from the earth that their movement is imperceptible and their positions are considered fixed.

The Sun

The sun is a star whose axis revolves in a small orbit only 280 miles in diameter. This is an insignificant distance when compared with the distance of the planets from the sun, and the sun is considered fixed in relation to the earth and the other members of the solar system.

The Planets

The planets, of which the earth is one, rotate on their own axes and revolve around the sun.

The orbits of all planets lie nearly in the same plane, the maximum inclination being about 23°. The earth has a rotation from west to east on its polar axis once each day. The earth also revolves in a counter-clockwise direction (as viewed from the north) in an elliptical orbit around the sun.

The plane of the earth's equator is inclined at an angle of 23° 27′ to the plane of the earth's orbit. This inclination of the earth's axis causes the four seasons of the year.

The other planets are divided into the two general classifications of superior and inferior planets. The inferior planets are so named because their orbits are closer to the sun than that of the earth. Those farther away are called superior planets.

The Moon

Of the satellites which revolve around the planets, the only one of interest to navigators is the moon, which revolves around the earth. It is the only heavenly body relatively near the earth (average distance 239,000 miles). It gives no light except the reflection of the sun's rays. The moon in its orbit around the earth moves to the eastward and therefore moves in opposition to the rotation of the earth. Thus it is that the moon rises approximately an hour later on each succeeding night.

CELESTIAL DEFINITIONS

CELESTIAL AIR NAVIGATION IS THE ART OF DETERMINING THE POSITION OF YOUR AIRPLANE BY THE AID OF CELESTIAL BODIES

The zenith (Z) of an observer on the earth's surface is the point on the celestial sphere directly overhead. **The nadir** is the point on the celestial sphere directly beneath the observer.

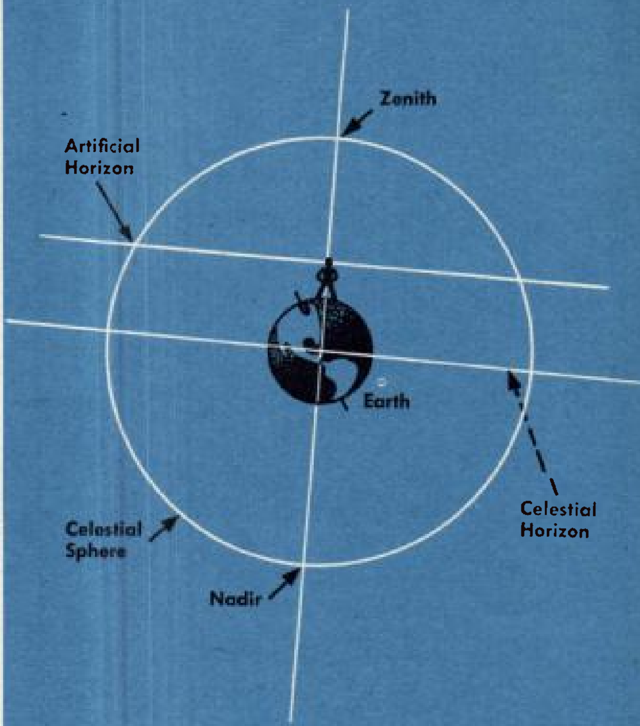
The celestial horizon is the great circle of the celestial sphere formed by passing a plane through the center of the earth perpendicular to the straight line joining the zenith and nadir. The celestial horizon is different from the **visible horizon,** which appears to mark the intersection of the earth and sky. The difference between the celestial and the visible horizon arises from two causes:

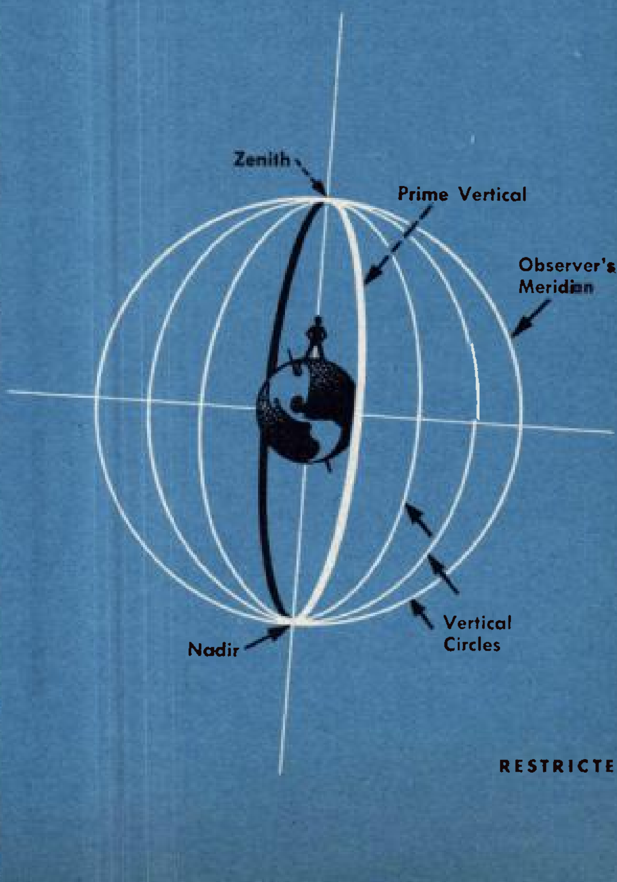
a. Your eye is always elevated above sea level. This gives you a range of vision exceeding 90° from your zenith. This range of vision exceeding 90° is called dip of the horizon.

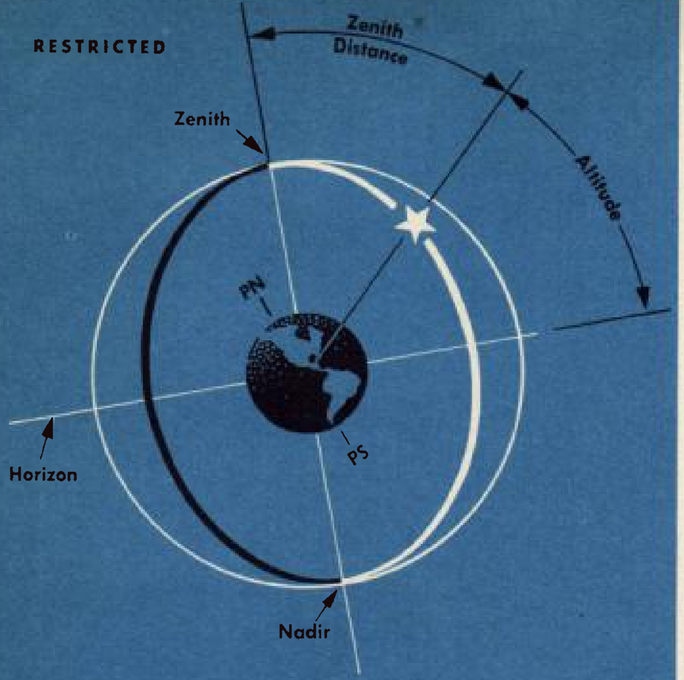
b. Your actual position is on the surface of the earth instead of at its center where the celestial horizon passes through the earth. This difference in horizon is called parallax.

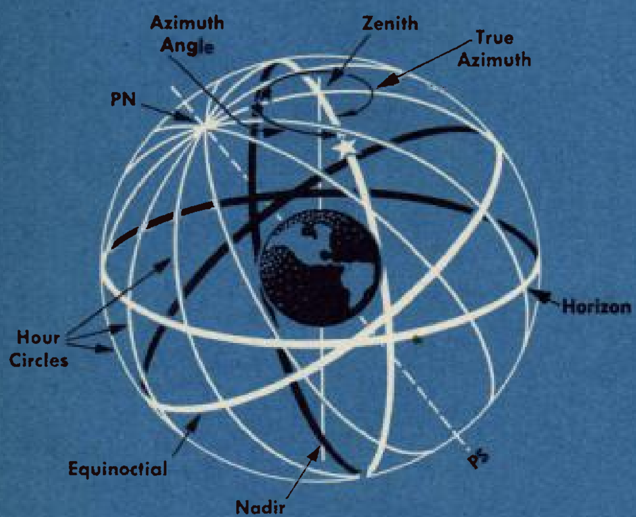
An artificial horizon is the true celestial horizon determined by some mechanical device such as the bubble in your sextant. This is the horizon used in aerial navigation because the visible horizon is of no value to you. The artificial horizon is always assumed unless otherwise qualified.

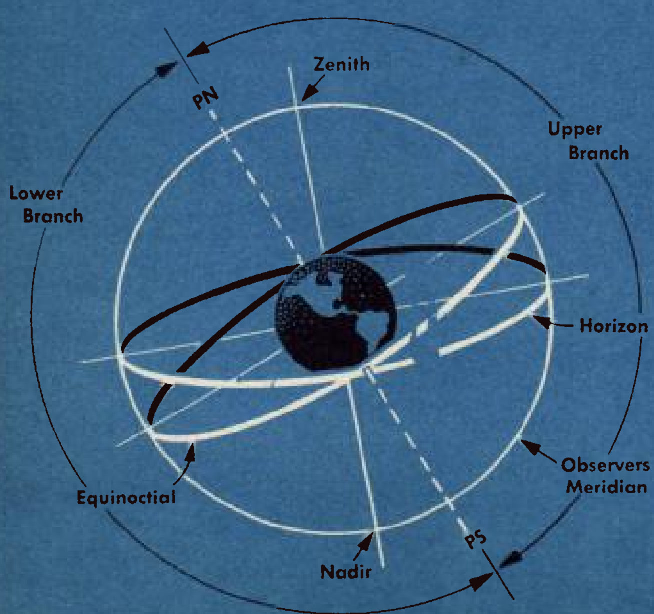
Vertical circles are great circles of the celestial sphere which pass through the zenith and the nadir. Your **prime vertical** is the vertical circle whose plane is at right angles to the plane of the meridian on which you stand.











The altitude (H) of any point on the celestial sphere is its distance above the horizon, measured upon the vertical circle passing through the point in degrees of arc. When you calculate the altitude of a body as it appears from a point of known latitude and longitude by any one of the several trigonometric methods available, call it the computed altitude, (Hc). When you measure the altitude of a body with a sextant, name the reading of the vernier scale as the sextant altitude, (Hs). When you correct the sextant altitude (Hs) for all errors of observation you get the true observed altitude, (Ho).

The zenith distance of any point is its distance from the zenith, measured in degrees of arc upon the vertical circle passing through the point. The zenith distance of any point that is above the horizon is therefore equal to 90° minus the altitude.

The azimuth of any point on the celestial sphere is the angle at your zenith between your meridian and the vertical circle through the point. Express the angle in degrees of arc. Measure it from either the north or south, to the east or west, to either 90° or 180°. Name it accordingly; N 50° E, or S 130° E. For convenience in plotting, if you are in the Northern Hemisphere measure the azimuth from the north to the right (clockwise) from 0° to 360°. Abbreviate this azimuth as Zn and do not precede it or follow it by directional abbreviations.

The equinoctial or **celestial equator** is the great circle formed by extending the plane of the earth's equator until it intersects the celestial sphere.

The celestial poles are the two points where the extended polar axis of the earth intersects the celestial sphere. Name the elevated pole the same as your latitude upon the earth.

Hour circles or **celestial meridians** are great circles of the celestial sphere passing through the poles. Form them by extending the planes of the respective terrestrial meridians until they intersect the celestial sphere. Meridians and hour circles are identical. The hour circle containing the zenith is the **celestial meridian of the observer,** or your meridian.

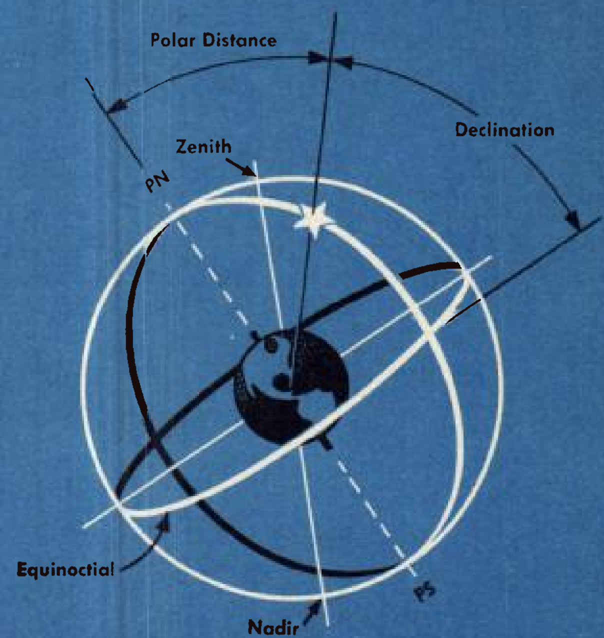
The upper branch of the celestial meridian is that half which lies on the same side of the poles as your zenith. The lower branch is the opposite half.

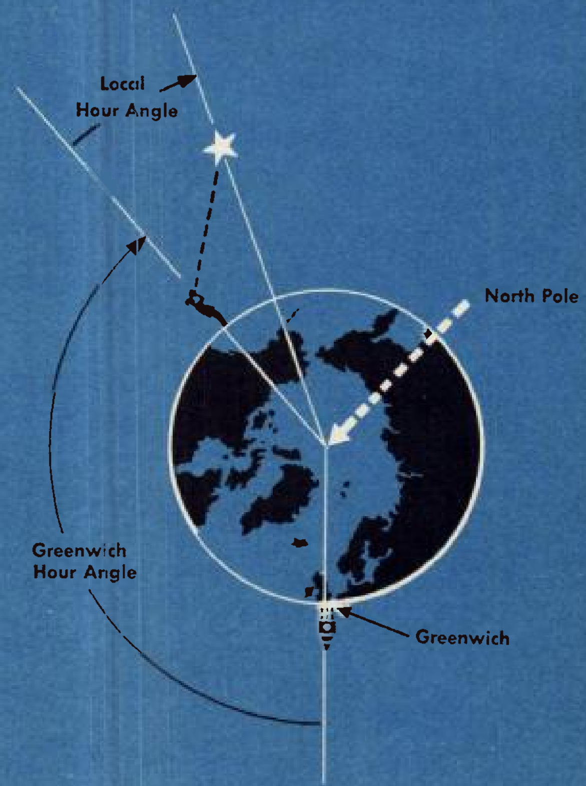
The declination of any point on the celestial sphere is its angular distance from the celestial equator measured on the hour circle which passes through that point. Designate it as north or south according to the direction of the point from the celestial equator. You can designate north declinations by a plus sign and south declinations by a minus sign; however, it is better practice to label declinations with the prefixes N or S, because the plus and minus signs are not meant to signify that N declination is always additive and S declination subtractive. Declination upon the celestial sphere corresponds with latitude upon the earth. By observing a celestial body at the instant it crosses your meridian you can determine your latitude. See Meridian Altitudes.

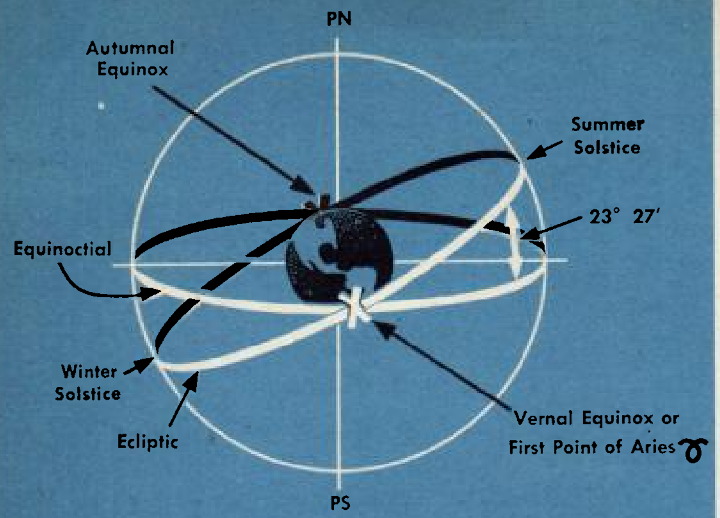
The polar distance of any point is its distance from the pole, measured upon the hour circle passing through the point in degrees of arc. It is equal to 90° minus declination, if you measure it from the pole of the same name as declination, or 90° plus the declination, if measured from the pole of opposite name. You can also refer to it as co-declination as it is equal to 90° minus declination.

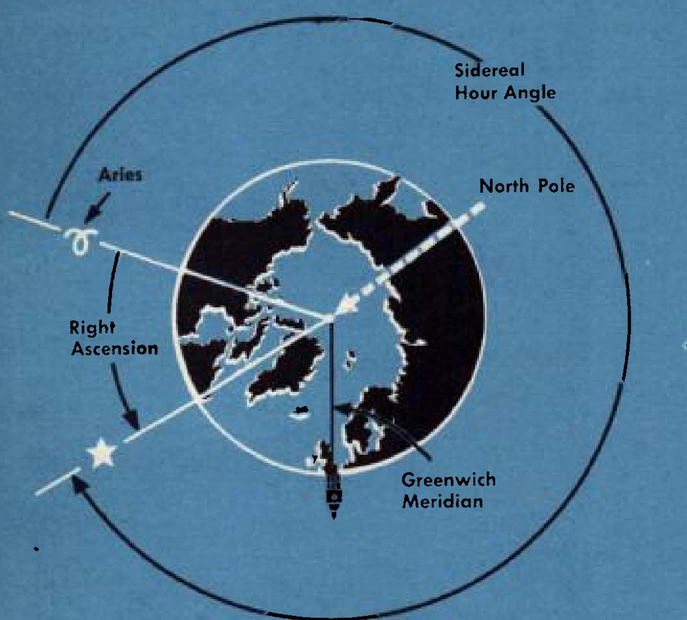
The local hour angle (LHA) of any point is that angle at the pole between the meridian of the observer (your meridian) and the hour circle passing through the point. Always measure it to the east or west from 0° to 180°. The principal exception to the 180° east or west method of measuring local hour angle is when you define the local hour angle of the vernal equinox. In this case measure the LHA from your meridian toward the west as a positive direction to 360°. The use of the Air Almanac has made it unnecessary for you to express hour angle in units of time. The local hour angle of a celestial body is merely the difference in longitude between your position and the celestial meridian through the body.

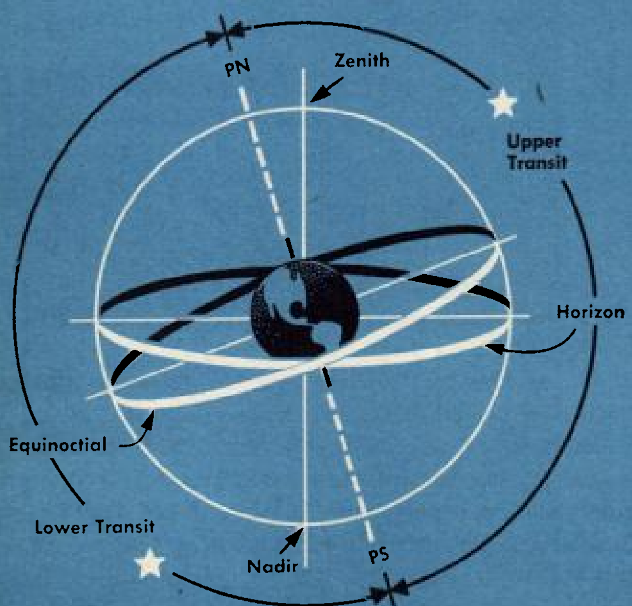
The Greenwich hour angle (GHA) of a heavenly body is the angle at the pole between the meridian of Greenwich and the hour circle of the body. Always measure it from the meridian of Greenwich to the west through 360°.











The ecliptic is the great circle representing the path in which the sun appears to move by reason of the annual revolution of the earth. The plane of the ecliptic is inclined to the plane of the celestial equator at an angle of about 23° 27′.

The equinoxes are the two points where the ecliptic intersects the celestial equator. The point where the sun appears to pass from southern to northern declination is called the **vernal equinox** or **the first point of Aries,** and designated by the sign of the ram's horn. Use the hour circle through the vernal equinox as the origin for locating stars on the celestial sphere, just as you use the meridian through Greenwich as the origin of longitude on the earth. The other point is called **autumnal equinox** and it is on the other side of the earth from the vernal equinox. The vernal equinox is a definite point in the heavens, even though it is not visible.

The solstices are points on the ecliptic at a distance of 90° or 6 hours from the equinoxes. In the Northern Hemisphere the **summer solstice** is the point where the sun appears to be at its greatest distance north of the equator, when the period of daylight is the longest. The **winter solstice** is the point where the sun appears to be farthest south of the equator, when the period of daylight is the shortest.

The right ascension (RA) of any point on the celestial sphere is the angle at the pole between the hour circle passing through the vernal equinox, and the hour circle through the point. It is measured from the hour circle of the vernal equinox eastward as a positive direction, from 0 hours to 24 hours. Always measure right ascension in hours and minutes and never in degrees of arc.

The sidereal hour angle (SHA) of any point on the celestial sphere is the angle at the pole between the hour circle passing through the point and the hour circle passing through the vernal equinox. Measure sidereal hour angle from the hour circle of the vernal equinox westward, from 0° to 360°. Sidereal hour angle is expressed in degrees whereas right ascension is expressed in units of time.

The instant at which any point of the celestial sphere is on your meridian is the time of **transit, culmination,** or **meridian passage** of that point. When the passage is over the half of the meridian which contains your zenith, it is in upper transit; when over the half containing the nadir, it is in lower transit. By observing a body as it passes over your meridian you can obtain your latitude.

ERRORS IN OBSERVATIONS

Errors

Learn how to compensate for all known causes of error. Remember, sextants are delicate and accurate optical instruments, and must be protected.

Never touch the index glass with your fingers or let any object strike it. Touching the glass leaves a film which makes it harder to see the bubble and celestial body while taking observations.

When making sextant observations in the air, you must take into account the following errors:

Sextant Error

There is an error in the instrument which is due to faulty adjustment of the bubble or the index prism. When you have found the error (see NIF 3-3-2), either apply it in reverse to the Hs (sextant altitude), or remove it by zeroing the sextant.

Atmospheric Refraction

This error in the observation is due to the light ray being bent toward the vertical by the earth's atmosphere. It is always a subtractive correction. This correction has been taken care of in the solutions by HO 218, Star Altitude Curves and Astrograph, for flight level of 5,000 feet. If the flight level differs greatly from 5,000 feet, or, if using one of the other solution forms to obtain the Hc, you must apply the correction for refraction to the Hs, using the tables at the back of the Air Almanac.

Dome Refraction

This is an error in observation introduced by shooting through a glass dome. This error usually increases with altitude, from about 0 to 10 minutes. To determine the error for your airplane:

1. Determine the sextant error accurately.
2. Shoot a series of observations through the glass dome. Use a range of altitudes.
3. Plot these shots against a computed curve in which refraction and sextant corrections have been applied in reverse.
4. The difference of altitude between your shots and the curve is the dome refraction. Make a critical table of the corrections similar to:

Hs	Correction
20°	
	-3′
25°	
	-4′
35°	
	-5′
50°	
	-6′
65°	
	-7′
80°	

Parallax

This error is introduced by assuming that you are at the center of the earth instead of at the earth's surface. This error is negligible except for observations of the moon. The parallax correction, which is always added to the Hs in observations of the moon, is determined from the tables in the Air Almanac.

Acceleration Error

This is an error in observation caused by the airplane movement which deflects the bubble so that it does not indicate true vertical. You can minimize this error by following these suggestions:

1. Notify the pilot when you are about to start shooting so he will hold the airplane steady.
2. Start shooting on an even minute and continue shooting for two minutes to average out acceleration errors which are due to the motion of the ship.
3. Use bubble about twice as big as the sun. A small bubble is sluggish and gives poor results.

CORRECTION FOR CORIOLIS ACCELERATION

LAT.	GROUNDSPEED						
	100	150	200	250	300	350	400
0	0	0	0	0	0	0	0
10	0.4	0.7	0.9	1.1	1.4	1.6	1.8
20	0.9	1.3	1.8	2.2	2.7	3.2	3.6
30	1.3	2.0	2.6	3.3	3.9	4.6	5.3
40	1.7	2.5	3.4	4.2	5.1	5.9	6.8
50	2.0	3.0	4.0	5.0	6.0	7.1	8.1
60	2.3	3.4	4.6	5.7	6.8	8.0	9.1
70	2.5	3.7	4.9	6.2	7.4	8.7	9.9
75	2.5	3.8	5.1	6.4	7.6	8.9	10.17

Coriolis Force

This error in observation is due to the rotation of the earth. This error increases with latitude and speed of the plane. Take care to determine whether the correction is enough to warrant the additional computation. Remember, the correction is at a maximum on beam shots.

Translate all lines right in Northern Hemisphere, left in Southern Hemisphere, perpendicular to track. Correction is in statute miles if your groundspeed is in statute miles, nautical miles if your groundspeed is in nautical miles.

Note explanation of "Z Correction for Bubble Sextant" which is combined with wander of the airplane caused by gyro precession. This correction is found in the rear of the Air Almanac.

You can overcome personal error only by constant, persistent practice.

Checking Sextant Error

Sextant error is the difference between what the sextant reads and what it should read if the instrument were in perfect adjustment.

1. The simplest and most accurate method of determining the sextant error is by using the collimator. Merely collimate the crosshairs or the star in the collimator with the bubble in the sextant and read the scale. If the scale reads above zero, the error is plus; if below zero the error is minus. Make certain that the collimator is level before checking the sextant.

2. If near a large body of water, you can use the natural sea horizon as a reference. Set the sextant on a stand, table, or place it in a clamp. Determine the height of the instrument above the water level. Split the bubble with the sea horizon. Apply dip correction to the sextant reading (you can find the amount of the dip correction from the back of the Air Almanac, but you must add it, not subtract it). The difference between the corrected sextant reading and zero is the sextant error.

3. If you know the altitude of the natural land horizon (determine it by means of a surveyor's transit or a sextant of known error) you can check the sextant on it. The sextant error is the difference between the sextant reading and the correct altitude of the horizon.

4. Construct a curve of the altitude of a celestial body. Plot Hc plus refraction, and minus parallax when shooting the moon. Compare with the sextant altitudes to obtain the sextant error. This method permits checking the error of the sextant at the altitudes which are most generally used.

5. If you set up a light or a pole at the same height as the sextant, 1,000 or more feet away, by means of a surveyor's transit or by a sextant with a known error, you can find the sextant error.

Remove the Error

After you have determined the sextant error you can remove it partially or completely by the methods described for each type of sextant. You should check the error frequently as it will change from time to time. Apply the sextant error mathematically in reverse to the Hs, if it is impractical to remove it. This is known as sextant correction.

It is a good idea to determine the altitude of some distant point from a place near the operations building and check your sextant just before takeoff.

Place a card with sextant number and error, date of check, and your name and rank in sextant case.

AIRCRAFT SEXTANTS

Know your sextant. The success of a vital mission, the lives of your fellow crew members, and the safety of your airplane are all dependent upon the accuracy of your calculations. They, in turn, depend upon the accuracy of your instruments and the skill with which you use them.

Tips

Always remove batteries from the sextant container as soon as your mission is completed. Corroding batteries ruin the rheostat and vernier-light battery case.

Keep the index mirror clean and free from greasy fingerprints. If the mirror does get dirty, clean it with lens paper or a well-washed handkerchief.

Severe changes of temperature may cause the index mirror to crack or break. Don't leave the instrument near a heating tube and then use it in a cold turret.

When you open the sextant case after a quick drop in temperature, moisture condenses on the sextant mirrors. To combat this, open the sextant case before you climb to a high altitude.

Batteries do not work well in extreme cold, so keep spares in a warm place, such as the pocket of your jacket, and replace them as often as necessary.

Always carry spare parts such as bulbs, batteries, and pencil leads in your sextant case.

Use a collimator tube, a precomputed curve, or a natural sea horizon to determine the amount of index error in your sextant. **Do not attempt to remove the error.** Note it and correct all subsequent observations by this amount. For any adjustments to your sextant consult an instrument specialist.

If your sextant requires the use of recording discs, be sure to keep them away from the heating tube of your airplane. If the case becomes hot, the wax on the discs melts and the whole supply sticks together.

If your sextant has a vapor bubble, be sure to release the bubble from the chamber during ascents, descents, and when you put the sextant away.

A-12 SEXTANT

Operation

There are two methods of using the sextant:

1. When you observe the sun, use the eyepiece and sunshades. You then are observing it indirectly, because the index glass reflects it to your eye.

2. When you observe the stars, use the direct method of sighting. This simplifies star finding and lessens the chance of observing the wrong star.

Median (Average) Sights

Take a series of shots, pressing the marking lever each time the body appears in proper position relative to the bubble. Take these shots only a few seconds apart.

It is good practice to observe a body for a period of one or two minutes in order to obtain the average time of the observation more readily.

Obtain the median reading in this manner:

1. If your shots are evenly spaced, use the middle mark on the rim of the drum. Rotate the drum until this mark is under the marking pencil. Then read the scale.

2. If your shots are not evenly spaced, rotate the drum until the visual average seems to be under the marking pencil. Your ability to estimate the correct median improves with practice.

Bubble

This sextant has a fixed bubble. The bubble assembly includes a bubble housing, two lenses with seals and locking rings, a filler hole, and xylene bubble fluid.

Optics

The index mirror is clear glass and optically flat. A clamp secures it on the same shaft that carries the sextant arm. With proper adjustment there is no lost motion between the arm and this mirror.

The lens tube assembly transmits the image of the bubble downward vertically from the bubble assembly and then up at an angle to the index mirror and your view.

The real field of the sextant is approximately 12°. See T.O. 05-35-15.

A-7 SEXTANT

Hold the instrument in both hands. Your right hand operates the micrometer drum while your left, besides furnishing additional support, operates the shade glass holder and the astigmatizer knob. When you use the artificial horizon, move the horizon shutter knob to its extreme position in the direction opposite that of the arrow. This keeps any direct horizontal light from entering the telescope.

Operation

1. Before taking a reading with this sextant, be sure to set the ratchet of the averaging device at 0 and adjust the pencil properly to give fine legible lines.
2. Sight through the instrument and bring the image of the celestial body into horizontal coincidence with the bubble.
3. To record the observation, press the trigger by moving your right thumb backwards without taking that hand off the sextant.
4. Repeat this procedure, without re-setting the ratchet, until you have recorded the desired number of observations.
5. Note the number in the ratchet and select the middle reading.
6. Having determined the middle reading, locate its pencil mark on the micrometer drum cover.
7. Align the pencil mark of the average reading with the end of the pencil.
8. Note the reading on the worm scale dial and micrometer drum scale. This quantity is the average angular altitude determined by the observations. The time of the observation is the median time between the start and finish of your observation.

Bubble

The bubble assembly which forms the artificial horizon consists of a field lens, bubble chamber, bottom glass, and diaphragm chamber with cap. A vapor bubble forms in the bubble chamber which, together with the diaphragm chamber, is filled with xylene. The bubble is formed and controlled in size by the deflection of a flexible diaphragm, which forms a wall of the chamber on the side of the bubble assembly. Control the deflection by turning the nut on the diaphragm cover. Radioactive luminous material, painted on a metal ring surrounding the bubble, amply illuminates it.

Before you put the sextant away in its carrying case, return the bubble control knob to neutral, loose on the shaft.

Optics

The instrument optics is so designed that the matching of the bubble's image with that of the body does not have to take place in the middle of the field. It is best to use the astigmatizer for accurate work because the way it flattens the image makes it easier for you to estimate the center of the bubble.

The real field of the sextant is approximately 12°.

See T.O. 05-35-4 for additional instructions on operation and care of this sextant.

A-8A SEXTANT

Operation

You can use this sextant for direct or indirect sighting.

1. Before you take any readings you must set the averaging device in the zero position. Do this by turning the vernier disc as far clockwise as possible. Then use the sextant in the usual manner.
2. As soon as you have taken a shot, place your right index finger in the concave portion of the handle and push it as far counter-clockwise as possible. Then return the handle to its original position. This operation moves the vernier disc counter-clockwise an amount equal to one-eighth of the total recording.
3. Repeat this procedure until you have taken a total of eight shots.
4. Then read the counter disc and vernier disc to obtain the average of these eight settings in degrees and minutes.

The average time is the time of the average altitude reading.

If the 0 line of the vernier disc points between two lines of the counter disc, read the lower of the two as the number of degrees. Add to this the reading of the vernier disc, expressed in minutes of arc.

In reading the vernier, follow the vernier disc counter-clockwise until a line of the counter disc appears to be a continuation of a degree line. The number of divisions in the vernier disc from 0 to the point where the lines coincide is the number of minutes you add to the scale reading.

A pencil averaging device is now available. To have your sextant modified, send it to any one of the following service commands:

Fairfield Air Service Command,
Oklahoma City Air Service Command, or
Sacramento Air Service Command.

Bubble

Use the dark field illumination of the bubble at night. This makes the bubble appear as a bright ring in a dark background. You can regulate the brightness of the bubble with the rheostat.

You can see directly through the center of the bubble to sight a heavenly body.

Optics

The focal length of the eye lens is equal to that of the objective lens.

The real field of the sextant is 9°.

See T.O. AN 05-35-7.

A-10 SEXTANT

Operation

Hold the sextant by its frame in the palm and fingers of your right hand. The control knob, which elevates the field prism, is down. Use your left hand to operate the control knob or to adjust the size of the bubble.

To register a line on the recording disc, move the plunger of the marker with your right forefinger.

The middle value of several readings in a series is the average of your observation. To obtain this reading, align the middle line of any group of readings with the index. Then read the counter to obtain this value in degrees and minutes.

If your observations are equally spaced, take a direct average. If they are not equally spaced, devise your own method of averaging them.

Bubble

Only the bubble itself is illuminated. This makes it easier for you to observe dim stars.

If the bubble disappears you can easily re-form it in this way:

1. Turn the sextant until the bubble-size knob faces downward.
2. Turn the bubble-size knob to its maximum INCREASE position, as indicated on the engraved diaphragm housing. Be careful not to force the knob past the limits of this position.
3. If the bubble is not visible, it may be formed in the diaphragm. Turn the knob to near its minimum position.
4. Hold the sextant firmly and snap your arm forward quickly, in order to release the bubble from the diaphragm housing.
5. An alternate method is to hold the sextant with the bubble chamber away from you and whip the sextant downward sharply.

Turn the bubble to maximum size when you put the sextant back in its case.

Optics

The auxiliary telescope and the eyeguard at the glass chamber housing are interchangeable. When you use the telescope you get a two-power magnification and your field is reduced approximately one-half.

The real field is approximately 14°.

The scales are illuminated. Replacement lights are provided, but in an emergency you can use the lamps out of the B-3 driftmeter, radio compass, or some other aircraft instrument.

See T.O. AN 05-35-12.

A-10A SEXTANT

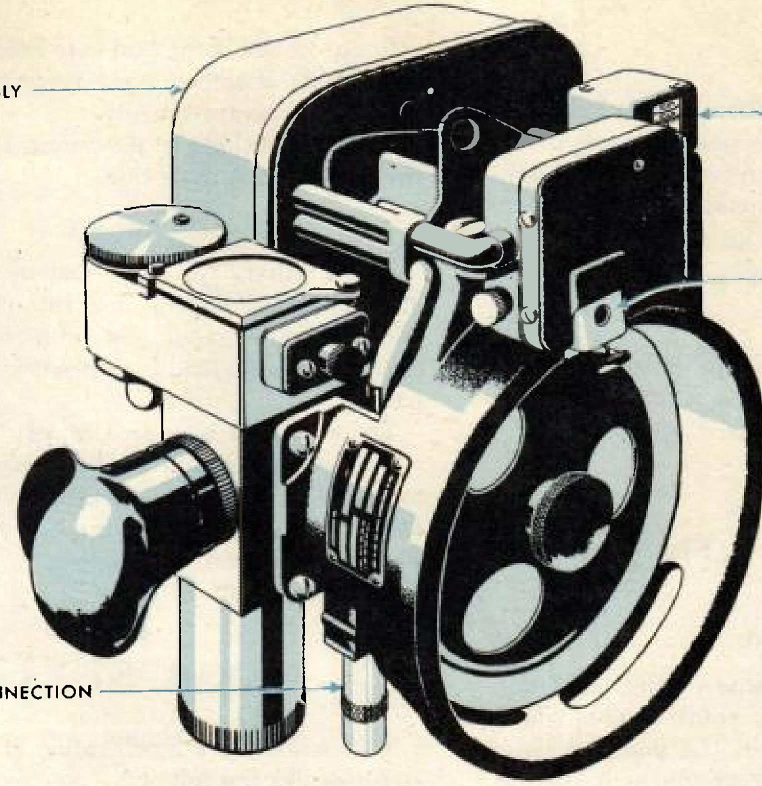
This sextant is a modification of the A-10 sextant and includes the following new features:

1. An automatic marking device operated by a solenoid timing mechanism, which makes a mark on a plastic disc. You can operate the marker manually if the timing mechanism fails.
2. An air-reservoir bubble chamber which permits the bubble to form more easily and produces a bubble which is less affected by temperature changes than the previous vapor-type bubbles.
3. An improved lighting system for the marking disc and counters.
4. A 3-cell battery case which operates the electric timing mechanism and the lighting system.
5. The rheostat which controls bubble illumination is on the sextant instead of on the battery case.

Operation

You must use the battery case to operate this sextant, both day and night. The batteries provide power for a small electric clock in the housing on the left side of the sextant. Approximately once every second, so long as you press the trigger above the marking disc, this clock energizes a circuit which actuates the solenoid marker on the right side of the sextant.

Shake the sextant lightly to make sure that the clock has started; it does not always start when the battery case is connected. As soon as you complete your observations, disconnect the batteries to preserve them.



A-10A SEXTANT

Determine the number of impulses of the marking mechanism per minute. Normally this number does not vary greatly even with extreme changes in temperature. Once you know it, you need only to count the clicks of the solenoid to time an observation.

In the air it may not be possible to hear the click of the marking device, but by resting your right index finger lightly over the marker you can feel its movement and count the number of impulses. At night the bubble light blinks at each impulse and you can use this means of counting them.

The marking device requires careful adjustment of the pencil lead so that there is sufficient clearance between the lead and the disc at the beginning of the stroke to allow the solenoid to gain momentum before the lead strikes the disc. If this adjustment is too close the lead doesn't slide over the disc and, consequently, won't make a mark. If the pencil lead is too far from the disc the mark made is too short. If you adjust it correctly, the lead should last for the entire flight.

You can operate the marking device manually by pressing the flat side of the marker with your right index finger.

General

1. After looking at your hack watch at the start you can time your observation accurately by counting the aural or visual impulses of the marker.

2. You can concentrate on maintaining collimation with the body without having consciously to space your observations at even intervals.

3. The automatic marker makes more uniform marks and eliminates movement of the sextant which occurs when you operate the marker button manually.

Bubble

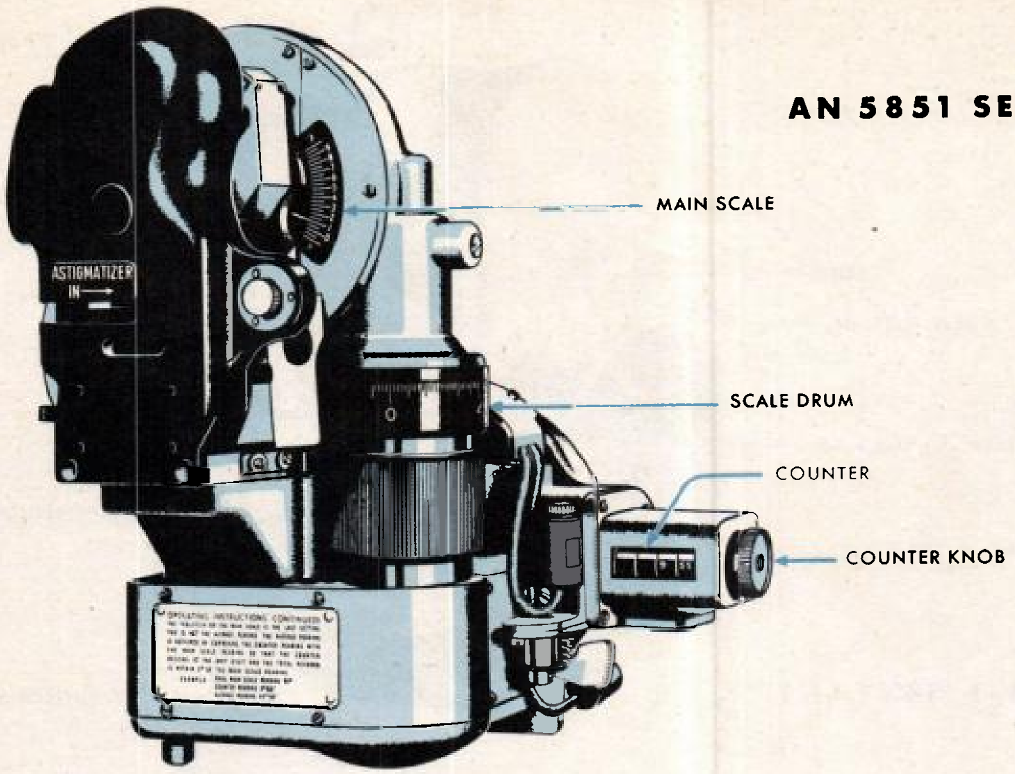
The new bubble consists of a double chamber with a large air reservoir. Change bubble size by transferring air from one chamber to the other. The bubble never disappears except through deliberate operation of the diaphragm.

A large change in temperature produces practically no change in bubble size because the reservoir acts as a buffer. If you can't change the bubble size as you wish by rotating the diaphragm control to its extreme limit, level the sextant during the return stroke. You can rotate the diaphragm control back and forth any required number of times.

Optics

The real field of view varies between 12° and 14°, but is reduced one-half when you use the telescope attachment. You sometimes have difficulty in locating the desired star; it happens with all horizontal-viewing sextants. This procedure may help you:

AN 5851 SEXTANT



1. Set the instrument to 0° altitude.
2. Pick up the star by direct sighting.
3. Bring the sextant to operating position slowly, keeping the star in the field of view by rotating the index knob.

See T.O. 05-35-33.

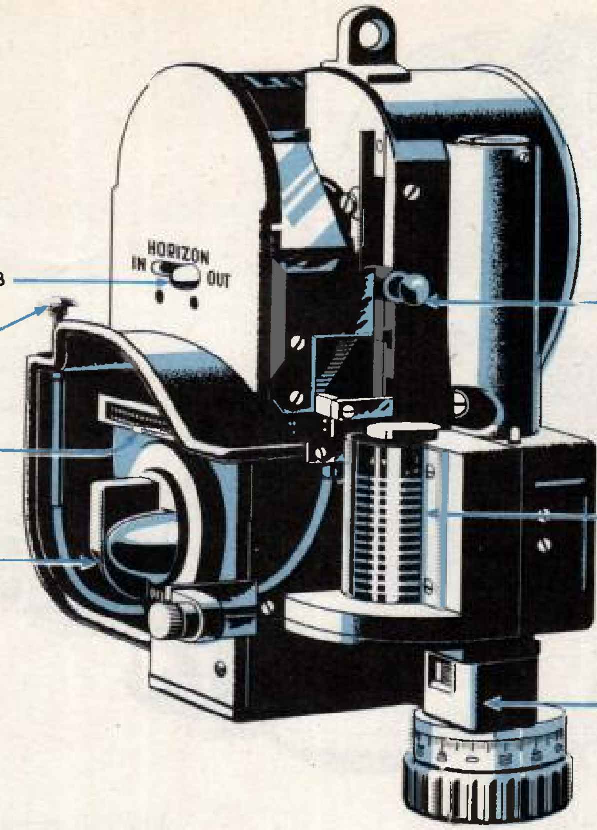
AN 5851 SEXTANT

Use the AN5851 sextant with the appropriate support arm. Like the A-10 and A-10A it is designed for horizontal vision. This sextant incorporates a chronometric, automatic averaging device which, at the end of a two-minute period, gives the average altitude on a counter.

The averaging mechanism picks off the setting of the instrument at two-second intervals and accumulates these values through a 60/1 gear reduction on the counter. Since a gear system does the averaging you must enter a full complement of 60 sights. You must, therefore, maintain collimation for a full two minutes. The reading on the counter is worthless if you stop observing before the two minutes have fully expired.

Operation

1. Set the counter to 0 by turning the counter knob. It is important that you do this accurately.
2. Wind the averaging device until you reach a solid stop.
3. Push lever 2 and rotate the scale drum to a stop. This operation engages the sextant with the averaging device and the stop indicates that the averager has been brought down to the base line.
4. Push lever 1 to engage lever 2. This operation disengages the averaging device from the sextant.
5. Take a preliminary sight. Push lever 2.
6. Again rotate the drum down to a stop, and if this amount of rotation is more than 2°, rotate the drum up to the sighted angle and collimate the star and the body.
7. If the amount of rotation is less than 2°, disengage the averaging device by pushing lever 1, rotate the drum down approximately one turn, push lever 2, and continue rotating the drum down to a stop. Then proceed with the sight. There is always a 15° spread between stops, which allows at least 2° on either side of the altitude of the body. This gives the drum room in which to rotate while the bubble is moving.
8. Push lever 3 to start the averaging device.
9. To obtain the average time, add 1 minute to starting time or subtract 1 minute from the time you finish your observation.
10. Maintain coincidence between the bubble and the celestial body. At the end of two minutes a



AN 5854-1 SEXTANT

shutter automatically moves into the field of view and obscures your vision.

11. To obtain the final average altitude, combine the counter reading with the main scale reading. (Do not read the scale drum; this indicates only the final altitude setting.) For example, if the counter reads 6° 35′ and the main scale pointer is between 4 and 5, the final reading is 46° 35′. Remember, the final main scale reading is within 2° of the average reading.

Bubble

In this type of sextant the star image and the bubble image are superimposed directly in the optical system and not by reflection, as in the A-10 series. You cannot see the star through the bubble, so use the cylindrical lens to astigmatize the star image, i.e., draw it out to a line instead of a point.

Optics

The real field of the instrument is 12°. Two-power magnification is built in.

Note that a rotatable polarizing filter in the eyepiece is designed to reduce horizontal (water) reflections of the sun at low altitude.

For general use, and always at night, remove this filter by pulling it straight out of the eyepiece. There is a finger ring attached to it for this purpose.

A horizon prism allows you to use the natural horizon.

See T.O. 05-35-22.

AN 5854-1 SEXTANT

Operation

Use the AN5854-1 sextant with the appropriate support arm. Hold the instrument by the handle, which is part of the sideplate, and by the graduated drum at the lower left side of the instrument. Operate the median averaging device with the index finger of your right hand. Press the cable button at each reading. Readings are recorded by the median assembly and are continued until the shutter automatically cuts off the field of view. Then, rotate the graduated drum until the median index is under the index line of the median assembly window, and read the angular altitude from the sextant scales.

To prevent any of the indexes from disappearing behind the median drum when you are determining the setting, the median drum is geared to turn half as fast as the graduated tangent screw controlling the sextant prism. This gear reduction also reverses the direction of motion of the median drum from that of the tangent screw.

Spread the series of observations over the particular oscillation cycle of your airplane. In normal flying conditions, space a series of 15 readings at intervals of approximately six seconds between readings. In extremely rough air, two series of 15 readings are recommended with an interval of approximately six seconds between series. Average the two medians to obtain an average of the 30 readings. The average celestial time for the series of 30 readings is the average time from the start to the finish of the observations.

Another method of using the averaging device is to rotate the series of indexes until they seem to be distributed evenly on both sides of the fiducial line. This reading is a good average.

Clear the median assembly and load the shutter for another series of readings by pressing the resetting pin and rotating the indexes back to the index fiducial line in the center of the window.

For use with the sun and bubble horizon, the instrument is equipped with five combinations of filters for various sun intensities or field brightness. With the real horizon reflector IN, you can use the astigmatizer lens to astigmatize the sun across the bubble.

You can view celestial bodies at night either through the clear openings or the astigmatizer lens in the filter mount.

Radium paint provides such adequate dark field illumination of the artificial horizon bubble at night that you rarely need electric light. However, variable electric light intensity is available to boost the level of illumination.

Optics

The shutter is a thin sheet of metal that automatically cuts off the telescope field at the end of the observation. The shutter drops on the sixteenth reading and not at the end of the fifteenth. The shutter is mounted directly above the objective lens and the filter mount assembly.

The real field of the sextant is 12°. Two-power magnification is built in. You sometimes have difficulty in locating the desired star, as is the case when you use any horizontal-viewing sextant. See procedure outlined under Optics, A-10A sextant.

All scales are illuminated. A red bubble filter is supplied to provide a red bubble for contrast against the sky. This is particularly suitable for use against a moonlit cloudy sky.

See T.O. 05-35-27.

WATCHES

In accordance with Technical Order 00-30-61-2 you are entitled to three watches: the A-11 hack watch, the A-8 groundspeed timer, and the AN5740 master watch. These watches are the best products the American watch industry can make in the quantity the Air Forces demand. The life of your watches and the performance they give you are largely a matter of the care you give them. You should take the following simple precautions:

1. Carry your master watch in the metal case provided. This protects the watch from shock and from large magnetic fields. Always try to carry the watch in a horizontal, face-up position.

2. Wind your master watch regularly and determine its rate so that you may gain confidence in its performance. This watch is one of the finest timepieces made today. It is adjusted for position and for temperature.

If you anticipate flying in extreme cold (below −20° C) it is advisable to carry the watch on a piece of string inside your flying clothing. The slight inconvenience which this causes in reading the watch is greatly outweighed by the improved rate of the watch.

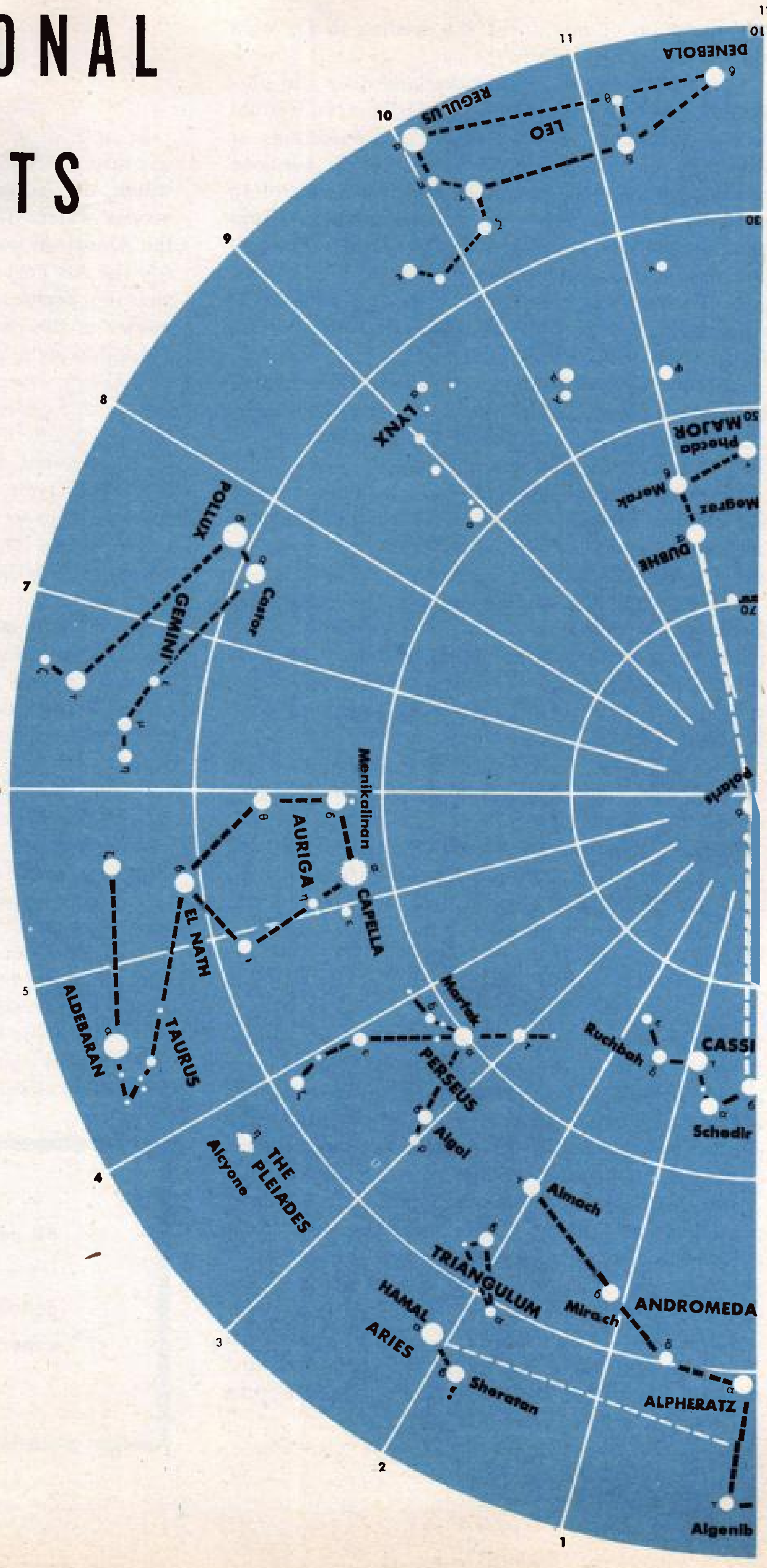
3. See that the screw-back and bezel of the watch are tightened securely at all times.

4. **Important: Your wrist watch is not waterproof,** so do not expose it to excessive moisture. The latest hack watches are supplied with a three-piece, dust-tight case. This simplifies maintenance and the rate of the watch is more constant. Take particular care to prevent water from running down your wrists after washing your hands; it collects around the stem of the watch.

5. Inspect your watch strap and strap pins occasionally to eliminate any chance of losing the watch.

Do not attempt to repair sextants or watches. They are delicate instruments and require expert adjustments.

NAVIGATIONAL STAR CHARTS



CONSTELLATIONS—**TAURUS**
H.O. 218 STARS—**CAPELLA**
OTHER STARS—**Almach**
CONSTELLATIONS—
POINTER SYSTEM—

small pointed tool which is in the carrying case.

f. Tighten the counter lock nut screw with the screw driver.

g. Turn the sun filter so that it does not cover the objective lens (natural horizon lens).

h. With the sextant set on zero, see if the collimator cross lines give a double image when viewed through the eyepiece. If you see a double image, rotate the thumb screw under the index mirror until the two images in the center of the cross hairs in the collimator tube coincide exactly.

You can also check the bubble position with the collimator tube. If when the bubble is balanced in the center of the field it is not in the center of the cross lines in the collimator tube, you must adjust the bubble chamber itself. Do this by adjusting the two bubble mount screws located at the side of the bubble chamber. A tool is provided for moving the screws. Turn them in opposite directions until they are taut but not under strain. Turn the screws in opposite directions until the cross lines and the bubble are centered. This is a process of trial and error.

With an unknown altitude. Set the micrometer drum to zero. Observe any heavenly body through the eye position. Have the sun filter away from the objective lens so that the light from the body passes through the telescope.

If you see a double image, rotate the micrometer drum until you only see one. Read the micrometer drum and note the difference in its reading from zero. This difference is the error and you should take several readings and average them to find the index error and the appropriate correction.

By means of a known altitude. Precompute a curve for any body and plot the sextant observations against the curve. The average difference is the sextant error. The sextant correction is the same as the sextant error, but the sign is reversed.

2. Adjust the averaging device for the A-8A, using the following method:

a. Loosen the lock screw which holds the stop screw and turn the stop screw counter-clockwise two or three turns. (The stop screw is the adjusting screw against which the averaging lever stops after a forward movement.)

b. Set various altitudes on the micrometer drum. Average eight shots without changing this setting.

c. Check the reading of the vernier drum against the micrometer drum.

d. By a process of trial and error adjust the stop screws so that you get the correct reading up and down the scale.

In isolated cases you will find that you can make no adjustment which will make the readings correct for the entire limit of movement of the drum. In this case, either compute the corrections you must apply for any desired altitude you have observed, or make the correction zero at 45° and assume that the errors at the limits of the scale will be so small as to be negligible for all practical air work.

Remember, when you turn the vernier drum back to zero, it goes sixteen minutes beyond the zero position. The factory makes this adjustment to leave a small amount of play at the zero setting. You take eight shots. The averaging device automatically picks up two minutes on each shot so that after eight shots the sixteen minutes does not enter into your final average. It is a good idea to check this averaging device from time to time to assure yourself that the instrument is operating properly.

Maintenance

You can replace the lamps by removing the shades after first loosening the set screw.

If your bubble chamber isn't operating properly, install the spare in the carrying case. Unscrew the two screws located on the right side of the frame beside the bubble chamber. When they are loose you can slip the chamber out and insert the new one. Then adjust for collimation again.

Test the battery case and cord just as you do for the A-10 sextant.

If the lighting system still fails, check the lamps and test the wiring in the instrument. The wire which connects the rheostat to the bubble lamp is very small and if it breaks you must replace it with a heavier wire. Let a qualified instrument repair man do this for you.

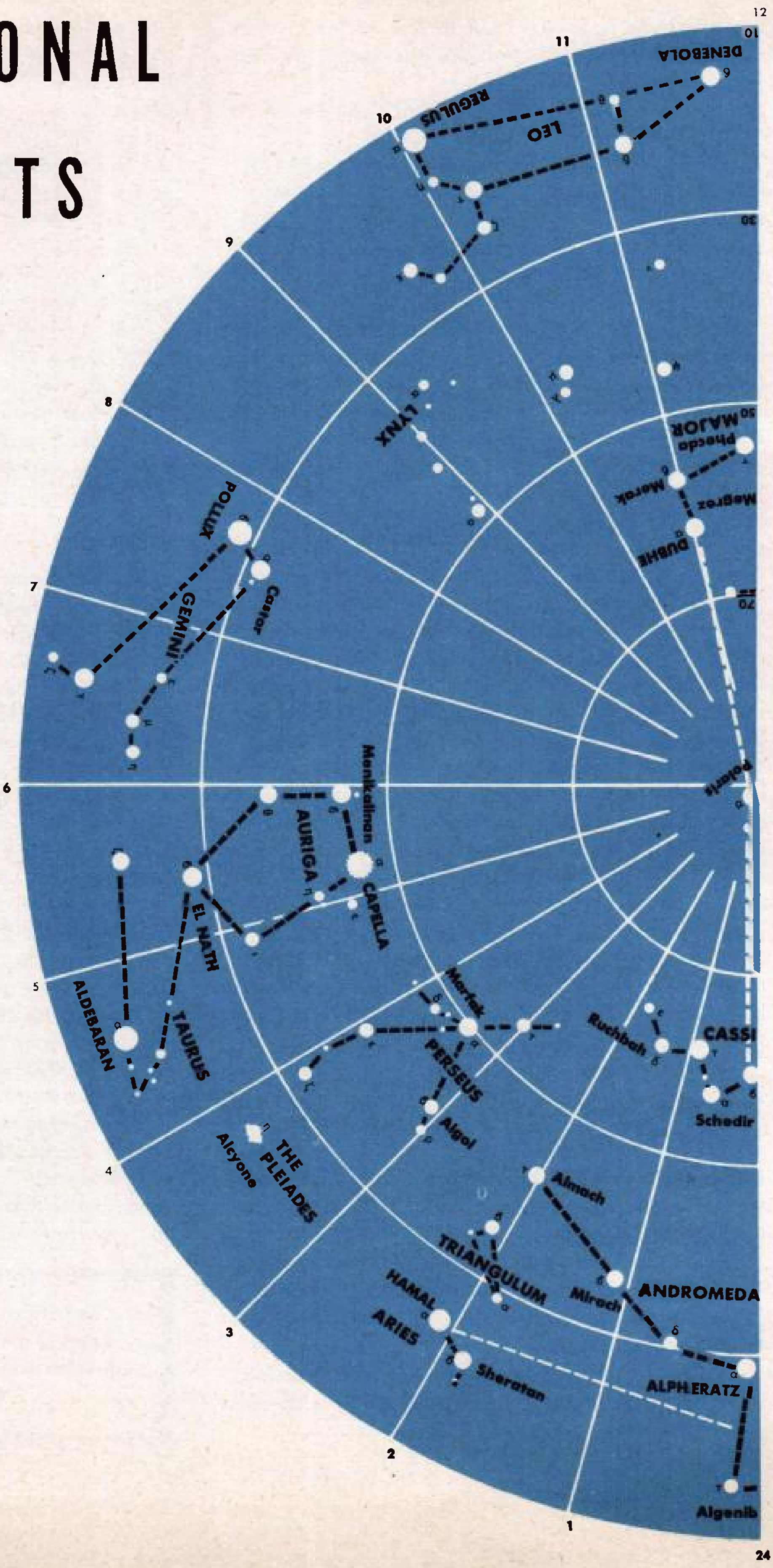
When flying at high altitudes observe the following precautions in the use of your sextant.

If the sextant is in its box during a quick drop of temperature and you then take it out, moisture will condense on the mirrors. Remedy—open the sextant case before you climb to a high altitude.

Batteries do not work well in extreme cold, so keep spares in a warm place (pocket of your coat) and replace them as often as necessary.

Check your chronometer daily and keep a running record of gains and losses. A rapid change of temperature changes the rate.

NAVIGATIONAL STAR CHARTS



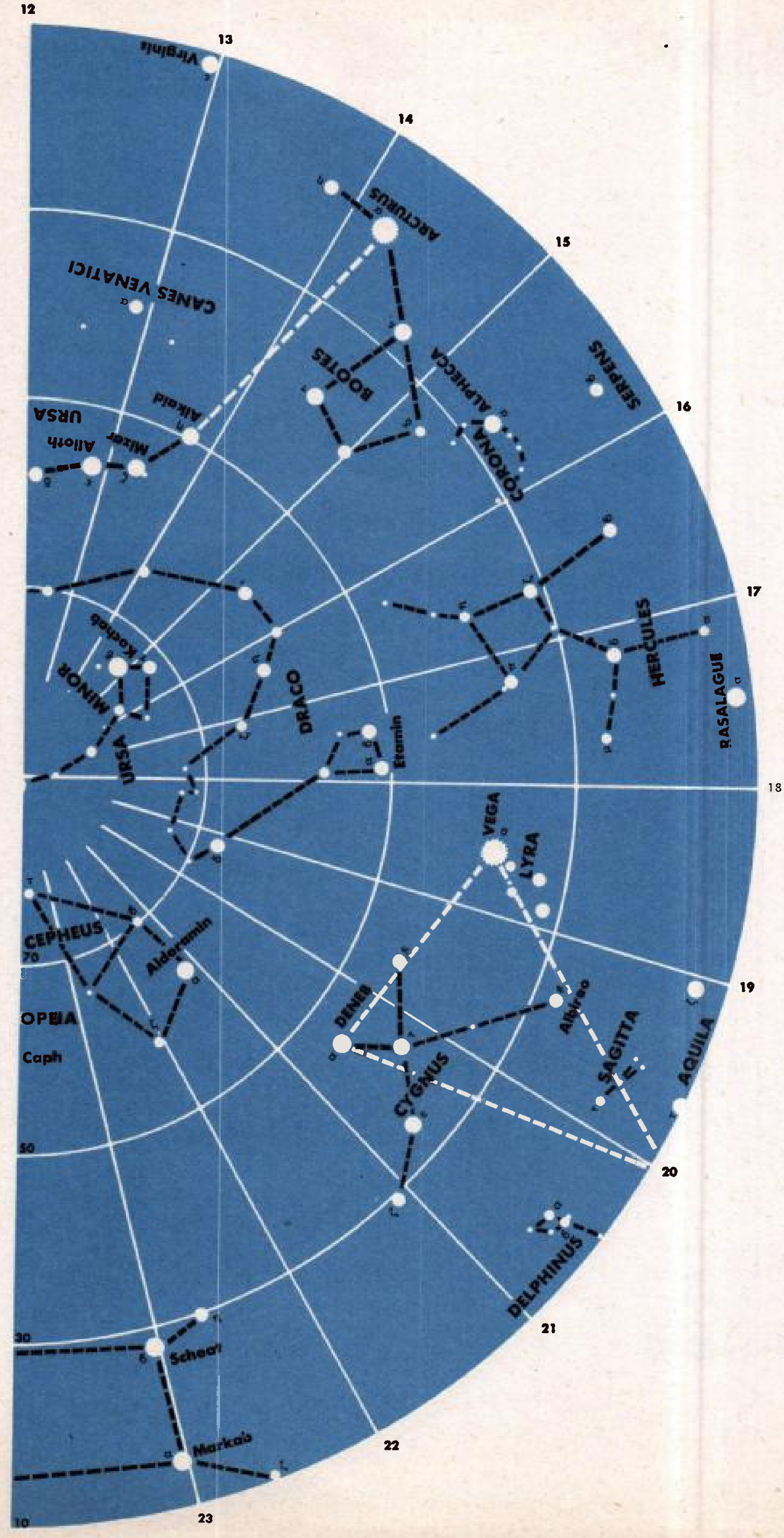
CONSTELLATIONS—**TAURUS**

H.O. 218 STARS—**CAPELLA**

OTHER STARS—**Almach**

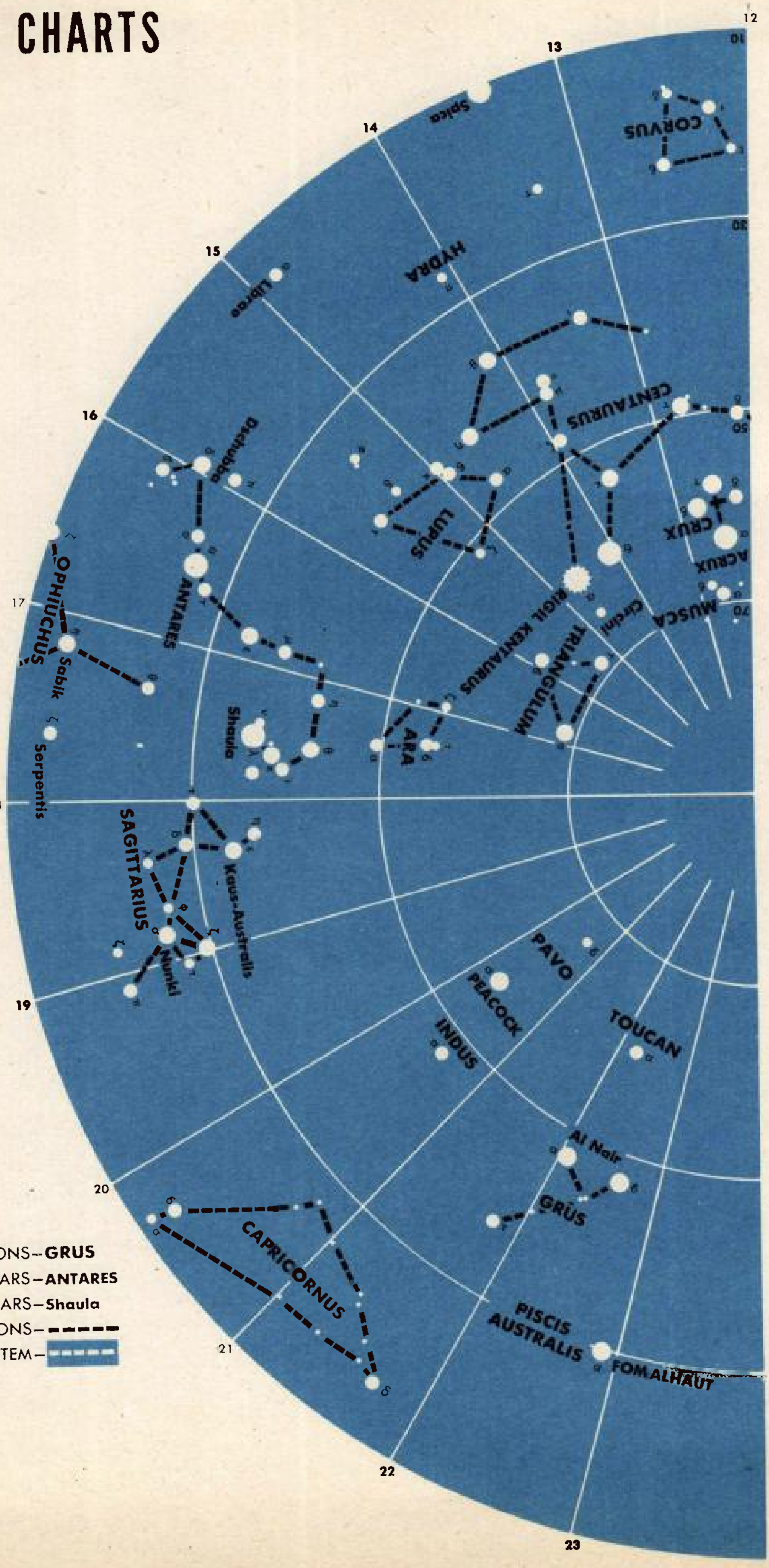
CONSTELLATIONS—

POINTER SYSTEM—

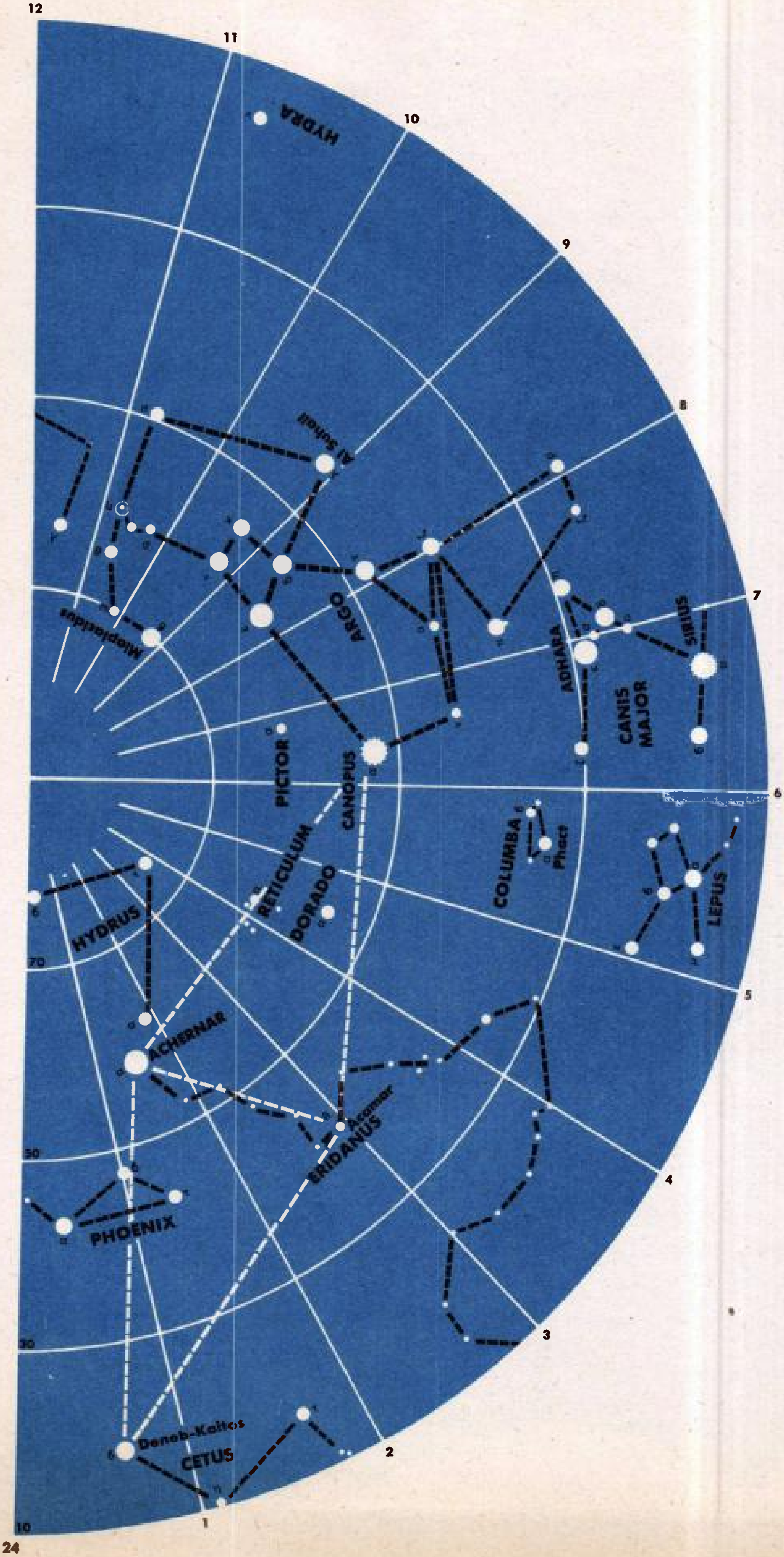


NORTH POLAR PROJECTION

NAVIGATIONAL STAR CHARTS

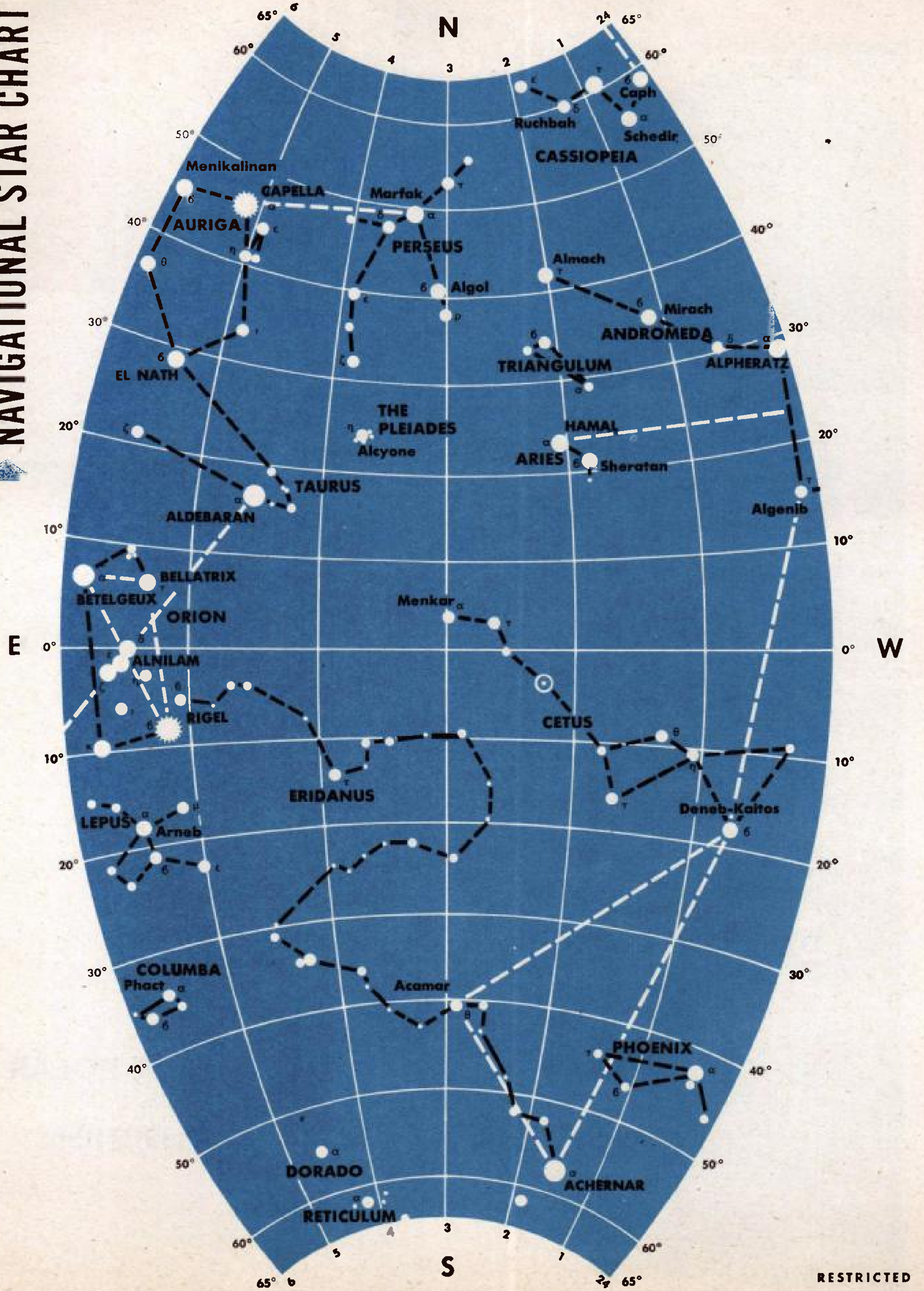


CONSTELLATIONS—**GRUS**
H.O. 218 STARS—**ANTARES**
OTHER STARS—**Shaula**
CONSTELLATIONS—
POINTER SYSTEM—



SOUTH POLAR PROJECTION

NAVIGATIONAL STAR CHART



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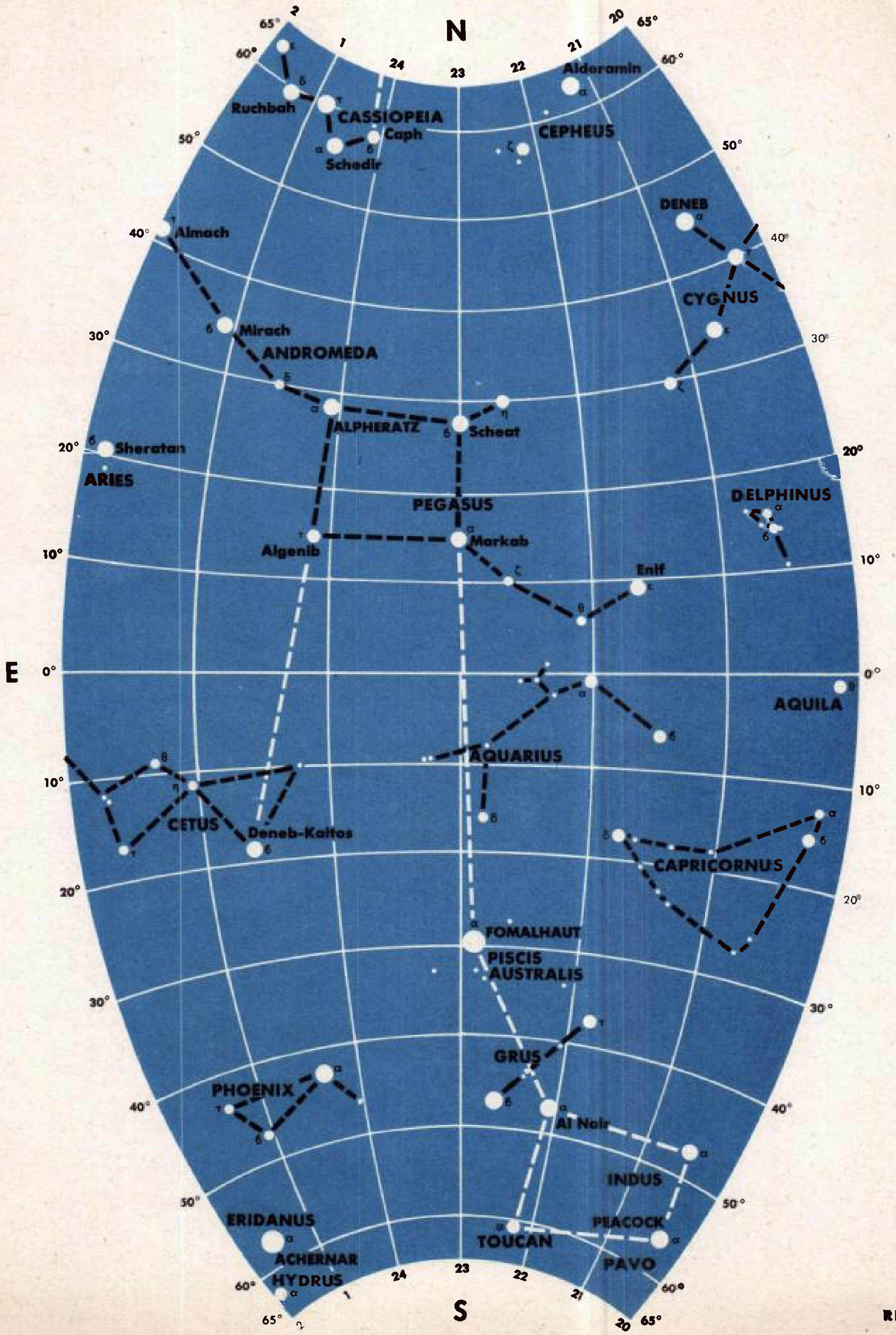

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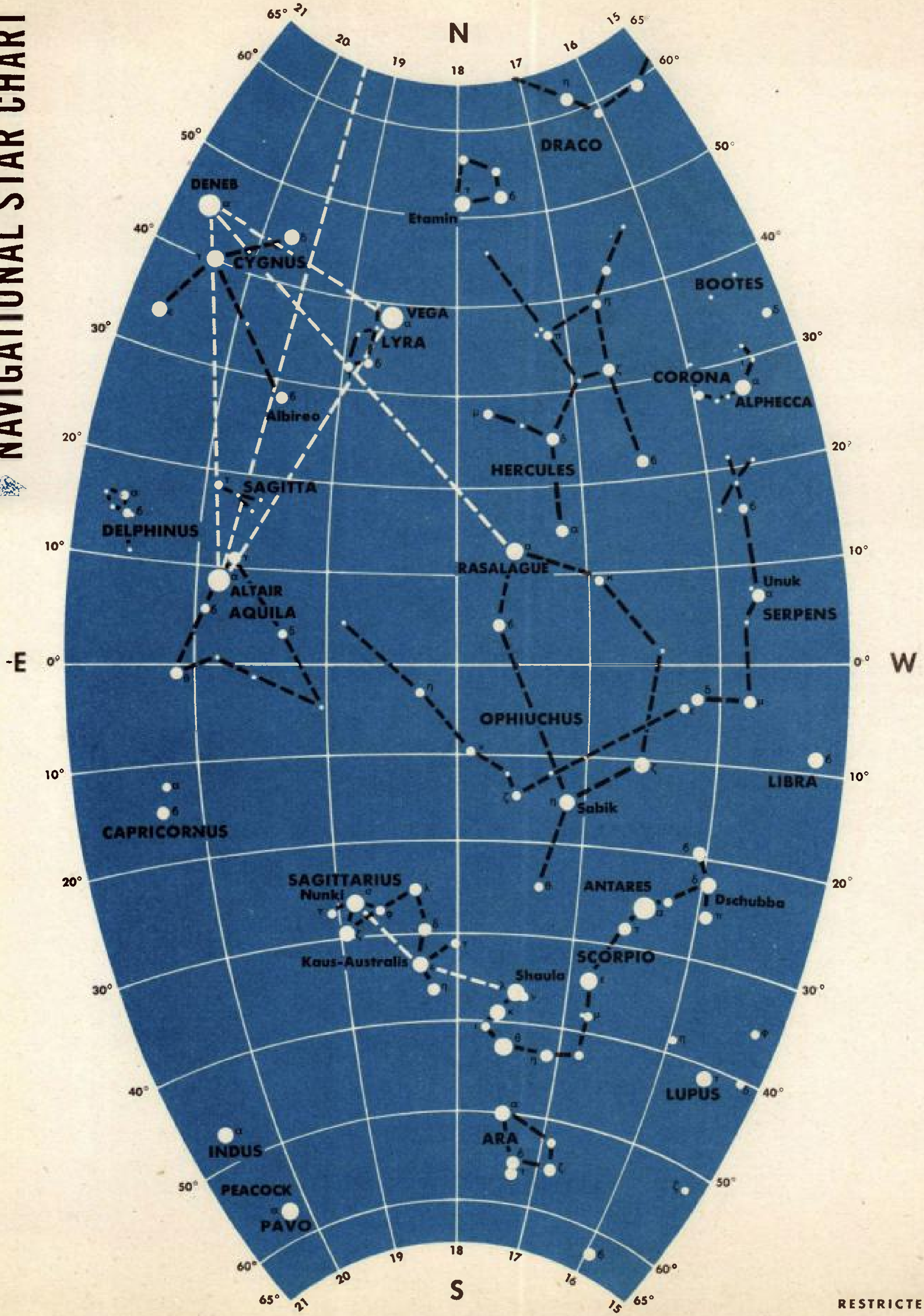

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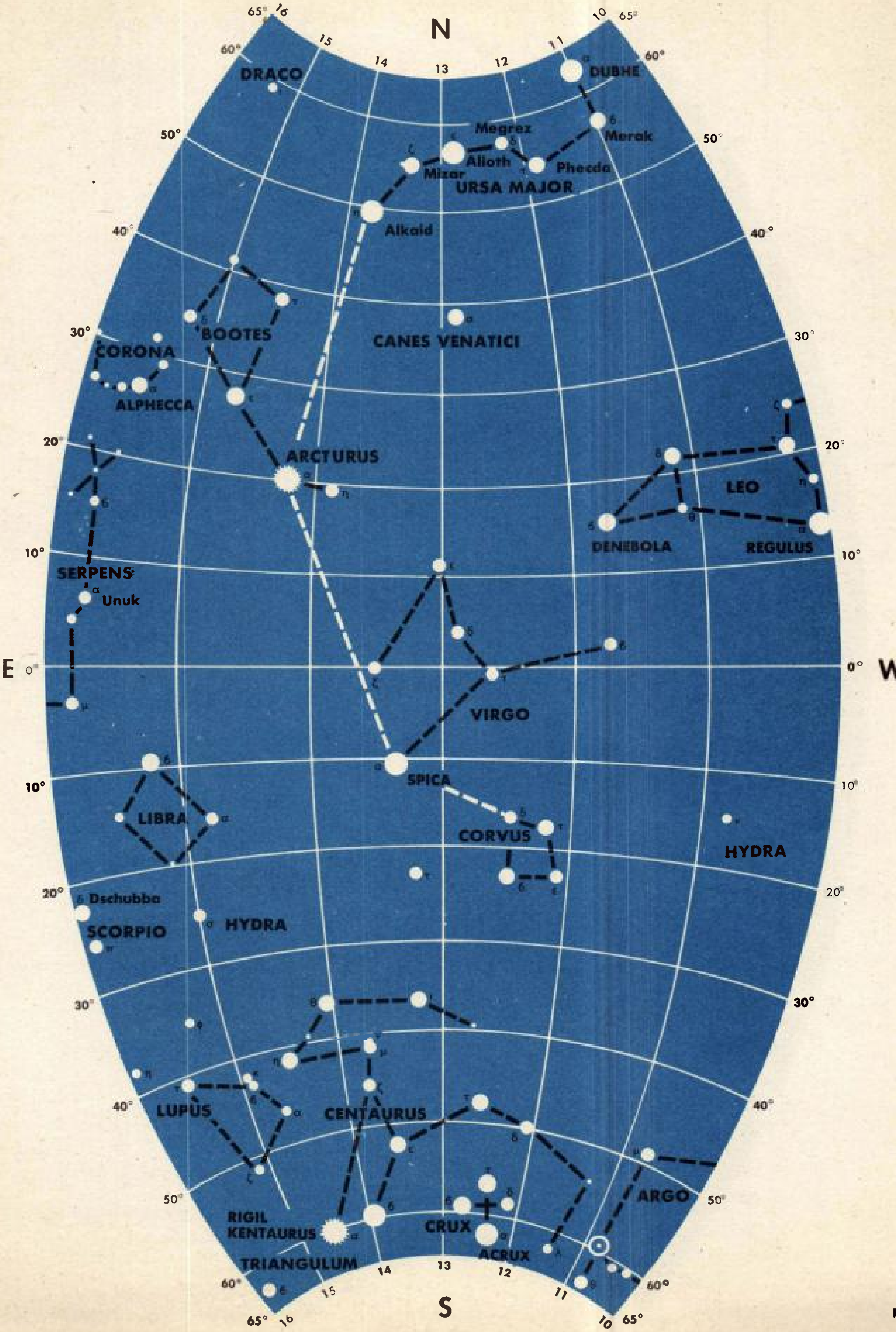
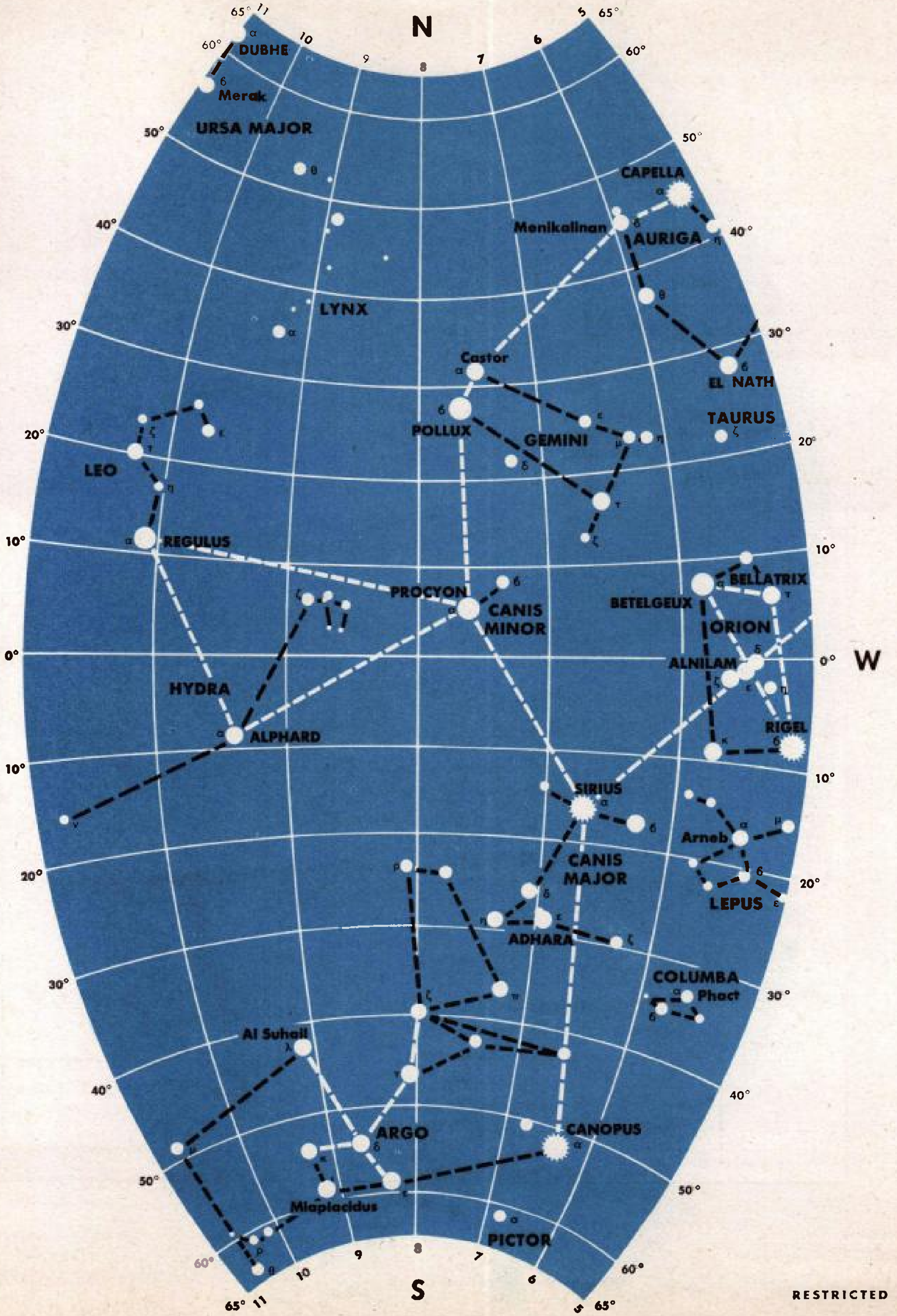


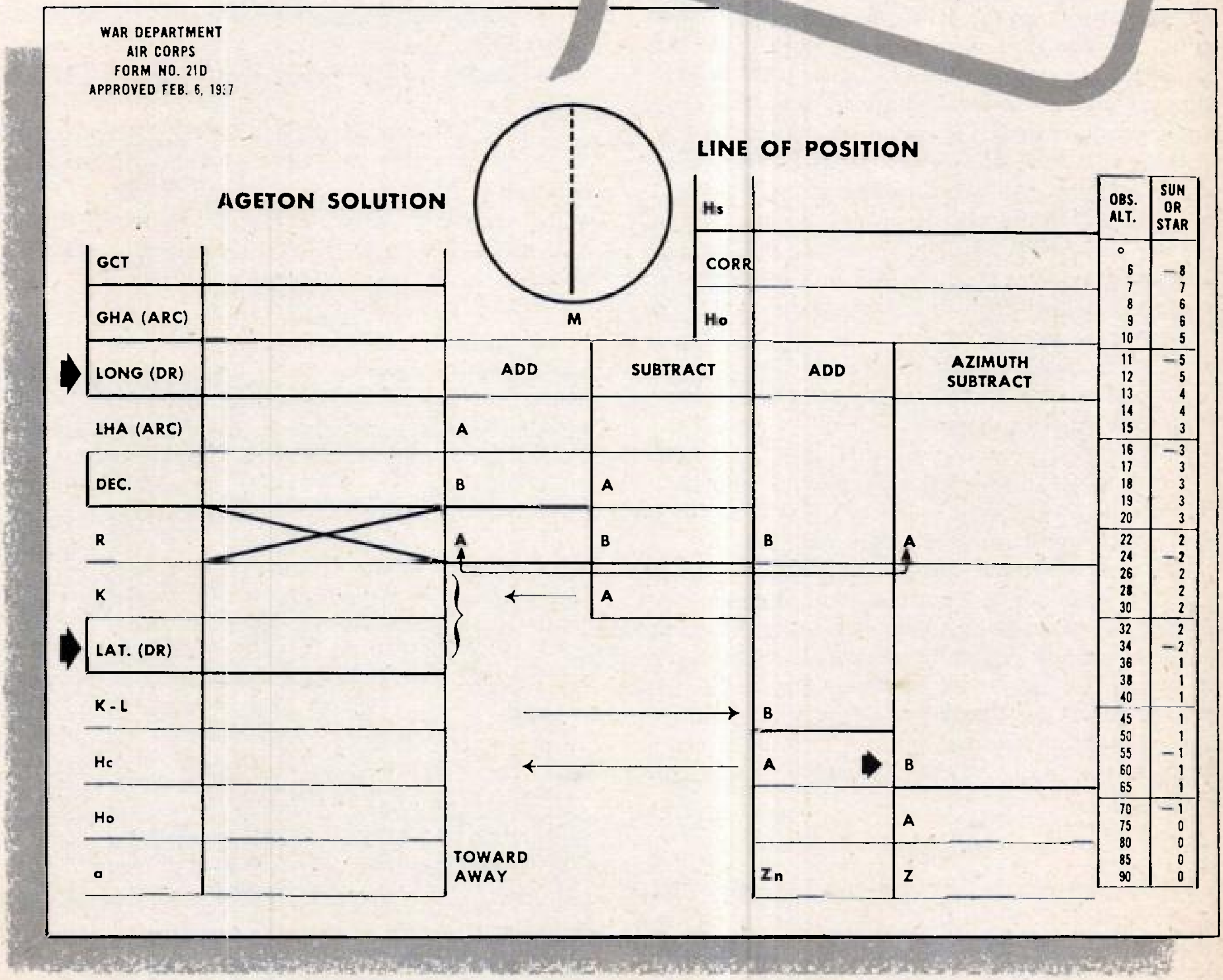
NAVIGATIONAL STAR CHART



AGETON SOLUTION

Ageton solves the astronomical triangle. Be sure you know how to use the forms properly, then follow the signposts. All rules governing use of this form are found in Ageton H. O. 211, Dead Reckoning Altitude and Azimuth table.

KNOW HOW TO WORK THIS SOLUTION IN YOUR SLEEP....



OBS. ALT.	SUN OR STAR
°	
6	—8
7	7
8	6
9	6
10	5
11	—5
12	5
13	4
14	4
15	3
16	—3
17	3
18	3
19	3
20	3
22	2
24	—2
26	2
28	2
30	2
32	2
34	—2
36	1
38	1
40	1
45	1
50	1
55	—1
60	1
65	1
70	—1
75	0
80	0
85	0
90	0

Almanac Tables

Digest all information contained in the Air Almanac. Check each new issue. Additions are being made, so study the changes until you understand their meanings and application thoroughly.

Sunrise and Sunset Tables

Tables for finding the local civil time of sunrise, sunset, beginning and ending of civil twilight, moonrise and moonset for latitudes between 60° S and 70° N are given on the P.M. side of the daily sheets in the Air Almanac. Graphs in the back of the Air Almanac extend these tables to higher latitudes. The columns under sunrise and sunset give the times when the **upper limb** is tangent to the visible horizon with the eye at the surface of the earth. The columns under twilight give the duration of civil twilight, which begins in the morning when the sun is 6° below the horizon and ends at sunrise. In the evening, civil twilight begins at sunset and ends when the sun is again 6° below the horizon. To find the time of the beginning of morning twilight, subtract the tabulated value from the time of sunrise. To find the time of the ending of evening twilight add the tabulated value to the time of sunset.

To convert local civil time (LCT) to Greenwich civil time (GCT) convert the longitude of your position into time (15° equals 1 hour) and add if it is west of Greenwich, subtract if it is east.

The times of sunrise, sunset, beginning and ending of twilight are affected by your altitude because of Dip and increased Atmospheric Refraction. The time of sunrise and beginning of morning twilight in the air are earlier than those on the ground, while the time of sunset and ending of evening twilight are later. The differences are given in the table in the back of the Almanac for various latitudes and heights.

Example

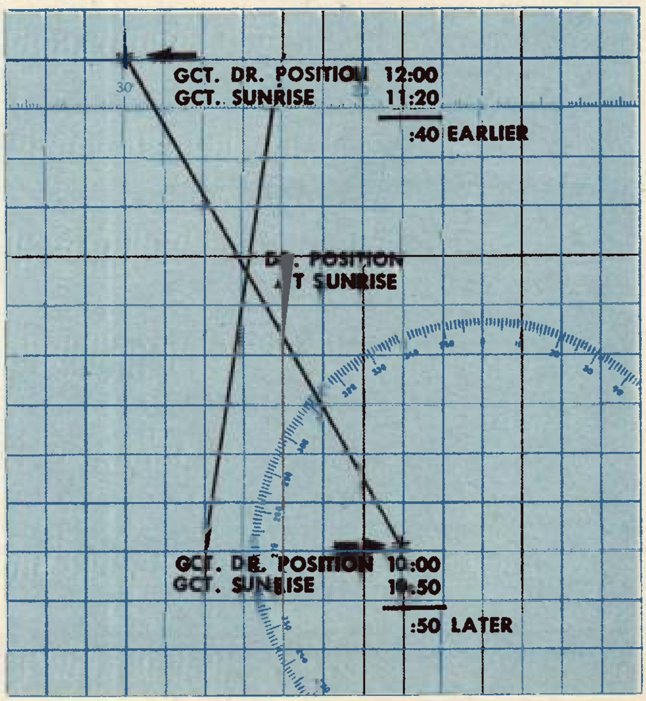
Sunrise occurs at ground level on 1 January 1944 at 40° north latitude at 07:22 LCT and twilight occurs 31 minutes earlier or at 06:51. However, at 10,000 feet sunrise is observed 12 minutes earlier or at 07:10 and twilight is observed 2 minutes earlier or at 06:49.

If DR longitude is 72° 30′ W you have to add 4 hours and 50 minutes to each of the above times to convert them to GCT.

Sunrise and Sunset in Flight

To find the time and position of sunrise or sunset on your flight path:

1. Estimate your approximate position at the time of the phenomenon.
2. Bracket this point with DR positions 2 hours apart.
3. Find time of phenomenon for each DR position.
4. Find the difference between GCT of phenomenon and GCT of DR position at both points.
5. Using any convenient scale, mark off these differences from both DR positions along parallels of latitude. Mark them off in opposite directions.
6. Draw a line to connect these two points. The



DR position of the phenomenon is where this line crosses your course line.

Solve this mathematically as follows:

GCT of 1st DR position	10:00
GCT of sunrise	10:50
	:50 Later
GCT of 2nd DR position	12:00
GCT of sunrise	11:20
	:40 Earlier

The sun rises five ninths of the time difference (02:00) after the time of the first DR position.

$\frac{5}{9} \times 120 = 66.6$ minutes.

Sunrise occurs at 11:07.

LOPs by Sunrise or Sunset

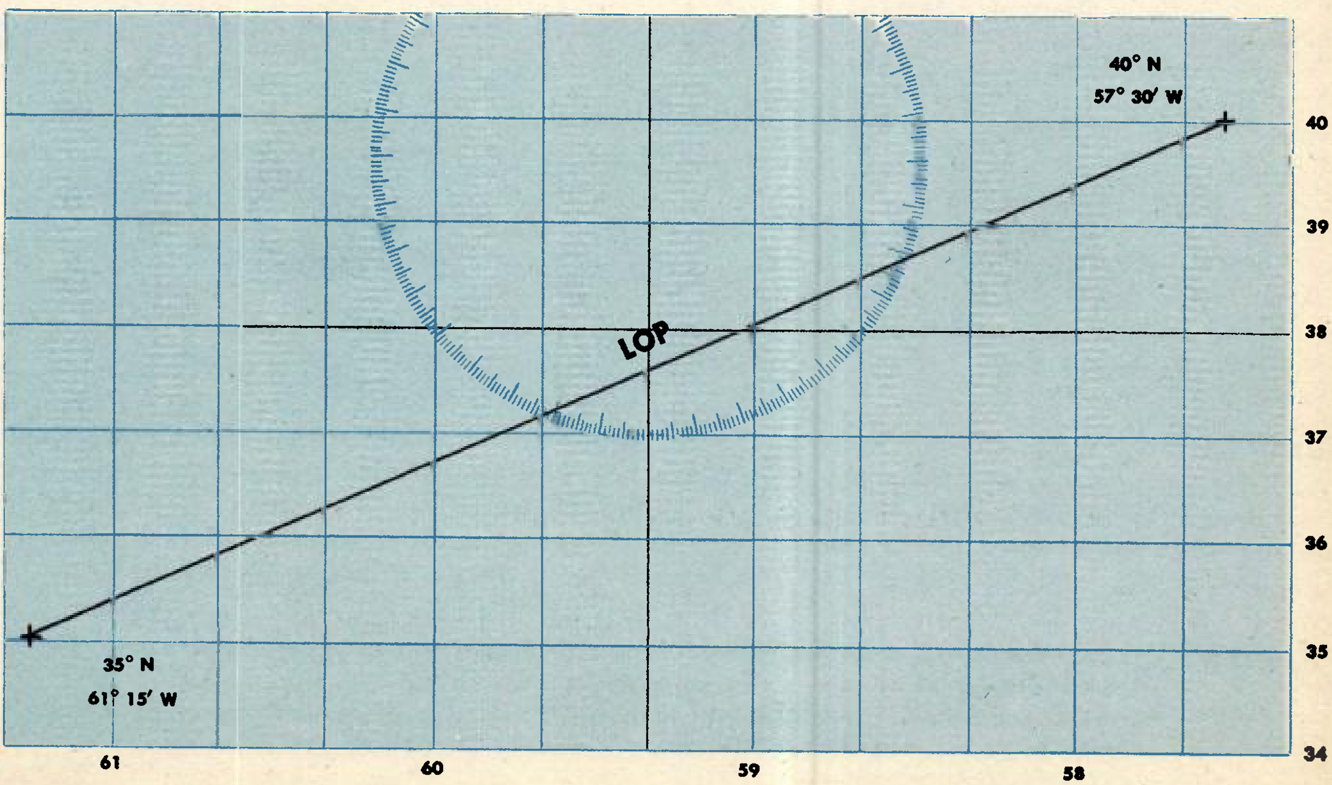
In an emergency you can use the observed time of sunrise or sunset to determine a LOP with a moderate degree of accuracy. Note the GCT when the sun's upper limb becomes tangent to the visible horizon. Use the Air Almanac to determine the LCT of the phenomenon, being sure to make the additional correction for altitude of the airplane. Extract values of LCT for latitudes on either side of your position. The difference between the GCT and the LCT is the longitude in units of time which is then converted into degrees and minutes (use the table in the back of the Almanac). Knowing the longitude for positions on either side of your DR position, plot these points and connect them with a straight line. This is your LOP.

Example

Flying at approximately 38° N, you observe the GCT of sunrise on 1 January 1944 to be 11:01. Your altitude is 10,000 feet. The P.M. page gives the LCT of sunrise at 35° N and 40° N as 07:08 and 07:22 respectively. The correction for altitude is minus 12 minutes and minus 11 minutes, giving values of 06:56. and 07:11. Subtract these from the GCT of 11:01 to get longitudes of 4 hours and 05 minutes and 3 hours and 50 minutes or 61° 15′ W and 57° 30′ W.

Corrections for Semi-diameter and Dip

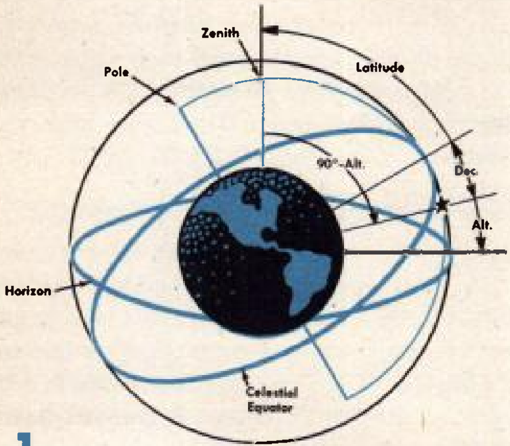
Many navigators have found that they obtain excellent results by using the sea horizon instead of the bubble horizon. When using the sea horizon, however, you must make a correction for Dip to all sextant altitudes. The Dip correction table is on the back cover of the Air Almanac. It is usual practice to make the lower limb of the sun or moon tangent to the sea horizon. Add the correction for semi-diameter to the sextant altitude. This correction is given on the A.M. side of the daily sheets. Occasionally it is necessary to observe the upper limb of the moon. When observing the upper limb, be sure to subtract semi-diameter from your sextant altitude.



OBSERVATIONS FOR LATITUDE

If the azimuth of a body is 0° or 180° from your position, it is on your meridian.

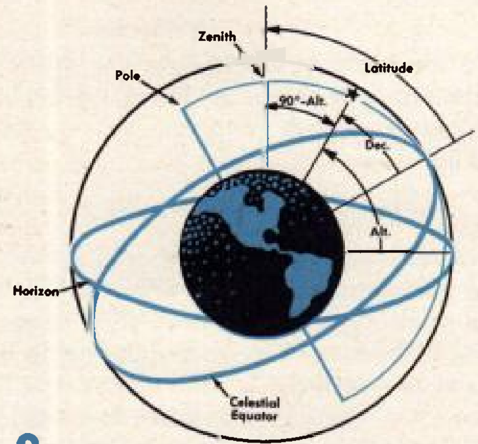
Use one of the following formulas to find your latitude.



1

When your latitude is opposite in name from the declination of the body,

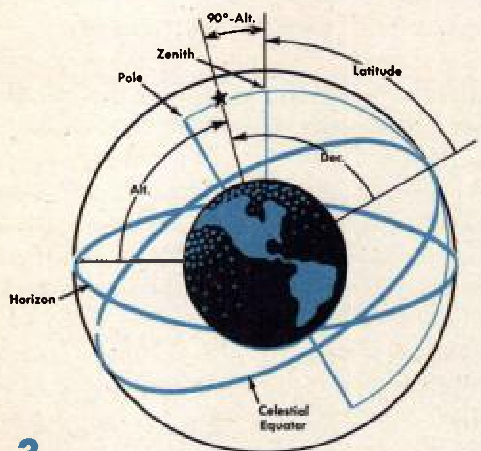
Latitude = (90° — Altitude) — Declination



2

When your latitude is the same name as the declination of the body, and the body is between you and the equator, (declination less than latitude)

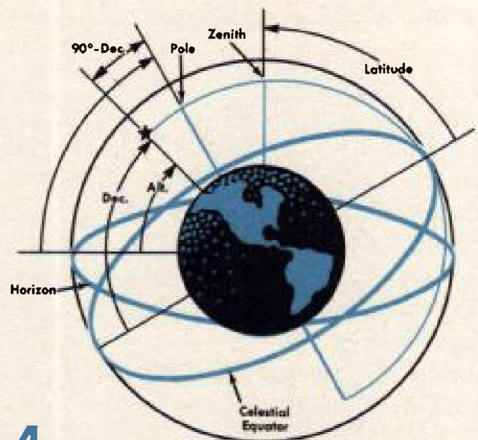
Latitude = (90° — Altitude) + Declination



3

When your latitude is the same name as the declination of the body and the body is between you and the pole, (declination greater than latitude)

Latitude = Declination — (90° — Altitude)



4

When your latitude is the same name as the declination of the body and the star is between the pole and your horizon,

Latitude = (90° — Declination) + Altitude

Altitude of pole equals latitude.

POLARIS **Find your latitude by observing the altitude of Polaris. At the time of observation, find the Greenwich hour angle of Aries by reference to the Air Almanac. Enter the Polaris table in the rear of the Almanac. Apply the correction shown opposite the local hour angle of Aries to the observed altitude of Polaris. The corrected altitude is your latitude.**

DAYTIME FIXES

Daylight Over-Water Flights

If you have to dead reckon over water for hours, under adverse conditions, during the daytime, celestial observations and good common sense will help you find your way. Here are some combinations that you can use:

Cross a sun line with a radio bearing. Remember, bearings and stations more than 200 miles away, or closer than 50 miles, are seldom accurate enough to give more than a general indication of position. Use radio bearings with caution. (See NIF 2-23.)

Cross a sun line with a moon line of position.

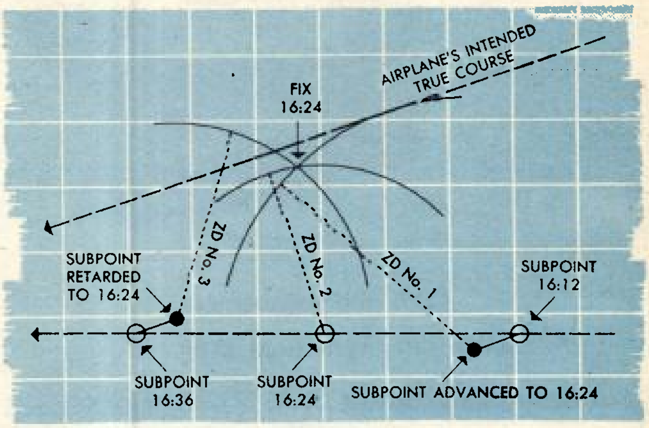
Cross a sun line with a coastline. If you are crossing a coastline, island chain, or some other terrestrial line on which you cannot fix your position definitely, obtain a fix by shooting the sun at the same time that you cross the terrestrial line.

Cross a sun line with another sun line. At local noon the azimuth of the sun changes rapidly, especially in low latitudes. The time interval varies with the latitude of the observer and the declination of the body.

For example, at 30° north latitude on June 1, the azimuth of the sun changes 57° in one hour. Take a sun line a half hour before noon, take one at noon, and take one a half hour after noon. Move them all up to the same time, to obtain a fix.

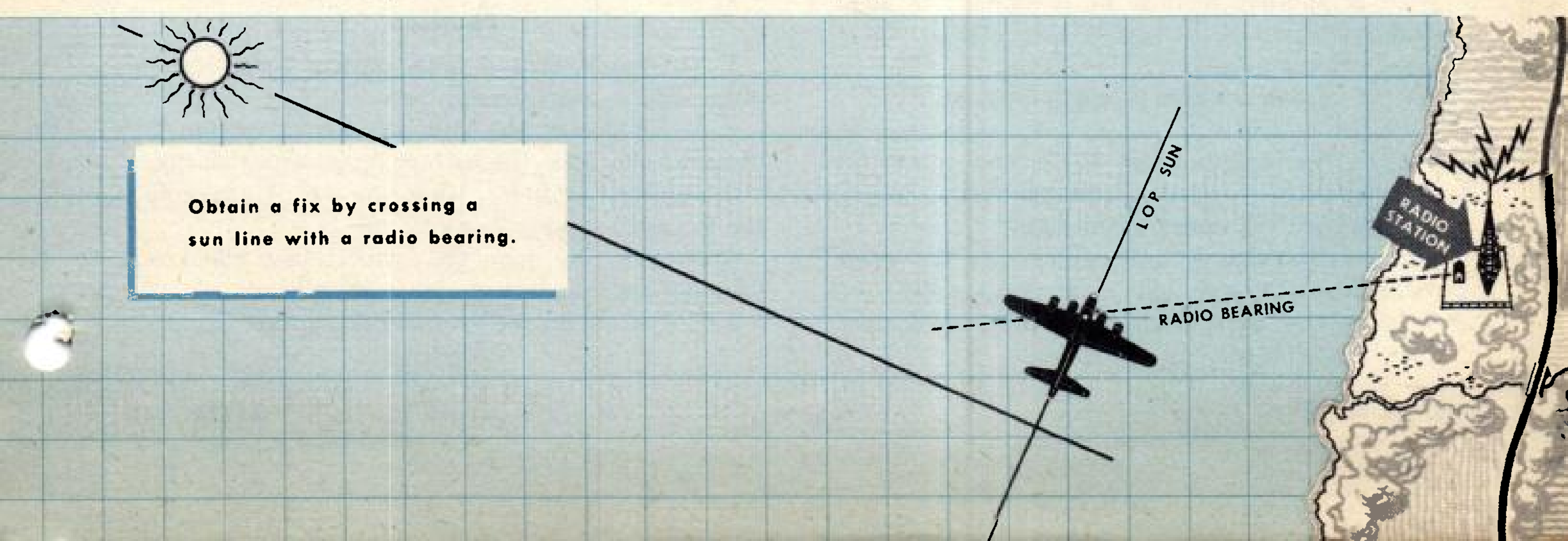
Meridian altitudes. Apply the rules involving combinations of observed altitude and declination.

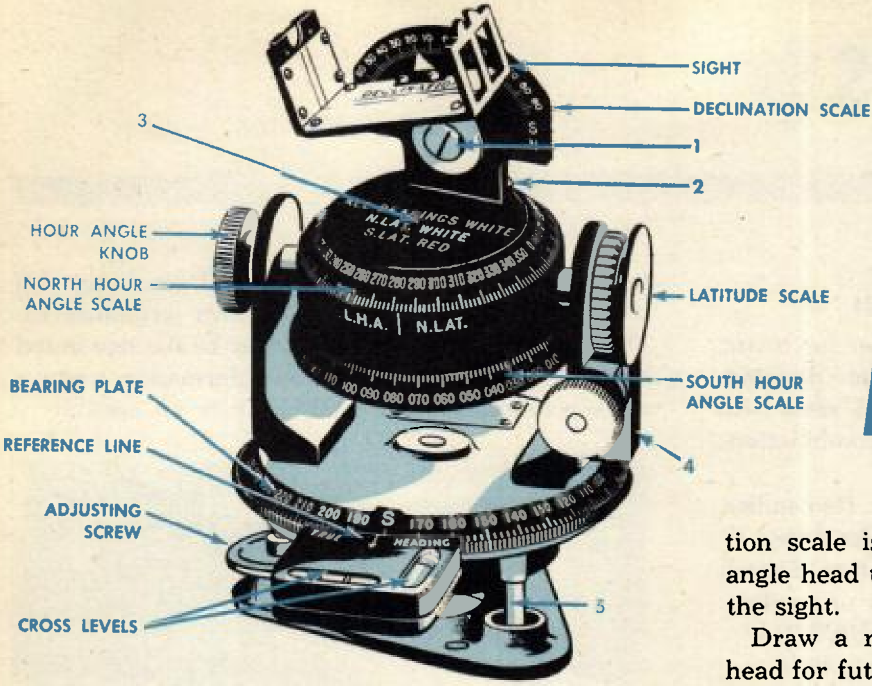
Advance one sun line to another over a period of time. While this method is not too accurate, it does give you a general picture of the trend of your flight. A little common sense helps a great deal in the interpretation of these lines. Move all sun lines with true airspeed or the best known groundspeed. The best known groundspeed may be the one found between two LOP's. Use this information when a more accurate groundspeed check is not possible.



High-Altitude Shots

If the altitude of the body is 85° or more, plot the usable arc of the circle of equal altitude. Plot the subpoint of the body by using Greenwich hour angle and declination as longitude and latitude. Swing a circle using 90° minus altitude (zenith distance) as the radius. You can do this with a piece of string. The line of position will be curved. To move up such a position arc for time, move up the sub-point of the body for groundspeed parallel to course and swing off a new arc from the new center. Two such circles intersect at two points. It usually is possible to select the reasonable intersection of the two circles and find the fix.





ASTROCOMPASS

Care and Adjustment

1. To tighten motion of sight gear:

Loosen locknut.

Turn shoulder screw until you obtain desired friction.

Tighten locknut.

2. Entire sight assembly must be mounted firmly. Tighten the two screws behind the declination scale to insure correct mounting. At certain times during the day, 1° error in LHA causes up to 10° error in azimuth.

To check:

Unloosen two rear screws.

Set true bearing at 180°.

Sight down declination scale (0° south latitude) to the true bearing index.

Move sight assembly until it is aligned.

Tighten screws.

Draw a reference line on the north hour-angle head for future alignment.

Here is another method of checking the sight assembly:

Level astrocompass.

Set the latitude scale to 0° north latitude.

Set LHA to 270°.

Set the declination index to 0° and rotate the astrocompass head until a suitable distant object passes through the center of the sight.

Set the LHA drum to 90° and rotate the astrocompass head through 180° until you see the same distant object again through the sight. If the declination scale is correctly aligned on the north hour-angle head the object will still pass exactly through the sight.

Draw a reference line on the north hour-angle head for future alignment.

3. Check the three screws above and below the hour-angle head to see that they are snug. They mount the LHA scales on enclosed drive assembly.

4. To obtain correct latitude settings, tighten the two screws which fasten the micrometer knob and worm to the upright. Keep tension between worm and worm gear by checking to see that the two screws holding the springs are secure. Increase spring tension by bending the spring slightly.

5. Vibration of the airplane causes errors if the azimuth circle does not have a sufficient amount of friction to stay on set readings.

Increase tension in this manner:

Clamp spring leg in depressed position.

Remove two opposite screws from yoke to separate upper section from base.

Remove locknut.

Adjust tension until desired drag results.

Replace locknut and mount in reverse order.

You can adjust these nuts without removing the base if you have a special socket wrench that reaches through the base.

Cautions

1. To obtain best results, always make several observations and average them.

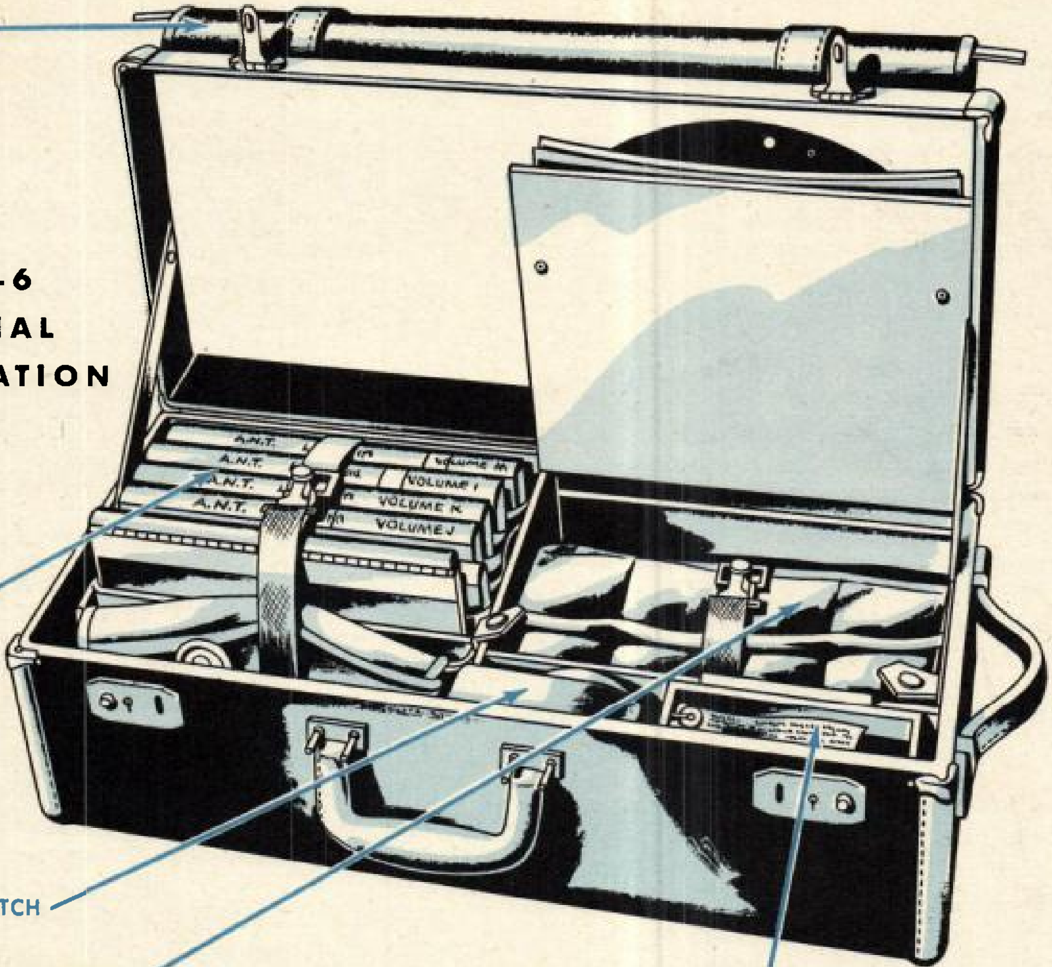
2. When declination and latitude are within 20° of each other, use the astrocompass as a pelorus.

3. In other latitudes, when the sun is above 45°, use the astrocompass as a pelorus.

4. Do not rely upon the astrocompass when you take bearings on bodies above 75° altitude.

5. Check alignment by using a sighting compass.

CELESTIAL NAVIGATION CASE



Take Care of Your Equipment

Type A-6 celestial navigation case is designed to carry all of your equipment, compactly and comfortably. Use it on every flight. Carry solution books and forms in the compartment constructed to fill this requirement. You can carry any type of sextant in the padded compartment equipped with the two tie-down straps. Always tighten the straps securely before closing the case.

Carry your maps in the outside pocket. They can either be folded or rolled.

Hang the insert containing your plotting equipment above your desk in the airplane.

Procure Type A-6 celestial navigation case through regular supply channels.

2. Place astrocompass in the standard and level.
3. Set the latitude and declination and LHA of the sun on the proper scales.
4. Rotate the astrocompass until the shadow of the bar falls between the parallel lines on the shadow screen.
5. Compare the true heading of the airplane with the astrocompass reading.
6. The difference between the two headings is the correction which must be applied to the astrocompass readings to obtain the true heading.
7. The error may be removed at one position of the astrocompass in the dome by loosening the base mounting screws and turning the standard until the two headings are the same. Tighten the base mounting screws and recheck alignment.

Another Method

1. Place a base standard on a saw-horse. Align it with a line drawn down the center of the horse.
2. Cut a notch at both ends of the line.
3. Align the saw-horse with the fore and aft axis of the airplane by dropping the plumb-bobs from the notches over a line parallel to the longitudinal axis.
4. Place the astrocompass on the saw-horse and find true heading. This is the correct true heading of the airplane.
5. Place the astrocompass in the base standard in the airplane to find the correction for that position.

Alignment Check

You can check the alignment by using the astrocompass as a pelorus. Set local hour angle at 0° or 180° and latitude at 90°. Obtain the bearing of some part of the airplane. Write this bearing down and keep it in your compartment so you can check alignment in flight on future missions.

Uses of the Astrocompass

1. **Check the true heading of the airplane.**
   a. Place the instrument in the mount and level it. An error of 1° in level may cause an error of 1° or more in observation.
   b. Set the latitude to the nearest degree.
   c. Calculate and set the local hour angle of the body to be observed on the proper hour angle scale.
   d. Set the declination of the body.
   e. Rotate the bearing plate until the sights are aligned on the body. In observing the sun or moon, rotate the bearing plate until the shadow cast by the shadow bar falls between the proper marks on the translucent screen.
   f. When the sights are aligned, read the true heading of the airplane against the lubber line.
2. **Steer a true heading.**
   a. Set the true heading you want to fly against the bearing plate lubber line.
   b. Set the instrument for latitude, declination and local hour angle and level it.
   c. Have the pilot turn the airplane until the selected body comes into your sights.
   d. Maintain heading by directional gyro.
   e. Check the true heading with the astrocompass at least every 15 minutes, altering the true heading steered on the directional gyro if necessary.
3. **Identify a star.**
   a. Place the compass in its mount and level it.
   b. Rotate the bearing plate until the true heading registers against the lubber line.
   c. Set the correct latitude.
   d. Turn the hour angle scale and adjust the declination scale until the star is on the sights.
   e. Read off the local hour angle of the star and its declination.
   f. Use the Air Almanac to calculate the sidereal hour angle of the star.
   g. From the table on the inside back cover of the Air Almanac, find the star by its declination and sidereal hour angle.
4. **Use as a pelorus.**
   a. Place the compass in its mount and level it.
   b. Set the true heading on the bearing plate, against the lubber line.
   c. Set the latitude scale to 90°. This makes the hour angle scales parallel to the bearing plate.
   d. Turn the hour angle knob until you sight the object, just as you would sight a star.
   e. Read the true bearing on the hour angle scale against the true bearing lubber line.
   f. Note that if the bearing plate were set to "N", you would read relative bearing.

Caution

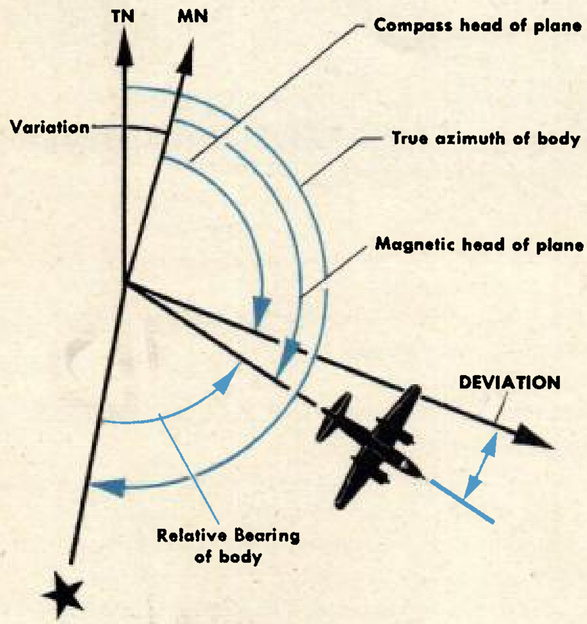
When turning the local hour angle scale, be sure to push in the knob. Don't force it.

When observing the sun or moon, be sure that the shadow of the bar on the front sight falls between the parallel lines on the shadow screen.

When observing any other body, place your eye behind the small magnifying glass and sight the star through the intersection of the white lines of the foresight. If you do not sight the star through the intersection of the white lines, you can still get a correct reading when it is vertically above the point of intersection of the white lines. Do not change the declination setting to put the star at the intersection.

CELESTIAL COMPASS SWING

Record the azimuth of the body observed and the relative bearing of that body from the heading of your plane, at a given instant of time. You can then find the magnetic heading of the airplane by using the following diagram:



Obtain the relative bearing of the body with your driftmeter, pelorus, astrocompass or gun turret.

Local Hour Angle Tables

Use the following local hour angle tables to make your air swinging easier.

This is an alternative to the more usual local hour angle graph employed when air swinging the compass by astrocompass. This critical table is both easier to prepare, and much handier to refer to while in the air.

1. Look up the Greenwich hour angle of the sun for the time at which you expect to begin the swing.
2. Convert this to local hour angle of the sun by applying your longitude in the usual way.
3. Add to the local hour angle the number of minutes necessary to increase it to the half degree; e.g., to 300° 11′ add 19′ = 300½°.
4. Correct time for this addition to the hour angle, by multiplying the number of minutes of arc added to the local hour angle by 4. The answer is **seconds of time** you must add to the original time.

Local hour angle of the sun alters at a rate of 1° in 4 minutes of time. Add 4 minutes to the time finally obtained above. This is the time at which the local hour angle reaches the next degree-and-a-half. Anywhere between these two times, you can set the whole degree on the astrocompass.

As an example:

You expect the swing to begin at 08:00 GCT and the Greenwich hour angle of the sun is 299° 53′. Local longitude is 5° 09′ West.

				GCT
299°	53′	=	GHA sun	08:00:00
−5°	09′		West longitude	
294°	44′	=	LHA sun	
+	46′		4 × 46 = 184 sec.	03:04
295½°		=	Local hour angle sun	08:03:04
and 296½°		=	Local hour angle sun	08:07:04

Therefore between 08:03:04 and 08:07:04, you can set 296° on your astrocompass. Then write the critical table as follows:

GCT	LHA Sun
08:03:04	
	← 296°
08:07:04	
	← 297°
08:11:04	
	← 298°
08:15:04	
	← 299°
08:19:04	
	← 300°
08:23:04	

Just keep adding 4 minutes and 1 degree each time. Then at any time between 08:15:04 and 08:19:04 the correct figure to set on your astrocompass is 299°.

If the swing doesn't start as soon as you expected it to, you can carry the table on for as long as necessary. If you carry it on for more than about 5 hours, an error of about 4 seconds of time is introduced.

ADJUSTMENT FOR TIME

PRECOMPUTED SOLUTIONS ARE GREAT TIME SAVERS

Two Methods of Adjusting for Time

1. The table that follows is self-explanatory with the possible exception that "Z" is the azimuth angle to the nearest pole. This can never be over 90°

Example

Make a precomputed solution for 0500 GCT on the body Dubhe. You find the azimuth to be 160°. The local hour angle is east.

a. At 04:55 you take an observation on Dubhe, at a dead reckoning latitude of 32° north, "Z", the azimuth angle to the nearest pole, is 20°.

b. Entering "Z," at 20° and latitude at 32° north, 4.4 is the change of altitude in one minute of time.

c. Since the observation was 5 minutes before the time of the solution, 4.4 is multiplied by 5. The correction you must apply to the observed altitude is 22 minutes of arc.

d. The rules directly below the table tell you whether to add the correction to the observed altitude or to subtract it from the observed altitude.

e. In this example the observation is early, and the local hour angle of the body is east. Local hour angle east means the body is rising. Add the correction to the observed altitude.

f. Be sure to move the line of position either up or back on the chart for distance run. For you must make a correction for your movement over the earth's surface, as well as for the motion of the body observed across the sky.

2. HO 218.

You can also use table IV in A.N.T. HO 218 to make adjustment for time.

Table IVa is the correction for the motion of the body for an interval of 3 minutes of time.

Table IVb is the correction for the motion of the body for any interval of time up to 3 minutes.

a. True azimuth being 160° and a correction for 5 minutes of time required at 32° north, enter Table IVa to find the correction for the motion of the body.

b. You find the figure plus 13 minutes. This is the correction for 3 minutes of time.

c. Enter Table IVb with 13 minutes at the required number of minutes of time, (2 in this case).

d. By interpolating between 12 and 15, you find the correction to be 9 minutes.

e. Add 13 and 9 to find the correction due to motion of body for 5 minutes. The correction is 22.

You can also use these tables to make the correction for your movement over the earth's surface.

Use the second part of Table IVa to find this correction for the motion of the observer.

Combine this correction with the correction for the motion of the body before entering Table IVb.

If you use this HO 218 solution you won't have to move the line of position once you have plotted it.

CHANGE OF ALTITUDE IN ONE MINUTE OF TIME (TABULATIONS IN MINUTES OF ARC)

LAT. \ Z	0°	2½°	5°	7½°	10°	12½°	15°	17½°	20°	22½°	25°	27½°	30°	32½°	35°	37½°	40°	42½°	45°	47½°	50°	52½°	55°	57½°	60°	62½°	65°	67½°	70°	75°	80°	90°	Z / LAT.
0°	0	0.7	1.3	1.9	2.6	3.2	3.9	4.5	5.1	5.7	6.3	6.9	7.5	8.0	8.6	9.1	9.6	10.1	10.6	11.0	11.5	11.9	12.3	12.7	13.0	13.3	13.6	13.8	14.1	14.5	14.8	15.0	0°
4°	0	0.7	1.3	1.9	2.6	3.2	3.9	4.5	5.1	5.7	6.3	6.9	7.5	8.0	8.6	9.1	9.6	10.1	10.6	11.0	11.5	11.9	12.3	12.6	13.0	13.3	13.6	13.8	14.1	14.5	14.7	15.0	4°
8°	0	0.7	1.3	1.9	2.6	3.2	3.8	4.4	5.1	5.7	6.3	6.8	7.4	7.9	8.5	9.0	9.5	10.0	10.5	11.0	11.4	11.8	12.2	12.5	12.9	13.2	13.5	13.7	14.0	14.4	14.6	14.9	8°
12°	0	0.7	1.3	1.9	2.5	3.1	3.8	4.4	5.0	5.6	6.2	6.7	7.3	7.8	8.4	8.9	9.4	9.9	10.4	10.8	11.2	11.6	12.0	12.3	12.7	13.0	13.3	13.5	13.8	14.2	14.4	14.7	12°
16°	0	0.7	1.3	1.9	2.5	3.1	3.7	4.3	4.9	5.5	6.1	6.6	7.2	7.7	8.3	8.8	9.3	9.8	10.2	10.6	11.0	11.4	11.8	12.1	12.5	12.8	13.1	13.3	13.5	13.9	14.2	14.4	16°
20°	0	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0	6.5	7.0	7.5	8.1	8.6	9.1	9.5	10.0	10.4	10.8	11.1	11.5	11.8	12.2	12.5	12.8	13.0	13.2	13.6	13.9	14.1	20°
24°	0	0.6	1.2	1.8	2.4	3.0	3.5	4.1	4.7	5.3	5.8	6.3	6.9	7.4	7.9	8.4	8.8	9.2	9.7	10.2	10.5	10.8	11.2	11.5	11.9	12.2	12.4	12.6	12.9	13.2	13.5	13.7	24°
26°	0	0.6	1.2	1.7	2.3	2.9	3.5	4.0	4.6	5.1	5.7	6.2	6.7	7.2	7.7	8.2	8.7	9.1	9.5	9.9	10.3	10.6	11.0	11.3	11.7	12.0	12.2	12.5	12.7	13.0	13.3	13.5	26°
28°	0	0.6	1.2	1.7	2.3	2.8	3.4	4.0	4.5	5.0	5.6	6.1	6.6	7.1	7.6	8.0	8.5	9.0	9.4	9.7	10.1	10.4	10.8	11.1	11.5	11.7	12.0	12.2	12.4	12.8	13.1	13.2	28°
30°	0	0.6	1.1	1.7	2.3	2.8	3.4	3.9	4.4	5.0	5.5	6.0	6.5	7.0	7.4	7.8	8.3	8.8	9.2	9.6	9.9	10.2	10.6	10.9	11.2	11.5	11.8	12.0	12.2	12.5	12.8	13.0	30°
32°	0	0.5	1.1	1.6	2.2	2.7	3.3	3.8	4.4	4.9	5.4	5.9	6.4	6.9	7.3	7.7	8.2	8.6	9.0	9.4	9.7	10.0	10.4	10.7	11.0	11.3	11.5	11.8	12.0	12.3	12.5	12.7	32°
34°	0	0.5	1.1	1.6	2.2	2.7	3.2	3.7	4.3	4.8	5.3	5.8	6.2	6.6	7.1	7.5	8.0	8.4	8.8	9.2	9.5	9.8	10.2	10.5	10.8	11.0	11.3	11.5	11.7	12.0	12.3	12.4	34°
36°	0	0.5	1.1	1.6	2.1	2.6	3.1	3.6	4.2	4.6	5.1	5.6	6.1	6.5	7.0	7.4	7.8	8.2	8.6	9.0	9.3	9.6	9.9	10.2	10.5	10.7	11.0	11.2	11.4	11.7	12.0	12.1	36°
38°	0	0.5	1.0	1.5	2.1	2.6	3.1	3.5	4.0	4.5	5.0	5.4	5.9	6.3	6.8	7.2	7.6	8.0	8.4	8.7	9.1	9.4	9.7	10.0	10.2	10.5	10.7	10.9	11.1	11.4	11.6	11.8	38°
40°	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	3.9	4.4	4.9	5.3	5.7	6.1	6.6	7.0	7.4	7.7	8.1	8.5	8.8	9.1	9.4	9.7	10.0	10.2	10.4	10.6	10.8	11.1	11.3	11.5	40°
42°	0	0.5	1.0	1.4	1.9	2.4	2.9	3.4	3.8	4.3	4.7	5.1	5.6	6.0	6.4	6.8	7.2	7.5	7.9	8.2	8.5	8.8	9.1	9.4	9.7	9.9	10.1	10.3	10.5	10.8	11.0	11.1	42°
44°	0	0.4	0.9	1.4	1.9	2.4	2.8	3.3	3.7	4.2	4.6	5.0	5.4	5.8	6.2	6.5	6.9	7.2	7.6	8.0	8.3	8.6	8.8	9.0	9.3	9.6	9.8	10.0	10.1	10.4	10.6	10.8	44°
46°	0	0.4	0.9	1.3	1.8	2.3	2.7	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.3	6.7	7.0	7.4	7.7	8.0	8.3	8.5	8.7	9.0	9.2	9.4	9.6	9.8	10.1	10.3	10.4	46°
48°	0	0.4	0.9	1.3	1.7	2.2	2.6	3.0	3.4	3.8	4.3	4.6	5.0	5.4	5.8	6.1	6.5	6.8	7.1	7.4	7.7	8.0	8.2	8.5	8.7	8.9	9.1	9.3	9.4	9.7	9.9	10.0	48°
49°	0	0.4	0.8	1.3	1.7	2.2	2.5	2.9	3.4	3.8	4.2	4.5	4.9	5.3	5.7	6.0	6.3	6.6	6.9	7.2	7.6	7.8	8.0	8.3	8.5	8.7	8.9	9.1	9.2	9.5	9.7	9.8	49°
50°	0	0.4	0.8	1.2	1.7	2.1	2.5	2.9	3.3	3.7	4.1	4.4	4.8	5.1	5.5	5.8	6.2	6.5	6.8	7.1	7.4	7.6	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.6	50°
51°	0	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.3	4.7	5.0	5.4	5.7	6.0	6.3	6.6	6.8	7.2	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.4	51°
52°	0	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.5	3.9	4.2	4.6	5.0	5.3	5.6	5.9	6.2	6.5	6.8	7.1	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.7	8.9	9.1	9.2	52°
53°	0	0.4	0.8	1.2	1.6	2.0	2.3	2.7	3.1	3.4	3.8	4.1	4.5	4.9	5.2	5.5	5.8	6.1	6.4	6.7	7.0	7.3	7.5	7.7	7.9	8.1	8.3	8.4	8.5	8.7	8.9	9.0	53°
54°	0	0.4	0.8	1.2	1.5	1.9	2.3	2.6	3.0	3.4	3.7	4.0	4.4	4.8	5.1	5.4	5.7	6.0	6.2	6.5	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.3	8.5	8.7	8.8	54°
55°	0	0.4	0.7	1.1	1.5	1.8	2.2	2.5	2.9	3.2	3.5	3.9	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.3	6.6	6.8	7.0	7.2	7.5	7.6	7.8	8.0	8.1	8.3	8.5	8.6	55°
56°	0	0.4	0.7	1.1	1.5	1.8	2.2	2.5	2.9	3.2	3.5	3.8	4.2	4.5	4.8	5.1	5.4	5.7	5.9	6.2	6.4	6.7	6.9	7.1	7.3	7.4	7.6	7.8	7.9	8.1	8.3	8.4	56°
57°	0	0.3	0.7	1.1	1.4	1.7	2.1	2.5	2.8	3.1	3.5	3.8	4.1	4.4	4.7	5.0	5.2	5.5	5.8	6.0	6.3	6.5	6.7	6.9	7.1	7.2	7.4	7.6	7.7	7.9	8.0	8.2	57°
58°	0	0.3	0.7	1.0	1.4	1.7	2.0	2.4	2.7	3.0	3.4	3.7	4.0	4.3	4.6	4.8	5.1	5.3	5.6	5.8	6.1	6.3	6.5	6.7	6.9	7.0	7.2	7.4	7.5	7.7	7.8	8.0	58°
59°	0	0.3	0.7	1.0	1.3	1.6	2.0	2.3	2.6	3.0	3.3	3.6	3.9	4.2	4.4	4.7	5.0	5.2	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.0	7.2	7.3	7.5	7.6	7.7	59°
60°	0	0.3	0.7	1.0	1.3	1.6	1.9	2.3	2.6	2.9	3.2	3.6	3.8	4.1	4.3	4.6	4.8	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.8	6.9	7.0	7.2	7.4	7.5	60°
61°	0	0.3	0.7	1.0	1.3	1.6	1.9	2.3	2.6	2.9	3.2	3.6	3.8	4.1	4.3	4.6	4.8	5.1	5.3	5.5	5.7	5.9	6.1	6.3	6.5	6.6	6.7	6.8	6.9	7.0	7.2	7.3	61°
62°	0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.5	3.8	4.0	4.2	4.5	4.7	5.0	5.2	5.4	5.6	5.8	5.9	6.1	6.2	6.4	6.5	6.6	6.7	6.9	7.0	62°
63°	0	0.3	0.6	0.9	1.2	1.5	1.7	2.0	2.3	2.6	2.9	3.1	3.4	3.6	3.8	4.0	4.3	4.5	4.8	5.0	5.2	5.4	5.6	5.7	5.9	6.0	6.2	6.3	6.4	6.5	6.7	6.8	63°
64°	0	0.3	0.6	0.9	1.2	1.4	1.7	2.0	2.3	2.6	2.8	3.0	3.3	3.5	3.7	3.9	4.2	4.4	4.7	4.9	5.1	5.2	5.4	5.5	5.7	5.8	6.0	6.1	6.2	6.3	6.4	6.5	64°
65°	0	0.3	0.6	0.9	1.1	1.4	1.6	1.9	2.2	2.5	2.7	2.9	3.2	3.4	3.6	3.8	4.1	4.3	4.5	4.7	4.9	5.0	5.2	5.3	5.5	5.6	5.8	5.9	6.0	6.1	6.2	6.3	65°
66°	0	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.1	2.4	2.6	2.8	3.0	3.3	3.5	3.7	4.0	4.1	4.3	4.5	4.7	4.9	5.0	5.1	5.3	5.4	5.5	5.6	5.7	5.9	6.0	6.1	66°
67°	0	0.2	0.5	0.8	1.0	1.2	1.5	1.7	2.0	2.3	2.5	2.7	2.9	3.2	3.4	3.6	3.8	4.0	4.1	4.3	4.5	4.7	4.8	5.0	5.1	5.2	5.3	5.4	5.5	5.7	5.8	5.9	67°
68°	0	0.2	0.5	0.8	1.0	1.2	1.5	1.7	1.9	2.1	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.1	4.3	4.5	4.6	4.8	4.9	5.0	5.1	5.1	5.2	5.4	5.5	5.6	68°
69°	0	0.2	0.5	0.7	0.9	1.1	1.4	1.6	1.8	2.0	2.3	2.5	2.7	2.9	3.1	3.3	3.5	3.6	3.8	4.0	4.1	4.3	4.4	4.6	4.7	4.8	4.9	5.0	5.0	5.1	5.3	5.4	69°
70°	0	0.2	0.5	0.7	0.9	1.1	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.1	3.3	3.5	3.6	3.7	3.9	4.1	4.2	4.3	4.5	4.6	4.7	4.7	4.8	4.9	5.0	5.1	70°
71°	0	0.2	0.4	0.6	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.4	2.6	2.8	2.9	3.1	3.3	3.5	3.6	3.7	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	71°
72°	0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.1	2.3	2.5	2.6	2.8	2.9	3.1	3.3	3.4	3.5	3.7	3.8	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.6	72°
73°	0	0.2	0.4	0.6	0.8	0.9	1.1	1.3	1.5	1.7	1.9	2.0	2.2	2.4	2.5	2.7	2.8	3.0	3.1	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.1	4.2	4.3	4.4	73°
74°	0	0.2	0.4	0.6	0.8	0.9	1.1	1.2	1.4	1.6	1.8	1.9	2.0	2.2	2.4	2.5	2.6	2.8	2.9	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.9	3.9	4.0	4.1	74°
75°	0	0.1	0.3	0.5	0.7	0.8	1.0	1.1	1.3	1.5	1.6	1.8	1.9	2.0	2.2	2.3	2.5	2.6	2.7	2.9	3.0	3.1	3.2	3.3	3.4	3.4	3.5	3.5	3.6	3.7	3.8	3.9	75°
LAT. / Z	0°	2½°	5°	7½°	10°	12½°	15°	17½°	20°	22½°	25°	27½°	30°	32½°	35°	37½°	40°	42½°	45°	47½°	50°	52½°	55°	57½°	60°	62½°	65°	67½°	70°	75°	80°	90°	Z \ LAT.

RULES

- IF OBSERVATION IS EARLY AND BODY RISING / SETTING CORRECTION IS ADDED TO / SUBTRACTED FROM OBSERVED ALTITUDE
- IF OBSERVATION IS LATE AND BODY RISING / SETTING CORRECTION IS SUBTRACTED FROM / ADDED TO OBSERVED ALTITUDE

RUDE STAR FINDER

KEEP YOUR STAR IDENTIFIER WITH YOU ALL THE TIME

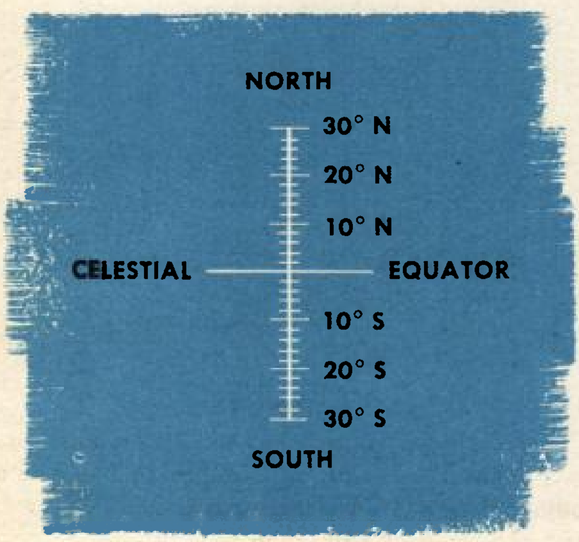
Use the template nearest your latitude and place the zero degree line over the local hour angle of Aries. This shows you the relative position of all the stars in the sky at the time of observation.

Remember, the local hour angle of Aries and the right ascension of your meridian are the same.

To plot a planet or moon on your star identifier:

1. Subtract the Greenwich hour angle of the planet or moon from the Greenwich hour angle of Aries (plus 360° if necessary).
2. Take these values from the same horizontal line in the Air Almanac.
3. Mark the resulting value on the outer edge of the star base and draw a pencil line to the pole.
4. Plot the planet or moon at a distance along this line equal to the body's declination. You can measure distance on the scale shown on the identifier instruction sheet, and transfer it to the base.

The scale is reproduced below.



Be sure to have the North Pole of the star finder up when you are in the Northern Hemisphere, and the South Pole up when you are in the Southern Hemisphere. This is important.

Example: Your dead reckoning position is 42° 25′ N 83° W on Saturday 22 April 1944 at GCT 23:20. Your true heading is 50°.

GHA Aries	200° 53′	
Longitude	83° W	
LHA Aries	117° 53′	This is the same as the right ascension of your meridian.

Place the 45° N template over the northern sky base. Rotate the template to bring the arrow of the 0°-180° line to 118° on the outer edge of the base.

The stars that will give you good course lines are:

1. Regulus approximate altitude 47°
2. Alphard approximate altitude 33°
3. Caph approximate altitude 26°
4. Ruchbah approximate altitude 35°

These are good course line stars because they bear approximately 90° from your heading of 50°.

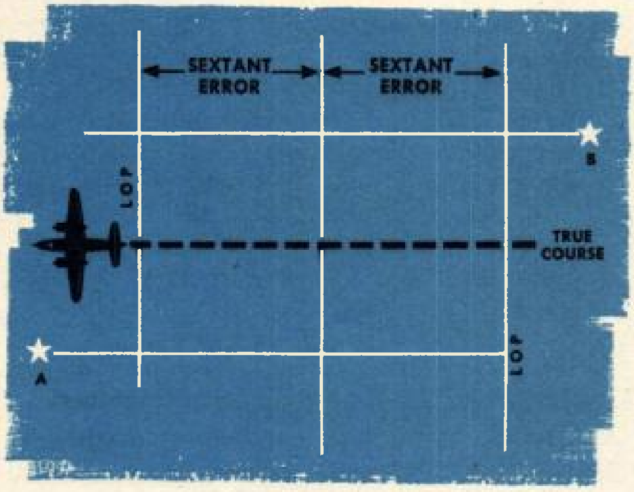
The stars that will give you good speed lines are:

1. Dubhe approximate altitude 58°
2. Alioth approximate altitude 43°
3. Mizar approximate altitude 39°
4. Rigel approximate altitude 27°
5. Bellatrix approximate altitude 40°
6. Betelgeux approximate altitude 45°
7. Alnilam approximate altitude 35°

These are good speed line stars because they lie nearly directly ahead or behind your airplane.

Whenever you are in doubt as to the identity of any star, use your star finder to give you the approximate altitude and bearing of the star from your position and heading.

Checking the Sextant in the Air



At Night

1. Observe a body on one side of the airplane that will give you a good course line.

2. Observe a body on the other side of the airplane that will give you a good course line.

Take 3 lines of position on each body, and reduce each set of 3 to a single line of position by moving them up or averaging them visually.

If it is possible to shoot forward and to the rear from the airplane you are flying, observe speed line stars and use them in the same manner.

If your observations are accurate and your sextant error is zero, all lines of position on bodies with the same or reciprocal azimuth will fall on top of each other after being reduced to the same time.

3. Measure the distance between the two lines of position and divide by 2. This is your sextant error.

4. The sign of the error is determined by the lines of position falling away from, or toward the bodies observed. If the lines of position fall away from the bodies observed, the correction is plus, if they fall toward the bodies observed, the correction is minus.

Pilotage Fix

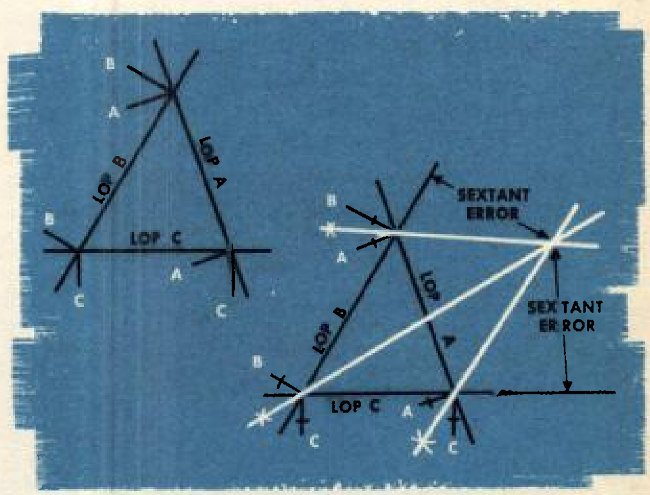
Take a set of observations while passing over a definite pilotage fix. Check your observations for sextant error against the pilotage fix.

Another Method

1. Shoot a 3 star fix and plot the lines of position.

2. If you get a large triangle, draw lines perpendicular to each line of position at the corners of the triangle. These lines represent the true azimuth of each of the bodies.

3. Bisect the angle formed by these lines at the corners of the triangle. The intersection of the bisectors is your most probable position. The difference between this point and the lines of position gives the sextant correction.



Remember

These methods determine the correction due to the sextant consistently shooting high or low on any body. It does not tell you your personal error which may vary on each shot from plus to minus.

CHECKING TIME

Precomputed Curve

Use a precomputed curve and a correct sextant to find the correct time. Measure a series of altitudes, recording each altitude and corresponding watch time. Plot each measured altitude exactly on the curve, and note the corresponding curve time. Then compare watch and curve times for watch error. The average of time discrepancies of a number of observations is the watch error.

Time Check by Equal Altitudes

Checking your time within a few seconds depends upon your ability to shoot accurately and to record your time accurately. You can use this method during the daytime by shooting the sun, and at night by shooting one of the stars or planets.

If a body has a constant declination, it passes evenly across the sky at a constant rate. When it is 15° east of your meridian, you will observe the same altitude as when it is 15° west of your meridian. The altitude of the body, therefore, depends upon the magnitude of the local hour angle. It takes the same length of time for the body to travel from a certain altitude east of your meridian to the meridian as it takes the body to pass from your meridian to the same altitude west of your meridian.

Use this fact to correct your watch as follows:

1. Observe the body an hour or so before crossing your meridian and record the Hs and the chronometer time. Take at least three sets of observations.

2. Observe the body after it has crossed your meridian, when its altitude is slightly higher than the last observation. Take several sets of observations until the Hs becomes less than that of the first observation.

3. Construct a small graph, plotting Hs against chronometer time, and draw a smooth curve through the plotted shots. Choose the times so that the two curves intersect on the graph.

4. Average the two times where the Hs curves intersect. This is the chronometer time of meridian transit. Compare this with the computed time of meridian transit to obtain the chronometer error.

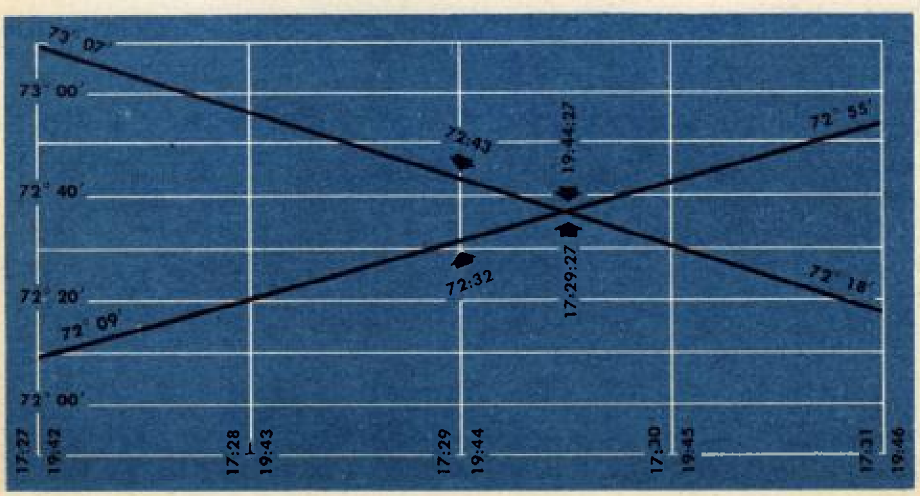
You can use this method on any star or planet as well as the sun. The fact that the sun's declination changes slightly during the interval between observations causes an error which is negligible. The advantage of this method is that you need not apply corrections for refraction or sextant error, and you don't need to know your latitude accurately.

Problem

As an example of this procedure, on 16 July 1943 the sun was observed at 97° 52′ W as follows:

Observations Sun Rising	Chronometer Time GCT	Observations Sun Setting	Chronometer Time GCT
72° 09′	17:27:00	73° 07′	19:42:00
72° 32′	17:29:00	72° 43′	19:44:00
72° 55′	17:31:00	72° 18′	19:46:00

Plot these observations on a graph. The time of intersection of the two curves is 17:29:27 and 19:44:27 GCT. The mean time is, 18:36:57 GCT, which is the chronometer time of meridian transit. The computed time of the meridian transit is 18:37:20 GCT, giving a chronometer error of −23 seconds.



TIME CHECK BY EQUAL ALTITUDES

DATE, 16 JULY 1943
LONG. 97° 52′ W
M.T. ⊙ = 18:37:20
M.T. CHRON. = 18:36:57
CHRON. ERROR = −23 SECONDS

LANDFALLS

Landfalls are of two types: course line landfalls and speed line landfalls.

Course Line Landfall

The easiest landfall to fly and things being equal, the most accurate, is the course line landfall.

1. Observe a celestial body that gives a course line, line of position. Plot it on your Mercator chart.
2. Advance the line of position through destination parallel to the one you just plotted.
3. Fly directly to the line of position through destination and turn toward destination.
4. Stay on this line of position until another line of position shows you to be off course.
5. Then repeat the process. But stay on a line of position through destination. There is no ETA in a landfall other than your best known groundspeed.

Speed Line Landfall

Because a course line is at times the more difficult type of line of position to observe, and because sometimes only speed lines are available, you will also fly a speed line landfall.

In this type of landfall fly definitely to one side of destination. When you reach the speed line through destination, turn and fly into destination.

Precomputed landfalls, intersection of Ho-Hc curves, and double Ho-Hc curves are variations of the simple landfall. Use these for speed line landfalls ordinarily. The double Ho-Hc curve is really a series of precomputed fixes. But it is used as a landfall.

In actual combat the use of landfalls is limited, for you must make most base approaches from certain bearings and at certain altitudes. To keep from arousing the interceptors on particular bases each time you approach them, you must give definite ETA's. This is impossible when flying a landfall.

In the interest of precomputed work, the following HO 218 precomputed landfall is a definite time saver.

HO 218 Precomputed Landfall

No curves to be drawn. No long hours of precomputed work. All work accomplished during the flight in your spare time. It is easy and accurate.

Here's How

1. Figure an approximate ETA for destination.
2. Pick a body that will give a good speed line.
3. Find the Greenwich hour angle of that body at 20 minute intervals. Each Greenwich hour angle will end in approximately the same number of minutes.
4. Use an assumed longitude to give you a local

hour angle of even degrees.

5. Enter HO 218 by an assumed position as close to destination as possible, and extract an Hc and an azimuth for each 20 minute interval.

6. Plot at least one line of position on your Mercator at your assumed position.

7. Measure the distance necessary to move this line of position through destination, and apply this correction to each Hc.

8. When approaching the line of position through destination, establish track by observation of course line stars if possible.

9. Observe the body for which you made the precomputation.

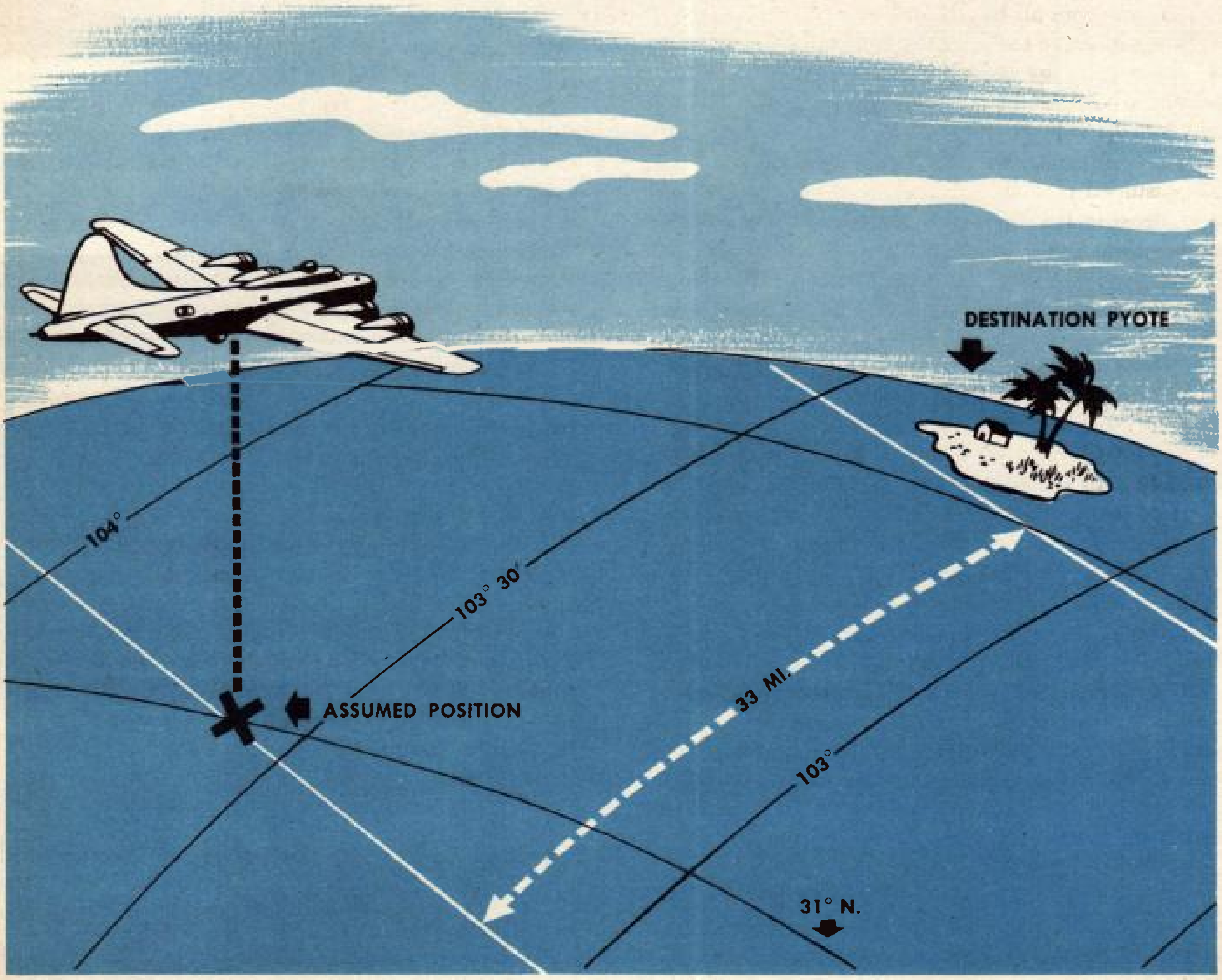
10. Visually compare Ho's with Hc's.

11. When Ho is equal to Hc, turn on the azimuth plus or minus 90°.

Problem

Depart from 34° 30′ N, 99° 30′ W, at flight altitude of 10,000 feet, flying a true course of 233°. This will place you about 35 miles right of destination, Pyote, 31° 31′ N, 103° 09′ W. Departure time is 18:50 GCT, with a dead reckoning groundspeed of 170 knots, which will make your arrival on the line of position through destination approximately 20:17 GCT, as the distance is approximately 248 nautical miles.

Precompute a table for 20:00 GCT to 21:20 GCT. Enter the Almanac as of the date April 26, 1943, at 20:00 GCT and find the Greenwich hour angle of the sun to be 120° 33′; 20:20 GCT is 125° 33′, 20:40 GCT is 130° 33′, 21:00 GCT is 135° 33′, and 21:20 GCT is 140° 33′. Note that at 20 minute intervals the number of minutes of Greenwich hour angle of the sun al-



ways agrees within a mile or two, which presents no great difficulties.

Then, assume a position of 31° N, 103° 33′ W, in order to work the solutions by HO 218.

Applying your assumed longitude to the Greenwich hour angle of the sun, you have local hour angles of 17° W for 20:00 GCT, 22° W for 20:20 GCT, 27° W for 20:40 GCT, 32° W for 21:00 GCT, and 37° W for 21:20 GCT.

Then enter the HO 218 solution book, under declination N13° 26′, and extract the Hc's and azimuth for the body.

	Hc	Azimuth
20:00 GCT	66°29′	225°
20:20 GCT	63°13′	233°
20:40 GCT5	59°36′	240°
21:00 GCT	55°45′	246°
21:20 GCT	51°46′	250°

Extract them all by opening the book but once.

You now have the change of altitude and azimuth of the body at the position of 31° N, 103° 33′ W. You want the altitude of the body at destination, Pyote, 31° 31′ N, 103° 09′ W.

To obtain this, draw the line of position through the assumed position for each of the time intervals, and measure the distance required to move each line of position through destination, Pyote. Apply the proper sign to the correction by noting whether this action is increasing or decreasing the altitude of the body. This is done as follows:

	Hc	Correction	Corrected Hc
20:00 GCT	66°29′	-36′	65°53′
20:20 GCT	63°13′	-35′	62°38′
20:40 GCT	59°36′	-33′	59°03′
21:00 GCT	55°46′	-32′	55°14′
21:20 GCT	51°46′	-30′	51°16′

You now have the altitude of the sun for 1 hour and 20 minutes at destination. When you approach the line of position through destination, start shooting.

As you shoot, visually interpolate between the Hc's you have computed, in order to compare your observations with your precomputed solutions. You can break down your Hc's to 5 minute intervals to make your interpolation easier, as below.

20:00 GCT	65°53′ (difference 49′)
20:05 GCT	65°04′ (difference 49′)
20:10 GCT	64°15′ (difference 49′)
20:15 GCT	63°26′ (difference 48′)
20:20 GCT	62°38′ (difference 54′)
20:25 GCT	61°44′ (difference 54′)
20:30 GCT	60°50′ (difference 54′)
20:35 GCT	59°56′ (difference 53′)
20:40 GCT	59°56′ (difference etc.)

Then start shooting. Your shots fall as follows:

	Ho	Hc
20:03 GCT	63°53′	65°23′
20:12 GCT	62°45′	63°55′
20:19 GCT	62°01′	62°45′
20:27 GCT	61°00′	61°22′
20:31 GCT	60°28′	60°39′
20:33 GCT	60°12′	60°17′

At 20:33 GCT you see that you are within 5 miles of the line of position through destination, so at 20:35 you turn on the line of position and continue to observe the body to make sure that you stay on it.

Remember

Find an assumed position as close to your destination as possible that will give you latitude and local hour angle of an integral degree.

Then solve for azimuth and altitude from this position for a time period in which you are sure you will reach the line of position through destination.

Draw the line of position through your assumed position, and measure the distances necessary to move them through destination. Bearing in mind whether you are correcting away from or toward the body, apply the proper sign to the correction. Apply these corrections to the computed altitudes.

As you approach the line of position through destination, take repeated observations on the body, visually interpolating to check the difference between Ho and Hc. When the Ho coincides with the Hc, turn on the azimuth plus or minus 90°.

SECTION 4 ★

TACTICAL OPERATIONS

THE MOST IMPORTANT PHASE OF NAVIGATION DEVELOPS FROM TACTICAL OPERATIONS, AND YOU CAN'T AFFORD TO BE SATISFIED WITH MEDIOCRE RESULTS. YOU HAVE TO BE RIGHT THE FIRST TIME.

CREW COORDINATION

It is your duty to understand thoroughly the duties of each crew member and when necessity demands it, to take over for any one of them. By the same token it is your responsibility to see that each individual crew member is aware of the navigational help he can give both in preparation for and execution of a mission.

Share responsibilities and duties with the crew in frequent conferences. The results of the talks you have with the other crew members must be tested in training before you get into combat. It is a team operation and it takes practice and constant correction before you can rely on each other.

Be open-minded. Your crew members may have some valuable suggestions to offer that will make your navigation easier and more accurate.

Aid from the Crew

The primary aids the various crew members are able to supply are suggested as follows:

PILOT

Correct technique of flying during the taking of radio bearings, drift reading, and celestial observations. During any evasive action, an attempt must be made to make variations from the intended course cancel out both in altitude flown and general heading maintained.

COPILOT

Pilotage by checking prominent landmarks under your direction.

BOMBARDIER

Drift readings must be taken and compared with yours at all times. Constant pinpoint pilotage must be maintained, especially on nearing and turning over Initial Point.

RADIO MAN

Radio bearings must be available upon your request, at any given instant. He must initiate requests for position reports at the proper time.

ENGINEER

Must understand all necessary calibrations and the alignment of all navigational instruments, in order that engine changes and new installations may be fully evaluated.

GUNNERS

The individual gunners must be conversant with the method of taking bearings both from the rear turret and the upper turret. They must be able to recognize all prominent landmarks along the proposed route of flight.

EFFECTS OF HIGH ALTITUDE

When you ascend into the atmosphere the air pressure drops. The higher you go the less dense the atmosphere becomes. At 18,000 feet the pressure is only 7½ pounds per square inch, or one-half of what it is at sea level. With increasing altitude the air also gets colder, up to 35,000 feet. Decrease in pressure on the body results in:

Oxygen want (Anoxia)
Expansion of trapped gases
Decompression sickness

Oxygen Want (Anoxia)

The air we breathe always contains the same proportion of oxygen—21%. When the air pressure drops, however, the oxygen pressure drops correspondingly. Oxygen pressure is necessary for maintaining the proper amount of oxygen in the blood. At sea level, the pressure is sufficient to keep the blood at least 95% saturated with oxygen. This degree of saturation is necessary for peak mental and physical efficiency. When the percentage of oxygen in the blood drops, your efficiency falls off. This condition is known as anoxia or oxygen want.

In flight, oxygen want begins to affect you at altitudes above 5000 feet. It does not seriously affect efficiency, however, below 10,000 feet, except at night or on long flights. Its effect is so gradual you may not notice it. In fact, you usually feel exceptionally good in the early stages. This is one of the things that makes oxygen want so dangerous.

Unless the deficiency in oxygen is made up, your mind becomes dull; your memory, judgment, and muscular control grow worse and worse; vision and hearing are poor. Fatigue and sleepiness set in; you may have fits of laughing and crying; and finally unconsciousness and even death may occur. Above 20,000 feet anoxia causes most people to lose consciousness within a short time.

The higher you fly, the longer you stay, the more you exert yourself, the more likely you are to suffer anoxia, unless you are wearing your oxygen mask.

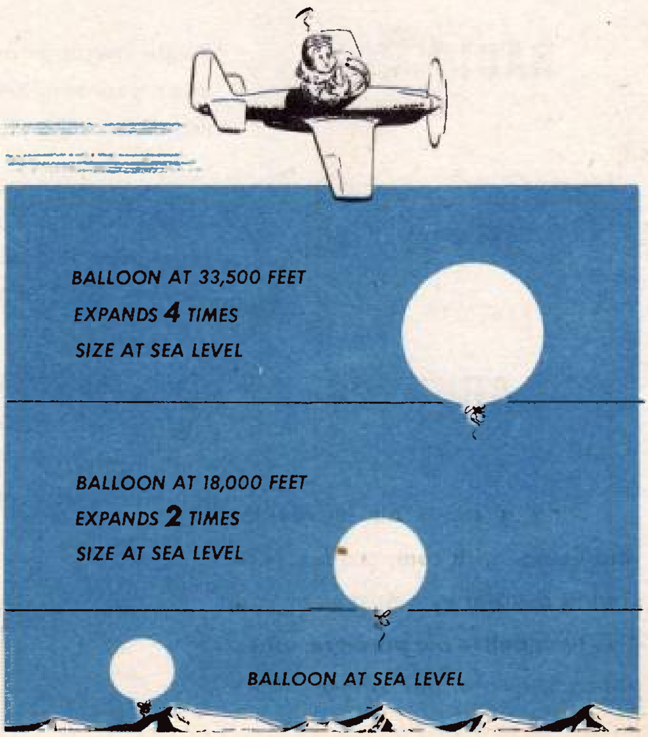
The only way to avoid oxygen want, unless your cabin is pressurized, is to use your oxygen equipment on all flights above 10,000 feet. On all flights of 4 hours or longer use oxygen above 8000 feet. Don't depend on your feelings. You can't rely on them to tell you when you need oxygen. Regulations require using oxygen any time you fly above an **indicated altitude of 10,000 feet above sea level.** This may not agree with the reading of your altimeter if you have set it to zero for a given field.

If you ever suffer from oxygen want, see your Flight Surgeon immediately afterward.

On night flights you should use oxygen (Auto-Mix ON or NORMAL OXYGEN) from the ground up. This helps improve your night vision.

Expansion of Trapped Gases

Expansion of body gases occurs in the stomach, intestines, sinuses, and middle ear with increasing altitude. As the outside pressure decreases, these gases tend to increase in volume and cause pain when they can't be released.



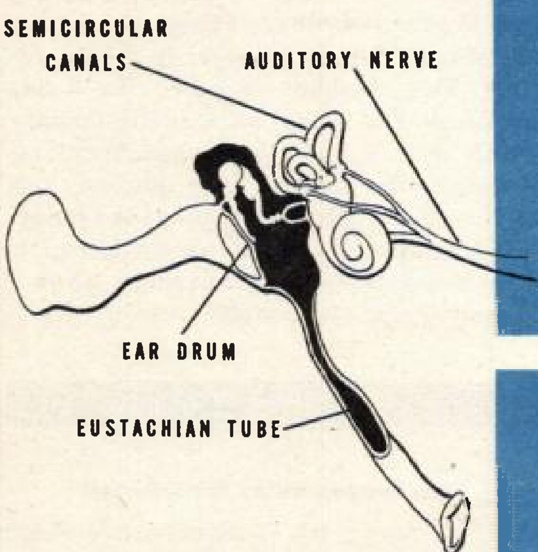
The volume of gas in the stomach and intestines tends to expand these organs like a balloon, and may cause cramps when you ascend to high altitudes. You can obtain relief by belching or passing wind. Otherwise it may be necessary to descend to a lower altitude. Gas troubles can be controlled, at least partially. When you are flying frequently, avoid gas producing food such as beans, cabbage, and carbonated beverages. Remember what foods give you trouble in flight and avoid them. Don't chew gum before or during high altitude flights. You swallow too much air when you chew.

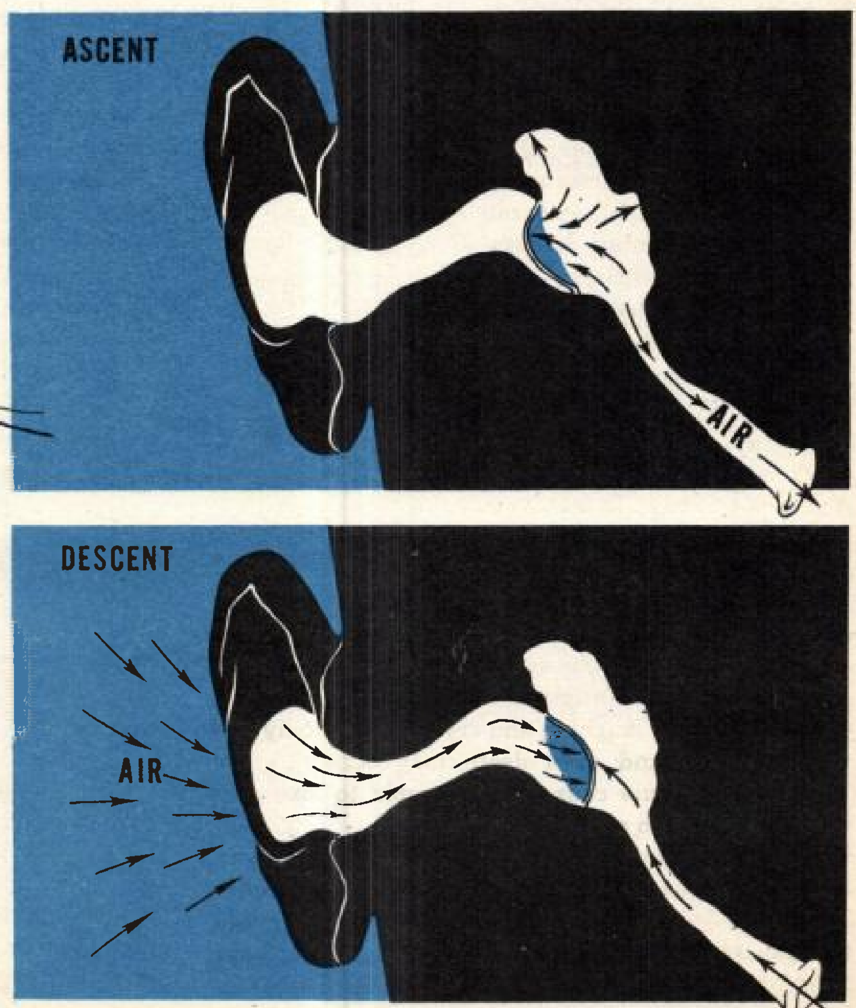
The Ears

The sinuses and middle ear are bony spaces in the head which contain air. These spaces have a moist lining like the nose and mouth. Ordinarily air leaves and enters the sinuses easily by way of small openings into the nose as you ascend and descend. As the air in the middle ear expands it pushes on the ear drum and makes your ear feel full. At intervals while you are gaining altitude the air slips out of the middle ear through a slit-like opening called the Eustachian tube. Each time this opens you hear a click and the pressure is equalized. During descent, however, you must make an effort to clear your ears. You can do this by swallowing, yawning, or pinching your nose and blowing gently with your mouth shut. This lets the air back in and equalizes the pressure. Practice clearing your ears. If you do this, it will increase the rate of descent you can stand comfortably.

When you have a cold the linings of the sinuses and the Eustachian tube are swollen. It may then be difficult or impossible to clear your ears, and you may suffer great pain as you lose altitude. Your ear drums may even rupture. Pressure changes in the sinuses are also painful. Therefore don't fly when you have a cold, unless it is absolutely necessary. If you have to fly, see your Flight Surgeon first.

INSIDE THE MIDDLE EAR





During a climb air leaves the middle ear with comparative ease. During descent you must clear your ears to equalize the pressure; otherwise your eardrums stretch. That's what makes them hurt.

ASCENT TO 25,000 FEET WITHOUT OXYGEN

a sample of normal hand-writing in flight at 2000 ft

Control specimen of normal handwriting.

10000 ft - breathless

No apparent effect.

15000 ft - feel uneasy generally punk feeling some numbness in legs and hands

Beginning muscular incoordination.

18000 ft [illegible]

Definite physical and mental inefficiency.

20000 ft: faint - numbness in legs: vision fading

Last zero off both 18,000 and 20,000—marked incoordination.

22000 ft: [illegible] pale to me feel better

Feeling better? Evidence of false feeling of well-being.

23000 ft: feel good except for deep breathing both legs numb

Feel good. Insight, judgment and coordination exceedingly faulty.

24000 feet - [illegible]

Mental and physical helplessness.

25000 ft oxygen turned on

Improvement with few breaths of oxygen.

3600 ft. things look brighter - Hearing returning feel o.k. now -

Last zero left off—general improvement, but not completely normal.

Be sure that your oxygen equipment is functioning perfectly, that you know how to use it, that your mask fits properly, and that you know what to do in an emergency. Sudden removal of your oxygen supply at 30,000 feet will produce great mental and physical inefficiency in 30 to 60 seconds and unconsciousness in 30 to 90 seconds.

See your Personal Equipment Officer for proper operation of your oxygen equipment.

Decompression Sickness

Not only do body gases expand when atmospheric pressure decreases, but nitrogen gas in solution in the body tissues tends to escape and form bubbles. This reaction is similar to what happens when you take the cap off a bottle of soda. The pain and discomfort which result are known as **decompression sickness or aeroembolism.**

Trouble seldom develops below 30,000 feet. However, you're more likely to get it the higher you go above this altitude, the longer you stay there, the faster you climb, and the more you exercise. Then the nitrogen in your body forms bubbles, which frequently appear about the joints and in the tissues. Pain results. This condition is called **the bends.** Sometimes a feeling of weight on your chest occurs, together with tightness and pain when breathing. This is known as **the chokes.** Your skin may feel irritated and begin to itch. This is called **the creeps.**

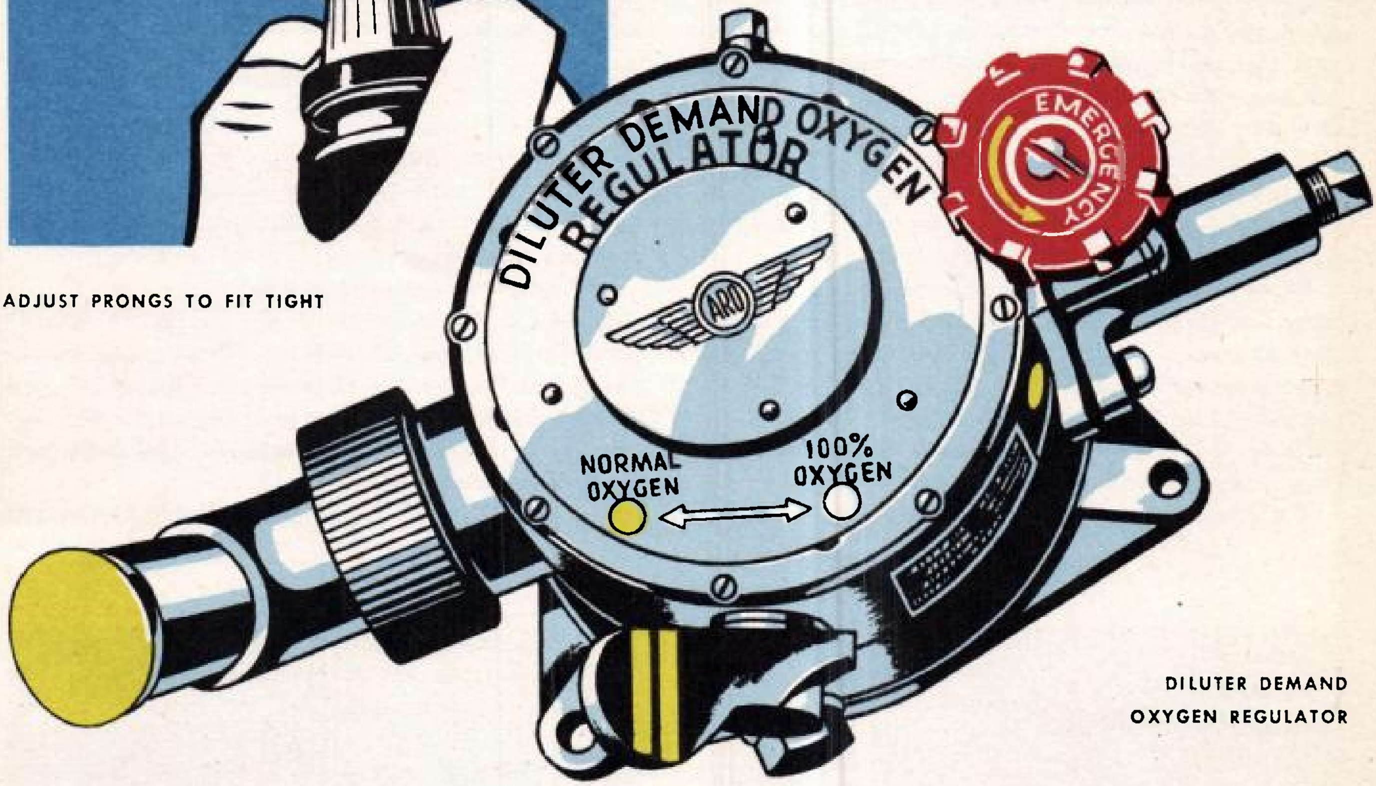
All of these conditions are relieved by descent to 20,000 feet or lower. If you ever have them, see your Flight Surgeon as soon as possible.

Five Golden Rules for Oxygen

1. Use oxygen for all flights above 10,000 feet.
2. Use oxygen from ground up on all night flights.
3. Use oxygen on all flights above 8000 feet if in excess of 4 hours.
4. Judge your need for oxygen by your altimeter: don't rely on your sensations.
5. Check all oxygen matters with your Personal Equipment Officer.

OXYGEN EQUIPMENT

ADJUST PRONGS TO FIT TIGHT



DILUTER DEMAND OXYGEN REGULATOR

General—Oxygen Systems

Oxygen systems are of two general types:

1. Demand System.
2. Continuous Flow System.

The demand system is automatic. It furnishes oxygen only when you breathe and in just the right amount at each altitude. Every time you draw a breath, oxygen is supplied with the proper mixture of air. All combat aircraft have demand oxygen equipment.

The continuous flow system supplies oxygen in a constant flow. To insure delivery of the proper mixture for each altitude, you must adjust a dial manually on the A-9A regulator to correspond with the altimeter reading. The A-11 regulator, used for passengers, is automatic.

Demand System

The demand oxygen system includes a demand type mask, diluter-demand regulator, pressure gage, and ball or blinker type flow indicator. In addition, a portable recharger hose is supplied at each crew position in heavy bombardment aircraft for recharging portable (walk-around) oxygen equipment from the oxygen system of the airplane.

Two types of demand oxygen masks are available —Type A-10A and Type A-14. They are used with the demand type regulators, the A-12 or AN-6004-1 regulator for permanent installations within the airplane, and the A-13 or A-15 regulator for portable use. The demand regulator is essentially a diaphragm-operated flow valve which opens by suction when you inhale and closes when you exhale. Types A-12 and AN-6004-1 are provided with two manual controls for use under special conditions—

the Auto-Mix or oxygen control lever, and the Emergency Valve.

With the Auto-Mix lever in the NORMAL OXYGEN or ON position, the A-12 and AN-6004-1 diluter-demand regulators automatically mix just the right amount of oxygen with the air for the altitude at which the plane is flying. This is accomplished by an aneroid control like the one in the altimeter. At sea level the aneroid is fully contracted and the air intake port is wide open while the oxygen port is closed. As the altitude increases and the pressure decreases, the aneroid expands and gradually closes the air intake port. Finally, at an altitude of 30,000 to 34,000 feet the air intake port is entirely closed. The oxygen port is wide open and delivers pure oxygen to the mask.

Remember, the normal position for the Auto-Mix lever is NORMAL OXYGEN or ON. When it is in that position the regulator automatically furnishes the proper amount of oxygen for all altitudes. When the Auto-Mix lever is in the 100% OXYGEN or OFF position, the air intake port is closed and pure oxygen is supplied at all altitudes.

The Type A-15 regulator, for portable use, is not provided with an Auto-Mix lever; the mixing of air and oxygen is entirely automatic.

When the red Emergency Valve knob on the regulator is turned on, the oxygen by-passes the demand mechanism in the regulator and enters the mask in a steady flow, regardless of breathing and of altitude. This valve, therefore, should not be opened except in emergency, as the oxygen supply will be exhausted quickly.

Precautions

Preflight Check:

1. Make sure mask fits properly. Check for leaks by holding thumb over end of hose and inhaling gently. Have your Personal Equipment Officer check size and fit with his special test set or Demand Mask Leak Detector, whenever possible.

2. Check the pressure of the oxygen system. It should not be less than 400 pounds per square inch.

Caution: When the Emergency Valve is open do not pinch the hose or block the outlet, for this causes the regulator diaphragm to blow out. Then be sure to close the valve tightly.

3. Check knurled collar and hose at outlet end of

A-14 DEMAND MASK

A-10A DEMAND MASK

regulator. They should be tight.

4. Check rapid-disconnect fitting on mask hose. Be sure rubber gasket is in place. Make sure male end of fitting fits tightly into the regulator hose. It should withstand a pull of 10 to 20 pounds. Your tubing may have the C-ring type disconnect; if so, check it the same way.

5. Clip oxygen-supply hose to clothing or parachute harness so that it allows movement of head without kinking or pulling the hose.

6. Be sure the Auto-Mix lever is in the NORMAL OXYGEN or ON position.

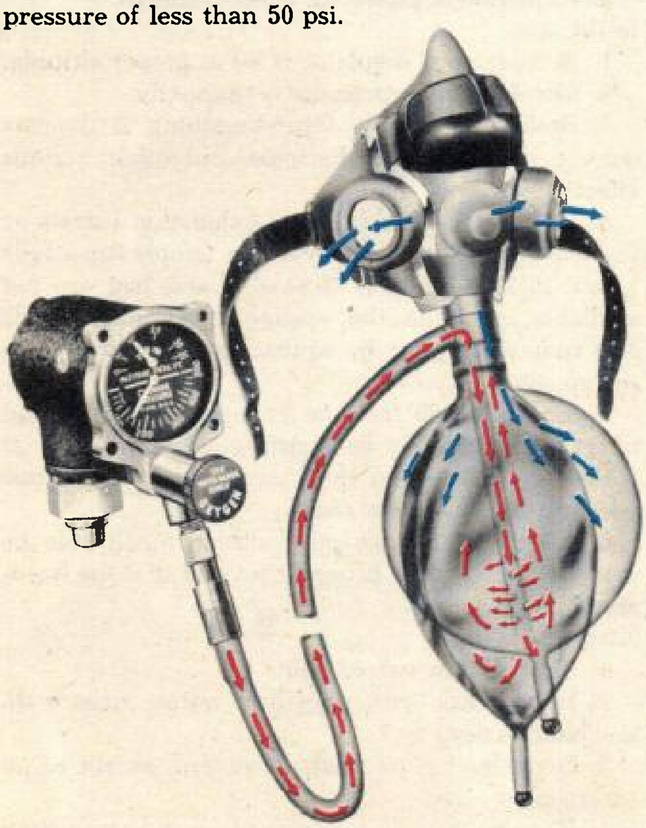
7. Turn Emergency Valve off tight.

In the Air:

1. Check the mask as soon as you put it on, by holding thumb over end of hose, inhaling gently.

2. Manipulate the mask at frequent intervals when the temperature is low, to free it of any ice that may form. Some masks have rubber flap (inhalation baffle) inside to prevent accumulation of moisture in oxygen inlet ports. **Know how to handle your mask if it freezes. Your life depends on it.** If possible, obtain a mask heater or carry an extra mask. See your Personal Equipment Officer.

3. Check the oxygen pressure gage frequently. The regulator does not function properly with a pressure of less than 50 psi.



A-9A Continuous Flow Regulator A-8B Oxygen Mask

Use the Auto-Mix lever in the OFF or 100% OXYGEN position only:

For the treatment of shock or hemorrhage, at any altitude.
For protection against fumes.
For protection against the bends, if your Flight Surgeon advises breathing pure oxygen from the ground up in special cases.
For symptoms of anoxia.

After a Flight:

Wipe the mask dry. Wash it frequently with soap and water, rinse well, and dry thoroughly. Masks with microphones should not be immersed in water; they should be wiped with a wet cloth.

Inspect mask and hose for cracks and punctures.

Don't lend your mask to anyone except in an emergency.

Continuous Flow System

Some of the older airplanes which do not operate at extremely high altitudes are still equipped with continuous flow oxygen equipment. The A-8B mask is used with the A-9A regulator in the continuous flow system.

The A-8B mask is a re-breather type. The bag helps conserve oxygen from the exhaled air. The mask contains 2 sponge-rubber discs in the turrets of the face piece. When you are exposed to freezing temperatures, squeeze the discs to free them of moisture; otherwise ice may block them.

The A-9A regulator is entirely different from the demand regulators. You get a continuous flow of oxygen by opening the valve until the needle on

Turn on Emergency Valve only:

To revive an unconscious crew member.
If regulator fails. **Watch flow indicator.**
When removing mask at altitude.
If mask slips during a pull-out.
If a hole is shot in the oxygen tube.

To Remove Mask at Altitude

1. Unhook mask on right side, but hold tightly against face.
2. Turn on Emergency flow.
3. Take 3 or 4 deep breaths.
4. Hold breath and drop mask.
5. Don't breathe outside air.
6. Replace mask and start to breathe.
7. Turn off Emergency flow.

You can repeat this procedure, if necessary, but **don't breathe outside air.**

the dial corresponds to the altimeter reading. If you adjust this valve to correspond to the altitude you always get the proper amount of oxygen. During ascent or periods of unusual activity, keep valve setting about 5,000 feet higher than your altitude.

In cargo type aircraft, passengers are supplied from an automatic continuous flow system. In this system the A-11 regulator supplies oxygen for 1 to 15 passengers. Passengers are equipped with A-8B or A-7A masks.

Precautions

Maintenance:

Have rate-of-flow checked every 10 days with a ground flow check-meter.

Keep all parts free of oil, grease, and dirt.

Check entire system for leaks. Pressure should be maintained overnight with all regulators in the "OFF" position, if there has been no appreciable change in temperature.

Make sure that the valve adjustment knob of regulator has enough resistance against turning to prevent its being accidentally moved during flight. If it is loose, tighten the valve gland packing nut.

Pre-Flight Check:

1. Check the cylinder pressure. It should show 400 pounds per square inch.
2. Open regulator flow valve wide and be sure needle registers maximum flow.
3. Make sure rubber gasket is present at end of mask hose.
4. Check connections between mask, bag, and connecting tube.
5. Make sure bayonet connection is locked.
6. Check re-breather bag for holes. Be sure plug is in bottom of bag.
7. See that exhalation disks are in place.
8. Carry extra sponge-rubber disks and protective shields for exhalation turrets or a protective fabric bag for entire mask. Take along an extra mask if you go to altitudes above 20,000 feet, in case the one you are wearing freezes.
9. Adjust mask straps for comfortable fit.

In the Air:

1. Be sure your regulator is set at proper altitude.
2. Check cylinder pressure occasionally.
3. Breathe normally. Over-breathing is dangerous; it may produce dizziness and other serious effects.
4. Put protective shields on exhalation turrets or use the fabric bag whenever the temperature falls below 10°F (–12.3°C). If shields and bag are not available, examine the sponge disks at intervals and remove any ice by squeezing them, or change the sponges.
5. Above 30,000 feet the re-breather bag should never be completely collapsed when you inhale. If it does collapse, open the valve further, no matter what the flow indicator reads.
6. After you change your station at altitude be sure the regulator is properly set and that the bayonet fitting is locked.

After a Flight:

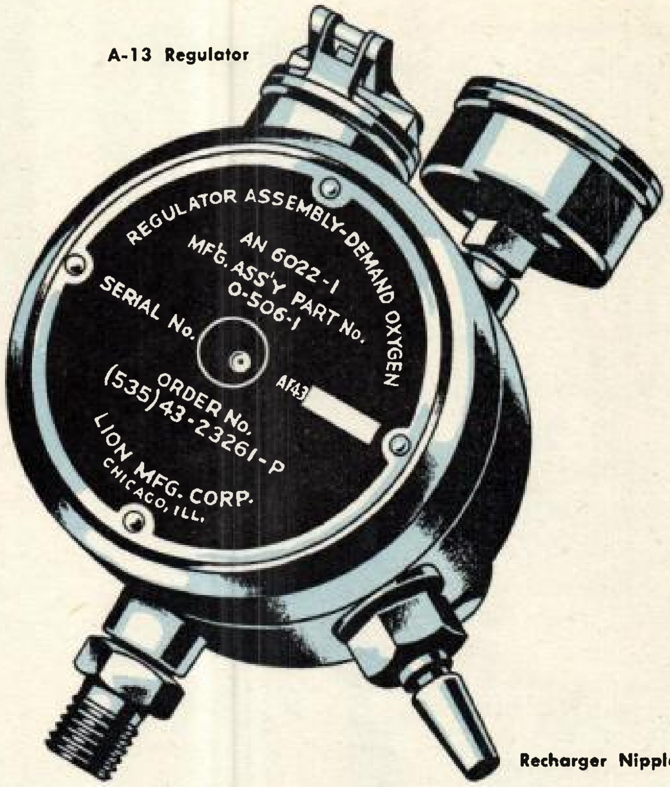
1. Shut all flow valves tight.
2. Wash mask with soap and water, rinse well, and hang to dry.
3. Don't lend your mask to anyone except in an emergency.
4. Keep your mask in a safe place and away from sunlight.

Warning

Be extremely cautious not to contaminate your oxygen equipment with oil, grease, or hydraulic fluid. Fire or explosion may result if even slight traces of oil or grease come in contact with oxygen under pressure.

Be sure that all lines, fittings, instruments, and other parts are free of oil, grease, and other foreign matter.

NEVER USE LUBRICANTS ON ANY PART OF THE OXYGEN SYSTEM



PORTABLE OXYGEN EQUIPMENT

Walk-Around Bottle

Large airplanes are provided with portable oxygen equipment consisting of walk-around oxygen cylinders and regulators. This equipment allows you to walk away from your oxygen station in the plane and provides an emergency source of oxygen.

Three types of portable assemblies are in use:

1. The A-4 cylinder and A-13 regulator. Duration of supply, 3 to 8 minutes.

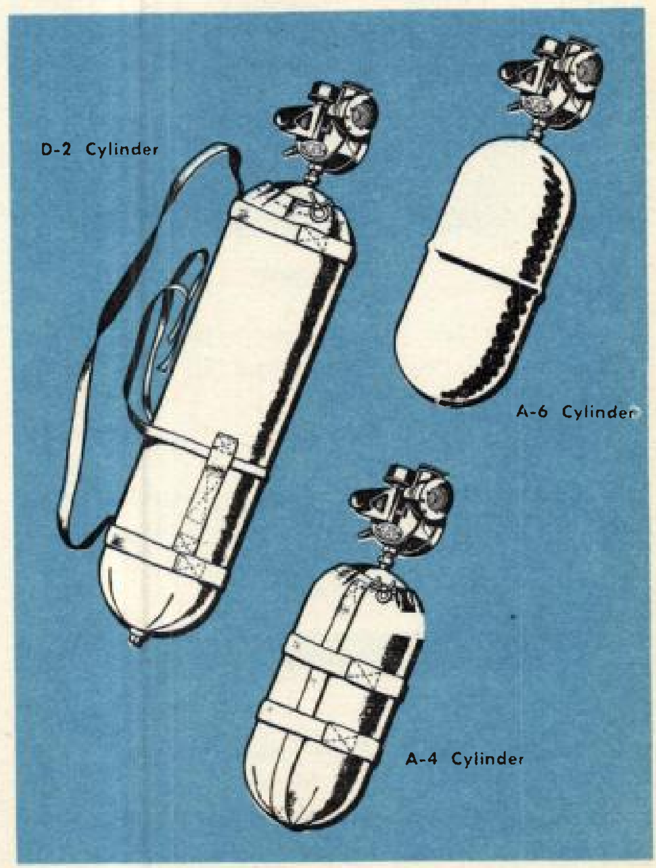
2. The D-2 cylinder, which has a harness for the shoulder, and A-13 regulator. Duration of supply, 20 to 50 minutes.

3. The A-6 cylinder and A-15 regulator, which has clip for attachment to the clothing or parachute harness and an Auto-Mix mechanism (but no lever). Duration of supply, 15 to 40 minutes.

The duration of supply is variable, depending upon the altitude and how much work you are doing. The only safe rule for using walk-around equipment is to watch the gage. Fill your cylinder before take-off and refill it from the plane's oxygen system whenever the pressure falls below 100 pounds per square inch.

To Use the Portable Unit

1. First check the pressure gage to make sure the pressure is at least that of the airplane's oxygen



H-2 Bailout Bottle

system. If it is not, recharge the cylinder by means of the portable recharging hose at each oxygen station.

2. Take a deep breath, hold it, then disconnect mask hose from regulator hose.

3. Quickly lift spring cover on walk-around regulator and plug in tight the male fitting of your mask hose.

4. Now start to breathe again.

On all flights above 30,000 feet. Keep your bailout bottle connected to your oxygen mask. This gives you most protection in an emergency.

Oxygen for Ditching

If you have to ditch, prepare for underwater escape from your plane by wearing your oxygen mask connected to your walk-around bottle and A-13 regulator. The duration of the A-4 portable cylinder is short under water, but with the D-2 portable cylinder you can breathe for about 6 minutes at a water depth of 10 feet.

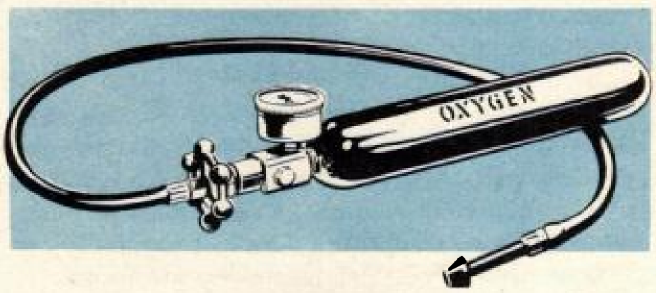
5. Fasten unit to yourself by means of clip or shoulder strap.

6. Watch for twisting or kinking of hose.

7. **Keep bottle filled! Refill at 100 pounds!**

8. Never leave your oxygen station at high altitude without a walk-around bottle.

BAILOUT OXYGEN CYLINDERS



H-1 Bailout Bottle

Two bailout oxygen cylinder assemblies are available for parachute descents from high altitudes. Both are completely self-contained units with pressure gage and release valve.

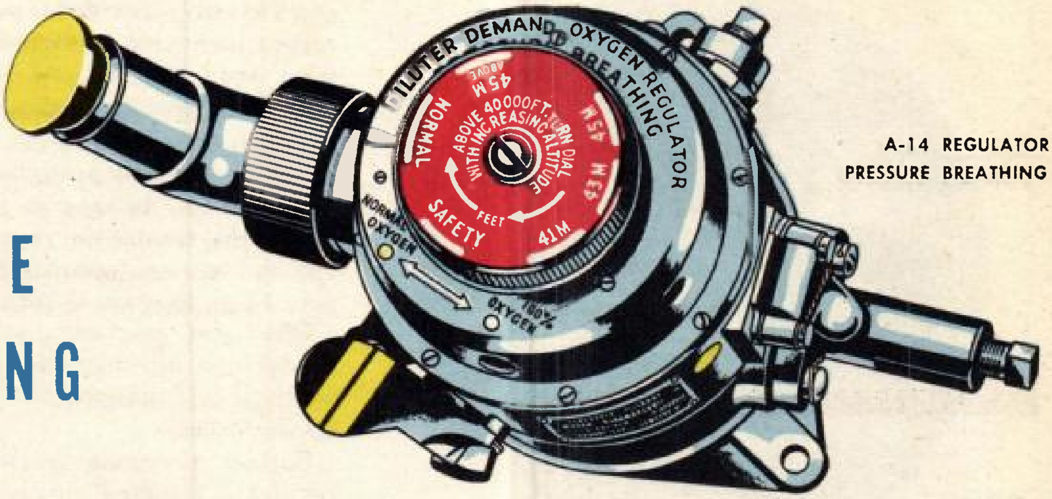
Either cylinder must be tightly fitted and securely tied in a pocket sewn to the flying suit or harness.

Before takeoff, check the cylinder's pressure gage. It should read at least 1800 pounds per square inch. Either cylinder assembly can be used in parachute descents above 30,000 feet.

Type H-1: Before jumping, grip pipe stem between your teeth and completely open flow valve.

Type H-2: Before jumping, pull the release to open flow valve. Then, disconnect the main oxygen tube and tuck it inside your jacket. If this is impossible hold your left hand over the free end. Then jump, keeping free end of main oxygen tube covered until parachute opens.

PRESSURE BREATHING



A-14 REGULATOR
PRESSURE BREATHING

Pressure demand equipment increases your safe ceiling. With it you have a greater safety factor between 30,000 feet and 40,000 feet. The extra pressure compensates for possible small leaks in your mask fit and insures your getting 100% oxygen. Breathing out against pressure takes a little effort, but you get used to it quickly.

With pressure demand equipment you can safely fly as high as 43,000 feet. In emergencies you can go even higher for brief periods.

The pressure demand oxygen system is the same as the regular demand system, except for the regulator and mask.

Pressure Demand Regulator Type A-14 is a Type AN-6004-1 diluter demand regulator to which a spring-weighted diaphragm has been added for pressure breathing.

Pressure Mask, Type A-13A or A-15, is a special one which must be used for pressure breathing. It can be used with some regular demand regulators (Aro type), but a regular demand mask cannot be used for pressure breathing.

Flow Indicator. Without pressure breathing the blinker works the same as with the regular demand system. With safety pressure or pressure breathing, the blinker may not work.

How to Use Pressure Demand Equipment

Below 30,000 Feet:

Use regulator just like regular demand regulator. It can be used with regular demand mask or with pressure breathing mask. With regular demand mask, you can obtain an emergency flow by turning the pressure dial on the regulator.

Above 30,000 Feet:

Use regulator for pressure breathing by turning dial clockwise. The regulator gives you 100% oxygen on demand. The farther you turn the dial the greater the flow pressure of oxygen.

How to Use Dial Control

Below 30,000 feet, keep setting on NORMAL.

Between 30,000 feet and 40,000 feet put setting on SAFETY.

Between 40,000 and 41,000 feet, set dial to 41M.

Between 41,000 and 43,000 feet, set dial to 43M.

Between 43,000 and 45,000 feet, set dial to 45M.

Above 45,000 feet, set dial to 45M ABOVE.

To be safe, always have the dial setting slightly higher than the altimeter reading.

Check Your Mask Before Each Flight

1. Do a suck test, as with regular demand mask, holding thumb over end of mask tube. This tests the fit and the exhalation valve. When you inhale, the mask should be sucked in toward your face.
2. Hook up mask to regulator, turn dial up to give oxygen under pressure, and hold your breath. Oxygen should stop flowing into mask. If it keeps flowing, check mask fit and exhalation valve.
3. Now breathe with oxygen under pressure to be sure you can exhale easily. If you can't, check with your Personal Equipment Officer.
4. Clean mask periodically with a wet cloth.

REFERENCE: Technical Order No. 03-50-31

Don't use pressure breathing below 30,000 feet. It wastes oxygen. Below 30,000 feet keep Auto-Mix Lever on NORMAL OXYGEN and the dial setting on NORMAL.

DANGEROUS GASES

The air you breathe while in flight should be free of all other gases except the oxygen from your mask. Exhaust gases, gasoline vapors, hydraulic fluid fumes smoke, or poison gas may contaminate the cabin air. In sufficient concentration, any of these is dangerous. You can protect yourself from them by knowing when to suspect their presence and by observing the necessary precautions.

Exhaust Gas

Exhaust gas is a mixture of several substances. Among them are carbon monoxide and oxides of nitrogen, both of which are poisonous. In exhaust mixtures, carbon monoxide is the more important, for it is present in larger amounts. Carbon monoxide acts by combining with the red cells of the blood and making them useless for carrying oxygen to the body tissues. This results in oxygen want or anoxia. As you ascend from sea level the dangers resulting from carbon monoxide increase, even below 10,000 feet, unless you use your oxygen mask.

In Flight:

The effects of carbon monoxide poisoning are similar to those caused by oxygen lack—shortness of breath, headache, nausea, dizziness, dimming of vision, poor judgement, weakness, unconsciousness, and death. The higher the concentration of the gas, the longer you breathe it, the higher the altitude (unless you use your oxygen mask), and the greater your activity, the more severe are the symptoms.

Like anoxia, carbon monoxide poisoning may give no warning. The gas itself has no odor, but you can be pretty sure of its presence if you smell exhaust gas. **The only safe rule for protecting yourself against carbon monoxide in flight is to wear your oxygen mask with the Auto-Mix in the OFF or 100% OXYGEN position whenever you smell exhaust gases. In this way you get pure oxygen to breathe and are completely protected from any gases in your compartment. As soon as you safely can, land and report the trouble to your Engineering Officer.** If you had any unpleasant sensations during flight see your Flight Surgeon as soon as possible.

Don't use your exhaust heater during combat. Enemy gun fire may cause dangerous leaks of exhaust gas into the cabin.

On the Ground:

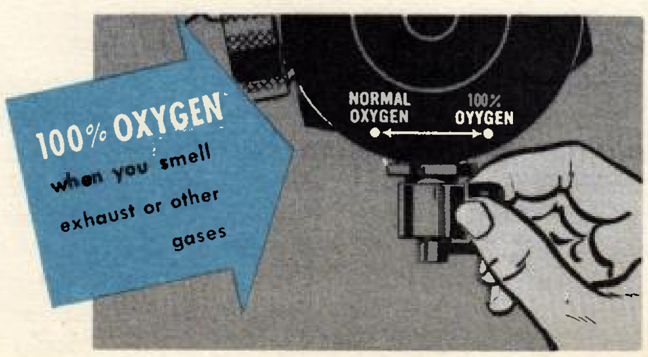
Carbon monoxide is always present in poorly ventilated hangars and garages when engines are running. Therefore, don't run any kind of engine longer than necessary inside closed hangars and garages. Ventilate such places as much as possible. If the doors must be kept closed, don't stay inside any longer than necessary.

In cold regions, where gasoline or oil stoves and lamps are used in closed buildings or tents, carbon monoxide is formed whenever fuel is burned. Cross-ventilation is your only reliable protection.

Gasoline Vapors

Gasoline vapors in aircraft cabins may cause serious trouble. Aviation gasoline contains special compounds which make its vapors more dangerous than those of ordinary gasoline. One gallon produces 30 cubic feet of vapor at sea level. These vapors are heavier than air.

Breathing gasoline vapors is harmful because the vapors are easily absorbed by the lungs. Even one-tenth of the concentration of gasoline vapor which is necessary to support combustion is dangerous if inhaled for more than a short time. Symptoms may include dizziness, nausea, headache, burning and watering of the eyes, restlessness, excitement, disori-



entation, disturbances of speech, vision, and hearing, convulsions, and unconsciousness.

One gallon of gasoline produces 1600 cubic feet of explosive vapor at sea level and has the blasting power of 83 pounds of dynamite.

If a gasoline leak occurs in your airplane, or if any occupant smells gasoline vapors during flight:

Ask the pilot to leave all electrical and radio equipment switches just as they are; the slightest spark may cause an explosion.

Ventilate the cabin if possible.

Have crew and passengers put on oxygen masks with Auto-Mix in OFF or 100% OYGXEN position. This excludes contaminated air from the lungs.

Have all aboard stop smoking; put on goggles, if available, to protect eyes from irritation; roll down sleeves and put on gloves, helmet, and other articles of clothing for protection against burns in case of fire.

Hydraulic Fluid Vapors

Some types of hydraulic fluid contain substances which are dangerous when their vapors are inhaled. They cause irritation of the eyes and breathing passages, headache, dizziness, and disturbances of judgment and vision. These harmful effects are increased by altitude or by high temperatures. Use your oxygen mask with Auto-Mix OFF (100% OXYGEN) if hydraulic fluid leaks into the cockpit.

A spray of hydraulic fluid ignites easily and spreads its flames rapidly. Be on guard against fire if a hydraulic leak occurs.

Smoke

Smoke may arise in the airplane from a variety of sources such as hot oil fumes, a break in the coolant fluid lines, or from signal flares. Some types of smoke are dangerous to breathe, but all smoke will irritate your eyes and throat and make you cough. Don't take chances. Wear your goggles and use your oxygen mask with the Auto-Mix OFF and breathe 100% oxygen until you clear the cabin of smoke.

Poison Gas

The poison gases which were known at the end of the last war are all heavier than air and tend to collect near the ground. Most of them have a distinctive odor:

Phosgene and Di-Phosgene (odor of musty hay or decaying leaves).

Chlorpicrin (sweetish smell, like licorice).

Mustard gas (smells like garlic or onion).

Lewisite (geranium-like odor).

Accurate identification of these gases may be impossible, because of the use of mixtures or of newly developed agents. Most of them cause irritation of the eyes and lungs.

A gas mask, of course, is the ideal protection against these poisons. When a gas mask is not available, your oxygen mask, together with goggles, provides the best type of protection. But be sure to keep the Auto-Mix OFF (100% OXYGEN).

Phosgene is formed when the carbon tetrachloride in your fire extinguisher comes in contact with fire. Ventilate aircraft thoroughly after extinguishing fire, to avoid unnecessary exposure to phosgene, or protect yourself by means of gas mask or oxygen mask.

First Aid

If a man is overcome, begin first aid at once:

1. Remove him from the source of the gas.
2. Give him pure oxygen to breathe, if available (turn on Emergency flow).
3. Begin artificial respiration immediately.
4. Keep him warm.
5. Send for a Medical Officer.
6. Never exercise a person who has been overcome by gas. This only makes him worse.

References: AAF Ltr 62-9, AAF Reg. No. 55-20

SMOKING IN AIRCRAFT IS PROHIBITED

During all ground operations.

During and immediately after takeoff.

During fuel transfer operations.

Immediately before and after landing.

Any time any occupant detects gas fumes.

In bomb bay or fuselage section containing auxiliary gas tanks.

In the passenger compartment of C-87 type aircraft at all times.

In the C-54 type aircraft when fuselage tanks are installed.

At any time or place whenever aircraft commander deems such action necessary for safety.

VISION AT NIGHT

Some animals see as well at night as during the day. Man cannot. But your efficiency and your effectiveness in night work depend on your night vision. Learn how to improve it.

Night vision differs from day vision. In daylight the center of the retina, or lining of the eye, is the most sensitive part of the eye. At night, however, the center of the retina can't see at all. It is called the night blind spot. In dim light the off-center parts of the retina are most sensitive. Try it. You see best at night when you look slightly off-center or to the side of the object you wish to see. The off-center parts of the retina also detect movement more easily than does the central part.

When searching the sky, earth, or surface of the sea at night, the most effective and simple method is scanning. Keep your line of sight fixed in one direction for about a second. Then move your eyes or head in jumps of 10 to 20 degrees, as in reading a book, and pause for a second or two at the end of each jump. In this way you cover the entire field in a series of eye or head movements and pauses.

If you remain in a dark room your eyes gradually see things which they could not see at first. This is known as **dark adaptation.** By adapting your eyes to darkness you increase their sensitivity 10,000 times; that is, after only 30 minutes in the dark you can see a light 10,000 times dimmer than any you could have seen in bright light. You can also adapt your eyes in a light room by wearing red-lensed goggles. It takes a half-hour to adapt to dark, but you lose your adaptation temporarily by exposing your eyes to bright light for only a brief period.

The retina is highly sensitive to oxygen lack. So on all night flights, except low altitude training missions, **use oxygen from the ground up.** It pays.

Ability to see at night depends upon your body's content of Vitamin A, obtained chiefly from eggs, butter, milk, cheese, liver, carrots, squash, peas, apricots, and peaches. Eat them liberally.

Dirt, oil, and scratches on Plexiglas, goggles, or windows make night vision more difficult. They scatter light and produce glare. Keep your goggles and windows clean and free of scratches.

AIDS TO NIGHT VISION

Stay in a dark room or wear red-lensed goggles. (Goggles, Assembly, E-1, Class 13, Stock No. 8300-331450) for a half-hour before any night operation.

Protect your adaptation. Don't expose your eyes to bright lights, either inside or outside airplane, before you take off on a mission or during flight.

Keep all non-essential lights in plane turned out and dim all essential lights.

Make readings fast; then look away. Don't look too long at lighted instrument panel or charts. Or use only one eye; the other will retain its dark adaptation.

Use red light at your desk, if possible. But remember then that red lines will not show as red on your charts.

Use oxygen from the ground up on night flights.

Keep windshield, windows, and goggles clean and free of scratches.

Practice off-center glances at night.

Get enough Vitamin A. Eat proper foods.

Don't Stare at Night

If you stare at a light in a dark room, you soon think the light has begun to move. The same thing happens when you stare at a light outside the airplane while flying at night.

CLIMATE AND HEALTH

The AAF has circled the earth. Its flying operations are conducted over every type of terrain, desert, jungle, and Arctic, where the temperatures range from higher than 130°F to lower than –50°F. Each region presents special problems in living. Learn what they are and how to cope with them.

WARM CLIMATE HEALTH

In warm regions such as the tropics, desert, or jungle several weeks may be required for your body to become completely adapted to the heat. During this period protect yourself from sunstroke or heatstroke by following a few simple rules.

Clothing

During the daytime protect yourself from the severe burns which may result from exposure to the intense rays of the sun. Wear a cap or sun helmet and lightweight clothing which exposes as little of the body as possible. Clothing should be loose and porous to permit evaporation of sweat. This helps cool you. Get in the habit of shaking out your clothes before putting them on, so as to rid them of flies, insects, and snakes. Tinted goggles or sunglasses protect your eyes from the glare of the sun; also from dust and sand. Protect exposed areas of body with sunburn protective ointment.

Don't sunbathe right away. It's dangerous, unless you develop a tan gradually. A good plan for sunning yourself is 5 minutes' exposure the first day, increased by 5 minutes each day until you are thoroughly tanned. Don't get burned!

Although the temperature may be intensely hot on the ground, the air is cooler the higher you climb; at high altitudes it is extremely cold. So be prepared to add or remove clothing according to the temperatures you encounter.

Even on the ground, nights are frequently cold in the desert. Anticipate rapid changes in temperature by having warm clothing available at night. Woolen socks are best for general use; they provide the greatest comfort because they absorb moisture well and are good insulators. Wear GI shoes. They keep out sand and protect your feet better than oxfords. You can also walk home in them.

Water and Salt

If your water supply is limited, you must use it sparingly. With care you can get along on surprisingly little.

Keep physical exertion at a minimum. Exertion makes you sweat; sweating makes you thirsty. Stay out of the sun as much as possible. Do your heavy work in the shade and during the cooler hours of late afternoon, evening, or early morning. Cut down on your smoking as it makes you thirsty; chew gum instead. Rest as much as possible, and take advantage of the breeze. Go easy on alcoholic drinks. They increase your body's need for water.

If you find yourself sweating heavily, salt your food liberally at meals to help make up for the salt lost through sweat. Your Flight Surgeon may advise taking salt tablets in addition. Check with him on the dosage, for salt tablets may do more harm than good if your water ration is limited.

If your body loses too much salt through sweating, you may get **heat cramps** in your muscles.

Sunstroke is usually caused by prolonged exposure to the direct rays of the sun, although it may occur even in cloudy weather. It is a serious condition. Symptoms may include headache, dizziness, red spots before the eyes, and vomiting.

Heatstroke is a similar condition resulting from exposure to excessive heat from any source.

All of these conditions can be prevented by avoiding sun, sweat, toil, and salt-loss as much as possible. A victim of sunstroke or heatstroke must have prompt treatment. Give him a bath in cold water, cover with wet sheets, or simply pour cold water over his clothes and fan him.

Disease

In the tropics and desert, certain diseases are usually present. Know what they are, how they are transmitted, and precautions to take, so you can avoid getting them. Guard constantly against:

Insects
Contaminated food and water
Breaks in the skin's surface

Insects

Mosquitoes in the tropics are your greatest danger. They transmit malaria, yellow fever, dengue, and other diseases which can lay you low as surely and effectively as an enemy bullet. Mosquitoes breed in water. They usually rest in the shade during the

day and bite at night. In dense jungles or dark rooms, however, they may bite during the day.

Keep yourself covered at night. Wear long trousers, sleeves, gloves, and headnet. Smear exposed surfaces of the skin, such as your face and neck, with mosquito repellent every 3 or 4 hours during late afternoon and night. Apply carefully, as mosquitoes will find and bite every small untreated spot even though it is completely surrounded by repellent. After dusk stay away from native villages and swamps. In heavily infested areas, wear clothing which has been treated with mosquito repellents.

Sleep under a bednet. Inspect and spray inside it to kill mosquitoes before entering. Tuck net under blanket or mattress. Keep it mended.

Use mosquito spray (Aerosol or DDT) liberally in your tents and buildings.

Malaria. This is one of the most widespread diseases in the world. It is a major military problem in South America, the Indies, Africa, the Middle East, India, Burma, Thailand, Indo-China, China, and Malaya. It is carried by the anopheles mosquito, which injects the malarial parasite into your blood.

The disease takes different forms with symptoms appearing about 2 weeks after infection. You may then experience headache, chills, fever, and other symptoms, depending on the type and severity of the disease. Prevention of malaria is largely up to you. Don't give the mosquitoes a chance. In certain regions you may be advised to take atabrine to help prevent malaria. If so, take it regularly, according to local directives and the instructions of your Flight Surgeon.

Other diseases transmitted by mosquitoes include:

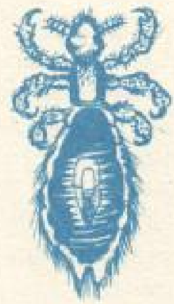
Yellow Fever. Confined at present to Eastern and Central Africa and the bulge of South America. Vaccinations against this disease protect you.

Dengue (Breakbone fever) occurs in tropical regions, chiefly at the end of the rainy season. Symptoms consist of muscle and joint pains, backache, fever, and rash. The mosquito which transmits it bites mostly during the daytime. You must protect yourself from it to avoid the disease.

Besides mosquitoes there are other pests you should steer clear of:

Flies. They breed in filth and transmit the germs of dysentery and typhoid from human waste to your food. Protection against flies requires screening of latrines and kitchens, proper disposal of garbage, and frequent spraying with Aerosol or DDT. Special types of flies may transmit other diseases, such as sand-fly fever, yaws, and sleeping sickness.

Mites. Small six-legged insects about the size of a pinhead, sometimes known as red bugs or chiggers. They transmit typhus or scrub typhus (Tsutsugamushi fever). This disease is prevalent in the Southwest Pacific and the China-Burma-India theater. It results in headaches, chills, and fever. Cover the body, avoid sleeping on the ground, and wear clothing impregnated with anti-mite fluids or insect repellents, for protection.



Lice. They carry the germs of typhus fever and relapsing fever. Lice hide in the seams of dirty clothing and spread from one person to another. Boil infested clothing or sterilize with chemicals.

Fleas. Most fleas are harmless. In India and South China, however, rat fleas transmit the deadly disease called plague. Avoid this threat by spraying your quarters with Aerosol or DDT and keeping rats out.

Food and Water

In warm climates foods spoil quickly. There is danger also of contamination of food and water by germs which cause typhoid, dysentery and cholera. You can prevent typhoid and cholera, to a large extent, by immunization injections. The dysenteries, however, cannot be prevented in this way. You must rely instead on sanitary measures and precautions. Know what foods are safe and how to protect yourself against those that may not be.

The safest food is served in Army messes. If canned rations are used they should be eaten soon after opening or stored in a cool place under fly-proof covers.

Food obtained from natives should be thoroughly cooked before eating. Thick-skinned fruits which can be peeled need not be cooked. Lettuce, radishes, celery, salad greens, melons, and strawberries are likely to carry disease germs. Never eat them raw. The natives commonly soak melons in water, often polluted, to increase their weight. Never use milk products such as butter, cheese, and ice cream, which are sold by the natives.

In desert and tropical regions, water also is important in transmitting intestinal infections. Consider all surface water unsafe, whether in streams, wells, fountains, ditches, or cisterns. Don't wash in it, don't brush your teeth with it, and above all don't drink it! Don't even put ice in your drinks unless the ice has been prepared by the Service. Native ice may harbor germs of dysentery or typhoid.

Water of questionable purity should always be sterilized before you use it. You can sterilize water in any one of three easy ways:

1. Boil it for at least 5 minutes.
2. Use Water Purification Tablets (Halazone). Add one tablet to the pint, shake, and wait a half-hour before drinking.
3. Add three drops of iodine to the quart, shake, and wait a half-hour before drinking.

Care of the Skin.

In hot climates, skin troubles are common. Treat even trivial cuts, scratches, and bites promptly (See NIF 7-15-1), or serious infection may result. Don't hesitate to see your Flight Surgeon. The following precautions will help keep you out of trouble.

Never walk about with bare feet in warm climates. Floors are likely to harbor the germ that causes athlete's foot. Consider all native areas infected. Small worms in the soil may burrow into the skin and cause infections such as hookworm or bilharziasis. Don't go swimming on beaches near native villages. The water may be contaminated with the flukes which cause schistosomiasis.

Bathe yourself and change your sox and underwear as often as possible. Keep the skin folds between the toes, in the armpits, and the groin clean and dry to prevent fungus infections like ringworm. Powder these parts liberally with GI foot powder.

Venereal Diseases.

In the tropics, venereal diseases are common, among prostitutes and most native women as well. In addition to syphilis and gonorrhea, large numbers of them are infected with chancroid, lymphogranuloma venereum, and granuloma inguinale. Don't give them a chance to give it to you. The treatment of these diseases is longer than their names.

COLD CLIMATE HEALTH

The principal hazard in cold weather operations is frostbite. It can be more serious than most people realize. It can cost you a finger or toe, even a hand or foot. Protect yourself with the proper equipment and by observing a few simple principles.

Clothing

All clothing should fit loosely. This applies particularly to your sox, boots, and gloves. Tight-fitting clothing interferes with the blood circulation and makes you more susceptible to frostbite. Individual garments should be light and porous. Wear several layers if possible. Two light garments afford better insulation than a single heavy one. Wear long woolen underwear on all flights over cold regions. Wear two or three pairs of loose-fitting woolen sox in sub-zero climates, but be sure that your boots fit loosely over them.

Leather shoes are dangerous in extreme cold. They not only afford poor protection, but may cause harm if they fit tightly over your sox. Don't wear ordinary GI shoes inside your winter flying boots. Use woolen sox and felt liners or electrically heated shoes instead.

If possible wear two pairs of gloves or mittens—a rayon or other light pair inside heavier ones (either A-9's, A-12's, or electric gloves). Mittens are better than gloves, for they allow your fingers to come in contact with each other and help keep them warm.

Keep your sox and underwear clean. After they have become soiled by body oils and secretions, they lose much of their insulation value.

Keep Your Clothing Dry

Wet clothing is almost worthless in protecting you from the cold. If any part of your clothing becomes moist, either by accident or through perspiration, take it off and dry it over a fire or change to dry clothing immediately. Wet feet and hands are particularly dangerous in cold climates for they fall easy prey to frostbite.

Exercise to keep warm but guard against overexertion in extreme cold. Overexertion makes you sweat and the perspiration may turn to ice inside your clothing. This is dangerous. If necessary to perform much physical work, open or remove some of your clothing in order to prevent perspiration. Don't put on a heavy suit until just before takeoff. Wipe your body dry; then dress slowly. Once dressed, exercise no more than necessary.

Electrically Heated Flying Suits

Electrically heated flying suits permit you to fly for long periods at extreme altitudes without getting cold. They have the advantage of eliminating bulkiness and permitting greater ease in moving about the plane. There is one great disadvantage, however, in relying on them while flying over cold regions. If your electric system fails, if you are forced down, or if you have to bail out, you are left without adequate protection against the cold. Always carry additional heavy clothing with you on such flights.

Know how to use your electrically heated suit, and treat it carefully. The electric heating elements are fragile. Hang your suit up to dry between flights, if possible, and have it tested by your Personal Equipment Officer. Two types are now in use, the F-2 and the F-3. They will protect you down to –40°F. If lower temperatures are encountered, add other flying clothing.

How to Wear the F-2 Suit

1. Wear your F-2 electrical suit over long woolen underwear. (If your suit is the F-1 type, wear additional clothing over it as well.) The F-2 suit affords adequate protection down to –40°F. If operating at lower temperatures, add other flying clothing.

2. Put on the shoes with inserts over lightweight woolen sox. Then connect the snap fastener tabs on the trouser leg to the corresponding snaps on the shoe insert. **Be sure that both pairs of snaps are properly connected.**

3. Connect the tab at the top of the trousers to the corresponding snap fasteners on the inside of the jacket at the right. Make certain both pairs of snaps are securely snapped together. Connect 6-foot lead cord to jacket pigtail.

4. Put on regulation flying helmet and auxiliary equipment. Protect your neck from the cold by wearing a wool or silk scarf.

5. Put on lightweight rayon gloves. Snap the tabs on the jacket sleeves to the corresponding snaps on the heated gloves. Then put on the electrically heated gloves.

How to Wear the F-3 Suit

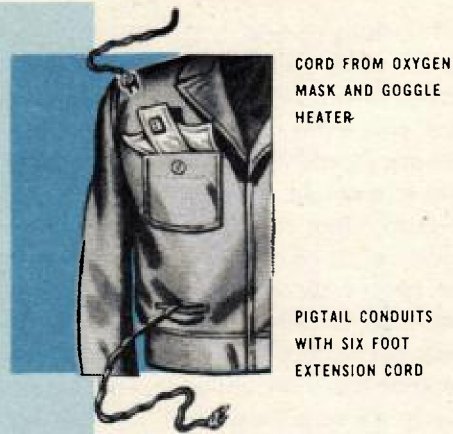
1. Begin to dress by putting on long woolen underwear, woolen sox, GI trousers and shirt.

2. Then add the F-3 electrically heated trousers. Adjust the shoulder straps to fit comfortably. Your F-3 heated jacket goes on next. Make sure both trousers and jacket fit properly.

3. Connect cord on right underside of jacket to receptacle at waistline of trousers. **Make certain both prongs of plug fit into receptacle.**

4. Now put on heated shoe inserts. Type F-2 is used for both F-2 and F-3 suits. **Connect both snap fasteners** on each leg of the heated trousers to snaps on shoe inserts.

5. Next come the A-9 alpaca-lined trousers. Reach inside right or left pocket and pull electric cord or



Your complete F-2 wardrobe should contain the following items of clothing:

1. Jacket
2. Jacket Insert, Heated
3. Trouser
4. Trouser Insert, Heated
5. Helmet
6. Shoes, Felt
7. Shoe Insert, Heated
8. Gloves, Heated
9. Rayon Glove Inserts
10. A-12 Mittens
11. Scarf
12. Lead Cord
13. Woolen Shirt
14. Light Socks
15. Long Underwear

F-2 ELECTRICALLY HEATED FLYING SUIT

pigtail through. Then put on the B-10 jacket.

6. Now, the finishing touches: outer boots, helmet, and scarf. Connect 6-foot lead cord to pigtail.

7. Check all previous steps. Then add your gloves; first, the rayon or silk gloves. Then snap tabs on sleeves of heated jacket to snaps inside gauntlets of electrically heated gloves. Now put on your heated gloves. Take along a pair of A-9 mittens, in case of emergency.

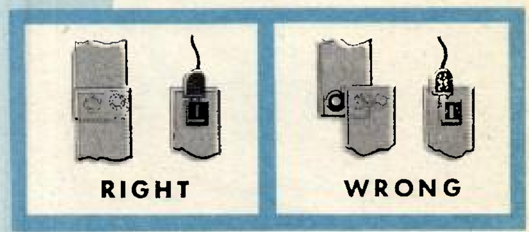
8. You can plug an oxygen mask heater or electrically heated goggles into the connecting block on the front of your trousers.

Connect your extension plug in the left receptacle of the built-in rheostat before takeoff and be sure that the suit is working properly. The plug can be locked into position by a simple clockwise twist. When in flight, keep the rheostat at the lowest comfortable heat. Don't ride hot, it will make you sweat.

Never rely on electrically heated suits alone when flying over cold regions.

Your electrical suit may affect compass deviation. Be sure to check it with the suit plugged in.

F-3 ELECTRICALLY HEATED FLYING SUIT



MAKE CONNECTIONS PROPERLY

Your complete F-3 wardrobe should contain the following items of clothing:

1. Jacket, Alpaca lined, Type B-10.
2. Jacket, Heated, Type F-3
3. Trousers, Alpaca lined, Type A-9
4. Trousers, Regulation GI
5. Trousers, Heated, Type F-3
6. Helmet
7. Shoes, outer felt or Type A-6
8. Gloves, Heated, Type F-2
9. Gloves, rayon or silk
10. Mittens, Type A-9
11. Scarf
12. Lead Cord
13. Shirt, Regulation GI
14. Socks, Regulation Wool
15. Long underwear

Check your suit after each flight. Look for excessive wear at all flexion points where electric wires might short out or break. If an ohmmeter is available, check the resistance of your suit at frequent intervals. The resistance in ohms is marked on the trousers, jacket, and each shoe and glove. If the ohmmeter shows the resistance to be more than 10% off, turn in the item for a new one.

Frostbite

Frostbite occurs most commonly in the fingers, toes, nose, ears, chin, and cheeks. It may set in gradually and painlessly and without your being aware of it. Numbness, stiffness, and a whitish discoloration of the affected part are among the first signs. Wrinkle your face frequently when exposed to cold air; if it feels numb, warm the affected part with your ungloved hand until sensation returns.

Crew members should watch each other's faces and be on the alert for areas of blanching. In this way serious trouble can be prevented. Frostbitten tissues may later become painful. Such tissues should

Warm hands by placing inside clothes under armpit

never be rubbed. Never apply snow or ice to a frostbitten part. If your hand becomes cold or numb, warm it by placing it inside your clothing or under your armpit. Frostbitten tissues should always be thawed gradually. When possible, thaw them at ordinary room temperature. They should never be placed near a heater or immersed in warm water or in kerosene. Any of these procedures may cause irreparable damage.

If frostbite occurs, cover the frostbitten area with a loose sterile bandage. Keep the patient comfortably warm with blankets or a sleeping bag and by giving him hot drinks; and give him 100 per cent oxygen to breathe (Auto-Mix OFF or 100% OXYGEN). Report to your Flight Surgeon immediately after returning from your flight.

In extremely cold weather never touch cold metal with your bare hands, even for a moment. Your skin may freeze to it. If by accident this should happen, thaw your skin loose from the metal by warming the latter or by urinating upon it—don't pull your fingers loose.

Don't touch cold metal with bare hands

Snowblindness

Snowblindness is caused by exposure of your eyes, even for brief periods, to the glare which exists in snow-covered regions. The resultant damage to your eyes may cause intense pain and seriously interfere with your vision for several days—sometimes even longer. The hazard of snowblindness is particularly great on sunny days, but the glare

Wear colored goggles or sunglasses

which results from a bright overcast is almost as dangerous. Always protect your eyes by wearing colored goggles or sunglasses. In the Arctic, snowblindness may be brought on by merely lifting your goggles a half dozen times.

Body Heat

Eat an abundance of fatty foods while in cold regions. Fats are rich in calories, which help you maintain body heat. Take hot drinks such as coffee, tea, cocoa, or soup in thermos jugs along with you on all flights. These also add to your body warmth.

Never drink alcoholic beverages to keep warm. They give you a false sensation of warmth but may do great harm by actually robbing you of your body heat, since they cause flushing of the skin. This loss of heat, together with the false sense of security which alcohol produces, makes alcoholic beverages dangerous to anyone who is exposed to cold.

Don't eat snow! Melt it before drinking

THE LOG

It is next to impossible to devise an ideal navigation log for all the various conditions of navigation which the AAF encounters in training, transport, and the theaters of operations. The new Aircraft Flight Log, AAF Form 21, contains the essential elements of all log requirements. AAF navigators are required to use this log. You can modify the use of certain columns when necessary.

In order to reduce the size of the log, such non-essential items as radius-of-action and interception diagrams, radio-bearing work sheet, winds and weather, pressure and temperature conversion scales, and celestial data have been omitted. Record any of this information in the observation columns.

Additions

Flight Plan. This has been added to meet a requirement of transport and combat operations.

Record of Sunrise, Sunset, etc., and Master Watch Rate. These entries are essential when you use celestial navigation.

Air Miles Column. Required by commands using the air position indicator.

Formation Position. Aid to staff navigation officers and interrogation officers in evaluating information which combat crew members have supplied.

Authentication. Your signature makes this an official document.

Fuel Consumption Data. Requirement for long-range cruise control.

General

One log sheet is sufficient for an 11-hour flight if you make an entry every 10 minutes.

It is suggested that you devise a rigid backing for your personal use, until a standard folder is available.

USE THE FOLLOWING ABBREVIATIONS. THEY HELP KEEP YOUR LOG NEAT AND FACILITATE ENTRIES:

A/C	Altered course—change of course to make same destination
AP	Air plot position; no-wind position
Alt	Altitude of celestial body or altitude of object above sea level
Alt Set	Altimeter setting (British terminology: QFF)
ATA	Actual time of arrival
Z	Azimuth (true, unless otherwise indicated)
C	Celestial fix
CAS	Calibrated airspeed
C/C	Change of course to new leg or destination
DR	Dead reckoning or dead-reckoning position
Dev	Deviation
D/F	Direction finding
DD	Double drift
EA	Enemy aircraft
ETA	Estimated time or arrival

AIRCRAFT FLIGHT LOG

PILOT NAVIGATOR CREW NO. Plane No. Organization Type Date

Eng. Start	T.O.	Land	Flight Time

Formation Position

Gross Wt. at T.O. Lb. Gal. Aboard at T.O.	
Alternate—	
Time to Alternate—	hrs. M.
Fuel Req'd to Alt.—	Gal.

SUN		MOON		TWILIGHT	
Rises	Sets	Rises	Sets	AM	PM

Watch Fast Slow

At GCT (Date)

Rate sec/hr Gain Lose

Departure Destination

OFFICIAL:

Navigator

Name Rank

Alt. Sett.
Dep
Dest

FLIGHT PLAN

From / To	True Course	Drift	Wind Used D / V	True Head'g	VAR	Mag Head'g	Temp °C / Alt	IAS / TAS (K)	G.S. (K)	Distance This Leg	Time	Elapsed Time	Fuel Consumed	Fuel Remaining
										Total	Total			Fuel Reserve

FLIGHT RECORD

T.O. Time	Date T.O.	W/V Used & or Drift	Headings TH	VAR	MH	Dev.	CH	Position Navigational	And/or Observation	General Observations	IAS	CAS (K)	Press Alt	Temp °C	TAS	Run Dist	Run Time	Air Miles	G.S.	To Run Dist	To Run Time	ETA

AAF FORM 21 FLIGHT PLAN AND LOG

ft	Feet
FA	Friendly aircraft
G	G fix
GS	Groundspeed
Ht	Height
H/F	High frequency (3000 to 30,000 kc)
IAS	Indicated airspeed
K	Knot(s)
km	Kilometers
Lat	Latitude
L	Left or port
Lt	Light
LH	Lighthouse
LS	Light vessel; light ship
LOP	Line of position
L/F	Low frequency (30-300 kc)
LO	Loran fix
Long	Longitude
Mag	Magnetic
M/F	Medium frequency (300-3000 kc)
M	Mickey; H_2X fix
m	Statute mile(s)
nm	Nautical mile(s)
min	Minute(s)
PP	Pinpoint; visual fix
PR	Position report
R	Right or starboard
R/A	Radius of action
RC	Radio compass fix
R/T	Radio; voice (British terminology: radio telephone)
RB	Relative bearing or azimuth
S/C	Set course (at beginning of each leg)
SL	Sea level
T	True
TAS	True airspeed
TMG	Track made good
TTT	Time to turn
Var	Variation
VH/F	Very high frequency (30,000 to 300,000 kc)
W/D	Wind direction
W/F	Wind force
W/T	Radio; code (British terminology: wireless telegraph)
W/V	Wind vector

LABEL ALL WIND DETERMINATIONS AS FOLLOWS:

AP	Air plot
API	Air position indicator
T/GS	Track and groundspeed
MD	Multiple drift

Besides these approved abbreviations there are others which are in general use within the Army Air Forces; you should use them to save time and space. It is essential to correlate all remarks and observations with time and position so that you may reconstruct the flight completely for the benefit of weather and intelligence officers, and for navigation analysis.

CHART PROCUREMENT

IF YOU ARE LOOKING FOR CHARTS, HERE IS WHERE TO GET THEM

You can obtain any type of aeronautical chart from one of the stores listed below.

BASE STORE St. Louis, Missouri, 710 N. 12th Blvd.

REGIONAL STORES Atlanta, Georgia, 1515 Spring St. N.W.
Oakland, California, 301 23rd Street.
San Antonio, Texas, 114 Camp Street.
St. Louis, Missouri, 710 N. 12th Blvd.
(separate unit from base store).
Washington, D.C. 1222 22nd Street, N.W.

Don't bother your sub-depot. They are not equipped to furnish them. Don't go to one of these stores as an individual with an individual order. Make a list of every chart everyone in your outfit wants, and get them all at once.

CHART DESCRIPTION

These charts are in the following groups:

1. Planning Charts, World Coverage, Scale 1:5,000,000.
2. Long Range Air Navigation Charts, World Coverage, Scale 1:3,000,000.
3. Plotting Charts, U.S. Coverage, Scale 1:1,000,000.
4. Pilotage Charts, World Coverage, Scale 1:1,000,000.
5. Pilotage Charts, Partial World Coverage, Scale 1:500,000.
6. Approach Charts, covering industrial centers and congested or strategic areas, Scale 1:250,000.
7. Target Charts, Scale approximately 1:125,000.

CHART CONSTRUCTION

Be able to construct a chart by use of meridional parts as well as by the graphical method.

Meridional Parts

The meridional parts of any parallel of latitude are defined as the length of an arc of a meridian between the equator and the parallel, as drawn on a Mercator chart, expressed in units of 1 minute of longitude at the equator. Because meridians are parallel to each other on the Mercator chart, each minute of latitude changes in size with its distance from the equator. Therefore, each parallel has a different number of meridional parts.

The table of meridional parts in Useful Tables H. O. No. 9, gives the distance from the equator of each minute of latitude in units of one minute of longitude at the equator. The distance of any other parallel of latitude from the principal parallel (the parallel to be used as a base for the chart) is the difference of meridional parts for the two taken from the tables and reduced to the scale of the chart.

If you want to construct a chart on a scale of 2″ to 1° of arc on the Equator, the minute or unit of measurement (one meridional part) will be $1/60 \times 2'' = 1/30''$.

Then 1° of latitude north or south of the equator is represented by $1/30'' \times 59.6 = 1.987''$. The value 59.6 is the difference between the meridional parts given opposite latitudes 0° 0′, and 1° 0′.

Therefore, at the equator each degree of longitude is represented by 2″; 1.987″ represents the distance from the equator to 1° of latitude, north or south.

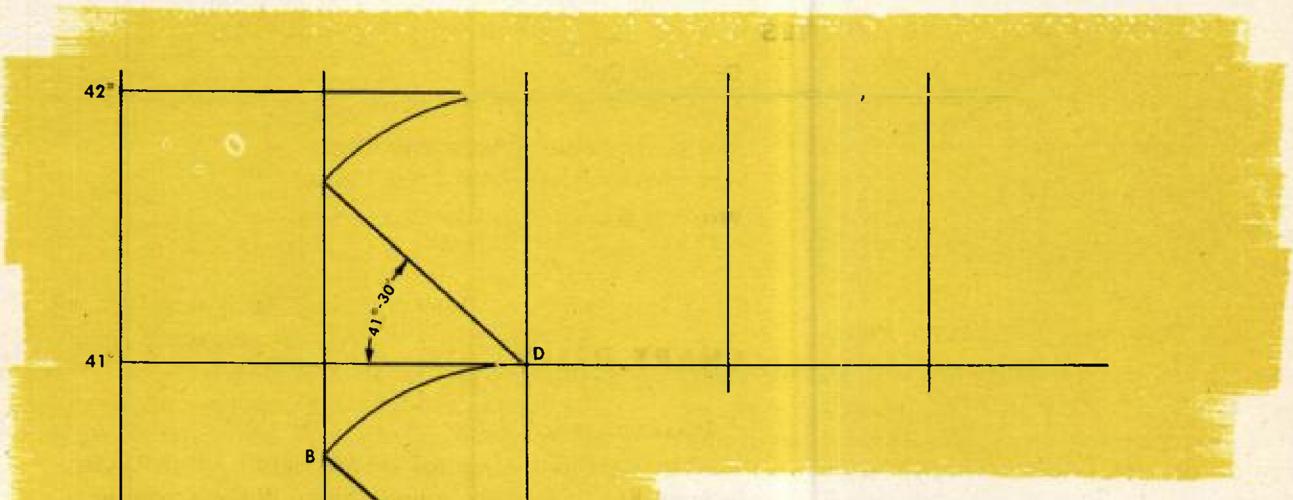
Between latitude 1° north or south and 2° north or south the process must be repeated in order to obtain the further expansion. Repeat this until the chart is completed.

Graphic Construction

The graphic construction of a Mercator is based on the assumption that the earth is a true sphere, in which case the meridians are true circles.

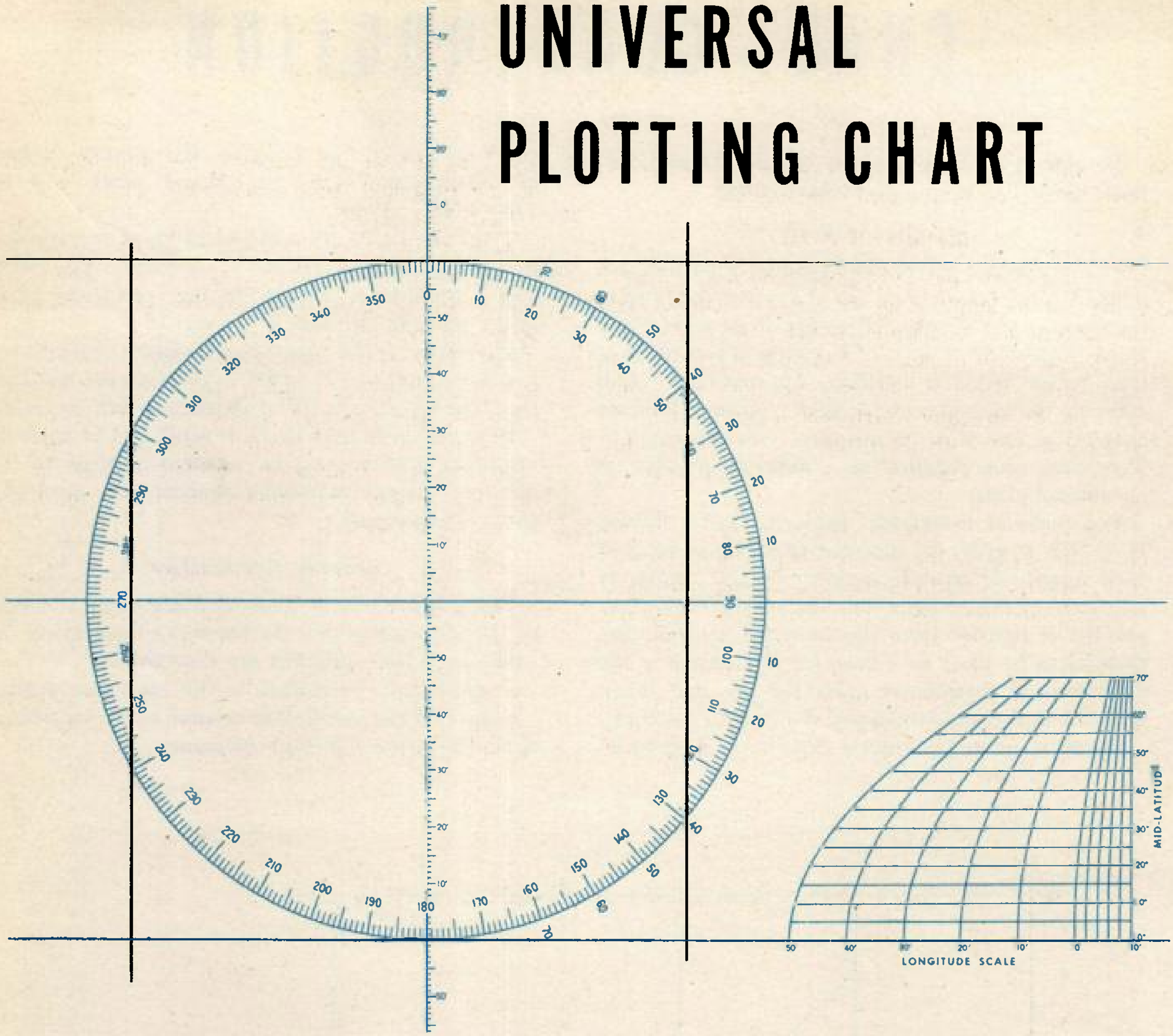
Construct the meridians to the scale you desire.

Construct the parallels in relation to the meridians as shown in the following diagram.



Lay off a line AB, so that angle BAC equals the mean latitude between the parallels 40° and 41° which is 40° 30′. Measuring upwards along the meridians from the base parallel 40°, lay off distance AD equal to AB, and through this point draw the parallel of latitude 41°. Repeat this process. Then subdivide the degrees into six equal parts. Each degree of latitude must be separately subdivided.

UNIVERSAL PLOTTING CHART



You can use it any place

Just as the name implies, you can use this small chart at any latitude from 0° to 70° either north or south, at any desired longitude. You can use it any place in the world except around the poles.

It includes at least 4° of latitude and longitude, and usually provides more than 4° of longitude.

Construction

To construct meridians at the mid-latitude you expect to use, take the following steps: Let us construct this chart at the mid-latitude of 35°.

1. Place your Weems plotter north and south parallel to the central meridian.
2. Set the straight edge of your plotter through the two points on the compass rose marked 35. Use the outer figures on the right half of the rose.
3. Construct a meridian on both sides of the central meridian in this manner.
4. Position other meridians with your dividers.
5. Use the scale in the lower right hand corner of the chart to divide degrees into minutes for accuracy in measuring position.

YOU NOW HAVE A HANDY MERCATOR PLOTTING CHART! USE IT!

Check List

MAKE A CHECK LIST AND USE IT BEFORE EVERY MISSION!

It must include the following:

1. Know possible weather conditions that you may encounter during the mission.
2. Be sure to:
   - (a) Select routes and flight altitudes carefully. In doing this, evaluate terrain, weather, winds aloft, and enemy opposition.
   - (b) Compute and check all courses and distances.
   - (c) Determine the probable duration of flight, and cruising time on fuel available.
   - (d) Take an inventory of, and thoroughly familiarize yourself with all available aids to navigation on and adjacent to your line of flight, including visual, radio, and celestial aids.
   - (e) Study all navigational procedures you intend to follow. Make full use of all navigational methods available for the flight and know how you intend to check each method against the others.
   - (f) Make a thorough preflight check to be sure that all your navigation equipment, charts (including weather charts), codes and ciphers, and data on radio aids are aboard. Test all of your instruments to see that they are functioning properly.

TACTICAL OPERATIONS IN THE VARIOUS THEATERS

Navigation in each of the various theaters of operations is basically the same. There are certain navigational aids, however, that you can use more readily in one theater than another because of weather, radio facilities (or lack of them), terrain features, and enemy installations.

No matter what theater of operations you are in you can be sure that pilotage and dead reckoning will be the basis of your navigation. Many combat missions are over short distances, where a combination of dead reckoning and pilotage gives you the best results. Where there are radio facilities, learn to use them and to rely upon them.

EUROPEAN

Dead reckoning and air plot supplemented by pilotage and radio aids are the basis of operational navigation in this theater. Weather information is good, but do not rely completely on a flight plan based on forecast winds aloft, because the weather fronts fluctuate constantly.

English maps are detailed and accurate but the close proximity of towns, railroads, rivers, and woods in the crowded English countryside and the striking similarity of English towns make pilotage difficult. Therefore, you must have a better than average degree of skill in pilotage. Best check points are railroads and woods. Continental maps are reliable but are not as detailed as English maps. Height of terrain figures are in meters rather than feet.

Radio facilities are excellent and include H/F D/F and M/F D/F stations, buncher, splasher, and multi-group beacons. Visual aids at night include aerial lighthouses and landmark beacons. Be sure to obtain locations and codes before takeoff. Searchlights direct lost aircraft or aircraft in distress to emergency landing fields, but you must know the procedures required. You must become thoroughly familiar with the abundance of radio aids.

Operations in this theater are on a large scale and maximum effort missions involve forces of 1000 planes or more. The navigation problem depends on your position in the formation:

1. If you navigate a wing ship, your follow-the-pilot procedure is greatly complicated because of limitations of formation flying.

2. If you are lead navigator it is your responsibility to see that the formation successfully completes its briefed route, finds the target, and adheres to its briefed route on the return trip.

MEDITERRANEAN

Dead reckoning and pilotage are the chief forms of navigation used in this theater. Pilotage is made easy by the definite and rugged coastlines of Italy and Yugoslavia. But on missions into the Balkans and into southern Germany, pilotage is difficult once you have crossed the Alps in northern Italy. Strategic towns are hidden in the Alps and the snowfall sometimes obliterates towns that otherwise would be considered good check points. Accordingly, only prominent check points such as large lakes or large towns are completely reliable for pilotage.

Celestial navigation is confined to the occasional observation of sun lines. Night operations are usually performed by British squadrons.

You can use air plot effectively while gaining operational altitude. Rugged and well-defined coastlines plus a climb to 15,000 or 20,000 feet by the time you reach the Alps give you a good chance to check metro winds and scale them accordingly.

HF/DF beacons, multi-group beacons, and local field beacons afford reliable radio aids.

Weather in this theater has been bad enough to justify the constant and effective use of blind-bombing aids. Since the targets attacked are approximately in the same weather belt as those attacked by the USAAF stationed in England, the weather problem at the target is about the same, often bad.

The navigational problem of assembly is made easy by the proximity of the heavy bomber fields. Assembly lines between the respective bases and offshore islands or some other reliable check point are normally used. Assembly is usually completed at convenient medium altitudes. The climb to operational altitudes is made before reaching enemy interception areas.

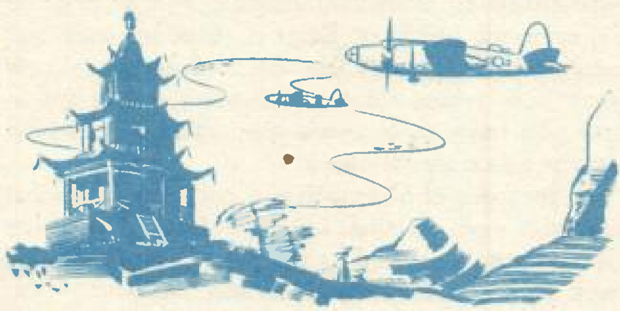
PACIFIC

Missions vary considerably in the Pacific Ocean Area. Dead reckoning is the basis of navigation on them all. Pilotage is a good aid. Maps are generally accurate along coastlines but have errors in elevation and location of features inland. Because the maps are not always reliable you may find an uncharted island occasionally.

In the Central Pacific celestial navigation is used in conjunction with dead reckoning on all missions. Many of the islands and atolls are plotted in error from 2 to 10 miles, usually eastward or westward. Interpretation of sun lines and fixes is important. Radio facilities are not always available in this area and you cannot always depend upon them because of local disturbances.

Be careful when you use clouds for pilotage. Cumulus often builds up around islands, but shadows of clouds also look like land.

Be sure that you understand the problems of plotting in South latitudes and East longitudes.



ASIATIC

Dead reckoning and pilotage are the chief forms of navigation used in this theater. Most missions are daylight missions, which means formations. Formations are small and no difficult navigational problem exists in assembling.

Good pilotage check points include well-defined coastlines and islands. Railroads are few and roads are difficult to distinguish. Sometimes inaccuracies exist in the location of these check points.

Radio aids include HF/DF facilities, homing beacons, and short range beacons. These facilities are reliable although they are not numerous.

Terrain features consist of rugged coastlines which are good check points, occasional lakes, rivers, and the mountains which taper down the western side of Burma.

Weather is an important navigation problem. The monsoon season begins June 15 and lasts until October 15, seriously curtailing operations during that period of time. During November the rain diminishes in intensity but cloud cover still prevails. After November, weather is good for operations.

ALEUTIAN

Much of the flying in this theater is on instruments because of poor visibility. Planes either fly at altitudes above the weather and combine dead reckoning with radio and celestial, or fly under the weather and use dead reckoning and radio to minimize the effect of the weather.

Pilotage is limited because visibility is poor and much of the territory is uncharted. This uncharted territory includes mountainous country.

You will often find weather at your home airfield bad enough to keep you from landing. It is frequently possible to stay above the overcast and wait a half hour or so while the weather clears enough for a safe landing. The weather moves with great speed in this area. There is the possibility that the field you are over will clear up for landing as fast as any other. Sometimes you may squeeze in by going out to sea and coming in under the ceiling.

Celestial navigation is restricted in the general Alaskan area because of weather. As you fly farther west the weather is clear enough to make celestial navigation possible some of the time.

You must be thoroughly proficient in every navigational method in this theater. You may need to use any one or all of your skills on every mission and upon very short notice. Remember, the Aleutian area is the weather mixing-bowl of the world.

PROCEDURE ON A COMBAT BOMBING MISSION

Details of flight planning and actual navigation are different in the various theaters of operations, but the general outline described below is a basis for navigation procedure in every theater. The plans for a mission are given to you at a general briefing. You make your own detailed plans at a navigators' special briefing.

At the general briefing the target is specified. The route and the intelligence features, such as expected opposition, flak, and fighters, are given. The general plan of assembly, formations, altitudes, etc., is discussed and explained.

At the navigators' briefing the group navigator or a designated assistant gives you all the details of the route to help you complete your flight plan. If time permits, always re-work your flight plan to check the group navigator's work.

At the airplane, brief your crew on particulars of the flight. Give them:

1. Times of coast crossings.
2. Times of fighter rendezvous.
3. Times of expected enemy interceptions.
4. Position of the airplane in the group and in the wing formation.
5. Location and time of crossing the front lines and borders of enemy countries.
6. The approximate location, by bearings and distances, of prominent check points which you want them to help you find.

It is a good idea to prepare a small-scale track chart with predicted times, courses, and distances, for your pilot. It will keep him informed of the progress of the mission.

Prior to takeoff, check your equipment and the calibration status of your flight instruments. In your log, record the time of starting each engine and the time the wheels leave the ground. Start dead reckoning immediately. If you are lead navigator you bear the responsibility of actually establishing courses and airspeeds for the entire formation. If you are navigating a wing airplane you must navigate carefully and accurately at all times to keep track of your position. You may have to rely upon metro winds at first but as soon as possible check these either by track and groundspeed or drift on two or more headings. Start a chart or scale and maintain it throughout the flight to compare winds found with winds forecast. If metro winds are in error you have an accurate conception of just how much and in what direction.

The methods of assembly of a bombing formation vary with each mission, but regardless of the plan followed you must keep a complete dead-reckoning check of the airplane's position and track.

Along the route to the target you must navigate with all your skill. Plot headings, fix your position to obtain winds, read drift or obtain drift readings from the bombardier, and record observations the crew members call in. It is your responsibility to know where you are at every moment throughout the flight.

It is your responsibility to identify the IP and the target. Between the IP and the target the airplane is under the control of the bombardier. A critical part of your mission is during the bombing run and just after the bombing run. Headings change rapid-

LONG RANGE CRUISE CONTROL

To become competent and qualified to navigate a long range flight you must first be able to use and understand airplane cruising charts, methods of cruise control, preflight planning, and methods of controlled flight. Many crews have been lost because they didn't have enough fuel to reach destination. **Don't let this happen to you.**

Use the following procedures to prepare for a long range flight:

Flight Analysis

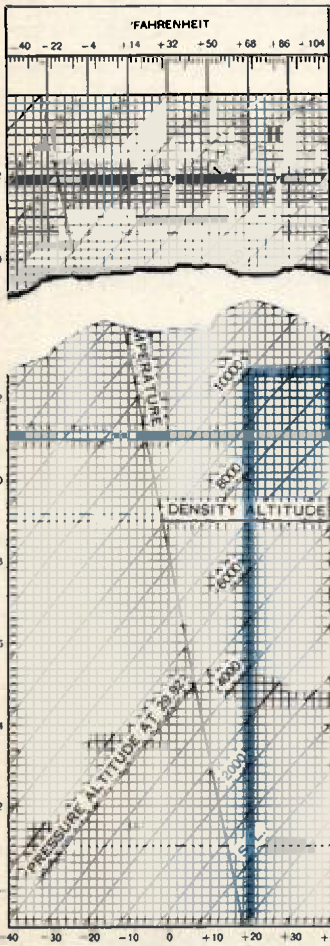
Assume your flight is from San Francisco to Hickam Field, T. H. Distance, 2110 nautical miles.

1. Check route weather conditions with your pilot and the weather office. Decide the altitude or altitudes at which the flight will be made. The considerations that direct your decisions are weather, effective wind, and navigation hazards.

2. After analyzing the flight you decide to fly at a pressure altitude of 10,000 feet, outside air temperature + 20°C.

3. Obtain the proper Long Range Cruise Chart from the Operations Officer, or from the T. O. on the airplane. Be sure that the chart contains the specifications that fit your airplane. Your airplane is a B-24J. It has Army paint on it, turrets and guns in combat position, C-3 jets, and uses Grade 100/130 fuel. Check with the flight engineer to be sure you are both using the same cruise control data. This is vital to proper planning.

LONG RANGE CRUISE CHART B-24J WITH C-3 JETS; TURRETS AND GUNS IN COMBAT POSITION–ARMY PAINT



OPERATING ADJUST.	GROSS WEIGHT ADJUSTMENT INTERVALS: 64,000 TO 60,000	PILOT'S FIGURES	60,000 TO 56,000	PILOT'S FIGURES	56,000 TO 52,000	PILOT'S FIGURES	52,000 TO 48,000	PILOT'S FIGURES	48,000 TO 44,000	PILOT'S FIGURES	
IAS RPM MP #/HR TAS BTI	150 CRUISING HORSE-POWER EXCEEDED	150	150 CRUISING HORSE-POWER EXCEEDED	150	150 CRUISING HORSE-POWER EXCEEDED	150	150 2100 30 1140# 208	150 2100	150 1950 10	150	
IAS RPM MP	152	152	152 CRUISING	152	152 2100 30.5	152					
BTI	2 HR: 48		190 3 HR: 15		190 3 HR: 40	156 1960	156 1860 31.5 1010# 190 3 HR: 57	156 1860	156 1760 31 932# 190 4 HR: 17	156 1760	
IAS RPM MP #/HR TAS BTI	157 2130 32 1340# 185 2 HR: 59	157 2130	157 2040 32 1170# 185 3 HR: 25	157 2040	157 1940 31.5 1062# 185 3 HR: 46	157 1940	157 1840 31.5 985# 185 4 HR: 3	157 1840	157 1740 31.5 916# 185 4 HR: 22	157 1740	
IAS RPM MP #/HR TAS BTI	159 2120 32 1270# 182 3 HR: 9	159 2120	159 2030 32 1220# 182 3 HR: 17	159 2030	159 1930 32 1030# 182 3 HR: 53	159 1930	159 1830 31.5 970# 182 4 HR: 7	159 1830	159 1730 31.5 900# 182 4 HR: 27	159 1730	
IAS RPM MP #/HR TAS BTI	160 2110 32 1210# 177 3 HR: 18	160 2110	160 2020 32 1090# 177 3 HR: 40	160 2020	160 1920 32 1020# 177 3 HR: 56	160 1920	160 1820 32 954# 177 4 HR: 11	160 1820	160 1720 31.5 886# 177 4 HR: 31	160 1720	
IAS RPM MP #/HR TAS BTI	162 2100 32.5 1165# 174 3 HR: 26	162 2100	162 2010 32 1070# 174 3 HR: 44	162 2010	162 1910 32 1000# 174 4 HR	162 1910	162 1820 32 940# 174 4 HR: 15	162 1820	162 1720 32 880# 174 4 HR: 33	162 1720	
IAS RPM MP #/HR TAS BTI	163 2100 32.5 1120# 170 3 HR: 34	163 2100	163 2000 32.5 1055# 170 3 HR	163 2000				163 1810			
IAS RPM MP #/HR TAS BTI	165 2100 32.5 1110# 167 3 HR: 36	165 2100									

SET ALTIMETER 29.92

4. Obtain the required information from the chart as follows:

a. Enter Density Altitude Chart at left of Long Range Cruise Chart on temperature line (+20°C).

b. Follow temperature line until it intersects pressure altitude curve (10,000 ft).

ly, enemy opposition interferes, and altitudes and airspeeds fluctuate. Your observations at this time are often the basis for a long dead-reckoning flight back to base. You must remain cool and work almost mechanically in recording all that takes place. When the target is bombed your responsibility is only half over. You must now find your way home. Turn on the IFF as briefed. You must be identified at established positions along your route and in many cases you must hit a certain corridor or check point to keep from alerting friendly forces. Navigate until the wheels touch down.

Immediately following each mission the crew is interrogated. Your log will do most of the talking if you have done your job. Every significant detail of the mission must be recorded along with the time, the altitude, and the position of the airplane when the incident occurred.

Computing TAS on a Climb

In working out dead-reckoning positions after long climbs or glides, or in calculating ETA beforehand, you must allow for the effect of true airspeed. True airspeed changes with a change of altitude.

You can obtain the distance flown by recording altitudes, times, and calibrated airspeeds regularly. There is a much simpler method, however. You can use it for long climbs or descents provided the indicated airspeed is kept constant or nearly constant throughout.

The method is as follows: Add to the altitude at the start of the climb two-thirds of the difference between the altitudes at the start and end of the climb. Use the altitude you obtain to convert calibrated airspeed to true airspeed. Use this true airspeed as the average for the whole climb.

Example: Suppose the climb is from 2000 to 17,000 feet. Add to 2000 two-thirds of the difference between 2000 and 17,000 feet; i.e., two-thirds of 15,000, or 10,000 feet. Convert calibrated airspeed to true airspeed at the resulting altitude, 12,000 feet, using a temperature based on the fact that there is normally a drop of 2° with each 1000 feet increase in altitude.

Because the rate of climb of all aircraft becomes progressively slower as the altitude increases, it takes longer for the last half of the climb than for the first half. Consequently, more time is spent at a true airspeed which is nearer the final value than the initial one. You obtain the actual average true airspeed for the whole climb by converting calibrated airspeed at a height which lies somewhere between the half-way and the final values.

By plotting height, time, and true airspeed on time curves it has been found that the true airspeed obtained by using a two-thirds value, multiplied by the duration of the climb, gives a distance which is within 1% of the actual distance covered during the ascent. **This method does not apply where rates of climb are predetermined at briefing and the airspeed is not constant throughout the climb phase.**

Computing Wind on a Climb

When you find the wind in flight, adjust your metro wind and use the adjusted wind in climb as shown below.

Metro wind at	Direction	Velocity
2000 ft.	200°	20k.
4000 ft.	210°	25k.
6000 ft.	220°	30k.
8000 ft.	225°	40k.
10,000 ft.	235°	45k.
12,000 ft.	240°	50k.
14,000 ft.	250°	60k.
16,000 ft.	260°	65k.

Average metro wind in climb	230°/42 knots
Wind found at 8000 feet	185°/50 knots
Metro in error	− 40/ + 10 knots
Wind used	190°/52 knots

Keep up with the air position at all times so you will always know your dead-reckoning position. If possible get a fix by celestial, radio, or pilotage to check the wind. Evaluate the accuracy of each fix.

If you take a fix at 16,000 feet and find the wind to be 180°/50 knots, apply the adjustment as follows:

Average metro wind in climb	230°/42 knots
Actual wind in climb	180°/50 knots
Correction to metro wind	− 50°/ + 8 knots
Wind used at 16,000 feet	210°/73 knots

IMPORTANT

Always work out a complete flight plan before takeoff, using latest available metro data. Mistakes can be made in the air and a flight plan helps you check air computations. If your navigation is interrupted because of enemy attack or the need to administer first aid you have a quick reference for picking up your work again.

c. Follow horizontal density altitude line from temperature/pressure altitude intersection to the left, and read density altitude (12,800 ft).

d. Use data for flight contained in bracket opposite density altitude (11,000 to 13,000 ft).

Definitions of other terms in columns on chart

IAS—Indicated airspeed
RPM—Revolutions per minute
MP—Manifold pressure
#/HR—Pounds of fuel used per hour
TAS—True airspeed
BTI—Bracket time interval (time to fly in weight bracket)

5. The true airspeed for your flight is 185 mph. Convert mph to knots to conform with your other computations. All computations are in knots.

6. Divide your proposed flight into zones as indicated by the winds aloft for the altitude of your flight. Each set of winds occupy a zone.

7. Obtain fuel consumed in climb from the T.O. on your airplane. Obtain fuel consumed after climb as follows:

a. Consult Long Range Cruise Chart in correct weight bracket of your airplane at takeoff.

b. Read #/HR figure.

c. Compute pounds of fuel used in each zone. Be sure to subtract weight of fuel used from gross weight of airplane at takeoff for each computation, and change #/HR figure as gross weight changes from one weight adjustment interval to another. Where #/HR figure changes in the middle of a zone use the proper #/HR figure for the portion of the zone applicable.

8. Make your flight plan as follows:

DATE 10 MARCH 1945

AIRPLANE TYPE B-24J NO. 4328015

FROM HAMILTON TO HICKAM, T.H.

FLIGHT PLAN

PILOT J. D. SMITH, CAPT

NAVIGATOR L. M. JONES, LT.

GROSS WEIGHT AT TAKEOFF 58,000

LB/GAL ABOARD AT TAKEOFF 16,200

FROM	TO	ZONE NO.	DIST.	TOTAL DIST.	TRUE COURSE	PRESSURE ALTITUDE	WIND DIRECTION AND VELOCITY	TEMP.	TRUE AIRSPEED	TRUE HEADING	GROUND-SPEED	ELAPSED TIME	TOTAL TIME	FUEL CONSUMED	FUEL REMAINING	REMARKS
CLIMB		C	26	26	241°	CLIMB	NO/WIND	+30°	147	241°	147	:12	:12	870	15,330	
	*	1	421	450	241°	10,000	60°/25K	+20°	161	241°	186	2:17	2:29	3400	12,800	
		2	300	750	241°	10,000	280°/40K	+20°	161	250°	128	2:20	4:49	5880	10,320	
		3	750	1500	241°	10,000	80°/30K	+20°	161	238°	190	3:57	8:46	9760	6440	
		4	610	2110	241°	10,000	150°/30K	+20°	161	230°	159	3:50	12:36	13,260	2940	
							/									
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POINT OF NO RETURN 4 ENG. 1010 MILES

ALTERNATE NONE

TIME TO ALTERNATE ______ HRS. ______ MINS.

...VE ...TION

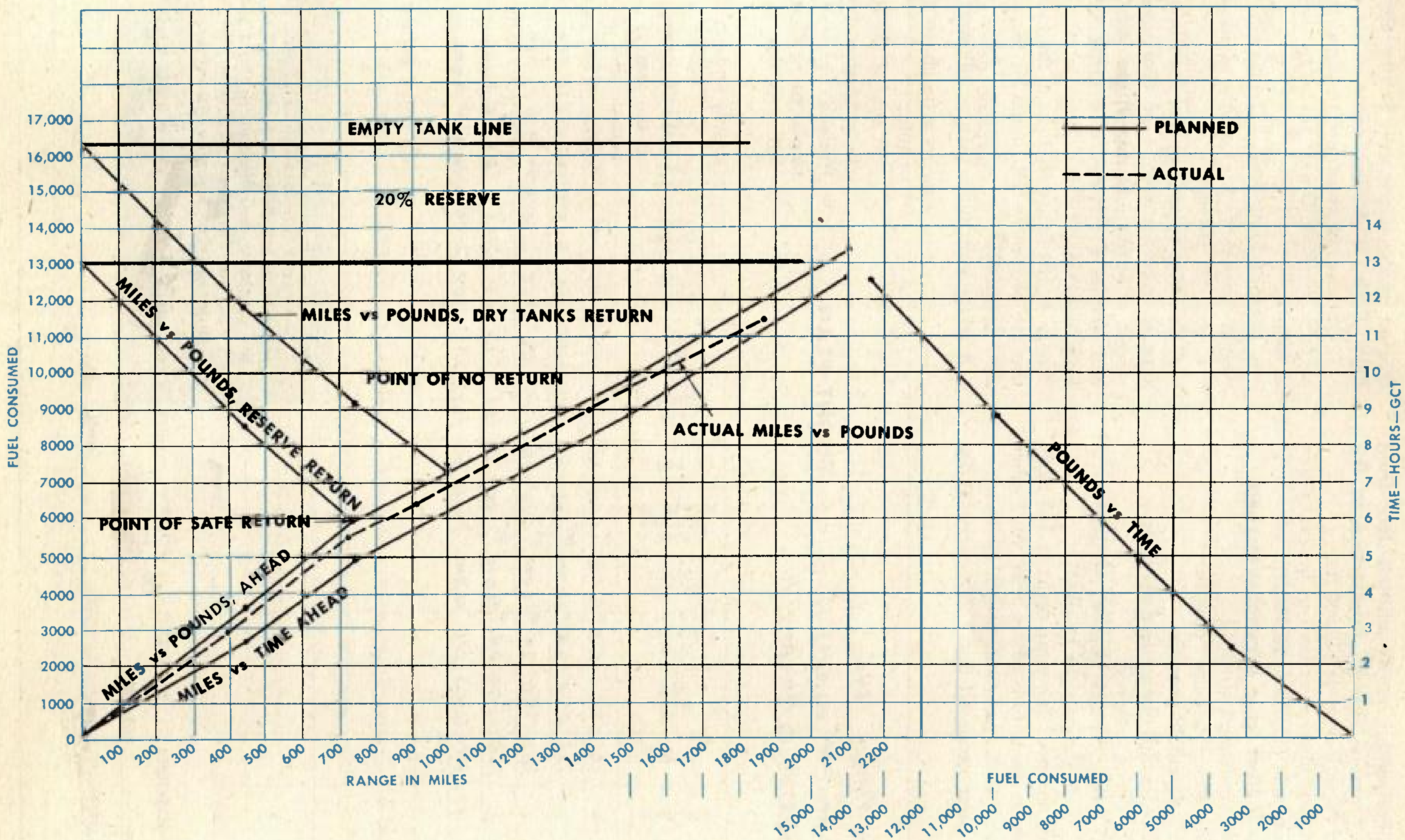
______ PILOT

______ OPERATIONS OFFICER

Take fuel consumed in climb and distance traveled in climb from the T.O. of the airplane, as indicated in flight plan. * You are in the 60,000 to 56,000 weight bracket for only 58 minutes of Zone 1. For 1 hr., 19 min. you are in the 56,000 to 52,000 weight bracket.

RANGE CONTROL CHART

FROM HAMILTON TO HICKAM, T. H.



9. Construct a Range Control Chart. This chart gives you a means of comparing estimated with actual flight performance. It projects flight trends during flight and forecasts critical conditions before they actually happen.

Plot the following six curves before takeoff:

a. Miles vs. pounds, ahead. Use the figures in Total Distance column and Fuel Consumed column of your flight plan. This shows the number of pounds of fuel you normally use for any given distance.

b. Miles vs. pounds, reserve return. Draw this curve by setting up a reserve and plotting Total Distance column and Fuel Consumed column on a reciprocal course. Use the wind on the reciprocal heading and use the same true airspeed. Re-figure pounds used and plot from empty tank line. Use a reserve of 10% to 20% depending upon your operation. Set up this reserve by decreasing the amount of fuel available on your chart. The point at which this curve crosses the first curve (miles vs. pounds, ahead) is your point of safe return. By turning back at this point, you can return to your departure point with a reserve of fuel in your tanks.

ZONE	GS	MILES	ELAPSED TIME	FUEL USED
No. 1	136	450	3:18	4480
No. 2	194	750	1:33	7115
No. 3	132	1,500	5:41	12,520
No. 4	163	2,110	3:44	15,940

c. Miles vs. pounds, dry tanks return. Draw this curve by plotting Total Distance column and Fuel Consumed column as above. Do not use a reserve. Use the wind on the reciprocal heading and use the same true airspeed. The point at which this curve crosses the first curve (miles vs. pounds, ahead) is your point of no return. By turning back at this point, you will reach your departure point with empty tanks.

d. Miles vs. time, ahead. Plot this curve from Total Distance column and Total Time column of your flight plan. This gives you a check on distance traveled for the time of the fix.

e. Plot pounds vs. hours to show fuel consumed at any given time. If your airplane has flow meters you do not need this curve.

During Flight

During flight, plot your performance curve in a dotted line from actual fixes. Plot pounds used vs. actual miles traveled.

Sample Analysis

Assume that the airplane does not have flow meters.

At the end of 8 hours a fix shows that you have traveled 1400 nautical miles:

1. Follow up the right side of the Range Control Chart, on the time scale, to 8 hours. Follow this grid line until it intersects pounds vs. hours curve.
2. Read the fuel scale at the bottom of the chart under this point. It indicates that you have used 9000 pounds.
3. Then enter the pounds scale at the left of the chart at 9000 pounds.
4. Follow the grid until it intersects vertically above the miles scale at the bottom of the chart at 1400 nm. This is your actual miles vs. pounds point.
5. Every time you obtain a fix, establish such a point on your chart.
6. Join these points by a dotted line. This gives you a curve on the trend of your flight.

You can also plot actual miles vs. time from flight data to compare with the precomputed miles vs. time ahead curve.

Be sure to establish a trend before reaching the point of no return.

PREFLIGHT CHECK

To do a reliable job of navigation your equipment must be in operating order on every mission. To assure yourself that you have all necessary equipment in the airplane before every flight and that this equipment is functioning properly, use the SCWAD system.

SCWAD SEXTANT

Before getting into the airplane, check your sextant on an object of known altitude. Do this by measuring the altitude of a pole or other object accurately, from a convenient position near the operations building, and checking your sextant on this pole before every mission. Don't rely on a land horizon of known altitude or a sea horizon, because at times poor visibility will restrict your vision.

SCWAD CHECK LIST

Keep a checklist in the airplane at all times. Don't trust your memory when you pack your equipment for a mission. Check all necessary equipment against a prepared list before you leave the ground.

SCWAD WATCH

Have your watch rated regularly. Set your watch before takeoff and note the error that will be introduced for each hour of the flight according to the daily rate. Hack the watch on the instrument panel before takeoff.

SCWAD ASTROCOMPASS

Be sure your astrocompass is aligned. One method of alignment is explained on NIF 3-10-1. Another satisfactory method follows:

1. Have a crew member stand on the longitudinal axis of the airplane, about 50 yards in front of or behind the airplane.
2. Set the astrocompass in its mount, level it, and sight on the crew member. If the bearing is not 360° or 180° adjust the mount or note the correction to be used.

The error introduced by the fact that the crew member is not exactly on the longitudinal axis of the airplane, or by the fact that the bracket is off-center, seldom exceeds 1°.

3. After the astrocompass is aligned, read the relative bearing of a prominent object on the plane such as a wing light, vertical stabilizer, or wing marking. Record the relative bearing and use it to check alignment in flight.

SCWAD DRIFTMETER

Check the alignment of your driftmeter (B-3) before takeoff.

At the 30-day calibration check:

a. Turn the trail angle through 85°.

b. Center the crosshairs on the pitot tube or some permanent part of the airplane.

c. Note the bearing.

d. Place this bearing on a card and keep the card on your desk permanently.

Before each flight:

a. Center the crosshairs on the object you used at the 30-day check.

b. Read the bearing from the azimuth ring.

c. Check this reading with the card on your desk.

EMERGENCY NAVIGATION

If you are down in unfamiliar territory and don't know where you are, the following procedure will help you determine your position.

Finding Longitude

To find your longitude you need accurate Greenwich Civil Time and a plumb line.

Sidereal, or star, time gains 3 minutes and 56 seconds every day on sun time because of the change of the earth's position in relation to the sun. At or about noon on 21 September, sidereal and solar time are identical. In one year sidereal time gains 24 hours on solar time and they again coincide.

To find local solar time from local sidereal time, subtract 3 minutes, 56 seconds from sidereal time for each day after 21 September. This is about 2 hours each month. Obtain sidereal time at night in the northern hemisphere as follows:

Polaris forms the center of a huge 24-hour clock in the sky. Beta Cassiopeia (Caph) is the hour hand which rotates counter-clockwise. You can read this clock accurately in two positions only, 24:00 and 12:00, when the two stars coincide with a plumb line. At this time local sidereal time is either 24:00 or 12:00.

1. Subtract the correct amount of time for the particular date and you get local civil time.
2. Compare this with Greenwich time and you have your longitude.

Remember, upper transit is 24:00 and lower transit is 12:00.

Example

Date, 28 December.

1. Set up a plumb line.
2. When Caph and Polaris line up with the plumb line, and Caph is above, it is 24:00 star time (upper transit).
3. Your watch reads 21:44:30 GCT.

9 Sept. (days remaining in September after 21st)
31 Oct.
30 Nov. 98 × 4 (1 minus 1/70) minutes per day
28 Dec. difference in local and sidereal time.
98 days

98 × 4 = 392 min.
Minus 392 × 1/70 = 5 min.
= 387 min. = 6 hrs., 27 min.

24:00 Star time, upper transit.
(Use 12:00 if it is in lower transit.)
− 06:27 The amount sun time lags behind star time on 28 Dec.
17:33 LCT at position of observation.

4. Apply a constant correction factor of − 4 minutes, 30 seconds to your GCT. This gives you 21:40 GCT. This correction factor is used because Caph is not exactly on a line from Polaris to the first point of Aries (the point from which sidereal time is measured). It is 4 minutes, 30 seconds off.
5. 21:40 GCT
− 17:33 LCT
04:07, difference between local civil time and Greenwich Civil Time. Convert to degrees. You are at 61° 45′ West Longitude.

Finding Latitude

Use the altitude of Polaris to find your latitude.

When Delta Cassiopeia or Mizar in the handle of the Big Dipper is horizontal to Polaris, Polaris represents the celestial north pole.

1. Attach a plumb line to the grommet of your plotter.
2. Put the plotter to your eye and sight Polaris along the plotting edge.
3. Let the plumb line hang free.
4. Read your latitude where the plumb line intersects the compass rose.

Driftmeter Check

An emergency driftmeter check can be performed in the air as follows:

1. Fly at approximately right angles to the wind.
2. Read and record the drift correction.
3. Make a 180° turn.
4. Read and record the drift correction on this heading.
5. If the driftmeter is aligned the readings are equal in magnitude but opposite in sign.

If they are not equal, add the recordings mathematically and divide by 2. This gives you the average. Then subtract the average from the larger drift reading, and apply this correction to all further drift readings.

Example

On a heading 90° to the wind you obtain a drift correction of + 7°.

On a reciprocal heading you obtain a drift correction of − 3°.

$3 + 7 = 10 \div 2 = 5$ (actual drift on each heading).

Apply a − 2° correction algebraically to all subsequent drift readings.

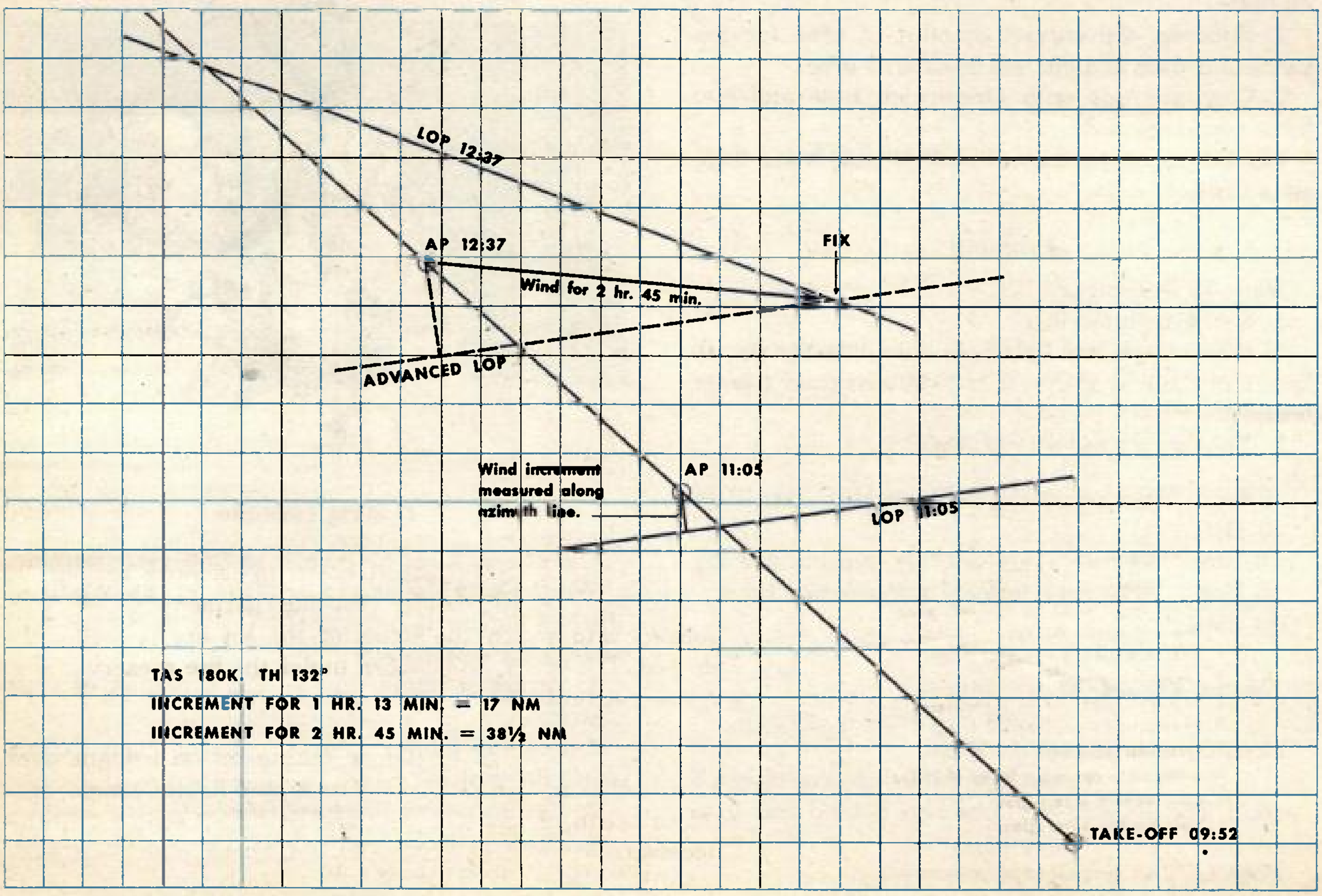
Caution: This procedure is subject to error unless headings flown are close to ± 90° to wind direction.

Noonday Fix

A suggested method by which you can advance sun lines to obtain a fix is described below. This is especially useful when you wish to advance a sun line that was observed before an alteration of course to a specific time after the alteration of course.

1. Measure the effect of the wind along the azimuth of the first LOP from your air plot position.
2. Convert the effect of the wind found by the first LOP to the time of the second LOP.
3. Draw in the azimuth line of the first LOP from air plot at time of second LOP.
4. Measure converted wind effect from air plot of second LOP along this azimuth.
5. Draw in first LOP from this point.
6. Fix is at intersection of LOP's.
7. Measure wind from air plot to fix.

An error in true heading or true airspeed does not cause an error in the fix, but it does cause a wind error.



AIR IDENTIFICATION AND CODE

RECOGNIZE ENEMY AIRCRAFT

Know the types of enemy aircraft you are most likely to encounter, and know everything about these models that your intelligence officer can tell you. Know their cruising speed, diving speed, gun placement and armor, maneuverability, size, caliber of guns, wing span, etc. You can never learn too much about the airplanes you are fighting.

Discipline yourself. Study models. Knowing the scale of models, stand on chairs or boxes and look down on them to simulate various altitudes. Spend as much time studying our land and surface craft as you spend studying enemy equipment. Study until your identification is always positive.

Study enemy airplanes from every angle of approach and every range.

Organize a watch when you are on the line without other duties. Make air identification a game. The first man to spot an airplane approaching the field is rewarded in some manner. The first man to recognize the type of airplane is also rewarded.

To keep from making incorrect guesses, penalize anyone who identifies an airplane incorrectly.

You won't help win the war by sinking our ships or destroying our tanks. Only by diligent practice can you become an expert. Only an expert can be sure of split second decisions. You must be right the first time.

BE PROFICIENT IN CODE

You must be able to send and receive at least to a standard of ten words per minute by aural code, and five words per minute by blinker.

A working knowledge of code is a must on routine missions, and under some circumstances it may be the difference between life and death.

A .—	M ——	Y —.——
B —...	N —.	Z ——..
C —.—.	O ———	1 .————
D —..	P .——.	2 ..———
E .	Q ——.—	3 ...——
F ..—.	R .—.	4 ....—
G ——.	S ...	5 .....
H	T —	6 —....
I ..	U ..—	7 ——...
J .———	V ...—	8 ———..
K —.—	W .——	9 ————.
L .—..	X —..—	0 —————

Practice blinker code on every mission. Get into the habit of doing a good part of your communications in code. Not only must you be able to send and receive code under the ideal conditions of a training classroom, but under the actual conditions of flight. Practice in the air at every opportunity

Intelligence

Combat Duties

On a combat mission it is your duty to keep a complete and exact record of the observations of all crew members. Each member of the crew must make it a habit to report to you immediately on the interphone any unusual events, circumstances or situations. It is up to you to make the crewmen aware of this responsibility.

Have a sketch map of the target on your desk. Use the driftmeter to observe bomb hits, anti-aircraft batteries, etc. Sketch them on your map as you see them.

The Four W's

The record must always include the four W's—What? When? Where? Who? and sometimes Why?

Remember this rule in recording everything you encounter on your missions so that the intelligence officer can make full and accurate deductions from your entries for his journal. It is from your reports, and those of other navigators, that he fills in his situation map, assists in planning future missions, and briefs combat crews.

On special photographic missions you will keep a record of the exact position, altitude, and direction of the airplane whenever a picture is taken. A photograph without this information is of little value to your intelligence officer.

In briefing a crew for a mission, the intelligence officer frequently will give specific instructions for the crew to make special observations at certain points. These specific requests are often made to check information obtained from other crews, or from higher echelons.

When such a request has been made, it is your duty to watch for the location, and as you approach the vicinity, to remind the other members of the crew of what to look for, and where and when to look. You will also record their findings.

Evaluation of Reports

Some members of the crew are more accurate in their observations than others. Some have more vivid imaginations than others. A few are backward in reporting their observations or are given to understatement. It takes time and patience to learn these characteristics of each member of the crew.

You must evaluate these characteristics of each member of your crew for the intelligence officer and thus aid him in making interrogations after each mission short and to the point.

Get information from crew members on the way home. It will be more accurate then than later.

POLAR NAVIGATION

Polar navigation is not for the amateur. While navigation techniques are basically the same in the Arctic as elsewhere, conditions peculiar to these regions naturally restrict the aids available. A few of these conditions are:

1. Weather and atmospheric phenomena.
2. Geomagnetic conditions which affect the behavior of the magnetic compass and radio.
3. The rapid convergence of the meridians near the pole. This makes it a lot harder to determine direction and maintain true course.
4. Prolonged periods of daylight in the summer, making it necessary to depend primarily upon the sun for celestial observations.

At the present time there is no real agreement on which techniques and equipment can be utilized best in these regions.

Pilotage cannot be relied upon because the terrain is covered either partially or completely with snow and ice at all times.

Compass directions become completely uncertain over the magnetic pole and the horizontal intensity upon which compass action depends is not distributed uniformly. Magnetic storms may cause fluctuations of the compass needle as great as 20° to 40°. Although no arctic route now being flown or in prospect of development comes within this area of uncertainty, the principal limitation to the use of the compass there is our inadequate knowledge of magnetic conditions in Arctic Canada and Greenland.

Radio aids are few and far between in the Arctic, except along well-established routes. Strong absorption of radio waves, even to the point of complete disappearance of all signals, is encountered.

Because many problems are still unsolved and proposed solutions have not been tested thoroughly, it is suggested that navigators fly in arctic regions only after careful preparation and study.

Natural Aids

In winter, wisps of drifting snow furnish a ready means of judging wind direction. Over extensive snow-covered areas, such as the Greenland ice cap, **sastrugi** also are reliable guides to wind direction. Sastrugi are ridges of hard-packed snow, a few inches to two or three feet high, which always develop with their axes parallel to the wind direction.

Sky maps are an arctic phenomenon which can be of aid if you interpret them properly. A uniform overcast with clouds at a very high level reflects the surrounding terrain. Level ice uniformly covered with snow consistently shows on the sky map as a plain white area. Broken surfaces, such as pressure ridges, pack ice, and areas of drifted snow give a slightly mottled appearance to the lower surfaces of the cloud. Blue or green ice becomes a greyish patch on the sky map. Open water, timber, and snow-free terrain show up as black areas in the cloud reflection.

A careful study of the sky map may help you determine which direction to travel to reach open water, snow-free areas, or heavy timber.

What are your ideas?

USE THIS PAGE TO KEEP A RECORD OF ANY IDEAS YOU HAVE ON THE IMPROVEMENT OF NAVIGATION

Aerial navigation must keep abreast of the increasing speed and range of modern aircraft. Without navigation that can keep up with or ahead of aircraft design, whole air forces may become impotent. The ideas for improving equipment, the navigator's compartment, and navigation techniques must come from you. As a navigation officer it is your responsibility to experiment and apply yourself to the problem of increasing your accuracy and speed in calculating position.

Airplanes eventually will travel at speeds above 600 miles an hour and over great distances, including polar regions. What techniques and instruments must you have to find your position quickly and accurately under these conditions? Perhaps a gyro sextant, an automatic solution of the astronomical triangle, unrestricted vision from the navigator's compartment, new aids to pilotage, and even more accurate radio aids may help solve the problems that will continue to arise.

NIF is anxious to learn promptly of all improvements in navigation and make this information available to all navigators. New navigation techniques submitted from commands and individual navigators already have found their place in NIF. (See NIF 2-2 and NIF 2-22.) A large part of the File has been revised to bring subject matter up to increased experience levels.

Great Circle. The distance is approximately 1,480 nm.

At A your course is 006°

At C your course is 090°

At B your course is 171°

The rate of change of your required course expressed in degrees true is most rapid at C, the nearest point to the pole.

Suppose now that for some reason the track you actually made good was ADB.

At A your track made good is 348°

At D your track made good is approximately 270°

At B your track made good is 190°

Therefore, in a flight from A to B, your track made good might have any value from 0° to 360° at some moment during the trip. A normal error in your dead reckoning position such as might occur during a long flight could mean that your track made good at the moment, expressed in degrees true, was far different from what you thought it was.

For any other flight, such as AE, though the rate of change of track true may not be as great as it is at C, it does change continuously and excessively from A to E.

To fly the great circle AB or AE by a succession of rhumb lines, i.e. by a succession of true courses, means a large number of course alterations. It is too much trouble to calculate them.

The change in magnetic variation is very rapid as you approach the pole, it is not a well known value, and the horizontal component of the earth's magnetic field is small. Compass courses are complicated and not at all accurate to follow.

In most cases longitude changes so rapidly that an error of any degree in your dead reckoning position causes a considerable difference between your actual longitude and your dead reckoning longitude. This gives you trouble when calculating the altitude and azimuth of heavenly bodies.

Wind velocities also give you trouble. A constant north-east wind over the whole route from A to B, means a head-wind to start with, and a tail-wind at the end of your trip. Also, if the wind at C and D is approximately the same with regard to your airplane's general track from A to B, say from a relative bearing of 45°, it is a south-east wind at C, and north-west wind at D. If the wind-direction is constant from A to E, with regard to your airplane's track, it is expressed as a great many different directions in degrees true, as you proceed from departure to destination.

Three Solutions

Here are three aids to provide you with a simple, quick, and accurate method of navigating from any point in this region to any other point, whether you pass to the right or left of the pole, or whether you pass directly over the pole.

1. The construction and use of a polar astrograph for use during Arctic night.
2. The measurement of directions in polar latitudes by the G system.
3. Navigating during Arctic Day and Twilight.

THE POLAR ASTROGRAPH

From approximately October 9 to March 5 in the succeeding year, the sun is 6° or more below the horizon of an observer at the North Pole. To make use of this astrograph, you must plan a flight so that the stars will be visible.

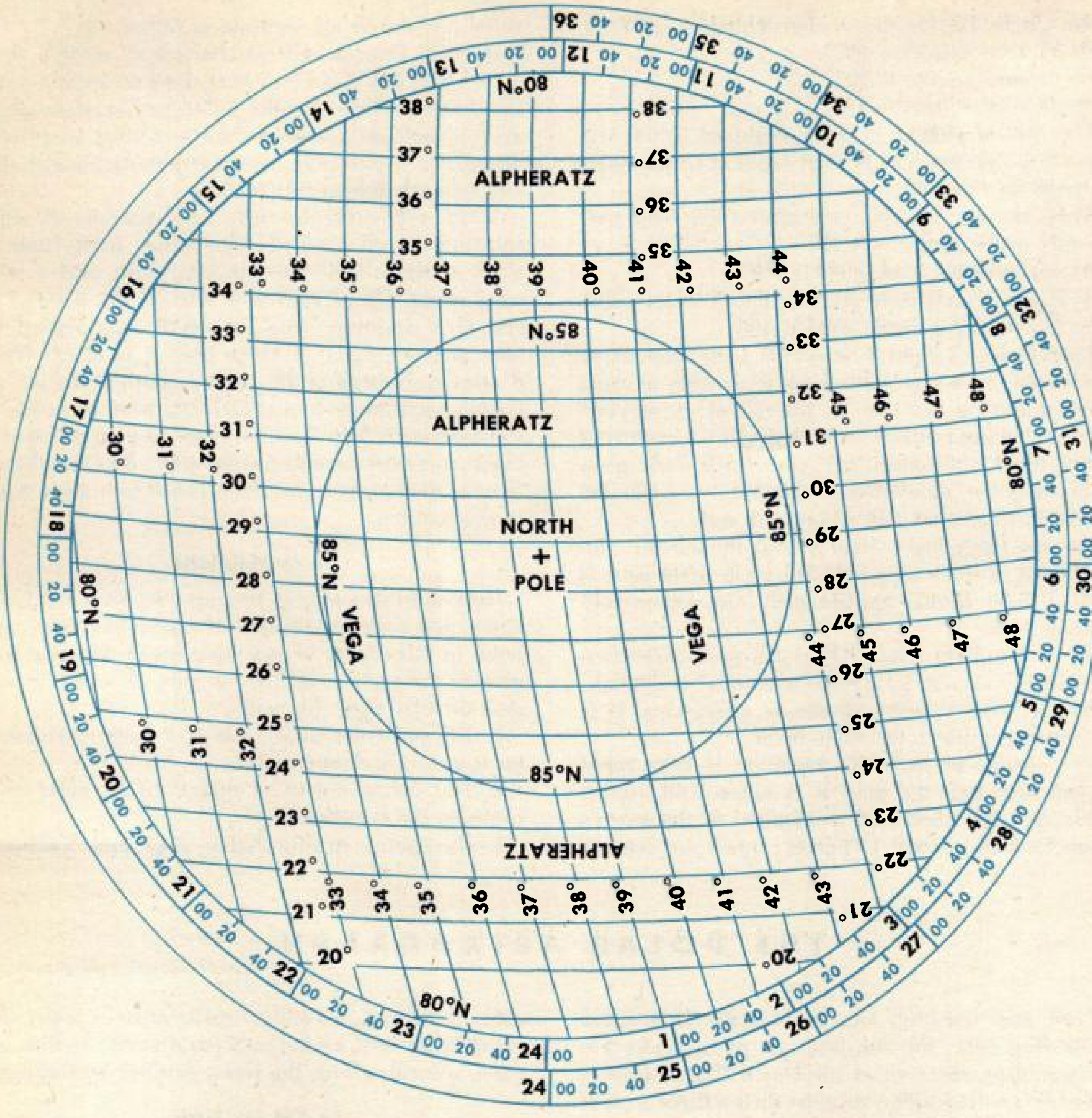
The simplest method of fixing your position is by sextant observation of the stars together with a polar astrograph constructed along the lines of the regular astrograph. The polar astrograph is a projector which throws the shadow of a set of intersecting star curves on your chart.

You do not need a roll of film. Draw the star curves on a film or glass plate, and place it between two glass plates. Use a stereograph projection. To set for latitude adjust the instrument until the shadow of the pole on the film coincides with the pole on the map. To set for scale, raise or lower the instrument until a reference parallel on the film, or plate, coincides with the same parallel on the map.

To Set for Time

To set the polar astrograph for time, print an astrograph time scale around the edge of the curves, or along any parallel of latitude such as 80°N. Revolve either the plate or the whole instrument about the pole as center, until the AMT of the sight coincides with the setting longitude for the date, as marked on your chart. Use the standard astrograph tables. The same figures are required as for normal latitudes.

If you project the whole of the region north of 75° N at once on your chart, which is completely spread out, you don't need to use a setting longitude in the



STAR CURVES FOR POLAR ASTROGRAPH LAT. 80° N TO NORTH POLE. SCALE AROUND EDGE IS AMT

same neighborhood as your dead reckoning position. The setting longitude used is Long W = GHA for 12 hours GCT, at which AMT = GCT.

If you use a larger scale chart so that your whole map is not spread out at once, construct the projector so that while the plate or film of star curves still rotates around the pole, only the required portion is projected on the chart.

An alternative method of building a projector is to construct a type of Baker Machine, consisting of a special transparent navigation chart with meridians and parallels on it, and underneath it the star curve chart pivoting at the pole. By using an AMT scale on the star curve chart, and the Greenwich hour angle for 12 hours GCT, which is printed on the back of the machine, to cover the whole year, you can set the curves very quickly for time. Mark the setting longitude on the transparent navigation chart, and after drawing the position lines and obtaining the latitude and longitude of the fix, move the fix to your navigation chart.

While construction of the Baker Type is easy and enables you to have several films, each one using a different pair of stars, it requires a fairly small scale. As a result you do have the trouble of dealing with two charts at once and transferring positions from one to the other. One of the great advantages of the projector type is that you can recognize the effect of errors of time and of observed altitudes on your navigation immediately. It is easy to see how accurate you must be. Make the plates interchangeable so that you can use different pairs of stars with the projector type. Or prepare several charts adjacent to each other on a roll of film, and put the appropriate star chart roller into place before adjusting for time. Either method is accurate and useful.

You can rotate the navigation chart about the pole in order to set the projected curves for time, but it is better to have the projector plate, film, or projector itself, revolve.

The AMT Scale

The AMT method of setting the curves for time is the best one, as it removes any worry about the accuracy of your dead reckoning longitude and calculations of hour angles. You don't have to refer to the Air Almanac constantly. You have no calculations to make and it is as simple as working the regular astrograph. Set AMT 12:00:00 at the point where the local hour angle is 000° 00′. If the whole polar region is not shown at once use the regular astrograph tables. Relist the tables of setting longitudes for polar work under Greenwich dates rather than local dates, to eliminate confusion and errors during the Arctic day and Arctic night.

Choice of Stars

Polaris is of little value for curves of this sort because it is directly overhead. If you do use it, you must draw equal altitude circles just as you do for any other star. Since you cannot take bearings on it with any accuracy, use other stars both for fixing your position and for taking bearings.

It is best to draw the curves for only two stars on the one chart of the whole region. Have the curves cross as nearly at right angles as possible. Draw other star curves on other plates if one or both of the main stars are obscured. Since you use the stars for both sextant observations and for taking bearings, Aldebaran, Dubhe, and any which cannot be seen all the time, are omitted.

The best pair is Vega-Alpheratz, with Arcturus-Pollux as a secondary pair. In the latter case, because of refraction, altitudes near the lower limit of 4½° for Arcturus are not reliable.

Use the following table as a reference.

TABLE OF STARS VISIBLE THROUGHOUT THE REGION

NO.	NAME	SHA	DECLINATION	ALTITUDE RANGE
3	Aldebaran	291° 49′	N 16° 24′	1° 23′ — 31° 23′
4	Alpheratz	358° 38′	N 28° 47′	13° 46′ — 43° 46′
5	Altair	62° 59′	N 8° 43′	6° 17′ — 23° 43′
7	Arcturus	146° 43′	N 19° 28′	4° 29′ — 34° 29′
8	Betelgeux	271° 58′	N 7° 24′	7° 36′ — 22° 24′
10	Capella	281° 52′	N 45° 57′	30° 56′ — 60° 56′
11	Deneb	50° 07′	N 45° 05′	30° 04′ — 60° 04′
12	Dubhe	194° 55′	N 62° 03′	47° 04′ — 77° 04′
15	Pollux	244° 32′	N 28° 10′	13° 10′ — 43° 10′
16	Procyon	245° 54′	N 5° 22′	9° 38′ — 20° 22′
17	Regulus	208° 39′	N 12° 14′	2° 45′ — 27° 15′
22	Vega	81° 15′	N 38° 44′	

Combined Use of Astrocompass and Polar Astrograph

The magnetic compass is not reliable in polar regions. The best method is to steer courses with your directional gyro and check the course with your astrocompass. If you were flying from A to B and there were no wind, a frictionless directional gyro would enable you to keep the airplane on the great circle route from A to B. This is ignoring the coriolis effect. Since the directional gyro is not frictionless, you must check it at regular intervals by taking bearings on the stars with your astrocompass.

Because of the rapid change in longitude and consequent rapid change of hour angle, the simplest and most accurate method of using the astrocompass is to use it in conjunction with the polar astrograph. The direction of the stars is at right angles to the equal altitude circles in the direction of increasing altitudes so that by using the astrocompass as a bearing plate, you can take azimuth and altitude from the astrograph, rather than latitude, local hour angle, and declination from the almanac.

Since Vega, Alpheratz, Arcturus, and Pollux appear in four different quadrants in the sky you can obtain satisfactory results by using them alone.

Map Projection

Since you measure the bearings of the stars from the curves, the projection must be conformal. This is necessary if you use the projector type of astrograph, in order to use the map for ordinary navigation methods. It also must be an azimuthal or zenithal projection, as the star curves must be rotated about the pole. The projection which satisfies both of these demands and is already used for polar latitudes, is the polar stereographic.

MEASUREMENT OF DIRECTION IN POLAR REGIONS

Much of the difficulty involved in trans-polar navigation results from the rapid convergence of the meridians. When flying directly over the pole, your course changes through 180° true. Also, at the pole itself every direction is south or 180° true. This is so merely because the pole has been chosen as the reference point for directions on the earth. The choice of another point on the earth's surface far removed from the pole from which to measure directions while in polar regions solves the difficulty.

Normally the use of the North Pole and the system of meridians is a convenient one because the magnetic needle aligns itself closely to the true meridian usually. But near the pole itself this is far from true, as you can see from a map of lines of equal magnetic variation which illustrates the magnetic variations from degrees true. Because you cannot rely upon your magnetic compass and you use the directional gyro checked by astrocompass as a direction indicator, there is no reason for you to continue to use degrees true for expressing directions in these latitudes.

In fact, as long as you use a type of conformal map projection, any system of lines can be drawn on the map from which to measure directions. If you use a projection such as the polar stereographic exclusively for polar navigation charts and polar weather maps, then draw a system of lines on the chart parallel to the meridian of Greenwich. The true meridian of Greenwich is expressed as 000° Greenwich or 000°G. Label the system of parallel lines on the map in the same manner. The opposite direction along each line is called 180°G and directions are measured in those regions clockwise from 0° to 360°G from any one of these parallel lines.

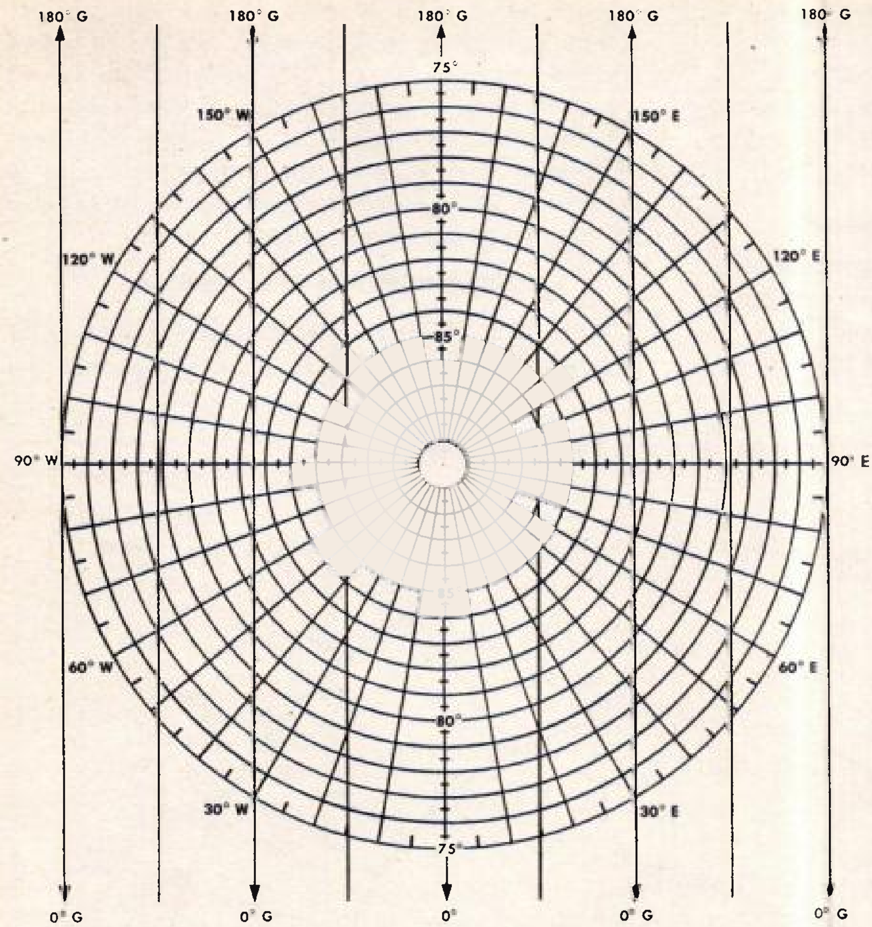
For a particular flight the required track from A to B could be used as a reference line, and all courses and wind directions measured relative to it. But for using weather maps, or for figuring a change of course, a simple unchanging standard such as degrees G, is much better.

Great Circle Routes

Since on the stereographic projection a straight line represents a great circle, the great circle track from A to B is represented as a single direction in degree G. You don't have to alter course for convergence of meridians.

Checking Gyro with Astrocompass

If the directional gyro did not precess, you could set the compass heading G on the directional gyro at the beginning of your trip and it would remain the same from A to B, except for changes in wind velocity and the coriolis effect. You must check the directional gyro continually because it does precess. Check direction with your astrocompass. Use it as a bearing plate and take the azimuth and altitude



POLAR STEREOGRAPHIC CHART WITH "G" SYSTEM

DIRECTION IN DEGREES G = TC {+ LONG. WEST / − LONG. EAST} ± 180°

ADD 180°, IF TC {+ LONG. WEST / − LONG. EAST} IS LESS THAN 180°

SUBTRACT 180°, IF TC {+ LONG. WEST / − LONG. EAST} IS GREATER THAN 180°

from the polar astrograph.

Set the polar astrograph properly for time. At your dead reckoning position, read the approximate altitude of one of the stars, and measure its direction or azimuth in degrees G. Set the azimuth reading on the astrocompass at the arrow labelled "TRUE BEARING" and set the altitude on the declination scale. Then swing the astrocompass around until you sight the star. Read your course in degrees G from the azimuth scale at the lubber line. Coriolis effect is of minor importance so ignore it.

An error of 100 miles or so in your dead reckoning position means but a small error in the calculated, or measured, bearing of the star in degrees G. So when you use this bearing on your astrocompass your measurement of course in degrees G is only slightly in error. The error is about the same in the polar regions as in normal latitudes. If you measure the bearing in degrees true in high latitudes, an error in dead reckoning position of as much as 100 miles gives you a considerable error in longitude. This means a considerable error in the calculated bearing of a star in degrees true which results in the same error in the measurement of course in degrees true. Since this error and the resulting confusion stems from the use of true north as a reference point for direction, always use degrees G rather than degrees true in these latitudes.

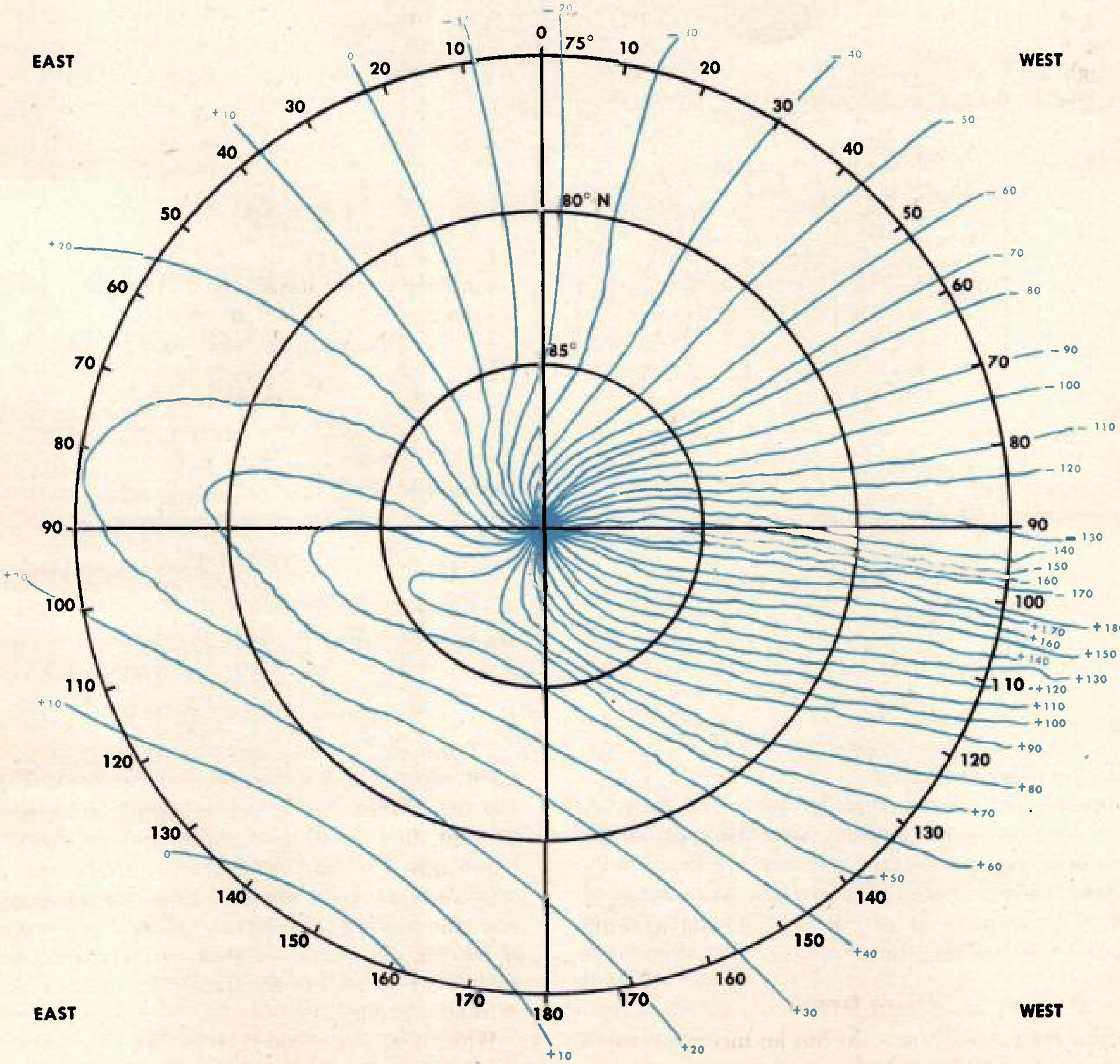
Measurement of Wind Directions

A constant wind speed from a constant direction in degrees true means a continuously changing wind velocity relative to your required track. A constant wind relative to your desired track is expressed as a wind blowing from a continuously changing direction in degrees true. Always measure wind direction in degrees G. You can express wind direction relative to your required track AB, but this does not have the same advantages as always expressing it relative to the same direction, as in degrees G. The weather forecast for the route must also express wind directions in degrees G.

Navigating into Polar Regions

When you fly from lower latitudes into polar regions express directions in degrees true until you

LINES OF EQUAL MAGNETIC VARIATION



reach 75°N. Then mark your position and your intended track on a polar chart and begin to navigate as outlined above.

Measurement of Position

You must express your position by latitude and longitude when you join the polar portion of your flight to the non-polar portion, so express position by latitude and longitude for polar navigation. This will give your polar navigation proper continuity.

Variation

Magnetic variation changes very rapidly near the pole. This is partly due to the proximity of the magnetic pole but is also due to the use of the true pole as the point from which you measure directions. By flying a small circle around the pole you pass through 360° of variation. In certain parts of the polar region the horizontal force is sufficient to allow a magnetic compass to give an approximate indication of direction provided that it is not corrected too much for deviation or shielded too greatly. During the bad weather or when the stars are obscured for a time you may find the mangetic compass of some use. An earth indicator compass or double pivoted magnetic needle will give you better results, however, because changes in magnetic dip do not affect them.

Express the numerical value of the variation relative to the direction of the Greenwich meridian. Express variation from 000°G as a positive number from 0° to 360°. This gives you course G when applied to your magnetic course and makes it easier to use the compass.

By expressing wind directions and magnetic variation in the same system you can tell at a glancc how many times you must alter magnetic course in order to fly from A to B.

ARCTIC DAY AND TWILIGHT NAVIGATION

When observing the sun, planets, moon, and odd stars whose declination lies between 10°S and 30°N use a Baker Machine type of astrograph with 4 sets of curves for declinations 5°S, 5°N, 15°N, and 25°N, respectively.

For any declination in the range 10°N—20°N use the curves for 15°N. First adjust them until the altitude at the pole is equal to the declination. To do this you must have a slot in the curves along the central meridian for 5° on either side of the 15° altitude curve. If declination is 18° 38′N move the curves along the central meridian until the altitude at the pole is 18° 38′.

Be sure to adjust for refraction. Then rotate the curves around the pole until the Greenwich hour angle of the sun, moon, planet, or star is set.

Use a stereographic projection because it is both conformal and azimuthal.

Maximum error arises when you use the curves for a declination 5° different from that for which they were constructed.

The maximum error in azimuth is about ½ or 1°, with the greater part of the area having azimuth errors much less than this.

Watch Errors

Fixes for a correct sextant but an incorrect watch are correct as to latitude but incorrect as to longitude. They are displaced east or west 15′ of longitude for every minute of watch error. An error of 4 minutes of watch time will cause your fix to be in error 1° of longitude which is only 15 nm at latitude 75°N and 10 nm at latitude 80°N. You need to record watch time only to the nearest ½ minute since an error of ½ minute of time will cause errors of less than 2 miles.

Rate of Change of Azimuth

If you are flying near the pole the true azimuth changes rapidly, but azimuth in degrees G changes slowly. You therefore cannot obtain a running fix from successive sun observations.

Navigation During Arctic Twilight

At the North Pole the sun is above the horizon for 6 months and below the horizon for the rest of the year. When it is 6° or more below the horizon, use the stars for navigation. During the Arctic Day use single position lines obtained from the sun. If you can plan your flight so that the position lines from the sun are parallel to your track when you are nearing destination your work will be easier. Always have your watch set accurately to Greenwich civil or sidereal time.

When you are located at either of the poles of the earth your zenith and the elevated pole coincide, and the plane of your horizon coincides with the plane of the equator. All vertical circles of azimuth cutting the horizon coincide with all meridians cutting the equator. All parallel circles of altitude coincide with similar parallel circles of declination.

Altitude is therefore always equal to declination, and azimuth is always equal to hour angle. Hour angle is the longitude of the celestial body's meridian as measured from Greenwich.

Forget solution books and use the Almanac, because every celestial body in the heavens has the true value of its coordinates accurately recorded in the Almanac. For any given instant of Greenwich civil time (GCT) you can obtain declination (altitude), and Greenwich hour angle (azimuth).

Your assumed position is always the elevated pole. When you observe the celestial body note the exact GCT. From the Almanac find the proper declination and Greenwich hour angle of the body for the exact GCT of observation. When the true observed altitude, Ho, is greater than the declination, Hc, go from the pole toward the celestial body along the azimuth, GHA. The azimuth is the meridian upon which the celestial body lies. If the observed altitude is less than the declination, go from the pole away from the celestial body along the azimuth or longitude equivalent to the Greenwich hour angle.

Observations on well separated bearings give as good a fix close to the poles as anywhere else on earth. For example: Near the pole, about midnight, on June 29, 1940, the true observed altitude of the moon by bubble sextant was 9° 48′ at a GCT of 23:15:12 and the true observed altitude of the sun 21° 58′ at 23:17:24 GCT.

Solution

MOON		SUN	
GCT	23:15:12	GCT	23:17:24
GHA	236°W	GHA	168°W
or	124°E		
declination	10°57′N	declination	23°12′N
Hc	10°57′	Hc	23°12′
Ho	9°48′	Ho	21°58′
Intercept 69 miles away		Intercept 74 miles away	

1. On any polar projection such as HO chart No. 2560 plot the meridian of 124°E. Since this is the moon's Greenwich hour angle, that body is located on this meridian.
2. Plot the meridian of 168°W. Since this is the sun's Greenwich hour angle, that body is located on this meridian.
3. Lay off a point 69 miles away from the moon.
4. Draw the line of position at right angles to the azimuth 124°.
5. Lay off a point 74 miles away from the sun.
6. Draw a perpendicular to the azimuth 168°W. The intersection of these two lines is your position.

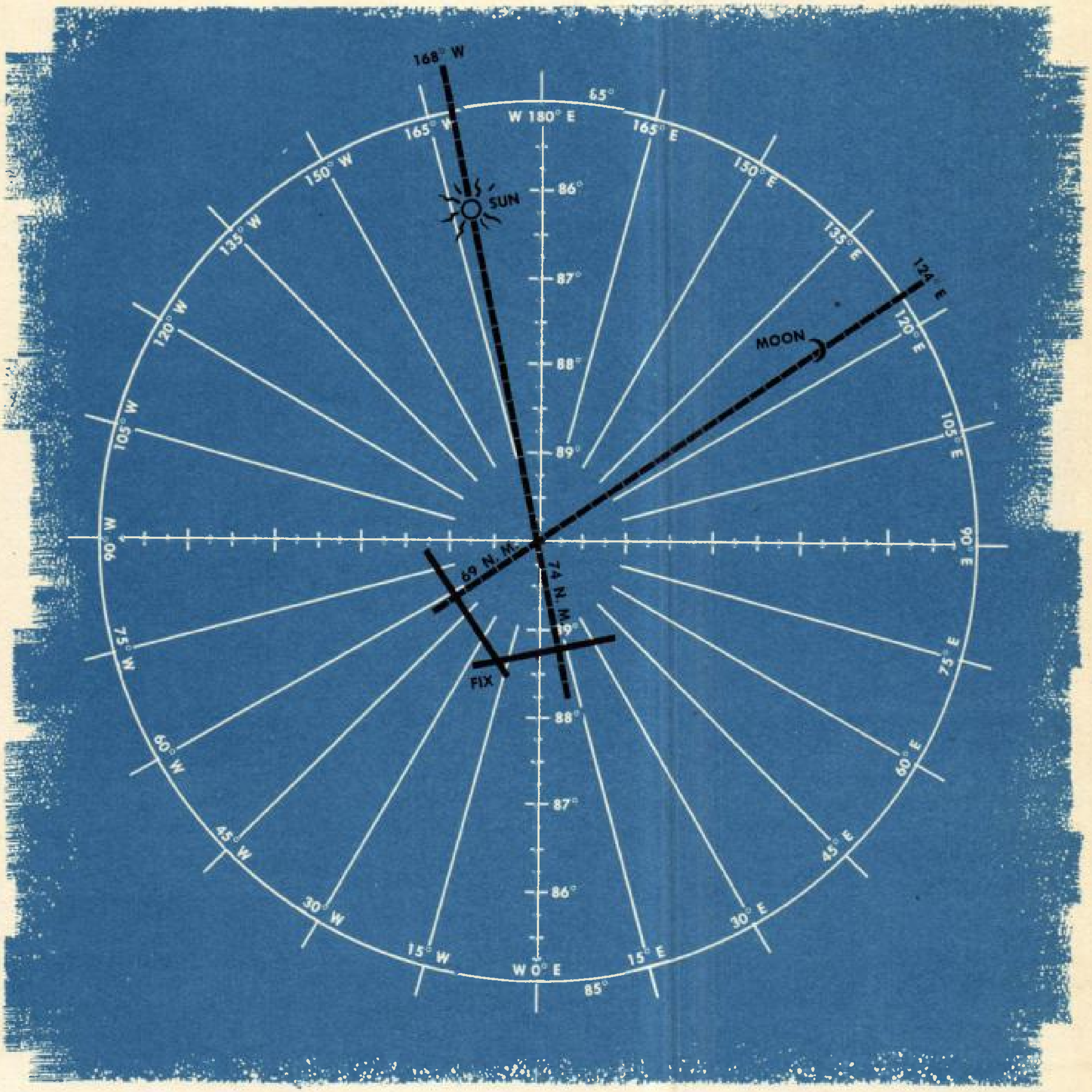
The best projections to use are the Polar Gnomonic Chart (H.O. 5405-1) the Azimuthal Equidistant Chart (H.O. No. 2560 or 2560A) or any stereographic projection chart.

Circles of equal altitude for the sun have a large radius near the poles, because the sun is always low. Within 5° of the pole the correction for a line of position does not exceed 3 minutes so the position line is correct when you use it as a straight line. When stars have a high declination the position line curves. This curve must be taken into consideration when plotting a straight line of position.

During twilight use the planets or moon as much as possible. You can use the moon for varying periods of each year. You can use Venus, Mars, Saturn and Jupiter at times, depending on their declination. Use polaroid filters and telescopic attachments on your sextant to get better results when observing stars. It is a good idea to experiment with filters and attachments to decide for yourself which ones give you the best results.

Refraction

The astronomical refraction is not great for the stars used on the polar astrograph, but allow for it in constructing the curves. When taking observations of the sun when it is low be sure to apply the correct amount of refraction. The atmosphere over the poles is dense and there is more refraction on a low observation there than any other place on earth. This is an important aspect of polar navigation. Proper use of refraction will improve your polar fixes.



PLOTTING THE LOP

What are your ideas?

USE THIS PAGE TO KEEP A RECORD OF ANY IDEAS YOU HAVE ON THE IMPROVEMENT OF NAVIGATION

WRITE YOUR IDEAS DOWN. DON'T PUT IT OFF OR YOU'LL FORGET ABOUT THEM.

SECTION 5

CREW DUTIES

YOU ARE A CREW MEMBER AS WELL AS A NAVIGATOR. KNOW YOUR EMERGENCY CREW DUTIES AS WELL AS YOUR NAVIGATION DUTIES FOR YOU WILL HAVE TO CALL ON EVERY SKILL ON EVERY MISSION.

CREW DUTIES

LEARN TO PINCH-HIT FOR EVERY OTHER MEMBER OF THE CREW

Many combat missions have been successful and many planes have returned to their bases because some member of the combat team was able to pinch-hit for a fellow member. What you can learn about piloting, bombardiering, gunnery, and radio operation may one day save you and your crew.

How much you know about the duties of the other members of your crew depends upon your initiative. Reading the brief discussion of duties of other crew members which follows in this section, will not make an expert out of you, but it may give you some idea of the crew's problems.

Talk these problems over with your fellow crew members, and handle the equipment until you know you can pinch-hit in case of an emergency.

Your fellow crew members have spent long weeks learning their particular skills and you won't be able to master their jobs, but you can learn a few important facts about every other crew position in the airplane. Check directly with the pilot, the bombardier, the radio man and the gunners. Know their general routine duties, know a few emergency measures, and operate from each of these positions at least once.

The information in this section is a guide to help you study the other crew duties. Use this information as a basis for improving your usefulness. Ask each crew member to explain points that aren't clear in your mind.

These are things that you will have to find time to do. Is your life worth the effort?

BOMBARDIER

Learn how to read drift with the bombsight, operate the bombardier's control panel, open and close the bomb-bay doors, turn the rack switches on and off, and release the bombs either in train or in salvo. The success of a mission may well depend upon your being familiar with the bombardier's equipment.

You are not expected to become an expert bombardier, but you must become so familiar with the bombsight and the mechanics of its operation that you are able to pinch-hit.

The bombardier checks his equipment and performs a mission in the following manner. Study this section and go through every operation under the supervision of your bombardier until you are qualified.

Before flight, the bombardier checks the C-1 autopilot to see that it is properly maintained. He flight-checks it prior to every combat mission.

He adjusts his equipment and adjusts the control-box pointers for best performance at the approximate altitude of the intended flight. This enables the pilot to use the equipment without much further adjustment.

The target folder contains target information in the form of maps and photographs. The aiming point and the paths in and out are indicated.

The bombardier studies these maps and photos and determines how he is going to identify the target. He anticipates the possibilities of camouflage. He studies landmarks leading to the target, and information on the alternate targets.

The target folder also gives him the bomb loading, the bomb interval for the train, the pressure altitude, and the indicated airspeed.

When he has the weather report, he computes the bombing altitude, true airspeed, tangent of dropping angle, drift, groundspeed, and intervalometer settings for the expected run.

The altimeter is always set with the Kollsman number at 29.92, so that it reads pressure altitude.

He must know how to estimate bombing altitude on his computers, both E-6B and C-2. (The official designations for these computers are AN5835 and AN5837, respectively.)

Preflight

Between briefing and takeoff, watch the bombardier preflight and check all of his equipment. Consider the following checklist as one which you may be called upon to use:

1. Sight and stabilizer: Set in disc speed and trail, zero automatic bombing computer, set in metro wind and true airspeed, and set expected tangent of dropping angle on sight.

The sight and stabilizer are set with the idea of checking and rechecking them in the air during the mission.

2. C-1 autopilot: Position the pointers so that the adjustment corresponds to that obtained on the previous flight check.

3. Bombardier's cockpit:

Indication lights (bombs, doors, intervalometer).

Intervalometer: Make settings determined at briefing.

Rack and door controls.

Oxygen.

Guns (covers, headspace, buffer, switch, ammunition).

Bombardier's kit: Should contain E-6B; C-2; tachometers; field glasses; stop watch; complete target folder (primary and alternate targets); tables for bombs loaded; pencil and paper; pen light, if mission is at night; tangent scales for AB computer for bombs loaded.

4. Bomb bay:

Prior to loading of bombs, racks should be run through with a bombsight automatic release mechanism and toggle switch, using intervalometer set for SELECT and TRAIN.

Bombs: Make sure that the shackle release and the arming levers are installed properly in the bomb-release mechanisms; check both the installation and the length of the arming wires; check fins (alignment, dents, etc.) and examine fuzes (safety pins, arming wires, settings, spinners).

After Takeoff

1. Turn on STAB, SERVO, and BS switches (may be turned off after checking, until about one hour from target).
2. After reaching an altitude of 1000 feet, turn on C-1 autopilot.
3. Pull bomb pins when safe to do so.
4. Check sight data.
5. Level stabilizer at altitude.

6. Determine winds as frequently as possible and use latest available wind to obtain pre-set data for bombing run. At takeoff, set on the computer the best available metro wind for the target. When you reach flight altitude, obtain the latest wind and use it in place of the metro wind.

Over Enemy Territory

In addition to obtaining the wind:

1. Keep up-to-date on the airplane's exact location, and spot enemy aircraft.

2. Watch weather, to determine whether target can be bombed or an alternate will be bombed.

3. Use field glasses to pick up the target as soon as possible. Be sure you are on the right target.

4. Check setting of racks, switches, and intervalometer (interval, number of bombs, train).

5. Pre-set drift.

6. Take over formation by use of the secondary clutch and C-1 autopilot before the turn over the Initial Point. In the event that the C-1 autopilot is shot out, the pilot can use the same procedure, following PDI.

7. Open bomb-bay doors at the IP and set rack lever to SELECT.

8. As you roll out of the turn over the IP, line up the trail rack on the target with approximate drift pre-set and level bubbles.

9. Begin evasive action. Check dropping angle and drift on first straight flight.

10. Continue evasive action and re-place lateral hair on target with displacement knob whenever possible. Level bubbles before turn on bombing run.

11. As the sighting angle index approaches the point where the desired run is to begin, start turning on the target. As the line over the trail racks nears the target, make shallow turn and pick up the target through the telescope. As fore-and-aft crosshair nears the target, engage bombsight clutch.

12. Place crosshairs on the target with turn and displacement knobs, level the bubbles, and raise the release lever.

13. Refine drift and rate to "Bombs away." When the indices meet, check to see if the intervalometer is working properly. If a malfunction occurs and all bombs are not released, salvo the remainder or change TRAIN-SELECT switch to SELECT and toggle them as rapidly as possible.

14. During the turn onto the target and the bombing run, keep the pilot informed of your progress.

15. After last bomb is out, call "Bombs away" and turn the ship over to the pilot.

16. Close the bomb-bay doors; then turn off equipment and, if time permits, make these observations:

Time over target.
Bomb hits.
Fighters.
Flak, accuracy and amount.
Weather.
Drift and tangent and heading.
Friendly aircraft in trouble.
Fires in target area.
Enemy shipping and transportation.
Any other military information.

Run for Lead Ship on High Altitude Mission

1 Bombardier takes over and makes turn to line airplane on target at IP. Opens bomb-bay doors and puts racks in select.
2 Notes drift and dropping angle from AB computer. Uncages. Places lateral crosshair on target.
3 Pre-sets dropping angle and drift.
4 Continues evasive action.
5 Re-positions lateral crosshair with displacement knob.
6 Levels bubbles.
7 Places crosshair on target with outside knobs, raises release lever, refines drift course and rate.
8 Bombs away; closes doors, observes.

Evasive Action

The bombardier must learn how to take evasive action, as only he can determine the path from the IP into the target. The pilot cannot see the target or determine how far he is from the bombing run.

The lead ship must remember, in taking evasive action, that a formation of planes is following. This limits the bank to about 12° maximum. The planes should roll into and out of turns slowly and smoothly. After every turn, the lead ship should fly an irregular path with turns of from 5° to 15° in azimuth, followed by a straight path of from 15 to 30 seconds, to allow the formation to keep closed up. During these straight stretches the bombardier presets drift and dropping angle, checks position of lateral crosshair, and levels bubbles.

The bombardier should keep the wind in mind, to allow the plane to come in on the predetermined heading, and the final turn should be made downwind, if practicable.

Evasive action involves a definite change in altitude and in course; not merely a change in altitude.

RADIO OPERATOR

Radio navigation is an indispensable aid in guiding your airplane. Know what your radio compass can do and what it cannot do.

Know the errors that affect its use.

Know how to compensate for these errors.

Recognize jamming by enemy transmitters.

Know the ranges and locations of all friendly facilities for each mission.

Learn to use the radio compass to full advantage for homing as well as for direction finding.

Study ground direction-finding facilities. To work with the radio operator in obtaining a fix or bearing, you must know medium frequency (MF/DF), high frequency (HF/DF), and very high frequency (VHF/DF) direction-finding facilities as you find them in various theaters of operations.

Understand all other radio aids to navigation, such as beacons, radio ranges, and broadcasting stations, and know when to use them.

Your working knowledge should include a familiarity with cryptographic materials which are carried on a mission. These items include authenticators, weather codes, aircraft codes, enemy contact report codes, frequencies, and such other items as the type of mission requires. Know how to use them.

You must attain proficiency in visual and aural code of at least five and 10 words per minute, respectively, in order to be able to use your radio aids properly.

In brief, you must be able to use the radio compass, have knowledge of all radio aids to navigation, and be able to receive and send code by telegraph and blinker. To acquire skill in the use of these aids you must apply yourself.

The Radio Operator's Job

Here are instructions for the radio operator. Study them carefully. You learn only by doing, so spend as much time as you can on the radio and use this outline as a guide so that you may ask intelligent questions.

Before Takeoff

1. Secure all pertinent information about the flight. Always include the following:

   Know your frequencies and call letters.

   Set your watch and the airplane's clocks accurately. (Use tower and ground station.)

   Get a radio mission folder.

2. Make a complete visual inspection of all the airplane's radio equipment.

   Consult the Form 1A.

   Check all antennas for breakage and fouling.

   Check facility charts.

3. Make brief operation check.

   Check filament voltages.

   Check power amplifier loading.

   Check dynamotors (for running conditions).

   Call all positions on the interphone (especially for high altitude missions).

   See that headsets and mikes are at each crew position for high altitude flights.

   Turn on the liaison receiver and allow it to warm up. (Use AVC positions.)

In the Air

Check into the net.

1. Tune in ground station on receiver.
2. Wait until transmissions cease before tuning the transmitter.
3. Give position report every 30 minutes. (This is not done in actual combat.)

Before Landing

1. Check out of the net.
2. **Make sure trailing wire is completely retracted.**

After Landing

1. Shut off all equipment.
2. Write any and all radio defects in Form 1A.
3. In case of failure to check out of net, inform the ground station verbally.

Remember

1. While flying formation, the radio operator in the lead airplane sends in reports for the formation on fixed wire. In case he is unable to do so on fixed wire he informs the formation leader of such failure. The formation leader then authorizes one of the wing airplanes to let out trailing wire in order to make contact and put in the report.

2. It is your responsibility to monitor the group frequency at all times when practicable.

3. Remember you are on a party line. Don't sit on the key. Keep it open for business.

4. In emergency, use any facilities available to get your message through and don't stand on ceremony.

5. Your equipment is precision-made so take care of it, on the ground and in the air.

Temporary Remedies

Most of the following statements are based on hypothetical situations which often occur during flight. Most radio failures can be remedied temporarily in the air.

1. If the command antenna breaks, you can rig an emergency antenna in flight. Do this by running a wire between the command transmitter and the knife switch located beside the liaison transmitter. You can use either fixed or trailing wire, depending upon the frequency.

2. Let out approximately 40 turns of trailing wire to allow the weighted ball to clear the end of the airplane, so it won't tangle with the tail guns and bang into the fuselage.

3. When the interphone fails during flight, if SCR-522 equipment is not installed you can remedy the situation temporarily by placing the jackboxes in command position and turning the selector switch (located on the control head in pilot's cockpit) on the No. 3 or No. 4 position.

4. When reception is impossible on all receivers, because of precipitation static or St. Elmo's Fire, dissipate the static by lowering the trailing wire 50 or more turns and grounding it to the body of the airplane. Use a piece of safety wire or any metal object available. **Liaison transmission and reception are not affected on fixed wire.**

5. In case of command failure, make control tower contact by under-tuning your liaison on voice, on 6210 kc. Remember, full or maximum tuning blocks the tower's receivers if your airplane is at the field or near the field.

6. If all your radio equipment fails or if radio silence has been imposed, use the Aldis lamp to signal other airplanes or the tower. The plexiglas nose offers the widest range of vision for this operation.

7. Use this method of setting the liaison transmitter on the same frequency as the ground station. Use the monitor switch and zero beat against the ground station. If you can't hear the ground station, use your frequency meter. Interpolation should be used as a final setting for the master oscillator only when:

You cannot pick up the ground station.

You cannot operate your frequency meter.

Distress Frequencies and Calls

In general, transmit distress signals on your assigned air-to-ground frequency. If you can't make contact using this frequency, use the following:

1. **The U.S. Emergency and Safety Frequency, 8280 kc.** This is guarded by the AAF, Navy, and Coast Guard.

2. **The International Distress Frequency, 500 kc.** By international law, all surface vessels maintain a watch on 500 kc for three minutes after the first and third quarters of each hour.

3. Any other available frequency on which you can make contact.

There are three basic types of distress signals.

1. **Security:** Use this signal when:

Your position is uncertain.

You expect an emergency.

If you can still proceed or can land at a suitable field with the aid of a ground station:

On CW, call TTT.

On VOICE, call SECURITY.

2. **Urgent or Emergency:** Use this signal when your airplane is in trouble and you require immediate navigational aid.

On CW, call a known ground station, using the prosign 0; or call an unknown station, using the signal XXX.

On VOICE, call PAN, or EMERGENCY.

3. **Distress:** Use this signal when your airplane is threatened with serious or imminent damage, and you need immediate help.

On CW, call SOS.

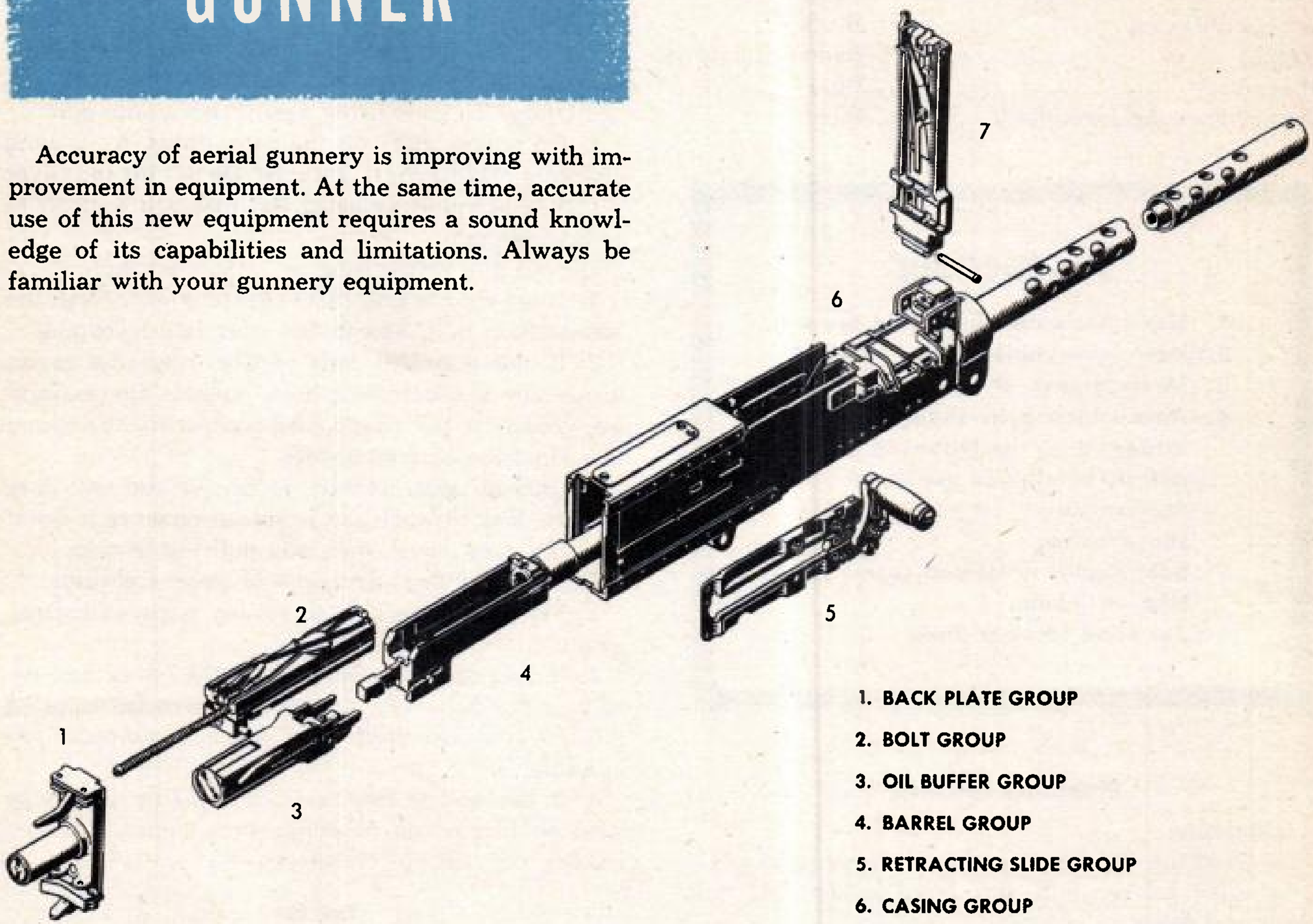
On VOICE, call MAYDAY.

Obtain the definition of Q signals from FM 24-13, which all Army aircraft carry.

These are the general duties of a radio operator. You can't learn all of them in the time that you have, but know enough about the operation of all radio equipment so that you can pinch-hit in an emergency.

GUNNER

Accuracy of aerial gunnery is improving with improvement in equipment. At the same time, accurate use of this new equipment requires a sound knowledge of its capabilities and limitations. Always be familiar with your gunnery equipment.



1. BACK PLATE GROUP
2. BOLT GROUP
3. OIL BUFFER GROUP
4. BARREL GROUP
5. RETRACTING SLIDE GROUP
6. CASING GROUP
7. COVER GROUP

Field Stripping

Field stripping is the removal of groups of parts from the gun without taking the groups themselves apart.

1. Raise the cover and **check to see that gun is in battery position and that there is no ammunition in the chamber.**
2. Remove the backplate.
3. Remove the driving spring rod assembly. **Caution:** Never attempt to charge the gun with the backplate removed and the rear end of the driving spring rod engaged.
4. Remove the bolt stud.
5. Remove the bolt group; rotate cocking lever to rear and release firing pin.
6. Pull out oil buffer and barrel groups part way.
7. Separate the oil buffer group from the barrel group.
8. Remove the barrel group.

To assemble the gun, reverse the above procedure. You can feed the caliber .50 machine gun from either side by changing the position of several parts. Before you fire it, be sure the gun is assembled properly for the direction of feed desired.

Ammunition

Types	Color of Tips
Ball	Unpainted
Armor-Piercing	Black
Tracer	Red or orange
Incendiary	Blue
Armor-Piercing Incendiary	Silver

Important:

1. **Never store ammunition in the sun.**
2. **Keep ammunition dry.**
3. **Never grease or oil ammunition.**
4. **Ammunition belts should be inspected for the following defects before you use them:**
   Short rounds.
   Loose rounds.
   Bent rounds or dented cases.
   Uneven linking.
   Corroded cases or links.

Handling the Gun

Charging:

1. Hold the charging handle with your palm up.

2. With one smooth and rapid movement, pull back and down.

Draw the handle all the way back and let go. Never ride the handle forward.

Loading:

1. Safety the gun.

2. Always feed double-link end of ammunition into the gun.

3. The cover should be closed. Push the first round into feedway until it is held in position by the belt holding pawl. Charge the gun twice. This puts a round in the chamber.

Firing:

1. Move safety to fire position.

2. Pull the trigger and hold it back so long as you want the gun to keep firing.

Unloading:

1. Safety the gun.

2. Raise the cover, lift up extractor assembly, and remove the ammunition belt.

3. Charge gun several times and look into the chamber to make sure no ammunition remains in the gun.

Malfunctions

If your gun won't stop firing:

1. Pull charging handle down on hand-held gun, but not all the way back. This holds the action out of battery. To start firing again, charge the gun.

2. On turret guns do the same thing by pulling charging cable a short distance. **Do not lift the cover—this stops runaway firing but makes it difficult to re-load the gun.**

If your gun stops firing in battery position:

1. Hand-charge gun twice, keeping an eye on the ammunition belt. Try to fire after each charging.

2. If the gun still fails to fire, raise the cover; make sure the extractor hook engages the extracting groove of the round, and make sure the round is against the cartridge stops.

3. Charge again and try to fire. If gun still does not fire, look through slot in side of receiver to see if the sear goes down when you pull the trigger.

If your gun stops firing out of battery position:

1. Try to charge gun to return parts to battery position.

2. If this does not work, raise the cover and try to pull the belt over against the cartridge stops. If the belt is stuck, check for binding in the container or chute.

3. If the belt is free, retract the bolt and make sure no live round or empty case in the T-slot is holding the bolt out of battery.

Turrets

If you are required to operate a turret, follow proper procedures. Carelessness may result in a serious injury for you or may even be fatal. Enter the turret after the airplane is in flight and get out before it lands.

B-29

The B-29 super-system of gunnery is called the Remote Control Turret System. Your turrets and a tail mount all operate by remote control. The gunners sit at controls inside the fuselage, where they have plenty of room and are away from the noise and shock of their guns. Their sights are connected to computers which figure out deflections automatically for any fighter within range.

Proper use of RCT requires good teamwork and plenty of practice. It enables the crew to meet attacks from any direction, and to concentrate the fire power where it will do the most good.

SIGHTING

On the ground you can fire point-blank from a stationary mount at a stationary target. In the air you are firing from a moving bomber at a moving target. You must use the right deflection to hit it.

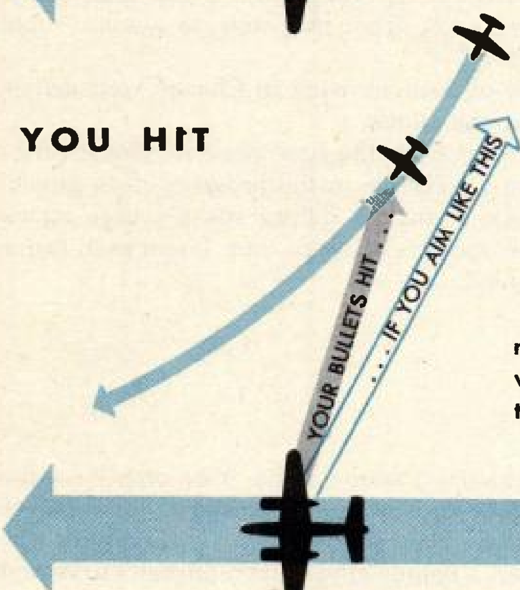
Three Rules of Position Firing

The first thing position firing takes into account is the forward movement of your bullets, caused by the forward movement of your bomber.

YOU MISS

If you try to shoot straight at the fighter or lead ahead of him, as you ordinarily would aim at a flying duck, you will miss because your bullets, carried forward by your own speed, pass ahead of him.

YOU HIT

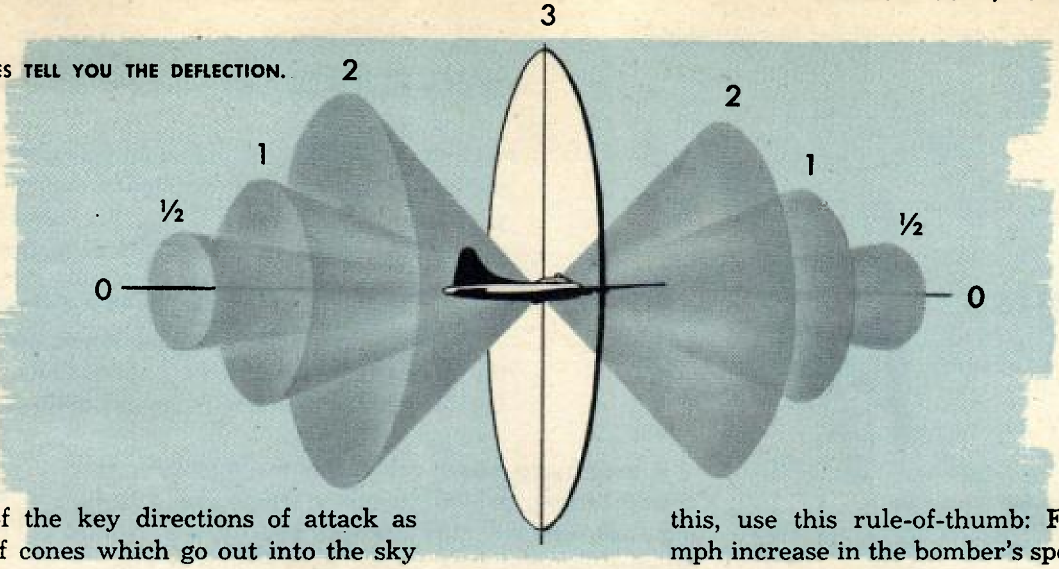


To hit, you must aim like this. Position firing corrects for the distance your bullets are carried forward by the speed of your bomber; now, they meet the fighter instead of passing in front of him.

To make this allowance, you apply the first rule of position firing: **Always aim between the attacking fighter and the tail of your own bomber, along the line of the fighter's apparent motion.**

The amount of deflection you take away from the nose toward the tail of your bomber is determined by the direction of the fighter's attack. It is measured in rads, and varies from 3 to 0 rads. A rad is the distance between the center and inner ring, or the distance between two rings in your 35-mil rad sight.

The second rule is: *Use the right amount of deflection.*



Think of the key directions of attack as surfaces of cones which go out into the sky around your bomber.

Remember these cones by number—½, 1, 2, and 3. The number gives the deflection in rads for any fighter on the surface of that cone, whether he attacks from the right or left, high, level, or low.

To hit any attacking fighter on cone ½, just off your fore-and-aft axis, use ½ rad of deflection. For any fighter on cone 1, use 1 rad; for any fighter on cone 2, use 2 rads. The 3-rad position is a wheel rather than a cone. But for any fighter on this wheel the gunner uses 3 rads.

The deflections shown in the above diagram are correct for a bomber flying at a true airspeed of 225 mph. If your true airspeed is more or less than this, use this rule-of-thumb: For each 50-mph increase in the bomber's speed, increase deflection ½ rad. For each 50-mph decrease, decrease deflection ½ rad.

The fighter never stays on one cone. His pursuit curve always forces him to slide sideways away from the nose and toward the bomber's tail. During the attack, he moves from one cone to another—and moves fast.

The rule of position firing is: **Change your deflection during the attack.**

When firing from the nose position you invariably increase deflection in the progress of an attack, and increase it fast. A fighter starts a nose attack on cone ½, moves swiftly to cone 1, and even faster toward cone 2.

SIGHTS

The **fixed-base, iron-ring sight** is the simplest aerial gun sight. It consists of a metal ring or set of equally spaced rings mounted on the back of hand-held guns, and a metal post and bead on the front. The 35-mil angle required for the 35-mil rad ring used in position firing is made at the post by keeping a fixed base between the post and ring.

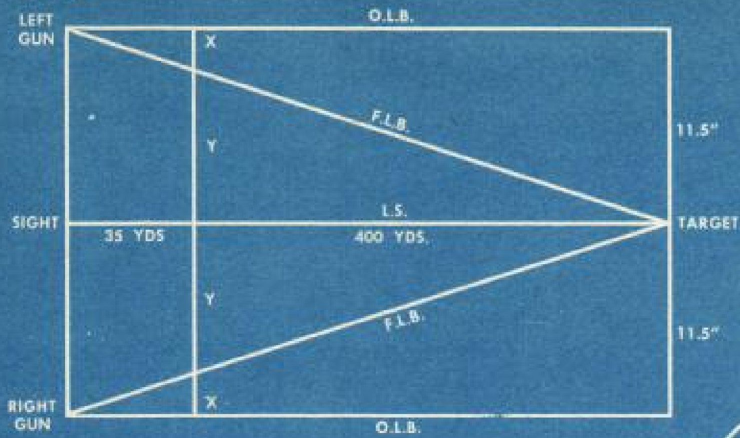
This is the way to calculate the required fixed base: Measure the radius of the ring and multiply by 30. The answer is the proper fixed base, in inches. A ring measuring one inch in radius requires a 30-inch fixed base.

To use the sight, hold the bead on the target and keep both bead and target lined up with the correct rad ring on either side, away from your nose.

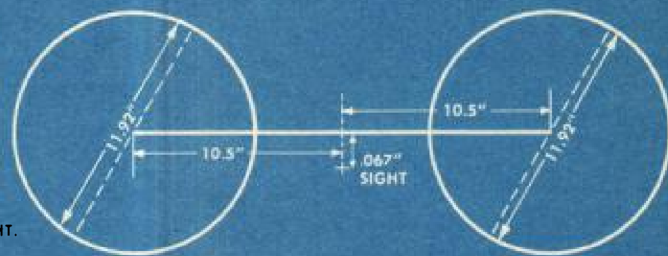
Compensating sights, a new development in the K-11 or K-13 series, automatically figure the proper deflections for fighters attacking on a pursuit curve. They mechanize position firing. You simply set the exact altitude and indicated airspeed of your bomber into the sight by means of a dial assembly on the sight. When a fighter attacks on a pursuit curve and is within range, put the sight dot on his nose and open fire. The sight takes care of deflection.

Optical sights permit the gunner to use any desired sight base and still maintain a 35-mil rad ring. When a fighter attacks on a pursuit curve, place the center of the sight between the target and your own bomber's tail, using the proper deflection.

Computing sights automatically compute the proper deflection for any type of attack. Before the fighter gets within range, the gunner sets his wingspan into the sight by means of the target dimension dial, keeps the fighter framed in the reticle by means of a range pedal or knob, and keeps tracking and firing.



$35:X = 400:11.5$
$400X = 402.5$
$X = 1.006$
$Y = 10.5$



THE CENTER OF THE DISC WILL BE 10.5" ON EITHER SIDE OF THE SIGHT.

PROBLEM

By constructing a chart to these measurements, and placing it at a distance of 35 yards from your guns, you can check their alignment before each mission. If you wish to change the range or bullet pattern construct a new chart.

LEARN HOW TO OPERATE AND PREFLIGHT THE TURRETS

Sperry Upper Local Turret

Preflight Operation.

Use this preflight procedure to get maximum performance during actual combat.

1. Clean Plexiglas panels in dome.
2. Check sight and guns by boresighting.
3. See that hydraulic breather cups are one-quarter full of oil.
4. Be sure that power clutches are engaged.
5. Check to see that hand cranks are disengaged. Do not disengage until after power clutches have been engaged.
6. Load ammunition boxes and feed ammunition just up to the guns.
7. Move main switch lever to "ON" position.
8. Move sight switch lever to "ON" position.
9. Close safety switches on hand control unit.
10. Allow hydraulic units and sight to warm up at least 5 minutes before takeoff.
11. Check response of azimuth and elevation mechanisms by manipulating the hand control unit.
12. Turn range knob and watch the reticles move in response.
13. Adjust reticle light to desired brilliance.

Flight Operation.

1. Charge guns twice.
2. When the target is sighted, set in the target dimension on sight.
3. Turn on fire selector switches.
4. Turn hand controls so that reticles stay on target (tracking the target).
5. Adjust range knob until reticles frame the target. Keep the target within the frames.
6. Close either firing switch.
7. When your ammunition is used up, charge the guns at least twice to clear out live shells.
8. Move guns to 0 elevation when not in use. Be sure to have the turret main power switch turned on before placing the gun safety switch on "FIRE."

In the event of power failure, you can control the turret by the handcranks. You can't track a target by using handcranks, since the movement of the guns and turret is too irregular for accurate sighting even if you could manipulate all the controls at one time. You can use the handcranks, however, for positioning the turret and guns so that they point to the approximate position of the target. **At any rate, make the enemy think your guns are operating. He can't tell if you're firing or not.**

Use this procedure to operate handcranks.

1. Engage azimuth and elevation handcranks.
2. Disengage power clutches.
3. Move turret and guns in desired directions.
4. When finished re-engage power clutches.
5. Be sure to disengage handcranks before operating power motor again.

Sperry Ball Turret—Operation

You must understand the safeguards provided, and follow the proper routine in operating the turret. Don't attempt to operate the turret before you are familiar with these instructions. Serious injury may result from incorrect operation.

Instructions for Entering Turret

1. Remove elevation handcrank from its clip and attach to shaft. Be sure that handbrake is locked.
2. Move elevation handclutch to "IN" position. It may be necessary to loosen the handbrake and rock it back and forth before the handclutch can be moved to "IN" position.
3. Use the clutch handle to move the elevation power clutch to "OUT" position. Then replace the handle to its place in the clip.
4. Loosen the elevation brake slowly while holding the elevation handcrank firmly.
5. Turn the hand elevation crank down until the turret revolves to low limit of elevation (–90°).
6. While holding hand elevation crank, open the turret door, reach inside and move the elevation power clutch to "IN" position.
7. Move the elevation handclutch to "OUT" position, then remove the elevation handcrank and replace it in its clip.
8. Enter the turret. Close the door securely. Be sure you push the door handles all the way up and lock the turret door before turning the main power and sight switches "ON."

Instructions for Leaving the Turret

1. Drive the turret to its low limit of elevation.
2. Turn main power and sight switches "OFF."
3. Open the door and leave the turret.
4. Attach the elevation handcrank.
5. Move the elevation handclutch to "IN."
6. While holding the elevation handcrank firmly, reach inside the turret and move the elevation power clutch to "OUT" position.
7. Close and latch the turret door.
8. Turn the elevation handcrank and elevate the turret to its upper limit (0°), and then lock the elevation handbrake.
9. Remove the clutch handle from its clip and attach it to the azimuth power clutch on top of the turret. Move the azimuth power clutch to "OUT" position and push the turret by hand until the guns point to the rear of the airplane.
10. Move the azimuth power clutch to "IN" position, then remove the handle. Replace it in the clip.

Preflight Operation Check

Use this preflight procedure to get maximum performance during actual combat.

1. Clean all Plexiglas.
2. Check the oil level in the breather tank of the hydraulic unit. (1/3 full.)
3. See that all handcranks and clutch levers are in their proper positions.
4. Turn the power switch "ON."
5. Turn the sight switch "ON."
6. Check the response of the azimuth and elevation mechanisms by manipulating the hand controls. Do not drive the guns down until they strike the ground.
7. Adjust the reticle light on the sight to the brilliance you want.
8. Work the range foot pedal and be sure the reticles move in response.
9. Make a check of alignment of your sight and guns by boresighting.
10. Lead your ammunition boxes and push the ammunition down to the guns.
11. Lift each gun cover plate and pull the ammunition down. Feed the first shell by hand into the magazine of the gun. Close gun cover plates.

In-Flight Operation

1. Enter turret.
2. Turn on power switch.
3. Turn on sight switch.
4. Charge the guns twice.
5. Turn on fire selector switches.
6. Set the target dimension on the sight when the target is sighted.
7. Use the hand controls to move the turret to keep the reticles on the target (tracking).
8. Operate the range foot pedal until the reticles frame the target.
9. Close either firing switch.
10. When your ammunition is used up, charge the guns at least twice to insure that no live shells are in the guns.
11. Turn fire selector switches "OFF."
12. Leave turret as described above.

During landing or takeoff, your guns must be in the horizontal position, pointing aft. Be sure there is no member of the crew in the turret.

You won't have the time to become as proficient a gunner as you are a navigator, but you must know how to use your gun and all of the turrets reasonably well. Take care of your own guns for your life depends upon their proper operation.

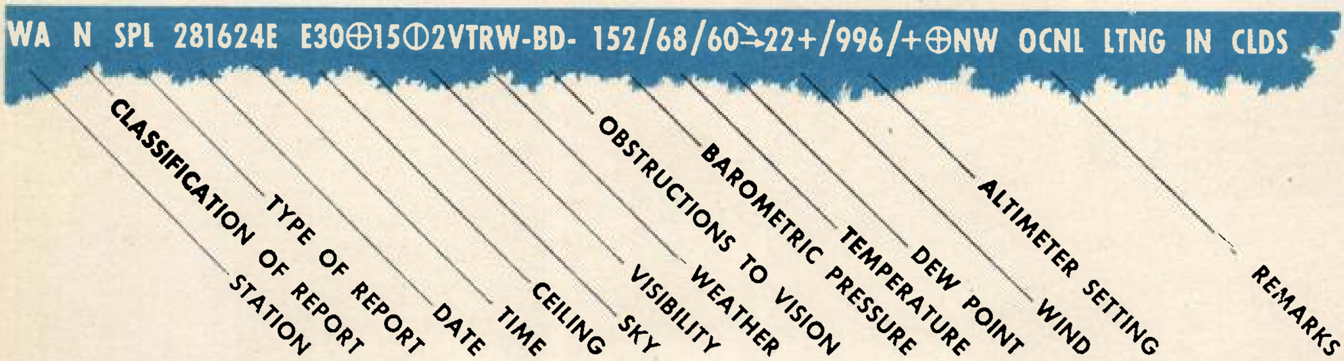
SECTION 6

NAVIGATION WEATHER

YOUR KNOWLEDGE OF WEATHER CONDITIONS, REACTIONS AND TRENDS, INFLUENCES EVERY NAVIGATIONAL DECISION YOU MAKE. BE SURE THAT YOU KNOW AND UNDERSTAND NAVIGATION WEATHER SO YOU CAN EVALUATE AND USE THE VARIOUS METHODS OF NAVIGATION ACCURATELY.

Weather Symbols

There are many symbols and combinations of symbols used in reporting weather by teletype. Being familiar with them and the standard procedure used in placing them in their proper sequence in the report will hasten your understanding of the weather picture. A typical teletype report appears below:



ALL TELETYPE REPORTS FOLLOW THE ABOVE EXAMPLE

It is deciphered as follows: Washington; observance of instrument flight rules required; special report at 1624, Eastern War Time; ceiling estimated at 3,000 feet; sky overcast, lower scattered clouds at 1,500 feet; visibility 2 miles, variable; thunderstorm; light rain shower; light blowing dust; barometric pressure 1015.2 millibars; temperature 68°F; dewpoint 60F°; wind, west northwest 22 miles per hour, strong gusts; altimeter setting, 29.96 inches; dark overcast to northwest, occasional lightning in clouds.

SYMBOLS USED ON TELETYPE SEQUENCES

SKY

○ Clear (less than 1/10 covered)

⦶ Scattered clouds (1/10 to 5/10 covered)

⦷ Broken clouds (6/10 to 9/10 covered)

⊕ Overcast (more than 9/10 covered)

No more than two sky symbols are grouped together. When there is no slant / all cloud bases are below 9,751 feet. When a sky symbol precedes a slant / those cloud bases are above 9,750 feet; when a sky symbol follows a slant / those cloud bases are below 9,751 feet.

⦶/, ⦷/, ⊕/ high scattered, etc.

⦶/⦶, ⦶/⦷, ⦷/⦶, ⦷/⦷, ⊕/⦶, ⊕/⦷ high scattered with lower scattered; high scattered with lower broken; etc.

⦶⦶, ⦶⦷, ⦷⦶, ⦷⦷, ⊕⦶, ⊕⦷ (no slant) scattered, with lower scattered; scattered with broken; etc.

The plus (+) or minus (−) sign preceding the cloudiness symbol indicates "dark" and "thin", respectively.

WEATHER

A plus (+) sign following indicates HEAVY, a minus (−) sign following indicates LIGHT, no sign indicates MODERATE

- **R** Rain
- **S** Snow
- **L** Drizzle
- **ZR, ZL** Freezing rain, etc.
- **E** Sleet
- **A** Hail
- **AP** Small hail
- **SP** Snow pellets
- **SQ, RQ** Snow squall, etc.
- **T** Thunderstorm (no −)
- **SW, RW** Snow showers, etc.
- **TORNADO** (always written out in full)

CLASSIFICATION

- **C** Satisfactory for contact flight
- **N** Requiring observance of IFR
- **X** Take-off and landing suspended
- (none) Station not at a controlled airport

OBSTRUCTIONS TO VISION

A plus (+) sign following indicates HEAVY, a minus (−) sign following indicates LIGHT, no sign indicates MODERATE

- **F—** Damp haze (no +)
- **F** Fog
- **GF** Ground fog
- **IF** Ice fog
- **H** Haze (no + or −)
- **K** Smoke
- **D** Dust
- **BS, BD** Blowing snow, etc.
- **BN** Blowing sand
- **GS** Drifting snow
- (figures) Miles and/or fractions of miles
- (none) Visibility 10 miles or more
- **V** (Following visibility figures) variable visibility

MISSING DATA

Indicated by the letter **M** entered in the place of the missing data.

WIND

The velocity is indicated by figures representing its value in miles per hour, calm being indicated by the letter **C**. Signs shown below, following velocity figures, indicate:

- **+** Strong gusts
- **−** Fresh gusts
- **E** Estimated

DIRECTION

Arrows flow with the wind as:

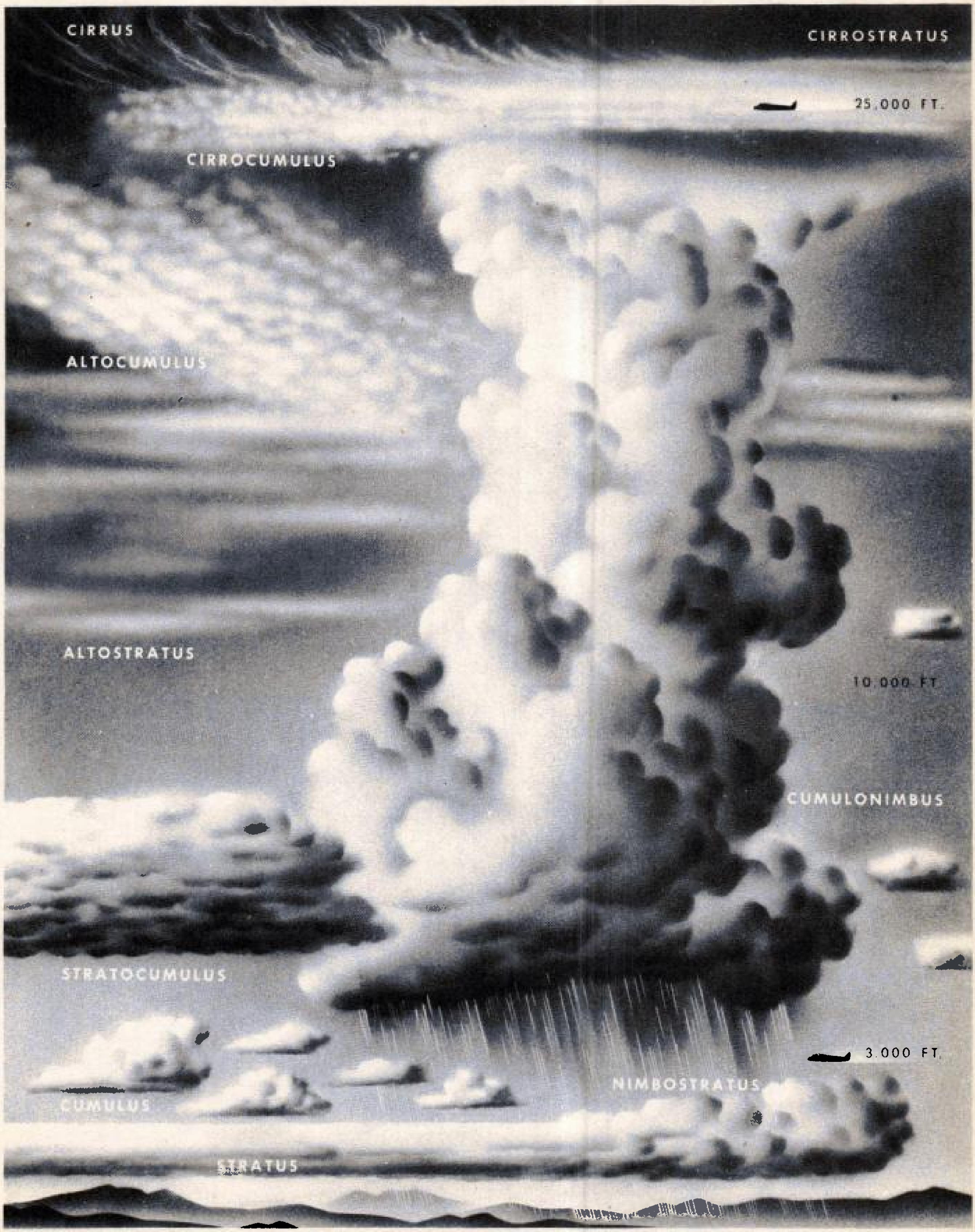
↓ North

↓↙ NNE ↙ NE, etc.

CEILINGS

Preceding ceiling figures

- **E** Estimated
- **M** Measured
- **W** Indefinite
- **A** Aircraft
- **P** Precipitation
- **V** (Following ceiling figures) variable ceiling
- **O** (Figure naught) ceiling is below 51 feet
- (no figures) Ceiling above 9,750 feet


CIRRUS
CIRROSTRATUS
25,000 FT.
CIRROCUMULUS
ALTOCUMULUS
ALTOSTRATUS
10,000 FT.
CUMULONIMBUS
STRATOCUMULUS
3,000 FT.
NIMBOSTRATUS
CUMULUS
STRATUS

WEATHER RECORDER

On all routine bombing missions or reconnaissance flights, you must make hourly weather observations.

A suggested simplified form is provided to make it easier for you to record your weather observations in flight. Use a code with this form if necessary.

Number the spaces opposite each separate description of weather before take-off. Number them consecutively or by code.

Space is provided at the bottom of the sheet to put coordinates of your position, time of observation, and the numbers that best describe each of the twelve phases of weather. Check the condition that best fits the situation, and record it.

The chart is as descriptive as possible so you only have to match visual observations with the appropriate descriptions shown on the chart.

1	2	3	4	5	6	7	8	9	10	11	12
VISIBILITY	NEAREST FLIGHT ALTITUDE	TEMP C°	CLOUD CONDITIONS	WEATHER CONDITIONS	REMARKS ABOUT COL. 5	WEATHER DURING PAST HOUR	WIND DIR. ALOFT	WIND FORCE ALOFT (MPH)	WIND ALOFT HOW DETERMINED	OFF INSTRUMENT FLIGHT POSSIBLE	REMARKS
ZERO	BELOW 500′	UNDER −30	CLR OR SCTD ABV 0-5/10 CLR OR SCTD BLO 0-5/10	CLEAR	NO REMARKS	CLEAR	CALM	CALM	DRIFTMETER DOUBLE DRIFT	ALL ALTITUDES	CLOUD BANK TO NORTH (OR EAST) PARALLELS COURSE
1 MI. OR LESS	2,000′	−25	BRKN ABV 6/10-9/10 CLR OR SCTD BLO 0-5/10	HAZE, SMOKE OR DUST	LIGHT SLIGHT THIN	HAZE, SMOKE OR DUST	N	1-5	DRIFTMETER AND GROUND CHECK	BELOW 1,000′	CLOUD BANK TO SOUTH (OR WEST) PARALLELS COURSE
1-2 MILES	4,000′	−20°	OVC ABV 10/10 CLR OR SCTD BLO 0-5/10	FOG PATCHES ON SURFACE	MOD. THICK	FOG PATCHES ON SURFACE	NE	5-10	NIGHT CELESTIAL FIXES	BELOW 2,000′	MOST CLOUDINESS OVER LAND
2-3 MILES	6,000′	−15°	CLR OR SCTD ABV 0-5/10 BRKN BLO 6/10-9/10	FOG ON SURFACE	HEAVY DENSE	FOG ON SURFACE	E	10-15	ASSUMED DRIFT AND GROUND CHECK	ABOVE 8,000′	MOST CLOUDINESS OVER WATER
3-5 MILES	8,000′	−10°	BRKN ABV 6/10-9/10 BRKN BLO 6/10-9/10	SCTD SHOWERS	WITH HAIL	SCTD SHRS	SE	15-20	DRIFTMETER & SOLAR LINE POSITION	ABOVE 9,000′	CONTACT FLYING TO N OR E
5-7 MILES	10,000′	−5	CLR OR SCTD ABV 0-5/10 OVC BLO 10/10	FQT SHOWERS	MOD. TURB.	FQT SHRS	S	20-30	FORECAST DIRECTION & GROUND CHK	ABOVE 10,000′	CONTACT FLYING TO S OR W
7-10 MILES	12,000′	0°	BRKN ABV 6/10-9/10 OVC BLO 10/10	RAIN	SVR TURB.	RAIN	SW	30-40	F'CAST DIRECTION & CELESTIAL FIXES	ABOVE 11,000′	INSTRUMENTS 15 MINS OR LESS
10-15 MILES	14,000′	+5°	OVC ABV 10/10 OVC BLO 10/10	SNOW OR WING ICING	FRONT N-S	SNOW OR WING ICING	W	40-60	ESTIMATED	ABOVE 12,000′	INSTRUMENTS APPROX 30 MINS
UNLIMITED	16,000′	+10°	IN AND OUT OF CLDS	SCTD THUNDERSTORMS	FRONT E-W	SCTD THUNDERSTORMS	NW	OVER 60	WIND UNKNOWN	ABOVE 15,000′	INSTRUMENTS 1 HR OR LESS
	OVER 18,000′	OVER +15°	IN SOLID OVC	MANY THUNDERSTORMS	PSD DEF. FRONT	MANY THUNDERSTORMS	UNKNOWN	UNKNOWN		IMPOSSIBLE AT ANY ALT.	NO REMARKS

REPORT NUMBER	COORDINATES	TIME GCT	1	2	3	4	5	6	7	8	9	10	11	12
1														
2														
3														
4														
5														
6														

You and the Weather

There are three major weather hazards which every flyer is bound to encounter: Fog, thunderstorms, and icing.

The purpose of this information is to emphasize the conditions which lead to the formation of **Fog** so that you may anticipate it and take advance precautions against it, to show you **Thunderstorms** as you will encounter them in actual flight and what to do about them; to remind you of the nature and types of **Icing Conditions** and how to anticipate, recognize and analyze them.

The object of this discussion is not to make you a weatherman or a forecaster, but to offer you some "Navigation Weather" based on Army, Navy, and Airline experience, to assist you in estimating weather during flight and to supplement your own good judgment, for which no formula or advice can be substituted.

The Flight Plan

You are planning a flight. From takeoff to landing, you will have control of practically everything **except** the weather. It makes little difference whether your flight is local or cross-country, you must fit your procedure into the pattern of winds and weather. If you don't, you may lose the opportunity to fly again.

First, check the weather map if one is available. It is a small scale picture of the weather in which are included the clues of weather trends. A weather map scales down the atmosphere to such an extent that symbols are necessary to represent measured quantities. It is to your advantage to know these symbols and to read them as you would a book.

Second, check current weather on latest teletype, and radio reports. Correlation of the latest weather map and weather reports will give you a motion picture of flight conditions.

Third, be sure en route weather is flyable. Icing, thunderstorms, strong head winds, extensive low ceilings and poor visibilities can keep you from reaching your destination especially if a few of these factors occur simultaneously.

Fourth, be sure both ceiling and visibility at your destination will be ample for landing procedures. Fogs, low clouds, drizzle, rain, snow, dust, smoke, blowing snow; all limit vision near the ground where you need it most.

Fifth, use every available means in estimating winds for your flight. It is much safer to have enough fuel for a 50 mph head wind which turns out to be only 30 mph, than to run out of gasoline because winds were 20 mph stronger than estimated.

Sixth, plan one or more alternate procedures against the possibility of flying into unforeseen or suddenly developing weather that makes your original plan impossible.

Seventh, work with a forecaster. Check your ideas against his and have him estimate en route as well as terminal weather. He's there to help you make your flight a safe one. When your forecaster suggests you postpone your trip, you'd better double-check the weather before taking off against his advice because you're the one who will be up there battling the elements.

FOGS

Fog may be defined as a cloud on the ground. It usually forms at night, as a result of the air being cooled by its contact with the ground, causing the air to become saturated. It also forms when surface winds carry air over terrain that permits slight super-saturation or when rain or snow falls into colder surface air.

Ground Fog

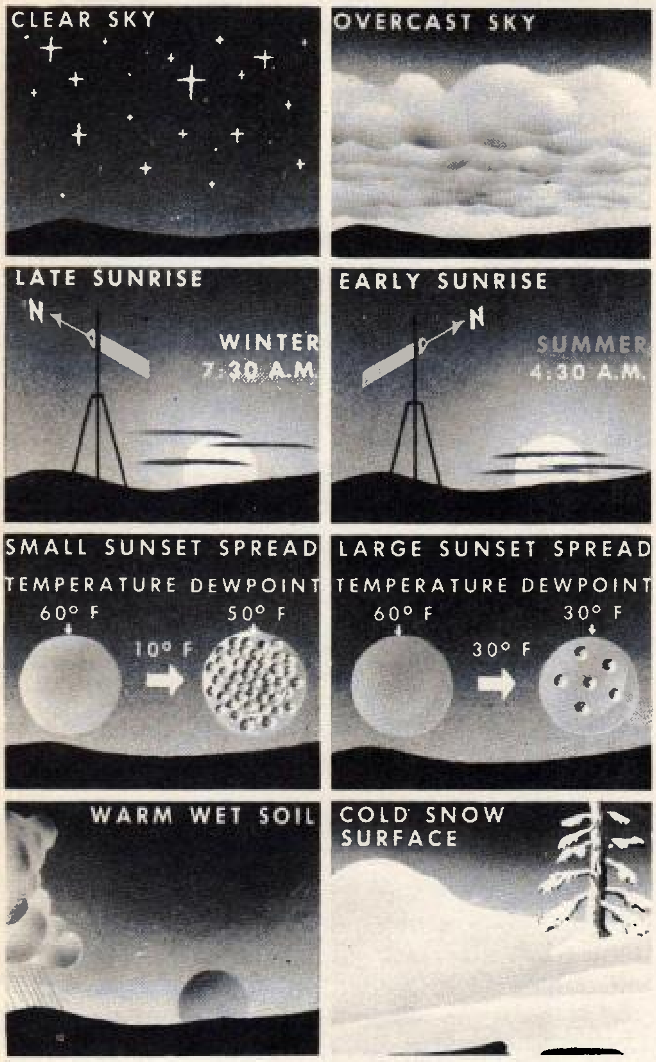
This type of fog forms in nocturnally cooled surface air. It first appears in valleys and depressions as isolated patches, or, if terrain is level, where saturation of air is greatest. Patches of fog join to form a layer which deepens until an hour or two after sunrise.

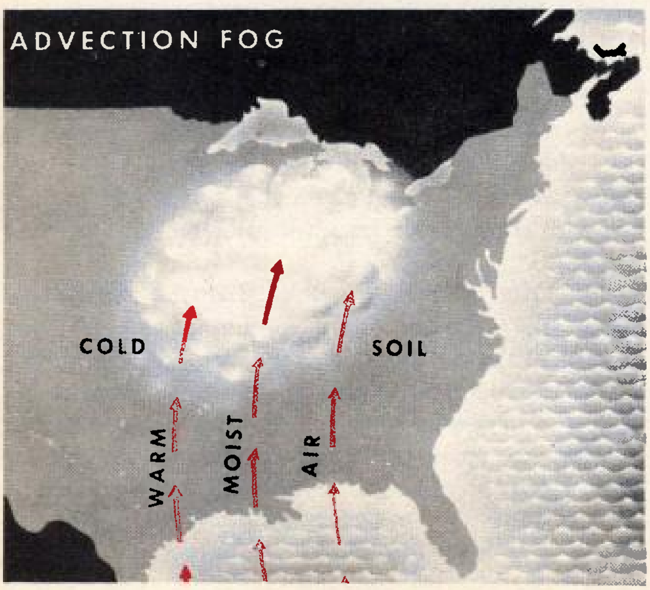
If you are planning a night flight, particularly if arrival at your destination is planned near sunrise, a careful search for factors favorable to ground fog in the destination area is mandatory. When doubt exists as to presence of fog, arrival a few hours after sunrise should be the alternate plan. Do not exhaust fuel circling an airport, waiting for fog to lift.

Airports on hill tops are last to become foggy; airports in moist valleys tend to fog-in early.

WEATHER CONDITIONS

FAVORABLE TO FOG | UNFAVORABLE TO FOG

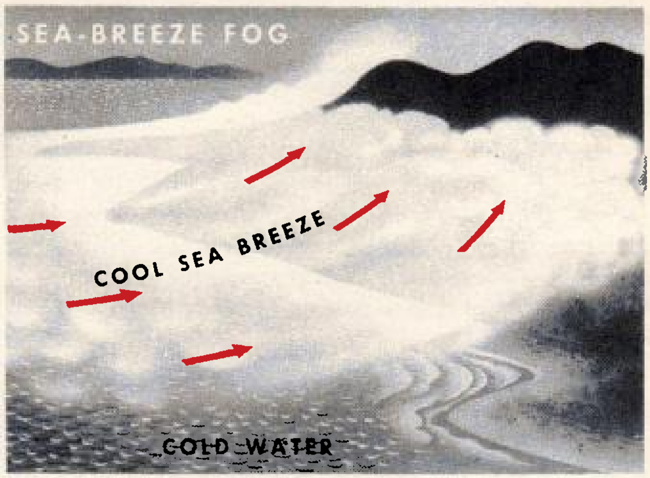




Advection Fog

This fog develops in winter or early spring as a result of warm moist air drifting over cold ground or snow. Winds blowing northward off the Gulf of Mexico cause normal advection fog. This is likewise true in Spring over the cold Great Lakes.

Normal type advection fog is usually extensive. If you get caught over a region where it is forming or drifting you may not be able to reach an alternate airport, therefore exercise extreme caution in flying over or toward regions where there is any chance of advection fog.



Sea Breeze Fog

Monsoon (sea breeze) fog is a feature of coastal areas where cool water lies close to sunheated land and is associated with a sea breeze. Inland from the shore the fog usually lifts into a layer of low clouds and then clears.

Monsoon fog often forms and spreads along coastal land in less than an hour. Because of the tricky nature of this fog, your flight plan to a coastal airport where a vigorous sea breeze is blowing, should include an alternate procedure to an inland field.

Precipitation Fog

Precipitation (rain) fog is the result of relatively warm rain or snow falling into a layer of colder air. Precipitation fogs are usually associated with temperate zone cyclone fronts, particularly warm fronts. Precipitation fog frequently is preceded by broken low scud clouds or by stratus which thickens to the ground. Sometimes, fog forms rapidly at ground level and extends quickly over large areas. If there is any possibility of precipitation fog at your destination, an alternate plan is your safety factor.

Upslope Fog

Upslope fog develops in uphill winds. It is a cloud resting on a slope or hill top. Upslope fog, therefore, is confined to hilly terrain, particularly in the western half of the United States and the Appalachian Mountain region.

Upslope fog often forms rapidly and over large regions. An alternate airport on the lee side of a hill, preferably as far down the base of the hill as possible, is a good alternate plan if you are going to fly where upslope fog is a possibility. If you have no alternate, don't fly blind; landing on hilly fogged-in terrain is disastrous.

Fog Warnings

1. When temperature and dewpoint are only a few degrees apart.
2. A widespread precipitation area.
3. Within 200 miles of seacoast—if the wind is from the water.
4. In the Fall and Spring if the airport lies near a large river or lake.
5. If the flow of air is directed up a broad, fairly steep slope.

Estimating Weather in Flight

Cumulus Clouds & Thunderstorms

Cumulus clouds are billowed in appearance as the result of vertical currents. A pilot seeing cumuli is warned immediately that vertical currents are present in and below the clouds. For practical purposes, cumuli can be classed in three categories:

1. Flat cumulus usually having considerably more lateral development than vertical.
2. Towering cumulus frequently having more vertical development than lateral.
3. Cumulonimbus, or the shower and thunderstorm cloud.

Flat Cumulus

Flat cumulus clouds are usually associated with favorable weather. They are readily identified by their lack of vertical development.

Air is mildly to moderately rough in and below the clouds but smooth above. Precipitation does not fall from them. Icing is light, occasionally moderate when their temperatures are below freezing. There is no particular need for staying out of flat cumulus unless light turbulence must be avoided or there is icing in the clouds.

Towering Cumulus

Towering cumulus has considerable vertical development and a great tendency toward turret-type finger tops each of which contains a strong vertical current. Towering cumuli are forerunners of showers and thunderstorms.

Turbulence in the towering cumulus is normally moderate and occasionally severe. Turbulence below the cloud is mild to moderate. Rain or snow does not fall from this type of cloud. Its presence, however, indicates that rain or snow fall is imminent. Icing in towering cumulus is moderate to heavy where temperatures are 32°F or less, particularly in the towering fingers and domes.

Avoid towering cumulus. A flight around the cloud will take only slightly more time than one through, and in flying around it you can avoid exposing your plane and yourself to danger.

Cumulonimbus

Cumulonimbus clouds are showers or thunderstorms. They assume many shapes and sizes but, in general, they appear as a massive towering cloud of great vertical and lateral development from which

rain or snow is falling. A thunderstorm is a typical cumulonimbus.

Turbulence is moderate to severe in the cumulonimbus. Updrafts and downdrafts are of such strength that aircraft, if caught, can be lifted thousands of feet upward or pushed downward against the ground. Icing in cumulonimbus where temperatures are 32°F and less is moderate to heavy. Hail, lightning, static in receivers, and St. Elmo's Fire in addition to icing, up and downdrafts, and severe turbulence are characteristic dangers of the thunderstorm.

It is mandatory that cumulonimbus be avoided in all your flights; only when trapped with no alternative plan should you proceed through a massive cumulonimbus. Several procedures are possible upon encountering thunderstorms or very large showers. In order, they are:

1. Circumnavigate, preferably about that side from which the storm came.

2. Fly over the top of a saddleback between two towering clouds.

3. Fly underneath when (1) and (2) are impossible but only when the base is several thousand feet

above highest terrain. Turbulence is moderate to severe and downdrafts are dangerous below the storm base. Hail might also be present.

4. Land at an airport and await the storm passage on the ground if there is an airport or suitable field available.

If it is necessary to fly through the storm clouds, you have several choices.

1. Enter a thunderstorm preferably through the thin spots where you can see sunshine or blue sky. Storm clouds, however, shift continuously and sometimes imprison a plane before it can get through a thin spot.

2. In flying through black spots you are likely to find rough air, hail, up and down drafts, and lightning. Black spots certainly are not pleasant but also not extremely dangerous.

3. Avoid greenish and slightly off-color spots. They are usually regions of severe turbulence. Off-color is due in part to presence of electrical charges.

4. Flying at altitudes above the freezing level is sure to cause moderate to heavy icing.

5. Never land at an airport during a thunderstorm. Wind shifts may be disastrous.

No flight through a thunderstorm is safe; some flight paths are only less dangerous than others.

HAZE LEVELS, OVERCAST BASES AND TOPS

Haze level is the top of a layer of air in which dust, smoke, haze and other debris are present. If impurities are numerous as they are in a dust storm, the haze level is as definite as the ground and horizon itself. Above the haze level, air is clear.

Fly above the haze level if you can. You have more visibility on top and there is no danger of getting dust into the engine. Air is smooth and carburetor icing is less likely.

Flights on Top of Cloud Layers

Advantages:

1. If a temperature inversion caps the cloud layer, air is smooth on top and usually carburetor icing will not occur.

2. If the cloud top is flat little icing will occur.

Disadvantages:

1. You cannot estimate ceilings from on top a solid cloud layer. Rather than guess, call ground stations for weather report.

2. If the cloud top is undulating and has a tendency to tower, icing is certain at or below 32° F.

Flights Under Cloud Layers

Advantages:

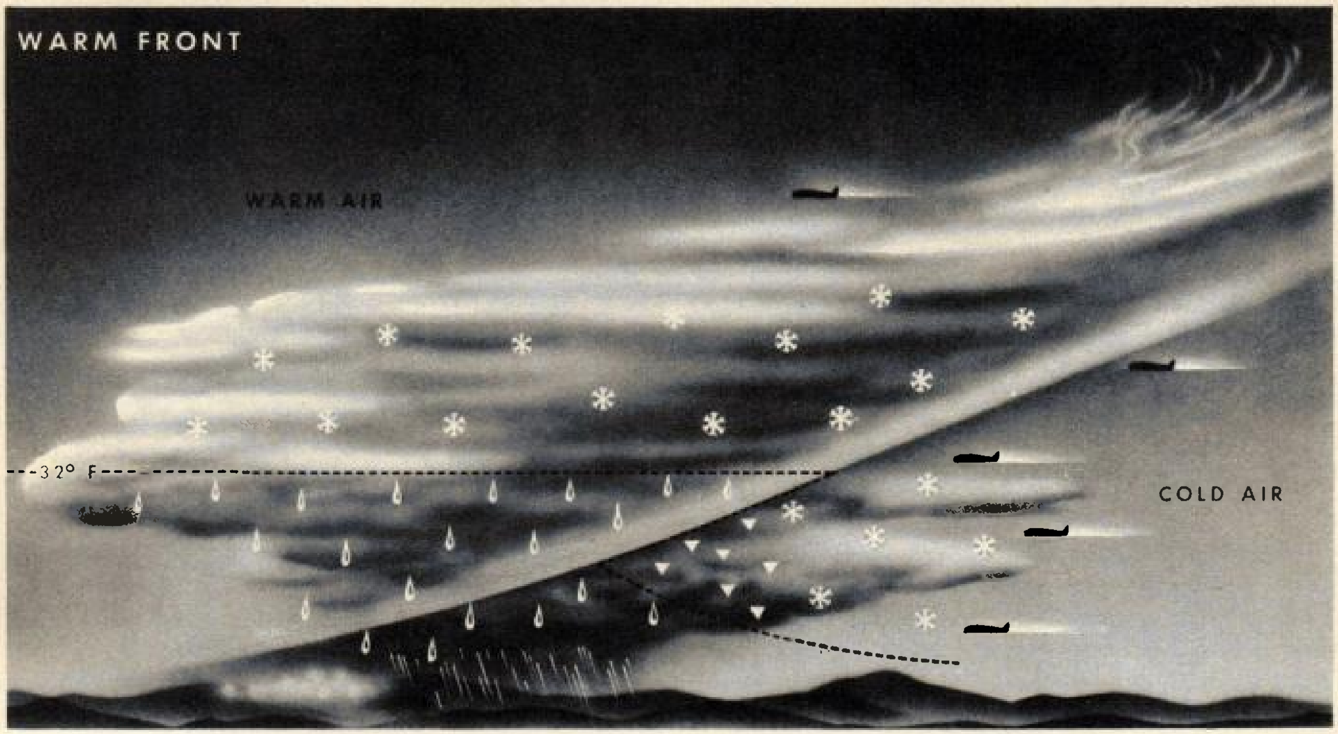
1. Contact procedure.

2. Icing in flat-based clouds is likely to be less than in undulating-based clouds.

Disadvantages:

1. You cannot estimate the top of a solid cloud when flying underneath. Pilot reports or sounding data must provide you with the necessary information.

2. Contact flights are dangerous in rough or hilly terrain; peaks sometimes merge with cloud bases causing zero-zero conditions.



Fronts

Warm Fronts

Warm Fronts form when a warm air mass moves into a region occupied by a cold air mass, the warm air causing mass cooling as it rises. When you fly toward the front from the cold air side, warm front clouds will first appear as cirrus. Cirrus merge with cirrostratus which descend and merge with altostratus from which rain or snow falls. In the rain region, scud, stratus and stratocumulus lie below the altostratus, and higher clouds and fog frequently cover a considerable area near the surface front.

You will often find rough air in the cold air below the frontal surface; mild or moderate turbulence is frequent in the warm air clouds above the frontal surface. There is also moderate turbulence in the frontal surface itself.

Expect precipitation static in a frontal cloud. It sometimes is too harsh to permit voice communication and may smother reception from radio ranges.

Choice of flight paths through warm front clouds are numerous. Five are illustrated in the warm front sketch above.

1. Over the top is smooth and ice free but it is often too high to be practical or even possible.

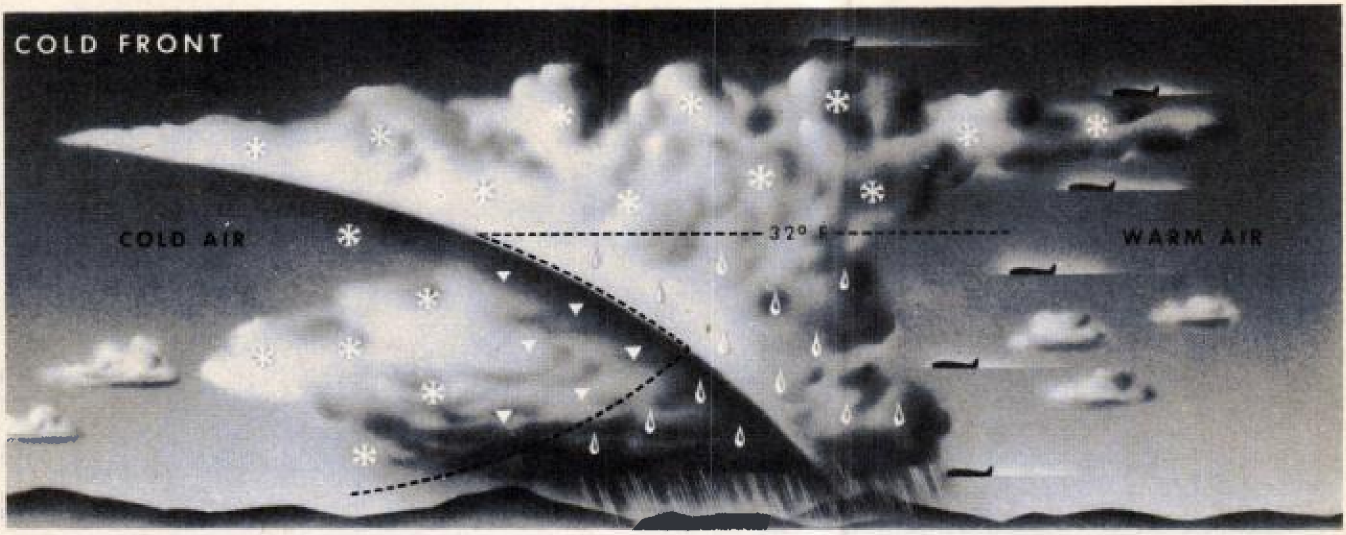
2. You may encounter limited icing in clouds at sub-freezing temperatures in both the cold and warm air; you are certain to find considerable static and may find turbulence of moderate degree in warm-air clouds.

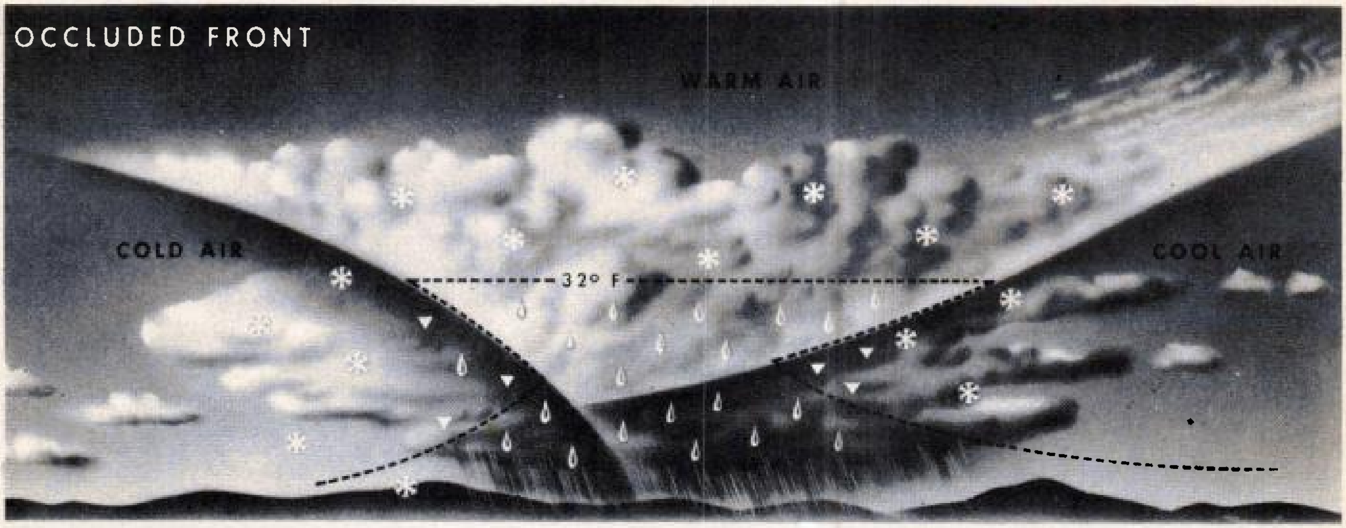
3. If you fly at an altitude just less than the freezing level in the warm air you eliminate serious icing possibilities, except for a relatively narrow band in the cold air before crossing the front. You must, however, expect rough air and static.

4. Altitudes somewhat below the freezing level of the warm air are free of icing in the warm air but present a very serious hazard in the cold air where sub-cooled rain droplets are present.

5. Contact flying in the frontal zone is dangerous. Clouds in nearly every well developed warm front include fog and scud at tree top heights.

The best choice is over-the-top. When you cannot get on top at some distance from the heavily clouded region your next best choice is a flight just below the freezing level of the warm air. Estimate the possibilities and plan your altitude accordingly. **Remember, it is usually easier to pick the right altitude approaching the frontal zone from the warm air side rather than the cold.**


COLD FRONT
COLD AIR
32° F
WARM AIR


OCCLUDED FRONT
WARM AIR
COLD AIR
32° F
COOL AIR


COLD FRONT LINE SQUALL

Cold Fronts

Cold Fronts form when a wedge of cold air moves into a region of warmer air. The warm air is forced upward and undergoes the process of cooling that may cause thunderstorms. These are generally concentrated in a zone 15 to 50 miles wide but may extend hundreds of miles in length.

Choose your flight path through Cold Fronts on the same basis as for Warm Fronts. Several flight paths with the plane approaching the Front from the warm side are indicated in the illustration above.

Line Squalls

Line squalls are intense cold fronts along which unstable air and cumulonimbus occur in a line for hundreds of miles. Towering thunderstorms in Summer and snow showers in Winter are the usual features of a line squall. Summer time prefrontal line squalls are vicious and violent thunderstorm lines. They lie some distance ahead of a cold front and travel with greater speed than the front which is reduced to a partially clouded windshift line.

Avoid both cold front and prefrontal line squalls. Only when trapped with no other alternative should you attempt to go through the squall clouds. Choice of path through line squalls:

1. Your best choice is to find an airport nearby and wait on the ground for it to pass.
2. Fly through a saddle back between two towered clouds but be sure this is in the clear.
3. Pick the clearest spot between two storm centers and head directly into the squall at 90 degrees to the line.
4. Fly through a thin spot where blue sky or sunshine is discernible through the break.
5. Enter through a dark spot, it will be rough but not as bad as other spots.
6. Fly underneath, turbulence will be moderate to heavy with possibility of hail, also up and down drafts.

Avoid off-color greenish or other off-hue spots, they are extremely turbulent and highly charged.

Remember that line squalls are violent by comparison with ordinary airmass thunderstorms. They often appear in an hour or two without warning. Be on the alert when flying in the warm sector of a temperate zone cyclone especially near the cold front. These are the places where line squalls usually first appear.

Occluded Fronts

Occluded front clouds occur when a warm front collides with a cold front. The weather along an occluded front contains a combination of warm and cold front characteristics.

When an occluded front winds up into a low pressure center, that has been intensifying, be prepared to look for weather that will combine the worst features of both cold and warm fronts.

Plan flight paths through occluded front clouds with the characteristics of both fronts in mind.

Cloud Features

Cloud features often help identify the cloud type and its probable origin, but you should never put full faith in what you can see from the ground or the air unless evidence is absolutely complete.

In general, frontal clouds will come across the sky in bands and in regular sequence from high types merging with and obscured by lower types.

Layers of stratus and stratocumulus not associated with fronts usually occur over somewhat irregular areas without smoothly cut edges. In contrast to frontal clouds they are not orderly. Stratocumulus clouds often occur in regions of thunderstorm activity. They may hide a thunderstorm if you are flying beneath them. Flying conditions are generally good over the top of stratocumulus, away from a front. When they occur alone, they do not indicate a front.

Cumulus clouds not associated with fronts occur at random. If you are unable to identify unexpected clouds properly in your flight path, proceed cautiously until you are sure they are harmless. Moisture in the air and clouds that result are responsible for practically all unfavorable and dangerous flying weather.

GETTING THE WEATHER

1. Weather in flight is no longer confidential. In an emergency, you can get any weather information you ask for "in the clear" during one transmission.
2. You may request Terminal or Landing Weather from Range Stations or Control Towers. Reply will be limited to any two stations "in the clear" for any one request.
3. You may transmit such weather information during flight as is requested.

Rules for Flying Weather

1. When approaching a thunderstorm, analyze it before you encounter the surrounding clouds. They may obscure important characteristics of the storm after you get into them.

2. Before attempting to fly any thunderstorm, study the situation thoroughly.

3. Whenever possible, circumnavigate a storm. Always fly around isolated air mass thunderstorms.

4. In coastal regions, where thunderstorms prevail along the mountains, fly a few miles to seaward and avoid them.

5. Thunderstorms over islands may be thousands of feet higher than those over the open sea. Fly around them.

6. Cold front thunderstorms generally stretch too far to fly around. Remember, the storm front is a series of individual storms linked by intervening clouds. If you must go through, fly between the storm centers or over the saddlebacks.

7. If you can't see blue sky beyond the storm and must go through, determine the direction the storm is taking and head in at a right angle.

8. Once you have headed into a storm, don't turn around on account of turbulence, rain, or hail. If you do, you'll have to fly through the same condition twice, and you may get lost. Hold your original course.

9. In entering the front of a thunderstorm, you will encounter updrafts. Go in low, and if conditions permit, fly underneath the base of the storm.

10. Entering a storm from the rear, you will experience downdrafts first. Go in high.

11. In flying under a storm, the higher the flight level, the rougher the trip. Fly about one-third of the distance from the ground to the base of the clouds if you can; but don't go underneath unless you can maintain contact flight.

12. Don't try to fly underneath a storm along mountain ranges unless there is a good ceiling and you can see peaks and ridges clearly. At sea you can usually count on being able to fly under any thunderstorm in daylight,

13. Never land at an airport when a thunderstorm is advancing toward the field. Shifting surface winds make it too hazardous. Wait until the storm center has passed, and the winds have stopped shifting, before you land.

14. When you expect to try level flight in flying a storm, get altitude before approaching it, so that you can inspect the storm line before selecting your course.

15. The altitude necessary to fly around the tops and over the saddlebacks of a thunderstorm will vary with the seasons and the latitude in which you encounter the storm. In high latitudes, 12,000 to 15,000 feet is generally sufficient. In the tropics, the tops of the saddlebacks may be above the ceiling of your aircraft and you may have to fly through the saddlebacks on instruments, a procedure recommended only for high performance aircraft. Over the open sea, 15,000 feet of altitude usually will clear the saddlebacks.

16. Lightning is of little consequence when you are flying an all metal, closed-cockpit plane, which acts as a perfect conductor. Don't worry about it. Switch on the light and keep your eyes on your charts and instruments, so that the bright flashes won't blind you. If you are flying in an open cockpit plane, or a plane with a plywood or plastic fuselage, better keep away from the lightning.

KEEP YOUR HEAD, KEEP YOUR COURSE—YOU'LL COME THROUGH

Remember This

1. Know your winds. Winds at cruising level determine your groundspeed. Study your winds aloft so as to know where the most favorable ones may be found. The wind always blows with low pressure to the left of the line of motion; i.e., if the wind is from the south, the low pressure area is to the west.

When the isobars on your weather map are crowded closely together, strong winds are indicated. Usually surface winds are less than those at higher altitudes because of the friction of air moving over uneven terrain. However, there are times when surface winds may approach those at higher levels and become too violent for safety.

2. When an active warm front is approaching, delay your takeoff until the front has passed, and even then, check to be sure you will not cross the warm front.

3. In winter be on the lookout for snow. If the temperatures are near, or below freezing, the precipitation is likely to be in the form of snow. If it is, remember that snow can cause a low effective ceiling in just a few minutes where before there was only an intermediate cloud layer with unlimited visibility. Snow static often makes your radio useless, and it is much easier for heavy snow to fall than heavy rain.

4. Carefully consider the intensity of each cold front before you attempt to fly through it. If there is any doubt in your mind, sit down and wait until it passes. Use your head to save your neck.

5. Avoid flight where icing conditions are likely to be found.

Special conditions you should watch for in Spring:

1. Formation of secondary storms on cold fronts.
2. Widespread low cloud area is still a hazard.
3. Cold fronts may be at their most violent stage.

During Summer, there is one paramount rule: **Thunderstorms are dangerous.**

If your flight plan and forecast work out as expected, and they will most of the time, you know what you are encountering. If, on the other hand, your forecast of winds and weather and your flight plan do not turn out as planned, you have no foolproof method of knowing actually what is ahead from what you can observe from the air. Contact ground stations often for weather reports, ask for advice or revised forecast, call other airplanes in the same area if possible, **consult Pilots' Advisory Service.** If you don't like the looks of what you are seemingly encountering, turn around while you still have time and proceed to your point of departure or some convenient field. Remember, you must play along with the weather and it's no disgrace to admit you are out-maneuvered.

No formula has ever been devised to fly bad weather nor has any substitute for experience and good judgment been discovered. The information offered here is intended merely as a guide; for detailed information study Technique in Weather T.O. No. 30-100 D-1.

TYPE	DEGREE OF CONTINUITY	ICING	TURBULENCE	VISIBILITY	THICKNESS	HEIGHT OF BASES	TACTICAL USES
CIRRUS CIRRO STATUS CIRRO CUMULUS	POOR GOOD IN CS	NONE, EXCEPT IN CARBURETOR	SLIGHT	500-1000 YARDS	VARIABLE	ABOVE 15,000 FT.	USELESS FOR EVASION. WHITE BACKGROUND MAKES EASY SPOTTING OF PLACES IN OR UNDER CI, CC OR CS ESPECIALLY AT NIGHT
ALTO STRATUS	GOOD	SLIGHT	SLIGHT	100-200 YARDS	1,000 TO 4,000 FT.	ABOVE 8,000 FT.	MOST SUITABLE—CAN BE USED FOR FORMATION FLYING
ALTO CUMULUS	POOR	SLIGHT TO MODERATE	SLIGHT TO MODERATE	20-25 YARDS	2,000 TO 4,000 FT.	ABOVE 8,000 FT.	CAN BE USED FOR TEMPORARY EVASION
STRATO CUMULUS	FAIR	MODERATE	SLIGHT TO MODERATE	20-25 YARDS	500 TO 4,000 FT.	1,000 TO 4,000 FT.	USED MOST BECAUSE OF FREQUENCY AND ALTITUDE
STRATUS	POOR TO VARIABLE	SLIGHT TO MODERATE	SLIGHT	20-25 YARDS	1,000 TO 4,000 FT.	0-2,000 FT.	NOT SUITABLE—TOO LOW
NIMBO STRATUS	GOOD	MODERATE TO SEVERE	MODERATE	10-15 YARDS	6,000 TO 8,000 FT.	0-1,000 FT.	NOT SUITABLE—CONTINUITY IS ONLY FAVORABLE FACTOR
CUMULUS	POOR	MODERATE TO SEVERE	MODERATE	15-20 YARDS	UP TO 8,000 FT.	800 TO 2,000 FT.	NOT SUITABLE—ALL FACTORS UNFAVORABLE
CUMULO NIMBUS	POOR	SEVERE	SEVERE	10 YARDS	20,000 TO 30,000 FT.	600 TO 1,600 FT.	DANGEROUS—CAN BE ENTERED IN CIRRUS AT TOP FOR EVASION FROM FIGHTERS

NAVIGATIONAL AND TACTICAL

USES OF CLOUDS

All clouds except Cirrus form, are with the attacker and against the defender.

Convection clouds (Cumulus and Cumulonimbus) in the daytime may help you locate a continent or large island.

Lack of radiation fog in continental areas may indicate bodies of water.

Sea fog over the ocean at night looks like a mass of land and may fool you.

The leaning of vertical development clouds (Cumulus and Cumulonimbus) will indicate the most favorable flight level for a fast trip, but does not indicate the actual wind direction.

The winds over the top of stratus type clouds are usually quite different from the winds below the clouds.

In passing through any type of Northern Hemisphere front in any direction, remember:

1. If you had right drift it will become less right or possibly left drift.
2. If you had left drift before crossing the front, it will either become right drift or none at all. These rules are reversed in the Southern Hemisphere and do not apply to the inter-tropic front.

Beware of shadows from Cumulus and Cumulonimbus clouds on water. They frequently look like islands.

Three Types

1. Exhaust trails: formed by the moisture emitted from the exhaust pipes.

2. Convection trails: formed by the heat from the engine causing the air in the wake of the plane to be lighter than the surrounding air. The heated air rises, and forms a true cloud.

3. Aerodynamic trails: formed by flying through nearly saturated air. The cooling as air passes over the wings lowers the temperature to the dew point and trails are formed.

General Characteristics

One outstanding fact must be remembered about such trails. You frequently do not know your airplane is leaving a trail even when you are expecting one. It is sometimes necessary to make a turn of 180° before you can see the trails. An explanation of this is that under certain atmospheric conditions, the trail forms just aft the engines and wings, and under varying conditions these trails may form at from 500 yards to 2 or more miles behind the plane. At 2 miles you may not see them.

You should understand the tactical importance of condensation trails. The disadvantage of such trails is apparent. When you operate at an altitude at which you are not readily visible from the ground, condensation trails give away your position and course of flight. They indicate the number of ships in your flight, and they provide a good means for enemy pursuits to close with bombers, using the trail as a cloud cover.

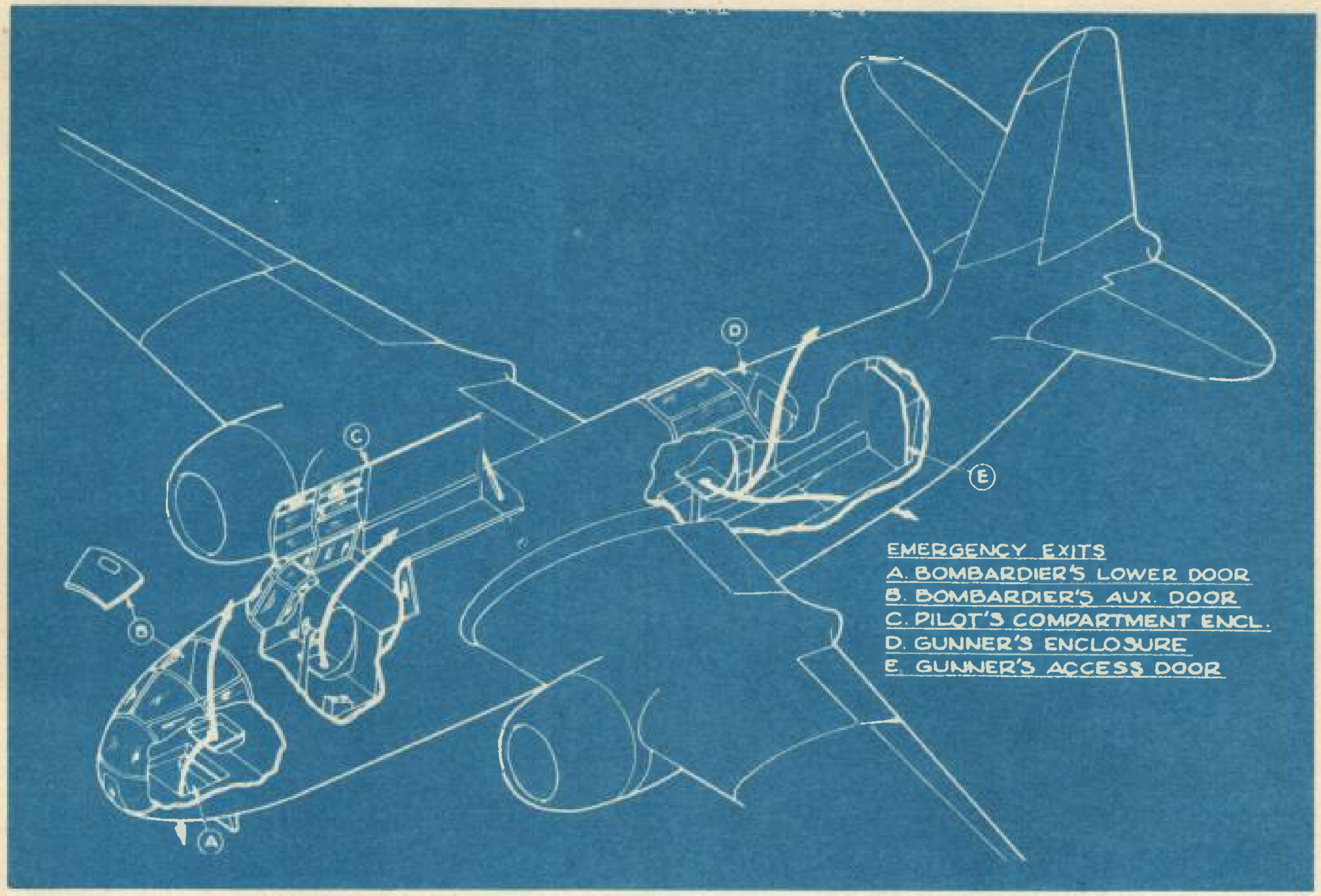
From the ground, condensation trails look like sky-writing. They usually form at very high altitudes and at low temperatures. Expect them when cirrus and cirrostratus clouds are present. These trails may form at lower altitudes and when no clouds are visible, if the atmospheric conditions are right for their formation.

When you see condensation trails, tell the pilot to climb or glide to a different level until the trails cease. Usually a change of altitude from 1000 ft. to 2000 ft. will eliminate the trails, but sometimes it may be necessary to change altitude at least 5000 ft. or more.

SECTION 7

EMERGENCIES

YOUR REACTION TO ANY EMERGENCY IN AN AIRPLANE MUST BE INSTANTANEOUS. YOU MUST DO WHAT IS NEEDED IN A BRIEF SPACE OF TIME, AND WHAT YOU DO MUST BE ABSOLUTELY RIGHT. STUDY THESE EMERGENCY MEASURES CAREFULLY.



Emergency Exits

All Army Air Forces airplanes contain means for quick exit, in the air, on the ground, or water.

Before you fly, be sure you know:

1. What exit to use.
2. How to use it.
3. When to use it.

Hold frequent practice drills on the ground. Teamwork and speed mean a lot in an emergency.

What Exit?

In flight, upper exits are dangerous because of the possibility of being caught by a propeller or of striking the tail. Use lower or side exits whenever possible. Study Handbook of Flight Operating Instructions to learn how to bail out of your particular airplane.

On the ground or water, fasten all lower hatches before landing. Dump all upper ones. They may jam upon impact and delay is dangerous. In an emergency, you can knock a hole in the skin of the airplane. If a handaxe is provided on the airplane, know where it is and how to remove it.

How To Escape

Emergency exits are provided with quick release red handles. Usually the door or hatch will be blown away by the windstream, if you pull the release and give the exit panel a light push.

For a crash landing on land or water, don't dump lower hatches. Dump the upper hatches, but remember that they may damage the tail assembly.

Hold practice drills before flight. Be sure you know your exact duties and the meaning of emergency signals by interphone, call light, or warning bell.

What To Escape

Any emergency is unexpected and unusual, so keep your wits about you. Be deliberate, even though hurried. Consider the situation; make a decision; then act.

FORCED LANDINGS

Any crash landing that you can walk away from is a good one. Many such landings are made, however, in which little or no damage occurs to airplane or crew. They are the results of forethought and adherence to a few fundamental principles. The following suggestions may help you. Think them over. Plan in advance for that day when you are confronted with a forced landing.

1. Stay calm. This is the primary rule for any emergency. Know what you intend to do, then do it.
2. Tell the pilot the direction of the wind so he can land as nearly upwind as possible, never more than 90° from the wind.
3. Check the landing gear with your driftmeter or whatever other means is available. Tell the pilot what its position is.
4. Clear your guns of all ammunition.
5. Stow your sextant or astrocompass if you have time. Sextants are hard to get. A little forethought may keep yours in working order.
6. Throw all equipment overboard that might be tossed around by the impact of landing.
7. Take your ditching position (See NIF 7-3-1).

Survival after Forced Landings

Your chances of survival after a successful forced landing in uninhabited territory depend upon the amount of preparation you have made for this emergency. Learn as much as you can about the area in which you are flying. You must know such things as:

1. Type of terrain, and any prominent landmarks that can help you orient yourself.
2. Kinds of foods you should look for.
3. Attitude of natives.
4. Natural dangers.
5. Health and first-aid precautions.
6. Approximate location of the enemy.
7. Rescue organization and procedure.

Your airplane and its equipment provide you with plenty of material to improvise shelter, signaling equipment, cooking utensils, etc.

Study your Survival manual. It gives a complete story of how to live off the land and make your way back home.

DITCHING

Some day you may be forced down at sea. You won't have time to ask questions, so prepare now for such an emergency.

Memorize the ditching and dinghy procedures your Base Personal Equipment Officer works out.

Inspection

Before taking off on an over-water mission, make the following checks:

1. **Emergency equipment.** See that it is complete, properly stowed, and that it has been inspected.
2. **Escape hatches.** Make sure that they operate properly.
3. **Life vests.** Blow your vest up by mouth and check the adjustment of waist and leg straps. Inspect CO_2 cartridge and see that valves are closed.

Procedure

Besides giving verbal warnings over the interphone, the pilot will use the standard ditching signals: six short rings, "Prepare for ditching;" one long ring, "Brace for ditching."

When you receive the ditching order, calculate the plane's position. Estimate your position at the time of actual ditching. Your position in the water will differ radically from your position at 10,000 feet, when the decision to ditch may have been made. Give this information to the radio operator. Then destroy secret papers. Give the pilot the direction and force of the wind so that he can determine his heading for ditching.

Jettisoning

Lighten the airplane by jettisoning bombs, guns, ammunition, and anything not essential to the airplane's operation. Throw out any objects lying loose or likely to be torn loose by the impact. Hold or firmly secure emergency equipment that you are going to take with you.

Close bomb-bay doors after jettisoning bombs. Close all lower hatches and the bulkhead doors.

General Crew Preparations

Take off neckties and open collars. Remove heavy boots, but keep on flying clothing and helmet for protection. See NIF 4-3-6 for use of oxygen mask.

Remove parachutes, except when you need the one-man life raft attached to the harness.

Keep life vests on at all times. **Do not inflate them until out of the airplane.**

Ditching Positions

All crew members must follow the standard ditching positions which AAF ditching posters recommend for various combat planes.

If there is no poster on your airplane, or you can't use the positions recommended, remember the following:

1. The best ditching position is to sit facing the tail of the plane, knees drawn up, back and head braced against a solid structure. If your head extends above the support, clasp your fingers tightly behind it to hold it from being snapped back. If there is not enough bulkhead room for all to brace against, some must sit farther aft than others, backs braced against the forward men's shins, feet and knees drawn up, hands clasped behind heads.
2. The second position is to lie on the floor of the plane, head to the rear and feet firmly braced against a solid structure. Bend the knees slightly. The best position for an injured man is the seated one. If such a position is not the injured man's regular one, have him trade places with someone.
3. Another position, in airplanes equipped with ditching belts, is to brace against the belts.
4. The pilot will warn you approximately five seconds before the impact so you can brace for the shock. Hold your position until the airplane comes to a stop; casualties occur when men relax immediately after the initial impact.

Abandoning the Airplane

Do not operate the manual raft release until the airplane comes to rest. Don't hold on to this release before or during ditching; you may pull it inadvertently.

Raft accessories kits, emergency radio, extra signaling equipment, navigation kit, extra rations and water must be removed. Take out the items you were assigned to take. If some member of the crew is incapacitated, make sure that you also take out the equipment he was designated to remove.

Boarding the Life Raft

Launch and board a raft from one of the wing tips if possible, to avoid damaging it on jagged edges.

Don't jump into the raft; you'll go right through the fabric.

Paddle away from the plane and tie the rafts together if there are more than one. Stay near the plane; it is easier for rescuers to spot you.

needed for a power landing, will also be jettisoned.

Bombs and depth charges should be salvoed if the plane has sufficient altitude. Bombs and depth charges, if not dumped, **must be placed on safe.**

All lower hatches and bomb doors must be securely fastened and landing gear retracted.

You and the Radio Operator

Upon receipt of the ditching order, calculate the plane's position, course and speed. Pass this information to the radio operator. Then destroy secret papers.

The radio operator tunes the liaison transmitter to MFDF and sends SOS, position, and call sign continuously.

He also turns IFF to distress and remains on intercommunication, clamping down the key on the pilot's order to "Take ditching posts."

Pilot and Co-pilot

The pilot and co-pilot open the escape hatch through which they will exit. They make sure that safety belts and shoulder harness are secured.

The pilot will keep up a running account of the ditching to keep you informed as to what is taking place outside the plane.

Crew

The duties of crew members obviously vary with the model of plane being flown. After performing such duties each man goes to, or remains at, his ditching post.

Equipment needed in the life raft is gathered and carried to the ditching posts by the personnel, and secured against the impact. Parachute pads, seat cushions, etc., are used to protect the face, head, and back against the shock of landing. When this is done the crew awaits the order to "brace for ditching." This order should be given by the pilot five seconds before the first impact.

Landing Impacts

Regardless of the plane, two impacts will be felt—the first a mild jolt when the tail drags the water, the second a severe shock when the nose strikes. Hold your crash position until the plane comes to rest.

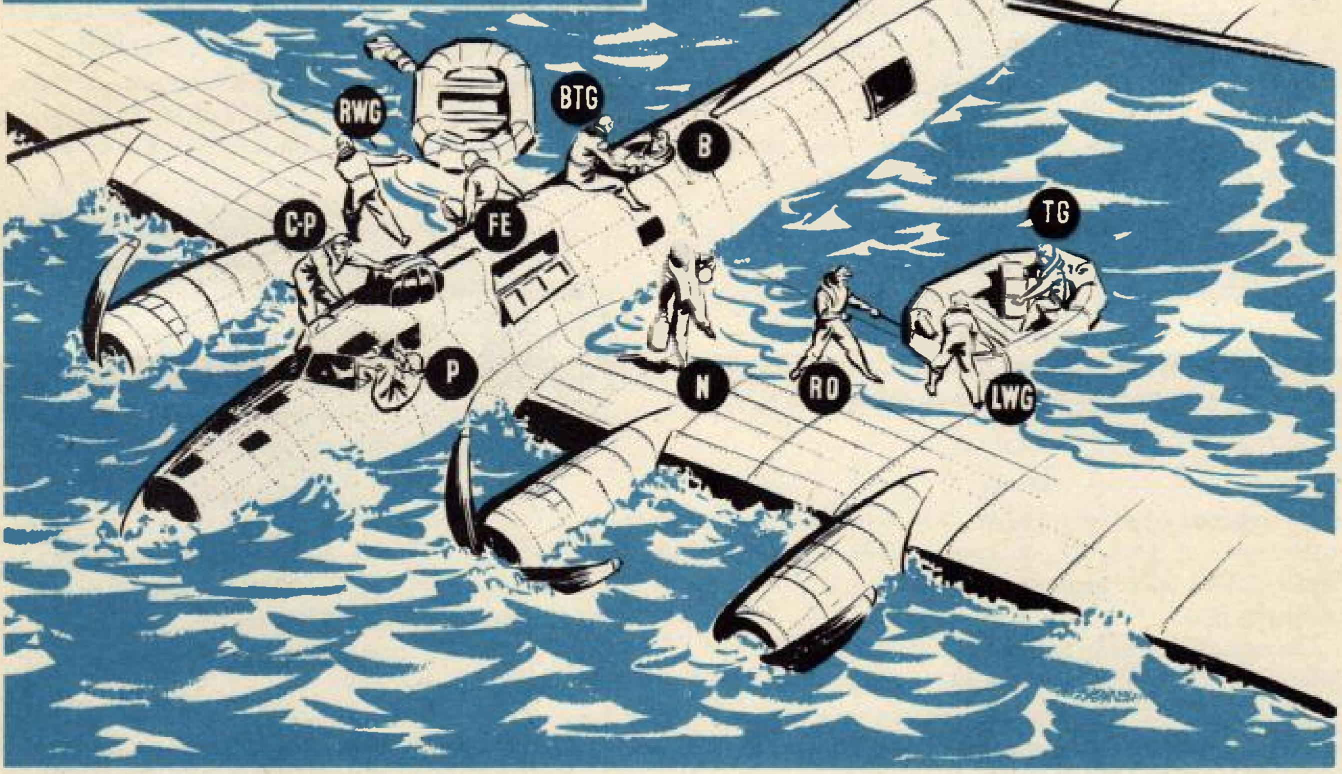
Do not inflate your life vest inside the plane unless you are certain that the escape hatch through which you will exit is large enough to accommodate both yourself and the inflated vest.

The radio operator tunes liaison transmitter to MFDF and sends SOS, position, and call sign continuously. He also turns IFF to distress and remains on intercommunication, clamping down key on pilot's order to "take ditching post." He relays information given him by you.

All loose equipment is jettisoned. Upper hatches are released to facilitate exit. Bombs and depth charges are salvoed if the plane has sufficient altitude; if not dumped, they are placed on SAFE.

Emergency equipment should be taken to the raft. Water is most important, then signal equipment. Remember to take the Very pistol, cartridges, signal mirror, emergency radio and sea marker. These will help in your rescue.

Don't jump into the raft. Beware of jagged wing surfaces when launching it.



DITCHING THE B-17

Speed in abandoning the B-17 is important, since the airplane will remain afloat for only a short time. However, equipment, which will be needed for survival in the open raft—especially water and signaling equipment—must not be forgotten.

After the plane has been successfully ditched and the crew abandons it, both rafts are automatically inflated by the ball turret gunner who pulls the dinghy release. The tail gunner, seated in the left raft, is first to exit from the radio compartment hatch. He secures equipment. You, second to exit, are shown at the side of the raft after you have stowed the emergency radio. The radio operator, shown holding a line attached to the left dinghy, is fifth to exit from the radio compartment. The right waist gunner is the third man to leave the plane. He assists in launching the right dinghy. The flight engineer, fourth out, is shown sliding off of the fuselage onto the right wing. The ball turret gunner, seventh man out, is shown astride the fuselage receiving emergency equipment from the bombardier, who is last to leave the radio compartment. The pilot exits from the left window of the pilot's compartment and takes command of the left dinghy. The co-pilot leaves from the opposite window and takes command of the right dinghy.

Abandoning the Plane

Dinghies should not be released until the plane has come to rest.

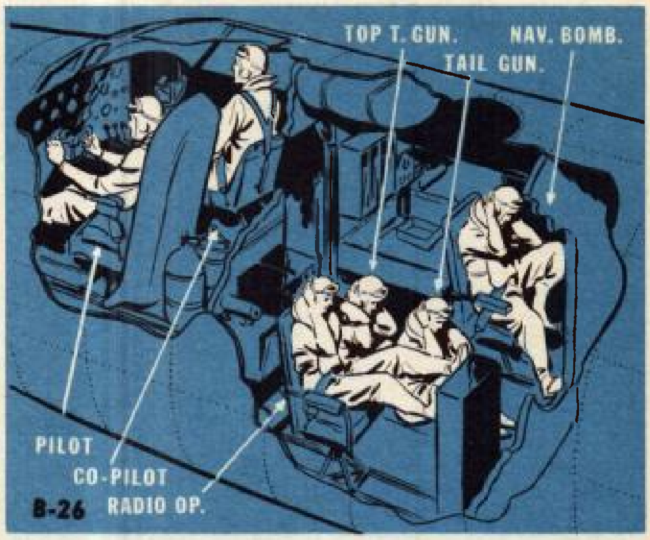
Exit in the order you practiced. However, injured men will receive first consideration and assistance. Speed is important, but life raft equipment should be taken aboard.

If ditching occurs at night bright lamps within the plane should be turned off. They may be snapped on after landing to guide nearby rescue parties.

Use care in launching the life raft to prevent punctures on ragged or sharp parts of the fuselage or wing surfaces.

If there are two dinghies, they should be tied together and should remain in the area until the plane has sunk. The outline of the aircraft will aid rescue planes.

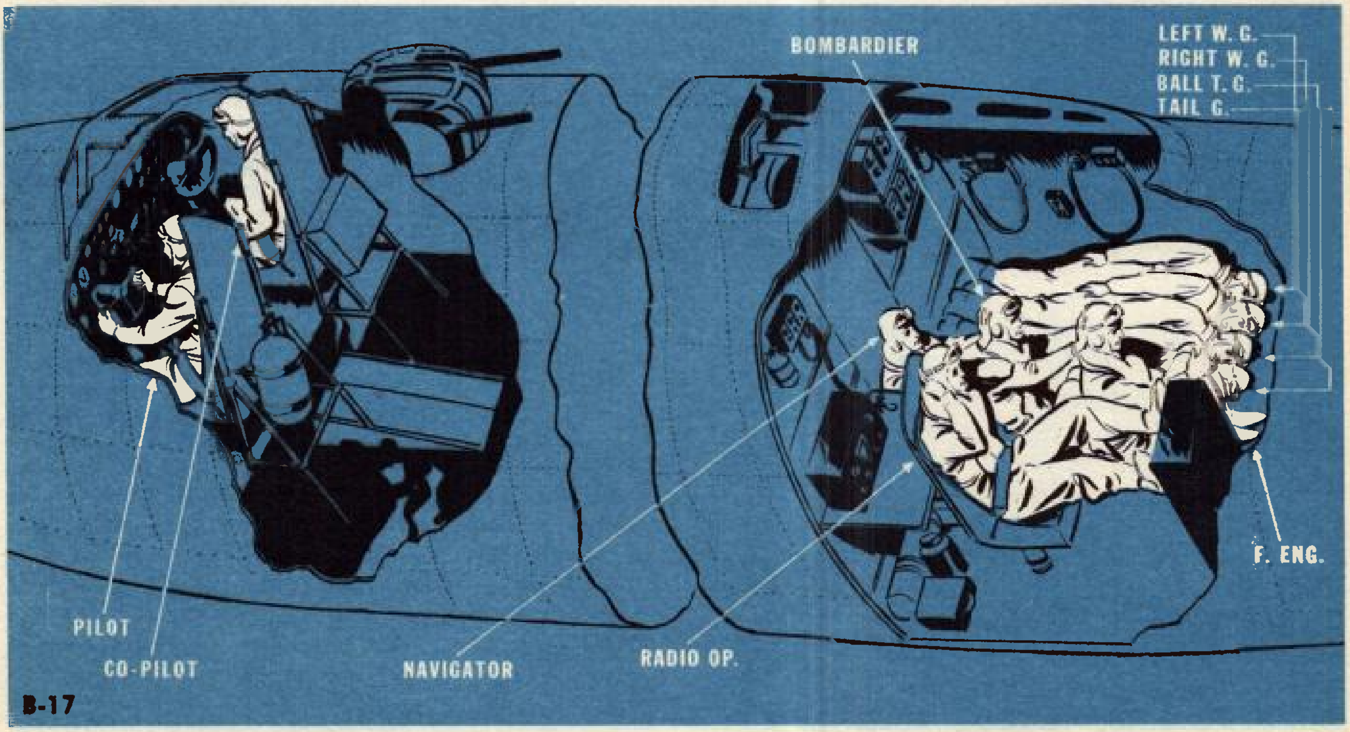
Some of the equipment needed will be stored in the raft; the remainder must be hauled aboard and securely fastened. Check to insure the presence of all necessary items—ration kits, emergency radio and signalling equipment, etc. Parachutes will come in handy as cover from the sun and sails. Protection against hot tropical sun is important since it causes bad burns and dehydrates the body.



Ditching Positions in the B-26

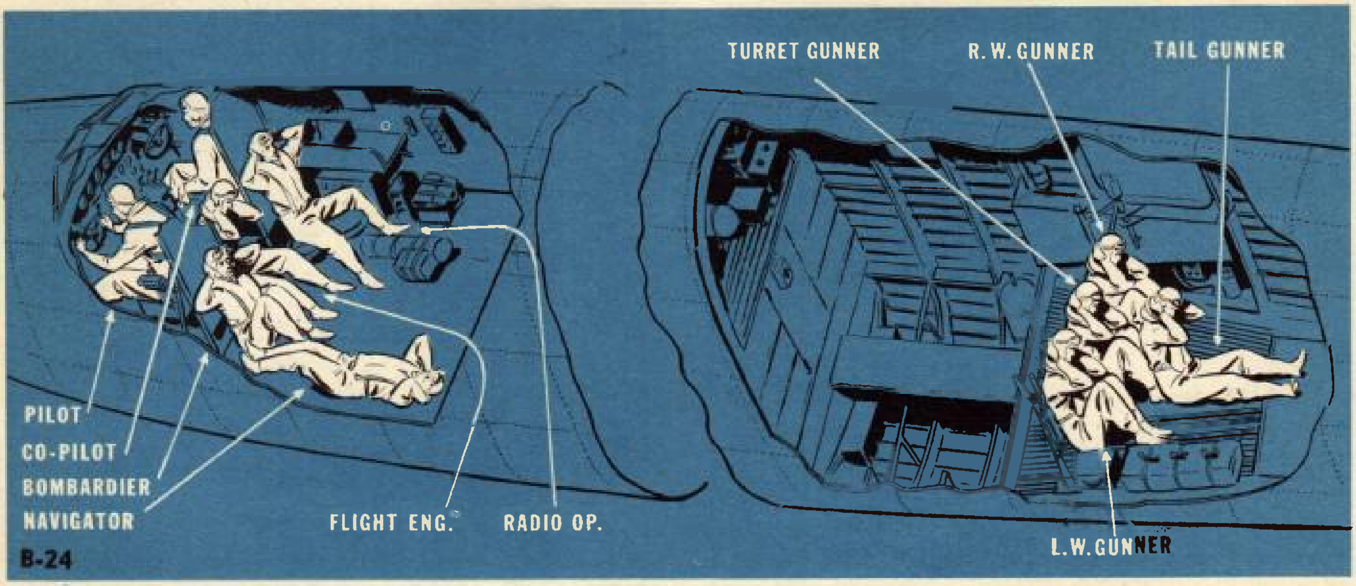
B-26. Co-pilot pushes his seat to rear, allowing you to exit from nose. Top turret gunner is braced against step leading to cockpit. His knees are drawn up, elbows close together to form a back support for tail gunner. All remain in position shown until plane comes to rest.

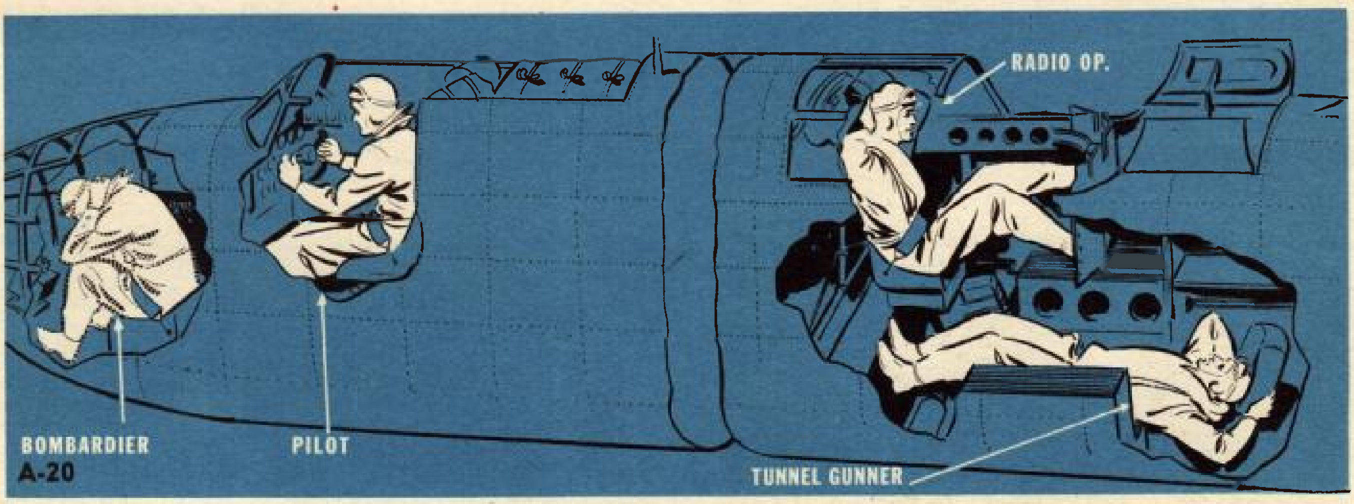
B-17. You are braced against closed door, knees drawn up, hands on the back of bombardier's head. Bombardier braced against your legs, holds head of man in front of him. Radio operator sits well back in seat, feet braced against radio equipment. Knees of all personnel in the supine position are slightly bent. All hold positions until plane comes to rest.

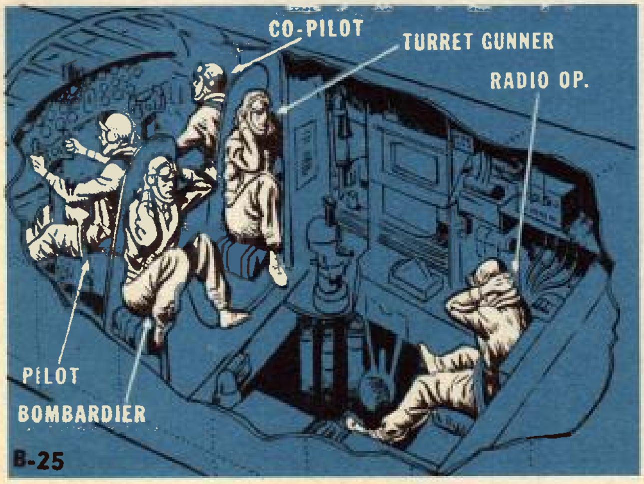


Preparing to Ditch the B-17

DITCHING POSITIONS







B-24. Ditching belt in the aft compartment is attached to gun mounts. Men brace against it as shown. Flight engineer, on cockpit step, also should use a ditching belt. Otherwise he should lie on floor, feet against step, knees bent slightly. Fasten down all loose equipment. Hold positions until plane stops. If help is near, crew should use one-man raft parachute and bail out.

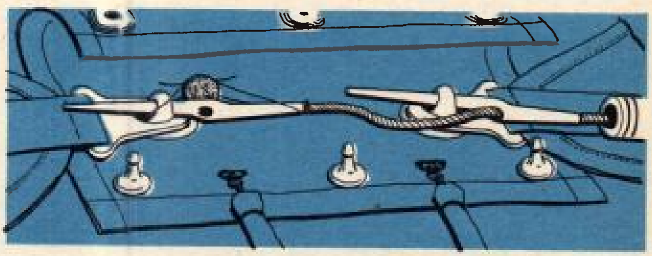
A-20. Bombardier should wear one-man dinghy parachute pack and bail-out of bottom nose hatch if rescue appears possible. Other crew members take positions shown and maintain them until plane comes to rest.

B-25. If there is sufficient time and altitude, crew members in the rear should crawl through the bomb bay to ditching positions in forward part of plane. Otherwise they should remain in the after compartment. Positions shown should be maintained until plane comes to rest.

Parachutes

All persons aboard Army airplanes will be equipped with standard-type parachutes. Wear your parachute whenever possible. Be sure you know the bail-out plan. It is excellent precaution to carry an extra parachute in multi-place airplanes.

CORRECT LANDING POSITION



BEFORE THE FLIGHT

Inspect your parachute. Remember, you may have to jump with it! Check the date of the last inspection. The packing interval should not exceed 60 days in the United States or 30 days in the tropics. Open the flap; make sure that the ripcord pins are not bent and that the seal is not broken. A bent pin or jammed wire may make it impossible to pull the ripcord. See that the corners of the pack are neatly stowed so that none of the silk is visible. See that the six or eight opening elastics are tight. Inspect each parachute you draw.

Put your parachute on and be sure the harness fits properly. The shoulder and chest straps should be snug without play; the chest buckle should be twelve inches below the chin. The leg straps should be snug. In fact, the harness should be comfortably snug when you are seated and disagreeably tight when you stand up.

IN FLIGHT

If you find yourself in serious trouble, prepare to put your bail-out plan in operation.

Consider These Points:

1. Note your altimeter reading.
2. Check the altitude of the terrain below.
3. Decide on a minimum altitude at which you can safely bail out. Take into consideration the flight characteristics of the plane and the kind of trouble you are having. Notify the pilot.
4. If you are still in trouble when you reach that minimum altitude—bail out.
5. Remember that in general it is safer to jump than to attempt a forced landing on hazardous terrain with a fully loaded plane.
6. If you have to bail out, help the pilot pick the best available spot.

THE BAIL-OUT

Know the emergency exits provided for the airplane and understand how and when to use them. Bail-out posters are supplied for most bombardment types of aircraft.

Practice making exits while wearing full equipment when the airplane is on the ground. Drill yourself in a standard bail-out procedure, including warning signals and exit signals.

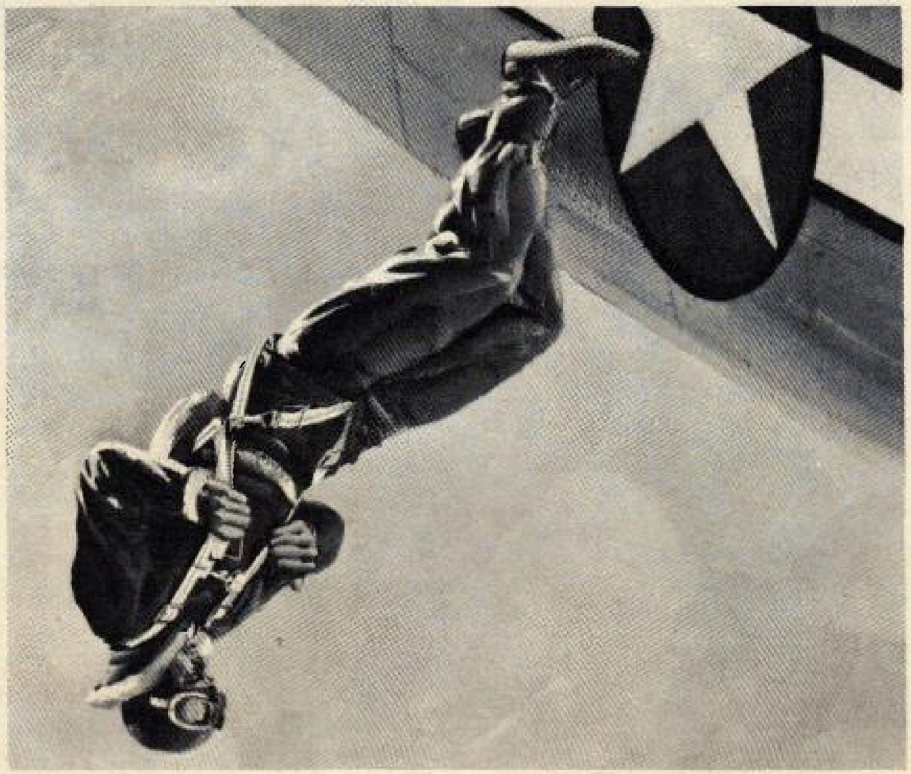
Jumping from Twin-Engine Trainers, Bombers, and Transports

You will normally use an escape hatch, the bomb bay, or a door, depending upon circumstances. Slide yourself to the edge of the opening and go out head first and straight down.

DRILL IS ESSENTIAL
You Must Know When, Where, and How to Leave the Airplane.

CLEARING THE AIRPLANE

Probably the most important single act, in any parachute jump, is opening the parachute only after you are clear of the plane. Wait until you are well away from the airplane before you pull the ripcord. Keep your eyes open. Look around. If you have enough altitude, wait at least five to ten seconds before pulling the ripcord.



PULLING THE RIPCORD

There is nothing complicated or difficult about getting your parachute safely open. Just:

1. Straighten your legs and put your feet together to reduce the opening shock, and to avoid tangling your harness.
2. Use both hands to grasp the ripcord pocket.
3. Grab the ripcord handle with the right hand, and yank! Keep your eyes open and look at the ripcord as you pull it.

THE DESCENT

About two seconds after you have pulled the ripcord, you will feel a sharp, strong tug as the canopy opens and bites the air.

Look up to see that the chute is fully open. If a suspension line traverses the top, or the lines are twisted, manipulate the lines to remedy the fault.

Do not worry about oscillations. They will almost certainly occur on your way down, but are of minor consequence. Do not attempt to check them or to slip the parachute, as such maneuvers are useful only to experts, and are dangerous below 200 feet.

Make a quick estimate of your altitude by looking first at the ground below and then at the horizon.

You will descend approximately 1000 feet per minute.

Observe your drift by craning your neck forward and sighting the ground between your feet, keeping your feet parallel and using them as a driftmeter.

Face in the direction of your drift.

While you cannot steer your chute, you can turn your body in any desired direction. **The body turn is the most useful maneuver you can learn because with it you can make certain that you land facing in the direction of your drift. It is simple and easy. Note carefully exactly how it is done.**

STUDY THE PICTURES. Practice the body turn in a suspended harness if you get the chance. This description may sound backward to you. Note with special care how these turns are executed and simply say to yourself:

"To turn right, right hand behind my head."

"To turn left, left hand behind my head."

HOW TO MAKE BODY TURNS

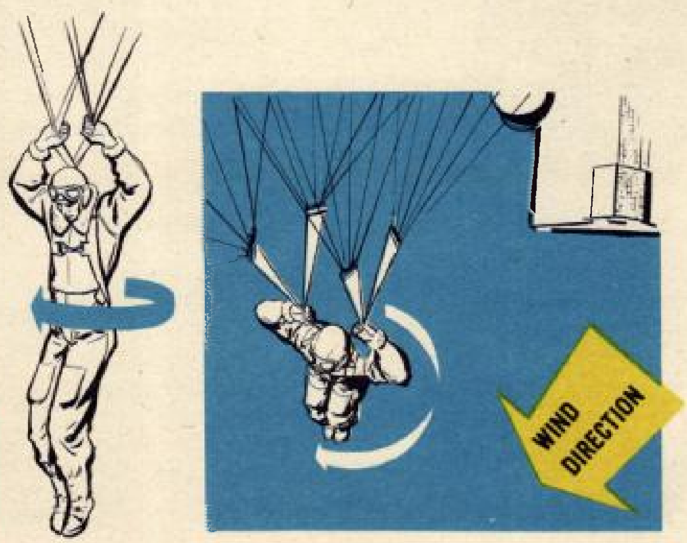
TO TURN YOUR BODY TO THE RIGHT:

1

Reach up behind your head with your right hand and grasp the left risers.

2

Reach across in front of your head with your left hand and grasp the other risers. Your hands are now crossed, the right hand behind, and in each you have two risers.



3

Pull simultaneously with both hands; this will cross the risers above your head and turn your body to the right. You can readily turn 45°, 90°, or 180° by varying the pull.

To turn to the left, reverse this procedure.

In the descent, start your body turn high enough to allow you to master it. Once you have made the turn, you will find that you can control your direction of drift perfectly. Hold the turn, or slowly ease up if necessary, to bring you in facing downwind. Continue to hold the risers, whether you have had to twist them to make a body turn or not, and ride right on into the ground this way.

THE LANDING

NORMAL LANDINGS

Whether you have made a body turn or not, keep your hands above your head, grasping the risers.

Look at the ground at a 45-degree angle, not straight down.

Set yourself for the landing by placing your feet together and slightly bending your knees, so that you will land on the balls of your feet.

Don't be limp; don't be rigid.

Relax, and keep your feet firmly together with your knees slightly bent, and your hands grasping the risers above. Now hold everything and ride on into the ground, drifting face forward.

At the moment of impact, fall forward or sideways in a tumbling roll to take up the shock.

High Wind

ABNORMAL LANDINGS

If there is a strong wind blowing across the ground when you land, do two things.

First, make certain that you carry out the procedures described above for a normal landing, **including the body turn to face you exactly in your direction of drift.**

Second, once you are down, roll over on your abdomen and haul in hand over hand on the suspension lines nearest the ground. Keep right on pulling them in until you grab silk. Then, drag in the skirt of the canopy to spill the air and collapse the chute. If you can't manage this maneuver on your face, go over onto your back, but haul in the suspension lines until you have got the bottom edge of the canopy, then spill the chute.

Trees

Tree landings are usually the easiest of all. If you see that you are going to come into a tree, drop the risers, cross your arms in front of your head, and bury your face in the crook of an elbow. You can see under your folded forearm. Keep your feet and knees together. If you get hung up high in a tree, consider first the possibility of immediate rescue before you try to climb down. Failing that, get out of the harness and cut the lines and risers to make a rope for climbing down.

Water

Safe water landings are simple if you know what to do. The ability to swim is an advantage but not a prerequisite. Follow the procedure outlined here for all types of parachutes except the QAC and the single-point quick release, instructions for which are given below. Begin preparing for the water landing as soon as the parachute is open.

1. Throw away what you won't need.
2. Pull yourself well back in the sling by hooking your thumbs in the webbing and forcing the sling downward along your thighs.
3. Undo your chest strap by hooking a thumb beneath one of the vertical lift webs, pushing firmly across your chest to loosen the cross webbing so that you can undo the snap. **This must be done before you inflate the Mae West, as the chest strap cannot be released over an inflated life vest.**
4. If you are securely seated in the sling, and have time, free the leg straps by doubling up first one leg and then the other, unsnapping the fasteners. Keep your arms folded, or hang onto the risers, so that you will not fall out of the harness. You can remove the leg straps in the water either by unsnapping them or by working them down over your feet if you have been unable to free them in the air.
5. As soon as you are in the water, inflate your Mae West, one half at a time. Either half will support you. **Remember, never inflate your life vest until you have unfastened your chest strap.**
6. Get clear of the parachute promptly, and stay clear.

Carry an accessible, serviceable knife to cut harness and suspension lines if necessary.

With the QAC (Quick Attachable Chest) pack, without risers, modify this standard procedure as follows:

1. Pull yourself well back in the sling and undo the leg straps.
2. As soon as you are in the water, release one side of the chest pack from the harness.
3. Then unfasten the chest strap.
4. Inflate the Mae West, one half at a time, but never until the chest strap is unfastened.
5. Get away from the parachute and shroud lines and stay away.

With the single point quick release harness, modify the standard procedure as follows:

1. Before reaching the water, turn the locking cap 90° to set the release mechanism for immediate operation.
2. As soon as you are in the water, but not before, pull the safety clip, and press hard on the cap to release the lock. The harness will then slide off.
3. Inflate the Mae West, one half at a time, but never until the harness has been released.
4. Stay clear of the parachute.

See Life Vest, NIF 7-10-1 and Life Rafts, NIF 7-12-1

NIGHT JUMPS

As soon as you are in the chute, prepare for a normal landing. Since you cannot see the ground on a dark night, you want to be ready to make contact at any moment. **Get your feet and knees together, your legs slightly bent. Hang onto the risers above your head and wait for contact.**

HIGH ALTITUDE JUMPS

A successful jump has been made from above 40,000 feet using oxygen on the way down; and from as high as 35,000 feet without bail-out oxygen apparatus. Free falls of from 10,000 to 30,000 feet have been made before the ripcord was pulled, with no harmful effects whatever. This evidence means that intelligence and self-control, plus normally-functioning equipment, can get you down safely from any altitude to which you can fly.

The chief hazards of high-altitude jumping are:

1. Intense cold.
2. Lack of oxygen.
3. Excessive speed.

The last may, of course, be encountered in any jump, but is particularly likely to accompany emergencies at high altitude. All three of these hazards are greatly reduced by making a long free fall before opening the parachute. Also, exposure to gunfire, falling debris, etc., is practically eliminated.

A free fall from 40,000 feet takes just over three minutes. The same descent by parachute takes about 24 minutes. If the parachute is opened at approximately 5,000 feet above the terrain (when the earth "begins to look green," details appear, the horizon "spreads," and the ground appears to rush up), the descent takes about seven minutes.

Remember that in many emergency jumps you may leave the airplane at a speed likely to exceed the terminal or maximum velocity of a free fall. Hence, you should wait to slow down to terminal velocity before pulling the ripcord to avoid injuring yourself or damaging the parachute. In from five to 15 seconds, you will reach terminal velocity in any fall, and will actually slow down all the rest of the way, from 320 feet per second (218 mph) at 40,000 feet to 160 feet per second (109 mph) at sea level. With the parachute open, your rate of descent varies between 40 feet a second at 40,000 and 20 to 24 feet a second at sea level.

If you have bail-out oxygen equipment:

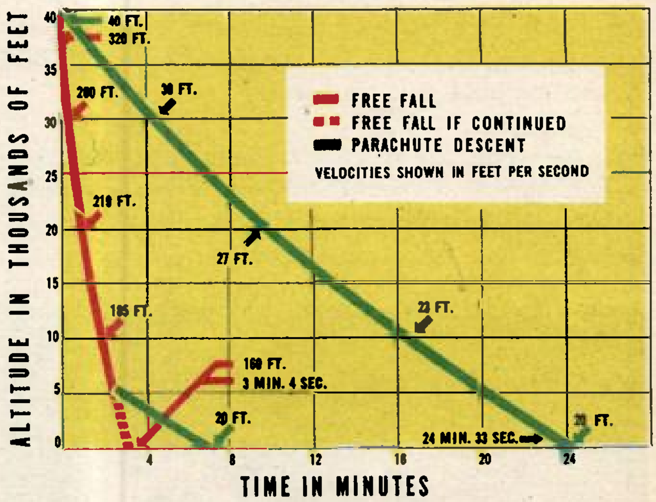
1. Take several deep breaths of oxygen from the plane's supply.
2. Turn on your bail-out oxygen supply.
3. Grip your pipestem between your teeth, or check your mask.
4. Dive clear of the airplane.
5. Wait as long as you safely can before pulling the ripcord.

If you do not have bail-out oxygen equipment:

1. Take several deep breaths of oxygen from the plane's supply.
2. Hold your breath and dive out.
3. Continue to hold your breath as long as you possibly can.
4. If you are above 30,000 feet, try to wait at least one minute before pulling the ripcord.

Except in extreme emergency, do not attempt a bail-out without bail-out oxygen equipment above 30,000 feet.

FREE FALL AND OPEN PARACHUTE DESCENT FROM 40,000 FT



The graph compares parachute descent from 40,000 feet, and combined free-fall and parachute descent with delayed opening of the parachute at 5,000 feet.

REFERENCE: Technical Order 13-5-2.

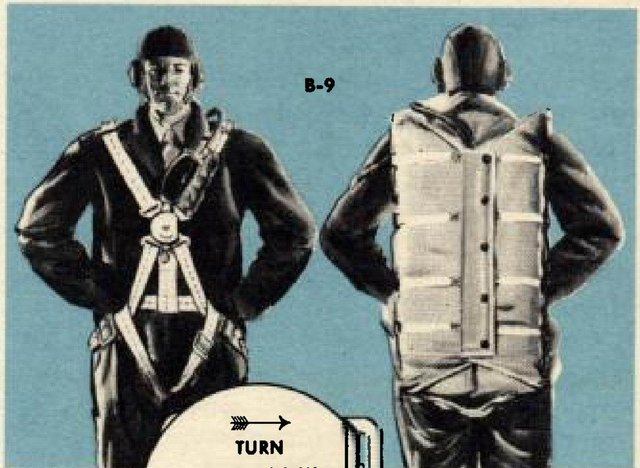
Parachute Types

BACK-TYPE PARACHUTES

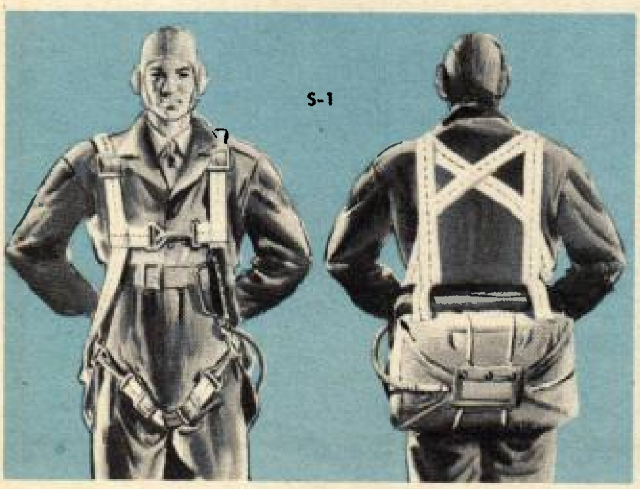
Type B-7 (AN6512). The chest straps and leg straps have bayonet type or snap fasteners. Note that parachute belt is worn outside harness to hold webbing snug.

Type B-8. Flexible back pack with bayonet type fasteners on chest and leg straps. Older type B-8 parachutes have snap fasteners.

Type B-9. Flexible back pack on single point Quick Release harness. To get out of Quick Release harness turn the cap clockwise 90°, pull safety clip, and strike the cap a sharp blow with the hand.



Cap is shown in safetied position.



SEAT-TYPE PARACHUTES

Type S-1, S-2, AN6510, and AN6511. Harness has back and seat pad. Chest and leg straps have snap or bayonet fasteners.

Type S-5. Same chute as S-1 with single point Quick Release harness.

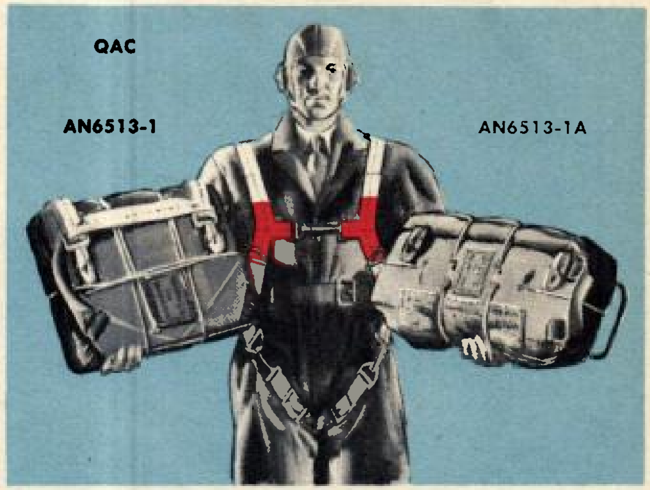
ATTACHABLE CHEST-TYPE PARACHUTES

Group 1 Assemblies

Type QAC (AN6513-1). Quick attachable chest-type parachute with square pack. Harness has snap fasteners on chest and leg straps. It has D-rings for attachment of pack.

Type QAC (AN6513-1A). Quick attachable chest-type parachute with barrel-type pack. Harness has snap fasteners on chest and leg straps. It has D-rings for attachment of pack.

Note: On both AN6513-1 and AN6513-1A parachute assemblies the snaps are on the pack and the D-rings are on the harness. Either of these packs can be used with the harness shown.

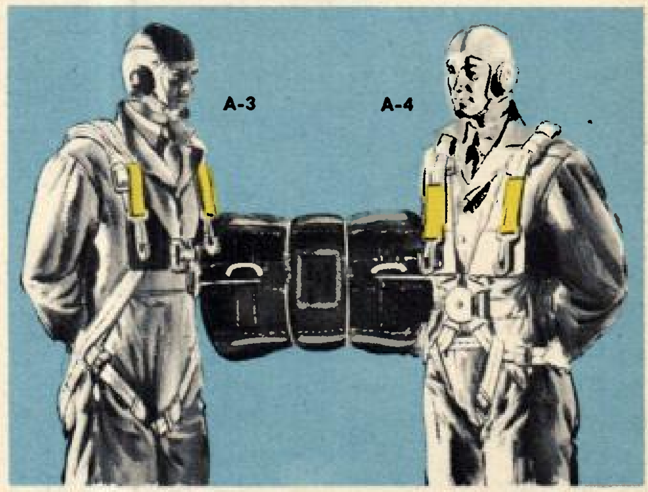


Group 2 Assemblies

Type A-3. Quick attachable chest-type parachute with barrel type pack. Harness has bayonet type fasteners.

Type A-4. Quick attachable chest-type parachute with barrel-type pack and single point Quick Release harness.

Note: On the A-3 and A-4 parachute assemblies the rings are on the pack and the snaps are on the harness. This pack can be used with either of the harnesses shown.



Caution!

Parachutes of Group 1 are not interchangeable with parachutes of Group 2.

The pilot is responsible for prevention of mismatching quick attachable chutes in his airplane.

Before the airplane moves for takeoff, inspect all attachable parachutes to see that the pack fits the harness. Snap each pack to its harness to make certain it matches.

If you find any pack which does not fit the harness, change either pack or harness to get the correct assembly.

Each group is to be identified by a color. The same color must be on both pack and harness.

Red identifies Group 1.

Yellow identifies Group 2.

Be sure all packs and harnesses in your plane match.

REFERENCE: Technical Order 13-5-39

PYROTECHNIC PISTOLS

When radio communication is inadvisable or when radio equipment has failed, brief coded messages may be sent with pyrotechnic signals. Do not use pyrotechnic signals to control important operations unless no other means is available. The various colored signals which are available for use with M2 and AN-M8 pyrotechnic pistols are assigned different meanings under a code that will be changed at frequent intervals in each edition of Signal Operation Instructions. The M11, red star parachute signal, however, is always used as a distress signal to be fired from the ground or from a life raft.

M2 Pistol

The M2 pyrotechnic pistol has a strong recoil. Use both hands to fire it if practicable. The signals themselves burn with an extremely hot flame; observe every reasonable precaution while handling or firing them.

1. **Fire signals only from airplane in flight** with the exception of the M11 distress signal.
2. Point the pistol in such a way as to prevent signals from striking any part of the airplane.
3. If a signal fails to ignite on the first attempt, try at least twice more. **If third or final try fails, keep the pistol pointed overboard and clear of all parts of the airplane for at least 30 seconds, then discard signal.**
4. **Discard a misfired signal, if possible, without handling the signal itself.** One method is to hold the pistol over an opening in the airplane and release the cartridge by pressing on the latch and allowing the signal to fall clear under the force of gravity. The force of the air blast prevents holding the pistol on the outside of most airplanes. **Be careful to prevent discarded signal from striking any part of the airplane.**
5. Do not discard misfired signals when flying over populated areas.
6. Fire the M11 distress signal as nearly straight up as is practicable.

AN-M8 Pistol

The AN-M8 pyrotechnic pistol is replacing the M2 pistol. It is fired by inserting and locking the barrel in a type M-1 mount. This mount is really a little "door," fastened rigidly to the airplane, that permits the pistol barrel to extend through the airplane outer skin. The mount absorbs the recoil of the pistol. Observe these precautions in using this pistol:

1. Place cartridge in chamber after pistol is inserted in mount, and only when immediate use is anticipated.
2. Since the pistol is cocked at all times when the breech is closed, **never leave a live signal in the pistol when it is removed from the mount.**

SMOKE GRENADES

Airplanes to be flown over sparsely settled regions on cross-country, patrol, or ferry missions will be equipped with either an M8 or an M3 smoke grenade. In the event of a forced landing, use the grenade as a marker to aid searching parties in locating the airplane which otherwise might be difficult to find.

Airmen observing smoke of the type produced by M8 or M3 smoke grenades will immediately attempt to locate the source.

The M8 smoke grenade burns about 3½ minutes, giving off a dense **gray** smoke, and is intended to be used primarily in heavily forested regions. It is easily distinguished from wood fires which give off a blue-gray or black smoke.

The M3 smoke grenade is designed to be used in snow-covered regions. It gives off a dense **red** smoke for 2 minutes which can be distinguished against a white snow background for about 4 miles by a person in an airplane.

Method of Firing M8 Smoke Grenade

1. Grasp the grenade with lever held firmly against grenade body.
2. Withdraw safety pin, keeping a firm grip around the grenade and lever.
3. Either throw the grenade with a full swing of the arm, or place on the ground and release.
4. As the grenade is released from the hand, the lever drops away, allowing the striker to fire the primer.

Method of Firing M3 Smoke Grenade

1. Pull the 3 vanes on the side of the grenade up and away from grenade body.
2. Place grenade in snow so that it is supported by the vanes in an upright position.
3. Keep lever held firmly against grenade and withdraw safety pin.
4. Release lever.

Safety Precautions

To avoid a fire, do not throw or place the grenade within 5 feet of dry grass or other readily inflammable material.

After the grenade is ignited, **stay at least 5 feet away from the burning grenade,** as heavy smoke develops and there is a tendency to throw off hot particles of residue.

Keep these smoke grenades dry. If the chemical contents of a grenade become wet, it will ignite. Future procurement of these grenades for the Army Air Forces will be packed in individual waterproof containers.

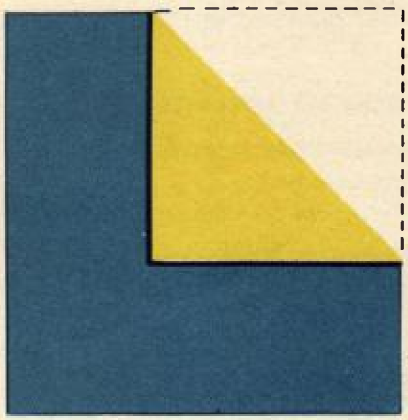
All smoke grenades will be shipped and handled in accordance with Interstate Commerce regulations. These regulations prohibit the shipment of these smoke grenades in personal baggage.

REFERENCE: T. O. 01-1-38, dated April 14, 1942

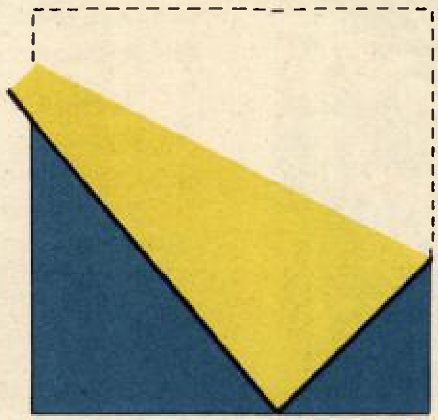
Panel Signals

Many of the emergency kits now supplied contain a large signal panel (roughly 10 ft. by 10 ft.). It is arc fluorescent yellow on one side and blue on the other. Immediately after you are forced down this panel should be spread out on the ground flat—yellow side up on dark backgrounds and blue side up on light backgrounds—the color will help rescue planes to find you. Once a rescue plane has located you, messages can be transmitted by folding the panel as indicated in the illustrations on these pages. If it is windy, hold the folds in place with rocks, sand, sticks, or improvised stakes if it is necessary. If several messages are to be transmitted don't change the folds too quickly—allow enough time for the rescue plane to read each signal and indicate that they understand it (generally by dipping the nose of the plane several times). These same signals can be transmitted with the square yellow-and-blue sail now a part of the equipment supplied with the large inflatable rubber life raft.

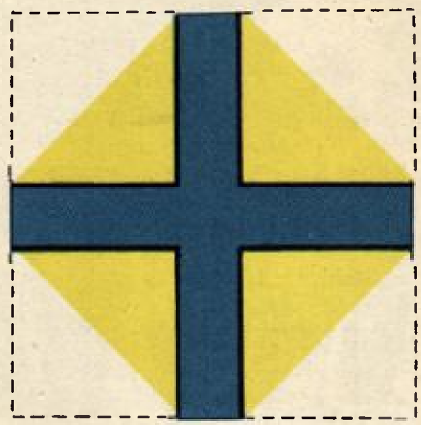
The emergency signal panel also can be used as a tent since its blue side is coated with a waterproof compound. Also, the blue side can be used as an excellent camouflage cover for a life raft if enemy aircraft are sighted.



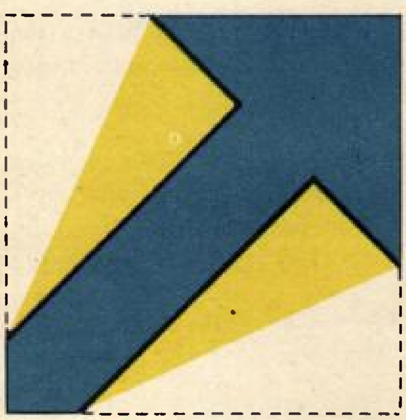
Need Gasoline and Oil, Plane is Flyable



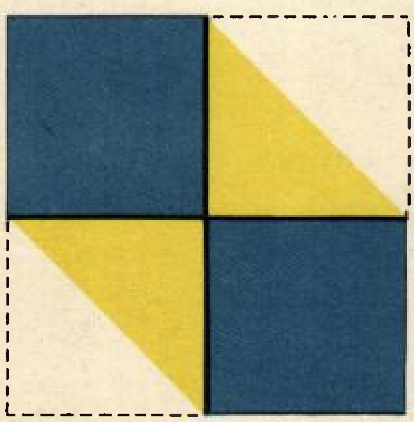
Need Tools, Plane is Flyable



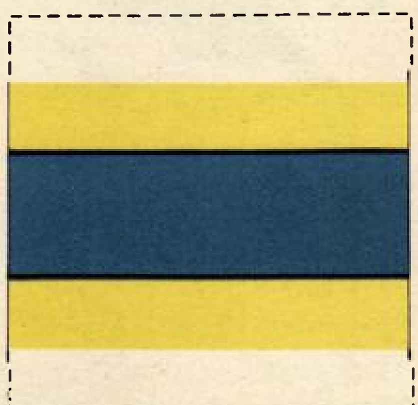
Need Medical Attention



OK to Land, Arrow Shows Landing Direction



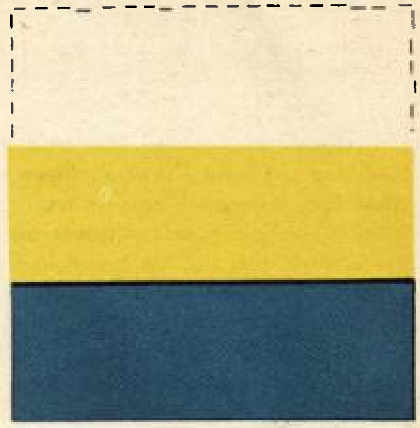
Do Not Attempt Landing



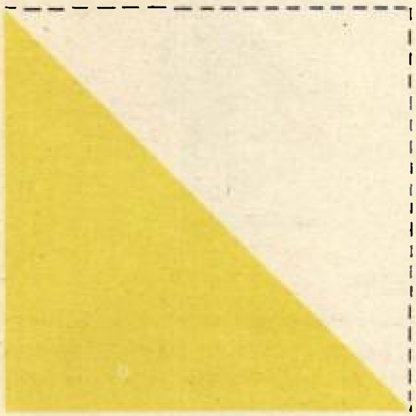
Indicate Direction of Nearest Civilization

Need First-Aid Supplies

Need Quinine or Atabrine

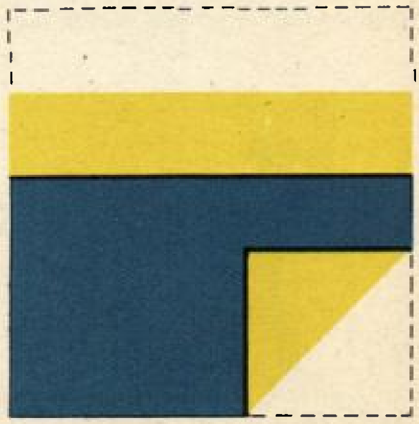


Should We Wait For Rescue Plane?

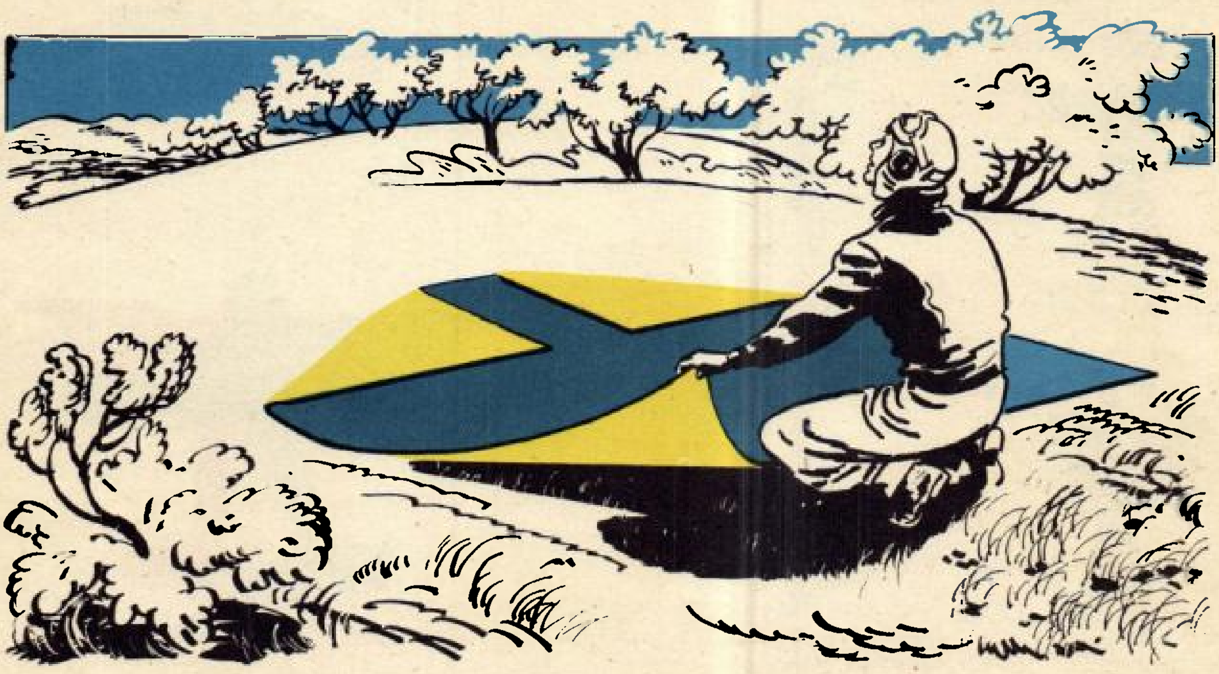


Need Food and Water

Need Warm Clothing



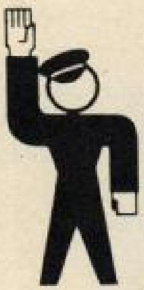
Have Abandoned Plane, Walking in This Direction ➡



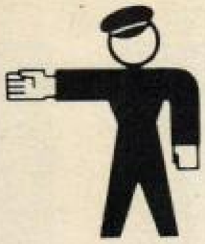
Body Signals

If a rescue plane flies low and circles your location and you are sure that you have attracted the pilot's attention, messages can be transmitted by the emergency body signals shown on this page. When performing the signals stand in the open, make sure that the background as it will be seen from the plane is not confusing, make the motions deliberately and slowly, and repeat each signal until the pilot indicates that he understands.

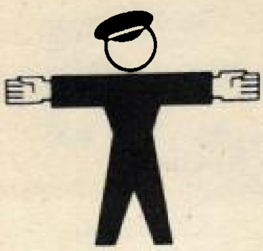
NEED MEDICAL ASSISTANCE—URGENT (Lie prone)



ALL O K
DO NOT WAIT



CAN PROCEED SHORTLY—
WAIT IF PRACTICABLE



NEED MECHANICAL HELP
OR PARTS—LONG DELAY

PICK US UP—
PLANE ABANDONED

DO NOT ATTEMPT
TO LAND HERE

LAND HERE (Point in
Direction of Landing)

OUR RECEIVER
IS OPERATING

USE DROP
MESSAGE

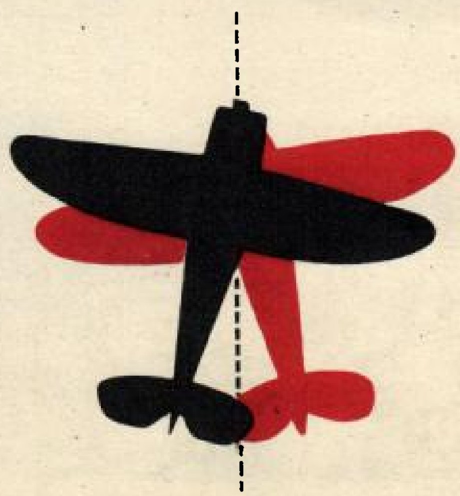
AFFIRMATIVE (Yes)

NEGATIVE (No)

HOW PLANE ANSWERS

The pilot of the rescue plane will answer your messages either by dropping a note or by dipping the nose of his plane for the affirmative (yes) and fishtailing his plane for the negative (no).

AFFIRMATIVE (Yes) DIP NOSE OF PLANE



NEGATIVE (No) FISHTAIL PLANE

VEST TYPE EMERGENCY KIT

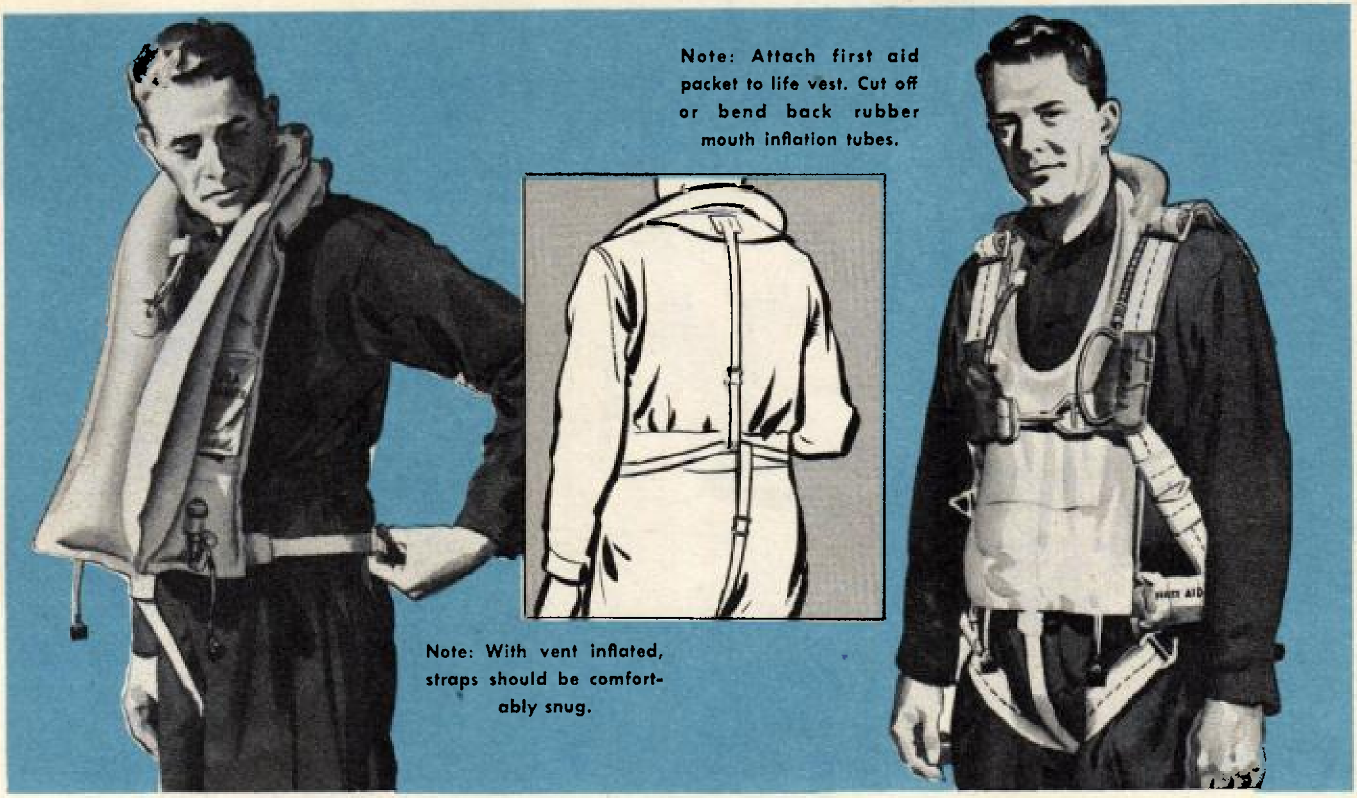
The following items of equipment are carried in the pockets of the vest:

- 1 hat (yellow on one side, OD on the other)
- 1 pair polaroid sun goggles
- 1 signal mirror, with lanyard
- 1 sharpening stone
- 1 fishing-sewing kit, in plastic container
- 1 collapsible spit and gaff
- 1 plastic water canteen (3-pint capacity)
- 1 Boy Scout knife
- 1 large knife (with 5-inch saw and blade)
- 1 package toilet tissue
- 10 yds bandage (with sulfa powder)
- 1 waterproof match-box with compass
- 20 matches
- 14 fire starting tabs
- 1 burning glass
- 1 signal whistle
- 1 oil container
- 1 waterproof cover for .45 cal. pistol
- 20 .45 cal. shot cartridges
- 1 First Aid Kit
- 1 Survival manual
- 2 vest-kit rations in tin containers
- 2 five-minute signal flares
- 1 mosquito headnet
- 1 collapsible container for boiling water
- 1 pair woolen insert gloves
- 1 pair leather outer gloves

Vest, Emergency Sustenance, Type C-1 was developed for the use of flyers forced down in isolated regions. It consists of an adjustable vest-like garment, fitted with pockets into which the items of the kit are conveniently stowed. The vest is to be worn under the life preserver vest and parachute.

PROTECT YOURSELF Before taking off on a flight over inaccessible or mountainous country, the Arctic, jungle, desert, or ocean, check your vest and be sure it contains all the necessary equipment. If it does not, check with your Personal Equipment Officer.

LIFE PRESERVER VEST



Wear your life vest whenever you fly over water.

When the vest is issued to you, put it on, inflate it by the mouth tubes. Adjust the straps. **With the vest inflated the waist strap should be tight, the crotch and back straps snug. After adjusting the back strap hand tack it to the waist strap.** Deflate the vest by opening the valves at the base of the mouth tubes. Roll the vest up to deflate completely. Be sure to close the valves tightly to prevent leak on automatic inflation. Wear the vest over the clothing and **under the parachute harness.** Tuck the vest under the collar of your flight jacket.

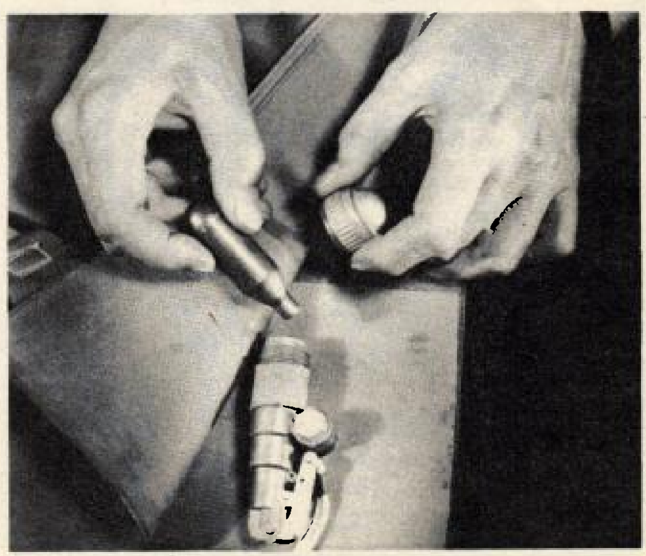
To inflate, pull one cord at a time so that if the mouth valves have been left open you will discover the error before you have discharged both CO_2 cartridges. One compartment will support you and will interfere less with swimming.

If the vest leaks, or fails to inflate completely from the CO_2 cartridge, fill by blowing into the mouth tubes. Open the valves while filling the vest by mouth, then reclose the valves tightly.

Note: cutting off or bending the mouth tubes flush with the retaining loop will prevent possible injury to your eye at the time your parachute opens.

Before each flight remove the cap from the inflator cylinder and inspect the CO_2 cartridge. If the seal at the tip is punctured replace the cartridge. With the lever which actuates the puncturing pin in the up position, parallel to the container, insert the new cartridge, seal end down. Always check the cap to be sure it is screwed down tightly.

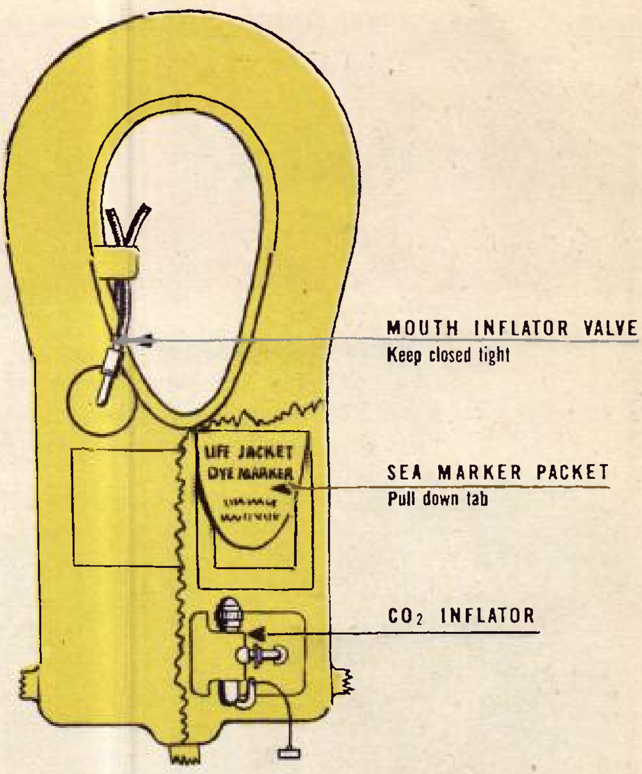
REFERENCES: Technical Order 13-1-3 and Technical Order 13-1-17.



Inserting CO_2 inflator. Screw cap down tight.

Sea Marker Packet

A sea marker packet is cemented to the life vest. When friendly airplanes approach, release the packet by pulling down on the tab. The dye will form a large green area lasting three to four hours. This will help airplanes to find you.



Caution

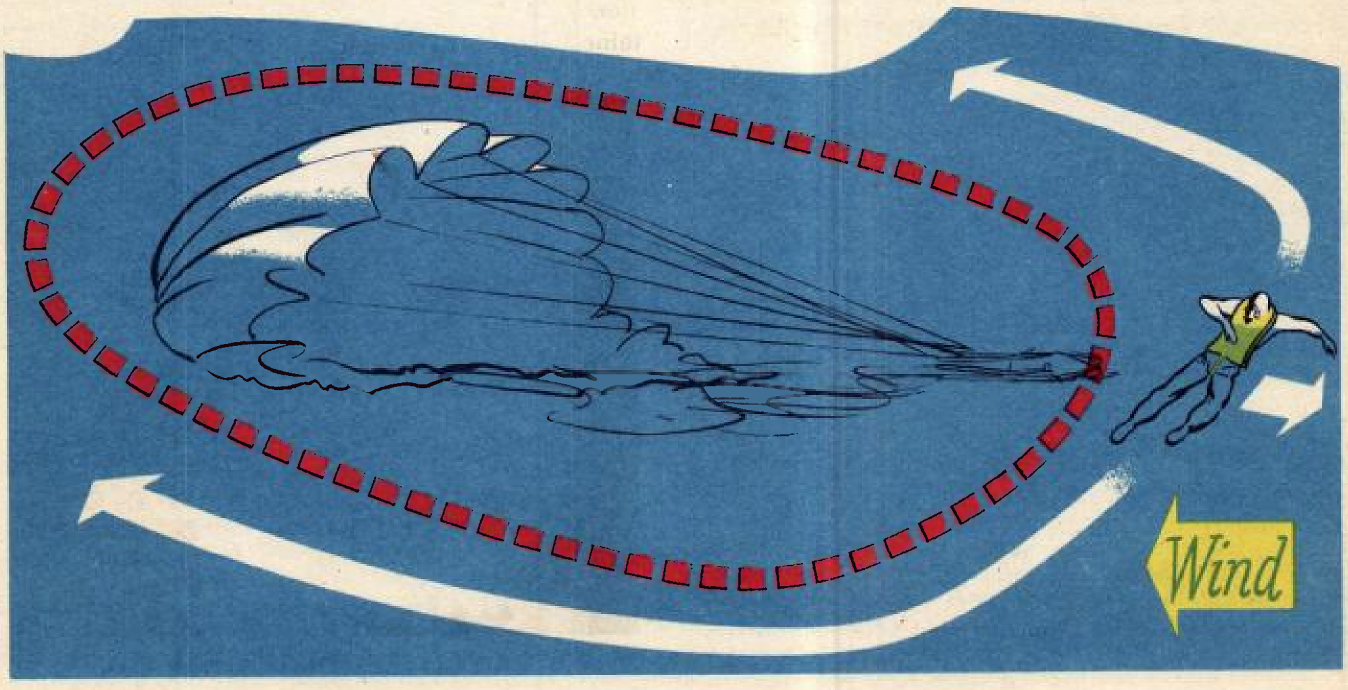
Before takeoff be sure your life vest cartridge containers are loaded with five CO_2 cartridges, **and that the container caps are screwed down tightly.** (See illustration.)

Always make certain that the mouth inflator valves are tightly closed before pulling the inflating cords.

Turn in your life vest for inspection every six months.

WARNING: STAY AWAY FROM YOUR CHUTE IN THE WATER

After parachuting into water you will have a tendency to drift downwind into the fallen parachute as soon as you inflate your life vest. To avoid entanglement with harness and shroud lines, work upwind, away from the chute, and stay clear. If you have a raft, salvage your parachute for sail, cover, and extra lines. If not, get away from the chute and stay away.



SWIMMING THROUGH FIRE

When an airplane is ditched at sea there is always the possibility that a smashed wing tank and engine will spread flaming oil and gasoline on the water. By using the following procedure, however, you can swim to safety through such a fire, even when you wear a life vest.

1. Jump feet first upwind of your airplane. Cover your eyes, nose and mouth with both hands. Take a deep breath. Hold breath until you rise to the surface.

2. Just before you reach the surface, make a breathing hole in the flames. Swing your arms overhead to splash flames away from head, face, and arms.

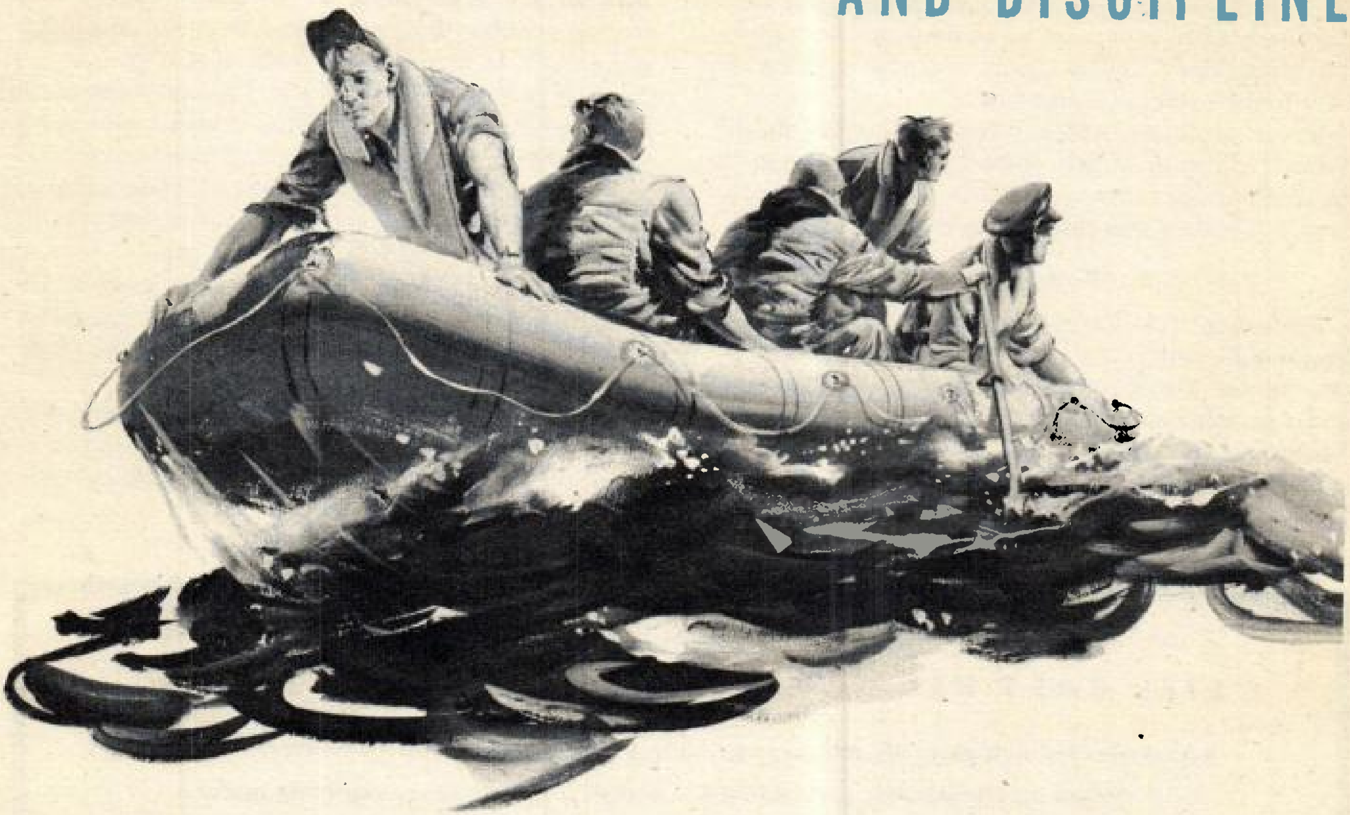
3. Swim into the wind. Use the breast stroke. Before taking each stroke splash water ahead and to the sides. Keep mouth and nose close to the water. Duck your head every third or fourth stroke to keep it cool. If there are several men, swim single file. Let the strongest swimmer splash a path so the rest can follow safely in his wake.

Swimming Under Water

If the heat is too intense or flames too high, swim underwater —out of the danger area. To do this:

1. Splash flames away from body.
2. Hold head near water level.
3. Deflate life vest by releasing valves.
4. Take a deep breath but do not inhale fumes.
5. Sink beneath the surface, feet first.
6. Swim upwind as far as possible.
7. Splash away the flames as you come to the surface. Take a deep breath and submerge again. Repeat procedure until you are beyond the fire.
8. Re-inflate life vest by mouth.

LIFE RAFT KITS AND DISCIPLINE



Equipment

Learn the use of life raft equipment now. Don't wait until you really need it. Ask your Personal Equipment Officer to demonstrate its use, and make the most of crew drills.

The parachute is a valuable item of equipment in a life raft. If possible, take at least one out of your plane when abandoning it. The parachute will float for about 5 minutes when packed. Parts of the canopy can be used for bandages, sunshade, or as a sea anchor. The shroud lines can be used for fastening and in rigging the sunshade.

If there are two or more rafts, connect them with line provided, to keep them from becoming separated. Fasten the kit and all loose gear to the raft with tight but easily untied knots.

Get the emergency radio into operation as soon as weather permits. Instructions are on the set. Keep all signaling equipment where you can get at it quickly. Keep flares, Very pistol, and cartridges as dry as possible. Use a flare only when a ship or plane is near. Fire the pistol almost vertically for maximum height and ahead of the plane so that the shot will be within the visibility range of the pilot.

Use the tarpaulin, yellow side up for a signal, blue side up for camouflage from the enemy.

Keep the sea anchor out. It will head you into the wind or check your drift.

Water and Food

Before any over-water flight, drink all the water you can. Don't run the possible risk of starting your raft expedition thirsty. The pilot is in charge of water rationing. Uninjured survivors should drink no water the first day. Each person should then drink a pint a day until the supply is exhausted. But don't give up even then. With care and good luck you can still survive for several days, even without water. Be prepared to trap rain water.

To cut down on your water requirements:

Rest as much as possible.

Expose your body to the breeze as much as possible, but protect against sunburn.

Shade your body without cutting off the breeze.

Keep clothing wet with sea water during the day, but not to the point of chilling.

If it rains, collect rainwater in the tarpaulin or sail after first rinsing off the salt. Then drink your fill slowly over the course of an hour or more. Store the remainder in all available containers. Then return to the ration of a pint a day.

Never drink sea water, urine, or compass fluid.

Don't eat flesh of fish, turtles, or birds, except in small quantities, unless you have a good water supply. If it makes you thirsty don't eat it at all.

Protection

Protection from the sun is vital in the tropics. By keeping shaded you will prevent sunburn and cut your water loss through perspiration. Rig the oars and tarpaulin as a canopy and stay in the shade. Your face, neck, arms, and legs are most liable to sunburn. Wrap exposed parts of the body with a piece of parachute, bandage, handkerchief, or a strip of underwear. Wet yourself, clothing and all, with sea water, but keep the water out of your mouth.

Continued exposure to sea water in the raft may result in a condition called **immersion foot.** When this occurs the legs and feet become swollen, sore, and numb, and blisters may form. You can help prevent immersion foot by keeping your feet as dry as possible and by moving them to encourage circulation. If they become swollen, don't rub them; this will only make them worse. Instead, cover them with the ointment in the First Aid kit and wrap them loosely with bandage or a strip of parachute.

Cover burns and skin irritations with the ointment and a light bandage. Don't prick or squeeze boils; bandage them instead.

You may go several days without a bowel movement. This is not harmful and is to be expected. Never take a salt water enema or a laxative. They increase your water loss.

Establish a watch routine if more than one man is aboard. Someone should always be on the alert.

Tie all injured persons to the raft, and as many others as your rope will allow.

LIFE RAFT KIT

Accessories for multiplace life rafts are carried in a kit and include the following items:

- Signal kit (Pyrotechnic projector and 6 flares).
- Emergency drinking water, 7 cans. Don't open before flight or water will spoil. Save cans for storing rain water.
- Sea marker, 3 cans. When you see a plane, pour a can of marker on the water and stir it with an oar. Do this quickly.
- Life raft rations, 7 cans.
- Flashlight, hand energized.
- Knife, floating, cemented to raft.
- Police whistle, to attract attention.
- First aid kit.
- Fishing kit. Don't let hooks puncture raft.
- Paulin for use as a sail.
- Paulin for signal, shade, camouflage, and catching rain water.
- Sun protective ointment, 4 tubes.
- Emergency signaling mirror.
- Wrist compass.
- Religious booklets.
- Water containers, 4.
- Cellulose sponge.
- Aluminum oars, 3.
- Hand pump and hose.
- Repair kit.
- Bailing bucket. Use it also for urinating; don't stand in raft.
- Repair plugs, 4.
- Ocean charts.
- Gatty's Raft Book.
- Survival booklet.
- Twine, 40 feet. Tie loose equipment to life raft.
- Sea anchor.

WARNING! **Be sure life raft is completely deflated before storing it away in the airplane. Use deflating pump. Air or carbon dioxide left in the life raft expands at altitude.**

One man LIFE RAFT

Raft lanyard goes *under* harness and clips to life vest ring.

Pre-Flight

The one-man life raft is stowed in a seat pack attached to the parachute harness. It is inflated after the jumper strikes the water.

When you put on parachute and life raft pack, **clip the lead strap from the raft to the ring of the life vest waist strap under the harness.** Otherwise you will lose the raft pack when you get out of the harness.

Before flight unsnap the pack cover far enough to expose the CO_2 cylinder. Test the locking pin.

In the Water

Pull open pack cover. Pull locking pin out of valve handle and open valve to inflate. Enter raft from small end by grasping hand straps and pulling.

Aboard the Raft

Keep your life vest on.

Top off inflation by blowing in the rubber mouth tube. Tighten valve after inflating.

Keep the CO_2 cylinder on the valve. The valve might leak if exposed.

Keep the lead strap from raft clipped to yourself.

Fasten down everything aboard.

The raft contains sea marker, sea anchor, bailing bucket, bullet-hole plugs, blue and yellow cloth, first-aid kit, repair kit, paddles, and water. The water may be replaced by a chemical sea water purification kit in some rafts.

To inflate raft pull out locking pin and open valve slowly.

Board raft from small end by pulling it under you.

Fire Fighting

IN FLIGHT

Use all extinguishers applicable and always aim at the base of the fire.

Keep your parachute away from the fire. Put it on as soon as possible.

Give the pilot a heading and an ETA for the nearest landing field. Inform him of any terrain obstructions in your flight path. If you are losing altitude, be sure your heading will circumnavigate these obstructions.

Give the radio operator your exact position, direction in which you are heading, and an ETA for the field. Be sure that he makes every attempt to get this message through.

Move to your proper position for bailout only when a crash seems imminent. At all other times, keep navigating. As long as the airplane is in the air you must know your exact location.

Engine Fires

At the first sign of a fire, if conditions permit, the pilot will take all necessary action to control it from the cockpit. His actions will depend upon the type of equipment he has.

In any engine fire your only duty is to stand by and transmit the necessary information to the pilot and radio man.

Fuel Tank and Amphibian Hull Fires

1. Give the pilot a heading to the nearest airfield.
2. Give the radio man your position and an ETA for the field.
3. Locate the source of the fire.
4. Inform the pilot.
5. If fire is accessible, use hand equipment in addition to the built-in equipment.
6. Continue navigating.

Cabin Fires

1. Give pilot and radio man the necessary information.
2. Close windows and all openings.
3. Locate source of fire.
4. Use all extinguishers available. (Open windows as soon as the flames are extinguished.)
5. Continue navigating.

Flare Fires

If flares in the racks ignite, release the flares at once. Pry them loose if they stick in the racks.

Other Fires

The pilot will attempt to extinguish wing fires or drop tank fires by slipping the airplane away from the fire or dropping the tanks.

Your only duty is to give the pilot and radio man the proper information and continue to navigate.

In case of fire, don't open emergency hatches or bomb bay doors in the air, except for bailout. External fires may be drawn into the cabin. Drafts will cause cabin fires to flare up.

Open emergency hatches just before landing if fire makes a crash landing necessary, to permit escape or rescue.

ON THE GROUND

Always have a member of the ground or air crew stand by with adequate, portable fire extinguishing equipment while the engines are being started.

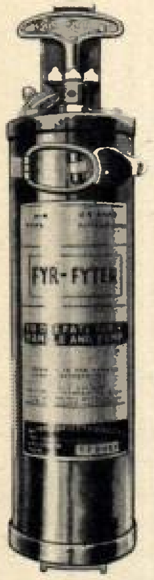
Starting an engine is a critical fire moment. Backfiring sometimes ignites excess priming fuel in the induction system. Fires spread rapidly.

In case of fire while starting engines:

1. Help crew use portable fire fighting equipment.
2. **Notify tower to rush crash equipment.**
3. See that all crew members clear the airplane.
4. Remove all of your equipment, such as sextant and astrocompass.

Fire Fighting Equipment in Airplanes

LEARN THE LOCATION AND PROPER USE OF FIRE EXTINGUISHING EQUIPMENT INSTALLED IN YOUR AIRPLANE.



"Fyr Fyter", hand-type fire extinguishers, having a carbon tetrachloride base, are found in most airplanes. Use this extinguisher primarily for fighting fires in the cockpit or cabin. It is unsuitable for extinguishing fires outside the fuselage during flight.

Aim at the base of the fire, remembering that your supply is limited and must be used effectively. The "Fyr Fyter" extinguisher in your plane has enough fluid to last for about one minute of continuous use. Its effective range is approximately 20 feet.

"CO_2", hand-type fire extinguishers, using carbon dioxide, also are found in large airplanes. Use this extinguisher for fighting fires inside the airplane.

The CO_2 extinguisher has an effective range of only 3 feet. The charge will last only 15 to 30 seconds, according to size of the unit. So aim at the base of the fire and move in close, on the upwind side. **Then pull the trigger release, directing the CO_2 straight at the base of the fire.** Move the discharge nozzle slowly across the flame area.

AIM AT BASE OF FIRE

Know the location of all extinguishers, their limitations, and how to use them.

AIM BEFORE PULLING TRIGGER

Both of these extinguishers are effective in combating fuel, electrical, and wood or fabric fires. CO_2 is rapid, clean, and easy to use. However, because of the small quantity in the cartridge, it might not be final in action.

Built-in CO_2 (carbon dioxide) systems are installed in some types of airplanes, so that engines, hulls of amphibians, gasoline tank compartments, or even cargo sections may be flooded with carbon dioxide gas in case of fire. First, set the extinguisher selector valve to direct the CO_2 charge to the desired location. Then pull the release handle. The operating controls are marked clearly to indicate their method of use.

Precautions

Stand back, but within effective range, when using the "Fyr Fyter", carbon tetrachloride extinguisher. Open windows and ventilators after fire is extinguished. **The fumes generated are poisonous.** See a doctor as soon as you land if you have inhaled excessive amounts of the gas or have swallowed even a small quantity of the liquid.

Don't touch any portion of the discharge nozzle of the CO_2 extinguisher. The extremely cold temperature of the carbon dioxide may cause severe burns.

CREW FIRE DISCIPLINE

Be sure that your air and ground crews are instructed in fire fighting procedures and methods of fire prevention.

RELEASE DROP TANKS BEFORE A WHEELS-UP LANDING

KIT, FIRST-AID, AERONAUTIC

Installed in Military Aircraft

Medical Supply Catalog No. 97765

SEAL: Not to be broken except in case of an actual wound or injury.

EXTERNAL POCKET: Contains iodine and adhesive compresses for minor injuries.

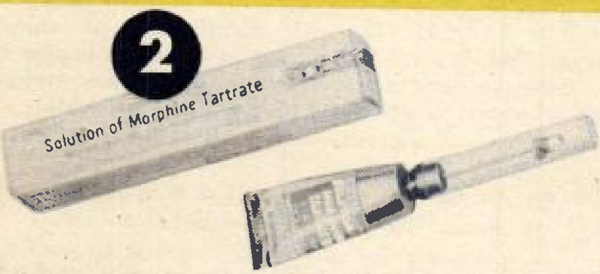
1. In the case of a wound, first stop the flow of blood. The clothing should be cut away and a compress or wound dressing applied after the sulfanilamide powder has been sprinkled into the wound. If a firmly applied dressing will not cause the bleeding to stop, or if there is actual spurting of blood from an artery, the tourniquet should be applied. A tourniquet must be released every twenty minutes and removed as soon as hemorrhage stops.
2. To relieve severe pain open the small cardboard container and follow directions given there in the use of the hypodermic syrettes of morphine. Do not hesitate to use the hypodermic to relieve suffering.
3. In case of head injury have the man lie quietly with head slightly elevated.
4. In the event of marked blood loss with shock and/or unconsciousness have the man lie horizontally or lie with the head down, if possible.
5. An adequate supply of oxygen is doubly important in case of serious injury. Use it generously.

CONTENTS

1. Tourniquet, (1)
2. Morphine syrette (2)
3. Wound dressing, small, (3)
4. Scissors, (1 pair)
5. Sulfanilamide crystals, envelope, (1)
6. Sulfadiazine tablets, (1 box of 12 tablets)
7. Burn ointment, (1 tube) (Boric or 5% Sulfadiazine)
8. Eye dressing set
9. Halazone tablets
10. 1" Adhesive compresses (1 box) (Contents of small outer pocket)
11. Iodine swabs (10) (Contents of small outer pocket)

NOTICE: Drugs Contained in This Kit are Potent and Must Be Used Correctly. Follow Directions!

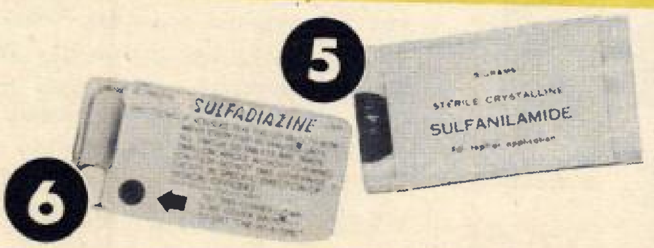
TOURNIQUET: To be used to stop flow of blood but use only if blood flow cannot be stopped with a wound dressing. *Caution:* Release tourniquet every 15-20 minutes and remove as soon as hemorrhage is controlled. (See NIF 7-15)



MORPHINE SYRETTE: To be used to relieve pain and should be employed without hesitation to prevent suffering. *Directions for use:* Remove transparent hood, grasp wire loop and push wire in to pierce inner seal, turning if necessary. Pull out and discard wire, thrust needle through skin at least half its length and inject solution by slowly squeezing the syrette from the sealed end. In extreme cold, warm syrette by holding under clothing next to skin.

WOUND DRESSINGS: Apply dressing with firm pressure into the wound and tie securely.

SCISSORS: Do not hesitate to cut away clothing and flying garments from the wound so that the dressing may be applied without hindrance.



SULFANILAMIDE POWDER: Sprinkle on the wound to prevent infection.

SULFADIAZINE TABLETS: To be taken internally if wounded. *Directions for use:* Take two tablets with water every five minutes until all twelve tablets are taken. Swallow whole without chewing.

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BURN OINTMENT: To be used on skin surface for all burns from any cause. *Directions:* Apply ointment liberally and without friction to all burned surfaces.

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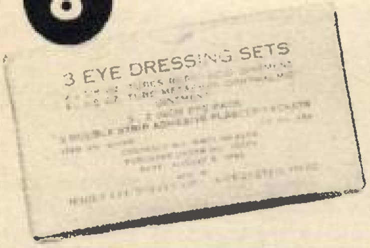

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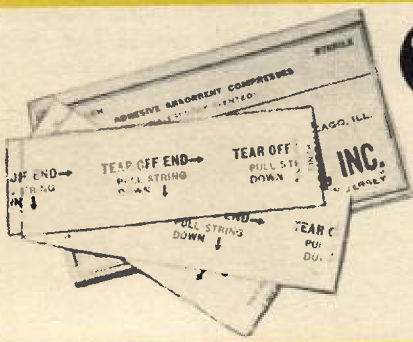
EYE DRESSING SET: Use for burns of the eye. Apply Metaphen ophthalmic ointment directly to the eyeball. Then apply the boric acid ointment to the inner surface of the eyelid. Cover the eye with a dressing and secure in place with adhesive strips.

HALAZONE TABLETS: For the disinfection of water. *Directions:* Add one tablet to a canteen full or a pint of water. After tablet dissolves wait 30 minutes before drinking. If water is greatly polluted use two tablets.



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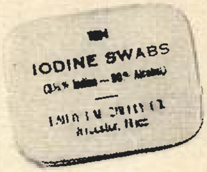
EXTERNAL KIT POCKET: Contains iodine swabs and adhesive dressings for minor injuries. Do not use iodine in serious wounds. (Use sulfanilamide powder.)



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KIT, FIRST-AID, FOR PNEUMATIC LIFE RAFT

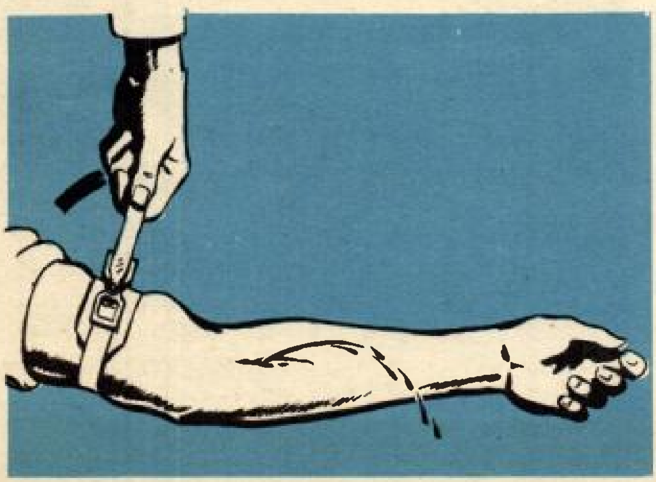
Medical Supply Catalogue No. 97769

This is a part of the life raft kit. (See PIF No. 8-11.) Contains morphine syrettes, bandage compresses, sulfanilamide powder, sulfadiazine tablets and burn ointment as illustrated in photos Nos. 2, 3, 5, 6, and 7.

PACKET, FIRST-AID, PARACHUTE

Medical Supply Catalogue No. 97785

To be attached to the parachute harness or Mae West life vest for constant availability. Should be carried in Gun Turrets and other cramped spaces where the larger Kit, First-Aid, Aeronautic, is not accessible. Contains tourniquet, morphine and wound dressing as illustrated in photos Nos. 1, 2, and 3. Packet can be opened by tearing either end of the outer container at the notch.



Your airplane is a good first-aid station. You have the Kit, First-Aid, Aeronautic, and the Packet, First-Aid, Parachute. Oxygen, is frequently available. Splints, or splint materials, are at hand. Hot drinks are often carried in thermos jugs. In certain bombers you will be provided with blood plasma. Familiarize yourself thoroughly with the first-aid supplies which you carry, and get clearly in mind just what you can do with them.

Wounds and Injuries

Wounds and injuries involve one or more of these problems: **pain, cuts, bleeding, broken bones, burns, frostbite, shock, and unconsciousness. Generally you** will have to deal with combinations of these, such as cuts which are bleeding, burns that cause pain, broken bones associated with cuts or burns, and so on. Shock usually comes on after a good deal of blood has been lost either inside the body (where you may not be able to see it), or on the outside. Shock also accompanies deep or extensive burns. Unconsciousness may be produced by a head injury, may follow shock, or may occur as a result of failure to get enough oxygen.

In giving first-aid, try to size up the general situation accurately. Then attend to the most serious problems first. Above all, use common sense.

Cuts and Bleeding

1. Expose wound by cutting nearby clothing with scissors.
2. Cover cuts with sterile dressings and apply firm pressure.
3. If this does not stop the bleeding, elevate the bleeding part.
4. If these measures fail to stop bleeding in arms or legs, apply a tourniquet in the middle of the upper arm or middle of the thigh. The tourniquet must be released every 15 minutes for at least a few seconds, depending upon the amount of bleeding.

Tourniquet (Warning)

A tourniquet must be removed, or temporarily released, every 15 minutes. **Failure to release the tourniquet often enough or long enough to provide an adequate circulation to the blocked portion of the arm or leg may necessitate amputation later.**

Pain

Use morphine at once for severe pain. This makes it possible for the patient to lie quietly, preventing aggravation of the injuries. Do not use more than one tube (½ grain) of morphine at any one time.

When giving morphine, mark down the time and dose on the patient's forehead or clothing with a pencil. Remember that an excess of morphine can be fatal. Do not give morphine to a person who is unconscious, who has a head injury, or who is breathing less than 12 times per minute.

To Give Morphine

1. Paint any small area of skin with iodine.
2. Remove the transparent cover from the morphine syrette.
3. **Push in the wire loop to puncture the inner seal;** then pull the wire out.
4. Thrust the needle through the skin, using care not to press morphine out of the tube while doing so.
5. Squeeze the tube slowly to inject the morphine.

Give Morphine:

1. To stop pain.
2. To decrease shock.
3. To facilitate moving the patient.

Don't Give Morphine:

1. To an unconscious person.
2. To a person with a head injury.
3. To a person who is breathing less than 12 times per minute.

Shock

You can tell when a patient is in shock by the total picture he presents rather than by any single sign. Usually he will have:

1. Lost considerable blood, or
2. Suffered severe burns, or
3. Been subjected to intense pain, or
4. Received a head injury.

His skin is pale, cold, clammy, or moist.

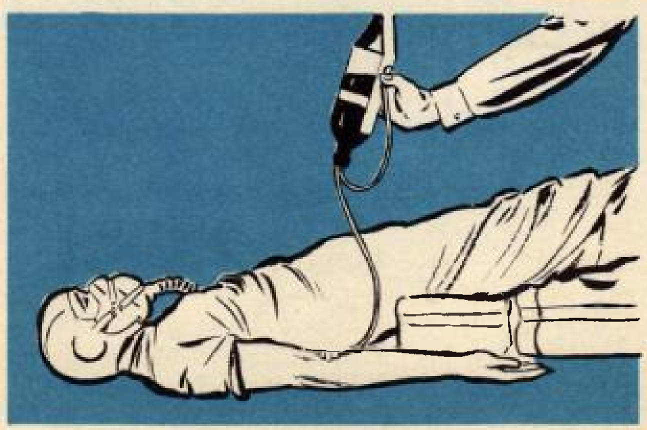
His breathing is shallow, and may be irregular.

His pulse is weak, rapid, thready, and often difficult to find.

Sometimes there is nausea and vomiting.

Treat shock by doing the following things as promptly as possible:

1. Stop any obvious bleeding.
2. Give pure oxygen to breathe. (Automix "OFF.")
3. Give morphine. (Exception: Head injury.)
4. Keep the patient warm with blankets, extra clothing, or a sleeping bag, but avoid excessive heat.
5. Loosen any tight clothing.
6. Place the patient with his head slightly lower



than his feet, to promote better circulation to the brain.

7. Inject plasma, when it is available, in accordance with the directions on the plasma package.

Fractures

1. If a broken bone is associated with a cut, sprinkle with sulfa powder and cover with a sterile dressing. If the dressing is firmly bound in place it will almost always stop the bleeding.

2. Give morphine.

3. Apply a temporary splint to the part, using wood, strips of metal, heavy cardboard, or any convenient pieces of equipment such as a machine-gun barrel or fire ax.

4. **Do not attempt to set the bone. Manipulation causes shock.**

Burns

For minor burns:

Squeeze burn ointment onto a sterile dressing. Then cover the burn gently with the dressing.

For severe burns:

1. Give morphine.

2. Treat shock. (Oxygen; plasma, if available.)

3. Apply burn ointment on sterile dressings, **and bind the dressings gently but firmly in place.**

4. Never open blisters resulting from burns.

For eye burns

Apply Metaphen ophthalmic ointment directly to the eyeball. Then apply the boric acid ointment to the inner surface of the eyelid. Cover the eye with a dressing and secure in place with adhesive strips, provided the skin around the eye is not burned. Do not touch the eye with your fingers, and do not rub it—either before or after the ointment has been applied.

Transportation of Wounded

If it becomes necessary to move an injured crew member improvise a litter with 2 poles and a pair of flying jackets. Turn the sleeves inside out and insert the poles through them. Then close the jacket over the outside of the poles. Additional support can be obtained by using boards or cardboard splints inside the jackets. Litters can also be improvised with poles and blankets. Take great care to be as gentle as possible in moving an injured person onto a litter. Keep his body as flat as possible at all times. Have 3 or more persons move and support him by placing their arms under his legs, buttocks, back, shoulders, and head.

Unconsciousness and Near-Unconsciousness

Oxygen lack, carbon monoxide poisoning, and head injury are important causes. Immediate treatment is vital, especially if breathing has stopped.

1. Give artificial respiration:

First, lay the patient face down with one arm bent at the elbow, his face resting on his hand, and his other arm extended beyond his head.

Second, open his mouth and remove all foreign substances such as false teeth and chewing gum. If his tongue has fallen back into his mouth, grasp it with your fingers and pull it well forward.

Third, give him pure oxygen. (Automix "OFF.") **If the patient has stopped breathing, turn on the emergency flow.**

Fourth, kneel astride the patient's thighs with your knees about even with his. Place the palms of your hands against the small of the patient's back, with your little finger over the lowest rib.

Fifth, with your arms stiff, swing your body forward slowly so that your weight is applied over the patient's back. This should take about 3 seconds.

Sixth, release your hands with a sudden snap and swing backward to remove all pressure from the patient. After about 2 seconds repeat the cycle.

Continue giving artificial respiration without stopping for 2 hours or longer, unless the person to whom it is being given begins to breathe normally.

2. Keep the patient warm.
3. Do not give morphine.

Frostbite

1. Fingers, toes, ears, cheeks, chin, and nose are the parts most frequently affected.
2. Numbness, stiffness, and whitish discoloration are the first symptoms.
3. Wrinkle your face to find out if it is numb; watch for blanched faces of your crew mates.
4. If frostbite occurs, warm the affected part gradually. Never rub or attempt to thaw it rapidly.
5. If blisters develop, do not open them. (See HEAT AND COLD, NIF 4-6-3.)

Failure of Oxygen Supply

If a crew member's oxygen supply fails above 10,000 feet, make every effort to replace his equipment or give him an emergency supply. If this is not practicable, descend to 10,000 feet as fast as safe operation permits. Loss of oxygen above 20,000 feet is critical, but there is no need for panic. **Get oxygen, or get down.**

Wound Disinfectants

1. Sprinkle Sulfa powder in open wounds.
2. Use iodine only for small cuts and scratches, which should not be covered by a dressing.
3. Never put iodine on or into large or deep wounds.

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