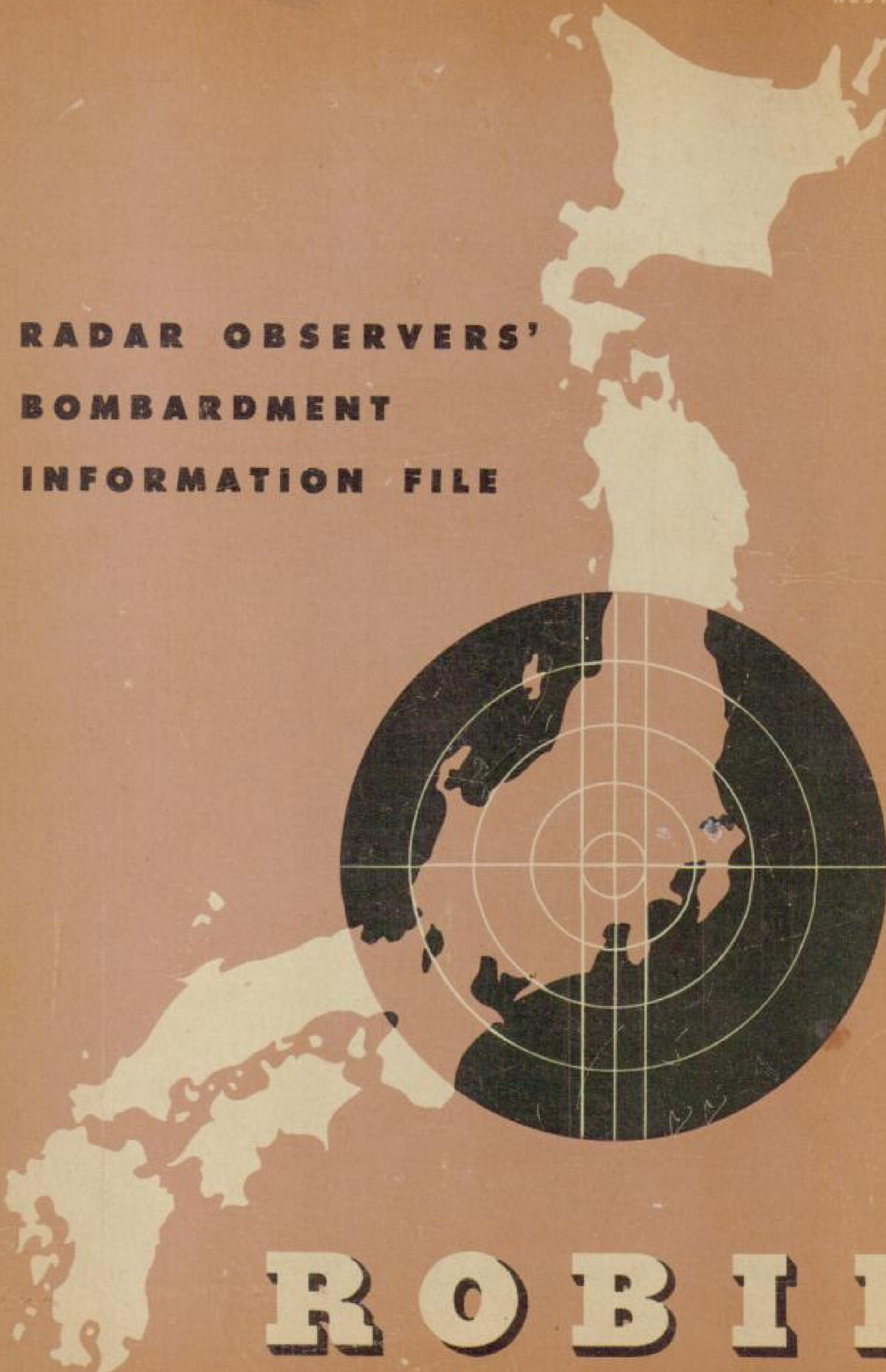
RESTRICTED

RADAR OBSERVERS' BOMBARDMENT INFORMATION FILE



ROBIF

THIS COPY OF ROBIF BELONGS TO . . .

[redacted]

NAME	RANK	SERIAL NO.	ORGANIZATION

IT CONTAINS THE REVISIONS LISTED BELOW

REVISION NO.	DATE OF REVISION	DATE FORM 24ZA CERTIFIED

AS YOU REVISE YOUR ROBIF WRITE REVISION NUMBERS AND DATES IN THE SPACES PROVIDED ABOVE

Table of Contents... DATED JULY 1945

IN accordance with the provisions of AAF Regulation 62-15, dated 24 November, 1944 and AAF Regulation 62-15A, dated 16 May, 1945, all AAF radar observers (bombardment) in the United States will certify that they have read and that they understand all instructions and information contained in the Radar Observers' (Bombardment) 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 ROBIF and its Table of Contents. The Table will be revised quarterly and distributed on the same basis as the Radar Observers' (Bombardment) Information File.

RADAR OBSERVERS' (BOMBARDMENT) INFORMATION FILE

Authority for ROBIF-AAF Regs. 62-15 and 62-15A ★ Table of Contents-AAF Form 24Z

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

I CERTIFY THAT I HAVE READ AND UNDERSTAND ALL SUBJECTS IN THE RADAR OBSERVERS' (BOMBARDMENT) INFORMATION FILE LISTED IN FORM 24Z, DATED JULY 1945.

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

SIGNED ____________________

RANK ____________________ ASN ____________________

CREW NO. ____________________ DATE ____________________

ORGANIZATION ____________________

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

HOW TO USE ROBIF

Your ROBIF Responsibility

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

1. Sign the receipt portion of Form 24ZA (which is always enclosed as the first sheet of every revision). Hand this receipt at once to the operations office where you receive the revision.
2. Read the directions on the envelope which contains the revision.
3. **Remove from your ROBIF 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. That way 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 ROBIF.
6. When you have done all of the above, **and not until you have done it all properly**, sign the compliance section of Form 24ZA 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 listed you have violated regulations and are subject to disciplinary action.

The duties outlined here require perhaps 2 hours a month. If you shirk or neglect these duties your ROBIF cannot be useful to you. It must be currently correct or you cannot add new revisions properly.

Radar Observers' (Bombardment) Information File is your book. It was designed to save you many hours of work. If it were not for ROBIF, 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.

General

The Radar Observers' (Bombardment) Information File is a manual of instructions and information of a general nature with which all AAF radar observers (bombardment) in continental United States are required to comply, in accordance with the provisions of AAF Regulations 62-15, and 62-15A.

ROBIF is designed to keep you informed promptly and conveniently of developments affecting techniques, instruments, and equipment. Check frequently to be sure you have read and understand the information it contains. ROBIF does not attempt, however, to provide specific engineering, maintenance, and supply information contained in T.O.'s.

What Page Numbers Mean

Each page in ROBIF is designated by 3 numbers. The **first number** indicates the section. For example, 7, which is Radar Intelligence. The **second number** refers you to the subject. For example, 7-3, Radar Reconnaissance. The **third number** lists the page. Thus, the second page of Radar Reconnaissance is marked 7-3-2.

Revisions

ROBIF will be revised from time to time as new information becomes available. These revisions will be issued as pages properly numbered to correspond to the present ROBIF numbering system. You will put the revised pages in their proper places in your copy of ROBIF.

To make the process as simple as possible you will receive revisions in an envelope upon which is printed a list of the pages you are to remove from your copy of ROBIF and replace with revised pages.

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

Often a whole subject will be revised completely and the revised pages may number more or less than the pages they replace. In such a case all the pages will 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 will find in the envelope a temporary certificate of compliance (Form 24ZA).

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

You will find that often only minor changes have been made on some pages. There is no special indication to show what sentences or paragraphs have been revised. It is felt that you should re-read the whole page in order to get the context of the old material in relation to the new.

Distribution of Revisions

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

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 Bldg.,
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 Officers will also report promptly on the activation or deactivation of any station.

Table of Contents (Form 24Z)

Every 3 months you will receive a new Table of Contents in the envelope with the latest revision. In order that you may identify it and be sure that you have the current table in your ROBIF, the following color key is used:

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

Check your copy of ROBIF against the Table of Contents regularly.

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

After the first revision 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.**

Don't Destroy Table of Contents

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 Officers' Responsibilities

1. Each Operations Officer is responsible that every radar observer attached to his base receives a copy of ROBIF and all revisions.

2. That every radar observer on his base signs a compliance form certifying that he has read and understands all material contained in ROBIF and revisions.

3. That the compliance certificates (Form 24ZA and Form 24Z) are placed in the Form 5 files of the individuals concerned.

When radar observers turn in their Forms 24Z at the end of the three-months period for which the forms are the current tables of contents for ROBIF, the Operations Officer will see that previously dated Forms 24Z and 24ZA in the Form 5 files are removed and destroyed.

WANTED: YOUR CRITICISMS OF ROBIF

We call your attention to AAF Regulation 62-15, which directs all AAF establishments to submit, to the address given at the right, items they desire to have included. This also means any criticism of material already in ROBIF—corrections, questions of interpretation, and mistakes.

Our aim is to keep ROBIF accurate, current, and fully useful. If you can help us do that, we will appreciate it. Write direct to:

Office of Flying Safety,
Information Files Branch, Buhl Bldg.,
Detroit 26, Michigan

AAF REGULATIONS)
No. 62-15 and No. 62-15A)
EXTRACT)

HEADQUARTERS, ARMY AIR FORCES
WASHINGTON, 14 MAY 1945

FLYING SAFETY

Information Files

AAF Regulation 62-15, 24 November 1944, is amended as follows:

1. **General.** To promote safe flying and operational efficiency, AAF pilots, navigators, bombardiers, radar observers (bombardment), 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, 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, nontechnical form in loose-leaf books, to be designated as follows:

* * * * * *

e. For radar observers (bombardment): "The Radar Observers' (Bombardment) Information File" (ROBIF).

* * * * * *

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.

a. **Publication of ROBIF.** The above provisions will apply to the preparation and publication of the Radar Observers' (Bombardment) Information File.

* * * * * *

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 table of contents is outlined in AAF Regulation 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:

* * * * * *

e. ROBIF: Through base operations officers, one copy to each radar observer (bombardment). Two copies to each command, group, and squadron to which radar observers (bombardment) are assigned. Copies to AAF schools and training establishments as required for the radar observers' (bombardment) training program, and such additional copies as the Chief, Safety Education Division, Office of Flying Safety, will determine as necessary. (**Note:** ROBIF will not be available for distribution to regularly maintained AAF files or individuals other than those designated in this paragraph.)

6. **Distribution in Overseas Theaters.** If commanding officers in overseas theaters and "alerted" areas so direct, PIF, NIF, BIF, ROIF, ROBIF, and revisions thereto will be procured by requisition to the Director, Air Technical Service Command, Wright Field, Dayton, Ohio, through the Publications Distribution Center of the air force service command in the theater of operations 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:

* * * * *

f. For Radar Observers (Bombardment): Form 24Z (the ROBIF Table of Contents) will be signed and used as a permanent record of compliance. When ROBIF and revisions are distributed, they will be accompanied by compliance forms (AAF Form 24ZA) which will provide temporary record of compliance. The use of AAF Forms 24Z and 24ZA is set forth in AAF Regulation 15-24.

* * * * * *

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 Regulation 15-24.

* * * * * *

11. **Definitions:**

* * * * * *

i. The term "radar observer (bombardment)" will be construed to mean any individual who holds a currently effective military aeronautical rating of aircraft observer (radar) and/or has any of the following primary MOS's or is in duty assignment in any of the following specialties: Radar Observer (Bombardment), 0142; Navigator-Bombardier, Radar, 1038, 1037; Bombardier, Radar, 1030, 1031.

By command of General ARNOLD:

OFFICIAL SEAL

HQ AAF

IRA C. EAKER

Lieutenant General, United States Army
Deputy Commander, Army Air Forces

AAF REGULATION)
No. 15-24)
EXTRACT)

HEADQUARTERS, ARMY AIR FORCES
WASHINGTON, 16 MAY 1945

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
AAF Form 24Z —ROBIF Table of Contents
AAF Form 24ZA—Temporary Compliance Certificate for ROBIF

(This Regulation supersedes AAF Regulation 15-24, 23 November 1944.)

TABLES OF CONTENTS OF INFORMATION FILES

1. * * * * * *

AAF Form 24Z is the table of contents for the Radar Observers' (Bombardment) 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 Regulation 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, 24R, or 24Z (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, 24R, or 24Z), 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, 24R, or 24Z) 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 Regulation 62-15, the Chief, Office of Flying Safety, will revise and publish AAF Form 24, 24N, 24B, 24R, and 24Z 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 24Z: Issue of 1 July (any year)—Red
Issue of 1 October (any year)—Gray
Issue of 1 January (any year)—Blue
Issue of 1 April (any year)—Yellow

3. **Distribution.** AAF Form 24, 24N, 24B, 24R, or 24Z 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 24Z: ROBIF 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, 24R, and 24Z 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:

Form 24ZA for Radar Observers' (Bombardment) 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 subparagraph a. below, and a main upper section, the use of which is described in subparagraph 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, 24RA, or 24ZA) 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 officer of the recipient's home station.

b. The main (upper) section of Form 24A, 24NA, 24BA, 24RA, and 24ZA 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. An individual concerned will sign this portion of the 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, 24RA, or 24ZA) 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 Form 24A, 24NA, 24BA, 24RA, or 24ZA) 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, 24R, or 24Z, whichever applies) and turned it in, when all previously dated compliance certificates (Form 24A, 24NA, 24BA, 24RA, or 24ZA) and the previous table of contents will be removed and destroyed. Compliance certificates for personnel for whom Form 5 files are maintained will be retained for record as directed by commanding officers.

6. **Distribution.** AAF Forms 24A, 24NA, 24BA, 24RA, and 24ZA 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, 24R, and 24Z become obsolete and will be destroyed six months after the date of issue.

b. Forms 24A, 24NA, 24BA, 24RA, and 24ZA 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

SECTION 1

GENERAL

The use of extremely short waves makes it possible to confine transmitted radar energy to a narrow beam. An object in the path of this beam reflects energy back to the radar set as mountain walls and buildings echo sound. Range and direction to the reflecting object then may be determined easily.

1

SUBJECTS IN SECTION 1

GENERAL

The subjects in this section of your book are of practical value but largely general in their application. The rest of ROBIF contains more specific discussion of the equipment and operational procedures you use during your tour of duty. Don't consider the procedures to be SOP's. Use them as a guide to the most successful use of your equipment.

ROBIF combines the best ideas from Army Air Forces training schools with techniques and procedures gleaned from extensive combat experience. It covers, necessarily, only the equipment which is classified Restricted. New equipment and modifications of old equipment which are currently classified Confidential or Secret will be discussed in subsequent revisions as soon as they are down-classified. Watch for your ROBIF revisions!

RADAR OBSERVER'S *Responsibility*

BEFORE FLIGHT, THE RADAR OBSERVER SHALL:

PLAN

- Distances
- Headings
- Altitudes
- Control Times
- Check Points
- Alternate Destinations
- IP and Target Approaches
- Landfall Approaches

WEATHER

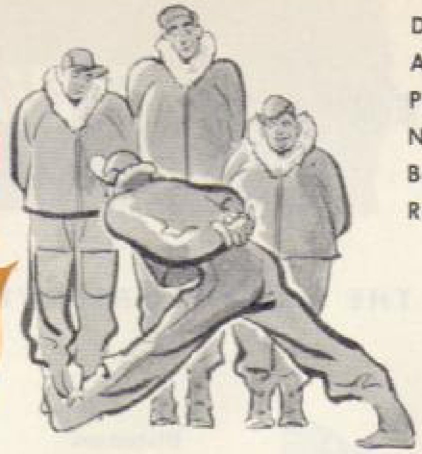
- Obtain Forecast Winds
- Obtain Forecast Fronts

EQUIPMENT

- Flight Plan
- Logs
- Navigation and Target Charts
- Target Folders
- Instruments and Tools
- Watches
- Tables for Navigation and Bombing
- Make Preflight Check of Radar Equipment

CREW

ASSURE HIMSELF THAT CREW KNOWS WHAT TO EXPECT OF HIM AND WHAT HE EXPECTS OF THEM



Discuss Mission
Agree on Coordination with
- Pilot
- Navigator
- Bombardier
- Rest of Crew

DURING FLIGHT THE RADAR OBSERVER SHALL:

1. Check radar set against radar altimeter, flux gate compass.
2. Check flight instruments against pilot's, engineer's, bombardier's.
3. Keep check on plane's position, whenever possible.
4. Keep up log book.
5. Furnish navigation data to other crew members on request.
6. Ask for navigation data from other crew members when necessary.
7. Obtain winds every 30 minutes, or oftener if possible.
8. Take scope photos of unusual returns as directed.
9. Calculate ETA's for all check points and turning points.
10. Assume control of airplane upon approach to IP and as directed by theater SOP.

UPON LANDING THE RADAR OBSERVER SHALL:

1. Fill out all reports and forms.
2. Analyze the completed mission for:
   - Improper planning
   - Errors made
   - New situations
   - Instrument errors
   - Crew coordination
3. Report to the Radar Intelligence Officer:
   - Intelligence data
   - Pictures taken
   - Criticisms and suggestions

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 help he can give both in preparing for and carrying out 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. By acting upon those suggestions you may make your navigation and bombing easier and more accurate.

IDEAL TEAMWORK

Here are suggested ways in which you and your fellow crew members may cooperate to achieve peak efficiency on missions:

PILOT

Uses proper technique of flying during wind runs, bombing runs, and fix-taking.

Notifies you of any intended deviations from a prescribed course, altitude, or speed.

YOU GIVE HIM: Necessary navigational data.

You are his eyes in fog or overcast.

COPILOT

Same as pilot.

NAVIGATOR

Checks your navigation, ETA's, winds, etc.

Takes over your navigation while you perform maintenance.

Operates your allied equipment, such as flux gate compass, SCR-718 altimeter.

YOU GIVE HIM: Checks on his navigation, such as fixes, landfalls, etc.

BOMBARDIER

Operates the bomb racks, fuzes, bomb-bay doors, etc.

Computes altitudes, groundspeeds, etc.

Takes vertical photos for you.

Operates bombsight in coordinated runs.

Operates affiliated radar equipment such as APQ-5B.

YOU GIVE HIM: Navigational data.

Locate the target for him in bad visibility.

Stand by for him in case of bombsight malfunction.

RADIO OPERATOR

Helps you with maintenance.

ENGINEER

Helps you in calibrating instruments.

Performs maintenance for you.

Operates main electrical power controls.

GUNNERS

Do your fighting for you.

Help with minor maintenance.

Security Measures

DESTROYING ABANDONED EQUIPMENT

In case it should become necessary to prevent the capture of your radar equipment or the likelihood of any part of it falling into hostile hands, **destroy it so that no part of it can be salvaged, recognized, or used by the enemy.**

Means of Destruction

1. Burning by means of incendiary grenades, or by igniting gasoline, oil, paper, or wood.
2. Explosives.
3. Hammers, axes, sledges, machetes, or any heavy object.
4. Gun fire or shell fire.
5. Bury all debris or dispose of it in streams or other bodies of water, where possible.

How to Proceed

1. If time is limited, destroy the radar equipment in the following order:

   Modulator, transmitter converter, and antenna assembly.
   Range unit.
   Receiver-indicator.
   Control box and computer.
   Junction boxes.
   Torque amplifier.
   Inverter and all cables.
   Allied equipment.
2. Obliterate all identifying marks. Destroy nameplates and circuit labels.
3. Demolish all panels, castings, and switchboards.
4. Destroy all controls, switches, relays, connections, and meters.
5. Rip out all wiring and cut interconnections of electrical equipment.
6. Smash every electrical or mechanical part, whether rotating, moving, or fixed.
7. Break up all operating instruments, such as keys, microphones, etc.
8. Destroy all carrying cases, straps, containers, and so forth.
9. Bury, submerge, or scatter all debris.

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. 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-way 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 as if it were 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, inspection must 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:

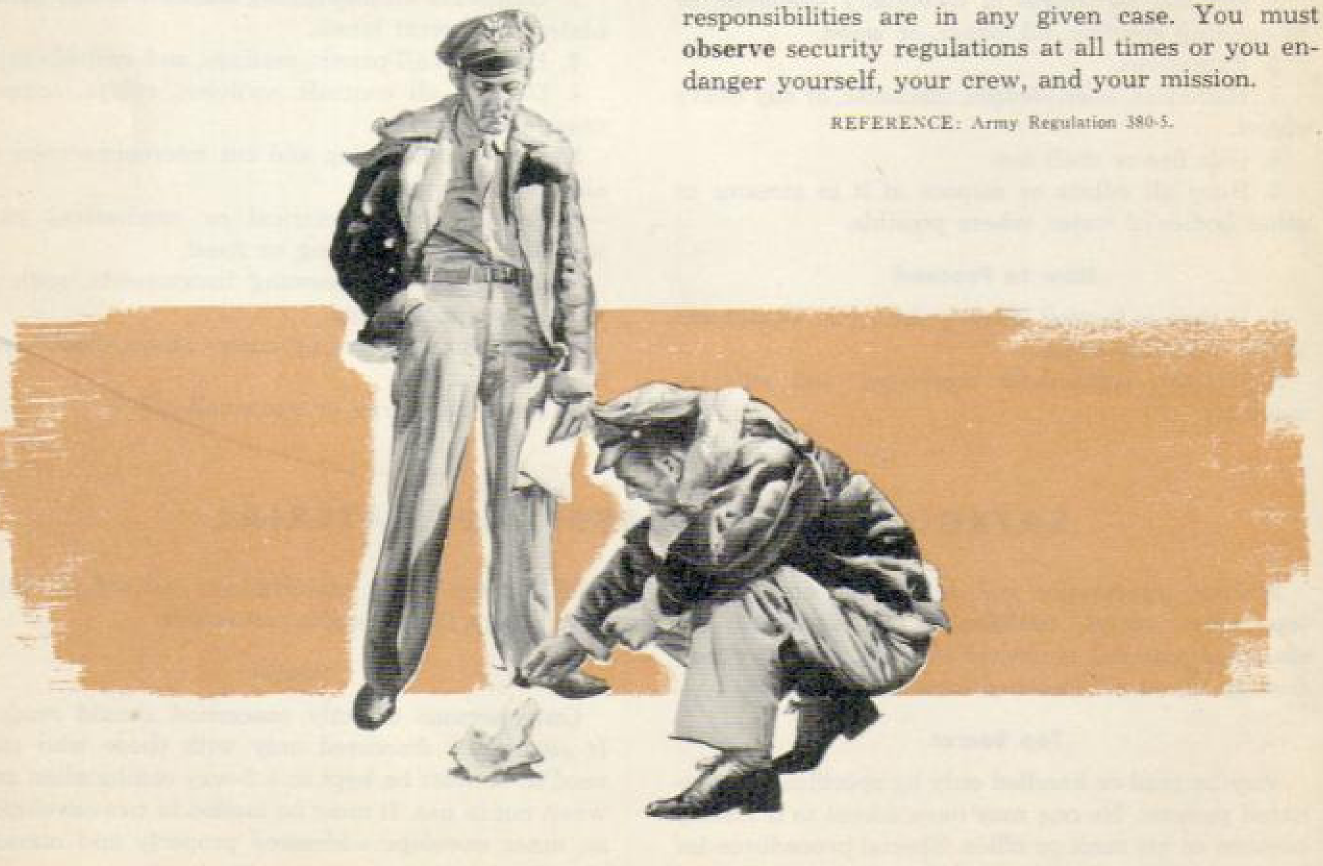
When you land at an Army Air Field, either post an armed guard or remove the equipment and place it in a locked safe or vault.

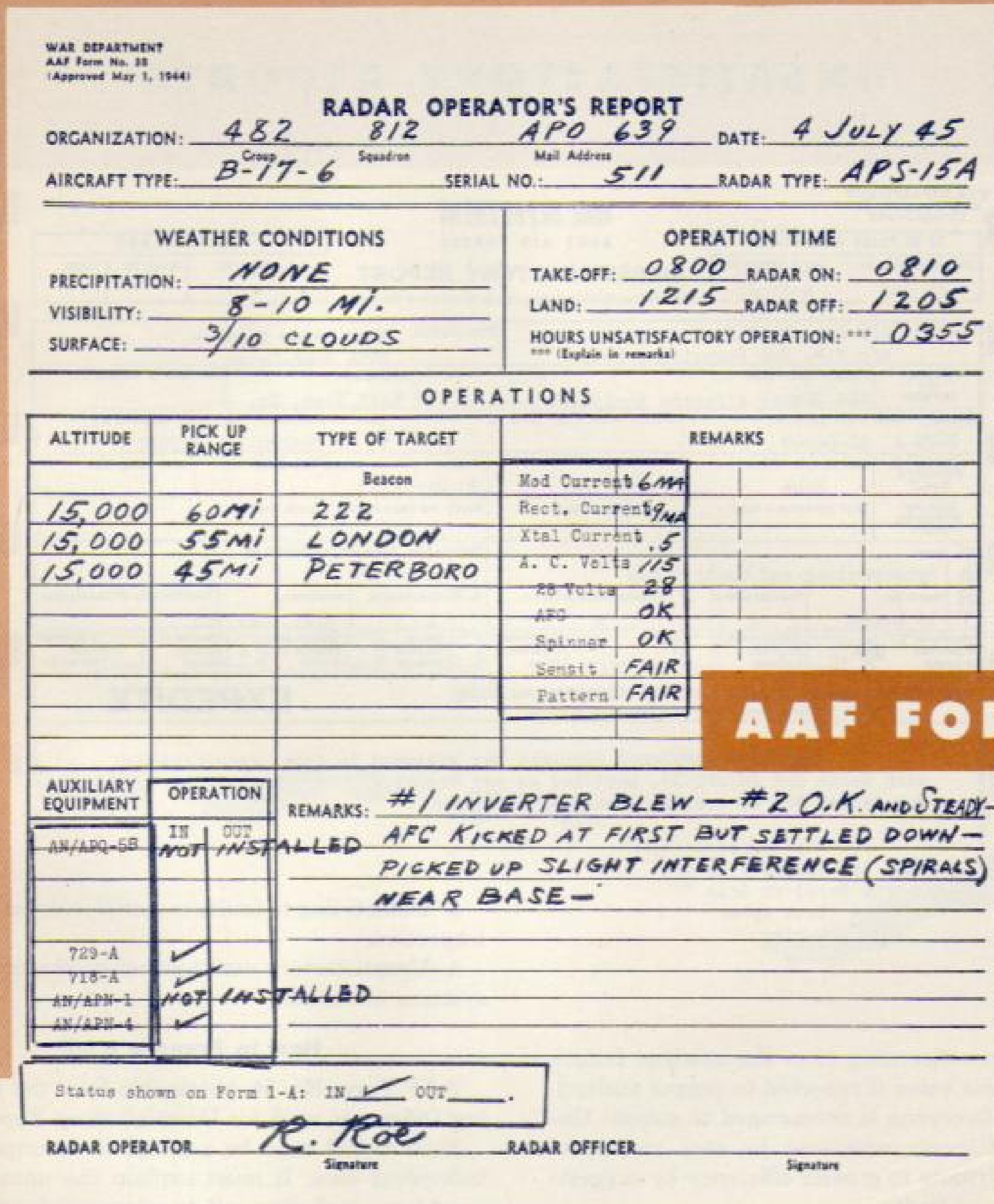
When you land at any other field, be sure that an armed guard is assigned to your airplane continuously. **Locking the airplane is not a substitute for a guard.**

When you are forced down in or near enemy-held territory, follow the procedure outlined under Destroying Abandoned Equipment.

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 endanger yourself, your crew, and your mission.

REFERENCE: Army Regulation 380-5.





WAR DEPARTMENT
AAF Form No. 38
(Approved May 1, 1944)

RADAR OPERATOR'S REPORT

ORGANIZATION: 482 (Group) 812 (Squadron) APO 639 (Mail Address) DATE: 4 JULY 45

AIRCRAFT TYPE: B-17-6 SERIAL NO.: 511 RADAR TYPE: APS-15A

WEATHER CONDITIONS		OPERATION TIME	
PRECIPITATION:	NONE	TAKE-OFF: 0800	RADAR ON: 0810
VISIBILITY:	8-10 MI.	LAND: 1215	RADAR OFF: 1205
SURFACE:	3/10 CLOUDS	HOURS UNSATISFACTORY OPERATION:*** 0355	

*** (Explain in remarks)

OPERATIONS

ALTITUDE	PICK UP RANGE	TYPE OF TARGET	REMARKS	
		Beacon	Mod Current	6MA
15,000	60MI	222	Rect. Current	9MA
15,000	55MI	LONDON	Xtal Current	.5
15,000	45MI	PETERBORO	A. C. Volts	115
			28 Volts	28
			AFC	OK
			Spinner	OK
			Sensit	FAIR
			Pattern	FAIR

AUXILIARY EQUIPMENT	OPERATION IN	OUT
AN/APQ-5B	NOT INSTALLED	
729-A	✓	
718-A	✓	
AN/APN-1	NOT INSTALLED	
AN/APN-4	✓	

REMARKS: #1 INVERTER BLEW — #2 O.K. AND STEADY — AFC KICKED AT FIRST BUT SETTLED DOWN — PICKED UP SLIGHT INTERFERENCE (SPIRALS) NEAR BASE —

Status shown on Form 1-A: IN ✓ OUT ____.

RADAR OPERATOR R. Roe (Signature) RADAR OFFICER ____ (Signature)

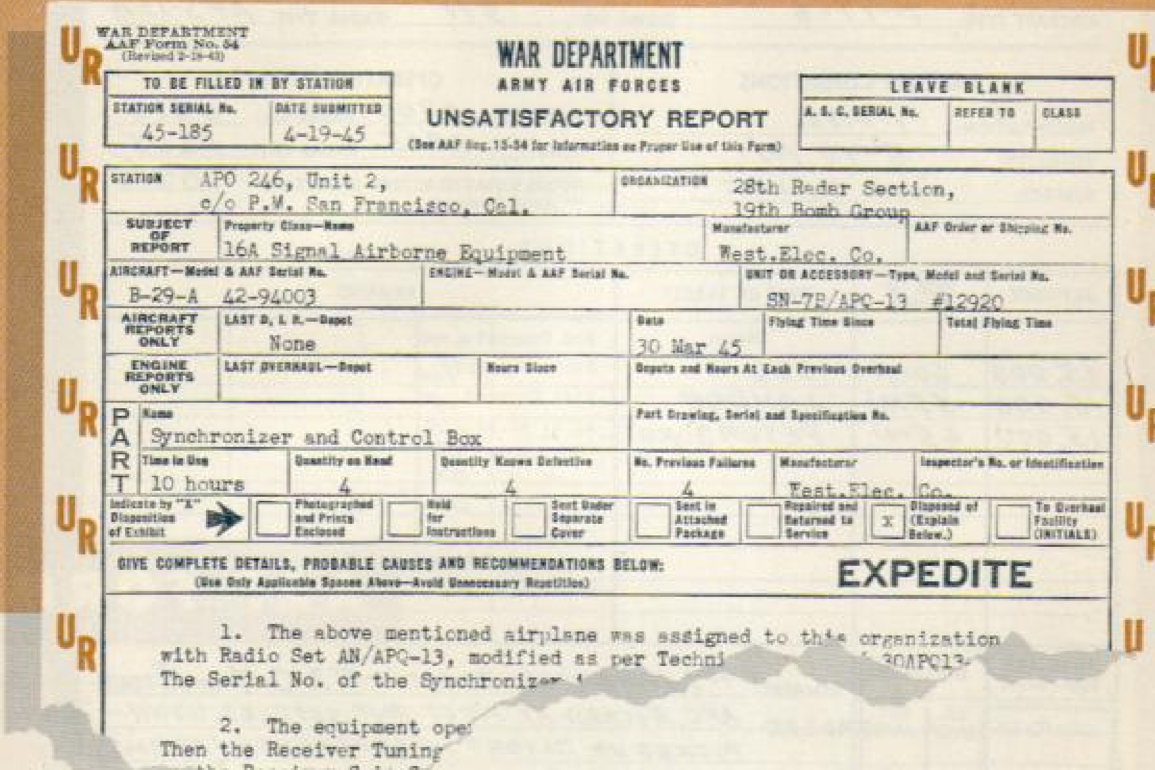
AAF FORM 38

AAF Form 38 is the radar operator's report to the maintenance section on the performance of his equipment. It also gives the next operator an indication of the performance he can expect and tells him whether or not any equipment trouble has been corrected.

Data on the meter readings and operation should be entered on the form near the end of the mission. Don't wait until you are on the ground and fill it out from memory. Fill in each column accurately and, in the REMARKS column, enter all information necessary to describe any trouble.

The Form 38 book is kept in the airplane near your position. At the end of each flight, the maintenance crew reads the report and, after correcting any trouble, enters a report to that effect on the back of the form. All Form 38's that have been filled out are collected at the end of each day and are kept on file in the radar maintenance shop to provide a history of each set.

UNSATISFACTORY REPORTS


WAR DEPARTMENT
AAF Form No. 54
(Revised 2-19-43)

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.: 45-185 — DATE SUBMITTED: 4-19-45

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

STATION: APO 246, Unit 2, c/o P.M. San Francisco, Cal.

ORGANIZATION: 28th Radar Section, 19th Bomb Group

SUBJECT OF REPORT — Property Class—Name: 16A Signal Airborne Equipment — Manufacturer: West.Elec. Co. — AAF Order or Shipping No.:

AIRCRAFT—Model & AAF Serial No.: B-29-A 42-94003 — ENGINE—Model & AAF Serial No.: — UNIT OR ACCESSORY—Type, Model and Serial No.: SN-7B/APQ-13 #12920

AIRCRAFT REPORTS ONLY — LAST D. L. R.—Depot: None — Date: 30 Mar 45 — Flying Time Since: — Total Flying Time:

ENGINE REPORTS ONLY — LAST OVERHAUL—Depot: — Hours Since: — Depots and Hours At Each Previous Overhaul:

PART — Name: Synchronizer and Control Box — Part Drawing, Serial and Specification No.:

Time in Use: 10 hours — Quantity on Hand: 4 — Quantity Known Defective: 4 — No. Previous Failures: 4 — Manufacturer: West.Elec. Co. — Inspector's No. or Identification:

Indicate by "X" Disposition of Exhibit: Photographed and Prints Enclosed; Held for Instructions; Sent Under Separate Cover; Sent in Attached Package; Repaired and Returned to Service; X 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. The above mentioned airplane was assigned to this organization with Radio Set AN/APQ-13, modified as per Techni ... 30APQ13- The Serial No. of the Synchronizer ...

2. The equipment ope... Then the Receiver Tuning ... the Receiver Gain ... first appea... ...ring

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 radar operator, 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.

Unsatisfactory Reports generally concern these four matters:

1. Failure of equipment.
2. Unsatisfactory design.
3. Defects due to faulty material, workmanship, or inspection.
4. Unsatisfactory maintenance or supply methods, systems or forms.

How to Prepare a UR

AAF Form No. 54, obtainable from the Engineering Officer, is used for Unsatisfactory Reports.

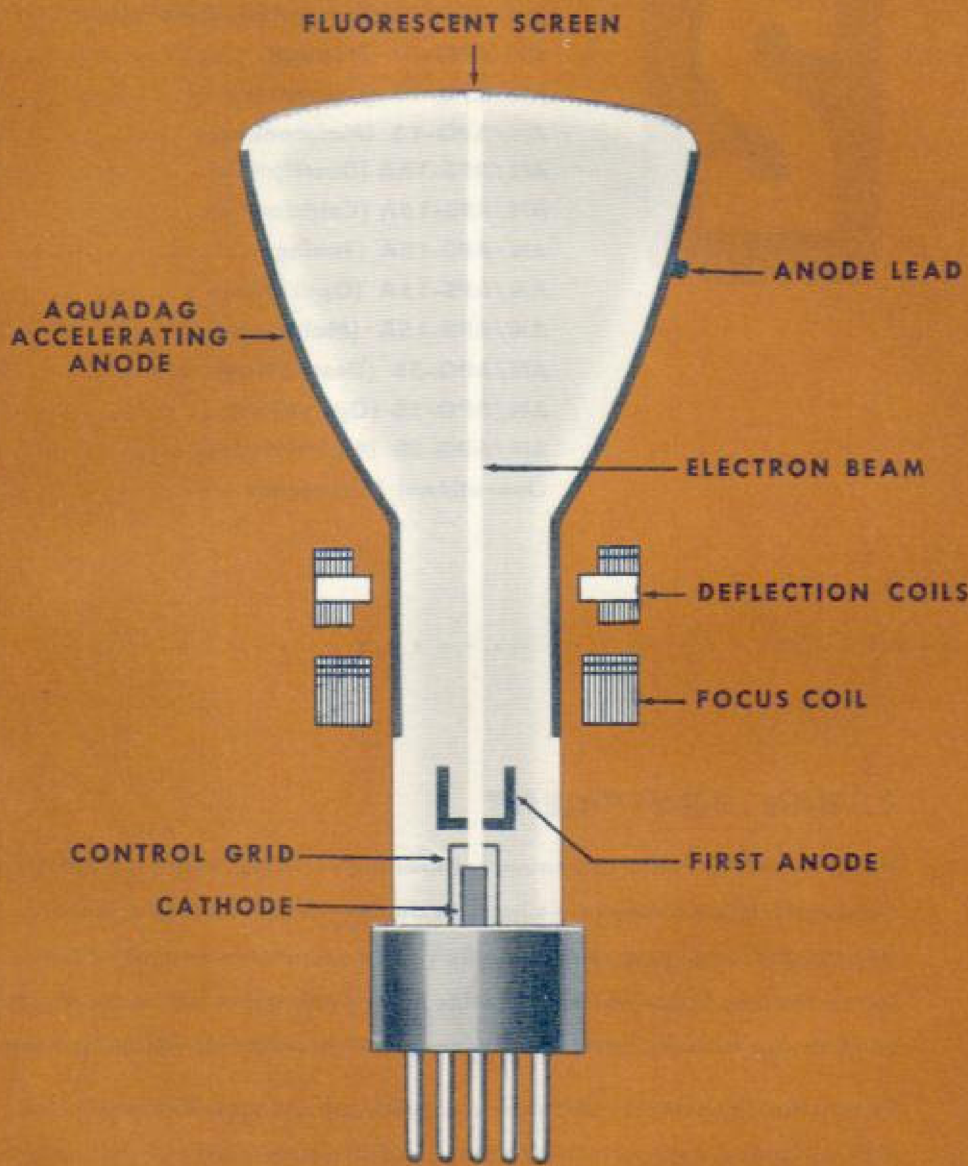
Each report must be a complete description of an individual case. It must explain the unsatisfactory condition, including all pertinent information, to enable investigation and correction of the trouble reported without the need for further requests for information. See AAF Regulation 15-54 for details 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 station Commanding Officer. It is then sent to the Director, Air Technical Service Command, Wright Field, Dayton, Ohio.

SECTION 2

RADAR EQUIPMENT



Radar waves travel about 186,000 miles per second. Because of the extremely short time interval required for the radar wave to travel to the target and return, radar sets use a special measuring device, the cathode ray tube. This tube creates an electronic beam which can be made to travel at any desired speed and is easily controlled.

2

SUBJECTS IN SECTION 2

RADAR EQUIPMENT

Never forget that radar equipment requires high voltages which are potentially dangerous. Use extreme care when you change tubes and fuses or make adjustments inside your set. Ordinarily you do not need to do maintenance. But on the long flights which are routine in Far Eastern theaters, radar observers must be able to make certain tube changes and adjustments within their sets.

Be sure that the power is off before you make any changes. Remember that high voltages are stored in some of the condensers even after you've turned the power off. Never ground yourself by holding on to a metal part with one hand while you reach into the set with the other.

AN/APQ-13 ★ Description

The AN/APQ-13 radar system is designed for high-altitude navigation and bombing through overcast, though it has the additional value of providing highly accurate beacon ranging. The system functions efficiently day and night under temperatures ranging from −40°F (−40°C) to +122°F (+50°C), in relative humidities as high as 90%, and at altitudes up to 35,000 feet above sea level. The total installed weight, including interconnecting cables and mountings for the various units, is approximately 630 pounds.

Basically, the AN/APQ-13 is a combined transmitter-receiver for high-frequency radio pulses. It is designed to operate from an electrical supply of 26-28 volts DC. Its maximum range for reception of ground returns is 100 miles. However, it can receive signals from a radar beacon as far as 300 miles away. (See ROBIF 4-4.)

Function

In brief, the system functions as follows: A train of extremely short but intense pulses of radio-frequency energy is transmitted in a beam from a rotating antenna. An object in the path of the beam reflects some of the energy, and the transmitting antenna intercepts a portion of this reflected energy. The received pulses, or echoes, are detected and amplified on the plan position indicator (PPI scope), where you can determine both the distance to, and bearing of, the object.

The indicating equipment consists of two identical PPI scopes, one for you and the other for the navigator. In these scopes the radial sweeps are synchronized with the transmitter pulse (to determine target range) and the circular sweeps are synchronized with the azimuth of the rotating antenna (to determine target bearing). You read the azimuth or bearing of the target directly from a scale on the scope, marked clockwise from 0° to 360°. Bearings you obtain when you are not using azimuth stabilization are all relative to the position of the intercepter. See ROBIF 4-2 for information on how to read bearings with azimuth stabilization on.

The principal parts of the AN/APQ-13 equipment with which you are concerned are: main control box, indicator, computer box, azimuth control box, synchronizer, range unit, and antenna unit.

Main Control Box

The main control box contains the switches which govern the operation of the system. Two meters indicate the various operating currents and voltages and the elevation tilt of the antenna. The main controls are:

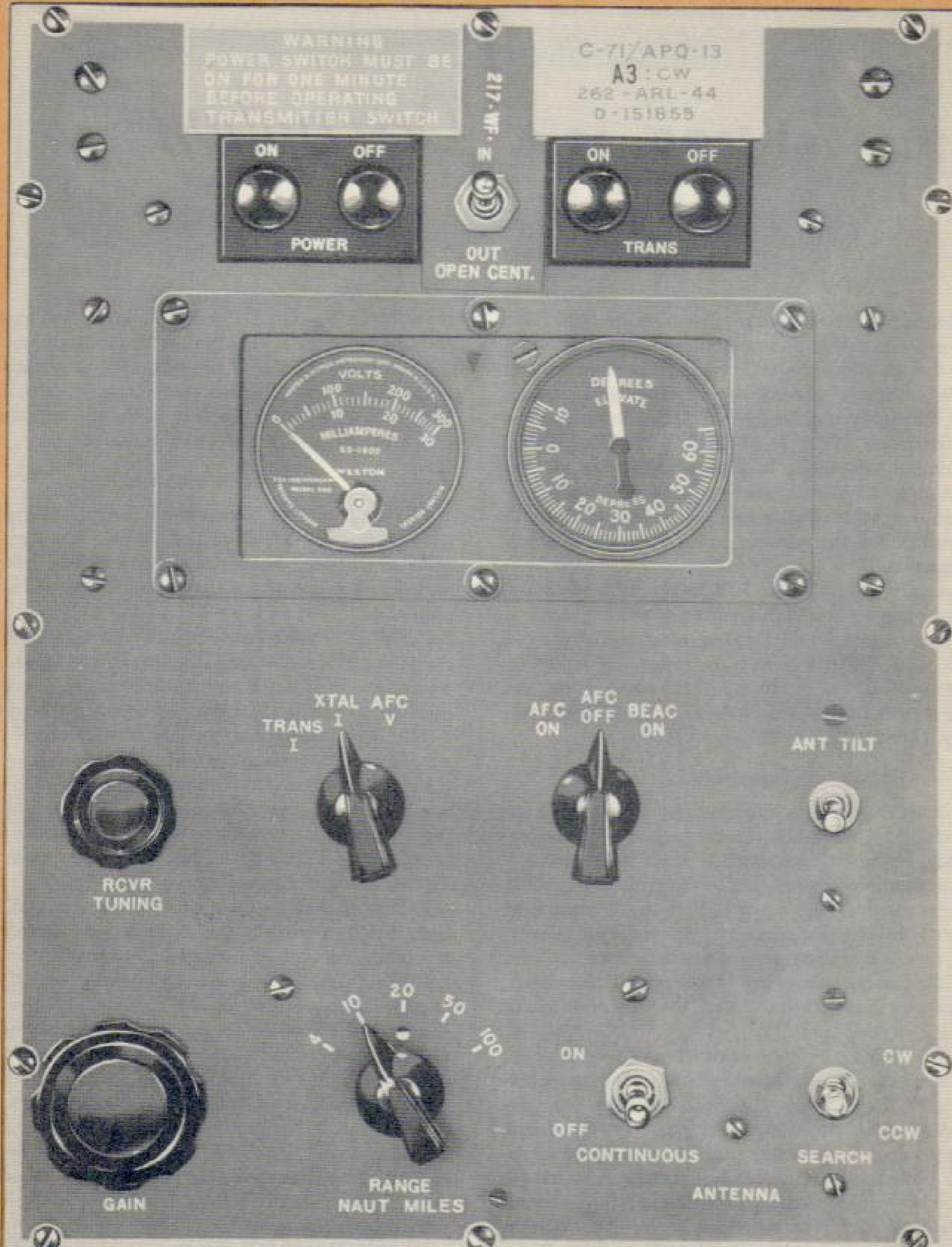
POWER: Pushbutton switch. The ON button starts the inverter which supplies power to all units except the modulator and transmitter; they require high voltage. The OFF button stops the inverter.

TRANS: Pushbutton switch which controls the supply of high-voltage current to the modulator and transmitter units. It is dangerous to apply high voltage immediately to the high-frequency transmitting tube. **Remember to wait at least five minutes after pushing the POWER button before you push the TRANS button ON.**

RCVR TUNING: Control knob with which you tune the receiver to the intermediate frequency, to obtain the best picture possible on the scope.

RCVR GAIN: Control knob with which you change the sensitivity of the receiver and the brilliance of the picture on the scope. By keeping the receiver-gain control down as far as possible, you differentiate between small and large targets, for a large target gives a brighter and larger return than a small one. When you are searching for rivers or bodies of water, however, turn up the receiver-gain control. This makes the terrain give an especially bright return on the screen in contrast to the weak return from the water.

RANGE NAUT MILES: Five-position switch with which you can select a maximum range of 4, 10, 20, 50, or 100 miles. When the switch is at 4, the



MAIN CONTROL BOX

scope covers four miles of range only if the OPEN CENTER switch is IN.

OPEN CENT: Toggle switch which allows the 4-mile sweep to begin either at the center of the scope or at a distance from the center equal to a 1-mile interval. You use the latter position to expand or separate returns from nearby targets when you are on search.

AFC-BEACON: Three-position switch which selects the type of operation desired. It enables you to use the set with or without AFC (automatic frequency control). With the switch at BEACON you can use the set as a homing device or navigational aid in conjunction with a radar beacon. When the switch is at AFC OFF, there is no automatic frequency control and you must tune the set manually. When the switch is at AFC ON, the set automatically keeps itself in tune and the manual tuning control has no effect. You must keep the AFC voltage properly adjusted in order to have the AFC circuit work satisfactorily.

TRANS - XTAL - AFC: Three - position selector switch used in conjunction with the volt-milliammeter on the control box. By placing the switch at XTAL I you can measure the current in the rectifying crystal of the receiver. When the switch is at TRANS I you can measure the current in the transmitting tube of the radio-frequency unit. When the switch is at AFC V, with the AFC-BEACON switch at AFC ON, you can read the voltage at the output of the AFC unit. With AFC OFF, you can read the repeller voltage supplied to the radar beat-frequency oscillator.

Note that the first two positions of the switch give a current indication. The last switch position enables you to measure voltage.

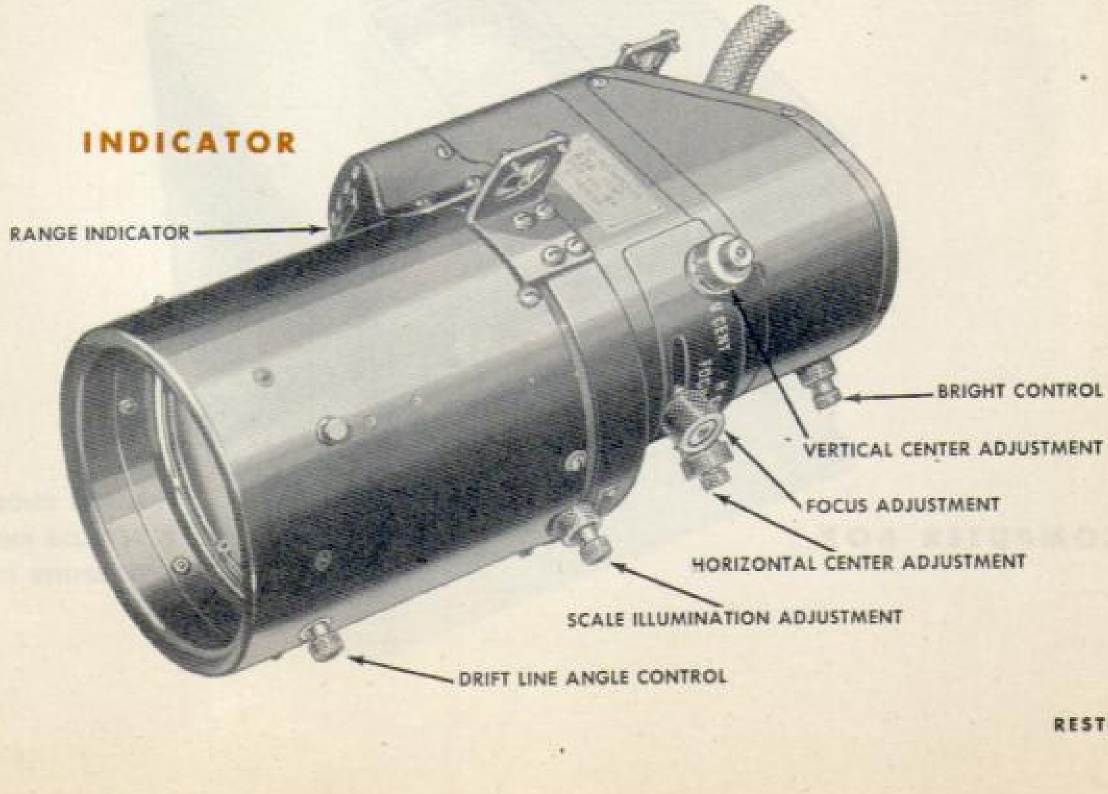
ANT TILT: Three-position toggle switch which controls the tilt of the antenna from 10° above to 45° below horizontal. You read the degree of tilt on a tilt meter on the control box. Hold the ANT TILT switch either up or down to tilt the antenna; when you release the switch, it snaps back to a neutral position.

CONTINUOUS: Toggle switch used to keep the spinner continuously rotating clockwise at above 20 rpm. Before turning this switch ON, be sure the indicators are properly phased. You should rotate the spinner two or three times with the SEARCH CW-CCW switch to avoid damage to the selsyn system.

SEARCH-CW-CCW: Three-position toggle switch similar to the ANT TILT switch, which rotates the azimuth motor either clockwise or counter-clockwise. It is effective only when the CONTINUOUS switch is OFF. When you release the switch it snaps back to a neutral position.

Indicator

The plan position indicator (PPI scope) is a cathode ray tube in which a map-like view of the area scanned is produced on a fluorescent screen by a rotating sweep line. On its face is a movable plastic



scale with five etched concentric circles which you can use for estimating distances on all ranges. Cursor lines are etched on this scale for your use in navigation. Degrees of azimuth are lettered on a fixed ring on the outside edge of the scope. The main scope is in your compartment; the auxiliary scope, in the navigator's compartment. The main controls are:

BRIGHT: Varies the brilliance of the sweep line on the scope.

SCALE CONTROL: Turns the bearing cursor to enable you to read an accurate bearing from the azimuth scale.

SCALE ILLUM: Adjusts the illumination of the plastic scale on the face of the scope.

H CENT: Shifts the sweep trace horizontally to the right or left, enabling you to set the sweep starting point equidistant from the right and left sides of the scope.

V CENT: Shifts the sweep trace vertically, enabling you to set the sweep starting point equidistant from the top and bottom of the scope. When you have centered the sweep properly with the H CENT and V CENT controls, its starting point is directly underneath the intersection of the etched drift lines on the plastic scale.

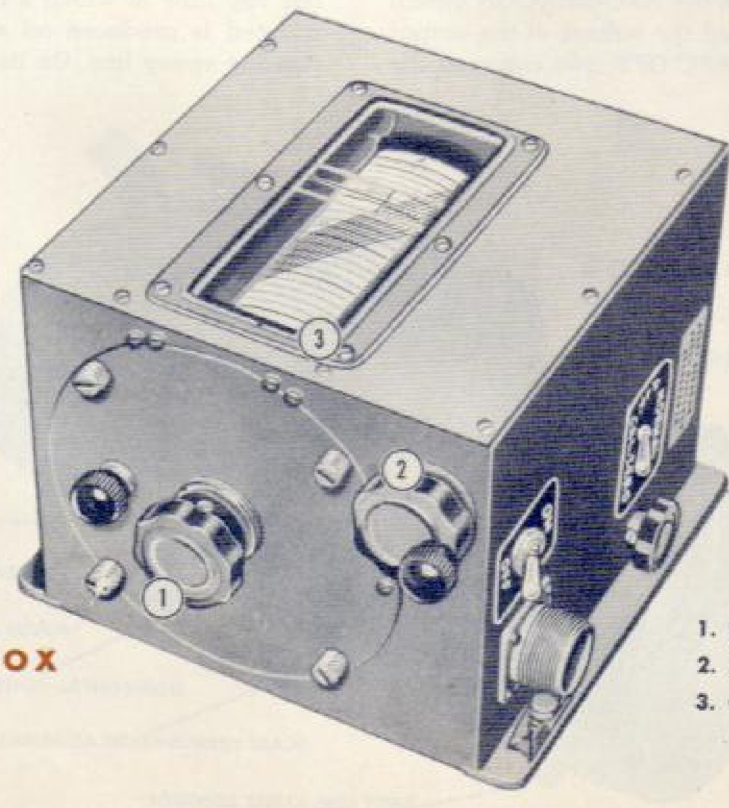
FOCUS: Varies the sharpness of the returns on the scope as you turn the knurled knob.

Computer Box

The computer box was designed to determine range and altitude accurately for the solution of the bombing problem. Two potentiometers regulate the voltage supplied to the range and altitude-delay circuits in the range unit. The range control positions a range signal at a slant range which varies between 0.5 and 15 nautical miles. The altitude control delays the beginning of the sweep on the scope for a time interval determined by the altitude set into the computer. The main controls are:

NORMAL-CAL ZERO: Toggle switch. At NORMAL it provides altitude delay of from 15,000 to 35,000 feet in the altitude circuit. You set the cross-hair according to altitude by rotating the altitude knob. When the switch is at CAL ZERO, the altitude delay circuit is by-passed.

ILLUM: Knob which adjusts the amount of illumination desired for the computer box.



COMPUTER BOX

1. RANGE KNOB
2. ALTITUDE KNOB
3. COMPUTER DRUM

AZIMUTH CONTROL BOX

BOMB-RELEASE MARKER: Toggle switch, marked ON-OFF, which places or removes the bomb-release circle on the scope.

ALTITUDE CONTROL: Knob with which you control the amount of altitude delay put into the altitude-delay circuit when the NORMAL-CAL ZERO switch is at NORMAL. This control removes the altitude hole from the scope entirely or varies its size as desired. The control doesn't work when the NORMAL-CAL ZERO switch is at CAL ZERO.

SLANT RANGE CONTROL: Knob which controls the range-delay circuit in the range unit. By means of this knob you can set the proper groundspeed, sighting angle, or slant range on the computer chart. The knob rotates the computer drum and its attached bomb-release chart to indicate from .5 to 15 nautical miles of slant range.

When you rotate this control you also cause the bomb-release circle to move a relative distance on the scope. In addition, you can use it in conjunction with the altitude control to determine the absolute altitude or bombing altitude of the airplane.

SLANT RANGE VERNIER: Used for fine adjustment of the range control.

Azimuth Control Box

The azimuth control box governs antenna sector-scan, sweep delay, and azimuth stabilization.

The main controls are:

HEADING: Toggle switch which ties in a pulse from the micro switch and cam of the antenna with the scope. When the switch is ON, a lubber line appears on the scope to show the airplane's heading; when it is OFF, no lubber line shows.

SWEEP DELAY MILES: Knob with 21 positions, which delays the start of the sweep on the scope from 0 to 200 nautical miles in 10-mile steps. It allows the use of ranges not available on the RANGE NAUT MILES switch. It is designed primarily to extend the area for beacon operation.

For instance, if the beacon is at a range of 220 miles, you can set the SWEEP DELAY MILES switch at 150 and the RANGE NAUT MILES switch at 100, and obtain signals on the scope from any beacon between 150 and 250 miles away.

AZIM STAB: Toggle switch marked ON-OFF. When this switch is ON, the flux gate compass is coupled to the radar system, thus maintaining true north at the top of the scope. This control makes the scope an oriented map with the airplane's true heading indicated by the heading line. When the switch is OFF, the top of the scope always represents the airplane's heading.

GYRO: Toggle switch marked CAGE-UNCAGE. In present systems this switch is inoperative. When the gyro is installed it operates in conjunction with the antenna-stabilization system. You cage it on landings, takeoffs, and when the airplane is exceeding a 60° angle of bank.

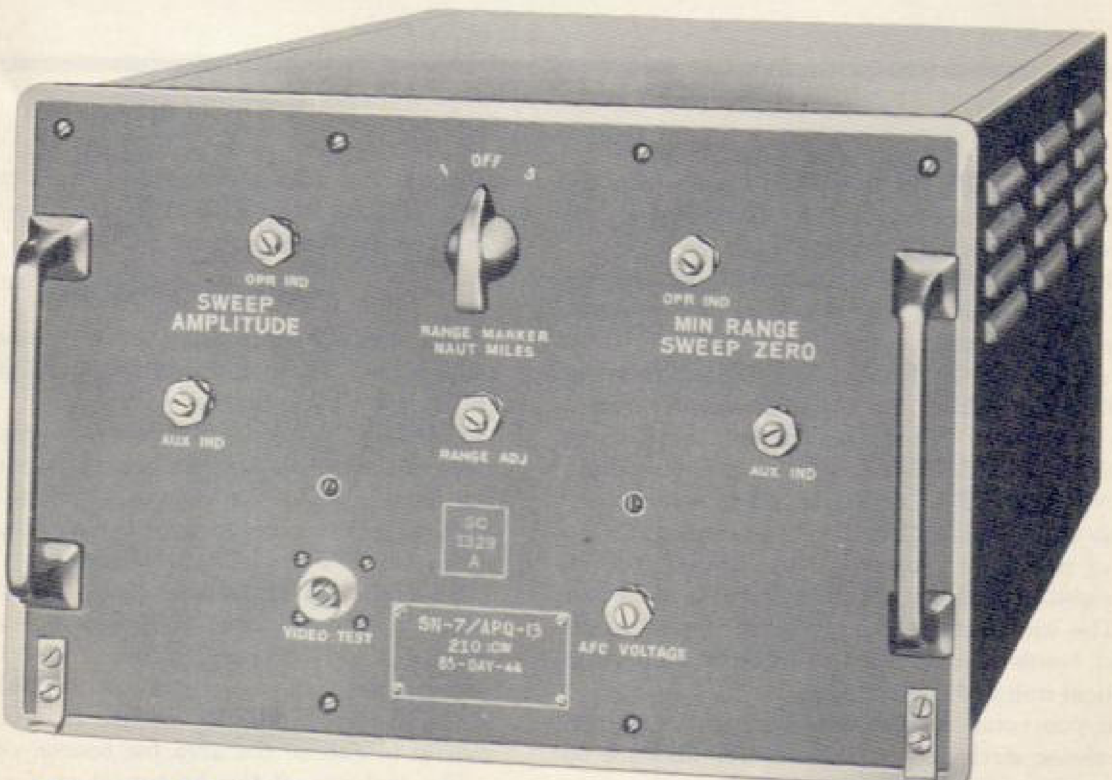
TILT STAB: Toggle switch marked ON-OFF. In present systems it is inoperative. When in use it operates the tilt-stabilization system and causes the antenna spinner to scan a constant angle with respect to the horizontal, despite minor maneuvers.

SECTOR SCAN: Toggle switch marked ON-OFF. When this switch is ON, you may scan any 60° sector within the forward 180° of the airplane's direction of flight, or within 90° on each side of the airplane's true heading. This switch works only when the ANTENNA CONTINUOUS switch on the control box is OFF.

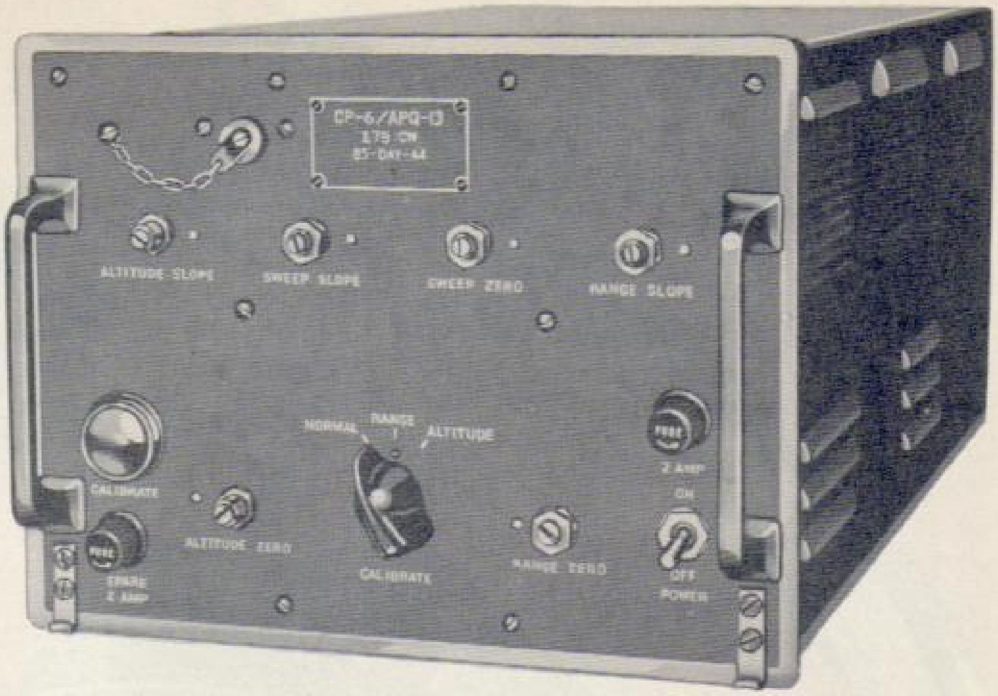
POS ADV: Knob which selects any 60° sector to be scanned through 90° on each side of the airplane's true heading.

Synchronizer

The synchronizer unit has two functions. One part contains the AFC circuit, several stages of intermediate-frequency amplification, the detectors, and the video amplifiers necessary for the receiver portion of the set. The other part of the synchronizer controls the sweep voltages and range markers applied to the scope. The sweep circuits produce sawtooth voltages to control the speed of the sweep for different ranges. A range-marker generator produces the range pips applied to the sweep. By syn-



SYNCHRONIZER UNIT



RANGE UNIT

chronizing the sweep with the received signals, this unit makes it possible for you to determine range and azimuth. The main controls are:

SWEEP AMPLITUDE: Screwdriver control which changes the amplitude (physical length on the scope) of the sweep without changing the range (time) it covers. Note that, as the sweep line lengthens, the number of range-marker pips remains constant, but their spacing increases. The scale of the map thus is altered in proportion to the amplitude of the sweep. The end of the sweep should be just within the limits of the scope.

RANGE ADJ: Screwdriver control which changes the range represented by the sweep line. The sweep line is lengthened and another pip added at the proper interval, but the physical spacing of the pips remains the same. The extent or range of the map thus is altered, but the scale remains constant as the amplitude of the sweep varies. You make the proper adjustment by placing the correct pip, for a given range, at the end of the sweep line.

RANGE MARKER NAUT MILES: Three-position switch which places 1-mile and 5-mile range markers (concentric circles of light) on the scope. Thus, on all ranges there is a range marker for every mile, or one for every five miles, of slant range.

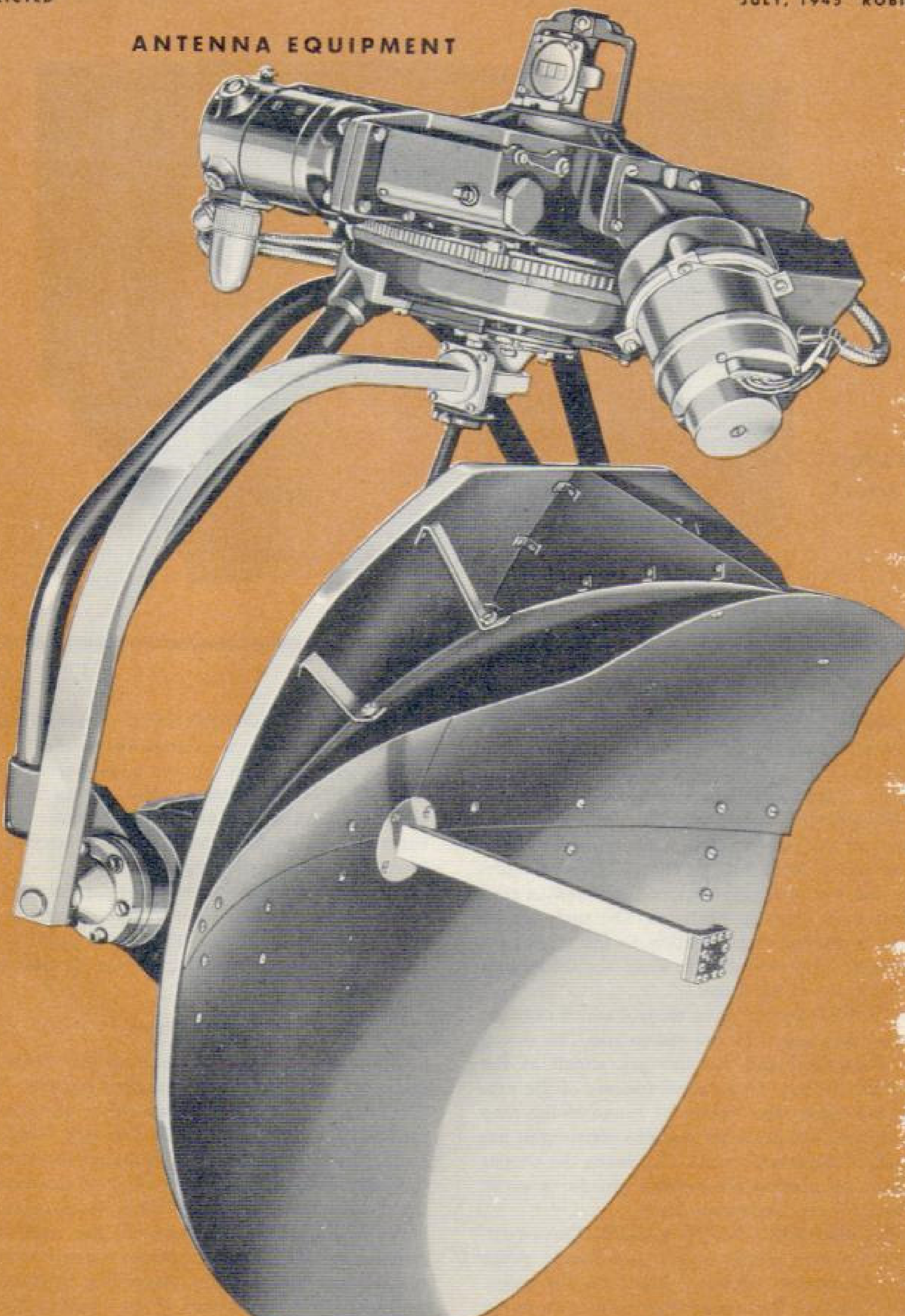
MIN RANGE SWEEP ZERO: Screwdriver control which you use to change the size of the open center on the scope. To set it properly, turn the OPEN CENTER switch on the control box to IN, set the RANGE switch to 4, and make the open center circle coincide with the first etched circle from the center of the scope.

AFC VOLTAGE: Screwdriver control which you use to change AFC voltage to give maximum target returns. If the AFC switch on the control box is ON, this voltage is maintained and the set remains constantly in tune.

Range Unit

The range unit is the heart of the AN/APQ-13 radar set. It contains six principal circuits: crystal-oscillator count divider, range-delay, altitude-delay, sweep-delay, calibrating, and 250-volt rectifier circuits. The unit controls the timing of the sweep and the bomb-release pulse circuits. You use sweep delay to vary the distance at which the selected range becomes effective. The delay in the bomb-release circuit controls the indication of the current bomb-release time for a target, depending upon the prevailing speed and altitude of the airplane. The altitude-delay circuit delays the beginning of the sweep.

ANTENNA EQUIPMENT



The main controls of the range unit are:

ALTITUDE SLOPE: Screwdriver control which adjusts the amount of delay between the transmitted pulse and the beginning of the sweep on the scope. You use this adjustment to calibrate altitude.

SWEEP SLOPE: Screwdriver control, generally considered something that only a mechanic should adjust. It is used to calibrate the sweep-delay circuits on the 10-mile delay or any multiple thereof up to 200 miles.

SWEEP ZERO: Screwdriver control, also usually adjusted only by a mechanic. It controls the start of the sweep to allow zero range to correspond to the zero-mile echo (delay inherent in the modulator).

RANGE SLOPE: Screwdriver control used to calibrate the range-delay circuit. It enables you to set the range on the chart to represent exact slant-range distances.

CALIBRATE: Neon lamp which dims (blinks) when two pulses under calibration coincide.

ALTITUDE ZERO: Screwdriver control used to set altitude delay at exactly 3 nautical miles on the calibrated scale of the computer.

CALIBRATE (switch): Three-position switch, marked NORMAL-RANGE-ALTITUDE. You use the NORMAL position during all operations except when you are calibrating the range unit. You use the RANGE position when you calibrate the range-delay circuits against the slant-range scale of the computer chart. You use the ALTITUDE position when you calibrate the altitude-delay circuits in the range unit against the computer's altitude scale.

RANGE ZERO: Screwdriver control used to set one mile of slant range at exactly one mile on the calibrated scale of the computer.

NORMAL-TEST COUNT: Toggle switch which permits normal operation of the set when it is at NORMAL. The TEST COUNT position is for maintenance only.

Antenna Equipment

The function of the antenna is to transmit the radio-frequency energy into space and receive the reflections of this energy. An RF waveguide transmission line connects the antenna to the radio-frequency unit.

The unit consists of a feed-horn antenna with a reflector, mounted on a spinner unit. The unit is so arranged that you can rotate it continuously in a horizontal plane at approximately 20 rpm, for search operation, or oscillate it over a selected arc for sector scanning. You can tilt it in a vertical plane through 55° (from 10° above to 45° below the horizontal). An elevation-position indicator on the main control box reveals the antenna's position.

The antenna drives a selsyn transmitter through a 1:10 gear ratio and the selsyn-repeaters in the indicators are reciprocally geared 10:1 to their deflecting coils. Thus the coils are interlocked to reproduce the position of the antenna in azimuth. Because of these gear ratios, the deflecting coils can interlock in any one of 10 angular positions with respect to the antenna. To overcome this difficulty and to insure that the antenna and indicator coils always maintain the same angular relationship, cam-driven phasing switches are provided on both the antenna equipment and the indicators.

Here is how the antenna conveys to you the direction of the airplane's flight:

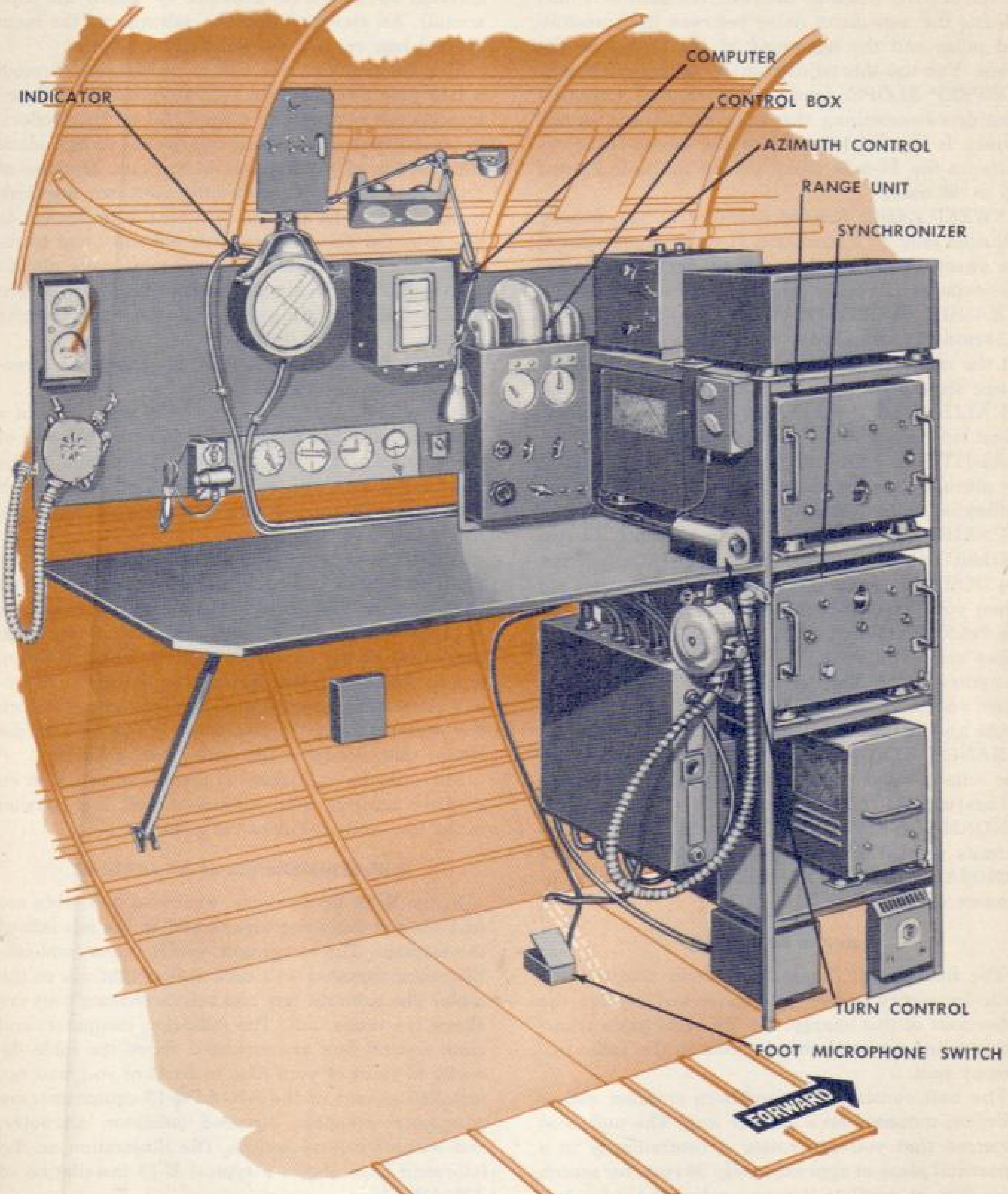
A heading switch closes when the antenna is in a position that coincides with the longitudinal axis of the airplane. This action applies extra bias to the indicator sweep and, as a result, the sweep which coincides with the airplane's heading momentarily brightens.

Auxiliary antenna equipment consists of an azimuth control box, torque amplifier, and the selsyn phasing unit. The primary purpose of these units is to place and keep true north at the top of the scope regardless of the airplane's heading. This condition, as you know, is called azimuth stabilization. A second purpose is to provide sector scanning in which the antenna beam is oscillated across one target rather than sweeping the entire 360° azimuth.

The antenna equipment is usually mounted in an inverted position with its fore-and-aft line parallel to the fore-and-aft line of the airplane.

Typical Installation of AN/APQ-13

In the B-29, for example, your seat and table are just back of the waist turrets and on the left side of the airplane. The range unit, synchronizer, and rectifiers are mounted on a rack at the right side of the table. The azimuth box and selsyn phasing unit are above the range unit. The indicator, computer, and main control box are mounted above the table directly in front of you. Also in front of you, and not installed as part of the AN/APQ-13 equipment, are a repeater compass, airspeed indicator, altimeter, and a bomb-release switch. The illustration on the following page shows a typical B-29 installation of AN/APQ-13.



B-29 INSTALLATION OF AN/APQ-13

AN/APQ-13 Range Unit Calibration

The accuracy of all measurements made with the AN/APQ-13 depends on the accuracy with which you calibrate the equipment. Normally, the set is calibrated on the ground and requires little attention in the air. Because of changes in temperature and voltage which take place during flight, however, you should check the calibration periodically and make corrections if necessary. It is especially advisable to check calibration shortly before beginning your bombing run or before taking any range measurements requiring high accuracy.

Calibrating Altitude

1. Turn the CALIBRATE switch on the range unit to ALTITUDE.
2. Set the altitude switch on the side of the computer at NORMAL.
3. Rotate the altitude control knob on the computer box to align the hairline of the pointer with the 3-mile marker on the vertical nautical-mile scale.
4. Adjust the ALTITUDE ZERO control on the range unit with a screwdriver to obtain maximum dimming of the CALIBRATE lamp.
5. Move the pointer toward the 5-mile marker and count 2 dimmings (4- and 5-mile dims). The pointer should be exactly at 5 miles.
6. Note the difference between the altitude setting for the 2nd dimming and the 5-mile setting; then move the pointer to the other side of 5 an **amount equal to the difference.**
7. Adjust the ALTITUDE SLOPE. If the initial error was below the 5-mile marker, turn the screwdriver adjustment counter-clockwise until the neon lamp is at maximum dimming. If the initial error was above the 5-mile marker, turn the adjustment clockwise.
8. Crank the altitude down to 3 miles. Readjust ALTITUDE ZERO until the light dims.
9. Check for dimming on the 4- and 5-mile markers. If maximum dimming occurs away from the 5-mile marker, repeat steps 6, 7, and 8.

Calibrate Zero Adjustment

1. Stop sweep.
2. Place open center IN.
3. Align the transmitter pulse with the end of the sweep line by removing cap and adjusting the CALIBRATE ZERO screw on the left side of the computer box.

Calibrating Range

1. Turn the CALIBRATE switch on the range unit to RANGE.
2. Turn the bomb-release marker switch ON.
3. Turn the altitude switch on the side of the computer to CAL ZERO.
4. Make sure the OPEN CENTER switch on the control box is OUT.
5. Place the RANGE MARKER NAUT MILES switch on the synchronizer at 1 mile.
6. Rotate the slant-range control knob to align the vertical hairline with the 1-mile true slant range showing on the marker at the top of the computer drum.
7. Adjust the RANGE ZERO control to obtain maximum dimming of the CALIBRATE lamp. Only one dimming is usual through the control's range.

8. Counting the dimming you have just obtained as the first one, rotate the drum slowly toward 13 miles and stop on the 13th dimming.

9. Note the difference between the range-drum reading for the 13th dimming and the 13-mile marker; then set the range drum on the other side of 13 **an amount equal to the difference.** Count the dimmings that occurred while you were re-setting the drum. When you make the RANGE SLOPE adjustment, you must dim the lamp this same number of times to get back to the original 13th dimming.

Example: At the 13th dimming the range setting reads 11. Turn the range drum to 15. Note that 4 dimmings occur while you are doing this. Accordingly, when you make the RANGE SLOPE adjustment, you must turn through 4 dimmings to get back to 13.

Always turn the RANGE SLOPE and RANGE ZERO screws in the same direction as the original error. In the example above, you would turn the RANGE SLOPE screw counter-clockwise, or toward 11. If the original dimming occurred at 13½ miles, you would turn the adjustment clockwise, or toward 13½.

10. Re-set range to 1 mile and adjust RANGE ZERO for maximum dimming.

11. Repeat steps 8 and 9 until dimmings occur exactly at 1 and 13 miles.

Check on Calibration

After you have completed the calibration you can check to see that the proper range pip has been set in this manner:

1. Turn the altitude switch to NORMAL.
2. Rotate the altitude control knob to 3 miles.
3. Set the slant range at 5 miles.
4. Check to see that the second range mark and the bomb-release circle coincide. If an appreciable error appears, re-calibrate range.

Sweep Slope Calibration

In order to obtain accurate ranges from a radar beacon, you must calibrate the sweep-delay circuit as follows:

1. Turn the CALIBRATE switch on the range unit to NORMAL.
2. Place the ALT toggle switch on the computer at CAL ZERO.
3. Turn the bomb-release marker switch on the computer OFF.
4. Turn the RANGE MARKER NAUT MILES switch on the synchronizer to 5.
5. Place the antenna CONTINUOUS switch on the control box at OFF.
6. Turn the AFC-BEACON switch to AFC OFF.
7. Turn the RANGE NAUT MILES switch to 100.
8. Turn the SWEEP DELAY MILES switch on the azimuth control box to 20. If the pulse-repetition frequency and sweep zero are correct, the transmitter pulse appears at the end of the sweep line on the scope.
9. If the transmitter pulse does not appear at the end of the sweep line, advance the setting of the SWEEP DELAY MILES switch until the pulse does appear.
10. Continue to advance the setting of the SWEEP DELAY MILES switch to see that the transmitter pulse appears at each successive 10-mile marker (every other 5-mile marker) as the switch setting changes.
11. Keep on advancing the switch until the pulse reaches the 10-mile marker nearest the start of the sweep line.
12. Now, advance the SWEEP DELAY MILES switch through three calibrations (normally, this would be from 110 to 140 miles of delay).
13. The transmitter pulses should appear at the outer end of the sweep line.
14. Continue to advance the SWEEP DELAY MILES switch until it reaches the 200-mile delay position. Check again to see that the transmitter pulses appear at each successive 10-mile marker.
15. If at any time from step 9 through step 11 the transmitter pulse does not change its position when you advance the SWEEP DELAY MILES switch, turn the SWEEP SLOPE control on the range unit clockwise and repeat the entire procedure.
16. If at any time the transmitter pulse jumps 20 miles (four range markers) when you move the SWEEP DELAY MILES switch forward only one setting, turn the SWEEP SLOPE control counter-clockwise and repeat the entire procedure.

***Note:* After each adjustment of the SWEEP SLOPE screwdriver control, set the SWEEP DELAY MILES switch back to 0 and repeat the entire procedure. Check and see that the transmitter pulse appears at the range marker which coincides with the setting of the SWEEP DELAY MILES switch. Continue to check and adjust the SWEEP SLOPE control until the sweep slope is calibrated.**

AN/APQ-13 *Tuning* ★

Tune-Up Procedure

You tune the equipment for search operation by setting the controls in the following positions:

1. When you have reached a safe altitude, ask the pilot's permission to lower the spinner turret.
2. Depress and hold the TURRET toggle switch DOWN. The green light goes out and the red light glows when the turret is fully down.
3. Call the pilot or engineer and ask to have all but one generator turned off.
4. Press the POWER ON button on the control box and check the tilt meter or range-indicator lights to make sure that current is flowing.
5. Check inverter voltage for 115 volts. If No. 1 inverter is fluctuating or is not at 115 volts, turn on No. 2 inverter and check.
6. Call the engineer and ask to have the generators turned on again.
7. Set RANGE NAUT MILES switch to 4.
8. Set RANGE MARKER NAUT MILES switch to 1.
9. Turn BRIGHT control clockwise until trace appears on scope.

WARNING

If no trace appears, do not push TRANS ON—check fuses and cables. If the transmitter is turned on with no "keep alive" voltage, the crystal is going to be damaged!

10. Center the sweep horizontally and vertically by aligning it with the crosshairs on the PPI scope.
11. With a screwdriver, turn the SWEEP AMPLITUDE until the sweep is just short of the edge of the scope or within approximately 1/32 inch.
12. Flip the OPEN CENT switch to IN.
13. Adjust the MIN RANGE SWEEP ZERO with a screwdriver until the inner end of the sweep coincides with the first etched mile circle on the scope.
14. Adjust the RANGE ADJ control with a screwdriver until four pips show on the sweep, the fourth at the end of the sweep.
15. Turn the SWEEP AMPLITUDE until the outer pip coincides with the edge of the scope.
16. Turn the RANGE NAUT MILES switch to 10 and the RANGE MARKER NAUT MILES switch to 5. Check for two pips, the second at the end of the sweep. Adjust the RANGE ADJ control, if necessary.
17. Turn the BRIGHT control clockwise until the trace is barely visible on the scope.
18. Adjust FOCUS on the scope to make the trace as sharp as possible.
19. Rotate the RCVR TUNING knob until the meter indicates maximum crystal current. It should indicate 0.6—1.1 milliamperes. You frequently find two nodes where the crystal current indicates between 0.6 and 1.1 ma. Choose the maximum reading.
20. Hold the SEARCH switch at CCW for several revolutions until the sweep rotates smoothly.
21. Hold the SEARCH switch at CW for two continuous revolutions before you flip the ANTENNA CONTINUOUS switch ON.
22. Press the TRANS ON button on the control box.
23. Turn the meter-current selector switch to TRANS I and check to see that the transmitter current is between 6 and 8 ma. If necessary, to obtain a proper reading, adjust the transtat with a screwdriver. Check the meter indication on all radar and beacon ranges. It should remain at between 6 and 8 ma.
24. Rotate the RCVR GAIN knob clockwise until

noise is faintly visible on the scope.

25. Turn the RANGE NAUT MILES switch to 20.

26. Turn the meter-current selector switch to AFC V.

27. With the ANTENNA CONTINUOUS switch, stop the sweep over an area which gives an echo. Adjust sweep, if necessary, with the SEARCH switch.

28. Adjust the AFC VOLTAGE control on the synchronizer for maximum return, keeping the voltage between 130 and 190v. Use a screwdriver to do this.

29. Adjust the RCVR TUNING knob for maximum returns, checking your voltage again for 130-190v.

30. Turn the AFC-BEACON switch to AFC ON.

31. Adjust the tilt of the antenna by manipulating the ANT TILT switch to obtain maximum return on the scope.

32. Select range with the RANGE NAUT MILES switch and turn the ANTENNA CONTINUOUS switch ON.

33. If you want to operate the set with azimuth stabilization on, first turn the ANTENNA CONTINUOUS switch OFF, then turn AZIM STAB switch ON.

CAUTION

If you want to operate the set with azimuth stabilization off, first turn the ANTENNA CONTINUOUS switch OFF. Then, wait until the sweep line stops its counter-clockwise movement before you flip the ANTENNA CONTINUOUS switch ON again.

The equipment is now tuned to search targets within the range selected. You can operate it with or without AFC and azimuth stabilization.

You can do mapping most effectively at the 4-, 5-, 10-, and 20-mile ranges. Scope returns at these ranges look much like the objects on the navigational chart. You can identify objects or an area quickly and positively.

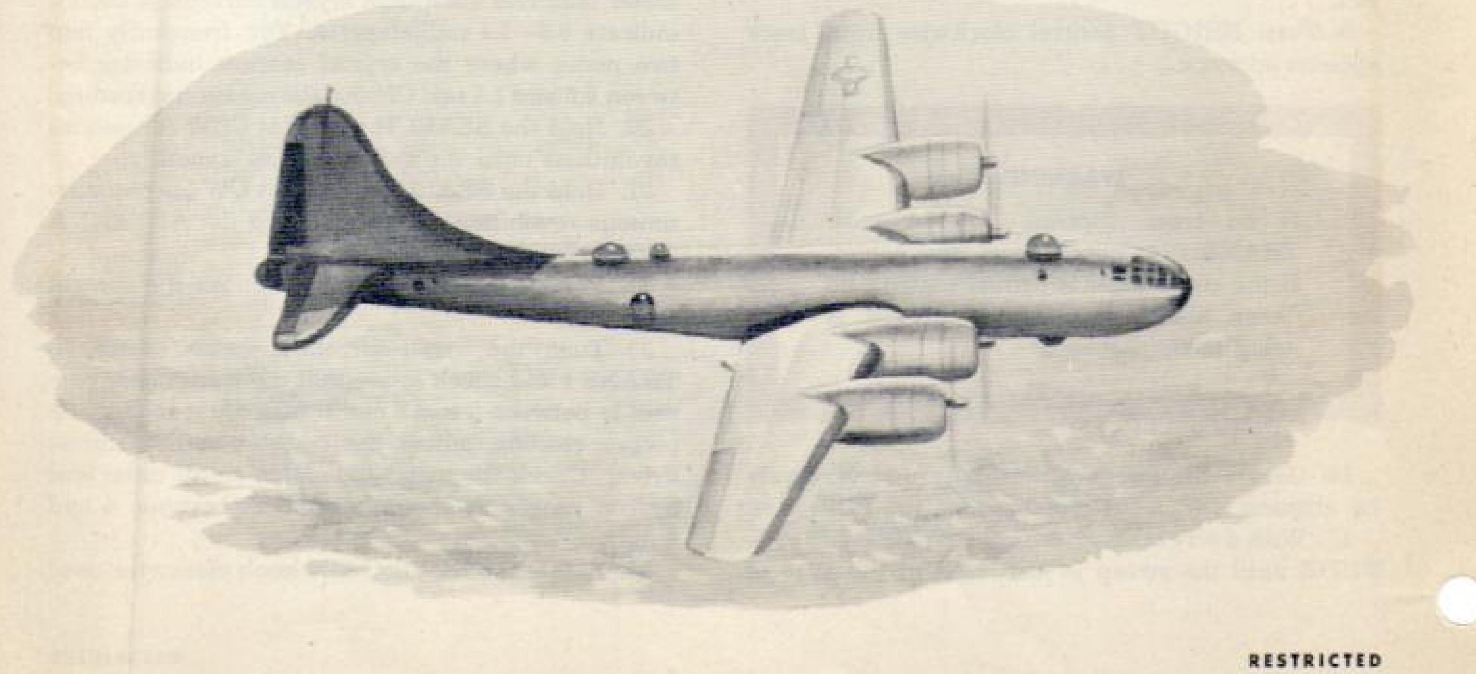
At the 50-mile and 100-mile ranges, distant objects appear as bright spots on the scope. These spots increase in size as the airplane approaches them. By changing the range setting you can make the spots identifiable as their shapes become better defined.

Tune-Up Procedure Over Water

If you need to re-tune the set over a large body of water, where a land object is not available within range of the scope, you can use the standard tune-up procedure with the following exception:

The edge of the altitude circle, representing a point directly beneath the airplane, reflects enough water return to show as a bright spot on the sweep line when the set is properly tuned. Tune the set with the RCVR TUNING knob until you obtain maximum brilliancy for these returns.

Set the antenna tilt at 0°, or at the normal elevation at which you have been operating the set; then, any land objects appear in focus on the scope whenever they come within radar range.



AN/APQ-13 ★ Operation

Pre-Operational Checklist

In order to protect the radar circuits and to insure smooth operation, you first must set the controls in specified positions. The following checklist is intended to help you make a pre-operational check of each unit and its control individually:

CONTROL BOX

Trans	OFF
Power	OFF
RCVR Tuning	Fully CCW
Meter Selector Switch	XTAL I
AFC-Beacon	AFC OFF
Antenna Continuous	OFF
Range Naut Miles	20
RCVR Gain	Fully CCW

INDICATORS

Bright	Fully CCW
Scale Illum	Fully CCW

COMPUTER

Alt Switch	CAL ZERO
Bomb-Release Marker Switch	OFF

AZIMUTH CONTROL BOX

Heading	OFF
Sweep Delay Miles	0
Azim Stab	OFF
Sector Scan	OFF

SYNCHRONIZER

Range Marker Naut Miles	OFF

RANGE UNIT

Normal—Test Count	NORMAL
Calibrate Switch	NORMAL

PRESSURE PUMP

Pressure Pump Switch	ON

Normal Beacon-Search Operation

Since search operation is the primary use of the radar set and beacon operation is used only intermittently, it can be assumed that normally you are operating according to the search-operation instructions. You are either tuning manually or using AFC.

To use the set for beacon reception, follow this procedure:

1. Turn the AFC-BEACON switch to BEACON. Now you must tune the set manually; beacon operation is possible only with manual tuning. When the AFC-BEACON switch is at BEACON, a different

beat-frequency oscillator is introduced into the circuit. Wait at least two minutes for this oscillator to warm up.

2. Place NORMAL-CAL ZERO switch at CAL ZERO.

3. Place the RANGE MARKER NAUT MILES switch in the desired position.

4. Use the RANGE NAUT MILES switch (control box), the SWEEP DELAY MILES switch (azimuth control box), and the various antenna controls to locate and identify beacons. Within a radius of 100 miles, you don't need to use sweep delay, although occasionally it may offer advantages.

The set then triggers off the ground station, which in turn sends out a beacon signal that can be picked up by the set and shown on the scope. The beacon return appears in code.

You can concentrate on a particular beacon by first turning the ANTENNA CONTINUOUS switch OFF. Then hold the ANTENNA SEARCH switch either at CW or CCW to rotate the antenna in either direction for any desired number of degrees. This concentrates the search in a desired sector.

After you have tuned in the beacon signal, measure its range and azimuth to the center of the closest indication.

OPERATING PRECAUTIONS

Here is a minimum list of precautions which you must observe faithfully. As you gain experience at operating the equipment, additional precautions become evident.

1. Turn off the equipment immediately if you note any abnormal operation.

2. Do not remove covers, change tubes, make adjustments inside equipment, or disconnect cables when the equipment (inverter) is running.

3. Keep the average intensity on both scopes as low as is consistent with satisfactory performance. Intense stationary spots on the scope may burn the material on the face of the cathode ray tube.

4. If the airplane power system fails during operation, turn off the equipment immediately. After the trouble has been remedied, you may turn on the equipment again.

5. If the pressure pump which pressurizes the RF unit fails, and excessive arcing occurs, you should turn off the radar equipment.

TURNING EQUIPMENT OFF

The following procedure is considered the briefest necessary for turning off your equipment. You must follow it strictly; any alteration of the procedure may result in injury to the scope or cause the phasing system to get out of phase.

1. Turn RCVR GAIN control fully CCW.

2. Turn your BRIGHT control fully counterclockwise.

3. Flip the ANTENNA CONTINUOUS switch OFF when the sweep is in the upper half of the scope. This is to protect the selsyn phasing system.

4. Turn GYRO switch to CAGE, if you have been using the gyro system.

5. Turn AZIM STAB switch OFF.

6. Turn HEADING switch OFF.

7. If you have been using the gyro system, wait 10 minutes and turn TILT STAB switch OFF.

8. Push the TRANS OFF button.

9. Turn off the entire equipment by pushing the POWER OFF button.

AN/APQ-13 ★ *Maintenance*

When something goes wrong, don't throw up your hands in despair and yell, "malfunction." Instead, look through these instructions to see if you can't locate your trouble and a remedy for it. Since most troubles are often simple things (a blown fuse, for instance) check all the circuits involved and make sure cables are hand-tight before you start thinking of new tubes.

If you do have troubles you can't fix, analyze them as carefully as possible for the benefit of the maintenance men. Remember, it is often impossible to get the set to act on the ground as it does in the air.

Finally, make out a complete operator's report. Give the distance of the farthest targets, the extent of mapping effect, and any other pertinent information you may discover.

The checklist below is by no means a complete list of the troubles which have been encountered in APQ-13 sets; it is merely a list of common troubles which you can fix in the air. Study it carefully.

CAUTION

Before you replace a fuse, you must press the TRANS OFF and POWER OFF buttons on the main control box. When you remove the cover of the junction box, J-40, that action opens a door switch which cuts off power from the equipment. You must replace this cover before you can resume operation of the set.

TROUBLE	CHECK
Power Troubles	
Inverter won't start.	Check 10-amp fuse in top of inverter.
Inverter starts momentarily, then stops.	Remove 20-amp fuse in top of inverter, start inverter, and then replace 20-amp fuse.
Inverter starts, but none of the other 28-volt circuits (tilt, antenna rotation, range lights, etc.) functions.	Check 30-amp fuse in top of inverter.
Inverter cuts out at altitude.	Switch to alternate inverter.
No 115v supply.	Check 20-amp fuse in top of inverter.
AC voltage high when power is first turned on.	Pull 20-amp fuse in inverter (fusing AC load) and let inverter heat for 15 minutes with no load, then replace fuse.
Inverter inoperative.	Switch to alternate inverter. If auxiliary is out, hook SCR-718 inverter to AN/APQ-13 by switching power cables.
Range unit inoperative.	Check 2-amp fuse on front of range unit. Then check fuse 1109 in JB-40 (located on left side of the airplane, usually near the set).
Transmitter Troubles	
Transmitter inoperative.	Check fuses 1106, 1109, 1110, 1111 in JB-40. Check to see that door on modulator is closed.
Transmitter current rises, then falls.	Adjust transtat current.
No transmitter current.	Check fuse 1106 in JB-40.
Transmitter kicks off when you change ranges.	Lower transmitter current by adjusting transtat.

TROUBLE	CHECK
Sweep Rotation Troubles	
Sweep won't rotate.	Check fuse 1102 in JB-40. Check 30-amp fuse in top of inverter and fuse 1113 in JB-40.
Sweep rotation in one direction only.	Check relays K1104 and K1105 in JB-40.
Sweep rotation in wrong direction.	Reverse selsyn leads in JB-40 (terminals 1132 and 1187).
Selsyns won't phase.	Make sure flux-gate inverter is ON and connections to torque amplifier in selsyn phasing unit are tight. (When you turn azimuth stabilization OFF, stop sweep at 0 before throwing azimuth stabilization switch OFF.)
Azimuth-Stabilization and Sector-Scan Troubles	
Sector scan inoperative.	Check fuse 1112 and 1113 in JB-40, and the two fuses in JB-87, located in the antenna unit.
Azimuth stabilization inoperative.	Check to see if flux-gate inverter is ON. Switch to alternate inverter and check fuse 1112 in JB-40. Check 5-amp fuse marked RADIO COMPASS, FLUX GATE COMPASS, and RADAR AMPLIFIER, in the fuse box in the navigator's compartment. Check cables and connections to selsyn phasing unit and torque amplifier.
Lubber line OFF when azimuth stabilization is ON.	Disconnect remote scope.

TROUBLE	CHECK
Voltage Troubles	
Bombing circle weak or non-existent.	Reduce gain. Check connections on cables from computer to azimuth control box. Check cable with green-white dot, from range unit to synchronizer. Finally remove range unit and turn potentiometer R-1615 fully clockwise.
Lubber line won't turn ON.	Check fuse 1112 in JB-40.
Scope Troubles	
No spot or trace on scope.	Check fuses 1102 and 1105 in JB-40. Check high-voltage connections to CRT.
Spot but no trace on scope.	Turn set OFF, then ON. Check fuse 1109 in JB-40 and the 2-amp fuse on the front of the range unit.
BRIGHT control inoperative.	Turn set OFF (so as not to burn out CRT) and check fuse 1108 in JB-40.
Fuzzy trace.	Check focus. Check high-voltage connection to CRT.
Spoke effect.	Reduce gain. Disconnect remote scope. Retune set and adjust 300v or 115v slightly.
Antenna Troubles	
SEARCH and CONTINUOUS inoperative.	Check fuses Nos. 1111 and 1113 in JB-40.

FUSED CIRCUITS

FUSE	CAPACITY	FUNCTION
JB-40 Power Distribution Box		
F1101	25 amp	Spare.
F1102	10 amp	115v to antenna and scopes.
F1103	Eliminated	
F1104	Eliminated	
F1105	2 amp	115v to HV rectifier.
F1106	15 amp	115v to RF unit and modulator.
F1107	3 amp	115v to test-scope connection.
F1108	3 amp	115v to regulated rectifier and synchronizer.
F1109	10 amp	115v to range unit.
F1110	5 amp	28v to crystal-gate relay and control box.
F1111	15 amp	28v to F1110, RF unit, and modulator.
F1112	10 amp	28v to phasing-switch shorting relay in JB-87, filaments of torque amplifier, sector-scan relay, and test-scope connection.
F1113	15 amp	28v to antenna unit and sector scan ON-OFF switch.
F1114	Eliminated	
Range Unit		
F1601	2 amp	115v to range unit.
JB-87-B Junction Box (Above Antenna Unit)		
F1303	1 amp	Sector-scan voltage from
F1304	1 amp	azimuth potentiometer.

Some Reasons Why Fuses Blow

F1102—This fuse feeds 115v AC to the selsyn system. It blows often if the selsyns are not phased properly. First, try to phase the selsyns with the CW-CCW search switch. If this won't work, try disconnecting one scope at a time to see if you can locate the trouble. Sometimes it is caused by the way you turn off AZIM STAB. Always stop the sweep at the top of the scope before you turn off AZIM STAB.

F1105—The high-voltage rectifier supplies high voltage to two sources: +4900 volts to the anodes of the two CRT's, and −1000 volts to the T-R box in the RF unit. A blown fuse generally indicates a short in one of these lines. Disconnect one scope at a time to see if you can locate the short.

F1106—Feeds 115v to the RF unit and modulator. No trouble has been encountered with this fuse that can be fixed in the air.

F1108—This fuse blows quite often. It supplies 115v to the regulated rectifier and synchronizer. A short in any of the outputs of the regulated rectifier can cause the fuse to blow; usually it is the +300v circuit. In the majority of cases, the short is in one of the scopes; try disconnecting one at a time.

F1109—Feeds 115v to range unit. No trouble has been encountered that can be fixed in the air.

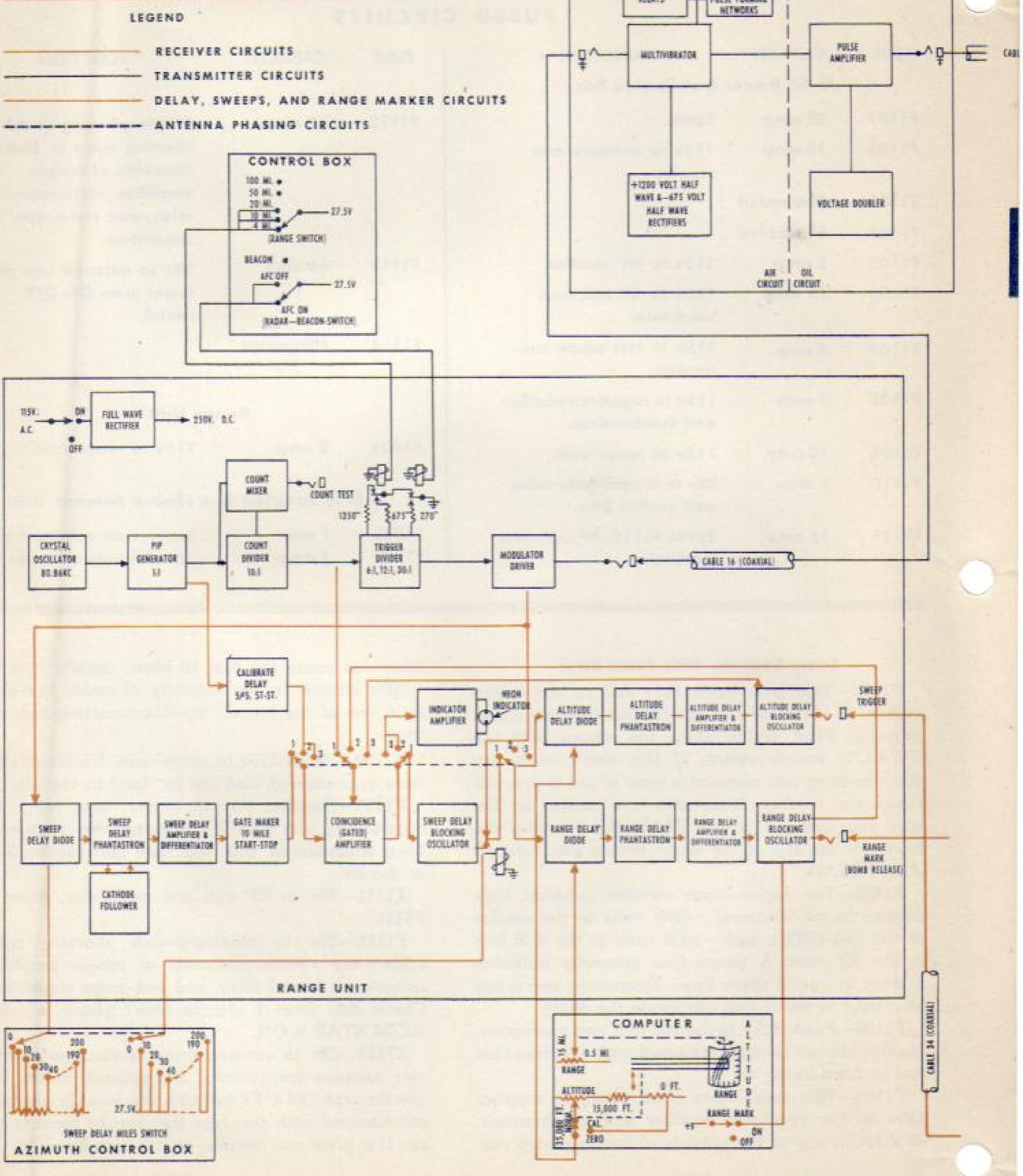
F1110—Supplies 28v to crystal gate relay and control box, and XMTR ON switch. No trouble has been encountered with this fuse that can be fixed in the air.

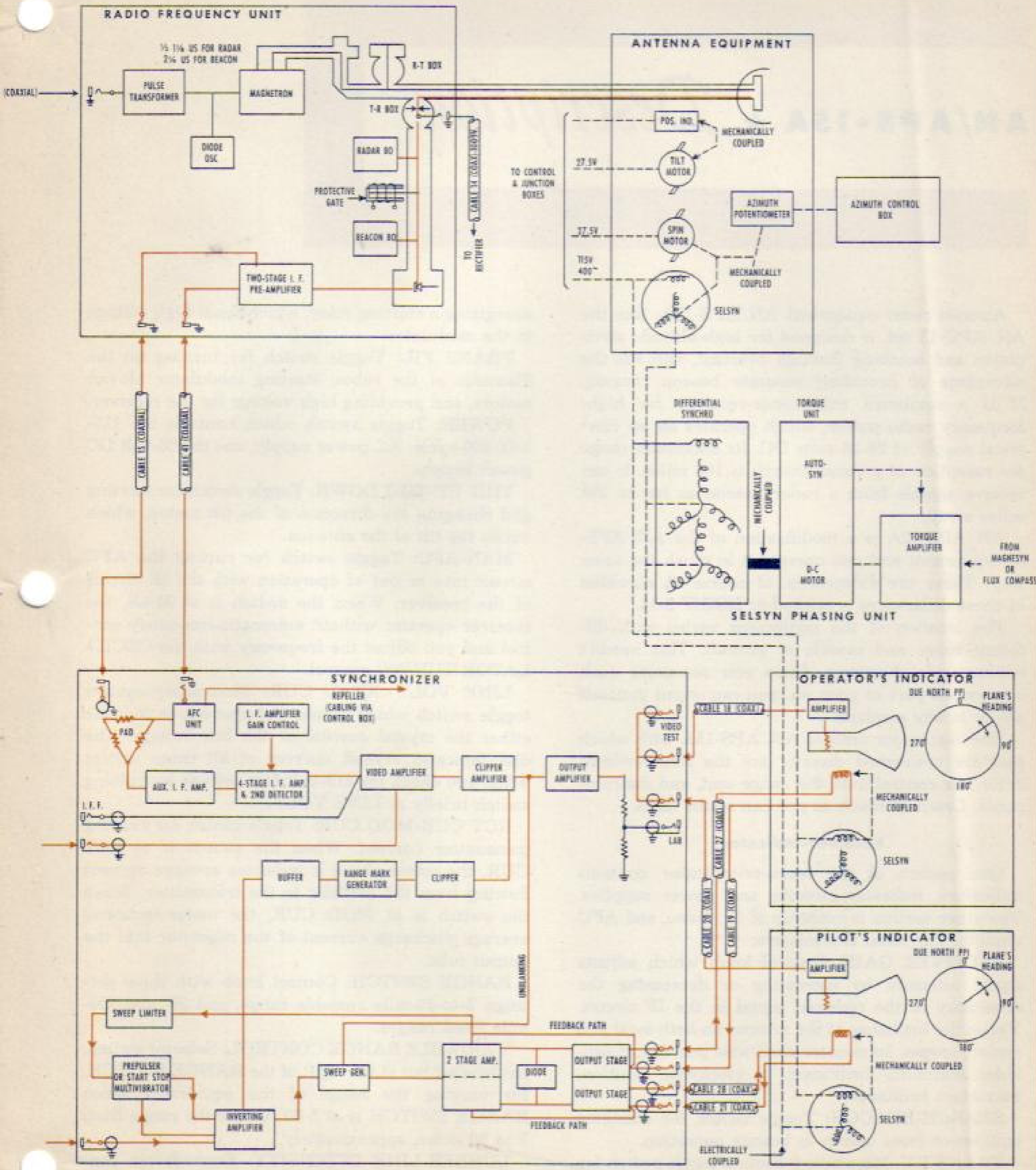
F1111—28v to RF unit and modulator. Same as F1110.

F1112—28v to phasing-switch shorting relay, lubber-line switch, filaments of torque amplifier, sector-scan biased relay, and test-scope connection. Check this fuse if selsyns won't phase in when AZIM STAB is ON.

F1113—28v to antenna unit (azimuth potentiometer, antenna drive motor) and azimuth control box (sector scan ON-OFF switch). No trouble has been encountered with this fuse that can be fixed in the air. If it gives you trouble, report it on Form 38.

BLOCK DIAGRAM (AN/APQ-13)




RADIO FREQUENCY UNIT
½ 1¼ US FOR RADAR
2¼ US FOR BEACON
(COAXIAL)
PULSE TRANSFORMER
MAGNETRON
R-T BOX
T-R BOX
DIODE OSC
RADAR BO
PROTECTIVE GATE
BEACON BO
TWO-STAGE I. F. PRE-AMPLIFIER
CABLE 14 (COAX) MODULATOR
TO RECTIFIER
TO CONTROL & JUNCTION BOXES
ANTENNA EQUIPMENT
POS. IND.
MECHANICALLY COUPLED
27.5V
TILT MOTOR
AZIMUTH POTENTIOMETER
AZIMUTH CONTROL BOX
27.5V
SPIN MOTOR
115V 400~
MECHANICALLY COUPLED
SELSYN
CABLE 15 (COAXIAL)
CABLE 41 (COAXIAL)
DIFFERENTIAL SYNCHRO
TORQUE UNIT
AUTO-SYN
MECHANICALLY COUPLED
TORQUE AMPLIFIER
D-C MOTOR
FROM MAGNESYN OR FLUX COMPASS
SELSYN PHASING UNIT
SYNCHRONIZER
REPELLER (CABLING VIA CONTROL BOX)
AFC UNIT
I. F. AMPLIFIER GAIN CONTROL
PAD
AUX. I. F. AMP.
4-STAGE I. F. AMP. & 2ND DETECTOR
VIDEO AMPLIFIER
CLIPPER AMPLIFIER
OUTPUT AMPLIFIER
I. F. F.
VIDEO TEST
LAB
BUFFER
RANGE MARK GENERATOR
CLIPPER
UNBLANKING
SWEEP LIMITER
PREPULSER OR START STOP MULTIVIBRATOR
SWEEP GEN.
INVERTING AMPLIFIER
2 STAGE AMP.
DIODE
OUTPUT STAGE
OUTPUT STAGE
FEEDBACK PATH
FEEDBACK PATH
CABLE 18 (COAX)
CABLE 27 (COAX)
CABLE 20 (COAX)
CABLE 19 (COAX)
CABLE 28 (COAX)
CABLE 21 (COAX)
ELECTRICALLY COUPLED
OPERATOR'S INDICATOR
DUE NORTH PPI
PLANE'S HEADING
AMPLIFIER
270°
90°
180°
MECHANICALLY COUPLED
SELSYN
PILOT'S INDICATOR
DUE NORTH PPI
PLANE'S HEADING
AMPLIFIER
270°
90°
180°
MECHANICALLY COUPLED
SELSYN

AN/APS-15A ★ *Description*

Aircraft radar equipment AN/APS-15A, like the AN/APQ-13 set, is designed for high-altitude navigation and bombing through overcast, and has the advantage of providing accurate beacon ranging. It is a combined transmitter-receiver for high-frequency radio pulses, which operates on an electrical supply of 26-28 volts DC. Its maximum range for reception of ground returns is 100 miles. It can receive signals from a radar beacon as far as 250 miles away.

AN/APS-15A is a modification of the AN/APS-15 equipment and you operate it in much the same way. There are differences, of course. A checklist of these differences is printed in ROBIF 2-14.

The location of the equipment varies with different types and models of aircraft. This needn't confuse you, however. Once you recognize each component part of your set, you can orient yourself easily in any airplane.

The four major units of AN/APS-15A with which you are concerned directly are the receiver-indicator, the control unit, the range unit, and the computer. Learn as much as you can about them.

Receiver-Indicator

One section of the receiver-indicator contains indicators, indicator circuits, and power supplies. The other section is made up of IF, video, and AFC circuits. The main controls are:

RECEIVER GAIN: Control knob which adjusts signal intensity by increasing or decreasing the sensitivity of the received signal in the IF circuit. Varies the brilliance of the returns on both local and remote scopes. In counter-clockwise position, it provides minimum brilliance; in clockwise position, maximum brilliance.

SEARCH-BEACON: Toggle switch for changing equipment from search to beacon operation.

TRANS HV: Momentary-contact toggle switch for energizing a starting relay, which sends high voltage to the modulator.

TRANS FIL: Toggle switch for turning on the filaments of the tubes, starting modulator blower motors, and providing high voltage for the receiver.

POWER: Toggle switch which controls the 115-volt, 400-cycle, AC power supply, and the 28-volt DC power supply.

TILT UP-TILT DOWN: Toggle switch for starting and changing the direction of the tilt motor, which varies the tilt of the antenna.

MAN-AFC: Toggle switch for cutting the AFC circuit into or out of operation with the IF circuit of the receiver. When the switch is at MAN, the receiver operates without automatic-frequency control and you adjust the frequency with the OSCILLATOR TUNING control.

LINE VOLT - XTAL CUR: Momentary-contact toggle switch which causes dial above it to indicate either the crystal current or the line voltage. The dial indicates crystal current at all times except when you check for 115-volt line voltage by holding switch briefly at LINE VOLT.

RCT CUR-MOD CUR: Toggle switch for reading transmitter current. When the switch is at RCT CUR, the meter above it indicates average current flowing from the rectifier to the transmitter. When the switch is at MOD CUR, the meter indicates average discharge current of the capacitor into the output tube.

RANGE SWITCH: Control knob with three settings: 5-to-30-mile variable range, and 50- and 100-mile fixed ranges.

VARIABLE RANGE CONTROL: Selector switch, not labeled but at the right of the RANGE SWITCH, for varying the range of the equipment when RANGE SWITCH is at 5-30. Varies the range from 5 to 30 miles, approximately.

LUBBER-LINE INTENSITY: Screwdriver control for varying the brilliance of the lubber line on the scope.

VIDEO GAIN: Control knob for adjusting signal intensity on PPI and A scopes by increasing the amount of video amplification. In the counter-clockwise position, it provides minimum intensity; in the clockwise position, maximum intensity.

A SCOPE FOCUS: Screwdriver control for focusing electronic beam on A scope to make images more distinct.

A SCOPE BRILL: Screwdriver control for increasing the brilliance of the sweep trace on the A scope.

LOCAL PPI FOCUS: Screwdriver control for narrowing the electronic beam which produces the trace on the local scope. It brings the beam into focus and makes the images more distinct.

LOCAL PPI BRILL: Screwdriver control for increasing the brilliance of range marks on the local scope. In the counter-clockwise position, it produces minimum brilliance; in the clockwise position, maximum brilliance.

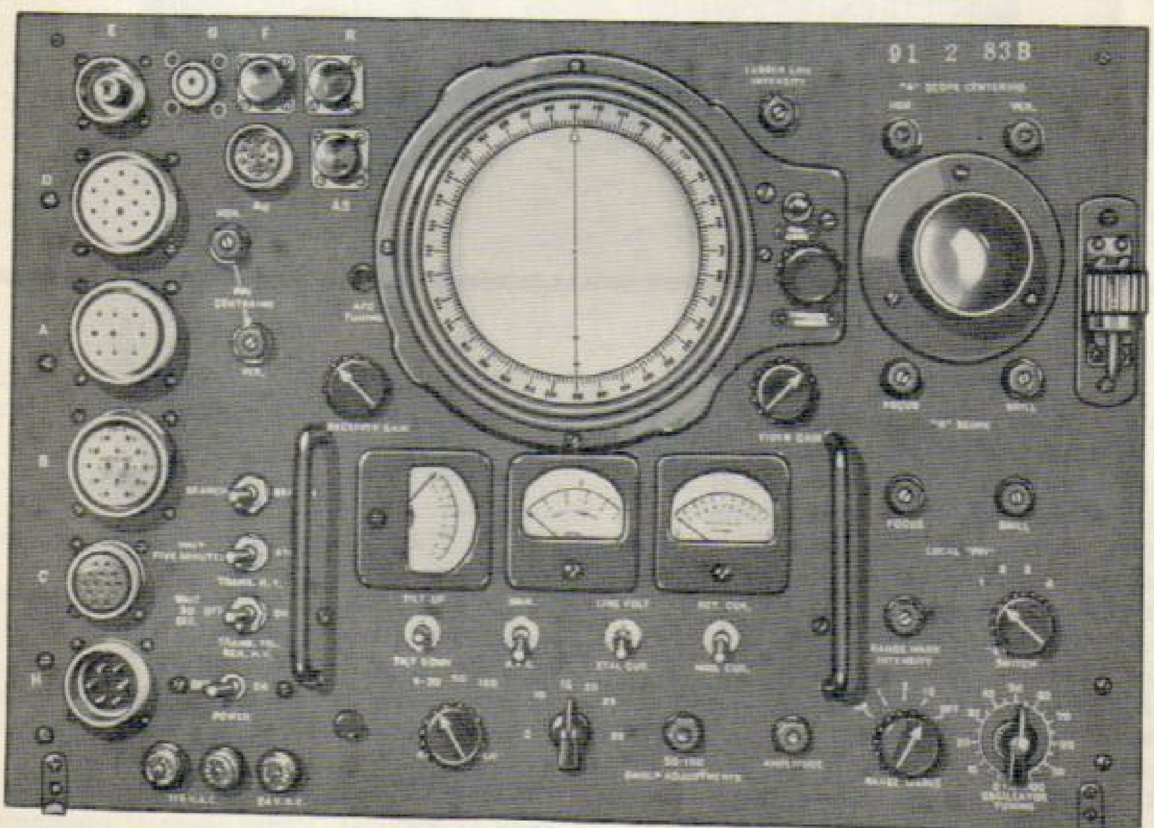
RANGE MARK INTENSITY: Screwdriver control for regulating the brilliance of range marks on both the local and remote scopes. In the counter-clockwise position, it provides minimum brilliance; in the clockwise position, maximum brilliance.

A SCOPE SWITCH: Control knob with four settings. Position 1 checks operating condition of receiver. Position 2 checks operating condition of transmitter. Position 3 checks AFC circuits. Position 4 checks the 5:1 divider of the range unit. Position 4 also checks coincidence of bomb-release marker with 1-mile mark when you calibrate the altitude dial. The bomb-release marker is applied to one plate of the A scope continuously.

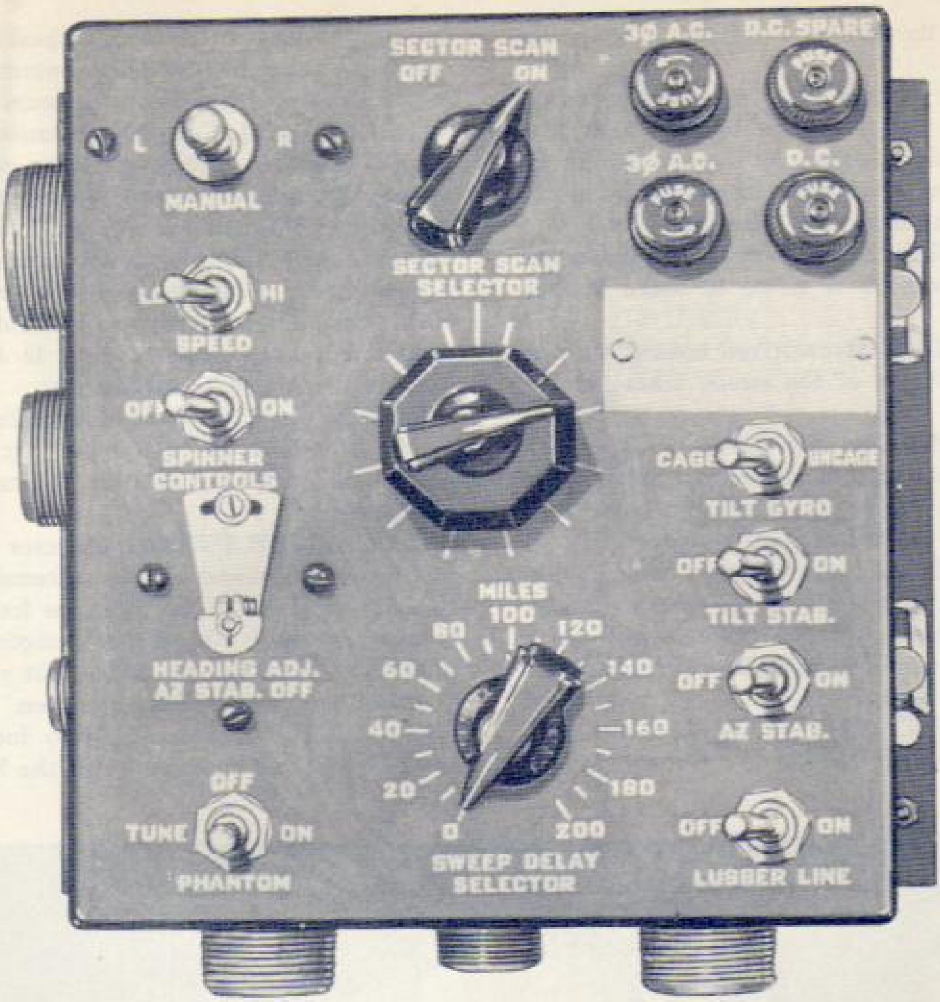
RANGE MARKS: Control knob for selecting 1-, 5-, or 10-mile range marks on any range of the equipment. In the BR position, it sets up the bomb-release circle.

OSCILLATOR TUNING: Selector switch for adjusting the frequency of the heterodyne oscillator to a difference of 30 mc. from the frequency of the transmitted pulse. This control functions only when MAN-AFC switch is at MAN, but you can use it in either search or beacon operation.

DIAL LIGHTS: Control knob for illuminating the azimuth ring on the edge of the PPI scope.



RECEIVER-INDICATOR



CONTROL UNIT

Control Unit

This unit contains most of the controls for operating your antenna. With it you can control the spinner, make adjustments for any degree of sector scanning you may require, up to 360°; provide tilt and azimuth stabilization, provide a lubber line, and select any amount of sweep delay you may choose from 0 to 200 miles.

There are four fuse holders mounted at the upper right-hand corner of the panel. The two at the left are for AC, the one at bottom right is for DC, and the one at top right is a DC spare.

The main controls of the control unit are:

MANUAL L-R: Momentary-contact toggle switch with which you can control the rotation of the antenna manually to the left or right.

SPEED LO-HI: Toggle switch for controlling speed of antenna's rotation. At LO it provides 12 rpm; at HI, 24 rpm.

SPINNER: Toggle switch for starting and stopping rotation of antenna.

PHANTOM: Momentary-contact toggle switch for controlling phantom target.

SECTOR SCAN: Selector switch for turning sector-scan action on or off.

SECTOR SCAN SELECTOR: Dual, concentric control knobs, one mounted above the other. Settings determine position and width of sector to be scanned.

SWEEP DELAY SELECTOR: Selector switch with 21 positions. Varies range of equipment from 0 to 200 miles by delaying sweep in 10-mile steps.

TILT GYRO: Toggle switch. At CAGE, it operates mechanism which holds the tilt gyro steady to avoid damage during violent maneuvers.

TILT STAB: Toggle switch for turning tilt stabilization on or off.

AZ STAB: Toggle switch for turning azimuth stabilization on or off.

LUBBER LINE: Toggle switch for turning lubber-line signal on or off. At ON, it places trace on PPI and PRI to show airplane's dead-ahead direction.

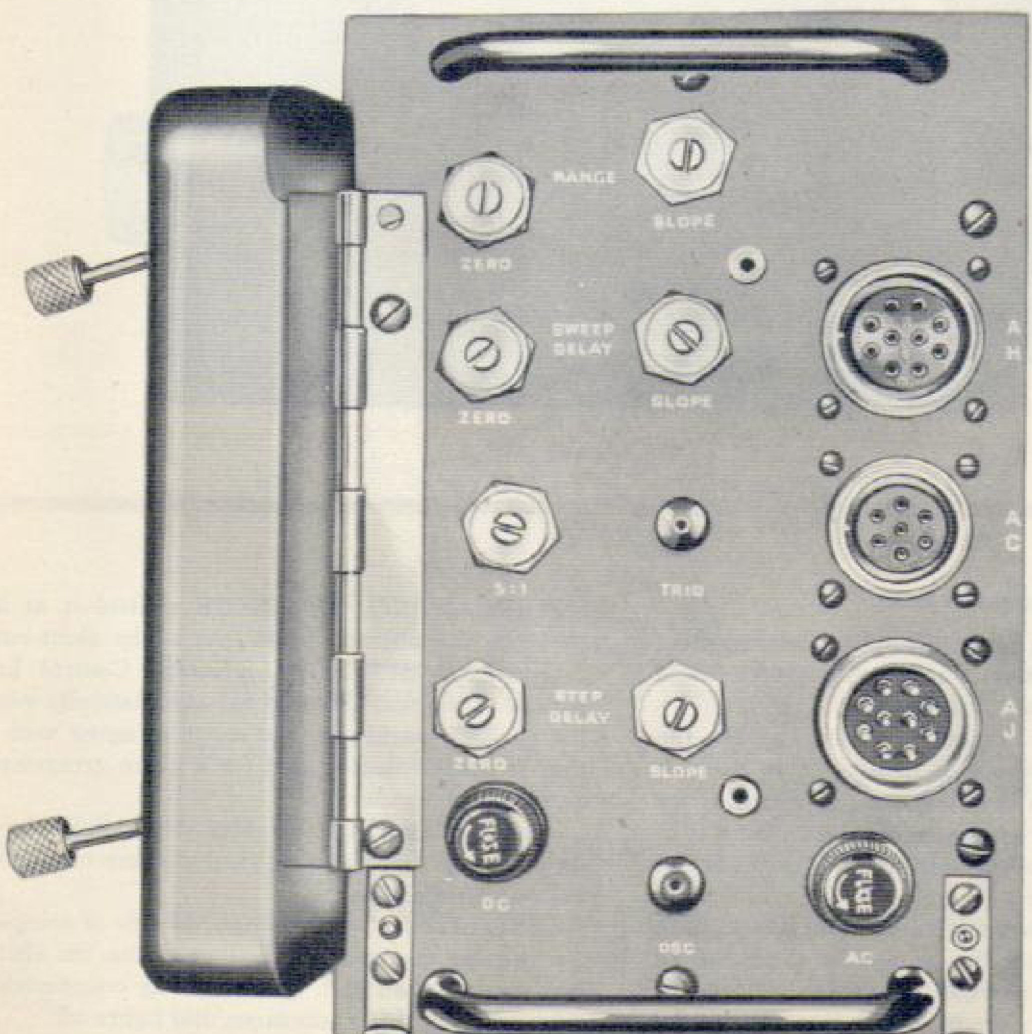
Range Unit

The primary job of the range unit is to provide crystal-calibrated circuits for all functions of your AN/APS-15A equipment. In addition, it provides delay and gate circuits, which make possible long-range navigation.

The front panel has seven screwdriver controls, three receptacles, two fuses, and two pin jacks for testing.

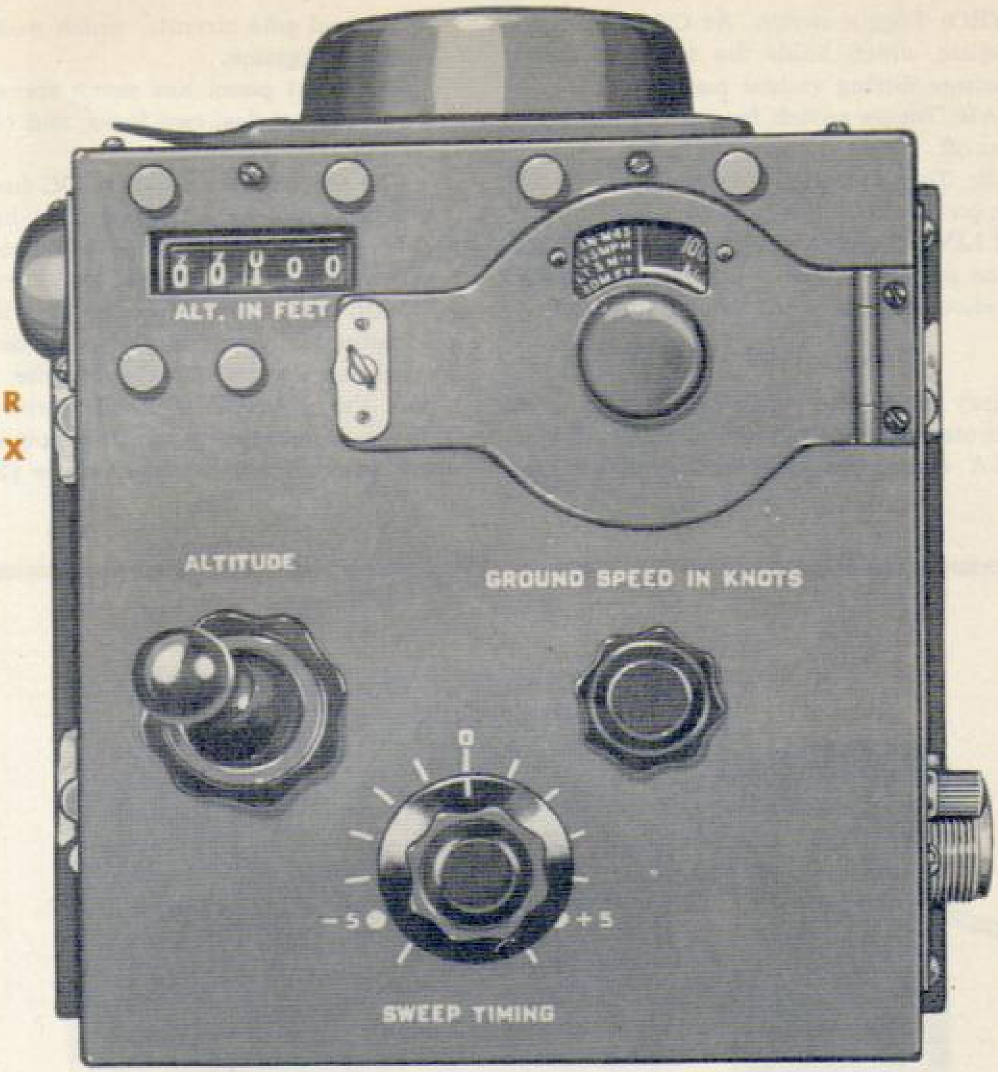
The screwdriver controls, DC fuse, and pin jacks are protected by a cupped door, hinged at the left side of the panel. The door is secured by two captive screws. To open it, release the screws.

With the exception of the fuse holders, the only adjustments you may have to use during actual operation are the 5:1 divider, the RANGE ZERO, and the RANGE SLOPE screwdriver controls. These are corrective controls you adjust when you calibrate the bomb-release circle (See ROBIF 2-7).



RANGE UNIT

COMPUTER BOX



Computer Box

The computer box automatically computes slant range when you set in your exact altitude and groundspeed. The main controls are:

SWEEP TIMING: Control knob for varying the beginning of the sweep. By turning it to the left from 0 (center), you can introduce as much as six miles of open center on the scope. By turning it to the right from 0, you can introduce as much as six miles of altitude delay.

ALTITUDE: Crank knob for varying the position of the BR marker on the scopes. It is geared to the counter above it, which measures altitude or slant range (in feet) up to 90,000 feet. When the GROUND SPEED IN KNOTS control is at its 0 position, the altitude indication is the slant range.

GROUND SPEED IN KNOTS: Control knob, geared to the dial above it, for automatically adjusting the BR marker on the scope to agree with the proper bomb-release point for a given groundspeed and type of bomb.

Twelve interchangeable discs are available for use on the computer, covering various types of bombs at various true airspeeds.

DIAL LIGHT: Control knob, on side of computer, for varying the amount of illumination on altitude and groundspeed dial. In completely counter-clockwise position, this knob turns dial lights off.

AN/APS-15A ★ Calibration

Bomb-Release Circle

Calibration of the AN/APS-15A is essentially a job for the mechanic. However, common sense dictates that you should be able to calibrate the set's bomb-release circle in flight. The mechanic may have forgotten to do it or, just as bad, may not have done a thorough job of it.

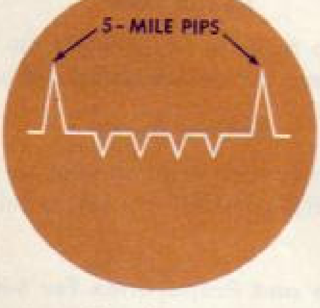
The units involved are the receiver-indicator, the range unit, and the computer box. You are already familiar with their various controls.

Here is the way to calibrate the bomb-release circle:

You must make two checks: a 5:1 divider check, and an altitude check. The best time to make them is just before your bombing run, i.e., prior to your approach to the IP.

5:1 Divider Check

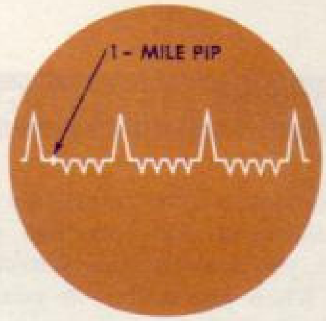
1. After the set has been operating for some time, turn the A SCOPE SWITCH to 4, the RANGE SWITCH to 5-30, and the variable range control to 5.
2. Check the wave form on the A scope. It should look like this:



The wave form has four negative pips between two positive pips. (If it does not appear this way, open the cover of the range-unit panel, and turn the 5:1 screwdriver control until you get the proper wave form on your A scope.)

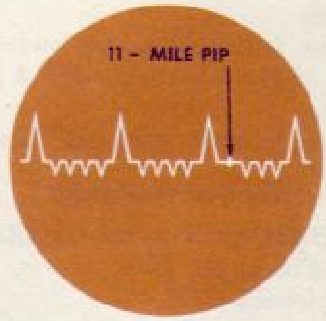
Altitude Check

1. Leave the A SCOPE SWITCH at 4 and the RANGE SWITCH at 5-30.
2. Move the variable range control to 15.
3. Crank the ALTITUDE control on the computer box until you get a 6000-foot reading on the dial. At this point the wave form on the A scope should look like this:



As you can see, the first-mile pip on the A scope has collapsed. If the pip does not collapse, open the range unit again and adjust the RANGE-ZERO screwdriver control until the pip collapses.

4. Crank the ALTITUDE control again until the dial reads 66,800 feet. The wave form then should look like this:



Note that the eleventh-mile pip has now collapsed. If it hasn't, adjust the RANGE-SLOPE control on the range unit until the pip collapses.

For all practical purposes the altitude check is now complete. However, play safe and check your results three or four times. Only then can you be sure that you've calibrated the bomb-release circle correctly.

Remember: Never attempt this calibration unless you are confident you can do it properly!

AN/APS-15A ★ Tuning

PRE-TUNING

In order to protect some of the circuits and insure smooth operation, you must pre-tune your AN/APS-15A. First, you must set the controls in specified positions. When you arrive at your airplane, complete the checks and verify the control positions listed here:

Transmitter Assembly

1. Check pressure pump to see that switch is off. Check 5-amp fuse for condition and security.
2. Check the 5-amp and 10-amp fuses on the transmitter panel. You need a 4½-inch screwdriver to accomplish this.
3. Check the four-position tap switch in either No. 1, No. 2, or No. 3 position. (No. 4 position is a dead position.)
4. Make sure that all cables are hand-tight.

Receiver-Indicator

1. SEARCH-BEACON switch at SEARCH.
2. TRANS-FIL switch OFF.
3. POWER switch OFF.
4. Check the two 115v AC fuses and the 24v DC fuse for condition and security. Be sure that each 115v AC fuse holder contains a 10-amp fuse and that the 24v DC fuse holder contains a 15-amp fuse.
5. RECEIVER GAIN fully counter-clockwise.
6. VIDEO GAIN fully counter-clockwise.
7. AFC—MAN switch at MAN.
8. Turn the following screwdriver controls counter-clockwise as far as they will go: A SCOPE BRILL, LOCAL PPI BRILL, 50-100 SWEEP ADJUSTMENTS, and AMPLITUDE.
9. Make sure that all the receiver-indicator cables are hand-tight.

Control Unit

1. SPINNER CONTROLS and SECTOR SCAN switches OFF.
2. SWEEP DELAY SELECTOR at 0.
3. LUBBER LINE and AZ STAB switches OFF.
4. Make sure all control unit cables are hand-tight.

Computer Box

1. Crank ALTITUDE knob until ALT. IN FEET dial reads 00000.
2. GROUND SPEED IN KNOTS dial at zero line.
3. SWEEP TIMING knob at 0.
4. Make sure that all the computer box cables are hand-tight.

Range Unit

Check 2-amp fuses in the holders on the bottom of the equipment for condition and security.

Remote Scope

If you have a remote scope in your airplane make sure that its BRILLIANCE control is fully counter-clockwise.

Tune-up and Preparation for Search

After takeoff, before you turn the POWER switch ON, make sure the airplane's central power system is working properly. For efficient operation of the set, the power output from the central power system should be 28 volts DC, plus or minus ½ volt. Any voltage above these limits may injure your set.

In a B-17, check with the pilot; in a B-24 or B-29, check with the engineer. When you are satisfied that the central power system is OK, tune up as follows:

TUNE-UP PROCEDURE

1. Turn POWER switch ON.
2. Place INVERTER SELECTOR switch either at No. 1 or No. 2 position.
3. Push inverter starting button.
4. Place LINE VOLT—XTAL CUR switch at LINE VOLT and check voltage meter for an indication of 115v. If the meter does not indicate 115v., adjust the voltage by means of the screwdriver control on the inverter control box.
5. Wait 30 seconds. Flip TRANS FIL switch ON. Make a note of the time you take to do this.
6. Tell the pilot you want to lower the radome, and on his OK, lower it.
   Caution: Never lower the radome at an indicated airspeed above cruising speed.
7. Set A SCOPE SWITCH at 1.
8. Turn A SCOPE BRILL clockwise until trace is visible on A scope.
9. Adjust A SCOPE FOCUS until you get a sharp line.
10. Adjust A SCOPE CENTERING HOR and VER until sharp line is centered on A scope.
11. Turn LOCAL PPI BRILL clockwise until trace is just visible on PPI scope.
12. Adjust LOCAL PPI FOCUS until you get a sharp line.
13. Turn AMPLITUDE clockwise until trace extends halfway across PPI scope.
14. Turn RANGE SWITCH to 100.
15. Turn VIDEO GAIN three-quarters to all the way clockwise.
16. Set RANGE MARKS switch at 10.
17. Turn RANGE MARK INTENSITY clockwise until range marks appear. Count range marks.
18. Turn 50-100 SWEEP ADJUSTMENTS slowly clockwise until 10 range marks appear, the tenth at the end of the sweep.
19. Flip SPINNER CONTROLS switch ON and SPEED LO-HI switch to HI.
20. Adjust PPI CENTERING HOR and VER until trace sweep is centered on scope; i.e., until the hole at the start of the sweep is in the exact center of the scope.
21. Adjust AMPLITUDE until 10th range mark is at edge of scope.
22. Turn RANGE SWITCH to 50. Make sure there are five range marks on scope. Turn RANGE MARKS switch to 5 and check for ten 5-mile range marks.
23. Turn RANGE SWITCH to 5-30.
24. Turn variable range control to approximately 5.
25. Turn LOCAL PPI BRILL counter-clockwise until trace disappears. Wait for a moment, then turn it clockwise slowly until you get a faint trace.

   If 5 minutes have elapsed since you turned the TRANS FIL switch ON, you are now ready to turn TRANS HV switch ON.

   Caution! If the temperature is extremely low, wait 5 to 10 minutes longer.

26. Turn TRANS HV switch on. Push switch to START, then release it.

27. Flip LINE VOLT-XTAL CUR switch to LINE VOLT. Check voltage meter for 115v.
28. Check transmitter current meter for 6 or 7 ma on MOD CUR position and 8 to 10 ma on RCT CUR position.

    Note: If correction for MOD CUR indication is less than 2.5 ma, adjust by using screwdriver vernier on the transmitter converter. If needed correction is more than 2.5 ma, use coarse adjustment on transmitter converter. (Four-place transformer primary-tap switch.)
29. Return transmitter current switch to MOD CUR.
30. Turn RECEIVER GAIN clockwise until approximately ¼ inch of grass (noise) appears on A scope.
31. Make sure that AFC—MAN switch is at MAN.
32. Tilt antenna toward ground (between 0° and −5°).
33. Turn OSCILLATOR TUNING switch until you obtain indication of approximate maximum deflection on XTAL CUR meter.
34. Pick up target on PPI scope by adjusting OSCILLATOR TUNING switch and antenna tilt control, then turn SPINNER CONTROLS switch OFF.
35. Flip SPEED LO-HI switch to LO.
36. Use MANUAL spinner control switch to stop sweep on target.
37. Turn OSCILLATOR TUNING control until you get maximum height of target trace on A scope.
38. Flip AFC—MAN switch to AFC and check to see that amplitude of target trace on A scope does not decrease.
39. If necessary, adjust AFC TUNING control until you get maximum height of target trace on A scope. This adjustment requires a 4½-inch screwdriver.

    Caution. Use extremely light pressure during adjustment.
40. Adjust antenna tilt control for return from farthest target.
41. Readjust LOCAL PPI BRILL and FOCUS controls to improve target definition.
42. Readjust RECEIVER GAIN and VIDEO GAIN to reduce noise and improve target definition.
43. Place SPEED LO-HI switch at HI and flip SPINNER CONTROLS switch ON.

    Your set is now tuned for normal search operation.

Tuning Tips

You can get maximum PPI-scope sensitivity out of your AN/APS-15A by using this procedure:

1. Turn RECEIVER GAIN fully CCW.
2. Turn VIDEO GAIN fully counter-clockwise.
3. Turn RANGE MARKS switch OFF.
4. Turn LOCAL PPI BRILL counter-clockwise until trace disappears. Wait a moment. Readjust the control clockwise until trace is just barely visible. This is your best setting for PPI brilliance.
5. Turn RECEIVER GAIN clockwise until you get a fairly bright picture on your PPI scope.
6. Readjust LOCAL PPI FOCUS for fine-line definition of the trace. For best results, turn the RANGE MARKS switch to 1 and adjust the focus for maximum definition on these range marks.

   Remember: You must readjust that focus every time you change the line voltage.
7. Reduce the picture by turning VIDEO GAIN clockwise until the picture has a normal brilliance level and good definition.
8. Conclude by setting the DIAL LIGHTS control for the degree of illumination you desire on the azimuth scale.

AN/APS-15A ★ *Operation*

SEARCH OPERATION

Most of the time you are going to be using your AN/APS-15A for search operation. In order to get the best possible results from the equipment, you must have a thorough knowledge of the operational uses of the following controls, and the effects they have on your PPI scope.

Azimuth Stabilization

When you flip the AZ STAB switch ON, true or magnetic north appears at 0 on the scope. If the local magnetic variation has been set into the flux-gate compass system, the returns on the scope are always going to appear in their proper relation to true north, regardless of the airplane's heading.

You must have some way to indicate this heading on the scope. The lubber line of the set provides the means. When you turn the LUBBER LINE switch ON, the lubber line appears on the scope and indicates true or magnetic heading.

Ranges

There are three ranges, 5-30, 50, and 100, available for your use on the RANGE SWITCH.

When you turn the switch to 50, the picture on your PPI scope represents an area 50 miles in slant-range radius around your airplane.

With the switch at 100, the scope presents a slant-range radius of 100 miles.

The 5-30 position of the switch is variable. Pick out the particular area you wish to range by adjusting the variable range control, which is located at the right of the RANGE SWITCH.

Your slant-range radius is approximately 5 miles when the variable range control is turned fully counter-clockwise, and approximately 30 miles when it is turned fully clockwise.

In navigation, where large picture areas come in handy, use the higher ranges. In bombing, where you need better definition, use the lower range.

Range Marks

The range marks appear on the PPI scope as concentric circles of light at 1, 5, or 10 miles, depending on how you set the RANGE MARKS switch. Use these marks to determine your exact slant range to any target.

Altitude-Delay Circuit

Use the altitude-delay circuit when you wish to eliminate the altitude hole in the center of your PPI scope.

You introduce altitude delay into the AN/APS-15A when you turn the SWEEP TIMING control to its plus values. **You can use sweep timing only on the 5-30 range; it has no effect on the 50- and 100-mile ranges.**

When you use altitude delay, simply turn your SWEEP TIMING control in the positive direction to the setting which corresponds to your exact altitude, anywhere up to 6 miles. This eliminates the altitude hole. Add this setting to your first range mark to determine your range.

Open-Center Circuit

When the RANGE SWITCH is at the 5-30 position, targets appearing near the center of the PPI scope tend to become crowded and you lose definition because of their excessively bright return. You can overcome this hindrance by using the open-center circuit, which is controlled by the negative values on the SWEEP TIMING control.

Remember: You can use open center only on the 5-30 range.

Sweep Delay

Sweep delay is used primarily in beacon operation, for radar navigation and homing.

BEACON OPERATION

Inasmuch as search operation is the primary function of your AN/APS-15A and you use beacon operation only intermittently, you can start beacon operation with the assumption that your set already is functioning according to the search-operation procedure previously described.

You must take several additional steps, however, to tune the set for beacon operation:

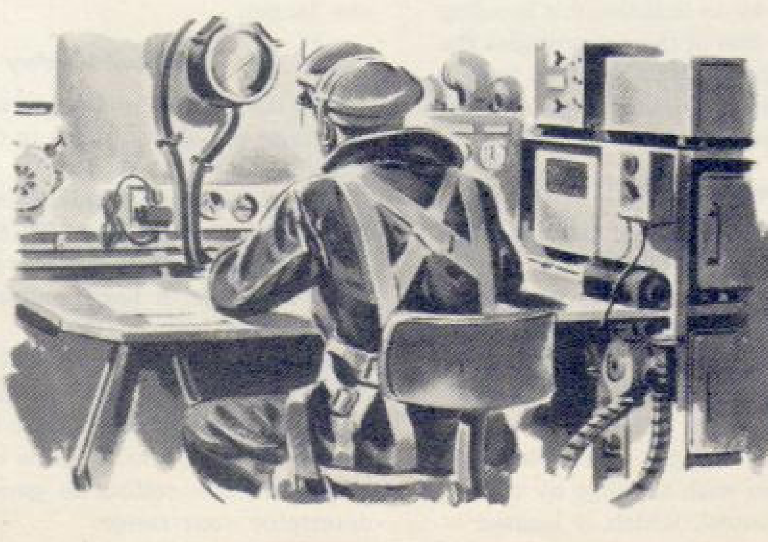
1. Flip SEARCH-BEACON switch to BEACON.
2. Tilt the antenna about 2° above normal search operation.
3. Rotate OSCILLATOR TUNING control to obtain near-maximum crystal current and adjust around this point to pick up beacon signals on your PPI scope.

Note: You may have to raise or lower the antenna tilt slightly to pick up these signals.

4. When you have located the beacon approximately, use SECTOR SCAN as required.
5. Use SWEEP DELAY SELECTOR to obtain necessary range for bringing in beacon signals.

Turning the AN/APS-15A OFF

1. Flip SPINNER CONTROLS switch OFF. On early models, the rotation of the PPI sweep may be counter-clockwise if, after you last used sector scan, you turned the SECTOR SCAN switch OFF before you flipped the SPINNER CONTROLS switch OFF.
2. Turn the following controls counter-clockwise as far as they will go:
   RECEIVER GAIN
   VIDEO GAIN
   LUBBER LINE INTENSITY
   A SCOPE BRILL
   LOCAL PPI BRILL
   RANGE MARK INTENSITY
3. Turn TRANS FIL switch OFF.
4. Turn POWER switch OFF.



AN/APS-15A ★ *Maintenance*

Although the amount of trouble shooting you can do on the AN/APS-15A is limited because of the complexity of the equipment, there are certain types of trouble you can readily remedy.

Any trouble you cannot correct should be localized to the particular unit causing the trouble. Enter all information about the faulty unit, together with a description of the symptoms, in your AAF Form 38, Radar Operator's Report Section, along with all the required entries for completion of the form.

The following checklist does not provide a panacea for all your maintenance troubles, but it should help. Use it.

Caution: Turn off equipment before you replace any fuse. Always replace a fuse with another of the same size.

TROUBLE	CHECK
Inverters	
Insufficient voltage. (less than 115v)	Adjust voltage screw on inverter control box. If voltage is still low, check with pilot or flight engineer on status of 28v DC central power system.
Inverter inoperative.	Switch to another inverter.
Auxiliary inverter fails.	Check fuses inside inverters by removing inverter-top covers. Replace blown fuses with spares provided.

Caution: Be careful not to short fuse clips against inverter housing when you are replacing fuses.

TROUBLE	CHECK
Receiver-Indicator	
Receiver-indicator inoperative.	Check 15-amp DC fuse.
PPI and A scopes inoperative. No meter readings.	Check 10-amp AC fuses.
Azimuth stabilization inoperative.	Check 1 ½-amp torque-amplifier fuse.
Picture on PPI scope revolves continuously with AZ STAB switch ON.	Turn AZ STAB switch OFF. If rotation continues, flip LUBBER LINE switch ON, loosen cable AG on torque amplifier, and disconnect it when lubber line is at 0 on the scope.
AFC inoperative	Turn AFC-MAN switch back to MAN, and use manual tuning.
PPI scope shows a mass of unintelligible light streaks when you turn from a low range to 100-mile range (double-triggered sweep).	Check 115v AC. Make adjustments if necessary. Then turn 50-100 SWEEP ADJUSTMENTS and AMPLITUDE controls counter-clockwise. Re-set controls carefully, using regular tune-up procedure for 100-mile range position.
Sweep rotates counter-clockwise.	Turn SPEED LO-HI switch to LO and snap SECTOR SCAN switch ON and OFF, making certain to turn it OFF when sweep is corrected.
No PPI scope picture.	Check MOD CUR and RCT CUR. If MOD CUR is nearly 0 and RCT CUR is only 2 or 3 ma, the power amplifier (715-B) tube in the transmitter, or the transmitter tube itself, is faulty. Note in AAF Form 38.
Range Unit	
Range unit inoperative.	Check 2-amp AC fuse.
Blower motor inoperative. Unit overheats.	Check 2-amp DC fuse.

AN/APQ-5B ★ *Description*

AN/APQ-5B is auxiliary radar equipment installed in the bombardier's compartment. He operates it, with your cooperation and in combination with your radar equipment and the usual equipment for visual bombing, to make blind spot-bombing possible. Although it was designed for low-altitude operation, he can use it with reasonable accuracy up to 40,000 feet.

It functions efficiently day or night at temperatures ranging from $-40°$ C to $+50°$ C ($-40°$ to $+122°$ F), and in relative humidities as high as 95%.

AN/APQ-5B is normally used with airborne search radars such as SCR-717A, SCR-717B, AN/APS-15A, AN/APQ-13, and the ASC, ASD, ASD-1, and ASH types. If properly installed it does not interfere with the normal functioning of associated equipment.

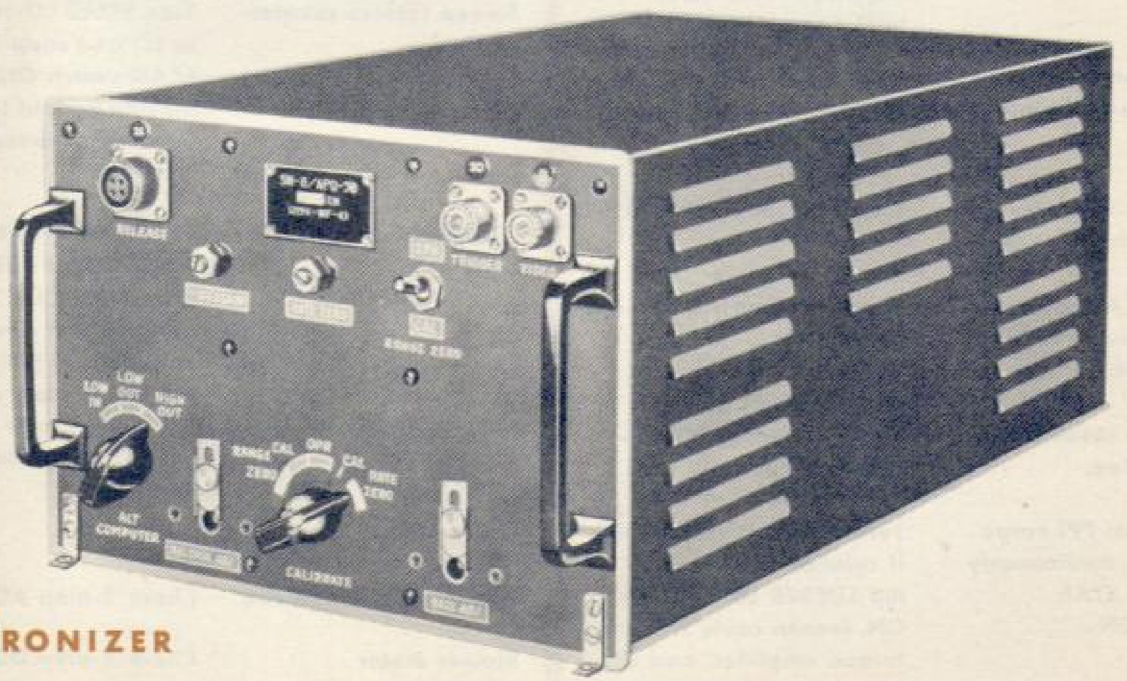
It also can be used as a search indicator with a range of 18 statute miles. This comes in handy when the bombardier is trying to locate a target at the beginning of a bombing run.

Finally, the AN/APQ-5B can be made to release a train of bombs, centered on the target, with a normal spread of 830 feet between the first and last bombs in the train. Operational tests of its use in this connection, made at an average airspeed of 160 mph, indicate a radial error of less than

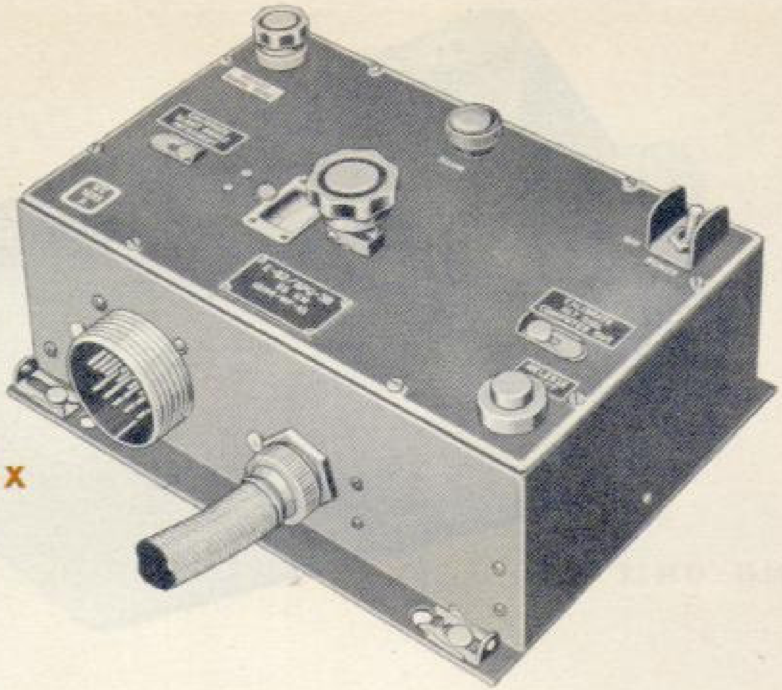
150 feet at altitude of 500 feet.
175 feet at altitude of 1000 feet.
185 feet at altitude of 1500 feet.
240 feet at altitude of 2000 feet.

The greater part of this error is in range rather than deflection. A train of three bombs should give a direct hit.

AN/APQ-5B indicator equipment contains eight major assemblies: synchronizer, control box, tracking unit, indicator, rectifier, junction box, capacitor unit, and compensator. Additional equipment required to obtain most effective results with the AN/APQ-5B, other than the usual search-radar installations, includes a bombsight stabilizer and Adapter Kit MX-30/APQ-5A.



SYNCHRONIZER



CONTROL BOX

Synchronizer

This unit is the heart of the AN/APQ-5B set. Operating from the radar trigger and video pulses and from data supplied by the control circuits, the synchronizer generates the necessary sweep for the scope. It also produces the desired track and release pulses at the proper instants. When the airplane approaches the release point in flight, the synchronizer fires the release relay electrically. The main controls are:

ALT COMPUTER: Selector switch with three settings, LOW IN, LOW OUT, and HIGH OUT.

At LOW IN, the range of the set is from 65 to 2000 feet. Computer is operative. Slant-release distance is computed automatically. Velocity and altitude dials (on tracking unit) indicate correctly.

At LOW OUT, the range is from 2000 to 5000 feet. Computer is inoperative. Slant-release distance is computed by setting the altitude dial manually. Spread dial (on control box) indicates directly in feet.

At HIGH OUT, the computer is inoperative. Slant-release distance is determined by altitude-dial setting and B factor inserted on spread dial.

VIDEO: Screwdriver control which adjusts the video signals on the B scope as they come from the associated radar set.

RATE ZERO: Screwdriver control which is used to set the tracking pip at zero velocity when the operator of the set is using the rate-zero control.

RATE ADJ: Screwdriver control used to calibrate the relative-velocity dial.

RANGE ZERO: Toggle switch used to insert trigger into video circuit.

CALIBRATE: Selector switch with five settings:

At RANGE ZERO the trigger pulse from the associated radar equipment is inserted into the bomb-release circuit for use in calibrating the release line. Operator does this calibration on the spread dial.

At the two settings marked CAL, the ground mechanic calibrates the set for range and rate.

The OPR position is used on the bombing run.

At RATE ZERO the operator calibrates the set for altitude, with the ALT COMPUTER at HIGH OUT. The position of the CALIBRATE switch keeps the tracking pip from moving down the time base when the SEARCH-TRACK switch is at TRACK.

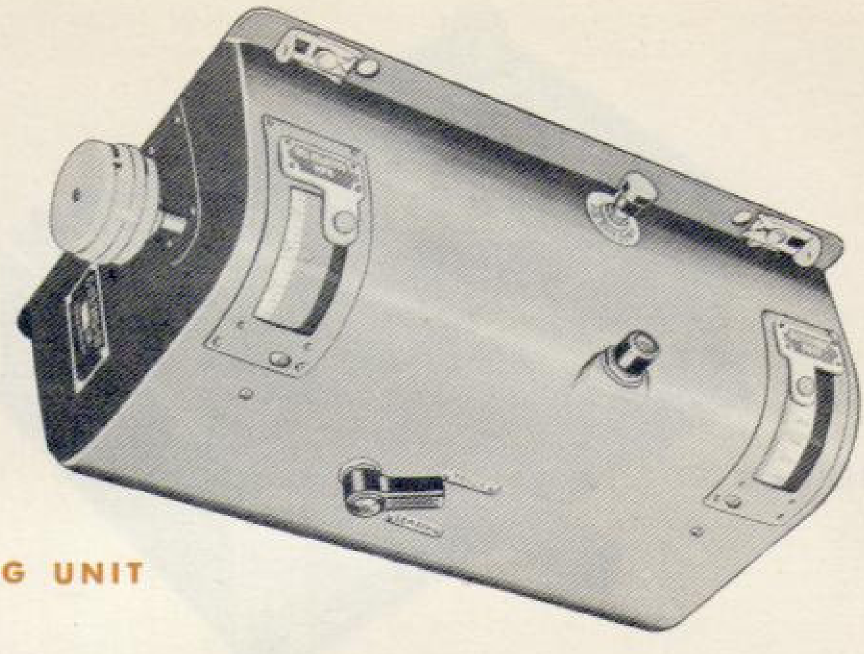
Control Box

The control box is at the bombardier's right, facing the front of the airplane. The main controls are:

POWER: Toggle switch which directly controls DC current and indirectly controls AC current to the set.

SLANT RANGE INCREMENT FEET: Control knob geared to dial which is commonly called the **spread dial.** Reads directly in feet. The spread dial has two functions:

1. For LAB it is used to add and subtract from the



TRACKING UNIT

slant-range release distance. Increasing the setting provides correction for bombs falling over. Decreasing the setting provides correction for bombs falling short.

2. For HAB it is used to insert the B factor of total slant-range release distance. In this case the dial reading is multiplied by 10 to show the B factor in total feet.

RELEASE RESET: Pushbutton used to re-set the bomb-release circuit during calibration. Re-sets the release relay, which is closed when the set is fired.

ILLUM: Control knob which regulates the amount of light on groundspeed, altitude, and spread dials.

ADJUST RANGE ZERO: Positions the release pip on the leading edge of the trigger when the equipment is being calibrated for range zero.

CALIBRATE SLANT RANGE INCREMENT: Screwdriver control used to calibfate the proper range on the slant-range increment dial for HAB.

CALIBRATE ALT DIAL COMPUTER OUT: Screwdriver control used to calibrate the altitude dial for computer-out bombing.

Tracking Unit

This unit contains the position, altitude, and groundspeed circuits. The main controls are:

ALTITUDE: Control knob and dial. They are used in three ways, depending on operating conditions.

In LAB, the operator sets absolute altitude into the dial. This establishes the basic altitude factor used in automatically computing slant-release distance.

In computer-out bombing, the operator sets a slant-release range into the altitude dial.

In HAB, the operator uses the altitude knob and dial to determine absolute altitude. The absolute altitude, when combined with indicated groundspeed, gives a B-factor setting for the spread dial in computing slant-release range.

REL VELOCITY MPH: Dial which indicates rate of closure.

RATE KNOB: Determines speed of tracking line.

POSITION KNOB: Determines position of tracking line.

SEARCH-TRACK: Selector switch with two positions. SEARCH provides range of 18 statute miles on the scope. (Bomb-release circuit is not cocked.) TRACK selects 1-mile sweep on the scope. Cocks bomb-release circuit and makes velocity control effective.

PILOT LIGHT: Indicates when power is on and when release circuit fires.

AUX RATE ZERO: Pushbutton used to stop the tracking line.

Indicator

The indicator, or B scope, contains a cathode ray tube and associated equipment. It provides radar pictures on a fluorescent screen for the bombardier.

A rubber hood shields the screen from stray light. High voltages, which the B scope requires, are supplied by the associated radar system.

The B scope obtains its sweep currents from the sweep circuits of the synchronizer and they may be brightened by range, echo, and release impulses from the video section of the synchronizer.

It provides a vertical sweep corresponding to approximately 19 statute miles for search operation, or an expanded sweep of approximately one mile for track operation.

In track operation, the horizontal range line appears as a trace in the center of the B scope.

For satisfactory tracking, the intersection of the center vertical crosshair with the horizontal range mark should coincide with the target trace.

When the airplane is approximately a half mile from the bomb-release point, the horizontal release trace appears at the bottom of the scope, and appears to move upward toward the range mark.

When the release trace coincides with the range mark the bomb is released automatically.

In search operation, the returns are similar to those picked up on most search-radar systems which use a B scope.

During search, the range marks appear between 0 and 9 miles on the scope, depending on the setting of the position control; the release trace appears near the bottom.

The main controls of the indicator are:

FOCUS: Control knob which focuses trace on scope in both search and track operation.

FOCUS SET: Thumbscrew which provides additional focus for trace in search and track operation.

H CENT: Thumbscrew which centers the trace horizontally.

DRIFT CORR: Thumbscrew with which operator determines ratio between movement of bombsight and shifting of trace on scope. Ratio should be 1:1.

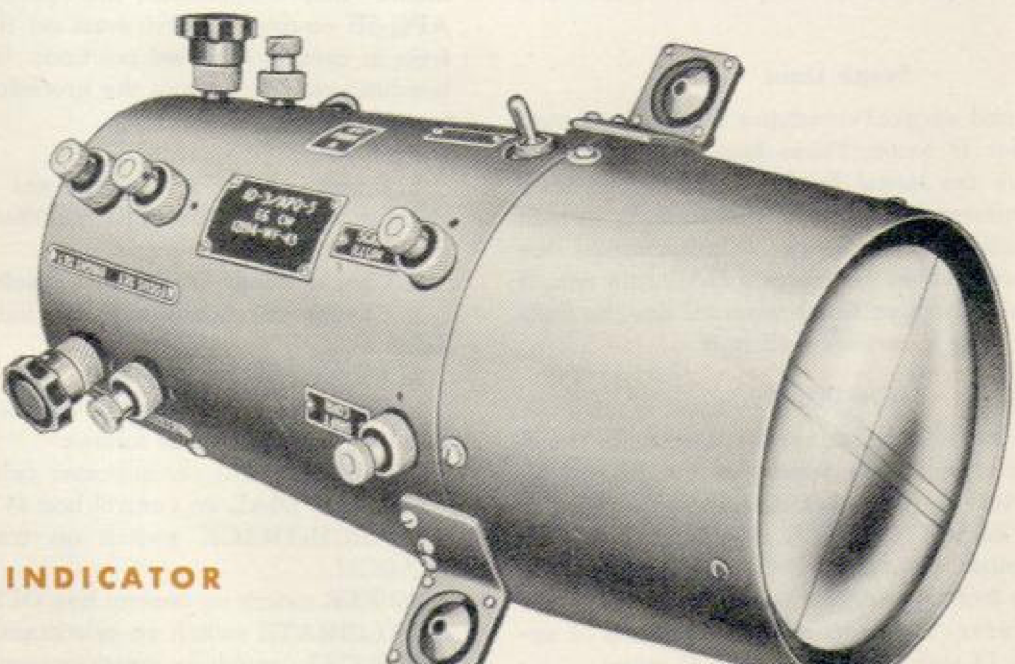
SCALE ILLUM: Thumbscrew which controls amount of illumination for the vertical lines on the scope.

BRIGHT: Control knob which governs brilliancy of returns in track operation.

BRIGHT SET: Thumbscrew which controls brilliancy of returns in search operation.

V CENT: Control knob which centers the trace vertically.

AZIM ON-OFF: Toggle switch which controls flow of azimuth voltage from radar antenna.



INDICATOR

AN/APQ-5B *Operation*

Since the AN/APQ-5B indicator is auxiliary equipment, it depends upon the associated radar equipment for:

1. A synchronizing or trigger pulse. AN/APQ-5B operator uses this pulse as the reference time.
2. A video or echo pulse for determining groundspeed and position settings.
3. An azimuth sweep for the horizontal deflection of the B scope.
4. A voltage for zone blanking, to prevent returns from objects to the rear of the plane from reaching the scope.

Scope Lines

Three etched vertical crosshairs form the azimuth scale on your B scope. These lines help the bombardier track the target for LAB. An etched horizontal line intersects the three vertical lines, ⅛ inch above the center of the scope. This horizontal line comes in handy when he makes a HAB rate run. If he places the return on this horizontal line, he finds it easier to judge a vertical shift in it.

Scope Display

When the set is in operation the display on the B scope depends upon the setting of the SEARCH-TRACK switch on the tracking unit.

With the SEARCH-TRACK switch at SEARCH, the synchronizer provides a 200-microsecond sweep which starts from the trigger pulse furnished by the associated radar. This puts a vertical sweep of approximately 18 statute miles on the B scope.

In addition, a horizontal mark or line, called the **tracking line**, appears anywhere between 3½ and 18 miles on the sweep, depending upon the setting of the POSITION control on the tracking unit.

When the SEARCH-TRACK switch is at TRACK, the set selects a 1-mile section of the 18-mile sweep and automatically positions it around the tracking line of the scope.

The bombardier uses both the SEARCH and TRACK positions—SEARCH to pick up his target, and TRACK to synchronize the computer unit during the bombing run. (See ROBIF 6-6.)

Pre-Bombing Procedure

In order to protect the indicator circuits and insure smooth operation, the operator of the AN/APQ-5B equipment first must set the various controls in certain specified positions. Up to the actual bombing run, he follows the procedure outlined below for both LAB and HAB.

Preflight:

1. Checks both the bombsight and autopilot clutches on the bombsight stabilizer for approximately 12 pounds of torque.
2. Checks bombs, racks, and shackles.
3. Checks the bomb-indicator lights against the bomb load.

In Flight:

1. Before he applies any power to the system, he positions the controls as follows:

BRIGHT control on indicator fully CCW.

SPREAD DIAL on control box at 0.

SEARCH-TRACK switch on tracking unit at SEARCH.

POWER switch on control box OFF.

CALIBRATE switch on synchronizer at OPR.

OPR-CAL switch on synchronizer at OPR.

ALT COMPUTER switch on synchronizer at LOW IN.

VIDEO GAIN counter-clockwise.

ALTITUDE dial on tracking unit at the altitude which is to be flown on the bombing run.

2. Turns on bombsight stabilizer and servo motors.

3. Asks you to turn inverter ON.

4. Turns POWER switch ON.

5. Waits two minutes for equipment to warm up.

6. Rotates BRIGHT control knob on indicator clockwise until sweep appears.

7. Has you stop your spinner dead ahead.

8. Flips AZIM switch on indicator OFF. Places drift index on bombsight stabilizer at 0.

9. Removes connector plug from compensator potentiometer on bombsight stabilizer. Uses H CENT control on indicator to center tracking line on center line of B scope.

10. Replaces connector plug on compensator potentiometer. If tracking line moves, he sets screw on top of compensator potentiometer and adjusts shaft until tracking line is centered again. Makes sure that drift index on bombsight stabilizer is at 0 when he is making this check. If the tracking line doesn't move, he simply replaces plug.

11. Flips AZIM switch ON. If you have your spinner on 0 azimuth, the tracking line should not move from the center line. If it does move, the bombardier's indicator equipment still will operate correctly, even though he can't correct the difficulty in flight. He makes a note of it on his operator's report and enters same on Form 1A.

12. Moves drift index to right drift on scale and checks to see if tracking line moves to the left on the scope. If it moves to the right, the compensator potentiometer is 180° out of phase. He adjusts it by loosening set screw on the compensator potentiometer and turning shaft through 180°.

13. Flips SEARCH-TRACK switch to TRACK and narrows tracking line with the FOCUS knob. Returns switch to SEARCH.

14. Has you start spinner rotating.

15. With AZIM switch ON and SEARCH-TRACK switch on TRACK, he adjusts VIDEO GAIN control on synchronizer and BRIGHT knob until he obtains a satisfactory picture on his scope.

16. Moves SEARCH-TRACK switch to SEARCH and, if necessary, re-sets intensity by using BRIGHT SET control on indicator.

Note: You must get a good picture on your scope before the bombardier attempts to set his GAIN SET or BRIGHT SET controls.

17. Checks operation of release relay:

GROUNDSPEED dial on tracking unit should indicate 375.

Tracking line should be at lowest point.

When he switches to TRACK, bomb-release line should rise, coincide with tracking line, and operate release relay. Red light on tracking unit should burn until relay is fired.

18. Calibrates RANGE ZERO, as follows:

Brilliancy down.
SEARCH-TRACK switch on SEARCH.
RANGE ZERO toggle switch to CAL.
CALIBRATE switch on RANGE ZERO.

Turns SPREAD DIAL to 0 and turns ADJUST RANGE ZERO knob on control box fully CCW.

Turns SEARCH-TRACK switch to TRACK.

Turns ADJUST RANGE ZERO knob until red light on tracking unit comes on.

Checks range zero by re-setting release relay with RELEASE RESET button on control box and by turning SPREAD DIAL to −250. **Note:** This is the only time he has to use the RELEASE RESET button.

Turns SPREAD DIAL up to ZERO. Red light should then go off and set should fire at 0.

He is now ready to make a bombing run.

How to Turn Equipment Off

When the bombardier is through using the AN/APQ-5B equipment, he must:

1. Throw POWER switch on control box OFF.
2. Position controls as follows:

BRIGHT	Fully CCW
SPREAD DIAL	0
ALTITUDE dial	65
SEARCH-TRACK switch	SEARCH
CALIBRATE switch	OPR
RANGE ZERO switch	OPR
ALT COMPUTER switch	LOW IN

AN/APQ-5B *Maintenance*

There are times when the bombardier finds it necessary to adjust or replace equipment which is giving him trouble in flight. In this event the following checklist may help him:

TROUBLE	CHECK
Scope entirely blank.	Check 5500 Hi-Volt cable for tightness of cannon-plug connection.
Scope still blank.	Check power cable for tightness of cannon-plug connection.
Scope picture only a dot at bottom of scope.	Check smallest shielded cable at rear of synchronizer for tightness of plug.
Scope picture still only a dot at bottom of scope.	Check positions of TRIGGER and VIDEO cables at synchronizer.
Scope picture has jumpy or erratic trace.	Check RECTIFIER cable, on rear of rectifier, for tightness.
Scope picture only half complete. Trace moves out to center and stops, or moves from center to side.	Check AMP fuses to the antenna J box on front framework of spinner.
No release of bombs, though bomb-bay doors are open, red light on bomb panel is on, racks are in SELECT, rack switches ON, and the red release light on the control box is on.	Check release cable on face of synchronizer for tightness of cannon-plug. Follow cable from synchronizer to bomb-rack panel, and check bottom row of screws. Screws 4 and 2 should be connected to wires from release cable.

TROUBLE	CHECK
No release trace.	When switch is at TRACK, if no release line shows on the scope, something is wrong with synchronizer. Make a note of fact on operator's report and enter same on Form 1A.
Release trace comes up but control box does not fire.	Something wrong with synchronizer.
Set fails to start.	1. Check the two 15-amp AC fuses in junction box on right-hand side of nose compartment. There are spares inside the cover. 2. Check inverter voltage. Should be 120v. If not, have radar operator adjust potentiometer under the inverter switch. At the same time have him check his control-box fuses; then check inverter opposite APU unit beneath flight deck, for burned-out fuses. In general, all voltages must be steady for proper operation. Check with flight engineer to be sure you are getting 28v from airplane generators.

OPERATIONAL DIFFERENCES BETWEEN THE APS-15, APS-15A, AND APQ-13

APS-15	APS-15A	APQ-13
PRESENTATION		
PPI scope on rec-ind and remote PRI scope for target presentation. A scope on rec-ind for tuning and monitor use.	PPI scope on rec-ind and remote PRI scope for target presentation. A scope on rec-ind for tuning and monitor use.	Two PPI scopes, each mounted separately for target and tuning use.
MONITOR SCOPE		
A scope on rec-ind with 4-position switch to choose signal: 1. Video output for tuning and determining altitude. 2. Transmitter triggering pulse. 3. AFC tuning indication. 4. 10:1 divider (range unit) calibration.	A scope on rec-ind with 4-position switch to choose signal: 1. Video output for tuning and determining altitude. 2. Transmitter triggering pulse. 3. AFC tuning indication. 4. Five-mile and 1-mile range marks for count check.	None.
SCOPE CONTROLS		
1. A-scope brilliance, focus, and centering controls above and below A scope on rec-ind. (All screwdriver controls.) 2. PPI scope centering control to left of scope. Focus and brilliance controls below and to the right on rec-ind. (All screwdriver controls.) 3. Remote or PRI scope centered by same controls on rec-ind. Focus control on top of PRI case.	1. A-scope brilliance, focus, and centering controls above and below A scope on rec-ind. (All screwdriver controls.) 2. PPI scope centering control to left of scope. Focus and brilliance controls below and to the right on rec-ind. (All screwdriver controls.) 3. Remote or PRI scope centered by same controls on rec-ind. Focus and brilliance controls on top of PRI case.	Separate brilliance, focus, and centering knobs mounted on each indicator.
INDICATION OF RANGE ON SCOPE		
None.	None.	Light above hood of scope for each range goes on when that particular range is used.

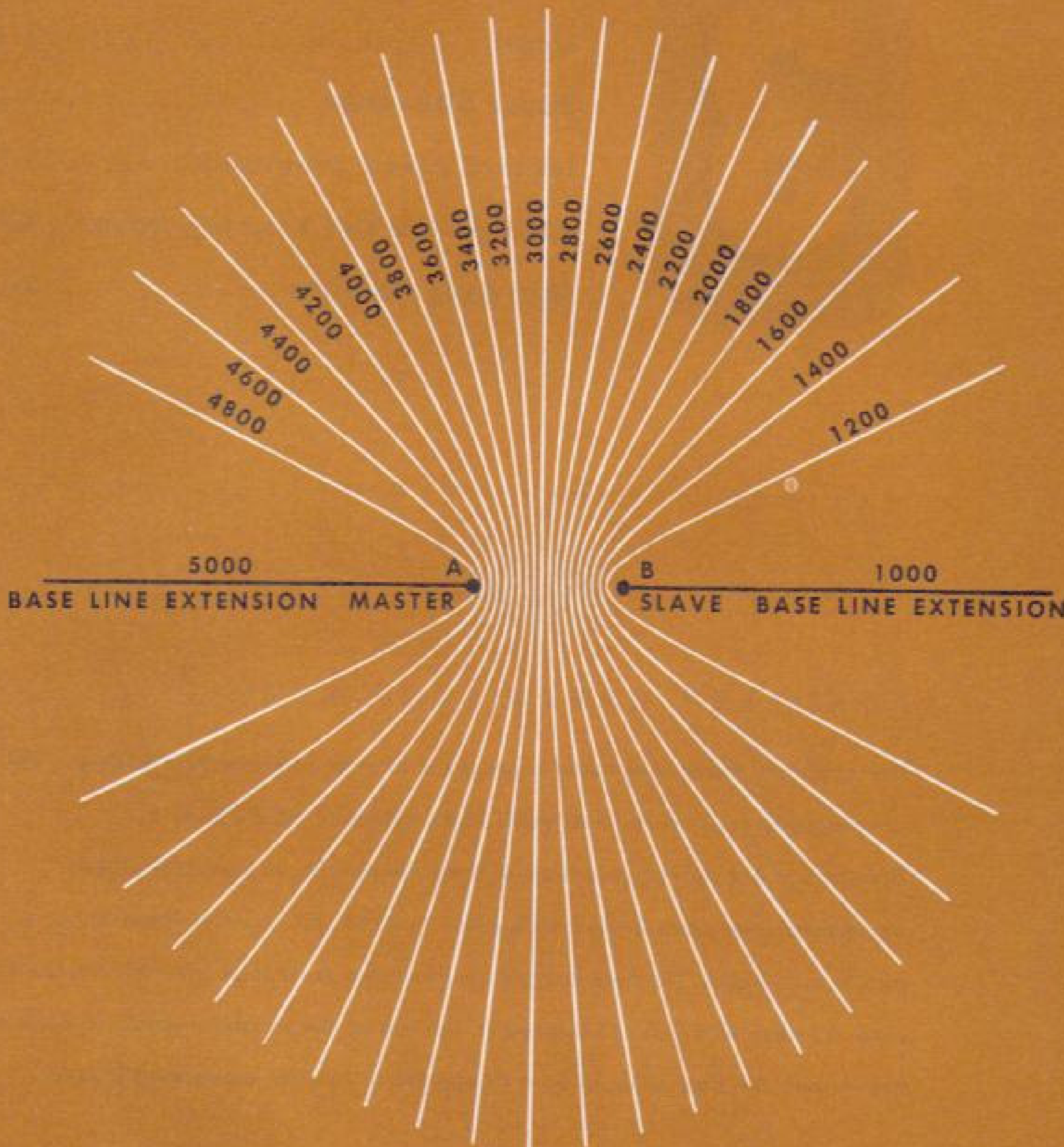
	APS-15	APS-15A	APQ-13
RANGE	5-, 20-, 50-, or 100-mile range by range switch on rec-ind unit. Range unit cannot be used with 100-mile range.	5-30-mile expandable range can be adjusted by knob on rec-ind panel. 50-, 100-mile range switch on rec-ind.	4-, 10-, 20-, 50-, or 100-mile range selected by range switch on control box.
SWEEP AMPLITUDE	Separate screwdriver control for each range located on lower right panel of rec-ind.	Controlled by sweep-limiter tube about a value set on 100-mile range by screwdriver control on rec-ind. 5-30-mile sweep can be varied by 5-30-mile sweep dial at lower center of rec-ind.	Operator's and auxiliary sweep-amplitude controls adjust all ranges simultaneously. Range adjustment controls duration of sweep for all ranges.
SEARCH FUNCTION	Search position of search-beacon switch on rec-ind.	Search position of search-beacon switch on rec-ind.	AFC-on or AFC-off positions of AFC-beacon switch on control box.
BEACON FUNCTION	Beacon position of search-beacon switch on rec-ind.	Beacon position of search-beacon switch on rec-ind.	Beacon position of AFC-beacon switch on control box.
PRECISION USE	Depends on position of range unit on-off switch on rec-ind.	Always.	Always.
RANGE MARKS	Controlled by range switch on rec-ind. 1 mile apart on 5-mile range, 5 miles apart on 20-mile range, 10 miles apart on 50-mile range, 20 miles apart on 100-mile range. Intensity controlled by range-mark intensity dial and video-gain dial.	1-, 5-, 10-mile marks or BR on any sweep. Intensity controlled by range-mark intensity dial and video-gain dial.	Controlled by range-mark switch on synchronizer. Choice of 1- or 5-mile markers on any range. No intensity control.
SLANT RANGE MARK	Only when range unit is on. Then controlled by range mark on-off switch on computer box. Amplitude controlled by screwdriver control No. 2 on range unit.	Always on A scope. Switched on PPI by range-mark intensity switch. Controlled by range-mark intensity screwdriver control and video-gain dial.	Controlled by bomb release on-off switch on computer box.
LUBBER LINE	On-off switch on control box. Shows heading of plane.	On-off switch on control box. Shows heading of plane.	On-off switch on azimuth control box. Shows heading of plane.

	APS-15	APS-15A	APQ-13
OPEN CENTER	Variable between 0 and 1 mile on all ranges. (Useful only on 5-mile range.) Moves time base with range unit off; blanks start of sweep only with range unit on, so not used then. Controlled by open-center control on rec-ind.	Variable up to 6 miles on 5-30 range, only if no sweep delay is set in. Sweep-timing control on computer.	Controlled by open-center switch on control box. Works only on 4-mile range and selects either 0 or 1-mile open center. Moves time base out on screen.
ALTITUDE DELAY	Zero with range unit off. With range unit on, it is variable between 10,000 and 36,000 ft. Controlled by alt. crank on computer box.	Variable up to 6 miles on 5-30 range, only if no sweep delay is set in. Controlled by sweep-timing control on computer.	Zero with normal-cal zero switch in cal zero position. Equal to altitude setting when at normal position. Switch on computer box.
SWEEP DELAY	Sweep-delay selector switch on control box chooses sweep delay of 0-200 miles in 10-mile steps, only when range unit is on.	Sweep-delay selector switch on control box chooses sweep delay of 0-200 miles in 10-mile steps.	Sweep-delay switch on azimuth control box chooses sweep delay of 0-200 miles in 10-mile steps.
AZIMUTH STABILIZATION	On-off switch on control box. If variations are set in on flux gate compass, causes true north always to be at top of scope regardless of plane's heading.	On-off switch on control box. If variations are set in on flux gate compass, causes true north always to be at top of scope regardless of plane's heading.	On-off switch on azimuth control box. If variations are set in on flux gate compass, causes true north always to be at top of scope regardless of plane's heading.
RECEIVER TUNING	Oscillator-tuning potentiometer on rec-ind controls tuning with AFC-manual switch (on rec-ind) in manual position or on beacon.	Oscillator-tuning potentiometer on rec-ind controls tuning. AFC-manual switch in manual position or on beacon.	Receiver control box controls tuning in AFC-off or beacon positions of AFC-beacon switch on control box.
AFC	AFC-manual switch on rec-ind at AFC while search-beacon switch is at search.	AFC-manual switch on rec-ind at AFC while search-beacon switch is at search.	AFC-on position of AFC-beacon switch on control box.
GAIN CONTROL	Receiver-gain control on rec-ind governs sensitivity of receiver. Video-gain control varies amplitude of output.	Receiver-gain control of rec-ind governs sensitivity of receiver. Video-gain control varies amplitude of output. PRI video gain is screwdriver control accessible through hole in bottom of dust-cover.	Receiver-gain control on control box governs sensitivity of receiver.

APS-15	APS-15A	APQ-13
TEST METERS		
1. Line voltage meter on rec-ind. 2. Modulator current on trans-current meter (rec-ind) only on mod position of mod-rct switch. 3. Rectifier current on trans-current meter (rec-ind) only on rct position of mod-rct switch. 4. Crystal-current meter mounted separately, plugs in jack on transmitter unit.	1. Line voltage on crystal-current line-volt meter of rec-ind when switch is in line-volt position. 2. Crystal current on crystal-current line-volt meter of rec-ind when switch is in crystal-current position. 3. Modulator current on trans-current meter (rec-ind) only on mod position of mod-rct switch. 4. Rectifier current on trans-current meter (rec-ind) only on rct position of mod-rct switch.	One test meter with 3-position switch mounted on control box. Positions: 1. Transmitter current. 2. Crystal current. 3. AFC voltage.
ANTENNA CONTROL		
Three azimuth controls on control box. On-off switch for continuous rotation. Hi-Lo switch chooses between 24 and 12 rpm when on. R-L manual control switch gives right or left rotation in off and low positions only.	Three azimuth controls on control box. On-off switch for continuous rotation. Hi-Lo switch chooses between 24 and 12 rpm when on. R-L manual control switch gives right or left rotation in off and low positions only.	Two azimuth controls on control box. Continuous-off switch for rotation at 20 rpm. CW-CCW for manually controlled rotation at 12 rpm in off position of continuous-off switch.
SECTOR SCAN		
Sector scan on-off switch on control box. Works only at On and Lo positions of spinner control. Sector-scan selector switch on control box chooses any 30° or multiple-of-30° sector out of entire 360°. With stabilization on, antenna scans same target area regardless of plane's heading.	Sector scan on-off switch on control box. Works only at On and Lo positions of spinner control. Sector-scan selector switch on control box chooses any 30° or multiple-of-30° sector out of entire 360°. With azimuth stabilization on, antenna sector scans same target area regardless of plane's heading.	Sector scan on-off switch on azimuth control box works only on continuous-off position. Scans any 60° section, continuously variable over 90° on either side of heading marker by position adjustment, potentiometer on azimuth control box. With azimuth stabilization on, the sector scan centers about the heading line.
ANTENNA TILT		
Manually-controlled tilt switch on rec-ind tilts spinner from +20° to –20°. Indicated on tilt meter above switch.	Manually-controlled tilt switch on rec-ind tilts spinner from +20° to –20°. Indicated on tilt meter above switch.	Manually-controlled tilt switch on control box tilts from +10° to –45°. Indicated on tilt meter on control box.

SECTION 3

AUXILIARY RADAR EQUIPMENT



With a chart of this kind and your Loran equipment you can easily determine a fix. There is only one line along which you can measure any given time difference between the signals from a pair of transmitting stations. You can determine your exact position along that line by crossing it with a line of position obtained from another pair of stations.

SUBJECTS IN SECTION 3

AUXILIARY RADAR EQUIPMENT

The auxiliary radar and radio equipment in your airplane has been put there to safeguard your life as well as to make missions more effective.

Though it is not part of your normal duties to operate or use most of this equipment, you have a vital obligation to know all you can learn about it and how it works. The time may come when you must take over for a wounded crew member who has specialized in the use of the auxiliary radar equipment. Remember, the time to learn how to operate or use this equipment is now!

Loran ★ RADIO SET AN/APN-4 AND RADAR SET AN/APN-9

DESCRIPTION

Loran, sometimes called LRN (Long Range Navigation), is a radio aid to navigation. It has been developed because of a great need for accurate navigation over long distances. With Loran, you can reduce errors in fixes to as little as 1000 feet, depending upon your ability to operate the equipment and the type of signal received. The equipment enables you to take fixes rapidly; you simply observe the equipment readings and plot them on specially prepared charts.

The AN/APN-4 equipment consists of two main assemblies, the receiver unit and the indicator unit.

The indicator unit contains the cathode ray tube, with its INTENSITY and FOCUS controls and the normal operating and tuning control.

The receiver unit contains the power switch, channel selector, filter switch, and fuses.

Cables connect these two units. **Before you turn the power switch ON,** always check and make certain that all cable connectors are fastened securely in position and that the POTENTIAL switch on the receiver's front panel is set in the proper position to provide the voltage available.

The equipment requires an AC power supply of either 80 or 115 volts, with a frequency of from 400 to 2400 cycles per second.

These are the principal ways in which the AN/APN-9 equipment differs from the AN/APN-4:

1. Both the receiver and the indicator are in a single container.
2. The set has a three-inch cathode ray tube with a magnifying lens, instead of a five-inch cathode ray tube.
3. The sweep on the cathode ray tube is logarithmic rather than linear.

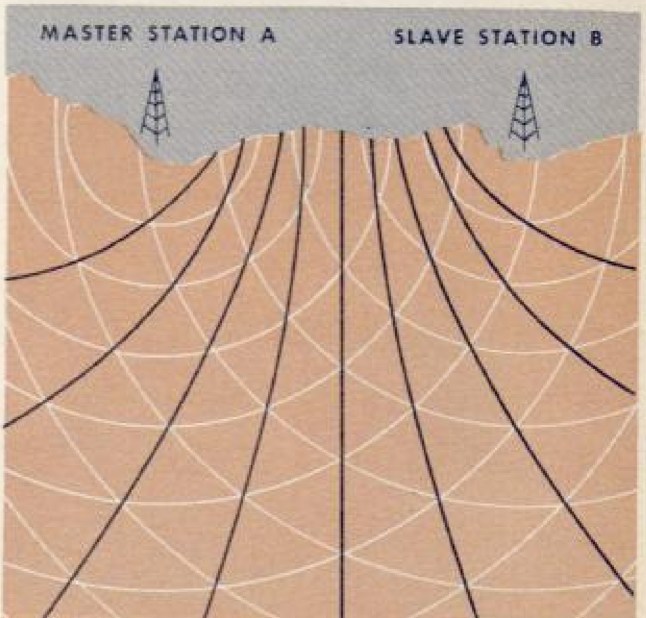
Theory of Fixing With Loran

Loran equipment is used in conjunction with ground stations which operate in pairs, each pair being synchronized. Such a pair consists of a master station and a slave station, called A and B respectively, and each pair has a number. The A and B stations are from 70 to 300 miles or more apart, depending on the geographical location. The B (slave) station is synchronized with the A station either by land lines or radio control.

Several pairs of stations form a chain, consisting of as many as eight pairs. These station pairs are numbered from 0 through 7 and all operate at the same radio frequency; that is, a receiver tuned to one frequency can pick up all station pairs of one chain. Each chain covers a certain portion of the earth; separate chains operate on separate frequencies to prevent interfering with each other.

Each pair sends out RF pulses of energy that are 40 microseconds long, but the number of pulses sent out per second varies slightly for each pair.

For example, the A and B stations of pair 0 send 25 pulses per second. Since the two stations work together their pulse rates are added. Station pair 0 is said to have a cumulative pulse rate of 50 per second. Station pair 1 sends out pulses at a slightly faster cumulative rate, which averages $50\frac{1}{8}$ pulses per second. Station pair 2 transmits $50\frac{2}{8}$ pulses per second, and so on.



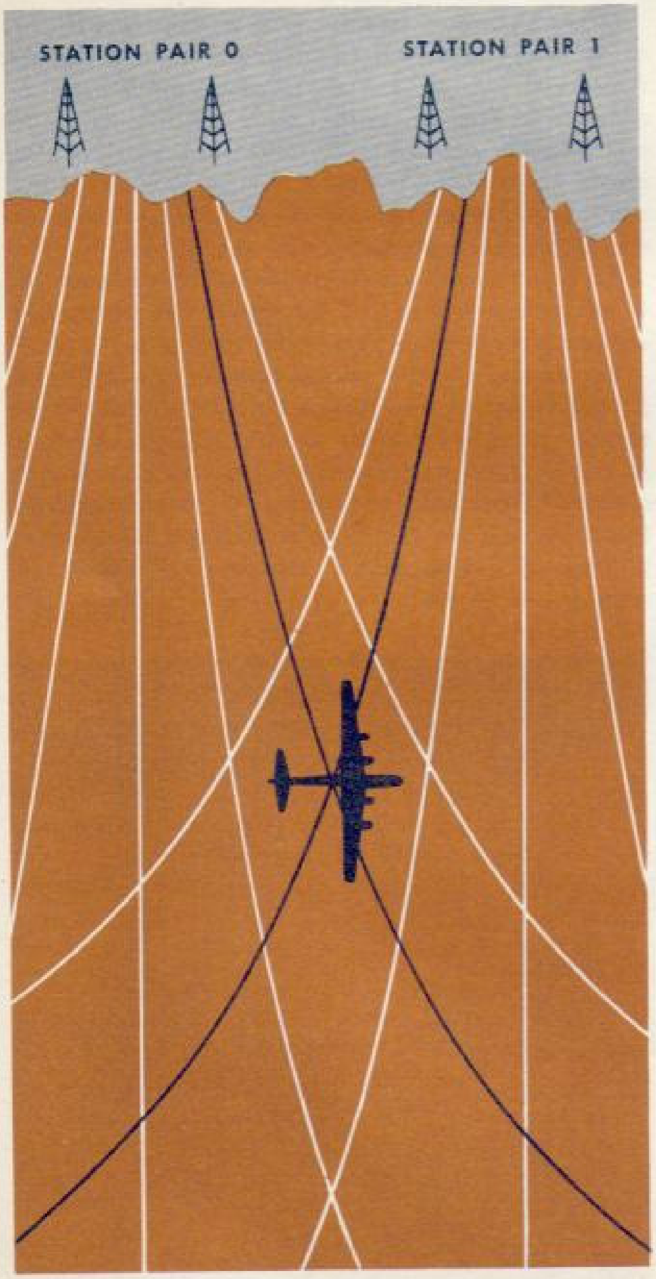
Heavy lines connect points at which you obtain same time-difference readings from the pair of stations.

You select a particular pair of stations in a chain, therefore, by changing the time-base frequency of your cathode ray tube to correspond with the pulse rate of the desired station pair. When you do this, only pulses received from the station pair selected remain stationary on the time base. Pulses from other station pairs still are received, but they drift continually across the cathode ray tube's screen.

If stations A and B of a pair transmit signals simultaneously, a receiver located anywhere along the perpendicular bisector of the two (equidistant from both) indicates a single time interval, as if the signal came from a single station. When the signal from one station in a pair arrives before the other, however, you know that your receiver is nearer the first station than the second.

WARNING

AN/APN-4 and AN/APN-9 employ high voltages which are dangerous and may be fatal if you come in contact with them. Use extreme caution when you work with the equipment.



You can fix your position by crossing two lines of position, obtained from two pairs of stations.

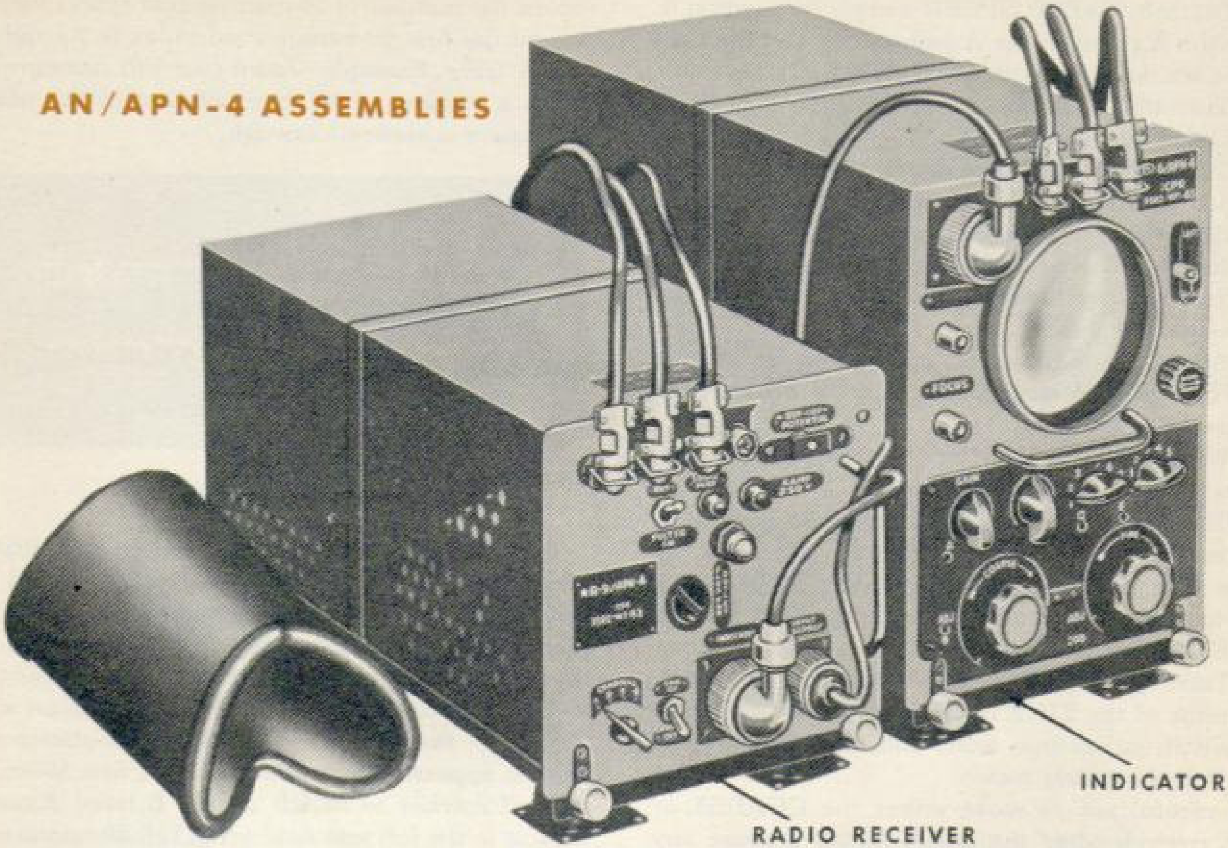
Suppose you receive the signal from station B 2000 microseconds before you receive the signal from station A. That fact indicates that your airplane is somewhere along a hyperbola connecting all the points in the area at which that same time difference in signal reception exists. The hyperbola, in effect, is a line of position obtained from this particular station pair. It is plotted on an especially prepared Loran chart and you can quickly find it.

Now, by repeating this whole process with signals from another station pair, you obtain a second line of position. Where these lines intersect is your fix. By plotting the values of your time-difference readings on the Loran chart you can translate them into specific terms of latitude and longitude.

Both master and slave stations, as stated before, send out 40-microsecond pulses at the rate of approximately 25 pulses per second. Between pulses, the stations rest for 39,960 microseconds. Since both stations send out identical signals and at the same transmission frequency, you need some way to tell the stations apart.

The master station always pulses first. There are three factors which cause time delay between the master station pulse and the slave station pulse. The first factor is the time it takes a pulse from the master station to get to its slave station. The second factor, which causes a time delay of approximately 20,000 microseconds, is introduced mechanically at the slave station. The third delay, a variable one, is added at the slave station for security reasons to confuse the enemy and make the system worthless to him. You must correct for this security delay by using tables furnished for that purpose.

AN/APN-4 ASSEMBLIES



INDICATOR

RADIO RECEIVER

OPERATION

To operate the AN/APN-4 equipment:

1. Turn the power (ON-OFF) switch ON. The pilot lamp on the receiver panel lights.
2. After approximately 30 seconds, the circuits warm up and green lines become visible on the face of the oscilloscope.
3. Set SWEEP SPEED to position 1.
4. Set the GAIN knob to the extreme counter-clockwise position. This prevents signals or interference from registering on the scope.
5. Adjust the INTENSITY control and the FOCUS control to obtain the finest possible trace.
6. Set AMP BALANCE to its middle position.
7. Turn the GAIN knob clockwise until you see pulses on the traces. Leave the knob at such a position that the tallest pulse has a height of about one and one-half inches.

Next, properly identify the pulses visible on the scope with the stations transmitting them so that you can find appropriate lines of position on your Loran charts. Do this by noting the radio-frequency channel, basic pulse rate, and specific pulse rate on which matching takes place, and by referring to the index on the chart preceding each time-difference reading. Index 1L0 means channel selector 1, low basic pulse rate, and station pair 0.

Emergency Operation

All adjustments or repairs must be made by trained maintenance men. All screwdriver adjustments on the sides of the indicator require depot maintenance. You, however, can make minor adjustments such as these.

If you don't get a pattern on the scope within five minutes from the time you turn the power switch ON, turn the INTENSITY control to the extreme right position. If you still don't get a pattern, check the 4-amp fuse on the panel of the receiver.

Use the Allen head wrench, mounted inside and at the rear of the indicator, to loosen or tighten the knobs on the front panel of the radio receiver or those on the indicator.

Pulse-Matching Procedure

After you have identified the stations, you must match the pulses. Do this by bringing the A and B pedestals into exact time relationship, using the two pulses as index marks.

1. Set the SWEEP SPEED switch to position 1. Place the A pulse on the A pedestal by shifting both pulses left or right with the LEFT-RIGHT switch.

2. Turn the COARSE control until the B pedestal falls under the B pulse.

3. Turn SWEEP SPEED switch to position 2. This expands the sweep so that it covers the tops of the pedestal (750 microseconds) and the pulses correspondingly are magnified horizontally. Adjust the GAIN control until the height of the pulses is approximately one inch.

4. Adjust the position of the B pulse by turning the FINE control until it lies directly beneath the A pulse.

5. With the LEFT-RIGHT control, move both pulses to the left edge of the traces.

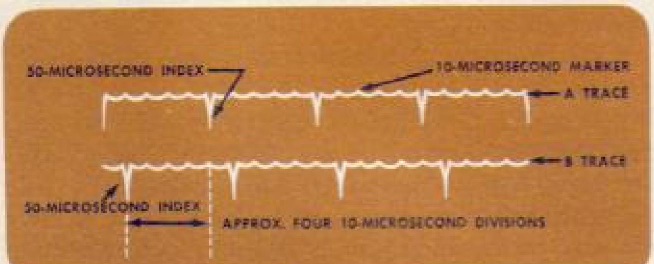
6. Turn the SWEEP SPEED switch to position 3. This magnifies the traces. Center the pulses on the traces with the LEFT-RIGHT switch. If the pulses tend to drift, you can stop them by adjusting the CRYSTAL PHASING control.

7. Turn the SWEEP SPEED switch to position 4. By means of the FINE control, bring the left edges of the two pulses into exact coincidence. Note the time that the pulses match.

Be careful not to move either the COARSE or FINE controls after the pulses match because any change in their settings introduces an error in the measured time difference.

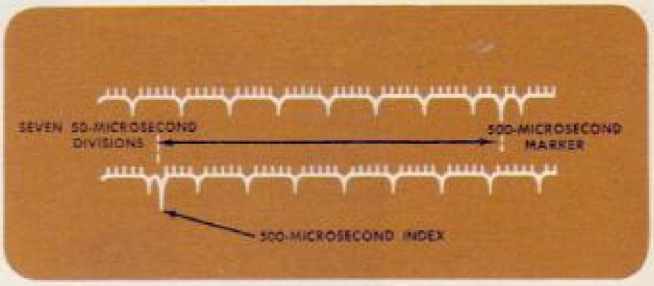
Measuring Time Difference

By matching the pulses you have aligned the pedestals so that the time difference between pedestals is the same as the time difference between pulses. In measuring the time difference, forget the pulses and measure the time difference between pedestals.



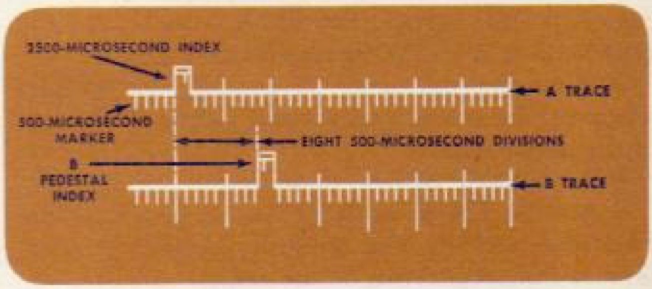
SWEEP SPEED POSITION 5

1. Turn the SWEEP SPEED switch to position 5. The small markers pointing upward mark 10-microsecond spaces; the longer markers pointing downward mark the 50-microsecond spaces. Use a 50-microsecond marker on the B trace as an index and count the number of 10-microsecond spaces between it and the first 50-microsecond index to its right on the A trace. **Example:** Count four full spaces, which gives a reading of 40. Interpolating to the nearest half space is accurate enough.



SWEEP SPEED POSITION 6

2. Turn the SWEEP SPEED switch to position 6. The two traces visible have 50-microsecond and 500-microsecond markers extending below the line. Every tenth 50-microsecond marker is longer and thus identifies a 500-microsecond marker. Using any 500-microsecond marker on the A trace as an index, count to the left the number of 50-microsecond spaces appearing between it and the first 500-microsecond marker to its left on the B trace. **Example:** Count to the left and note seven full 50-microsecond spaces, or a reading of 350 microseconds. Add this to the 40 microseconds obtained in the preceding operations to get a total of 390 microseconds.



SWEEP SPEED POSITION 7

3. Turn SWEEP SPEED switch to position 7. The two traces on which pedestals are visible contain 2500, 500, and 50 microseconds. Using the left edge of the A pedestal as an index, count the number of full 500-microsecond spaces which appear between this index line and the left edge of the B pedestal. Count only full spaces; ignore any portions of a 500-microsecond space. There are eight full spaces, or 4000 microseconds. Add these to the number obtained in the two previous steps and obtain a total of 4390 microseconds.

This final reading is the difference in microseconds between the times of arrival of the transmitted signals. Use it to identify a Loran line of position on your chart, or enter the special tables and locate points of latitude and longitude through which to draw a line.

Because one set of figures locates you on one line of position only, ordinarily you must take a reading on another pair of stations to get a fix.

However, when you can read only one pair of stations, you may obtain a fix by crossing one Loran line of position with a sun line or radio bearing. This procedure is especially helpful in locations where the lattice lines intersect at a small angle.

AN/APN-9

OPERATION

To operate the AN/APN-9 equipment:

1. Turn the RECEIVER GAIN control clockwise until the STATION rate identification (pilot light) lights. Wait at least five minutes to allow the equipment to warm up.
2. Refer to the approximate geographical location of the airplane on Loran charts, determine which RF CHANNEL, PRR, and STATION rate to use, and set the corresponding controls accordingly.
3. Set the FUNCTION switch to position 1.

4. Rotate RECEIVER GAIN control clockwise until the pulses appear on the scope.

5. If pulses are not stationary, turn DRIFT to correct a slight movement.

6. Turn RIGHT-LEFT switch to right or left, as required, to place both pulses on the lower trace.

7. With both pulses on the lower trace, turn the RIGHT-LEFT switch to the left until the pulse appearing at the **left** moves to the extreme left end of the lower trace. If necessary, make a closer setting of the DRIFT control to hold the pulse at this position.

8. Adjust the COARSE DELAY control until the variable delay marker is under the pulse appearing to the **right.**

9. Turn the FUNCTION switch to position 2.

10. If the pulses in the upper and lower traces are not of the same amplitude, adjust the RECEIVER GAIN and AMPLITUDE BALANCE controls.

11. Turn the RIGHT-LEFT switch to the left until the pulses on each trace are moved to the left. If the pulses drift, adjust the DRIFT control until movement ceases.

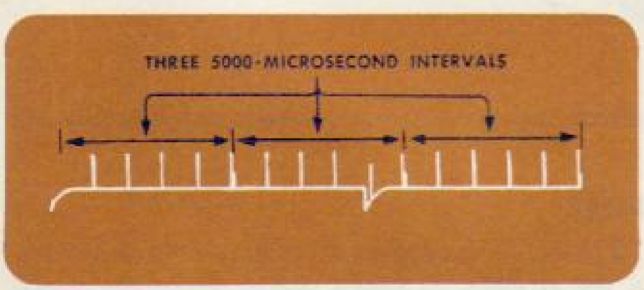
12. If the pulses are not lined up precisely, adjust the FINE DELAY control until one signal is directly over the other.

13. Turn the FUNCTION switch to position 3. The upper and lower traces now are superimposed and the pulses should coincide. If they do not coincide, adjust the FINE DELAY and AMPLITUDE BALANCE controls until they do. If the pulses drift, adjust the DRIFT control until this movement ceases.

Measuring Time Difference

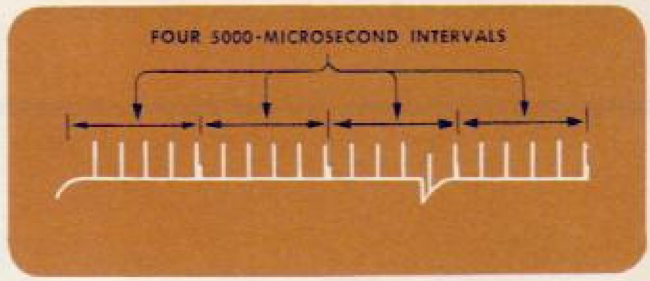
Caution: To avoid serious errors, do not change the setting of any controls except that of the FUNCTION switch.

1. Turn the FUNCTION switch to position 4. A single trace divided into 5000- and 1000-microsecond



FUNCTION POSITION 4 (PRR at H)

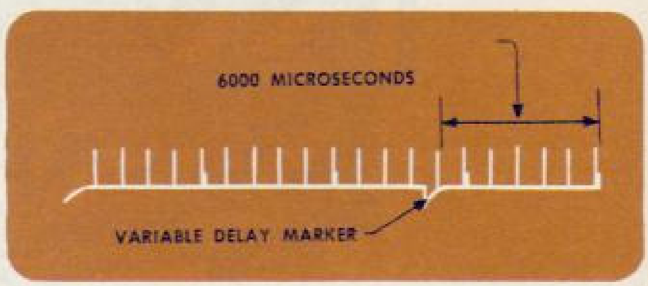
intervals should appear on the scope. If you have the PRR switch set at position H, the length of the trace is divided into **three** 5000-microsecond intervals, each 5000-microsecond interval subdivided into **five** 1000-microsecond intervals.



FUNCTION POSITION 4 (PRR at L)

If you have the PRR switch set at position L, the length of the trace on the scope is divided into **four** 5000-microsecond intervals, each 5000-microsecond interval subdivided into **five** 1000-microsecond intervals.

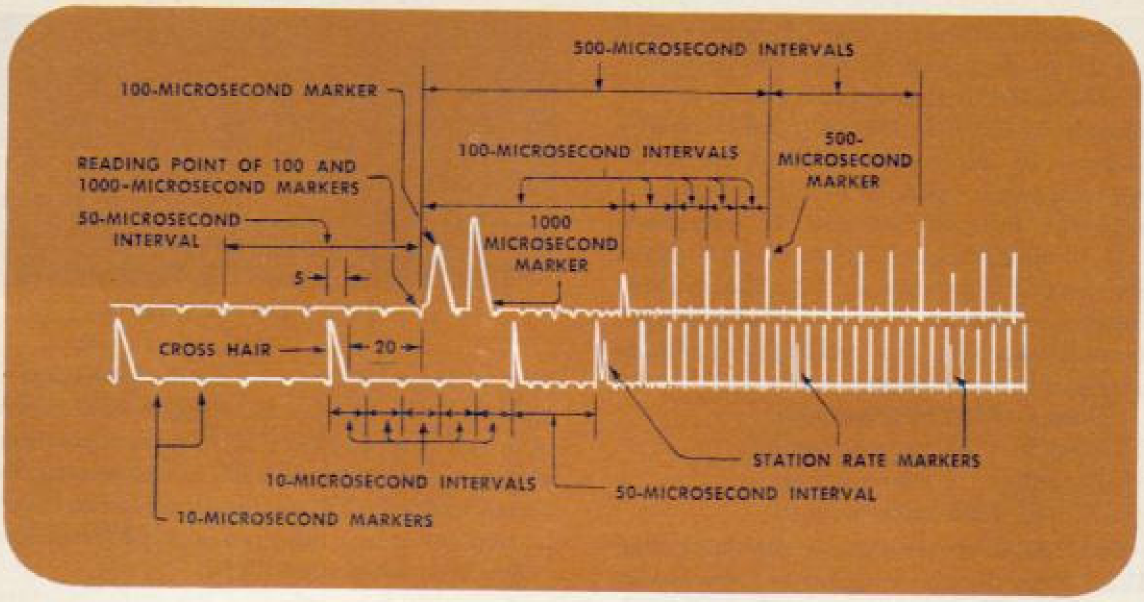
2. The position of the variable delay marker on the trace depends upon the time difference of the received signals. Measure the indicated time difference by counting the number of 1000-microsecond intervals from the extreme right end of the trace (0 microsecond) to the nearest 1000-microsecond marker to the right of the sharp edge of the variable delay marker. As a check on the final reading, esti-



FUNCTION POSITION 4 (For Reading)

mate the remaining distance in microseconds between this 1000-microsecond marker and the sharp edge of the variable delay marker. The above illustration indicates a reading of approximately 6250 microseconds. This reading is within ± 250 microseconds of the correct value.

3. Turn the FUNCTION switch to position 5. Two traces should appear on the scope: the upper trace divided into 10-, 50-, 100-, 500-, and 1000-microsecond intervals, the lower trace divided into 10- and 50-microsecond intervals. The crosshair used for read-



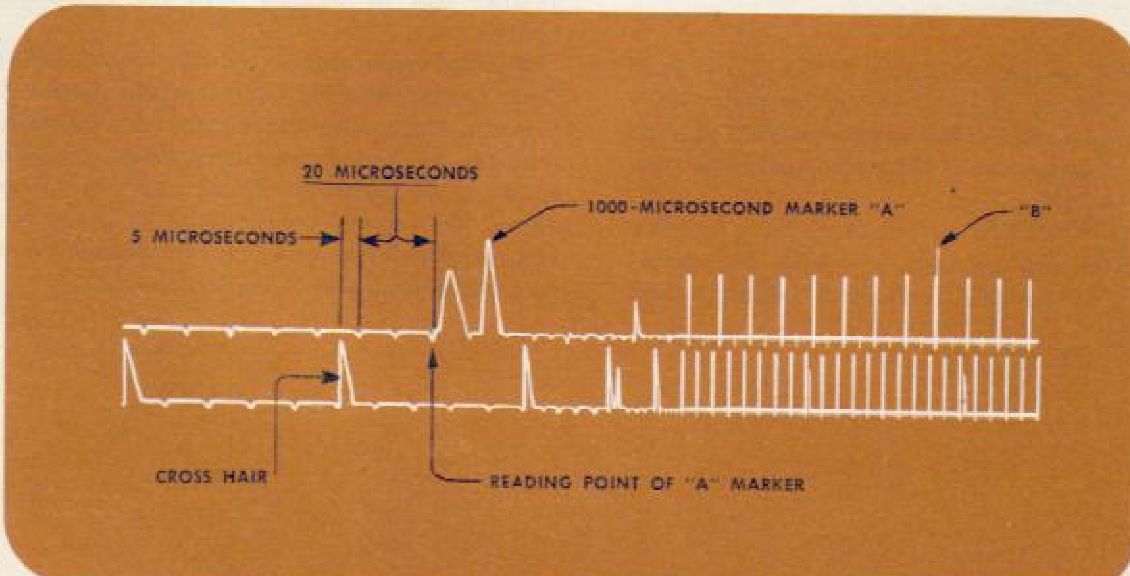
FUNCTION POSITION 5

ing the indicated time difference appears on the lower trace and is **always the 50-microsecond marker located approximately 40 to 70 microseconds from the left edge of the trace.** Another 50-microsecond marker usually appears to the left of the crosshair. Do not confuse this marker with the crosshair.

Step 2 resulted in a reading within 250 microseconds of the correct value. You can now obtain a reading within one microsecond by proceeding as follows:

4. Locate the first 1000-microsecond marker on the upper trace whose **reading point is to the right of the crosshair.** The illustration below shows two 1000-microsecond markers, A and B. It is extremely important, whenever marker A is the first 1000-microsecond marker to the right of the crosshair, that the **reading point** of this marker is always the point from which you measure. This 1000-microsecond marker is the same marker that completed the last 1000-microsecond interval read in step 2.

5. Now locate the first 10-microsecond marker on the upper trace to the right of the crosshair. Read



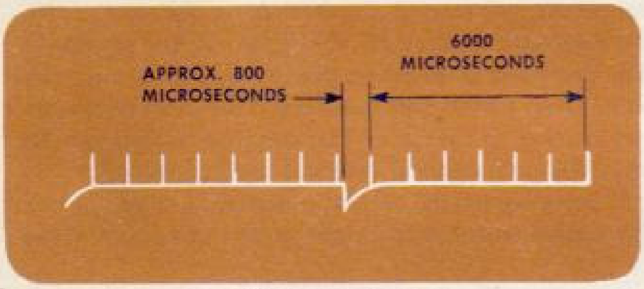
How to Obtain Time-Difference Reading Within One Microsecond of Exactness the time interval between this 10-microsecond marker and the reading point of the 1000-microsecond marker identified in step 4, by counting the intervals indicated by the 500-, 100-, 50-, and 10-microsecond markers. In the bottom drawing on 3-1-7, this reading indicates a value of 20 microseconds.

6. Estimate the interval between the crosshair and the first 10-microsecond marker on the upper trace to the right of the crosshair. The above illustration indicates a value for this interval of approximately five microseconds. The reading you obtain now is the total of three readings:

Step 2—6000 microseconds
Step 5— 20 microseconds
Step 6— 5 microseconds
Total—6025 microseconds

Always add 100 microseconds to the total fine reading. This brings the above figure to a final total of 6125 microseconds, which represents the indicated time difference.

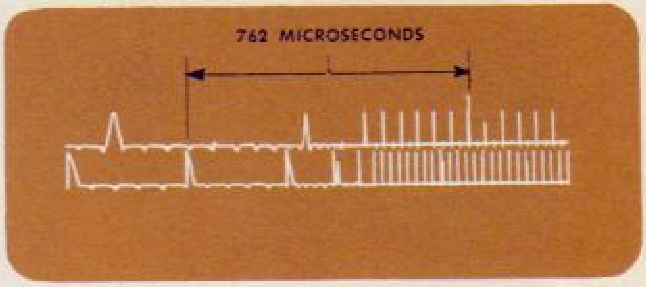
The following example indicates another time difference:



FUNCTION POSITION 4

FUNCTION switch at position 4. The above illustration indicates a reading of six complete 1000-microsecond intervals (6000 microseconds) plus an estimate of approximately 750 microseconds for the remaining interval.

With the FUNCTION switch at position 5, a fine reading of 762 microseconds, to which 100 microseconds must be added, is indicated, making a total



FUNCTION POSITION 5

fine reading of 862 microseconds. When you add this amount to the number of complete 1000-microsecond intervals read in FUNCTION switch position 4, you obtain a final total of 6862 microseconds. The estimated interval (750 microseconds) read in position 4 is supplanted by a finer reading of 862 microseconds.

See T.O. AN-08-30APN9-2.

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 this reading and station-pair characteristics (channel, basic, and specific recurrence rate).
4. Set a course to cross this line, and when the pulses appear matched on the scope you have crossed the desired LOP.
5. Change heading to keep the pulses superimposed. This keeps you on course along the desired LOP. Take fixes along the LOP 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. SS Loran is restricted to use at night, when you can obtain sky waves consistently. It gives increased range and coverage and you can arrange the stations to give larger angles of crossing for LOP's.

Radar Altimeters

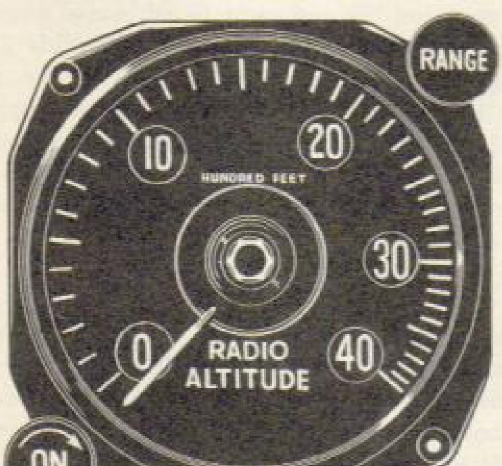
AN/APN-1

The AN/APN-1 is called the low-altitude absolute altimeter. It operates on the reflection theory: a transmitting circuit sends out frequency-modulated pulses which are reflected back to the airplane and received by the receiving antenna.

The transmitter and receiver comprise one unit which weighs 24 pounds. The unit is located in the pilot's compartment.

The time it takes for a transmitted signal to travel to the ground and back is interpreted electrically as a specific altitude on an altitude indicator. This indicator is so calibrated that it is equally useful on two ranges. On the low range (0 to 400 feet) each mark on it equals 10 feet of altitude. On the high range (0 to 4000 feet) each mark on the indicator equals 100 feet of altitude. The first 400 feet of the high range is not used, however, because it is inaccurate.

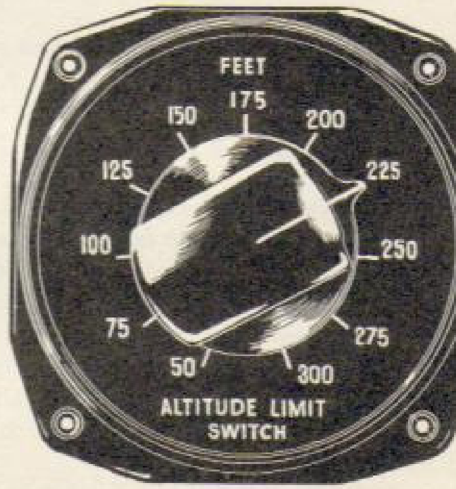
The APN-1 is not affected by atmospheric changes; it indicates absolute altitude up to 4000 feet over land and water. It is highly accurate (having a circuit error of only 6 feet) and dependable.



These are the switches on the APN-1:

ON-OFF: When ON, this switch applies 27.5 volts to the Tx/Rx unit and operates the altimeter.

RANGE: This switch makes it possible to select a low or high range for the altitude indicator.



LIMIT: On the low range, this switch indicates altitudes from 50 to 300 feet, each calibration being equal to 25 feet. On the high range, it indicates altitudes from 500 to 3000 feet, each calibration being equal to 250 feet. The switch enables the pilot to pre-select an altitude within the range of the switch, and turn on the **altitude limit indicators.**

These indicators are red, white, and green lights. When the LIMIT switch is on, if the airplane is flying at the pre-selected altitude the white light stays on. If the airplane is 10 or more feet higher than the pre-selected altitude, the green light goes on; if it is 10 or more feet below the pre-selected altitude, the red light goes on. This tolerance holds true only on the low range; on the high range it is increased 10 times.

Note: The autopilot can be used in conjunction with the APN-1.

Operation

1. Allow the set to warm up for one or two minutes.

2. When you are flying within the limits of the low range, make sure the RANGE switch is at LOW. When you are flying at an altitude between 400 and

4000 feet, be sure that the RANGE switch is on HIGH. **This is of crucial importance.**

Uses

1. **Evasive action.** Under enemy attack, an airplane equipped with APN-1 can drop safely to an extremely low altitude (approximately 50 feet).

2. **Skip bombing.** With the APN-1, it can be done with greater accuracy.

3. **Patrol work over water in total darkness.** Use of the APN-1 provides greater safety. Because of its precision and efficiency it is used to set the pressure altimeter.

4. **Low-altitude bombing.** The bombardier sets up his altitude from the APN-1.

SCR-718

The SCR-718 altimeter is a high-altitude absolute altimeter. It is a complete radar transmitter and receiver, sending out pulses, receiving and timing their return, and thus giving you your height above the earth directly below you. It is primarily an aid to navigation and high-level precision bombing. You also use it in determining any error in the altitude-delay circuit. It does not warn you of obstructions to your flight, such as mountains.

This altimeter indicates altitudes from 0 to 40,000 feet. When it is properly adjusted, it deviates less than 50 feet from indicating exact height above ground or water. The possible 50-foot error is due largely to the broad calibrations on the indicator dial. You can achieve greater accuracy if you always read the dial carefully. Repeat details of operation until you become expert in the use of the altimeter.

Operation

The controls and the indicator are on the same panel.

To turn on:

1. Rotate the REC GAIN control clockwise one-half turn.

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 until it does appear.

4. Rotate control until the circle is just barely visible as a luminous ring at the outer edge of the black calibrated scale.

5. Adjust the 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 ZERO ADJ knob until the counter-clockwise edge of the reflection pulse is exactly over 0. This setting is important if you are using the altimeter for a low-altitude clearance.

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 the REC GAIN control.

After you rotate this control halfway through its path, a second pulse appears near the 0 mark. This is called the **reference pulse,** because its counter-clockwise edge is used as a reference line. When you read altitude from the reflection pulse you must account for any deviation of the reference pulse from 0. If the reference pulse is not directly over 0, add to your altitude the number of feet it indicates to the left of 0, or subtract the number of feet it indicates to the right of 0.

For other than low-altitude measurements, you can adjust the reference pulse to 0 with the ZERO ADJ knob. Then read altitude directly from the reflection pulse. The additional 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 trailing, or counter-clockwise, edge of the pulse where it intersects the green circle. For example, 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).

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.

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

After one revolution of the reflection pulse, you must add 5000 feet to each reading. In such a case, the indicator shown would indicate 3000 + 5000, or 8000 feet. 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 aneroid 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:

Aneroid altimeter reads............23,000 feet
Map shows altitude of terrain....... 3,500 feet
Radar 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 15,000 + 3000, or 18,000 feet.

Cautions

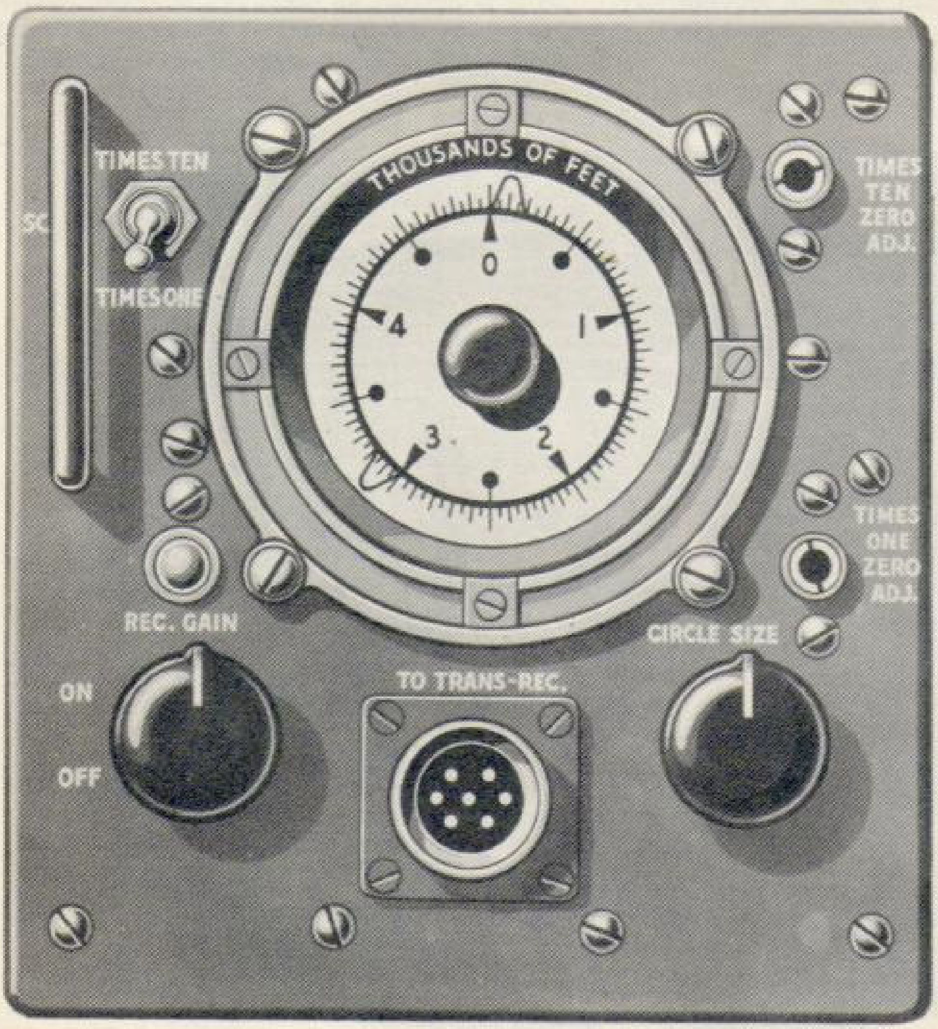
Check irregularities by watching the shape of the luminous circle. Inaccuracies result if the circle is off-center or not truly circular.

The altimeter does not work well above 40,000 feet. It may break down at altitudes above 45,000 feet.

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 flight, if the pilot light does not work, 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.



SCR-718
High-Altitude Absolute Altimeter

IFF AND ALLIED EQUIPMENT

SCR-695A

The SCR-695A is a Mark III IFF airborne transpondor, by means of which your airplane identifies itself in response to interrogations from ground, shipborne, or airborne radar equipments of proper frequency.

This set is a receiver-transmitter which gives a coded reply to all interrogation equipment on the I band (157 mc — 187 mc) and responds to an interrogating pulse at a preselected frequency on the G band (194 mc — 211 mc). In order to provide further security it is possible to control the coding of this reply with a selector switch.

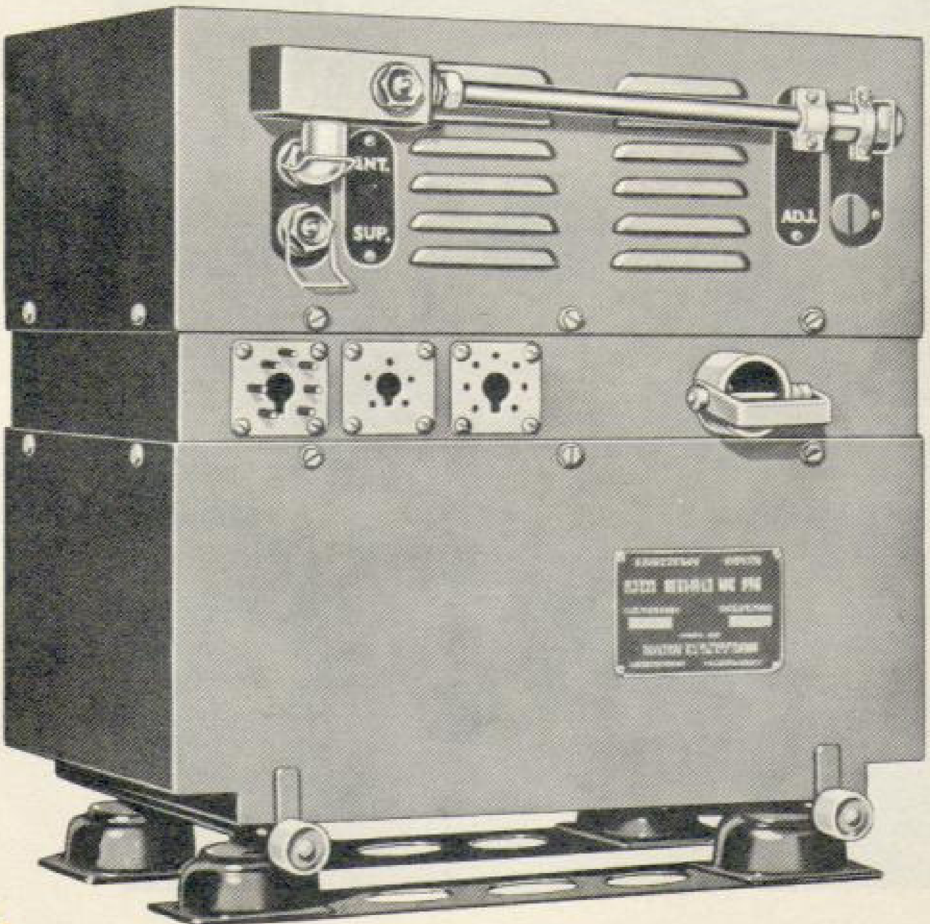
The main units consist of the transpondor, the control box, and the pilot's controls. The set operates on 27.5 volts DC, taken from the airplane's primary power supply. It contains an inertia switch which automatically destroys the vitals of the set when given a severe jolt, such as that which occurs in a forced landing.

Cautions

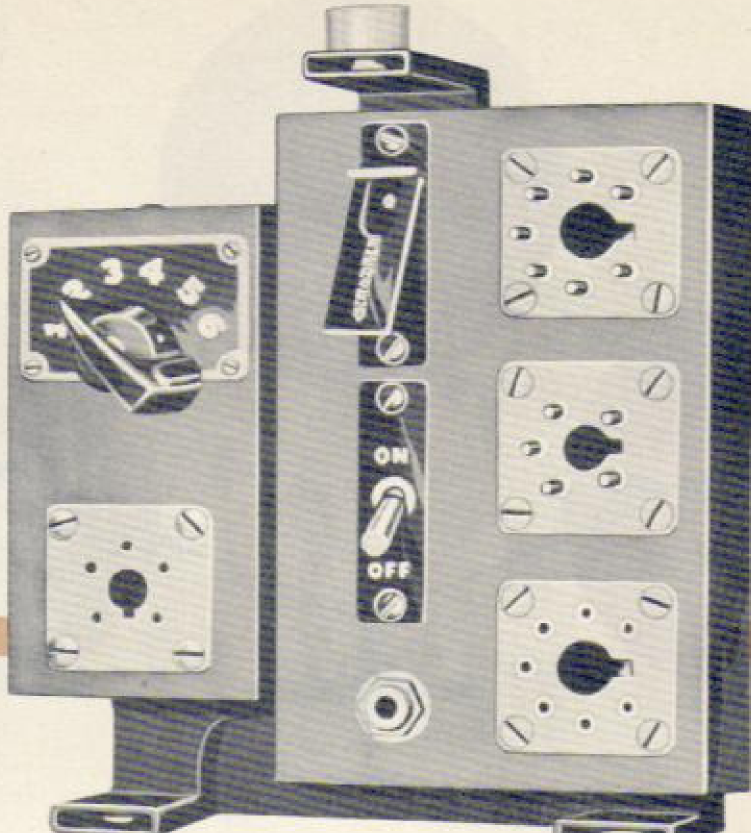
1. You must keep the EMERGENCY switch OFF at all times except in an emergency. Otherwise, all interrogating sets assume you are in trouble; this switch causes the SCR-695A to transmit a characteristic emergency signal.

2. You must press **both destructor switches simultaneously** to destroy the vital parts of the receiver-transmitter. Be careful not to destroy them accidentally.

3. Your IFF is valueless unless you switch it on. If it is not on, all operators of radar interrogating sets—whether for early warning, anti-aircraft control, fighter control, night fighter aircraft, or any air-



SCR-695A



SCR-695A
Control Box

Press Both Buttons Simultaneously to Destroy Equipment

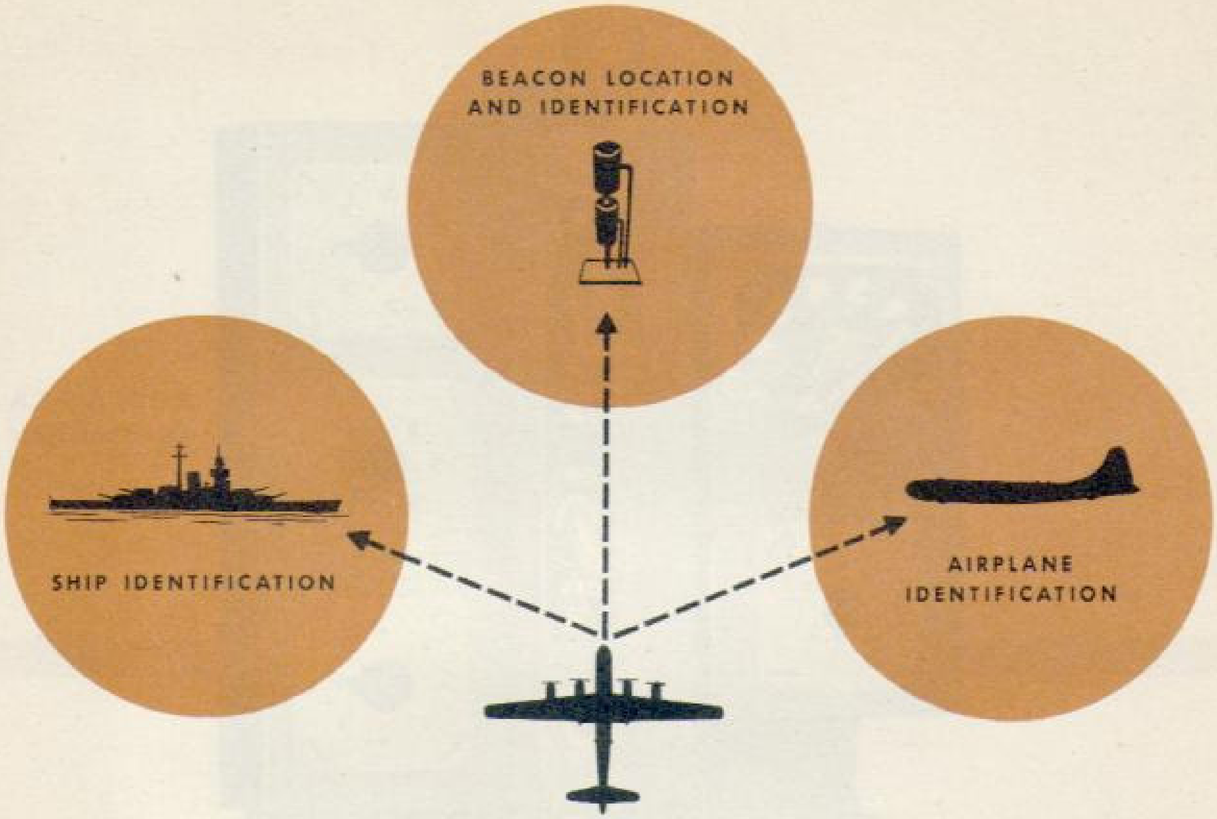
craft with SCR-729A installed—are going to consider your plane as hostile until they can identify it visually. And that may be too late!

Operation

1. Check the detonator in the receiver-transmitter to see that the plug is not connected.
2. Check to see that the inertia switch is not tripped.
3. Set the selector switch on the control box to the position designated for the mission.
4. Make sure that the EMERGENCY switch on the control box has not been knocked ON.
5. Set the G-band switch at the pilot's station to the position designated for the mission.
6. Set both the ON-OFF switch on the control box and the ON-IFF-OFF switch at the pilot's station to ON.
7. Check the detonator lights; **if they are not lighted,** connect the detonator plug on the receiver-transmitter.
8. Insert an earphone plug into the jack on the control box. When the equipment is not transmitting, you hear a slight hissing sound; when it is transmitting, you hear a tone. This tone starts and stops at intervals determined by the code set up on the selector switch and by the setting of the G-band switch.

Before landing:

9. Set both the ON-OFF switch on the control box and the ON-IFF-OFF switch at the pilot's station to OFF.
10. Remove the detonator plug on the receiver-transmitter.



SCR-729A and AN/APN-2

The radar set, SCR-729A, is a complete radio receiver and transmitter with a scope on which you can read range with considerable accuracy and you can read azimuth roughly. The returns identify friendly aircraft or surface vessels equipped with IFF, and locate and identify beacons of the proper frequency. They also can be used in conjunction with the AN/CPN-7 for blind-landing approaches.

SCR-729A weighs 75 pounds, has a frequency of 160-186 mc, operates effectively at ranges of 10, 50, and 100 nautical miles, and requires 80 or 115 volts of power at 400-2400 cps. The main units of the set are a transmitter-receiver, indicator, control box, and antennas. It has a transmitting and a receiving antenna on each side of the airplane.

Operation

1. Turn ON-OFF switch on control box and ON-OFF switch on indicator to ON.
2. Allow set to warm up for 5 minutes.
3. With IR-DI switch at DI and the receiver GAIN control on the control box set at the maximum counter-clockwise position, adjust FOCUS and INTENSITY controls on the indicator for a clear trace.

The IR-DI switch has three positions: IR for momentary operation, DI for constant operation, and the center position for stand-by.

4. Adjust GAIN to proper level.
5. Set the HIGH-LOW switch on the control box to the briefed position. This set receives on two frequencies and transmits on one.
6. Use the HIGH-LOW switch and the IR-DI switch further as flight conditions require.
7. Use the 10-50-100 range switch as necessary.
8. If the trace is not centered, use the VER CENT and the HOR CENT controls on the indicator to accomplish this.

Note: All receiver and transmitter adjustments and all calibration **must be done by maintenance men;** the procedures require test equipment.

AN/APN-2

The AN/APN-2 radar set is an interrogator-responsor similar to the SCR-729, but it has these principal differences:

The frequency range is slightly higher.

There are two receiver frequencies and five transmitter frequencies.

The transmitter may be keyed.

AN/APS-13 ★ Tail Warning Radar

Radio Set AN/APS-13 is a lightweight radar set which gives an airplane pilot, or any other aircrew member who can see or hear it, a visible and audible warning that a hostile airplane is behind or approaching from the rear.

The usable range of this set is from 200 to 800 yards, and within an area extending up to 30° on both sides of the airplane and from 45° above it to 45° below it. The set doesn't work above 50,000 feet or below 3100 feet. Ground reflections determine the lower limit.

The main units include the antenna, transmitter-receiver, indicator light with brilliance control; warning bell, ON-OFF switch, and test switch. The set operates on 27.5 volts, which is the primary aircraft power supply.

Caution

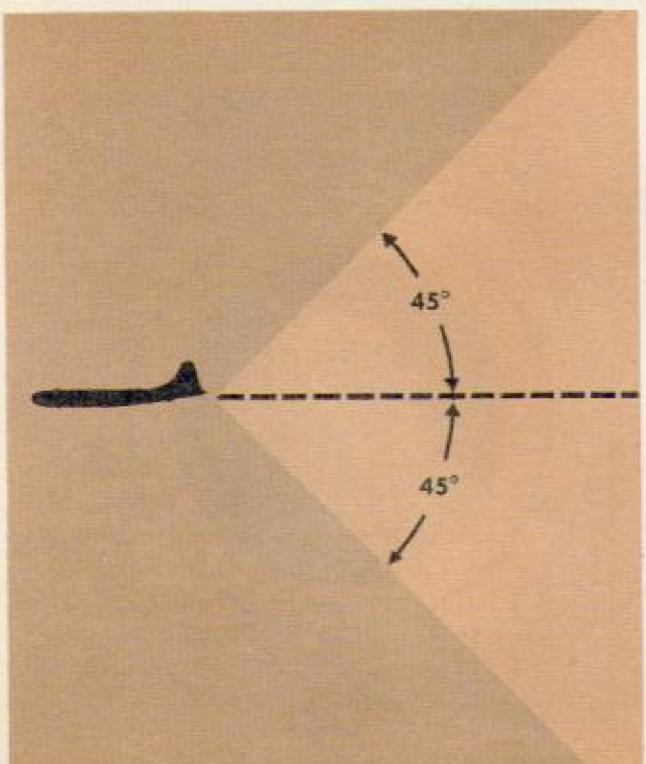
The warning bell must be where the pilot can hear it clearly but where crew members cannot hear it; they might mistake it for the bailout signal.

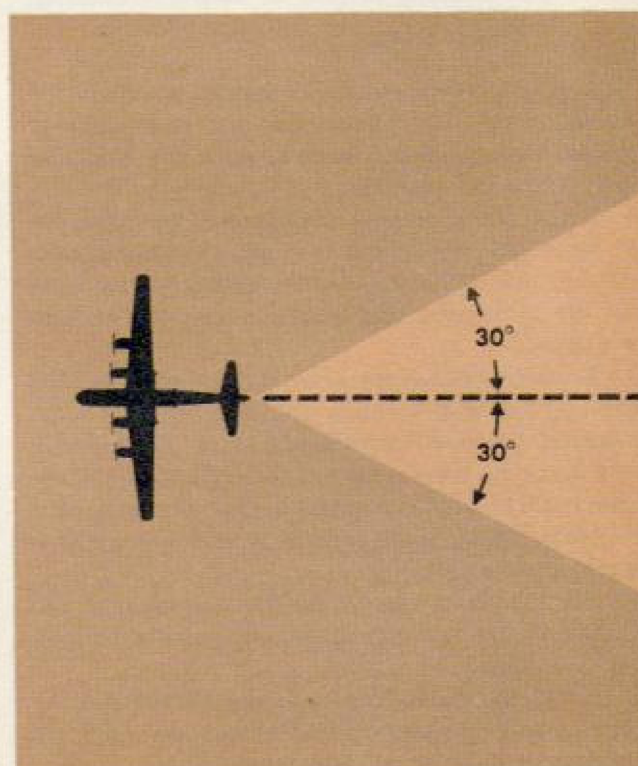
Operation

1. Turn the power switch ON.

2. Wait at least three minutes for the tubes to warm up, then hold the test switch up. If the indicator lights and the warning bell rings, the equipment is operating properly. You can adjust the intensity of the indicator light with the rheostat.

3. **You must set the GAIN CONTROL correctly.** Adjust the screwdriver control on the front panel of the transmitter-receiver so that the receiver sensitivity is well below the level at which the tube noise can trigger the relay and give a false warning. If you reduce the sensitivity too far, however, it won't detect aircraft within the required range. Have a competent radio technician check this before you start out on a combat mission.





Flux Gate Compass

The gyro flux-gate compass system is a remote indicating compass 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, the flux gate compass eliminates all turning errors set up by the vertical component of the earth's magnetic field.

The master indicator has a large compass face graduated in degrees. An indicator gives the corrected reading, which is the compass reading mechanically corrected for deviations. A small cut-out gives the uncorrected reading, or compass heading. With the variation knob, offset the outer dial so that it reads true heading instead of magnetic heading.

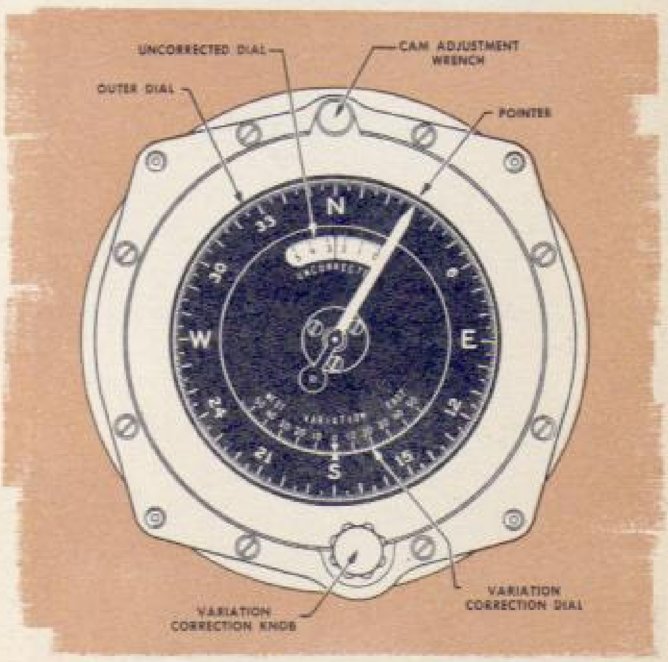
Operation

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 uncaged all the time, except when you are 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 it and the cycle is completed automatically.
4. Set the gain control on the amplifier at the highest position at which it does not make the indicators oscillate.
5. Offset the outer dial with the variation knob and read true heading on the master indicator and secondary indicators, or repeaters.

Used with APS-15A or APQ-13

When you use the flux gate compass with APS-15A or APQ-13 equipment, the PPI scope becomes another repeater or secondary indicator if you turn the azimuth-stabilization switch ON. The heading line then becomes a compass needle and the whole scope picture becomes oriented with North always at the top of the screen. With variation set in the master indicator, all headings and bearings on the PPI are true; with variation taken out or at 0 on the master indicator, all readings become magnetic.

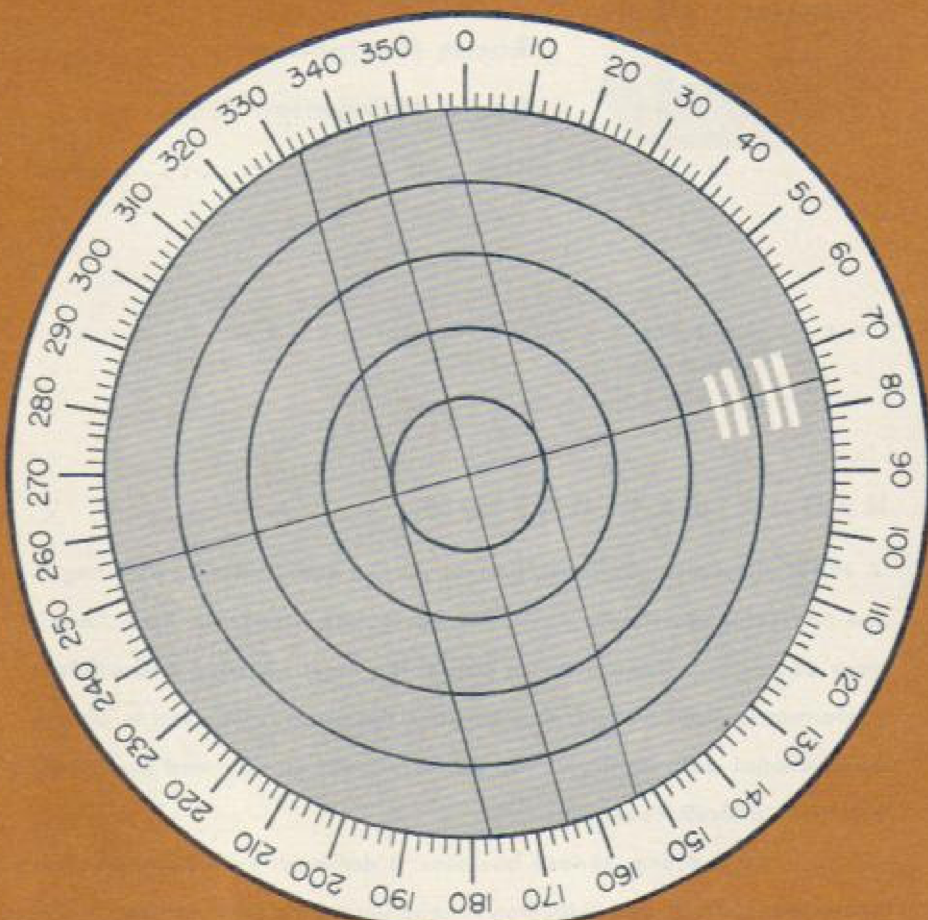
Since small discrepancies sometimes exist between the master and secondary indicators, a check of those deviations should be made and a correction card installed near the PPI.



Master Indicator, Flux Gate Compass

SECTION 4

RADAR NAVIGATION



Use the available beacon stations to simplify your navigation. You can use the radar beacon to obtain a single line-of-position fix or you can make use of it for homing. Measure range to the leading edge of the nearest signal and measure bearing at the exact center of the signals. Be sure that you know the code of the stations along your route.

4

SUBJECTS IN SECTION 4

RADAR NAVIGATION

A radar observer spends the greater part of every mission assisting the navigator or actually doing the navigation. Know the limitations of your equipment. Know how to obtain the most effective and efficient performance from it. You must practice the procedures used to obtain navigational data until you can perform them quickly and accurately under the most difficult conditions.

Flying is an exacting, serious business. It demands everything you have of knowledge, effort, and skill. Don't make your crew pay for your mistakes.

PPI SCOPE INTERPRETATION

The PPI scope gives the navigator an accurate means of taking radar fixes to check and correct his dead-reckoning position. Successful use of the radar set, however, depends upon the navigator's skill in interpreting scope returns and identifying targets.

Effect of Radar Beam

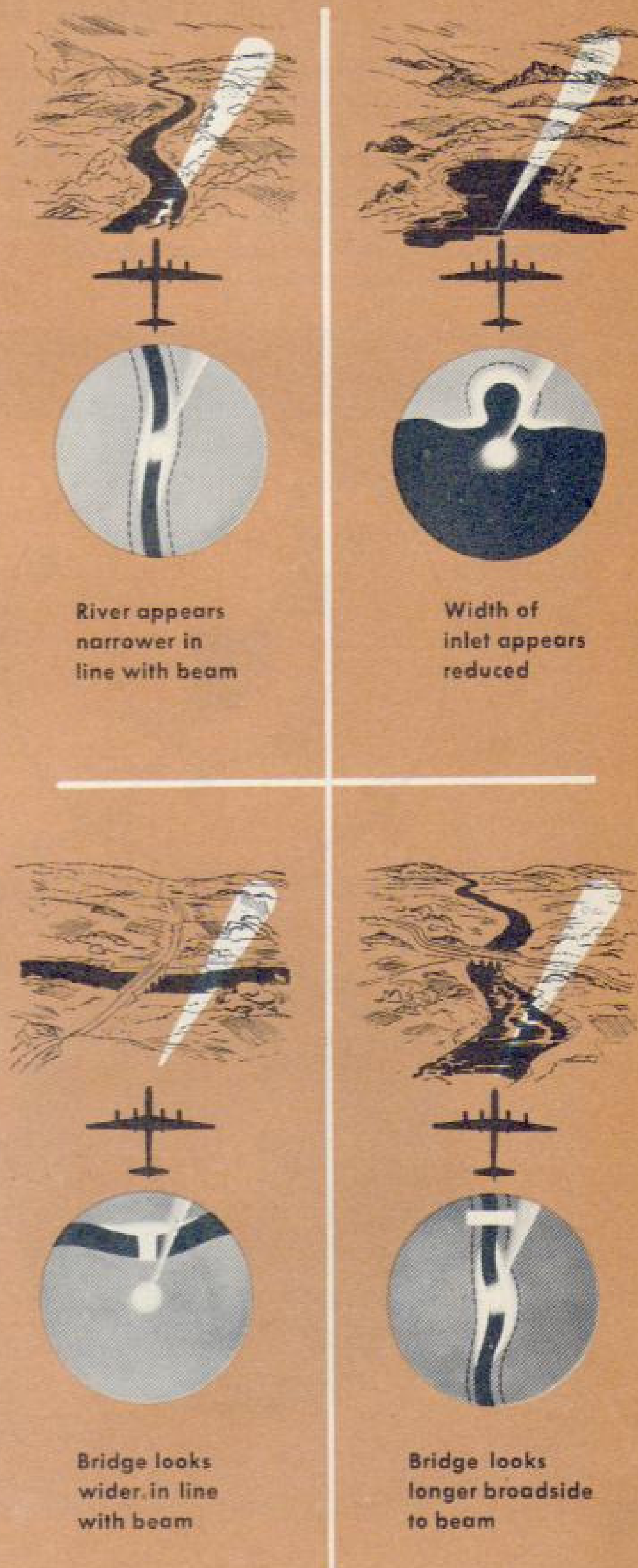
The picture you see in your scope is not always a true representation of the size of the object. There is always a beam-width error. This error causes all objects to appear broader than they actually are. The bright returns from the banks of a river tend to move the banks together, especially when the river is lying parallel to the beam. The same effect is true for landing strips and narrow bays and inlets. A bridge at right angles to the beam appears longer.

Distortion at Short Ranges

Distortion of areas at short ranges is another error you must recognize and correct. When no altitude delay is set in, returns from the area directly beneath the airplane appear spread out. This is especially noticeable when the ground range is five miles or less. That is why you should do your navigating with the set turned on the 50-mile range, using targets 20 miles or more away, to determine fixes.

Getting Oriented

Before you can use a target return to make a radar fix, you must identify it. You can use your dead-reckoning position to orient your airplane on the chart before comparing the chart with the picture on the scope. Rivers, bridges, lakes, dams, and cities, especially if they are close to a river or lake, are the most easily identified targets to use when you study the scope. Compare rough bearings and ranges of returns as they appear on the scope with similar objects and their bearings and ranges on the chart. Then when you have oriented your airplane's position and identified your returns, you are ready to take accurate fixes.



EFFECT OF BEAM—WIDTH ERROR

TYPICAL SCOPE RETURNS

If you keep in mind the basic reasons for the contrast in a land-and-water return, it simplifies scope interpretation.

Water areas appear dark because the radar beam strikes the water and is reflected away at the same angle it strikes the surface. Land areas appear brighter because there are many surfaces which reflect part of the beam back to the spinner.

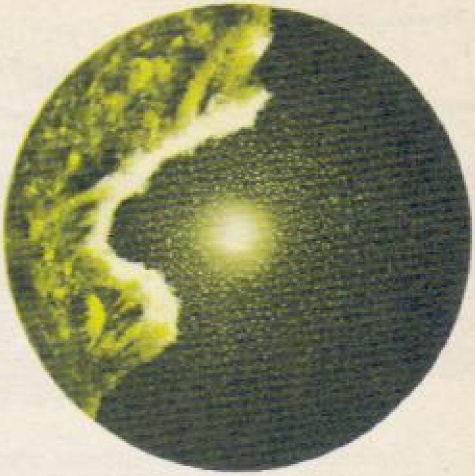
The area directly beneath the airplane, whether water or land, always is the brightest part of the scope because the beam strikes at a 90° angle. This area is called normal ground (or sea) return.

The drawings which appear on the following two pages comprise a check chart of the most commonly observed objects and the typical returns they give you on the scope.

Distortion of Area Beneath Airplane

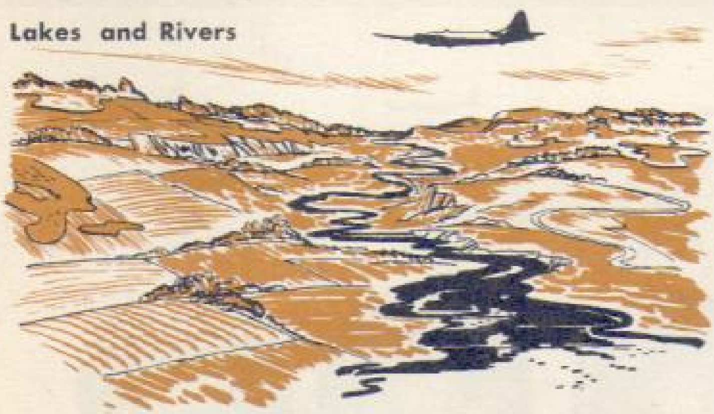
Returns from Land and Water

Coastline with Prominent or Rough Cliffs



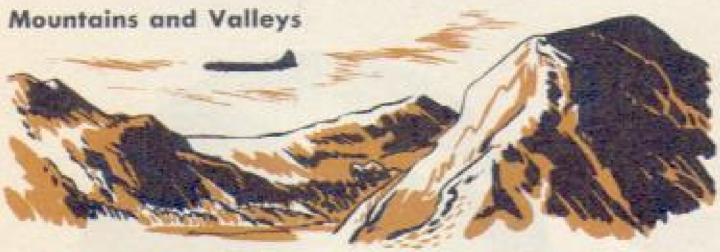
High ground and bluffs give returns with low gain. Only the bright return of coastline appears. The land is dark.

Lakes and Rivers



There may be no dark return from small rivers or lakes. Look for the outline of far banks which may be brighter than surrounding land.

Mountains and Valleys

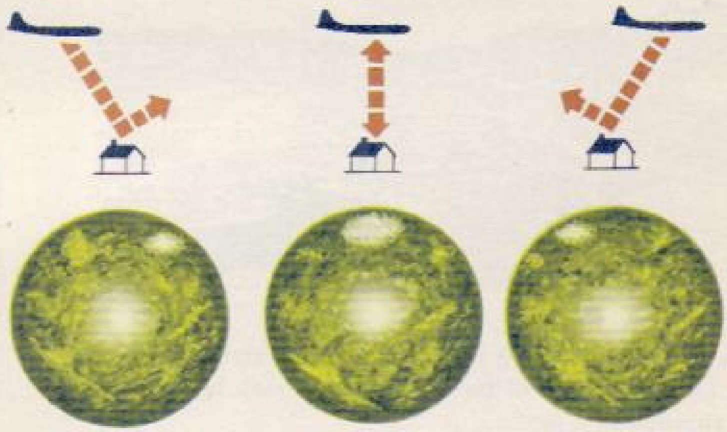


Near slopes appear increasingly brighter as the beam falls on the more vertical slopes of the mountains. Far slopes are completely dark because the beam does not strike them. The ridge line is brightest. An isolated mountain peak appears as a bright spot, similar to a small town. Look for the bright peak with a deeper shadow behind it. You can distinguish these darker areas from lakes because the brightest return from a lake is always the far shore.

Cities, Towns, and Airfields

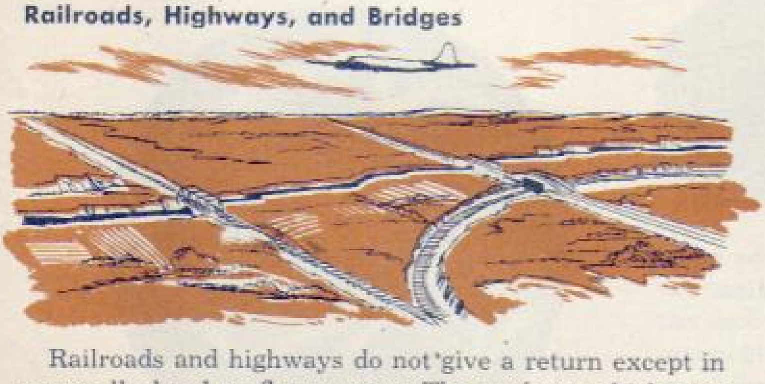
A large number of reflecting surfaces present returns of varying brightness. The relative brilliance changes as the airplane changes bearing.

Small Towns and Groups of Buildings

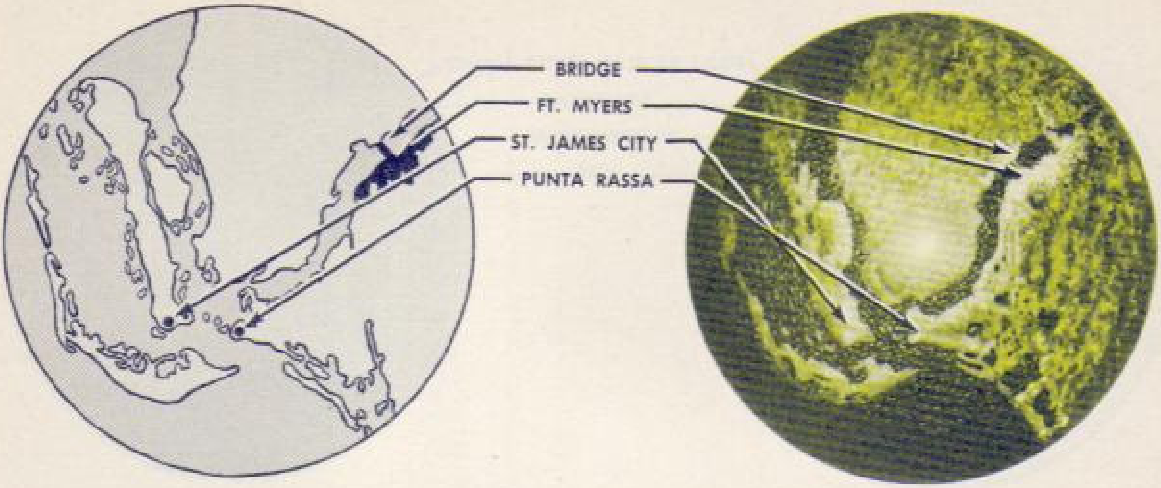


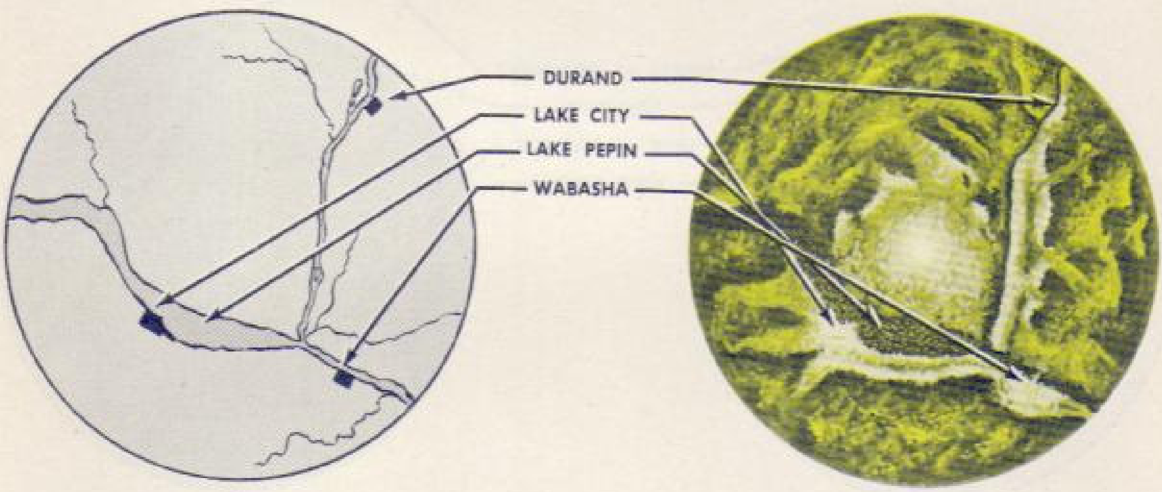
Glinting effect is especially noticeable and results in brightest returns when the airplane is broadside to the reflecting surface. In the United States, glinting effect is most noticeable on bearings of 0°, 90°, 180°, and 270°, because most building walls line up North-South and East-West. This is called **cardinal point effect.**

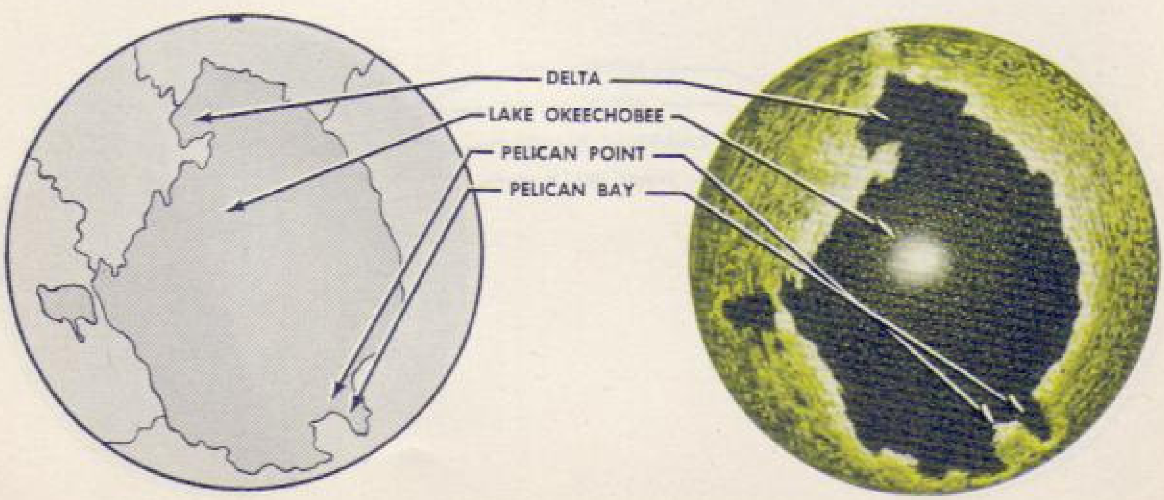
Railroads, Highways, and Bridges

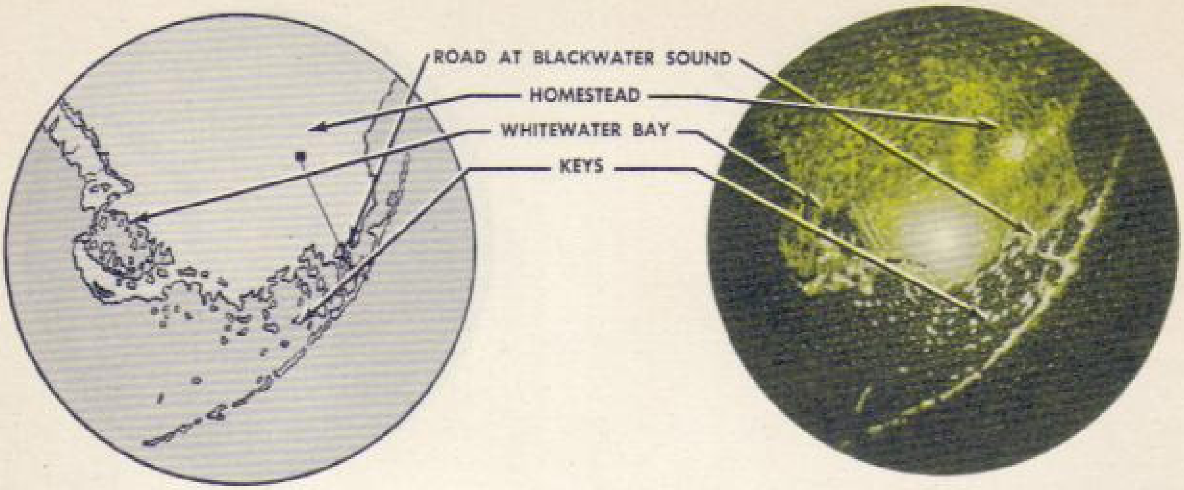


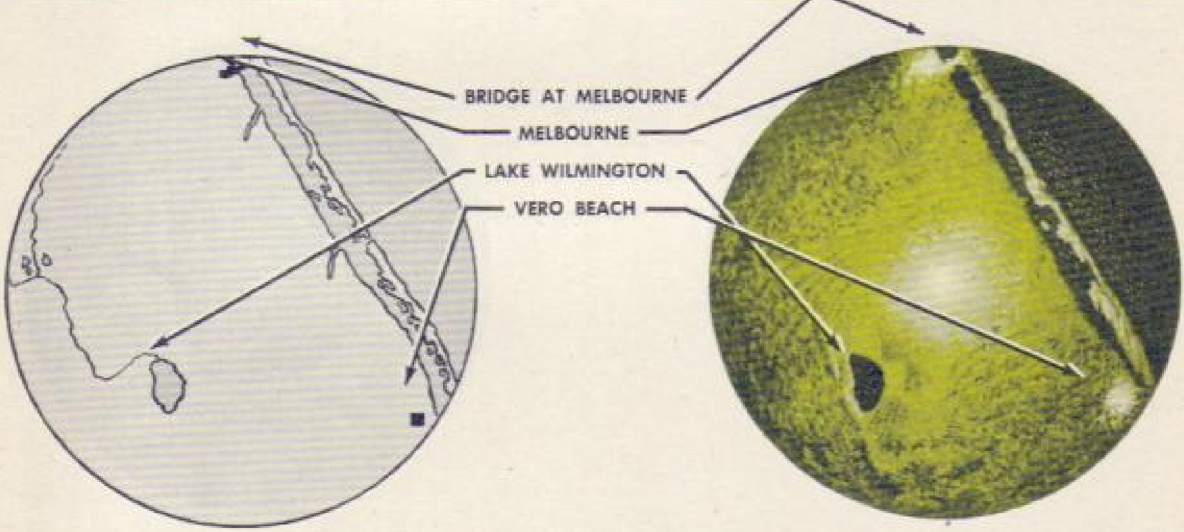
Railroads and highways do not give a return except in unusually level or flat country. The surfaces which give returns are embankments or fills, concrete and metal culverts, and bridges along roadways. Bridges over water appear in the scope as bright returns.

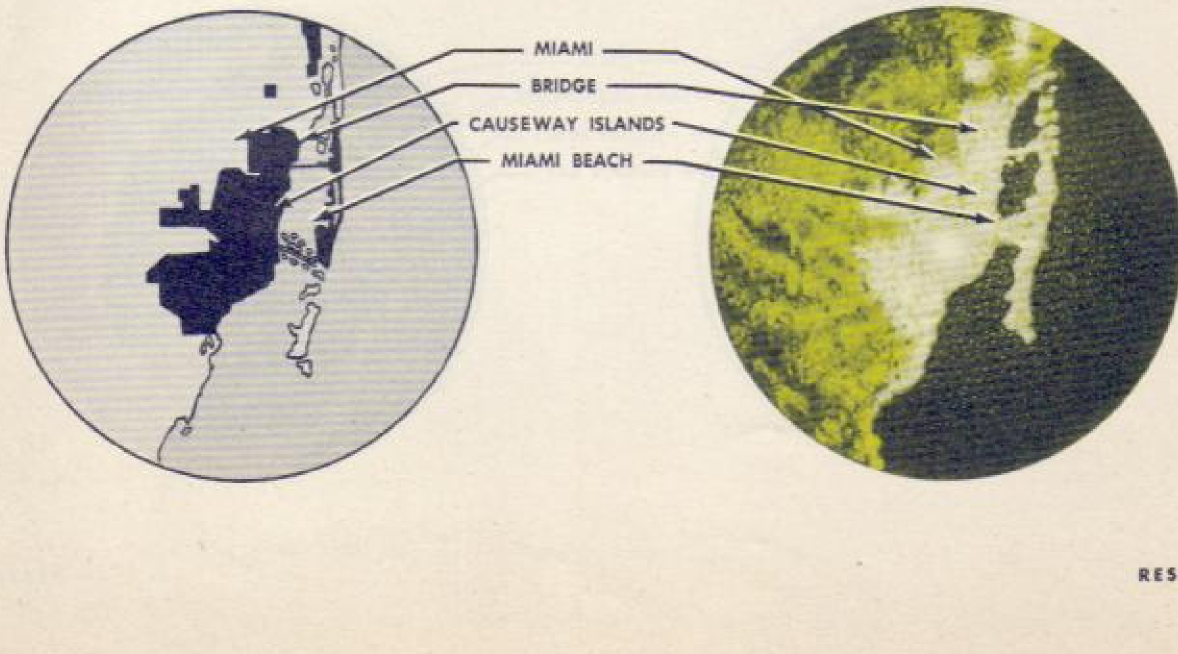

BRIDGE
FT. MYERS
ST. JAMES CITY
PUNTA RASSA


DURAND
LAKE CITY
LAKE PEPIN
WABASHA


DELTA
LAKE OKEECHOBEE
PELICAN POINT
PELICAN BAY


ROAD AT BLACKWATER SOUND
HOMESTEAD
WHITEWATER BAY
KEYS


BRIDGE AT MELBOURNE
MELBOURNE
LAKE WILMINGTON
VERO BEACH


MIAMI
BRIDGE
CAUSEWAY ISLANDS
MIAMI BEACH

Radar Fixes

Radar fixes simplify navigation; by means of them you can measure distance and azimuth with greater accuracy and speed than by other usual methods.

When you have identified a target in the PPI scope, keep it as a guide until another target is picked up. Watch the scope for new check points and select **small bright returns** for accuracy in plotting.

Navigate on the 50-mile range as much as possible because the visible area then includes more check points and scope interpretation is easier.

CAUTIONS

When you use your radar set, navigate without using altitude delay. In this way you get true slant range without having to add for altitude delay.

When you have to use a large return, always use the same part of the return for making measurements.

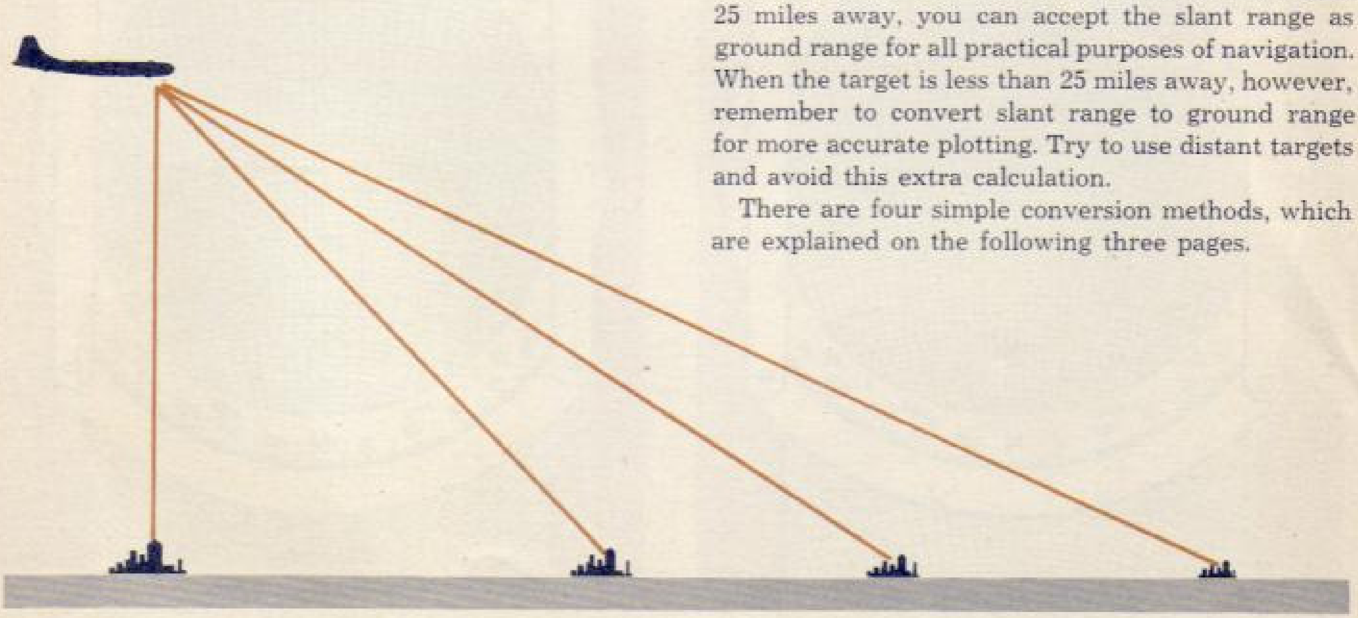
Try to take bearings on even minutes or half minutes in order to simplify calculations.

When azimuth stabilization is OFF, any bearing you take is a relative bearing. Remember to apply the formula:

Relative Bearing + True Heading = True Bearing

Always plot the true bearing on your chart.

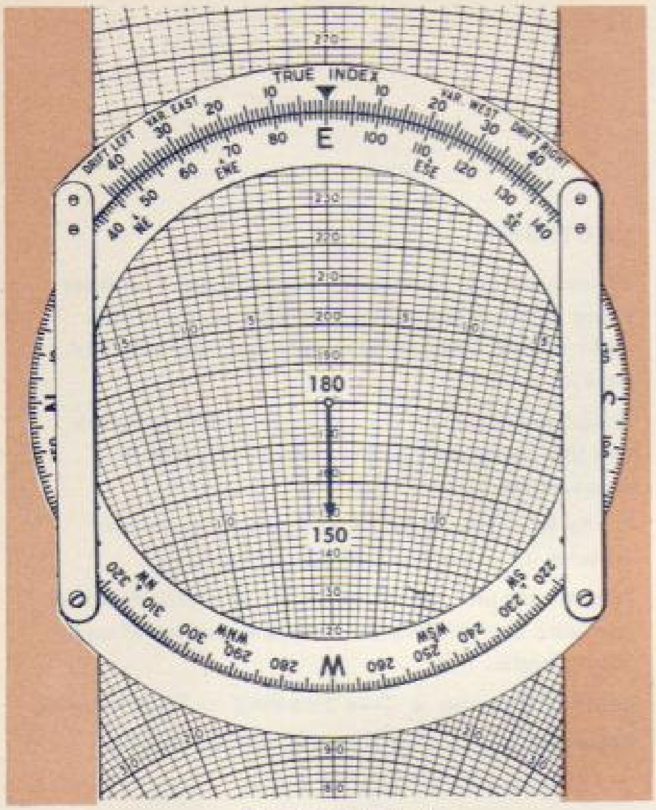
CONVERTING SLANT RANGE TO GROUND RANGE



Slant range is the distance measured from the center of the PPI scope to the range markers or bomb-release marker.

When you take a radar fix on a target more than 25 miles away, you can accept the slant range as ground range for all practical purposes of navigation. When the target is less than 25 miles away, however, remember to convert slant range to ground range for more accurate plotting. Try to use distant targets and avoid this extra calculation.

There are four simple conversion methods, which are explained on the following three pages.



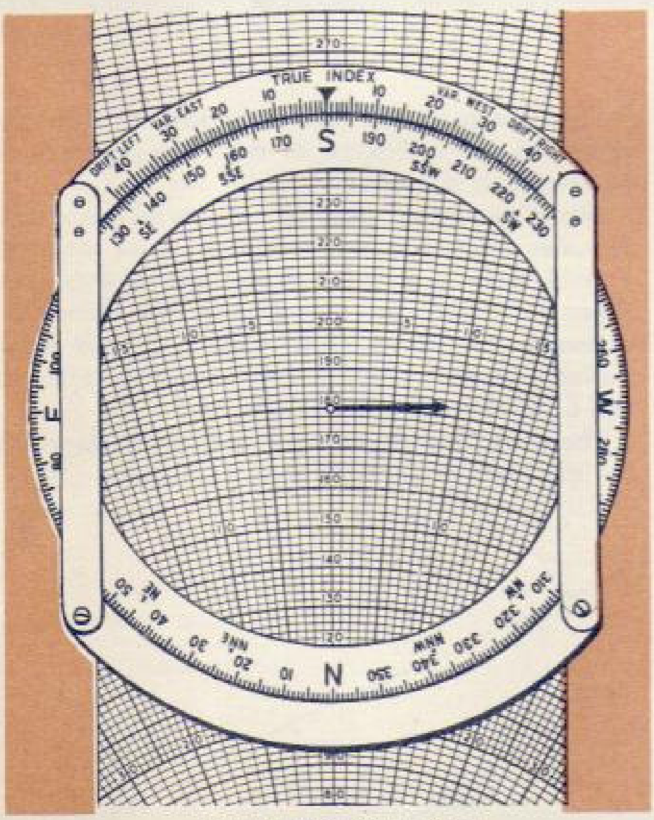
Altitude 3nm (30)

E-6B COMPUTER METHOD

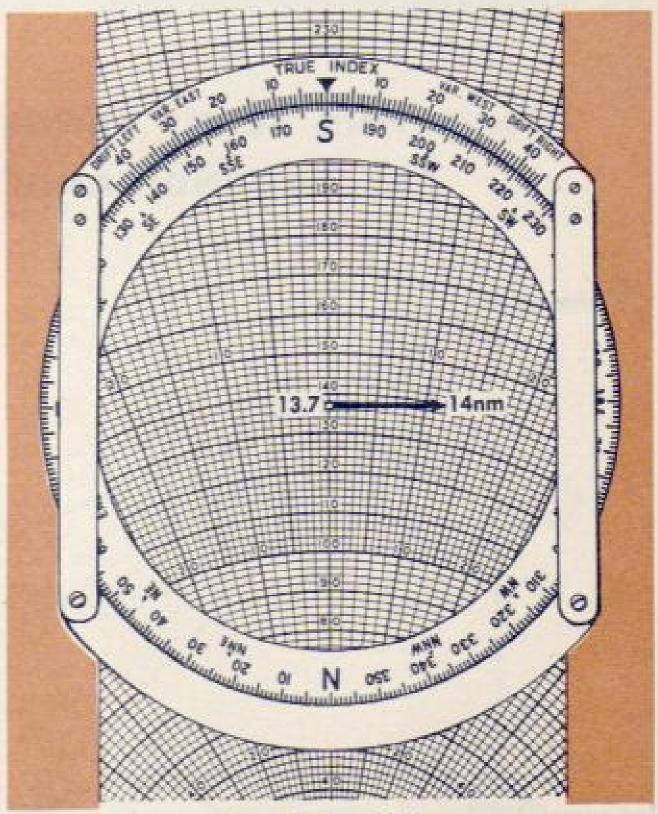
You can convert slant range to ground range on the E-6B computer by constructing the right triangle of ground range, slant range, and altitude in nautical miles (nm).

Convert the absolute altitude from feet to nautical miles by dividing by 6080. Set the computer azimuth with the index on a cardinal heading. Using the vector side of the slide, measure down from the grommet the amount of the absolute altitude in nautical miles. For easier reading, let a scale of 10 on the computer equal one mile and draw in the vector representing altitude. Rotate the computer 90° to another cardinal heading.

Slant range is represented by a groundspeed line on the computer slide. For instance, if the slant range is 14 nautical miles, use the 140 groundspeed line. Adjust the slide so that the correct groundspeed line is under the outer end of the plotted altitude vector. Then read the ground range under the grommet. Divide by 10 for the actual ground range.

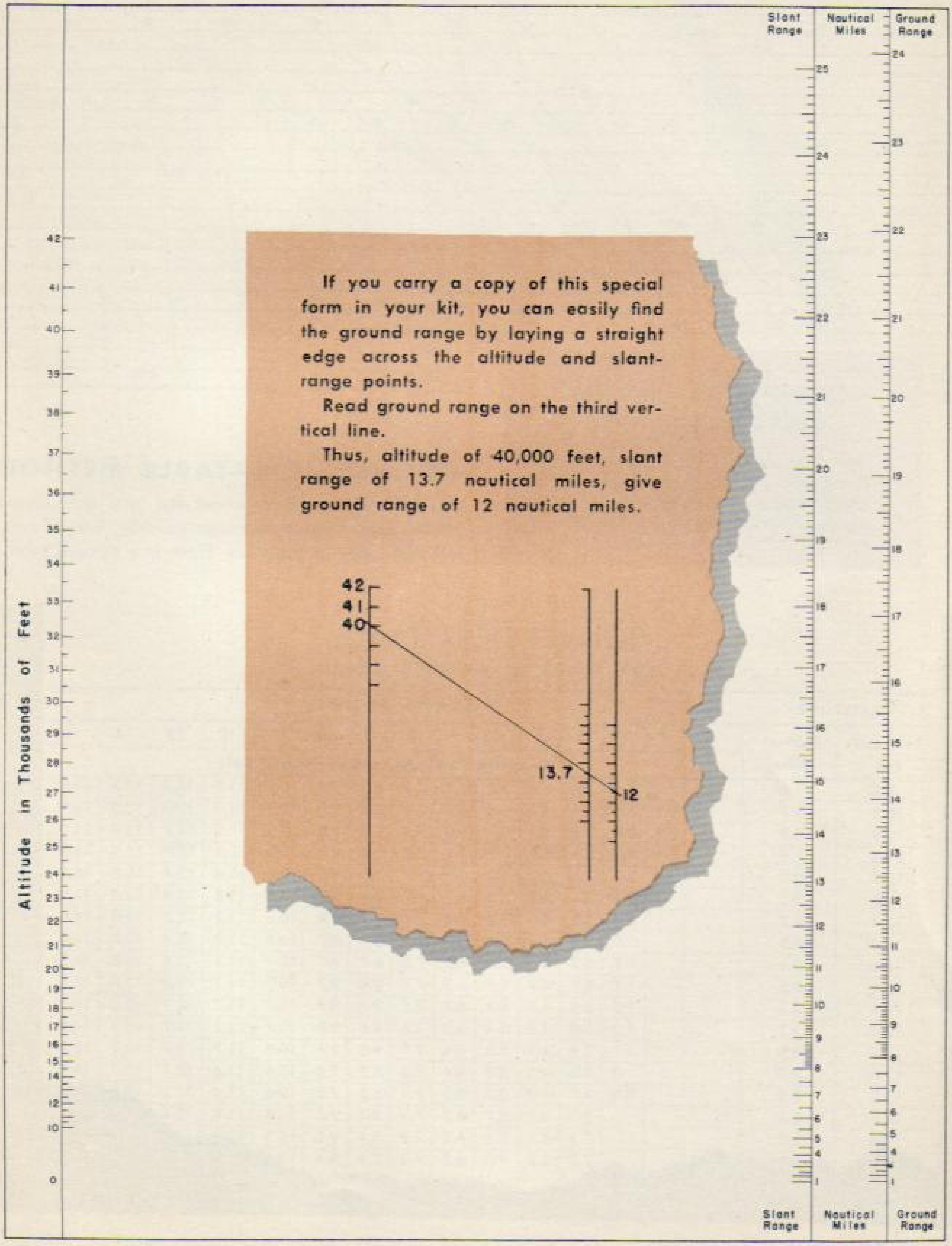


Rotate 90° to left (or right)



Ground range 13.7nm

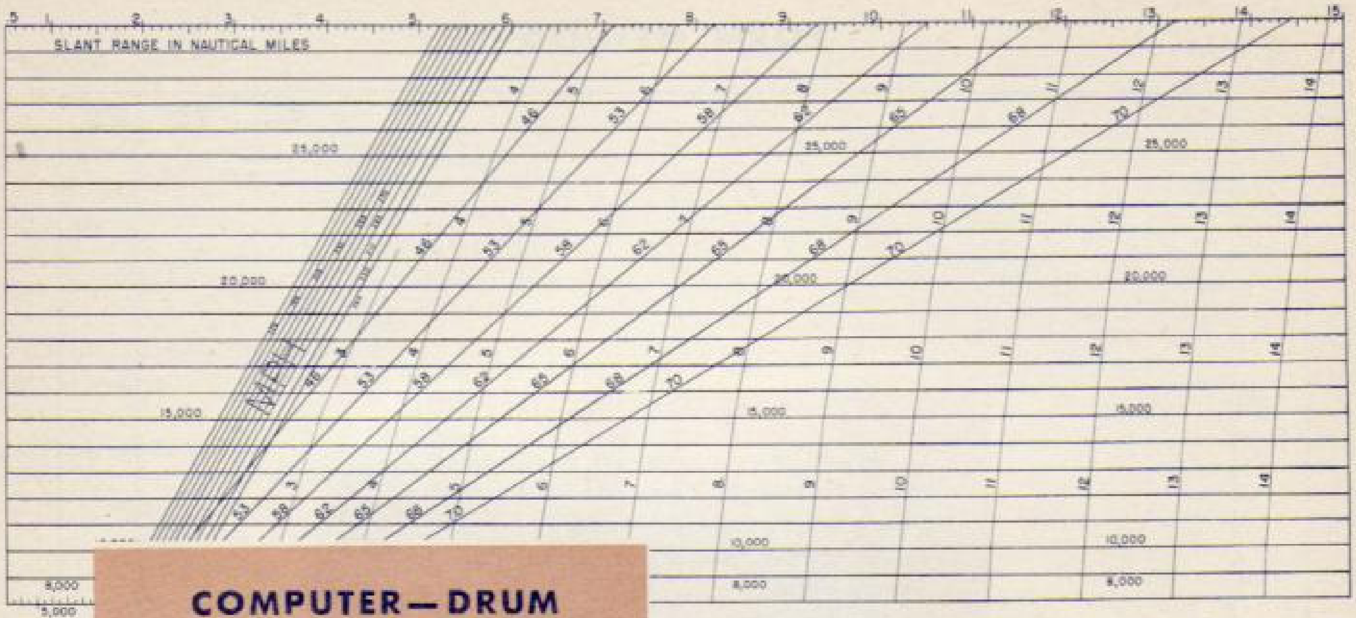
FORM METHOD



If you carry a copy of this special form in your kit, you can easily find the ground range by laying a straight edge across the altitude and slant-range points.

Read ground range on the third vertical line.

Thus, altitude of 40,000 feet, slant range of 13.7 nautical miles, give ground range of 12 nautical miles.



COMPUTER—DRUM CHART METHOD

With the aid of this chart on the computer drum you can convert slant ranges, up to 15 miles, directly to ground ranges.

CONVERSION—TABLE METHOD

In order to make it easier for you to convert slant range to ground range quickly, keep a conversion table in your kit. Here is a sample table.

CONVERSION TABLE
Slant Range to Horizontal Range

ALTITUDE		SLANT RANGE														
Thousand Feet	Nautical Miles	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Corresponding Horizontal Ranges in Nautical Miles														
9.7	1.6		1.2	2.5	3.7	4.7	5.8	6.8	7.8	8.9	9.9	10.9	11.9	12.9	13.9	14.9
10.3	1.7		1.1	2.5	3.6	4.7	5.8	6.8	7.8	8.8	9.9	10.9	11.9	12.9	13.9	14.9
10.9	1.8		0.9	2.4	3.6	4.7	5.7	6.8	7.8	8.8	9.8	10.9	11.9	12.9	13.9	14.9
11.6	1.9		0.6	2.3	3.5	4.6	5.7	6.7	7.8	8.8	9.8	10.8	11.8	12.9	13.9	14.9
12.2	2.0		0.0	2.2	3.5	4.6	5.7	6.7	7.7	8.8	9.8	10.8	11.8	12.8	13.9	14.9
12.8	2.1			2.1	3.4	4.5	5.6	6.7	7.7	8.8	9.8	10.8	11.8	12.8	13.8	14.9
13.4	2.2			2.0	3.3	4.5	5.6	6.6	7.7	8.7	9.8	10.8	11.8	12.8	13.8	14.8
14.0	2.3			1.9	3.3	4.4	5.6	6.6	7.7	8.7	9.7	10.8	11.8	12.8	13.8	14.8
14.6	2.4			1.8	3.2	4.4	5.5	6.6	7.6	8.7	9.7	10.7	11.8	12.8	13.8	14.8
15.2	2.5			1.7	3.1	4.3	5.5	6.5	7.6	8.6	9.7	10.7	11.7	12.8	13.8	14.8
15.8	2.6			1.5	3.0	4.3	5.4	6.5	7.6	8.6	9.7	10.7	11.7	12.7	13.8	14.8
16.4	2.7			1.3	3.0	4.2	5.4	6.5	7.5	8.6	9.6	10.7	11.7	12.7	13.7	14.8
17.0	2.8			1.1	2.9	4.1	5.3	6.4	7.5	8.6	9.6	10.6	11.7	12.7	13.7	14.7
17.6	2.9			8	2.8	4.1	5.3	6.4	7.5	8.5	9.6	10.6	11.6	12.7	13.7	14.7
18.2	3.0			0.0	2.7	4.0	5.2	6.3	7.4	8.5	9.5	10.6	11.6	12.6	[illegible]	
18.8	3.1				2.5	3.9	5.1	6.3	7.4	8.4	9.5	10.6	11.6	12.6		
19.5	3.2				2.4	3.8	5.1	6.2	7.3	8.4	9.5	10.5	[illegible]	[illegible]		
					2.3	3.8	5.0	6.2	7.3	8.4	9.4	[illegible]				

AZIMUTH STABILIZATION

There are two ways to view the picture you see in the PPI scope, depending on whether or not you use azimuth stabilization.

If you turn the azimuth stabilization switch ON, the output of the flux gate compass is tied into the radar set. The PPI scope then becomes another remote compass indicator and you see the pattern on the scope as it appears on your chart. The top of the scope represents either true or magnetic north, depending on whether variation has been set in.

Azimuth Stabilization ON

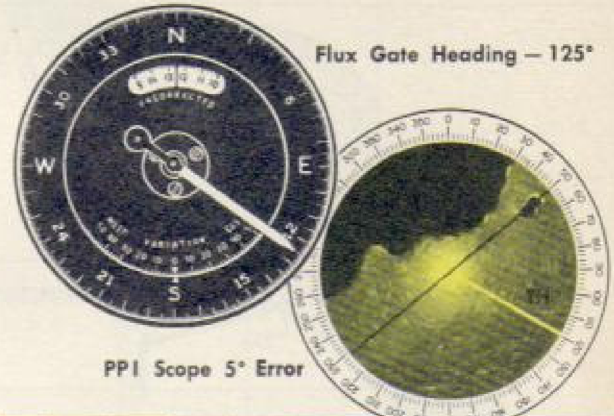
It is easier to navigate with azimuth stabilization ON. The lubber line always points in the same direction that the airplane is heading. You read true or magnetic bearings on the azimuth scale and the pattern on the scope is always oriented with your chart on all headings of the airplane. On each new heading, always check the lubber line of the PPI scope with the master flux-gate reading to detect a possible error. If an error is apparent, apply the amount of error to all bearings taken on that heading.

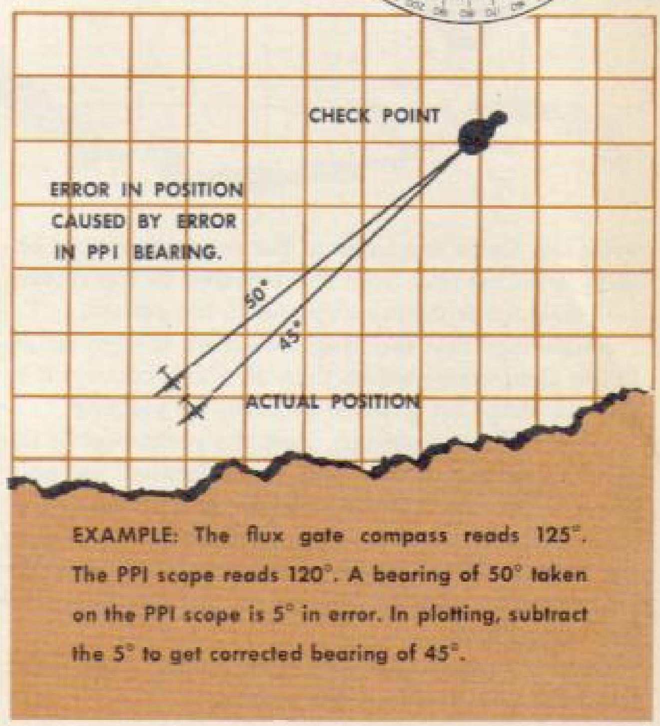
Azimuth Stabilization OFF

When you turn azimuth stabilization OFF, the top of the scope represents the true heading and the lubber line remains at 0°. The bearings you take are relative bearings. You must then add the true heading to the relative bearing to get a true bearing. The pattern of the scope shifts with each new heading; accordingly, you have to orient the chart with the scope pattern.

Remember to set the variation control on the flux gate compass to correspond with the variation of the area on the chart.

If the flux gate compass does not operate, ask the pilot for readings from the B16 magnetic compass. Turn azimuth stabilization OFF and take relative bearings from the scope.



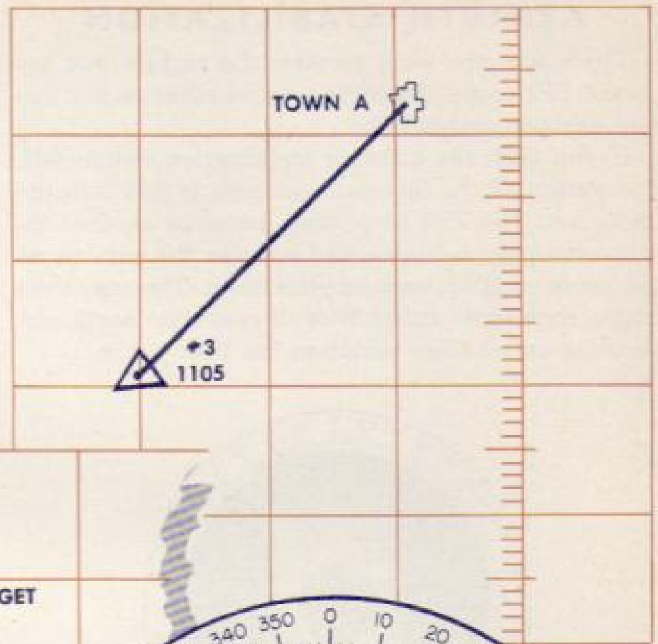


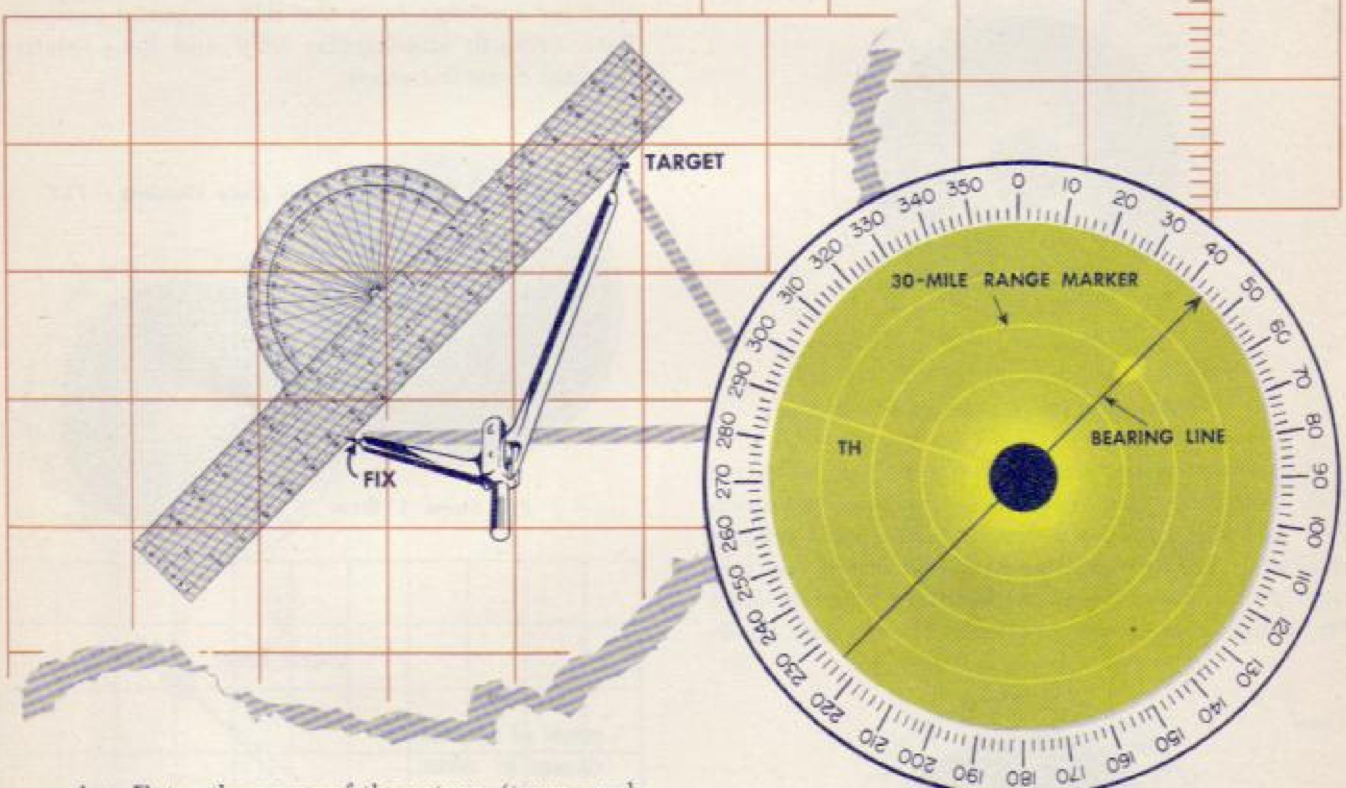
RANGE AND ONE BEARING

A single bearing and distance provide a quick, accurate fix, if the identity of the return is known.

Select a town or other bright return which you can identify on the PPI scope.

Move the bearing line into position over the return and read the true bearing to it. As quickly as possible, read the range by using the bomb-release circle or one of the range markers. Take the time of the observation and record the information in your log. Enter the name of the return (town or object), true bearing from the airplane to the return, and distance from the airplane to the return.





Remember that the range observed is slant range. If the slant range is less than 25 miles, convert it to ground range for greater accuracy in plotting.

With a Weems plotter, draw the reciprocal of the return bearing which you have located on your chart. Set a pair of dividers to the ground range that you obtained, by measuring off that distance along the scale on the chart. With one point of the dividers on the target, step off the correct distance along the line of position.

By this process you have determined your radar fix at the time you took the bearing.

Hints

Bearings can be read as true, magnetic, or relative, depending upon the condition of azimuth stabilization. Navigate with azimuth stabilization ON for this type of fix in order to read true bearings.

You may have sweep delay or altitude delay in operation. To obtain true slant range, be sure to add this delay to the slant range which the range marker or bomb-release circle indicates.

You can measure range more accurately by the bomb-release circle than by trying to interpolate a return between two range markers.

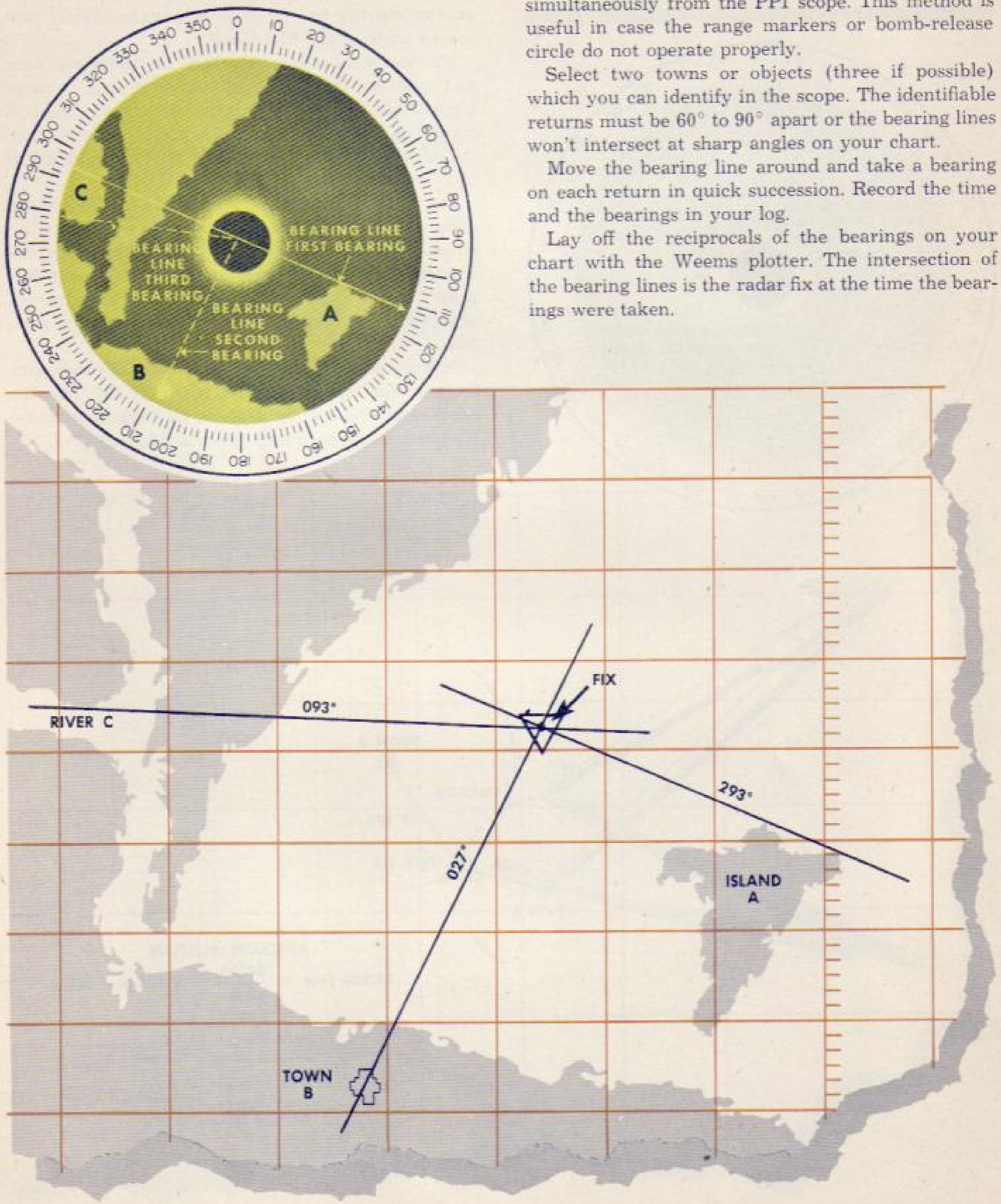
CROSSING TWO OR MORE BEARINGS

You can get an accurate fix without using range, by crossing two or more bearings obtained almost simultaneously from the PPI scope. This method is useful in case the range markers or bomb-release circle do not operate properly.

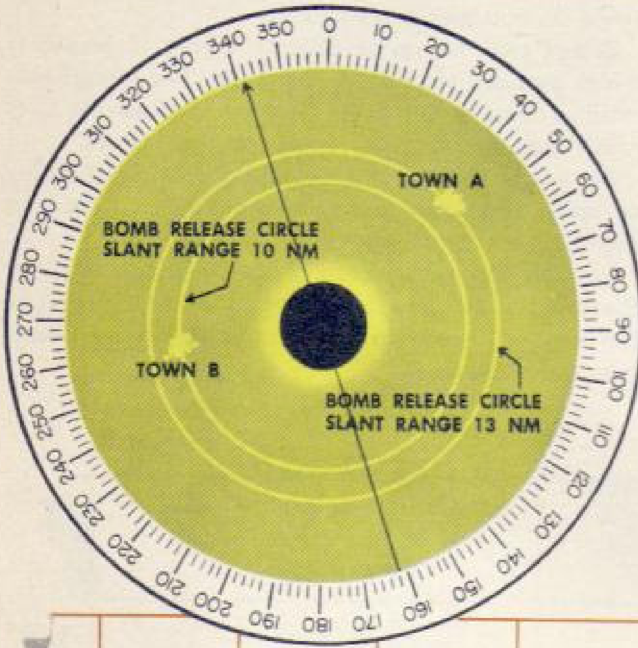
Select two towns or objects (three if possible) which you can identify in the scope. The identifiable returns must be 60° to 90° apart or the bearing lines won't intersect at sharp angles on your chart.

Move the bearing line around and take a bearing on each return in quick succession. Record the time and the bearings in your log.

Lay off the reciprocals of the bearings on your chart with the Weems plotter. The intersection of the bearing lines is the radar fix at the time the bearings were taken.



CROSSING TWO OR MORE RANGES



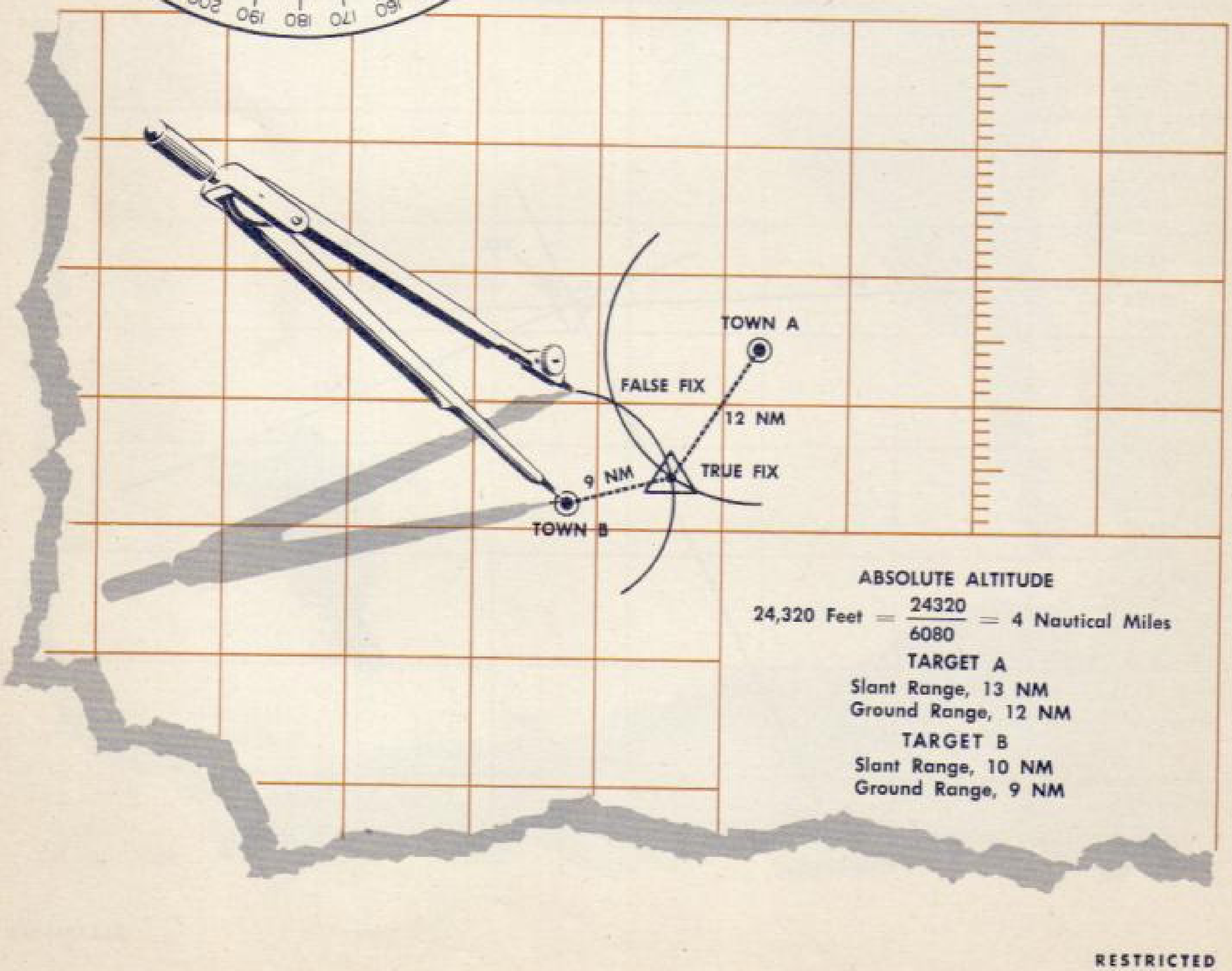
If azimuth stabilization and compass fail, you can plot a fix with ranges only. However, you must be able to identify two or more returns on widely separated parts of the PPI scope.

Use the bomb-release circle or the range markers and measure the true slant range of two or three identifiable returns in quick succession. Make a record of these ranges and the time of observation.

Convert the true slant range to ground range, if the distance is less than 25 miles.

Set a draftsman's compass to one of the ground distances observed, using the distance scale on the chart. Place one point of the compass on the respective check point and draw an arc on the chart. Repeat this for each ground range and each return observed. The intersection of the arcs is your position.

It is possible that two arcs may cross at two points. In that case one intersection is a false fix. You can determine which is the true fix by scope interpretation and dead-reckoning information.



Determining GROUNDSPEED, WIND, AND DRIFT

Radar simplifies the problem of accurately determining groundspeed, wind, and drift to supplement the navigator's dead reckoning.

From a series of radar fixes (or from only one fix), you can obtain the track made good from a starting point. Find your groundspeed by dividing the distance from the starting point to the last fix by the time elapsed. You can obtain true heading and true airspeed from the compass and the airspeed indicator. You then have all the data you need to determine wind and drift.

The most common methods for putting together the known data and computing the unknown data are:

Air Plot. From a wind vector drawn on the chart between the no-wind position and true position (found with one or more radar fixes), measure the direction and velocity of the wind.

Target Timing (E-6B Grid Method). Take two or more successive bearings on a check point as it moves across the scope and intersects the range markers. Plot the fixes on the square grid of the E-6B computer. It is easy then to measure track, drift, and distance traveled. You can calculate your groundspeed on the back of the computer.

As a variation of this method, you can take fixes at six predetermined ranges, using the bomb-release circle in place of the range markers.

Multiple Drift Correction. This is a way to kill any error in the drift calculated by target timing for the proposed bombing-run course. It is fully discussed in ROBIF 6-2.

Target on Heading. When the target is directly under the true-heading marker and passes across the scope to the opposite side, you can obtain the drift by a simple calculation of the bearings. Then you can find the groundspeed and wind by using the E-6B computer.

Passing Over Target. You can use this special method to determine drift when the airplane is directly over a target. When the return moves away from the center of the scope, the drift is the difference between the true heading and the reciprocal of the true bearing of the target.

AIR PLOT

Always Know Your Dead-Reckoning Position From Air Plot

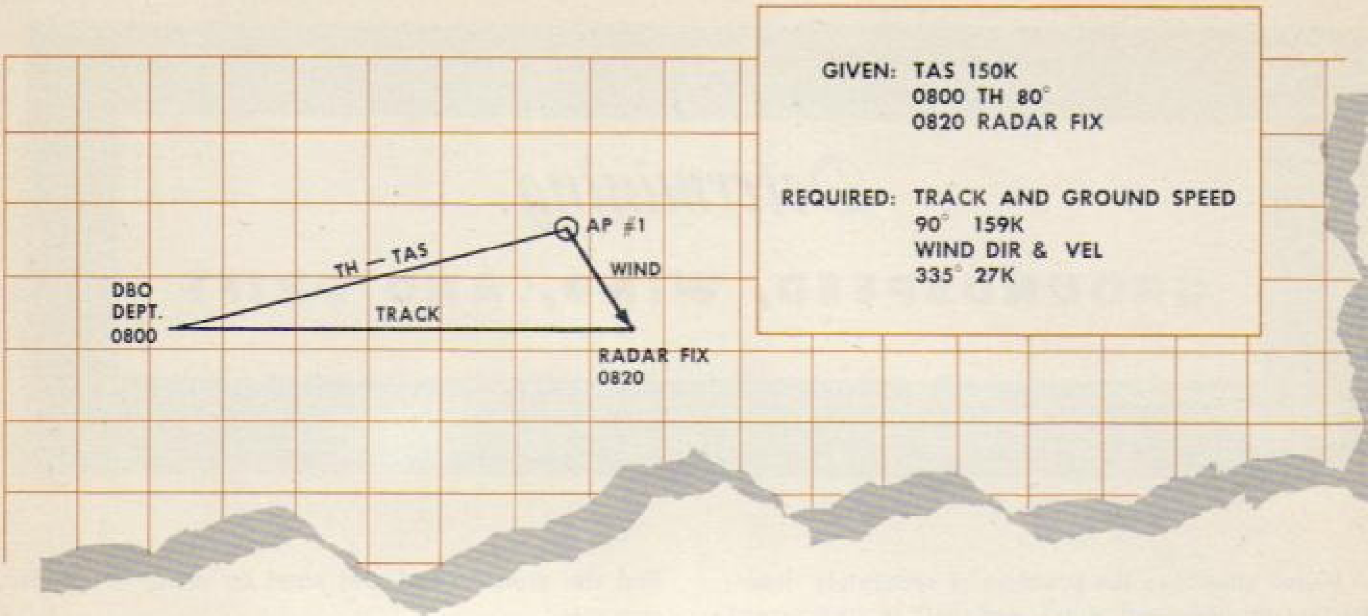
Air plot is a means of determining your air position (no-wind position) by plotting true heading and true airspeed on the chart.

Air plot is an invaluable aid to radar navigation. By using the vector drawn on the chart, you can easily determine the ground position and thus be able to identify returns in the PPI scope by comparing them with definite check points on the chart.

Obtaining a Wind

To determine wind from air plot, you must establish your actual position by means of a radar fix and mark this fix on the chart. The line connecting the air position and the fix represents the direction and effect of the wind for the total elapsed time.

Measure the length of this wind vector with a pair of dividers and figure the proportional distance represented by one hour's time. For example, if the airplane has been flying two hours, you must halve



the wind vector for two hours to obtain the windspeed for one hour. If the airplane has been flying one-half hour, you must double the wind vector to obtain the windspeed for one hour. Always remember to get the wind velocity in knots by using the right proportion of time.

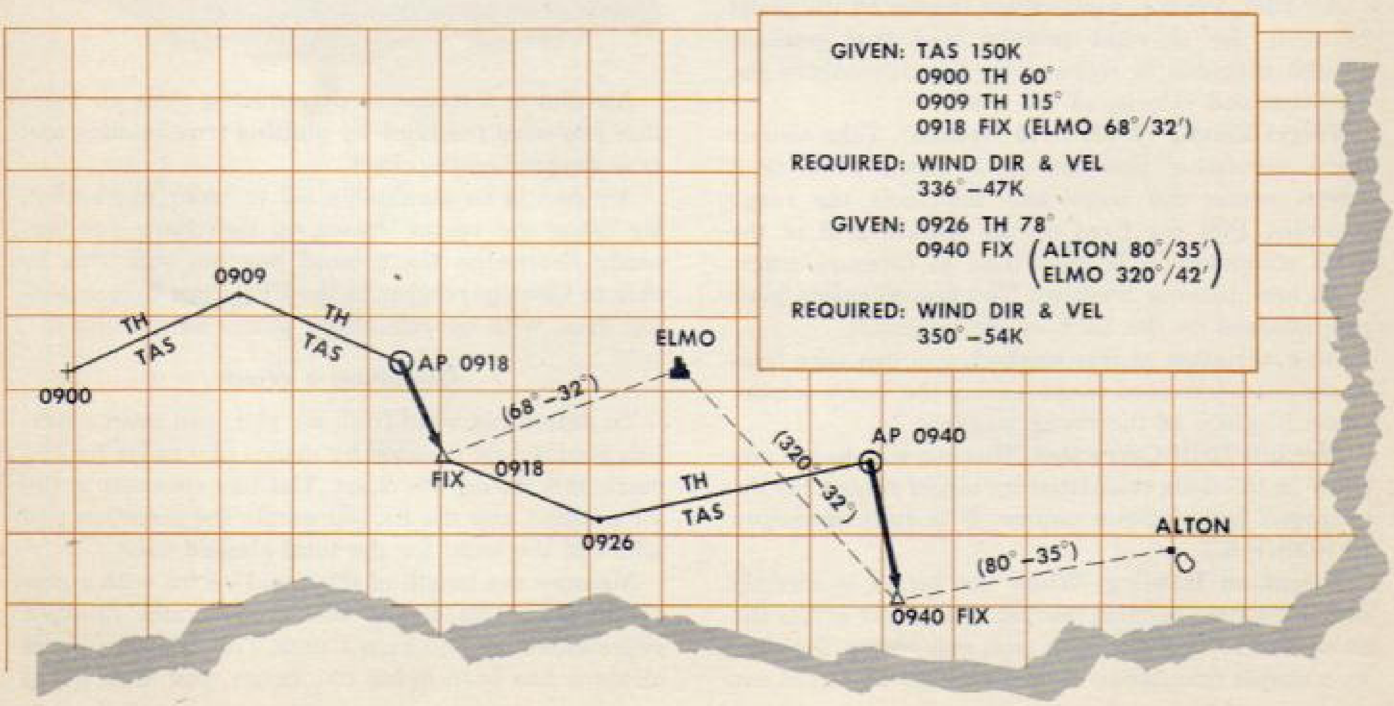
The true bearing from the air position to the fix is the direction from which the wind is blowing. Remember this rule of thumb: The wind blows the airplane from air position to fix.

Average Winds

You may take fixes as frequently as every 10 minutes. However, to obtain average winds, plot the wind vector at fixes taken at least 20 minutes apart and average several of them, or at fixes taken no more than an hour apart.

Groundspeed and True Course

To find groundspeed and average true course, draw a line between the latest fix and a fix you took about 20 minutes earlier. Place a Weems plotter on the track line and read the true course. Measure the



length of the track with dividers. Using the back of the E-6B computer, find the groundspeed in knots.

Enter the data in the log. Using the wind obtained from the fix, find the corrected heading and start a new air plot from the latest fix position.

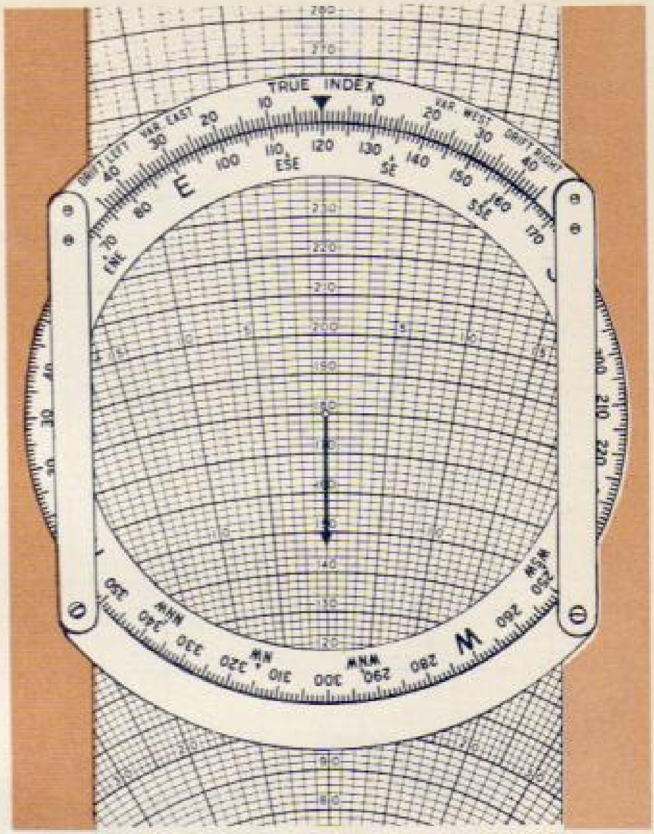
Killing Drift

Since you now know the wind direction and velocity, you can find a corrected true heading to destination by using the vector side of the E-6B computer. In this way, from an initial point to a target or on any short leg, you may practically kill the drift from the start.

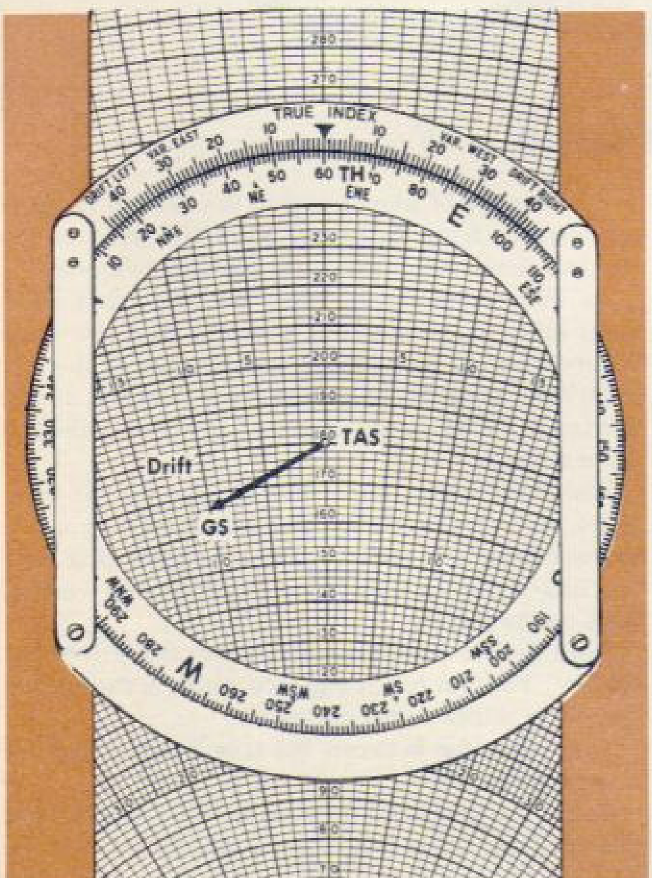
Determine the estimated time of arrival (ETA) by measuring the distance to destination and dividing by the groundspeed, using the E-6B computer.

Always figure an ETA to the next check point and to destination. You can easily use an ETA obtained in this way to identify approaching returns on the scope, if there are no prominent check points.

Radar navigation is essentially pilotage. You must work from check point to check point to keep from getting lost.



W=120°/33K



TH=60° TAS=180K GS=166K Drift=10°L

E-6B Vector Method of Obtaining Wind

With the E-6B computer, you can quickly determine a wind without drawing in the air position on the chart.

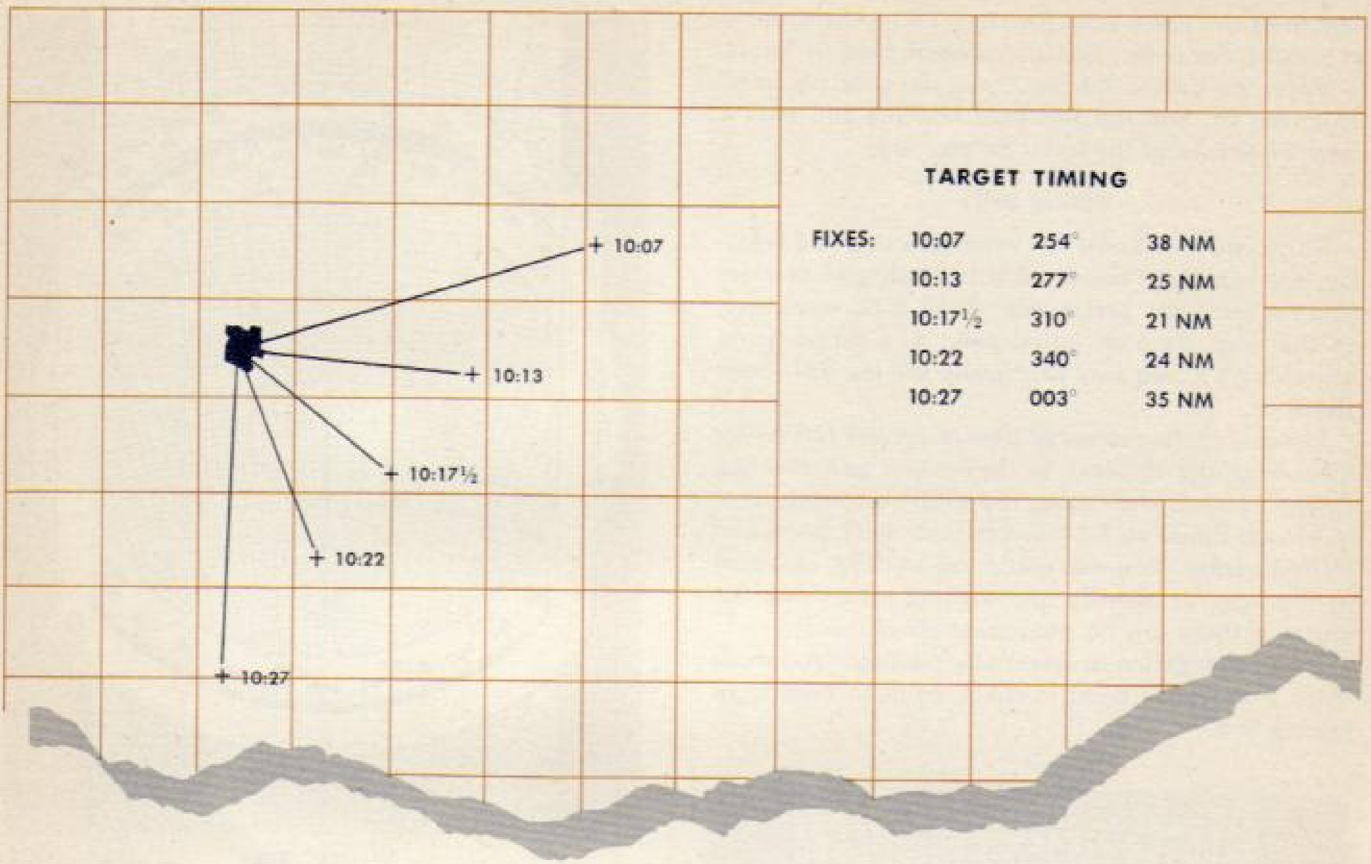
After you have taken a radar fix, find the average track-made-good and the groundspeed to the fix position, as explained above.

Determine the average true heading from the flux gate compass and convert the indicated airspeed to true airspeed.

Using the vector side of the E-6B computer, place the true heading under the true index and the true airspeed under the grommet.

Count off the degrees of drift (right or left of the true-heading line) for the track-made-good. Place a dot at the intersection of the groundspeed arc and the drift line. This is the end of the wind arrow. Draw in the arrow from the grommet to this point. Rotate the azimuth ring until the wind arrow points straight down from the grommet. The lower end of the arrow indicates the wind velocity in knots.

You now can read the direction of the wind by looking under the true-index marker.



TARGET TIMING

E-6B Grid Method

You can easily determine drift, track, and groundspeed by taking a series of bearings on a return as it moves across the scope and by recording the time. You need not identify the target, but you should pick it up ahead of the airplane and more than 20 miles to one side.

There are several ways to take the bearings, but they all give you essentially the same information. Here is one method:

As the target intersects one of the range markers, measure the range and true bearing of the target and record the time accurately or start a stop watch. Timing accuracy is essential in order to obtain an accurate groundspeed.

Convert slant range to ground range, if the target is less than 25 miles away.

Place the square grid of the computer slide under the transparent face and center the 0 under the grommet.

Turn the azimuth ring until the true bearing is opposite the index. Measure down from the grommet a number of units equal to the ground range of the airplane from the target. Mark this point on the vertical center line of the grid with a small cross.

As the return moves across the scope and intercepts other range markers, make at least two more observations of time, range, and bearing at the moment the return is under the range marker. If you are using a stop watch, stop it at the time of the last observation.

Plot these range and bearing fixes on the computer face as you plotted the first fix. Draw a line through the fixes and rotate the azimuth ring until the line connecting the fixes parallels the vertical lines on the grid.

Read the track or its reciprocal, at the true-index marker. You can tell at a glance which is the correct track and which is the reciprocal.

The difference between the true heading and the track is the drift.

Count the grid units between the first and the last fixes plotted, to get the distance traveled. Using the back of the computer, divide this distance by the elapsed time to obtain the groundspeed.

Determining Wind

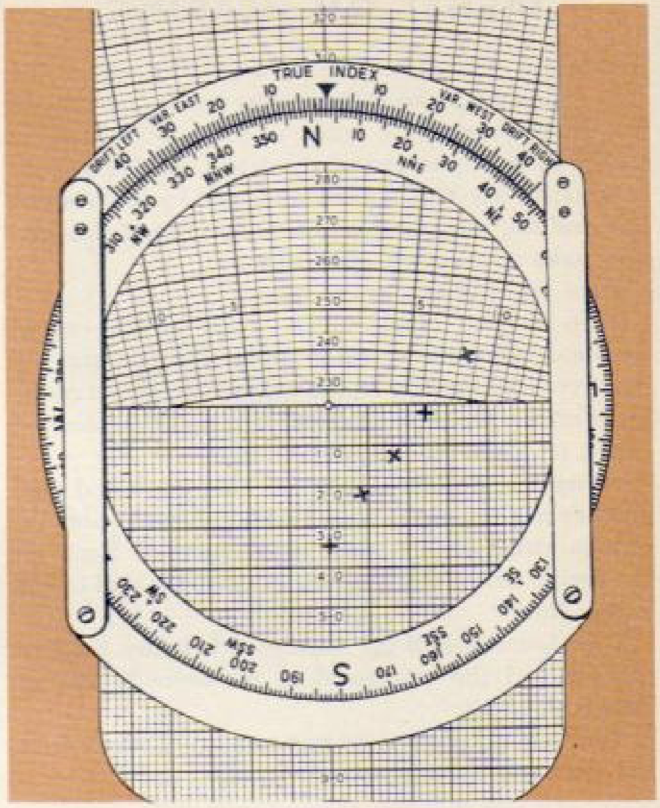
When you have obtained track and groundspeed in this manner, and know your true heading and true airspeed, you can determine the wind on the E-6B computer in the way explained under the heading, Air Plot.

Using Predetermined Ranges

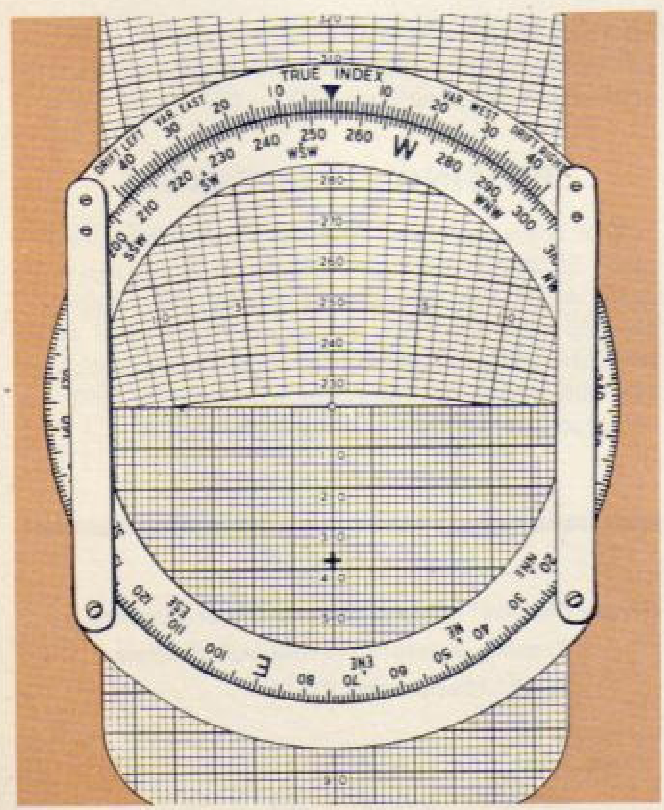
As a variation of the E-6B grid method, you can make use of the same procedure with predetermined ranges. The check point selected should pass across the scope about 5 miles from the airplane's track.

Turn on the bomb-release circle and get a series of bearings as the check point intercepts the leading edge of the bomb-release circle at predetermined ranges. For greater accuracy, use a stop watch to obtain the time of each measurement and the total time of the run. Then, if the return is lost at any time during the run, you can obtain groundspeed and drift from the information already recorded.

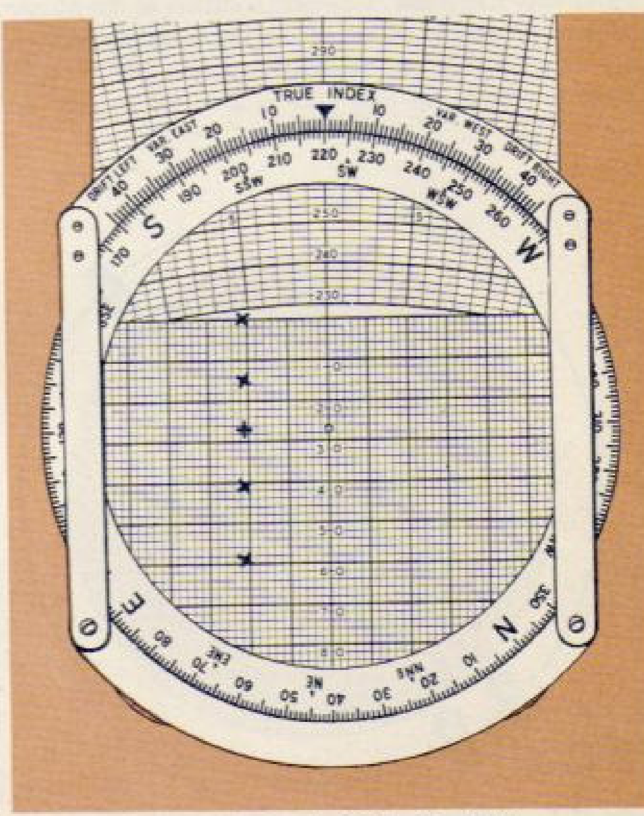
For example, with the set on the 20-mile range, take fixes at 14, 11, 8, 8, 11, and 14 nm. Plot the fixes and work out the solutions on the E-6B computer as described on the previous page.



Last bearing: 1027,03°/35



First bearing: 1007,254°/38



TH=210 Track=220° GS=180K

TARGET ON HEADING

When a prominent object appearing under the true-heading line crosses a range circle and crosses the same range circle again on the opposite side of the PPI scope, you can easily determine the drift. It is equal to one-half the angle formed by the heading line and the reciprocal of the cursor line at the time you make your second observation.

Here is the procedure to follow:

Turn on the bomb-release circle or the range markers. When the object is under the true-heading line, read the bearing at the instant the object intersects either the bomb-release circle, on a selected range, or one of the range markers.

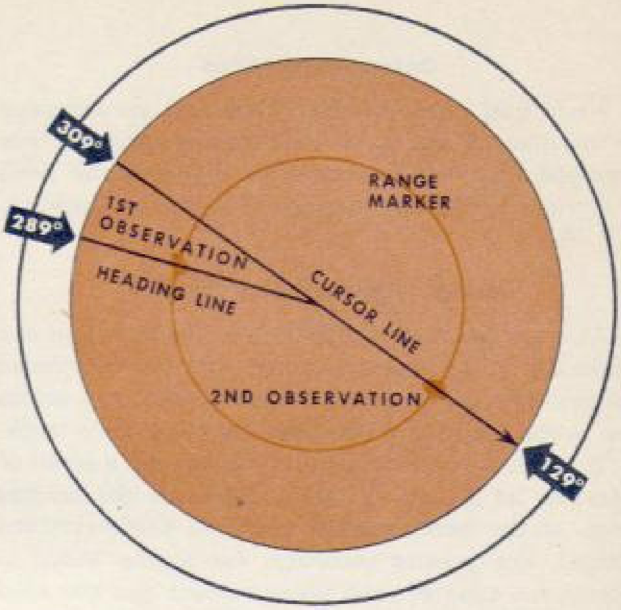
Watch the object pass across the scope and take another bearing at the instant it intersects the bomb-release circle or the same range marker. Read off the reciprocal of this bearing at the back end of the cursor line.

Calculate one-half the difference between the first bearing and the reciprocal of the second bearing. This is the drift.

You can determine groundspeed and wind from the two fixes by using the E-6B computer.

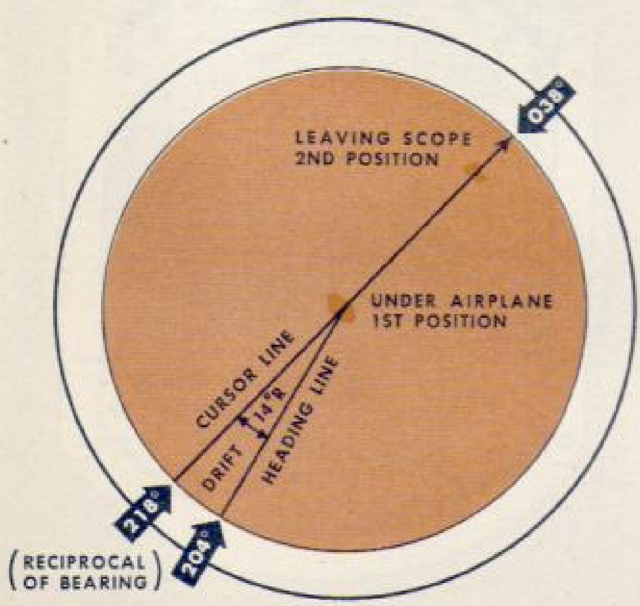
Mathematical Solution

You may use a mathematical solution of the above problem to obtain the drift. In the example shown here, add the first and second bearings (289° + 129° = 418°). Divide by two (418 ÷ 2 = 209°). Add or subtract 90° to obtain true course. (209° + 90° = 299°). The drift is the difference between the true course and the heading. (229° − 289° = 10° Rt.).



Given: TH 289°
First bearing 289°
Second bearing 129° (Reciprocal 309°)

Required: Drift and Track
10° R, 299°



PASSING OVER TARGET

This is a simple way to obtain drift when the airplane is passing over a check point. It is frequently used when the airplane is climbing for altitude directly over the field. As the return moves away from the center of the scope, read the true bearing. The difference between the true bearing and the reciprocal of the true heading is the drift.

Given: TH 204°—Return directly under airplane.
Bearing of return leaving top of scope is 38° (Reciprocal: 218°)

Find: Track and Drift
218°, 14° R (218° − 204° = 14°)

Racon Navigation

If you are flying within the range of a racon, as Radar Beacon AN/CPN-6 is called, you can use it either for homing or for determining the position of the airplane. The range of the racon depends upon its site and your altitude. If you are flying at 20,000 feet you should pick up the racon reply at 170 nautical miles or more.

Slant Range

To determine your distance from the racon, measure the distance in nautical miles from the center of the scope to the first arc of the racon signal, either by using the bomb-release circle or range markers.

Add this distance to the setting of the SWEEP DELAY selector switch to obtain the slant range from the racon to your airplane.

Azimuth

Determine the bearing of the racon from the airplane as follows:

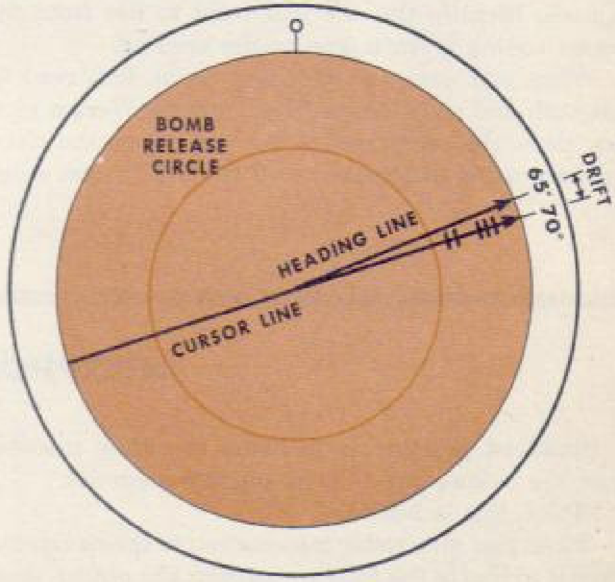
Move the cursor line over the center of the racon signal. Read the bearing directly from the azimuth scale.

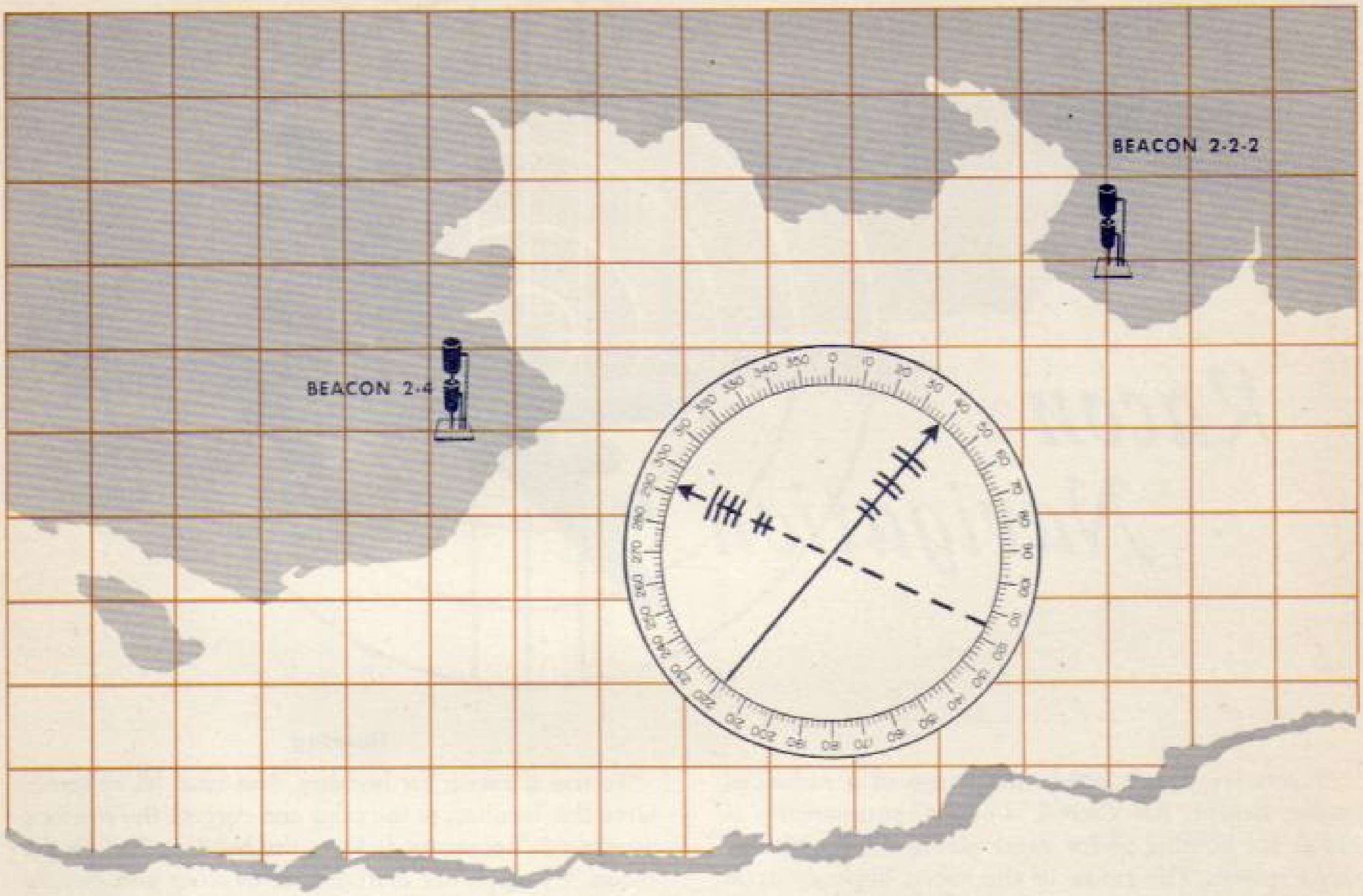
Note: When you are close to the racon, decrease the length of the arcs of the signal by decreasing RECEIVER GAIN. Your azimuth reading then is more accurate.

Homing

To use a racon for homing, first read its azimuth. Give this heading to the pilot and correct the heading as often as necessary to keep the heading line on the racon. By applying drift to the bearing you can fly a straight course to the racon.

Note: Unless you apply drift, in homing, you fly a parabolic course to the racon.





Navigation

You can navigate with racon, using one or more signals. Identify the one you want to use from the racon coding given to you in the briefing.

When you navigate with one racon, first read its azimuth and slant range. Then, using a Weems plotter, draw the reciprocal of the bearing on the chart you are using and measure off from the racon a distance corresponding to the range. This point is your position.

You also can take two bearings simultaneously on two racons. Plot the reciprocals of the bearings on the chart. The intersection of the bearing lines is your position at the time of the observation.

Do not stop the radar antenna on the racon signal; this results in excessive triggering of the racon and keeps it from responding to other aircraft.

INTERPHONE PROCEDURE

Standard practice is to name the crew member you are calling and then to identify yourself:

"Pilot, this is Mickey."

When you give radar information to the navigator, give it to him in the following order: Fix object, time, bearing, and distance.

Example: "Golden Gate Bridge; time, one four three zero; two four three degrees, one eight miles."

Give information to other members of the crew in terms of the clock system:

"Golden Gate Bridge, nine o'clock, one eight miles."

RADIO NAVIGATION AIDS

Radio aids are valuable in all navigation, contact or instrument. You should make the fullest practical use of radio facilities to aid you in your navigating. Obviously it would be foolish to depend upon radio navigation alone. Several conditions might arise that would make such navigation impossible.

Static, for example, is the greatest hazard to radio navigation. During electrical storms radio reception is sometimes impossible, making it necessary for you to use other methods.

Then, too, atmospheric conditions affect navigation by radio. Sometimes you can't make contact with range stations 10 miles away. Don't think immediately that your radio is out. Fly out your ETA over the station and try contacting it again before you conclude that you are off-course.

Using Radio-Range Beam Legs

Use radio-range beam legs just as you use visual check points. Use them at all times on both instrument and contact flights.

Here is an example:

Assume you have taken off from Charlotte to fly to Norfolk. After takeoff you tune the radio to the Greensboro range to determine your position in area X thus: If west of the Greensboro southeast leg, you hear the Greensboro N signal; if east, the Greensboro A signal. In both cases the strength of the background (on-course) signal determines your proximity to the Greensboro southeast leg. A solid on-course signal of the Greensboro southeast leg indicates your general position along the line of flight. As you progress along the flight, you can tune to successive stations adjacent to your route and identify your position relative to them.

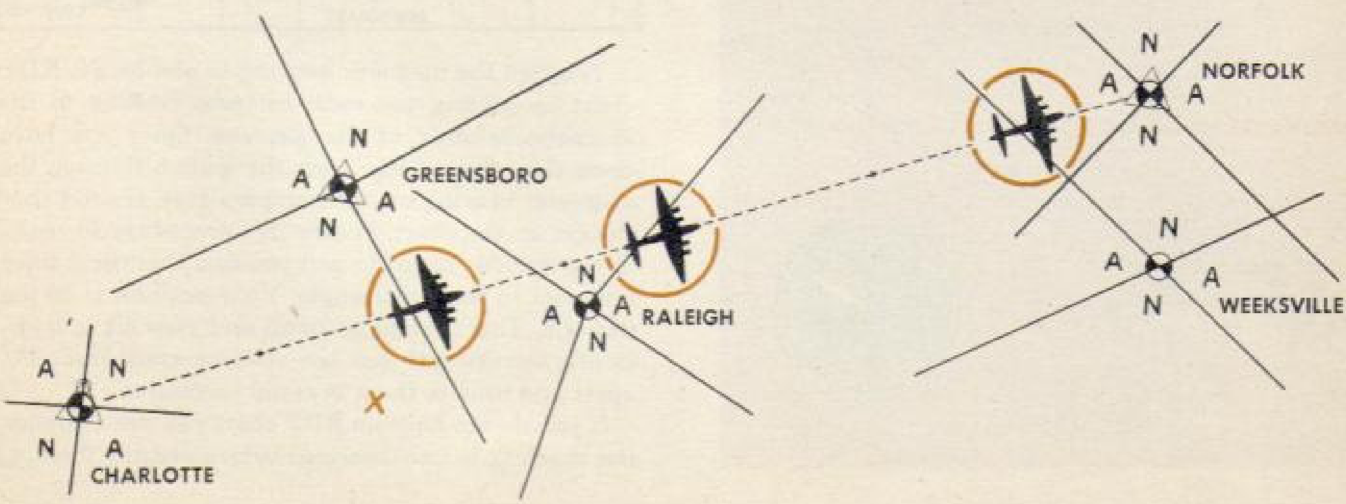
International Morse Code is used for all code signals in radio navigation.

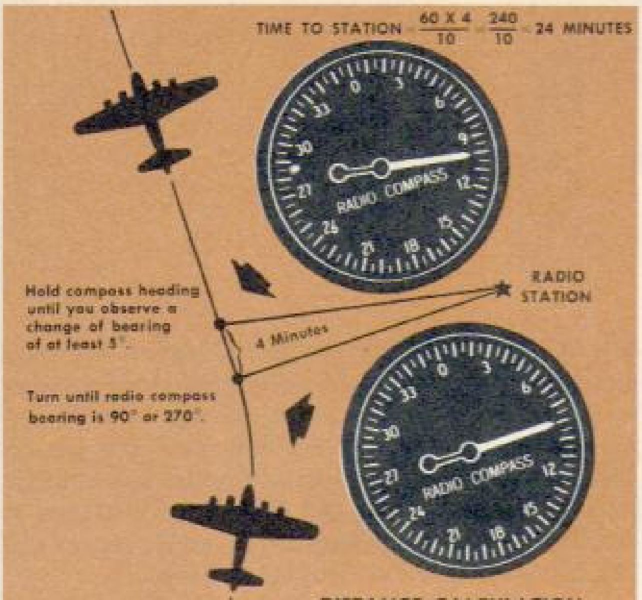
Radio in conjunction with visual check points is an easy method of determining your position.

If you are flying off the airways you can find your exact position by using both the beam and a topographical feature as check points.

Radio Compass

The radio compass is a receiving apparatus which senses direction; because of this fact, it naturally is a valuable navigational aid. When you make use of the radio compass you depend upon the directional loop to determine your direction from the radio station to which your set is tuned. The bearing indicator needle of the automatic radio compass points to 0° when the airplane is headed toward the station to which the set is tuned. A crosswind, of course, causes the airplane to drift to one side or the other





DISTANCE CALCULATION

of the bearing toward the station.

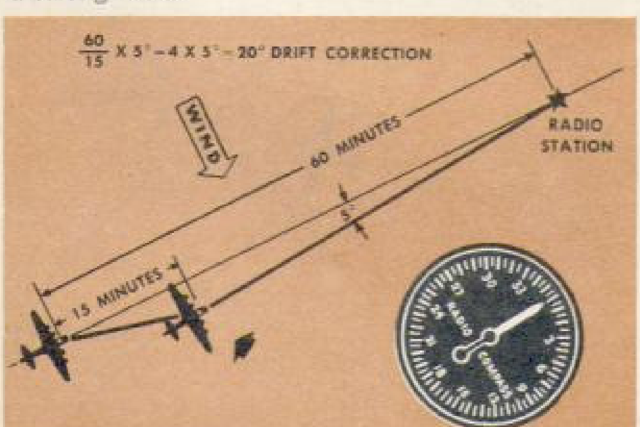
Drift becomes apparent when you note the movement of the indicator needle away from 0° while a constant gyro heading is being flown. The change in reading of the needle may be used to calculate distance to station and necessary drift correction.

To compute the distance to a station, turn the airplane until the azimuth is on 90° or 270°. Hold a constant heading. Note the time required for a reading change of approximately 5°. Compute the distance or time to the station by the equations:

$$\text{Minutes to station} = \frac{60 \times \text{Minutes flown between bearings}}{\text{Degrees of bearing change}}$$

$$\text{Distance to station} = \frac{\text{TAS} \times \text{Minutes flown between bearings}}{\text{Degrees of bearing change}}$$

This method is reasonably accurate unless there is a strong wind.

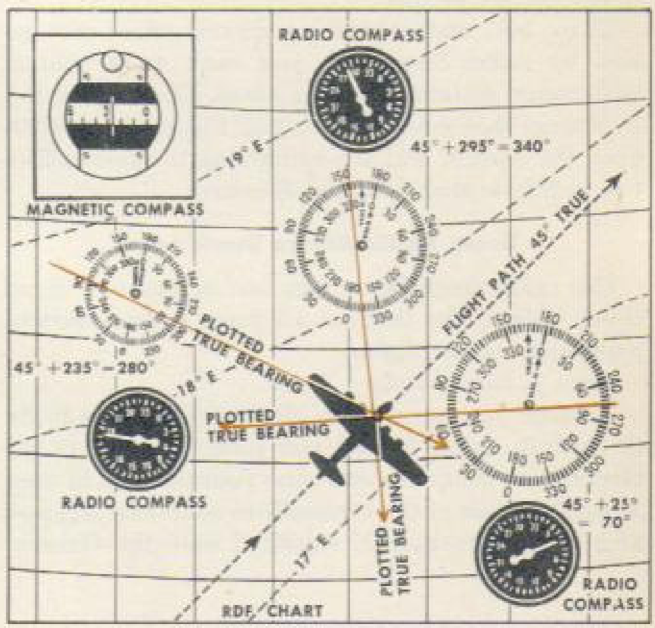


DRIFT CALCULATION

To find the necessary drift correction after the distance to the station is known, fly a gyro heading toward the station and note the change in radio-compass bearing after flying a reasonable length of time. Divide the total time to the station by the time flown and multiply the result by the number of degrees change in the radio-compass bearings. This value is the drift correction in the direction indicated by the radio-compass needle.

How to Take Fix with Radio Compass

When you take a fix with the radio compass, locate the stations you expect to use on an RDF chart, tune in and identify them, and record the exact tuning-dial reading for each station. You then can tune rapidly from one station to another and keep errors to a minimum. Fly a constant heading while you tune to the selected stations in rapid succession and record the radio-compass readings.



You find the magnetic bearing to plot on the RDF chart by adding the radio-compass reading to the magnetic heading of the airplane. Once you have done this, draw a line from the station through the magnetic bearing on the compass rose around that station on the chart. Follow this procedure for each of the stations tuned to and you find that these lines intersect to form a triangle. Your position is in the triangle. This triangle is small and your fix is sufficiently accurate if you use stations more than 30° apart and tune to them in rapid succession.

If you do not have an RDF chart you must change the bearings to true bearings before plotting them.

The Log

The log is the record of the flight. It must tell the complete story from the standpoint of both navigation and intelligence. Before the flight begins, plan carefully and enter all basic information in the Flight Plan section of the log. You obtain this data from the Flight Order or Operations Order.

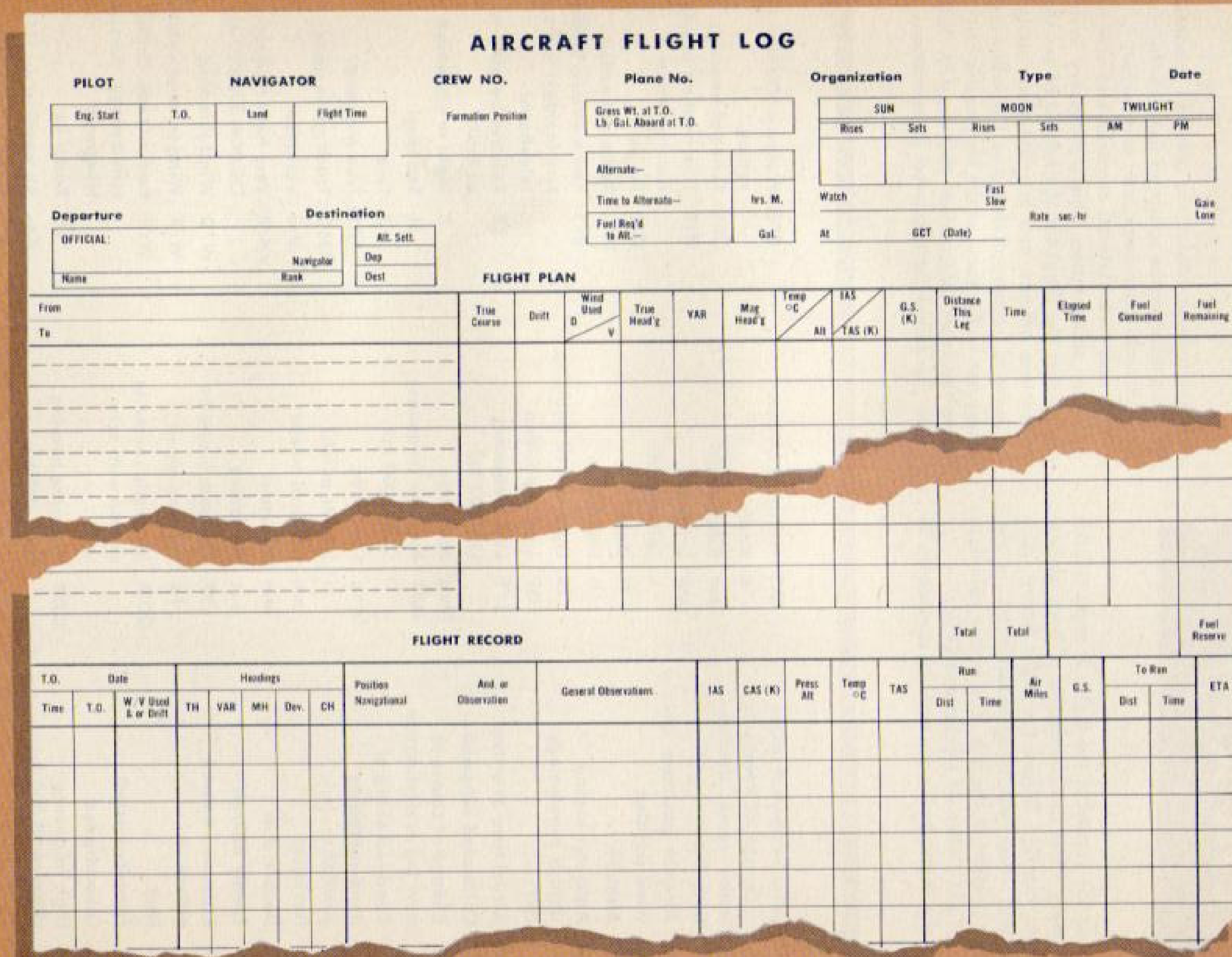
During the flight, make log entries accurately. If an error in your navigation becomes apparent, you then can uncover the source of the error by checking back through your work, and can correct it.

You must correlate all remarks and observations with time and position. This is necessary in order to reconstruct the flight for the benefit of weather and intelligence officers, and for navigation analysis.

A typical log is reproduced on the following page. It may not be the same as the log you use but it illustrates the basic information that must be kept.

Use the following approved abbreviations:

A/C	Alter (or altered) course—change of course to make same destination
AP	Air-plot position; no-wind position
Alt	Altitude
Alt Set	Altimeter setting (British terminology: QFF)
ATA	Actual time of arrival
CAS	Calibrated airspeed
C/C	Change of course to new leg or destination
DR	Dead reckoning or dead-reckoning position
Dev	Deviation
DD	Double drift
EA	Enemy aircraft
ETA	Estimated time of arrival
ft	Feet
FA	Friendly aircraft
GS	Groundspeed
H/F	High frequency (3000 to 30,000 kc)
IAS	Indicated airspeed
K	Knots
km	Kilometer(s)
Lat	Latitude
L	Left or port
Lt	Light
LH	Lighthouse
LS	Light vessel; lightship
LOP	Line of position
L/F	Low frequency (30-300 kc)
Mag	Magnetic
M/F	Medium frequency (300-3000 kc)
Long	Longitude
m	Statute mile(s)
nm	Nautical mile(s)
min	Minute(s)
o/c	On course
PP	Pinpoint; visual fix
PR	Position report
QDM	Magnetic course to station with zero wind
QDR	Magnetic bearing from station
QFE	Pressure-altitude setting
QDL	Series of bearings
QTE	True bearing in relation to station
QTF	Fix
R/A	Radius of action
R/T	Radio—Voice (British terminology: radio telephone)
RB	Relative bearing or azimuth
R	Right or starboard
SL	Sea level
T	True
TAS	True airspeed
TMG	Track made good
Var	Variation
VH/F	Very high frequency (30,000-300,000 kc)
W/D	Wind direction
W/F	Wind force or velocity
W/T	Radio—code (British terminology: wireless telegraph)
▽	Radar fix
—⊖—	Air position



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 Rate sec./hr Gain Lose
At GCT (Date)

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

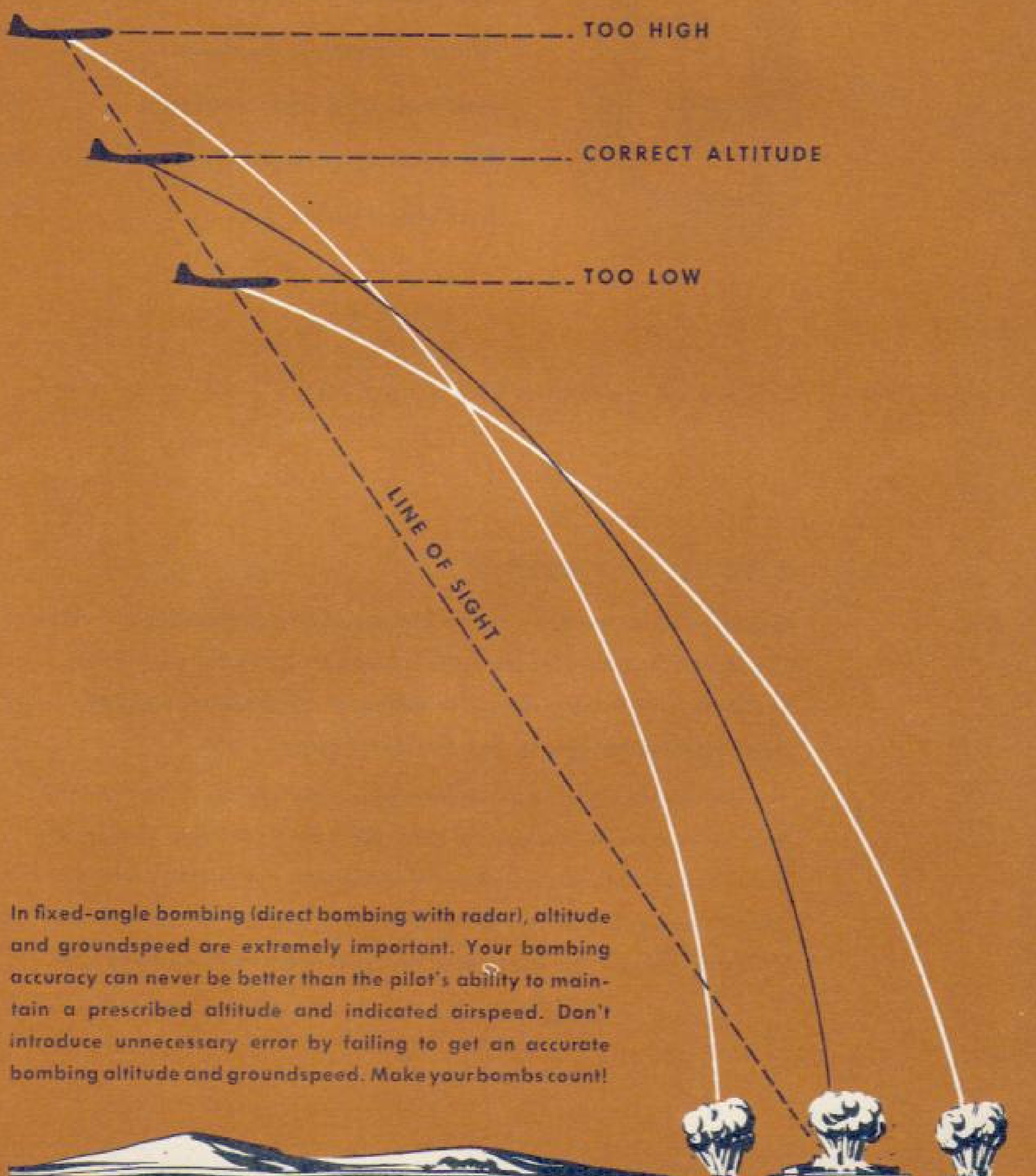
FLIGHT RECORD

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

SECTION 5

RADAR BOMBING



In fixed-angle bombing (direct bombing with radar), altitude and groundspeed are extremely important. Your bombing accuracy can never be better than the pilot's ability to maintain a prescribed altitude and indicated airspeed. Don't introduce unnecessary error by failing to get an accurate bombing altitude and groundspeed. Make your bombs count!

5

SUBJECTS IN SECTION 5

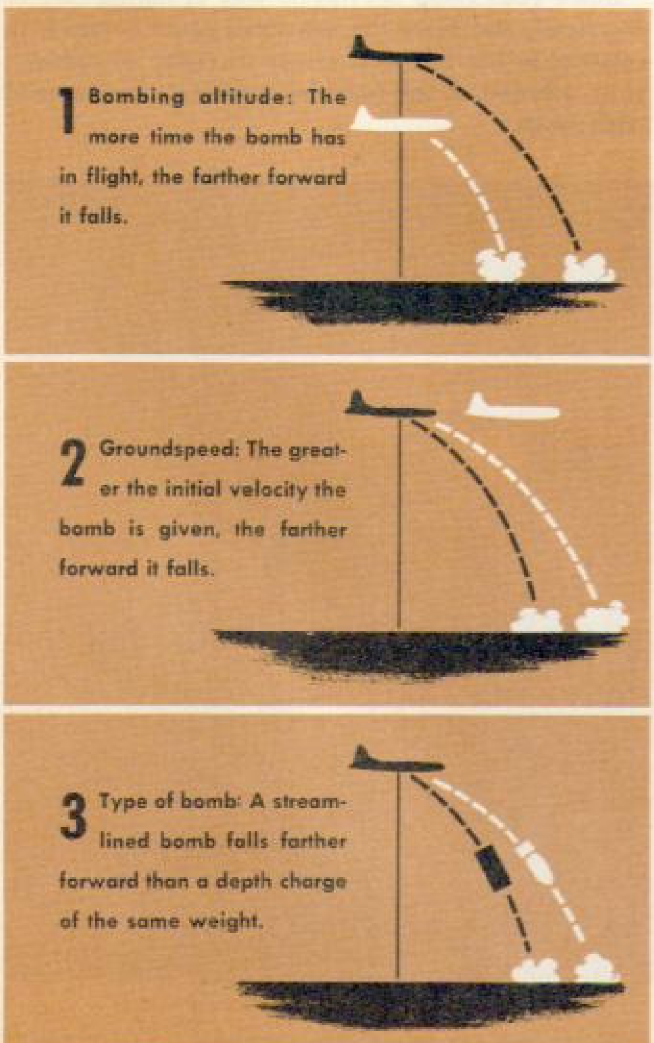
RADAR BOMBING

Combat missions are flown for the purpose of dropping bombs on a target. The success or failure of the entire mission may depend upon you. You must have a complete understanding of the bombing problem, radar bombing equipment, and the use of bombing aids.

You can reduce errors to a minimum only when you are aware of them. You can improve the accuracy of radar bombing by compensating for the limitations of the equipment and by eliminating procedural errors. You may miss the target through lack of experience but there is no excuse for missing it because you put the wrong data into your radar bombing equipment.

THE BOMBING PROBLEM

Because a bomb leaves a bomber with the same forward velocity as the airplane, it falls forward as well as downward. To place a bomb on a target, therefore, the bombardier must consider the forward distance it is going to travel as well as the direction it is going to fall, in determining the actual release point. That distance depends on three things:

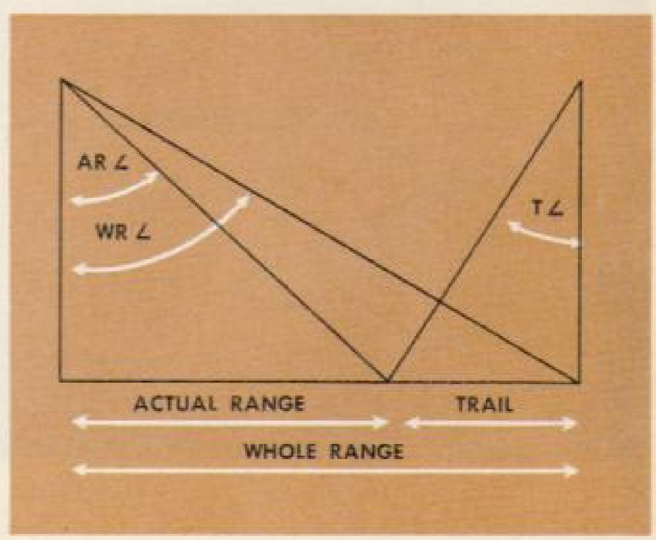


If a bomb could be streamlined perfectly, so that it would offer no air resistance and would retain its initial velocity, the airplane dropping the bomb would be directly over the target at the time the bomb struck it. However, since there is no such thing as perfect streamlining, the bomb lags or trails behind the airplane. At the moment of impact, the airplane is some distance beyond the target. This distance, measured along the ground, is called **trail (T)**. The trail value varies for different bombs and is given as a mil value in the bombing tables. A mil is a tangent value which subtends a distance on the ground equal to .001 of the altitude.

The distance along the ground that the bomb actually travels in its flight is called **actual range (AR)**. The actual range plus the trail, then, is the distance that the airplane flies during this same time. That total distance is called **whole range (WR)**.

You can find whole range by multiplying the actual time of fall (ATF), the number of seconds from release point to impact, by the groundspeed in feet per second.

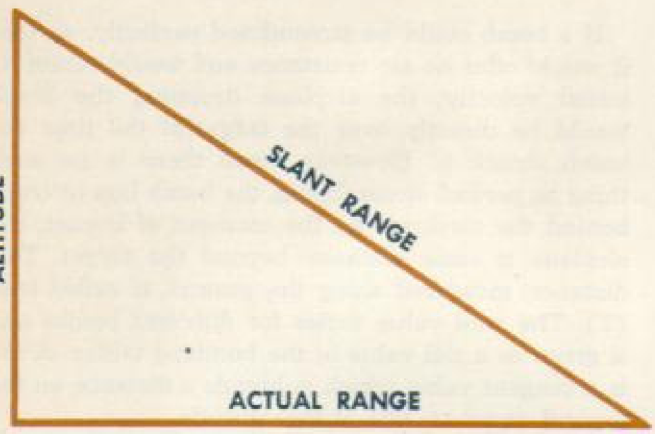
When you know the whole range, you can find the actual range by subtracting the trail.



The Range Problem

Slant range is the distance from your position in the air to the target—measured by your radar set. You want to know how to determine the slant range that equals the actual range of the bomb. The problem is one of solving a simple right-angle triangle. The sum of the squares of the two sides is equal to the square of the hypotenuse:

$$(\text{Slant range})^2 = (\text{Actual range})^2 + (\text{Altitude})^2$$

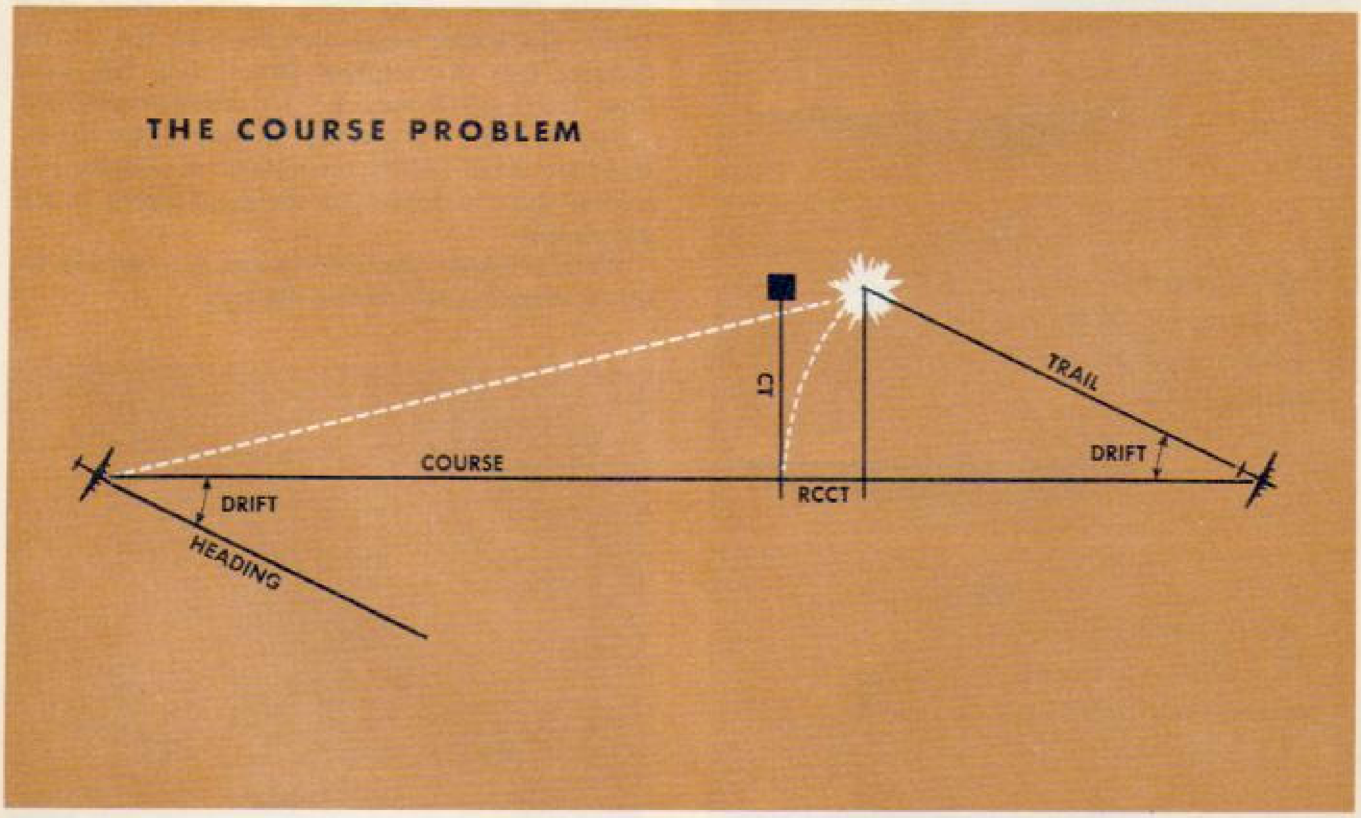


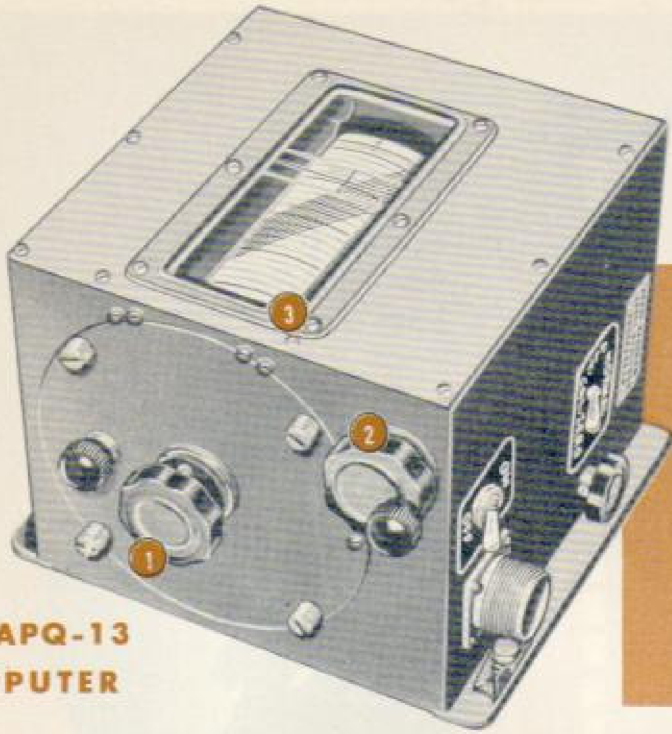
The Course Problem

If an airplane is flying directly into a headwind or with a tailwind, its **true heading (TH)** and **true course (TC)** are the same. To get a hit on a target under such circumstances it is necessary merely to track over the target.

When there is a crosswind, however, the airplane must crab into the wind at an angle equal to the angle of drift in order to track over the target. This presents another problem, since the bomb always trails along the TH or longitudinal axis of the airplane; it is affected by the same wind. Therefore, in a crosswind, the bomb does not make good the same track as the airplane. It falls downwind a distance called **crosstrail (CT).** The size of this crosstrail distance depends upon the drift angle and the trail of the bomb. The airplane must fly a course parallel to the collision course and crosstail distance upwind of the target.

Since your radar set has no way of taking care of crosstrail, and since the crosstrail error is minor in relation to the inherent errors in radar equipment, your solution of the bombing problem is concerned with range.





1. RANGE KNOB
2. ALTITUDE KNOB
3. COMPUTER DRUM

RADAR BOMBING EQUIPMENT

AN/APQ-13 COMPUTER

By turning the range knob you can change the bomb circle from .5 to 15 nautical miles.

Read setting of bomb circle from the range drum.

In radar bombing, your airplane's H_2X radar set (AN/APQ-13 or AN/APS-15) helps you solve the bombing problem by:

Indicating a track over the target.

Determining the absolute altitude of the airplane.

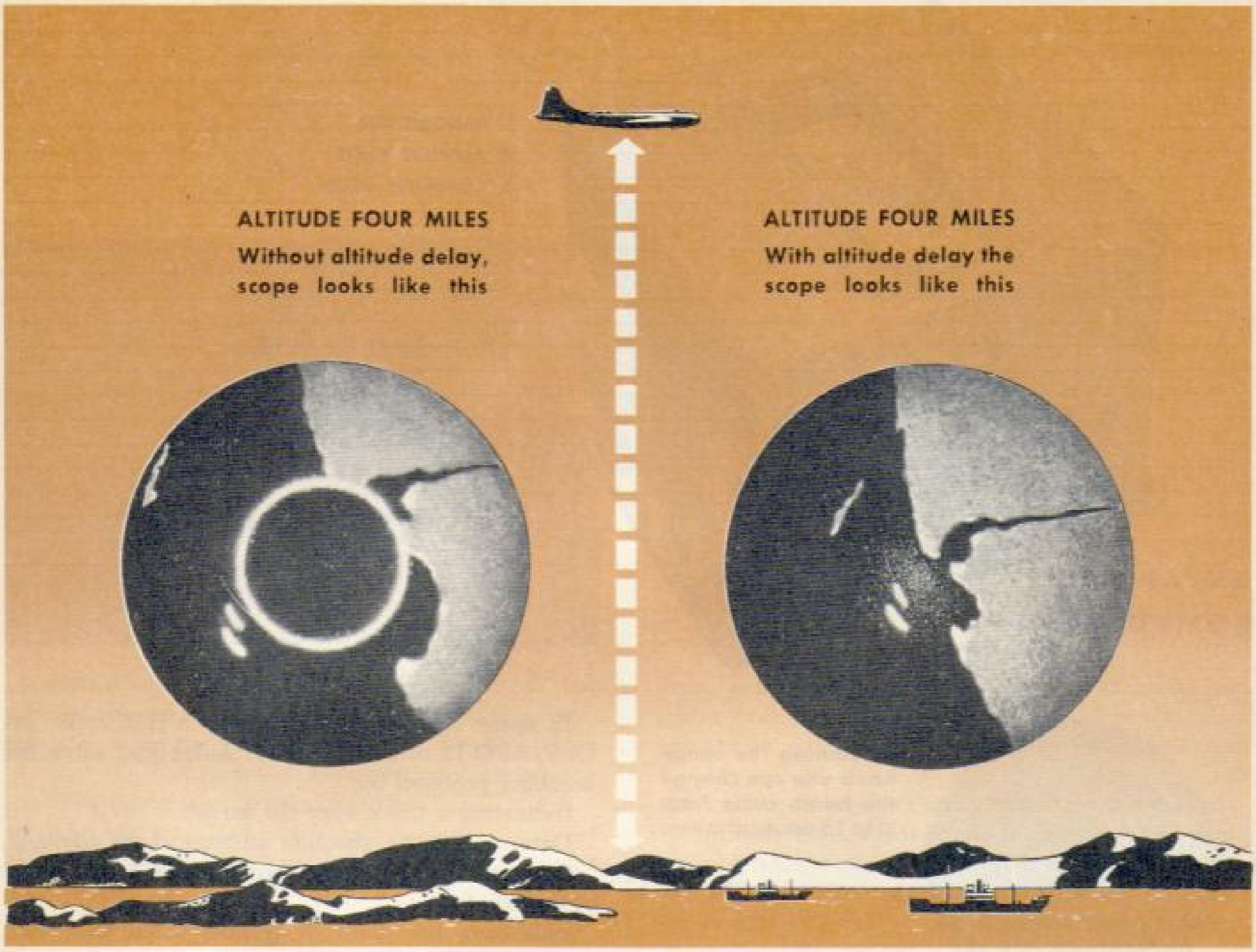
Computing a slant range equal to the actual range of the bomb.

Indicating the point of release when this slant range is reached.

The computer box on the radar set helps solve the range problem through the operation of two knobs—a range knob and an altitude knob.

The **range knob** controls a potentiometer in a bomb-release circuit which introduces electrically a signal or bright spot into the sweep line on the scope. This range signal appears a given number of microseconds after the transmitted pulse leaves the antenna. The delay in microseconds between the transmitted pulse and the range signal equals an exact distance that the radar wave travels. By varying the potentiometer you can change that delay time.

A range drum (which the range knob controls) is calibrated in nautical miles of slant range. By turning this drum (varying the potentiometer) you can move the bright spot (range signal) along the sweep line between .5 and 15 nautical miles of relative distance. Since the sweep line moves around the face of the scope, the range signal appears as a circle and is called the **bomb-release circle.**



The **altitude knob** controls a potentiometer in an altitude-delay circuit. This is another timing device which delays the beginning of the sweep a given number of microseconds after the transmitted pulse. Its purpose is to hold back the beginning of the sweep until the transmitted pulse has had time to be reflected from the ground directly below the airplane. By using altitude delay you can eliminate the **altitude hole**, the gap on the scope between its center and the first ground return.

When you turn the altitude knob, a cursor moves up or down on the face of the computer drum against an altitude scale in nautical miles. This tells you how much delay has been introduced.

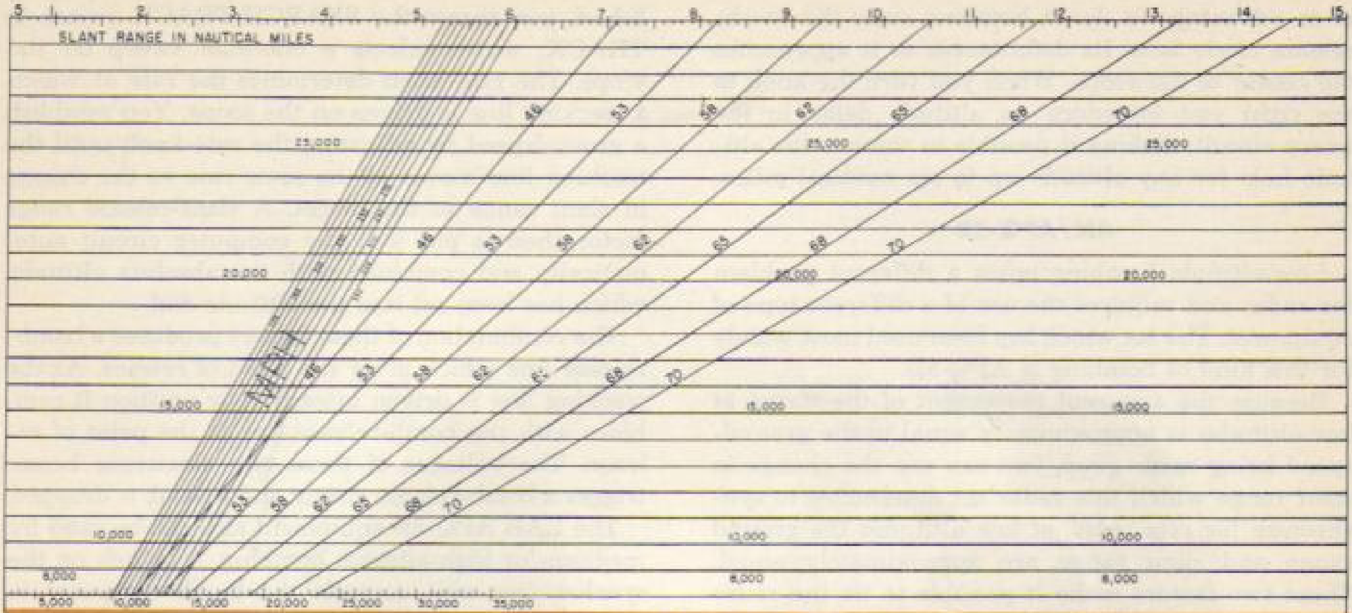
Altitude delay does not affect the slant range read from the range drum. The bomb-release circuit is divorced completely from the altitude circuit; the pip appears a given number of microseconds after the transmitted pulse regardless of altitude delay.

If you are going to bomb accurately, you must determine a slant range that subtends the actual range of the bomb at the point of release. This slant range varies with altitude and groundspeed.

It would be impractical to work out a slant range for every combination of altitude and groundspeed you might have. But a graph on the computer drum helps you determine the proper slant range. This graph is lined at the proper slant ranges for a given bomb at all feasible altitudes and a constant groundspeed. These slant ranges are plotted as a groundspeed line on the chart. Groundspeed lines are established for groundspeeds of from 170 to 350 mph.

You can position the bomb-release circle at the proper slant range automatically by setting the altitude scale at your bombing altitude and the range drum at the appropriate groundspeed line.

The computer chart sometimes is calibrated in degrees of slant range as well. In coordinated bomb-



COMPUTER-DRUM CHART

ing (described later) the radar equipment must make it possible for you to know exactly how many degrees of slant range the target is from your position.

In order to plot slant range in degrees on the computer chart, the slant range for a given number of degrees (70°) was determined geometrically for certain altitudes. It then was plotted for each altitude and these points were joined by a degree line. A degree line also was plotted for 68°, 65°, 60°, and so on.

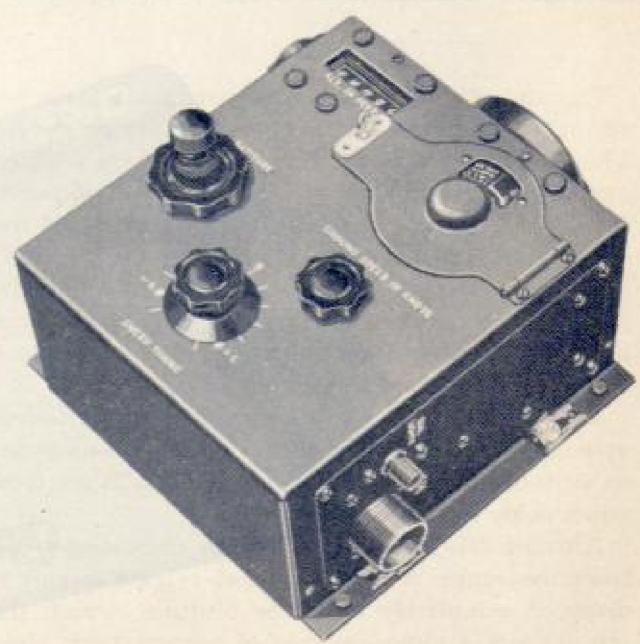
The degrees of slant range selected for the computer drum were not chosen haphazardly. They depend on the **apparent movement** of the target. It takes the target about the same time to appear to move from 70° to 68° as it does for it to appear to move from 53° to 46°, for example.

AN/APS-15A Computer Box

Your APS-15A equipment has a new and more accurate dial-type computer box. The dial computer was designed primarily for the H + B method of direct bombing. In this method, the slant range at which the airplane must be from the target at release point is divided into two components: an H factor (absolute-altitude component) and a B factor (groundspeed component). These components are combined electrically to produce a bomb-release circle at the proper slant range.

Greater accuracy is achieved since the groundspeed calibrations are more widely spaced on the groundspeed dial. Also, it is possible to determine the trail factor of the bombing problem more accurately through the use of various B-factor discs for various types of bombs. Twelve discs are supplied with the equipment for three basic bomb types.

A SWEEP TIMING knob controls both open center and altitude delay. When you turn the knob to the left, the scope returns and the bomb-release circle move out from the center of the scope. This



AN/APS-15A COMPUTER

is an advantage in direct bombing since the bomb-release circle loses its definiteness as it approaches the center of the scope. When you turn the knob to the right you introduce an altitude delay in the sweep circuit, making it possible to remove the altitude hole for any altitude up to six nautical miles.

AN/APQ-5B

Low-altitude bombing poses a different problem for radar and requires the use of a different type of equipment. The set which has been used most widely for this kind of bombing is APQ-5B.

Because the apparent movement of the target at low altitudes is approximately equal to the ground-speed being made good, you can use the change in slant range which this radar set determines to synchronize for rate. Also, at low altitudes the ground range and slant range are approximately equal. These two factors make it possible to tie the radar return into a **tracking unit** on the APQ-5B and thus control the speed at which the return is driven toward you on the scope.

You introduce a bomb-release line (similar to the bomb circle on the APQ-13 and APS-15A) into this equipment and position it properly by means of a rate knob and an altitude knob.

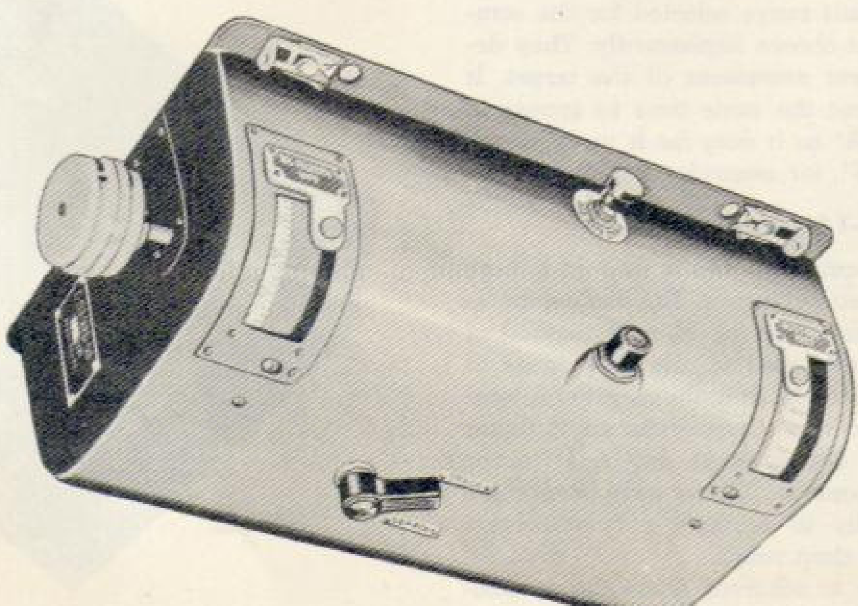
The SEARCH-TRACK switch on the tracking unit makes it possible for you to locate the target out to a distance of 18 miles. The drift knobs of the bombsight then are used to determine the track over the target. When the track is approximately established, you throw the SEARCH-TRACK switch to TRACK, which selects a one-mile sweep on the scope. The rate knob determines the rate at which a tracking line is driven on the scope. You establish a groundspeed by adjusting the rate knob until the tracking line moves at the same rate as the change in slant range to the target. A slant-release range factor then is put into the computer circuit automatically and combined with the absolute altitude, which has been set into the altitude dial.

The combination of these factors produces a bomb-release line which gives the point of release. As the tracking line is driven toward your position it combines with the bomb-release line at the point of release. The voltages of these two electronic beams trigger a bomb-release circuit and a bomb is dropped.

The LAB APQ-5B equipment also can be used for medium- or high-altitude bombing. A switch on the **synchronizer unit** controls the bomb computer in three positions:

1. LOW-IN: The computer is operative and slant-release distance is computed automatically.
2. LOW-OUT: The computer is inoperative. Slant-release distance is determined by setting an altitude-dial reading calculated from a conversion chart.
3. HI-OUT: The computer is inoperative. Slant-release distance is determined by the altitude-dial setting and a B factor entered in the spread dial (on control box).

The LOW-OUT and HI-OUT positions are used for fixed-angle bombing only.



TRACKING UNIT • AN/APQ-5B (FRONT VIEW)

METHODS OF RADAR BOMBING

DIRECT BOMBING

Radar equipment helps you solve the bombing problem in two main ways. The first of these, called direct bombing, uses a precomputed slant range for the release of the bomb. Since the primary problem is to find a slant range equal to the actual range, you must know your altitude and groundspeed during the bombing run. With these values and a specific type of bomb you can determine both the actual range and slant range.

It is easy enough to find your altitude. Your real task is to find an accurate groundspeed. The usual way of doing this is to find a wind in the vicinity of the target and use an E-6B computer to obtain the groundspeed for the bombing run. Then, with whatever type of computer box you are using, you position a bomb-release circle on the scope at the proper slant range.

After the bomb-release circle has been set, your job is to track the airplane over the target and to release the bombs when the target return and the bomb-release circle coincide.

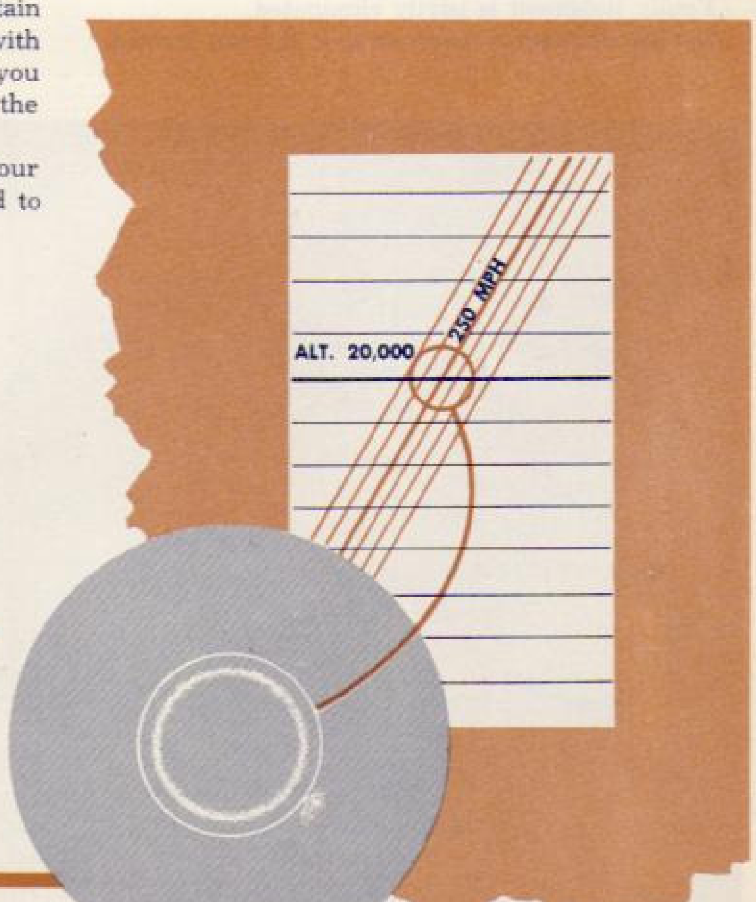
Direct bombing is inaccurate in these respects:

Distortion takes place as the target approaches the center of the scope.

The target sometimes is lost in the bloom of the ground returns before the bomb-release circle is reached. You then must guess at the release point.

Even when the return is not lost, you may have the common tendency to release too soon or too late.

If the groundspeed used is not accurate, a considerable error may be introduced. At 20,000 feet this error can be as much as 400 feet for every 10 mph of groundspeed.



Set altitude and groundspeed into your computer to place the bomb-release circle at proper slant range.

GROUNDSPEED MUST BE CORRECT

COORDINATED BOMBING

Coordinated bombing—the second method—coordinates the bombsight with the radar return to overcome some of the deficiencies of the direct method of bombing. It makes it possible to synchronize the bombsight for rate, thus nullifying a change in the wind or heading, or any inaccuracy in your computed wind.

The line of sight of the bombsight is identical to the slant range determined by the radar. You must work closely with the bombardier to coordinate the bombsight with the scope return so that the **sighting angle change** on the bombsight takes place at the same rate as the **slant range change** shown on your PPI scope. When this is accomplished, the bombsight determines a rate of closure and establishes a dropping angle for the particular bomb which is being used. When the sighting angle (slant range) equals the dropping angle the bombsight automatically drops the bombs.

Coordinated bombing has these advantages:

The bombsight is synchronized for groundspeed.

Faulty judgment is partly eliminated.

Synchronization is made early in the run and distortion of the target return or loss of it doesn't affect the release point.

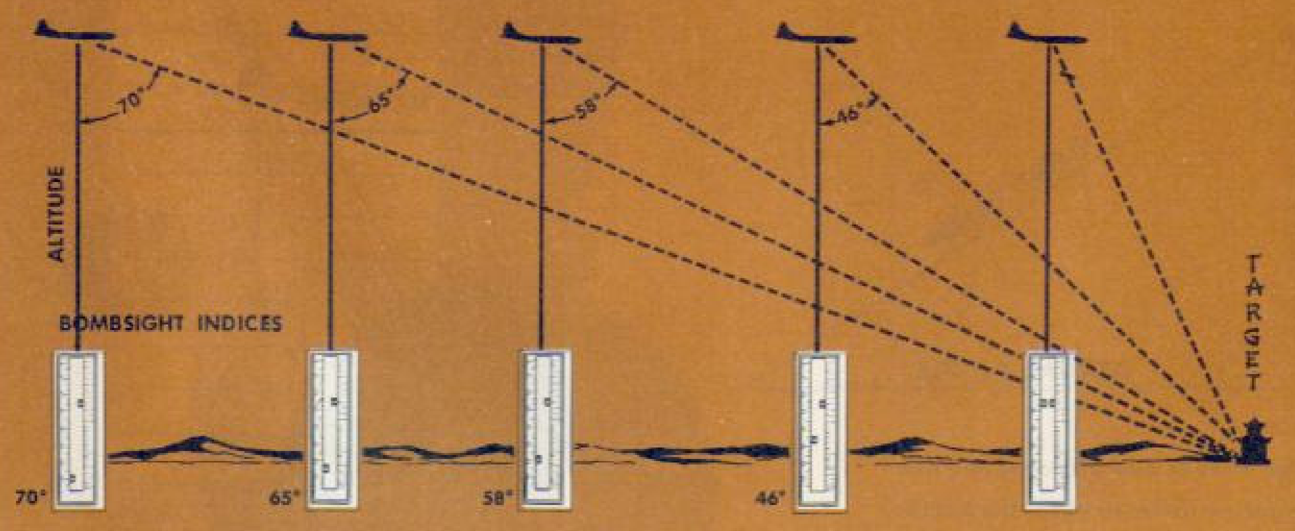
The correct trail can be set into the bombsight.

In case a break in the cloud cover occurs, the bombardier is all set to take over.

In order for you and the bombardier to accomplish this synchronization of the bombsight, you must give the bombardier certain information. From the bombing altitude, type of bomb, and expected groundspeed, he sets the correct disc speed, trail, and approximate dropping angle in the bombsight. He sets the sighting index at 70°. You set the computer drum at 70° of slant range.

When the target crosses the 70° slant-range marker on your indicator you signal the bombardier to start the rate mechanism of the bombsight. Degrees of slant range then are checked against the successive sighting angles as you close on the target. The rate end of the bombsight is adjusted until the target closes on the scope at the same rate as the sighting angle changes on the bombsight. The bombardier then lifts the trigger, sets the racks, and the sight automatically releases the bombs.

The procedures used in both types of radar bombing are discussed in Section 6.



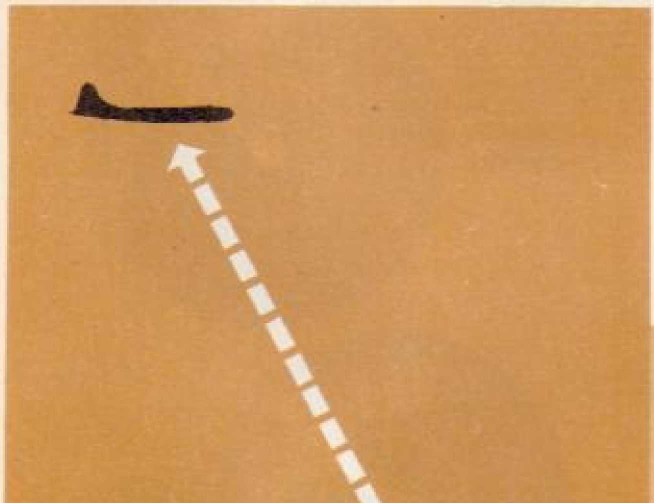
SIGHTING ANGLE ON BOMBSIGHT MUST BE COORDINATED WITH SLANT RANGE

ERRORS IN THE USE OF RADAR

INHERENT ERRORS

No radar bombing is better than the ability and experience of the radar operator. Yet, even if you know how to get the most out of the equipment, it has limitations which you cannot exceed. If you don't know what these limitations are, you are likely to anticipate bombing results which you are most unlikely to achieve.

APQ-13 and APS-15A equipment, though a marked improvement over earlier models, has attained only relative refinement. The resolving power, or resolution, of the equipment is limited. To expect it to go beyond its limitations is like trying to draw a line a hundredth of an inch wide with a crayon a tenth of an inch wide.



A small object like a lighthouse becomes wider and longer because of inherent radar errors.

Fuzziness in a scope picture makes bombing inaccurate. There are three inherent causes of fuzziness:

The duration of the transmitted pulse.

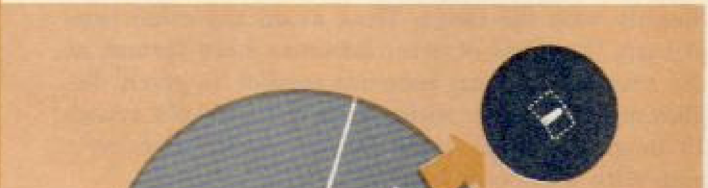
The width of the radiated beam.

The diameter of the electron beam (size of spot) which paints the scope picture.

Duration of the Pulse

An APS-15A or APQ-13 radar transmitter fires for a total of only 675 microseconds out of each full second on the shorter ranges. Each time the transmitter fires on these ranges the pulse lasts ½ microsecond. Brief as this is, it is long enough to impair the resolution of the scope.

In the ideal case of a point target and an instantaneous pulse, the scope image also is a point. Since the reflected pulse lasts exactly as long as the transmitted pulse (½ microsecond), the scope return spreads out radially by this amount. Calculations based on the speed of the radiated wave, range, and altitude show that, in a typical case, resolution is so affected that a point target spreads radially a distance equal to 500 feet on the ground. As a consequence of this condition, two points 500 feet apart are merged into a single return.



Width of the Beam

If the beam which the antenna sends out were a plane surface it would sweep over a point target instantaneously and the scope image likewise would be a point. Actually, the beam is a 3° wedge (measured in the slant plane). Consequently, a point target appears as a 3° arc on the scope. This is distortion in azimuth. At 40,000 feet of slant range, two reflecting points must be at least 1700 feet apart before resolution begins. At shorter distances the scope smears them together.

In taking a bearing on the 3° arc, you naturally try to bisect it. Even so, there is likely to be a residual error of about ¾°. For a slant range of 40,000 feet that equals 530 feet. This error, accordingly, is roughly of the same magnitude as that which the duration of the pulse causes, but it occurs in azimuth instead of in range. It can be increased greatly, however, by poor operating technique, and in any case, since it increases with distance, it is the largest of the resolution errors at long ranges.

Remember, beam width increases the return so that it appears on the scope as an area exaggerated 1½° on each side. Always split the return when measuring azimuth.

Size of the Spot

Another defect in resolution is caused by the size of the luminous spot which paints the scope picture. This error occurs both in range and azimuth. With the best possible focus, the diameter of the spot on the APS-15A and APQ-13 is 1/30 inch, but it is safer to assume it to be 1/20 inch under average operating conditions. The size of the spot is the same on all ranges, but the geographical area under it varies directly with the range. Thus, as on any other type of map, this kind of error becomes more serious as the scale of the map becomes smaller (a given displacement on a map with a scale of 1:1,000,000 causes 10 times the flight error that it would cause on a map with a scale of 1:100,000.

For a spot with a diameter of 1/20 inch a point target on the five-mile range appears on the scope as a circle about 1000 feet in diameter on the ground. Since the spot also forms the bomb-release circle, the circle's diameter likewise corresponds to 1000-feet ground range. On the 10-mile range this increases to 2000 feet, on the 20-mile range to 4000 feet.

In practice you find that you can reduce these inherent errors with the skill you gain from experience. You then are taking fullest possible advantage of your radar equipment.

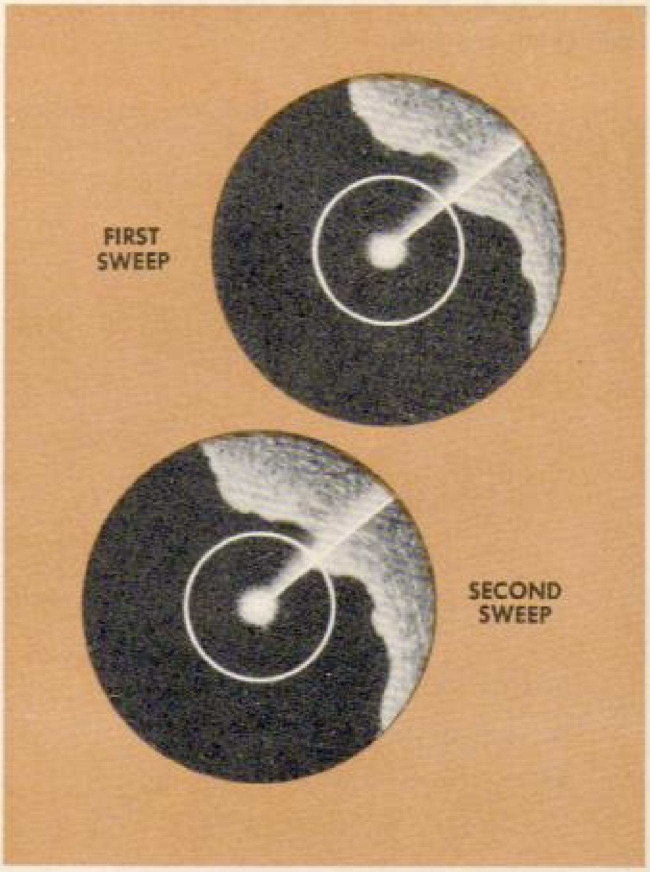
PROCEDURE ERRORS

The equipment is maintained and calibrated for the maximum accuracy of which it is capable, but you must avoid errors in procedure which reduce that accuracy. Here are some common ones:

Sector Scan

Assume that in a given case it is possible for you to judge the coincidence of the target with the outer edge of the bombing circle within 300-feet ground range. If at this time the spinner is rotating through 360°, it is likely that at one scan the target is still beyond the bomb-release circle while at the next scan, three seconds later, it already is well inside the circle. At 250-mph groundspeed, the airplane covers about 1000 feet in this interval and the bombs may miss by this amount.

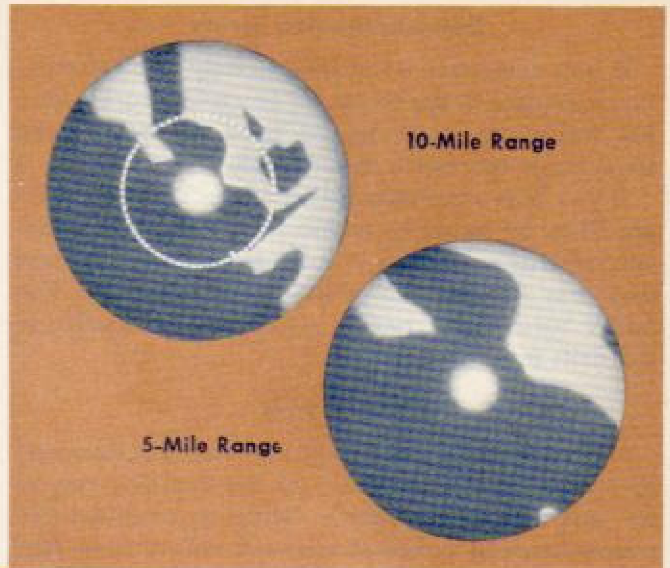
Always use sector scan on the bombing run. With a 60° angle the time between successive scans is reduced to between one-half and one second, and this source of error is minimized.



Apparent movement of the target during one revolution of the sweep.

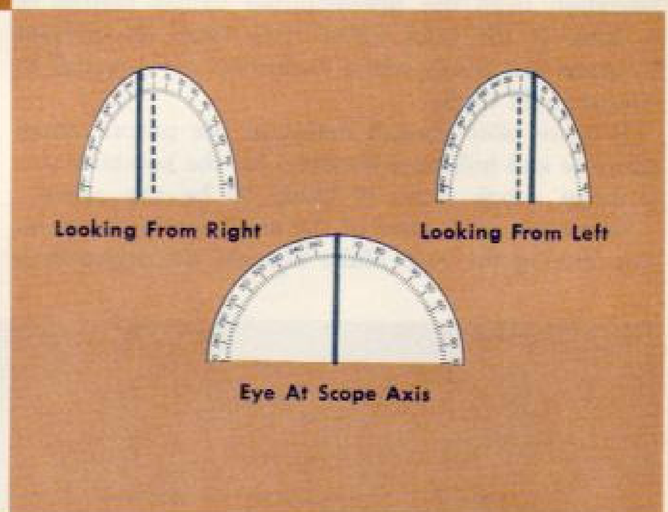
Range Setting

At best, the scope reproduces a large area on a small surface, and it has been shown that the adverse effect of spot size on resolution is greater in the longer ranges. On the bombing run the five-mile range almost always affords the best obtainable resolution and detail. That is what it is for; use it. It gives you a relative close-up of the target area.



Parallax

The cursor line is about half an inch nearer to the operator than the scope screen. As a result, you can make a substantial error in reading the bearing if you look at the scope from one side or the other. This error alone may amount to as much as 800-feet ground deflection. Cultivate the habit of keeping your eye on the axis of the scope when you are making observations.



Judging Release Point

Because the return grows fuzzier as it nears the center of the scope, it is hard for you to judge the correct release point. If the diameter of the bomb-release circle is small it is more difficult to judge coincidence than it is when the bomb-release circle is expanded. The bombing circle should never be less than two inches in diameter, even if you have to crank down the altitude dial to a value below the actual altitude.

Bomb-Release Circle Should Never Be Less Than Two Inches In Diameter

Dead-Reckoning Errors

If you determine wind inaccurately, the information you place in the computer box is inaccurate also. An inaccurate groundspeed used in determining slant range can cause considerable error.

If you base your calculation of the TH to fly from the IP to the target on an incorrect wind determination, a large correction is going to be necessary, and that may change the groundspeed radically. The faulty turn which results also makes it harder to kill drift into the target.

Pilot Errors

No matter how accurately you may put data into the radar set, the accuracy of the bombing can be no better than the pilot's ability to maintain the proper heading, indicated airspeed, and altitude. Any variation from the precomputed values results in a miss. If the pilot turns away from the correct heading the bomb has a deflection error equal to the error in track.

If your pilot doesn't maintain the precalculated altitude and indicated airspeed for the bombing run a large range error is likely to be the result.

Convince your pilot of the need for his cooperation during the run. Make him see the importance of his task in the job to be done. Use of the automatic pilot during the bombing run reduces pilot error considerably. Urge your pilot to use it; that's what it's for.

Slant-Range Errors

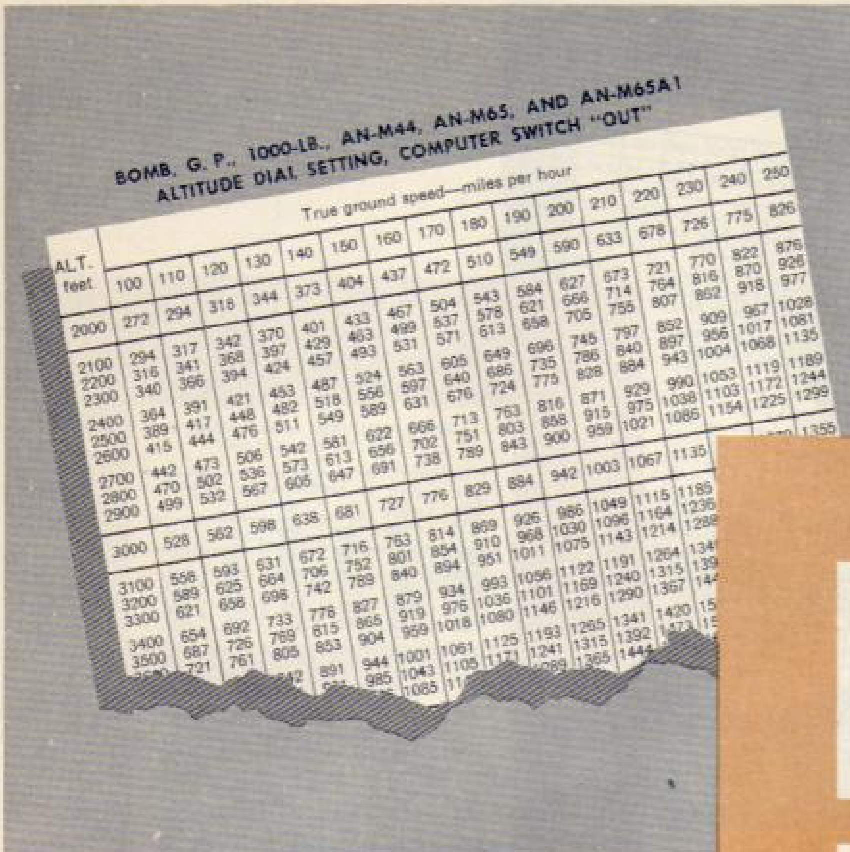
If the slant-range circuit has not been calibrated properly, the bomb-release circle may be off by several hundred feet. In direct bombing this results in an error equal to the error in the range circuit. In coordinated bombing the error may be much larger, since a slant range of 70° as read from the radar may be a sighting angle 10° larger or smaller. When the bombardier tries to synchronize the bombsight with such slant ranges, the dropping angle which the bombsight computes may throw the bomb several thousand feet from the target.

Errors in Coincidence of Slant Range and Sighting Angle

A 1/5-second delay in interphone signal results in a 100-foot range error under normal conditions. An error of 1/4° in sighting-angle setting also results in a 100-foot range error in the same situation.

It takes many hours of practice before you and the bombardier can coordinate the radar and bombsight accurately. Practice at every opportunity.

Bombing ★ Tables



BOMB, G. P., 1000-LB., AN-M44, AN-M65, AND AN-M65A1
ALTITUDE DIAL SETTING, COMPUTER SWITCH "OUT"

ALT. feet	True ground speed—miles per hour															
	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250
2000	272	294	318	344	373	404	437	472	510	549	590	633	678	726	775	826
2100	294	317	342	370	401	433	467	504	543	584	627	673	721	770	822	876
2200	316	341	368	397	429	463	499	537	578	621	666	714	764	816	870	926
2300	340	366	394	424	457	493	531	571	613	658	705	755	807	852	918	977
2400	364	391	421	453	487	524	563	605	649	696	745	797	852	909	967	1028
2500	389	417	448	482	518	556	597	640	686	735	786	840	897	956	1017	1081
2600	415	444	476	511	549	589	631	676	724	775	828	884	943	1004	1068	1135
2700	442	473	506	542	581	622	666	713	763	816	871	929	990	1053	1119	1189
2800	470	502	536	573	613	656	702	751	803	858	915	975	1038	1103	1172	1244
2900	499	532	567	605	647	691	738	789	843	900	959	1021	1086	1154	1225	1299
3000	528	562	598	638	681	727	776	829	884	942	1003	1067	1135	[illegible]	[illegible]	1355
3100	558	593	631	672	716	763	814	869	926	986	1049	1115	1185	[illegible]	[illegible]	[illegible]
3200	589	625	664	706	752	801	854	910	968	1030	1096	1164	1236	[illegible]	[illegible]	[illegible]
3300	621	658	698	742	789	840	894	951	1011	1075	1143	1214	1288	[illegible]	[illegible]	[illegible]
3400	654	692	733	776	827	879	934	993	1056	1122	1191	1264	[illegible]	[illegible]	[illegible]	[illegible]
3500	687	726	769	815	865	919	976	1036	1101	1169	1240	1315	[illegible]	[illegible]	[illegible]	[illegible]
3600	721	761	805	853	904	959	1018	1080	1146	1216	1290	1367	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	891	944	1001	1061	1125	1193	1265	1341	1420	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	985	1043	1105	1171	1241	1315	1392	1473	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1085	[illegible]	[illegible]	1289	1365	1444	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Aiming point, offset upwind in feet, for each 10 degrees of drift

ALT. feet	True air speed—miles per hour			
	100	150	200	250
2000	0	10	10	10
3000	10	10	10	20
4000	10	10	20	30
5000	10	20	30	40

Effect of a 10-mile-per-hour range wind on altitude dial setting
[Add for tail wind, subtract for head wind]

ALT. feet	True ground speed—miles per hour			
	100	150	200	250
2000	0	1	1	2
3000	1	2	3	4
4000	1	3	4	6
5000	1	3		

In addition to regular ballistic tables for the bombardier, the Army Air Forces have published tables for use with your radar equipment.

One set of tables, BTF LAB and H+B—1, is designed to be used for low-altitude bombing and the H+B method of bombing.

The other set of tables, BTF SR-1, is applicable to 18 types of bombs and is designed to be used with H_2X drum-type computers. You enter one of these tables with your absolute altitude and groundspeed to determine the slant range for release point for a particular bomb. This slant range is given in nautical miles; you must convert it to feet (nm × 6080) before you can use it with the dial-type computer on the APS-15A equipment.

BTF LAB and H+B—1 Tables

These tables include:

1. Table of true groundspeeds in mph corresponding to indicated groundspeeds of from 100 to 400 mph at altitudes from 4000 to 41,000 feet.

2. LAB tables for:

Altitude-dial settings (computer switch OUT) for altitudes from 2000 to 5000 feet and true groundspeeds from 100 to 400 mph.

Effect of a 10-mph range wind on altitude-dial setting.

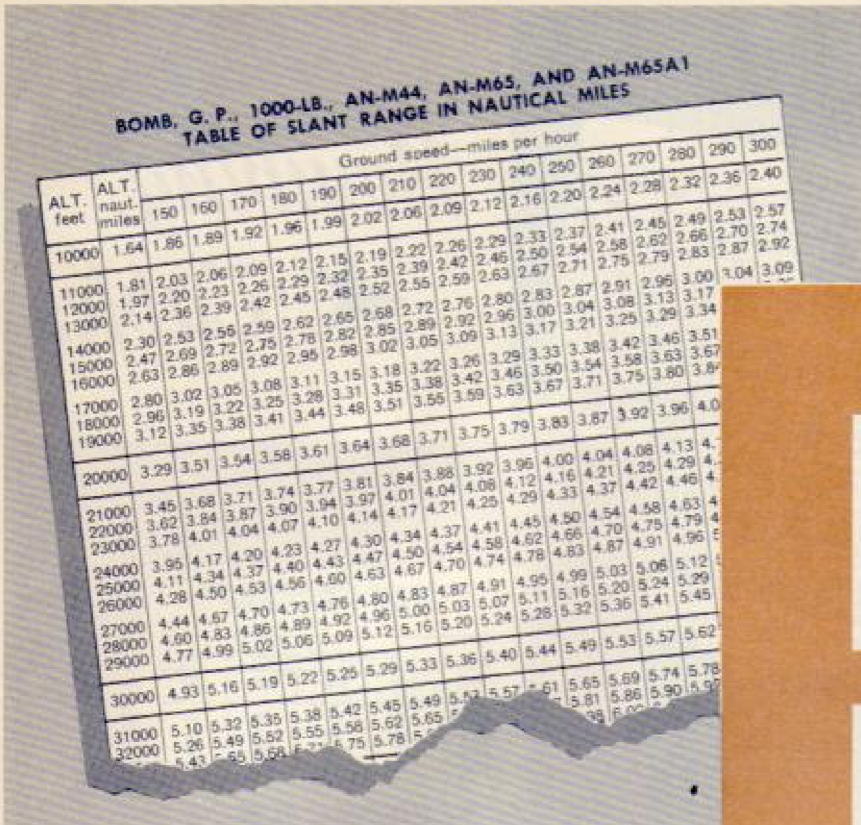
Aiming point, offset upwind in feet, for each 10° of drift.

3. H+B—1 tables for:

Spread-dial settings at altitudes from 4000 to 40,000 feet and indicated groundspeeds from 100 to 400 mph.

Effect of a 10-mph range wind on spread-dial setting.

Aiming point, offset upwind in feet, for each 10° of drift.



BOMB, G. P., 1000-LB., AN-M44, AN-M65, AND AN-M65A1
TABLE OF SLANT RANGE IN NAUTICAL MILES

ALT. feet	ALT. naut. miles	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
10000	1.64	1.86	1.89	1.92	1.96	1.99	2.02	2.06	2.09	2.12	2.16	2.20	2.24	2.28	2.32	2.36	2.40
11000	1.81	2.03	2.06	2.09	2.12	2.15	2.19	2.22	2.26	2.29	2.33	2.37	2.41	2.45	2.49	2.53	2.57
12000	1.97	2.20	2.23	2.26	2.29	2.32	2.35	2.39	2.42	2.46	2.50	2.54	2.58	2.62	2.66	2.70	2.74
13000	2.14	2.36	2.39	2.42	2.45	2.48	2.52	2.55	2.59	2.63	2.67	2.71	2.75	2.79	2.83	2.87	2.92
14000	2.30	2.53	2.56	2.59	2.62	2.65	2.68	2.72	2.76	2.80	2.83	2.87	2.91	2.96	3.00	3.04	3.09
15000	2.47	2.69	2.72	2.75	2.78	2.82	2.85	2.89	2.92	2.96	3.00	3.04	3.08	3.13	3.17	[illegible]	[illegible]
16000	2.63	2.86	2.89	2.92	2.95	2.98	3.02	3.05	3.09	3.13	3.17	3.21	3.25	3.29	3.34	[illegible]	[illegible]
17000	2.80	3.02	3.05	3.08	3.11	3.15	3.18	3.22	3.26	3.29	3.33	3.38	3.42	3.46	3.51	[illegible]	[illegible]
18000	2.96	3.19	3.22	3.25	3.28	3.31	3.35	3.38	3.42	3.46	3.50	3.54	3.58	3.63	3.67	[illegible]	[illegible]
19000	3.12	3.35	3.38	3.41	3.44	3.48	3.51	3.55	3.59	3.63	3.67	3.71	3.75	3.80	3.8[illegible]	[illegible]	[illegible]
20000	3.29	3.51	3.54	3.58	3.61	3.64	3.68	3.71	3.75	3.79	3.83	3.87	3.92	3.96	4.0[illegible]	[illegible]	[illegible]
21000	3.45	3.68	3.71	3.74	3.77	3.81	3.84	3.88	3.92	3.96	4.00	4.04	4.08	4.13	[illegible]	[illegible]	[illegible]
22000	3.62	3.84	3.87	3.90	3.94	3.97	4.01	4.04	4.08	4.12	4.16	4.21	4.25	4.29	[illegible]	[illegible]	[illegible]
23000	3.78	4.01	4.04	4.07	4.10	4.14	4.17	4.21	4.25	4.29	4.33	4.37	4.42	4.46	[illegible]	[illegible]	[illegible]
24000	3.95	4.17	4.20	4.23	4.27	4.30	4.34	4.37	4.41	4.45	4.50	4.54	4.58	4.63	[illegible]	[illegible]	[illegible]
25000	4.11	4.34	4.37	4.40	4.43	4.47	4.50	4.54	4.58	4.62	4.66	4.70	4.75	4.79	[illegible]	[illegible]	[illegible]
26000	4.28	4.50	4.53	4.56	4.60	4.63	4.67	4.70	4.74	4.78	4.83	4.87	4.91	4.96	[illegible]	[illegible]	[illegible]
27000	4.44	4.67	4.70	4.73	4.76	4.80	4.83	4.87	4.91	4.95	4.99	5.03	5.08	5.12	[illegible]	[illegible]	[illegible]
28000	4.60	4.83	4.86	4.89	4.92	4.96	5.00	5.03	5.07	5.11	5.16	5.20	5.24	5.29	[illegible]	[illegible]	[illegible]
29000	4.77	4.99	5.02	5.06	5.09	5.12	5.16	5.20	5.24	5.28	5.32	5.36	5.41	5.45	[illegible]	[illegible]	[illegible]
30000	4.93	5.16	5.19	5.22	5.25	5.29	5.33	5.36	5.40	5.44	5.49	5.53	5.57	5.62	[illegible]	[illegible]	[illegible]
31000	5.10	5.32	5.35	5.38	5.42	5.45	5.49	[illegible]	5.57	[illegible]	5.65	5.69	5.74	5.78	[illegible]	[illegible]	[illegible]
32000	5.26	5.49	5.52	5.55	5.58	5.62	5.65	[illegible]	[illegible]	[illegible]	5.81	5.86	5.90	[illegible]	[illegible]	[illegible]	[illegible]

Aiming point, offset upwind in feet, for each 10 degrees of drift

ALT. feet	ALT. naut. miles	True air speed—miles per hour			
		150	200	250	300
10000	1.64	40	40	80	110
20000	3.29	90	120	170	220
30000	4.93	150	210	280	360
40000	6.58	230	310	410	530
45000	7.40	270	370	490	620

Effect of a 10-mile per hour range wind on slant range in nautical miles (Add for tail wind, subtract for head wind)

ALT. feet	ALT. naut. miles	Ground speed—miles per hour			
		150	200	250	300
10000	1.64	0.001	0.002	0.003	0.003
20000	3.29	0.002	0.003	0.004	0.005
30000	4.93	0.003	0.004	0.006	0.007
40000	6.58	0.004	0.005	0.007	0.009
45000	7.40	0.004	0.006	0.008	0.010

BTF SR-1 Tables

These tables give slant range in nautical miles for:

1. Degrees of slant range from 70° to 10°, at altitudes from 2000 to 44,000 feet.
2. Groundspeeds from 150 to 450 mph, at altitudes from 1000 to 44,000 feet.

They also contain corrections for differences between true airspeed and groundspeed (trail correction), and corrections in aiming point to counteract crosstrail.

How to Use BTF SR-1 Tables

The table reproduced here is for the 1000-lb. GP bomb, AN-M65. Assume that your bombing altitude is 20,000 feet, groundspeed 250 mph, and true airspeed 210 mph. You then use the table in the following manner:

1. Locate 20,000 feet at left of page and find the intersection of the 250-mph groundspeed column with this line. The uncorrected slant range is 3.87 nautical miles.

2. Since the trail of the bomb is a function of true airspeed, you must correct this 3.87 value for the difference between groundspeed and true airspeed. The difference is 40 mph.

Enter the table for effect of a 10-mph range wind with 20,000 feet and 250 mph, and find a correction factor of .004. For a 40-mph difference, you must multiply this difference by 4 ($4 \times .004 = .016$). Add the correction, for the wind is a tailwind.

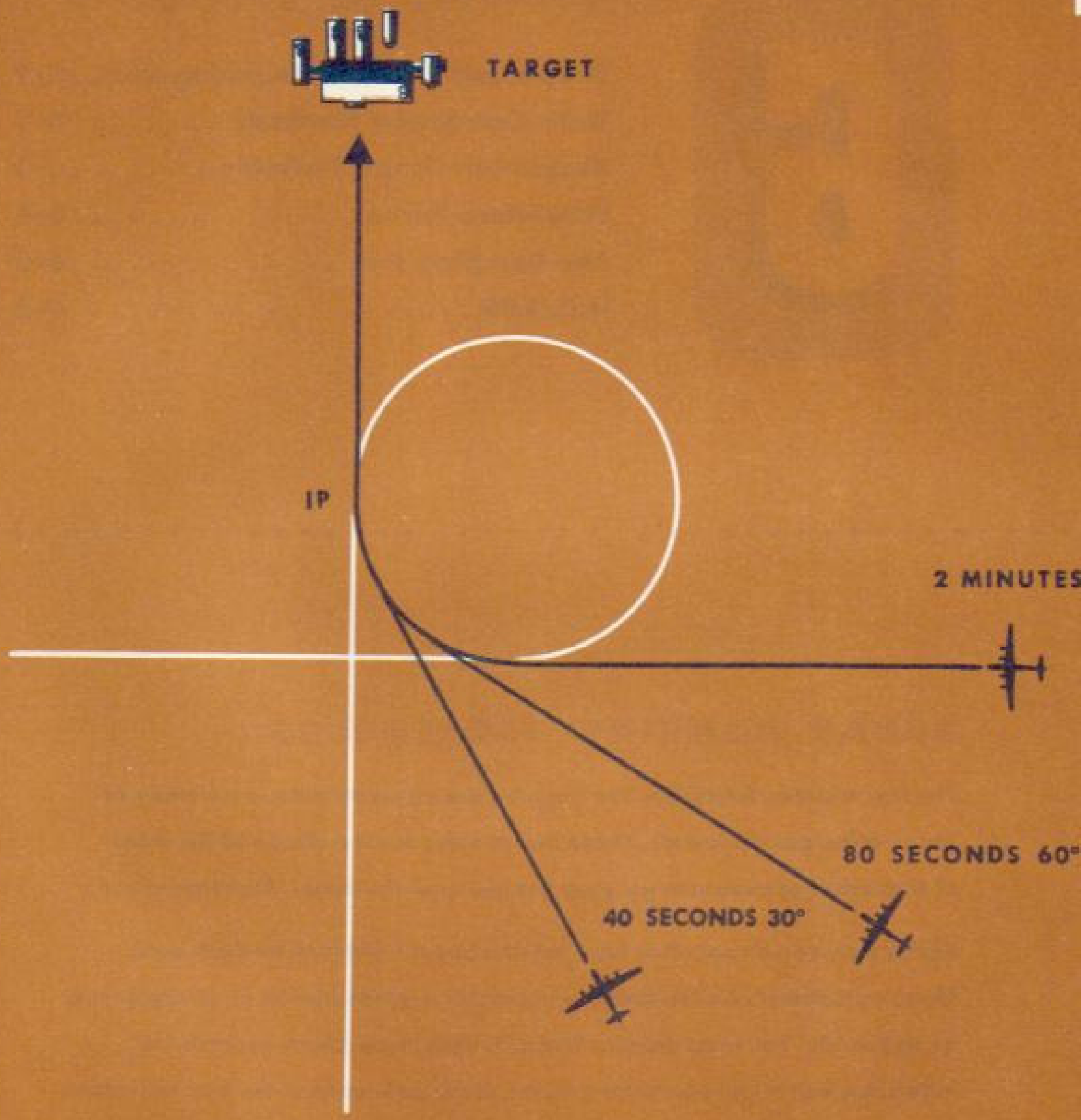
The corrected slant-range value then becomes 3.866, or 3.89 nautical miles.

3. The radar equipment has no way to take care of crosstrail so the table gives an offset aiming point for each 10° of drift.

If you were drifting 8° right, you would enter the table with 20,000 feet and 210-mph true airspeed. With these factors you find that for each 10° of drift you should offset your aiming point by 130 feet (interpolate between 120 and 170). If you were drifting 8° right, you would take 8/10 of 130 to find the offset aiming point. To compensate for crosstrail you would aim 104 feet to the left of the target.

SECTION 6

RADAR BOMBING PROCEDURES



It takes approximately eight minutes to make a 360° quarter-needle-width turn. To improve your navigation into a target, you must consider the time consumed in turning over the IP. At 200 mph IAS, a B-29 takes about two minutes to make a 90° turn. During this time it travels approximately 5½ miles in the direction of the IP.

6

SUBJECTS IN SECTION 6

RADAR BOMBING PROCEDURES

The few minutes during the bombing run are moments when your hours of preparation pay dividends. Those few minutes are the climax of the work of thousands of people to get your bomber over the target. Make them pay!

Remember, you do not have time to think about what is to be done next. Those adjustments and techniques necessary to place bombs on a target must be automatic. You must practice and drill until there can be no hitch, no indecision that might snafu the mission. Study your procedures and know how to obtain the most efficient performance from your radar equipment.

RADAR BOMBING PROCEDURES

PREPARATION FOR THE BOMBING RUN

There are three main reasons why high-altitude bombing with H_2X radar is not as accurate as visual bombing with the bombsight:

1. The equipment cannot give you as fine a degree of definition as your eye can detect. Beam width, size of spot, and pulse width all tend to distort the scope picture.

2. Equipment as complicated electrically as your radar set is likely to get out of adjustment. No matter how careful you are in the operation of it, if your set is not calibrated properly any bombing done is going to be inaccurate.

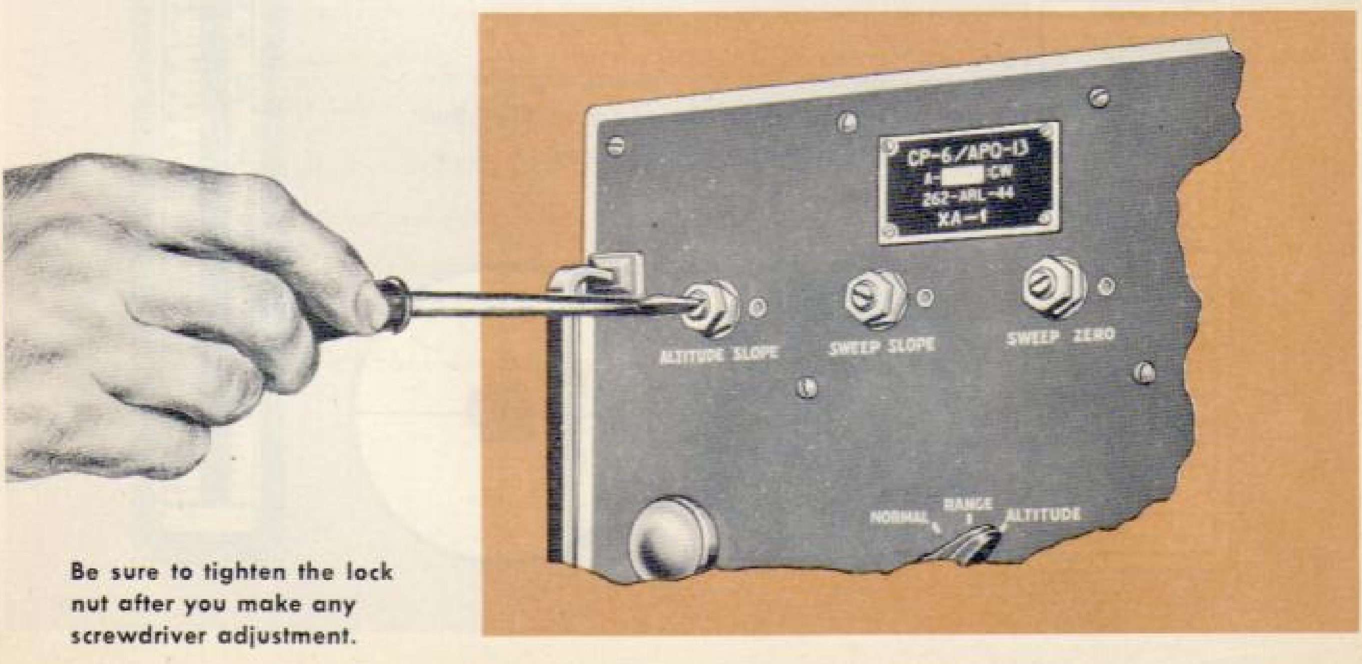
3. Your procedure in tuning, killing drift and judging the release point or slant range is going to affect the results. Your procedural mistakes are likely to be responsible for most of the error that takes place.

The first of these three reasons for inaccurate bombing is out of your hands. You can minimize the other two by careful operation and experience.

Calibration

To obtain the best results with the radar equipment, you must see that it is calibrated accurately. Even though calibration is primarily the job of the maintenance men, you know that such occurrences as voltage changes, changes in the fidelity of units, and even the jarring that the set takes in flight can cause the equipment to get out of calibration. You must know how to check range and altitude calibration and know the adjustments necessary to re-calibrate the computer box.

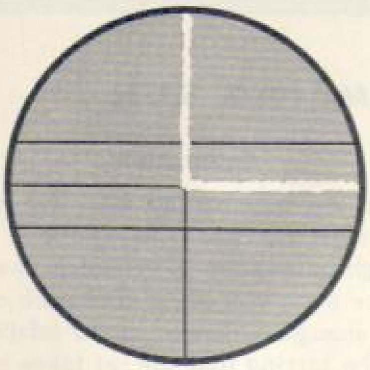
Section 2 contains a discussion of the steps in calibrating range and altitude. For bombing, remember that the potentiometers are not linear throughout their range and that the smart operator calibrates range and altitude for that section of the drum he is going to use. Calibrate range between 3 and 9 miles instead of following the usual procedure of calibrating between 1 and 13 miles.



Be sure to tighten the lock nut after you make any screwdriver adjustment.

Centering Scope Picture

In order to insure accurate bearings for wind determination and accurate turns into the target from IP, make sure that the scope picture is properly centered. There are several ways to do this but the surest and easiest method is this:

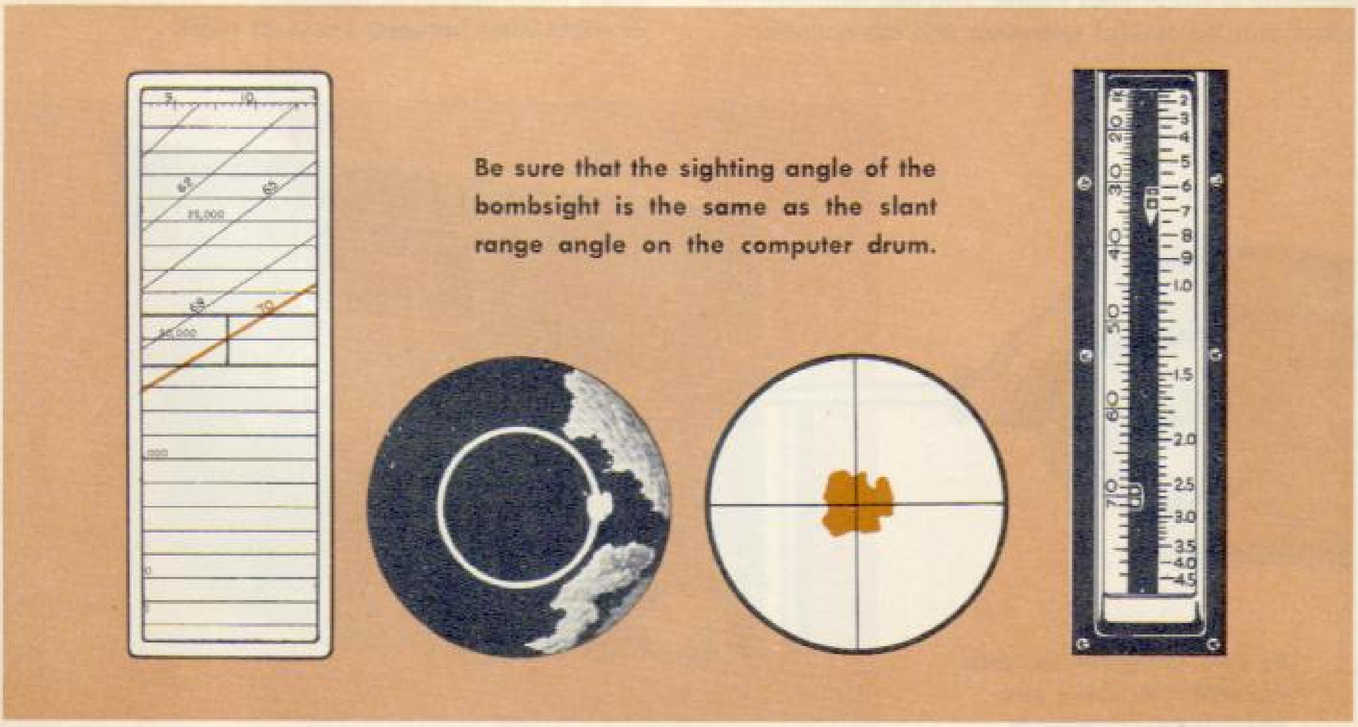


1. Place etched cursor at 360°.
2. Turn sweep (with CW-CCW switch) until it is at 360°.
3. Adjust the H CENT until sweep line is exactly under cursor.
4. Turn etched cursor to 090°.
5. Turn sweep line to 090°.
6. Adjust with V CENT until sweep is exactly under cursor.

Slant Ranges and Sighting Angles

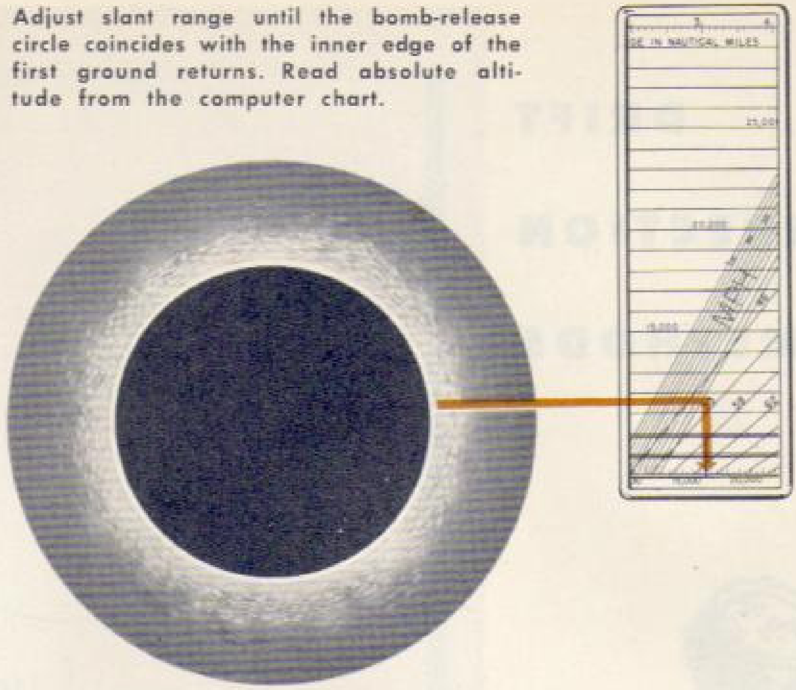
One of the largest errors in coordinated bombing is caused when the degrees of slant range on the computer chart do not coincide with the sighting angles of the bombsight. It is up to you and the bombardier to check for any discrepancy that exists. You can do this in the following manner:

1. Choose a small but easily distinguishable target (point target where possible).
2. When you come into the test run ask the pilot to maintain exactly the selected heading, altitude, and indicated airspeed.
3. Bombardier levels the sight (bubbles) and places sighting index at 70°.
4. Bombardier kills course and keeps the lateral hair on the target throughout the run.
5. You set slant range at altitude and 70°.
6. Use your gain and tilt to get maximum resolution of the target.
7. Call off range at 70°, 68°, 65°, etc., making sure that you use the same part of the return for each judgment.
8. Bombardier notes the position of his sighting angle at each slant range.
9. If the computer-drum scale is in error, either re-position the scale on the drum or make a new scale. Make this sighting-angle check for different altitudes.



Be sure that the sighting angle of the bombsight is the same as the slant range angle on the computer drum.

Adjust slant range until the bomb-release circle coincides with the inner edge of the first ground returns. Read absolute altitude from the computer chart.



Caution

After the turn at IP, you are going to use sector scan to improve the definition. **Be sure that you preset the sector scan for the briefed heading.**

Determining Wind

Before you get to the IP you should determine a wind. The importance of finding wind accurately cannot be overemphasized. The correct heading and groundspeed depend upon the accuracy of the last wind estimate you make before turning onto the bombing run.

You should try to get a wind in the vicinity of the IP where possible. Remember that winds taken over a long period are average winds, and may not be the same as the wind over the target. Even though there are several disadvantages to the target-timing method (see ROBIF 4-3), it is your best bet for obtaining a wind accurately in the vicinity of the IP. Request your pilot to maintain a constant heading and indicated airspeed during the wind run. Choose a small but bright return for measuring bearings and ranges.

If it is possible, try to obtain a wind on the same heading as the expected bombing run. A wind on the same heading eliminates errors in true heading and indicated airspeed.

Bombing Altitude

There are three ways to determine your bombing altitude:

1. Use a C-2 or E-6B computer.
2. Take altitude from the SCR-718 (high-altitude altimeter).
3. Use the computer box of your radar.

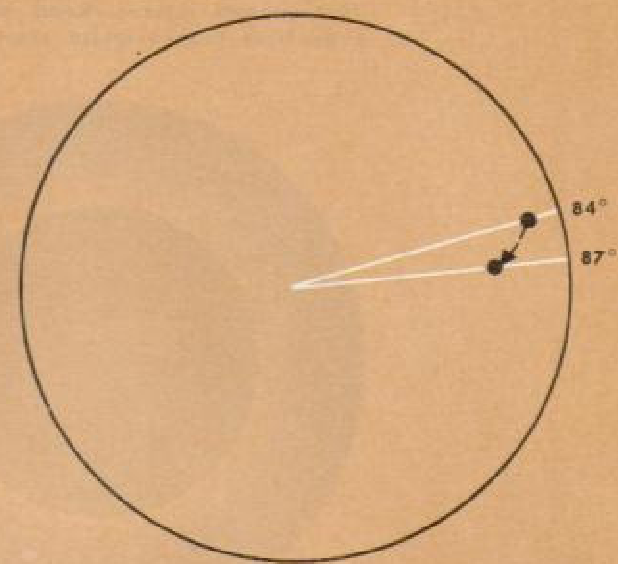
It is preferable to use the computer box to find altitude. Since the bombing altitude is set into the computer in solving the bombing problem, any error in the altitude circuit thus is compensated.

Here is the procedure to follow:

1. Leave altitude delay circuit off.
2. Turn on bomb-release circle.
3. Adjust slant range until the bomb-release pip coincides with the inner circle of the altitude hole (or rides the leading edge of the first ground return on the A scope).
4. Read absolute altitude in feet at the bottom of the scale; or, where slant range in feet is not available, convert nautical miles to feet on the E-6B.
5. Check this value with SCR-718 (if you are using APS-15A, note the difference and apply it to the slant-range dial setting).
6. Determine difference in terrain elevation at target and apply this difference to the setting on the computer box for the bombing run.

DRIFT CORRECTION METHODS

There are several drift-correction methods in current use. The method you use depends upon the type of equipment you are using and upon the skill that you have developed in the necessary technique. Of the four main methods, each has advantages and disadvantages. The methods vary in complexity and accuracy. The four used with your radar equipment are the Double Correction method, the Correction Factor method, the Quadruple Drift Correction method, and the Multiple Drift method.



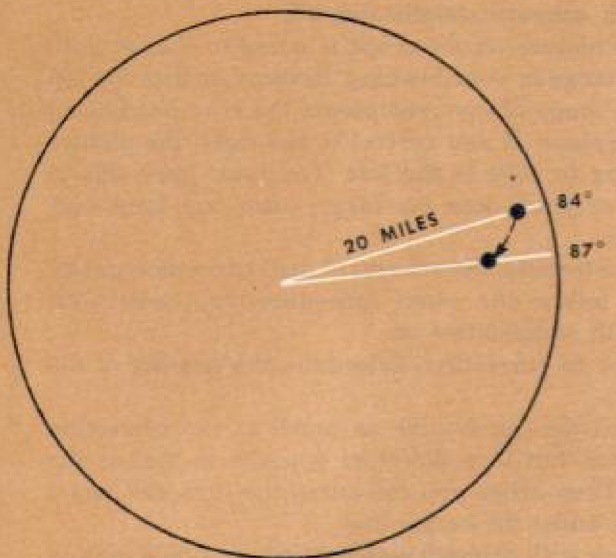
Double Correction

1. After taking up such a heading that the course line bisects the target, check the flux gate compass to be sure that the pilot is holding a constant heading.
2. If the target drifts off course, rotate the course marker until it is again over the aiming point.
3. Measure the angle of movement. Tell the pilot to turn **twice this amount in the same direction.**
4. Re-set the flux gate marker.

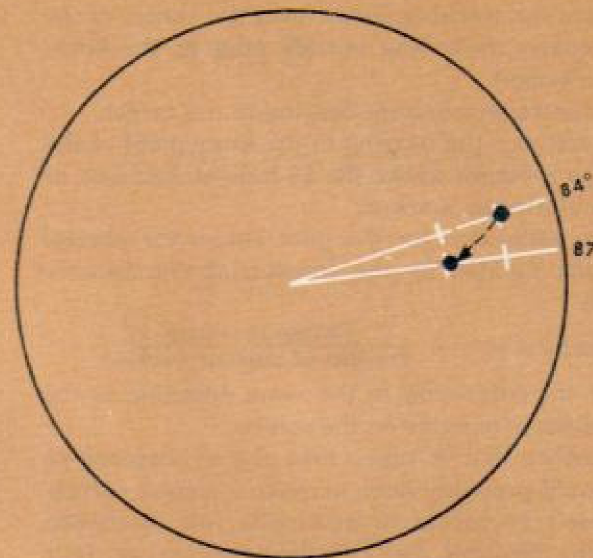
Repeat this process until the target no longer drifts off the course marker. **Always be sure to use the same part of the target area for drift correction.**

Correction Factor Method

1. After taking up such a heading at IP that the course line bisects the target, check the flux gate compass to be sure the pilot is flying a constant heading.
2. Write down the bearing to the target. At the same time note the distance to the target and start timing with a stop watch.
3. Divide the distance to the target by 4 to obtain the correction factor.
4. At the end of one minute, readjust the course



CORRECTION FACTOR METHOD { 3° DRIFT IN 1 MIN. CORRECT 15° TO THE RIGHT



QUADRUPLE DRIFT CORRECTION { TARGET DRIFT 3° CORRECT 12° TO THE RIGHT

marker. Multiply the difference between this new course setting and the old one (one minute earlier) by the correction factor. The product is the change to be made in the airplane's heading.

The turn to be made is to the left or right, according to the adjustment of the course marker. Always turn in the same direction that the target appears to be drifting.

5. As soon as the airplane has completed this required turn, set up the course marker again, start timing another minute, and repeat the procedure.

Quadruple Drift Correction

In this method, two marking lines are added to the rotating filter of the PPI scope on the regular APS-15A equipment. These markers are short lines, or tick marks, on the course marker. One, labeled 0, is located two inches from the center. The other, labeled 4, is located $1\frac{7}{16}$ inches from the center.

1. After taking up such a heading that the course line bisects the target, check the flux gate compass to be sure that the pilot is flying a constant heading.

2. Adjust the sweep-amplitude control to bring the center of the target directly under the 0 mark.

3. With the sweep-amplitude control left as above, wait for the target return to drift in until the center lies directly opposite the 4 mark.

4. If the target is off the course marker, rotate the PPI filter to place the course marker over the target again. Note the change in bearing.

The correction to be made in the heading of the airplane is **four times** the angle through which the course marker turned, and in the same direction.

5. Readjust the sweep-amplitude control to place the target under the 0 mark again, and repeat the above procedure.

You also can use a combination of the Double Correction and the Quadruple Drift Correction methods. With this combination method you eliminate most of the drift by means of Quadruple Drift Correction, as soon as you have turned onto the bombing run, while the target is still 20 to 30 miles away. After the initial correction, you make the remaining corrections by the Double Correction method.

When you use this combination of methods there is less chance of overcorrecting as the target moves toward the center of the scope. Moreover, you do not have to expand the scope after the first correction and therefore do not interfere with the bombing method being used.

Multiple Drift Method

1. Place the tracking cursor over the target as the return comes under the outside edge of the scope (20-mile range).

2. Measure an accurate bearing to the target.

3. Determine the bearing to the **same point** of the return as it comes under the 16-mile etched line or the 15-mile range marker.

4. The correction for the pilot equals the change in bearing divided by the fraction of the distance traveled.

$$\text{Correction for pilot} = \frac{\text{Change in bearing}}{\text{Fraction of distance traveled}}$$

Make the correction in the same direction as the target appears to move on the screen.

Remember that it takes time for an airplane to turn. You'll probably have to make a second correction. Don't be afraid to make the full correction which the Multiple Drift method determines. It is best to throw in an extra degree or two, depending on the size of the correction. As a rule of thumb, add 1° for each 10° of correction. This correction formula works on all ranges.

With azimuth stabilization off:

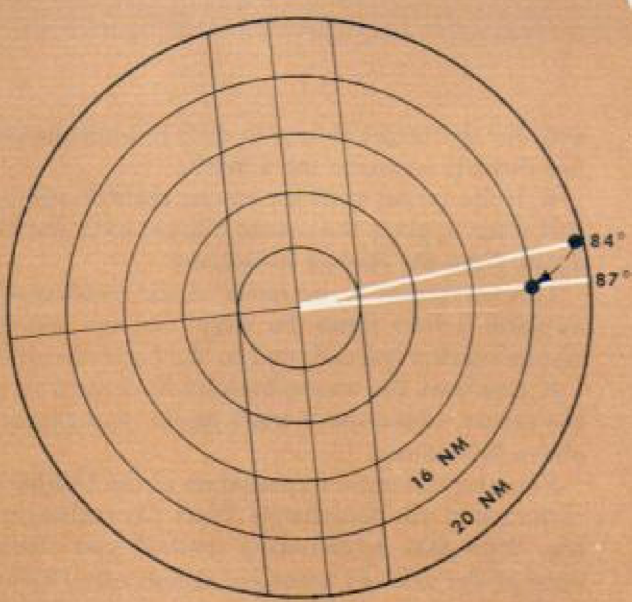
The picture on the scope is going to change with any change in your heading. Remember that the top of the scope always represents the true heading of the airplane. **If you correct to the right, the picture is going to shift to the left.** You must keep this in mind or you'll lose the target after any large correction.

To determine the amount of drift correction necessary, follow the same procedure you used with azimuth stabilization on.

Prior to correction, determine the bearing of the target.

Move the cursor line as much as the correction calls for, but in a direction opposite to that of the turn. Then, when you roll out of the turn, the target moves under the cursor line.

Bomb with azimuth stabilization on. Avoid getting fouled up by the apparent movement of the target during the turn.



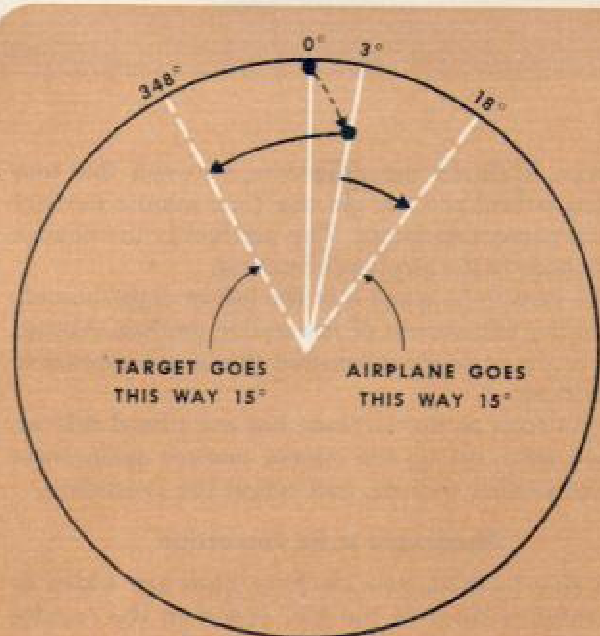
MULTIPLE DRIFT METHOD

DRIFT 3° BETWEEN

20 AND 16 NM

ETCHED LINES

$$\text{CORRECTION} = \frac{\text{BEARING CHANGE}}{\text{FRACTION OF DIST.}} = \frac{3}{\frac{1}{5}} = 15^\circ$$



WITH AZIMUTH STABILIZATION OFF

DRIFT 3° BETWEEN

20 AND 16 NM

ETCHED LINES

CORRECT 15° TO THE RIGHT

MAXIMUM SCOPE DEFINITION ★

During the bombing run you must tune your set for maximum scope definition. You can use your gain and tilt to resolve a large return into its component parts. This helps you choose an aiming point within a large city. Certain sections of the city are built up more than others. These sections give brighter returns than the more open districts. By limiting the video return, you can eliminate the weaker returns and yet keep the stronger ones on the scope.

You can get maximum scope definition for bombing with this procedure:

1. Turn on sector scan.
2. Turn up gain control until screen begins to bloom.
3. Turn down intensity control until picture shows

WITH INCREASED GAIN, RETURNS LOOK LIKE THIS

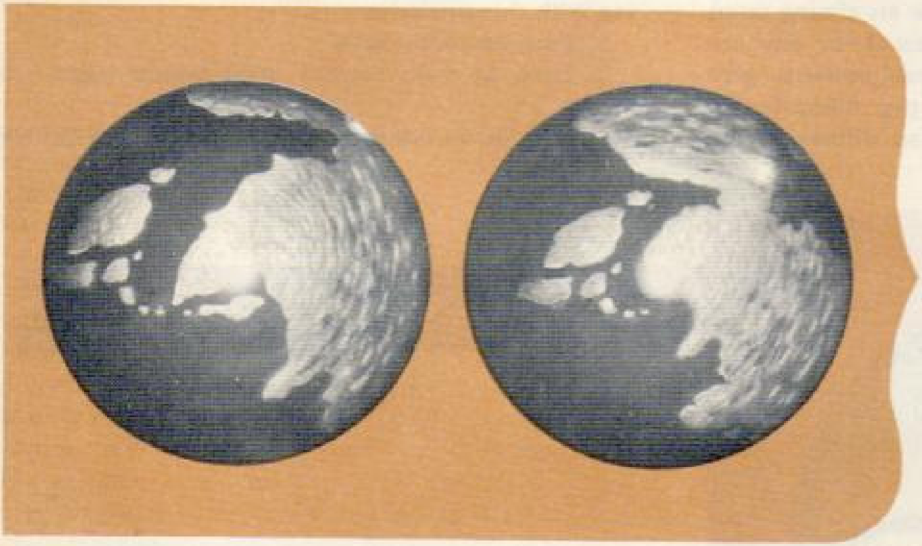
WITH REDUCED GAIN, RETURNS LOOK LIKE THIS maximum contrast of returns and background.

4. Reduce gain until target return breaks up.

Use your tilt control—don't hold the switch down. Engage it a bit at a time. Otherwise, you lose the return. On some aircraft installations you may find that you get better returns on a close-in target by raising the tilt slightly, instead of lowering it.

Switch range scales during bombing approach as the target comes in range. This magnifies the picture on the scope.

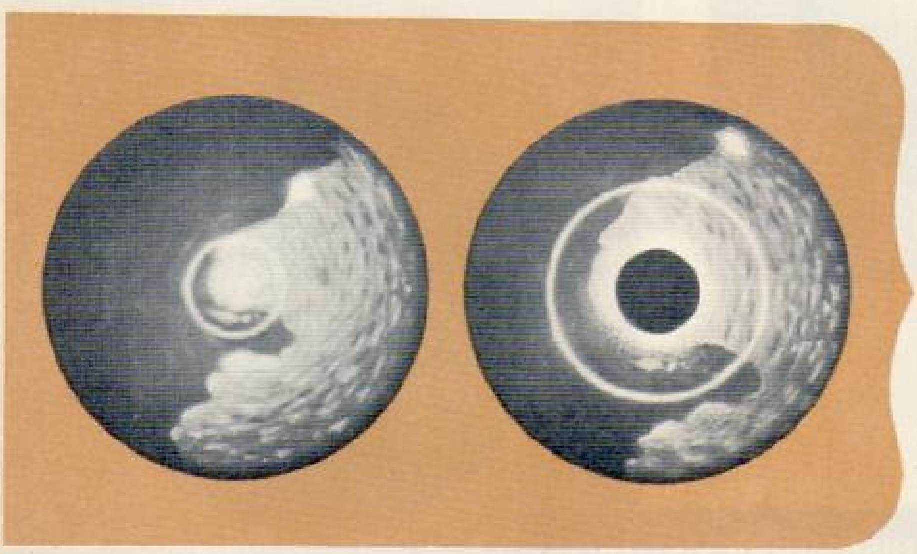
It is sometimes desirable to use the five-mile range even on a target somewhat farther away than that. This range gives better definition than is possible on the 10-mile range; it also makes it possible to obtain a more accurate sighting angle for each return. Here is the procedure to follow:



1. Put in altitude delay.

2. Crank in more altitude than the airplane is flying.

3. The whole picture is pulled toward the center of the scope. The picture becomes distorted near the center but, as the target moves in, you can reduce the altitude delay. Be sure to re-set the correct altitude before you call off the next sighting angle.



If you are doing direct bombing it is to your advantage to expand the bomb-release circle to a diameter of at least two inches. As the target moves in, crank down the altitude dial on the APQ-13 and APS-15 until the bomb-release circle is this size. You then can judge the coincidence of the target and bomb-release circle more easily.

On the APS-15A, you can obtain the same results by using sweep timing.

Procedure Turns

The procedure turn is standard in theaters where large formations of bombers are used. The turn has to be relatively shallow. You must take into account the size of the formation and the type of bomber in determining the angle of bank and the time to turn. To increase the accuracy of your navigation and bombing, you should make allowances for the time lost during the turn and for the effect on position which the turn produces.

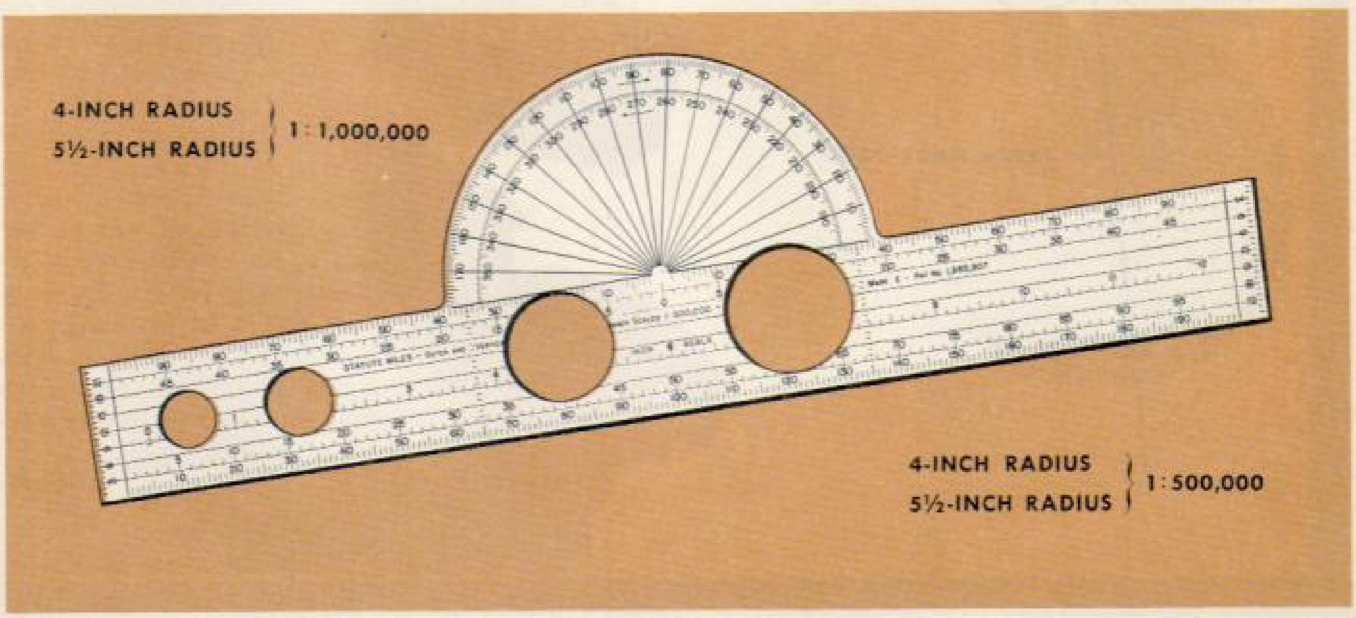
Quarter-Needle-Width Turn

The turn is made at one-quarter of one needle width; hence its name. It takes approximately eight minutes to make a 360° quarter-needle-width turn.

The true airspeed is a factor governing the radius of the turn. Since missions are flown at the most efficient cruising airspeed, you can compute the circumference of the turn for the expected true airspeed. When you know the circumference, you can readily compute the radius of the turn.

For all practical purposes you can use a constant radius for any procedure turn made by a formation of bombers of the same model. B-17 or B-24 formations, for instance, have a radius of approximately four nautical miles. B-29 formations have a radius of 5½ nautical miles. Since you navigate on a constant scale map (Lambert Conformal), you might as well cut out both a 4-mile and a 5½-mile circle on your Weems plotter.

In order to make good the track from the IP to the



target, draw a line from the target and extend it through and beyond the IP. If you are a few miles to the right or left of the briefed track (for safety's sake, never more than 5 miles) simply extend the line through the IP. Using the Weems plotter, select the proper radius of turn and draw a circle on the inside of the two lines.

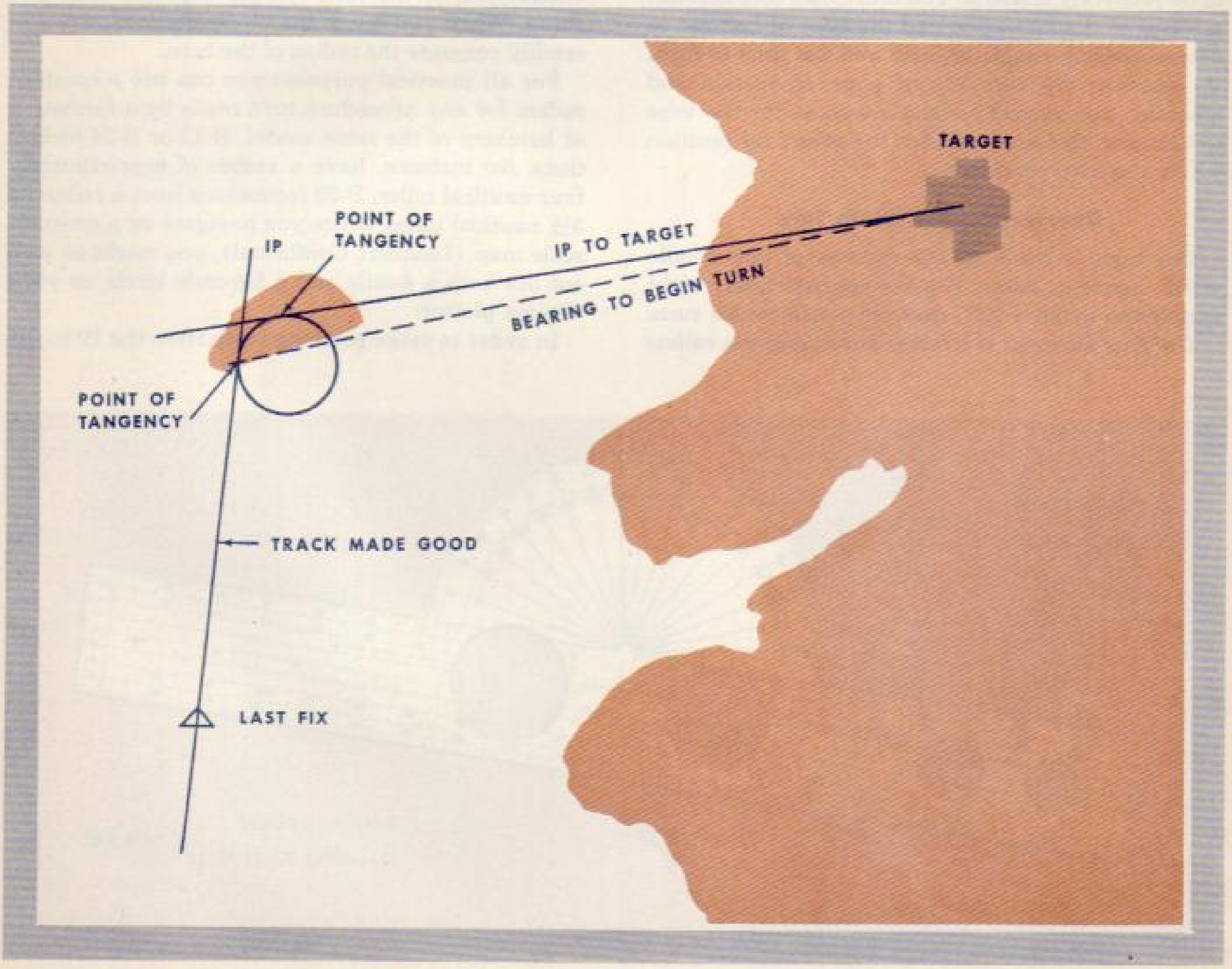
From the point of tangency (IP track) measure the bearing to the target. When you read this bearing on the scope, tell the pilot to turn to the calculated heading to the target. The pilot immediately starts to execute the turn. When he rolls out, the airplane theoretically is at the point of tangency on the track to the target. Since wind was not taken into account, the formation is not going to be exactly at the point of tangency but it'll be close to it.

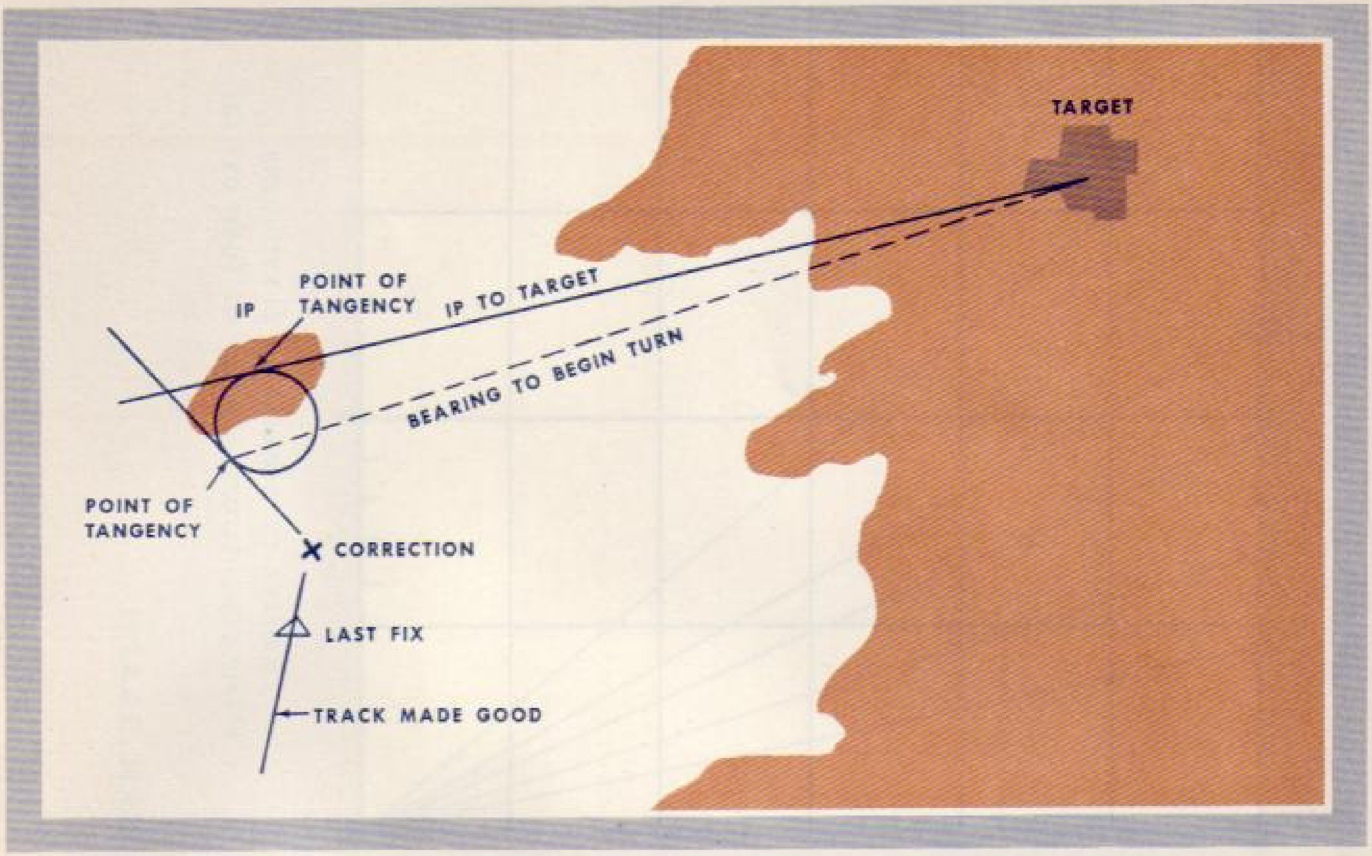
You are given an IP during briefing in order to be able to determine the approach or track to the target. You can make good the IP as well as the track, however, by correcting the airplane so that the IP is the point of tangency.

REMEMBER

It is best to roll out of the turn either over the IP or on the track to the target before the IP. **Never roll out between the IP and the target.**

To compute the time loss in a procedure turn, remember that it takes approximately eight minutes to make a 360° procedure turn. Therefore, figure one minute for every 45° of turn.





Graphic Method

A second system for varying the procedure turn to suit various aircraft, groundspeeds, etc., is called the graphic method. In this method, you determine the point at which the turn begins by entering graphs with the speed of the airplane, degree of bank, and the distance from IP to target to find an angular setting of the bearing cursor on the scope. When the target comes under the cursor it is time to begin the turn.

The radius of turn is a function of the angle of bank and the groundspeed of the airplane. The cursor-line displacement is a function of the radius of the turn and the distance from IP to the target. You can use these factors to develop the graphs which you utilize in this method. The graphs can be expressed in the following formulas:

$$\text{Tangent of bank angle} = \frac{\text{Velocity}^2}{\text{Radius of turn} \times \text{gravity}}$$

$$\text{Tangent of cursor-line displacement} = \frac{\text{Radius of turn}}{\text{Distance from IP to target}}$$

Example:

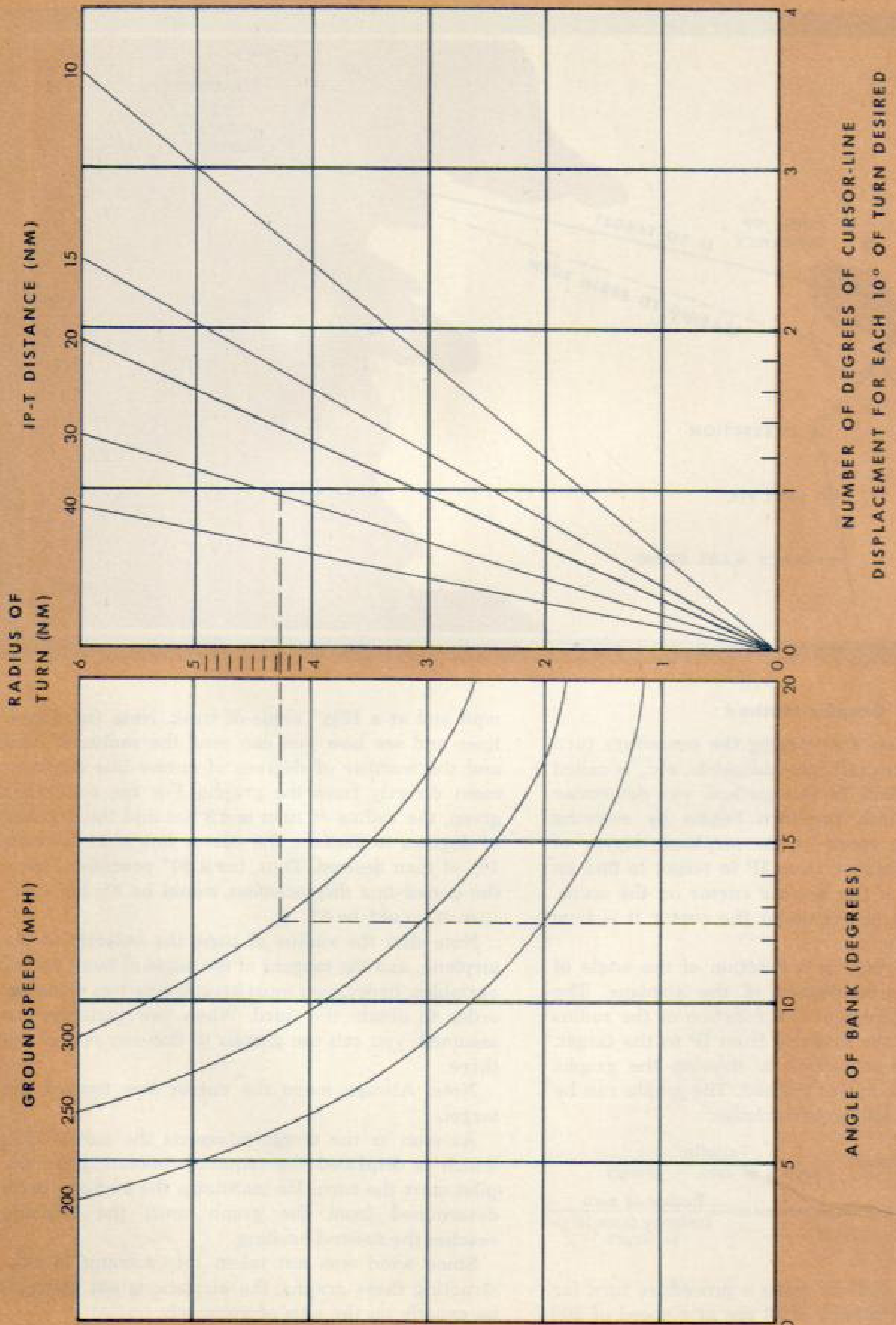
Suppose you want to make a procedure turn for an IP-to-target distance of 30 nm at a speed of 300 mph and at a 12½° angle of bank. Note the dotted lines and see how you can read the radius of turn and the number of degrees of cursor-line displacement directly from the graphs. For the conditions given, the radius of turn is 4.3 nm and the number of degrees to displace the cursor line is 1° for each 10° of turn desired. Thus, for a 90° procedure turn, the cursor-line displacement would be 9°; for a 60° turn it would be 6°.

Note that the radius of turn, the velocity of the airplane, and the tangent of the angle of bank are all variables; hence, you must assume any two values in order to obtain the third. When two variables are assumed, you can use graphs to find any one of the three.

Note: Always move the cursor line **toward the target.**

As soon as the target intersects the cursor line, which is displaced the required amount, have the pilot start the turn. He maintains the angle of bank determined from the graph until the airplane reaches the desired heading.

Since wind was not taken into account in constructing these graphs, the airplane is not going to be exactly on the axis of approach.



PROCEDURE TURN GRAPH

THE *Bombing Run*

DIRECT BOMBING PROCEDURE

1. Before you make the turn at IP, place the cursor over the target and determine the track to be made good.
2. From your E-6B determine the true heading to fly.
3. Make a procedure turn over IP. Try to turn over IP so that the pre-set track is accurate.
4. After the turn, locate the target and make necessary corrections to track over it.
5. Determine the groundspeed for this heading from the E-6B and set this value in the computer.
6. Have bombardier open the bomb-bay doors.
7. Make corrections for course and drift with one of the prescribed drift-correction methods.
8. Use your gain and tilt control to maintain maximum target resolution as target approaches bomb-release circle.
9. When the inner edge of the target enters the bomb-release circle, release the bombs.

COORDINATED BOMBING PROCEDURE

In coordinated bombing, you follow the same procedure as in direct bombing. In addition, however, you and the bombardier must coordinate the bombsight with the scope returns so that the proper rate of closure is set into the bombsight.

1. Before reaching IP, give the bombardier the bombing altitude, expected groundspeed, and drift on the heading to target.

2. The bombardier refers to his bombing tables and determines disc speed, trail, and an approximate dropping angle to set into the bombsight.

3. You place the bombing altitude and the predetermined slant-range angle (usually 70°) under the index on the computer. (If you are using the APS-15A dial-type computer, determine slant range from the degrees-to-slant-range chart located on the side of the computer.

4. As the target approaches the slant-range setting notify bombardier to be ready to turn on rate motor. Then give him continuous slant-range checks in the following manner:

Mickey: "Rate switch; seven zero coming up, seven zero, seven zero, ... now!"
"Six eight, six eight .... now!"
"Six five, six five .... now!"
"Six two, six two .... now!"

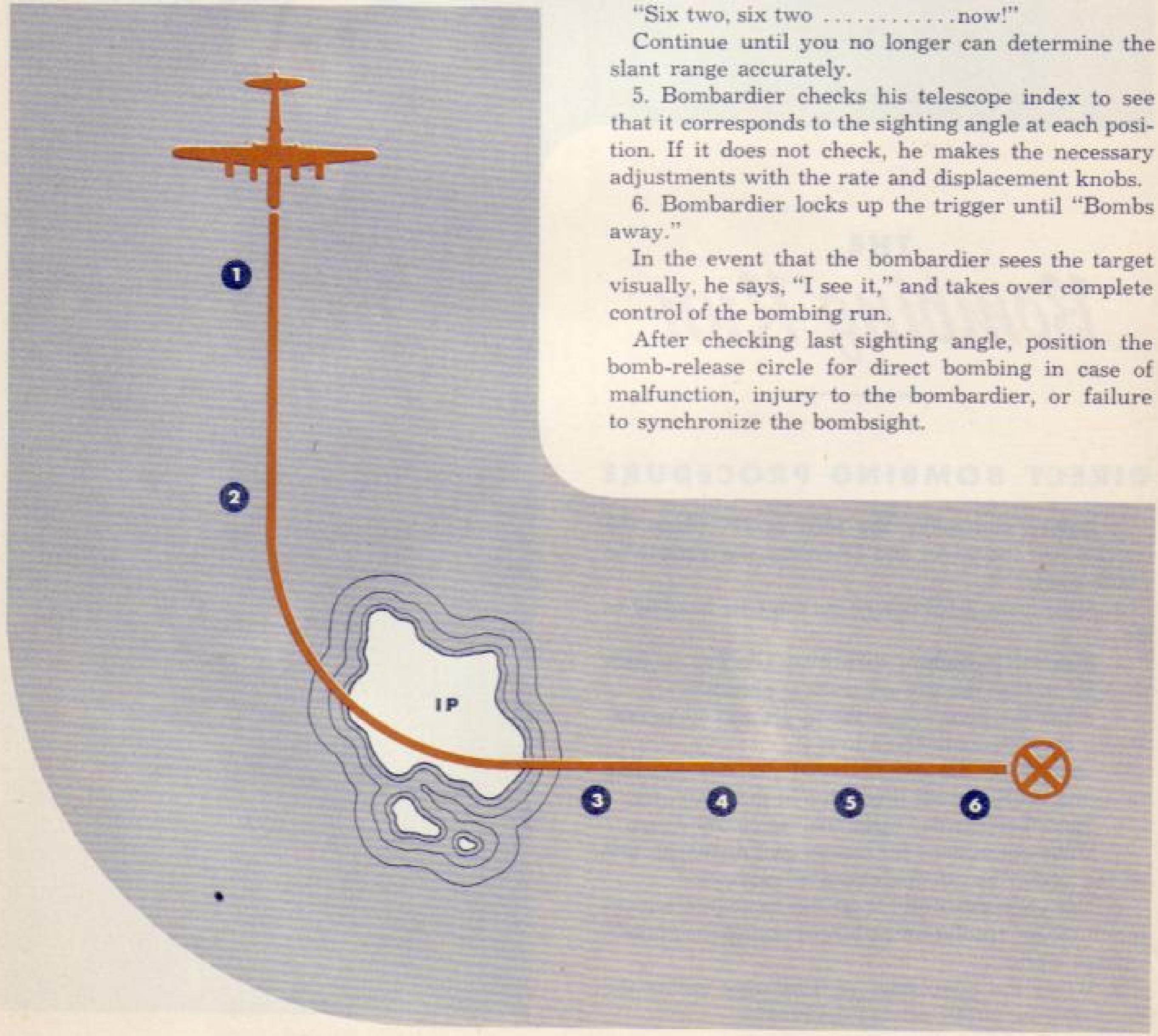
Continue until you no longer can determine the slant range accurately.

5. Bombardier checks his telescope index to see that it corresponds to the sighting angle at each position. If it does not check, he makes the necessary adjustments with the rate and displacement knobs.

6. Bombardier locks up the trigger until "Bombs away."

In the event that the bombardier sees the target visually, he says, "I see it," and takes over complete control of the bombing run.

After checking last sighting angle, position the bomb-release circle for direct bombing in case of malfunction, injury to the bombardier, or failure to synchronize the bombsight.



H₂X/LAB

LOW-ALTITUDE BOMBING (LAB) PROCEDURE (65-2000 FEET)

Prior to the bombing run, the bombardier must calibrate the AN/APQ-5B completely, with the aid of the checklist. He makes sure that all bombing equipment is ready for use and helps the pilot set up the autopilot, if it is to be used.

You, meanwhile, must calibrate your radar set completely. Make sure that it is ready to use; then search the area and pick up the targets to be bombed.

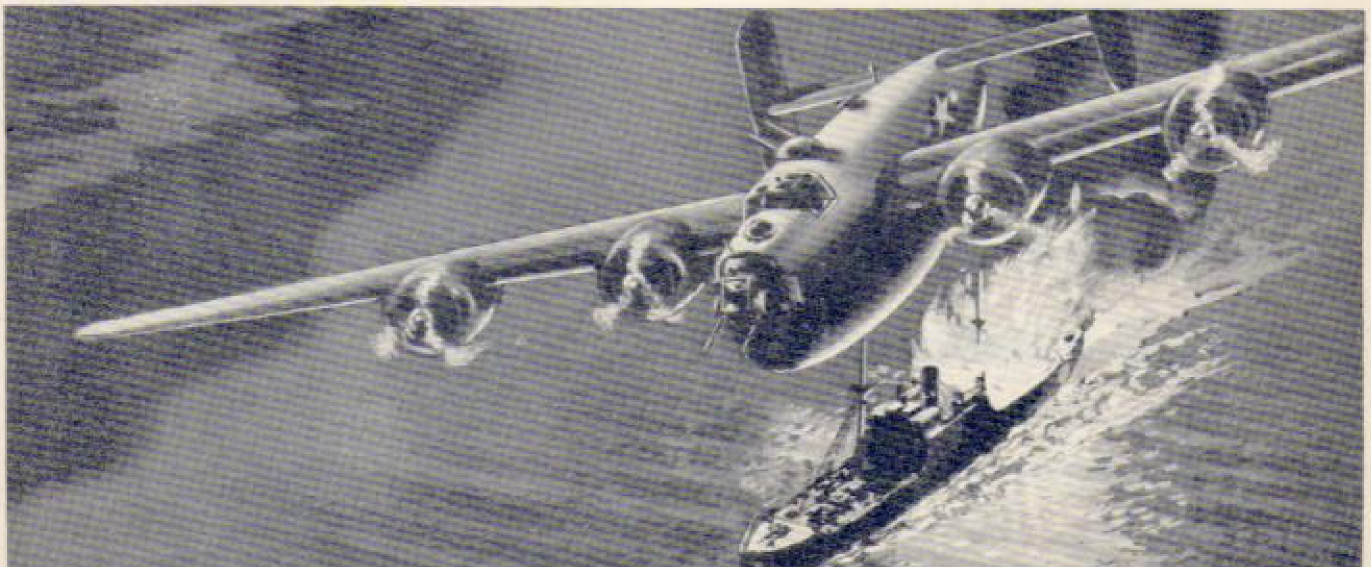
The pilot, in addition to setting up the autopilot, must check to see that the APN-1 (low-altitude absolute altimeter) is ready for use and must set his pressure altimeter.

Teamwork among you, the bombardier, and the pilot is essential to a good bombing run. Interphone procedure is particularly important to you and the bombardier. All other crew members should stay off the interphone during the bombing run, except in an extreme emergency, in order to avoid confusion.

Your Job

1. Pick up the target and give the pilot the necessary directions to enable him to fly towards it.
2. Tune for maximum target return, so that the bombardier's scope gives him a clear picture.
3. Always give azimuth indication or correction first (for example, "Right, 20°") so that the pilot may put the airplane on the heading to the target immediately. Then, call out range.
4. Continue to guide the pilot, giving azimuth, then range, until the bombardier calls "PDI on." From here on, neglect azimuth indications and call off range only.
5. Call off range every mile until you reach the 5-mile point, then call off range every half-mile until "Bombs away."

Note: It is vital to the success of a bombing run that you adjust tilt and receiver gain so as to keep a clear target return on the bombardier's scope.



The Bombardier's Job

1. As soon as the target is identified in the scope, he bisects it with the tracking line and switches from SEARCH to TRACK.

Note: You already have the target dead ahead by your corrections to the pilot. Most of the drift is taken out by this time.

2. When the target is within a few degrees of center, horizontally, he clutches in bombsight clutch (and disengages autopilot clutch, if he is using it). Notifies pilot, "PDI on."

3. Kills rate with the rate knobs. Double grips rate knobs to keep the target on the tracking line. In order not to lose the target, he rides it on top of the tracking line. Stops synchronizing on the target at 1½ miles. **With the position knob only,** he holds the target with its bottom edge barely protruding below the tracking line.

4. Sets up a collision course with the bombsight's course knobs. If the target is not dead ahead when the run starts, he brings it to the center with the outer (turn) knob. Any movement of the target from center normally is a result of drift.

After each course correction is made, he waits for the pilot to call "Level" before he puts in another correction (on PDI runs only). This prevents false indications of the target on the scope.

5. Unlocks bomb racks at the 3-mile range.

6. As soon as the bombs have been released, he calls "Bombs away," switches from TRACK to SEARCH, locks bomb racks, engages autopilot clutch (if autopilot is being used), disengages bombsight clutch, and tells pilot "OK to turn."

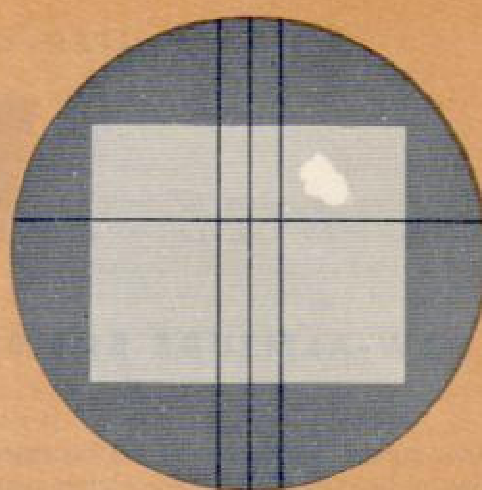
The Pilot's Job

1. Follows your directions, calling "Level" after he completes each course correction, to let you know that the airplane is on an even keel.

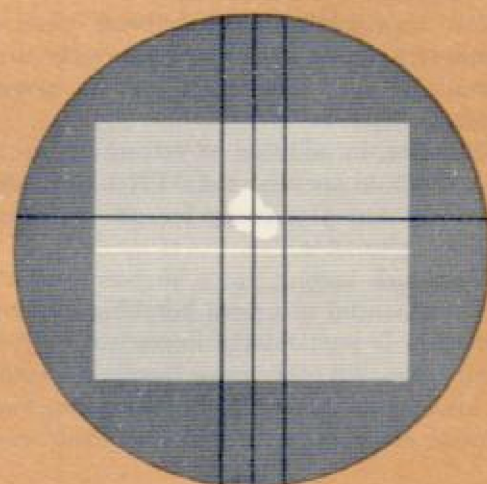
2. As soon as the bombardier calls "PDI on," he follows PDI (when not using autopilot). He calls "Level" after each PDI correction is washed out.

3. Maintains constant altitude and airspeed.

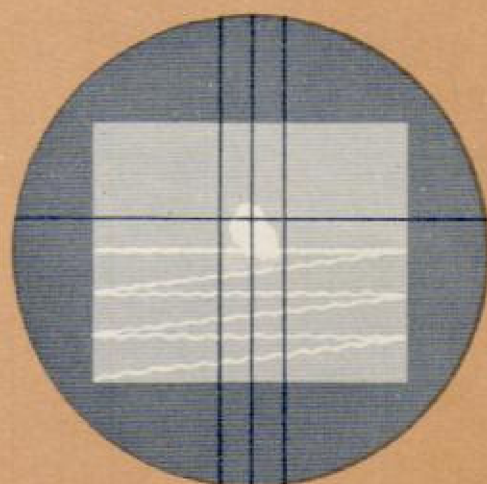
STOP CORRECTING INTO TARGET WHEN BOMBARDIER SAYS, "PDI ON".



Bring Target to Center with Turn Knob



Switch from SEARCH to TRACK, Kill Rate



Bombs Away When Electronic Beams Coincide

COMPUTER-OUT BOMBING PROCEDURE

(2000-5000 FEET)

Interphone procedure for computer-out bombing is the same as for a regular LAB run. Duties of the crew members also remain unchanged.

You must obtain a clear picture on the B scope for the bombardier. He determines slant-release range and sets it in manually. In order to obtain the slant-release range for the groundspeed and altitude flown, he must calibrate the AN/APQ-5B's range zero equipment with the computer in LOW-IN position.

You must be calibrating your radar set while the bombardier is setting up for the run.

On the Bombing Run

You: Direct the pilot to fly toward the target.

Bombardier: 1. Sets up the course as in a normal LAB run. His computer switch, however, must be in the LOW-OUT position.

2. Must obtain rate in the following manner:

At the beginning of the run, he synchronizes on the target as in normal LAB procedure.

Note: Synchronization is correct only to a certain distance from the target. This distance varies with altitude. The best rule for him to follow is to synchronize up to a distance equal to the altitude divided by 1000. If, for example, the altitude is 3000 feet, synchronization is correct up to 3 miles from the target.

You: Must call off range every mile until you reach the 5-mile point. Then call off range every half-mile until you hear "Bombs away."

Bombardier: 3. When the proper groundspeed has been determined, stops synchronizing and enters a table of Altitude-Dial Settings (Computer Out) LAB for his correct altitude-dial setting.

The LAB bombing tables and conversion charts are consolidated into one table, which gives the correct altitude-dial setting opposite groundspeed.

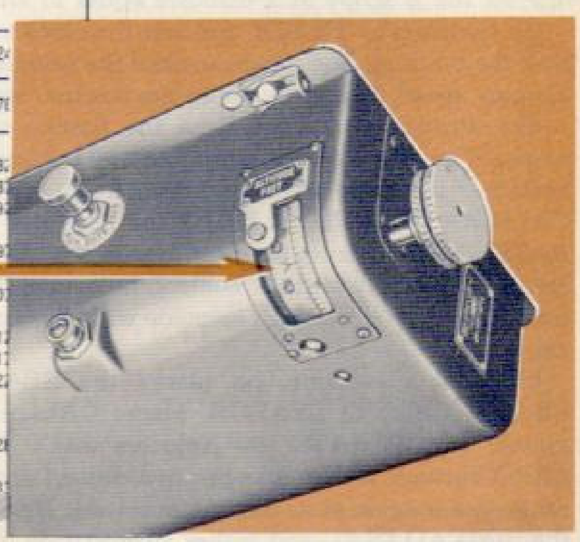
4. Sets the altitude-dial reading on the altitude dial and, with the position knob only, continues tracking the target to the release point. The rate knob serves no function except to obtain proper groundspeed.

You: Must keep the target on the bombardier's B scope, using receiver gain and tilt, so that he may bomb effectively. He can hit only what he sees.

ALTITUDE DIAL SETTING, COMPUTER SWITCH "OUT"

ALT. feet	True ground speed—miles per hour													
	100	110	120	130	140	150	160	170	180	190	200	210	220	230
2000	271	294	318	345	375	406	439	475	513	552	593	637	683	730
2100	294	317	343	371	402	434	469	507	546	587	631	677	725	775
2200	317	341	368	397	429	464	500	539	580	624	670	718	768	820
2300	340	366	394	425	458	494	532	572	615	661	709	759	811	866
2400	364	391	421	453	488	525	565	607	[illegible]	699	749	801	856	913
2500	390	418	449	482	518	557	598	642	688					
2600	416	445	477	512	549	589	632	678	[illegible]	777	831	888	947	1008
2700	443	473	506	542	581	623	668	715	765	818	874	932	993	1057
2800	471	502	536	574	614	657	703	752	804	859	917	977	1040	1107
[illegible]	499	532	567	606	648	692	740	790	844	901	961	1024	1089	1158
[illegible]						728	777	829	885	944	1006	1070	1138	1209
[illegible]								870	927	[illegible]		[illegible]	[illegible]	1261
[illegible]								[illegible]	970					

Enter table of altitude-dial settings with your groundspeed and altitude. Set this reading into the altitude dial.



HIGH-ALTITUDE BOMBING (HAB) PROCEDURE (AN/APQ-5B)

(ABOVE 5000 FEET)

In HAB (or HI-OUT) bombing the computer switch is at HI-OUT. The bombardier sets the SPREAD DIAL at 0, the rate knob at the approximate groundspeed (which you must give him), and the altitude dial at the normal or minimum setting of 65 feet.

He calibrates the AN/APQ-5B, determines the absolute altitude of the bombing run, either with the SCR-718 altimeter or his E-6B computer; and helps the pilot set up the autopilot.

You must calibrate and tune your radar set to its maximum efficiency.

On the Bombing Run

You: Must pick up the target at 20-25 miles and direct the pilot's flight towards it. Must give correction (for instance, "Right, 20°") and call off range every mile.

Bombardier: Calls "Down tilt."

You: Must set the spinner at −5° and turn on sector scan.

Bombardier: Must determine altitude with the AN/APQ-5B. He does this by placing SEARCH-TRACK switch at SEARCH and rotating the position control until the tracking line is about one-quarter of the distance up the scope. This places the release line on the B scope at a distance equal to altitude.

He switches to TRACK and lets the clock run so that the tracking line moves toward the release line. He may speed this up by using the position knob.

The altitude ring rises from the bottom of the scope. When it reaches a point halfway between the bottom of the scope and the tracking line he switches CALIBRATE to RATE ZERO (or uses the AUX RATE ZERO control) in order to stop the clock. By careful use of the altitude control, he brings the release line up and makes it coincide with the altitude ring.

When this is done, he places the SEARCH-TRACK switch at SEARCH, places CALIBRATE switch at OPERATE (or releases AUX RATE ZERO button), and rotates position control until the range line is again at its maximum setting. He checks the SPREAD DIAL and makes sure it is on 0.

He then tells you to resume normal tilt, and as soon as the target appears at the top of the B scope, he sets the tracking line on the target.

You: Stop making course corrections from here on and call range every mile.

Pilot: Calls "Level" after each PDI correction (if he is not using the autopilot).

Bombardier: Starts killing course as soon as the target appears at the top of the scope. He makes initial course corrections on SEARCH and refines course on TRACK.

As soon as he sets up his course approximately on SEARCH he must set up his rate.

He sets the rate and B factor in the following manner:

1. On SEARCH he bisects the target with the tracking line.
2. Switches to TRACK.
3. Holds the target on the tracking line by double gripping the rate knobs; avoids large double-grip corrections.

You: Must call off range exactly at 7 miles.

Bombardier: 4. Stops synchronizing at this point and reads his groundspeed from the RELATIVE VELOCITY dial.

5. Enters the HAB tables with altitude and groundspeed to find the B-factor setting for the SPREAD DIAL.

6. Puts the proper setting on the SPREAD DIAL.

You: Must keep calling the range to the bombardier until he calls "Bombs away."

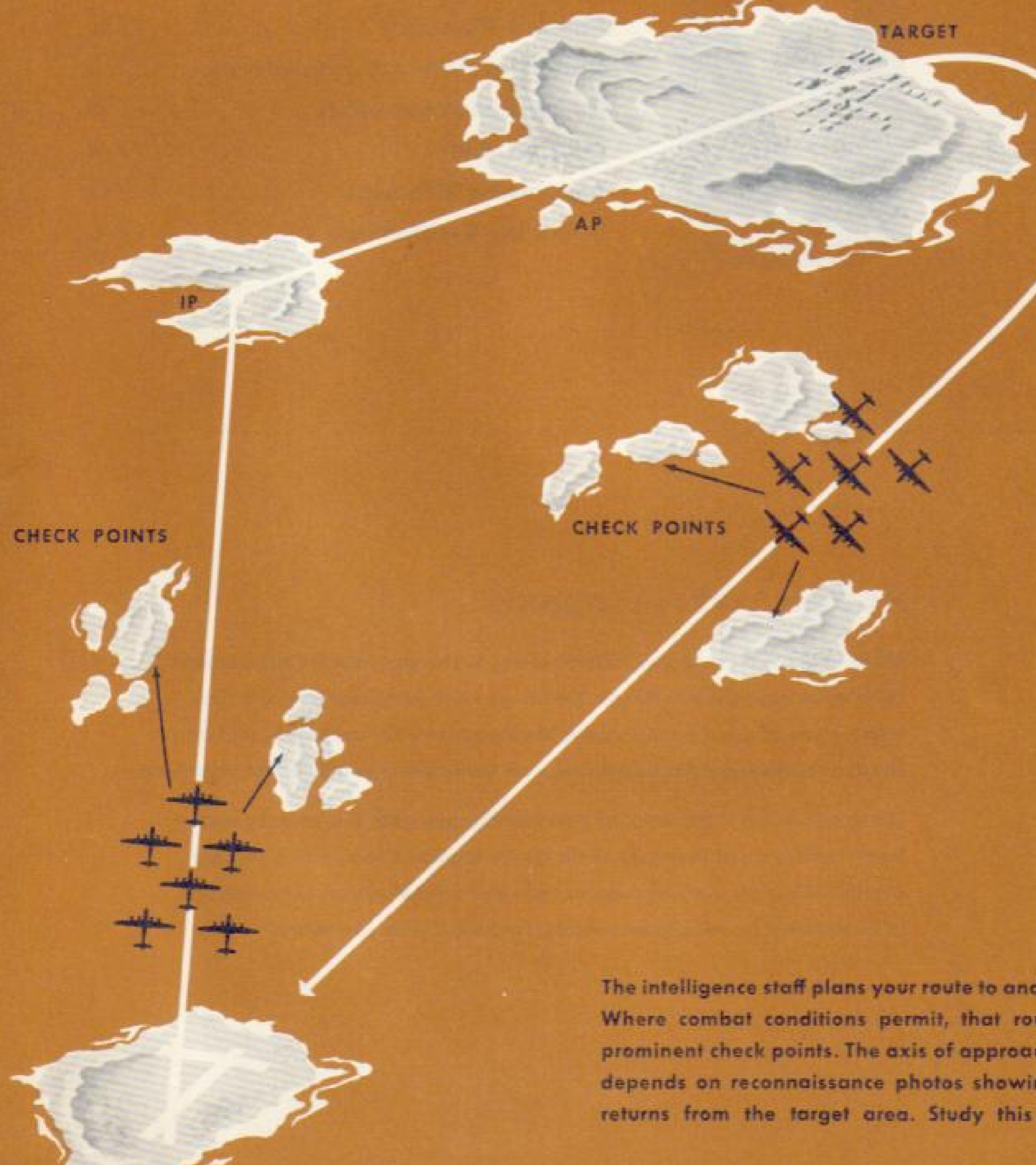
Bombardier: 7. Turns the rate knob (inner knob) to a velocity of 125, continues to refine course, and keeps the target on the tracking line with the position knob (outer knob) only. He holds the target on the tracking line so that the bottom edge barely protrudes beneath it as the range decreases and the airplane approaches the release point.

8. After the bombs are dropped, locks the bomb racks, switches from TRACK to SEARCH, engages autopilot clutch, disengages bombsight clutch, and tells the pilot "Your ship."

Remember: You must keep a clear target return on the B scope during the entire bombing run.

SECTION 7

RADAR INTELLIGENCE



The intelligence staff plans your route to and from the target. Where combat conditions permit, that route is based on prominent check points. The axis of approach into the target depends on reconnaissance photos showing the strongest returns from the target area. Study this data carefully.

7

SUBJECTS IN SECTION 7

RADAR INTELLIGENCE

Much of the success of any mission is due to the groundwork accomplished before you ever get into the air. Before you risk your neck over a target, many hours of good honest sweat have gone into the preparation of maps, charts, overlays, predictive devices, and scope photographs of the target area.

This preparation is the work of your intelligence staff. It is no easy task. Study their job and then give them all the cooperation of which you are capable. Only by working together can you enable subsequent missions to be planned for maximum success. For you, it's life insurance!

Mission Planning

Planning is deciding what to do in a systematic way, and doing it better on that account. Military planning takes in a combat objective and the means of attaining it. Military planning is based on intelligence, that is, on the known facts of the combat situation. Radar is an important contributing factor in aerial intelligence.

No one man can possibly do the overall planning of aerial combat missions. But you are furnishing the raw material for the planning of future missions every time you bring back a good scope photo. Scope photography and analysis are the foundation of radar intelligence and radar mission planning, which the **radar intelligence officer** handles as a part of general combat intelligence.

In the critical moments of a bombing mission you have your hands full with combat duties which automatically take precedence over everything else. But you are also the flight representative of the radar intelligence officer. He depends on you for his primary data, while you depend on him for planning and advance information. Neither of you can do a good job without the other.

FACTORS IN MISSION PLANNING

The planning of a typical bombing mission, once such primary factors as target, aircraft, and bomb load have been determined, breaks down into the following elements:

1. Route to the target.
2. Check points for navigation.
3. An initial point (IP), usually within 25 to 45 miles of the target, where the turn in the direction of the target is made.
4. An aiming point (AP), which in current practice is usually within the target area, but which may be some more clearly defined object located at a known position with reference to the target.
5. Route and check points from the target back to the base.

Radar plays a part in the selection of every one of these items, but it isn't the whole story. A given axis of approach might be known to give the clearest returns from the target, yet be ruled out by the concentration of anti-aircraft batteries along it. Again, the best radar check points might be found along a route which, because of unfavorable winds, would impose excessive fuel requirements on the flight. What it amounts to is that radar visibility is important, but, like every other factor in mission planning, it sometimes has to give way to even more important tactical or technical considerations.

A detailed discussion of the factors of mission planning listed above follows:

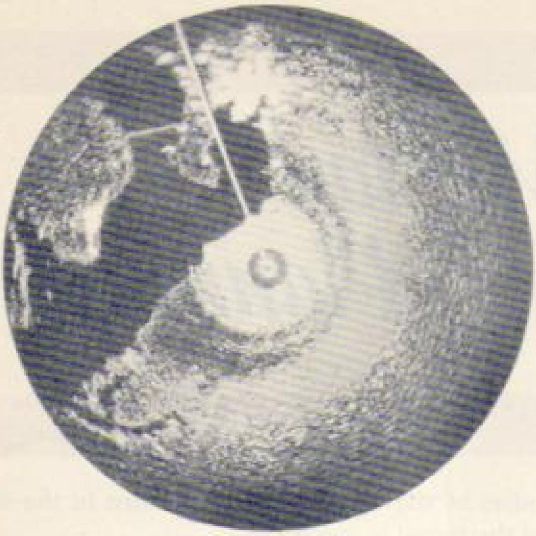
BASE TO INITIAL POINT

Leaving Friendly Territory

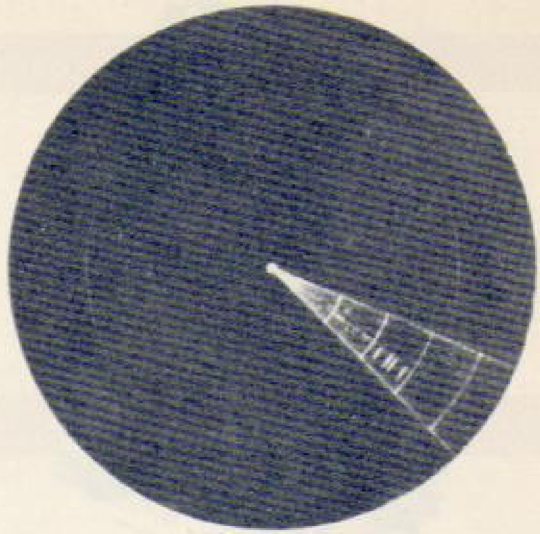
On the first leg out you may take back-bearings on well-known features of the area near the base. These provide checks on the calibration of the equipment as well as establish the course. This part of the run requires the least attention in planning and briefing, but demands considerable activity by you.

Radar Beacons

Although of greater importance on the return to base, radar beacons are also useful in the early stages of the mission. If you are not already familiar with the characteristics of the beacons in the area, this



Maximum radar range is 100 miles.



Maximum beacon range is 300 miles.

is the best time to find out. The special advantage of radar beacons is that, while the range of APS-15A and APQ-13 equipment is limited to about 100 miles for reflected signals, the beacon transmitter responds up to 240 miles for APS-15A and 300 miles for APQ-13.

Selecting Check Points

Check points should be located along the route at 50- to 75-mile intervals or less. They should not be closer to the course than 10 miles, to avoid plotting errors caused by distortion at short range, or more than 50 miles off the course. The best check points are those which give small but bright returns, since they are easy to pick up and give the most accurate fixes.

The planning officer collaborates with you and the other radar operators in charting those check points which have been found most serviceable on previous bombing missions or in reconnaissance.

If no such data is available, the planning officer must select check points according to his best judgment, from navigational and topographical charts. For example, on an overwater mission, an island with steep bluffs on the side toward the planned course would be expected to give bright though probably not continuous returns. On this account it might be preferred to a flat island which would have less land-water contrast. But size, shape, and location would also be considered in making the selection.

Peculiar shapes which are certain to show up on the scope and make identification easier are most desirable for check points. On land these include mountains with steep scarps or cliffs, isolated peaks, buttes, prominent bends in large rivers, lakes, or isolated cities. Along the coast, harbors, promontories, peninsulas, the mouths of large rivers, islands, and similar features make the best check points.

Whenever possible, there should be at least one reliable check point on the scope. In an area where radar navigation is frequently necessary, it is justifiable to modify the route accordingly. A lost flight wastes more fuel than one which goes the long way around but always knows where it is.

The limits of resolution of APS-15A and APQ-13 equipment are discussed in Section 2. The radar intelligence officer, if he is to do a good job in planning the navigational and bombing phases of a mission, must reckon with these limits and never forget that convenient location on a route does not make an object visible on the scope.

On your part, if a check point given in the mission plan does not materialize when expected, don't decide offhand that it cannot be seen. Look for it by changing the gain and the antenna tilt. Almost anybody can learn to operate a radar set after a fashion, but it takes sustained effort to get the most out of it.

Plotting

To take maximum advantage of the check points indicated in the plan, it is best to plot range and bearing on the points available. Bearings alone from two check points also give an accurate fix, provided the points are about 90° apart. The smaller the angle, the less accurate the fix. This type of plotting is least affected by distortion at short ranges. Intersecting ranges is the least accurate of the three methods of obtaining a fix and generally is used only in case azimuth stabilization fails.

Additional Check Points

On long over-water missions, aircraft may drift considerably off course because of the scarcity of island check points. Because of this, not only should the radar features on course be indicated, but also the features on either side for a distance of, say, 100 miles. With this help, formations may get back on course with the least uncertainty and delay.

INITIAL POINT

Location

The direction and length of the bombing run are agreed on in advance and incorporated in the mission plan. If a line representing this range and azimuth is drawn from the target, its other end represents the IP, which marks the beginning of the bombing run. Since the formations rarely come in on this course from their assembly points, the IP usually is also a **turning point** over which each airplane executes a procedure turn designed to put it on the track toward the target. You should be familiar with the turning characteristics of your airplane so that you may be able to tell the pilot the right instant to begin the turn in order to roll out of it **over the IP and on course.**

Types of IP

The planned IP does not always coincide with an object visible by radar and sometimes is briefed merely as an intersection of coordinates in a given locality.

Occasionally the bombing track is the prolongation of the previous navigational course. In that case the IP is not a turning point, and the flight heads directly for the target as soon as it becomes visible. Even when a turn is required, the target often appears on the scope early enough to serve as a check point in reaching the IP.

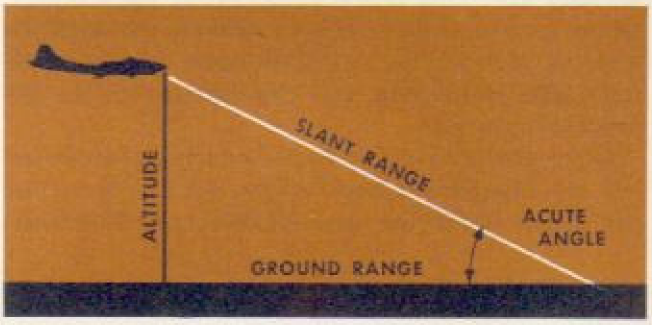
THE TARGET AREA

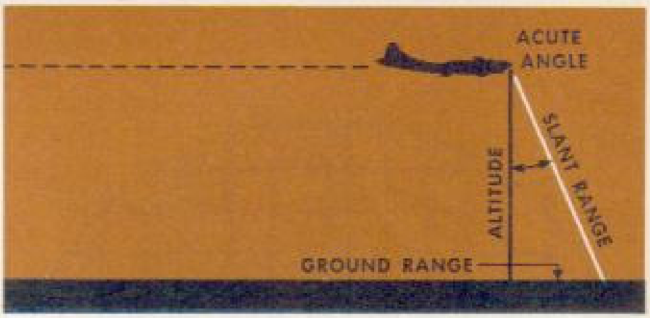
Scope Interpretation

The average time for a bombing run is about six minutes. A great deal of critical activity must be crowded into this interval. To make this activity count, you must:

1. Identify the target at the beginning of the run.
2. Estimate the actual location of the target. Carefully compare the scope presentation with your target charts.

Short-Range Distortion of Radar Images





Radar measures slant range, not ground range (which is what the airplane flies). At the longer ranges—25 miles or more—the two are identical for all practical purposes. This is because in a right triangle the length of the horizontal side, representing the ground range, approaches the length of the hypotenuse as the angle between the two becomes small.

At short ranges, where the ground range is small compared with the altitude of the airplane, the triangle is turned into the vertical position with the acute angle on top. The slant range now approaches the altitude in length. In the extreme case, where the airplane is directly over a reflecting object, the slant range is the altitude, and ground range is zero.

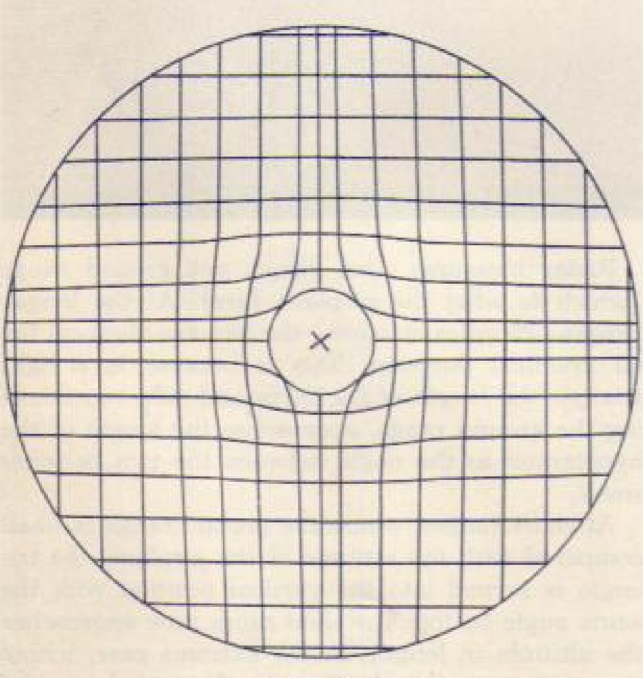
Under this condition the altitude or **vertical** distance appears on the scope as **horizontal** distance. Instead of appearing at the center of the scope, an object directly under the airplane moves out from the center a distance corresponding to the altitude. The point center becomes a circular area with a radius of H (altitude).

This causes a serious distortion of the target pattern. The grid lines, straight near the circumference of the scope, bulge outwards at the center. As a result, points in a straight line on the ground are in a curved line on the scope. Objects under the airplane or nearby are magnified on the scope, since in effect the altitude circle has been thrust through them. With this **barrel distortion,** targets at a distance appear closer to centered objects than they actually are. This is the condition of **open center,** better termed **altitude hole** or **altitude circle** to distinguish it from the artificial open center which, regardless of altitude, you can create with the appropriate control.

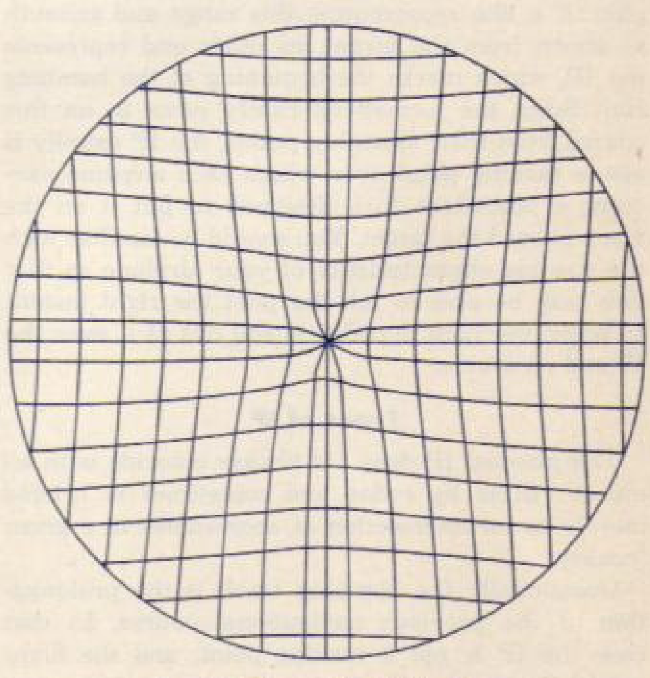
If the center is closed by introducing altitude delay, the distortion is less obvious, but it is there just the same, only in the opposite direction. This is the condition of **closed center**, which involves what is called **pincushion distortion.** The straight grid lines now bend in toward the center. Points in a straight line on the ground again appear on a curved scope line, this line being convex in the opposite direction from that in the open center condition.

Correction for Short-Range Distortion

For accurate bombing some compensation must be made for this type of distortion. It is not difficult to calculate geometrically the actual slant range from the airplane to any point on the ground, but this does not supply a corrected picture on the scope. However, radar intelligence officers are in a position to analyze scope photographs by such means and to correlate them with true-plan pictures of the area. Accordingly, they can brief what you are going to see on the scope as you near the target. This, in conjunction with your own experience in observation and analysis of scope photos, enables you to visualize the target more or less as it is from the distorted image on the scope. A partial correction may also be made arbitrarily by setting in a certain amount of altitude delay, but less than the actual altitude of the airplane.



Typical Barrel Distortion

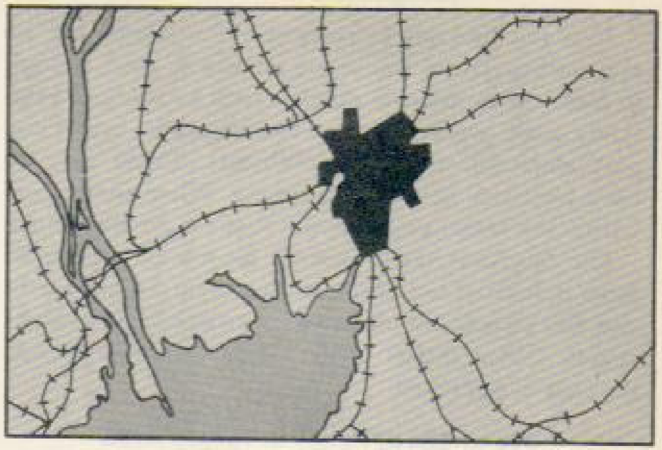


Typical Pincushion Distortion

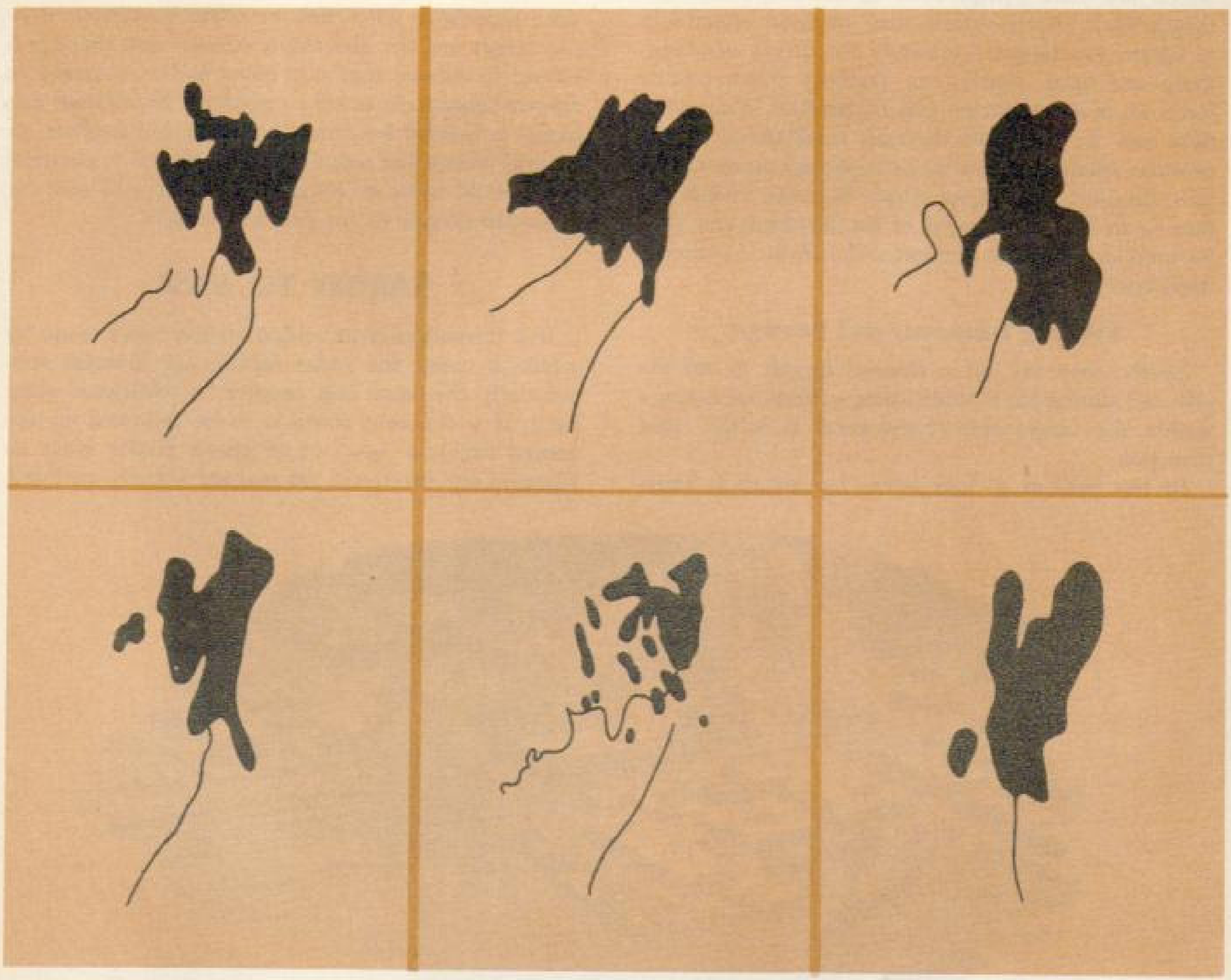
Typical Variations in Appearance

Aside from altitude distortion, the apparent shape of targets varies with angle and distance. A scope photograph represents an area as seen from one particular direction and no other.

Compare the actual outline of the city of Nagoya with the tracings of radar photographs. The variations are pronounced. Nevertheless the principal features are present in almost all of the tracings and the target remains recognizable. What it amounts to is that in the majority of instances all you can expect from a scope presentation is a caricature of the real thing. But, as in any good caricature, there is a basic likeness in spite of the exaggeration of some features and the omission of others.



Actual Outline of the City of Nagoya



Tracings from Radar Photographs of Nagoya

Recognition of Details

It is not enough to recognize the target and its approaches. Often the scope picture is good enough in close-up to indicate details, such as bridges, relatively small water areas, docks, seawalls, broad airport runways, and similar objects. These may be used for more precise positioning. When they occur within the target you may use them as aiming points.

The brightest radar returns from such targets as large industrial buildings, railroad marshaling yards, and city streets are obtained by an approach at right angles. Other things being equal, this may dictate the axis of approach.

Use of Check Points in Target Area

Often there are objects in the vicinity of the target which are more conspicuous on the scope than the target itself. Such objects may be used effectively to locate the target accurately for direct bombing. They are used, that is, as close-up check points. Even an invisible target can be bombed if accurate data can be obtained through intelligence on its position relative to one or more conspicuous reflectors. Similarly, an object which becomes visible before or in the early stages of the bombing run may be used as a guide to a target which does not emerge until later.

Bombing Inaccuracy and Damage

Bombs may fall off a desired target, or off the selected aiming point, and still do substantial damage within the target area if the error is in the right direction.

In the case of a dock area, for instance, overshooting might place the bombs in the water, while undershooting would damage a highway or railroad network leading to the docks. Mission planning therefore should take into account the damage center of gravity of a large target; if it is otherwise suitable, this is the best aiming point.

Concentration of Bursts

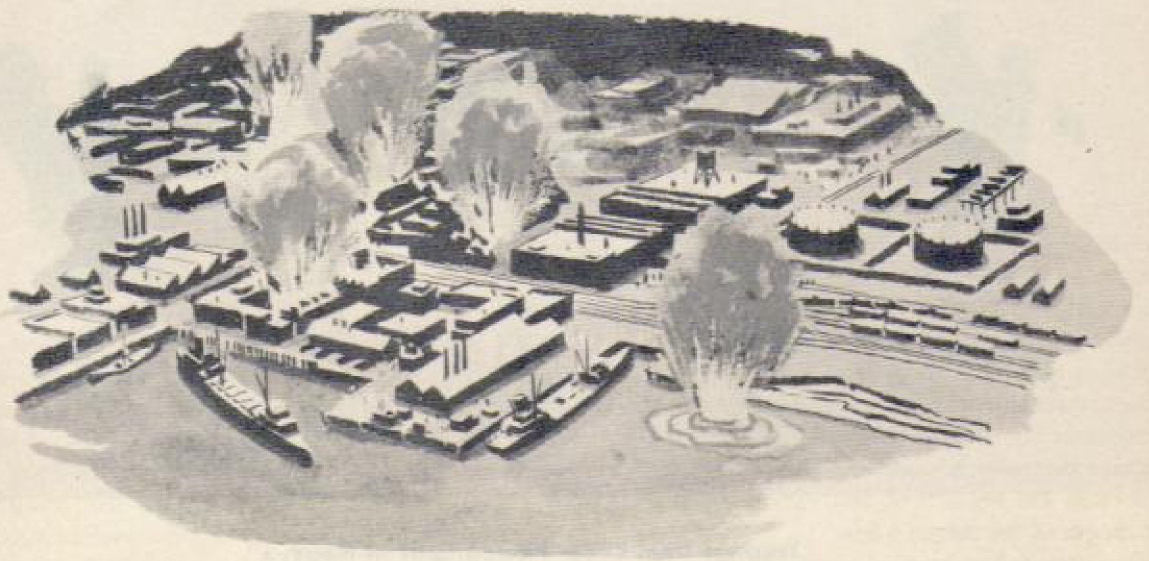
In radar as in visual bombing, well-concentrated bursts indicate good coordination within the formation. This is a desirable condition, but it puts added responsibility on the pathfinder planes. If the radar work is inaccurate, the bombing might better be scattered than concentrated in the particular case.

Alternate Targets

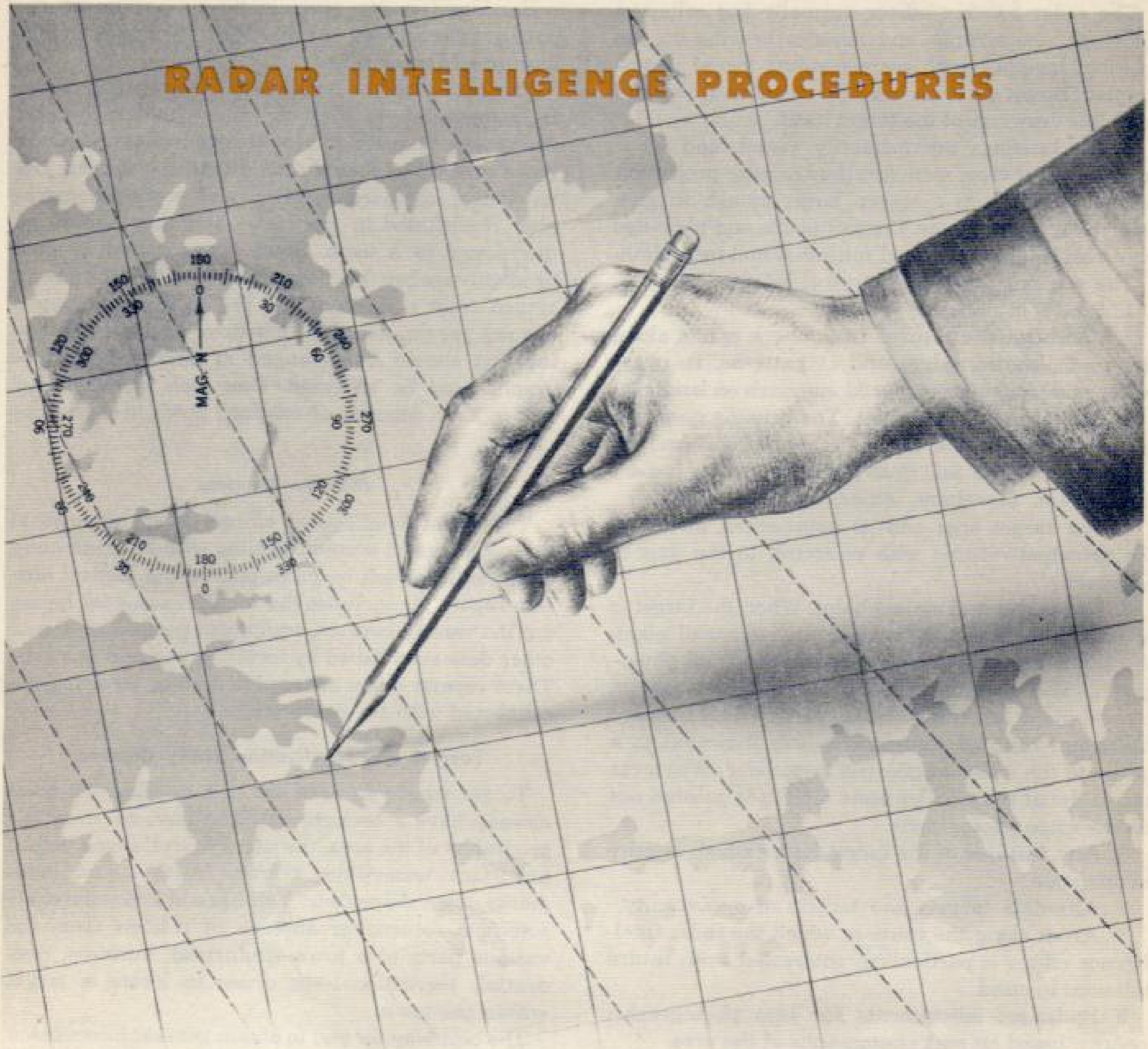
Alternate targets may be briefed on a radar mission, especially when flak or other conditions over the target are not accurately known and there is a strong likelihood that it is going to be necessary to change targets during the operation. Sometimes one target is briefed for visual bombing and another, or several others, for radar bombing. So far as possible, you should have as complete briefing and aids for alternate targets as for primary targets.

TARGET TO BASE

If a formation is to return on the same route by which it came, the radar factors are likewise substantially the same and require no additional planning. If a different route is to be followed on the return flight, a new set of check points must be planned and briefed in the manner already outlined.



RADAR INTELLIGENCE PROCEDURES



Here, in outline, is what the radar intelligence officer does:

1. Studies, digests, and correlates available scope and optical photographs of routes and targets with navigational charts of the same areas.

2. Where available scope photographs are lacking in either quantity or quality, plans reconnaissance missions over the indicated areas.

3. Plans the radar phases of bombing missions and incorporates the results in the radar-approach and target charts of the target folder.

4. Prepares radar briefing and instructional material and performs the usual pre- and post-mission functions of air intelligence officers: briefing, interrogation, mission reporting, and target study.

Briefing

It is possible to have a successful mission despite an indifferent briefing, but a good briefing gets you off to a good start. Radar intelligence officers vary in ability and initiative just like the rest of us. If a briefing is unsatisfactory in any respect, it is up to the flying personnel present to ask questions which bring obscure points into focus and bridge any gaps. You should have a reasonably detailed and specific idea of the mission before you take off.

The radar briefing officer normally has collected all scope photographs and mosaics bearing on the mission, together with corresponding visual photographs. Target pictures are annotated and overlaid with line drawings of the target itself.

Radar briefings are primarily visual, and for a large group of crew members they require projection of the material on a screen large enough to give everybody a clear view. Contact prints and blow-ups may also be passed around for individual inspection.

The principal topics of a typical briefing are:

1. Routes in and out.
2. Characteristic returns from check points along the route, shown singly and in patterns. In over-water missions there is special emphasis on landfalls.
3. Route from IP to target. The briefing goes into greater detail as the target is approached and all radar features on this final leg of the route (coastlines, lakes, elevations, cities) are identified.
4. The target area and its approaches, including the principal returns with reference to the axis of approach.
5. The target and aiming point. When the target is of considerable extent, such as an industrial plant, the limits are shown on a large-scale visual photograph. The various sections of the plant—shops, power plant or transformer yard, administrative buildings, railroad connections—are indicated as a guide to the zones of greatest sensitivity. Whatever target detail the smaller scale affords is pointed out on the scope photographs.
6. Any features of the target folder which require explanation.
7. Alternate targets and targets of opportunity.
8. Areas along the route in which the radar intelligence officer is particularly interested, with future missions in mind.
9. Radar-set adjustments for best photographic results, based on past photographs of the area.

Interrogation

After a mission, you are in the best position to check the relation between the preparations and what actually happened. You may also have new information of value. Interrogation enables you:

1. To contribute information for the improvement of radar mission aids and future planning.
2. To help correct errors in preparation and execution.
3. To aid in assessment of:

Performance of personnel and equipment.

Bombing results (principally by means of the photographs and log entries made during the bombing run and bomb fall).

The best place to hold radar interrogation is the H_2X room, where files of scope photographs and charts are at hand for immediate reference. Only those concerned should attend (radar observer, DR navigator, bombardier, pilot, and scope photographer if included in the crew) and they should be questioned as a team. Since interrogation is most productive when held immediately after the crews return from a mission, and the scope photographs are not yet processed at that time, a supplementary meeting should be arranged at which the photographs may be analyzed. One such meeting may suffice for a number of missions flown in close succession.

Mission Reports

The radar intelligence officer of an operational unit prepares an account dealing with H_2X planning and results, which becomes part of the **tactical mission report.** He includes the route, reasons for laying out the various courses, equipment performance, and other data established by interrogation and analysis. These reports make instructive reading for everyone connected with the operation.

Target and Navigation Study Classes

To get what you need out of a briefing you must already have a background. You have to know the geography of the area, the usual routes, check points, important waterways, terrain features and landmarks, town shapes, etc. You have to know the characteristic returns or absence of returns from the various parts of a town—industrial, business, residential, recreational—in order to locate a target within the town.

The best way for you to obtain general information of this kind is to attend study classes. A radar study class is essentially a series of preparatory radar briefings in which there is time for extended discussion and debate. Such discussion is not possible in a mission briefing, which hits only the high spots for that particular operation.

The more experienced H_2X operators, as well as radar intelligence officers, conduct study classes for the less experienced men. Whether as student or instructor, you cannot spend your time to better advantage. Either way you learn—and radar is a field in which there's lots to learn.

Radar Reconnaissance

Radar missions have been flown successfully, using simulated scope photographs and other predictive data, despite the lack of previous radar reconnaissance. Such missions, however, start under a heavy handicap. As a rule, reconnaissance is indispensable for:

Developing suitable objectives.

Guiding the striking forces to the objectives; that is, locating and recording check points, initial points, and aiming points.

Although you want to obtain as much intelligence data as possible on every mission, the reconnaissance plane has obvious advantages over your bomber. The bomber is bound to a formation under enemy fire. Bombing is its primary objective. The reconnaissance plane flies alone, usually out of range of flak, and its sole function is to secure intelligence.

Photographic reconnaissance requires a fast airplane equipped with H_2X and optical cameras. Simultaneous pictures of the scope and the ground are taken at the main check points, the IP, and the target. Such photographs are a primary source of intelligence for radar missions.

MISSION AIDS

Any reproduced material obtained from the radar map and target folder and carried in the bomber is called a mission aid. Such material includes a wide variety of scope photographs, real or synthetic; target and navigation maps, interpretative drawings and overlays, and other published briefing material.

Security

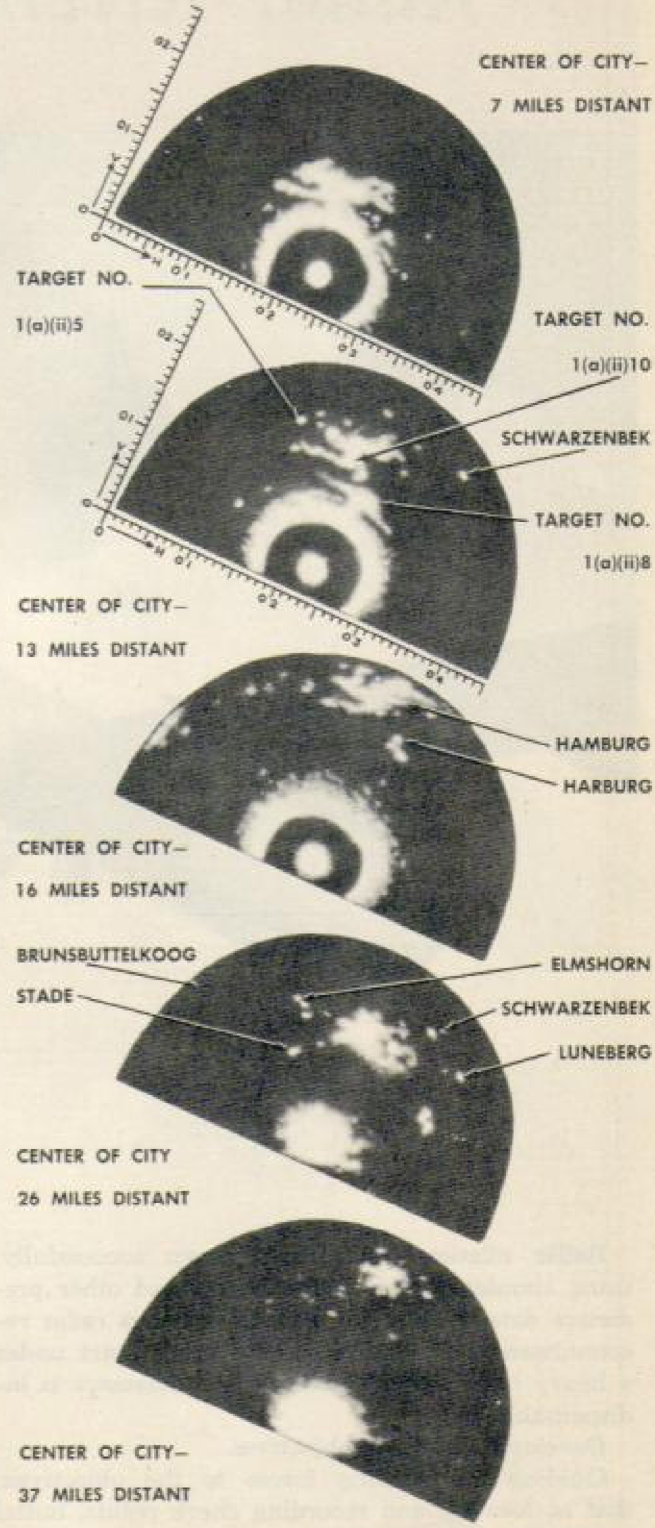
You must not carry on a mission any documents which indicate future targets, or reveal the scope or direction of our intelligence data. Documents classified Secret or Confidential automatically fall into this category. You may carry Restricted material unless it is marked "Not to be taken into the air on offensive missions." Thus, of the two Pathfinder charts shown on the following pages, the one designated RPC-9 was taken into the air, while the one designated RPC-9A, which reveals prospective targets, was limited to use at the base.

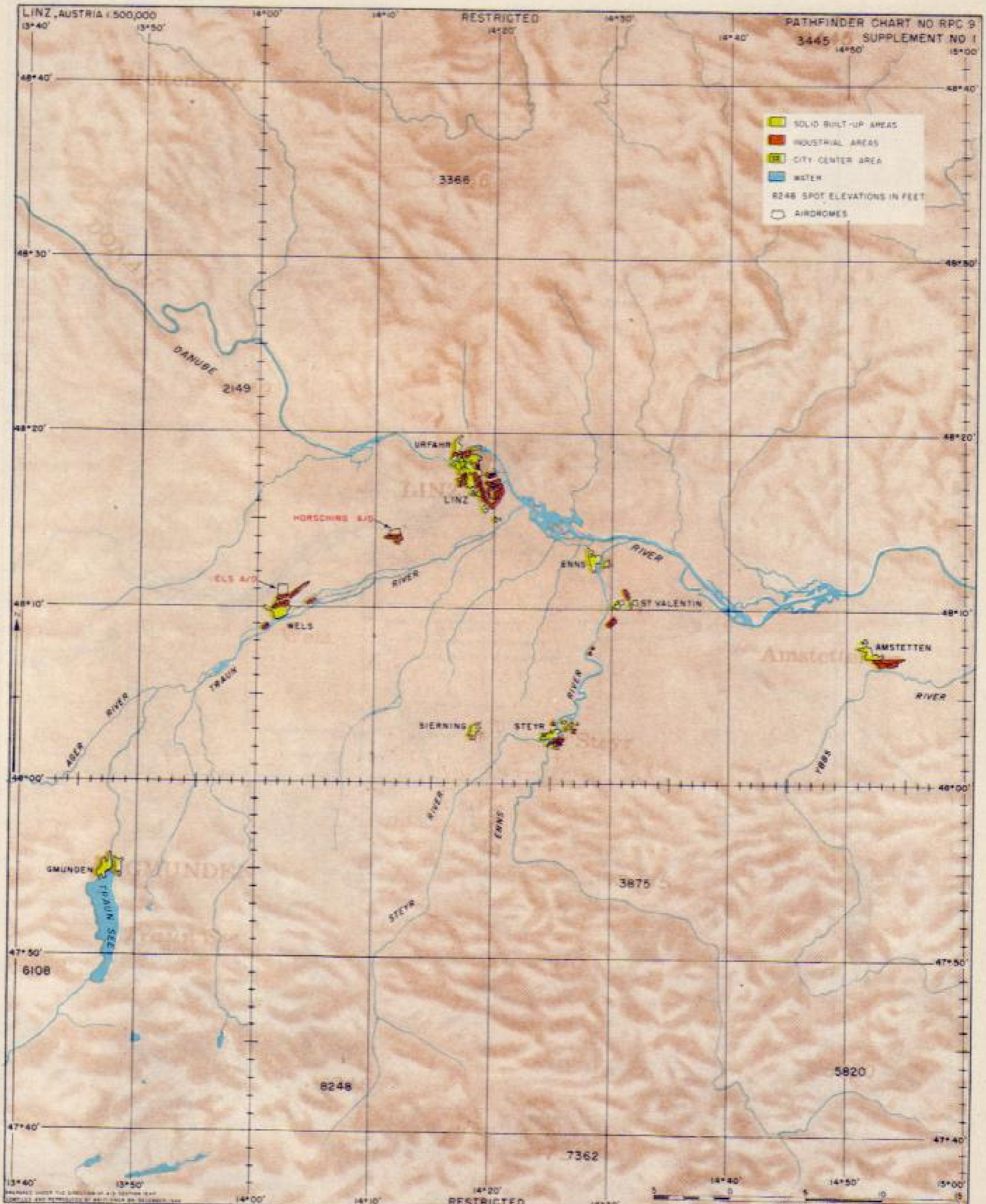
Radar Navigation and Target Charts

Radar already has influenced aeronautical map making to some extent. Various types of charts which show or suggest the way terrain and inhabited localities appear on the PPI scope are now being issued. A number of devices which aid radar navigation and target interpretation and correlate scope photographs with maps of the corresponding areas are in use in the various theaters of air war. The field as yet is entirely unstandardized, and may be expected to continue so for some time.

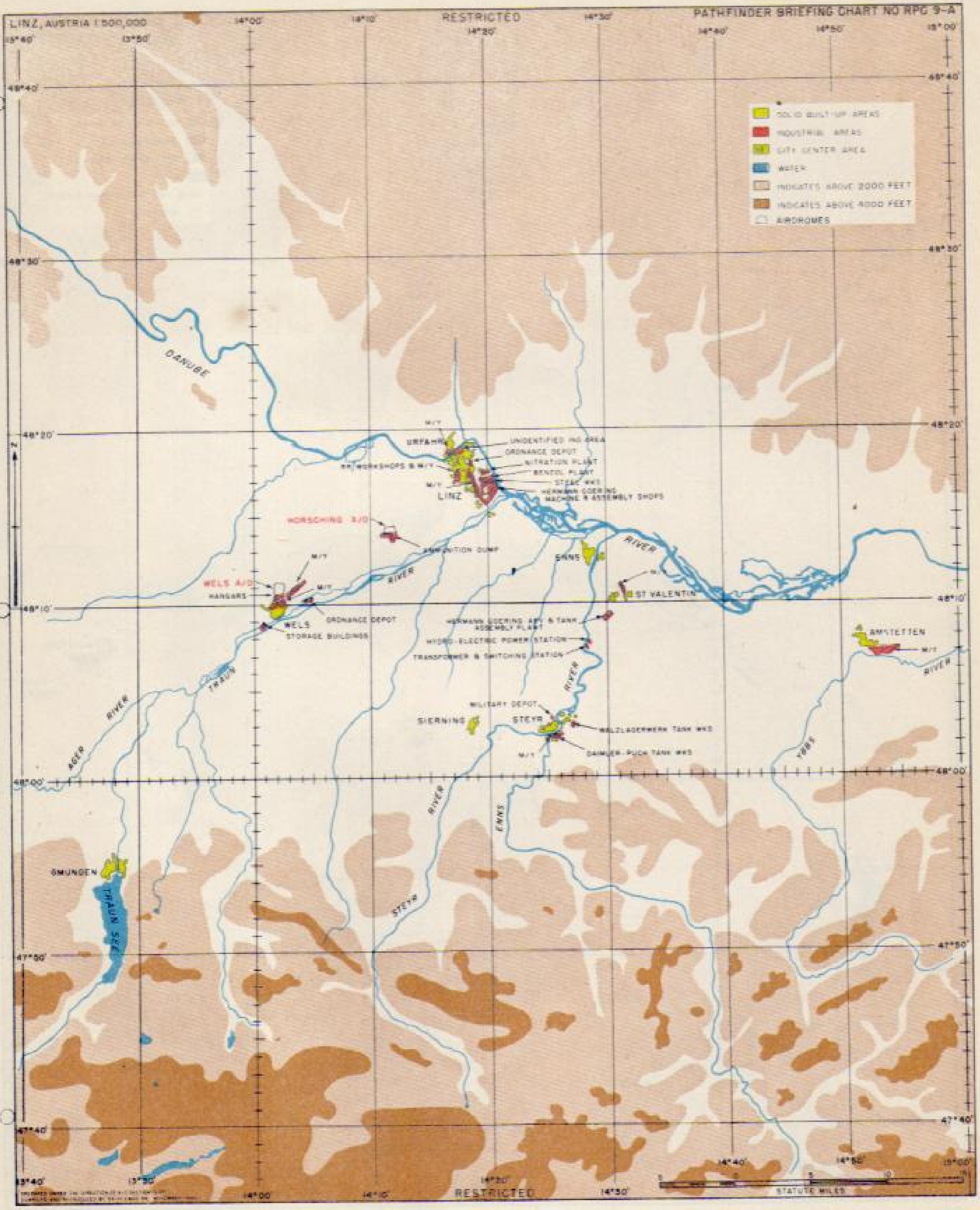
Typical charts, and combinations of charts with scope presentations, are reproduced here. Those ascribed to a particular air force may or may not represent the present practice of that air force. Furthermore, radar operators in the field do not necessarily use all these types. Some men prefer simply a navigation chart and a series of scope photographs clipped together in proper sequence (right) or arranged in the form of a navigation or approach strip.

HAMBURG—H2X APPROACH STRIP FROM SOUTH NO. 1
HEADING 25°. AZIMUTH STABILIZATION ON.
RANGE UNIT OFF. PHOTOGRAPHS TAKEN 13 JULY 1944

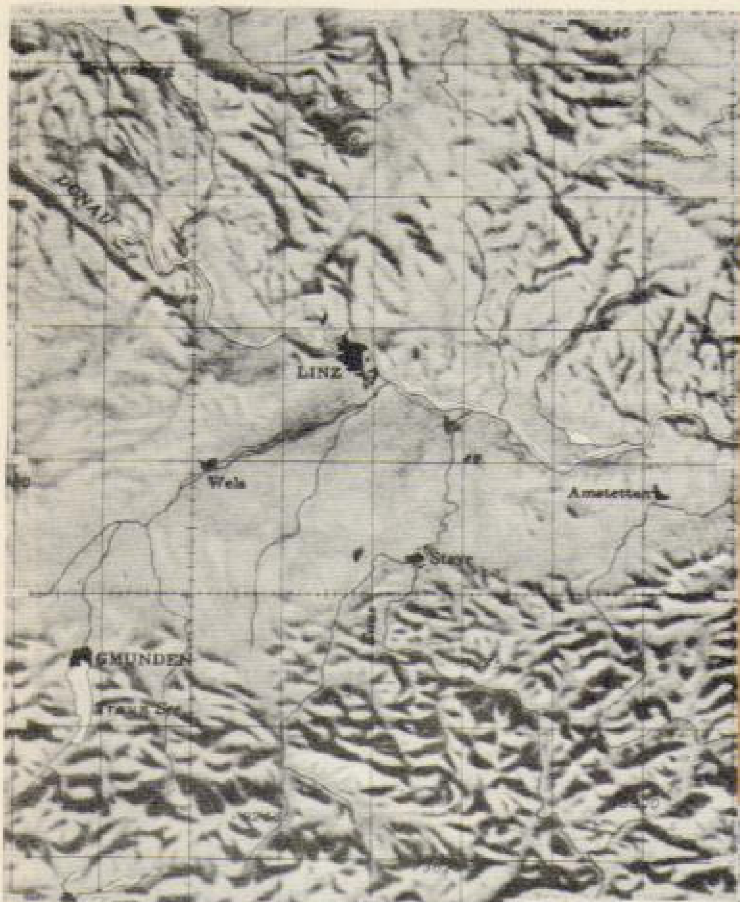




Pathfinder chart RPC-9 shows a particular target.



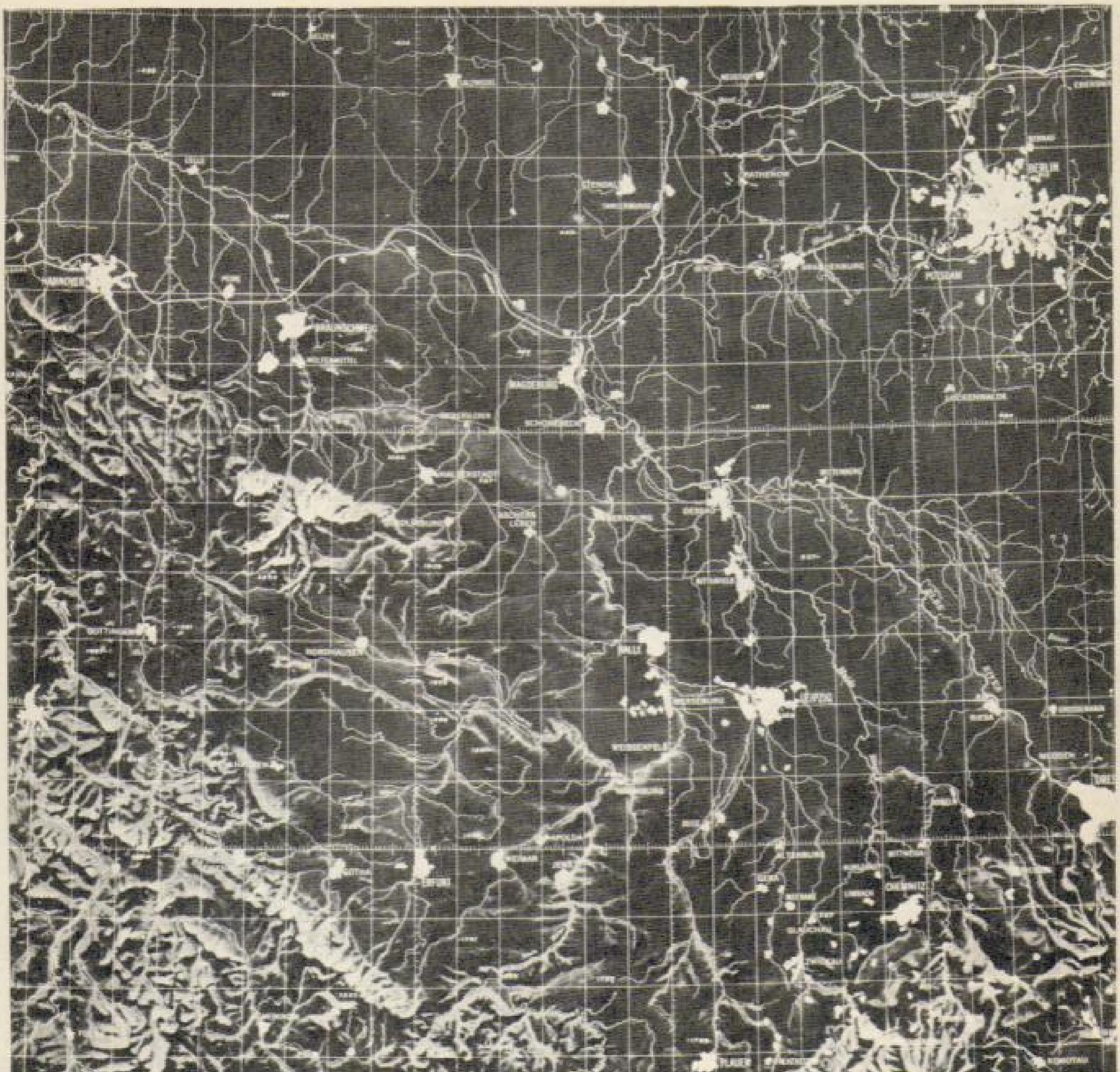
Pathfinder chart RPC-9A shows prospective targets.



ETO EXAMPLES

Colored Pathfinder charts of the 15th Air Force are shown on the two preceding pages. On these charts, cities appear in yellow, as they do on a standard aeronautical chart; relief, in shades of brown darkening as altitude increases; water, in blue. Industrial areas of cities are indicated in red.

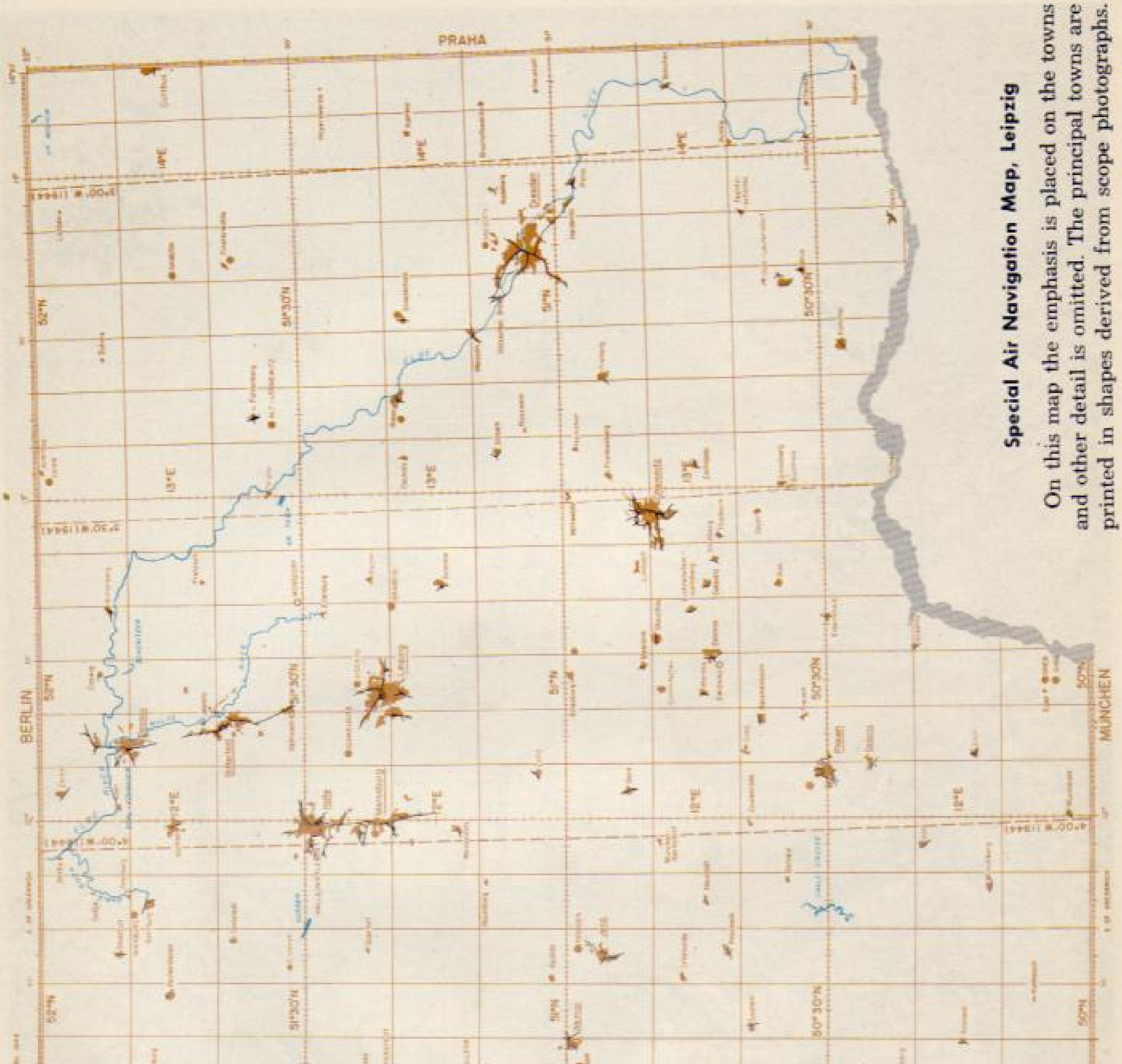
The corresponding negative relief chart (right) suggests a scope photograph: relief is in black and white, water is black, cities are white. Positive prints (above) are the reverse.



Negative Relief Map

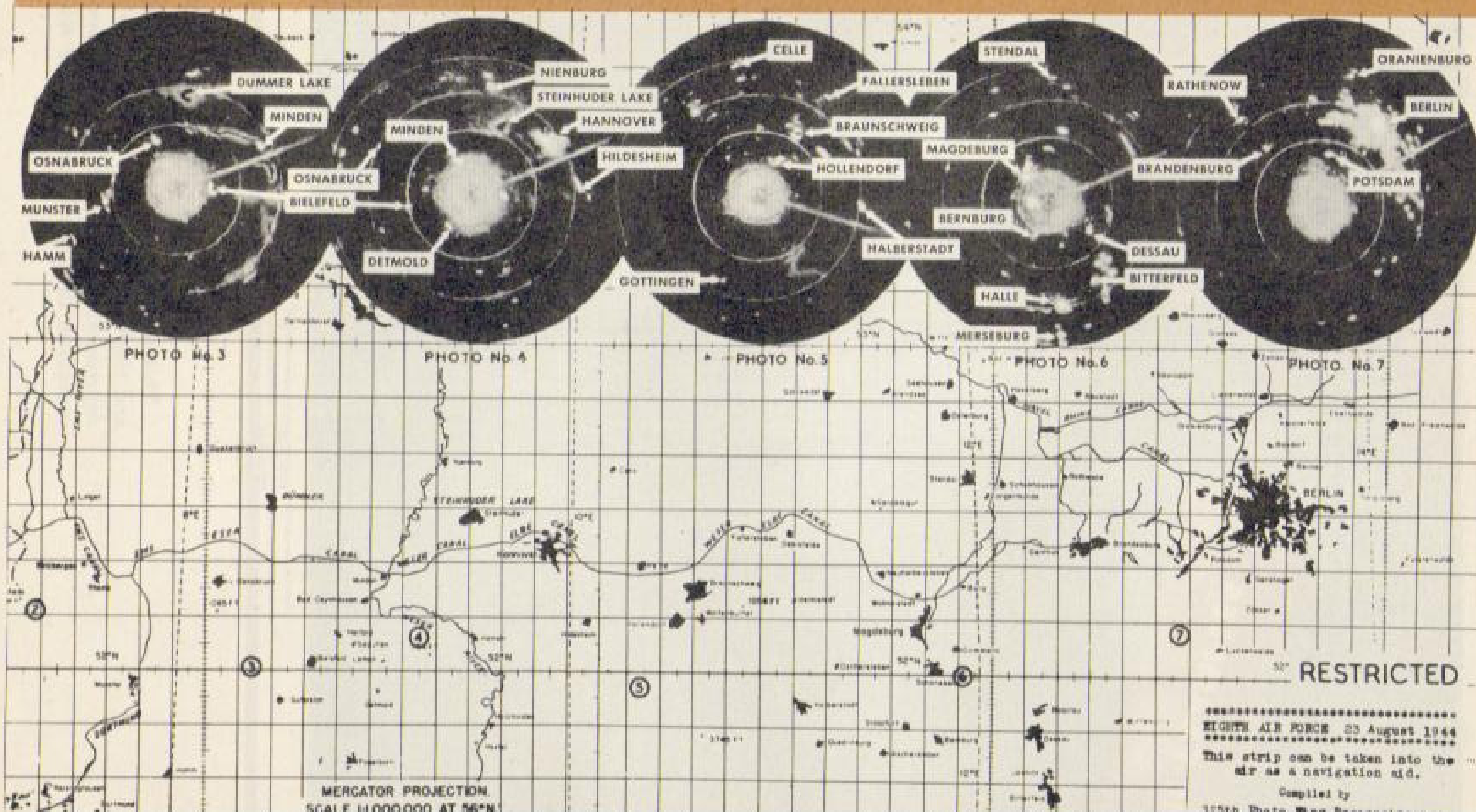
Relief Maps, Central Europe

On the opposite page is one of a series of negative navigational relief charts of Central Europe; on this page is the corresponding positive.



Special Air Navigation Map, Leipzig

On this map the emphasis is placed on the towns and other detail is omitted. The principal towns are printed in shapes derived from scope photographs.



H_2X Navigation Strip, Amsterdam to Berlin

On this page a series of scope photographs has been combined with a chart of the same general type as the special air navigation map of Leipzig.

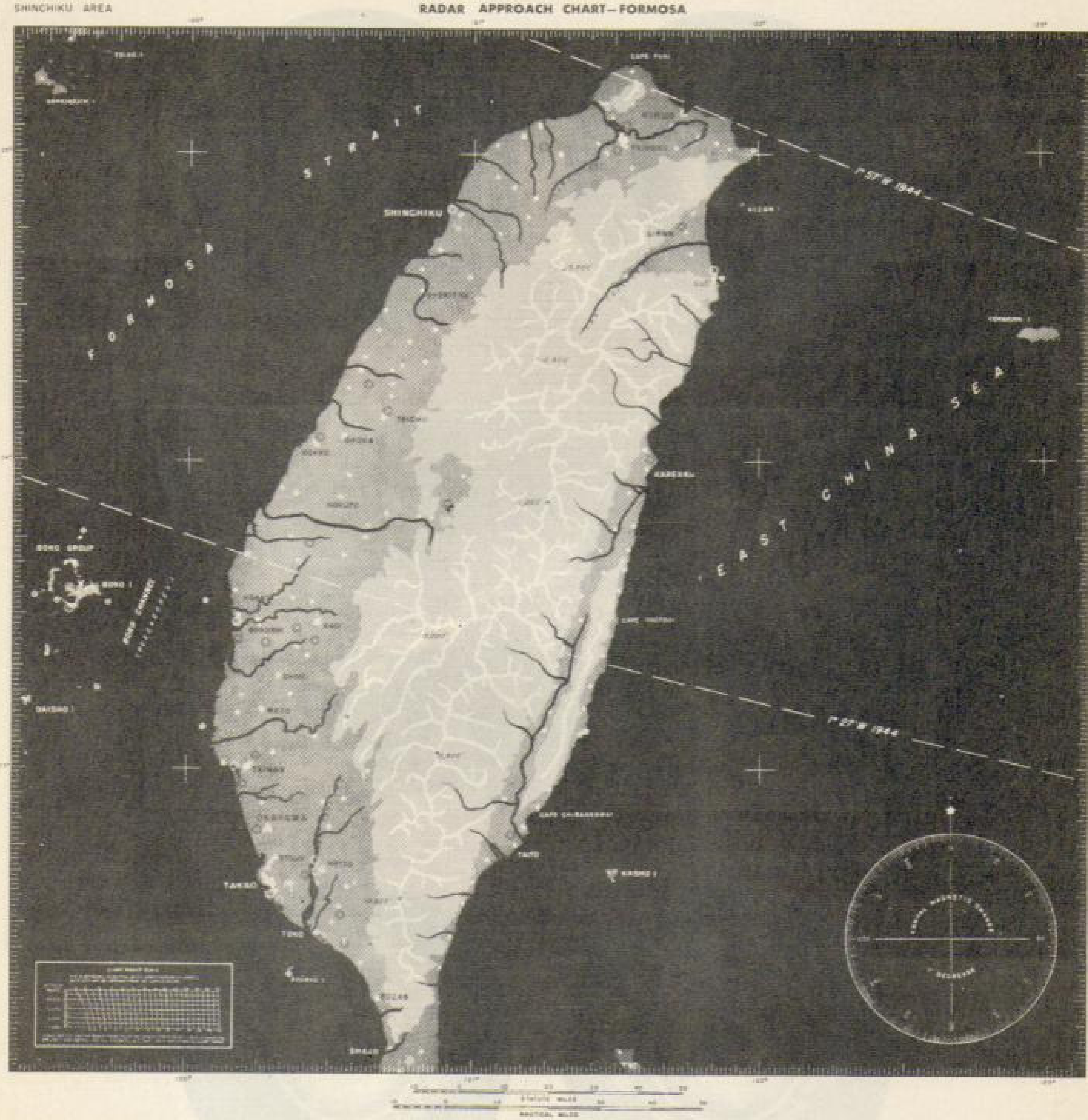
ASIATIC-PACIFIC EXAMPLES

Radar Approach Chart, Manchuria

This negative type of map shows relief in white, and there is no attempt to indicate elevations and depressions in detail. In other respects it broadly resembles the Pathfinder negative relief charts.

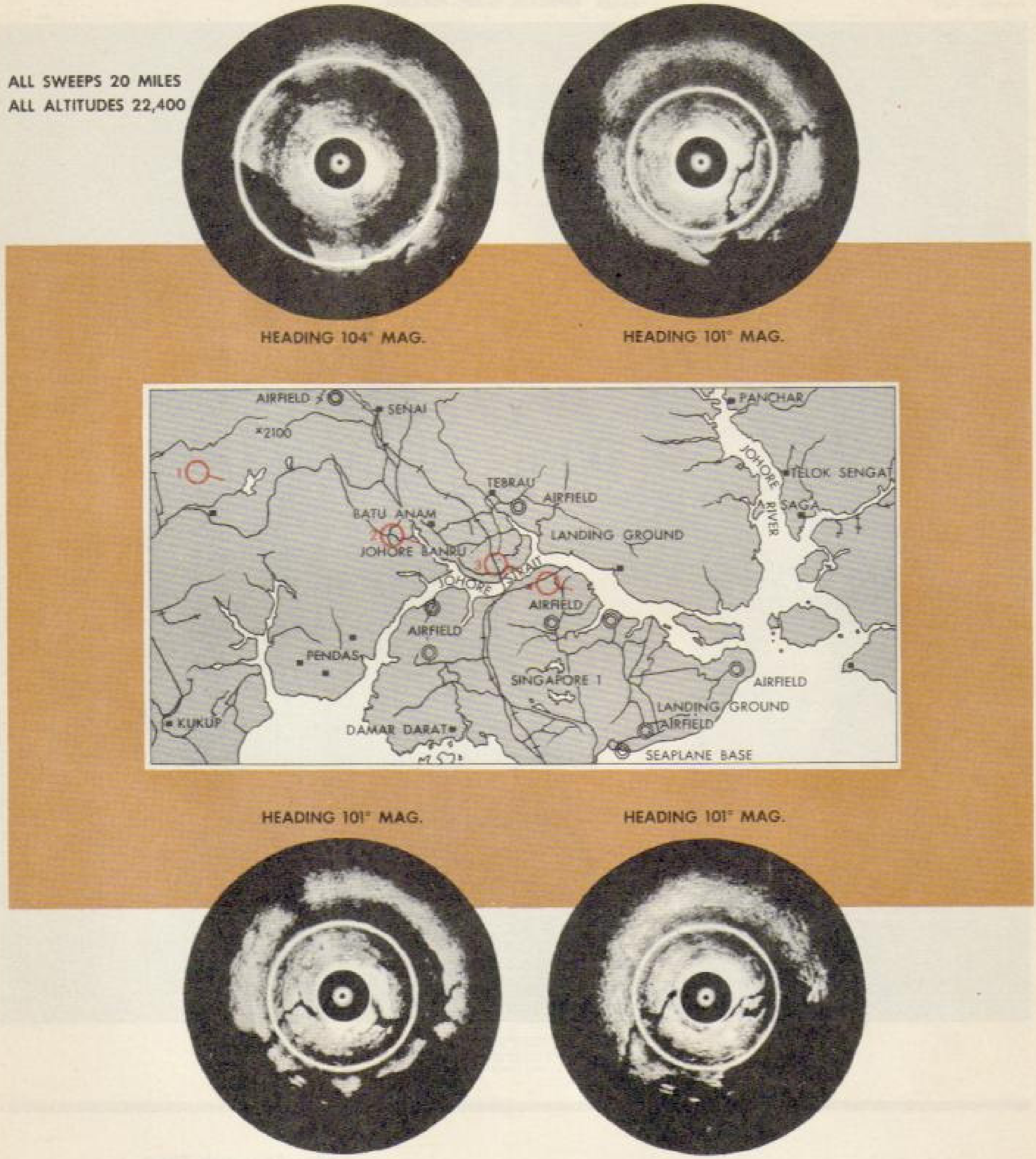
SHINCHIKU AREA

RADAR APPROACH CHART—FORMOSA



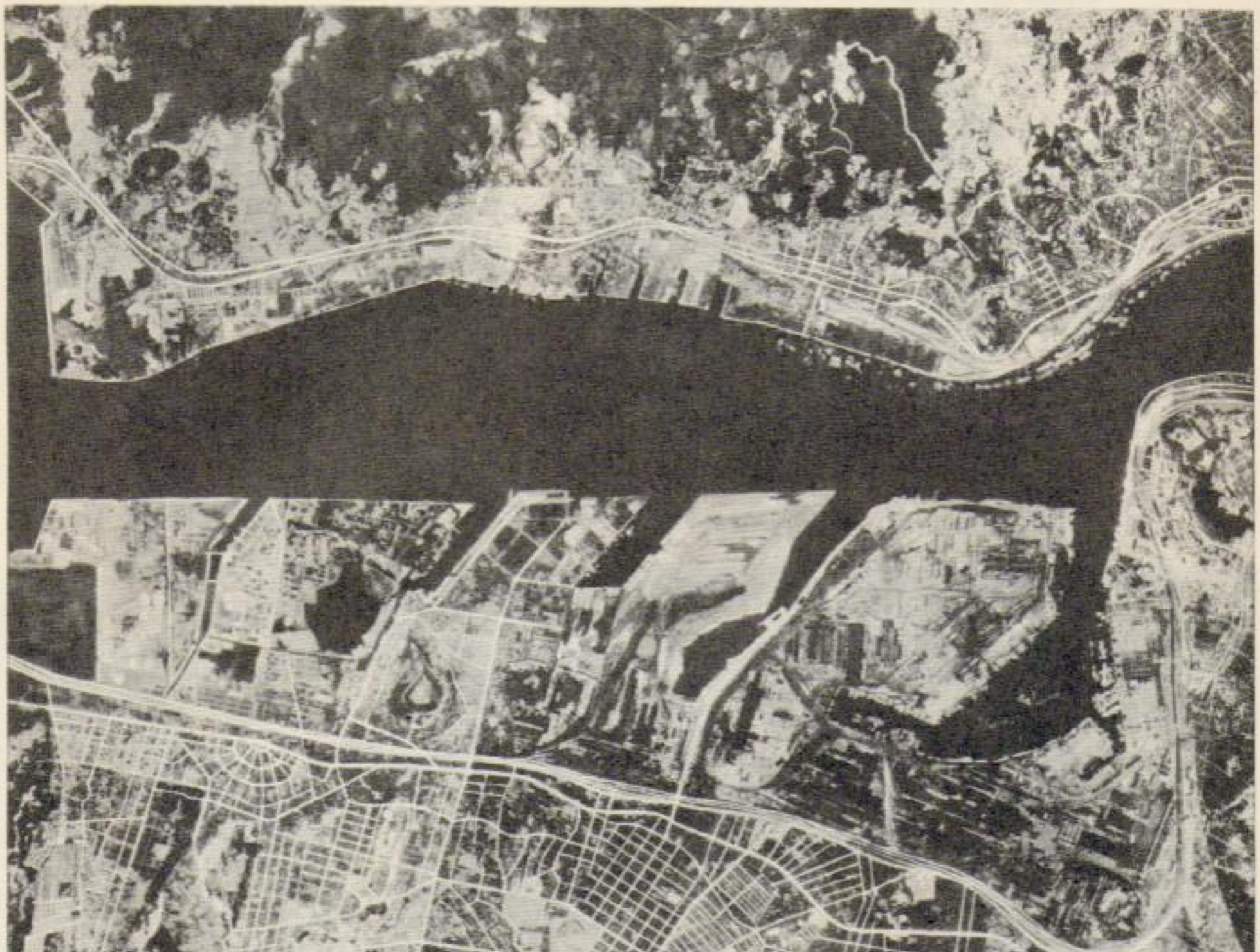
Radar Approach Chart

This is another negative relief chart; the white lines on it indicate the highest contours of the terrain.



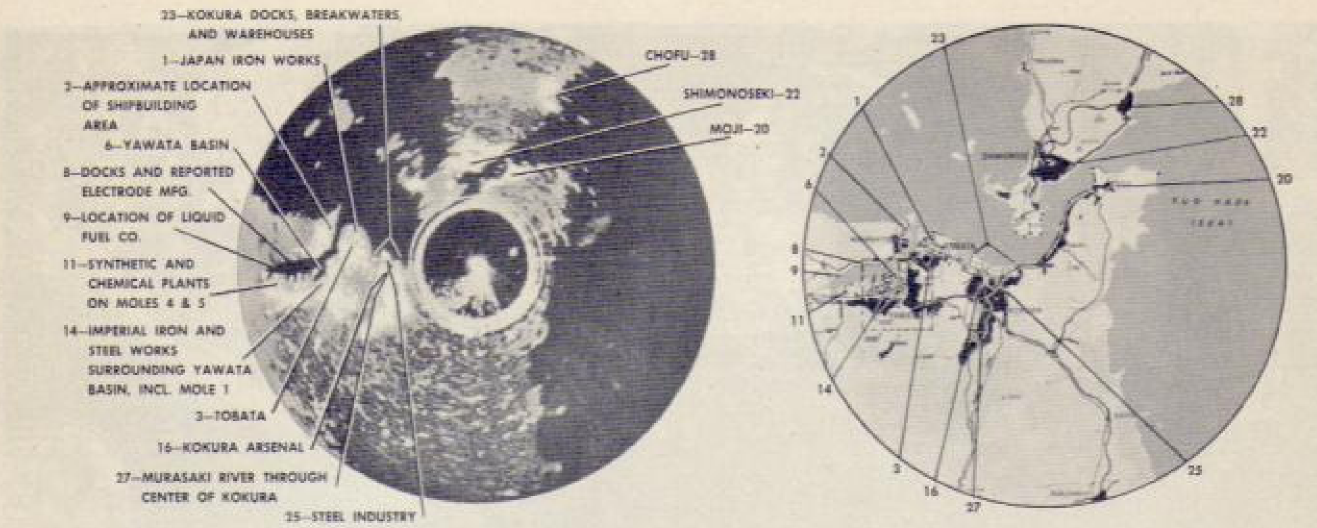
Radar Photograph Analysis, Singapore Area

In this representation of the Singapore area, the exposure locations of the scope photographs are marked on the chart.

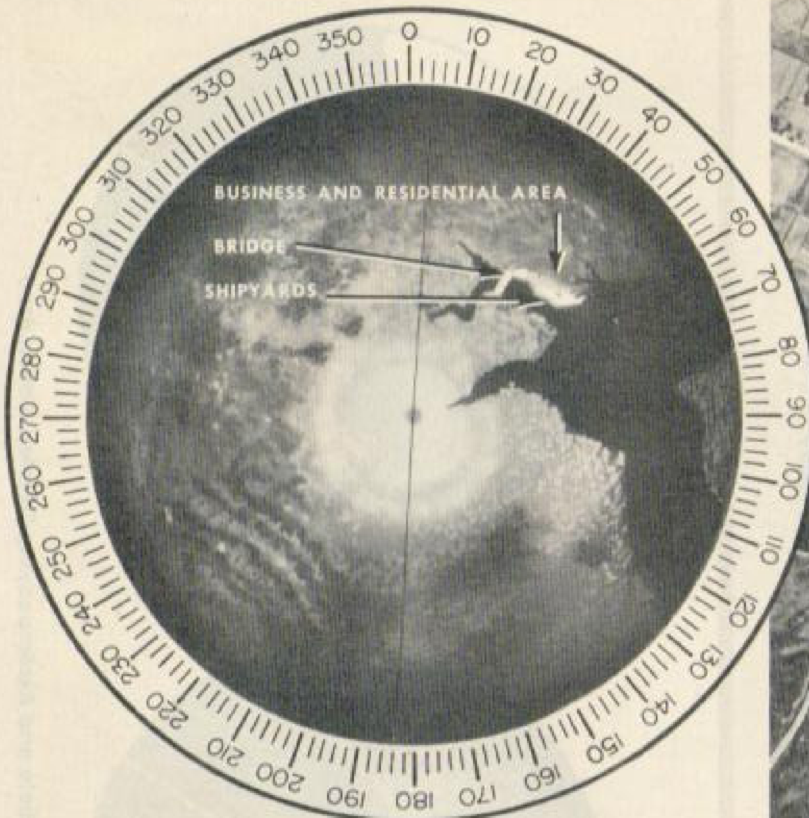


Interpretation of PPI Scope Photographs; AC/AS, Intelligence

This is part of an elaborate intelligence analysis embracing most of the available types of radar mission aids: a target chart, an aerial photo mosaic, and three groups of photographs, only one of which is shown (on following page). The scope photographs are accompanied by a circular map of the same area, which bears identical annotation.



Scope Photos And Analysis Chart of the Target Area Shown on the Preceding Page



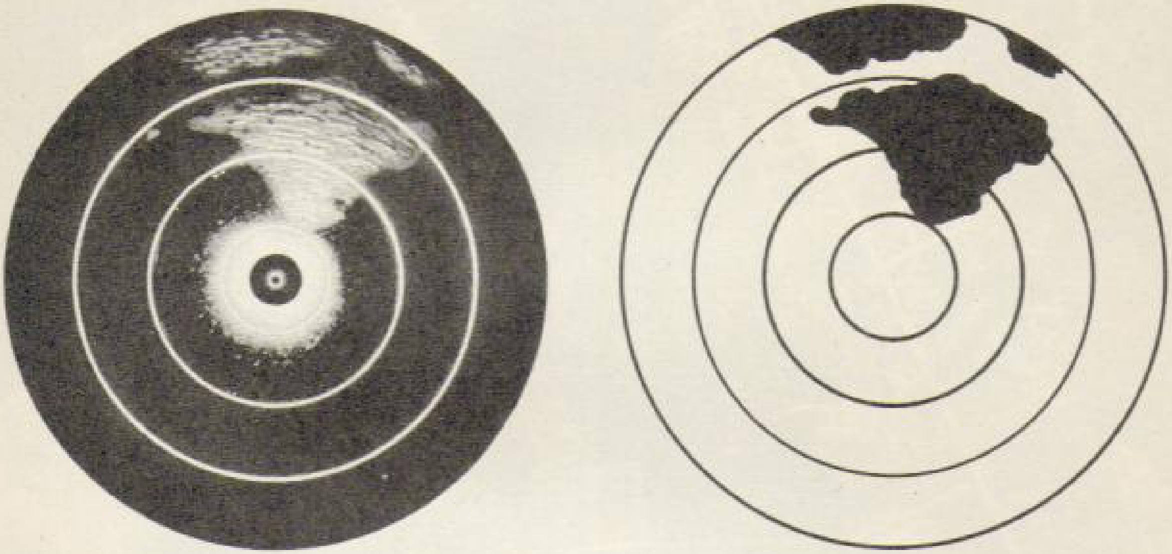
Target Area Annotation

The visual picture of the target area is marked so that its various parts correspond to those of the scope picture. In the scope picture the shipyards, which in this instance are the target, give bright returns and the business area also is well defined.

Overlays

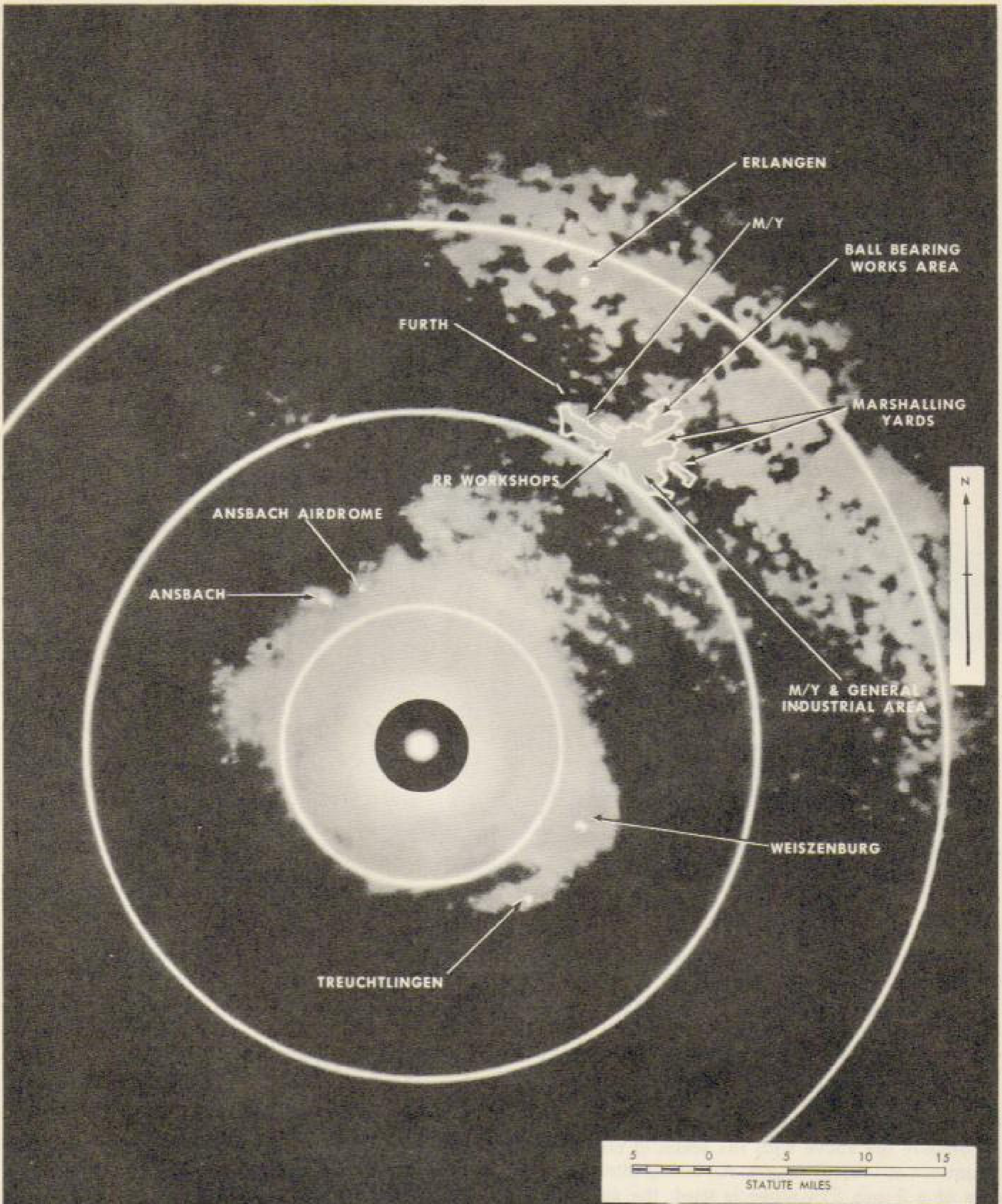
For briefing, you can clarify the shapes of scope images by line or solid overlays. An example of line overlay is the outline of Nurnburg on Pathfinder Briefing Scope Photo No. RPC-2E. It shows you the locations of targets within the area. You can block out land areas in black for rough schematic purposes.

The overlay corresponding to the scope photograph of the Darien area shows land in white instead of black, and towns in black.



Scope Photo and Accompanying Overlay, Isle of Wight

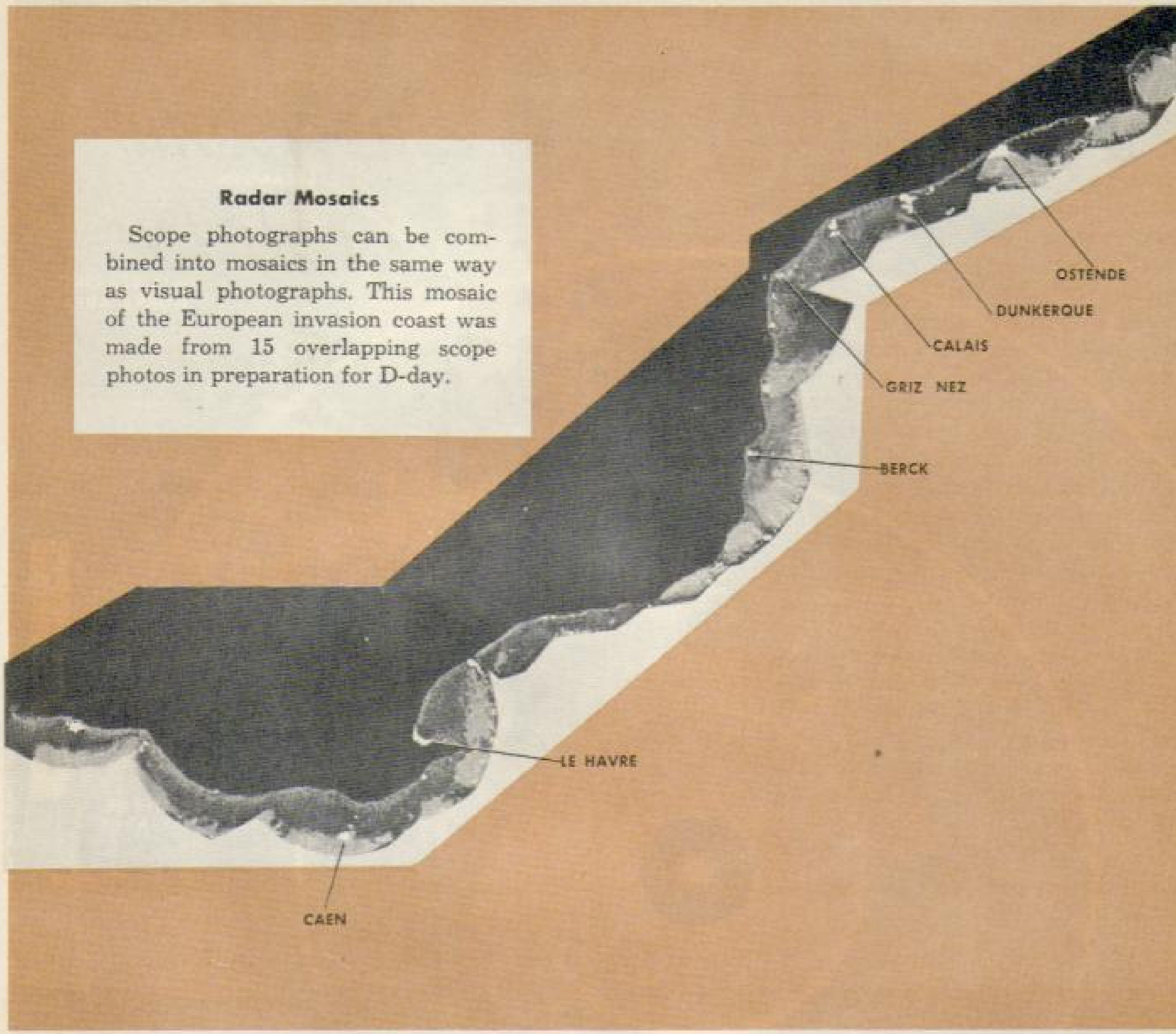
Scope Photo and Accompanying Overlay, Darien Area



Line Overlay of Nurnburg

Radar Mosaics

Scope photographs can be combined into mosaics in the same way as visual photographs. This mosaic of the European invasion coast was made from 15 overlapping scope photos in preparation for D-day.



Scales

Here are the scales of the charts generally used for radar navigation and bombing:

1. Radar navigation maps, scale 1:1,300,000 to 1:1,000,000.
2. Approach charts, scale 1:500,000 to 1:250,000.
3. Target charts, scale 1:180,000 to 1:125,000.

The corresponding aerial photographs usually have scales of 1:65,000 to 1:10,000.

Compare the above with the scales of radar presentations at various ranges. Assuming that the full area of a 5-inch PPI scope is used, the scales are approximately as follows:

5-mile range	1:150,000	(Corresponds to target chart)
10-mile range	1:300,000	(Corresponds to large-scale approach chart)
20-mile range	1:600,000	(Corresponds to small-scale approach chart)
50-mile range	1:1,500,000	(Corresponds to navigation map)

The scope presentation never approaches the usual scale of aerial photographs.

Supersonic Predictor

Prediction is the preparation of synthetic scope photographs, using maps or models based on known topographical and cultural features of enemy areas.

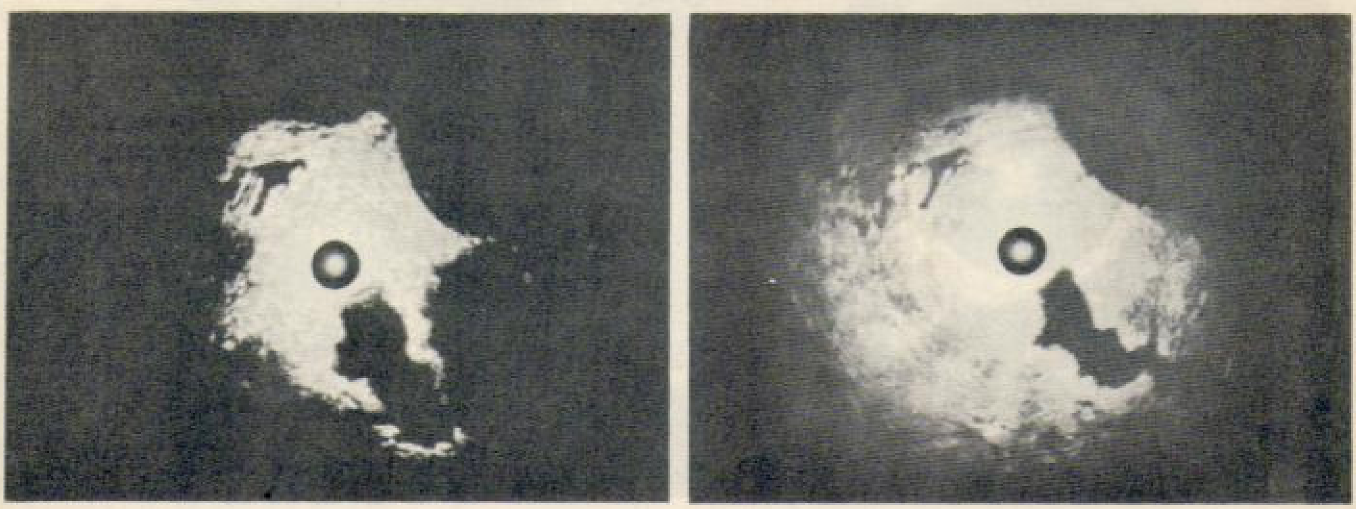
An elaborate and often highly effective planning device is the supersonic predictor, which is essentially a radar set that emits and receives waves through water instead of air.

You use this radar equipment just as if it were in an airplane. But the equipment, instead of feeding into a radar antenna at 9375 megacycles, energizes at 15 megacycles a quartz crystal suspended in a shallow tank of water above a special terrain map or model. This (ultrasonic) map is built on a sheet of plate glass, which is left clear to reproduce water areas. Sand sprinkled on varnish represents land, cities are built with carborundum, mountains with modeling clay. Plastics now are being used in quantity production.

The supersonic crystal rotates like the disc of the radar and scans the map in exactly the same way as the radar antenna scans terrain. It picks up the echoes and converts them into signals of intermediate frequency which are fed into the radar circuits and appear on the scope. Effects of slant range, beam width, etc., are reproduced automatically.

The accompanying scope photograph of Tokyo was made from a B-29. Beside it is a corresponding scope photograph made on a supersonic predictor, which used a map of the same area constructed according to standard aeronautical charts, supplemented by **non-radar intelligence.** This map was built before any radar material from this area became available. In short, it was such a map as could be constructed, without benefit of reconnaissance, to represent any enemy territory. Yet the operational PPI photograph and the supersonic photograph hardly could correspond more closely.

Simulated scope photographs of entire bombing missions thus can be produced in the laboratory, without risk and at small expense. Though it must be used with discretion, the supersonic predictor is a promising aid in mission planning and briefing.



Simulated (left) and Actual Scope Photographs of Tokyo Area

BOMBING ASSESSMENT

Radar photography makes it possible to estimate the results of bombing without visual strike photographs. This type of radar bombing analysis has two objectives:

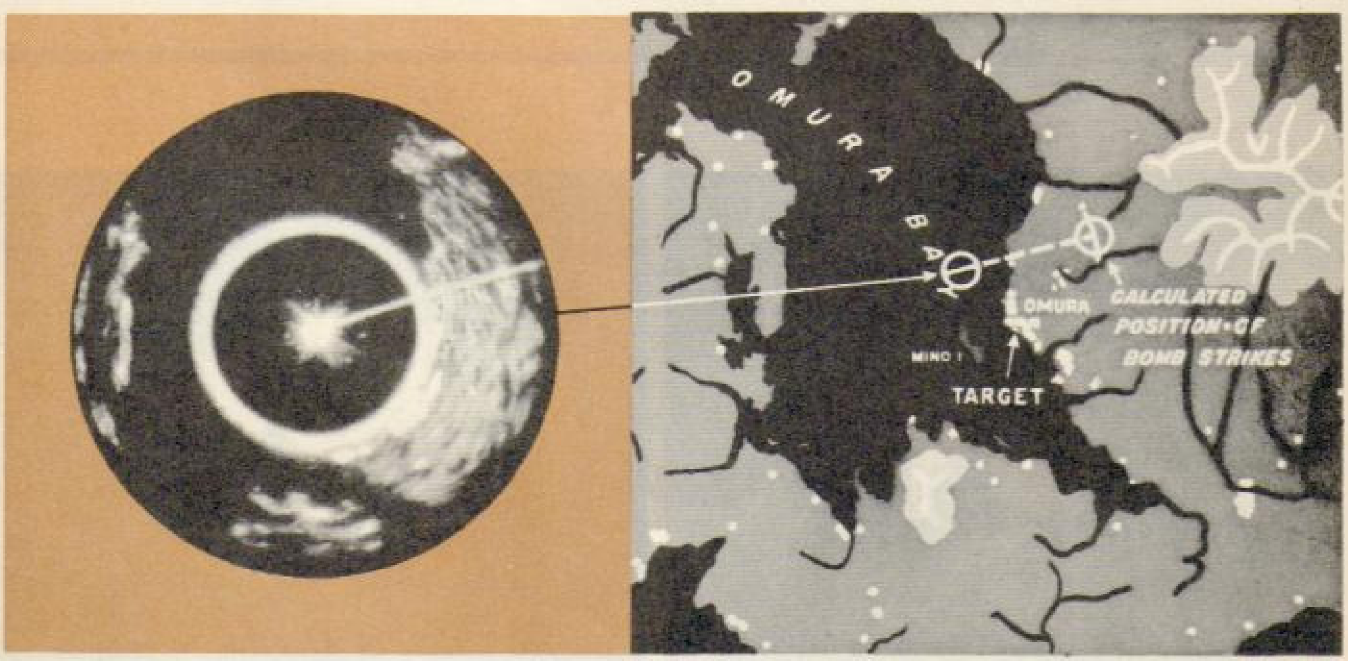
1. Assessing coverage of the target for general intelligence purposes. By plotting scope photographs it is possible to find out approximately where bombs fell.

2. Preparing a critique of the bombing run from pilotage, navigational, and radar standpoints. This is most helpful for the instruction of crew members, since it tends to prevent inaccurate fixes, procedural errors, failures in coordination, radar and photographic malfunctions and the like, all of which are revealed by the scope photographs.

You can use the following scope photograph of a bomb release, for example, to determine the probable impact area. It fixes the position of the airplane at release point. Accordingly, since you already know your groundspeed, altitude, and the type of bomb used, you can find the actual range. In this instance it is 3.58 nautical miles. When you measure this distance along the track made good (disregarding crosstrail), you locate the probable point of impact.

The above analysis reveals that the target area (Omura) was missed by approximately 3 miles. By carefully studying the scope photos taken on the approach to the IP and during the bombing run you could determine definitely whether the error was in target identification, bombing-run procedure, or navigation.

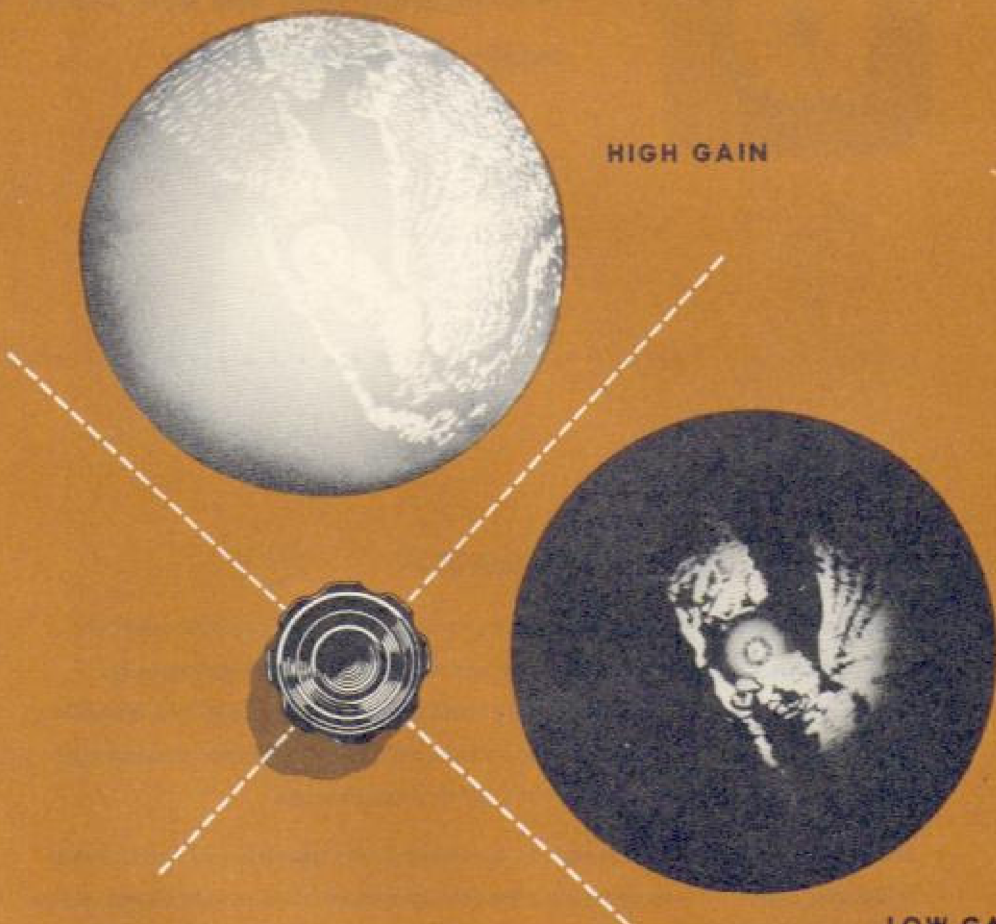
A detailed analysis of scope photos makes it possible to determine whether a mission was a success or failure and assess the contributing reasons. For the success of future missions, it is necessary that you cooperate as fully as possible with the radar intelligence officer.



Scope Photograph Taken at Position of Bomb Release

SECTION 8

RADAR PHOTOGRAPHY



Good scope photographs depend upon your ability to tune the set. You must use the focus and brilliance controls to obtain maximum definition. The trim of the plane is important for a complete picture. With practice you'll learn how to set gain and tilt in order to obtain the best scope pictures.

8

SUBJECTS IN SECTION 8

RADAR PHOTOGRAPHY

Scope photography makes it possible to determine the success or failure of a mission. During the heat of the bombing run, you are going to be too busy to worry about where your bombs are falling. If you are bombing through cloud cover, in many cases you won't know, until the photographs have been developed, whether you hit the target or not.

Scope photographs are absolutely essential in the planning of subsequent missions. Learn how to use your camera equipment and practice tuning your radar set until you know the settings which provide the best scope photos. It's best to take too many rather than too few photographs. No photographic mission was ever a failure as a result of taking too many pictures.

General Principles

Radar photography serves the same purpose in radar operations that visual photography does in visual operations. In one way it is simpler than visual photography; there is only one thing to be photographed—the scope. But in other respects it is more complicated, since it depends on the correct adjustment of the radar set as well as the camera.

Scope pictures are made by mounting a camera of suitable design so that it faces the cathode ray tube at a fixed distance. The tube produces an actinic light which readily affects the usual types of photographic films. All other illumination must be excluded by means of a light-tight cone between the scope and the camera lens. If any external light gets in it fogs the film, just as if the camera itself had a light-leak.

To get a good radar picture you must start with a good scope presentation. The photograph will be no better than the scope display. Getting the best possible display is up to you. The rest depends largely on the photographic technicians, since in current practice they load and adjust the camera and process the film.

Camera Adjustments

The principal camera adjustments are the lens opening or aperture, and the focus of the lens. In radar photography both of these are fixed for a particular mission. The proper lens opening depends on the sensitivity or speed of the film. It is controlled by a diaphragm in front of the lens. The diaphragm is calibrated numerically in "f" settings. The lower the "f" number, the larger the aperture and the more light reaches the film through the lens. At f6.3, for example, the lens on a given camera may be wide open; at f16 it is stopped down so that only a fraction of the available light reaches the film. There is also a shutter in front of the diaphragm which, when open, exposes the film.

The light must be focused sharply on the film, or a blurred image results. The focus setting is more critical than the aperture setting. Errors in the latter may be compensated to a limited extent in development and printing, but there is no cure for poor focus. However, since in a given camera assembly the lens is always at the same distance from the scope, there is little excuse for improperly focused pictures. It is only necessary to set the distance between the lens and the film for a sharp focus, and to keep it so.

Film Emulsions

Two classes of film emulsion are used in radar photography. Class N has a daylight rating of 200, Class L a daylight rating of 100. Class L therefore requires a larger lens opening than Class N.

All photographic emulsions deteriorate with age, particularly under tropical conditions of heat and moisture. As far as possible, film should be kept in a cool, dry place. Deteriorated Class N may be much less sensitive (slower) than fresh Class L stock. Overage film should be scrapped, although, if nothing else is available, it sometimes gives fair results with increased exposure and, if necessary, extra time in development.

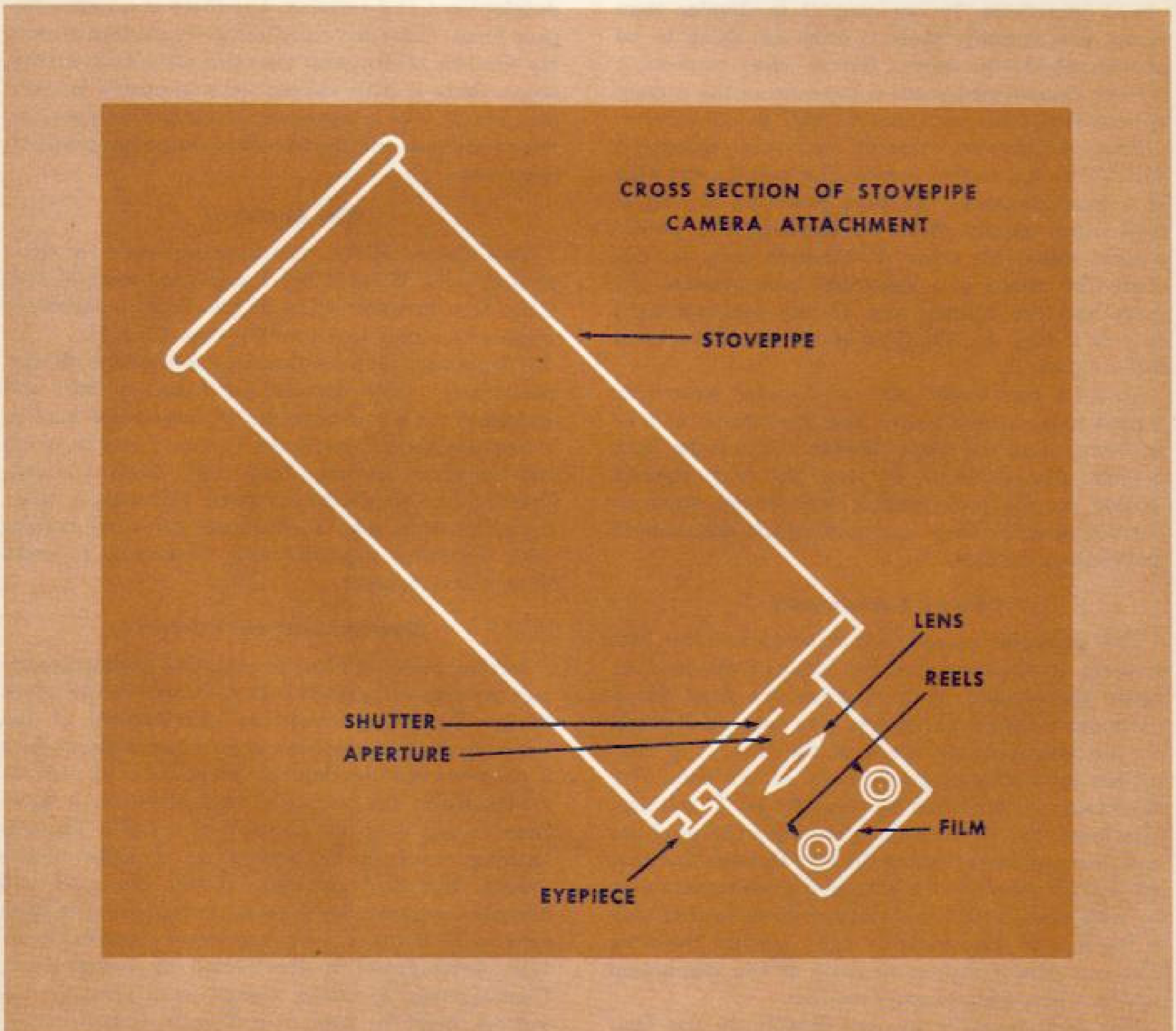
Development and Printing

Development involves running the exposed negative through a chemical bath to bring out the latent image. Processing comprises development of the negative, rephotographing or printing it to produce a positive, and developing the positive. It also includes fixing the negatives and prints in a hypo bath so that they can be exposed to light. There is nothing novel in the processing of scope photographs. Standard solutions (D-76) are used and complete negative development should occur in from nine to 13 minutes. Like any other chemical reaction, development is accelerated by temperature. Consequently, in timing a negative or print the developer must be kept at a definite temperature—usually 68°F.

Printing may be by contact, in which case the print is the same size as the negative, or by optical projection, which yields enlarged prints. Standard motion picture negatives may be enlarged to 4 x 5 inches, 5½ x 5½-inch negatives to 20 x 24 inches. A transparent print of motion picture size may be projected on a screen and thus enlarged several thousand-fold in area. The definition of the negative determines the amount of enlargement which is practicable in a given instance. There is no practical advantage in obtaining an enlargement, of course, unless the detail in the negative is too small to be seen in the original size.

If it is desired to retain all possible detail and the entire range of tones from black to white, a scope negative is best printed on a soft paper, producing a comparatively flat print. If greater contrast is desired, a more contrasty paper is used. This involves some loss of detail. Print development may be forced to produce a black background with gray to white returns from a flat negative.

If all the foregoing steps have been skillfully managed, the prints are going to be practically as clear as the original scope presentation. Even when there is some loss in quality, the photographs may still yield valuable information.



PROCEDURES

RADAR

Operate the radar set as you would normally. A scope display which is good to look at is good to photograph. Bring in the target carefully by use of the tilt and gain adjustments on the set. Focus the display on the scope as accurately as possible, and keep it centered.

The aperture on the camera is pre-set for average scope-display intensity. Consequently you must try to maintain average brilliance for best photographic results. There may be times when you will reduce the gain to accentuate contrast between light and dark portions of the target area. A photograph made during this interval is likely to be underexposed. In an underexposed scope picture the predominant tone is dark, the highlights gray and contracted; there is not much to see in a picture of this sort, detail is lacking.

An overexposed picture is flooded with light and even the dark portions are milky in appearance. The highlights spread and lose definition. Because of the predominance of highlights, such a picture contains more to look at than one which is underexposed, but it does not yield a greater amount of information.

A correctly exposed picture retains the tone scale of the original in its various shades of black, gray, and white. To get such a picture, you must vary the gain and brilliance controls reciprocally. When you turn up the gain considerably, reduce the brilliance, and vice versa. Small changes in gain do not require readjustment of the brilliance control, but in general you should try to keep the two balanced.

If your camera equipment is mounted on a remote scope, its presentation determines the quality of the pictures. Since you make your adjustments on the master scope, you must check the remote scope at intervals and be sure that the brilliance of the two matches.

During the approach to the IP, the range unit should be turned off when the range setting is 50 miles or more (not possible on AN/APQ-13). With range settings of 20 miles or less and altitudes of 15,000 feet and up, you may crank in 10,000 feet of altitude delay. During the bombing run the setting of the range unit is determined, of course, by the bombardment requirements. Use your gain and tilt to maintain maximum definition of the target.

CAMERA

Don't change the camera adjustments, unless you are so instructed in advance of the mission and briefed on exactly what you are to do. Ordinarily the optical adjustments are best left to the photographic technicians; you have enough to do with the radar set.

There is, however, one factor in which the radar and photographic functions overlap. That is the timing of the picture. All scope pictures are time photographs, not snapshots. The shutter on the camera must be opened at a given instant and closed at a later instant. The interval between is determined by the sweep cycle. On the APQ-13 and APS-15A it should, therefore, be three seconds for a 360° revolution of the sweep. If it is greater, part of the scope picture is going to be double-exposed, with resulting blurring of the image in this sector. If it is less, part of the scope surface will be unexposed.

On later types of scope camera equipment, this is done automatically. As the spinner revolves it makes an electrical contact which opens the shutter; when the spinner returns to the same point the shutter is electrically closed. But with some types of equipment in current use you must accomplish this manually.

The best procedure is to select a return in an unimportant section of the presentation for a reference point (or use the heading marker for this purpose). Open the shutter as the sweep line passes over this reference point. Close the shutter as near to the same point as possible. You may be off a fraction of a second, but the resulting defect is in the least significant part of the picture. Moreover, you will find that the more experienced you become, the more nearly you can eliminate this defect.

When you use a removable cone, press it down tightly to prevent light leaks between the contact edges and the scope. If you have occasion to reload the camera in flight, keep the cartridge or roll away from strong light, both before and after exposure. Wrap it in opaque paper or tinfoil. Daylight-loading film rolls may have slight leaks which cause fogging only when exposed to direct light rays.

When to Take Pictures

During the base-IP run on a bombing mission, take a picture every 25 miles on the 50- or 100-mile ranges when over land or when photographing island check points over water.

Approaching the IP, take a picture every 10 miles on the 20-mile range.

From IP to bomb-release point, take a picture at least once every mile on the 10- or 5-mile ranges. At 210 mph this means a picture every 17 seconds or less, and of course presupposes automatic operation of the camera.

Forthcoming scope cameras are provided with intervalometers which expose a picture every 16 cycles, every 128 cycles, or at shorter intervals as set. A photograph is taken automatically at the time of bomb release by means of a switch operated from the bomb toggle switch. This photograph is identified by a light flash.

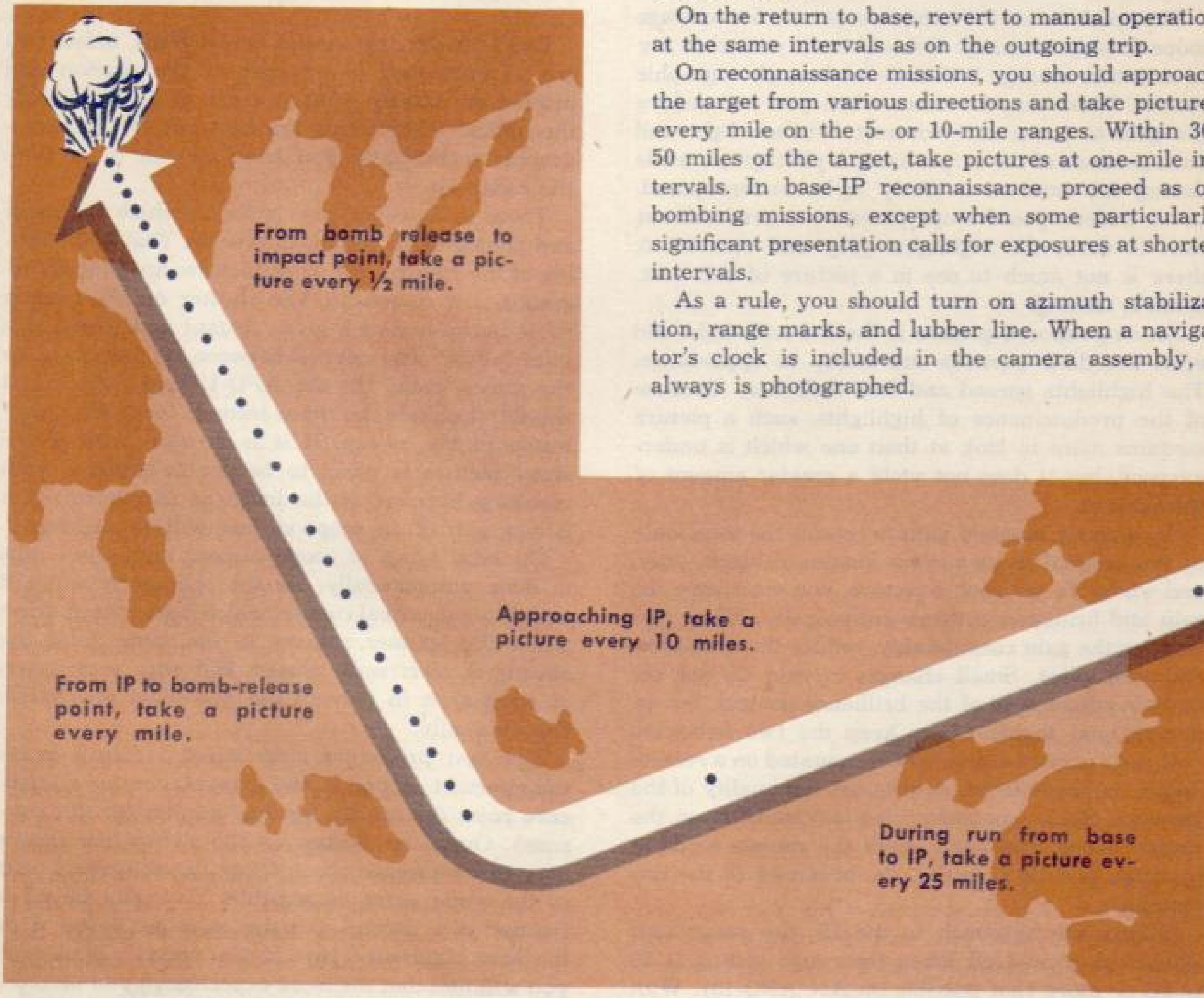
Take too many pictures rather than too few; no mission was ever a photographic failure because of too many pictures.

From bomb release to impact time, take a picture at least once every half-mile for purposes of target identification and study of the airplane track in plotting bomb fall.

On the return to base, revert to manual operation at the same intervals as on the outgoing trip.

On reconnaissance missions, you should approach the target from various directions and take pictures every mile on the 5- or 10-mile ranges. Within 30-50 miles of the target, take pictures at one-mile intervals. In base-IP reconnaissance, proceed as on bombing missions, except when some particularly significant presentation calls for exposures at shorter intervals.

As a rule, you should turn on azimuth stabilization, range marks, and lubber line. When a navigator's clock is included in the camera assembly, it always is photographed.



PHOTOGRAPHIC LOGS AND DATA CARDS

SCOPE PHOTO LOG

ROLL	PICT	TIME	AZ STAB	RNGE	SWEEP DELAY	ALT.	TARGET IDENTIFICATION	REMARKS
7	9	1237	ON	20	—	21000	K.C. 37° 19 MI.	
	10	1248	ON	50	—	21000		DR 3914-9642
	11	1301	OFF	12	—	22000	LEAVENWORTH 10° 15 MI.	
	12	1347	ON	20	—	22000	LAWRENCE, KAN. 137° 10 MI.	R.R.
	13	1355	ON	50	—	21000	TOPEKA A.A.B. 270° 10 MI	

Operational conditions permitting, you should keep a log to supply essential data on the scope photographs you take. In the absence of such data, which requires only a few minutes to record, many hours may have to be spent later in trying to figure out the when, where, and what of the pictures. Sometimes this is impossible, and the pictures are useless.

You may keep either a dual-purpose log (navigational and photographic), or a log specifically for photographic purposes, depending on the requirements of the mission. In either case the following information must be included:

Name of the AAF organization.

Type of mission and mission number.

Airplane number.

Your name.

Date.

Roll number, exposure numbers, or both.

Any additional information the briefing officer may request.

Thereafter, the dual-purpose log includes the usual navigational entries, such as times, fixes, true course, drift, temperature, ETA's, etc., and, under Remarks, the photographic entries.

The photographic entries should comprise a running account of the ranges at which the pictures were taken, notes on outstanding or peculiar scope displays, and tell if azimuth stabilization was on. If your camera assembly is not equipped with a watch, or if the watch is not operating properly, you must also enter the time each picture was taken.

When keeping a photographic log, record the time each picture was taken, the exposure number, the outstanding target on the scope presentation, the true heading and altitude of the airplane, the range setting, amount of altitude delay, and whether azimuth stabilization was on. Include any other pertinent information, such as the time of bomb release, arrival at the IP, etc.

Some camera assemblies have a means for photographing a data card for each scope picture. This obviates the need for a separate log. You record the same information on the data cards as you would on a log. The airplane number, mission number, date, and other general data may be written on the cards before the mission. You add individual data for each exposure. Remember to change the information on the data cards as flight conditions change, or considerable confusion results.

Radar Camera Assemblies

The table shows the camera assemblies in current use and their principal characteristics.

Camera Assembly Type No.	Camera Type No.	Used With	Negative Size	Print Size	Number of Exposures per Roll
0-6 0-7 0-8	K-35 K-35 K-35	APQ-13, APS-15A and others	35mm 35mm 35mm	Double frame (1x1 ½ in.)	36
0-5		APQ-13 and APS-15A	35mm	Single frame	1600
0-11		APQ-13 and APS-15A	35mm	Double frame (1x1 ½ in.)	800
0-9	K-24	APQ-13	5 ½x5 ½ in.	5x5 in.	125/250
0-10	K-24	APS-15A	5 ½x5 ½ in.	5x5 in.	125/250

0-6, 0-7, AND 0-8

These are the "stovepipe" models. They differ only in their cones. 0-6 and 0-7 are used with the APQ-13 radar, 0-8 with the APS-15A. Special adapters permit the use of these assemblies with other types of equipment, such as the SCR-717B.

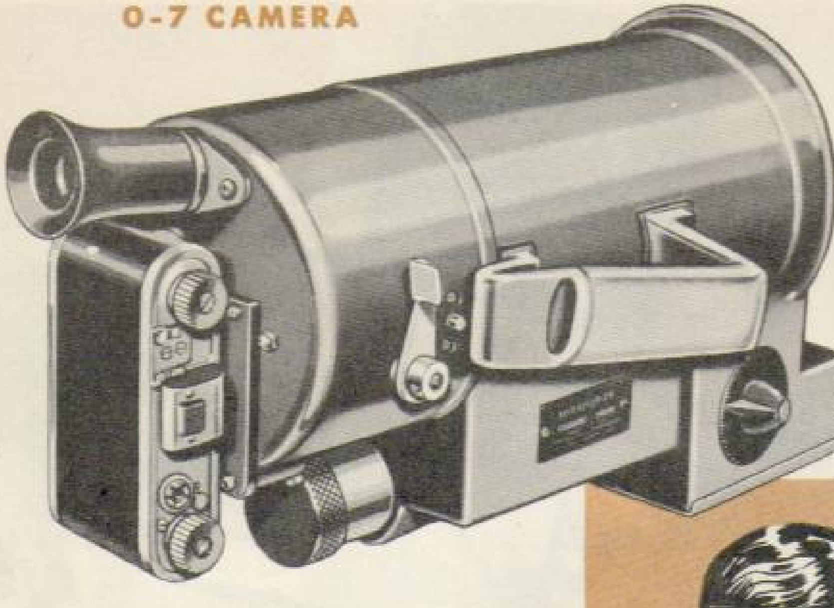
The 0-7 cone contains a watch and a radar range indicator, which are photographed along with the scope presentation. These are not provided with the 0-6 and 0-8. On all models a peepsight at the camera end of the cone enables you to view the scope while taking pictures.

All three models incorporate the K-35 camera, which operates as a still camera but uses 35mm movie film. Since the film cartridges hold only 36 exposures, you often have to reload during a mission.

The operation of these assemblies is entirely manual. You must apply the cone to the scope face, open and close the camera shutter by means of a thumb trigger mounted on the cone, and move the next frame into place for another photograph by turning a knob. The time required for these operations makes it next to impossible to secure adequate photographic coverage during the bombing run, unless a photographer flies the mission and a remote scope is available from which he can work.

On the 0-7 the watch must be wound and synchronized, and the range indicator turned to the same number as the range nautical mile switch on the radar set whenever the latter is changed. The dry cells which illuminate the watch and range indicator must be checked before each mission. The lights go on when you open the shutter.

O-7 CAMERA



O-5 AND O-11

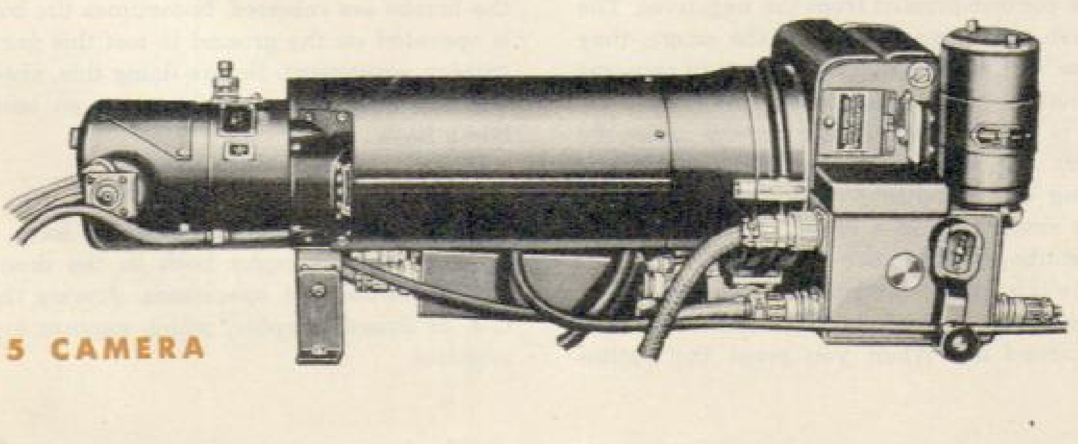
The 0-5 is an automatic-recording camera assembly designed for use with the APQ-13 and APS-15A. The camera is a 35mm type which makes 1600 single-frame exposures on a 100-foot roll. Unless the mission is started with the film largely expended, it is therefore unnecessary to reload in flight. An exposure-counter indicates the amount of unexposed film left in the magazine.

A beam-splitting mirror in the adapter enables you to view the scope while taking a picture. Since the design incorporates the data-card feature previously described, it is necessary to wind and synchronize the watch and check the dry battery and light, as on the 0-7 camera.

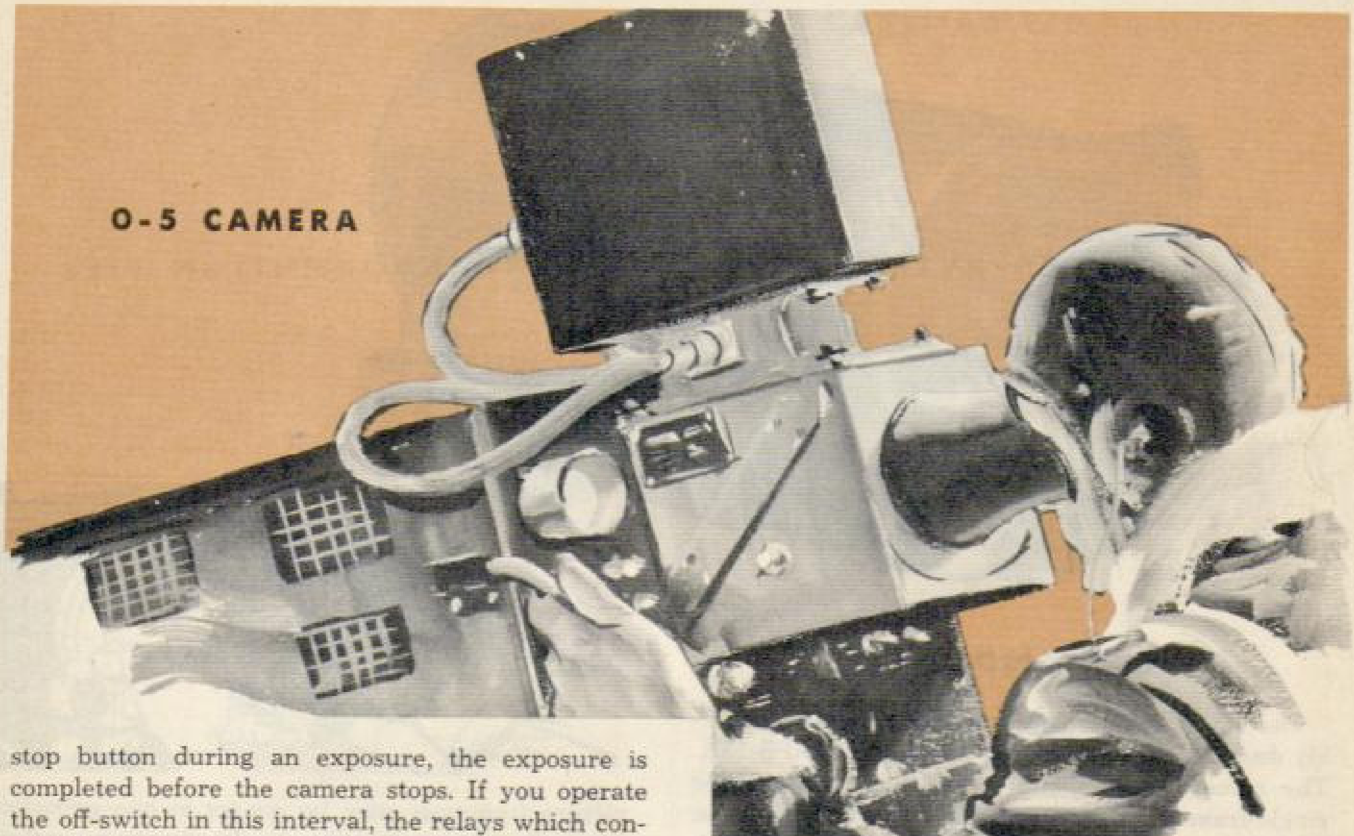
On the 0-5 the camera shutter is synchronized with the radar sweep line and opens automatically for a complete cycle each time the exposure switch is operated. The film feed likewise is automatic. The picture frequency may be pre-set at one exposure per cycle, one every other cycle, one every eighth cycle, or one every 64th cycle. Actually, on some models the camera operates every 16 cycles on the eight-cycle setting, and every 128 cycles on the 64-cycle setting. On all models the camera operates only while the antenna is rotating.

The 0-11 is a later and comparatively trouble-free version of the 0-5. Otherwise it differs principally in that it exposes a double-frame picture 1 x 1½ inches in size, instead of a single frame. Consequently, with the same 100-foot roll, it takes only 800 pictures instead of 1600 on one loading.

Caution: Some 0-5 models have both start-stop buttons and an on-off power switch. If you press the



K-35 CAMERA



stop button during an exposure, the exposure is completed before the camera stops. If you operate the off-switch in this interval, the relays which control the mechanism are thrown out of synchronization and you have to go through a somewhat complex re-synchronization procedure. On such models, **don't turn the power off until the camera movement has stopped.**

O-9 AND O-10

0-9 is used with the APQ-13 and 0-10 with the APS-15A; otherwise the two are identical. Both work on a remote scope and use a modification of the standard K-24 aerial camera. Unlike the cameras previously described, they do not expose motion-picture film, but 5½ x 5½-inch negatives, of which there are 125 or 250 to a magazine. Five by five-inch pictures are contact-printed from the negatives. The pictures have a 1:1 image ratio to the scope; they are the same size, that is, not reduced as in cameras which use motion picture film.

A watch is incorporated in the camera assembly and requires the usual winding, synchronization, and checking of its lighting system. An auxiliary light fogs a small spot in a corner of the negative when the bombs-away picture is taken.

To operate this camera assembly you merely have to press the camera switch button after the power has been turned on. When you press the button momentarily, the camera takes one picture, which is automatically timed by the rotation of the antenna. When you hold the button down, the camera takes a picture every cycle, until the button is released. Unexposed film is pulled down automatically for each exposure as long as any is left in the magazines. The amount remaining is indicated by an exposure counter. The magazine should be changed when there are still five exposures remaining.

Caution: In some 0-9 and 0-10 installations the camera bomb-release circuit, which exposes and marks the bombs-away scope picture, is wired in parallel with the bombs-away switch of the airplane. In this way a picture is taken automatically when the bombs are released. Sometimes the bomb-switch is operated on the ground to test this portion of the camera equipment. Before doing this, **check personally** to make sure that there are no bombs in the bomb bays.

Other Types

Several other types of cameras have been used for scope photography both in the domestic zone and in theaters of operations. Among these is the C-3, or Speed Graphic, which exposes a 4 x 5-inch negative.

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