Figure 27-10. Astrotracker

Figure 27-11. Astrotracker Control and Indicator Groups

AUTOMATIC ASTROTRACKER

The automatic astrotracker is an optical electromechanical system which provides a continuous true heading reference. Since it uses a celestial rather than magnetic reference, the astrotracker is independent of the earth's magnetic field. It can therefore provide accurate navigation data in both hemispheres and in both polar regions.

The astrotracker can locate, lock on, and track celestial bodies of the first, second, or third magnitude. These include stars with the photomagnitude of Polaris or brighter, planets (with the exception of the moon), and the sun.

Components

The automatic astrotracker system includes the following groups:

- Astrotracker
- Control Group
- Indicator Group
- Amplifier and Computer Group
- Power Group

ASTROTRACKER. The astrotracker, shown in figure 27-10, is composed of a tracking telescope which is stabilized by a vertical reference gyro. A hemispherical glass dome is mounted at the top center of the astrotracker housing. The dome projects above the fuselage skin and admits light from celestial bodies to the tracking telescope. The astrotracker modulates the light waves and a phototube converts the modulated signal to a usable electric signal for the computer group.

CONTROL AND INDICATOR GROUPS. The control group contains the control panels required for operating the astrotracker system and inserting the required input information. The indicator group displays the input and computed output information. See figure 27-11.

POWER GROUP, AND AMPLIFER AND COMPUTER GROUP. The power group supplies the required power to all astrotracker systems while the amplifier and computer group determines the output data of true heading, true azimuth, celestial altitude, altitude intercept, and heading correction.

Operation

To accomplish its function, the astrotracker system solves for the celestial values of altitude and azimuth. It must have these necessary inputs:

latitude, longitude, Greenwich Hour Angle. Sidereal Hour Angle, and declination.

INSERTING INFORMATION. Though normally supplied by automatic navigation computers, latitude and longitude can be manually inserted by the navigator. All celestial information can be obtained from the *Air Almanac* (GHA of the body, GHA of Aries, SHA, and declination). Stars available for tracking can be obtained from the morning, evening, and polar sky diagrams in the *Air Almanac*. The photo-magnitude of stars (labeled S-4) are also listed in the *Air Almanac*. The phototube is used to convert the light from celestial bodies to an electrical signal. Its ability to sense light from celestial bodies differs from the ability of the eye to see the light. For example, Antares has a visual magnitude of 1.2 but a photo-magnitude of 3.7.

COMPUTING AND DISPLAYING INFORMATION. After the required information is inserted, a mechanical analog computer computes the true azimuth (Zn) and the computed altitude (Hc). These values are displayed for the navigator's reference as well as being used in the system to position the optical telescope in altitude and azimuth. However, to position the optical telescope in azimuth, the relative bearing of the body to the aircraft must be computed. The astrotracker system accomplishes this by subtracting the best available true heading from the true azimuth (Zn — TH = RB). The best available true heading used for the computation of relative bearing is supplied from an alternate true heading system. The selected body should then be within the optieal telescope search pattern.

When the telescope locks onto the body, the astrotracker system computes two values: altitude intercept and heading correction. Altitude intercept is the difference between the computed altitude (Hc) which initially positioned the telescope and the actual altitude of the body. Heading correction is the difference between the computed relative bearing and the actual relative bearing of the body. Next, the astrotracker computes the true heading by applying this correction value to the best available true heading supplied by the alternate true heading system.

With the advent of high speed aircraft, the need for accurate heading information becomes more and more acute. The astrotracker supplies this heading information with an accuracy of ± 6 minutes of arc.

Astrotrackers are also designed for space vehicles, missile guidance systems, and satellite applications. They can lock onto inertially stable star directions to serve as sensors of space vehicle attitudes. When used on nearby solar bodies, the direction information can be used with respect to solar coordinate systems to develop accurate position information as well as vehicle attitude.

INERTIAL NAVIGATION

The speed of present-day supersonic aircraft and missiles demands navigational systems more sophisticated than those of the past. The problem has been solved by the development of a reliable, accurate inertial navigation system. Inertial navigation is based on the measurement of acceleration and is derived from Newton's laws of motion. Though the fundamental concept of inertial navigation has been known for years, the delay in developing a workable system resulted from the inability to manufacture inertial components to the extreme precision required.

Advantages

There are many important military advantages in this system. Some of these are:

- An inertial system is a self-contained unit requiring no external inputs other than operating power. For this reason, it cannot be affected by electronic countermeasures.
- The inertial system is small and versatile. It can be designed for missiles, fighters, or bombers.
- In theory, there is no limit to the accuracy of an inertial system. Manufacturing precision and design are the only factors that limit the system accuracy.

Inertial Principle

The principle on which an inertial navigation system functions is simple. Once an accurate fix or position is set into the system, the inertial unit maintains a correct read-out of the aircraft position during flight. This inflight DR is obtained by adding the distance flown to the position set at the beginning of flight. The distance flown is computed from information provided by a device called an accelerometer.

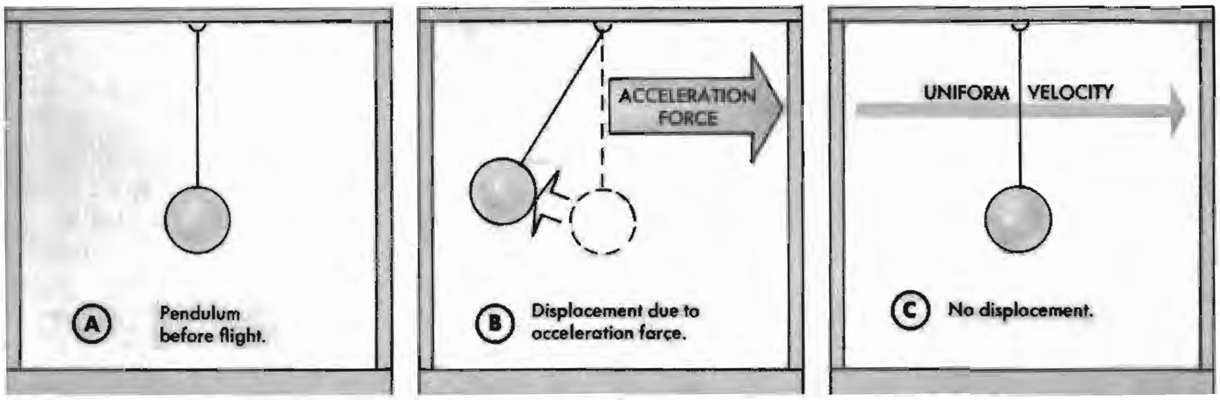


Figure 27-12. Principle of Accelerometer

Accelerometer

Many sophisticated concepts are built into an accelerometer. All are based on the principle of measuring the distance a mass is displaced by an acceleration force. Figure 27-12 shows basically how an accelerometer works. Illustration *A* shows the configuration of the accelerometer before take-off. Illustration *B* indicates what happens to the pendulum in flight during airspeed changes. By knowing the mass of the pendulum and the amount of the deflection, the acceleration of the aircraft can be computed. Multiplying acceleration by time produces velocity. This velocity is again multiplied by time to obtain the distance traveled. When acceleration ends and velocity is constant, the pendulum returns to its original position as shown in Illustration *C*.

One disadvantage of an accelerometer is that it cannot distinguish between a displacement of the pendulum caused by acceleration and a displacement caused by gravity. Because present-day accelerometers have such a high degree of sensitivity, an apparent acceleration output is produced by gravity if the accelerometer is tilted more than two seconds of arc out of the true vertical. To solve this problem, the accelerometers are mounted on a gyro-stabilized platform.

The Stable Platform

The stable platform is the heart of an inertial system. Figure 27-13 illustrates a typical platform mounted in a gimbal system that is stabilized by high-precision gyros. The number of gyros in a stable platform varies. Normally, 3 are used, two to stabilize the vertical plane and one to stabilize the horizontal or directional plane. The number of gimbals used in a stable platform also varies. If two gimbals are used, the platform is limited to about 70° of pitch and 90° of roll; if three are used, however, the platform movement in pitch and roll is unlimited.

Monitoring Systems

Inertial systems tend to develop errors if left unaided over long periods of time. These errors result from gyro drift, accelerometer errors, and computer errors. To correct for drift, the inertial system is monitored by other navigational systems such as Doppler radar, search radar, or an astro-tracker. Depending on the task to be accomplished, these systems may be employed in any combination.

Doppler is used to level the stable platform initially in flight. In many inertial systems, it periodically checks the platform for accuracy throughout the mission. The initial leveling process requires from 20 minutes to 1½ hours and is accomplished by comparing Doppler velocity with accelerometer velocity. The difference between these velocities results from the tilt of the stable platform. After the leveling process is completed, the inertial unit is sufficiently accurate to carry on the navigational process for a limited time without the aid of a monitoring system.

An astrotracker is often used to correct the heading information produced by the inertial unit. The highly accurate celestial heading computed by the astrotracker is used to correct the inertial heading. It is also used to rate the drift of the inertial

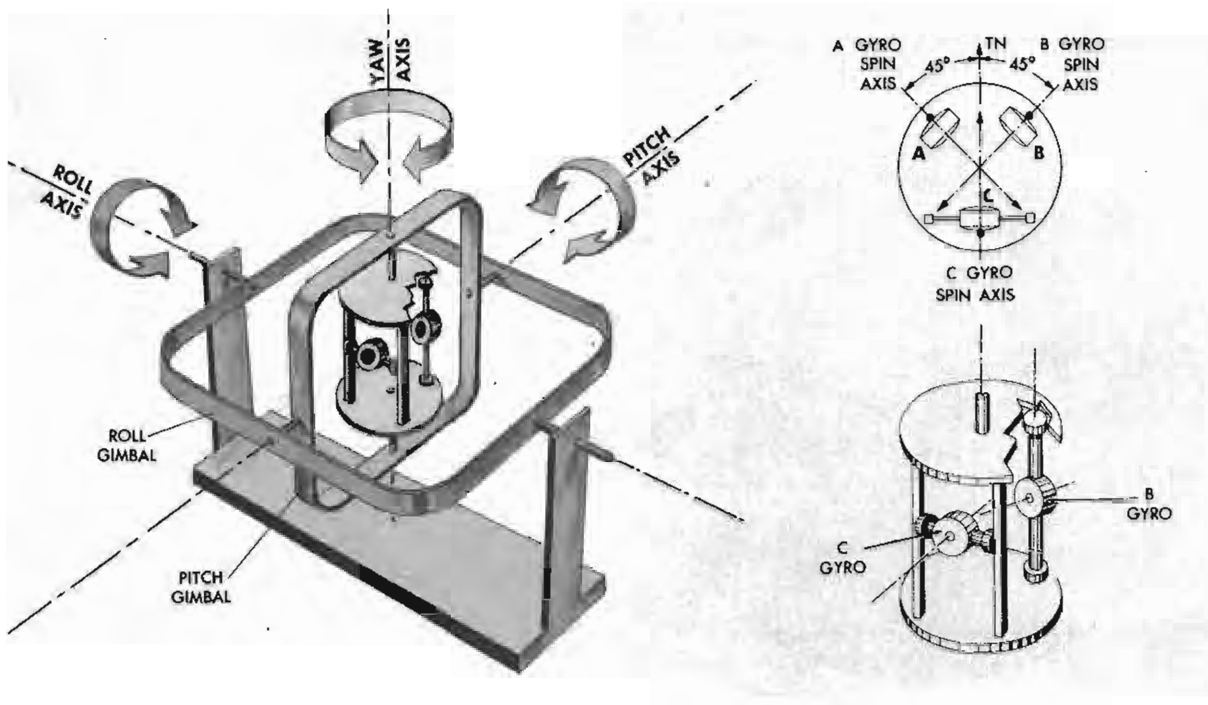


Figure 27-13. Principle of the Stable Platform

unit. The drift rate is then applied to the azimuth gyro on the stable platform as a correction factor to produce an inertial heading.

In some cases, a search radar is used to correct the present position determined by the inertial system. This is especially true during the critical period when the stable platform is being leveled. When the leveling process is completed, the inertial system can supply the present position read-out while the search radar is turned off. This is of particular advantage whenever radio silence must be observed.

Summary

An inertial system is no better than its poorest component. It is important, therefore, that the accelerometers, computer, and stable platform be designed and constructed to eliminate any possible inaccuracy. Furthermore, these components must be combined to form an overall inertial system that will correctly position an aircraft.

While a completely inertial system is theoretically the ultimate in a navigation system, other navigation systems are presently required, both to provide inputs and to act as backup to the inertial system.

NAVIGATIONAL COMPUTER SYSTEMS

In the same way an autopilot frees a pilot from the manual operations of flying, a navigation computer system relieves the navigator of many manual operations required to direct the aircraft in flight. When automatic sensing devices like the Doppler and astrotracker are tied into a navigation computer system, the navigator is automatically provided current readings of present latitude and longtitude, groundspeed, and heading. The navigation computer system thereby eases the navigator's work load and frees him to make the decisions that are beyond the capability of computers.

Modern aircraft are capable of speeds and ranges which require the navigator to perform extensive calculations rapidly and accurately. Consider a flight from the United States to a foreign country. The route could pass through areas of land, water, and ice caps. The navigator must contend with overcast, undercast, day, and night. He faces altitude changes, turning points, and mandatory ETA requirements. To handle all these conditions at the speed of sound or faster, the navigator uses automatic navigation computers.

The navigational computer system consists of:

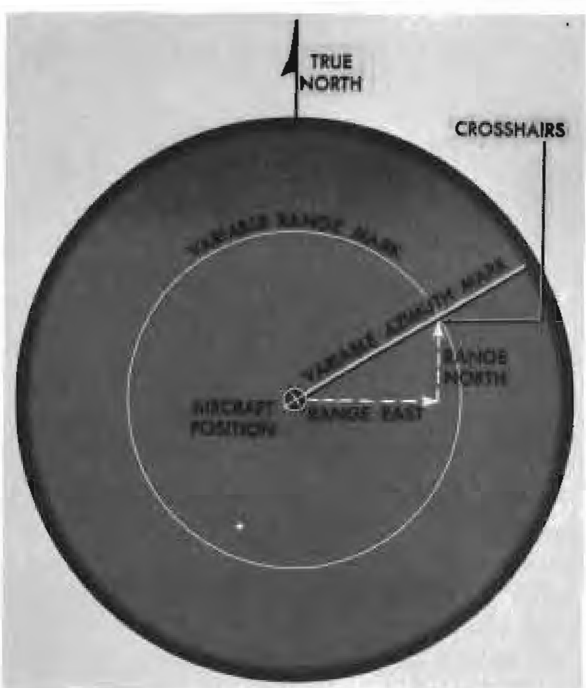


Figure 27-14. Radar Crosshairs

- The data-gathering units (sensors) such as radar, Doppler, and astrotracker.
- Computer units where the computations and comparisons are made.
- Navigation panels containing the dials and controls which give the navigator a system monitoring and control capability.

Sensors

RADAR. When a radar set is incorporated with the computer system, movable electronic crosshairs are displayed on the radarscope so that range and direction of radar returns can be measured and inserted into the computer (see figure 27-14). The crosshairs consist of a variable range mark and a variable azimuth mark. They can be maneuvered with a crosshair control handle. On the radarscope, they resemble a single fixed range mark and a heading mark. By moving the crosshair control handle, the navigator simultaneously changes the position of the crosshairs and the corresponding coordinate measurements (east-west and north-south) being fed to the navigation computers. The function is completed almost instantaneously.

When the navigator positions the crosshairs on a given return, the computers determine the distance between the aircraft and the return. If the coordinates of the return have been set in the computer, the computer can maintain a running account of the aircraft latitude and longitude by an electromechanical process.

DOPPLER. Doppler radar's contribution to the computer system is groundspeed and drift. These two outputs can be put to several uses in the computer system. Doppler groundspeeds can be used to drive the present position latitude and longitude counters. Doppler outputs can be used in platform leveling and in checking inertial groundspeed in an inertial system. Doppler radar is an essential part of most navigation computer systems.

ASTROTRACKER. The astrotracker is another data-gathering unit in a computer system. Its accurate measurement of true heading regardless of local magnetic variation makes the astrotracker a valuable addition. The navigation computer system can combine astrotracker true heading with Doppler drift to produce current aircraft track. The astrotracker also provides celestial LOP information which can be used by the navigation computer for fixing.

INERTIAL NAVIGATION. The inertial unit is used to feed position information into the computers. Once the inertial sensor is leveled and in operation, it is used to update continually the present position counters.

LORAN-C. Loran-C, discussed in Chapter 21, fits well in an automatic computer system. Some computer systems have the coordinates of Loran stations stored in them; during flight, the navigator selects the stations he wants to use and the computer does the rest. Fixing is automatic and occurs in somewhat the same way that a navigator takes a celestial fix. An assumed position is determined by the computers; the Loran position is then applied to this assumed position. A series of credibility checks and approximations are applied automatically by the computer. The result is an accurate Loran fix. When the computers function in the Loran mode, continuous present position and groundspeed information is still available.

TACAN. TACAN can be easily added to a computer system. Since the TACAN output is given in the form of a range and bearing, the computers need only the coordinates and frequency of the TACAN station being used. This data can be set into the computers before the mission begins.

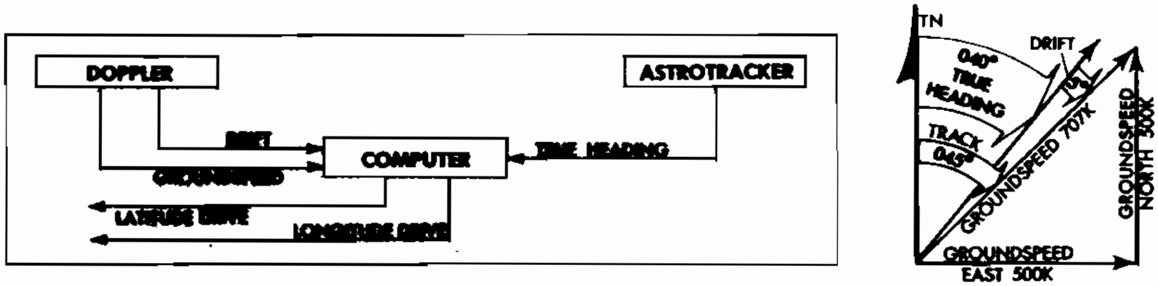


Figure 27-15. Present Position Counter Drive

Some corrections must be applied to TACAN outputs to increase accuracy. The bearings received from TACAN are magnetic; therefore, the computer must have an accurate magnetic variation value at all times. This is usually built into the computer. TACAN range output is expressed in slant range; absolute altitude above the station must be applied to the slant range to produce exact ground range.

Computer Unit

The two basic types of navigation computers most used are the analog and the digital.

ANALOG. An analog computer is comparable to the navigator's hand-held computer in that a graphic replica of the problem to be solved is constructed in order to find the answer. The analog computer is generally larger than the digital computer, partially because many components must be added to solve a wide variety of problems. Some of these computers weight as much as 2,000 pounds. The analog computer has one main advantage, it is not as sensitive to temperature and pressure changes as the digital system.

DIGITAL. The digital computer, a relative newcomer to the field of navigation, is generally lighter and more compact than the analog system. In some cases, the digital computer weighs less than 100 pounds. It computes navigation problems in a much different manner than does the analog computer. It is unnecessary to design a digital computer expressly for the navigation problems it is to solve. Properly programmed, the same computer could be used in fields other than navigation. This is possible because the digital computer deals strictly with numbers. This requires that all inputs be changed to a numerical value before they are sent to the computer. All outputs likewise must be converted back to terms which are meaningful to the navigator.

DETERMINING POSITION. Regardless of computer type, the problems to be solved by a navigation computer remain the same. The ever-present problem facing the navigator is determination of aircraft position. With a computer system, it is not necessary to estimate a position based on a track and groundspeed derived from the last known position. The computer always displays the current position for convenient reading.

Example.

Figure 27-15 illustrates an example which depicts determination of present position using astrotracker and Doppler information.

The astrotracker sends a true heading of 040° to the computer and the Doppler registers groundspeed of 707 knots and drift of 5° right. The true heading and drift are combined in the computer to produce a value of track; in this case, 045°.

The groundspeed can be resolved around the direction of track to produce values of groundspeed to drive the latitude and longtitude counters. In this case, the groundspeed north and east is 500 knots. Though this process seems basically simple, a few corrections must be applied to the groundspeed components before they are sufficiently accurate for present position drive. These corrections, done within the computer, include such things as compensation for convergence of meridians and for the imperfect shape of the earth

DETERMINING HEADING TO DESTINATION. Another question the navigator often faces is, "What is the heading to destination?" This question is also answered by many navigation computer systems. The computer first computes the required track, either rhumb line or great circle. To do this, it computes the direction and distance from the present latitude and longitude to the destinatior latitude and longitude. The present track, taken from the inertial system in this instance, is then compared to the required course to destination; the difference is a heading correction. Groundspeed may be applied to the distance to destination, and a time-to-go may be computed to provide a continuous ETA.

Navigation Panels

The navigation panels comprise the greatest part of the computer system visible to the navigator. Panel appearance and operation vary with each computer system. The multitude of counters, dials, switches, buttons, control knobs, and selectors give the navigator maximum use and control of the system. Selectors that determine which sensors will be used and which read-outs will be given, permit the navigator to switch from one mode of operation to another.

The computer system aids the navigator in other ways. Most modern computers have limits built into them so they will not accept unreasonable information. For instance, if the coordinates of a fix point are set one degree of latitude in error, the computer rejects the fix because the information is totally incompatible with information already in the computer. A rapid change in groundspeed from a sensor might be rejected and that sensor output no longer used because it would be considered unreliable.

So far in this discussion, only basic navigation has been considered. A sophisticated computer system can solve ballistic problems and automatically release bombs and missiles. If the system is installed on a transport type aircraft, cargo drops and notification of bailout time to paratroops can be controlled by the navigation computer.

All computer systems do not contain all the sensors or have all the capabilities described above. The mission requirements of the aircraft dictate what the computer system should comprise. With advancements in science and engineering, automatic computer systems will have increased capabilities and uses. The systems will become lighter and more compact thereby increasing the practicability of installing them on more aircraft.

SUMMARY

While all the automatic navigation systems in use today appear to spell complexity, they have been designed to assist the navigator with the myriad of navigation problems associated with high speed aircraft. Each system is relatively simple to operate and provides its information as a part of the overall navigation problem. The use of Dopplers, astrotrackers, inertial systems, and navigation computers which combine these inputs into the solution of this overall problem serve to simplify and reduce the tasks of the navigator.

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

J. P. McCONNELL, *General, USAF*
Chief of Staff

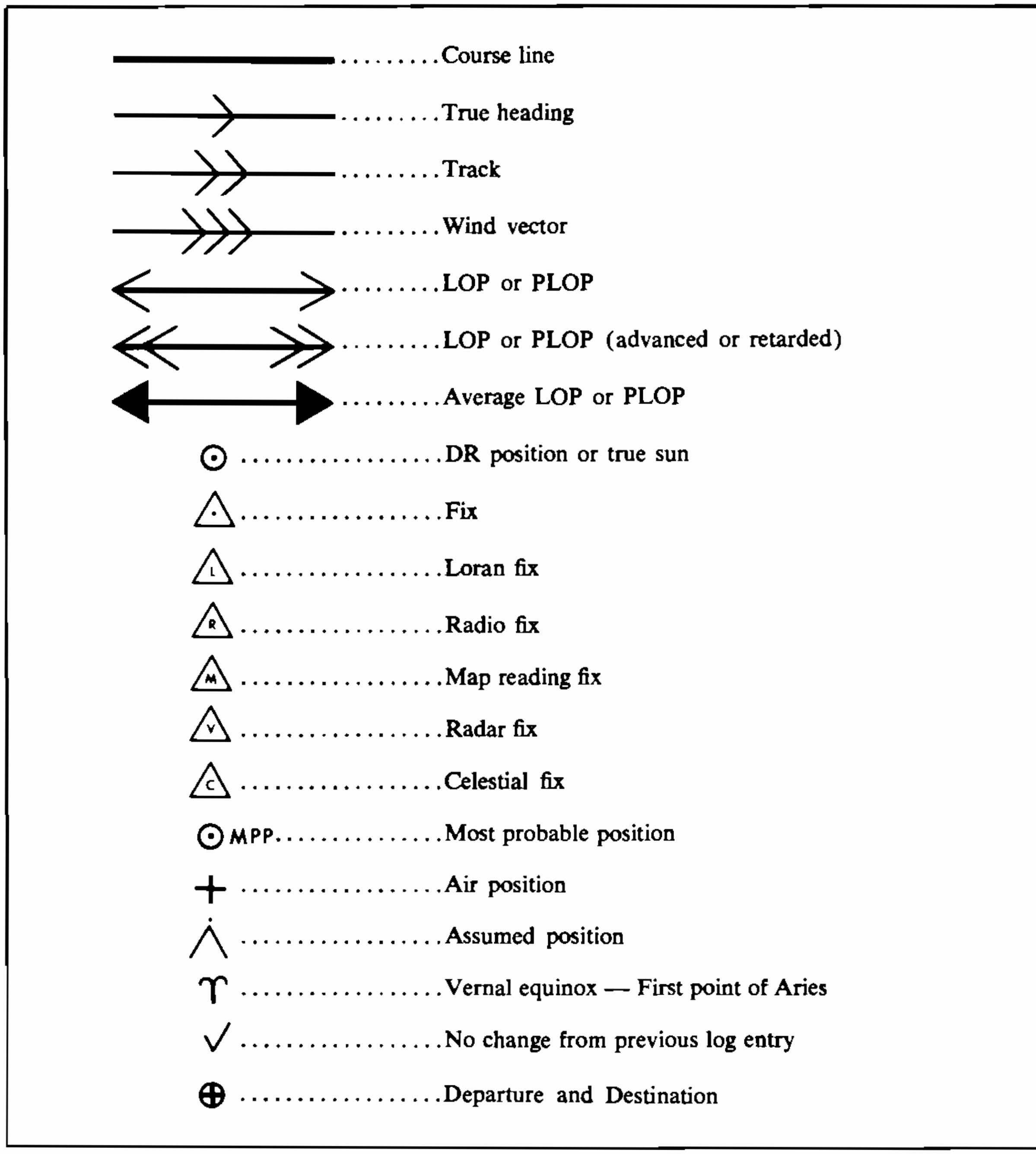
JOHN F. RASH, *Colonel, USAF*
Director of Administrative Services

Summary of Revised, Deleted, or Added Material

Chapter 1 lists U.S. Observatory and U.S. Navy Hydrographic Office publications prescribed for Air Force use. Chapter 24 designates AF Form 21, Navigator's Log for general navigation use. Previous Chapter 1, Vol. 1, and Chapters 9 and 12, Vol II, have been deleted. New chapters added are Chapter 3—Maps and Charts; Chapter 6—Lines of Positions, Bearings, and Fixes; Chapter 7—Map Reading; Chapter 8— Practical Application of DR and Map Reading; and Chapter 19— Grid Navigation. The following former chapters have been revised: Chapter 3, Vol II, is included in the present Chapter 12—Time; Chapter 13, Vol II, has been expanded into five separate chapters; Chapter 14, Vol II, has been updated and renumbered Chapter 27. All material has been reorganized, updated, and expanded to permit quick reference to specific information and inclusion of new material by changes, and to incorporate the most recent information on principles and procedures of various types of navigation. Detailed information on specific equipment which is subject to frequent change is not included.

ATTACHMENT 1

Symbols



ATTACHMENT 2

Abbreviations

A

AA	absolute altitude
A/C	alter course, aircraft, aircraft commander
ACIC	Aeronautical Chart and Information Center
ADC	automatic drift control
ADF	automatic direction finder
AF	audio frequency
AFC	automatic frequency control
A/H	alter heading
alt	altitude
AM	amplitude modulation, ante meridian
ant	antenna
AP	airplot, air position, assumed position
API	air position indicator
ARA	airborne radar approach
ARTCC	Air Route Traffic Control Center
AS	airspeed
ATA	actual time of arrival
ATC	Air Traffic Control
AVC	automatic volume control
AWS	Air Weather Service
az	azimuth

B

BAS	basic airspeed
BAT	basic air temperature
BD	Bellamy drift
BFO	beat frequency oscillator
BMT	beginning of morning twilight
BPA	basic pressure altitude
BTA	basic true altitude

C

CAS	calibrated airspeed
CCW	counterclockwise
CDI	course deviation indicator
CF	Coriolis force
CH	compass heading
Cl	climb
cm	centimeter
comp	computer, compass
corr	correction, corrected
CPC	constant pressure chart
CRT	cathode ray tube
CW	clockwise, continuous wave

D

"d"	correction to tabulated altitude for minutes of declination
D	D-soundings, difference between TA and PA
D_1, D_2, etc.	successive D readings
DA	density altitude, drift angle
DAS	density airspeed
DC	drift correction
DCA	drift correction angle
DD	double drift
Dec	declination
dept	departure
dest	destination
dev	deviation
DF	direction finder
DG	directional gyro
DH	desired heading
DME	distance measuring equipment
DR	dead reckoning

E

E	east, error
EAD	effective air distance
EAP	effective air path
EAS	equivalent airspeed
EET	end of evening twilight
ETA	estimated time of arrival
ETAS	effective true airspeed
ETP	equal time point

F

FAA	Federal Aviation Agency
FAR	Federal Air Regulations
FH	final heading
FIR	Flight Information Regions
FLIP	Flight Information Publications
FM	frequency modulation
FSS	Flight Service Station

G	acceleration caused by gravity
GAT	Greenwich apparent time
GC	grid course
GCA	ground controlled approach
GEOREF	World Geographic Reference System
GH	grid heading
GHA	Greenwich hour angle
GMT	Greenwich mean time
GN	grid north
GP	gyro precession
griv or GV	grid variation, grivation
GS	groundspeed
GST	Greenwich sidereal time

H

H	altitude, height, high
Hc	computed altitude (celestial)
HF	high frequency (3,000-30,000 kHz)
Hg	mercury
H.O.	Hydrographic Office (U.S. Navy)
Ho	observed altitude
Hp	precomputed altitude (celestial)
Hs	sextant altitude (celestial)
Hz	cycles per second

I

IAS	indicated airspeed
IAT	indicated air temperature
ICAO	International Civil Aviation Organization
IF	intermediate frequency
IFF	Identification Friend or Foe
IFR	Instrument Flight Rule
IH	initial heading
ILS	instrument landing system
ind	indicated
intcp	intercept
IP	initial point, identification of position
IPA	indicated pressure altitude
ITA	indicated true altitude

J-K

k	knots
K	constant
kHz	kilocycles (1000 cycles) per second
km	kilometer

L

L	low
lat	latitude
LAT	local apparent time
LCT	local civil time
LF	low frequency (30-300 kHz)
LHA	local hour angle
Lm	midlatitude
LMT	local mean time
Ln	loran
L.O.	level off
long	longitude
LOP	line of position
LOS	line of sight
L-R	left-right
LST	local sidereal time

M

m	meter
M	moment, Mach number
mb	millibar
MB	magnetic bearing
MC	magnetic course
MC&G	mapping, charting, and geodetic
MF	medium frequency (300-3000 kHz)
MGRS	Military Grid Reference System
MH	magnetic heading
mHz	megacycles per second
mm	millimeter
MN	magnetic north
mph	miles per hour
MPP	most probable position
ms	microseconds
MSL	mean sea level

N

N	north, nadir
NM	nautical miles
NMC	National Meteorological Center

O

OAT	outside air temperature

P

PA	pressure altitude, parallax
PAV	pressure altitude variation
PGF	pressure gradient force
PLOP	pressure line of position
PM	pulse modulation, post meridian
pos	position
PPI	plan position indicator
pps	pulses per second
PR	position report
PRF	pulse recurrence frequency
PRR	pulse recurrence rate
PRT	pulse recurrence time
PW	pulse wave

Q

Q	correction applied to Ho of Polaris

R

r	radius
R	refraction
RB	relative bearing
RF	radio frequency
RMI	radio magnetic indicator
R/T	receiver/transmitter

S

S	south, speed
SD	semidiameter
SDC	single drift correction
sext	sextant
SHA	sidereal hour angle
SID	standard instrument departure
SIF	selective identification feature
SSB	single sideband
STC	sensitivity time constant

T

TA	true altitude
TAMPA	true altitude minus pressure altitude
TAR	terrain avoidance radar
TAS	true airspeed
TAT	true air temperature
TB	true bearing
TC	true course
temp	temperature
tgt	target
TH	true heading
TN	true north
TO	takeoff
TP	turning point
Tr	track
T/R	transmitter/receiver

U

UHF	ultra high frequency (300-3000 mHz)
UIR	Upper Information Region
UPS	Universal Polar Stereographic
UTM	Universal Transverse Mercator

V

var	variation, variable
VFR	Visual Flight Rule
VHF	very high frequency (30,000-300,000 kHz)
VLF	very low frequency (below 30 kHz)
VOR	VHF omnidirectional range (omnirange)
VRM	variable range marker

W

W	west
WAC	World Aeronautical Chart
WD	wind direction
WS	wind speed
W/V	wind velocity, wind vector

X-Y-Z

Z	azimuth angle
ZD	zenith distance, zone difference
Zn	true azimuth
ZN	pressure pattern displacement
ZT	zone time

ATTACHMENT 3

Explanation of Terms

ABSOLUTE ALTIMETER—An instrument designed to indicate the actual height of an aircraft above the terrain. It works on the principle of measuring the time interval between transmission of a signal and the return echo from the earth's surface, or by measuring the phase difference between the transmitted signal and echo.

AGONIC LINE—A line on a chart joining points of no magnetic variation.

AIR ALMANAC—A joint publication of the US Naval Observatory and British Royal Observatory covering a four-month period. It contains tabulated values of the Greenwich hour angle and declination of selected celestial bodies, plus additional celestial data used in navigation.

AIR DISTANCE (AD)—Distance that is measured relative to the mass of air through which an aircraft passes; the no-wind distance flown in a given time (TAS x time).

AIRPLOT (AP)—A continuous plot of a graphic representation of true heading and air distance.

AIR POSITION (AP)—The no-wind position of an aircraft at a given time.

AIRSPEED (AS)—The speed of an aircraft relative to its surrounding air mass.

Calibrated Airspeed (CAS)—Indicated airspeed corrected for pitot-static installation and/or the attitude of the aircraft.

Equivalent Airspeed (EAS)—Calibrated airspeed corrected for compressibility-of-air error.

Indicated Airspeed (IAS)—The uncorrected reading obtained from the airspeed indicator.

True Airspeed (TAS)—Equivalent airspeed corrected for density altitude (pressure and temperature).

AIRSPEED INDICATOR (ASI)—An instrument which gives a measure of the rate of motion of an aircraft relative to the surrounding air.

AIR TEMPERATURE

Basic Air Temperature (BAT)—Indicated air temperature corrected for the instrument error.

Corrected Mean Temperature (CMT)—The average between the target temperature and the true air temperature of flight level.

Indicated Air Temperature (IAT)—The uncorrected reading from the free air temperature gage. Also known as outside air temperature (OAT).

True Air Temperature (TAT)—Basic air temperature corrected for the heat of compression error.

AIRWAY—An air corridor established for the control of traffic and marked with radio navigation aids.

ALTER COURSE (A/C)—A change in course to a destination or a turning point.

ALTER HEADING (A/H)—The change in heading to make good the intended course.

ALTIMETER—An instrument that measures the elevation of an aircraft above a given datum plane.

ALTIMETER SETTING (ALT Set)—Station pressure reduced to sea level, expressed in inches of mercury or millibars. When this value is set into the altimeter, the instrument reading is indicated true altitude.

ALTITUDE—The height of an aircraft above a given datum.

Absolute Altitude (AA)—True altitude corrected for terrain elevation; the vertical distance of the aircraft above the terrain.

Basic Pressure Altitude (BPA)—Indicated pressure altitude corrected for instrument error. Also known as flight-level pressure altitude (FL PA).

Density Altitude (DA)—Basic pressure altitude corrected for temperature; the vertical distance of the aircraft above the standard datum plane.

Indicated Pressure Altitude (IPA)—The reading of the pressure altimeter with 29.92 set in the Kollsman window.

True Altitude (TA)—The density altitude corrected for pressure altitude variation (PAV); the vertical distance above mean sea level.

ALTITUDE, CELESTIAL—Angular distance of a celestial body above the celestial horizon, measured along the vertical circle.

Computed Altitude (Hc)—A mathematical computation of the correct celestial altitude of a body at a specific geographic position, for a given date and time.

Observed Altitude (Ho)—The sextant altitude corrected for sextant and observation errors.

Precomputed Altitude (Hp)—Computed celestial altitude corrected for all known observational errors and adjusted to the time of the observed altitude.

Sextant Altitude (Hs)—A celestial altitude measured with a sextant; the angle measured in a vertical plane between an artificial or sea horizon and a celestial body.

ALTITUDE DELAY—A controlled delay applied to the start of the trace to eliminate the altitude hole on the PPI-type display.

ALTITUDE HOLE—The blank area in the center of the PPI, the outer edge of which represents the point on the ground immediately beneath the aircraft.

ARIES, FIRST POINT OF (♈)—The point on the equinoctial where the sun moving along the ecliptic passes from south to north declination. Also known as vernal equinox.

ASSUMED POSITION (AP)—The geographic position upon which a celestial solution is based.

ASTRODOME—A transparent bubble mounted in the top of an aircraft fuselage through which celestial observations are taken.

ASTRONOMICAL TRIANGLE—A triangle on the celestial sphere bounded by the observer's celestial meridian, the vertical circle, and the hour circle through the body, and having as its vertices the elevated pole, the observer's zenith, and the body.

AURAL NULL—The determination by ear of the point of zero or minimum audio signal from a radio compass, which occurs when the receiver radio signal picked up by the two sides of the rotatable loop antenna cancel one another. This point indicates that the plane of the loop is perpendicular to the direction of the transmitted signal and is used as a means of determining radio bearings in flight.

AZIMUTH ANGLE (Z)—The interior angle of the astronomical triangle at the zenith measured from the observer's meridian to the vertical circle through the body.

AZIMUTH STABILIZATION—Orientation of the picture on a radarscope so as to place true north at the top of the scope.

AZIMUTH, TRUE (Zn)—The angle at the zenith measured clockwise from true north to the vertical circle passing through the body.

BASE LINE—The shorter arc of the great circle joining the master and slave Loran stations.

BASE LINE EXTENSION—The extension of the base line through and beyond the master and slave Loran stations.

BEACON—A ground navigational light, radio, or radar transmitter used to provide aircraft in flight with a signal to serve as a reference for the determination of accurate bearings or positions.

BEAM WIDTH—The effective width in azimuth of radiation from an antenna.

BEAM-WIDTH ERROR—An azimuth distortion of a radar display caused by the width of the radar beam.

BEARING—The horizontal angle at a given point, measured clockwise from a specific reference datum, to a second point. The direction of one point relative to another, as measured from a specific reference datum.

Magnetic Bearing (MB)—The horizontal angle at a given point, measured from magnetic north, clockwise, to the great circle through the object or body and the given point.

Relative Bearing (RB)—The horizontal angle at the aircraft measured clockwise from the true heading of the aircraft to the great circle containing the aircraft and the object or body.

True Bearing (TB)—The horizontal angle at a given point measured from true north clockwise to the great circle passing through the point and the object or body.

BELLAMY DRIFT—The net drift angle of the aircraft calculated between any two pressure soundings.

BLIP—The display of a received pulse on a CRT; a spot of light representing a target; (Loran) an upward deflection of the trace representing the received signal. Also known as pip.

BRANCH, LOWER—Half of an hour circle opposite from "upper branch," defined below.

BRANCH, UPPER—That half of an hour circle or meridian which contains the celestial body or the observer's position.

CELESTIAL EQUATOR—The great circle formed by the intersection of the plane of the earth's equator with the celestial sphere. Also known as Equinoctial.

CELESTIAL MERIDIAN—A great circle on the celestial sphere formed by the intersection of the celestial sphere and any plane passing through the North and South poles. Any great circle on the celestial sphere which passes through the celestial poles.

CELESTIAL NAVIGATION—See *Navigation Aids.*

CELESTIAL OBSERVATION ERRORS (Sextant)

Acceleration Error—An error caused by the deflection of the liquid in the bubble chamber due to any change in speed or direction of the aircraft.

Coriolis Error—The error introduced in a celestial observation taken in flight resulting from the deflective force on the liquid in the bubble chamber, as caused by the path of the aircraft in counteracting the earth's rotation.

Index Error—An error caused by the misalignment of the sighting mechanism of the instrument.

Parallax Error—The difference between a body's altitude above an artificial or visible horizon and above the celestial horizon. The error is present because of the fact that the body is not at an infinite distance.

Personal Error—Errors in celestial observations caused by sighting limitations of the observer, or visual interpretation which he uses in collimating the body during observations.

Refraction Error—An error caused by the bending of light rays in passing through the various layers of the atmosphere and/or the astrodome of the aircraft.

Rhumb-Line Correction—The correction applied for the bubble-acceleration error caused by the rhumb-line path of the aircraft.

Wander Error—The bubble-acceleration error caused by a change of track during the celestial-shooting period.

CELESTIAL POLES—The points of intersection of the extension of the earth's axis with the celestial sphere.

CELESTIAL SPHERE—An imaginary sphere of infinite radius whose center coincides with the center of the earth, on which all celestial bodies except the earth are imagined to be projected.

CHART—A graphic representation of a section of the earth's surface specifically designed for navigational purposes. A chart may also be referred to as a map. Although a chart is usually specifically designed as a plotting medium for marine or aerial navigation, it may be devoid of cultural or topographical data.

CHECK POINT—A geographical reference point used for checking the position of an aircraft in flight. As generally used, it is a well-defined reference point easily discernible from the air. Its exact position is known or plotted on the navigational chart, and was selected in preflight planning for use in checking aircraft position in flight.

CIRCLES

Circle of Equal Altitude—A circle on the earth which is the locus of all points equidistant from the subpoint of a celestial body. The altitude of a celestial body is the same measured from any point on the circle.

Diurnal Circle—The daily apparent path of a body on the celestial sphere caused by the rotation of the earth.

Great Circle—Any circle on a sphere whose plane passes through the center of that sphere.

Hour Circle—A great circle on the celestial sphere passing through the celestial poles and a given celestial body.

Small Circle—Any circle on a sphere whose plane does not pass through the center of that sphere.

Vertical Circle—A great circle on the celestial sphere which passes through the observer's position and is perpendicular to the horizon.

CO-ALTITUDE (co-alt)—The small arc of a vertical circle, between the observer's position and the body (90° — altitude).

CO-DECLINATION (co-dec)—See *Polar Distance.*

CO-LATITUDE (co-lat)—The small arc of the observer's celestial meridian, between the elevated pole and the body (90° — latitude).

COLLIMATION—The correct alignment of the images of the bubble of a sextant and the object being observed.

COMPASS—An instrument which indicates direction measured clockwise from true north, or grid north.

Direct-Indicating—A magnetic compass in which the dial, scale, or index is carried on the sensing element.

Magnetic—An instrument which indicates direction measured clockwise from magnetic north.

Remote Indicating—A magnetic compass, the magnetic sensing unit of which is installed in an aircraft in a position as free as possible from causes of deviation. A transmitter system is included so that the compass indication can be read on a number of repeater dials suitably placed throughout the aircraft.

COMPASS DIRECTION—The direction measured clockwise from a particular compass needle which is more often than not displaced from the magnetic meridian by local deviating magnetic fields.

COMPASS ROSE—A graduated circle on a map or chart, marked in degrees clockwise from 0° through 360° for use as a reference in measuring bearings and courses.

COMPASS SWING—A procedure for determining compass deviation on various aircraft headings for use in compensating or calibrating the compass. This can be done either on the ground or in the air.

CONSOL—A rotating radio signal system used for long range bearings.

CONSTELLATION—A recognizable group of stars by means of which individual stars may be identified.

CONTOUR LINES—Lines drawn on maps and charts joining points of equal elevation; also, a line connecting points of equal altitude on a constant-pressure chart.

CONTROLLED TIME OF ARRIVAL—A method of arriving at a destination at a specified time by changing direction and/or speed of an aircraft.

CONTROL POINT—The position an aircraft must reach at a predetermined time.

COORDINATES

Celestial (1)—The equinoctial system involves the use of sidereal hour angle and declination to locate a point on the celestial sphere with reference to the first point of Aries and the equinoctial.

Celestial (2)—The horizon system involves the use of azimuth and altitude to locate a point on the celestial sphere for an instant of time from a specific geographical position on the earth.

Celestial (3)—The Greenwich system involves the use of Greenwich hour angle and declination to locate a point on the celestial sphere with reference to the Greenwich meridian and the equinoctial for a given instant of time.

Geographical—The latitude and longitude used to locate any given point on the surface of the earth.

Grid—A system of coordinates in which the area concerned is divided into rectangles which are in turn subdivided, and in which the subdivisions or the dividing grid lines are designated by numbers and/or letters to serve as references in locating positions or small areas. Also a rectangular grid or fictitious chart graticule which is oriented with grid north.

Polar—A system of coordinates used in locating a point by direction and distance from an origin.

Rectangular—A system of coordinates based on a rectangular grid; sometimes referred to as grid coordinates.

CORIOLIS ERROR—See *Celestial Observation Errors.*

CORIOLIS FORCE—An apparent force due to the rotation of the earth which causes a moving body to be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

COURSE—The direction of the intended path of an aircraft over the earth; or the direction of a line on a chart representing the intended aircraft path.

expressed as the angle measured from a specific reference datum clockwise from 0° thru 360° to the line.

Great-Circle Course—The route between two points on the earth's surface measured along the shorter segment of the circumference of the great circle between the two points. A great circle course establishes the shortest distance over the surface of the earth between any two terrestrial points.

Grid Course—The horizontal angle measured clockwise from grid north to the course line. The course of an aircraft measured with reference to the north direction of a polar grid.

Magnetic Course—The horizontal angle measured from the direction of magnetic north clockwise to a line representing the course of the aircraft. The aircraft course measured with reference to magnetic north.

True Course (TC)—The angle measured clockwise from true north to thc line representing the intended path of the aircraft.

Course Line—A line of position which is parallel or approximately parallel to the track of the aircraft. A line of position used to check aircraft position relative to intended course.

CRAB—A correction of aircraft heading into the wind to make good a given track; correction for wind drift.

CRUISE CONTROL—The operation of an aircraft to obtain the maximum efficiency on a particular mission (most miles per amount of fuel).

"D" SOUNDING—The difference between pressure altitude and true altitude as determined at a given time in flight (true altitude minus pressure altitude).

DATUM—Refers to a direction, level, or position from which angles, heights, depths, speeds, or distances are conventionally measured.

DAY

Civil Day—The interval of time between two successive lower transits of a meridian by the mean (or civil) sun.

Sidereal Day—The interval of time between two successive upper transits of a meridian by the first point of Aries (23 hours 56 minutes).

Solar Day—The interval of time between two successive lower transits of a meridian by the true (apparent) sun.

DEAD RECKONING—The directing of an aircraft and determining of its position by the application of direction and speed data to a previous position.

DEAD-RECKONING (DR) POSITION—The position of an aircraft determined for a given time by the application of direction and speed data only.

DECLINATION (dec)—The angular distance to a body on the celestial sphere measured north or south :hrough 90° from the celestial equator along the ɩour circle of the body (comparable to latitude).

DEVIATION (dev)—Compass error caused by the magnetism within an aircraft; the angle measured from magnetic north eastward or westward to the direction of the earth's lines of magnetic force as deflected by the aircraft's magnetism.

DEVIATION CORRECTION—The correction applied to a compass reading to correct for deviation error. The numerical equivalent of deviation with the algebraic sign added to magnetic heading to obtain compass heading.

DIP

Celestial—The angle of depression of the visible sea horizon due to the elevation of the eye of the observer above the level of the sea.

Magnetic—The vertical displacement of the compass needle from the horizontal caused by the earth's magnetic field.

DIURNAL CIRCLE—See *Circles.*

DOG LEG—A route containing a major alteration of course (as opposed to a straight-line course.)

DOUBLE DRIFT (DD)—A method of determining the wind by observing drift on an initial true heading and two other true headings which are flown in a specific pattern. Also called multiple drift.

DRIFT—The rate of lateral displacement of the aircraft by the wind, generally expressed in degrees.

DRIFT ANGLE—The angle between true heading and track (or true course), expressed as degrees right or left according to the way the aircraft has drifted.

DRIFT CORRECTION (DC)—Correction for drift, expressed in degrees (plus or minus), and applied to true course to obtain true heading.

DRIFTMETER—An instrument used for measuring drift.

ECLIPTIC—The great circle on the celestial sphere along which the apparent sun, by reason of the earth's annual revolution, appears to move. The plane of the ecliptic is tilted to the plane of the equator at an angle of 23° 27′.

EFFECTIVE AIR DISTANCE (EAD)—The distance measured along the effective air path.

EFFECTIVE AIR PATH (EAP)—A straight line on a navigation chart connecting two air positions, commonly used between the air positions of two pressure soundings to determine effective true airspeed (ETAS) between the two soundings.

EFFECTIVE TRUE AIRSPEED (ETAS)—The effective air distance divided by the elapsed time between two pressure soundings.

ELEVATED POLE—That celestial pole which is on the same side of the equinoctial as the position of the observer.

EQUAL ALTITUDE—See *Circles.*

EQUATION OF TIME—The amount of time by which the mean sun leads or lags behind the true sun at any instant. The difference between mean and apparent times expressed in units of solar time with the algebraic sign, so that when added to mean time it gives apparent time.

EQUATOR—The great circle on the earth's surface equidistant from the poles. Latitude is measured north and south from the equator.

EQUINOCTIAL—See *Celestial Equator.*

EQUINOX

Autumnal Equinox—The point on the equinoctial when the sun, moving along the ecliptic, passes from north to south declination. This usually occurs on 21 September.

Vernal Equinox—The point on the equinoctial where the sun, moving along the ecliptic, passes from south to north declination. This usually occurs on 21 March.

FIELD-ELEVATION PRESSURE—The existing atmospheric pressure in inches of mercury at the elevation of the field. Also known as station pressure.

FIX—The geographic position of an aircraft for a specified time, established by navigational aids.

FLIGHT PLAN—Predetermined information for the conduct of a flight. That portion of a flight log that is prepared before the mission.

GEOREF—An international code reference system for reporting geographical position (similar to rectangular coordinates).

GEOSTROPHIC WIND—The mathematically calculated wind which theoretically blows parallel to the contour lines, in which only pressure-gradient force and Coriolis force are considered.

GRADIENT WIND—Generally accepted as the actual wind above the friction level, influenced by Coriolis force, pressure gradient, and centrifugal force.

GRATICULE—A system of vertical and horizontal lines that is used to divide a drawing, picture, chart, etc., into smaller sections. On a map the graticule consists of the latitude and longitude lines.

GREENWICH MERIDIAN—The prime meridian which passes through Greenwich, England, and from which longitude is measured east or west.

GRID NAVIGATION—A method of navigation using a grid overlay for direction determination.

GRIVATION (griv)—The angle between grid north and magnetic north at any point.

GROUND PLOT—A graphic representation of track and groundspeed.

GROUND RANGE—The horizontal distance from the subpoint of the aircraft to an object on the ground.

GROUND RETURN—The reflection from the terrain as displayed on a CRT.

GROUNDSPEED (GS)—The actual speed of an aircraft relative to the earth's surface.

GROUND WAVE—A radio wave that is propagated over the surface of the earth and tends to parallel the earth's surface.

HEADING—The angular direction of the longitudinal axis of an aircraft measured clockwise from a reference point.

Compass Heading (CH)—The reading taken directly from the compass.

Grid Heading (GH)—The heading of an aircraft with reference to grid north.

Magnetic Heading (MH)—The heading of an aircraft with reference to magnetic north.

True Heading (TH)—The heading of an aircraft with reference to true north.

HEAT-OF-COMPRESSION ERROR—The error caused by the increase in the indication of the free air temperature gage, due to air compression and friction on the case around the sensitive element.

HERTZ (Hz)—The standard unit notation for measure of frequency in cycles per second; i.e., 60 cycles per second is 60 Hz.

HOMING—A technique of arriving over a destination by keeping the aircraft headed toward that point by reference to radio, Loran, radar, or similar devices.

HORIZON

Bubble Horizon—An artificial horizon parallel to the celestial horizon, established by means of a bubble level.

Celestial Horizon—The great circle on the celestial sphere formed by the intersection of a plane passing through the center of the earth which is parallel to the plane tangent to the earth at the observer's position.

Visible Horizon—The circle around the observer where earth and sky appear to meet. Also called natural horizon or sea horizon.

HOUR ANGLE

Greenwich Hour Angle (GHA)—The angular distance measured from the upper branch of the Greenwich meridian westward through 360° to the upper branch of the hour circle passing through a point.

Local Hour Angle (LHA)—The angular distance measured from the upper branch of the observer's meridian westward through 360° to the upper branch of the hour circle passing through a body.

Sidereal Hour Angle (SHA)—The angular distance measured from the upper branch of the hour circle of the first point of Aries westward through 360° to the upper branch of the hour circle passing through a body.

HOUR CIRCLE—See *Circle.*

INDEX ERROR—See *Celestial Observation Error.*

INHERENT DISTORTION—The distortion of the display of a received radar signal caused by the design characteristics of a particular radar set.

INITIAL POINT (IP)—A preselected geographical position which is used as a reference for the beginning of a run on a target.

INTERCEPT, CELESTIAL—The difference in minutes of arc between an observed altitude of a celestial body and its computed altitude for the same time. This difference is measured as a distance in nautical miles from the plotting position along the azimuth of the body to determine the point through which to plot the line of position.

INTERNATIONAL DATE LINE—The anti-meridian of Greenwich, modified to avoid island groups and land masses; in crossing this Greenwich anti-meridian there is a change of local date.

ISOBAR—A line joining points of equal pressure.

ISOGONIC LINE (Isogonal)—A line drawn on a chart joining points of equal magnetic variation.

ISOGRIV—A line drawn on a chart joining points of equal grivation.

ISOTACH—A line drawn on a chart joining points of equal wind speed.

ISOTHERM—A line drawn on a chart joining points of equal temperature.

KNOTS (k)—Nautical miles per hour.

LANDFALL—The first point of land over which an aircraft crosses when flying from seaward; also as used in celestial navigation, the procedure in which an aircraft is flown along a celestial line of position which passes through destination.

LATERAL AXIS—An imaginary line running through the center of gravity of an aircraft, parallel to the straight line through both wing tips.

LATITUDE (lat)—Angular distance measured north or south of the equator along a meridian, 0° through 90°

LINE OF CONSTANT BEARING—An unchanging directional relationship between two moving objects.

LINE OF POSITION (LOP)—A line containing all possible geographic positions of an observer at a given instant of time.

LOG—A written record of computed or observed flight data; generally applied to the written navigational record of a flight.

LONGITUDE (long)—The angular distance east or west of the Greenwich meridian, measured in the plane of the equator or of a parallel from 0° to 180°.

LONGITUDINAL AXIS—An imaginary line running fore and aft through the center of gravity of an aircraft, parallel to the axis of the propeller or thrust line.

LORAN—See *Navigational Aids.*

LUBBER LINE—A reference mark representing the longitudinal axis of an aircraft.

MACH NUMBER—The ratio of the velocity of a body to that of sound in the medium in which the craft is moving.

MAGNETIC DIRECTION—A direction measured clockwise from the magnetic meridian.

MAP READING—See *Navigational Aids.*

MAP SYMBOLS—Figures and designs used to represent topographical, cultural, and aeronautical features on a map or chart.

MARKER BEACONS—Radio beacons established at range stations, along airways, and at intermediate points between range stations to assist pilots and observers in fixing position.

Fan-Type—A 75-megacycle radio transmitter usually installed at strategic points along a radio range across the on-course signal. The signal is produced in a space shaped like a thick fan immediately above the transmitter. The signal may be received visually or aurally, depending on the receiver.

M-Type—A low-powered, nondirectional radio station which transmits a characteristic signal once every few seconds. The range of the receiver is approximately 10 miles.

Z-Type—A special 75-megacycle radio which transmits a signal within the cone of silence to enable the pilot to identify his position over the range station. The signal may be picked up visually or aurally depending on the receiver used. In Air Force aircraft, a marker-beacon light flashes on as the aircraft enters the cone of silence.

MASTER STATION—The primary or control transmitter station, the signal of which triggers the transmitter of one or more other stations. Also a transmitter station, the signals of which are used by other stations as a basis for synchronizing transmissions.

MEAN SEA LEVEL (MSL)—The average level of the sea, used to compute barometric pressure.

MEAN SUN—An imaginary sun traveling around the equinoctial at the average annual rate of the true sun.

MERIDIONAL PART—A unit of measurement equal to one minute of longitude at the equator.

MINIMAL FLIGHT PATH—A path which affords the shortest possible time en route, obtained by using maximum assistance from the winds.

MOST PROBABLE POSITION (MPP)—The computed position of an aircraft determined by comparing a DR position and an LOP or a fix of doubtful accuracy determined for the same time, in which relative weights are given to the estimated probable errors of each.

NADIR—The point on the celestial sphere directly beneath the observer's position.

NAUTICAL MILE (NM)—A unit of distance used in navigation, 6080 ft; the mean length of one minute of longitude on the equator; approximately 1 minute of latitude; 1.15 statute miles.

NAVIGATION AIDS—Any means of obtaining a fix or LOP as an aid to dead reckoning.

Celestial—The determination of position by reference to celestial bodies.

Consol—A rotating radio-signal system used for long-range bearings.

Loran—An electronic aid to navigation whereby a line of position may be determined by measuring electronically the time difference between the receipt of pulsating signals of radio energy received from two different synchronized transmitting stations.

Map Reading—The determination of position by identification of land marks with their representations on a map or chart.

Pressure Differential—The determination of the average drift, or the crosswind component of the wind effect on the aircraft for a given period by taking "D" soundings and applying the formula

$$ZN = K \frac{(D_2 - D_1)}{ETAS}$$

where ZN is the cross wind component, K is the Coriolis constant, ETAS is the effective true airspeed, and D_1 and D_2 are the values of the pressure soundings.

Radar—The determination of position by obtaining information from a radar indicator.

Radio—The determination of position by the use of radio facilities.

NORTH

Compass North—The direction indicated by the north-seeking end of a compass needle.

Grid North (GN)—An arbitrarily selected direction of a rectangular grid. In grid navigation the direction of the 180° geographical meridian from the pole is almost universally used as standard grid north.

Magnetic North (MN)—The direction towards the north magnetic pole from an observer's position.

True North (TN)—The direction from an observer's position to the geographical North Pole. The north direction of any geographical meridian.

PARALLAX ERROR—See *Celestial Observation Errors.*

PERSONAL ERROR—See *Celestial Observation Errors.*

PITCH—Movement of an aircraft around the lateral axis.

PITOT—A cylindrical tube with an open end pointed upstream; used in measuring impact pressure, particularly in an airspeed indicator.

PITOT-STATIC TUBE—A parallel or coaxial combination of a pitot and static tube. The difference between the impact pressure and the static pressure is a function of the velocity of flow past the tube and may be used to indicate airspeed of an aircraft in flight.

POLAR DISTANCE—Angular distance from a celestial pole or the arc of an hour circle between the celestial pole and a point on the celestial sphere. It is measured along an hour circle and may vary from 0° to 180°, since either pole may be used as the origin of measurement. It is usually considered the complement of declination, though it may be either 90° —declination or 90° +declination, depending upon the pole used.

PRECESSION

Apparent—The apparent deflection of the gyro axis, relative to the earth, due to the rotating effect of the earth and not due to any applied forces.

Induced (Real)—The movement of the axis of a spinning gyro when a force is applied. The gyro precesses 90° from the point of applied pressure in the direction of rotation.

Of the Equinox—The average yearly apparent movement of the first point of Aries to the west.

PRECOMPUTED CURVE—A graphical representation of the azimuth and/or altitude of a celestial body plotted against time for a given assumed position (or positions), and which is computed for subsequent use for celestial observations. Used in celestial navigation for the determination of position, or to check a sextant.

PRESSURE ALTITUDE VARIATION (PAV)—The pressure difference, in feet, between mean sea level and the standard datum plane.

PRESSURE LINE OF POSITION (PLOP)—A line of position computed by the application of pressure pattern principles. Specifically, a line parallel to the effective air path and ZN distance from the air position for a given time. (See *Navigational Aids.*)

PROCEDURE TURN—A constant-rate turn of an aircraft in flight; used for computing the radius of turn and time required for its execution when very accurate navigation is required in controlling time or maintaining accurate, briefed tracks; usually associated with the turn made at the initial point of a bomb run to insure that the bombing run is made on the briefed axis of attack.

PROJECTION (CHART, MAP)—A process of mathematically constructing a representation of the surface of the earth on a flat plane.

PULSE DURATION OR PULSE WIDTH—The duration, in microseconds, of each pulse in a radar transmission.

PULSE-LENGTH ERROR—A range distortion of a radar return caused by the duration of the pulse.

PULSE RECURRENCE RATE (PRR)—The number of pulses transmitted per second by a radar or radio transmitter. Also known as pulse recurrence frequency (PRF).

PULSE RECURRENCE TIME (PRT)—The interval of time, in microseconds, between the transmission of two successive radar or radio pulses.

QUADRANTAL ERROR—The error in a radio direction indication introduced by the bending of radio waves by electrical currents and structural metal in the aircraft. It may also refer to magnetic-compass errors resulting from the same causes.

RADAR BEACON (RACON)—A stationary transmitter-receiver which sends out a coded signal when triggered by a radar pulse.

RADAR BEAM—A directional concentration of radio energy.

RADAR NAUTICAL MILE—The time required for a radar pulse to travel out one nautical mile and the echo pulse to return (12.4 ms).

RADIO COMPASS (ADF)—A radio receiver equipped with a rotatable loop antenna which is used to measure the bearing to a radio transmitter.

RADIO FREQUENCY (RF)—Any frequency of electrical energy above the audio range which is capable of being radiated into space.

RADIO NAVIGATION—See *Navigational Aids.*

RADIUS OF ACTION—The maximum distance that an aircraft can fly from its base before returning to the same or alternate base and still have a designated margin of fuel.

RADOME—A bubble-type cover for a radar antenna.

RANGE CONTROL—The operation of an aircraft to obtain the optimum flying time.

RANGE DEFINITION—The accuracy with which a radar set can measure range—usually a function of pulse shape.

RANGE, MAXIMUM—The maximum distance a given aircraft can cover under given conditions by flying at the economical speed and altitude at all stages of the flight.

REVOLUTION (of the earth)—The earth's elliptical path about the sun which determines the length of the year and causes the seasons.

RHUMB LINE—A line on the surface of a sphere which makes equal oblique angles with all meridians. A loxodromic curve.

ROTATION (of the the earth)—The spinning of the earth from west to east on its own axis which determines the days.

RUNNING FIX—A fix determined from a series of lines of position, based on the same object or body and resolved for a common time.

SCAN—The motion of a beam of RF energy caused by rotating or displacing the reflecting element or the antenna in relation to the reflecting element. The search pattern of an antenna.

SEMIDIAMETER (SD)—The value in minutes of arc of the radius of the sun or the moon.

SEXTANT—An optical instrument whose prism moves in an arc of 60°, enabling it to measure the altitude of a celestial body up to 120°. The term is commonly applied to all instruments measuring the altitude of a celestial body.

SINGLE-DRIFT CORRECTION—A technique used in pressure-pattern flying wherein a net drift is determined and the correction applied to the course.

SKY WAVES—A radio signal reflected one or more times from the ionosphere.

SLANT RANGE—Measurement of range along the line of sight.

SLAVE STATION—The station of a network which is controlled or triggered by the signal from the master station.

SOLSTICE—Those points on the ecliptic where the sun reaches its greatest northern or southern declination. Also the times when these phenomena occur.

Summer—That point on the ecliptic where the sun reaches its greatest declination having the same name as the latitude.

Winter—That point on the ecliptic where the sun reaches its greatest declination having the opposite name as the latitude.

SPEED LINE—A line of position that intersects the track at an angle great enough to be used as an aid in determining groundspeed.

SPOT-SIZE ERROR—A distortion of a radar return caused by the size of the electron spot in a cathode-ray tube.

STANDARD DATUM PLANE—An imaginary surface containing all points having a barometric pressure of 29.92 inches of mercury at a temperature of 15° centigrade. See *Altitude, Density*.

STANDARD LAPSE RATE

Temperature—A temperature decrease of approximately 2° centigrade for each 1,000 feet increase in altitude.

Pressure—A decrease in pressure of approximately 1 inch of mercury for each 1,000 feet.

STAR MAGNITUDE—A measure of the relative apparent brightness of stars.

STATUTE MILE—5,280 feet or .867 nautical miles.

SUBPOINT—That point on the earth's surface directly beneath an object or celestial body.

SUN LINE—A line of position obtained by computation based on observation of the altitude of the sun for a specific time.

SWEEP—The luminous line produced on the screen of a cathode ray tube by deflection of the electron beam. Also called time base line. See *Trace*.

SWEEP DELAY—The electronic delay of the start of the sweep used to select a particular segment of the total range.

TARGET-TIMING WIND—A wind determined from a series of ranges and bearings on the same target taken within a relatively short period of time.

TIME

Apparent Time—Time measured with reference to the true sun. The interval which has elapsed since the last lower transit of a given meridian by the true sun.

Greenwich Apparent Time (GAT)—Local time at the Greenwich meridian measured by reference to the true sun. The angle measured at the pole or along the equator or equinoctial (and converted to time) from the lower branch of the Greenwich meridian westward through 360° to the upper branch of the hour circle passing through the true (apparent) sun.

Greenwich Mean Time (GMT)—Local time at the Greenwich meridian measured by reference to the mean sun. It is the angle measured at the pole or along the equator or equinoctial (and converted to time) from the lower branch of the Greenwich meridian westward through 360° to the upper branch of the hour circle through the mean sun.

Greenwich Sidereal Time (GST)—Local sidereal time at Greenwich. It is equivalent to the Greenwich hour angle of Aries converted to time.

Local Apparent Time (LAT)—Local time at the observer's meridian measured by reference to the true sun. The angle measured at the pole or along the equator or equinoctial (and converted to time) from the lower branch of the observer's meridian westward through 360° to the upper branch of the hour-circle passing through the true (apparent) sun.

Local Mean time (LMT)—Local time at the observer's meridian measured by reference to the mean sun. It is the angle measured at the pole or along the equator or equinoctial (and converted to time) from the lower branch of the observer's meridian westward through 360° to the upper branch of the hour circle through the mean (or average) sun.

Local Sidereal Time (LST)—Local time at the observer's meridian measured by reference to the first point of Aries. It is equivalent to the local hour angle of Aries converted to time.

Mean Time—Time measured by reference to the mean sun.

Sidereal Time—Time measured by reference to the upper branch of the first point of Aries.

Standard Time—An arbitrary time, usually fixed by the local mean time of the central meridian of the time zone.

Zone Time—The time used throughout a 15° band of longitude. The time is based on the local mean time for the center meridian of the zone.

Z or Zulu Time—An expression indicating Greenwich mean time. Usually expressed in four numerals (0001 through 2400).

TIME ZONE—A band on the earth approximately 15° of longitude wide, the central meridian of each zone generally being 15° or a multiple removed from the Greenwich meridian so that the standard time of successive zones differs by one hour.

TRACK (Tr)—The actual path of an aircraft over the surface of the earth, or its graphic representation; also called track made good.

TWILIGHT—That period of day, after sunset or before sunrise, when the observer receives sunlight reflected from the atmosphere.

Astronomical Twilight—That period which ends in the evening and begins in the morning when the sun reaches 18° below the horizon.

Civil Twilight—That period which ends in the evening and begins in the morning when the sun reaches 6° below the horizon.

Nautical Twilight—That period which ends in the evening and begins in the morning when the sun reaches 12° below the horizon.

VARIABLE RANGE MARKER (VRM)—An electronic marker, variable in range, displayed on a CRT, for purposes of accurate ranging; sometimes called bomb-release pip.

VARIATION (var)—The angle difference at a given point between true north and magnetic north expressed as the number of degrees which magnetic north is displaced east or west from true north. The angle to be added algebraically to true directions to obtain magnetic directions.

WIND—Moving air, especially a mass of air having a common direction or motion. The term is generally limited to air moving horizontally or nearly so; vertical streams of air are usually called currents.

WIND DIRECTION AND FORCE—The direction from which, and the rate at which, the wind blows.

WIND DIRECTION AND VELOCITY (W/V)—Wind direction and speed. Wind direction is the direction from which the wind is blowing expressed as an angle measured clockwise from true north. Wind speed is generally expressed in nautical miles or statute miles per hour.

YEAR, APPARENT SOLAR—The period of time between two successive passages of the mean sun through the first point of Aries. It has a mean value of 365 days 05 hours 48.75 minutes. This period contains one complete cycle of the seasons and is less than the sidereal year owing to the precession of the equinoxes.

YEAR, SIDEREAL—The period of time between two successive passages of the sun across a fixed position among the stars. Its value is constant, and equal to 365 days 06 hours 09 minutes, a true measure of the earth's period of orbital revolution.

ZENITH—The point on the celestial sphere directly above the observer's position.

ZENITH DISTANCE (ZD)—The angular distance from the observer's position to any point on the celestial sphere measured along the vertical circle passing through the point. It is equivalent to coaltitude, but when applied to a body's subpoint and the observer's position on the earth it is expressed in nautical miles.

ZN (Pressure Pattern Displacement)—In pressure pattern flying, the displacement in nautical miles, at right angles to the effective airpath, due to the crosswind component of the geostrophic wind.

ATTACHMENT 4

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