FORTY-FIVE POUNDS OF AUTOMATIC NAVIGATION

BY GEORGE LIESKE, *Project Supervisor,*
FORD INSTRUMENT COMPANY

. . . . . a description of the Computer Set, Latitude and Longitude, AN/ASN-6, a new dead-reckoning computer for aircraft.

. . . . . designed and manufactured by FORD INSTRUMENT COMPANY, Division of Sperry Rand Corporation.

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Forty-five Pounds of Automatic Navigation

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Lacking all ground-to-air communication, pilot of plane can rely on AN/ASN-6 Ground Position Indicator to give him position.

> **The AN/ASN-6 Ground Position Indicator System was designed and developed by Ford Instrument Company under the auspices of the United States Air Force, in conjunction with the Communications and Navigation Laboratory, Wright Air Development Center, Dayton, O.**

THE need for increased automaticity in aircraft has been made critical by high-speed jet planes. The pilot navigator, occupied with flying his plane at 500 miles an hour or better, has no opportunity to plot his position with plotting board and computers. In time of war, not only must he give his attention to the panel full of dials, but he must also elude pursuing enemy planes, and be on the alert against ground antiaircraft fire. Moreover, radio blackout will have silenced all signals from his home base. It was therefore inevitable that he would have to be provided with an automatic dead-reckoning instrument dependent on no ground-to-air communication whatever. The Ford Instrument Company developed and is now manufacturing for the USAF such an instrument. It is called the AN/ASN-6 Ground Position Indicator.

The AN/ASN-6 weighs approximately 45 pounds, and although it contains almost 2,000 different items, its total volume is just over one cubic foot. Only the dials of the instrument take up space on the instrument panel, its operational gear may be located in a remote part of the plane where space is available.

Hermetic sealing provides controlled atmosphere for most working parts. Corrosion is reduced, and the instrument is capable of operating over a temperature range of from —54°C to 71°C in widely varying environments such as high humidity, dust - laden atmospheres, and high altitudes.

WHAT IT DOES

To furnish the information needed, the Ground Position Indicator must add to the pilot's initial longitude and latitude the changes in these position factors that result from the plane's movement through space. To accomplish this, it must mathematically consider speed and true heading and the speed and direction of the wind. Using this information, it calculates the plane's present position and displays the changing longitude and latitude continuously on counters mounted in windows of the instrument.

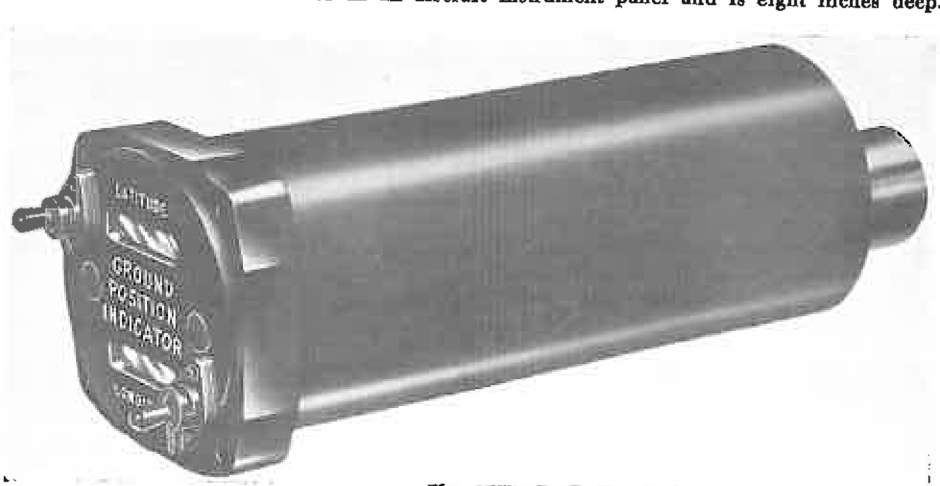
Provided the pilot has been given correct set-in-data, the plane's position will be displayed accurately to within 1.5 per cent of the distance traveled.

TAKE-OFF

The pilot climbs aboard his plane, turns to his Ground Position Indicator, sets in his present position, his magnetic variation for the location he is starting from, and the wind speed and direction as indicated by his meteorological charts. Once he is in the air, he releases a departure switch, and the computer begins computing continuously his position. He need not monitor his GPI. It is another "man" aboard, one who is charged with the sole responsibility of continuously recording the position of the plane. If an enemy attacks and the pilot must interrupt his original flight program to fly an evasive course, all he need do when he has escaped is consult his "helper" to learn his present position and from that proceed to get back on his original course.

The Ford Instrument Company's AN/ASN-6 Ground Position Indicator is not an end in itself. Although the AN/ASN-6 is in full production for the Air Force, Ford engineers are developing new potentials for the basic

AN/ASN-6 consists of four units. The Indicator unit below fits in the standard mounting-hole for a three-inch indicator in an aircraft instrument panel and is eight inches deep.



LATITUDE AND LONGITUDE COMPUTER SET ASN-6

S. I. FRANGOULIS
Project Supervisor
Ford Instrument Company
Long Island City, New York

OPERATION of most aerial navigation systems depends principally on some contact with the ground, or in rare cases with some celestial body. For all the improvements in modern radio and radar navigation systems, it is frequently desirable and sometimes imperative to enable the pilot to navigate over considerable distances without depending on ground contact, and to permit him to make all navigational computations from information developed solely within the aircraft.

The system developed for this purpose performs simultaneously the function of dead reckoning the airplane ground position and of computing the course and distance of the airplane to its destination. The dead-reckoning part of the system represents in itself an independent useful navigational instrument, the ground position indicator. Originally developed for the US Air Force, the ASN-6 Latitude and Longitude Computer Set, computes automatically and continuously the map coordinates of the present position of the airplane. Another variant, which is known as the lightweight version of the ground position indicator, computes east-west and north-south coordinates of the aircraft relative to a selected base or origin.

Addition of several simple auxiliary devices permits use of outputs of the ground position indicator to obtain the course and distance to a destination of known coordinates. Specifically, use of the additional equipment (known as the ASN-7 Computer Group) provides rhumb line course and rhumb line distance

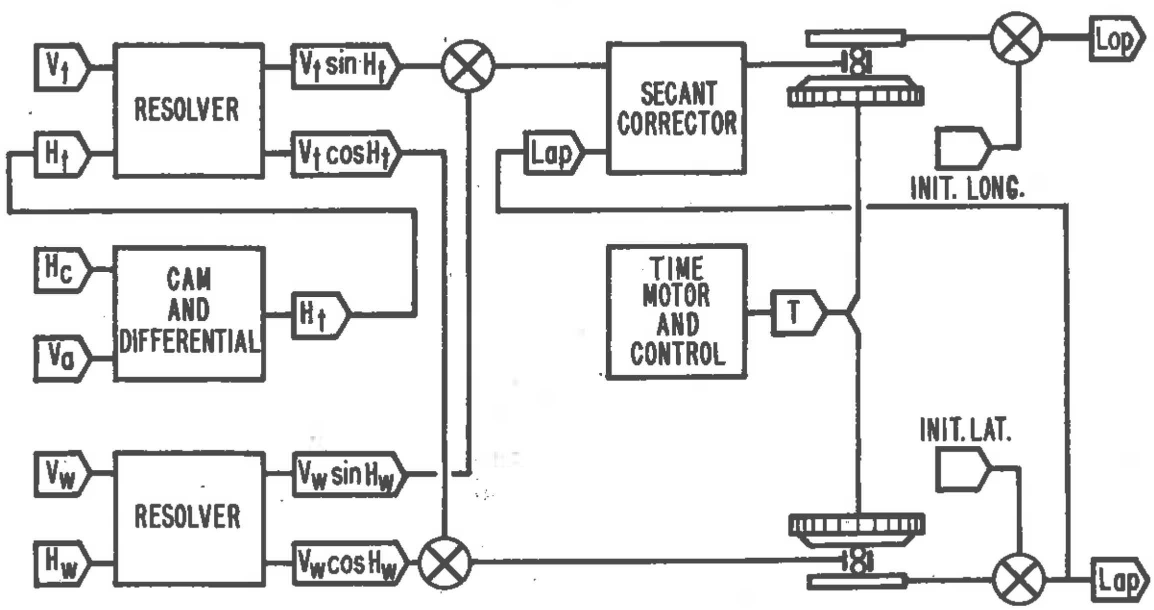


Figure 1—Flow diagram, Ground Position Indicator.

in nautical miles, and provides the pilot with a complete navigational system, telling him where he is, how far he has to go, and what course to fly to get there.

● ● Inputs and Outputs

The input data are obtained from instruments solely on board the aircraft, with the following automatic inputs necessary for the proper operation of the computer set:

1) magnetic heading from a slaved gyro magnetic compass.
2) true air speed from a true air speed computer and transmitter.
3) compass transmission error correction.

The computer set also requires the following three inputs which are inserted manually into the system:

1) wind force.
2) wind direction.
3) magnetic variation.

The outputs, naturally, are the coordinates of the present position of the aircraft and the distance (in nautical miles) and course to go. While normally displayed by means of counters and pointers, some outputs can also be relayed by synchro transmission to dependent equipment on board the airplane, such as for operation of dead-reckoning tracers, for remote indication, or for tie-in with the autopilot.

Block diagrams of the equipment, showing inputs, outputs and principal computing elements, are given in Figures 1 and 2.

Two basic navigational computations are performed by the equipment: computation of the map coordinates of the airplane position, and computation of the course and distance to go. These are calculated in two steps—first finding the aircraft ground position, then calculating the course and distance to go.

To find the aircraft ground position, the instrument has to add to the coordinates of the take-off point the coordinates covered by the plane from the take-off to the present position. The ground distance an airplane covers is ground speed integrated over flying time. The airplane ground speed is obtained by measuring

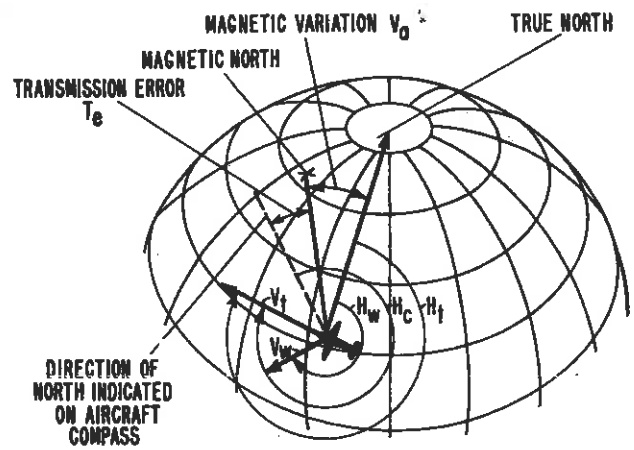


Figure 3—Geometry of aerial navigation.

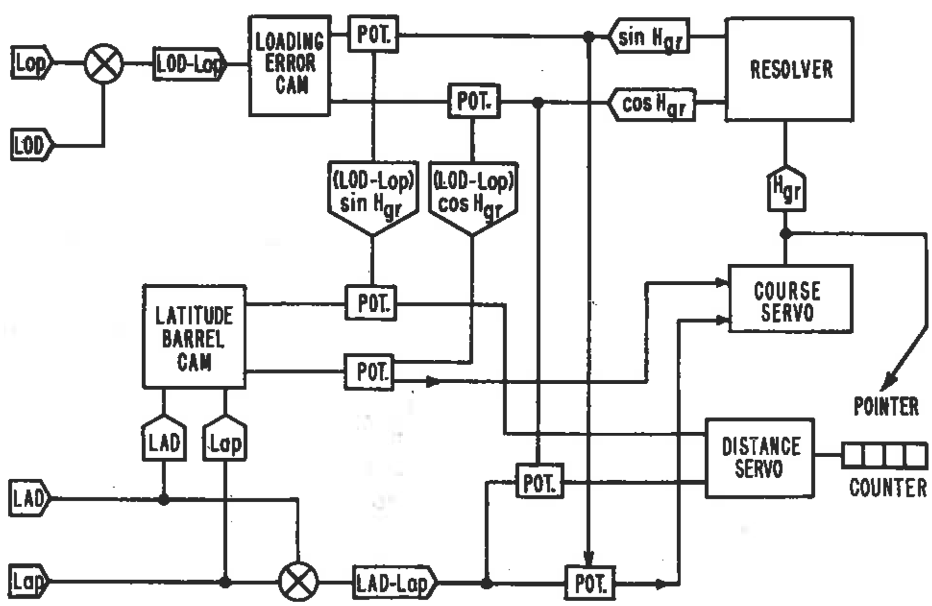


Figure 2—Flow diagram, Course and Distance Computer.

the speed of the airplane relative to the surrounding air (measuring the true air speed) and by adding to this air speed the speed of the air mass relative to the ground (wind speed), which the pilot ascertains before take-off. (He can also receive this information by radio while in flight, but this is not essential.)

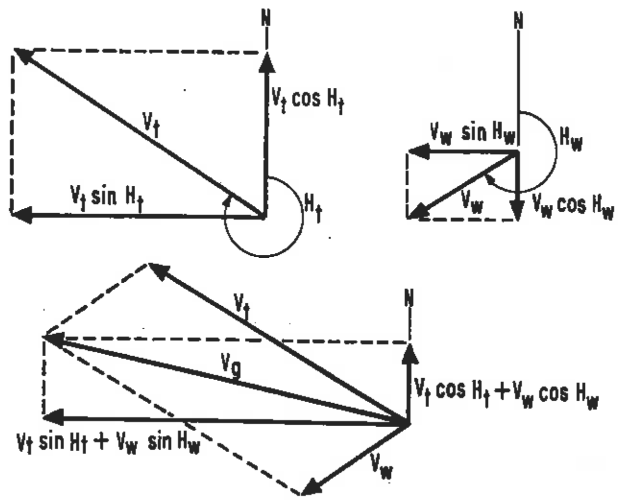


Figure 4—Resolution of ground velocity & wind vectors.

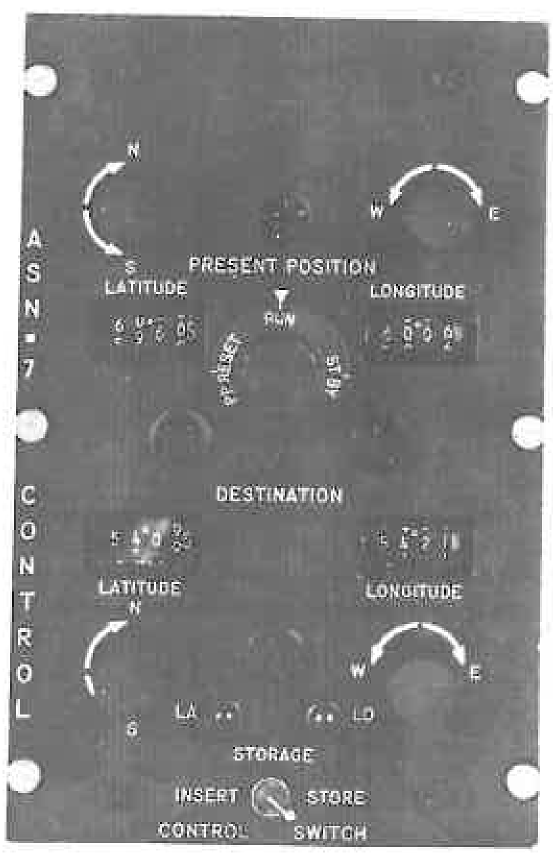


Figure 5—Control Unit, Course and Distance Computer.

Thus, the ground position of an aircraft at any time during flight depends on its true air speed (V_t), true heading (H_t), wind speed (V_W), and wind heading (H_W). Figure 3 shows the geometry and the relationship of the various quantities used in the ground position indicator. True airspeed, wind force and wind heading are direct inputs to the system, while true heading is derived from the remaining inputs, namely magnetic heading (H_c), compass transmission error (T_e), and magnetic variation (V_a). Therefore,

$$H_t = H_c + T_e + V_a,$$

Figure 6—Control Unit, Ground Position Indicator.

where T_e and V_a are positive when measured clockwise from their reference axes.

The N-S ground speed of an aircraft is the algebraic sum of the latitudinal components of true air speed and wind speed, $V_t \cos H_t + V_W \cos H_W$. A vector diagram relating the various velocity and heading components is given in Figure 4.

The length of arc traversed in the N-S direction is equal to

$$\int_0^t (V_t \cos H_t + V_W \cos H_W)dt,$$

with a similar expression holding for the arc traversed in the E-W direction.

Conversion from distances to geographic longitude and latitude is a simple matter. If the airplane speed is given in knots, the distances are in nautical miles and one nautical mile equals one minute along the meridian. Nautical miles can be converted directly into degrees latitude; additional multiplication by the secant of latitude, to correct for meridian convergence, is automatically performed by the equipment to change the east-west nautical miles into degrees of longitude.

Thus, by automatically adding the number of degrees latitude and longitude covered by the airplane from the time of take-off to the degrees latitude and longitude corresponding to the take-off point, the computer determines continuously the latitude and longitude of the airplane's present ground position.

The next step is to compute the remaining distance to go and the course the airplane must follow to reach its destination. With the latitude and longitude of the destination point known and set into the instrument, the instrument automatically subtracts the coordinates of the destination from the present ground-position coordinates and calculates the remaining air distance and the course.

If *LOP*, *LOD*, *Lap*, and *Lad* are respectively the longitudes and latitudes of the present position and destination, the course and distance computer section solves the following equation for the course to destination *(Hgr)*:

$$\tan Hgr = (LOD - LOP)/[\ln(\sec Lad + \tan Lad) - \ln(\sec Lap + \tan Lap)];$$

and for the distance to destination,

$$D = (LOD - LOP)\cos La \sin Hgr + (Lad - Lap)\cos Hgr,$$

where cos *La* is a complicated function of latitude:

$$\cos La = (Lad - Lap)/[\ln(\sec Lad + \tan Lad) - \ln(\sec Lap + \tan Lap)],$$

which is instrumented with a three-dimensional cam.

Figure 7—Ground Position Indicator counters.

Figure 8—Pointer and Counter, Course and Distance Computer.

Presentation

Performance of the equipment is automatic. Before take-off, the pilot sets the present longitude and latitude counters to the coordinate of the air base. He next sets the coordinates of the destination. This causes a dial indicator on the panel board to show automatically either the present position alone or the present position plus the course and distance to destination, Figures 5, 6, 7 and 8.

After take-off, when the plane has reached its altitude, the present position and the course and distance to go are continuously displayed on the indicator. But the pilot can make some refinements and adjustments at any time. These adjustments are sometimes necessitated by changes in wind speed and sometimes are made merely to check on the present-position indication should the plane be passing over a landmark with known coordinates.

The ground position indicator alone weighs approximately 45 pounds; adding the course and distance computer increases the weight to 65 pounds. The respective volumes are 1.3 and 1.8 cubic feet. The equipment operates at aircraft speeds from 70 to 800 knots. Meridian convergence considerations and vagaries of the earth's magnetic field limit its latitude to $\pm 70°$.

The weight and space limitations inherent in all airborne equipment were successfully coped with in the design of this equipment by using precision cams to generate the non-linear and non-sinusoidal functions used in the computer. Such a non-linear function is the residual deviation and the compass-transmission-error correction. A special cam is also used to compensate for the loading error of some of the potentiometers used. A rhumb-line computation is used for the course and the distance; a precise three-dimensional cam gives the intricate functions of latitude necessary for the computations. Electric potentiometers and resolvers are used for the linear and sinusoidal functions. Electronic amplifiers are used to control the servo motors in the system, for resolver isolation, and to produce an accurate time standard.

While the principal functions of the system are as described above, many other features are incorporated for greater versatility. For example, an alternate destination or a second destination can be set into the equipment when necessary. Deviations from the flight path, such as detours around storms, are permissible without affecting the instrument's operation.

Flight longer than 1000 miles can be accommodated through an information-storage device built into the computer, which enables the pilot to breakdown his set-in flight plan into segments shorter than 1000 miles. While the equipment is designed to operate between 70°N and 70°S latitude, corrections can be made to maintain accuracy of the calculations should the airplane fly beyond the latitude limits. END

The AN/ASN-7

. . . AN AIRBORNE NAVIGATIONAL SYSTEM
WHICH DISPLAYS COURSE AND DISTANCE

An outgrowth of Ford Instrument's ASN-6, the ASN-7, is an automatic navigational system which continuously displays the rhumb-line course a pilot should follow and the rhumb-line distance he has to go to get to his destination - regardless of how his flight path changes. In addition, it displays the present position (latitude and longitude) of the plane at all times.

This computing system is designed for distances up to 1000 miles without resetting and for operation between 70° north and south latitude. It can easily handle flights over 1,000 miles by simple resetting. Course and distance are displayed on the small indicator illustrated on the other side of this page - which shows direction and nautical miles.

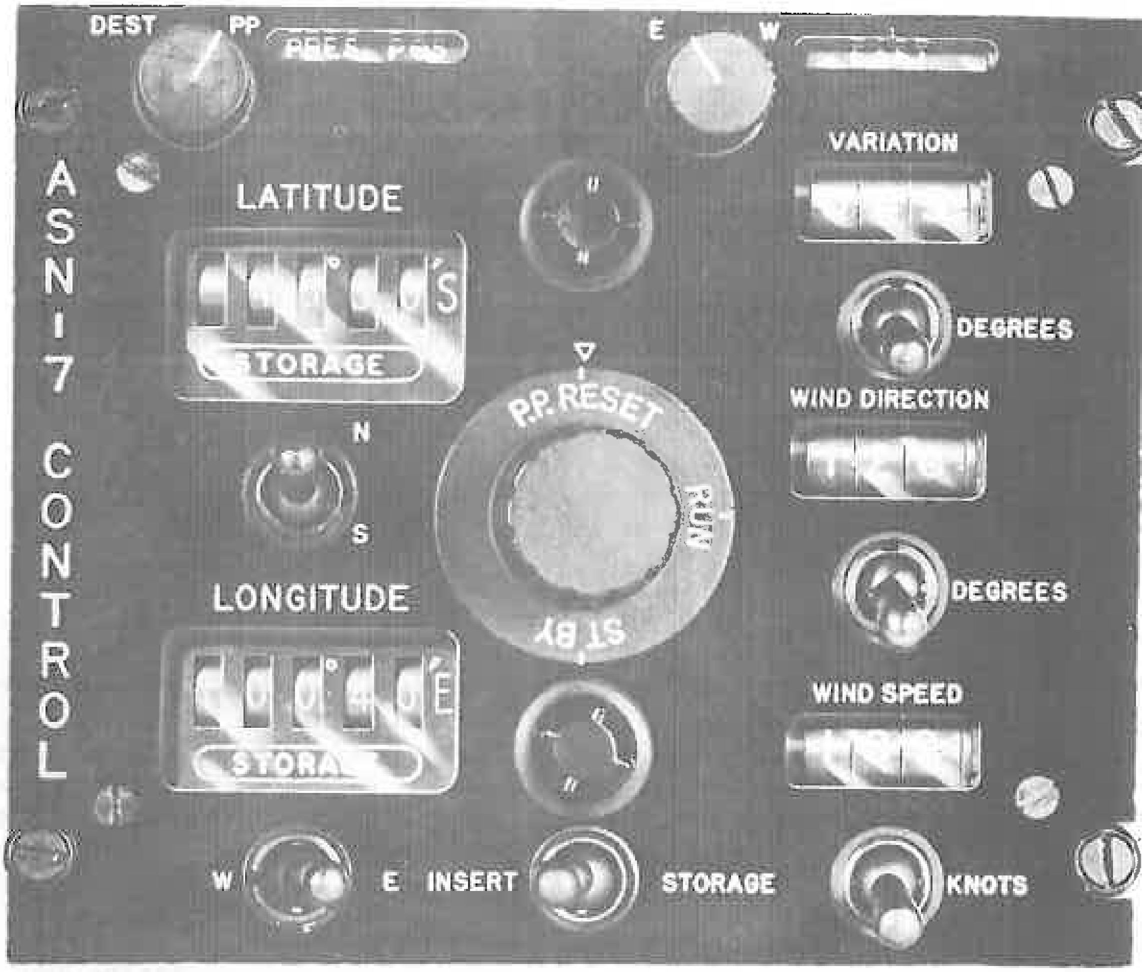
The ASN-7 employs some of the units from the ASN-6, and includes a new control unit, as well as the course-distance indicator shown. The control unit, also illustrated, serves both as an indicator, displaying present latitude and longitude, and as an input into which the pilot sets the latitude and longitude of his destination, using slew switches. This destination can be set in at any time, and changed at any time - but the system will continue to tell the pilot what direction to fly and how far he has to go to his new destination. Provision is made so that an alternate or succeeding destination can be set in prior to take-off in a storage circuit.

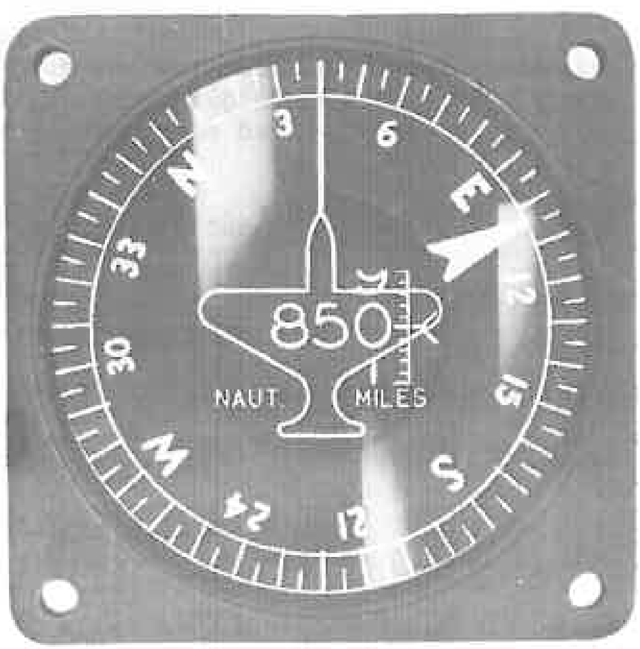
Otherwise, the inputs to the ASN-7 are the same as in the ASN-6. The pilot sets in his magnetic variation, wind speed and wind direction on the control unit illustrated. In addition, the ASN-7 has an automatic magnetic variation computer permitting automatic compensation if desired.

A top feature of the system is that it permits a pilot to take off from one point and fly to accomplish a mission - using the ASN-7 to guide him there. Then, when his mission is accomplished, he can set in the latitude and longitude of his home field, another field, or his carrier (or insert a previously stored destination) and follow the system's direction on return.

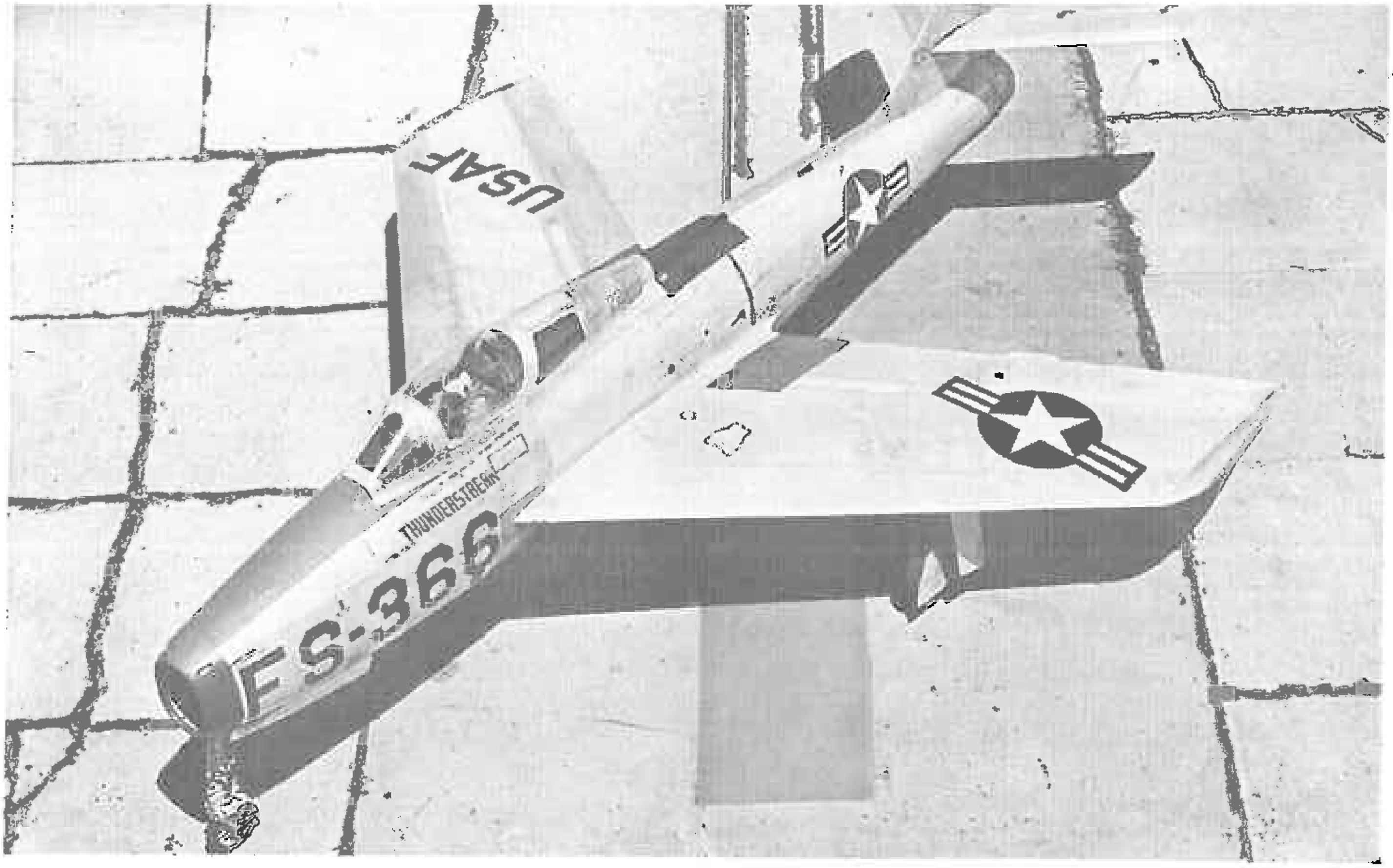
Total weight of the present version of the ASN-7 is about 65 lbs. and its volume is about 2 cu. ft. Its accuracy matches that of the ASN-6 (1.5% total distance traveled for present position) and is 6 miles on course and distance.

FORD INSTRUMENT COMPANY
Division of Sperry Rand Corporation
31-10 Thomson Avenue
Long Island City 1, N.Y.





Control and indicator units of ASN-7 Course and Distance Computer shown full size.

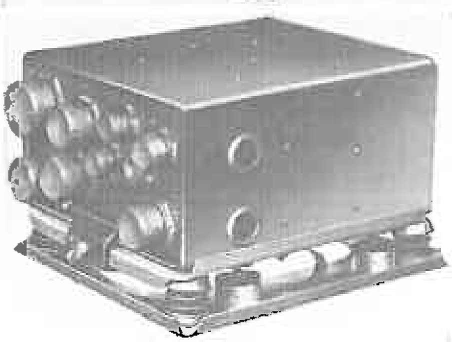


Many super-fast jet aircraft of the USAF similar to Republic's sleek, swept-wing F-84F Thunderstreak will be equipped with this new aid to flight control and plane navigation.

engineering done in connection with this instrument.

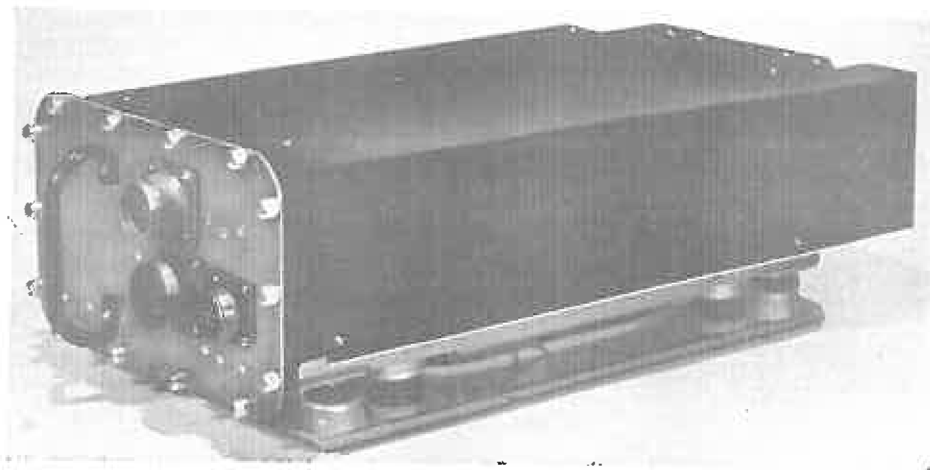
SOME POTENTIALITIES

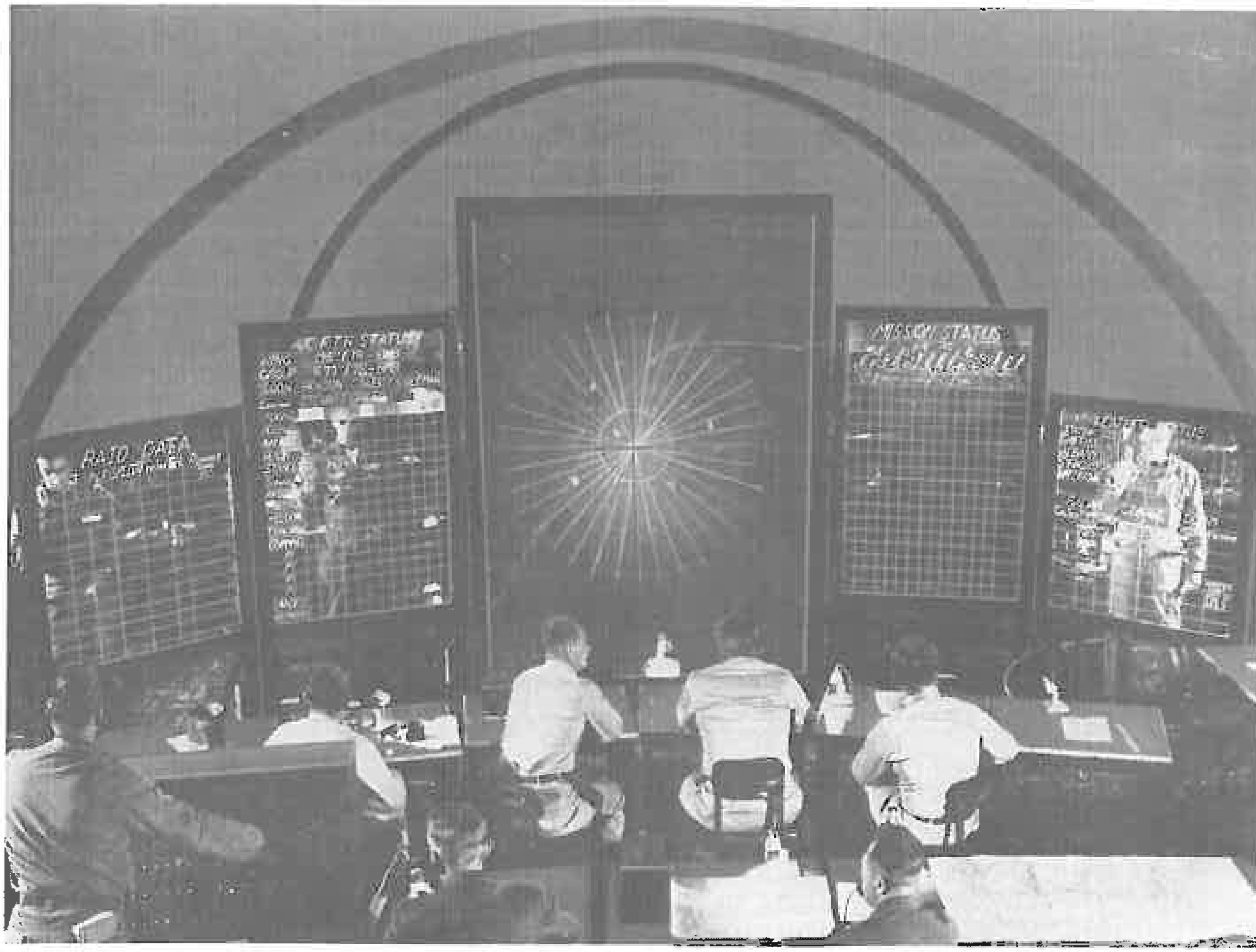
The AN/ASN-6 tied in with other devices, such as radio or radar navigational aids, could become an instrument to give more accurate wind information to the pilot and navigator. Its adaptation into a course and distance computer would not be impossible—the position of the ultimate destination would be set on the instrument and the indicator would tell the pilot if he is on the right course and what distance he has yet to fly. Or the same information might be fed directly to the automatic pilot, and the entire flight would become automatic. There are adaptations that would be valuable aids to aerial cameras used for mapping; and since the AN/ASN-6 is a passive system, it could be used with initial guidance for a missile or bomber to bring it to a target area, at which point some other guidance system could direct it to its pin-point target.



Upper photo is of Computer Control Unit. Hermetically sealed to provide controlled atmosphere for working parts, it is mounted in cockpit console. Below is photo of the Computer, which is also hermetically sealed and is remotely mounted from the Control.

Amplifier, which is remotely mounted and gasket sealed, houses instrument's electronic units. All are in sub-units that can be pulled out and plugged in for easy maintenance.





Official U.S. Air Force Photograph

Friend or foe? Tactical defense officers in MINK control center watch movements of aircraft as reported from radar warning sites. This is equipment developed under the direction of Rome Air Development Center.

ROME AIR DEVELOPMENT CENTER PROVIDES AIR DEFENSE EQUIPMENT FOR OUR AIR FORCE

One development agency for the Air Force's ground-based electronic equipment is Rome Air Development Center, located at Griffiss AFB in Rome, N. Y. One of the ten centers of the Air Research and Development Command, RADC is concerned with the air defense of our nation, with providing equipment for tactical supremacy, and with developing ground complexes for various navigation systems to aid all aircraft. In addition, RADC is charged with data handling improvements for the Air Force intelligence mission.

RADC is the responsible center for development, through its various contractors, of such end products as radar sites, including improved tubes, circuits, antennae, and shelters; ground communications equipment and associated support items; IFF (Identification Friend or Foe) environments, and electronic countermeasures.

Bringing complex systems from the written requirements to the actual hardware items to be used in the various Air Force commands is a long and tedious business which draws upon the skills of RADC's 500 civilian and military engineers and their many counterparts in private industry.

FORD INSTRUMENT COMPANY

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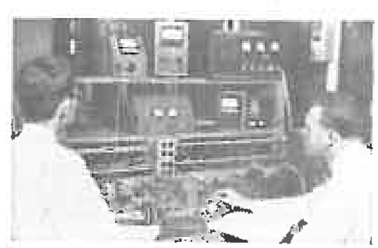
31-10 Thomson Ave., Long Island City 1, N. Y.

This is one of a series of ads on the technical activities of the Department of Defense



Engineers at Ford Instrument Company working on a special Air Force project in one of the company's laboratories.

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