DESCRIPTION OF
GROUND POSITION INDICATOR
TYPE A-1

Prepared for U. S. Air Force

by

FORD INSTRUMENT COMPANY

Division of The Sperry Corporation

Long Island City, New York

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DESCRIPTION

OF

FORD GROUND POSITION INDICATOR TYPE A-1

The Ford Instrument Company Ground Position Indicator System Type A-1 consists of four airborne instruments that continuously compute and display present latitude and longitude of an aircraft in flight.

GENERAL DESCRIPTION

Input data are obtained from instruments solely within the aircraft. For greater output accuracy and automatism, G.P.I. Type A-1 can be operated with radar inputs.

Components of the G.P.I. system are: The Indicator Unit, Preset Control Box, Computer Unit, and Amplifier Unit.

The Indicator Unit (Figure 1) is mounted on the instrument panel; it displays on counters the present latitude and longitude of the aircraft; it also holds two slewing switches for setting in the latitude and longitude of the point of departure.

The Preset Control Box (Figure 2) is console mounted within convenient reach of the pilot; wind direction, wind force, and variation are manually set in this box. When radar is used, wind force is zeroed.

The Computer Unit (Figure 3) and the Amplifier Unit (Figure 4) may be placed at any accessible location. The Computer Unit receives true air speed and compass heading from other instruments.

The weight of the system, exclusive of cables, is about 45 pounds. Range is unlimited, but system operation is limited to latitudes less than 70°.

Electrical requirements: 115 v., 400~; 28 v. D.C.

PRINCIPLES OF OPERATION

The variables entering into the ground position determination are shown in Figure 5. To determine the aircraft's ground speed, and from this speed the ground position, we must know the vectors of true airspeed Vt and of wind force Vw. Wind direction Hw and force Vw are assumed to be available. True air speed Vt is also available; we can find its true heading Ht by algebraically adding to the magnetic heading Hc the values of magnetic deviation De and magnetic variation Va.

The latitudinal and longitudinal components of true air speed and of wind force are found by reference to Figure 6. The latitudinal component of true air speed --- Vt cos Ht, is added to the latitudinal component of wind force --- Vw cos Hw. The addition yields the latitudinal speed of the aircraft: Vt cos Ht + Vw cos Hw.

To find the longitudinal speed of the aircraft, we must allow for meridian convergence. This allowance is made by multiplying the east-west component of the aircraft's ground speed by the secant of present latitude. The east-west component is the sum of the east-west components of true air speed and wind force: Vt sin Ht + Vw sin Hw.

Accordingly, the longitudinal speed of the aircraft is (Vt sin Ht + Vw sin Hw) sec Lap, where Lap is the present value of latitude.

<u>Present Position</u>

The changes in latitudinal and longitudinal positions are generated by the time integrals of the latitudinal and longitudinal speeds. These changes are added to the values of initial latitude and longitude, which are put into the system at take-off, to yield the aircraft's present ground position. In equation form, present latitude and present longitude (Lop) may be expressed as:

$$\text{Lap} = \int_0^t (\text{Vt cos Ht} + \text{Vw cos Hw})\,dt + \text{Lai},$$

$$\text{Lop} = \int_0^t (\text{Vt sin Ht} + \text{Vw sin Hw}) \text{ sec Lap } dt + \text{Loi},$$

where Lai and Loi denote initial latitude and longitude, respectively; and t denotes the "time" variable of integration.

The Ford Ground Position Indicator Type A-1 uses the preceding equations in the following form:

$$\text{Lap} = \int_0^t (\text{cos Ht} + (\text{Vw/Vt})\text{cos Hw})\ d(\text{Vt}\cdot t) + \text{Lai},$$

$$\text{Lop} = \int_0^t (\text{sin Ht} + (\text{Vw/Vt})\text{sin Hw})\ d(\text{Vt sec Lap}\cdot t) + \text{Loi}.$$

Radar Operation

When the Ford Ground Position Indicator Type A-1 is used with associated radar the wind force knob is zeroed. Automatic inputs are true ground speed, drift angle, and magnetic heading; manual input is variation.

DESCRIPTION OF COMPONENTS

The packaging of the Ford Ground Position Indicator Type A-1 features miniaturized units, readily producible, extremely flexible, compact and light in weight. The system consists of four self-contained separate units: Preset Control Box, Computer Unit, Amplifier Unit, and Indicator Unit.

Preset Control Box

The Preset Control Box contains components necessary to set remotely wind direction, wind force, and variation data into the system. The input control knobs are connected to coarse and vernier dials, and to transmitters for conveyance of the signals to the Computer Unit.

Computer Unit

The Computer Unit includes the majority of mechanical and electro-mechanical computing elements. The unit receives wind force, wind direction, and variation signals from the Preset Control Box. True air speed is received from a Type A-1, A-2, C-1, or C-2 True Airspeed Computer, or equal. Magnetic heading is received from a Type J-2, J-4, or N-1 Slaved Gyro Magnetic Compass. Magnetic heading is corrected by a cam-type compensator for residual deviations. The deviation corrections and magnetic heading are then added to magnetic variation to generate true heading.

Amplifier Unit

The Amplifier Unit includes electronic and electrical components for operation of the other units. The power supply section delivers 26-volt 400-cycle power to synchros, 24-volt 400-cycle power to resolvers. Power is obtained from the 115-volt 400-cycle single-phase aircraft supply, and from a 28-volt D.C. power source.

Ground Position Indicator

The Ground Position Indicator is a panel-mounted unit that receives changes in latitude and longitude from the Computer Unit, and continuously displays present latitude and longitude on veeder-type counters. The counters are resettable during operation of the system.

ACCURACY

The maximum total air-position error is expressed as a percent of the computed nautical miles traveled. If the maximum component errors and maximum combinations of these errors are assumed, then the actual air-position error should be about 1.5%. For radar operation, the figure should approximate 0.7%. Since it is improbable that all errors will reach their maximums at the same time, it is expected that the overall errors may be less.

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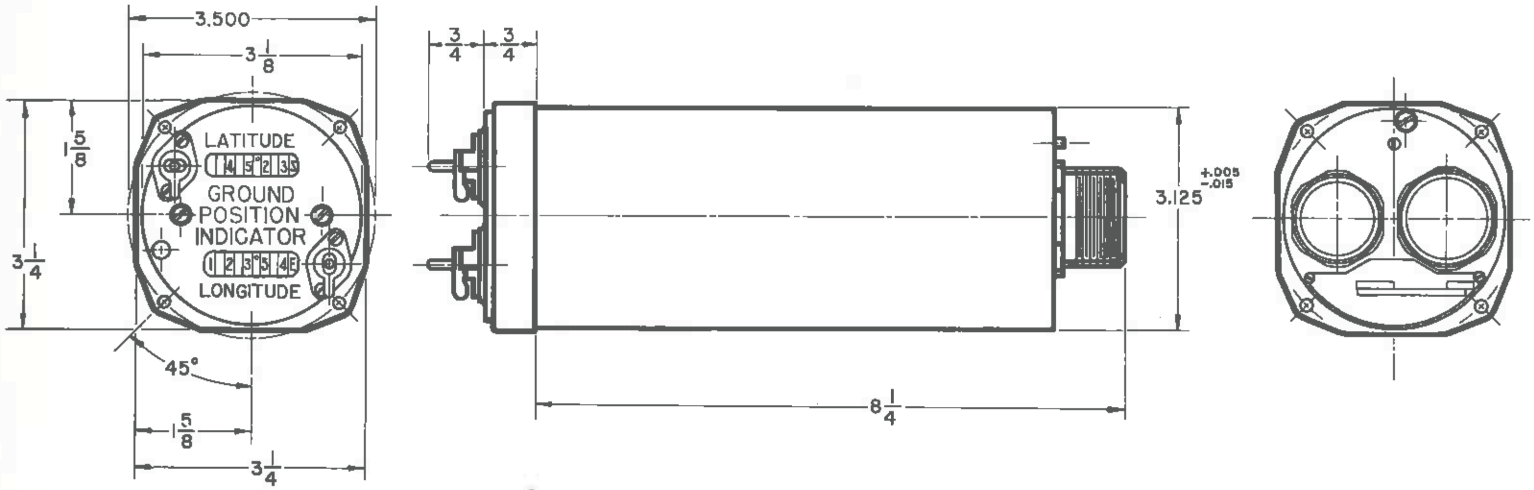
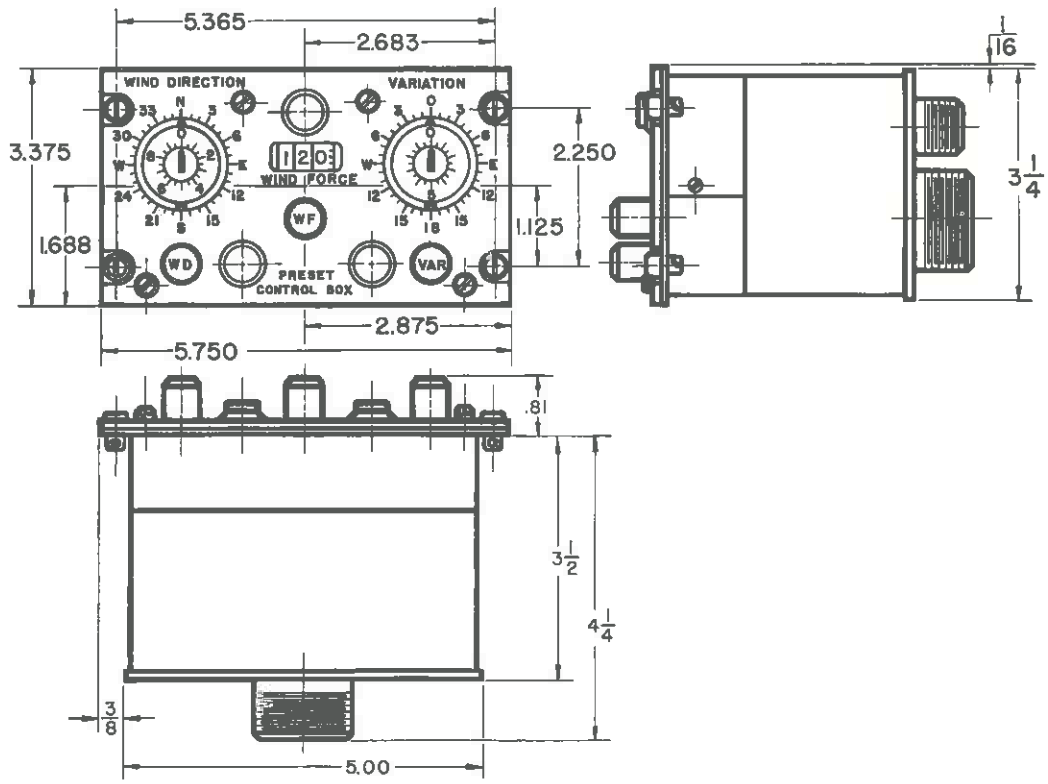


Figure 1.



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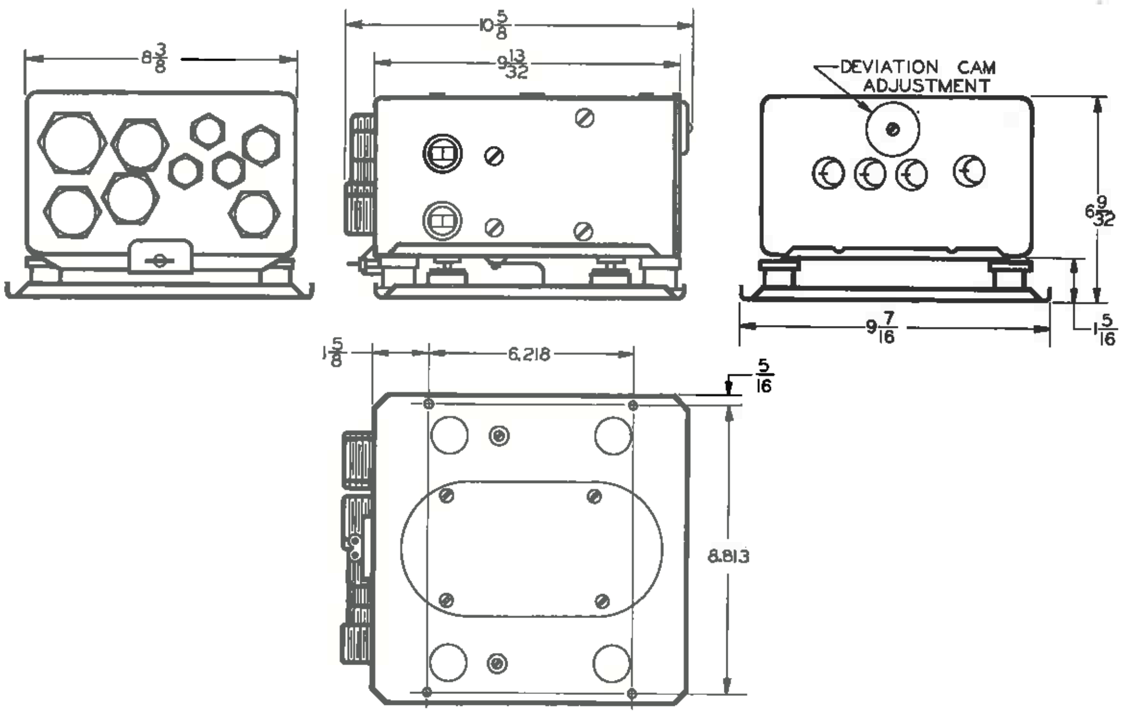

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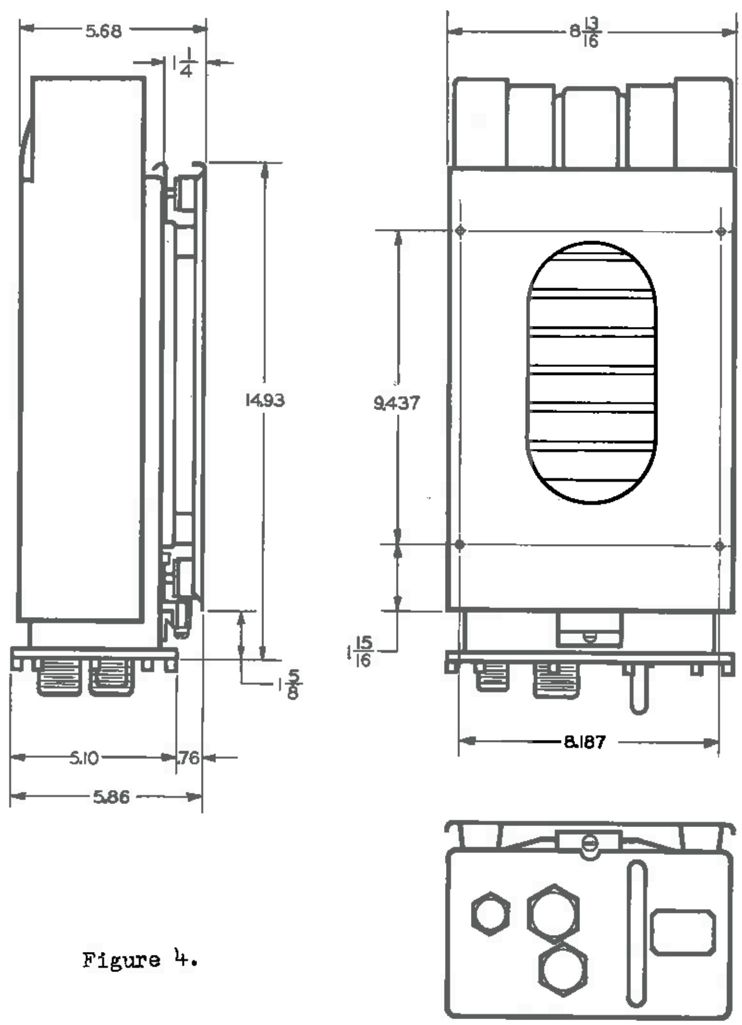

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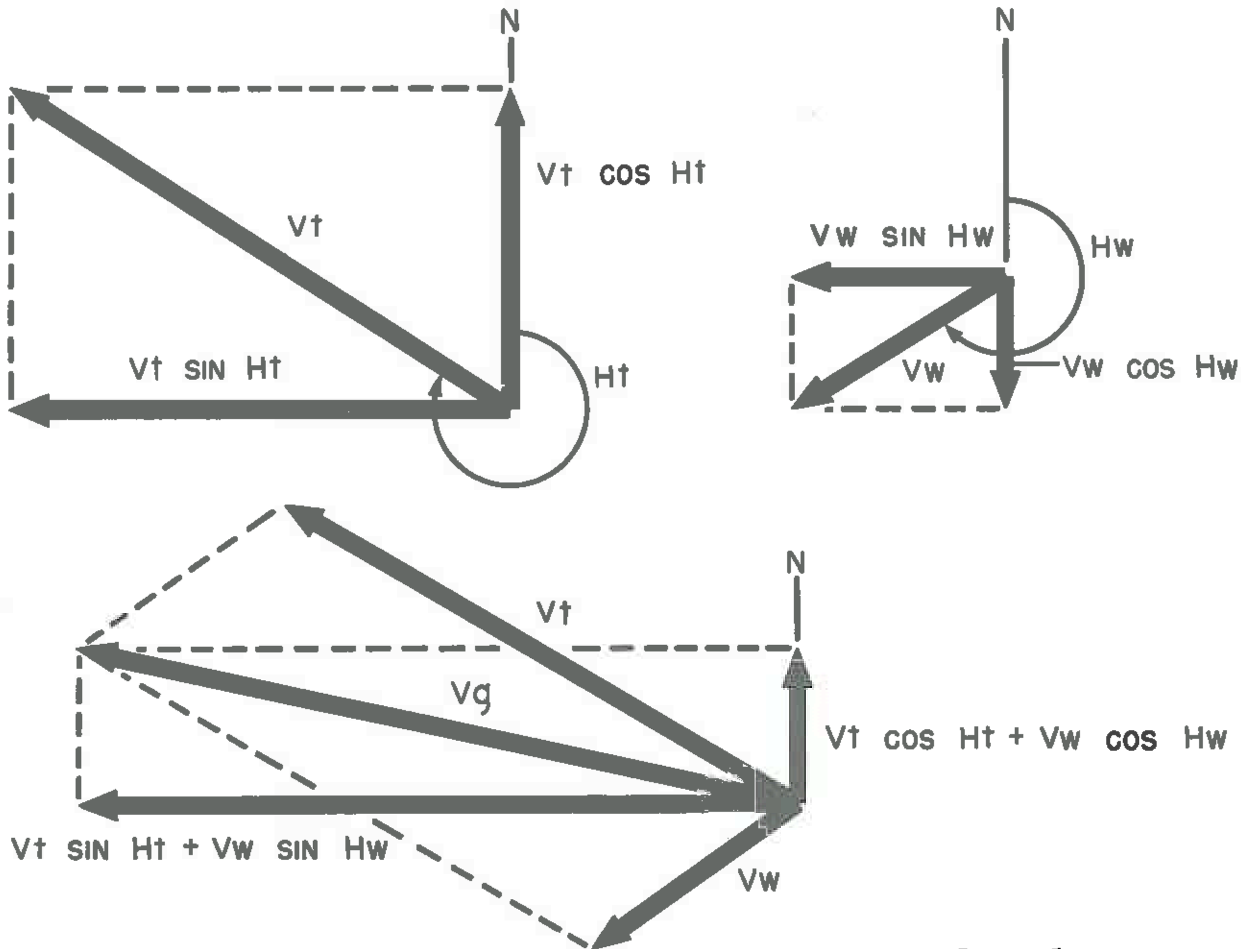
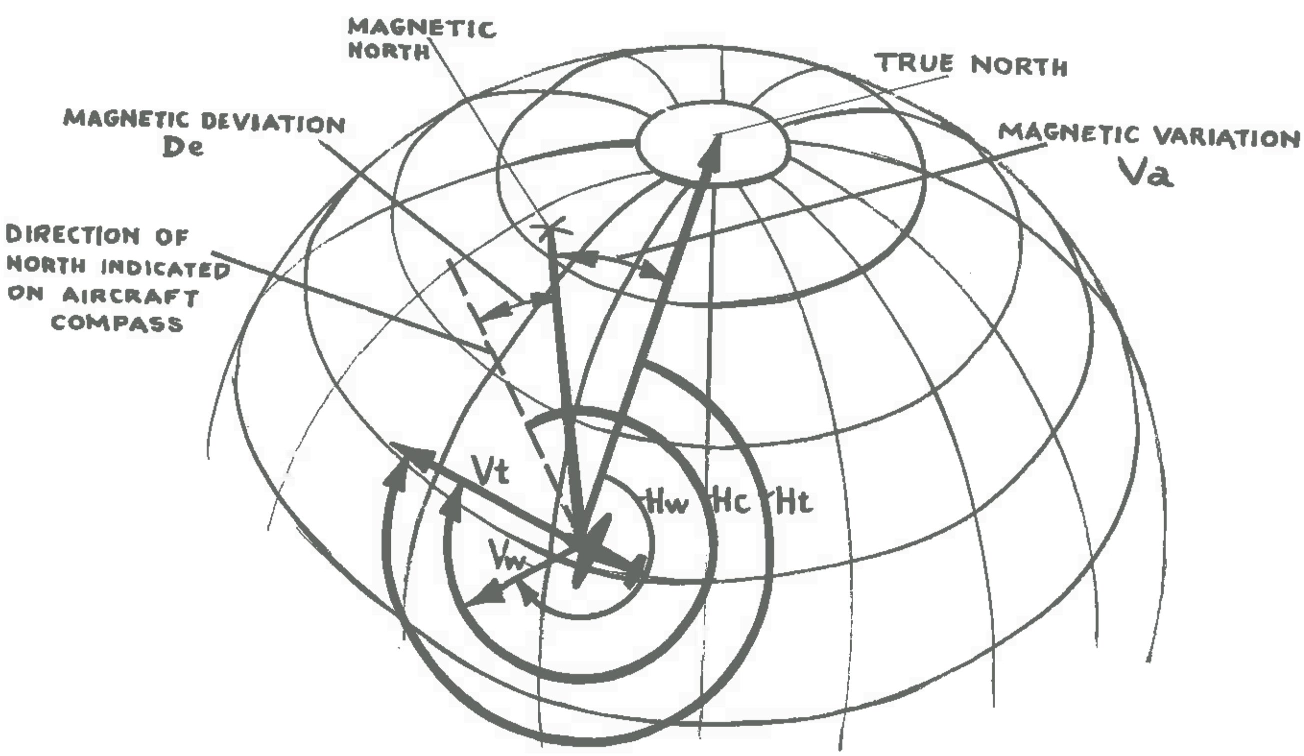


Figure 5.



GEOMETRY FOR THE GROUND POSITION INDICATOR

Figure 6.