



LIGHTWEIGHT
**AUTOMATIC
PILOT**

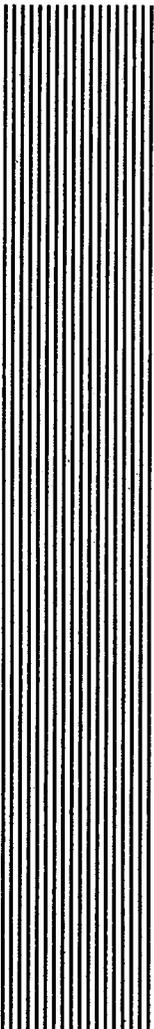
AP-102

DESCRIPTIVE SPECIFICATION

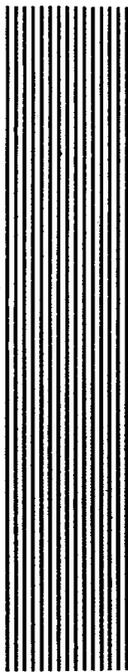
Collins

R A D I O C O M P A N Y

DESCRIPTIVE --- SPECIFICATIONS



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Printed in U.S.A.

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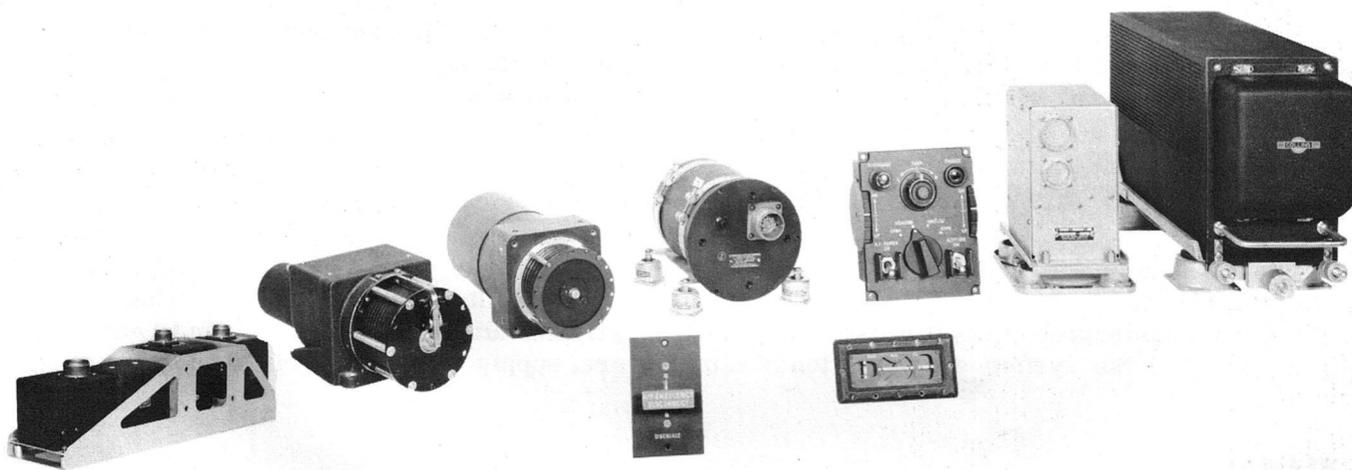
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LIGHTWEIGHT AUTOMATIC PILOT AP-102



V358-06-P

Figure 1. SYSTEM COMPONENTS.

AUTOMATIC PILOT AP-102

INTRODUCTION

Complete flight directors, automatic pilots, and magnetic compasses have been produced by Collins Radio Company for commercial aircraft application for several years. Due to the complexity and relatively large size and weight of these equipments, operators of small aircraft have been forced to choose control systems with only the most basic flight functions.

Collins past experience, plus the use of new design and engineering techniques, has brought the development of a complete line of lightweight flight control units applicable for use in lightweight aircraft. These new systems permit substantial savings in both size and weight and give the pilot all of the flight assistance formerly available to the commercial operator only.

Collins Automatic Pilot AP-102 is an efficient, lightweight system for flying an aircraft automatically during cross-country flight or during approach to instrument landing system (ILS) runways. It serves as a companion unit to Collins other new lightweight airborne equipments, Flight Director System FD-107 and Magnetic Compass MC-102.

The AP-102 operates on the same basic principles as the past Collins AP-101 series. A considerable reduction has been accomplished in equipment size and weight, however. The mechanical operation of the control surface servo mechanisms has also been modified in line with the weight-volume saving techniques.

OUTSTANDING FEATURES

LIGHTWEIGHT, SMALL VOLUME

Use of the most advanced engineering techniques and available components provides a high quality automatic pilot weighing approximately 66.5 pounds, with the new Computer-Amplifier 562C-2 housed in a standard short 1/2-ATR case. A previous version of the Computer-Amplifier was housed in a long 1/2-ATR case.

TRANSISTORS AND MAGNETIC AMPLIFIERS

The new automatic pilot design incorporates the reliability of proved magnetic amplifier and transistor circuitry. The high efficiency of these devices results in low temperature rise. Long life and low maintenance costs can also be expected. Particular attention has been given to gain and null stability of the system as a function of temperature, supply voltage, and other environmental factors.

RELIABILITY

Circuit and equipment components have been selected on the basis of reliability as well as performance. The number of relays and other such components has been held to a minimum by using well planned and coordinated design procedures.

AUTOMATIC PILOT/FLIGHT DIRECTOR COMBINATION

A lightweight flight director system, such as the Collins FD-107, must be employed as a companion unit with the Automatic Pilot AP-102. The former furnishes attitude and steering data to the AP-102 and permits complete visual monitoring of the automatic system. The combined operation allows an efficient common use of components and offers operational features not available from using the flight director separately. The pilot may, at any time he desires, take manual control and fly the system as a flight director. The FD-107 installation does not disturb the use of the AP-102.

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This combination provides a considerable saving in equipment size and weight. The 66.5-pound automatic pilot and the 23-pound Flight Director FD-107 offer complete flight control at a weight of less than 90 pounds.

SERVICE ADVANTAGES

Use of functional subassemblies in the form of modular, plug-in subunits facilitates equipment maintenance and servicing. By checking through means of test points, a faulty unit can be located easily, removed, and replaced with a spare. The equipment is returned to service quickly, and repair of the subunit may be accomplished later at a convenient location.

Equally important, this modular design concept permits ease in updating or modifying the system simply by replacing one or more plug-in modules with interchangeable new designs. The modules are standard wherever possible, allowing the same type of subunit to be used in several circuit applications.

MOUNTING

The AP-102 is designed to be compatible with several different types of mounting, as follows:

1. Standard ARINC radio racks with forced-air cooling provisions.
2. Individual shockmounts without forced-air cooling provisions.
3. Shelf-type radio racks without forced-air cooling provisions.

SYSTEM COMPONENTS

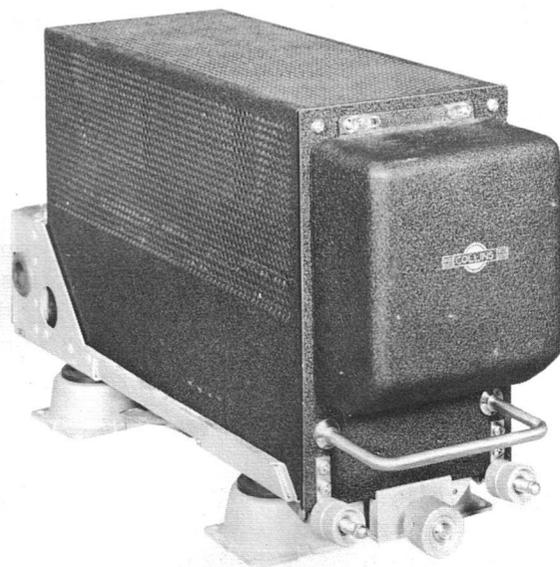
Automatic Pilot AP-102, shown in figure 1, consists of the following components:

Computer-Amplifier 562C-2
Shockmount 349D-4
Pedestal Controller 614E-2
Switching Unit 614E-3
Shockmount 349P-1
Altitude Controller 590A-2
Sensing Unit 345A-3
Primary Servo 334C-4
Servo Mount 351B-4
Trim Tab Servo 334D-1-14
Trim Indicator 327D-1W
Emergency Disconnect 121A-2

COMPUTER-AMPLIFIER SHOCKMOUNT

Collins Computer-Amplifier 562C-2, shown in figure 2, is housed within a standard short 1/2-ATR case. It contains servo amplifier channels for all three control axes, glide slope and altitude hold computing circuits, turn coordination circuits, main power transformer, and isolated voltage supplies.

Modular construction is employed in the 562C-2. Circuits are separated functionally into 15 modular subunits. Six identical, interchangeable low-level amplifiers and three servo



V358-07-P

Figure 2. COMPUTER-AMPLIFIER 562C-2, housed in a standard short 1/2-ATR case, is mounted on SHOCKMOUNT 349D-4.

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amplifiers drive the primary servos. A front panel module contains test points for input and output signals and primary flight adjustment potentiometers. Additional modules contain computing circuits, engage circuits, and a power transformer.

The 562C-2 weighs 21-1/4 pounds and has dimensions of 5-1/4 x 7-3/4 x 17-1/4 inches. Connections to external components are made through two 45-pin connectors at the rear which mate with connectors on Shockmount 349D-4.

Shockmount 349D-4 is employed with the computer-amplifier to furnish the necessary vibration isolation for airborne environments. Outline and mounting dimensions for the 562C-2 and its mounting are shown in figure 12.

PEDESTAL CONTROLLER

Pedestal Controller 614E-2, shown in figure 10, is the control center for Automatic Pilot AP-102. The unit contains switches and controls which enable the pilot to operate the AP-102. It must be used in conjunction with Switching Unit 614E-3.

The power switch is used to control power to the computer-amplifier and primary servos. The four-position function selector knob, marked GYRO, HEADING, NAV/LOC, and APPR, is employed to select the mode of operation. The altitude switch is used to energize the Altitude Controller clutch in GYRO, HEADING, and NAV/LOC and to turn on the pitch control motor. It is interlocked so that it will not operate in APPR or when the pitch control knobs are moved. The pitch controller circuit is operated by knobs on either side of the 614E-2. This circuit controls the pitch attitude of the aircraft in GYRO, HEADING, and NAV/LOC when the altitude switch is off. During APPR or altitude hold, the pitch control motor drives the pitch controller to correct the attitude of the aircraft. The turn controller knob, used to maneuver the aircraft in the GYRO mode, becomes inoperative when other functions are selected. Complete pedestal controller services are described in the section beginning on page 7.

The unit, provided with a connector for electrical connections at the rear, is constructed of an aluminum chassis and an edge-lighted front panel. All circuits are protected by dust covers. Weight of the 614E-2 is approximately 2-3/4 pounds. It is 4-1/2 x 5-5/8 x 4-1/2 inches in size. Outline and mounting dimensions are shown in figure 14.

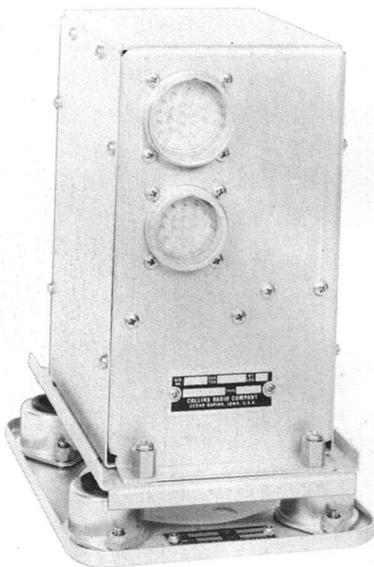
SWITCHING UNIT, SHOCKMOUNT

Switching Unit 614E-3, shown with Shockmount 349P-1 in figure 3, is used in combination with the pedestal controller. The unit provides fading and switching circuits and other control circuits for the AP-102. The fader potentiometers reduce channel gains to zero when changing functions or engaging, then "fade in" new commands slowly so that transient signals are removed. The unit also contains an engage holding relay, a-c power interlock relay, disengage light, localizer time-delay relay, fader relay, and engage switch. All circuits are protected by a dust cover.

The 614E-3 weighs approximately 3-1/4 pounds and is 5-5/16 x 3-5/8 x 6 inches in size. Shockmount 349P-1 weighs approximately 1/2 pound. Outline and mounting dimensions of the 614E-3 and 349P-1 are shown in figure 15.

ALTITUDE CONTROLLER

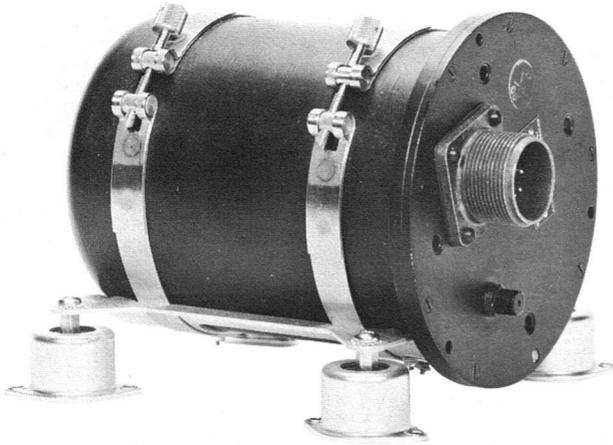
Collins Altitude Controller 590A-2, shown in figure 4, is a barometric altitude sensor with a clutch engaging mechanism. The altitude controller senses a change in altitude by detecting the corresponding change in barometric pressure, then converts this change into a proportional electrical signal.



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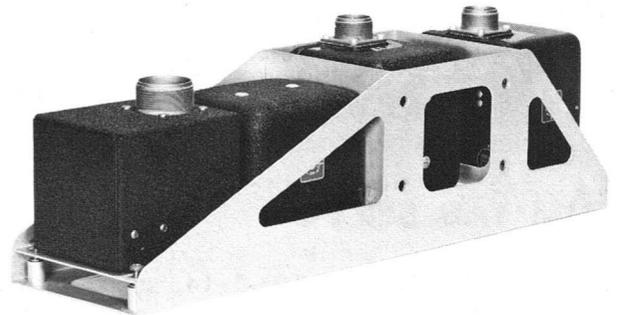
Figure 3. SWITCHING UNIT 614E-3, on SHOCKMOUNT 349P-1, operates with Pedestal Controller 614E-2.

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Figure 4. ALTITUDE CONTROLLER 590A-2 senses changes in altitude by detecting changes in barometric pressure.



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Figure 5. SENSING UNIT 345A-3 provides pitch yaw and roll axis information.

Electrical connections are made through a single connector. A static air hose connection to a 1/8-inch pipe thread is required. The 590A-2 may be located at any convenient location in the aircraft but should be as close as possible to the static air line to keep the length of the connecting hose at a minimum. Appropriate static line lengths and diameters should be obtained prior to installation.

The unit, equipped with special shockmount, is 5-3/4 x 5 x 6-13/16 inches in size and weighs approximately 2-1/4 pounds. Outline and mounting dimensions are shown in figure 13.

SENSING UNIT 345A-3

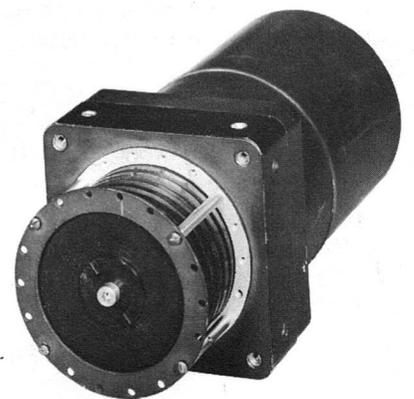
Sensing Unit 345A-3, shown in figure 5, consists of three rate gyroscopes, a relay box, and a supporting framework. The gyros are mounted so that they provide rate of change of attitude information in the yaw, pitch, and roll axes. When a preset rate of turn has been established, switch contacts in the yaw rate gyro close and operate a relay in the relay box which interrupts the power to the roll erection motor in the vertical gyro. The yaw and pitch rate gyros have maximum rates of six degrees per second. The roll rate gyro has a maximum rate of 20 degrees per second. The 345A-3 weighs 7.6 pounds and over-all measurements are 16-3/8 x 4-9/16 x 4-3/4 inches.

PRIMARY SERVO AND SERVO MOUNT

Three identical Primary Servos 334C-4, one of which is shown in figure 6, are used to position the aircraft aileron, rudder, and elevator surfaces. Each Primary Servo contains a split series d-c motor, position feedback synchro, rate generator, engage clutch, and necessary gearing. All electrical connections are made through a single multiple-contact connector at the rear.

Three identical Servo Mounts 351B-4, one of which is shown with the 334C-4 in figure 6, are employed with the primary servos. Each servo mount contains a capstan and mounts a primary servo.

Servo amplifiers in the computer-amplifier supply control power to the 334C-4 servos for positioning the 351B-4 capstans. The servo is engaged to the capstan by a 28-volt, d-c clutch. When the power is released, the face gears of the primary servo



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Figure 6. PRIMARY SERVOS 334C-4, with SERVO MOUNTS 351B-4, position the control surfaces.

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and servo mount disengage, the servo mount face gear being withdrawn by a flexure diaphragm. The diaphragm is connected to a splined shaft in the servo mount on which the capstan is mounted. When the primary servo is disengaged, the capstan is free to turn on ball bearings.

Each 334C-4 weighs approximately 4-1/4 pounds and is 3-3/4 x 3-3/4 x 6-1/2 inches in size. Each 351B-4 is approximately 3-3/4 x 3-3/4 x 3 inches in size and weighs 2-1/4 pounds. Outline and mounting dimensions for the two units are shown in figure 17.

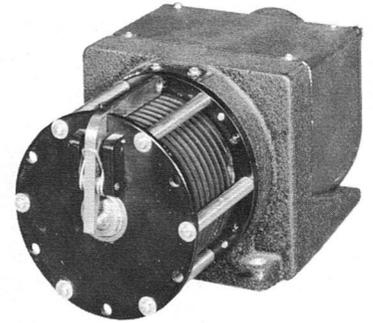
TRIM TAB SERVO

Trim Tab Servo 334D-1-14, shown in figure 7, is a direct-drive servo used to control the position of the elevator trim tab

of the aircraft. The servo is engaged with a magnetic clutch which couples the drive motor to the output capstan. After electrical engagement, the capstan can be mechanically disengaged. The trim tab servo can be overpowered by the pilot and has limit switches which confine the cable travel, preventing possible trim tab damage.

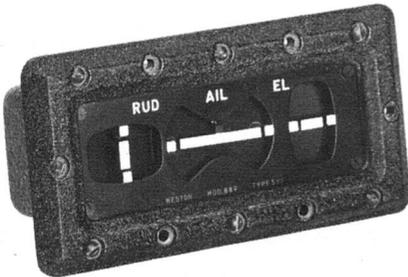
The 334D-1-14 has a maximum torque of 55 inch-pounds. This torque may be adjusted by changing a resistor in the control module of the Computer-Amplifier. The unit is mounted in a position on the aircraft frame best suited for the particular installation. It should be located for ease in servicing and mounted to a substantial airframe member.

Including its mounting frame, the 334D-1-14 weighs 6-1/2 pounds and is approximately 4 x 3-11/16 x 9-1/2 inches in size. Outline and mounting dimensions are shown in figure 17.



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Figure 7. TRIM TAB SERVO 334D-1-14.



V358-13-P

Figure 8. TRIM INDICATOR 327D-1W reports the trim condition.

TRIM INDICATOR

Collins Trim Indicator 327D-1W, shown in figure 8, is a three-axis trim indicating instrument. It receives aileron, rudder, and elevator position signals to show the pilot the trim condition of the aircraft.

The 327D-1W, housed in a rectangular case 4-1/32 x 1-3/4 x 2-1/32 inches in size, weighs approximately 1/2 pound. Connections are made at solder terminals at the rear. It should be mounted in a location where it can be seen easily by the pilot. Outline and mounting dimensions are shown in figure 19.

EMERGENCY DISCONNECT

Emergency Disconnect 121A-2, shown in figure 9, provides a means for disengaging the AP-102 system in case of emergency.

The 121A-2 consists of a positive-acting switch in a 1-13/16 x 3-3/16 x 4-inch housing mounted on the aircraft control panel.



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Figure 9. EMERGENCY DISCONNECT 121A-2 disengages the system in emergency.

DESCRIPTIVE SPECIFICATIONS

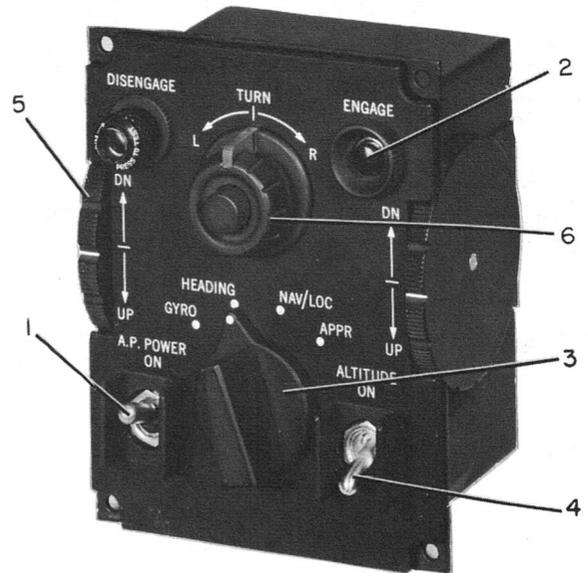
In its normal position, the switch permits 28-volt, d-c power to flow through the engage circuitry. With the switch thrown, the solenoid circuits are opened and the solenoid leads are grounded.

The emergency disconnect weighs approximately 3/8 pound; the outline and mounting dimensions are shown in figure 20.

HOW THE SYSTEM WORKS

The pilot selects functions, monitors, and controls the aircraft by the use of the pedestal controller and two other cockpit instruments included in Flight Director System FD-107, Approach Horizon 329B-2W, and Course Indicator 331A-2CW.

Pedestal Controller 614E-2, shown in figure 10, is the center of operations for the AP-102. The pilot controls engaging, selection of mode of operation, and maneuvering with this instrument.



V358-16-P

Figure 10. PEDESTAL CONTROLLER 614E-2 serves as the system control center.

ENGAGING

Twenty seconds after the power switch (1) is turned on, the system is ready to be engaged. The automatic pilot is then engaged by simply depressing the engage button (2).

No transient occurs in the engaging process. The aircraft continues to fly as before with new commands "faded in" slowly by Switching Unit 614E-3 during engagement or changing of functions with the function selector (3).

CHANGING FUNCTIONS

Switching between the four modes of operation (GYRO, HEADING, NAV/LOC, and APPR) is accomplished by rotating the function selector (3).

As mentioned earlier, new commands are slowly "faded in" when changing functions. The aircraft gradually stops doing what one mode calls for and begins following directions for the new function. The result is that changes take place smoothly, with no abrupt transition, and are under the pilot's direct control at all times.

DISENGAGING

The AP-102 is normally disengaged by pressing the electrical release button located on the aircraft steering wheel. This completely unmeshes the gears in the primary servos, leaving the capstans free to turn on ball bearings. The release system is designed for fail safe operation.

Another independent method of disengagement is accomplished by throwing the emergency disconnect switch.

The AP-102 is also disengaged by turning the power switch (1) off. If any power to the system is interrupted, the automatic pilot disengages itself.

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The AP-102 may be overpowered while engaged. The maximum cable pull is limited by controlling the maximum current in the servo motor. Resistors are inserted in the aircraft junction box to control this current. The human pilot can easily overpower the automatic pilot.

HOLDING ALTITUDE

Operation of the altitude switch (4) during GYRO, HEADING, or NAV/LOC operation provides automatic holding of a barometric altitude with the AP-102. The aircraft will automatically adjust its pitch attitude to hold the altitude at which the altitude controller was engaged.

The altitude switch is interlocked with the pitch control (5) on either side of the 614E-2. If the pilot decides at any time to climb or descend, he simply rotates the pitch control in the appropriate direction. The altitude switch automatically disengages, and the switch returns to the OFF position.

"GYRO" FUNCTION

When the function selector (3) is in the GYRO position, the pilot controls the AP-102 with the turn control (6) and the pitch control (5).

In this mode of operation, the automatic pilot controls the roll and pitch of the aircraft and holds whatever altitude is selected. GYRO is used when the pilot desires direct control of the aircraft in maneuvering rather than automatic flying of a heading, altitude, or radio path.

"HEADING" FUNCTION

When the function selector (3) is in the HEADING position, the automatic pilot controls the aircraft by acquiring and holding whatever heading the pilot sets up on the course indicator of Flight Director FD-107. Either large or small heading changes may be made by resetting the heading marker of the course indicator.

This mode of operation is useful in either cross-country or terminal area flight. It may also be of special help during maneuvers such as the procedure turn prior to an ILS approach or while observing a radio path as shown on the Course Indicator. Radio paths may be followed by making small heading corrections or flown automatically in the NAV/LOC function.

"NAV/LOC" FUNCTION

The AP-102 receives VOR, localizer, or navigational computed radio course deviation information. This causes it to fly the aircraft so as to center the course bar of the course indicator (of the FD-107). The aircraft is then on the radio course.

In the NAV/LOC, or navigation-localizer, mode of operation, with the VOR receiver tuned to a localizer frequency, the AP-102 will fly the aircraft automatically along the localizer path until the glide slope is intercepted during an ILS approach. On the final leg of the procedure turn, the function selector (3) is moved to the NAV/LOC position.

"APPR" FUNCTION

The APPR, or approach, mode of operation is employed by the pilot when the glide slope is intercepted during an ILS approach. The aircraft is flown automatically onto the glide slope path by the AP-102 and continues along this path until the pilot takes over the system for landing.

During final approach, the associated Flight Director FD-107 monitoring of the automatic pilot through the approach horizon and course indicator comes into full-scale use.

SPECIFICATION SUMMARY**SYSTEM WEIGHT**

COMPONENT UNIT	APPROXIMATE WEIGHT
Computer-Amplifier 562C-2	21.25
Shockmount 349D-4	2.0
Pedestal Controller 614E-2	2.75
Switching Unit 614E-3	3.25
Shockmount 349P-1	0.5
Altitude Controller 590A-2	2.25
Sensing Unit 345A-3	7.6
(3) Primary Servo 334C-4	(4.25) 12.75
(3) Servo Mount 351B-4	(2.25) 6.75
Trim Tab Servo 334D-1-14	6.5
Trim Indicator 327D-1W	0.5
Emergency Disconnect 121A-2	0.4
	66.50 lb

APPROXIMATE INPUT POWER REQUIRED

POWER SOURCE	NORMAL POWER	MAXIMUM POWER
27.5 v d-c	66 watts	80 watts
115 v 400 cps	264 va	425 va

The inverters used to supply autopilot power should be determined prior to installation.

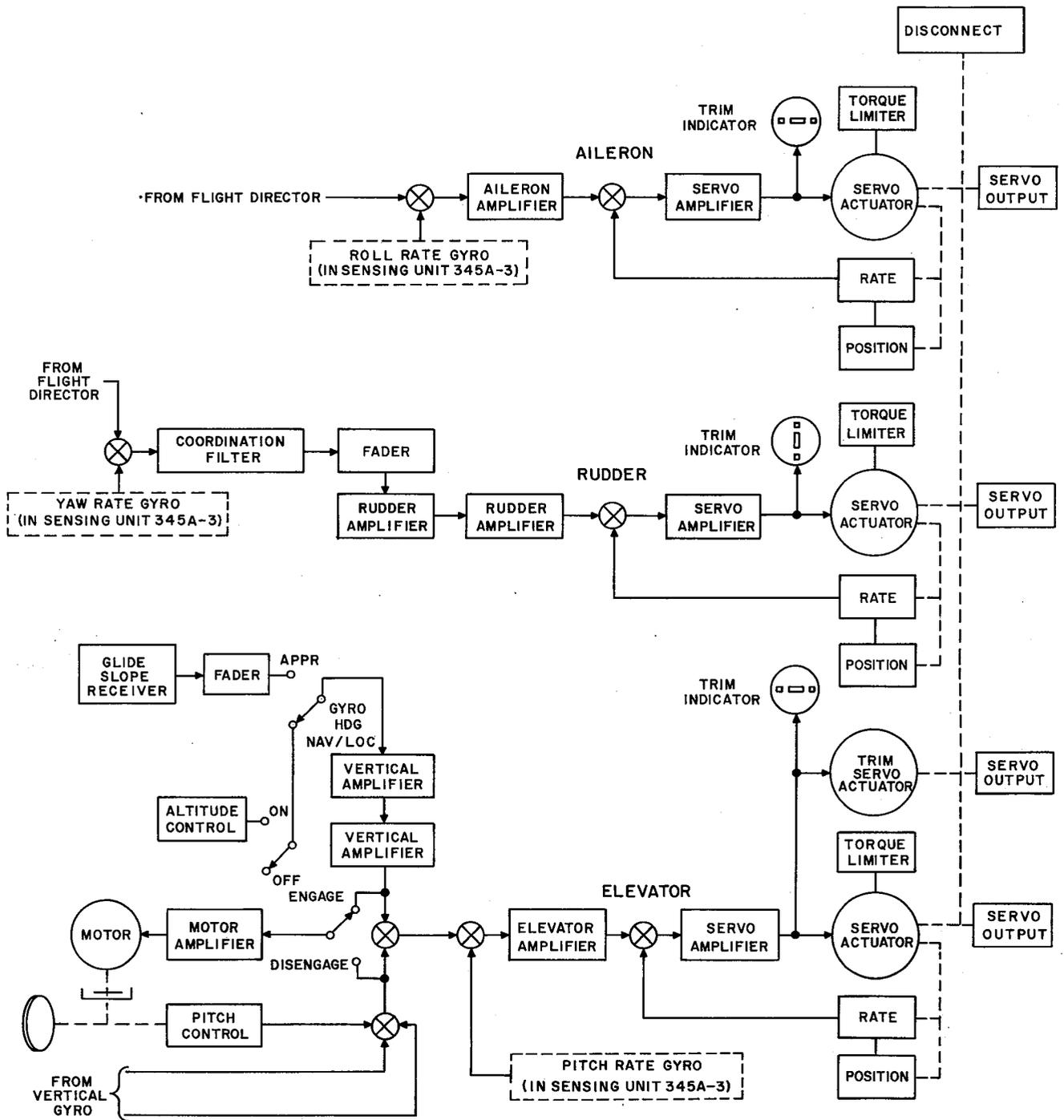
ASSOCIATED EQUIPMENT

Gyro Stabilized Magnetic Compass MC-102
Lightweight Flight Director System FD-107

VOR (Navigation-Localizer) Receiver 51R
Glide Slope Receiver 51V

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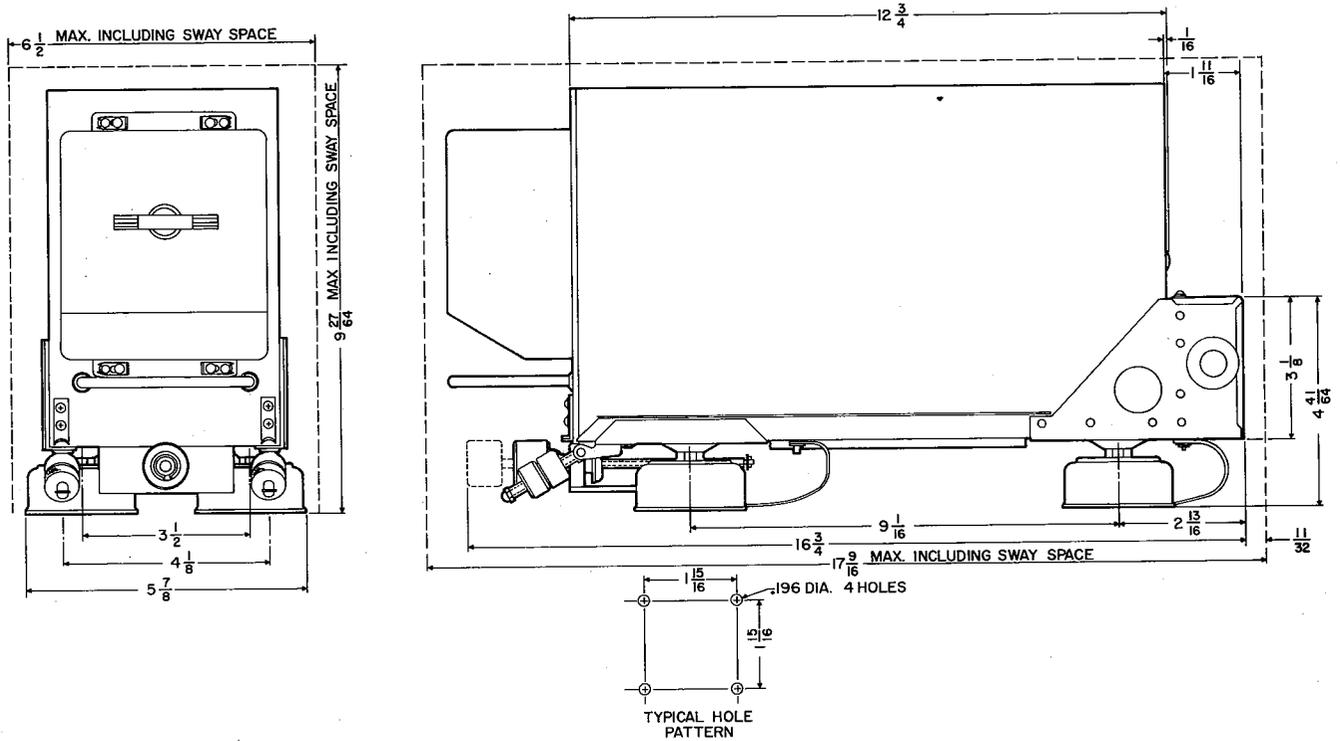
BLOCK DIAGRAM



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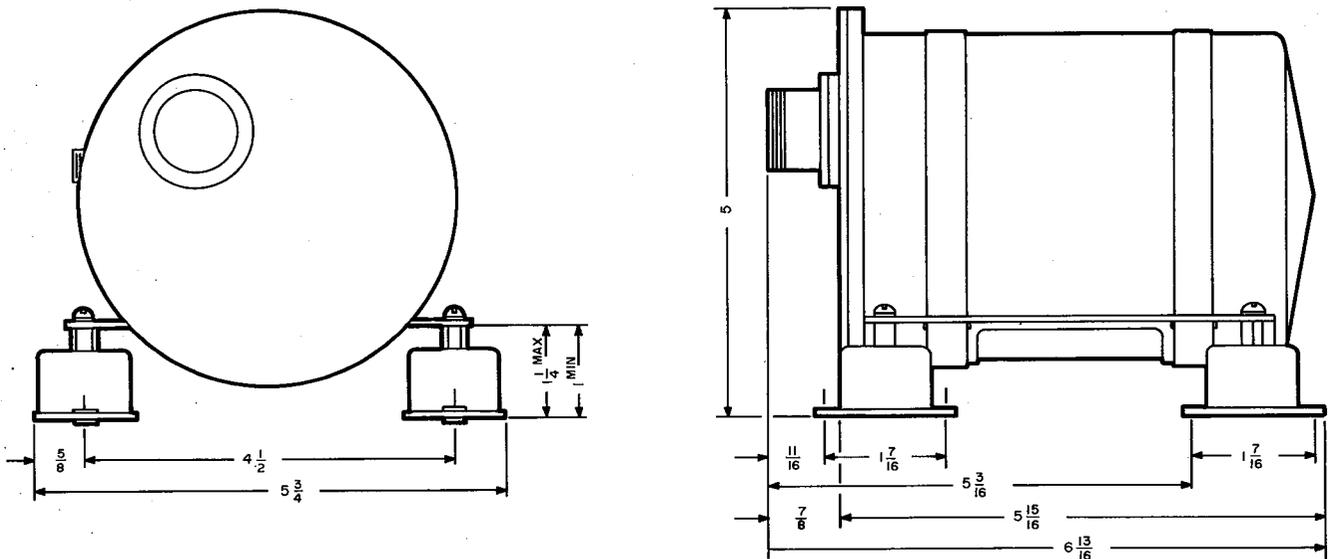
Figure 11. AUTOMATIC PILOT AP-102, Block Diagram.

INSTALLATION DIAGRAMS



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Figure 12. COMPUTER-AMPLIFIER 562C-2 and SHOCKMOUNT 349D-4, Outline and Mounting Data.



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Figure 13. ALTITUDE CONTROLLER 590A-2, Outline and Mounting Data.

AUTOMATIC PILOT AP-102

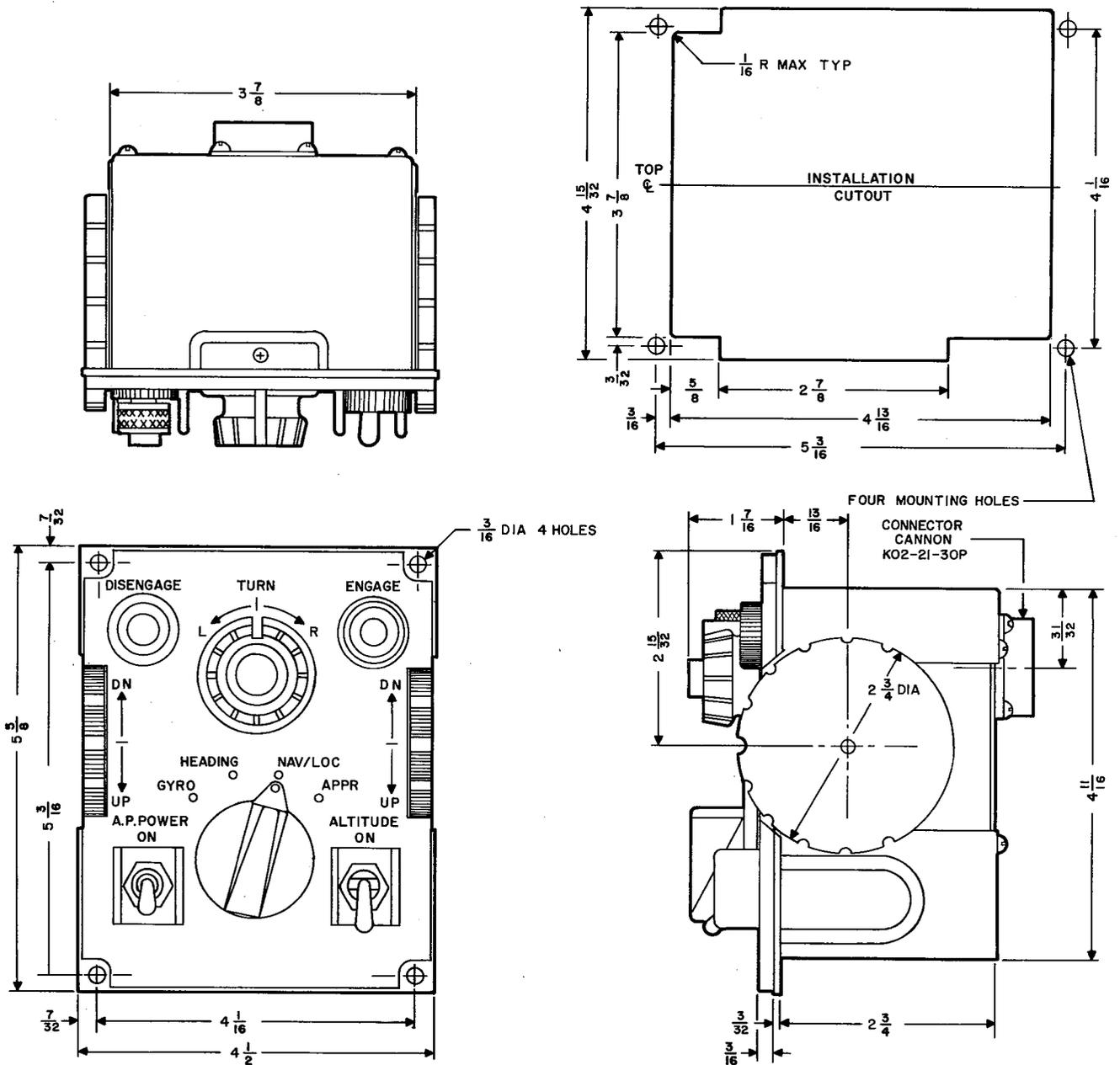
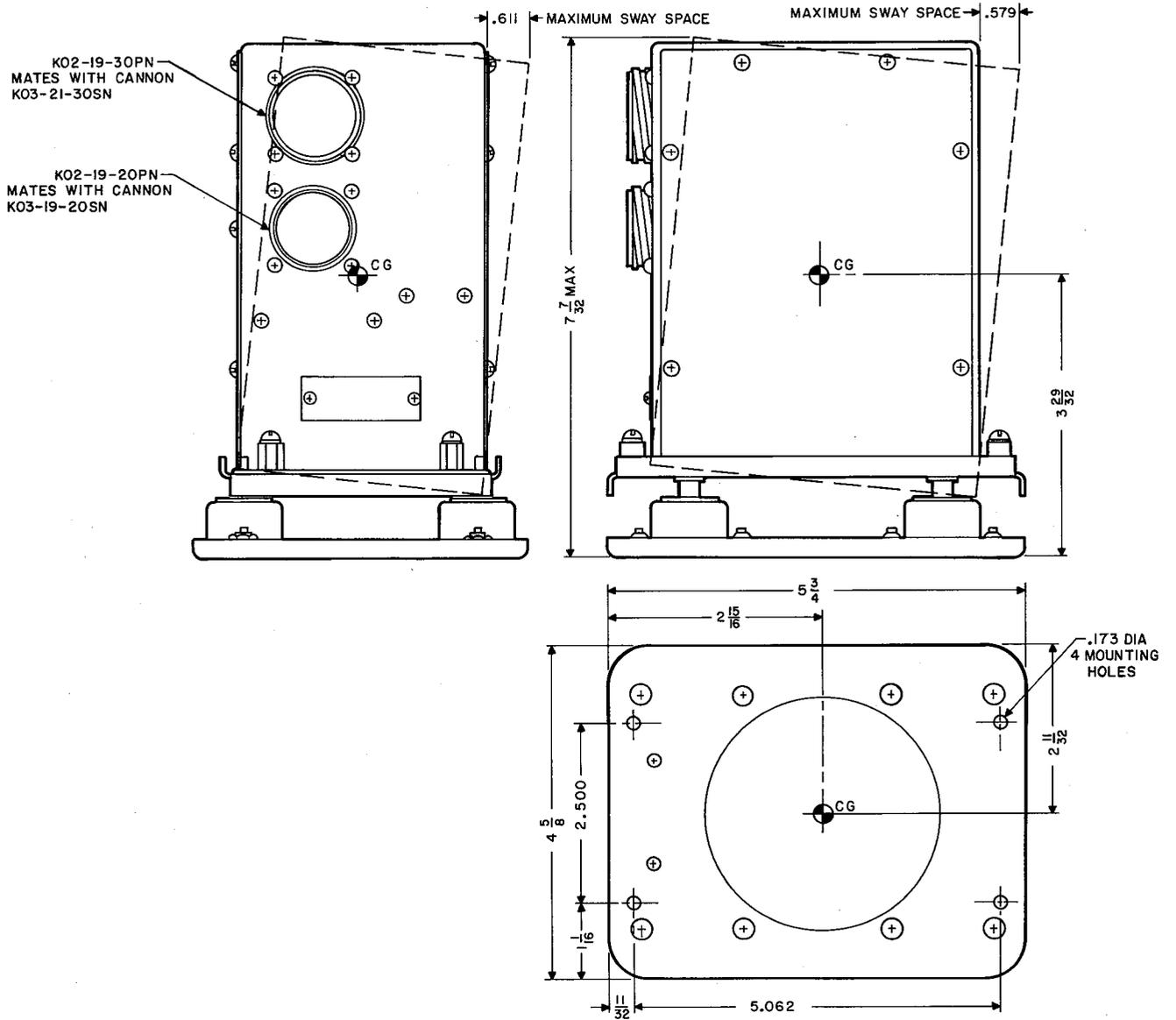


Figure 14. PEDESTAL CONTROLLER 614E-2, Outline and Mounting Data.

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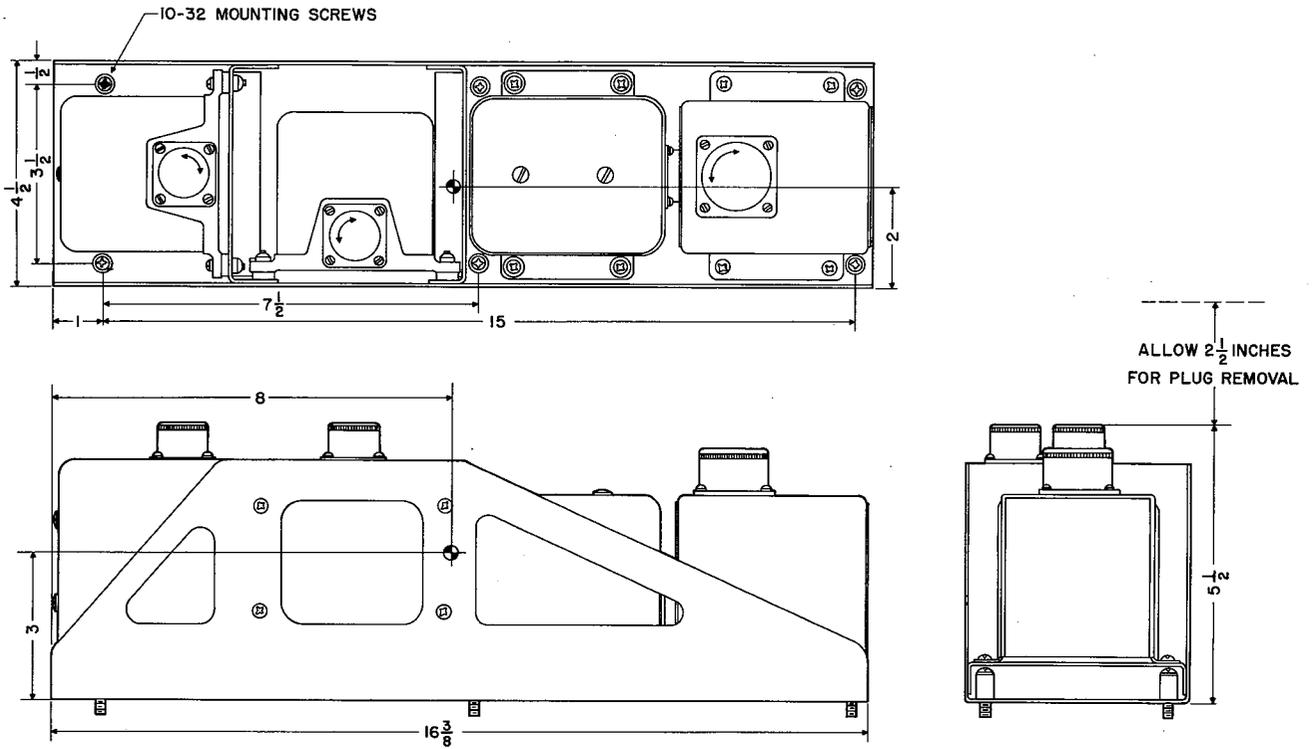
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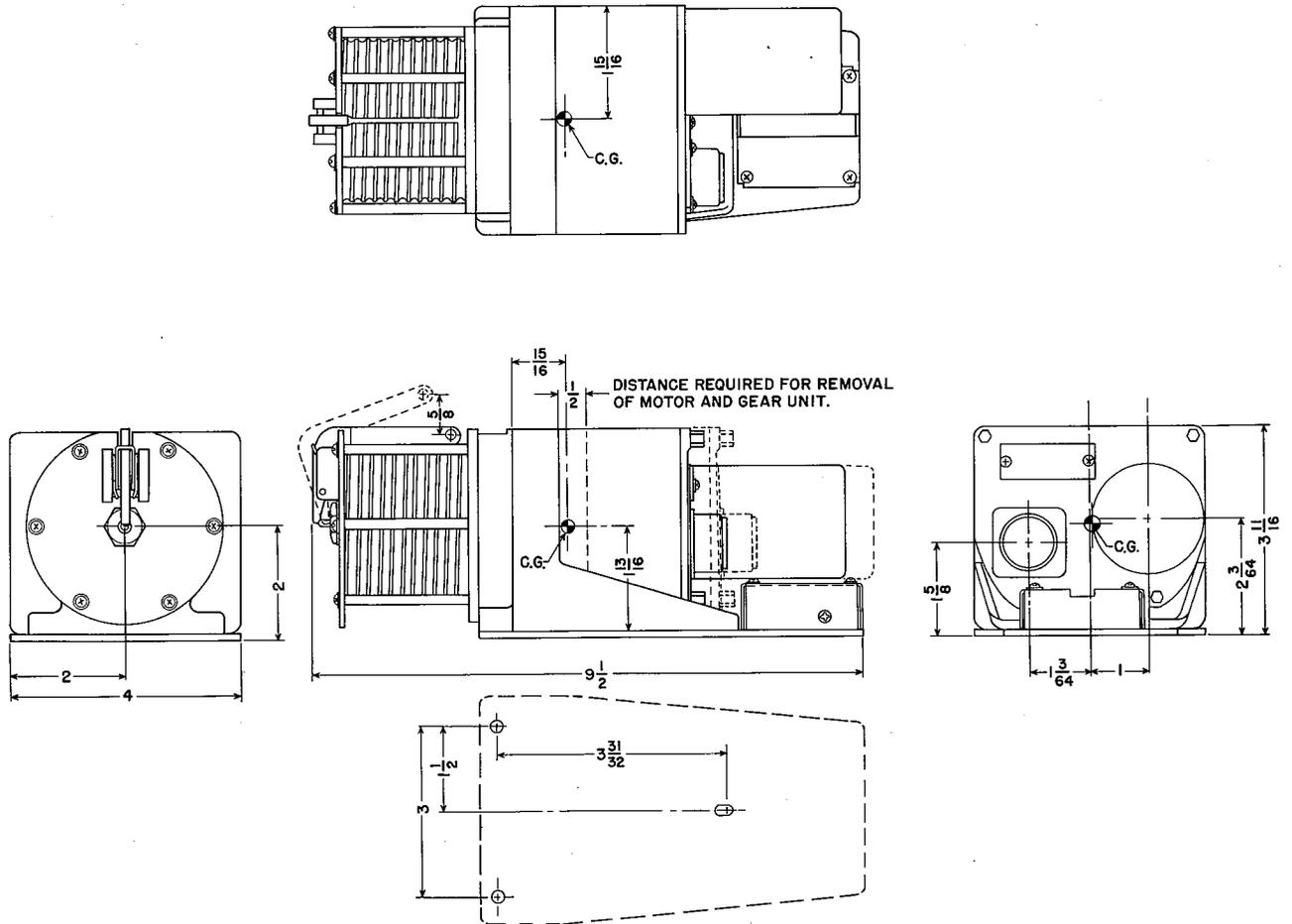
Figure 15. SWITCHING UNIT 614E-3 and SHOCKMOUNT 349P-1, Outline and Mounting Data.

AUTOMATIC PILOT AP-102



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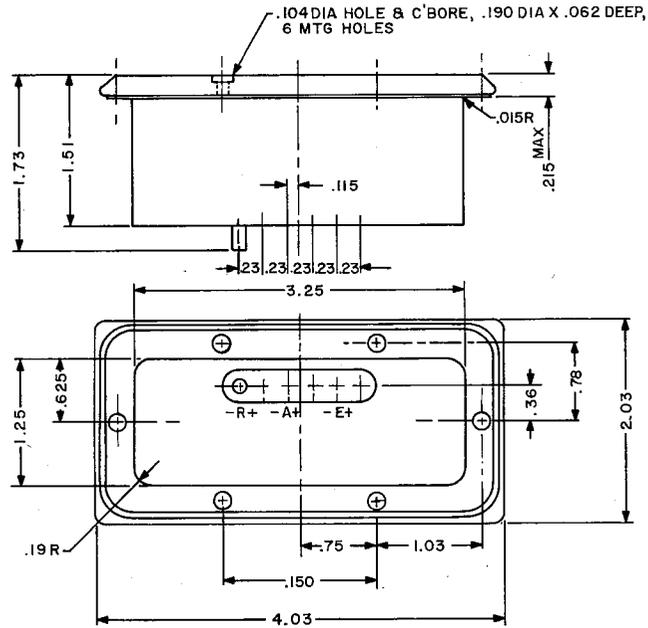
Figure 16. SENSING UNIT 345A-3, Outline and Mounting Data.



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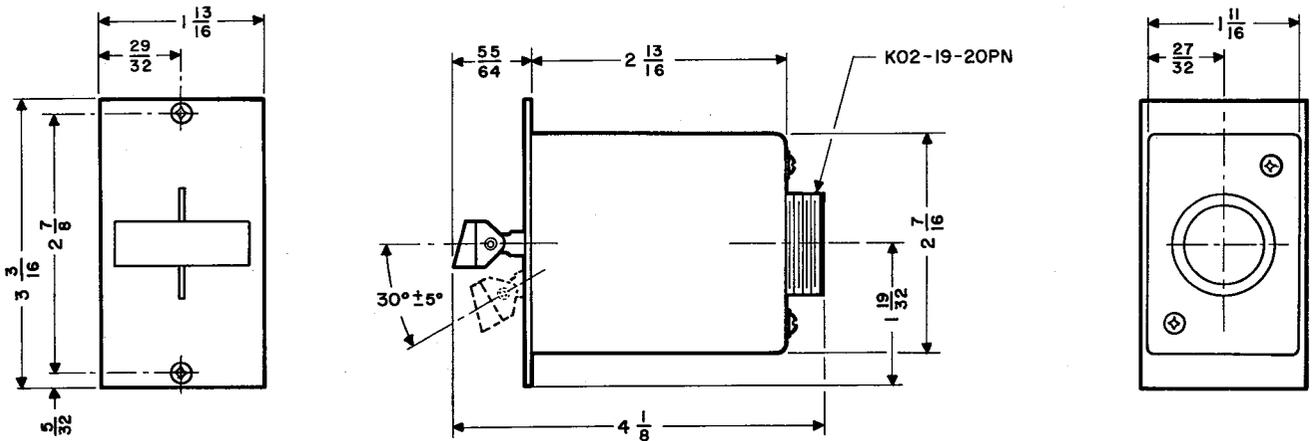
Figure 17. TRIM TAB SERVO 334D-1-14, Outline and Mounting Data.

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Figure 19. TRIM INDICATOR 327D-1W, Outline and Mounting Data.



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Figure 20. EMERGENCY DISCONNECT 121A-2, Outline and Mounting Data.



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