What's It Doing NOW?!

Autopilots and Archers
(with a nod to the Skylane)

By Kent E. Berwick, CFI-MEI

Questions to consider:

What is an autopilot?

What is it's "job"?

How does it work and why do we care?

What can (or can't) it do?

How do I make it do that?!

The Autopilot: An Avionics System Designed to serve two primary purposes

Enhance a pilot's flight control capabilities,

and

Reduce cockpit workload by putting the airplane in an automatic flight mode.

Both purposes are served only IF you are proficient with it's use!

CAUTION

This autopilot system uses the pilot's panel mounted heading and attitude gyros for sensing. In the event of a gyro failure or a vacuum (or air) supply system failure, autopilot operation must not be attempted.

Does this CAUTION apply to either (or both) OFC Archer(s)?

"Hold on," you say,
"Both aircraft have standby vacuum systems."

NOTICE:

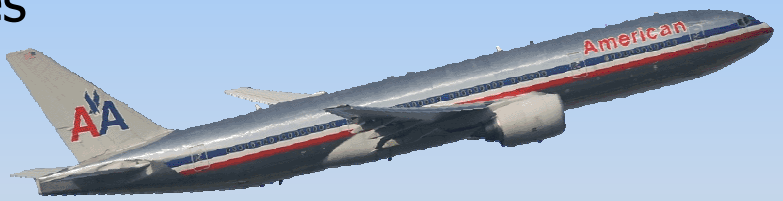
"Vacuum powered and/or Vacuum gyro directed autopilot operation may be unreliable when the Standby Vacuum System is the sole source of vacuum. Vacuum powered or Vacuum gyro directed autopilot should be OFF when operating with a failed primary vacuum system."

(Note that the AFM Supplements for the Standby Vacuum System in both airplanes contain this limitation)

Autopilots come in many forms

Simple: Wing leveler
Example: Mooney M20 (pre 201)
How used? Turn it OFF to turn.

Complex: Autoland with Autothrottles
Example: Boeing 777
How used? Engage, select or program all parameters.



Some Terminology

- 1,2 or 3 axis -- Roll (Ailerons), Pitch (Elevator), Yaw (Rudder)
- Rate based or Attitude (Position) based?

Turn Coordinator

A rate gyro won't tumble in an unusual attitude. Pilots are instructed to use the turn-and-bank or turn coordinator instrument to level the wings during recoveries. Rate gyros are inherently more reliable than attitude gyros.

or

Attitude Indicator.

Responsiveness is the primary advantage of a position-based system. Attitude information is more advantageous for rapid recovery from in-flight upsets. Most attitude-based autopilots are more responsive than rate-based systems because they can correct the position-error input more rapidly with less course / heading error during correction.

- Nav Tracking or Coupling?

The essential difference between tracking and coupling is the autopilot's ability to calculate and fly the intercept of an en route or approach navigational signal. A tracker does not have the capability to fly an intercept.

OFC Autopilot Characteristics

AUTOPILOT TYPE	N8261H	N4384F	N7362Y
Axes	2 axis Roll and Pitch	1 axis Roll only	2 axis Roll and Pitch
Rate or Attitude based	Rate	Attitude	Rate
Turns to a heading	Std Rate	20° bank	Std Rate
Tracker or Coupler	Tracker Only	Coupler, up to 45° intercept	Coupler, up to 45° intercept

AUTOPILOT "MODES" and Nomenclature

Different companies use different words to label the function controls. As you can see in the next slides, among the three airplanes there is almost no agreement as to how to label the button that engages the desired "Mode".

The booklet describing the Century IIB autopilot (which is called the Autocontrol IIIB in 84F) is particularly heinous in its lack of standardized terms. Almost any time you can't figure what they are referring to, they mean the heading bug. They NEVER mean the OBS. The AFM Supplement is better written. However the Century IIB booklet goes into greater detail on how to fly course reversals and approaches.

The only really unclear label on 61H's autopilot is STB. It means *"stabilization"* mode and it is a basic bank angle control mode. This is the mode that engages when you press the ON/OFF button. You steer by turning the knob labeled "Push". Pressing the knob toggles between STB and HDG mode.

AUTOPILOT "MODES" and Nomenclature

Lateral (Roll) Modes	**61H**	**84F**	**62Y**
Bank Angle	STB	ROLL	PULL TURN
Heading	HDG	HDG	HDG SEL
NAV Intercept	no	yes, 45°	NAV INT (+BACK CRS)
Nav Tracking, Enroute	NAV	NAV	NAV TRK
Nav Tracking, Approach	APR	OMNI	NAV TRK+ HI SENS
Nav Tracking, Localizer	APR	LOC NORM	NAV TRK+ HI SENS
Nav Tracking, Back Course	REV	LOC REV	NT+HS+BACK CRS
Heading Bug is referenced in: (i.e. HDG BUG must be properly set)	HDG only	All except ROLL	HDG SEL and NAV INT not sure about others
Crosswind correction Capability	no spec	up to 15°	no spec

AUTOPILOT "MODES" and Nomenclature

Vertical (Pitch) Modes	**61H**	**84F**	**62Y**
Altitude Hold	ALT	no	ALT
Vertical speed	no	no	VS
VNAV (GPS)	no	no	GS
ILS G/S	no	no	GS

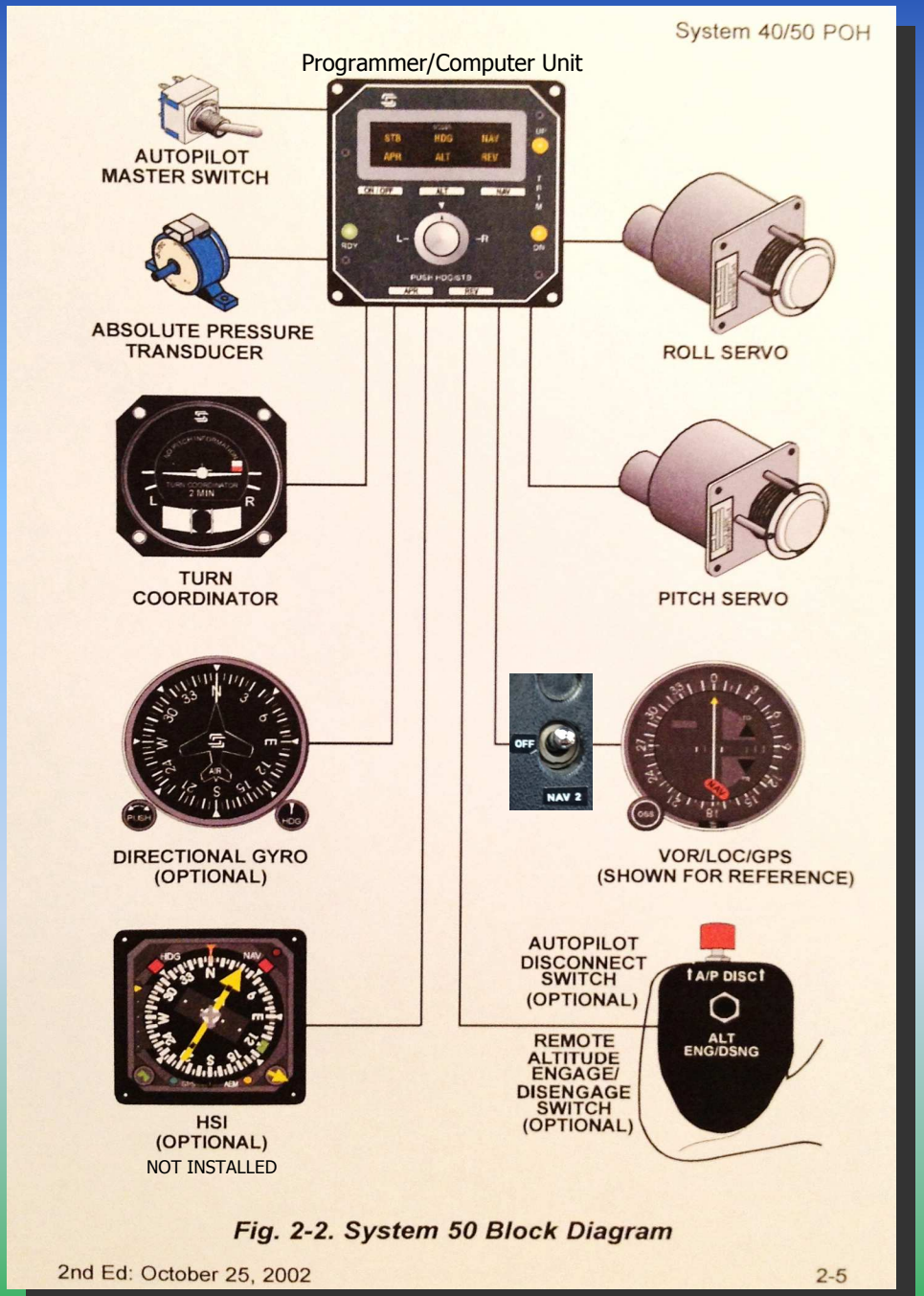
Limitations

	61H	84F	62Y
Max Airspeed, KIAS	140	149	160(PSS)
Takeoff and Landing	OFF	OFF	OFF
Flaps	10° max in ALT	N/A	10°max and >=95 KIAS (PSS)
Bank Angle			30 deg or less (PSS)
Go Around/Missed Approach			PSS use prohibited

Autopilot Panel in N8261H

Note the AP Off-On-Test switch and the Nav1-Off- Nav2 switch

Block Diagram Autopilot in N8261H



This is a “rate based” autopilot. It uses the turn coordinator.

Autopilot Panel in N4384F

Note the lack of a Nav1 / Nav2 switch. It's Nav1 only.

Piper Autocontrol IIIB Autopilot Block Diagram: N4384F

A/P ON engages the autopilot in the ROLL mode

This is an “attitude (position) based” autopilot. It uses the Attitude Indicator

Command Console

Mode Selector

Note

HDG ON/ HDG OFF rocker switch connects whatever the Mode Selector is selecting to the autopilot. Ensure the desired mode is selected before engaging HDG ON

Attitude Indicator

Directional Gyro

Roll Servo

VOR/LOC/GPS

Controls

N8261H:

Autopilot Master Switch
Programmer/Computer Unit
Nav 1 / OFF / Nav 2 Switch
Heading Bug

N4384F:

Command Console
Coupler Mode Selector (Radio Coupler)

Heading Bug AKA:

Course Selector
Course Selector DG
Course Selector Indicator
DG Course Indicator
DG Course Selector Indicator

A Note About The Heading Bug

Heading Bug: Max lead is about 160°.

That is to say when the heading bug is near the bottom of the case it MAY NOT do what you want it to. These autopilots will always turn in the shortest direction to the bug in heading mode.

Autopilot Panel in N7362Y

STEC
PSS

Cessna 300A Navomatic

N7362Y 300A Block Diagram

Note this is two separate and independent systems with separate On/Off switches

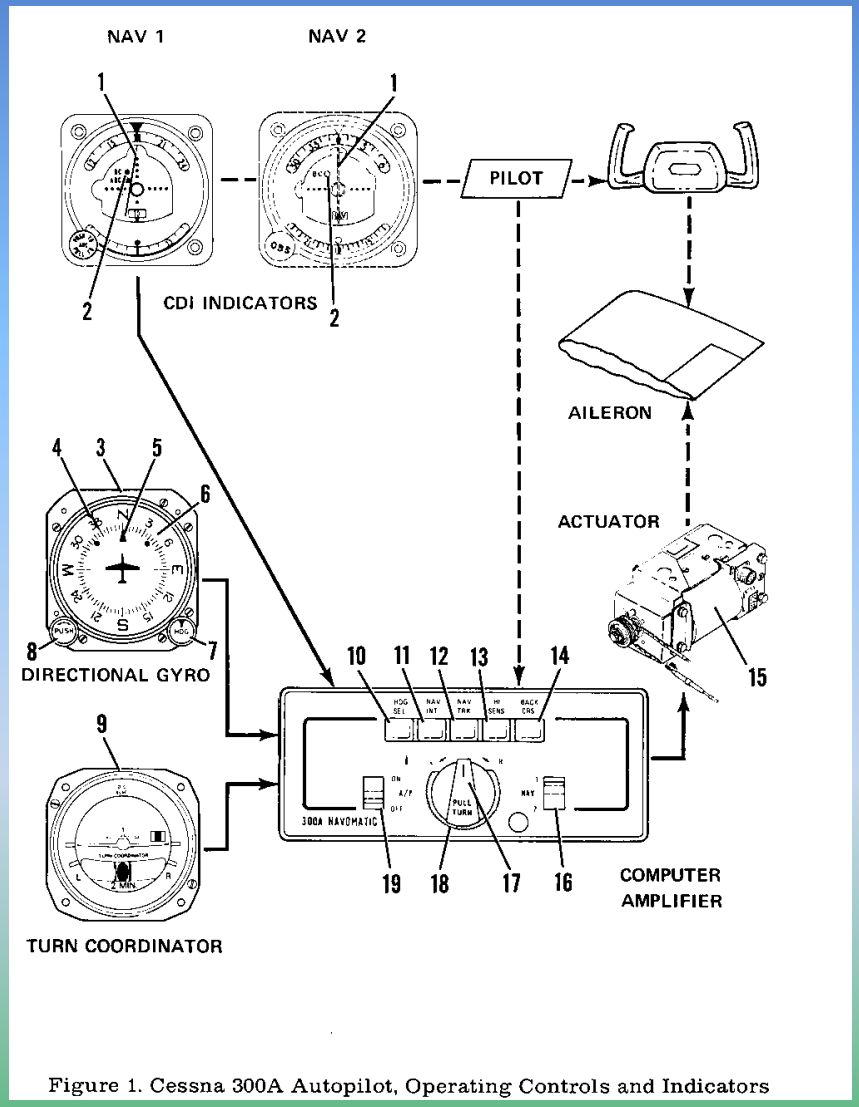
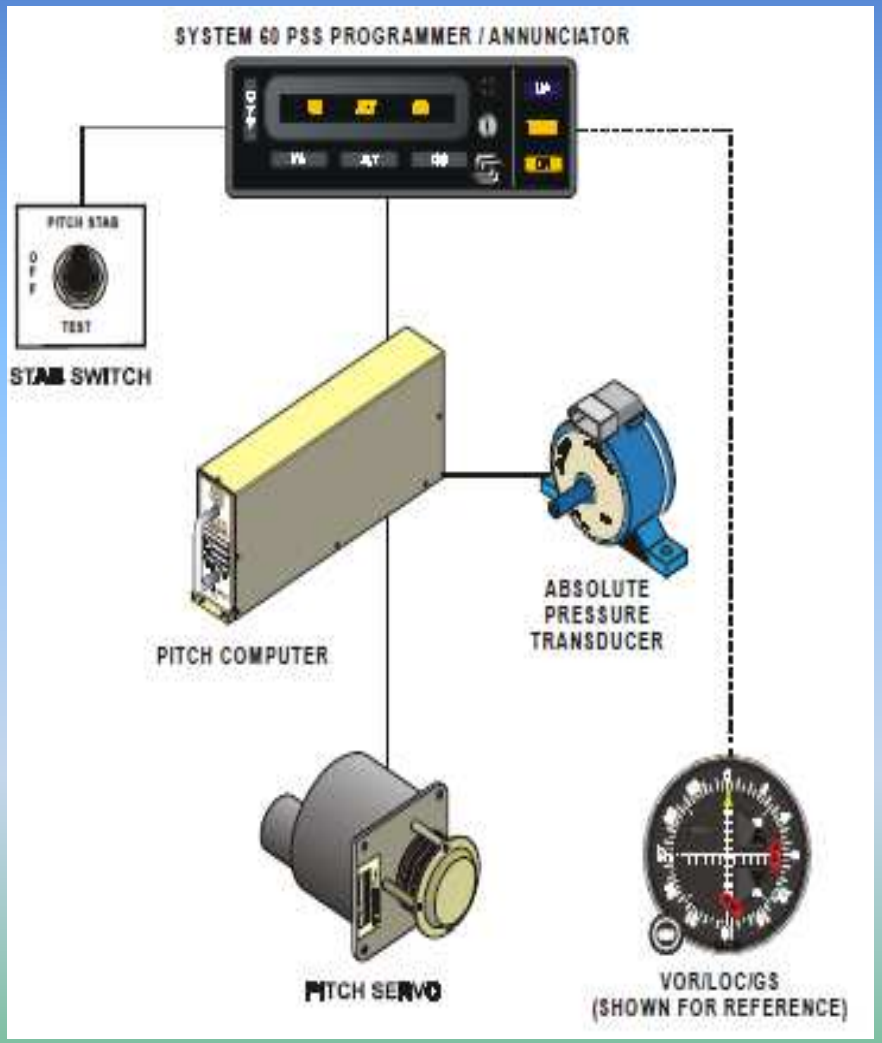
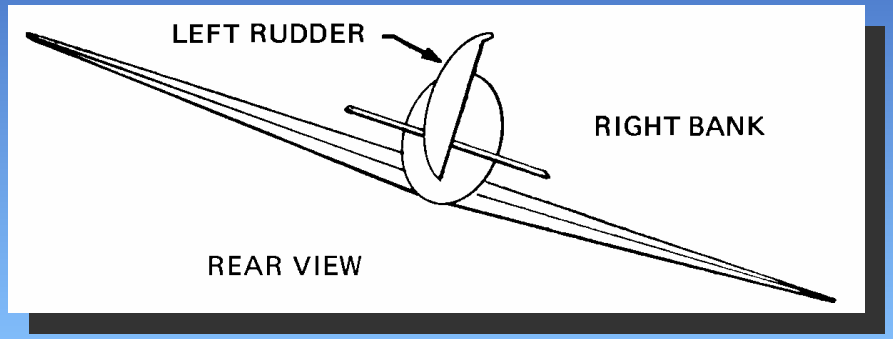


Figure 1. Cessna 300A Autopilot, Operating Controls and Indicators



Aircraft Trim Effects



An important point to remember is that while the autopilot is maintaining heading the airplane should never fly with a wing low. This statement applies equally to an airplane without an autopilot.

Consider the effect of rudder trim in the above drawing. Viewing the airplane from the rear, note that with left rudder applied the right wind must be lowered to offset the rudder effect and keep the heading constant, i.e., the left turn effect of the rudder is canceled by the right turn effect of the bank.

Since the autopilot is slaved to heading this is exactly what it will do in order to hold a heading when the rudder is out of trim.

Thus when operating on autopilot heading mode, if the aircraft flies with one wing low while maintaining heading, this indicates the rudder trim is required in the direction of the low wing.

Operating Procedures

The standby vacuum system in both airplanes includes a normal procedure to check the system before takeoff.

"Idle engine at low speed, momentarily pull the standby vacuum knob OUT-ON and check the vacuum gauge. Normally the vacuum reading will be slightly higher.

After checking system push the Standby Vacuum System knob IN-OFF.

Check that vacuum gauge reading has returned to the previous reading."

N4384F: PILOT'S PREFLIGHT PROCEDURE

1. Place Mode Selector in HDG mode and place A/P "ON-OFF" switch to ON to engage roll section.

2. Rotate roll command knob left and right and note that the control wheel responds in the proper direction, then center knob.

3. Set correct compass heading on DG and turn HDG bug to aircraft heading. Engage HDG ON rocker switch and rotate HDG bug left and right. Aircraft control wheel should turn the same direction as the bug.

4. Grasp the control wheel and manually override the autopilot servo in both directions.

5. Tune and Identify VOR or VOT station. Position Mode Selector to OMNI mode. Engage A/P ON and HDG ON rocker switches and rotate the OBS to cause the CDI needle to swing left and right slowly. Observe that the control wheel rotates in the direction of the needle.

6. Disengage autopilot before takeoff

N8261H: PREFLIGHT PROCEDURE

NOTE: During system functional checks the system must be provided adequate DC voltage (12 or 24VDC minimum as appropriate)

MANDATORY PRE-FLIGHT TEST

1. AP Master Switch - Move to TEST position.

   A. Observe that all lights and annunciators illuminate.
   B. Observe the following light sequence of the trim indicators: (Sequence requires 9 seconds.)
      Initially both trim UP & DN lights are illuminated.
      UP light extinguishes momentarily and re-lights.
      DN light then extinguishes and will remain off

2. AP Master Switch - Move to ON position, observe ready (RDY) light illuminates. Autopilot can be engaged and disengaged repeatedly without repeating the test sequence until electrical power is removed. Once power is interrupted the test must be re-conducted to get a ready indication. If the ready light does not illuminate after the test a failure to pass the test is indicated and the system will require service.

NOTE: ALTITUDE MODE CANNOT BE ENGAGED UNLESS POWER IS ON FOR MORE THAN 15 SECONDS.

System Functional Test

There are seven (7) more steps to complete a functional test which should be performed periodically although I find no guidance on that point.

N7362Y PREFLIGHT PROCEDURE

None found for the 300A Navomatic A/P.

One page procedure for the STEC System 60 PSS.
Found on OFC Website Club Documents.

N4384F: AUTOPILOT ENGAGE SEQUENCE (IN FLIGHT)

1. ***Trim aircraft*** to a wings level flight attitude.
2. Center roll knob and engage A/P "ON" switch.
3. Select "HDG" mode on Mode Selector
4. Center HDG Bug and engage HDG "ON" switch.

N8261H: System 50 In-Flight Procedures

CAUTION

Conduct the required Pre-flight test, if necessary, in flight. However, the pitch servo will engage and disengage as part of the Self-Test. Therefore do not attempt flight maneuvers during the power-up test.

If the pilot fails to trim the aircraft, the UP or DN Trim Light will annunciate and after 4 seconds the trim light will flash.

1. Check the RDY light ON.
2. ***Trim aircraft*** for desired flight conditions. Maintain Yaw Trim during all Autopilot operations.
3. Center Turn Knob and press and release ON/OFF Switch.
4. Set Turn Knob to level flight or turn, as desired.
5. Set HDG bug to desired heading (if installed) and press and release Turn Knob to engage HDG Mode. Select headings as desired.

NOTE: Although the ALT Hold may be selected whether in a climb or descent, Step 6 is the preferred method for selecting ALT Hold to prevent the need for excessive trim corrections.

6. At the desired altitude, trim aircraft for level flight conditions, set power/elevator trim and engage ALT Hold.
7. Disengage ALT Mode to climb or descend

N7362Y: AUTOPILOT ENGAGE SEQUENCE (IN FLIGHT)

INFLIGHT WINGS LEVELING

1. ***Airplane Rudder Trim-*** ADJUST for zero side slip ("Ball" centered on Turn Coordinator)
2. PULL-TURN Knob – CENTER and PULL out.
3. A/P ON-OFF Switch – ON
4. Autopilot TRIM Control – Adjust for zero turn rate (wings level indication on Turn Coordinator)

So… How do I make it do that?!

So… How do I make it do that?!

This presentation originally began as a project to compare, contrast, and promote understanding of the autopilots installed in the two Archers in our fleet. I hope it has introduced you to the wonderful world of electronic flight control assistance available to you in all of our airplanes.

Rather than just read you the manuals, I have tried to provide an understanding of the basic modes and various terminology and even more confusing nomenclatures used by the various manufacturers. Now you should have enough understanding to read and understand the often confusing documentation provided by the aircraft and autopilot companies.

This presentation is intended to supplement the approved documentation and not to replace it. Proper reading of the official supplements is highly recommended. And any differences between this and the official documents, the official documents take precedence.

With that in mind, the references at the end of this presentation are all available on the club website.

A/P Usage Strategy

While not neglecting your own skills, to be proficient with the autopilot you have to use it and stay in practice with it.

Once you are proficient with it:

The AP can function as a second pilot, but only when it's on!

Flying with AP on is like having a two pilot crew, flying with AP off is a single pilot crew.

You can monitor the AP, the AP can not monitor you.

A/P Usage on Flight Tests

From the Instrument Rating Practical Test Standards:

"The applicant is expected to utilize an autopilot and/or flight management system (FMS), if properly installed, during the instrument practical test to assist in the management of the aircraft. The examiner is expected to test the applicant's knowledge of the systems that are installed and operative during the oral and flight portions of the practical test. The applicant will be required to demonstrate the use of the autopilot and/or FMS during one of the nonprecision approaches. The applicant is expected to demonstrate satisfactory automation management skills."

A/P Usage: A Common Trap

Always consider your current NAV mode when making changes to the navigation radios or GPS.

A Common Trap

If you are flying direct to the airport, in GPS mode and given the clearance “Fly present heading, vectors for --- approach”

If you activate approach without first switching to HDG mode the CDI may go to full scale deflection and aircraft may turn to heading which would give 45 intercept. Avoid this problem by switching to HDG mode before activating VTF (Vectors To Final).

A/P Tips

Always keep a hand on the controls when engaging or disengaging an autopilot.

Always have hand on yoke when within 1000’ AGL if quick AP override is needed.

Always verify mode annunciated is what you have selected, and expect to see.

Caution: N4384F Only

So, back to the question presented at the beginning:

This autopilot system uses the pilot's panel mounted heading and attitude gyros for sensing. In the event of a gyro failure or a vacuum (or air) supply system failure, autopilot operation must not be attempted.

The autopilot in 84F is Position (Attitude) based and relies on the Attitude Indicator operating properly. An AI failure or a vacuum system failure renders the autopilot unusable. Not so for 61H and 62Y.

The Standby Vacuum System

Both Archers have similar manifold pressure driven "emergency" standby vacuum systems which state **"Vacuum powered and/or Vacuum gyro directed autopilot operation may be unreliable when SVS is the sole source of vacuum. Such autopilot should be OFF when operating with a failed primary vacuum system."** *Only the autopilot in 84F is affected by this restriction.* The others rely on the turn coordinator.

Note, however, *this "system is for emergency or standby use only"* and **"CONTINUED IFR FLIGHT IS NOT RECEMMENDED AND IMMEDIATE ACTION SHOULD BE TAKEN TOWARD VFR CONDITION OR LANDING"**

So in the event of an Attitude Indicator or vacuum system failure in 61H or 62Y, you will have a functioning basic autopilot. In 61H the only mode you will lose is HDG. You have help flying the airplane if you want it. This is where system knowledge pays off.

In 84F you will lose the complete autopilot.

In either case in IFR conditions you are still an emergency aircraft.

References

General

Autopilots: Understanding Their Role in Cockpit Workload, Safety and Convenience (S-TEC)
(S-TEC Understanding Autopilots PDF) (under GNS530 and Other Training)

N4384F

Century IIB Autopilot Flight System Pilot's Operating Handbook
(Century IIB Autopilot PDF) (Very badly written but more complete)
N4384F FAA Airplane Flight Manual Page 9-9 “Autocontrol IIIB Autopilot Installation”
(84F Autopilot Supp PDF) (More readable)
Standby Vacuum System Supplement for 84F
(84F SVS Supp PDF)

References

N8261H

S-TEC System 40/50 Autopilots Pilot's Operating Handbook
(S-TEC 50 Autopilot PDF)

S-TEC FAA Approved POH and Airplane Flight Manual Supplement for PA-28-181, S-TEC System 50 Automatic Flight Guidance System (14 Volt) for N8261H
(61H Autopilot Supp PDF)

Standby Vacuum System Supplement for 61H
(61H SVS Supp PDF)

References

N7362Y

Cessna R182 POH Supplement Cessna Navomatic 300A Autopilot
(N7362Y POH Part 3 PDF pages 123-128) or
(62Y Autopilot Supp PDF)

S-TEC System 60 PSS, Pitch Stabilization System Pilot's Operating Handbook
(S-TEC 60 Altitude Hold PDF)

S-TEC Supplement to POH/AFM for Cessna R182 with S-TEC System 60 Pitch Stabilization System
(62Y S-TEC PSS Supp PDF)

I used the supplement listed below for the PSS

(http://www.redskyventures.org/doc/cessna-poh/Cessna_182_C182RG_1981_POH_scanned.pdf pages 421-440)


Have Fun and Be Safe!