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AUTOMATIC FLIGHT CONTROL SYSTEM DEVELOPED FOR AB212 "COMBAT S.A.R. HELICOPTER" OF THE ITALIAN AIR FORCE AND FOR AB412 "CARABINIERI"

B. BELLUCCCI

B. PAGGI

AGUSTA GROUP
HELICOPTER DIVISION
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AUTOMATIC FLIGHT CONTROL SYSTEM DEVELOPED FOR AB212 "COMBAT S.A.R. HELICOPTER OF THE ITALIAN AIR FORCE AND FOR AB412 "CARABINIERI"

B.BELLUCCI, TEST PILOT

B.PAGGI, FLIGHT TEST ENGINEER

ABSTRACT

This system has been developed to be fitted on the AB212 helicopter for the Combat S.A.R.role of the Italian Air Force. It has also been installed on the AB412 helicopter for the Italian Military Police "CARABINIERI" (S.A.R. version). The system is a Sperry SPZ-7300 Four Channel AFCS.
The SPZ-7300 features are:
- Complete 4 Axis SAS/Autopilot
- Duplex for Safety (P & R)
- 3 Cue Attitude Director Indicators
- Automatic Preflight and Test
- System Diagnostics and Monitoring
- Mycroprocessor Based

Pilot interface with the Sperry system is through the Helicopter Controller and Flight Director mode selector. These units provide complete mode selection, engage functions and coupling control for the system.

INTRODUCTION

This paper describes the operation, equipment and tipical flight applications for the system for the Agusta AB212/AB412 Helicopters.
This AFCS has been developed upon the erlier analogic three channel AFCS maintaining the basic system (Helipilots, actuators, a few sensors) implemented by the new digital flight path computer, collective channel parallel actuators on the other three channels and new sensors.

1. GENERAL DESCRIPTION

The SPZ-7300 System is a four channel automatic flight control system, having the capability of automatically controlling the pitch, roll, yaw, and collective axis of the helicopter. The primary components of this system are two redundant Helipilots and a Digital Flight Path Computer.
The dual Helipilots each drive series actuators to provide control of the aircraft pitch and roll axis. The Helipilots can function together or individually.
Each Helipilot system is independent having its own electrical system, gyro reference, computer and series actuators.
The Digital Flight Path Computer has direct control of the yaw series actuator and the pitch, roll, yaw, and collective parallel actuators. The Flight Patch Computer can operate independently of the Helipilots to provide visual flight director commands on the ADI when navigating, or it can be coupled to the Helipilot systems for fully automatic flight path control. The Flight Path Computer utilezes the same electrical system and gyro reference as Helipilot No.1 (Figure 1).

SPZ-7300 Four Channel AFCS

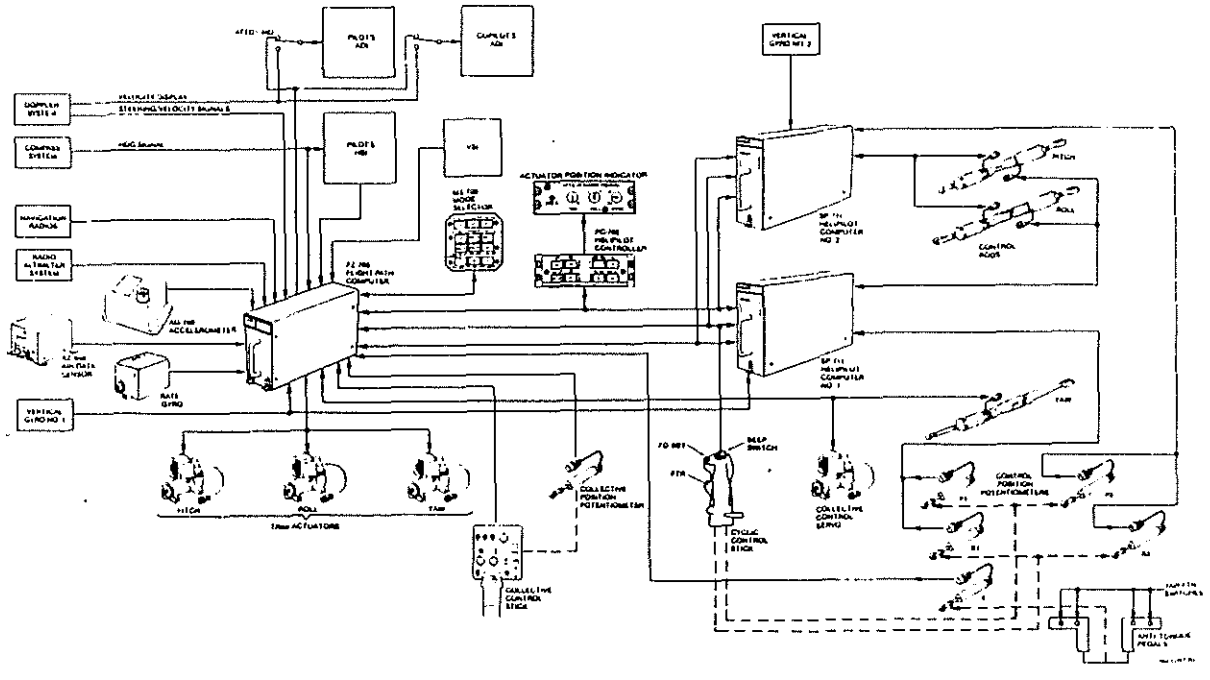


Figure 1

2. PANEL MOUNTED COMPONENTS

The AFCS cockpit components are the following:
- Attitude Director Indicator (ADI)
- Horizontal Situation (HSI)
- MS-700 Mode Selector (Fig.2)

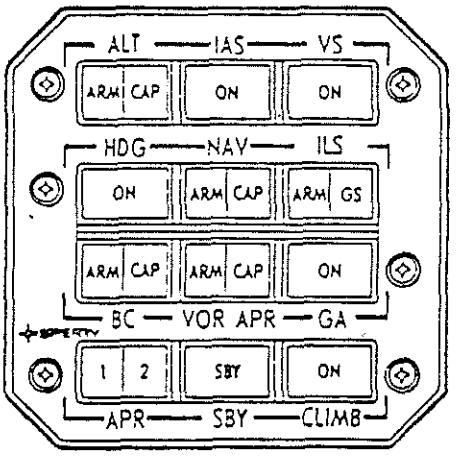


Figure 2

- AL-300 Digital Display Panel:
  the AL-300 displays momentary informations of Altitude Airspeed, Vertical Speed, ground Speed (DOPPLER), and Radar Altimeter when these modes are selected. Furthermore can be used to preselect the above mentioned path control modes using the set knob for Altitude and collective and cyclic Beep Trims to preselect the others. It is besides used to perform the Pre-Flight test fault (Fig.3)

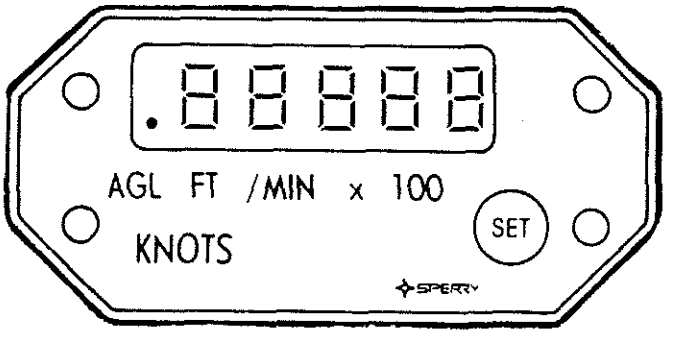


Figure 3

- PC-702 Helipilot Controller (Fig.4)

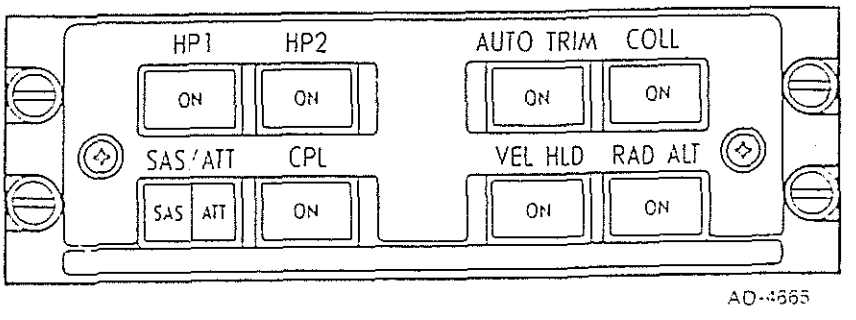


Figure 4

- Doppler radar navigation *
- VOR/DME navigation *
- TACAN navigation *

* peripheral systems

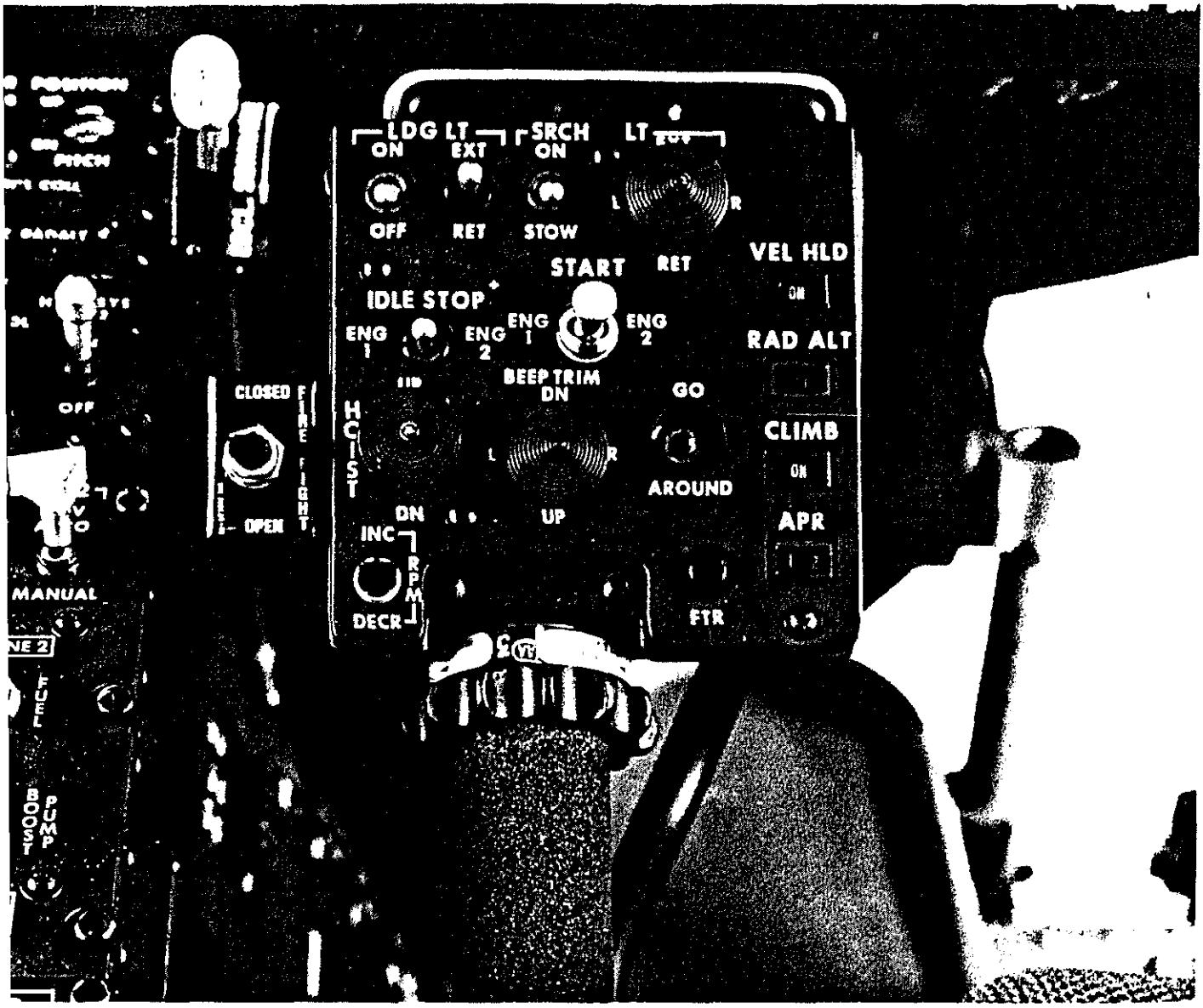
3. RACK MOUNTED COMPONENTS

The AFCS components are the following:
- FZ-703 Digital Flight Path Computer
- Helipilot Computer (2 each)
- Vertical Gyro (2 each)
- Directional Gyro
- AZ--649 Air Data Sensor

4. OTHER COMPONENTS

- Go-Around (GA), Approach 1/2(APR), CLIMB, Radio Altitude Hold (RAD ALT) and Velocity Hold (VEL HLD) Remote Switches - Mounted on the pilot's collective stick, these switches are used to collective stick, these switches are used to remotely engage or disengage the indicated modes of the Flight Path Computer (Fig.5 - See page 5).
- Collective Force Trim Release Switch
- Collective 4-way Beep Trim Switch - Mounted on the pilot collective stick fore/aft motion of this switch slews the RAD ALT reference and the VS reference when operating in 3Q, while left right motion slews the yaw heading hold reference at low speed (below 60 kts) and lateral acceleration trim reference at high speed (above 60 kts) (Fig.5 - See page 5).
- Remote Flight Path Computer Stanby (Pilot and copilot cyclic stick)
- Collective Force Trim Release Switch (Pilot and copilot collective sticks).
- Cyclic Force Trim Release Switch (Pilot and copilot cyclic sticks).
- Cyclic 4-way Beep Trim Switch - Mounted on pilot and copilot cyclis sticks, fore/aft motion of this switch is used to slew pitch attitude, airspeed, and logitudinal velocity references. Fore/aft motion will also slew VS reference when operating 2Q. Left/right motion of the switch slews roll attitude and lateral velocity reference when the proper modes are engaged.
- Collective Force Trim Switch - Mounted in consolle, releases the collective electromagnetic brake.
- Cyclic Force Trim Switch - Mounted in console releases the cyclic and pedal electromagnetic brakes.
- Yaw Force Trim Release Switch (Pilot and copilot pedals).
- Actuator Position Indicators (API) - These meters indicate relative position of the Helipilot actuators about a neutral point.
- Sensors.

FIGURE 5


LDG LT
ON
EXT
SRCH
ON
LT
OFF
RET
STOW
START
RET
VEL HLD
IDLE STOP
ENG 1
ENG 2
ENG 1
ENG 2
RAD ALT
BEEP TRIM
DN
GO
CLIMB
HOIST
AROUND
UP
APR
DN
INC
RPM
DECR
FTR
CLOSED
OPEN
FINE
FLIGHT
MANUAL
FUEL
BOOST
PUMP
OFF

5. HELIPILOT/FLIGHT COMPUTER SYSTEM CONTROLS AND MODES OF OPERATION

The SPZ-7300 system operates in three basic modes of operation.
The Helipilots themselves operate in either the attitude hold (ATT) mode or the stability augumentation (SAS) mode. They also may operate in the coupled (CPL) mode where they receive flight path commands from the Flight Path Computer. When the Helipilots are coupled to the Flight Path Computer the pilot selects the desired flight path mode using the appropriate button on the Helipilot Controller or Mode Selector.

5.1 Helipilot

5.1.1 SAS/ATT

Whenever HP1 or HP2 is engaged the AFCS will come on in the ATT mode. Pressing the SAS/ATT button provides a means of selecting SAS or ATT.
In the ATT (attitude hold) mode the helicopter will maintain the pitch and roll attitude existing at the time of engagement, assuming the Flight Path Computer is in the standby (SBY) mode. This attitude will be maintained indefinetely and the pilot may fly completely "hands off".
The pilot may fly through the system by normal maneuvering with the cyclic controls. However, if the cyclic force trim switch is not operated, the aircraft will returm to the previous attitude when the stick is released. A new attitude reference may be established by operation of the cyclic force trim release or by "beeping" the four-way cyclic trim switch in the desired direction. If autotrim is enabled, the pitch and roll trim actuators will automatically retrim the cyclic stick as necessary to keep the series actuators working about center position.
The SAS (Stability Augmentation System) mode is a "hands on" mode. In this mode the pitch and roll axes operate to provide short term stability or motion damping. The "stability augmentation" is most evident while the pilot is maneuvering at low altitudes and low airspeeds. The pilot provides control to guide the ship while the Helipilots correct attitude changes due to turbulence.
Typical use is for VFR operations where frequent maneuvering is required. Control motions may be applied either with or without force trim released. If a single Helipilot is operating in the SAS mode, engagement of the other Helipilot will reset it to the ATT mode.
During both the ATT and SAS modes the yaw axis is controlled from Helipilot No.1 only. (There is no yaw control in Helipilot No.2).

During low speed operation (airspeed less than 60 kts) the yaw axis provides heading hold, maintaining a fixed heading. A new heading reference may be established by operating the pedal force trim release and maneuvering to a new heading or by "beeping" the four-way collective trim switch left or right. During high speed operation (airspeed greater than 60 kts) the yaw axis performs a damping function only - it does not maintain heading.
It does however maintain a constant lateral acceleration (ball trim on the inclinometer).
The acceleration reference can be changed by beeping the four-way collective beep trim switch left or right if the pilot chooses to retrim the aircraft.

5.1.2 CPL

Any time the attitude mode is engaged and a valid flight director mode is engaged, the Helipilot system will automatically couple to the Flight Path Computer pitch and roll commands. This is annunciated by the illumination of the CPL "ON" legend. The pilot may inhibit the coupling function by pressing the CPL button and manually flying the helicopter to satisfy the flight path command bars on the ADI. Once this is done, all pitch and roll coupling will be inhibited until the CPL button is again pressed, or either Helipilot is re-engaged.
Flying in the CPL mode allows long term hands-off flight. The AFCS accepts pitch and roll commands from the Flight Path Computer and drives the series actuators as required to satisfy the commands. The pilot may monitor AFCS coupler performance by occasionally observing the corresponding cockpit instruments.
In the coupled mode, the operation of the yaw axis at high speeds is identical to that in the SAS and ATT modes. Yaw heading hold at low speed is inhibited if a roll mode is selected.

5.1.3 AUTO TRIM

Automatic trim keeps the pitch, roll and yaw linear actuators operating near their center of travel, thereby maintaining full authority and relieving the pilot of continuous actuator monitoring. Auto trim is operational in the yaw axis any time that HP1 is engaged as indicated by the AUTO TRIM annunciator. If both Helipilots are engaged in the ATT mode, pitch and roll autotrim are also operational. Trim action can be interrupted by applying force to the controls, pressing the AUTO TRIM button to disengage auto trim, disengaging HP1, or via the cyclic force trim switch in the pedestal.

In the Flight Patch Computer detects an auto trim malfuction, the AUTO TRIM annunciator will flash on and off and auto trim will be inhibited. To reset the trim monitor, the AUTO TRIM switch must be pressed twice to disengage and then re-engage auto trim.
Auto trim is inhibited during normal ground operation.

5.1.4 COLL

The collective couple annunciator will automatically light if HP1 is engaged and a 3-Q flight path computer mode or RAD ALT mode is selected, indicating that the collective axisis engaged. Pressing the COLL button will decouple the collective axis, turning off the collective servo. The 3-Q mode will remain select, and the collective can be manually flown to satisfy the collective cue on the ADI. Once the collective is decoupled, all collective coupling is inhibited until the COLL button is again pressed or either Helipilot is re-engaged.
If the collective is moved out of detent against the collective spring, or if RAD ALT, APR1, APR2, or CLIMB is engaged with and invalid condition in the collective axis detected by the Flight Path Computer, the collective couple annunciator will flash on and off when the collective is coupled to indicate that the collective command is not being followed.

5.1.5 RAD ALT

Pressing the RAD ALT button will engage the radio altitude hold mode. Engaging RAD ALT will override the ALT, VS and GA mode. The RAD ALT mode is collective only mode. If HP1 is engaged, the COLL annunciator will light indicating that the collective axis is holding radio altitude automatically. If the radio altimeter system is invalid, or if the mode is engaged at an altitude greater than 2000 feet AGL, the collective cue on the ADI will be biased from view and the COLL annunciator will flash on and of indicating that the collective is not holding radio altitude. In this condition the collective will be frozen. A new radio altitude hold reference may be established by beeping forward (to descend) or aft (to climb) on the four-way collective beep trim switch. Setting the desired radio altitude on the AL-300 display. The reference may also be changed by pressing the collective FTR switch, flying to a new altitude, and releasing FTR or by simply moving the collective against the spring. When the collective is returned to the detent, the system will hold the new altitude.

5.1.6 VEL HLD

Pressing the VEL HLD button with the Doppler valid and airspeed less than 60 kts will engage the Velocity Hold mode. Once in this mode the FPC utilizes longitudinal and lateral velocity information from the Doppler combined with longitudinal and lateral acceleration from the accelerometer to provide commands to maintain the longitudinal and lateral aircraft velocities existing at time of engagement. Engaging one or both Helipilots will allow the system to automatically maintain velocity by coupling the FPC commands through the Helipilot pitch and roll axis, as indicated by illumination of the CPL light. The velocity hold reference can be changed by pressing the cyclic FTR switch, flying the aircraft to the desired velocity, and releasing the FTR switch.
Once the FTR switch is released, the system will maintain the new reference. The reference can also be changed by pressing the 4-way cyclic beep switch in the desired direction to set the velocity desired on the AL-300 display.
In the Doppler is not valid at the time the VEL HLD button is pressed both Helipilots must be on to allow engagement of Velocity Hold. In this case, the system will be in an inertial damping mode using only information from the accelerometer to provide short term velocity hold and will not use information from the Doppler, untill the Doppler becomes valid again.
The pitch and roll command bars will be biased from view in this condition and the CPL light will remain off.

5.2 MODE SELECTOR

This section describes the modes and combinations of modes that are available through the Mode Selector.
All these modes are available for automatic (coupled) flight path operation by engaging either Helipilot system ATT (both systems for APR2 and CLIMB) and selecting the desired mode on the Mode Selector.
When coupled, the system will automatically satisfy all pitch, roll and collective commands necessary to capture and track the desired flight path.
All modes engageable on the Mode Selector are intended for use at airspeeds above 60 kts except for CLIMB and APR2.

5.2.1 HDG

The heading select mode is selected by pressing the HDG button on the Mode Selector. In the HDG mode, the Flight Path computer provides inputs to the roll steering pointer to command a turn to the heading indicated by the heading bug on the HSI. When HDG is selected, it overrides the NAV, VOR APR, ILS, BC, CLIMB and APR2 modes.

5.2.2 NAV

The NAV mode provides steering commands for VOR, localizer and doppler navigation system. Each is described separately below.

VOR/TACAN MODE

Pressing the NAV button on the Mode Selector with the navigation receiver tuned to a VOR/TACAN frequency and VOR/LOC selected on the NAV switching unit engages the VOR/TACAN mode. When outside the lateral beam sensor trip point, the roll steering pointer receives a heading select command as described above and both the NAV ARM and HDG mode annunciators are illuminated. Upon reaching the lateral beam sensor trip point, the system automatically switches to the VOR mode - HDG and NAV ARM annunciators extinguish, the NAV capture "NAV CAP" annunciator illuminates, and a command is generated to capture and track the VOR/TACAN beam.
When passing over the station, an overstation sensor detects station passage, removing the VOR/TACAN deviation signal from the command until it is no longer erratic. While over the station, course changes are made by selecting a new course on the HSI.
If the NAV receiver is not valid prior to the capture point, the lateral beam sensor will not trip and the system will remain in the HDG mode.

LOCALIZER (LOC) MODE

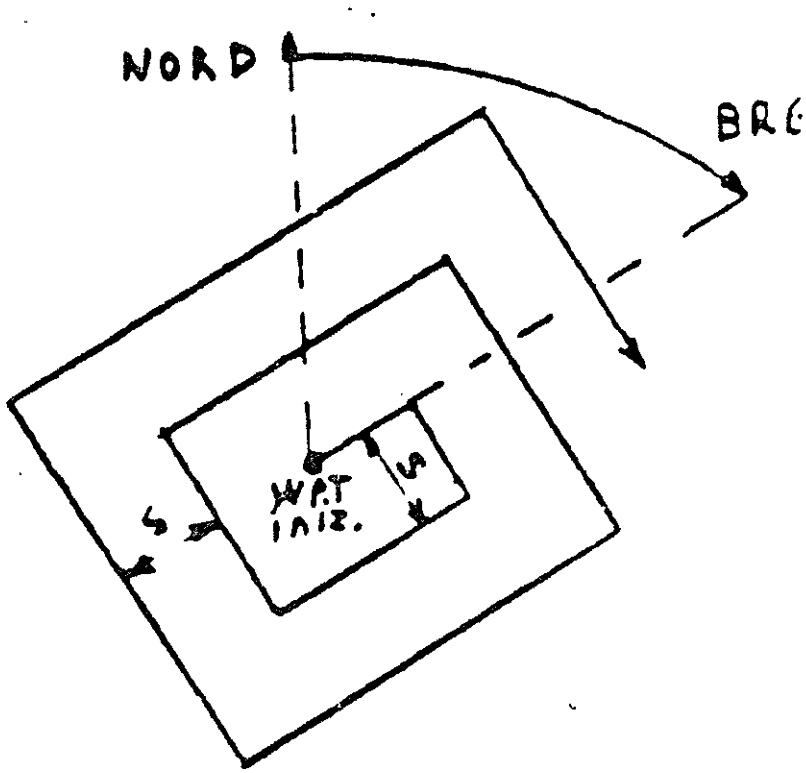
The localizer mode is selected by tuning to a LOC frequency, setting the course pointer to the inbound runway heading, and pressing the NAV button on the Mode Selector with the NAV select unit in the VOR/LOC position. Mode selection and annunciation in the LOC mode is the same as the VOR mode.

LNAV MODE

Pressing the NAV button on the Mode Selector with Doppler selected on the NAV switching unit engages the LNAV mode. Upon engaging the LNAV mode, the NAV capture "NAV CAP" annunciator illuminates indicating that the AFCS is directly following the "steering" commands supplied by the Doppler.
Tipical Doppler features are:
- Route navigation composed by
  . 15 waypoints
  . 10 target of opportunity
  . 25 WPT memory

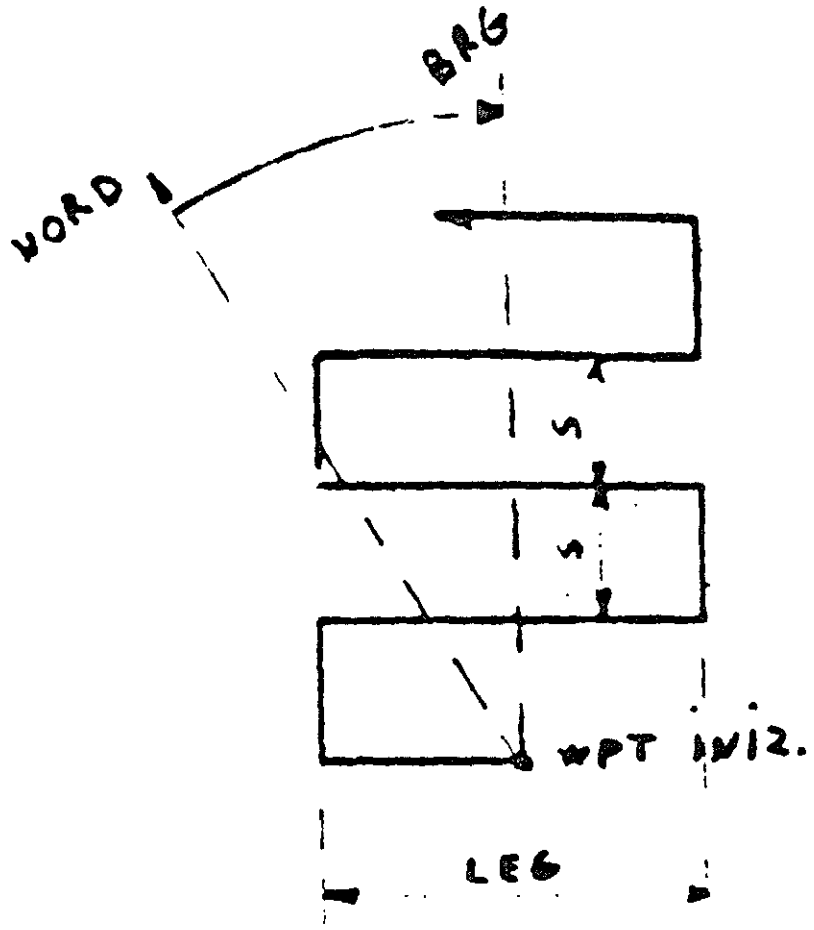
- Search pattern navigation:
  . creeping ladder (Fig.6)

Figure 6



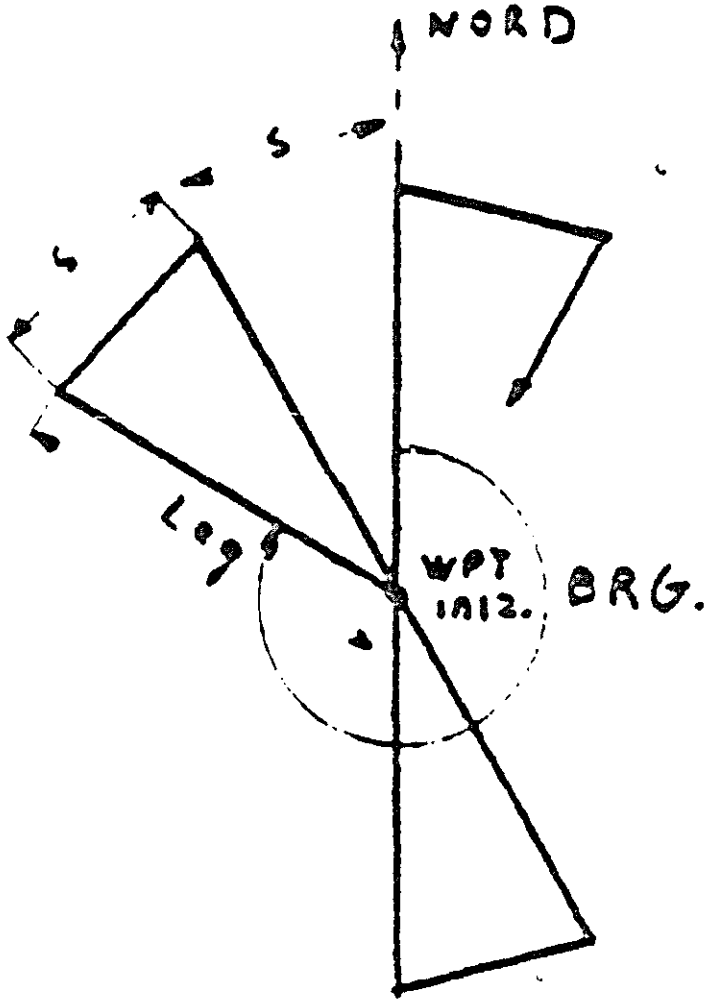
. expanding square (Fig.7)

Figure 7



. cloverleaf sector (Fig.8)

Figure 8



5.2.3. TACAN APR

Pressing the VOR APR button on the Mode Selector with the navigation receiver tuned to a VOR/TACAN frequency and VOR/LOC selected on the NAV switching unit engages the VOR/TACAN approach mode.
The mode operates identical to the VOR mode with the gains optimized for a close-in approach.
This mode should be used if the distance to the station is less than 10 miles.

5.2.4. BC

The back course mode is selected by setting the course pointer to the FRONT COURSE heading and pressing the BC button on the Mode Selector with VOR/LOC selected on the NAV switching unit.
Using this procedure produces normal sensing i.e., "fly towards the bar".
Glideslope capture is locked out when in the BC mode.
When BC is selected outside the lateral beam sensor trip point, BC ARM and HDG will be annunciated.
At the capture point, BC CAP will be annunciated with BC ARM and HDG extinguished.

5.2.5. ILS

The ILS mode is used to make a full ILS approach.
Pressing the ILS BUTTON with a LOC frequency tuned and VOR/LOC selected on the NAV switching unit arms both the localizer and glideslope modes.
The initial localizer capture angle is set using the heading bug similar to the VOR mode.
With the ILS mode armed, the pitch and collective axis can be in any other 3Q or 2Q Mode except GA, APR 2 or CLIMB.
When reaching the vertical beam sensor trip point with glideslope valid, the system automatically switches to the glideslope mode, as indicated by the illumination of the "ILS GS" annunciator.
For 3Q operation, the IAS annunciator remains illuminated, while the other pitch or collective mode and the ILS ARM annunciators extinguish.
In this mode, the pitch axis is holding airspeed while the collective axis is following the glideslope beam.
For 2Q operation, the IAS annunciator is not illuminated.
The pitch axis now follows the glideslope beam while the collective remains stationary.
The pilot must manually re-position the collective to control airspeed during the descent.
At capture, for 3Q and 2Q operation, a command is generated to asymptotically approach the glideslope beam.
Capture can be made from above or below the beam.

Glideslope capture is interlocked so that the localizer must be captured prior to glideslope capture.
If the glideslope receiver is not valid prior to capture, the vertical beam sensor will not trip and the system will remain in the existing pitch and/or collective mode.
If the approach is continued below the normal decision height, a flare will be initiated in both 3Q and 2Q modes to level off the aircraft and maintain 50 feet AGL over the runway.
This auto level feature is inhibited if the radio altimeter is invalid,

5.2.6. IAS

The indicated airspeed hold mode is selected by pressing the IAS SWITCH on the Mode Selector.
The system will maintain the airspeed existing when engaged.
This reference airspeed may be changed incrementally at 3 Knots/sec by operating the four-way cyclic beep trim switch fore and aft.
If coupled, the reference May also be changed by pressing the cyclic FTR, flying to a new airspeed, and releasing FTR.
If the airspeed mode is engaged along with either ALT, VS, ILS GS, or RAD ALT modes, the system will operate in a 3Q mode.
Airspeed, which is a pitch axis mode only, will be maintained by the pitch axis, while the other modes will be controlled by the collective axis.
When the IAS mode is selected the reference airspeed will automatically be displayed on the AL-300 for 5 sec after mode engagement.
After the 5 sec display the AL-300 will blank.
Pressing the airspeed beep switch (fore-aft cyclic beep) will slew the airspeed reference at approximately 3.5 Kts/sec.
The AL-300 will display the airspeed reference signal during the beep plus 5 sec after the beep command has stopped.
Also, pressing cyclic FTR resyncs THE IAS mode, therefore, at AL-300 displays the airspeed reference signal while holding the FTR switch plus 5 sec.

5.2.7. ALT

The barometric altitude hold mode is selected by pressing the ALT button on the Mode Selector.
When ALT is selected, it overrides all other pitch or collective modes except IAS.
The system will maintain the barometric altitude existing when engaged.

To change the altitude reference the ALT mode can be disengaged, the aircraft flown to the new desired altitude, and the mode re-engaged.
If the system is coupled and being flown in the 2Q mode, the Pitch axis is holding the altitude.
A new altitude can be obtained by pressing the cyclic FTR, flying to a new altitude, and releasing the cyclic FTR.
The system will hold the altitude at which the FTR was released.
If the system is being operated 3Q (both IAS and ALT selected) with coupled collective, the collective axis is maintaining altitude.
A new altitude can be obtained by pressing collective FTR, flying to the new altitude and releasing.
After initial power up of the AFCS if the pilot moves the set knob on the AL-300 the display will slew from the present altitude to an altitude commanded by the set knob.
If the pilot does not press the ALT switch to ARM the preselect mode the AL-300 preselect altitude will blank after 15 sec.
If ALT ARM is selected, the preselect altitude will remain in view on the AL-300 until 5 sec after the preselect altitude has been captured.
If while ALT ARM the pilot selects any other pitch or collective mode the AL-300 will display the corresponding reference value for 5 sec then revert back to the altitude preselect value.
Selecting another pitch or collective mode will not disengage ALT ARM.
If the pilot wishes to select ALT hold at his present altitude he may do so by simply pressing the ALT button without moving the AL-300 set knob.
The ALT CAP annunciator will light indicating altitude hold is engaged.
If the Pilot has set a preselect altitude and ARMs the ALT mode, then decides he would like to hold his present altitude, he may do so by pressing ALT which will disengage ALT ARM and blank the AL-300, then press ALT again which would immediately engage ALT CAP.
Pressing SBY will also disengage ALT ARM and blank the display.
As indicated above on initial power up the preselect set knob will begin slewing from the present altitude.
Once a preselect value has been set the next time the set knob is adjusted it will begin slewing from the previously selected value.

5.2.8. The vertical speed select mode is engaged by pressing the VS button.
When VS is selected it overrides all other vertical modes (except IAS).
The vertical speed reference is set by beeping forward (to descend) or aft to climb on the four-way cyclic beep trim switch.
The vertical speed reference is set on the AL-300 display.
With the addition of the AL-300 the vertical speed modes becomes a vertical speed hold with a beep command instead of vertical speed select.
2Q operation, the pitch axis maintains the selected vertical speed.
For 3Q (IAS and VS), vertical speed is maintained through the collective axis.

5.2.9. GA
Pressing the GA switch will engage the go-around mode if airspeed is greater than 60 knots.
When GA is selected, it overrides all other modes.
GA is a 3Q mode.
The collective axis will command a fixed collective position to provide the required power to achieve a climb of 750 fpm at the best rate of climb airspeed.
The pilot can cancel the collective command by pressing collective FTR and positioning the collective as desired.
The pitch axis will command an appropriate climb rate based on airspeed.
If airspeed is above 65 knots, the pitch axis will command a 750 fpm climb.
If airspeed is between 55 and 65 knots, the climb rate will be between zero and 750 fpm.
Should the aircraft slow to less than 55 Knots, the pitch axis will fly level (zero climb rate).
The roll axis will hold the heading existing at time of engagement.
Once the go-around climb-out is established, a roll mode may be selected without cancelling GA.

5.2.10. APR
The 3Q approach-to-hover mode is engaged by pressing the APR button on the Mode Selector or collective stick.
This mode actually consists of two separate sequential modes, APR 1 and APR 2.
For normal operation, pressing the APR button will engage the APR 1 mode.
After the APR 1 sequence is completed, pressing the APR button again will engage the APR 2 mode.

5.2.11. APR 1

The approach 1 mode may be engaged any time radio altitude is valid, greater than 20 feet and less than 2000 feet, airspeed is greater than 55 knots, and the approach 2 mode engagement conditions are not met.

If the above conditions are met, pressing APR will engage APR 1 mode.

The APR 1 and RAD ALT annunciators on the Mode Selector will light.

If the initial airspeed is greater than 60 Kts the aircraft will begin to decelerate.

When the aircraft reaches 60 Kts, the Mode Selector IAS annunciator will light and the aircraft will hold 60 Kts. (Both IAS and APR 1 are on.)

After the decel has been established thru pitch, the RAD ALT annunciator will extinguish and the collective axis will begin a descent at 500 fpm to an altitude of 200 ft AGL.

At 200 feet the RAD ALT annunciator will automatically light.

If APR 1 is selected below 200 ft the collective axis will hold the radio altitude existing at the time of engagement.

If during the APR 1 the pilot momentarily presses the cyclic FTR or the cyclic fore or aft beep switch, the system will discontinue the decel, engage IAS, and hold the existing airspeed.

The collective command will continue descent to 200 ft.

If the pilot momentarily presses the collective FTR or the collective up or down beep switch, the system will engage RAD ALT and hold the existing radio altitude but continue to decel to 60 Kts.

For normal operation the APR 1 mode will dring the aircraft to 200 ft radio altitude and an airspeed of 60 Kts.

Any lateral mode will not be affected by APR 1.

5.2.12. APR 2

Pressing the APR button will engage the approach 2 mode if radio altitude is valid, greater than 20 feet and less than 250 feet, and airspeed is valid, and less than 65 Knots.

If the Doppler is not valid, the airspeed must be greater than 55 Kts.

APR 2 will override all other modes.

The collective axis will command a descent rate of 200 fpm to an altitude of 50 feet at which time RAD ALT will automatically engage. If radio altitude is less than 50 feet, the collective axis will maintain the altitude existing at time of engagement.

Engaging APR 2 will also automatically engage IAS.

When radio altitude is below 175 feet and the mode been engaged for at least 5 seconds, the IAS annunciator will extinguish, and the pitch axis will command a deceleration using information from the longitudinal accelerometer.
If the Doppler is valid when APR 2 is engaged, the deceleration will continue until the aircraft has obtained Doppler velocity of 0 Knots.
Loss of Doppler valid during the approach will force the FPC to approximate Doppler velocity using information from the longitudinal accelerometer only.
The approach will continue until the approximate 0 Knot velocity is reached, if the Doppler remains invalid.
If the Doppler is not valid when APR 2 is engaged, the FPC will revert to a backup method of performing the deceleration and will not use the Doppler for the approach.
In the backup method, the deceleration will continue for a calculated period of time that will slow the aircraft to approximately 15 Knots airspeed.
When the final velocity is reached, the VEL HLD mode will automatically engage and the APR 2 annunciator will extinguish.
At this point the pilot may fly thru the system to maneuver the aircraft to a specific flight condition or hover point.
If the Doppler is valid when APR 2 is engaged, the roll axis will maintain zero lateral Doppler Velocity.
If the Doppler is not valid when APR 2 is engaged, the roll axis follows a programmed attitude command to maintain a lateral velocity of approximately zero in a zero crosswind condition.
If a crosswind does exist, the pilot can beep the cyclic four-way beep trim switch left or right to change the roll attitude to compensate for the crosswind.
This action will cancel the programmed attitude and the system will maintain the roll attitude to which the pilot beeps.
If during APR 2 the pilot momentarily presses the cyclic FTR or the cyclic fore or aft beep switch, the system will discontinue the decel, engage VEL HLD and hold the existing aircraft velocity.
The collective command will continue descent to 50 ft.
If the pilot momentarily presses the collective FTR or the collective up or down beep switch, the system will engage RAD ALT and hold the existing radio altitude but continue to decel.
If an automatic APR 2 maneuver is completed the AL-300 will not display the Doppler velocity signals when VEL HLD automatically engages since the longitudinal and lateral references will be zero.

If the decel of APR 2 is discontinued at some time during the approach by pressing VEL HLD, cyclic FTR, or fore or aft beep, the AL-300 will display the longitudinal velocity reference for 5 sec.

5.2.13. CLIMB

Pressing the CLIMB button will engage the climbout-from-hover mode if radio altitude is valid, greater than 20 feet and less than 200 feet, and airspeed is less than 60 Knots.
The CLIMB mode will override all other modes.
The collective stick will remain at the hover position or increase slightly to prevent the aircraft from drooping below the reference altitude.
The collective stick will remain at this setting until the climb rate equals 200 fpm at which time the collective will maintain 200 fpm rate of climb to an altitude of 200 ft.
At 200 ft the RAD ALT hold mode will automatically engage.
An acceleration command will be programmed into pitch over a 5 sec time period to provide a smooth climbout maneuver.
When the aircraft reaches 60 Kts the system will revert to the IAS hold mode.
When both 200 ft and 60 Kts have been reached the CLIMB annunciator will extinguish.
Any lateral flight director mode be selected once the climb maneuver is completed.
If the Doppler is valid when the CLIMB mode is engaged, the roll axis will maintain zero lateral Doppler velocity.
If the Doppler is not valid when CLIMB is engaged, the roll axis will hold the hover attitude existing at CLIMB engagement, then transition to a wings level condition after approximately 15 sec.
For this condition, the pilot may trim the roll attitude during CLIMB using the cyclic beep switch.
When the aircraft reaches 60 Kts the roll axis will revert to heading hold until another roll mode has been selected.
During the climb mode monemtarily pressing the cyclic FTR or the cyclic fore or aft beep switch will disengage the acceleration command.
The system will engage VEL HLD and hold the existing longitudinal velocity.
The collective command will continue to 200 ft.
Momentarily pressing the collective FTR or the collective up or down beep switch will engage RAD ALT and hold the existing radio altitude, but the system will continue to accelerate to 60 Knots.

6. OPERATIONAL ASPECTS

The SPZ 7300 has been developed by AGUSTA and SPERRY (now HONEYWELL) to meet the ITALIAN AIR FORCE S.A.R. requirements for day, night and all weather operations.
The first aim was to find a Flight Control System to be introduced in the already existing and operating helicopters like AB212 and 412.
It was needed something of a new technology to improve the basic capability of the aircraft to be used in the role for the next 15 years.
Therefore, after some technical assessment, it was decided to go on developing with SPERRY the SPZ 7300 having in wind to make it easy to operate, reliable and comfortable during all the manoeuvres.
It has been said quite a lot about all the operational modes, but it is important to emphasize the Automatic Approach to hover and the Climb.
In the first one it was decided for high flexibility enabling the pilot to fly, if needed, throught the autopilot by using cyclic and collective beeper trim to change or select altitude and velocity.
The "climb" mode was related to a climb rate of 200 feet/min; this allow not to loose altitude at any speed engagement below 60 KIAS.

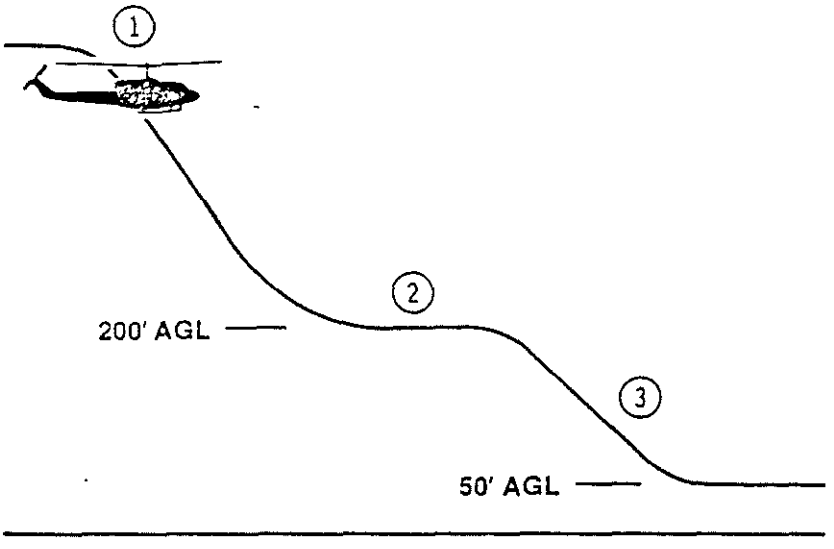
6.1. Automatic Approach To Hover

The approach mode is a two stage automatic transition to a hover a 50 feet AGL, each stage of which is engaged by pilot action. (Fig. 9).
Engage APR on the Mode Selector, APR 1 will light and the aircraft will begin to decelerate. The aircraft will then begin a 500 fpm descent.
During APR 1 any roll mode (e.g., HDG) will remain engaged (if already engaged) and may still be used to steer the aircraft. (1)
As the aircraft approaches an altitude of 200 ft AGL it will automatically level off. RAD ALT will automatically engage to maintain 200 ft. IAS will automatically engage when the ship has slowed to 60 knots and the APR 1 light will go out.
The second stage of the approach is now initiated the pilot again engaging APR on the Mode selector. APR 2 will light, all other modes will be cancelled, and the aircraft will begin a 200 fpm descent. When the aircraft descends below 175 feet it will begin an automatic deceleration. During APR 2 way is maintaining aircraft heading. (2)

As the aircraft approaches an altitude of 50 feet it will automatically level off. RAD ALT will automatically engage to maintain the 50 feet hover altitude. When the ship has slowed to a hover, the VEL HLD mode will automatically engage, maintaining the zero knot hover, and the APR 2 light will go out. The pilot can now use the cyclic four-way beep switch to make any heading or altitude changes. (3)

Figure 9

Automatic Approach To Hover



6.2. Climb

The climb mode will automatically transition the aircraft from hover to a 200 fpm climb. (Fig. 10)
After climb out heading is established, engage CLIMB on the Mode Selector. The aircraft will begin to accelerate and then will begin a 200 fpm climb. Lateral drift can be corrected by beefing left or right on the cyclic four-way beep switch. The yaw axis will maintain aircraft heading.
As the aircraft approaches 200 feet AGL, it will begin to level off.
The RAD ALT mode will engage to maintain 200 feet. When airspeed reaches 60 knots, the IAS mode will engage to maintain 60 knots and the CLIMB light will go out. The roll axis will maintain aircraft heading until a roll flight director mode is engaged.

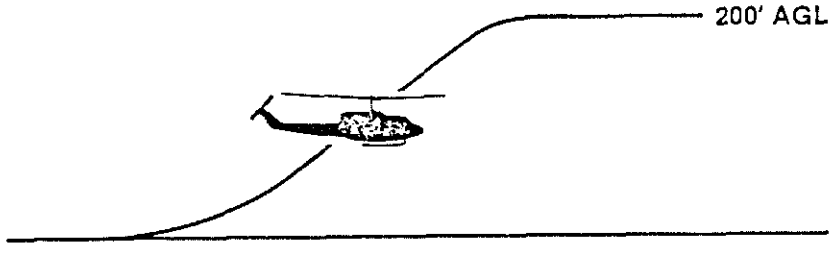
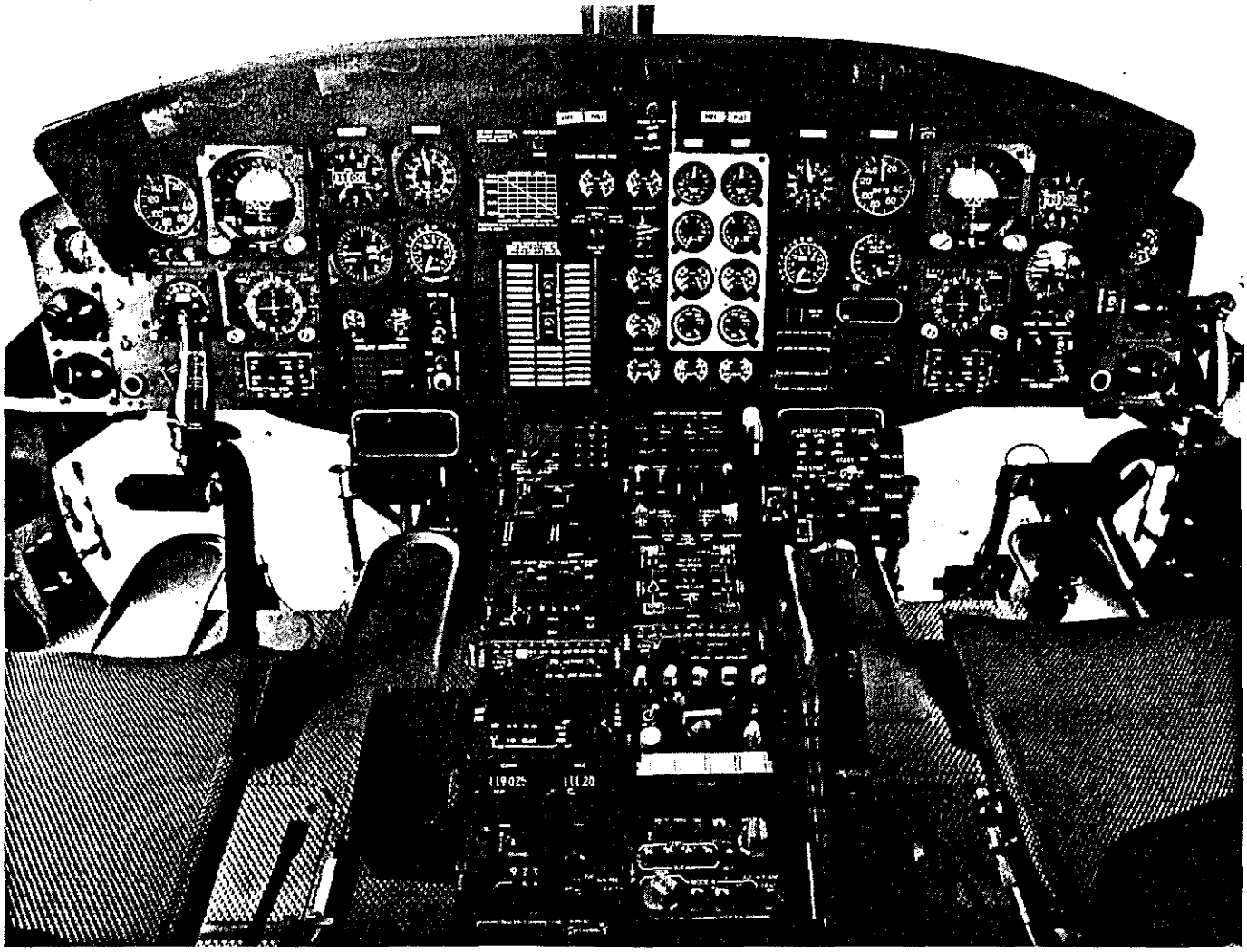


Figure 10

It is remarkable to point out that the aircraft fly smooth and gently throughout all the manoeuvres. The altitude changes during the letdown procedure and the hover acquisition were kept to a minimum to give comfort to the aircrew operating in poor weather conditions.
The aircraft reacts very gently to any pilot input through the autopilot.
Above all, it is important to state: the System will continue to operate, without Doppler, using the accelerometer signals to descend and decelerate to hover altitude maintaining the same flying characteristics as with the Doppler valid.
The aircraft and flight Control System performance allowed to fly in relative wind from any direction and flights test up to 30 KTS in real enviromental conditions were conducted with good results.
Fig. N° 11 shows the instrument panel of the AB212 S.A.R. CONFIGURATION.

Figure 11



7. CONCLUSIONS

The AFCS here described was developed to meet the S.A.R. mission requirements of ITALIAN AIR FORCE on existing and proved helicopter like AB212.
This has been obtained updating an already existing AFCS implemented with new digital computer.
Further more the similarity between the AB212 and AB412 gave the possibility to install the same system with few software changes on the four blades version.
Next step will be the Navy version of this system implemented with the CABLE MODE for the Sonar equipment to be installed on the AB212 ASW.
The result in cost-effectiveness terms has been remarkable considering the number of different type on which the system can be installed.