SECTION 1 - GENERAL

The Garmin GPS155XL panel mounted unit contains the GPS sensor, the navigation computer, a CRT display, and all controls required to operate the unit. It also houses the data base cartridge with plugs directly into the back of the unit.

The data base cartridge is an electronic memory containing information on airports, navaids, intersections, SID´s , STAR´s, Instrument approaches, special use airspace, and other items of value to the pilot.

Every 28 days, Jeppesen Sanderson processes and downloads data base informations for the region onto the data base cartridges. Jeppesen makes these data base cartridge updates available to Garmin GPS155XL users.

Provided the Garmin GPS155XL navigation system is receiving adequate usable signals, it has been demonstrated capable of and has been shown to meet the accuracy specifications of:

- VFR/IFR enroute oceanic and remote, enroute domestic, terminal, and instrument approach (GPS, Loran C, VOR, VOR-DME, RNAV) operation within the U.S: National Airspace System, North Atlantic Minimum Navigation Performance Specifications (MNPS) Airspace and latitudes bounded by 74°North and 60° South using the WGS-84 coordinate reference datum in accordance with the criteria of AC 20-138, AC 91-49, AC 120-33. Satellite navigation data is based upon use of only the global positioning system (GPS) operated by the United States.

- Operational criteria for the use of Navigation Systems in European airspace designated for Basic RNAV Operations in accordance with AMJ20X2 (Leaflet 2 rev.1)

5.11.98

SECTION II

LIMITATIONS

1. The GARMIN GPS 155XL Pilot's Guide, P/N 190-00067-20, Rev. A, dated February, 1998, or later appropriate revision, must be immediately available to the flight crew whenever navigation is predicated on the use of the system.

2. The GPS 155XL must utilize software version 2.03 or later FAA approved revision. The software version is displayed on the GPS 155XL self test page immediately after turn-on for 5 seconds.

3. IFR enroute and terminal navigation is prohibited unless the pilot verifies the currency of the data base or verifies each selected waypoint for accuracy by reference to current approved data.

4. Instrument approaches must be accomplished in accordance with approved instrument approach procedures that are retrieved from the GPS equipment data base. The GPS equipment data base must incorporate the current update cycle.

   (a) Instrument approaches must be conducted in the approach mode and Receiver Autonomous Integrity Monitoring (RAIM) must be available at the Final Approach Fix.

   (b) Accomplishment of ILS, LOC, LOC-BC, LDA, SDF, and MLS approaches are not authorized.

   (c) Coupling of the autopilot/flight director to GPS deviation data on the arc segment of approaches incorporating an arc transition is not authorized.

   (d) When an alternate airport is required by the applicable operating rules, it must be served by an approach based on other than GPS or Loran-C navigation, the aircraft must have the operational equipment capable of using that navigation aid, and the required navigation aid must be operational.

   (e) VNAV information may be utilized for advisory information only. Use of VNAV information for Instrument Approach Procedures does not guarantee Step-Down Fix altitude protection, or arrival at approach minimums in normal position to land.

5. The aircraft must have other approved navigation equipment installed and operating appropriate to the route of flight.

6. If not previously defined, the following default settings must be made in the "SET" menu of the GPS 155XL prior to operation (refer to Pilot's Guide for procedure if necessary):

   (a) **nav** ..... k t (sets navigation units to "nautical miles" and "knots")

   (b) **alt** .....f t fpm (sets altitude units to "feet" and "feet per minute")

   (c) **map datum** .. WGS 84 (sets map datum to WGS-84, see note below)

   (d) **posn** ..... deg-min (sets navigation grid units to decimal minutes)

NOTE

In some areas outside the United States, datums other than WGS-84 or NAD-83 may be used. If the GPS 155XL is authorized for use by the appropriate Airworthiness authority, the required geodetic datum must be set in the GPS 155XL prior to its use for navigation.

5.11.98

SECTION III

EMERGENCY PROCEDURES

ABNORMAL PROCEDURES

1. If GARMIN GPS 155XL navigation information is not available or invalid, utilize remaining operational navigation equipment as required.
2. If "RAIM POSITION WARN" message is displayed the system will flag and no longer provide navigational guidance. The crew should revert to an alternate means of navigation.
3. If "RAIM NOT AVAILABLE" message is displayed in the enroute, terminal, or initial approach phase of flight, continue to navigate using the GPS equipment or revert to an alternate means of navigation appropriate to the route and phase of flight. When continuing to use GPS navigation, position must be verified every 15 minutes using another IFR-approved navigation system.
4. If "RAIM NOT AVAILABLE" message is displayed while on the final approach segment, navigation will continue for up to 5 minutes with approach CDI sensitivity (0.3 nautical mile). After 5 minutes the system will flag and no longer provide course guidance with approach sensitivity. Missed approach course guidance may still be available with 1 nautical mile CDI sensitivity by executing the missed approach operation described in Section IV paragraph 2(f) of this Airplane Flight Manual Supplement.

SECTION IV

NORMAL PROCEDURES

1. DETAILED OPERATING PROCEDURES

Normal operating procedures are described in the GARMIN GPS 155XL Pilot's Guide, P/N 190-00067-20, Rev. A, dated February, 1998, or later appropriate revision.

2. APPROACH MODE / RAIM PREDICTION

General Approach Mode Procedures

NOTE

Coupling of the autopilot to GPS deviation data in approach mode is not authorized. Approach mode

operation should be accomplished with flight director selected in NAV mode and autopilot disconnected.

The information contained in this section is vital for successful operation of the GPS 155XL during approach mode. The following is a summary of the approach navigation features provided by the GPS 155XL:

(a) The pilot may, at any time, select an approach that is available for the destination airport (see Pilot's Guide for more information on selecting approaches). The destination airport is defined to be the last waypoint in the active route or the current direct-to airport.

NOTE

If the destination airport is the active waypoint when an approach is selected, the active waypoint will automatically change to the IAF of the selected approach. If it is desired to NOT automatically change to the IAF, the pilot should HOLD mode with the "GPS SEQ" switch on the annunciator unit prior to selecting the approach.

(a) Once an approach has been selected, the GPS 155XL will automatically arm the approach mode when the aircraft is within 30 nautical miles of the approach airport.

(b) When approach mode is available and the aircraft is within 30 nm of the destination airport, the GPS APR (GPS Approach) annunciator will indicate ARM, and the GPS 155XL will provide a smooth CDI scaling transition from 5.0 nautical miles full scale to 1.0 nautical mile full scale. In addition, the GPS 155XL will perform receiver autonomous integrity monitoring with a protection limit of 1.0 nautical mile. When approach mode is available and armed, the pilot may at any time deactivate the approach mode by pressing the GPS APR (GPS Approach) Switch on the annunciator unit. Pressing the GPS APR switch a second time will re-arm approach mode.

(c) If the aircraft is within 3.0 nautical miles inbound to the FAF and the pilot has deactivated the approach mode with the GPS APR Switch, the message "Arm Approach Mode" will be displayed. Pressing the GPS APR switch will re-arm the approach mode.

(d) When the GPS 155XL approach mode has been armed (ARM annunciator illuminated), the GPS SEQ switch has been set to AUTO, and the aircraft is within 2.0 nautical miles of the FAF, the

ACTV (Active) annunciator will be illuminated and the CDI scale sensitivity will start to change from 1.0 nautical mile full scale to 0.3 nautical mile full scale. In addition, the GPS 155XL will perform receiver autonomous integrity monitoring with a protection limit of 0.3 nautical mile.

(e) When flying the final approach leg of an active approach, the pilot may activate the missed approach by pressing the GPS APR switch to deactivate the approach mode. The GPS 155XL will then continue to provide course guidance along the final approach path to the MAP (Missed Approach Point), change the CDI sensitivity to 1.0 nautical mile full scale, and extinguish the ACTV (active) annunciation. After crossing the MAP (Missed Approach Point), the pilot may activate the missed approach holding waypoint by simply pressing the direct-to key (the GPS 155XL will display the waypoint coordinates of the missed approach holding point or the first waypoint in the missed approach procedure if more than one) followed by the ENT key. If an intercept course other than the direct-to navigation course is desired (which is often the case) the pilot should press the GPS SEQ (GPS Sequence) switch so that the HOLD annunciator illuminates.

NOTE

It is the pilot's responsibility to assure that the missed approach procedure is accomplished in protected airspace. The missed approach procedure must be flown as depicted on the approach chart and normally should not be started until the aircraft has arrived at the MAP.

Approach Waypoint Sequencing

If the GPS 155XL is being used to navigate directly to an Airport (no route active), selecting an approach automatically loads the waypoints of the selected approach into the active route, and selects the Initial Approach Fix (IAF) as the active waypoint. If a route is active when the approach is selected, the approach waypoints beginning with the IAF are automatically added to the end of the route. Upon arrival at each waypoint, if the GPS SEQ switch is set to AUTO, the GPS 155XL will automatically sequence to the next waypoint in the route. When the missed approach point (MAP) is passed, the GPS 155XL will stop sequencing and continue to provide course guidance along an extension of the final approach path.

Course Reversals (Procedure Turn)

If a course reversal is required, the pilot must set the required outbound course on the HSI and select HOLD mode with the GPS SEQ switch prior to crossing the FAF outbound. The GPS 155XL will then provide the appropriate course guidance outbound from the fix. Upon starting the course reversal (procedure turn outbound), the pilot must set the charted inbound approach course on the HSI. When intercepting the approach course inbound, the pilot must set the GPS SEQ switch to AUTO. The GPS 155XL will provide guidance inbound to the FAF on the course which was set on the HSI at the time the GPS SEQ switch was changed from HOLD to AUTO.

NOTE

It is important that the GPS SEQ switch be changed from HOLD to AUTO after the HSI course pointer is set to the inbound approach course. For GPS approach activation to occur, the GPS SEQ switch must be set to AUTO prior to crossing the FAF inbound.

Approach Vectoring

The approach route loaded when an approach is selected includes all of the normal approach segments. Normally, the first approach waypoint encountered is the IAF. If ATC is providing vectoring on the approach, any waypoint on the approach may be manually selected as the first waypoint of use. If, for example, ATC provides vectors to the final approach course, the FAF should be selected as the first approach waypoint to use. When informed by ATC that you are being provided vectors to the final approach course, select the FAF by placing the cursor over that waypoint on the RTE page, and pressing the DIRECT-TO key followed by the ENT key. The GPS SEQ switch must be placed in the HOLD position, and the HSI course pointer used to select the inbound final approach course. Upon intercepting the inbound final approach course, place the GPS SEQ switch in the AUTO position.

Approach with DME arc segments

Approach procedures which utilize a DME arc transition may be flown using the GPS 155XL.

For course guidance along the DME ARC, the pilot must select the NAV Position Page on the GPS 155XL and assure that the reference waypoint displayed is the approved reference facility for the DME ARC. The distance to the reference facility is depicted on the right of the

screen and may be used in the same way that a DME presentation would be used to fly the arc. Once established on the DME ARC, the pilot must select HOLD mode using the GPS SEQ switch. (Ensure HOLD is accomplished on the intermediate fix located at the intersection of the arc and the course which completes the arc.) Set the HSI to the published intermediate or final approach course. The HSI will then display course deviation relative to that course. When the intermediate or final approach course has been intercepted, the pilot must select AUTO mode using the GPS SEQ switch.

NOTE

AUTO mode must be selected at least 2 nm prior to the next waypoint.

If an autopilot/flight director is used, the pilot must select HDG mode on the autopilot/flight director and manually adjust heading as necessary to maintain the required path along the DME ARC. Once the final approach course has been intercepted, NAV or APR mode may be selected on the autopilot/flight director if desired.

Holding at a fix

The GPS 155XL may be used to hold at any waypoint by simply selecting that waypoint and placing the GPS SEQ switch in the HOLD mode. The HSI course pointer may then be used to select the holding or non-holding course as appropriate.

RAIM Prediction

As indicated in Section 2, GPS approaches are not authorized unless RAIM is available at the FAF. RAIM availability at the destination may be predicted using the GPS 155XL. To display predicted RAIM availability for the current destination, select "RAIM Prd?" from the NAV-TIME menu. When the ENT key is depressed with the cursor on the "Compute RAIM?" prompt, the GPS 155XL calculates the predicted availability of RAIM at the displayed waypoint for a time interval of 15 minutes before, to 15 minutes after the displayed ETA. Actual availability of RAIM may vary depending upon satellite conditions existing upon arrival at the destination.

3. SYSTEM SWITCHES / ANNUNCIATORS

An integrated switching and annunciation unit is used with the GPS 155XL system. This unit is located on the instrument panel in the pilot's primary field of view as illustrated below.

(a) NAV / GPS switch and annunciators - By depressing this switch, the GPS 155XL data and the NAV (VOR/ILS) data will be alternately displayed on the pilot's HSI and selected for the autopilot / flight director input. The source of data being displayed will be annunciated on the face of the annunciator unit with either a white NAV legend or a green GPS legend as appropriate. The GPS CDI indicator will be displaying GPS information permanently.

(b) GPS Message (MSG annunciator) - When the GPS 155XL has a new message, the amber MSG annunciator will flash. When this occurs, press the MSG key on the GPS 155XL to view the message. Continue to press the MSG key on the GPS 155XL until the page you were viewing prior to pressing the MSG key is re-displayed. As long as the condition which created the message continues to exist, the Message annunciator will remain illuminated. A MSG annunciator is also located on the Copilots CDI.

(c) GPS Waypoint (WPT annunciator) - When the GPS 155XL detects that the aircraft is 15 seconds from the next programmed waypoint or turn anticipation point, the amber WPT annunciator will flash and the CDI depiction on the CDI Page will be replaced by a flashing "Next dtk xxx°" prompt. Approximately 2 seconds before the turn anticipation point (calculated for 15 degrees of bank) the WPT annunciator will turn on steady. This is the indication that you should start the turn to the next DTK. Upon passing the waypoint (or half way through the turn), the annunciator will automatically extinguish.

(d) GPS SEQ switch and annunciators (HOLD/AUTO) - When AUTO sequencing mode is enabled, depressing this switch disables automatic GPS waypoint sequencing and enables course entry from the pilot's HSI course needle. The amber HOLD legend is illuminated. If depressed again, the GPS system re-enables automatic waypoint sequencing, captures the selected course from the HSI course needle, and illuminates the green AUTO legend.

NOTE

If the To / From indicator on the CDI / HSI indicates "From" when the GPS SEQ switch is pressed to re-select AUTO mode from HOLD mode, the GPS 155XL will automatically calculate a course to the next

waypoint from the aircraft's current position and automatically sequence to that waypoint.

(e) GPS APR switch and annunciators (ARM / ACTV) - The GPS 155XL Approach ARM Mode is automatically engaged when the pilot has selected an approach and the aircraft is within 30 nm of the approach airport. When the approach mode has been armed or activated, the approach mode may be deactivated by depressing the GPS APR switch. When the approach mode has been armed, the white ARM annunciator will illuminate. When the GPS 155XL then detects that conditions are acceptable and the aircraft is within 2 nm of the FAF, the green ACTV annunciator will illuminate and the white ARM annunciator will simultaneously extinguish. If the pilot has deactivated approach mode by pressing the GPS APR switch, pressing the switch a second time will re-arm approach mode.

(f) LAMP TEST switch. When this switch is depressed, all annunciators in the unit will illuminate until the switch is released.

4. PILOT'S DISPLAY

PILOT: The GPS 155XL System data will appear on the Pilot´s HSI when it has been selected using the NAV / GPS switch described in paragraph 3(a) above.

COPILOT: The GPS course deviation information will be displayed on the GPS CDI indicator.

5. AUTOPILOT / FLIGHT DIRECTOR OPERATION

Coupling of the GPS 155XL System steering information to the autopilot/flight director can be accomplished by engaging the autopilot/flight director in the NAV mode, with the NAV / GPS switch set to GPS. When the autopilot/flight director system is using course information supplied by the GPS 155XL System and the course pointer is not automatically driven to the desired track, the course pointer on the HSI must be manually set to the desired track (DTK) indicated by the GPS 155XL. For detailed autopilot/flight director operational instructions, refer to the FAA Approved Flight Manual Supplement for the autopilot/flight director.

NOTE

Coupling of the autopilot to GPS deviation data in approach mode is not authorized. Approach mode operation should be accomplished with flight director selected in NAV mode and autopilot disconnected.

When the autopilot/flight director is using data supplied by the GPS 155XL and the GPS 155XL is in Route mode, the course pointer must be reset to the new desired track (DTK) at each route leg change.

SECTION V

PERFORMANCE

No change.

SECTION VI

WEIGHT AND BALANCE

See current weight and balance data.

SECTION VII

AIRPLANE & SYSTEM DESCRIPTIONS

See GPS 155XL Pilot's Guide for a complete description of the GPS 155XL system.

Air Radio Service GmbH.
MOT I-09
Vienna, Austria

Aircraft Make:	PIPER
Aircraft Model:	PA-34-200T
Aircraft Serial Number:	34-8133066
Repair Station:	AIR RADIO SERVICE, Vienna
Approval Nr.:	I-09
Work Order Nr.:	98.5562

APPROVED AFM SUPPLEMENT
Garmin GPS155XL GPS Navigation System

This document must be carried in the airplane at all times. It describes the operating procedures for the Garmin GPS155XL GPS Navigation System when it has been installed in accordance with the Air Radio Service EO Nr. 98.5562 dated 28.10.1998.

For airplanes with an FAA Approved Airplane Flight Manual, this document serves as the ACG Approved Garmin GPS155XL Flight Manual Supplement. For airplanes that do not have an approved flight manual, this document serves as the ACG Approved Garmin GPS155XL Supplemental Flight Manual.

The information contained herein supplements or supersedes the basic Airplane Flight Manual only in those areas listed herein. For limitations, procedures, and performance information not contained in this document, consult the basic Airplane Flight Manual.

Austro Control GmbH (ACG) APPROVED

Sign: _____ Date: 20.11.1998

City: Vienna State: Austria

Micro Line WXR-200A

Operational Controls

All operating controls for the WXR-200A Weather Radar System are located on the indicator. For the rectangular IND-200A Indicator, the controls are on the right front of the indicator. For the optional IND-201 Indicator, the controls are along the bottom edge of the indicator. Operationally, both indicators provide the same functions. The following paragraphs describe the controls and their function.

> *NOTE* Except for the OFF and STBY functions, the following discussion assumes the system is operating (one of the four ranges is selected).

range switch

OFF - Removes power from the weather radar system.

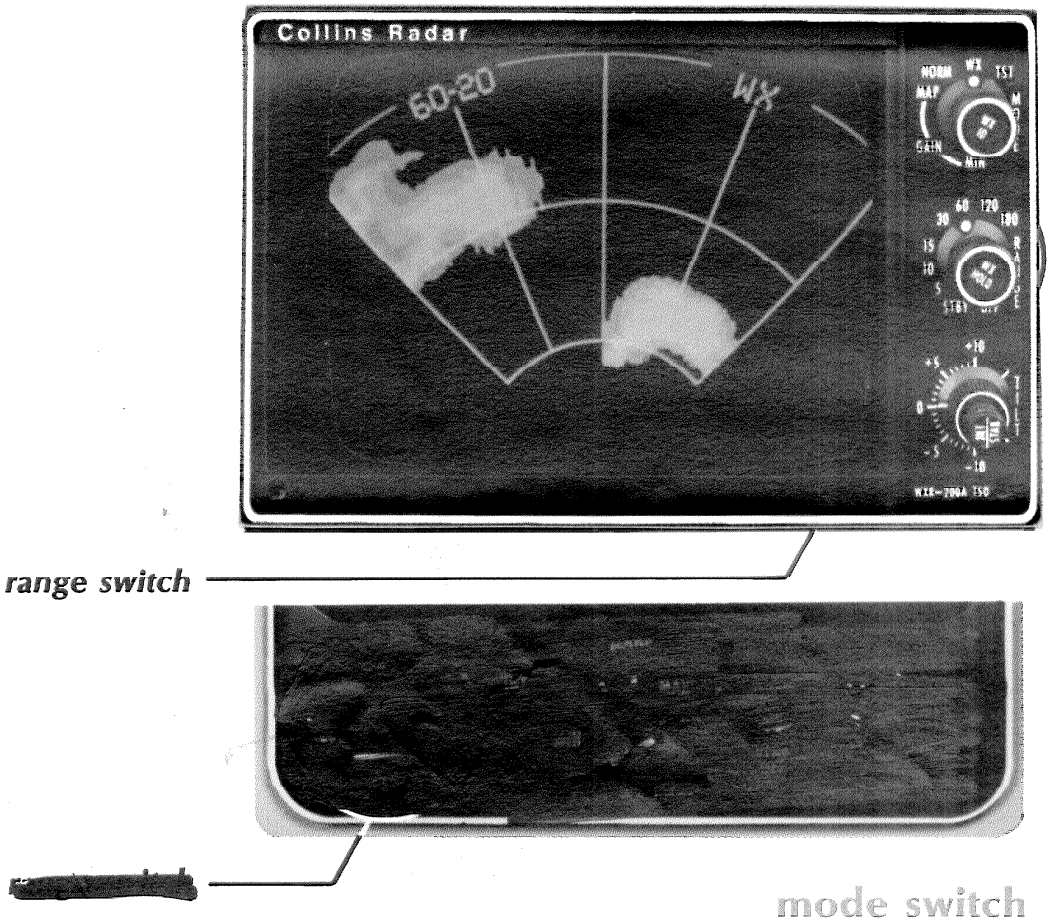
STBY - Power is applied to the system and a 60-second warmup period is initiated. The indicator display and transmitter circuits are inhibited during the 60-second warmup period, and whenever STBY is selected. Range marks and azimuth lines should appear within 20 seconds after applying power. The antenna scan drive circuit is also inhibited in STBY if the MODE switch is in any position except TST. If the MODE switch is in TST and the RANGE switch is in STBY, the antenna will scan. STBY is displayed at the top of the screen provided TST and/or HOLD are not selected.

5 - The antenna begins to scan, and after the 60-second warmup period has elapsed, transmitter is energized. This position selects 30-nautical-mile range (maximum) with three 10-mile range marks. 30-10 is displayed at top left of the screen, and the selected mode is displayed at top right of the screen.

60- Same as 30 except selects 60-nautical-mile range (maximum) with three 20-mile range marks (60-20 is displayed).

120- Same as 30 except selects 120-nautical-mile range (maximum) with three 40-mile range marks (120-40 is displayed).

180- Same as 30 except selects 180-nautical-mile range (maximum) with three 60-mile range marks (180-60 is displayed).



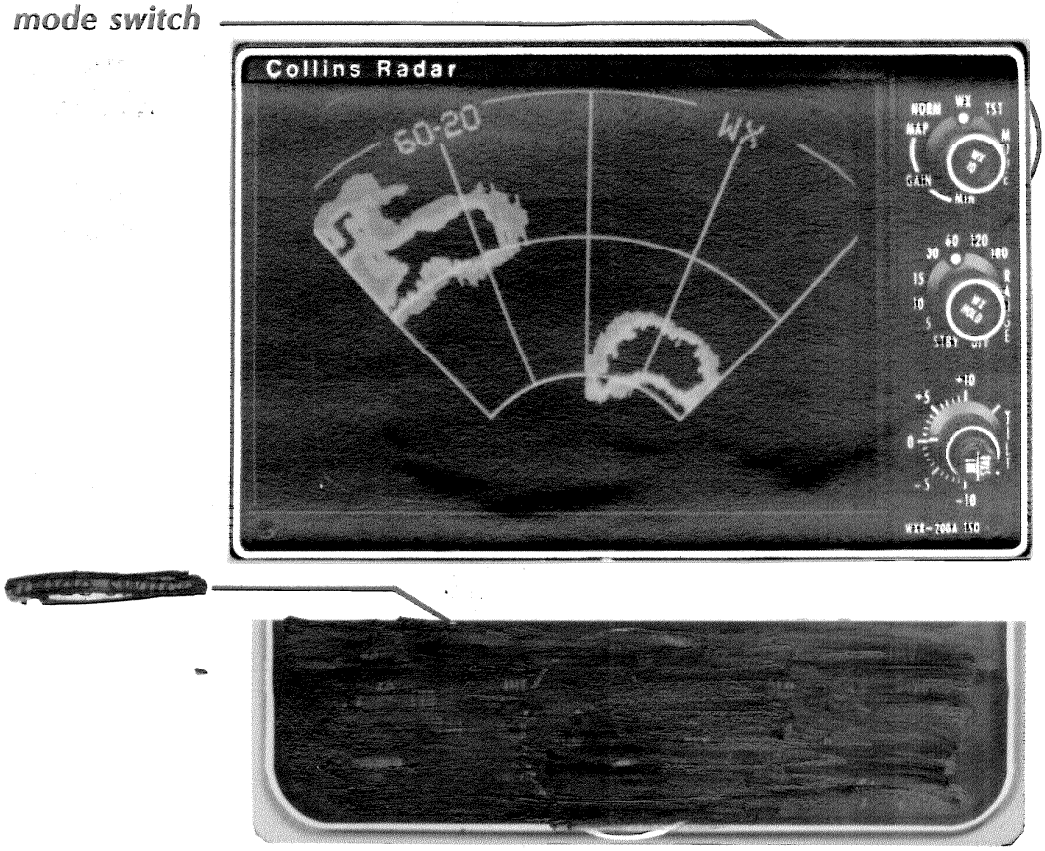
TST- Initiates the self-test function. After system warmup time (approximately 60 seconds) has elapsed, the display shown on page 15 should appear. The status light should be on. WX and 30-10 will be displayed at top of screen.

WX- Enables the automatic cyclic contour mode in the indicator. Contouring storm cells will appear as a

black area outlined by two lighter levels of brilliance for the first three sweeps, then the contouring cell will become the brightest area on the display for the next sweep. (In WX mode, the first three sweeps are contoured and the fourth sweep is noncontoured.) WX mode and selected range are displayed at top of screen.

MAX-MIN-Selecting one of the five manual gain positions disables the automatic cyclic contour feature. The ability of a target to be displayed is dependent on the particular gain setting used. All detectable targets will be shown in one of three distinct levels of brilliance (plus the black indicator screen), depending on the gain setting used and the radar echo strength. The status light should be on for all of the manual gain positions except for MAX. This is to remind the pilot that the system is operating in a low gain condition, and some targets may not be displayed. The selected range will be displayed at the top left of the screen and the word MAP will appear at the top right for all of the manual gain settings.

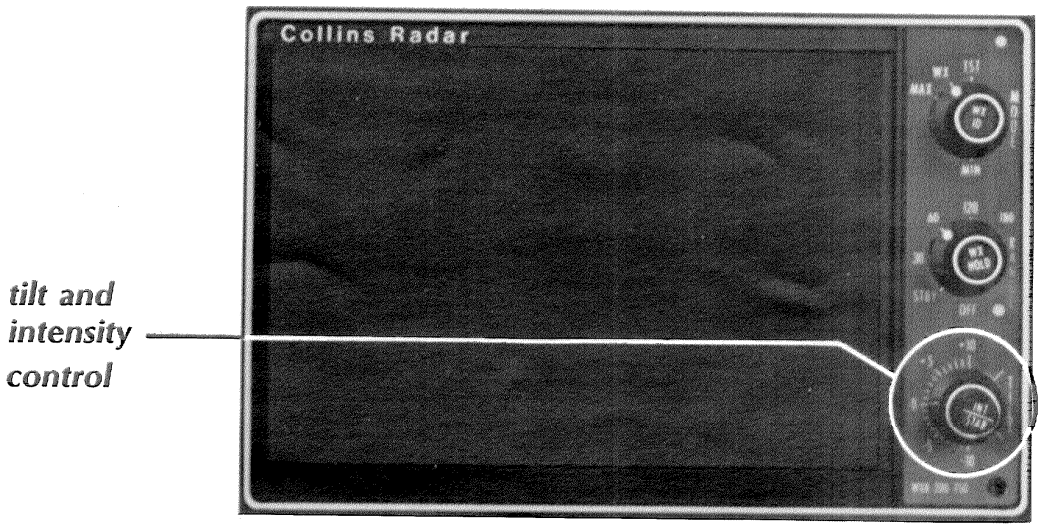
WEATHER IDENTIFICATION (WX ID for IND-200: PUSH WX IDENT for IND-201) - The momentary weather identification button is used to verify that a displayed target has a contouring area. When WX mode is selected, the weather identification feature can be used to verify that a contoured area (dark hole) is actually a storm cell. If the dark hole is a storm cell, pressing the weather identification button will cause the dark hole to become the brightest of the three levels of brilliance displayed on the indicator. Returns not contouring will be erased from the display. If the weather identification button is pressed and the dark hole remains, then this particular area does not represent a contour or a storm cell. If one of the manual gain settings is selected and the weather identification button is pressed, only detectable contouring storm cell targets will be displayed and the rest of the screen will be dark. Releasing the weather identification button allows the system to return to normal operation within approximately 10 seconds.

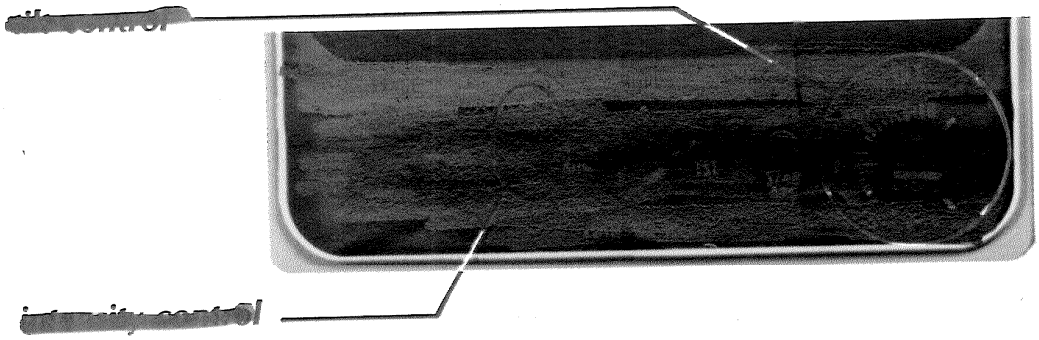


tilt and intensity controls

TILT - The TILT control manually adjusts the pitch axis of the antenna from approximately +15 to -15 degrees to allow the best target presentation.

INT - Controls the intensity of the indicator display. This control is concentric with the TILT control on the IND-200. The optional IND-201 has a separate intensity control.





weather hold and stabilization controls

IND-200 (WX HOLD and STAB switches, and hold monitor)

WX HOLD - The push on/push off WX HOLD button allows the display on the indicator to be frozen until a different range is selected or until power is removed from the system. Target updating will not occur when operating in the WX HOLD mode. Selected range and the word HOLD will appear at the top of the screen.

HOLD MONITOR - Lights whenever WX HOLD mode is enabled to remind the pilot that the display is not being updated.

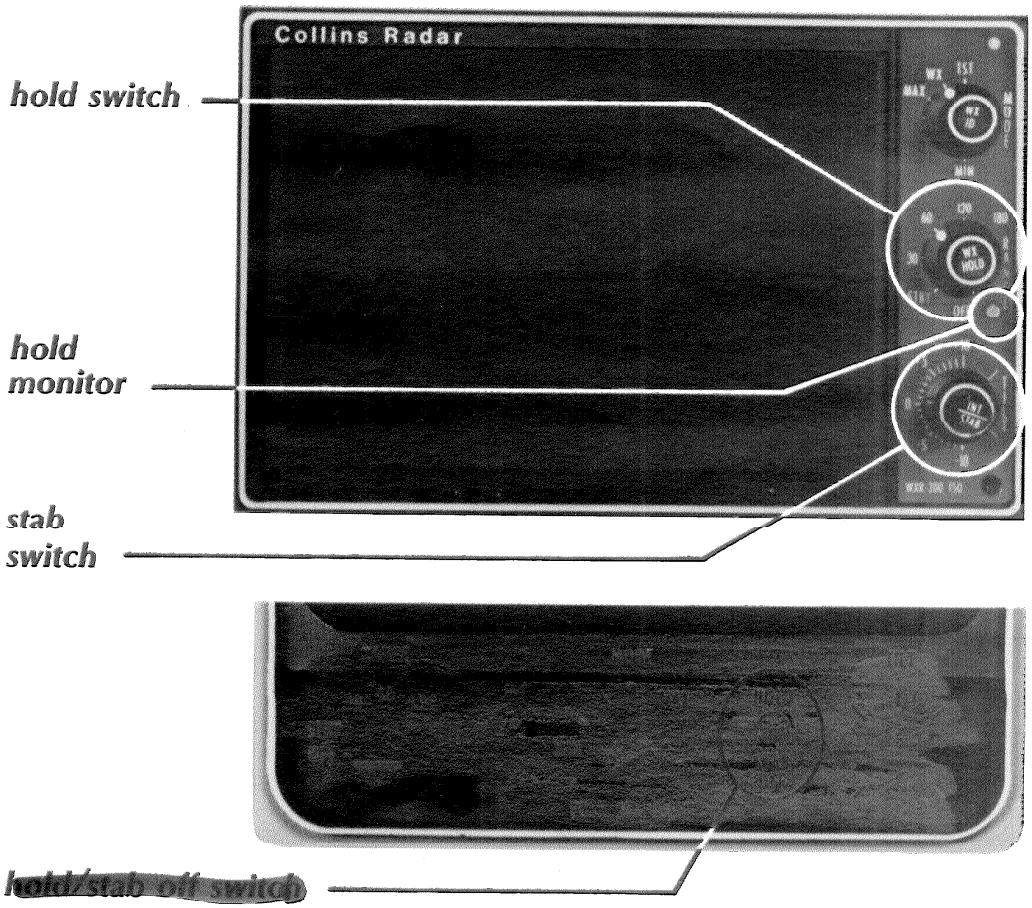
STAB - Pulling the STAB switch outward disables the antenna pitch correction circuits. This function is used in case of gyro input signal failure.

IND-201 (HOLD/STAB OFF switch)

HOLD - Placing the three-position toggle switch in HOLD position allows the display on the indicator to be frozen until a different range is selected or until power is removed from the system. Target updating will not occur when operating in the HOLD mode. Selected range and the word HOLD will appear at the top of the screen and the status light will be on.

STAB OFF - Placing the toggle switch to STAB OFF position disables the antenna pitch correction circuits. This function is used in case of gyro input signal failure.

CENTER - The center position is the normal operating position.



status light

The status light is a multifunction indicator that provides the following functions:

1. Under normal operating conditions, the status light will not be on in WX or MAX mode. The status light will turn on if the transmitter shuts down. To reset the system, momentarily position the RANGE switch to STBY, then reselect the desired range.

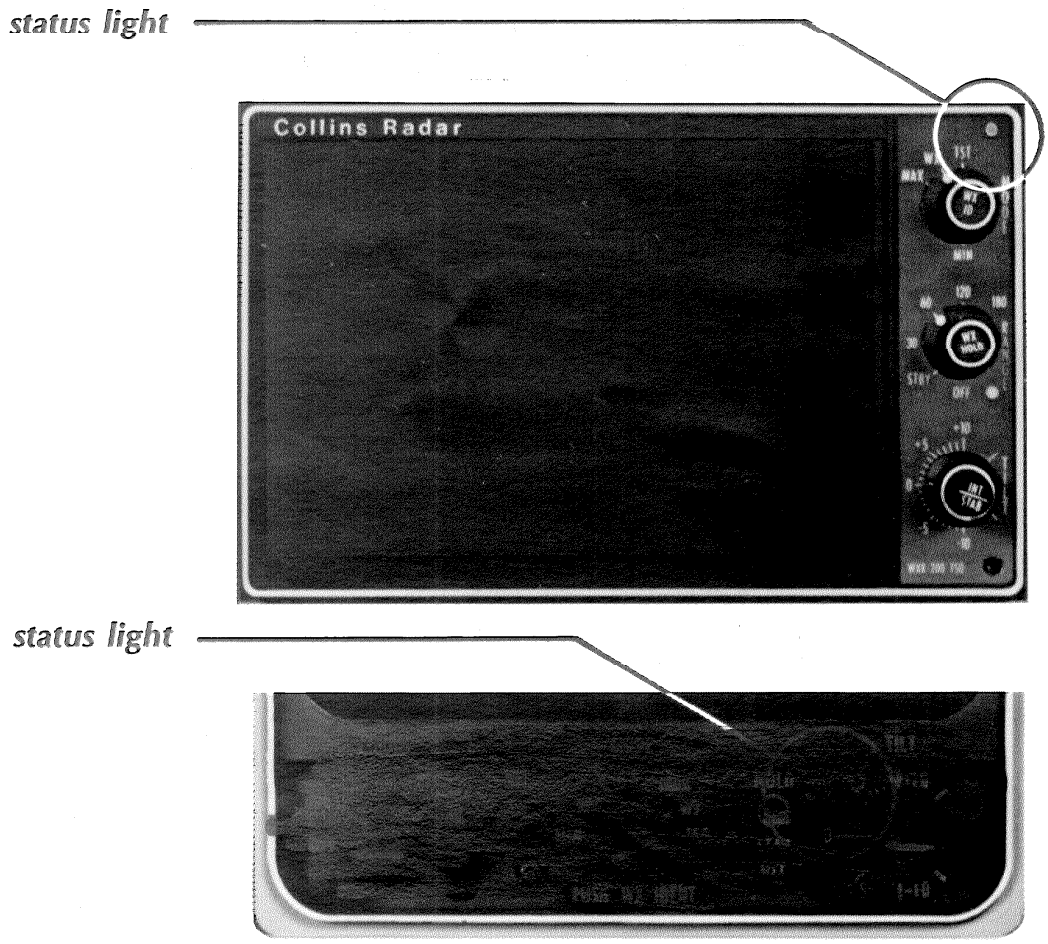
2. The status light will be on if any manual gain position except MAX is selected. This serves as a reminder to the pilot that the system is operating at a reduced gain level.

NOTE

If the status light remains on and the MODE switch is in WX or MAX, then a malfunction is indicated and the system should be turned off.

3. The status light will be on whenever the MODE switch is positioned to TST.

4. For the IND-201, the status light will also be on whenever HOLD is selected.



Section 3
Preflight

The operational status of the weather radar system should be verified before each flight by performing the following procedure.

WARNING

DO NOT TURN THE WEATHER RADAR TO ANY POSITION EXCEPT OFF, STBY, OR TST WHEN THE ANTENNA WILL BE DIRECTED TOWARD GROUND PERSONNEL, NEARBY HANGARS OR OTHER LARGE METAL BUILDINGS, OR OTHER AIRCRAFT. NEVER OPERATE THE RADAR DURING FUELING OR DEFUELING OPERATIONS. REFER TO FAA ADVISORY CIRCULAR NO. 20-68 IN THE BACK OF THIS PILOT'S GUIDE FOR FURTHER INFORMATION.

1. Verify that radar bus circuit breaker is on.
2. Position controls on the IND-200 or IND-201 Indicator as follows:

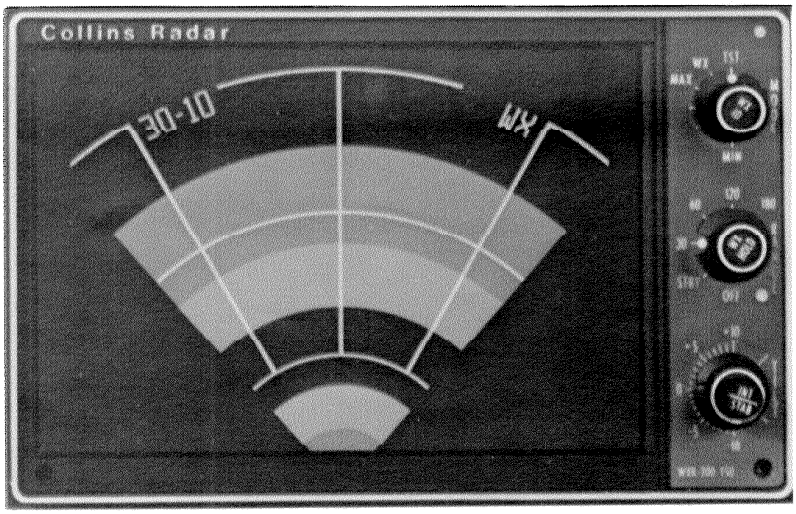
   RANGE switch to STBY.

   MODE switch to TST.

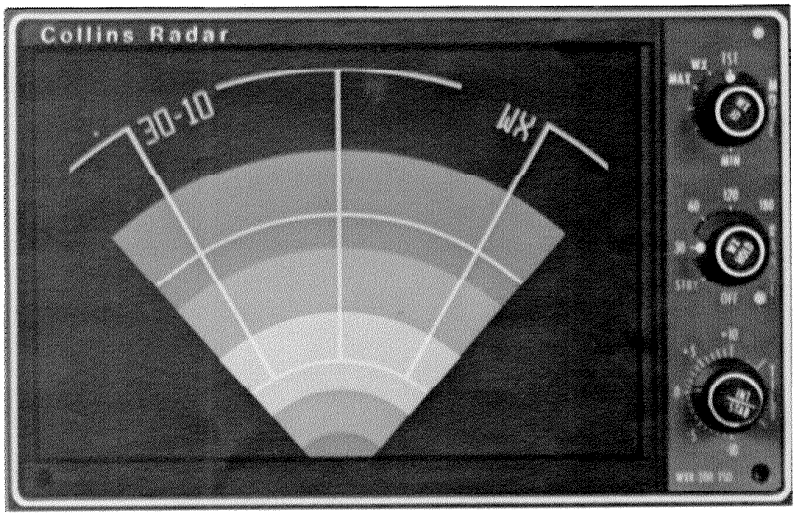
   WX HOLD to off (HOLD/STAB switch to center position for IND-201).

   TILT control to +5 degrees. (After approximately 20 seconds, three range marks and azimuth lines should appear) and the alphanumerics 30-10 and WX will be displayed at the top of the screen.

3. After approximately 60 seconds, the test pattern shown below should appear. The display will alternate with three contouring and one noncontouring test pattern. Adjust INT control for desired brightness.



Contouring Test Pattern



Noncontouring Test Pattern

4. Verify the following items on the display:

   a. The status light is on.

   b. There are three distinct levels of brightness from apex to center of screen.

   c. From the lower center of the display there are five distinct bands extending outward (excluding the range marks). The shading of these bands is as follows:

      - First band is light shading.
      - Second band is intermediate shading.
      - Third band is the cyclic contour band and cycles from brightest shading to dark in a one to three ratio.

- Fourth band is intermediate shading.
- Fifth band is light shading.

d. No noise is present on the display.

e. Momentary select WX mode, then reselect TST. Actuate the weather hold function before completion of the test pattern. Note that the test pattern 'freezes' on the display. On the IND-200, note that the hold light is on. The word HOLD should appear at top right of screen. Turn off the weather hold function and the display should return to normal updating.

WARNING BEFORE ENERGIZING THE TRANSMITTER, ENSURE THAT THE ANTENNA WILL NOT BE DIRECTED TOWARD PERSONNEL, HANGARS, OR CONTAINERS HOLDING FLAMMABLE MATERIAL.

5. Position controls on the IND-200 or IND-201 Indicator as follows:

   RANGE switch to 30.

   MODE switch to WX.

   WX HOLD to off (HOLD/STAB switch to center position for IND-201).

   INT control as desired for best display.

6. Verify that the status light is off, 30-10 is displayed at top left of screen, and WX is displayed at top right of screen.

7. Adjust the TILT control between +15 and 0 degrees. Observe that close-in ground clutter appears at the lower settings and any local detectable weather appears at the higher settings.

8. Position RANGE switch to STBY.

This completes the preflight test.

Section 4
Operation

The primary function of the WXR-200 Weather Radar System is to aid the pilot in the direction and avoidance of thunderstorms and the turbulence that is generally associated with these storms. Normal rainfall, hail, moderate to heavy wet snow, and in some instances, possible icing conditions can also be detected by the system. By tilting the antenna downward, the radar provides a terrain mapping function.

Each operator normally develops specific techniques and procedures for using weather radar. It should be noted that the basic operational techniques for the WXR-200 system are no different from the techniques used with earlier generation radars.

NOTE

Because full operation of the WXR-200 system is possible approximately 60 seconds after turn-on, the pilot may choose to leave the RANGE switch in the OFF rather than the STBY position when there is no significant weather in the immediate vicinity of the aircraft. By doing so, the life of the magnetron transmitting tube will be greatly extended, which in turn will lower the cost of maintenance.

departure and enroute

After takeoff, scan the area of intended flight using the 30- or 60-mile range and the WX mode. Plan the departure accordingly. Adjust the TILT control for minimum ground return (INT control can be adjusted for desired brightness).

NOTE

Proper use of the TILT control allows the experienced operator to achieve the best knowledge of storm cell size, height, and relative direction of movement.

While enroute, systematically reevaluate the displayed weather conditions both in the immediate area, and using a longer range, in the distant region of planned flight. With the aircraft in level flight, a slight amount of antenna uptilt may be necessary to minimize ground clutter. The proper amount of tilt will depend on the aircraft attitude and altitude, and the operating range selected.

weather recognition and avoidance

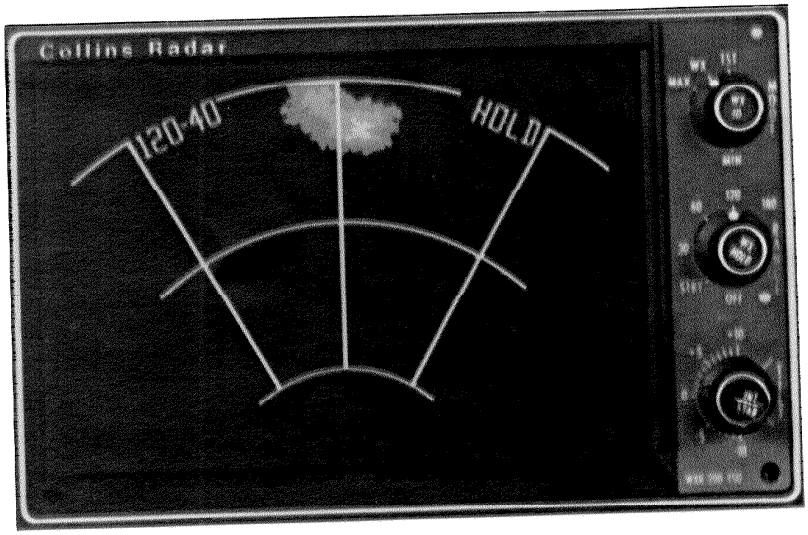
Experience soon enables the pilot to properly analyze various types of storm displays. Illustrations showing typical storm displays are included in the Weather Radar Interpretation section of this pilot's guide. The key to avoiding detected weather is to first determine the heading change needed to bypass a storm safely. Establish the aircraft on the appropriate heading and then recheck the display to see if further heading changes are required. The direction and rate of movement of the storm itself

can be determined using the weather hold function as discussed in the following paragraph.

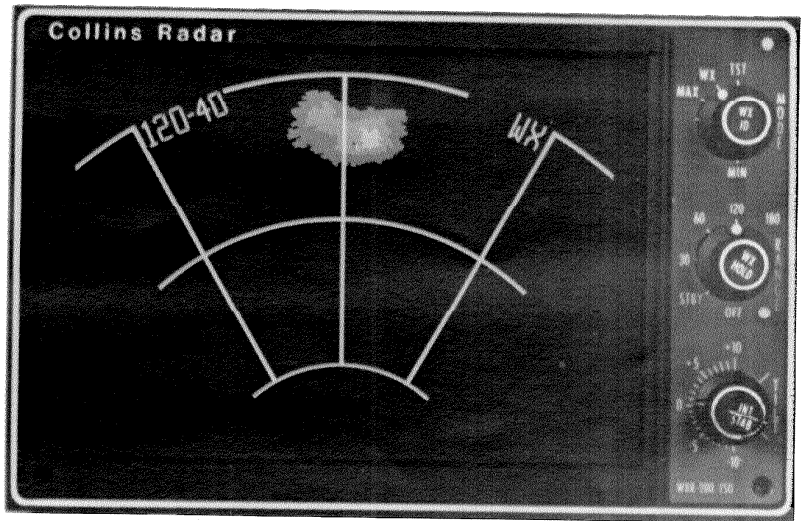
use of weather hold

The weather hold function allows the pilot to evaluate storm direction and rate of movement relative to the aircraft's present heading. The hold function will provide the greatest assistance when used on the longer ranges. On the shorter ranges, the weather situation can change too rapidly to justify using the hold function.

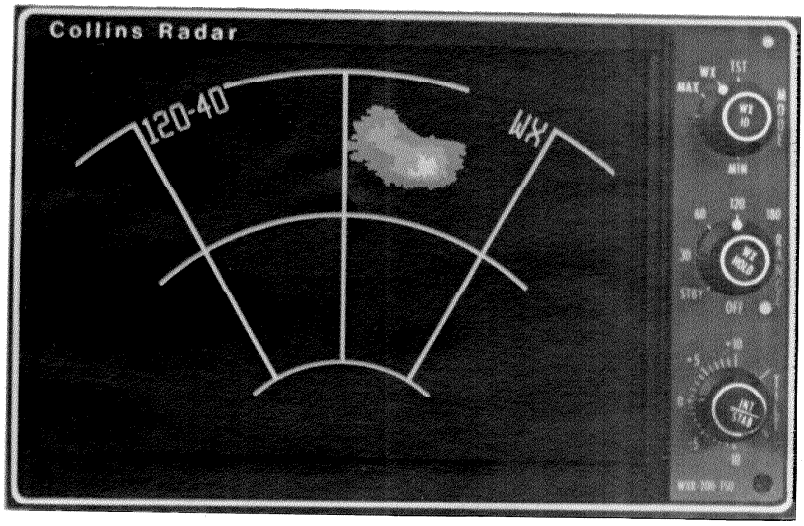
Assume the 120-mile range is selected and the display shows a storm approximately 90 miles dead ahead. Actuate the weather hold function and maintain the existing aircraft heading.



After a couple of minutes, turn off the weather hold function. The display now shows the storm to be approximately 80 miles range and still dead ahead. Movement of a storm along any straight line leading to the apex of the display tells the pilot that the aircraft and storm drift rates are nearly equal and continuation of present heading will result in penetrating the storm. Action should be taken now to alter the flight path.



If after a couple of minutes in weather hold the display shows the storm to be approximately 80 miles range, but positioned slightly to the right of the line from the previous position of the storm to the apex of the display, the storm is apparently moving across the track of the aircraft. The storm system can probably be safely bypassed with only a minor heading change to the left.

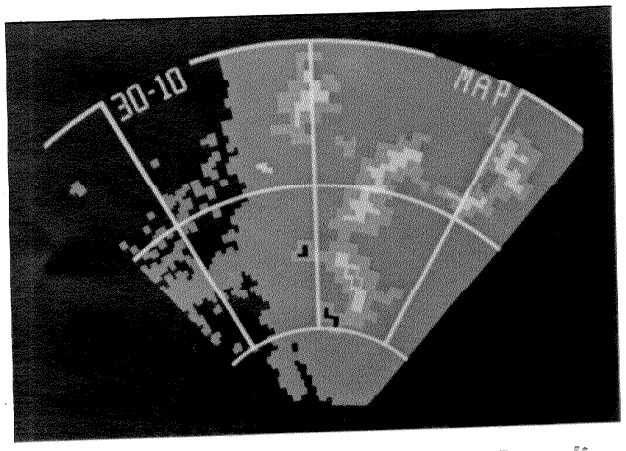


Any change in aircraft heading changes the location of storms on the display. Thus, maintaining constant heading during use of weather hold aids interpretation of changes in the display.

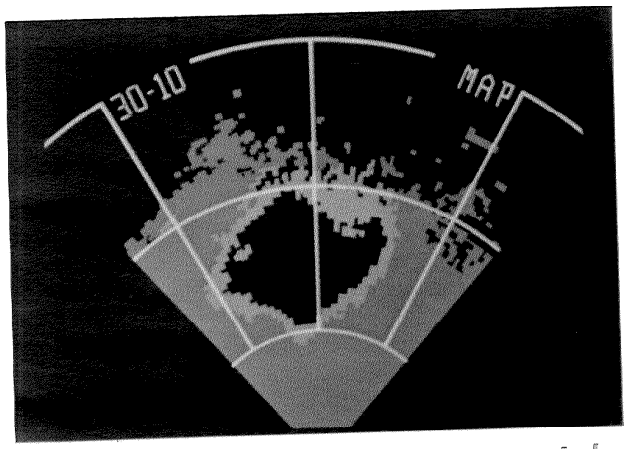
terrain mapping

Terrain mapping operation should be done with the MODE switch positioned to MAX or one of the lower gain positions to inhibit the automatic cyclic

contour circuits and reduce the signal level if necessary. The selected range and the word MAP will appear at the top of the screen. Use the TILT control to adjust the antenna downward until the desired amount of terrain is displayed. Antenna beamwidth, aircraft altitude, aircraft attitude, and the amount of downward tilt all affect the area of terrain that can be detected and displayed. The greater the amount of downward tilt, the closer the detected terrain will be to the aircraft and the smaller the area that will be covered. As experience is gained, the pilot should be able to interpret displays that indicate lakes, rivers, coastlines, mountains, cities, and larger structures. The following illustrations show typical terrain mapping displays of a coastline and a large inland lake. The bright areas on the display indicate land, while the water, being a poor reflector of radar waves, is the dark areas. The small bright areas to the left of the coastline are sea clutter caused by swells or waves.



Coastline



Lake

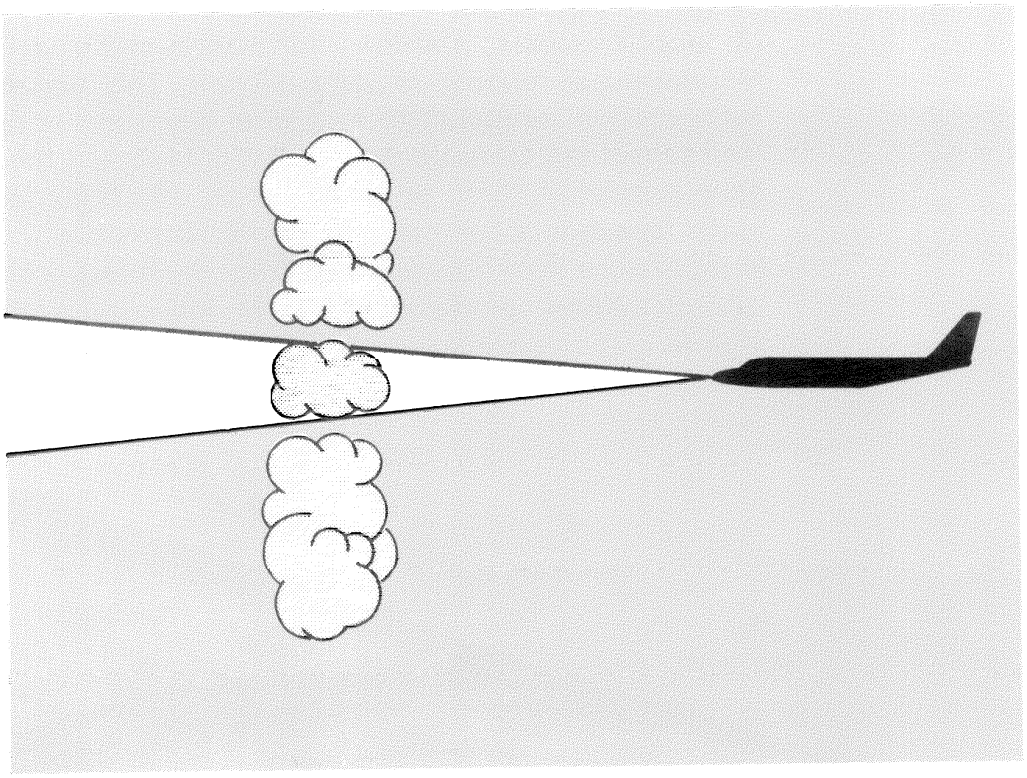
Section 5

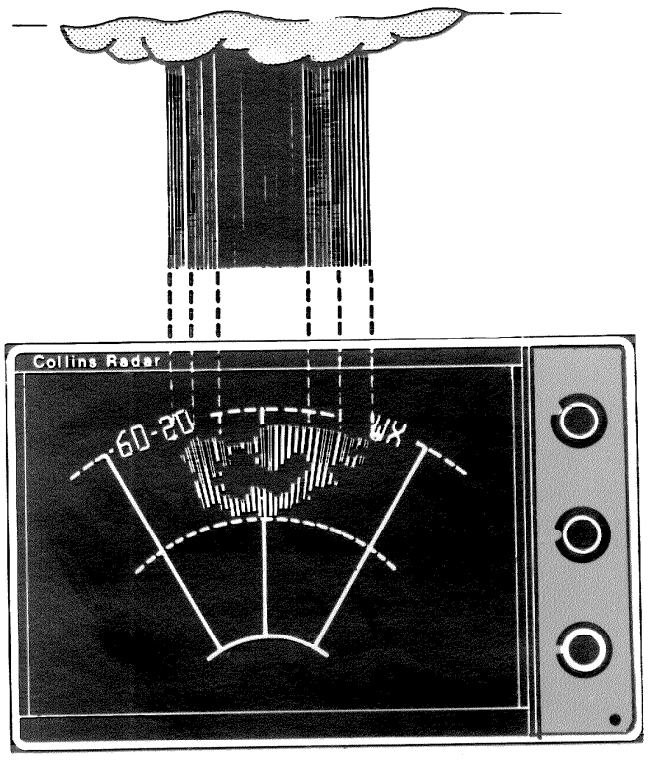
Weather Radar Interpretation

Flight hazards due to weather conditions are primarily the result of turbulence and hail. Wet hail can be detected by radar, but turbulent air by itself will not provide a radar echo. (Examples are clear-air turbulence and aircraft vortices.) Areas having high rainfall rates are ordinarily associated with turbulence, and it is from this rainfall that radar echoes are reflected and the accompanying turbulence associated with the rainfall is implied. In some instances the radar echoes may be severely attenuated in passing through large areas of moderate rainfall rate or small areas of high rainfall rate. This may mask or cause strong targets at a farther range to appear much less intense than they actually are. The WXR-200 displays a cross section of a storm as shown in the following illustrations.

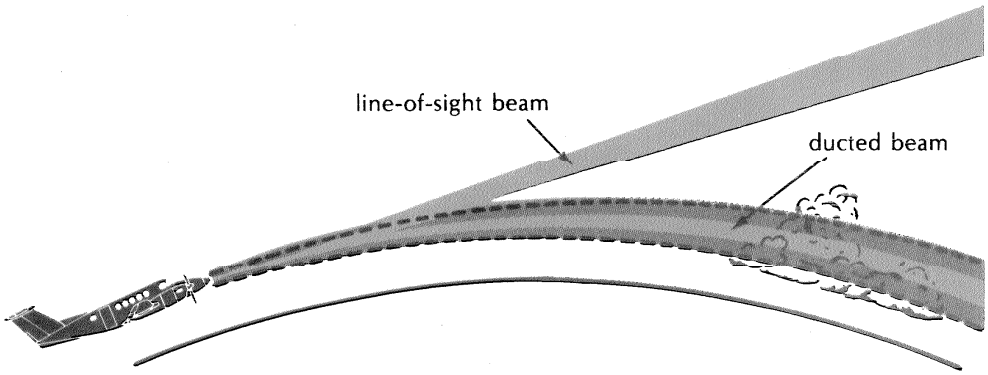
The four-intensity level display provided by the WXR-200 greatly aids the operator in interpreting, displayed targets. A typical storm cell can show three levels of brightness: the lightest level of shading indicates areas of light rainfall rate, the intermediate level of shading indicates areas of moderate rainfall rate, and when in WX mode, a contouring area will be the brightest level of shading for one sweep, then dark for three sweeps. A contouring area is the core of a storm cell and indicates the area of heaviest rainfall rate and generally, the area of greatest turbulence. The fourth level of intensity is the dark screen around the perimeter of a storm cell. This indicates that no detectable rainfall is present in those areas and flight hazards in those areas due to weather conditions should be minimal.

Some clouds, often of the cumulus and stratus types, do not contain sufficient moisture to reflect a detectable echo; however, these clouds are usually not a hazard to flight. Precipitation from clouds not associated with severe turbulence does not present a flight hazard. This precipitation does not display an intense contourable target.




Collins Radar
60-20
WX

A nonhazardous phenomenon occasionally encountered is ducting of radar signals. This occurs with certain temperature and humidity conditions and causes targets to be detected at distances farther than normal. A duct, or broad tunnel which guides radar signals in a curving path, can be formed when temperature increases and humidity decreases with altitude. These gradients occur in inversion conditions and may not remain for a long period of time.



Radar signals must be located in or close to the duct to be trapped in it. Signals at an angle of 1 or 2 degrees, or more, to the duct will not be trapped. Elevating the antenna a few degrees will get the beam out of the duct. This technique can be used to differentiate between distant thunderstorms and ducted ground echoes which may be mistaken for cloud targets.

thunderstorms

Updrafts and downdrafts in thunderstorms carry water throughout the cloud. The more severe the drafts, the greater the amount of water contained in the cloud. From the intensity of radar echoes from this moisture, assumptions can be made about the turbulence involved. In the WXR-200 system, when the displayed target intensity is the brightest level of

shading, due to large amounts of water, the turbulence is more severe. The steeper the intensity gradient of a target (as seen in contouring WX mode), the stronger the turbulence. Areas which show a contoured display should be avoided by a wide margin.

Along squall lines, individual cells are in different stages of development. Areas between closely spaced, intense echoes may contain developing clouds not having enough moisture to produce an echo. The lightest level of shading may or may not be displayed which would indicate light rainfall rates or no rainfall, yet these areas could have strong updrafts or downdrafts. In penetrating a squall line, fly as far from building cells as possible. Avoid contoured areas of the display — areas of intense turbulence — by at least ten miles, or more whenever possible. Targets with wide areas of uniform lightest level of shading are generally precipitation without severe turbulence.

Thunderstorm development is rapid. A course that appears clear may contain cells a short time later. When viewing the shorter ranges, periodically switch to longer ranges to observe distant conditions. This permits early planning of necessary avoidance maneuvers.

Studies have shown that thunderstorms tend to travel in the direction of the winds around the 10,000-foot level. New cells generally form on the side of a cloud in the direction toward which it is moving, usually an easterly direction. Newly developing cells often do not contain sufficient water to reflect an echo, yet they can cause severe turbulence. In general, detour to the diminishing side of thunderstorms, especially if passing at close range.

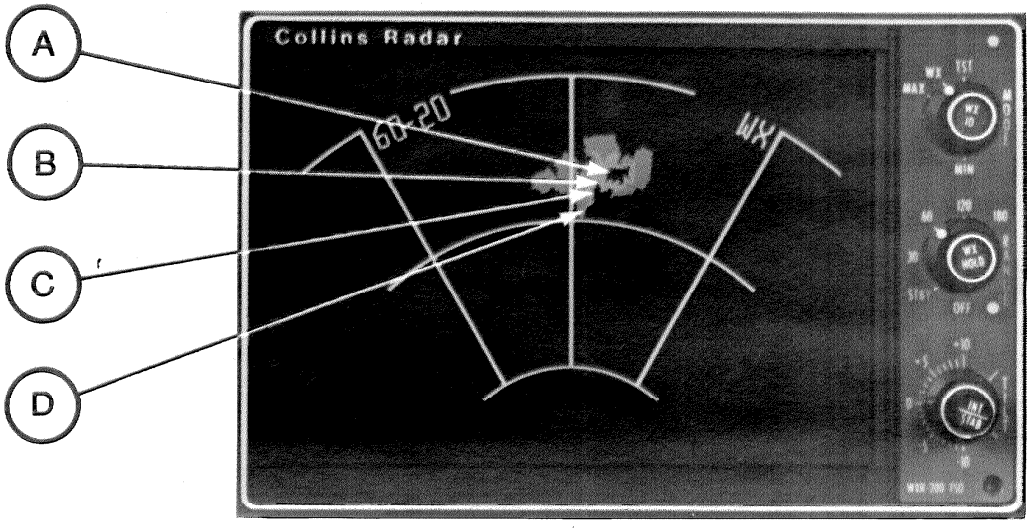
The following illustrations show a typical return from a thunderstorm and explains the use of the WX ID (weather identification) function. The IND-200 Indicator is shown for this discussion.

Ⓐ The dark area represents a contoured storm cell. On one out of four sweeps, this area will be the brightest level of shading displayed. This is the core of the thunderstorm. Extreme to severe turbulence in this and adjacent areas will almost always be present. This turbulence is capable of structurally damaging an aircraft and must be avoided.

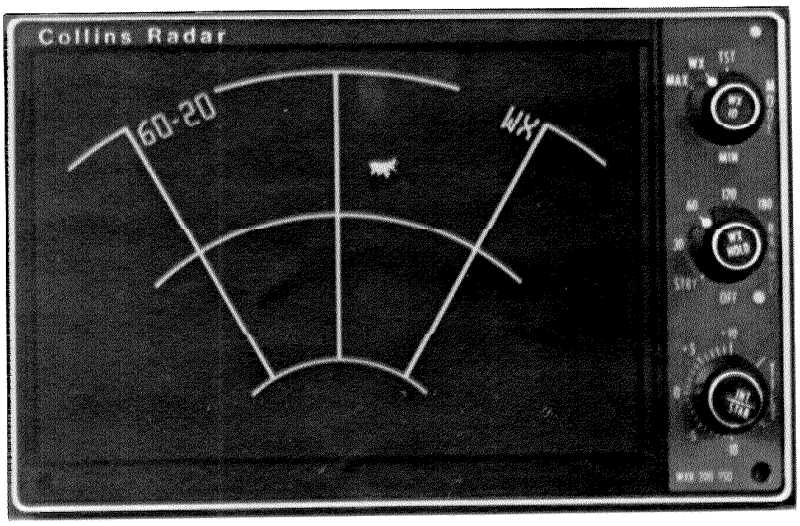
Ⓑ Note the sharply defined contouring area adjacent to the very narrow outer ring of lighter precipitation as shown by the light to intermediate level of shading. This indicates a maximum change in the rate of rainfall laterally within the storm. (This is called a "steep rainfall gradient.") The sharp line of change from lighter or moderate to heavy rainfall most always indicates a sharp vertical shear zone. Severe closely spaced updrafts and downdrafts are normally present in this area. This means severe turbulence and this area must be avoided.

Ⓒ The area with the intermediate level of shading indicates that the amount of rainfall would be moderate. Although lower in rainfall level than the contouring area, moderate to severe turbulence may still be expected in this area. Flight through this area should be avoided.

Ⓓ The wide area with the lightest level of shading indicates that the amount of rainfall would be light. Depending on the direction of storm movement, the upwind outer edge of this area would generally contain little or no turbulence. Moderate turbulence would still be expected on the downwind side of the storm.



Momentarily press the weather identification button. The contoured area of the storm cell assumes the brightest level of shading as shown below. Returns not contouring will be erased from the display. This gives the pilot a method of quickly identifying the location of only the contoured areas. The weather identification timer in the indicator allows the system to return to normal operation within approximately 10 seconds or after the weather identification button is released, if held over 10 seconds.



tornadoes

The extreme case of severe turbulence is a tornado. Cumulonimbus-mamatus clouds producing tornadoes have in a few instances been related to a characteristic target display. The display is not usually different from that of a regular thunderstorm.

Radar displays of clouds from which tornadoes were confirmed have, on occasion, shown the formation of a hook pattern in connection with the tornado. A narrow, fingerlike portion extends from the cloud display and, in a short time, curls into a hook and closes on itself. Other echoes associated with tornadoes are V-shaped notches and doughnut shapes. These shapes do not always indicate tornadoes, nor are tornado echoes limited to these characteristic patterns. Of the confirmed radar observation of tornadoes from target thunderstorms, most displays have not shown shapes different from those of a normal thunderstorm display.

Conditions conducive to tornado formation produce severe updraft and downdrafts that carry large amounts of water to great heights. Clouds that give a bright display with steep rainfall gradients and produce an echo at high altitudes (TILT control up more than usual) are indicative of tornado-forming conditions. In no case should these clouds be penetrated. Avoid them by a margin of at least 20 miles since turbulence extends outward from the echo-producing area for large distances.

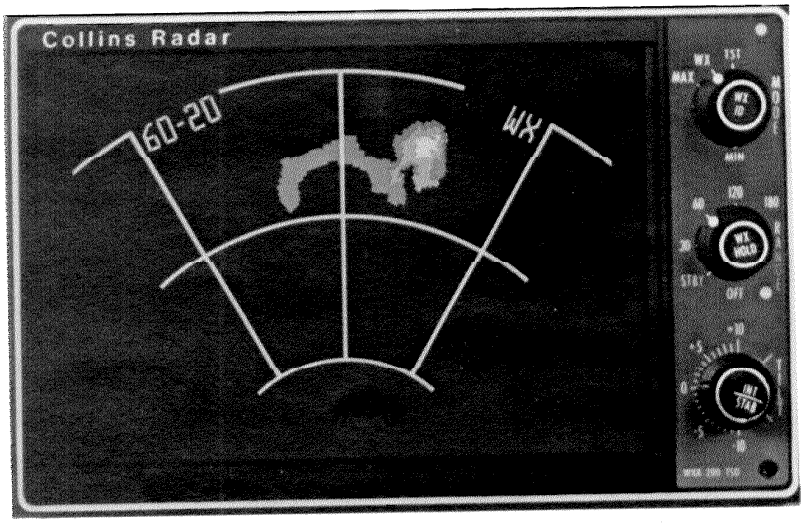
hail

Hail results from updrafts carrying water high enough to freeze. Consequently, the greater the height of a thunderstorm echo, the greater the probability that it contains hail. An estimate of the height can be made by the amount of antenna uptilt required to view the upper part of the target echo. In the upper regions of a cloud where ice particles are "dry" (no liquid coating on the particle), echoes will be less intense. Liquid water reflects about five times more radar energy than solid ice particles of the same mass. Since hailstones are considerably larger than water drops, and are usually coated with a thin layer of liquid water, the echo intensity from "wet" hail is greater than that from rainfall. Thunderstorm targets having an intensity greater than that associated with maximum rainfall will most likely contain hail.

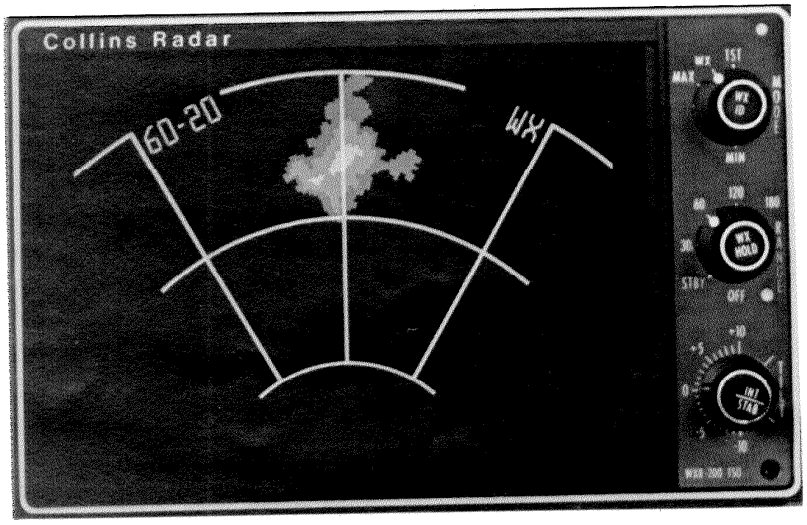
It is not always possible to determine from the display whether the echo is from hail or from rain. Instances have been reported of hail targets producing fingerlike protrusions up to five miles long and blunt protuberances up to three miles from the edge of thunderstorm echoes. In parts of the country where hail occurs often, bright extensions from thunderstorms generally indicate the presence of hail. This same type of display is also associated with new convective cells that may not yet contain hail.

As with tornadoes, there are no uniquely distinctive displays that are, in all cases, associated with hail. Protruding fingers, hooks, scalloped edges, and U-shapes are display shapes that have been associated with hail, yet hail echoes are not limited to these shapes. These displays, however, do indicate areas of severe turbulence and must be avoided by a wide margin.

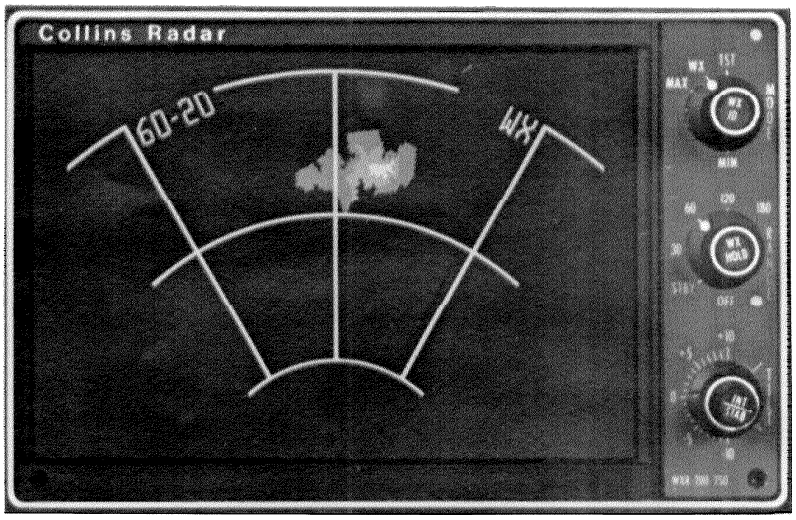
The following illustrations show typical displays that may be associated with hail.



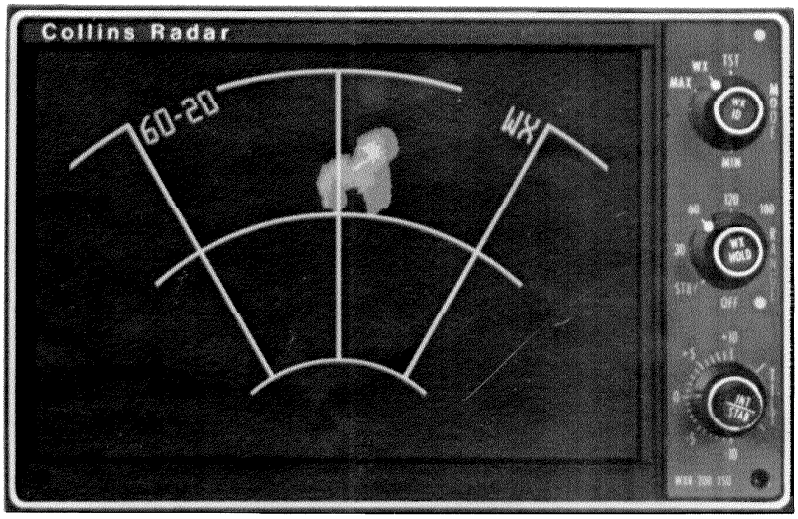
Finger



Hook



Scalloped Edge



U-Shaped

Echoes from hail can appear quickly and along any edge of a storm cell. These echoes can also change in shape and intensity in a very short period of time. For this reason, close and careful monitoring of the display is required.