2.3.2.2.5 Flight Director Attitude Indicator (FDAI)

The FDAIs provide displays to the crew of angular velocity (rate), attitude error, and total attitude (figure 2.3-6). The body rate (roll, yaw, or pitch) displayed on either or both FDAIs is derived from the BMAGs in either gyro assembly (1 or 2). Positive angular rates are indicated by a downward displacement of the pitch rate needle and by leftward displacement of the yaw and roll rate needles. The angular rate displacements are "fly-to" indications as related to rotation control direction of motion required to reduce the indicated rates to zero. The angular rate scales are marked with graduations at null and ±full range, and at ±1/5, ±2/5, ±3/5, and ±4/5 of full range. The variable full-scale deflection ranges obtained with the FDAI SCALE switch are as follows:

- Pitch rate ±1 deg per sec, ±5 deg per sec, ±10 deg per sec
- Yaw rate ±1 deg per sec, ±5 deg per sec, ±10 deg per sec
- Roll rate ±1 deg per sec, ±5 deg per sec, ±50 deg per sec

Servo-metric meter movements are used for the three rate indicator needles.

The FDAI attitude error needles indicate the difference between the actual and desired spacecraft attitude. The attitude error signal can be derived from several sources: The uncaged BMAGs from GA-1, the CDUs (PGNCS), or the ASCP-GDC/IMU (figure 2.3-8). Positive attitude error is indicated by a downward displacement of the pitch error needle, and by a leftward displacement of the yaw and roll error needles. The ranges of the error needles are ±5 degrees or ±50 degrees for full-scale roll error, and ±5 degrees or ±15 degrees for pitch and yaw error. The error scale factors are selected by the FDAI SCALE switch that also establishes the rate scaling. The pitch and yaw attitude error scales contain graduation marks at null and ±full scale, and at ±1/3 and ±2/3 of full scale. The roll attitude scale contains marks at null, ±1/2, and ±full scale. The attitude error indicators utilize servo-metric meter movements.

Spacecraft orientation, with respect to a selected inertial reference frame, is also displayed on the FDAI ball. This display contains three servo control loops that are used to rotate the ball about three independent axes. These axes correspond to inertial pitch, yaw, and roll. The control loops can accept inputs from either the IMU gimbal resolvers or the GDC resolvers. Selecting the source is covered in paragraph 2.3.2.3.

The control loops are proportional servos; therefore, the angles of rotation of the ball must correspond to the resolver angles of the source. The FDAI, illustrated in figure 2.3-6, has the following markings:

a. Pitch attitude is represented on the ball by great semicircles. The semicircle (as interpolated), displayed under the FDAI inverted wing symbol, is the inertial pitch at the time of readout. The two semicircles that make up a great circle correspond to pitch attitudes of θ and θ+180 degrees.

b. Yaw attitude is represented by minor circles. The display readout is similar to the pitch readout. Yaw attitude circles are restricted to the following inertial angles: 0±90 degrees (270 to 0 degrees and 0 to 90 degrees).

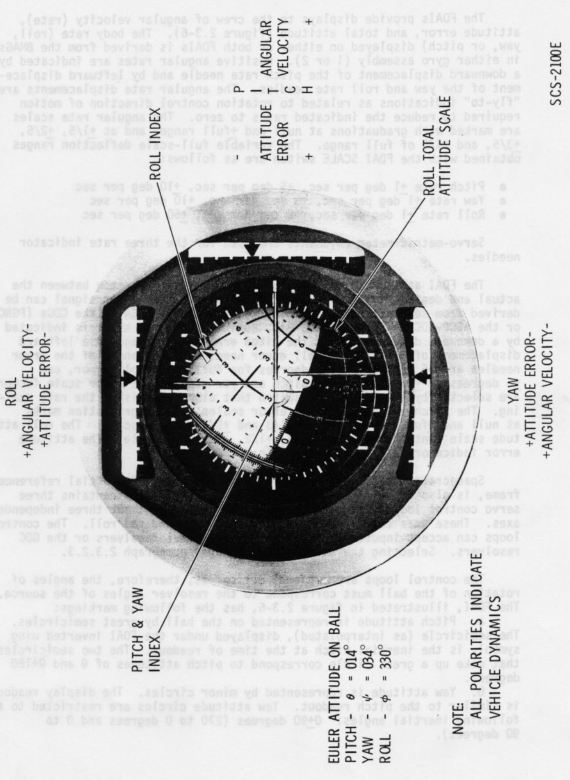

Figure 2.3-6. Flight Director Attitude Indicator

c. Roll attitude is the angle between the wing symbol and the nearest pitch attitude circle. The roll attitude is more accurately displayed on a scale attached to the FDAI mounting, under a pointer attached to the roll (ball) axis.

d. The last digits of the circle markings are omitted. Thus, for example, 3 corresponds to 30, and 33 corresponds to 330.

e. The ball is symmetrically marked (increment wise) about the 0-degree yaw and 0/180-degree pitch circles. The following comments provide clarification for areas of the ball not shown in figure 2.3-6.

1. Marks at 1-degree increments are provided along the entire yaw 0-degree circle.
2. The pitch 0- and 180-degree semicircles have 1-degree increments between the 330- and 30-degree yaw circles and 5-degree increments out to 75 and 285 degrees.
3. Numerals along the 300- and 60-degree yaw circles are spaced 60-pitch degrees apart. Note that numerals along the 30-degree yaw circle are spaced 30-pitch degrees apart.

f. The red areas of the ball, indicating impending gimbal lock, are defined by $270 < yaw < 285$ degrees and $75 < yaw < 90$ degrees.

2.3.2.3 Functional Switching Concept

The SCS utilizes functional switching as opposed to "mode select" switching.

Functional switching requires manual switching of numerous independent panel switches in order to configure the SCS for various mission functions (e.g., midcourse, ΔVs, entry, etc.). Mode switching would, for example, employ one switch labeled "midcourse" to automatically accomplish all the necessary system gain changes, etc., for that mission phase. Thus mode selection simplifies the crew tasks involved, but limits system flexibility between various mode configurations.

Function select switching, on the other hand, requires more crew tasks, but offers flexibility to select various gains, display scale factors, etc., as independent system capabilities. Function select switching also allows flexibility to "switch out" part of a failed signal path without affecting the total signal source (e.g., SCS in control of the vehicle with GN displays still presented to the crew).

2.3.2.3.1 Display Switching Interfaces

The FDAI switches determine the source of display data, the FDAI(s) selected, and the full-scale deflections of the attitude error and rate needles. The source of rate information for display will always be from BMAG 2 unless BMAG 1 is put into a backup rate configuration. Other switches also modify the data displayed and these will be pointed out as they are discussed. Both FDAIs are also assumed to be properly energized from the power switching panel.

2.3.2.3.2 Spacecraft Control Switching Interfaces

There are two sources of vehicle controls selectable from the SC main display console, SCS or CMC. CMC is the primary method of control and the SCS provides backup control. The vehicle attitude control is obtained from the reaction control engines and the thrust vector control from the service propulsion engine.