DOCKET NO. **SA - 510**

EXHIBIT NO. **13 J**

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

Boeing 737 Wake Encounter Simulation

737 Wake Encounter Simulation

Wake Parameters

- Circulation - Measure of wake energy related to lift of wake generating aircraft

  For the DAL 727-200 at flaps 1, the maximum theoretical wake circulation energy was calculated to be 2400 ft^2/sec (assuming no dissipation). Using industry standard wake strength evaluation techniques, a dissipation of about 30% was determined for the atmospheric conditions at the time of the accident. This value gave a nominal wake circulation energy of 1700 $^2/sec$. The sensitivity of the 737's response to circulation was determined by varying circulation between 2100 ft^2/sec (13% dissipation) and 1100 ft^2/sec (55% dissipation). A value between 1500 and 1700 ft^2/sec was agreed upon for the circulation by investigators and pilots to give a realistic wake encounter, based on pilot experience and engineering judgement.

- Core Radius - The radius of the component of the wake velocity field where solid body rotation is believed to occur.

  Values of core radius used ranged from 2 ft to 8 ft, and were based on theoretical fluid mechanics calculations and experimental measurements from NOAA flight tests.

- Core span - The distance between the center of the cores.

  A value of 85 ft was used and was based upon theoretical fluid mechanics calculations and experimental measurements from NOAA flight tests.

737 Wake Encounter Simulation

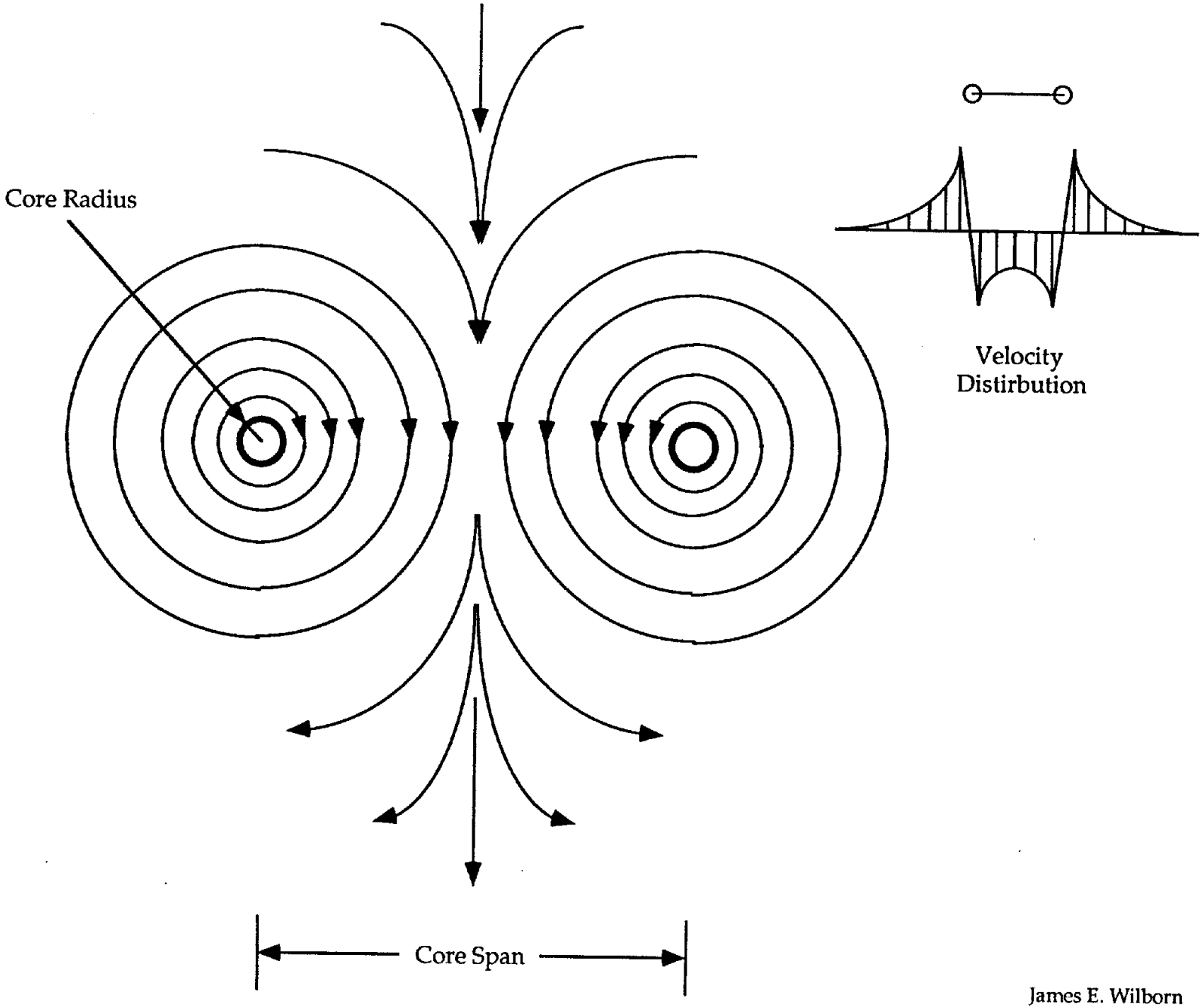
Wake Location, Orientation and Motion

- Location - Wake altitude and ground X and Y location can be specified.
- Orientation - The wake can be aligned along any heading, and can be pitched about its minor axis and banked about its major axis.
- Motion - The wake can be set to translate vertically and horizontally.

Wake Visual

- MCAB - The wake is visualized from the MCAB cockpit as two parallel cylinders colored purple and gold for visual clarity. A red line runs parallel to the cylinders along the centerline between the cores as a reference marker.
- SGi Station - The wake is visualized on the SGi graphics station as two parallel spiraling helixes for the first 5000 ft, and then as two parallel rectangular parallelipipeds.

Wake Vortex Model



James E. Wilborn
December 8, 1994

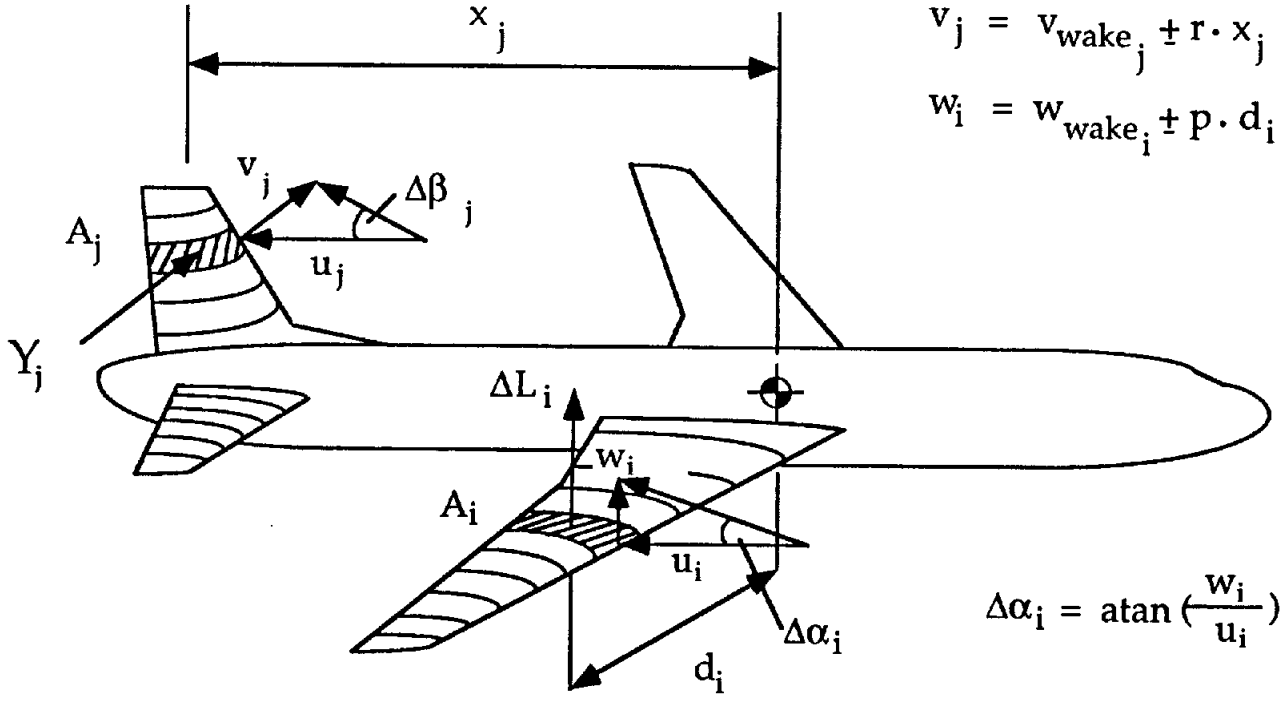
Distributed Lift Modeling

$$u_i = u_{wake_i} \pm r \cdot d_i + U$$

$$u_j = u_{wake_j} + U$$

$$v_j = v_{wake_j} \pm r \cdot x_j$$

$$w_i = w_{wake_i} \pm p \cdot d_i$$

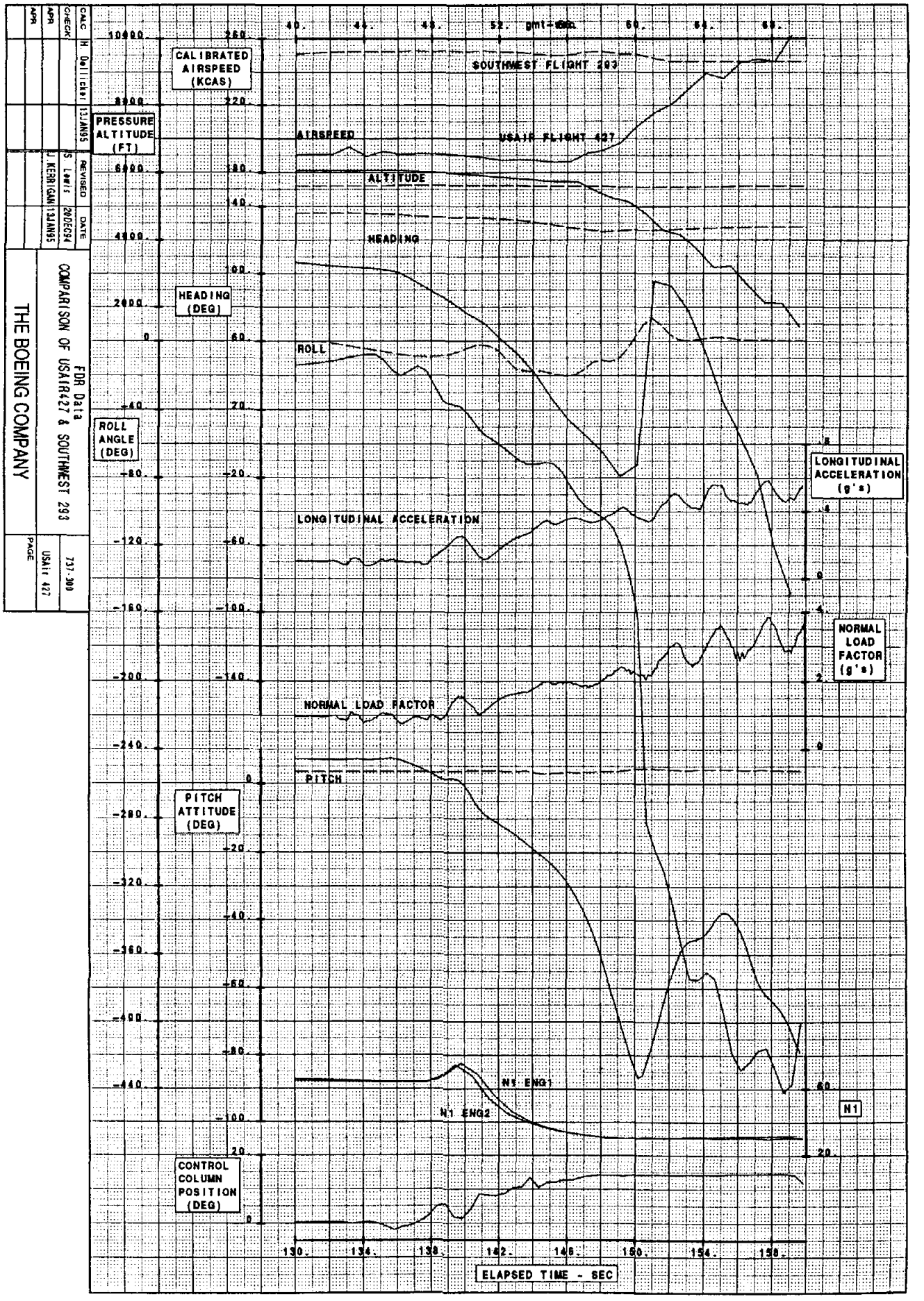


$$\Delta\alpha_i = \text{atan}\left(\frac{w_i}{u_i}\right)$$

$$\Delta\beta_j = \text{atan}\left(\frac{v_j}{u_j}\right)$$

$$\Delta L_i = \frac{C_{L_{\alpha_i}} \cdot \Delta\alpha_i}{q \cdot A_i} \qquad \Delta\mathcal{L}_i = \Delta L_i \cdot d_i$$

$$\Delta Y_j = \frac{C_{Y_{\beta_j}} \cdot \Delta\beta_j}{q \cdot A_j} \qquad \Delta N_j = \Delta Y_j \cdot d_j$$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PRESSURE ALTITUDE (FT)
HEADING (DEG)
ROLL ANGLE (DEG)
PITCH ATTITUDE (DEG)
CONTROL COLUMN POSITION (DEG)
SOUTHWEST FLIGHT 293
USAIR FLIGHT 427
AIRSPEED
ALTITUDE
HEADING
ROLL
LONGITUDINAL ACCELERATION
NORMAL LOAD FACTOR
PITCH
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N1 ENG2
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NORMAL LOAD FACTOR (g's)
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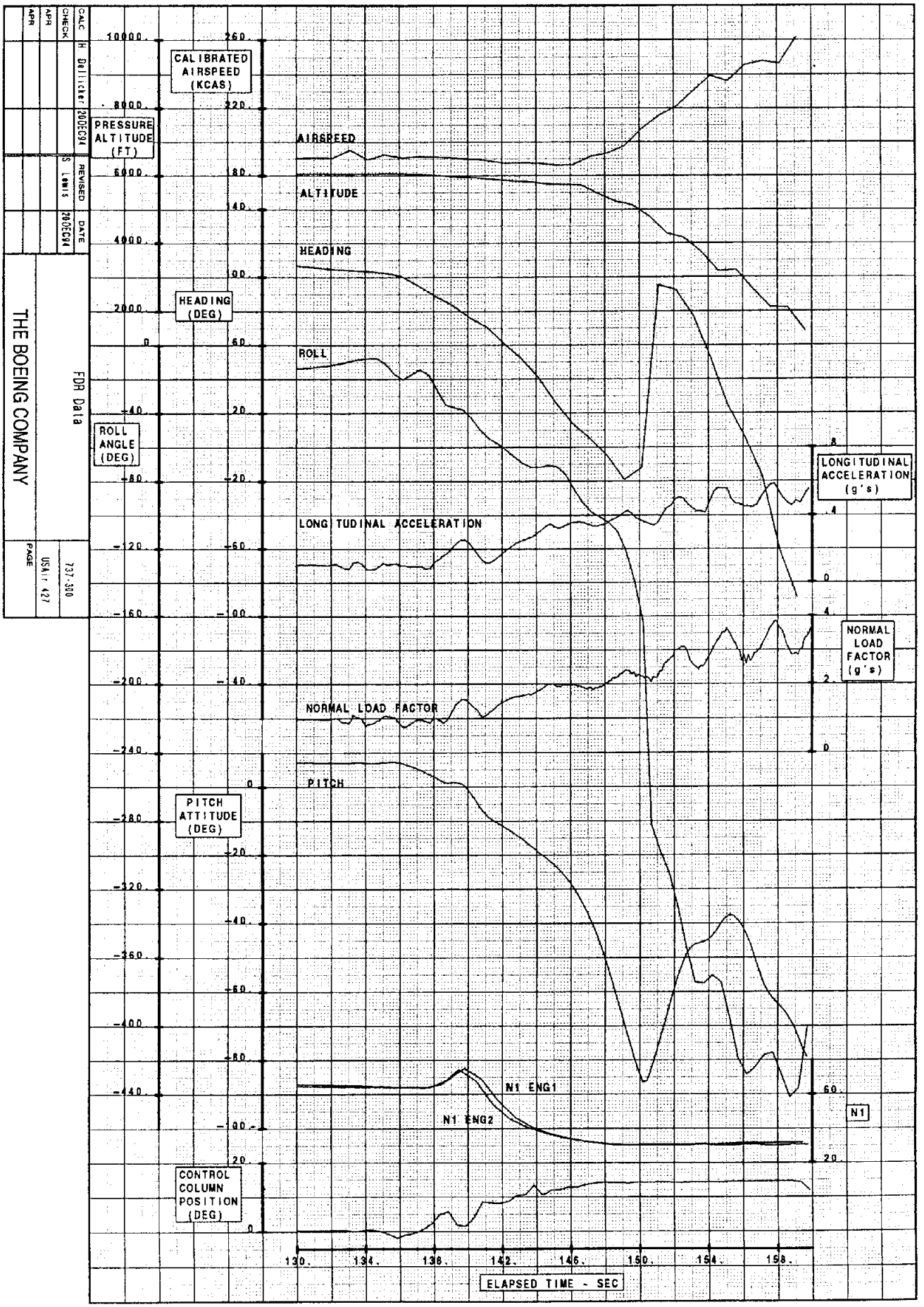
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PITCH ATTITUDE (DEG)
CONTROL COLUMN POSITION (DEG)
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NORMAL LOAD FACTOR
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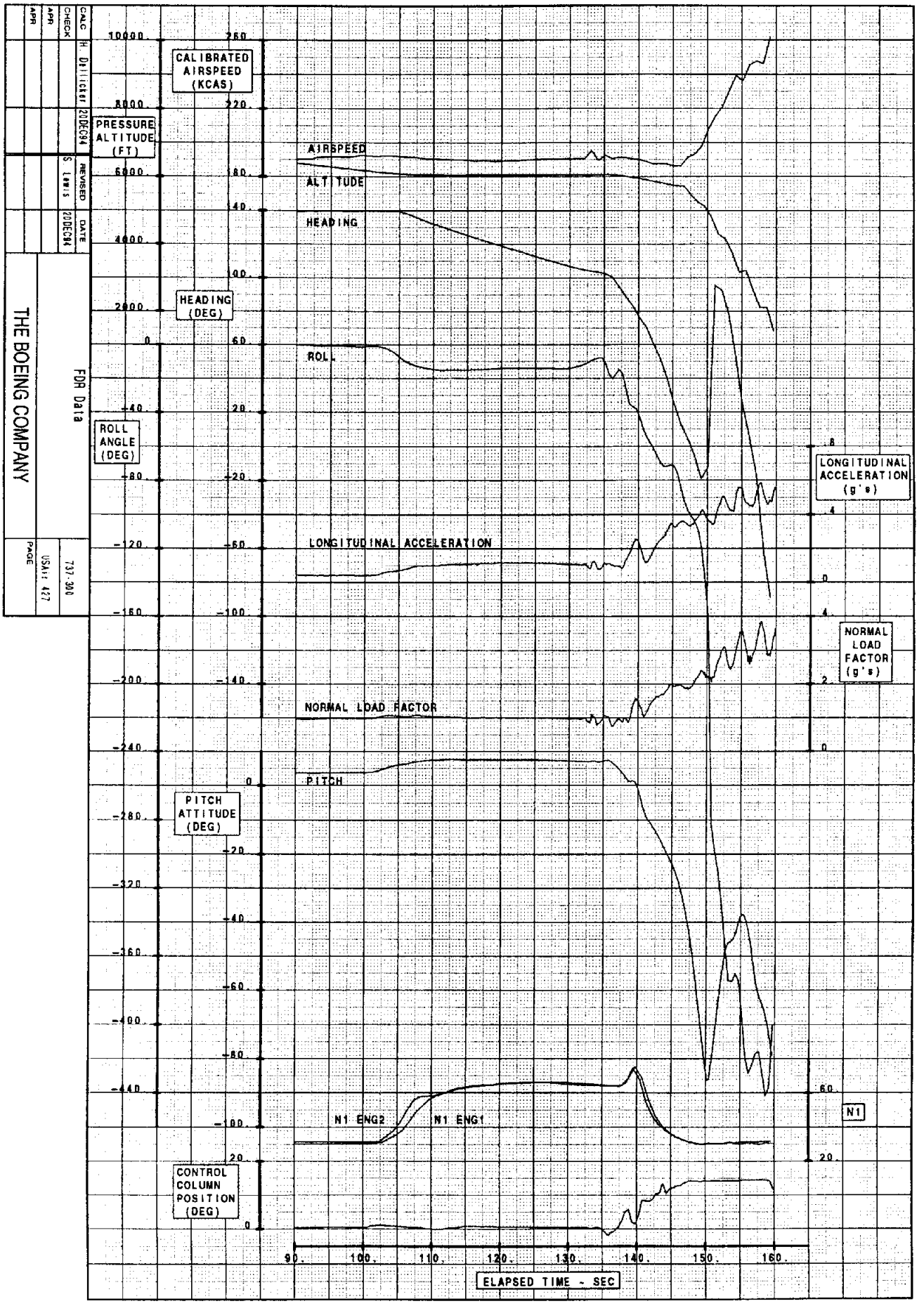
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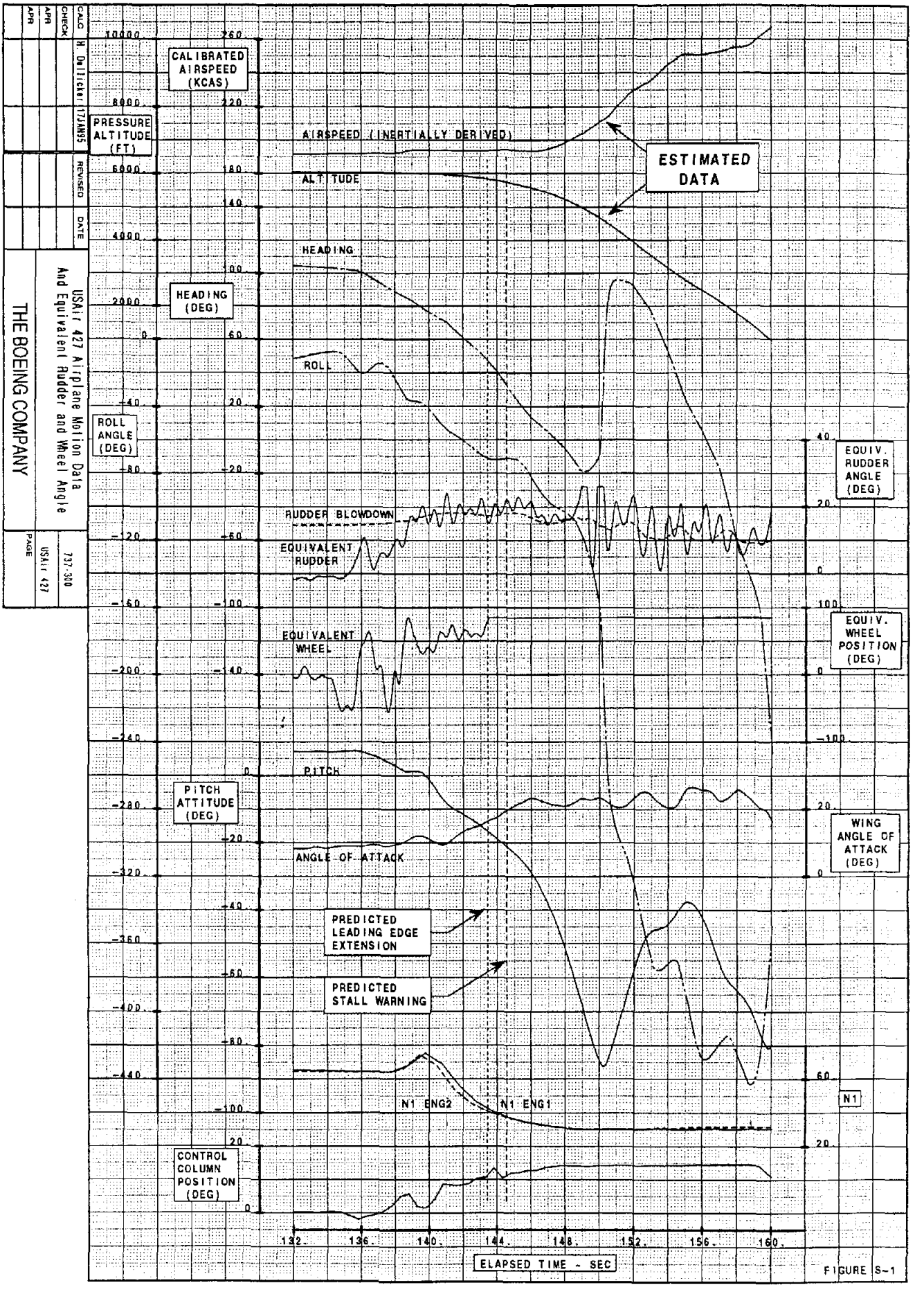
ELAPSED TIME - SEC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And Equivalent Rudder and Wheel Angle
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HEADING (DEG)
ROLL ANGLE (DEG)
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ANGLE OF ATTACK
PREDICTED LEADING EDGE EXTENSION
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EQUIV. WHEEL POSITION (DEG)
WING ANGLE OF ATTACK (DEG)
N1
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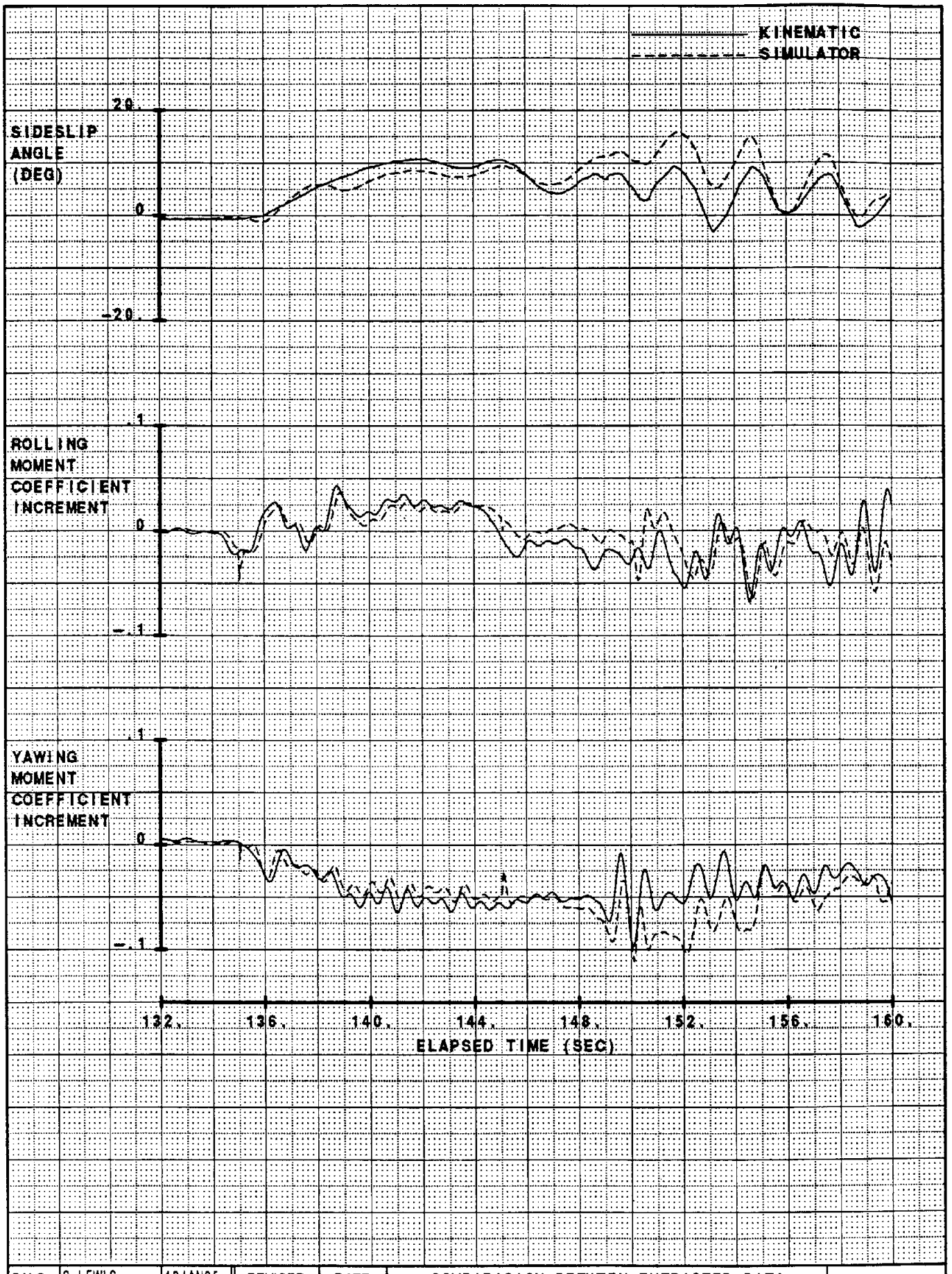
FIGURE S-1



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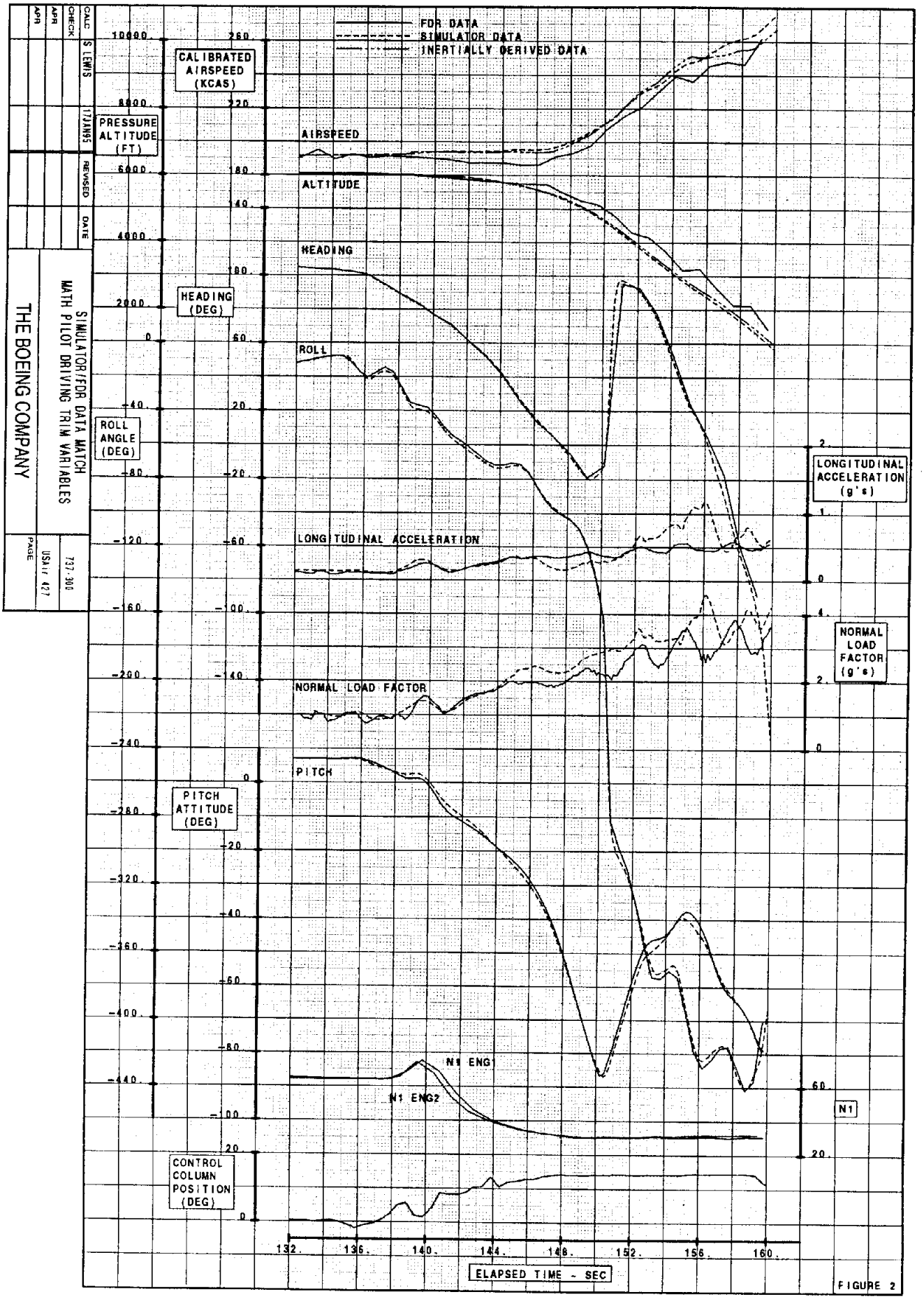
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FIGURE 2

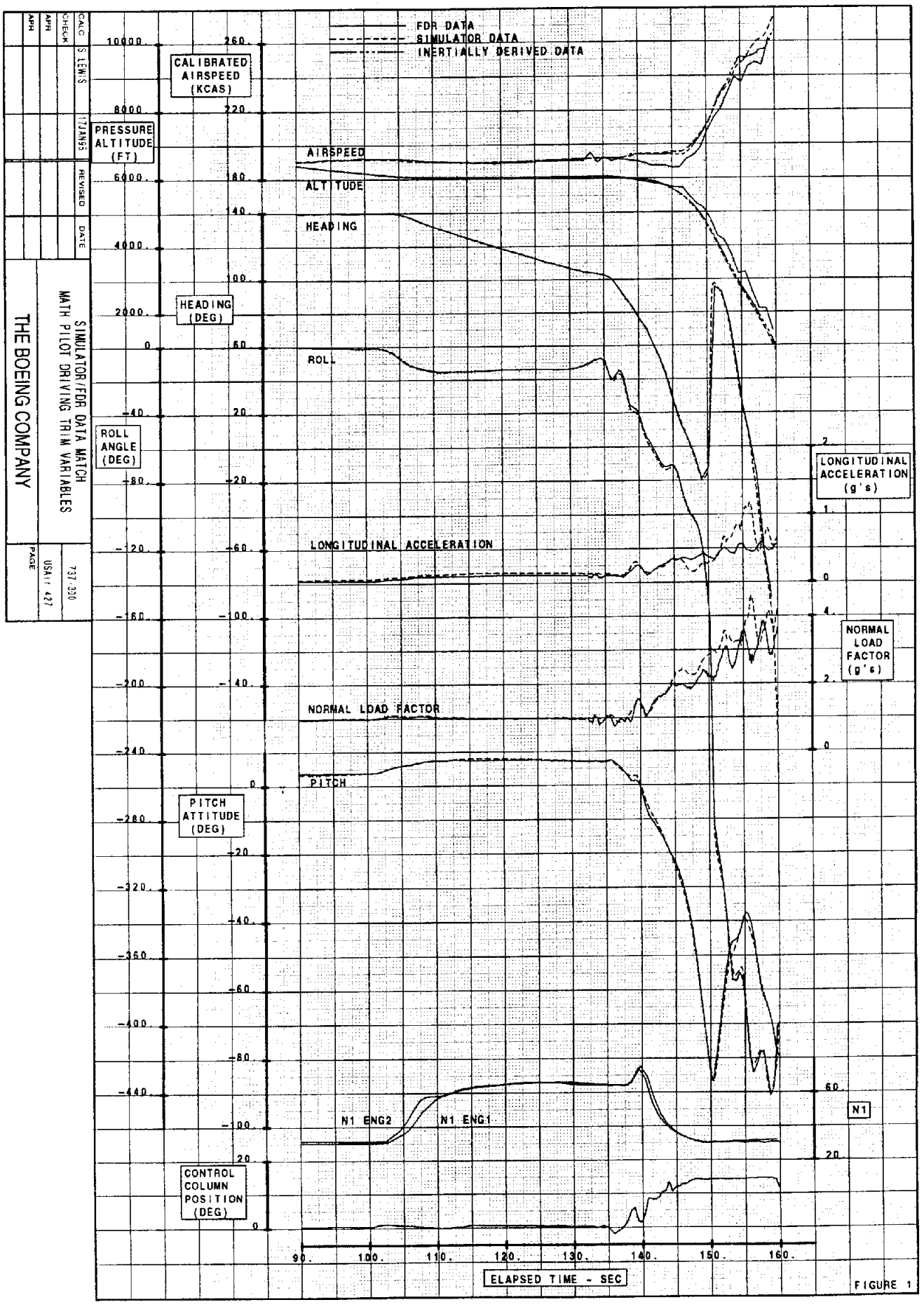
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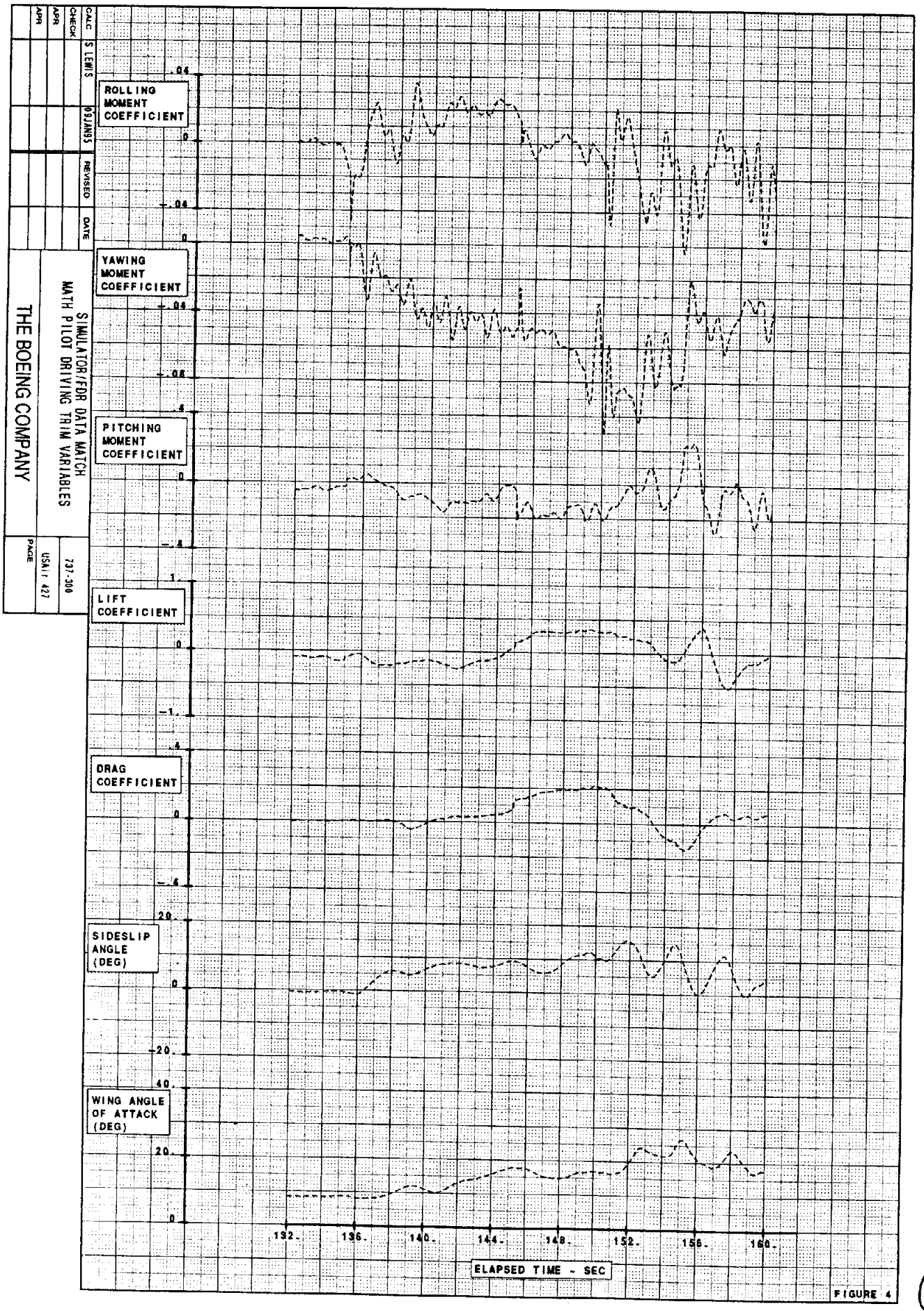
FIGURE 1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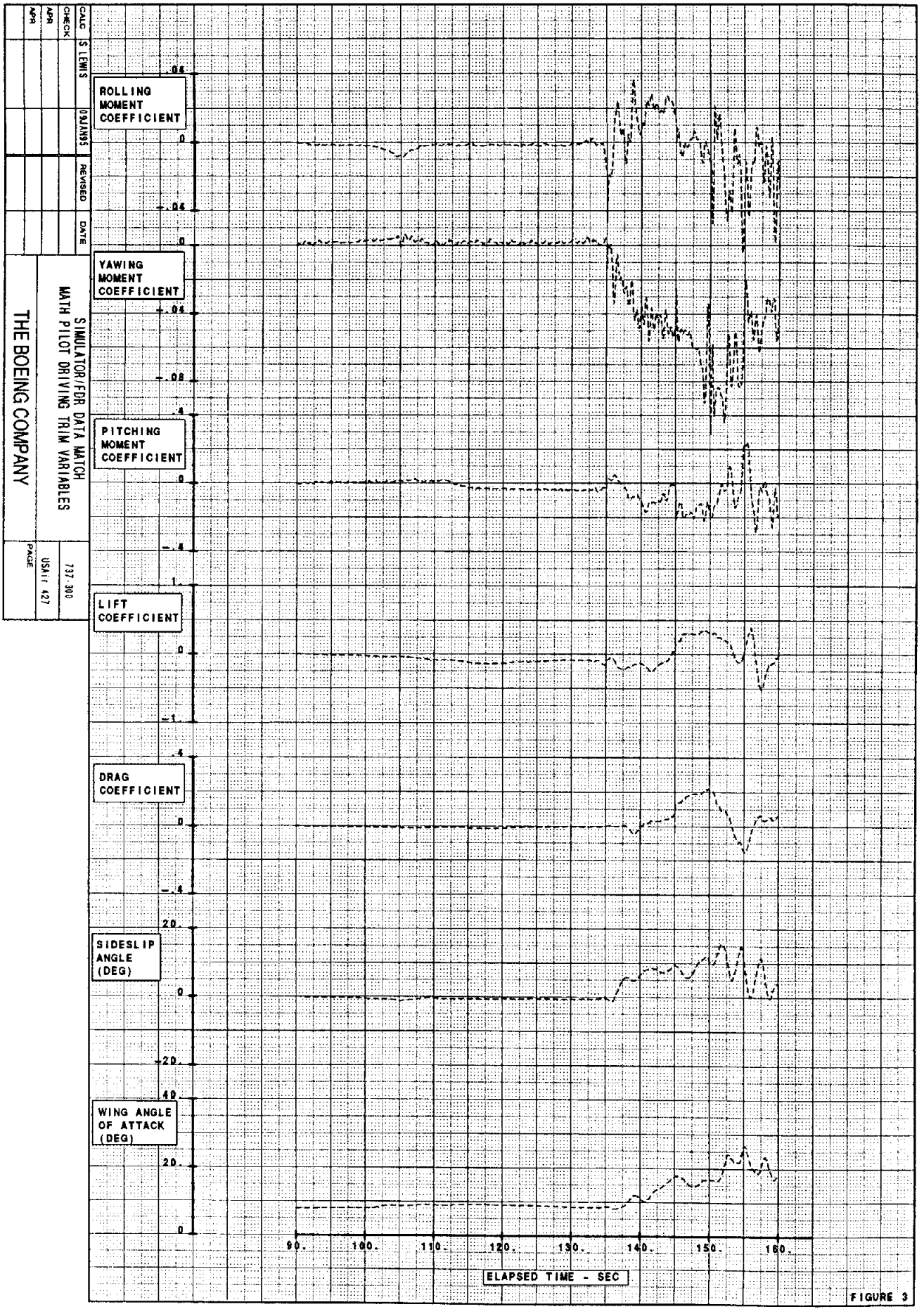
ELAPSED TIME - SEC

FIGURE 4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ELAPSED TIME - SEC

FIGURE 3

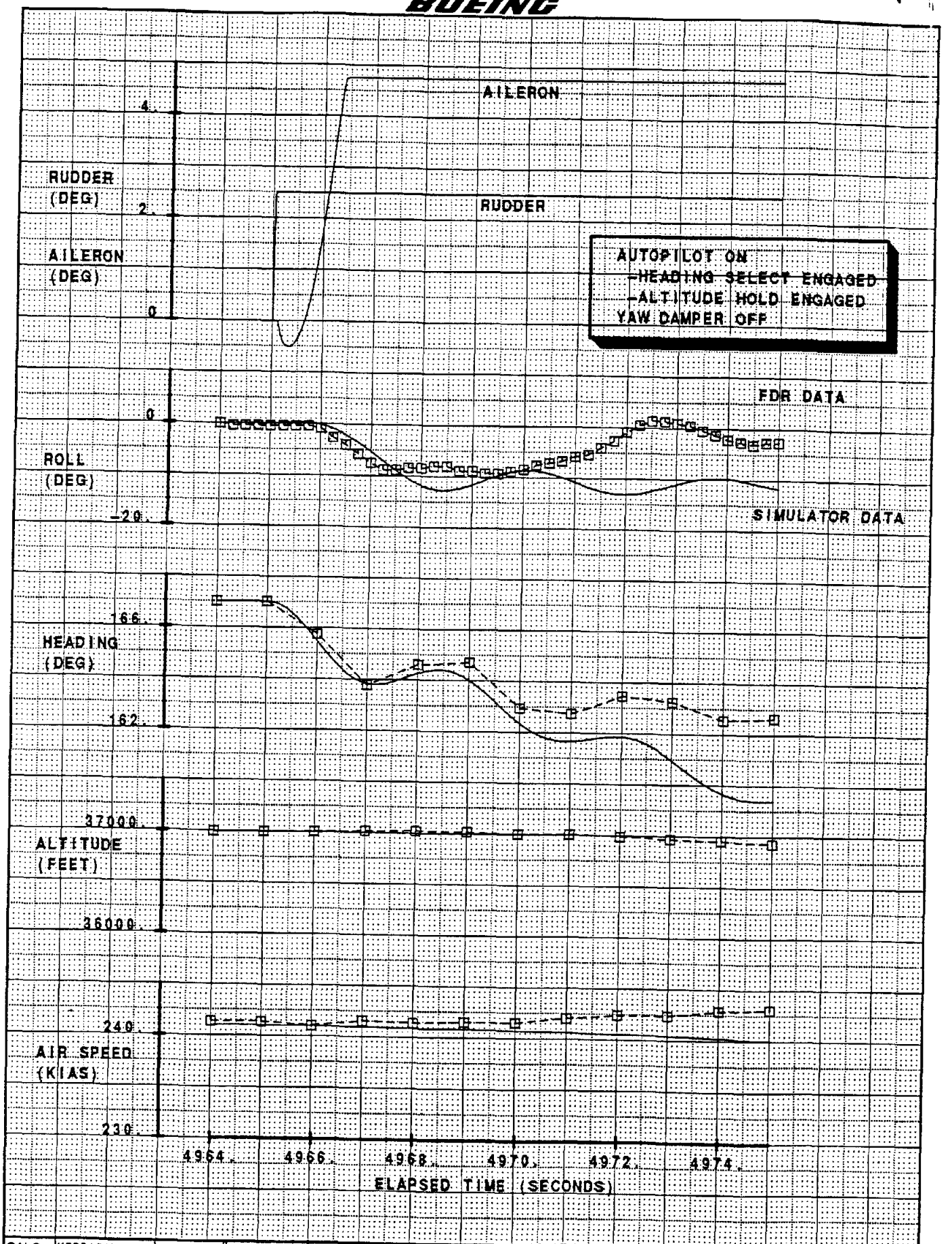

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FIGURE 14

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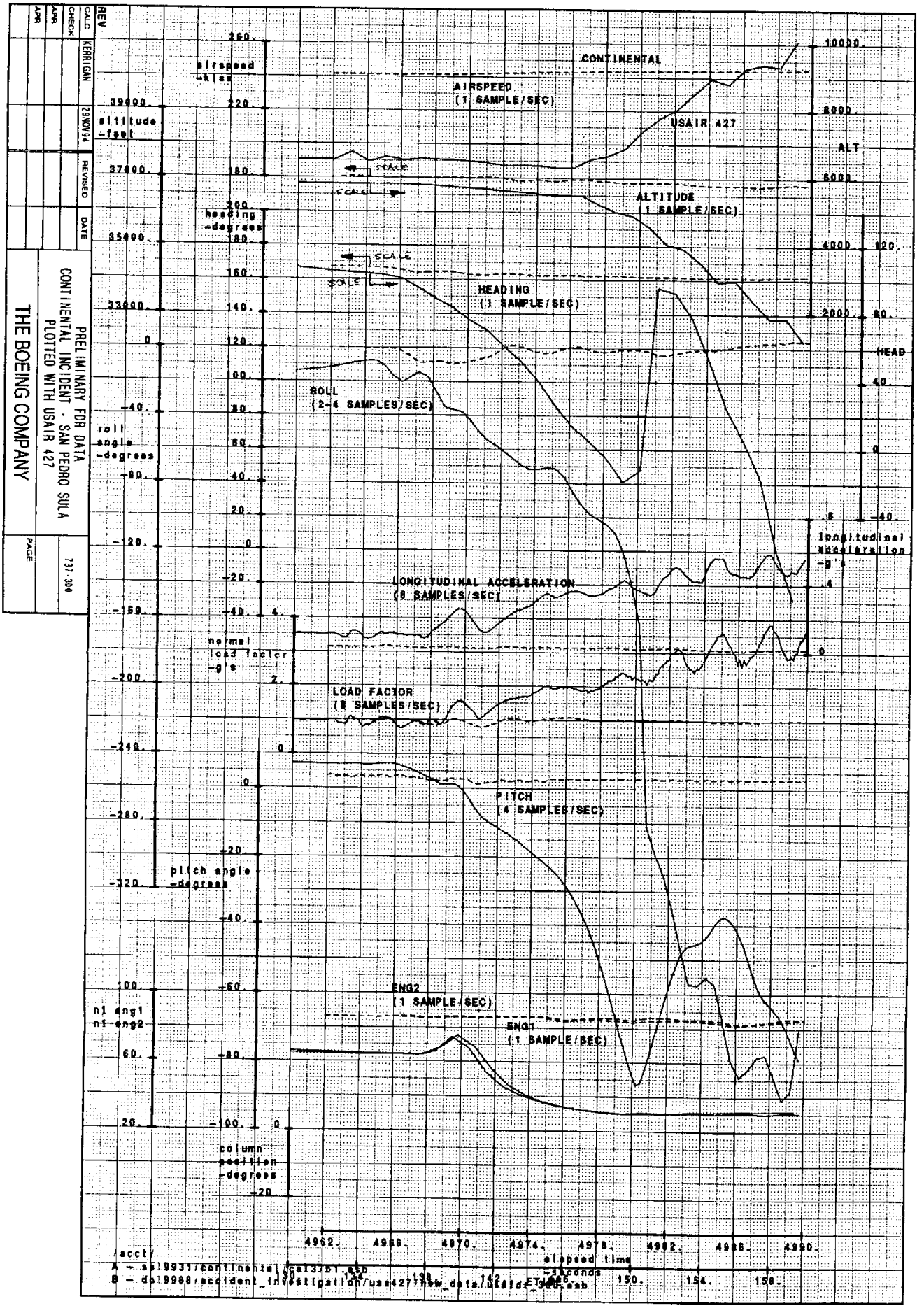
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heading -degrees
roll angle -degrees
normal load factor -g's
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USAIR 427
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LOAD FACTOR (8 SAMPLES/SEC)
PITCH (4 SAMPLES/SEC)
ENG2 (1 SAMPLE/SEC)
ENG1 (1 SAMPLE/SEC)
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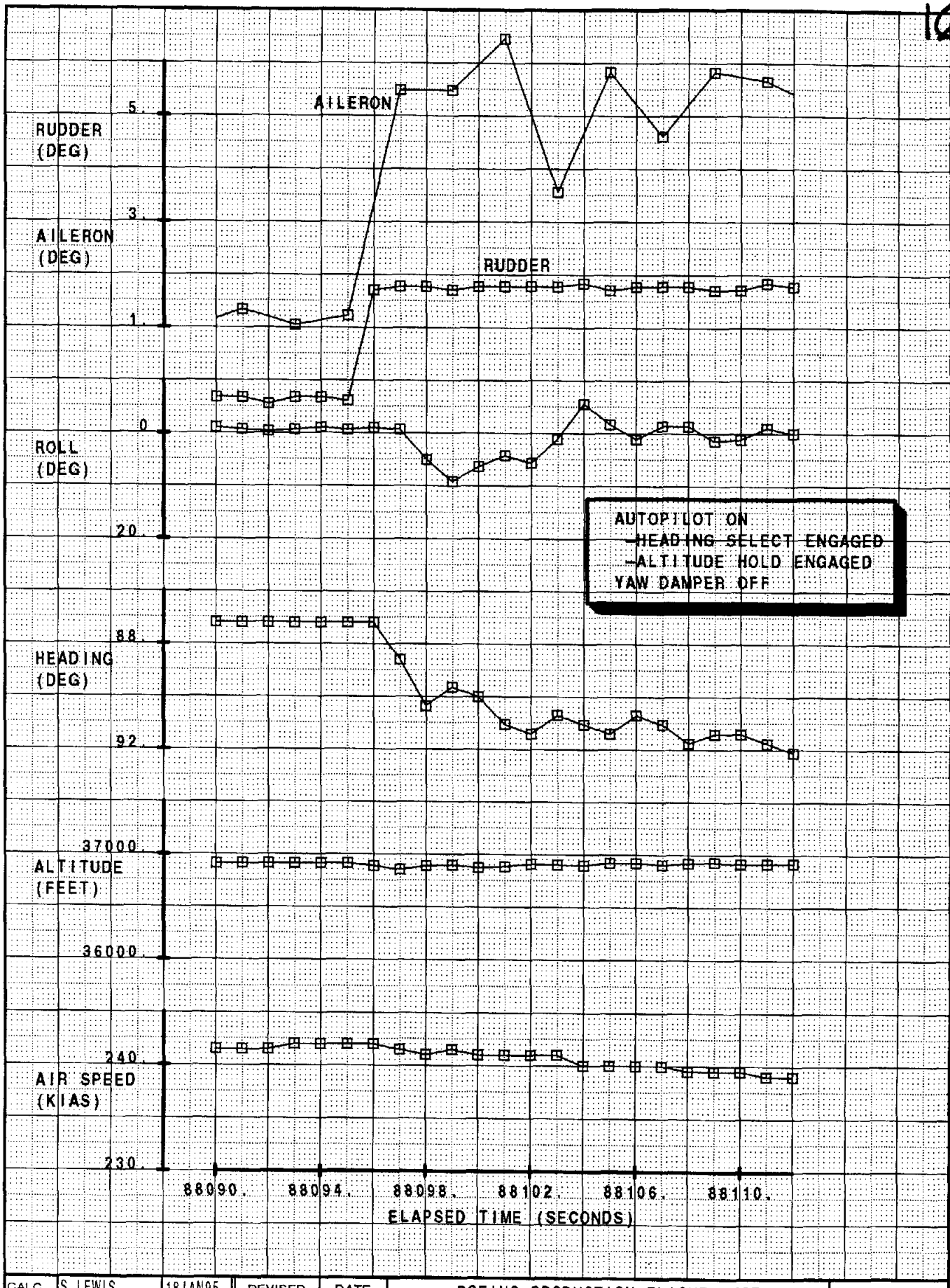

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