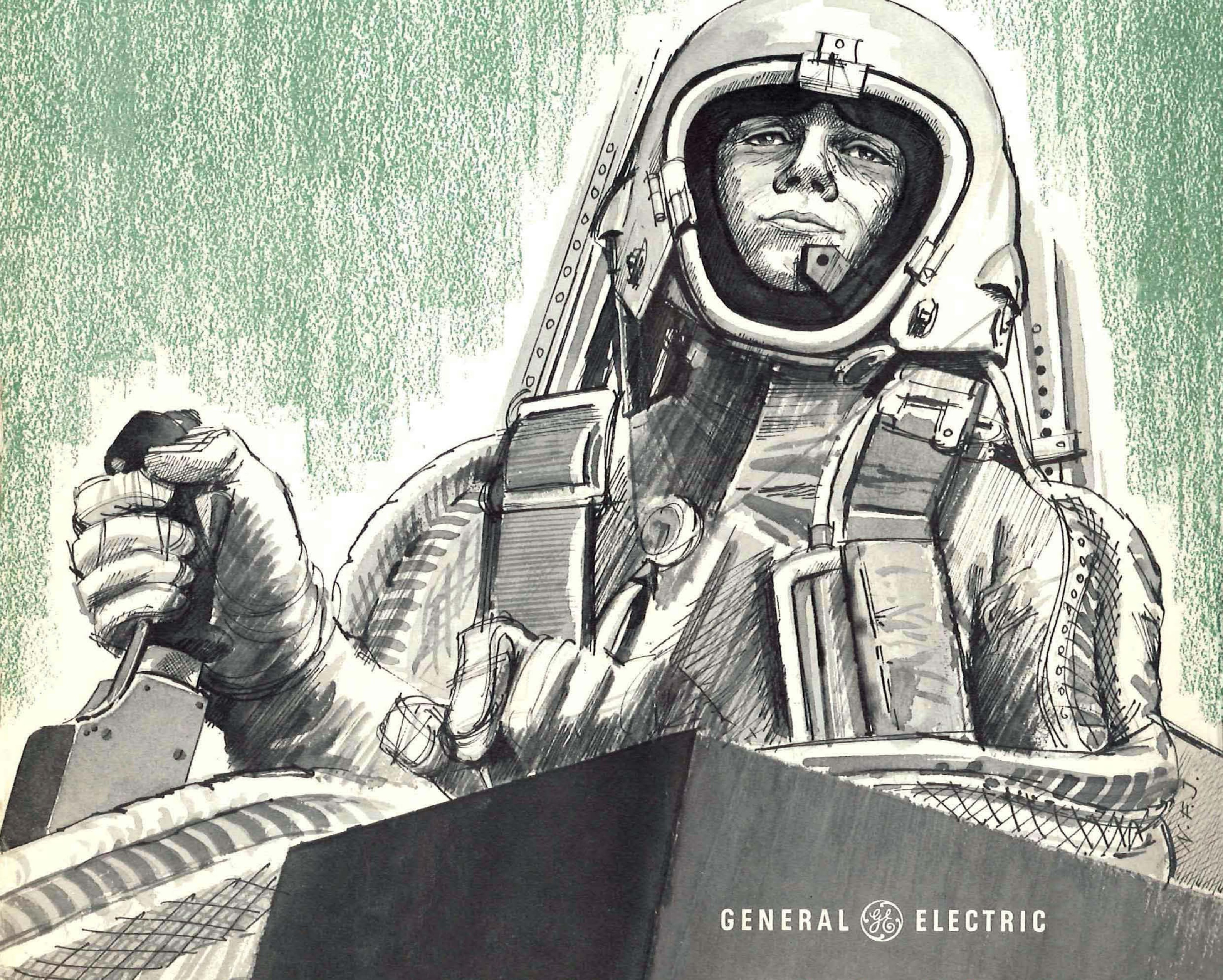
AN/ASA—32
Automatic Flight Control System



GENERAL ELECTRIC

AN/ASA-32 SYSTEM COMPONENTS

AUTOMATIC CONTROL AMPLIFIER TESTER

AN/ASA-32 Flight Control System

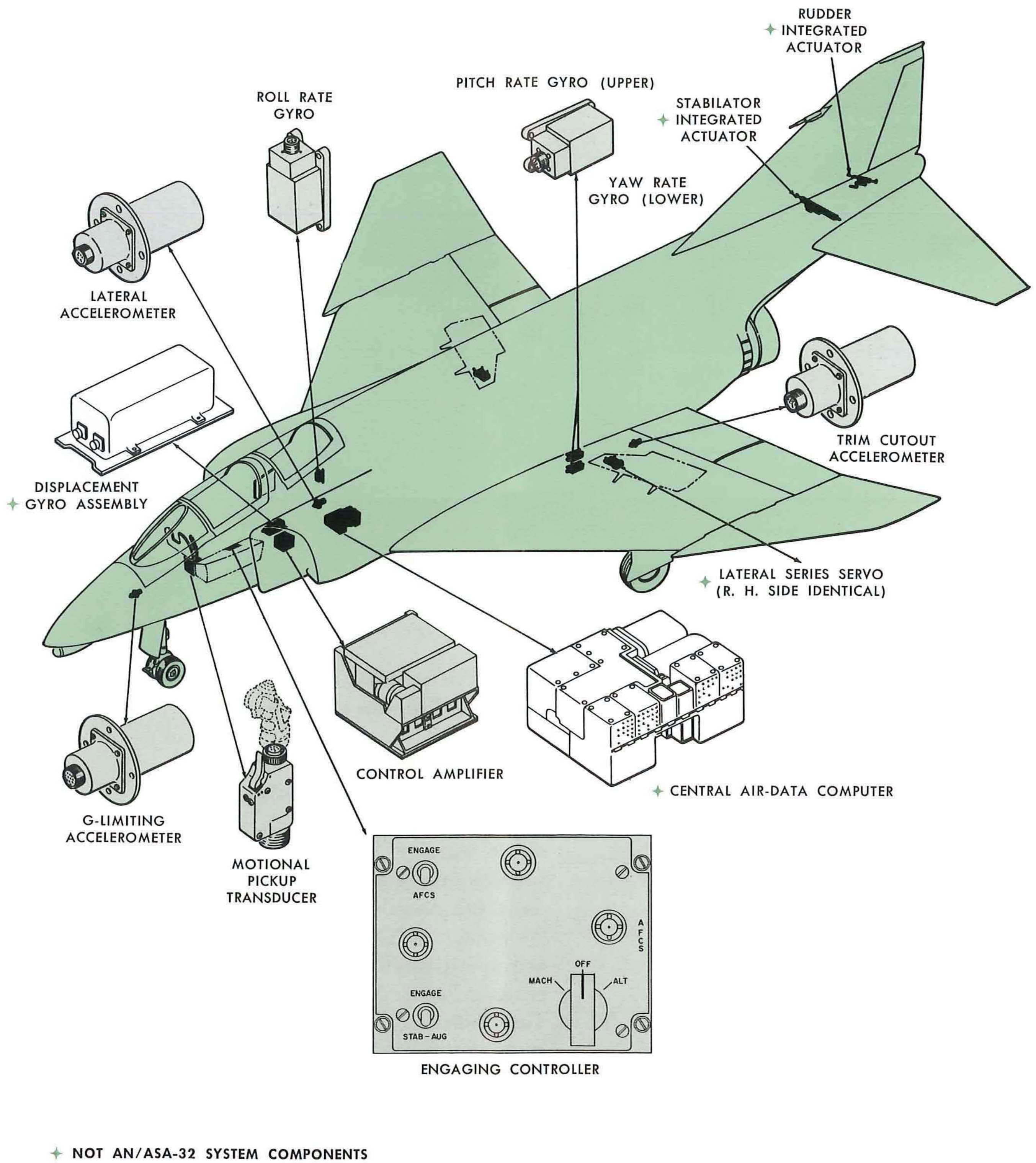
Produced in quantity for the McDonnell F-4 *Phantom II*, the AN/ASA-32 automatic flight control system is now in service around the world. Accorded a high degree of pilot acceptance, the AN/ASA-32 system has proved its performance, reliability, and ease of maintenance under operational conditions.

The entire AN/ASA-32 system weighs only 45 pounds. The sensing elements are the same as those used in the AF/A42G-8 flight control system aboard the F-105 aircraft. The control amplifier consists of fully-transistorized, plug-in modules for ease of maintenance and adaptation. Automatic test equipment has been developed for the system.

Data sheets describing the individual AN/ASA-32 system components are available upon request.

System Features

- **Three-axis stability augmentation**
- **Pilot relief modes which maintain:**
  - **Attitude,**
  - **Heading,**
  - **Altitude or Mach number**
- **Vectoring, traffic control, and automatic carrier landing capability in conjunction with the General Electric data link coupler**
- **Proportional-force pitch maneuvering**
- **Automatic pitch trim cutout and acceleration limiting**
- **Automatic sideslip control and turn coordination**

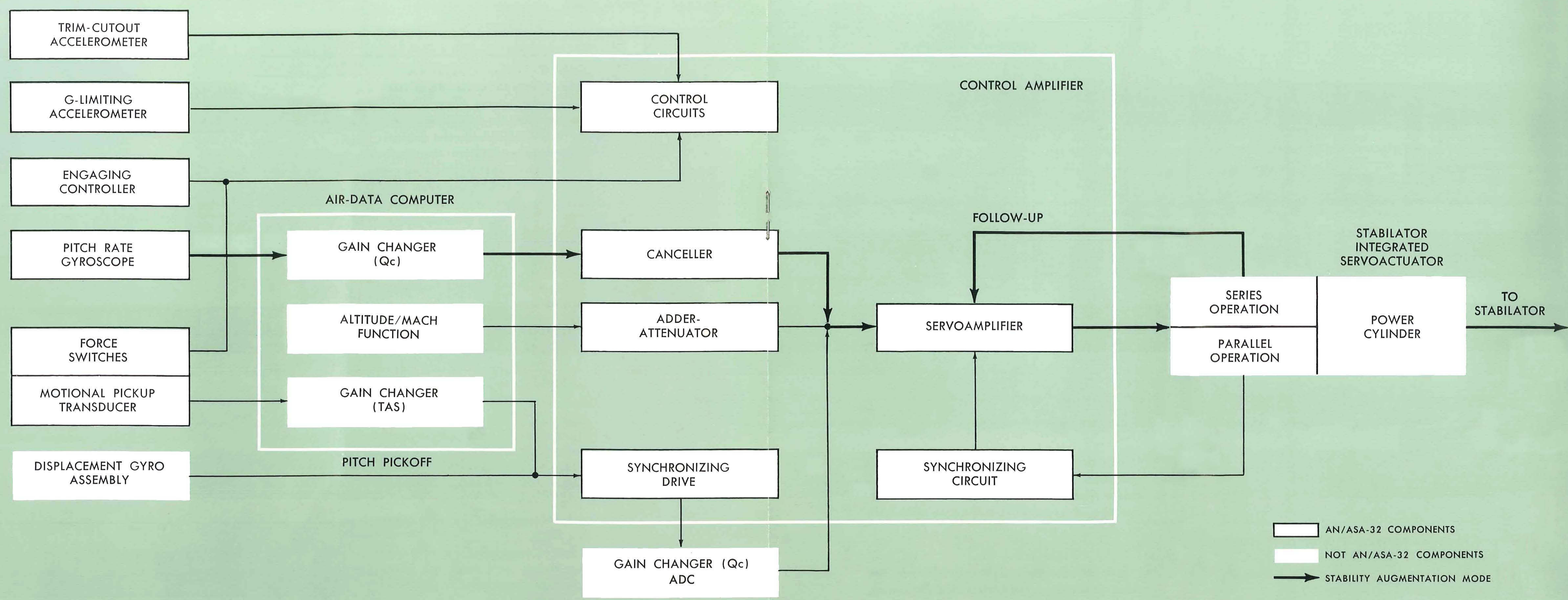


SYSTEM FUNCTIONS

In the *stability augmentation* mode of operation, the flight control system detects aircraft oscillations about the pitch, roll and yaw axes and deflects the control surfaces to counteract the oscillations. These control surface movements are not felt by the pilot. The stability augmentation mode also provides automatic turn coordination or sideslip control during maneuvers.

In addition to the stability augmentation mode, the pilot can select several relief modes of operation: the automatic flight control, altitude-hold, and Mach-hold modes. When the *automatic flight control* mode is engaged, the system maintains aircraft attitude and heading within ±0.5 degree of the reference established at the moment of engagement. In the *altitude-hold* mode, the system maintains altitude within ±50 feet of the reference altitude. In the *Mach-hold* mode, the system maintains Mach number within ±0.03 percent of reference. The pilot can select any of these flight aids from the engaging controller in his cockpit, except that the system cannot be operated in both altitude- and Mach-hold modes at the same time.

In conjunction with the General Electric data link coupler, three additional modes of system operation are available. In the *vectoring* and *traffic control* modes, aircraft heading is commanded by an external source through the data link coupler. In the *automatic carrier landing* mode, pitch and roll attitude (within prescribed limits) are commanded through the data link by an automatic carrier-based landing system.



SYSTEM OPERATION

In the stability augmentation mode, system operation is basically similar in the pitch, roll and yaw channels. Rate gyroscopes, aligned to the primary aircraft axes, produce signals proportional to the rate of aircraft motion in pitch, roll and yaw. The gyro signals are amplified by the control amplifier and applied to the hydraulic servo-actuators which deflect the control surfaces to damp the oscillations.

Pitch Channel

In the stability augmentation mode, the pitch rate gyro signal is scheduled through an air-pressure potentiometer in the aircraft's air-data computer. The potentiometer modifies the magnitude of the signal to yield constant control response independent of airspeed and altitude.

The signal then is applied to a canceller-amplifier which blocks low-frequency signals produced by normal airplane maneuvers.

In altitude- and Mach-hold modes of operation, error signals from the central air-data computer are passed through an adder-attenuator module in the control amplifier. The adder-attenuator fades signals in and out when the relief mode is engaged to prevent transients.

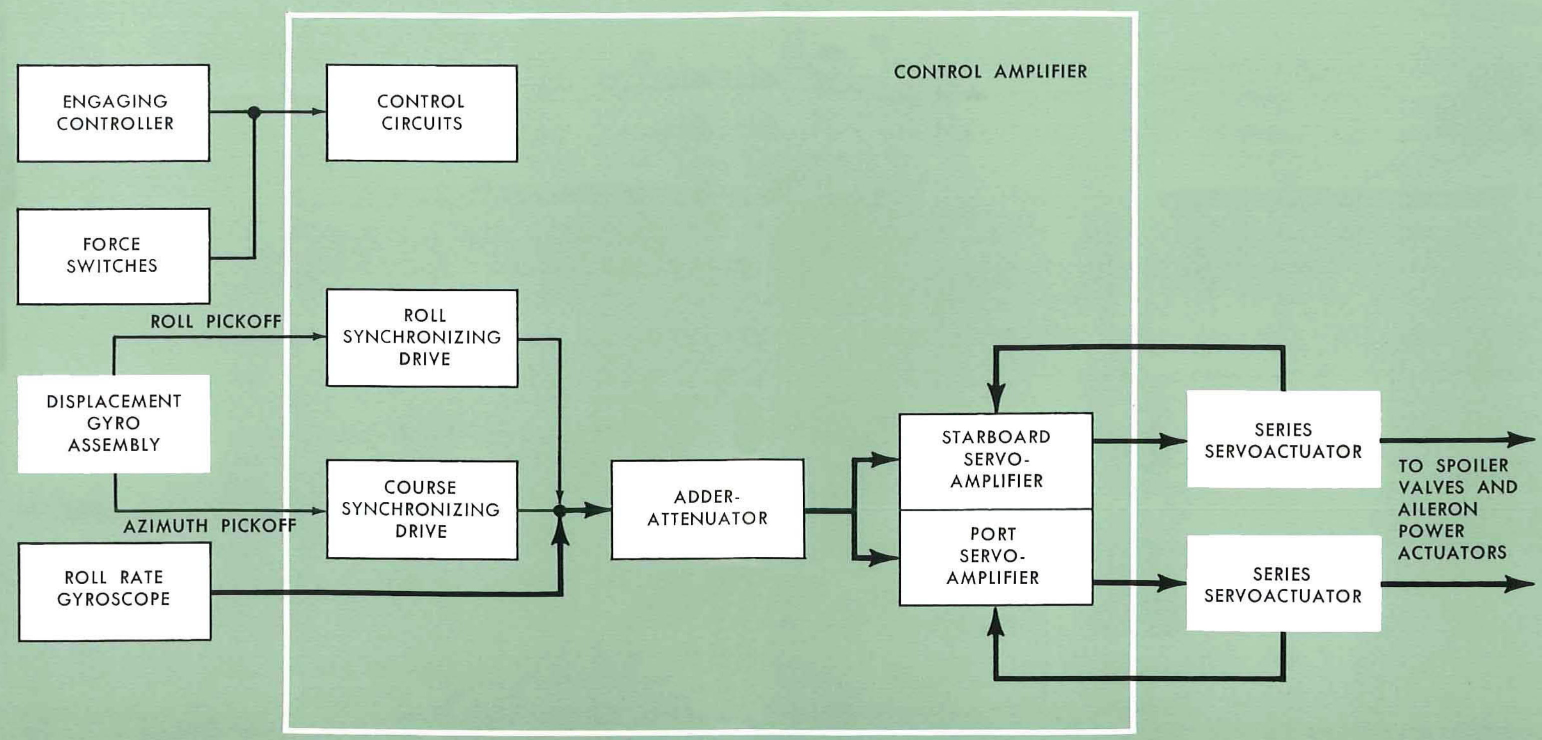
Pilot inputs, proportional to the force applied to the motional pickup transducer mounted on the control column, are scheduled through the central air-data computer to the synchronizing drive. The synchronizing drive integrates the pilot's steering commands into the servo loop.

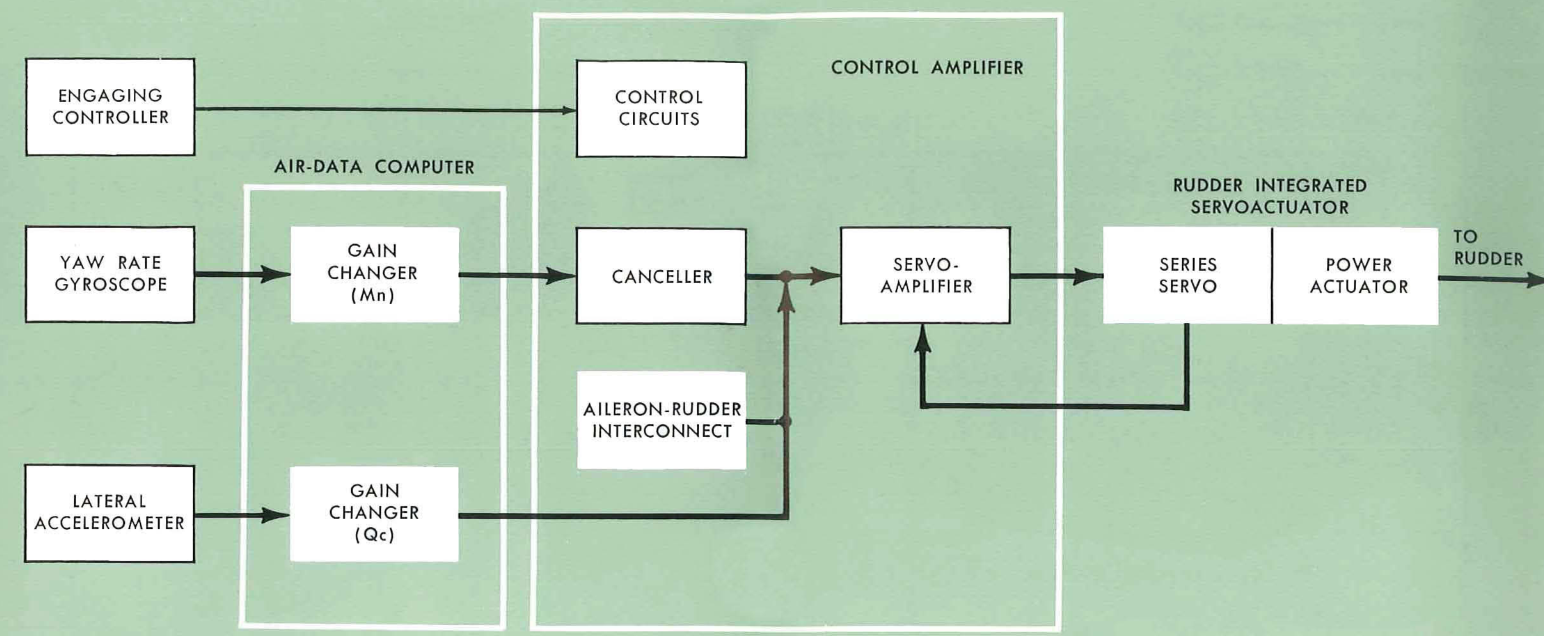
The synchronizing drive also keeps the error outputs from the vertical and directional gyroscopes at null until the automatic flight control mode is engaged, preventing engagement transients. After modification by the pressure potentiometer, the automatic flight control mode error signals are applied through the servoamplifier to the servo-actuators.

Pitch force switches deactivate the relief modes when the pilot maneuvers the aircraft. When the force applied by the pilot drops below the switch closing limits, the automatic flight control modes are reactivated, and the prevailing aircraft attitude becomes the reference attitude for automatic operation.

A follow-up signal, proportional to control surface displacement, is fed back directly to the servoamplifier to prevent control "overshoot." A follow-up signal also is sent through the follow-up synchronizing circuit to make pitch trim adjustments as the aircraft center of gravity changes during the mission.

An important safety feature is provided by the g-limiting and trim-cutout accelerometers. The g-limiting accelerometer deactivates the automatic flight control mode if it senses accelerations in excess of +4 g or —1 g. The trim-cutout accelerometer disconnects the pitch trim system if its +3 to 0g limits are exceeded. In addition, the pilot can disconnect the entire flight control function from a switch on his motional pickup transducer.





Roll Channel Operation

In the stability augmentation mode, roll operation is similar to the pitch channel, except that roll rate signals are fed directly into the adder-attenuator since air-data gain scheduling is not required.

In the automatic flight control mode, two error signals, from the vertical and directional gyroscopes, are required. These error signals are kept at null by the roll and course synchronizing drives until the automatic flight control mode is engaged. One or the other synchronizing drive output is applied to the servoamplifier with the stability augmentation signals from the roll rate gyroscope.

Unlike the pitch channel, pilot roll inputs are applied directly through the control column and mechanical linkages to the control surfaces. Roll force switches deactivate the automatic flight control mode when the pilot maneuvers the aircraft. If the bank angle after completion of the maneuver is greater than 5 degrees, the system maintains the angle prevailing at the moment of automatic reengagement. If the bank angle is less than 5 degrees, the system returns the aircraft to wings-level attitude.

Yaw Channel Operation

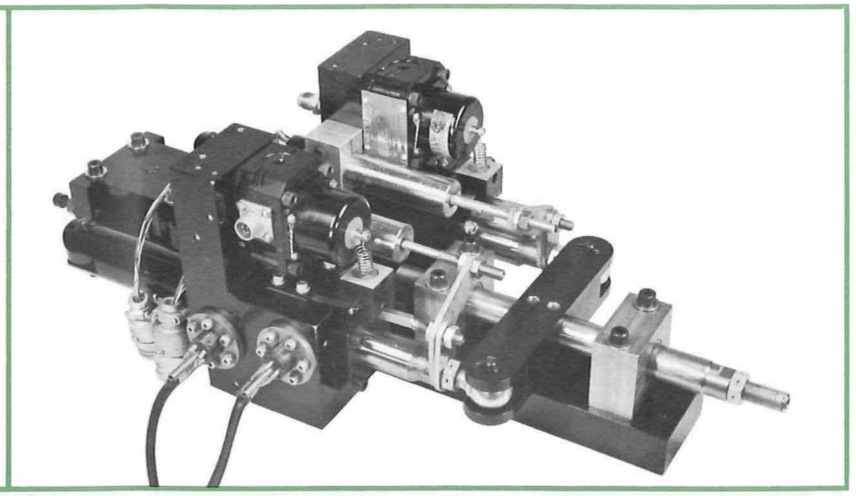
In the stability augmentation mode, yaw channel operation is identical to the pitch channel.

In both stability augmentation and the automatic flight control modes, a linear accelerometer measures lateral accelerations. The accelerometer signal is scheduled through the air-pressure potentiometer and applied to the actuator through the yaw servoamplifier to counteract sideslip.

The AN/ASA-32 system operates in conjunction with the aircraft aileron-rudder interconnect function to provide automatic turn coordination. In the stability augmentation mode, with aircraft speed below 225 knots, aileron deflection can cause a proportionate rudder deflection up to 15 degrees. The rudder command is introduced into the system through the yaw servoamplifier.

DATA LINK COUPLER

FAILURE-CORRECTING ACTUATOR



Data Link Operation

An advanced AN/ASA-32 system, currently being flight tested, gives the aircraft automatic vectoring, traffic control and automatic carrier landing capability. A special coupler permits the flight control to receive commands from the AN/ASW-21 data link.

In the vectoring mode, the data link furnishes heading signals to direct the aircraft to a target. In the traffic control mode, the data link guides the returning aircraft into a predetermined traffic pattern near the carrier. In the automatic carrier landing mode, pitch and roll commands from the AN/SPN-10 landing system on the carrier are coupled to the flight control. The pilot can land the aircraft manually from attitude displays commanded by the data link if he wishes. In the event he receives a "wave off" from the carrier, the coupler and flight control disengage automatically.

NEW DEVELOPMENTS

General Electric is conducting many development programs to improve flight control system performance and reliability. Of particular interest are the following.

Failure-Correcting, Self-Adaptive Flight Control

Under development for the US Bureau of Naval Weapons is a flight control system which provides these features:

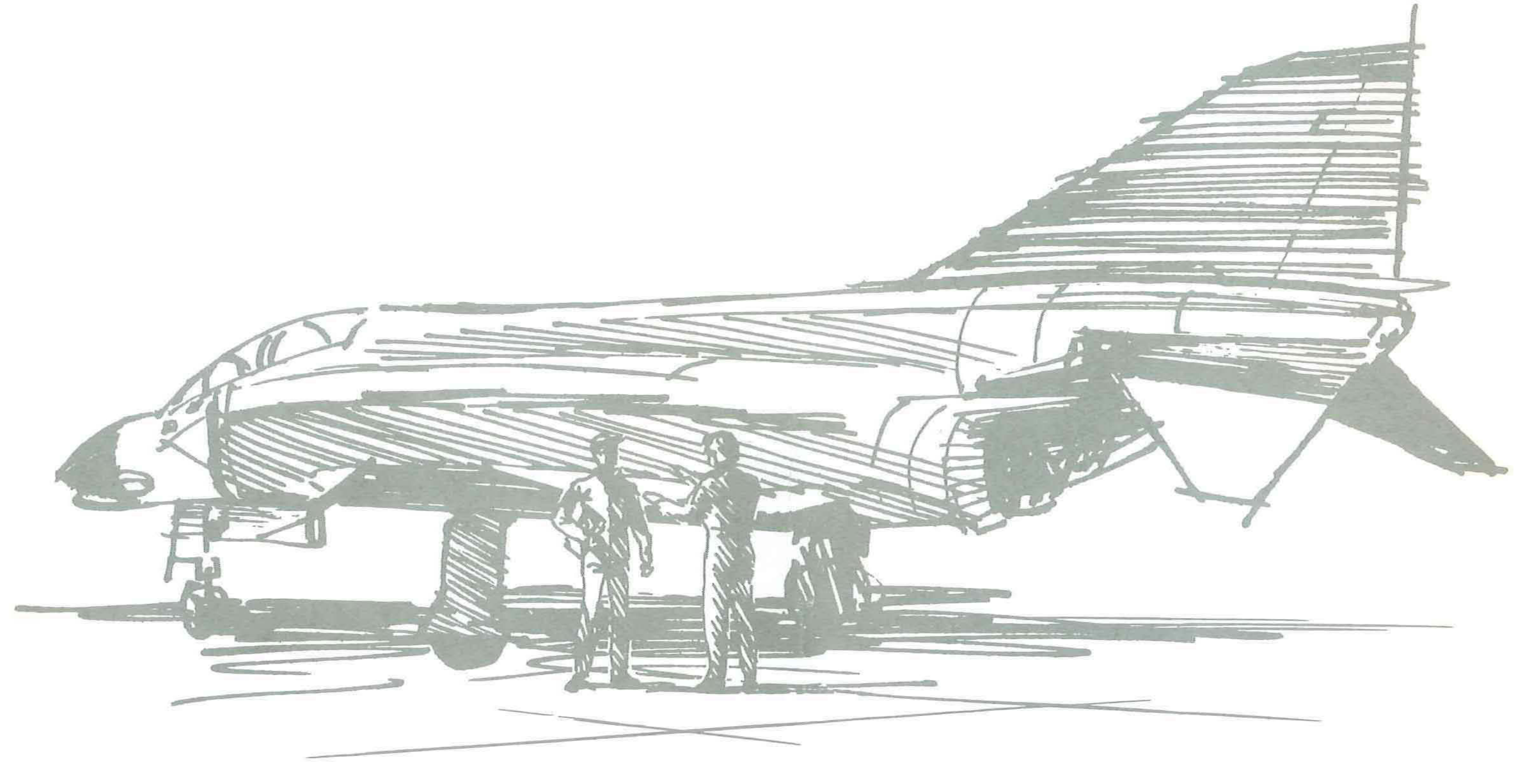
- Self-adaptive gain control without external inputs
- Hybrid digital-analog pulse-time computation
- Redundant channels with majority-logic voting
- Failure-correcting hydraulic servoactuators
- Microelectronic circuit construction

Self-adaptive stability augmentation is afforded in all three aircraft axes without use of an air-data computer. The General Electric self-adaptive method employs a damping sensor which measures aircraft response to normal gust disturbances. Control system gain is adjusted to keep system response invariant regardless of changes in the flight environment and aircraft characteristics.

The hybrid computation technique permits a completely solid-state computer mechanization. Analog quantities are represented by pulse-width modulated signals. Thus, arithmetical operations can be performed without the use of electromechanical devices.

The system employs three identical control channels for each aircraft axis. Majority-logic voters compare pulse-width signals at selected points in the identical control channels. Any significant difference between signals is detected, and the erroneous signal is blocked by the voter. Thus, the system operates properly even after a failure in one of the channels.

All of these features have been flight tested in an F-4 aircraft. In addition, the new system has dual hydraulic servoactuators, which operate properly in spite of a failure. Furthermore, about 60 percent of the control computer is built of microelectronic integrated circuits.



F-111 Automatic Flight Control System

General Electric also is designing a flight control system for the F-111 aircraft. This system incorporates many new features and is the most advanced aircraft control system under development today.

Terrain Following Flight Control

Advances which permit self-adaptive operation, vastly increased reliability and microelectronic circuit packaging portend a control system having superior terrain following capability. Under US Air Force sponsorship, General Electric is investigating the application of predictive path computation and dynamic control optimization to such a system.

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