Automatic Stabilization for Helicopters

The major part of a lecture given before the Helicopter Association on October 3 consisted of an exceptionally informative description of the A.S.E. (automatic stabilization equipment) used in the Sikorsky HSS-1N helicopter. Entitled All-weather Helicopter Systems, the paper was by Walter Gerstenberger, chief of dynamics, Sikorsky Division of United Aircraft.

After discussing basic considerations of bad-weather flying for military and civil helicopters, Mr. Gerstenberger turned to the HSS-1 and HSS-1N (U.S. Naval designations for the two versions of the S-58).

Two independent sets of powered controls were provided, he said, one operated by an engine-driven hydraulic pump, the other by a rotor-driven pump. D.C. power was furnished by engine-driven and rotor-driven generators, and A.C. was supplied by three inverters, so arranged to take full advantage of the redundancy to provide safe flight during emergencies.

Automatic stabilization had been in operation for several years on the HSS-1 and had proved a good solution to the problem of providing the pilot with a vehicle he could handle easily and without too much dependence upon external visual cues. It had a reliability of about one malfunction in 800 flight hours, and it was probable that this reliability could be at least doubled. There was little doubt that during the 801st hour the pilot could fly this helicopter on his instruments, without the A.S.E. equipment, without ill effect.

A.S.E. was developed by Sikorsky exclusively for helicopter use from fundamentals first conceived ten years ago. Describing its operation, Mr. Gerstenberger said that whilst the pilot must be the prime authority in the direction of his vehicle he needed help, in order that his mental and visual capabilities should not be saturated. A.S.E., which introduced stabilization signals without taxing the pilot with the details, was an example of this concept. It permitted certain functions which could be delegated to automatic control. By limiting the authority of the control to the point where it could still perform its task, yet leave the pilot inherently in full authority at all times (especially during emergencies) a fail-safe condition existed, in which 100 per cent reliability was not required for the sid. This might be contrasted to a control which could not be duplicated by the pilot, e.g., the fuel control of a turbine, where failure of the instrument would lead to a safe condition, but could not be duplicated by the pilot, and the integrity of the turbine that it appeared more feasible to increase the reliability of the automatic control, or rely on several engines, than it is to allow the pilot to control the turbine manually.

Incorporation of additional features for improved limited-visibility flying in the HSS-1N preserved this concept of delegation of limited authority used in the HSS-1, but extended it to the rotor r.p.m. control in the form of a throttle governor and to the Doppler hover mode with the facility of automatic approach to the hover. The HSS-1N was an anti-submarine helicopter, and the additional facilities provided for round-the-clock operation. Here was an interesting example of a solution to the difficult problem of the approach-to-hover over water with sufficient accuracy to permit the sonar transducer to be lowered into the water without damage, all this being accomplished with no dependence on outside visual references. The results were from the combined efforts of the U.S. Navy's Bureau of Aeronautics, Naval Air Development Command, West Chest, numerous electronic component manufacturers and Sikorsky Aircraft.

Apart from the automatic control equipment, the instrument panel (illustrated on the adjacent page) was a radical departure from the A.S.E. panel once the engine was started. As before, the A.S.E. panel provided engagement and disengagement of the A.S.E. panel. The results of the new HSS-1N were that the pilot's hovering indicators. In the coupler, they were combined with the sonar transducer. In the new HSS-1N, said Mr. Gerstenberger, important features had been added, such as the pitch, roll and yaw stability. BAR ALT gave you altitude retention. After you lowered the sonar transducer you switched to ASW cable and ASW ALT for automatic hover over the water. The conventional cyclic stick, with A.S.E., normally fed through mechanical linkage and a hydraulic servo working through a differential link, to make small, limited-authority corrections through the hydraulic servo, to the blades. Electric servos used to derive signals from gyro, the stick and the stick-position senser. The resulting signal was then amplified and fed to the electric servos. Thus, in normal operation, the attitude of the helicopter was stabilized at an attitude determined by the pilot's stick position. The stick-centering spring was used in conjunction with a magnetic clutch. When the clutch was engaged, the spring provided stick-feel, and a referenced position, if the pilot removed his hand from the stick. Disengaging the clutch allowed the pilot to shift his reference. Another feature of the HSS-1 was the sonar coupler, which operated from a cable-angle senser. The sonar coupler, which sent a command signal that was introduced into the A.S.E. to maintain the helicopter's altitude over the sonar transducer.

In the new HSS-1N, Mr. Gerstenberger, important features had been added in the pitch-and-roll channel. A Doppler ground-speed sensor system had been added and could be selected as the primary sensing for the coupler. The automatic control circuits of the coupler would bring the helicopter to a hover from any lateral or longitudinal flight condition. However, in order to make it possible for this control to work through the whole flight regime, it had been necessary to extend the automatic control authority beyond the limits provided by the servomotor input. The magnetic clutch had therefore been replaced by another actuator so that, when the coupler called for a signal in excess of what could be provided by the differential input, a signal was sent to this third control to move the stick slowly in the proper direction; this maintained the automatic control within its limited authority. When the collective is not engaged, the stick control could be used by the pilot to make small adjustments to the stick trim.

The altitude channel was basically the same as the pitch channel except that the pilot's control was the collective. Altitude errors were detected by a barometric senser, and the collector was fed either by the hydrostatic depth-senser or by the expanded-scale radar altimeter. In order to accomplish the job of stabilizing the helicopter between forward flight and hover, a collective open-loop-and-balance spring was used across the hydraulic servo, in conjunction with a collective-stick position-senser, to provide automatically that the attitude of the helicopter from forward flight to hover was brought to hover forward and altitude.

The HSS-1N's instrument panel. A, co-pilot's flight instruments; B, navigation; C, powerplant and services; D, pilot's flight instruments.