UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36362

STEBG-TD

25 FEB 1964

SUBJECT: Report of Test, USATECOM Project No. 4-4-0108-02, Military Potential Test of the 'Door Hinge' High-Speed Rotor System

TO: Commanding Officer
US Army Aviation Test Activity
Edwards Air Force Base, California 93523



1. References.

a. Letter, Bell Helicopter Company, 22 October 1963, subject: "Flight Evaluation of Bell's High Speed Door Hinge Rotor System."

b. Letter, STEBG-TPD, US Army Aviation Test Board, 9 January 1964, subject: "Plan of Test for the Bell Door Hinge Rotor Helicopter."

2. Authority.

a. Directive. Letter, AMCRD-DM-A, Headquarters, US Army Materiel Command, 3 December 1963, subject: "Bell Helicopter Proposal for High Speed Door Hinge Rotor System," with 1st Indorsement, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 31 December 1963.

b. Purpose. To contribute a qualitative "service pilot" opinion to USATECOM Task No. 4-4-0108-01 (US Army Aviation Test Activity is the coordinating agency).

3. Background. Bell Helicopter Company developed the "Door Hinge" High Speed Rotor System from company funds to meet an Army requirement for helicopter operation at high airspeeds with a low vibration level. In October 1963, Bell offered to provide a commercial

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Bell 204B (UH-1B type helicopter), equipped with the "Door Hinge" rotor for Army evaluation of the rotor at no cost to the government. Headquarters, US Army Materiel Command (USAMC), requested that US Army Test and Evaluation Command (USATECOM) accomplish a military potential evaluation of the "Door Hinge" rotor system in December 1963. USATECOM designated the US Army Aviation Test Activity (USAATA), Edwards Air Force Base, California, as the coordinating agency and the US Army Aviation Test Board (USAAVNTBD) as contributing agency to conduct a 20-flight-hour evaluation at the manufacturer's test flight facilities, Fort Worth, Texas.

4. Description of Materiel.

a. "Door Hinge" Rotor. The "Door Hinge" rotor, designated Model 540 by the manufacturer, is a two-bladed, semi-rigid type with a flapping hinge and underslung feathering axis, which incorporates a unique pitch-change bearing arrangement (door hinge). All the bearings in the hub assembly are Teflon-lined sleeves; therefore, the hub requires no lubrication.

b. Rotor Installation. The "Door Hinge" rotor was mounted on a commercial Model 204B Helicopter. The 204B is similar to the UH-1B except that it has a longer tail boom to accept a 48-foot rotor blade.

5. Test Objectives. The objectives were

a. To determine whether the "Door Hinge" High-Speed Rotor System has advantages in speed and vibration level compared to the 44-foot and 48-foot rotor systems presently utilized in the UH-1 series helicopters.

b. To determine other significant advantages and disadvantages.

6. Scope. The USAAVNTBD portion of the test was conducted during the period 13-21 January 1964 at the manufacturer's test flight facilities, Fort Worth, Texas. The Model 204B Helicopter with the "Door Hinge" rotor system installed was flown a total of 5 hours and 35 minutes at gross weights of 7500, 8500, and 9500 pounds. A

standard production UH-1B was flown once at a gross weight of 8500 pounds for a comparison of vibration levels and autorotational characteristics. Test results showed that

7. Findings. (Details of test are contained in inclosure 1.)

a. The "Door Hinge" rotor system offered significant advantages in the reduction of vibration at high speeds compared with rotor systems presently used in the UH-1 series helicopters.

b. The approximate 70-percent increase in rotor inertia made autorotation touchdowns less critical to perform, particularly above gross weights of 8000 pounds.

c. Blade slap noise was significantly reduced at high airspeeds and gross weights.

d. Operational suitability was improved by higher speeds, greater maneuverability, and better autorotative characteristics.

e. The simplicity of the rotor hub design and the use of Teflon bearings which require no lubrication improved the maintenance suitability.

f. The rotor system design would permit an increase in the maximum gross weight of UH-1B Helicopters. It was concluded that

8. Conclusions.

a. The Model 540 "Door Hinge" High-Speed Rotor System improves the operational suitability of UH-1 type helicopters, particularly at high speeds.

b. The Model 540 "Door Hinge" High Speed Rotor System improves the maintenance suitability of UH-1 type helicopters.

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9. Recommendations. It is recommended that:

a. The "Door Hinge" High Speed Rotor System be further developed and further testing be conducted to determine its full potential.

b. The "Door Hinge" High Speed Rotor System(s) be developed as a product improvement program for the UH-1B and UH-1D Helicopters, and be incorporated in production models as soon as practicable.

1 Incl
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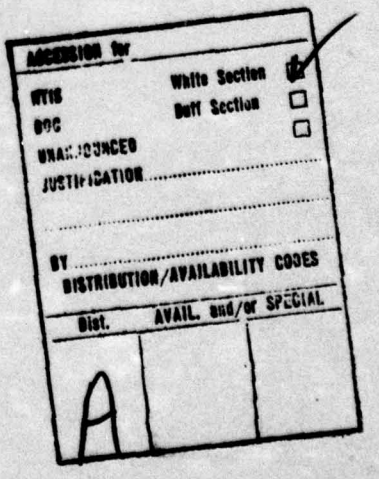
A. J. RANKIN
Colonel, Armor
President

Copies furnished:
CG, USATECOM



## DETAILS OF TEST

1. Vibration. The most significant feature of the "Door Hinge" rotor system was the reduction in two-per-revolution vibration. At all tested gross weights (7500-9500 pounds), the helicopter was limited by available power rather than by vibration. Vibration levels did not significantly change with variations in gross weight and airspeed under all tested flight conditions. For a comparison of vibration levels a portable accelerometer was carried in the test helicopter and in the standard UH-1B at a gross weight of 8500 pounds. The accelerometer was placed just to the rear of the copilot's seat, the point of greatest vibration amplitude in the cockpit. A comparison of the two resulting tapes indicated that the vibration level of the test aircraft at 130 knots indicated airspeed was equivalent to that of a standard UH-1B at 80-85 knots.

2. Maneuvering Flight.

a. Angles of bank to approximately 75 degrees were made at gross weights to 8500 pounds at airspeeds from 60-120 knots. Bank angles of 45 degrees were made at 120 knots at a gross weight of 9500 pounds. Control feel was positive and no vertical two-per-revolution vibration was encountered.

b. Abrupt pull-ups were made at all gross weights from straight and level flight and dives of 2000 feet per minute. Control feel was very good and there was no tendency to "mush out."

c. Blade stall was not approached during any maneuver.

3. Throttle "Chops." Throttle "chops" were made at all tested gross weights and at airspeeds from zero to Vmax. The highest airspeed was 140 knots at 7500 pounds. There were no adverse tendencies, and only the normal yaw reaction was encountered.

a. During the throttle "chops," reduction of collective pitch was delayed from 1-3 seconds with no adverse control requirements or change in pitch or yaw. Rotor r.p.m. decay was slightly slower than that of the standard UH-1B rotor system. The time required for the rotor r.p.m. to recover to normal after entering the autorotation varied, depending on whether airspeed was maintained or a flare entered. The high rotor inertia did not have a perceptible adverse effect on recovering rotor r.p.m. The altitude required to regain r.p.m. depended on airspeed. At low airspeeds, more altitude was required.

b. The rate of sink was comparable to that of the standard UH-1B. However, the approximate 70-percent increase in rotor inertia made the touch-down considerably less critical, particularly at gross weights above 8000 pounds where the performance of the 44-foot diameter blade becomes marginal.

4. Criticality of R. P. M. The high r.p.m. limits of the prototype installation tested were critical because the blade retention straps were the laminated UH-1B type and not the improved wire wound straps. Limits were:

Power on: 285-324 r.p.m.
Power off: 300-330 r.p.m.

5. Noise Level. The characteristic Bell blade slap was significantly reduced at high airspeeds and gross weights. It could not be induced to any appreciable extent by abrupt pull-ups or tight turns. At low airspeeds (60-70 knots), the slapping noise was normal.

6. Boost Controls. A dual boost pump was installed for collective control. This was required because the prototype blade mass balance was not as it would be in production, i.e., the blade balance material, 45 pounds/tip, was located in the blade leading edge. The resulting force prevented the pitch control from being manually operated with boost off above 85 knots at a gross weight of 9500 pounds. In production models, this condition could be corrected easily by repositioning the blade tip weights.

7. Attitude. The flight attitude did not vary to a measurable extent during hover, cruise, or Vmax from that of a standard UH-1B.

8. Time Required for Rotor R. P. M. to Decay to Zero at Shutdown. The time required for the rotor r.p.m. to decay to zero at shutdown did not vary significantly from that of a standard UH-1B.

9. Stability. Stability in hovering and cruise was comparable with that of the UH-1B.

10. Trim. The trim device would not hold trim at airspeeds above approximately 130 knots.

11. Flare Characteristics. The flare characteristics could not be investigated as desired because the high rotor speeds encountered in

abrupt flares would exceed the structural limitations of the laminated-type blade retention straps installed on the test helicopter. The use of wire-wound retention straps scheduled for use on the 48-foot rotor blade will eliminate this problem.

12. Compatibility with 48-Foot Rotor. The "Door Hinge" hub assembly as developed for the 27-inch chord, 44-foot diameter rotor blade is not compatible with the 48-foot rotor. However, the basic design could be adapted as a new hub assembly for the UH-1B and UH-1D with 48-foot rotor blades.

13. Maintenance Requirements. The reduced number of parts and the use of Teflon bearings should significantly reduce maintenance requirements.