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BUETTNER CUEING CONCEPT FOR HELICOPTER FLIGHT CONTROL

By

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Final Report

U. S. ARMY AEROMEDICAL RESEARCH LABORATORY

Fort Rucker, Alabama 36362

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Familiarization was obtained with a helicopter flight control cueing concept developed by a retiring senior flight instructor, with emphasis on its potential application to night vision imaging systems. It consisted of a simple set of windshield marks arranged to provide precision in contact control of pitch attitudes. Students trained with it seemed to find advanced contact and instrument training much easier than traditionally trained students, and experienced helicopter pilots introduced to the concept felt it provided

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) substantial improvement in their control precision. Conclusions from this exploratory familiarization were that Buettner-type cue sets (a) have potential for reducing perceptual ambiguities in helicopter control with night vision devices, (b) increase precision and lead in helicopter contact control, (c) should provide a high level of transfer to instrument training, (d) with slight extension have potential as an approach aid, particularly for an underslung night vision device, and (e) appear to have potential for very simple helicopter simulator visual displays that should have considerable value for initial or transition training.

SUMMARY

Familiarization was obtained with a helicopter flight control cueing concept developed by a retiring senior flight instructor, with emphasis on its potential application to night vision imaging systems. It consisted of a simple set of windshield marks arranged to provide precision in contact control of pitch attitudes. Students trained with it seemed to find advanced contact and instrument training much easier than traditionally trained students, and experienced helicopter pilots introduced to the concept felt it provided substantial improvement in their control precision. Conclusions from this exploratory familiarization were that Buettner-type cue sets (a) have potential for reducing perceptual ambiguities in helicopter control with night vision devices, (b) increase precision and lead in helicopter contact control, (c) should provide a high level of transfer to instrument training, (d) with slight extension have potential as an approach aid, particularly for an underslung night vision device, and (e) appear to have potential for very simple helicopter simulator visual displays that should have considerable value for initial or transition training.

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INTRODUCTION

The perceptual cues and processes involved in helicopter control are of major significance in understanding and improving both contact and instrument flight, and assume even greater importance when helicopter control is accomplished through use of indirect view electro-optical night vision aids. However, the perceptual phenomena involved in helicopter flight control remain an ambiguous and largely undefined subject area that is presumed to be highly individualistic with each pilot in many of its aspects. In defining the characteristics for new generation night vision aids, perceptual cueing techniques that might reduce perceptual ambiguity and improve helicopter control precision merit careful consideration. This report documents preliminary consideration of such a perceptual cueing technique that reportedly had been used in both primary and advance (instructor pilot) helicopter contact flight training with considerable success.

The perceptual cues used in the various helicopter maneuvers and how they are used are seldom precisely defined, and for many students the cues instructors claim they should use seem like verbal myths that they don't ever manage to "see" throughout their helicopter training. How the helicopter should move through space or relative to a point is clearly defined for various maneuvers, but some of the cues used in-flight to define positions and rates are quite ambiguous for the student to grasp. Many experienced pilots, including some instructors, admit in private they have never seen some of the visual cues they are supposed to be using. Others apparently do see these cues, but have no positive way of conveying what they are using to students other than by example. Learning to fly a helicopter, particularly the approach, is consequently largely a process of example matching osmosis using generally undefined sets of perceptual cues.

Objective tests repeatedly have shown that experienced helicopter pilots are very inaccurate in defining the actual flight paths they have flown on approaches--an indication the cues they use are not particularly precise. Claimed straight-line approach paths actually turn out to be convex curved paths above or concave curved paths below the straight line approach path, or sometimes a combination of both. Arcing below the straight-line path early in the approach and above it late in the approach is common. The angles of approach descent paths are routinely overestimated by almost all pilots.

Observation of pilots indicate a variety of approach techniques seem to be used, and large corrections late in the approach are not at all uncommon. Among experienced pilots some may routinely need almost no corrections late in the approach, and others may need large corrections much of the time. For these latter pilots, it is apparent that cues and control technique early in the approach are not sufficiently precise to assure a minimal control termination, or at least are not being used.

The large expanse of windshield or bubble characteristic of helicopters tends to provide less definitive visual attitude reference cues than are available in fixed-wing aircraft. A bug spot or similar mark on the windshield frequently is used as an attitude reference cue, particularly for pitch.

The cueing concept documented in this report is basically an elaboration of the bug spot reference mark in accord with the flight response characteristics of helicopters. It was evolved over a number of years by Otto A. Buettner on a trial and error basis during the course of operational flying and instruction in helicopters. A technique of instruction was developed to exploit the potential of the cueing concept for developing maximum precision and lead time in control for contact flying, and maximum skill transfer to instrument flying.

As he neared retirement Buettner was interested in getting his cueing and instructional techniques documented. He recognized that his cue-based techniques were uniquely different from standard instructional procedures, and believed, from student feedback, that they produced a more proficient helicopter pilot, particularly in instrument flight and advanced contact maneuvers. Initial review indicated that Buettner was indeed highly successful as a helicopter flight instructor, and that his cueing technique might have potential for application in night vision aids. Therefore, it was agreed to attempt to document the techniques in exchange for the opportunity to explore their application in greater detail in a limited scope flight training environment.

The author participated in flight training using the Buettner cueing concept in order to attempt to assess its potential advantages and disadvantages, with particular reference to restricted visibility flying through the use of night vision sensors such as low light level TV, FLIR, and night vision goggles. It was anticipated the cueing technique might have potential not only for training, but for resolving some of the perceptual problems in using night vision sensors for helicopter maneuvers and operations.

PROCEDURE

Aerodynamics Review. Prior to beginning flight instruction, a review of basic helicopter aerodynamics was presented by Buettner on an interactive basis with the author and a second student, with a twofold purpose of providing background to the author essential to understanding helicopter control consequences and response to control actions in relation to the cue set, and to review the presentation format in regard to figures and verbal content for student understanding. A second trial presentation to a group of USAARL personnel was given to obtain further critique of the format. The aerodynamic section essentially followed the content of Chapter 2 of TM 1-260, Rotary Wing Flight. The results of this revision effort are now incorporated in the current version of this manual, FM 1-51.

Cueing Concept Review. The cueing concept was reviewed in detail using extensive blackboard and paper-pencil sketches. The application and use of the cue set in each flight training exercise was reviewed in detail prior to attempting it during flight, so that the students fully understood how to employ the cues in the exercise.

Flight Demonstrations and Training. The author received approximately ten hours of demonstration and flight training using the cue set and photographing its use; and a second subject about six hours of flight training and demonstration. In approximately ten flight training and demonstration hours, one subject (the author) completed all the exercises listed on Figure 1 in at least cursory fashion, except for autorotations and emergency procedures, which were only demonstrated. A second subject with a tendency to overcontrol in about six hours progressed only to the point where he could use basic attitudes on a rough basis. Most of his progress came in the last training period when he started to resolve his overcontrol problem by shifting from arm control to a fingertip control method. This second subject student could see the cue relationship with the terrain he was supposed to achieve, but could not sustain them due to overcontrol.

Additional Approach Aid Cues. The author explored the potential of an additional set of cues at a depression angle below the original Buettner cue set, corresponding to a normal approach angle. The intention was to explore using this second set as a reference for the descent initiation point and for a descent angle reference during the approach.

Previous Student Interviews. A final activity was a review discussion by the author with two recent students of Buettner in a methods of flight instruction course. The views of these experienced pilots were solicited in regard to the advantages and disadvantages of the cueing technique in flight training and operational flying.

		Solo Check (12–15), Failure Rechecks (16–20)																			
	Hrs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Introduction	Preflight inspection	D	P	C	C	C	C	C	C	C	C	←	—	—	—	—	—	—	—	—	→
	Cockpit procedure	D	P	C	C	C	←	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Introduction to controls	D	P	C	←	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Antitorque pedals single control exercise (student on pedals)	D	P	C	←	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Basic flight attitudes for hover, acceleration, and deceleration	D	P	C	←	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Collective pitch and throttle (I. P. on cyclic, student on pedals and collective)	D	P	C	←	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	→
Attitude - Power Heading Control	Basic flight attitudes - low level 3 to 5 feet acceleration, coasting hover, deceleration	D	P	P	C	←	—	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Normal takeoff control of attitude and heading to 50 feet or above		D	P	C	C	←	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Establishment of slow cruise attitude at 50 feet or above		D	P	C	C	←	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	Normal approach control of attitude and heading from 50 feet (to open area)		D	P	C	C	←	—	—	—	—	—	—	—	—	—	—	—	—	—	→
Traffic Pattern	Normal takeoff (using basic attitudes and power settings)			D	P	P	C	C	C	C	C	C	C	C	←	—	—	—	—	—	→
	Traffic pattern *(using basic attitudes and power settings)*			D	P	P	C	C	C	C	C	C	C	C	←	—	—	—	—	—	→
	Normal approach (using basic attitudes)			D	P	P	P	C	C	C	C	C	C	C	←	—	—	—	—	—	→
Airwork	Attitude control/airspeed			D	P	P	P	C	C	C	C	C	C	C	←	—	—	—	—	—	→
	Power control/altitude			D	P	P	C	C	C	C	C	C	C	C	←	—	—	—	—	—	→
	Pedal trim control			D	P	P	P	C	C	C	C	C	C	C	←	—	—	—	—	—	→
	Turns - 90°, 180°, 360°			D	P	P	C	C	C	C	C	C	C	C	←	—	—	—	—	—	→
	RPM control for stabilized cruise, slow cruise, climb, descent				D	P	P	C	←	—	—	—	—	—	—	—	—	—	—	—	→
	RPM control *during full range power change*				D	P	P	C	←	—	—	—	—	—	—	—	—	—	—	—	→
	Methods of cross-check				D	P	P	C	C	C	C	C	C	C	←	—	—	—	—	—	→
	Forced landing entry straight ahead, maximum distance (with power recovery after entry)				D	D	P	C	C	←	—	—	—	—	—	—	—	—	—	—	→
	Forced landing entry straight ahead, *shortened glide (with power* recovery after entry)					D	D	P	C	←	—	—	—	—	—	—	—	—	—	—	→
Hovering	Hovering - stationary						D	P	C	C	C	C	←	—	—	—	—	—	—	—	→
	Hovering, moving sideward and rearward, and *90°, 180°, 360° turns*						D	P	C	←	—	—	—	—	—	—	—	—	—	—	→
	Takeoff to and landing from hover						D	P	C	C	C	C	←	—	—	—	—	—	—	—	→
	Hovering autorotation						D	D	P	P	C	C	←	—	—	—	—	—	—	—	→
Forced Landings and Basic Autorotations	Forced landing entry with bank and turn (with power recovery after bank established)							D	P	C	←	—	—	—	—	—	—	—	—	—	→
	Forced Landing (all above) to termination with power							D	P	P	C	C	C	←	—	—	—	—	—	—	→
	Basic autorotation and landing								D	P	C	C	C	←	—	—	—	—	—	—	→
	Recovery from low rotor rpm or bounce									D	←	—	—	—	—	—	—	—	—	—	→
	Basic autorotation 180° and landing									D	P	C	C	←	—	—	—	—	—	—	→
	Antitorque failure										D	D	←	—	—	—	—	—	—	—	→
Solo	First supervised solo												x	—	—	—	—	—	x		
	Second supervised solo													x	—	—	—	—	—	x	
	Third supervised solo														x	—	—	—	—	—	x

Legend: D - Introduction/Demonstration

P - Practice and Student Oral Summary

C - Check Accomplished Material

←——→ - Completed and on Review as Required

x - Solo

Figure 1. Outline of Flight Training and Demonstration Exercises with Typical Training Progress Plan (From TM 1-260, Rotary Wing Flight, 6 Jan 69)

THE BUETTNER CUEING CONCEPT

The cueing concept of Buettner for helicopter flight control consists of a set of marks in a vertical row placed about one and one-half inches apart on the windshield in the UH-1 as shown in Figure 2. (In other aircraft, with windshields farther ahead of the pilot, they are more widely spaced in proportion to pilot eye to windshield distance.) The exact spacing of these marks for a specific aircraft should be the spacing which results in a two and one-half degree angle between the marks at normal pilot eye to windshield distance. A set of five marks is used consisting of a center circle or zero, and two marks above and two below it at about one and one-half inch spacing. The two upper marks are referred to as acceleration marks, with the first above the center as A-1, and the second as A-2. The lower marks are referred to as decelerations D-1 and D-2 respectively. They are drawn with the helicopter parked on level ground by drawing the mark to become A-1 on the horizon line (or its estimated approximate level) with a grease pencil. (See Figure 3a) The center zero is drawn below this mark about one and one-half inches, and the remaining marks filled in at about one and one-half inch spacings. To be exact adjustments should be made in the spacing of these marks to account for the effect of windshield slope. (The lower marks should be more widely spaced than the upper marks to produce equal angular spacings of two and one-half degrees.) The form of the marks is not critical; only numerals were used by Buettner. The horizontal marks shown in photographs in this report were used to attempt to assure they would photograph satisfactorily.

In use the acceleration and deceleration sectors are shifted in reference to the CG hang of the helicopter. With a full load of fuel the UH-1 hovered with the horizon at or just below the zero mark. With the rearward CG shift as fuel burns off the hover reference mark moves back to hover horizon reference at about the D-1 mark. Acceleration and deceleration levels are referenced to wherever the CG hang happens to be during that period of flight. The cue set is arbitrary, therefore, in that it must be imagined to shift with shifts in CG. It does, however, provide specific pitch attitude reference cues that can be mentally adjusted in accord with CG.

Buettner was attempting to use an adjustable plastic slide for cues that could be adjusted to maintain a single reference picture with CG shifts, but could not get a satisfactory easily removable method of attaching it during the USAARL flights. The vertical line of pitch reference cues on the windshield also provides a convenient but crude roll angle reference. It also provides a precise windshield reference for directional control at a hover and during flight that is available to both pilots.

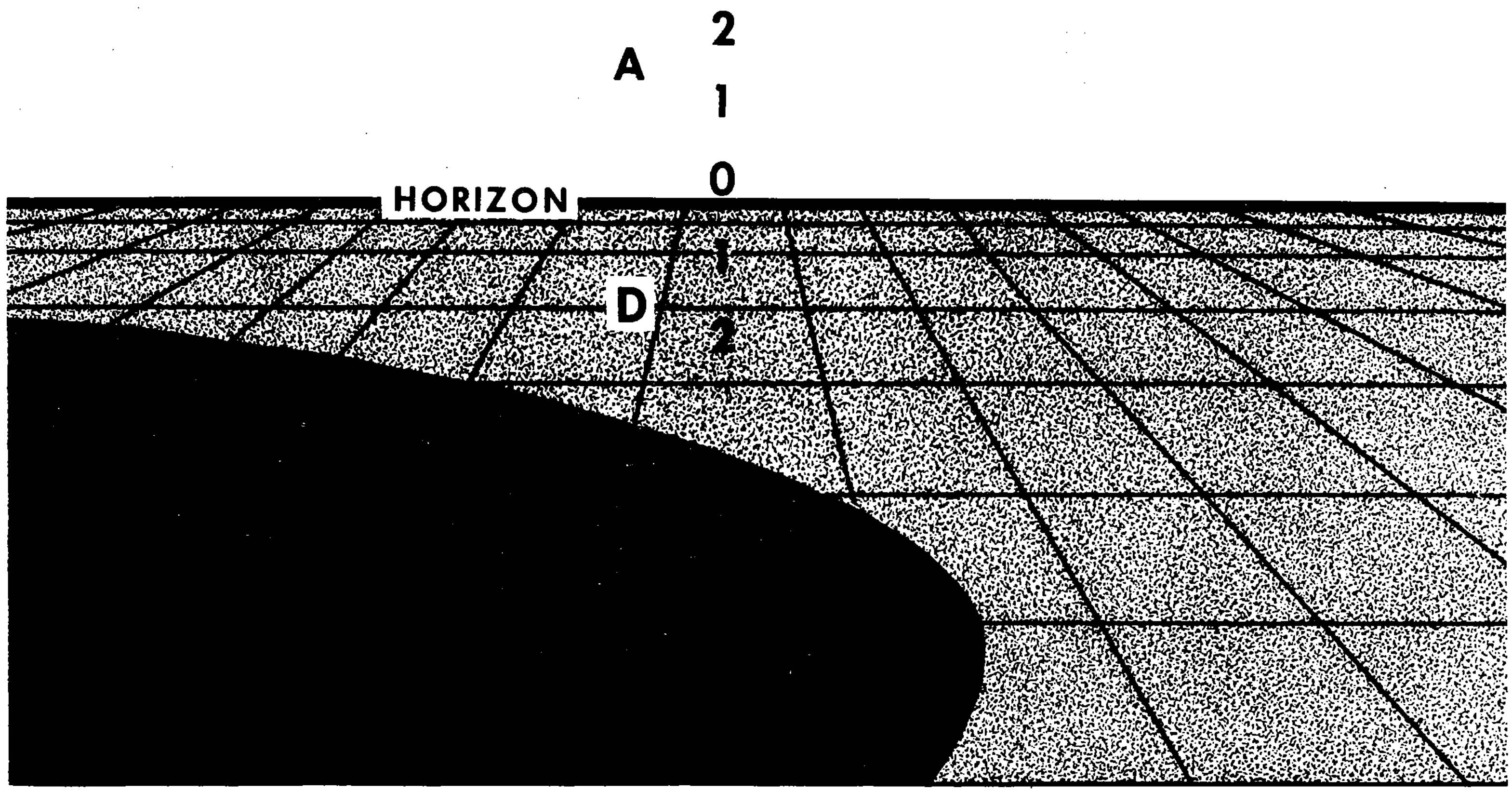


FIGURE 2. SCHEMATIC OF BUETTNER CUEING MARKS PLACED ON WINDSHIELD OF HELICOPTER.

A B C

FIGURE 3. PHOTOGRAPHS OF BUETTNER CUES SHOWING SEQUENCE OF: A. PARKED ON GROUND, B. SKID LIGHT, AND C. HOVER.

It should be noted the cue set on the windshield was aligned directly above the pedals from the normal head position. For non-side drifting flight, therefore, terrain objects behind the cues should move directly between the pedals just before passing.

Contact Attitude Flying. Buettner's primary point of emphasis was that control of a helicopter should be a matter of reason and logic coupled to knowledge of the aerodynamic characteristics of helicopters. With this approach he was convinced that a large part of contact flight training and skill should transfer almost directly to instrument training. The spacing of his contact cue set, at the two and one-half degrees of the one bar width of the artificial horizon instrument, was designed to facilitate instrument attitude flying through development of skill in his contact attitude flying technique.

Attitude and Power. Control of attitude and power was presented as the key to helicopter flight control, with primary emphasis on pitch attitude. Roll and pedal control were de-emphasized as minor nuisance aspects that should be learned and relegated to subconscious attention levels as soon as possible for most maneuvers, except when they neared becoming control limiting factors. Roll and pedals received mention usually as a consideration in trim of one sort or another (i.e., ball centered, drift compensation).

Basically, helicopter control was presented as a matter of pointing the nose in the desired direction of movement, controlling speed by pitch attitude changes, and height or height rate by power (collective pitch).

Synopsis of Use of Buettner Cueing Concept. Figure 4 presents a synopsis of the application of the Buettner windshield cues in flight control. The performance groups into two primary attitudes for normal operations and autorotations: hover/70 knot attitudes, and 90 knot attitudes. Accelerations and decelerations may vary over a wide range, but two units would be the normal maximum range except during landing flares. A one unit deceleration would usually be used for approach until a need for greater deceleration is evident. The amount of correction needed in a normal turn, if any, is about one-half unit, but in the UH-1 Buettner indicated it could not be consistently predicted as to direction, apparently due to slight differences in rigging.

USE OF CUES IN FLIGHT EXERCISES

Editions of TM 1-260 from about 1965 contain some brief material regarding the cueing concept in chapters 3 and 4. If familiarity

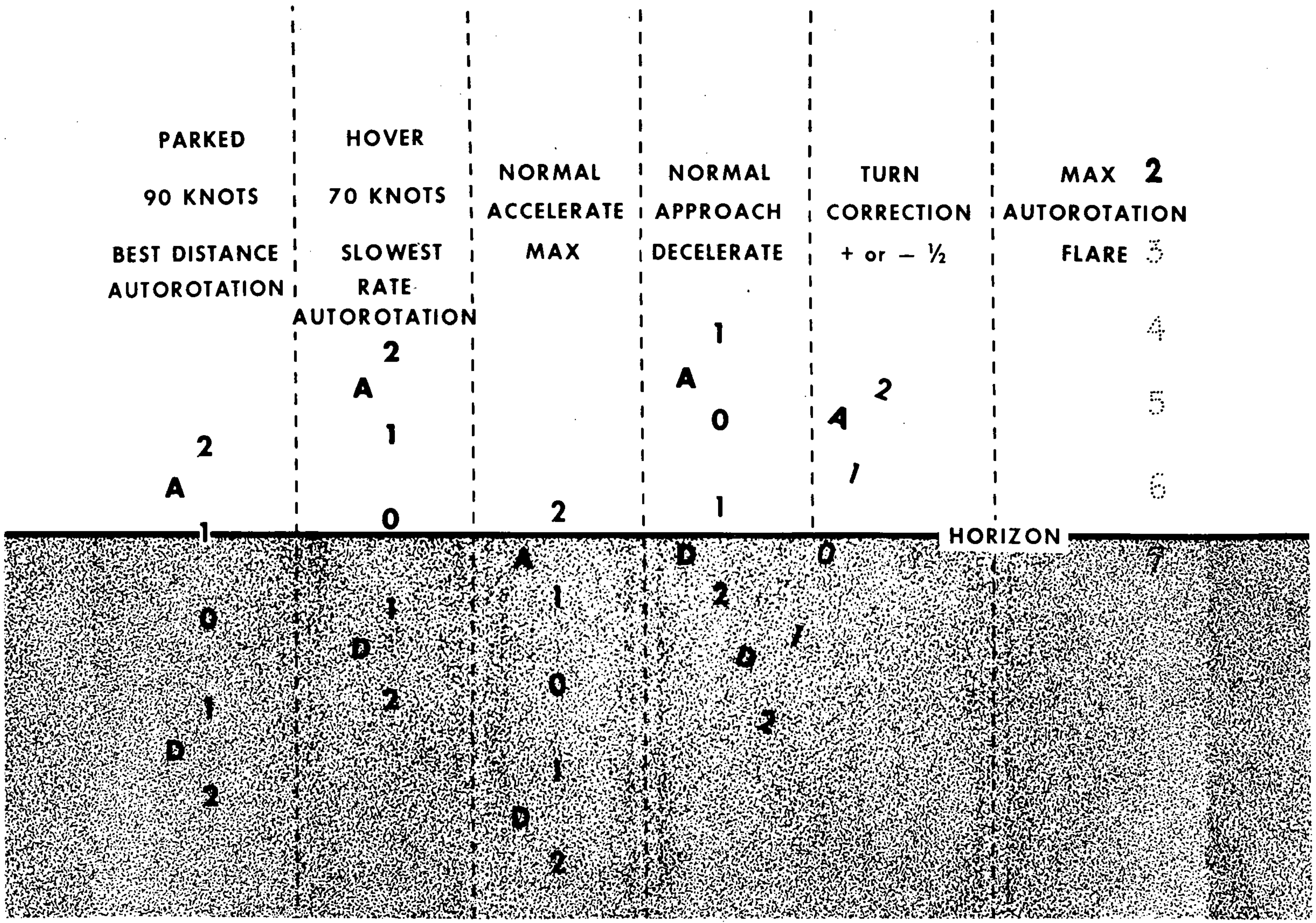


FIGURE 4. SYNOPSIS OF USE OF BUETTNER CUES IN HELICOPTER MANEUVERS.

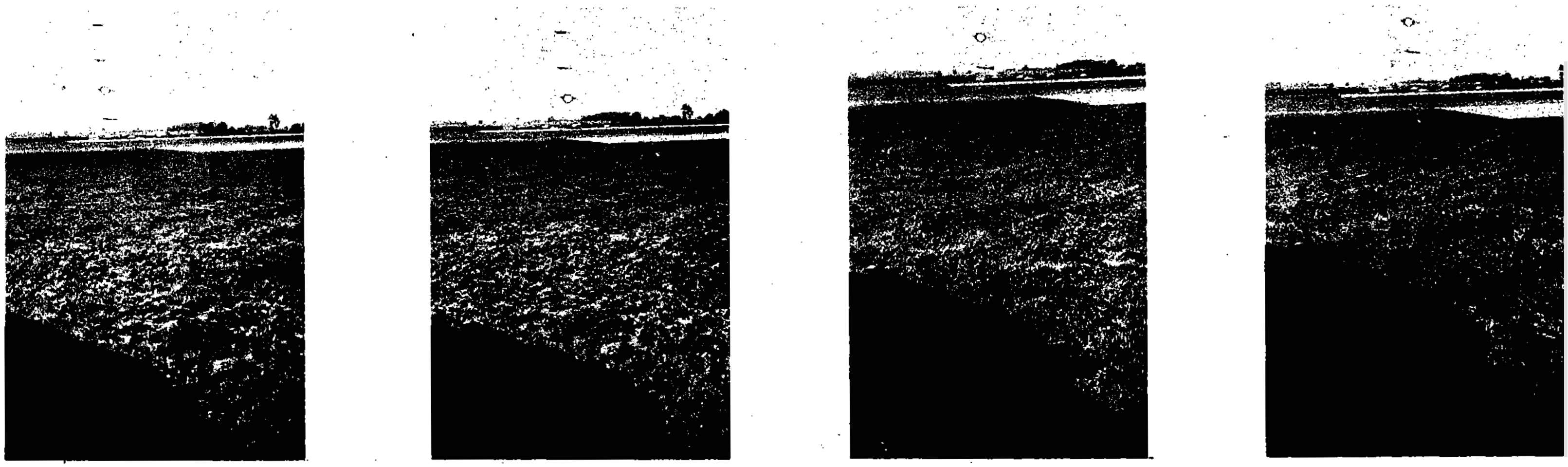
exists with the cueing concept, the description of maneuvers in Chapter 4 generally indicate how the cues would be used in accomplishing each maneuver, although the cue set is not referred to specifically. A copy of TM 1-260, which is no longer published, is filed with the master copy of this report in the USAARL library.

Pedal Control. Use of the cue set is introduced with the student controlling only the antitorque pedals and the instructor controlling the other parameters while in a hover. The cue marks are placed on some distant object, and the student attempts to keep the marks on the object by controlling direction through use of pedals. Although the windshield of the UH-1 is close to the pilot's eye position, there was no difficulty in clearly perceiving both the windshield marks and the distant objects simultaneously. Although one eye was not closed, double image problems were not noted. As holding direction through pedal control began to develop to an acceptable level, basic flight attitudes in pitch were introducted.

Basic Pitch Attitudes. Basic pitch attitudes are introduced using a hover-accelerate-coast-decelerate exercise that is based on precise control of pitch attitude (see Figure 5). The basic attitude while in a hover is noted in terms of the vertical position of the horizon or tree line in regard to the windshield marks. A change in pitch attitude of one-half a cue space from the hover pitch attitude is used to provide a slow acceleration or deceleration, lowering the nose one-half mark to accelerate, raising it one-half mark from the hover reference for deceleration. After accelerating to a brisk walk speed the hover attitude is resumed for a period of coasting prior to decelerating to a hover. Emphasis is placed on the fact the helicopter will coast almost indefinitely at the hover attitude once it is already moving, and that a deceleration attitude must be introduced to slow it down to a stop.

Collective Control. With the instructor on the cyclic, the student was asked to control both collective pitch and pedals, noting the interactions between the two and the control pressures required in one to compensate for movement in the other. Maintaining the windshield marks on an object while using the collective is emphasized, and some abrupt collective movements introducted by the IP to illustrate the time relationships needed.

Accelerate-Coast-Decelerate. With the student attempting to use all of the controls the accelerate-coast-decelerate exercise is performed (see Figure 5) within the limits of available field length and the student's control abilities. The instructor assists on the controls as required to keep the student out of trouble and let him concentrate primarily on pitch attitude and directional control.



A B C D

FIGURE 5. SEQUENCE ILLUSTRATING: A. HOVER, B. ACCELERATING ONE-HALF UNIT, C. COASTING, AND D. DECELERATING ONE-HALF UNIT.

The emphasis is on pitch attitude control, and trying to maintain a stable hover is not pushed. However, as ability to precisely maintain pitch attitude develops, ability to use the other controls seems to also develop without any significant explicit attention.

Short Takeoff and Approach Exercise. As student ability in the accelerate-coast-decelerate exercise develops it can be extended to higher speeds and acceleration/deceleration rates until it shifts into the takeoff and approach regimes. As speed develops at one-half unit acceleration another one-half unit nose-down attitude is added, then another and another to produce a smoothly accelerated takeoff with a final two unit acceleration attitude until 70 knots is reached, where hover/70 attitude is used for climbout. This sequence is illustrated in Figure 6. Once takeoff occurs, however, the climb is stopped at 50 feet and 30-50 knots and a spot for an abbreviated approach selected. At the proper angle a deceleration attitude and collective lowering is initiated to maintain a line of approach to the selected landing spot. With sufficient area available to allow it, this exercise allows practice of a larger number of takeoffs and landings for a given period of time in comparison to a full standard pattern.

Airwork. The 70 knot slow cruise and 90 knot normal cruise attitudes are established and flown using the windshield marks, with hover attitude being used as tentative 70 knot cruise attitude, and an additional unit of acceleration (nose down pitch) being used for 90 knot cruise. These attitudes are illustrated in the last two scenes of Figure 6. Standard turns are suggested as usually requiring up to about one-half unit of cyclic pitch adjustment that is unpredictable from helicopter to helicopter and direction. Pedal use for trim control is stressed during all airwork.

Traffic Pattern. Traffic pattern work stresses using basic attitudes and power settings during takeoff, pattern, and approach. The latter phases of an approach are illustrated in Figure 7. It shows a 70 knot cruise attitude initially followed by a series of D-1 (one unit of deceleration) attitudes up to the touchdown spot where a hover attitude is assumed in the last frame. This sequence should result in a gradual reduction of airspeed throughout the approach deceleration. During the approach the line of descent is controlled with collective on a continual basis as required, keeping track of power. By monitoring power (torque) with regard to flight idle power readings an appreciation of rate of descent can be maintained. At times power may reach or go below flight idle values, an indication the helicopter is actually in an autorotation condition or near it. This was accepted early in the approach, but emphasized as a potentially nonrecoverable situation near the landing spot.

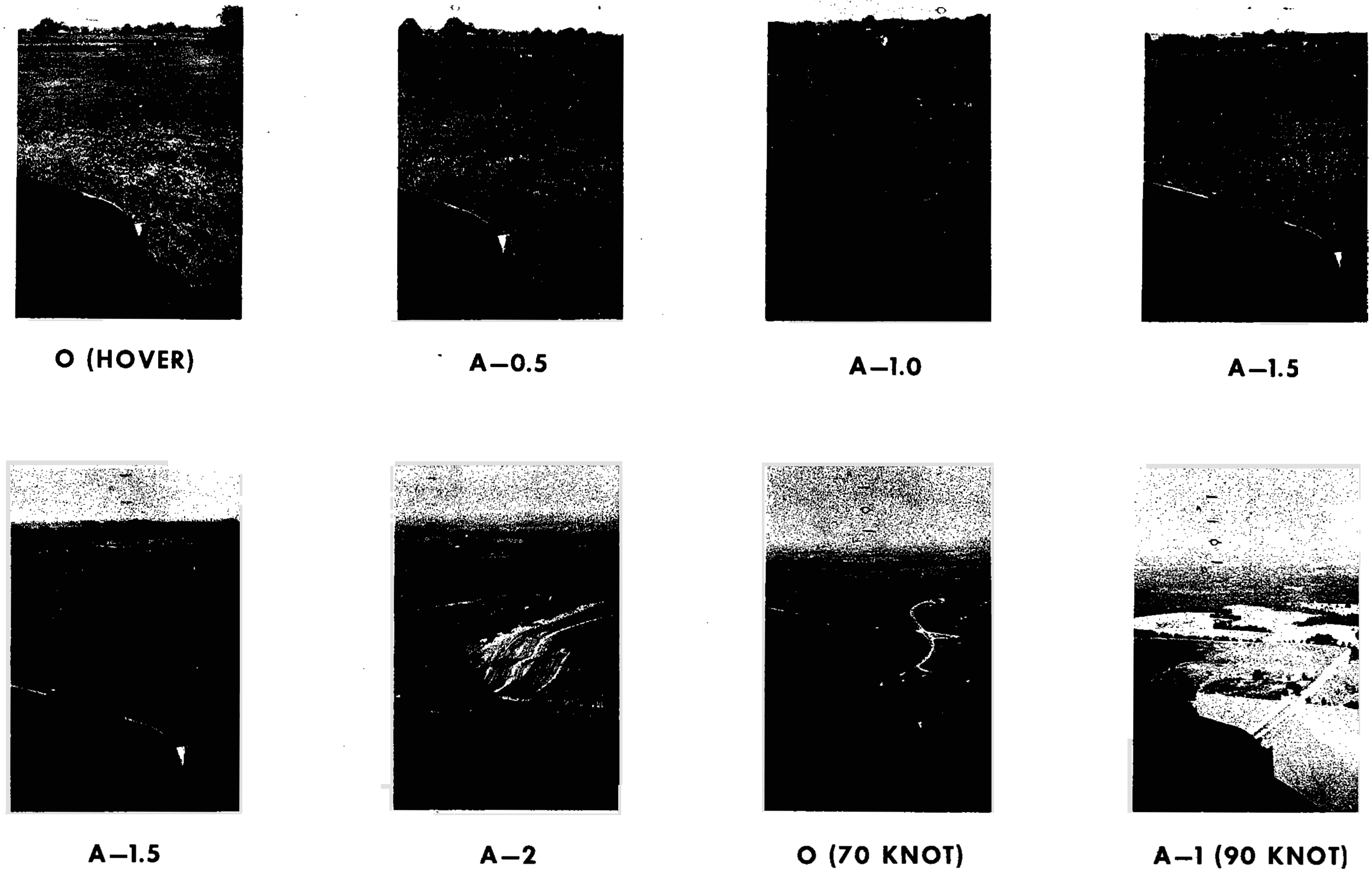


FIGURE 6. SEQUENCE INDICATING ATTITUDES DURING TAKEOFF FROM A HOVER AND CLIMBOUT. VALUES FOLLOWING 'A' UNDER SCENES INDICATE UNITS OF ACCELERATION ON THE BUETTNER PITCH ATTITUDE SCALE ON THE WINDSHIELD.

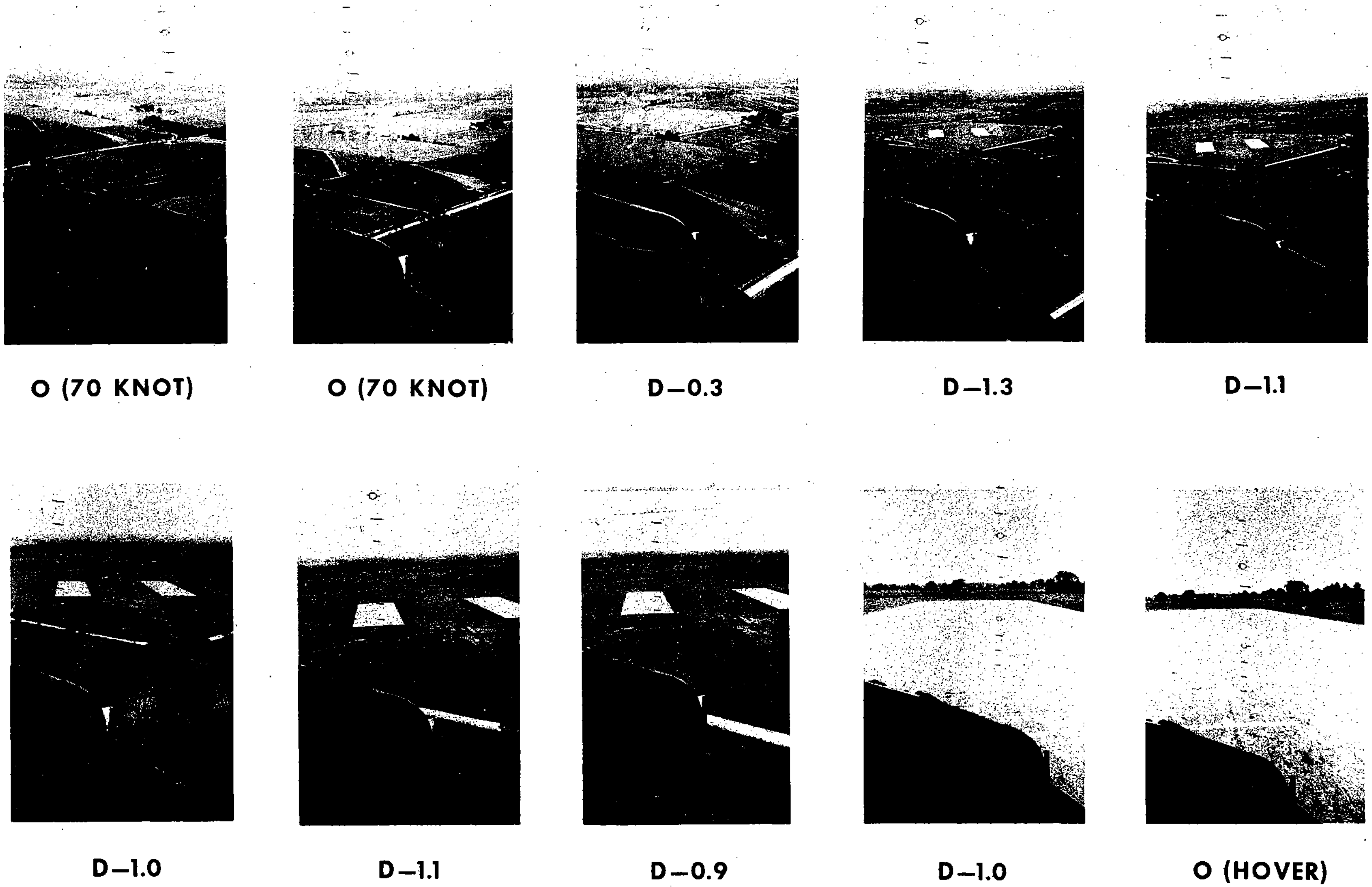


FIGURE 7. SEQUENCE ILLUSTRATING ATTITUDES DURING APPROACH TO A HOVER. VALUES FOLLOWING 'D' UNDER SCENES INDICATE UNITS OF DECELERATION ON THE BUETTNER PITCH ATTITUDE SCALE ON THE WINDSHIELD.

Takeoffs from a hover and cruise attitude are illustrated by the sequence of slides in Figure 6.

Takeoffs to Hover and Landing From a Hover. Takeoff to and landing from a hover were performed using a gradual sequence of power settings along with close monitoring of attitude. The attitude sequence is illustrated in Figure 3, from (a) on the ground, (b) front of skids off ground, (c) to hover attitude. Adding or taking off power in small increments of one-fourth or one-half a percent was given emphasis as a means of providing a smooth and gradual lift off or set down that allows a full cross-check just prior to complete lift off. Noting of power at flight idle and at lift off was used as the basis for cruise and other power reference values.

Autorotations. Autorotations were demonstrated with emphasis on adopting the 70 or 90 knot pitch attitude on entry, RPM control with collective, and the range of pitch attitudes on landing during cyclic flare and collective pull/touchdown, which could reach D-5 to 7 during maximum flare before reducing flare for touchdown.

ASSESSMENT OF BUETTNER CUEING CONCEPT

Flight Training Observations. The set of marks on the windshield used by Buettner, although extremely simple, appear to provide positive cues that can be applied without trial and error in accomplishing most helicopter maneuvers. However, an initial "set up" or CG hang check is required, as well as checks on the direction and amount of cyclic pitch needed in turns. When combined with rubrics for application of power in the various maneuvers, the Buettner cues provide a large amount of control lead that is not available with traditional contact helicopter control techniques. With traditional techniques there is an almost continual sequence of trial and error in which "what is happening now" are the major cues used for control actions. With the Buettner cues, however, an attitude is assumed and held with full confidence as to what the consequences will be 10 or 20 seconds or even a full minute ahead in time. Thus, it satisfies one of the primary criteria for "good" manual control---allowing the pilot to adopt a control transfer function with a large lead term. Small corrections on a short-term basis around the adopted attitude are used, but maneuvers are accomplished in large part by adopting and holding the attitude and power settings that will produce the desired changes in state of the helicopter.

The Buettner cue set, however, is not a complete flight control reference that eliminates the need for other traditional perceptual judgments in helicopter control. It eliminates most of the judgments and trial and error in takeoff, cruising flight, and hover. During approach and autorotations the Buettner cues are used as a major control reference aid, but other perceptual judgments were regarded as essential. Among these were monitoring the "apparent ground speed of a brisk walk" as a cue for initiating final approach descent and for monitoring the proper angle and rates of forward and vertical speed. The manual description is: "Apparent ground speed is that phenomenon experienced by the aviator of a helicopter in a descent at a constant airspeed when he observes an apparent increase of speed as altitude is lost. To maintain a constant apparent ground speed during a descent, the aviator must reduce airspeed as altitude is lost." A second was direct judgment of the proper angle of approach through recognition of the line of intercept or collision, based on object flow patterns on the windshield away from this intercept point. With undershoot the touchdown spot flows upward on the windshield, and downward with overshoot. Positive collective control is used to maintain the touchdown spot without apparent flow, with respect to the eyes during the first third of the descent, with respect to the seat pan during the middle third, and with respect to the skids during the last third of the approach descent. Other suggestions for approach angle cues used by other instructors were considered as less desirable but still probably acceptable. Tracking descent angle with respect to eye position throughout the approach using a vertically off-set touchdown spot could be used, but still would require consideration of skid clearance of barriers. It was regarded by Buettner as having problems, such as in pinnacle type approaches, when the background did not provide structured perceptual cues.

It is the author's assessment that the apparent ground speed perceptual judgment is probably prone to considerable within and between pilot variability. The repeatability error in this judgment during a single approach is uncertain, but would be guessed to be on the order of 10 or 20 percent, and much greater over time and between different pilots.

The zero flow line on the windshield, although probably difficult for students to perceive early in training, was assessed as probably being a sensitive and consistent cue for most pilots once they recognize the phenomenon and develop experience in using it. The use of it, however, does require a period of time of observation to observe the flow, or a memory for a prior pattern. This would suggest that scan dwell times in regard to it may be long if it is directly attended to, which is uncertain.

Prior Students' Interview. Two recent students of Buettner in a course required to be designated as Aviation School instructor pilots were interviewed in regard to the Buettner cueing concept.

They were both very positive regarding the advantages of the cues and Buettner training in significantly improving their contact control precision and awareness of exactly what the status of their helicopter was and was going to be. They both indicated they believed they were at least average and probably better than average pilots for their level of experience of approximately 2000 hours. They did not think they would have learned much in the course that would have improved their actual flying skill if they had not had Buettner as an instructor. They indicated his training had really opened their eyes to how sloppy their previous skill had been in comparison to their high precision attainable with the Buettner cues and techniques. They indicated they believed a student trained with the Buettner cues/ techniques should be a much better helicopter pilot who would be much less prone to get himself into trouble. It was their opinion, not supported by any actual experiences, that a student with Buettner-type contact training should find it much easier to learn instrument flying.

However, these two new instructor pilots indicated they were not using the Buettner cueing technique in training their students in spite of their conviction it should produce a better helicopter pilot. The basis for this appeared to be almost entirely due to peer pressures or fear of ridicule by other instructors. There was some mild concern that a student trained with the Buettner cues might get into trouble if he encountered situations where they could not be used---such as at night or being unable to place the marks on the windshield. It was their opinion, however, that lack of the cueing marks were unlikely to cause a pilot to get into trouble because they just were not that essential. They were regarded as an aid, not an element essential to flight control.

EXTENDED WINDSHIELD MARKS AS AN APPROACH CUE

The photographs shown in this report include an additional set of cues below the Buettner cues that were used to explore their utility as an approach aid. It was noted in the early training demonstrations that the vertical position on the windshield of the touchdown spot remained constant at the initiation and during the first third of the final approach descent. The lower set of marks were an attempt to determine whether they could be used as an approach reference in conjunction with or in lieu of the Buettner cues. It was hoped this would allow the need for use of the less definitive "apparent ground speed" and "intercept point" cues to be minimized or eliminated. It turned out this first "cut" at this approach cue set was not placed or spaced correctly, due to the lack of any systematic analysis at the time when the photographs were taken. Assessment during that flight, and subsequently of the slides taken during it, suggest that such a set of definitive cues for approach should have merit if appropriately placed.

Placement of Approach Cues. The correct placement of these approach cues should be (for a normal approach) about seven degrees visual angle below the Buettner cues from the normal eye position. Their spacing should be adjusted to provide equal visual angle spacing to that between the Buettner cues. Due to the slope of the windshield, their actual spacing will be farther apart than the Buettner cues. The actual visual angles that need to be used for shallow, normal and steep approaches need to be determined objectively, since helicopter pilots tend to overestimate their approach angles by a good margin. The seven degree angle suggested here is below the 8-10 degree range used to describe the normal UH-1 approach, and is only a guess as to the proper angle. It may need to be six or even five degrees, or possibly actually 8 or 9 degrees.

Use of Approach Cues. The approach cues would be used with respect to the touchdown spot in a manner similar to the way the Buettner cues are used with respect to the horizon. The final approach would be flown at pattern altitude, until the touchdown spot on the approach cue set reached the Buettner attitude numbers being held on the horizon (which should be a 70 knot attitude). At this time, a one unit deceleration should be adopted as pitch attitude on both sets of cues. This value should be held on the touchdown spot through pitch attitude cyclic control and collective tracking descent control as required to eliminate non-attitude vertical movement of the touchdown spot from the desired angle.

In practice the above description would have to be modified to include use of a reference point that is vertically above the desired touchdown spot by the skid to eye height. This would result in the actual control reference spot being about ten times skid to eye height beyond the desired touchdown spot (or about 50 feet).

The approach cues and procedures described above would seem to have the potential for substituting clearly defined cues for the more difficult perceptual judgments of apparent ground speed of a brisk walk and intercept point. They would be used with an offset touchdown spot in a manner very analogous to the way the Buettner cues are used with respect to the horizon. No flight assessment has yet been performed, however. Analysis of the slides obtained with Buettner making approaches strongly suggest the approach cues and procedures defined should work, but they have not yet been confirmed.

DISCUSSION

A primary area of interest in the Buettner cueing concept was in regard to its potential for application in night vision display systems. This more detailed exposure to use of the cues has increased the belief they have considerable merit for resolving certain perceptual difficulties in flying by use of night vision systems---both indirect view systems and night vision goggles. Buettner-type cues in night vision system images would not be expected to resolve all of the problems in flight control with these devices, but it is believed they should provide some worthwhile advantages. In particular, it is believed they might eliminate or reduce the tendency to drift rearward and up when attempting to hover with night vision devices.

The second approach cue set would seem to be of value in assisting in approach and landing with night vision devices in that it provides a single definitive cue for the traditional perceptual discriminations or judgments that seem to be quite difficult with these devices. The location of the imaging device on the helicopter would seem to be a consideration, however, in assuring clearance of barriers in the approach and in routine nap-of-the-earth flight. A roof/mast mounted imaging device, although highly desirable for target acquisition, would seem likely to introduce unacceptable barrier/obstacle clearance judgment errors if used for flight control, due to parallax. An underslung sensor would seem to be preferable from a flight control standpoint. With such an image source and the suggested approach cues, skid obstacle clearance should be evident without any need for perceptual/mental translations in regard to object or sensor offsets. The simplicity of Buettner-type cues should be an advantage in mechanization and keeping image clutter to a minimum.

In the area of simulation, the use of Buettner-type cues would seem to have potential for very simplified visual displays that could provide worthwhile training if properly exploited. Most of the potential here would seem to be in initial or transition training, although some potential for advanced skills may also exist.

A more complete objective assessment of the potential of the Buettner cueing concept in student pilot training would seem highly desirable, although the problem of negative reaction to the concept by instructors would have to be circumvented.

It is fairly evident that Buettner received some degree of peer pressure and ridicule because of his unorthodox training techniques. He generally ignored it and proceeded because he was convinced his techniques produced a better helicopter pilot, and because he consistently received reinforcing feedback from his students of the advantages his techniques provided them in advanced training. Although some of the peer pressure he received was of the good-natured type to be expected by anyone in a group who does things differently, the negative reactions of other instructors seemed to run much deeper than this. In addition to the normal negative reaction to anything different that isn't understood, many instructors apparently felt the windshield marks were "cheating" or "crutches" that were beneath the dignity of real helicopter pilots. In part this may have been a valid basis of concern over any aid used in training that may not be available consistently during operational flying. In part it may have been due to a hazing mentality that has always existed to a degree among most flight instructors. They got their training the hard way, and could be anticipated to resist most things that make it easier to get through training---particularly if they were not involved in developing it. The fact the Buettner instruction techniques do not fit in with normal utilization of stage fields early in training is an additional complication that can hinder application and assessment of the Buettner cues and training techniques.

It should be noted that, although the Buettner techniques are different from typical school-type training, subsequent discussion has indicated they generally conform with the emphasis used in test pilot training. Considering the more detailed maneuver analysis and proficiency expected of test pilots, this conformance lends support to the Buettner cues and techniques as a logically sound approach to helicopter flight control and training.

Of major interest would be whether the Buettner windshield cues and flying techniques actually provide the strong positive transfer to instrument flying that would logically be expected. The direct analogy of Buettner's contact attitude control techniques with those used for instrument flying provide logical support for the informal observations of his students that this is the case. If this is in fact the situation, a variety of training programs could be developed emphasizing either or both flight and synthetic training to reduce helicopter pilot training time and costs, or to improve the quality of the pilot produced.

CONCLUSIONS

Although this effort was strictly exploratory in nature, a number of conclusions nevertheless seem warranted.

1. Buettner-type cue sets appear to have potential for reducing some of the perceptual ambiguities that characterize using night vision devices for helicopter control.

2. Buettner cues increase the precision and control lead in contact control of a helicopter.

3. Contact training with Buettner cue techniques should provide a high level of positive transfer to instrument training.

4. A Buettner-like approach cue appears to have potential, particularly in regard to an underslung night vision aid.

5. Exploitation of Buettner-type cues appears to have potential for very simple visual displays for helicopter simulators having considerable training value for initial or transition training.

REFERENCES

1. TM 1-260, Rotary Wing Flight, Headquarters, Department of the Army, Washington, D. C., 6 January 1969, with changes through No. 4, 19 March 1973.