KAMAN

Rotor Tips

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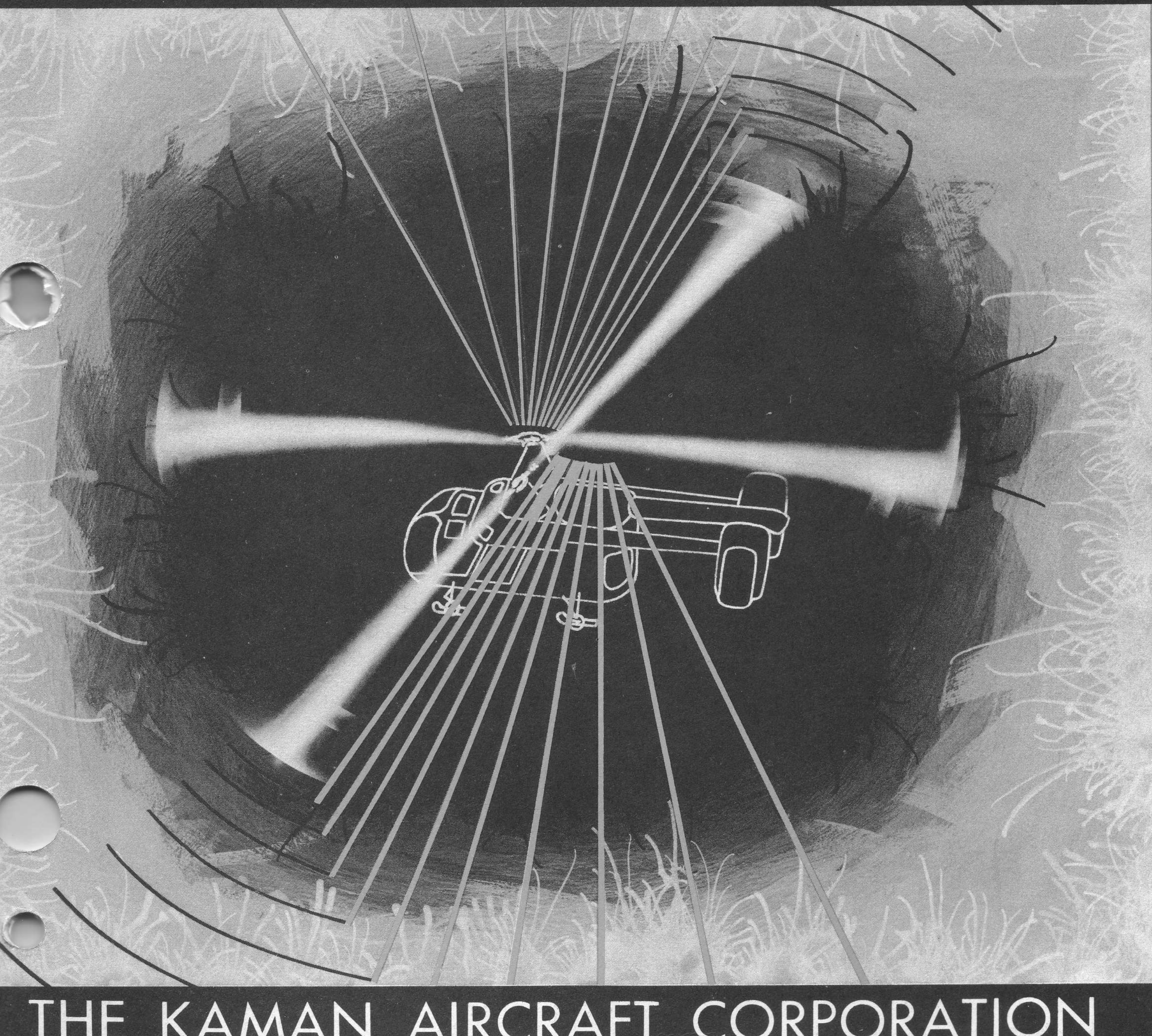

THE KAMAN AIRCRAFT CORPORATION

PIONEERS IN TURBINE POWERED HELICOPTERS

KAMAN

Kaman Rotor Tips

OCTOBER, 1960

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IN THIS ISSUE

NEXT MONTH: **RELIABILITY**

THE COVER

Artist's impression of unique design formed by rapidly whirling, twin rotors on the H-43B. This synchropter configuration is also found on the H-43A, HOK-1 and HUK-1.

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SYNCHROPTER

by E. J. POLASKI
Asst. Supervisor
Service Engineering Section

Much has been printed regarding the synchropter—the term used to describe the twin-rotor design found in all Kaman helicopters currently being used by the U.S. Air Force, Navy and Marines—but most of this material has dealt with performance, advantages, unique design and so on. This article is primarily concerned with information which will be of interest to mechanics, the men who rig and maintain the aircraft. Included is an explanation as to what actually takes place within the flight control system mechanically when rudder pedal, cyclic or collective control is applied.

Briefly, for those not familiar with the synchropter design, it consists of two, 2-bladed rotors mounted side-by-side on separate pylons and phased 90 degrees to one another. As viewed from the top, the rotors are counter-rotating with the right rotor turning clockwise and the left rotor turning counter-clockwise. Both rotors are mounted on individual shafts (splined on the H-43B and bolted on the H-43A, HOK-1 and HUK-1) and are driven by a common transmission. No tail rotor is required on the helicopter because the counter-rotating rotors nulify rotor torque reactions. Conventional fins, rudders (H-43B only) and an elevator are included as an empennage assembly for directional stability. The semi-rigid rotor heads incorporate individual lead-lag hinges and a common flapping or "teeter" hinge. This teeter hinge serves the function of equalizing the lift on the upwind, or high airflow velocity, side of the rotor disc to that on the downwind, or low airflow velocity, side. This is common in all rotary-wing aircraft. The teeter hinge axis is not perpendicular to the spanwise axis of the blades, but is offset 60 degrees. This introduces a reduction in the angle of incidence as the blade teeters up, and an increase as it teeters down, thus reducing the amount of flapping necessary for equalization of lift.

One of the most unique features of the rotor system is the "servo flap", a small airfoil located about three quarters of the distance from hub to tip on the trailing edge of each rotor blade. These flaps are controlled by the pilot through push-pull control rods and function as an aileron tab does on a fixed-wing aircraft. When the trailing edge of the flap is moved upward, the blade reaction is—trailing edge downward. This increases

rotor pitch or lift in the same manner as the aileron on a fixed-wing aircraft causes it to bank. Thus the helicopter pilot can cause the angle of attack of the flap to increase or decrease in pitch, causing the blade to alternately dive or climb.

The servo flap, as the name implies, does the work of more complicated servo units used in other helicopters. The forces felt by the pilot are only those transmitted by the flap and are so light as to be negligible.

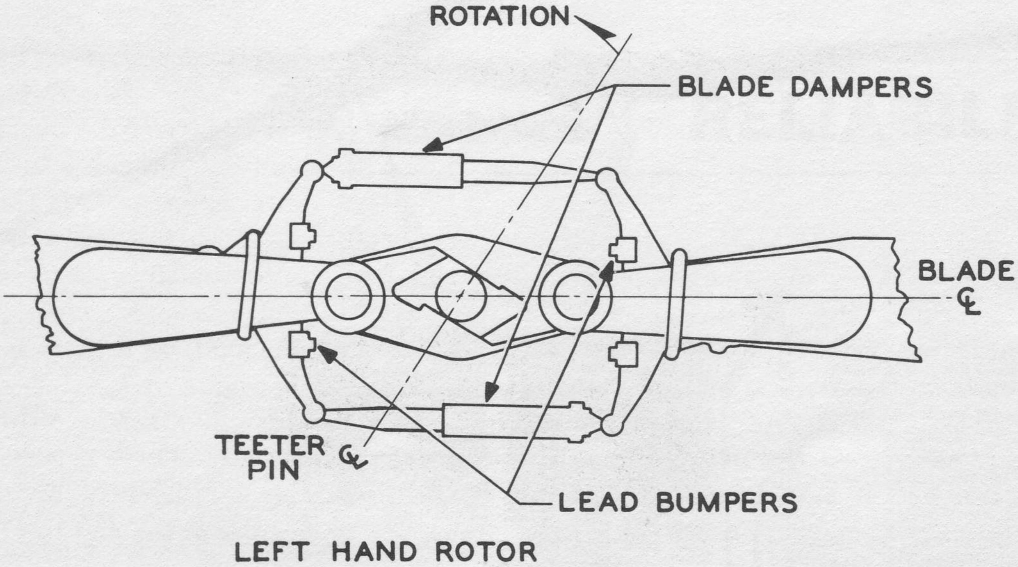
Another feature of the synchropter rotor system is the absence of pitch change bearings. The blades, made primarily of wood, are fixed in metal grips to the hubs. The flaps, reacting with the blades' trailing edges, actually twists the blades against their own torsional stiffness. This stiffness is called "spring constant." The amount of stiffness or spring constant is designed into the blades and held to close tolerances, otherwise, if the amount of stiffness was not controlled, the resulting more limber blade would react much more quickly than the stiffer blade, causing a noticeable out-of-track condition. One other feature of the rotor system is blade folding. The blades can be folded about the lead and lag hinge, positioning them parallel to and on either side of the fore-and-aft centerline of the aircraft. To do this, lead stops on one rotor and lag stops on the opposite rotor can be folded to allow greater blade movement. Once the blades are in the folded position, a hook-shaped lock is positioned by hand and engages the blade grip, thus securing the blades in a folded position.

Other unique components of the synchropter are the "reverser" and the differential cyclic shifter (DCS). No attempt will be made at this time to analyze their functions as they will be covered in detail in subsequent paragraphs.

The above completes the description of the synchropter. Before venturing into the basic control systems, it should be mentioned that, although Kaman Aircraft has entered into the field of single rotors for the Navy's HU2K-1, the intermeshing rotor design is by no means being abandoned. As Charles H. Kaman, company president, pointed out in an article for Aviation Week, "We believe that each rotor configuration has particular advantages, and that it is our job as designers and manufacturers to chose the rotor arrangement best suited to the requirements."

The synchropter has proven many times the particular advantages of its twin-rotor design.

Vertical ascent and all other flight maneuvers of the synchropter are accomplished by shifting the lift/drag resultant of the rotor plane. This, in turn, is brought about by three primary control systems: collective, cyclic and directional. Included under the directional system are differential cyclic (fore-and-aft), differential collective, and the directional stabilization system (DSS). The latter is found only in the H-43B.



LEFT HAND ROTOR

COLLECTIVE SYSTEM— The primary components involved in this system are the collective sticks, throttle and push-pull control rods connected to the servo flaps through the azimuth assembly. As in any other helicopter, the prime function of this system is to control vertical ascent and decent. Raising the collective lever causes the servo flap trailing edge on each rotor blade to move upward, inducing more positive pitch in all four blades, collectively and equally, (see figure 1). This increases lift and causes the helicopter to rise. Conversely, lowering the collective lever decreases lift causing the helicopter to descend. The engine power is synchronized automatically with these pitch changes to hold the rotor rpm constant.

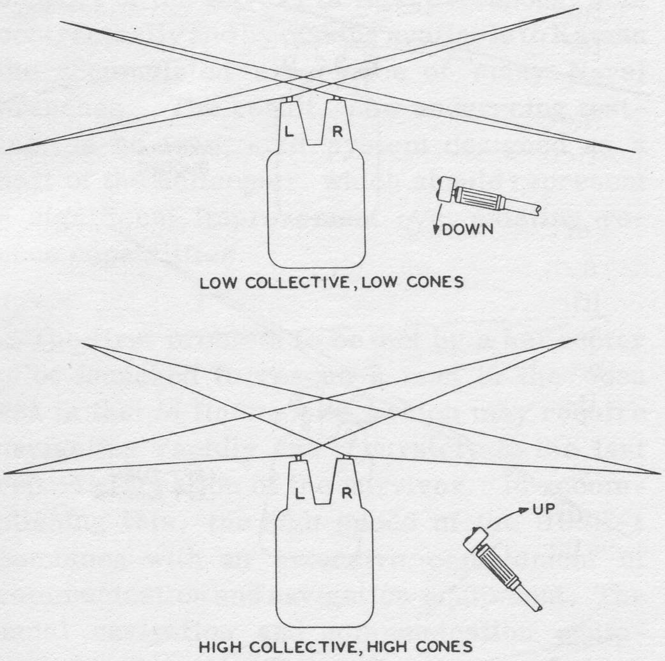


FIG. I COLLECTIVE SYSTEM

CYCLIC SYSTEM— Major components of the cyclic system are the cyclic control sticks and push-pull rods connected through the azimuth assembly to the servo flaps. Movement of the cyclic stick in a given direction, causes both rotors to tilt and fly the helicopter in the same direction and at a speed relative to the amount of stick movement. When the cyclic stick is moved forward, both left-hand and right-hand rotors tilt forward equally, (see figure 2); the same is true of aft cyclic stick movement.

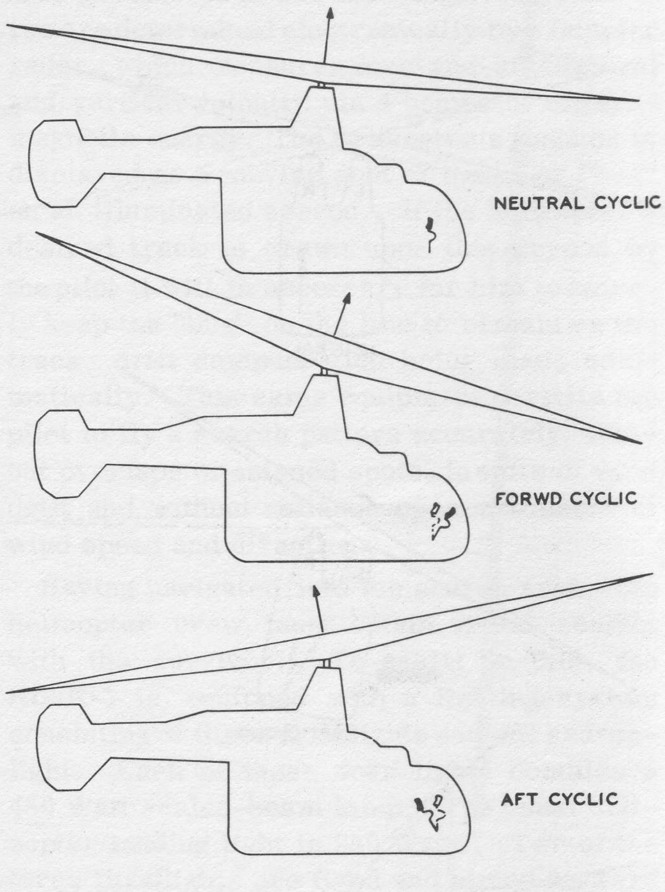


FIG.2 FORE AND AFT CYCLIC

Application of lateral cyclic stick DOES NOT result in both rotors tilting sideways, (laterally) the same amount as in fore-and-aft movement. Moving the cyclic stick to the left will cause the left rotor to tilt in proportion to the amount of the left control input but the right rotor will follow this movement of the cyclic stick up to a maximum of six per cent of the full control travel, (see figure 3). It is then brought to a stop for, if it were allowed to continue further, the blades would strike the opposite hub. Moving the cyclic stick to the right causes a similar reaction. The right rotor tilts in proportion to the amount of control input and the left rotor follows this movement up to the maximum of six per cent of the full control travel. This limiting action is automatically controlled by the cam azimuth in the H-43A, H-43B and HUK-1. In the HOK-1 mechanical stops are provided that are adjustable when each new azimuth assembly is installed.

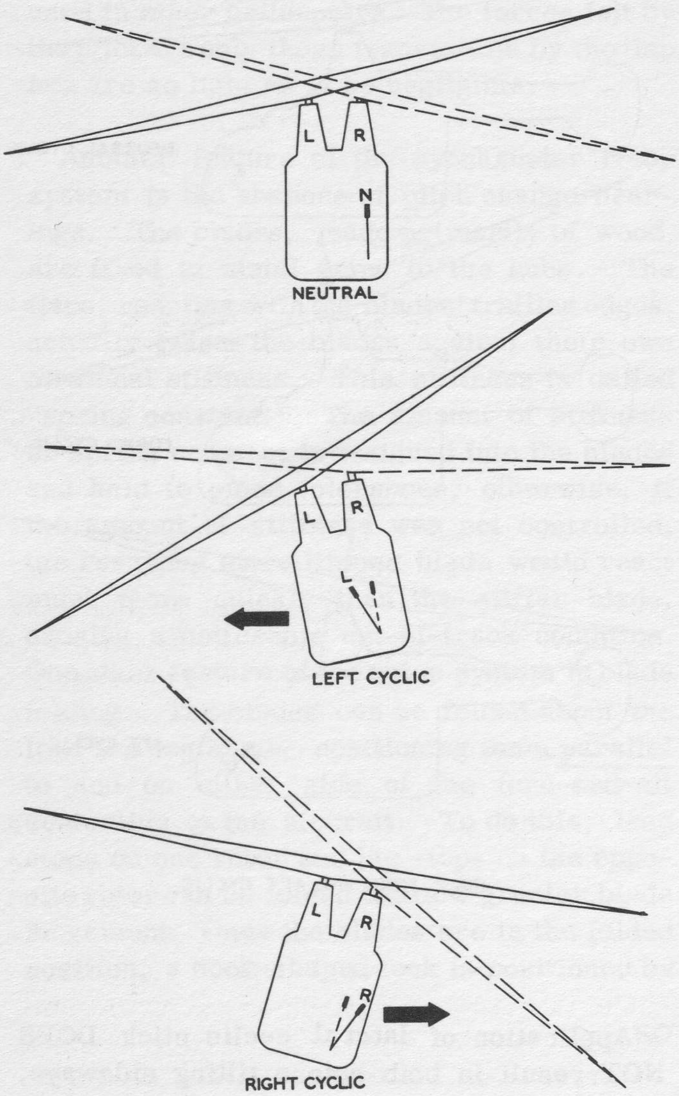


FIG. 3 LATERAL CYCLIC LOOKING FORWARD

DIRECTIONAL CONTROL SYSTEM, "POWER-ON"— Up to now, the synchropter rotors reacted in much the same manner as any other helicopter. However, in the directional system the similarity ends. Due to the counter-rotating rotors, as explained in previous paragraphs, rotor torque is nulified. It is important to keep in mind that this is true only if both rotors are equally adjusted relative to pitch or lift. So far in our discussion, we know how to fly vertically and in any given direction. To make turns, directional pedals are linked mechanically to the basic collective and fore-aft cyclic systems. Turning of the synchropter is brought about by intentionally changing the relationship between the rotors with application of the pedals.

When the pilot applies rudder pedal, both differential collective and differential cyclic are induced into the rotors. For example, when right rudder pedal is applied, the left rotor increases in pitch and the right rotor decreases in pitch (see figure 4). This action

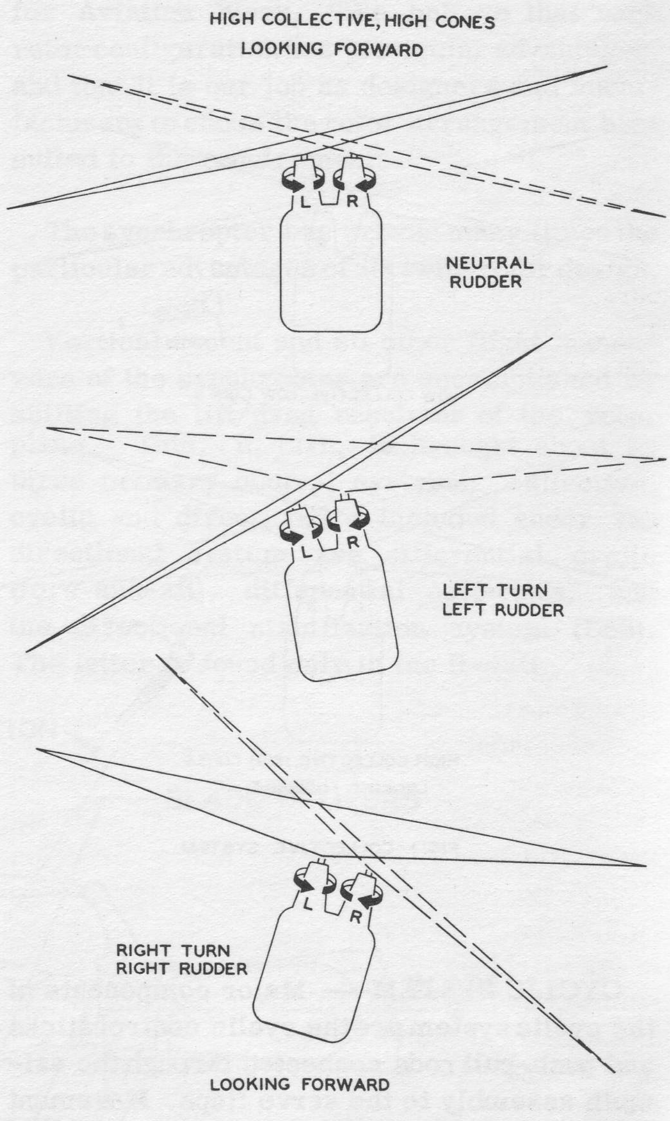


FIG. 4 DIFFERENTIAL COLLECTIVE, POWER ON

continued on page 14

ADVANCED WATER RESCUE CONCEPTS

by G. HACKENBERGER
Chief, Equipment Section
C. B. PACKARD
Asst. Project Engineer

Any man who goes to sea must at least consider the possibility that sooner or later he will find himself in the sea. If this occasion arises his survival will depend upon two factors; his training and ability to meet this emergency, and upon the capabilities, human and mechanical, which can be brought to bear to rescue him. Since a prime mission of Kaman Aircraft's new HU2K-1 helicopter is rescue, the opportunity for providing improved methods of performing open-sea pickups has been given careful consideration throughout its development. This effort has had the continuous support of the Bureau of Naval Weapons, both contractually and by making available to Kaman the accumulated experience of many Naval branches. The result, now undergoing testing, is an integrated system designed as a part of the helicopter, which should represent a significant improvement over existing rescue capabilities.

The first problem to be met by a helicopter pilot launched to rescue a man in the open sea is that of finding him, which may require navigating rapidly and accurately to the last reported location of the survivor. In accomplishing this, the high speed of the HU2K-1 combines with an extensive complement of communication and navigation equipment. The usual navigation and communication equipments, such as UHF voice communication radio, TACAN navigation equipment, and both low frequency and UHF automatic direction finders are installed in the HU2K-1. It is also equipped with two-way voice radio operating in the MHF marine bands, for reliable communication from low altitudes over the water and with an automatic dead-reckoning navigation system for continuous determination of position independent of outside radio information. The heart of this system is the navigation computer, into which are fed the helicopter's magnetic heading, true airspeed, true ground speed and drift angle. The latter two are determined electronically by a Doppler radar, which measures fore-and-aft, lateral and vertical velocity via 4 beams of electromagnetic energy. The helicopter's position is displayed as a moving spot of light, or "bug" on an illuminated screen. If the helicopter's desired track is drawn upon this screen by the pilot it will be necessary for him to merely keep the "bug" on the line to remain on the track, drift compensation being made automatically. This same equipment permits the pilot to fly a search pattern accurately, without overlaps or missed spots, in spite of wind drift and without reliance upon estimates of wind speed and direction.

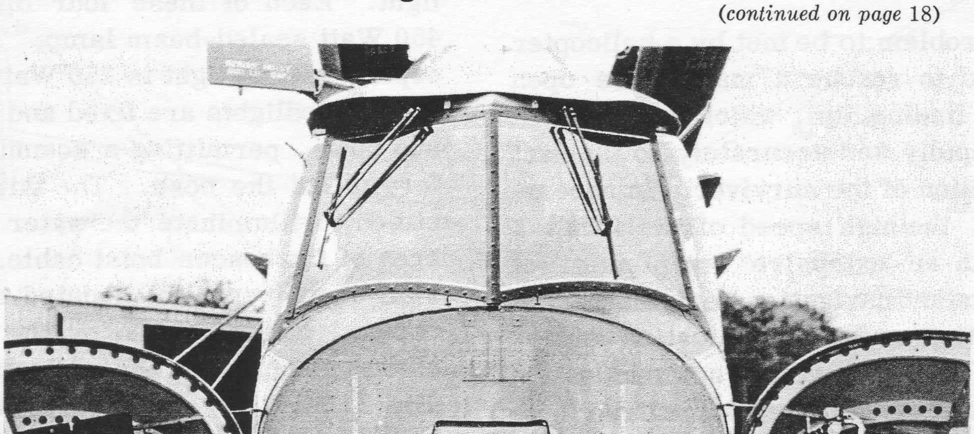
Having navigated into the search area, the helicopter crew must obtain visual contact with the survivor. To assist in this, the HU2K-1 is equipped with a lighting system consisting of three floodlights and one searchlight. Each of these four lights contains a 450 Watt sealed-beam lamp. The usual helicopter landing light is 250 Watts. Two of the three floodlights are fixed and aimed forward and down, permitting a scanning of the area forward of the nose. The third is fixed and aimed to illuminate the water surface in the area of the rescue hoist cable. The searchlight is universally mounted under the helicopter, and is aimed by the pilot using an electric control on the collective stick grip. The HU2K-1 is designed to accommodate a new, high power 2.5 KW searchlight pod presently being developed under Navy sponsorship. When available, this light can be mounted from bomb shackles on the left hand side of the helicopter, and will provide a controllable beam for search extending to distances of one half mile.

Considerable extra attention has been paid to the rescue hoist installation. The hoist is hydraulic, and is carried on the end of a retractable boom which stows within a nacelle until ready for use. In addition to preserving aerodynamic cleanliness, this internal stowage protects the hoist from environmental hazards, increasing reliability. The hoist is provided with 100 feet of stainless steel non-twisting cable, and fitted with a cable-cutter under control of the pilot, actuated by a button on the pilot cyclic stick grip. The hoist can lift 600 lbs. at 100 feet per minute, and may be fitted with a variable-speed attachment so that speed of hoisting can be gradually and continuously varied by the crewman. The hoist hook has also been studied, and a hook will be available preserving the advantages of instant one-hand loading, but which cannot be tripped open by movement of the load, which has occurred occasionally with present hooks.

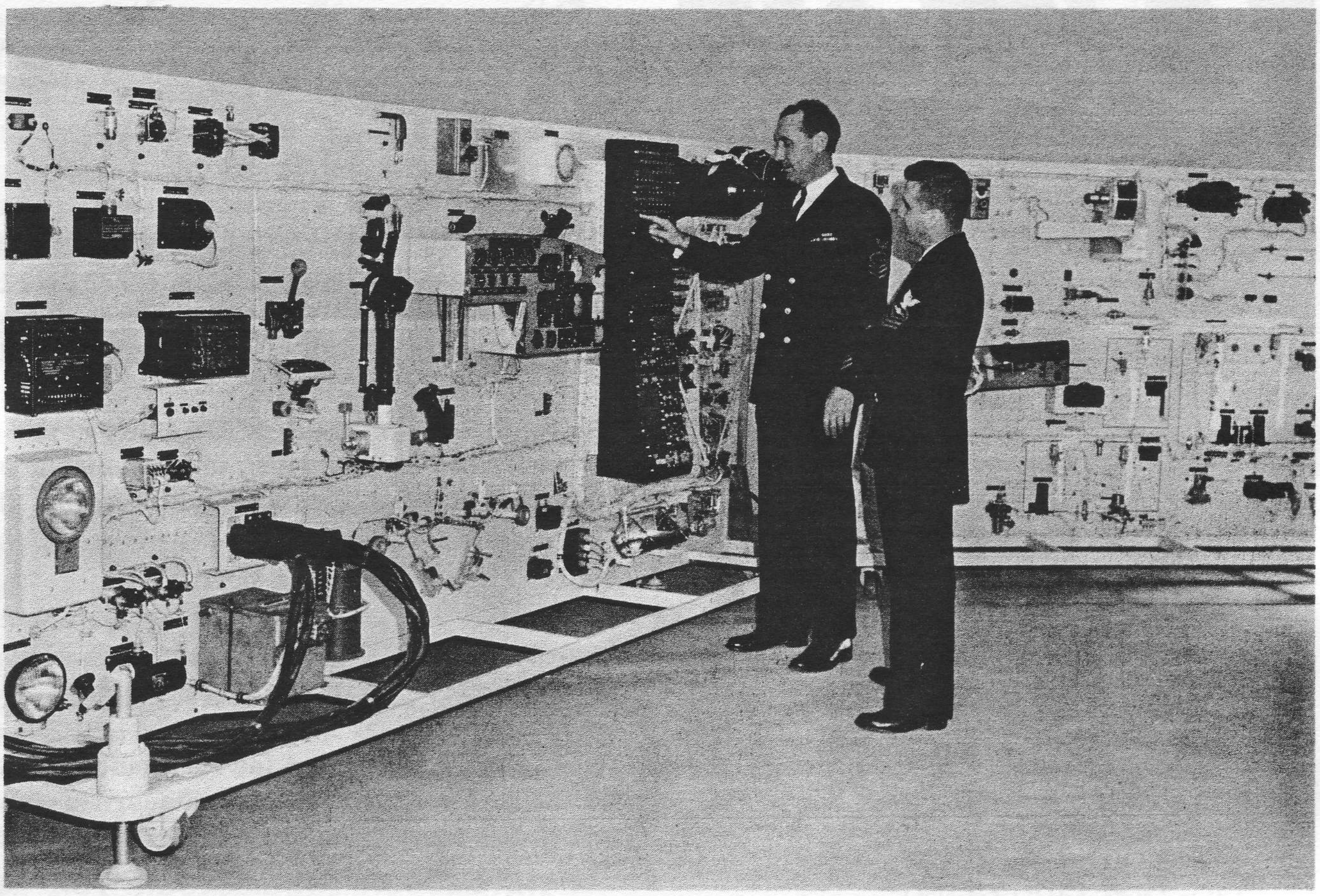
To assist the pilot in making let-downs, and in hovering, safely and with confidence, in all kinds of weather, the HU2K-1 is equipped with Kaman-designed Automatic Stabilizing Equipment which largely relieves the pilot of the strain of maintaining the let-down path and subsequent hover. Although the pilot continues to fly the helicopter through his normal flight controls, the stabilizing equipment virtually takes over the task of maintaining the attitude and speed or hover the pilot has selected. It also maintains a desired altitude, either in forward flight or hover. This altitude-holding feature is always operative, and acts whenever the pilot releases pressure on the collective stick, after it has been properly trimmed, to maintain the altitude existing when the stick was released. In addition, the pilot is provided with a true ground speed instrument which indicates when a true hover, relative to the sea surface, has been achieved. The response of this cross-pointer instrument to helicopter motions, and the electronically-derived rate-of-climb data also displayed on it are expected to make instrument-hovering quite feasible. Coupling of these electronic data into the ASE permit a virtual hands-off hover at any altitude over any point, regardless of winds, turbulence, or visibility.

Perhaps the most significant single feature in improvement of rescue capability of the HU2K-1 will be afforded by a guide boom for the hoist cable. Present helicopter rescue techniques present the pilot with a formidable task; he must fly the helicopter, maintaining horizon contact by looking out forward, and at the same time maneuver so as to position the rescue device (usually a seat or net) ad-

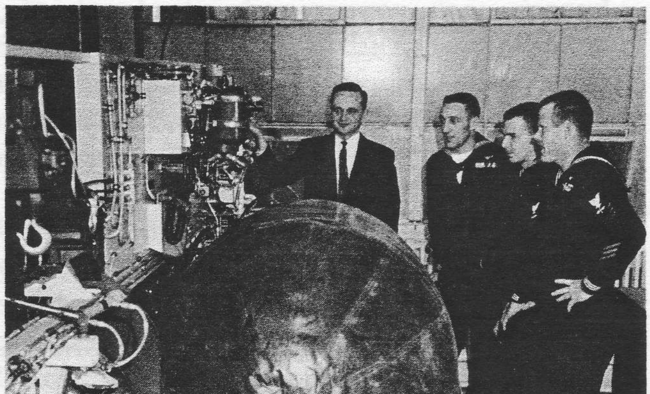
(continued on page 18)



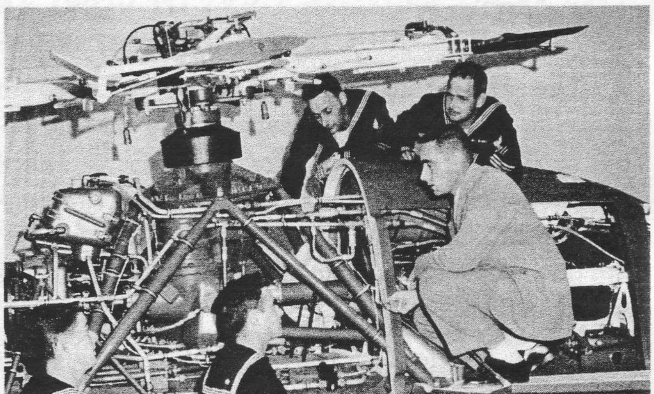
NAVIGATIONAL AND COMMUNICATIONS EQUIPMENT located behind HU2K-1's clam shell doors will aid in accomplishing high-speed, long-range search and rescue missions.



FAMILIARIZATION—Verle F. Knight, AEC; left, and Robert E. Mikesell, AEC; examine controls on 18-foot long HU2K-1 electrical training panel. The two chiefs are among the 13 mechanics and electricians from the Naval Air Test Center, NAS Patuxent River, Maryland, currently attending a factory training course at Kaman Aircraft on HU2K-1. Three other Navy groups will also participate during the next six months.



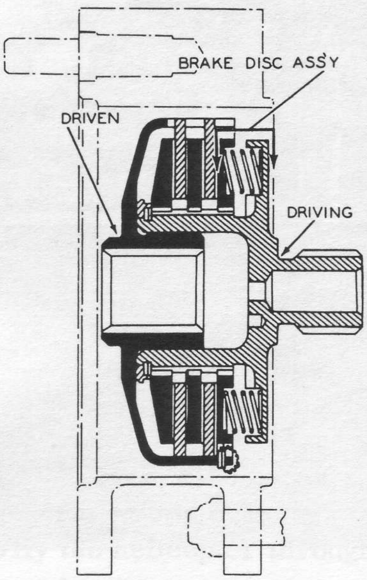
KING-SIZE—Flotation gear on HU2K-1 hydraulic training panel is inflated by KAC Instructor Homer Helm. Watching are, left to right, Donald E. Felix, AD1; Edward J. Dachtler, AD2; and Robert H. Hagler, AD1. The helicopter's entire hydraulic system and components are mounted on the training panel.



INTENT—Aviation machinists from the Naval Air Test Center are checked out on the full scale, 20-foot-long HU2K-1 training panel by KAC Instructor Raymond Vokes. Left to right are John R. Biagini, ADR3; Harry Stein, ADRAN; Kenneth L. Adams, AD2; and William R. Mullis, AD2.

Q's AND A's

If you have a question regarding Kaman Aircraft maintenance, send it along to Rotor Tips. The Service Department's analysts will be glad to answer it.

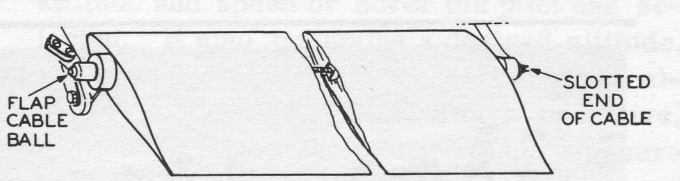


Q. WHAT IS THE PURPOSE FOR THE SLIP CLUTCH USED ON THE DC GENERATOR MOUNTING PAD OF THE H-43A AIRCRAFT? (Applies H-43A)

A. The slip clutch is designed to prevent shearing the generator shaft during acceleration or de-celeration of the engine. A large amount of energy is required to start the generator into motion, conversly, due to its' inertia momentum it will not slow down as quickly as the engine.

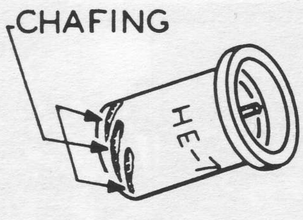
Torque range for the slip clutch is given as 400-600 inch pounds; slip values above or below these ranges is cause for rejection.

To check the slip clutch (1) remove the generator; (2) using a piece of square hex stock to fit in the spline of the clutch, and a standard 3/8 inch drive torque wrench at the other end of the adapter, read the torque to determine its value. Another method is to use an old generator shaft ground square on one end to fit an adapter for the 3/8 inch drive torque wrench. — C. W. J.



Q. WHAT CAN BE ONE CAUSE FOR THE ROTOR BLADES TO BE INTERMITTENTLY OUT OF TRACK IN FLIGHT? (Applies HOK-1, HUK-1, H-43A, H-43B)

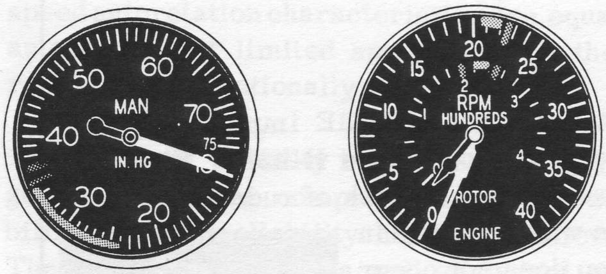
A. A binding flap cable at the inboard end of the servo flap is one cause of intermittent out of track. If a flap cable is found binding, the first thing to do is to twist the outboard slotted end of the cable with a screw driver. If a reasonable amount of turning force does not free the cable, remove the outboard nut and tap the cable gently with a plastic mallet which should free it. A more permanent solution to the problem is to lap the flap cable socket. This can be done by using a discarded cable and ball assembly and some double 'o' grit. Then clean the ball and cable shank and wipe on a coat of light oil before re-installing. — C. J. N.



IGNITOR PLUG

Q. WHAT IS A PRIME CAUSE FOR IGNITOR PLUG FAILURE? (Applies H-43B)

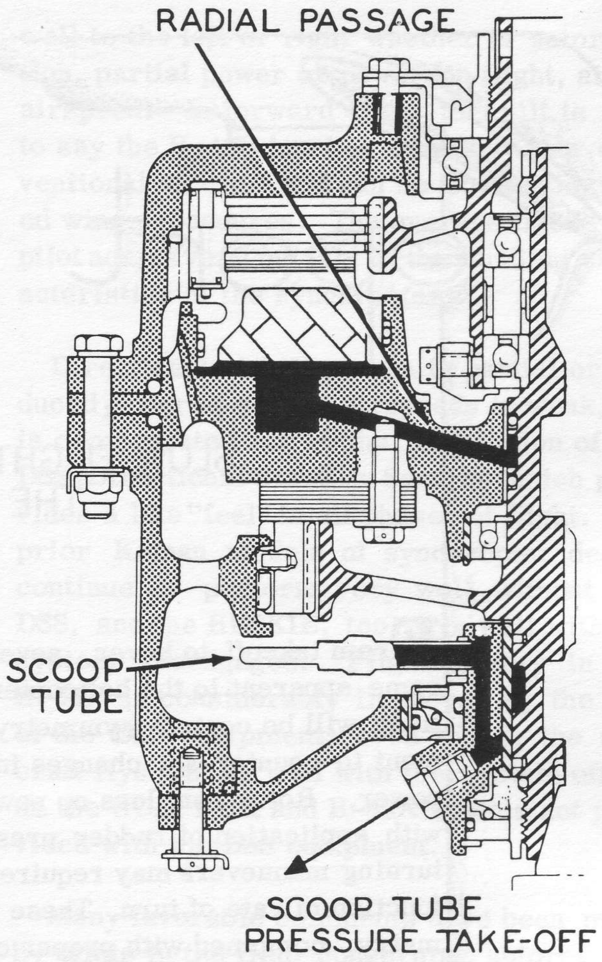
A. Ignitor plug malfunctioning has been caused by constant chafing and rubbing between the ignitor plug and the combustion chamber liner. The openings in the liner for the ignitor plug will vary and shift with heat and vibration. This results in contact between the ignitor plugs and the combustion liner which causes breaking of the ignitor plug porcelain insulator. This, in turn, will give an improper electrical discharge or no discharge. Use the following method to check and correct this malfunction. Remove the ignitor plug to inspect the roundness of the combustion liner opening. To correct any out-of-roundness of the opening, first remove the ignitor plug adapter. Then, by using a suitable circular file, remove the material from the area of out-of-roundness. Caution: The maximum allowable material that may be removed to correct this condition is .003 inch. — R. T. C.



Q. AN INCREASE OF MANIFOLD PRESSURE DOES NOT NECESSARILY ACCOMPANY A PROPORTIONAL INCREASE IN BRAKE HORSEPOWER. WHY? (Applies HOK-1, HUK-1, H-43A)

A. Engine brake horsepower does depend upon manifold pressure setting, however it is also a function of engine rpm, mechanical condition of the engine and the atmospheric variations.

While holding manifold pressure constant any increase in engine rpm will result in an increase in BHP. In order to develop the same amount of BHP between two mechanically different engines, the inferior one must have a higher manifold pressure setting to compensate for its irregularities. The same, holds true for atmospheric variation; a higher manifold pressure setting will be required during a hot and humid day as compared to a cold and less humid condition. Because of the above variables, an increase in manifold pressure does not necessarily yield a proportional increase in brake horsepower. — E.S.M.



Q. WHY WILL THE ROTORS CONTINUE TO REMAIN ENGAGED IN FLIGHT, POWER-ON, EVEN THOUGH THE CLUTCH OIL PRESSURE MAY DROP TO ZERO BECAUSE OF AN OIL LEAK? (Applies HOK-1, HUK-1, H-43A)

A. Clutch pressure is taken at the scoop tube and indicates scoop pressure only. Even though no pressure is indicated on the gage, oil is trapped in two radial passages in the clutch down-stream of the scoop tube. Sufficient amount of oil pressure is generated due to centrifugal force on this trapped oil to maintain operating pressure in the power piston. Providing the pilot maintains his power setting and does not throttle back, the rotors will continue to remain engaged indefinitely depending on internal leakages. In the event the needles do begin to separate under these circumstances it will be gradual, warning the pilot to execute a power-off landing immediately. — C.W.J.

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Report FROM THE READY ROOM

SLOW FLIGHT CHARACTERISTICS OF THE H-43B HUSKIE

From takeoff to hover, several features of the HUSKIE immediately become apparent to the helicopter pilot checking out in the H-43B. First noticed will be control symmetry, as exemplified by lack of rudder requirement to counter-act changes in torque with changes in power. Rotor rpm loss or power droop does not occur with application of rudder pressure, although extreme turning manuevers may require power adjustments as a function of rate of turn. These features of control symmetry, combined with proper control sensitivity, produce a docile helicopter in a hover.

AL ASHLEY
Test Pilot

In general, all helicopters to date have been limited in their operations, and scope of operating conditions, due to power limitations. A highly successful, and different, power concept has been incorporated in the H-43B whereby it is torque-limited rather than power-limited. Since we are torque-limited, the pilot monitors the torquemeter installed in the helicopter to avoid delivering more power to the drive system than it is designed to take. The torquemeter registers actual horsepower being delivered regardless of rpm and can be used to gage a "Go - No Go" situation from the standpoint of power available. For example, if 35 psi of torque is required to lift a certain gross weight at sea level, it will require 35 psi of torque to do the same job at ten thousand feet.

The fact that the aircraft is now torque-limited permits as much as 25% power reserve, on a standard day, improving performance greatly in high temperature and altitude conditions. When the HUSKIE encounters flight conditions requiring more power to perform efficiently, the pilot can draw on the power reserve right up to design stress of the various power transmission parts. The success of this concept can be seen in the recent altitude record set by a standard, production-line H-43B in its climb to 30,000 feet at mission gross weight.

Moving from a hover into forward flight, the HUSKIE maintains a nearly level flight attitude and picks up translational lift as low as eight knots. Operating at maximum gross weight is made easier by a very effective ground cushion that can be used to advantage in boosting the helicopter through the normally more critical translational period without exceeding hover power.

The H-43B has a rapid rate of climb at speeds just above translational (15-20 knots) which makes clearing obstacles easier and minimizes space required to operate. Slow speed autorotation characteristics are equally as good so that limited space flying in these regimes is operationally sound.

Directional stability in power-on flight is good. A pleasing compromise between stability and controllability has been achieved. The helicopter responds well to control with a comfortable sensitivity and overall handling is made easier by the symmetrical control system. As a result of this control symmetry, all maneuvers can be accomplished equally well to the left or right whether in autorotation, partial power or power-on flight, at any airspeed. In forward flight then, it is safe to say the H-43B handles similarly to a conventional aircraft and can be flown using fixed wing procedures. The average fixed-wing pilot adapts very quickly to the handling characteristics of the synchropter.

Directional stability when in partial or reduced power at slower airspeeds is weak, but is compensated for by the installation of the DSS (Directional Stability System) which provides a like "feel" in all phases of flight. The prior Kaman models of synchropter design continue to perform very well without the DSS, and the HUSKIE, too, flys well with the system disengaged. Flight quality in the H-43B is considerably improved by the use of the DSS equipment, even though the aircraft flys just as well with the system off as do the HOK, HUK and H-43A models not provided with the DSS equipment.

Many favorable comments have been made by pilots in the field concerning autorotation

characteristics of the H-43B. When operating in the slower speed ranges, it is comforting to know the HUSKIE can be autorotated successfully from slightly over translational airspeeds (15-20 knots) and from comparatively low altitudes. Rotor rpm decay subsequent to throttle-chop is slow, and, since the HUSKIE autorotates at an rpm lower than its normal powered operating range, more time is available for smooth autorotation entries. Good rotor rpm stability provides for a comforable linear rate of descent in autorotation. A moderate flare at the proper time gives a nice rotor rpm increase and plenty of "stopping power" is available. The H-43B is equipped with sturdy landing gear capable of withstanding an eight foot per second drop, and since there is no torque reaction due to the symmetry of the control system, power recoveries and power losses in a hover are easy to handle. These autorotating characteristics, together with a comfortable rate of descent, (1500 feet per minute or less) reduce the "Dead Man's Curve" by helicopter standards as we know them.

"Power settling" in the most difficult landing situation should be no problem. Our testing has revealed that better than 500 feet per minute rate of descent with zero airspeed is required to approach this phenomenom. These parameters should be considerably beyond the normal scope of operation.

In analyzing these characteristics, it can be seen that the H-43B HUSKIE has nearly unlimited mission applications in its weight class where slow speed and refined control are required for the unique capabilities of the helicopter to be fully utilized.

The H-43B is at home in the flight regimes briefly mentioned here. There are many techniques which can be learned to extract the maximum performance from any helicopter, but fewer are required of the HUSKIE pilot to enable the completion of the mission assigned. K

Synchropter *continued from page 6*

is known as differential collective and causes the left rotor to have more lift and the right rotor less lift, thus banking the helicopter to the right in the same manner a fixed-wing aircraft banks to the right. Since both rotors are no longer of equal pitch, the rotor with the HIGHER pitch produces a greater torque reaction than the rotor with the lower lift. An unbalanced condition then exists which causes the helicopter to turn in the direction of the greatest torque, or to the right in this case. Conversely, when left rudder pedal is applied, the right rotor increases in pitch, the left rotor decreases in pitch causing the helicopter to bank and turn to the left since the greatest lift and torque reaction is now about the right rotor. It must be remembered that this occurs while the helicopter is in powered flight.

As differential collective is induced in the rotors, another action, known as differential cyclic, takes place simultaneously. Application of right rudder pedal not only causes the left rotor to increase in pitch, but also tilt forward, (see figure 5). The right rotor decreases in pitch collectively and tilts aft.

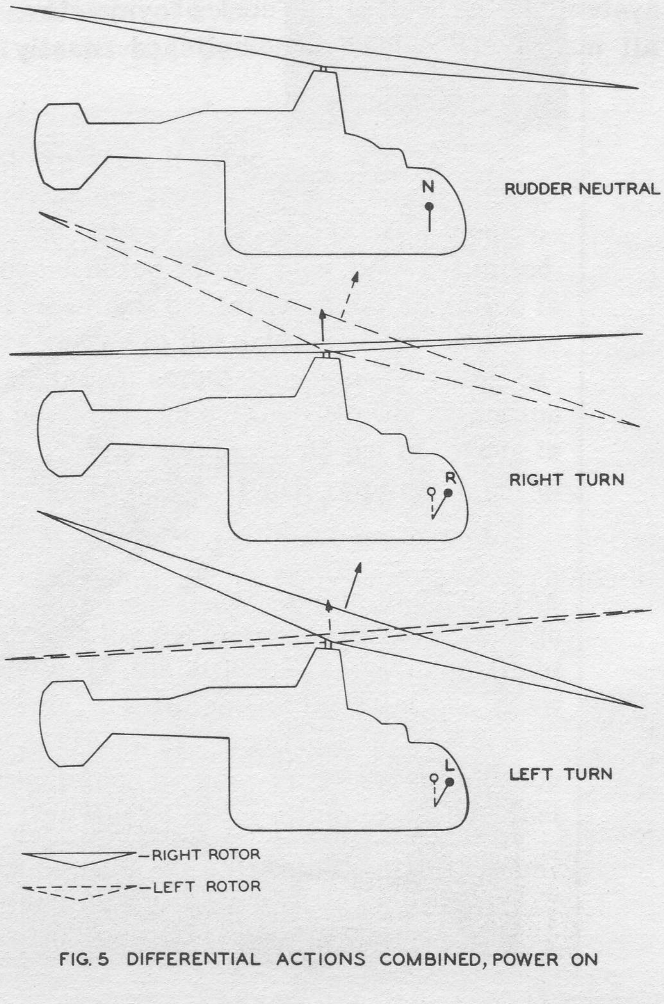

FIG. 5 DIFFERENTIAL ACTIONS COMBINED, POWER ON

This action shifts the lift/drag resultant forward on the left rotor, causing it to "pull" in the turn and aft on the right rotor, producing drag. Thus an aerodynamic force is induced which assists the helicopter in the turn to the right. The action of differential cyclic may be compared to the use of oars in turning a row boat. When in a right turn, the oarsman facing the stern uses the oar in his right hand to pull the boat around in the direction of the turn and either pushes with his left oar or allows it to drag in the water to assist in turning. Application of left rudder pedal in the helicopter causes the right rotor to "pull" and the left rotor "drag," turning the aircraft to the left, producing exactly the opposite result of right rudder.

DIRECTIONAL CONTROL SYSTEM, "POWER-OFF" (AUTOROTATION) — As described in previous paragraphs during power-on flights (engine driving the rotors), advantage is taken of the differential torque reaction to turn the helicopter. We have learned that in the synchropter configuration, the aerodynamic characteristics are such that the greatest torque reaction is about the HIGH lift rotor. During power-off flights the rotors are driven by an external force, the flow of air up through the rotors as the helicopter settles. Again, due to the characteristics of the synchropter configuration, the rotor having the LOWER pitch now provides the greatest torque reaction, therefore, the differential collective torque reaction created during power-on flight is exactly opposite to that created during power-off flight. As a result, with the application of right pedal in autorotation, the helicopter would turn left or into the high pitch rotor were it not for a mechanism known as the reverser. The purpose of this device is to maintain a consistant relationship between the application of rudder pedal and direction of turn. This is accomplished by reversing the differential collective in the rotors while in autorotation thus making the inside rotor in a turn the high pitch rotor and the outside rotor the low pitch rotor (see figure 6). The helicopter then turns in the desired direction.

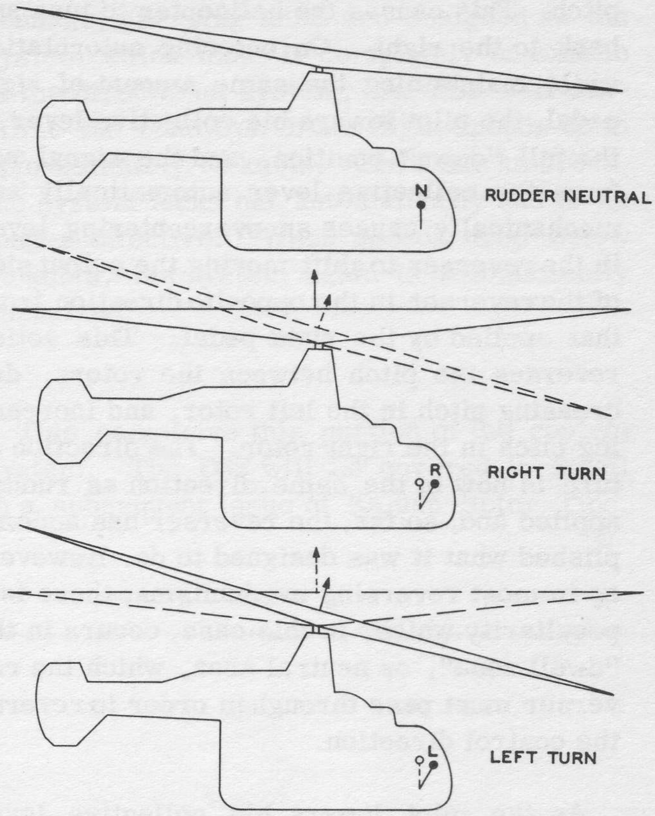

FIG. 6 DIFFERENTIAL ACTIONS COMBINED, POWER OFF

REVERSER — To accomplish the above, the reversing mechanism is installed in the control linkage between the rudder pedal and collective system. Its only purpose is to reverse the differential collective to the rotors when in full autorotation. The reverser mechanism is a self-contained unit consisting of three control connections — input from the rudder pedals; output to the collective system; signal from the collective lever.

The reverser never needs adjustment other than initial rigging after installation. It is designed to mechanically and automatically reverse the differential collective input to the rotor from the pedals as required between power-on flight and autorotation. The reverser has two main control positions, "normal" and "reverse". During normal power-on flight, the reverser is in the normal position. With application of right pedal, the left rotor increases pitch and the right rotor decreases pitch. This causes the helicopter to turn and bank to the right. On entering autorotation while maintaining the same amount of right pedal, the pilot lowers his collective lever to the full "down" position, and the signal rod from the collective lever automatically and mechanically causes an overcentering lever in the reverser to shift moving the output side of the reverser in the opposite direction from that applied by the right pedal. This action reverses the pitch between the rotors, decreasing pitch in the left rotor, and increasing pitch in the right rotor. The direction of turn is now in the same direction as rudder applied and, so far, the reverser has accomplished what it was designed to do. However, as in most reversing mechanisms, there is a peculiarity which, in this case, occurs in the "dwell zone", or neutral area, which the reverser must pass through in order to reverse the control direction.

As the pilot lowers his collective lever from a normal power-on flight condition to the full "down" position for autorotation, the reverser shifts from normal to reverse. During this time, at some intermediate collective lever position, the reverser passes through this dwell zone. There are times in flight when the pilot may fly at this intermediate stick position (partial power flight during a letdown). If he were to apply rudder pedal with the reverser in the dwell zone, there would be no differential collective output and all the pilot would be relying on for a turning force would be differential cyclic. Consequently, the directional control would become insufficient due to the lack of differential collective, a powerful turning force.

To overcome this peculiarity, which is a marginal condition, a control linkage has been added to the differential cyclic system to augment the differential cyclic control. This is called the differential cyclic shifter.

DIFFERENTIAL CYCLIC SHIFTER (DCS)— The primary purpose of the DCS linkage is to increase the output of the already present differential cyclic control so there will be adequate directional control whenever the reverser is in, or near, the "dwell zone" (see the schematic diagram figure 7 for the principle of operations). Illustrated is a rudder pedal, collective stick, DCS linkage and a rotor disc. Crosses (+) indicate fixed pivot points.

The rudder pedal is linked to the DCS linkage by an input control rod. An output control rod links the rotor disc thru a bell-crank. The collective lever is illustrated by three different stick positions, numbers 1, 2 and 3. Position (1) is full down collective (autorotation). In this position, cam "A" is at its lowest point in the DCS link slot. Movement of rudder pedal at down (1) collective position causes the rotor to tilt a small amount about its neutral position. With the collective lever at the intermediate (2) position, reverser dwell zone, point "A" rises to the upper end of the link slot. Movement of rudder pedal at this collective position causes maximum rotor tilt (differential cyclic), increasing the effectiveness and compensating for the little or no differential collective output condition which exists. UP collective position (3), normal power-on flight, causes point "A" to travel back down toward the bottom of the link slot thereby reducing the amount of differential cyclic to its normal output. The reason is that differential collective is now in play with the reverser in its normal operating range. If point "A" of the DCS was allowed to remain at the upper end of the link slot, the pilot would be over controlling in his turns.

Further application of collective stick above position (3) has no effect on the DCS as this motion is absorbed in a bungee (HOK, HUK, H-43A) located between the collective lever and DCS link assembly. In the H-43B a programmer cam is used, incorporating an override slot.

DIRECTIONAL STABILIZATION SYSTEM (DSS)— The H-43B turbine-powered helicopter is the newest in the Kaman family of synchropters and incorporates an automatic stabilization system. As previously mentioned, we have two turning forces, differential collective and differential cyclic incorporated to allow directional control. We now have a third turning force in the H-43B, the DSS. The DSS is incorporated in the directional control system in order to augment the control during partial power descents when the differential collective output is at, or near minimum. In other words, it assists the differential cyclic in maintaining good directional control.

The DSS is completely electronic with no mechanical linkage between rudder pedals and the movable rudder surfaces at the empennage. Sensing units are designed in the system which make it completely automatic of the directional system, the DSS will stabilize the condition in all flight speeds up to approximately 78 knots. Above this airspeed, the system locks out automatically and is no longer effective. When speeds drop below 78 knots, the system again is automatically energized.

This completes this portion of the control system. The DSS will be covered in detail in a subsequent issue of Kaman Rotor Tips. K

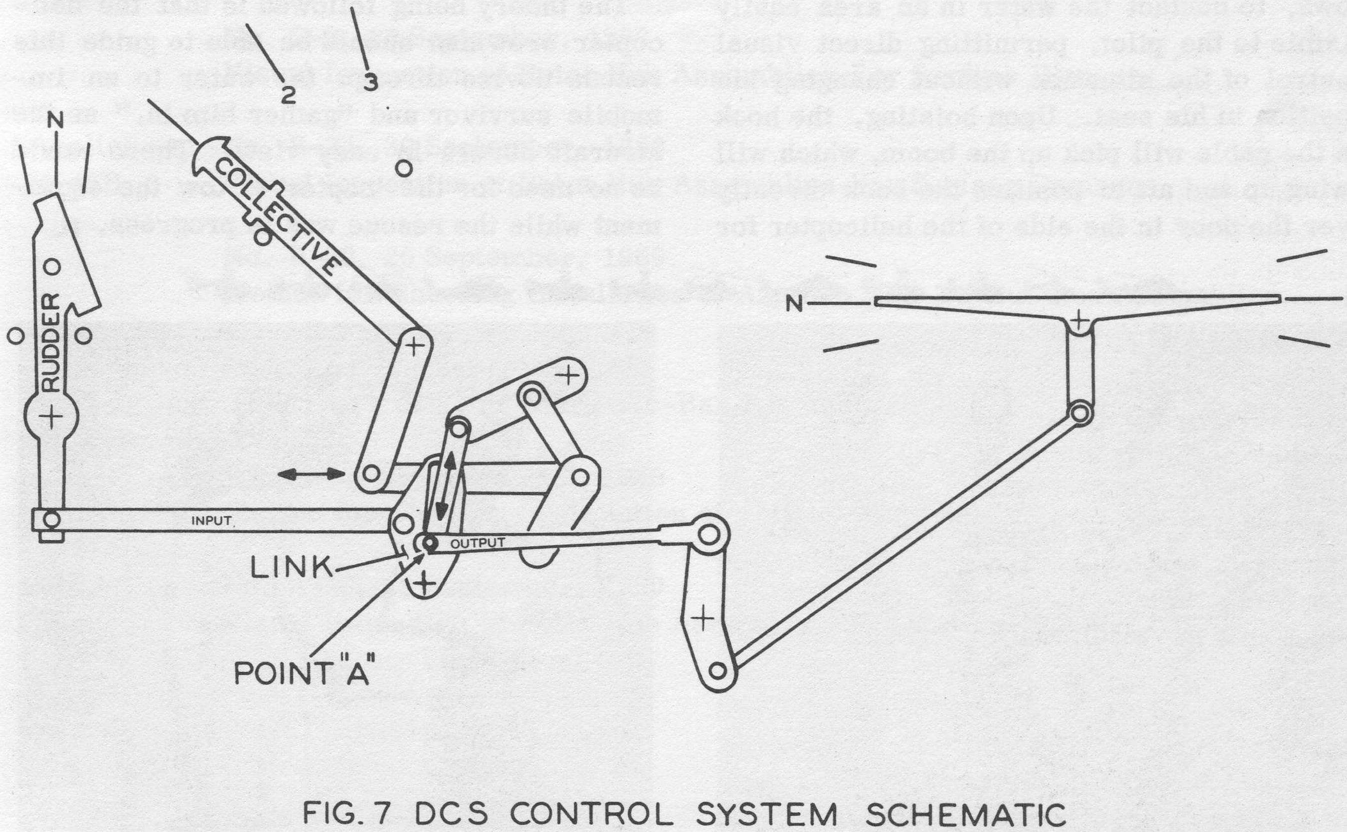

FIG. 7 DCS CONTROL SYSTEM SCHEMATIC

Advanced Water Rescue Concepts

continued from page 8

jacent to the survivor in the water. In the case of the net, he must actually drag the net up to and dip out the immobile survivor. The hoist cable is trailing behind the helicopter completely out of his area of vision; and the pilot must depend upon intercom signals from the crewman, or risk peering out and back with consequent loss of horizon reference at low altitude. The problem is further complicated by the fact that the hovering helicopter and wave-tossed survivor each has its independent motion, not necessarily in phase. It would be easier to grab a prize with the mechanical claw in the penny arcade, while blindfolded.

The HU2K-1 installation will rectify this situation by means of the guide boom which attaches to the nose of the helicopter and protrudes about 8 feet sideways. The hoist cable will pass through the end of this boom and then down, to contact the water in an area easily visible to the pilot, permitting direct visual control of the situation without changing his position in his seat. Upon hoisting, the hook on the cable will pick up the boom, which will swing up and aft to position the hook directly over the door in the side of the helicopter for easy access to the survivor. The "pole-vaulting" action of the boom keeps the survivor in view of the pilot and clear of the side of the helicopter until the last few feet of the hoist travel, when he is swung directly into the door.

This guide boom should be useful not only in rescue operations, but in routine helicopter utility chores, such as transfer of personnel and mail.

In conclusion, Kaman engineers are constantly studying ways of improving helicopter rescue techniques and devices. Now in the research stage, for example, is self-propelled equipment, similar to a miniature floating drydock, which can be attached to the hoist cable. It would be inflated by the crewman and powered by twin screws driven by electric motors. Power for the motors, and steering signals, are delivered from the helicopter via conductors buried in the hoist cable.

The theory being followed is that the helicopter crewman should be able to guide this rescue device through the water to an immobile survivor and "gather him in," as the aircraft hovers in easy view. There would be no need for the 'copter to tow the equipment while the rescue was in progress. K

CAPTAIN WALTER C. McMEEN, USAF, receives a Kaman Scroll of Honor from Harold W. Hines, KAC Field Service Representative at Luke Air Force Base, Arizona. Lt. Ryland R. Dreibelbis (left) and TSgt. William H. Erkert also received Scrolls for their part in a recent rescue mission. The three men crewed an H-43B HUSKIE during the rescue of three teen-age mountain climbers. In addition, Captain McMeen, who commands the Search and Rescue Unit at Luke, performed another rescue with the HUSKIE recently, in the Grand Canyon.

MASTER SERGEANT LeROY E. CATRON, USMC, and Acting Corporal Eddie R. Scott are presented Kaman Scrolls of Honor by Lt. Col. Clarence F. Zingheim, Commanding Officer, Marine Aircraft Repair Squadron 17, Iwakuni, Japan. Sergeant Catron, a veteran helicopter pilot, with Scott as crewman, rescued a U.S. Navy pilot following a mid-air collision of two jet aircraft. The rescue was performed in a Kaman HOK-1. Looking on is Lt. Col. Charles D. Garber (right), Facility Operations Officer. (Official USMC Photo)

CURRENT CHANGES

FIELD INFORMATION DIGESTS (KAMAN)

Applies — H-43A	No. C-1, 19 September, 1960 Installation of Rotor Blade Tie-Bar Assembly.
	No. C-2, 28 September, 1960 Method for Checking Installation of Azimuth Bar-To-Hub Rotor Assemblies.
	No. C-3, 30 September, 1960 Visual Inspection of Rotor Hub Assemblies For Surface Damage.
Applies — H-43B	No. B-24, 30 September, 1960 Visual Inspection of Rotor Hub Assemblies For Surface Damage.
	No. B-30, 26 September, 1960 Method for Checking Installation of Azimuth Bar-To-Hub Rod Assemblies.
Applies — HOK-1 HUK-1	No. A-54, 9 September, 1960 Installation of Rotor Blade Tie-Bar Assembly.
	No. A-55, 26 September, 1960 Method for Checking Installation of Azimuth Bar-To-Hub Rod Assemblies.
	No. A-56, 30 September, 1960 Visual Inspection of Rotor Hub Assemblies For Surface Damage.

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