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MR. MAC'S HELICOPTERS

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McDonnell Aircraft established a worldwide reputation as a developer and producer of excellent fighter aircraft. Far less well known is McDonnell's long experience with helicopter programs. From the founding of McDonnell Aircraft in 1939 into the early 1960s, substantial effort was invested in helicopter technology. McDonnell helicopter programs included the world's first twin-engine helicopter, the first ramjet-powered helicopter to fly, and the first aircraft to successfully transition from rotor-borne vertical flight to wing-borne horizontal flight. Despite such accomplishments, none of these helicopter programs reached the production stage. While the McDonnell name would ultimately become associated with production helicopters when McDonnell Douglas acquired Hughes Helicopters in 1984, company founder and helicopter advocate James S. McDonnell (Mr. Mac) would not witness that event, having died in 1980.

INTRODUCTION

McDonnell Aircraft, today incorporated into The Boeing Company's Integrated Defense Systems organization, is widely known for its many successful fighter aircraft programs, from the XFD-1 *Phantom* of 1946 (first U.S. jet fighter to land on, and take off from, an aircraft carrier), through the 5000+ Vietnam-era F-4 *Phantom II*s, to the F/A-18E/F *Super Hornets* entering Fleet service today. A largely unknown aspect of McDonnell Aircraft technical developments is its substantial experience with helicopter programs.

Fig. 1. James S. McDonnell, Jr. (Mr. Mac), ca. 1941.

Shortly after founding the McDonnell Aircraft Company in St. Louis in July 1939, James S. McDonnell, Jr. (Mr. Mac, Fig. 1) began to pursue a developing interest in the potential represented by vertical flight, i.e., the helicopter. By mid-1942 he had invested substantially in the Platt-LePage Aircraft Corporation, builders of the U.S. Army's first helicopter, the XR-1 (Fig. 2). (It is worth noting that the XR-1 had the same twin-rotor configuration as the German Focke-Achgelis Fa-61, which had received wide publicity in early 1938 as the world's first "practical" helicopter.) In June 1942, McDonnell arranged for a number of his engineers to learn the techniques of helicopter engineering at the Platt-LePage plant in Pennsylvania.

Fig. 2. Platt-LePage XR-1A.

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XHJD-1 (MODEL 37)

The McDonnell engineers assigned to Platt-LePage quickly went to work applying their new-found knowledge to the design of a much-bigger helicopter of the same general configuration as the XR-1, proposing their Model 37 design to the U.S. Navy as a research helicopter. Responding favorably, the Navy ordered one example of the machine as the XHJD-1 on 15 May 1944. To be larger than any helicopter then in existence, and the first with two engines, the XHJD-1 was intended to be a testbed for study of the effects of rotor diameter, disk loading, variations in rotor-blade flap and lag angles, and other variables. Nevertheless, the Model 37 was also intended to be a prototype suitable for Navy antisubmarine and Coast Guard search-and-rescue operations, and capable of being put into production.

Ground testing of McDonnell's first helicopter began in early 1946, the first flight of the XHJD-1 *Whirlaway* occurring on 27 April (Fig. 3). Over the ensuing 2½ years an extensive flight research program was conducted, with more than 250 hours of Navy- and McDonnell-sponsored flight time logged by the flying laboratory. Carrying 1800 pounds of instrumentation, the big XHJD-1 generated a wealth of information on helicopter design and operation.

Fig. 3. McDonnell XHJD-1 Whirlaway

XH-20 (MODEL 38)

While the XHJD-1 was under development, McDonnell engineers were also at work on an unusual helicopter at the other end of the size range. Combining the helicopter with another concept of great interest at the time, i.e., jet propulsion, the McDonnell Helicopter team produced the world's first ramjet helicopter, two examples of which were ordered as the XH-20 by the Air Forces in July 1946. Strictly experimental, the XH-20 *Little Henry* consisted of a very simple open frame that supported a pilot's seat, fuel tanks, and controls. On top was an 18-ft diameter, twin-bladed rotor carrying a 10-lb ramjet burner at each of the tips. This jet-propelled rotor concept eliminated the engine parts, gearboxes, and transmissions associated with conventional shaft drive, in addition to simplifying the rotor-blade pitch control system".

Initial ground testing of the Model 38 concept involved tethered runs of a testbed using gaseous propane for fuel (Fig. 4). After conversion of the rotor-tip ramjets to operate on gasoline, the first free flight of an XH-20 was made on 29 August 1947. The flight testing program that followed was successful, continuing into 1951 (Fig. 5). While the ramjet approach to helicopter power did offer several advantages over conventional shaft drive, the noise and high fuel-consumption rate of the ramjets prevented the diminutive *Little Henry* from achieving production status.

Fig. 4. McDonnell Model 38 testbed

Fig. 5. XH-20 *Little Henry* ramjet helicopter

PRESSURE JET ROTORS, etc.

At about the time of the XH-20 testing, i.e., ca. 1947, two German helicopter engineers arrived in the United States, finding employment in McDonnell's Helicopter Research (later Engineering) Division. These individuals, Friedrich (Fred) von Doblhoff, an Austrian of noble background[2], and Dr. Kurt Hohenemser, a Berliner who had taught at Goettingen[3], would have great impact on McDonnell's helicopter programs. Doblhoff, for example, while an engineer with the Wiener-Neustaedter Flugzeugwerke (WNF), had led the development of a jet-rotor helicopter (WNF-342, Fig. 6), first in the world, that was successfully built and test-flown in 1940-1945.

Fig. 6. Doblhoff's WNF-342.

Doblhoff and one of his WNF-342 helicopters were brought to the U.S. by the Air Forces after World War II under "Operation Paper Clip", the program that recruited hundreds of top German technical personnel. Dr. Hohenemser had participated in successful helicopter developments at the German Flettner concern. Doblhoff's "pressure-jet rotor" concept involved piping high-pressure air from a compressor out to the rotor-blade tips, where it was mixed with fuel and burned in combustors. Thrust of the resulting hot jets thus drove rotation of the rotor. Another concept developed out of the work of these men was the "unloaded rotor principle" in which conventional fixed wings were used to generate lift in forward flight, reducing the rotor loading, avoiding blade dynamic stall, etc.

The notion of combining the pressure-jet rotor and unloaded-rotor concepts into a single high-speed vertical-takeoff vehicle was explored extensively in a Navy-sponsored research program conducted by McDonnell during May 1949 – December 1950[4]. This analytical and experimental study investigated characteristics of lightly loaded rotors at high flight speeds and their application to a high-speed ship-to-shore transport vehicle[5]. In addition to wind tunnel testing, transition (between vertical and wing-borne flight) testing was conducted with a novel truck-mounted fixed-wing rotorcraft model (Fig. 7) that was driven up and down Muroc Dry Lake (now Edwards Air Force Base) and the Bonneville Salt Flats. This testing approach avoided the complications of severe wind-tunnel wall interference. Results of this research effort supported the concept that the optimum configuration for a fast ship-to-shore assault transport would be the "convertiplane," i.e., a craft combining rotor lift for takeoff and landing with conversion to wing-borne flight at high forward speeds.

XHRH-1 (MODEL 78)

Based on the results of the Navy-sponsored rotary-fixed wing aircraft research, McDonnell designed its Model 78, a large, twin-engine, compound aircraft (Fig. 8) that was submitted to a Marine Corps competition for a ship-to-shore transport helicopter, winning a contract for three prototypes in 1951. Given the military designation XHRH-1, the large (30,000 lb) Model 78 featured conventional propellers and stub wings for thrust and lift to sustain forward flight while carrying 30 fully equipped troops at 220 knots. For vertical flight, the turboprop powerplants were to be uncoupled from the propellers and instead connected by clutches to compressors that pumped high-pressure air out to the jets at the tips of the 32½ ft long rotor blades. Unfortunately, the XHRH-1 did not proceed beyond the mockup stage (Fig. 9). Faced with budget limitations,

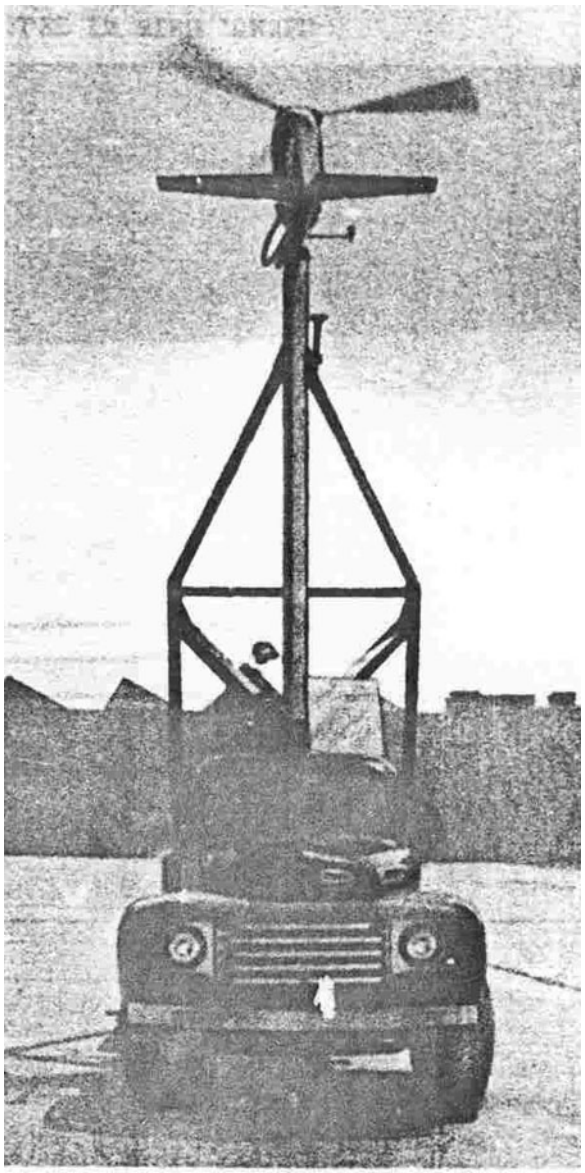

Fig. 7. Truck-mounted rotorcraft test rig.

Fig. 8. Artist's rendering of XHRH-1.

and concerned about development problems likely to be encountered with such a complex compound vehicle, the Navy terminated the XHRH-1 contract in 1953.

Fig. 9. XHRH-1 mockup.

MODEL 79

Meanwhile, McDonnell continued to seek an outlet for the principles and design simplicity developed in the XH-20 ramjet helicopter. Efforts were made to market a knock-down, fold-up version as a light scout and observation vehicle for the Army, without success. Based on scaling up (to 27 ft diameter) of the rotor system of the XH-20, the McDonnell Model 79 (sometimes called *Big Henry*) was designed in 1950 as a utility agricultural helicopter for crop spraying and dusting (Fig. 10). First flight of the single-seat Model 79 took place on 26 March 1952. Despite a glowing market forecast for the Model 79, it did not enter production, and development was halted in mid-1953.

Fig. 10. Fred Doblhoff (left) showing Model 79 *Big Henry* controls to J.S. McDonnell.

XV-1 (MODEL 82)

McDonnell's pressure-jet driven unloaded rotor concept finally reached the flight-test stage in the XV-1 "Convertiplane" program. Designed for a joint Army/Air Force high-speed liaison/observation aircraft competition, the Model 82 (XV-1) emerged as one of three winners. (Another winner, the Bell XV-3 twin tilt-rotor, led to the NASA/Bell XV-15 and ultimately to today's V-22 *Osprey*.) McDonnell received a contract in February 1952 for two prototypes of the single-engine, two-seat XV-1. The 550-hp Continental reciprocating engine was coupled to a pair of Boeing centrifugal compressors that provided air to the rotor-tip jet burners for vertical flight; for high-speed forward flight, the engine power was shifted to a fixed-pitch Macauley pusher propeller. The propulsion system of the XV-1 was thus very similar in concept to Doblhoff's original WNF-342 arrangement. A "hot-whirl" test stand was established for dynamic testing of XV-1 rotor blades and tip combustors (Fig. 11). Testing of the full XV-1 rotor was conducted in the NASA-Ames 40×80 Ft. Tunnel in 1954; the complete XV-1 configuration was tested there in 1955.

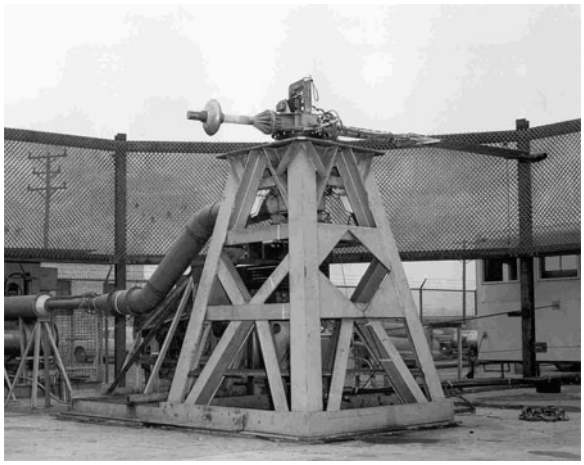

Fig. 11. XV-1 Rotor blade whirl rig.

During their successful flight-test program (Fig. 12), which began with the first hovering flight on 11 February 1954, the two XV-1s scored several "firsts", including the first successful conversion from helicopter takeoff to conventional wing-borne flight, and (unofficially) the first 200 mph flight by a rotorcraft. Despite company efforts to sell the XV-1 to the Army, Air Force, and Navy, no production orders were obtained, and the program was finally canceled in 1957.

Fig. 12. XV-1 in full flight.

XHCH-1 (MODEL 86)

Further development of the McDonnell pressure-jet rotor was undertaken when the XHCH-1, a conventional helicopter design, was selected by the Navy as winner of a competition for a cargo-unloading helicopter (Fig. 13) in the spring of 1952. The complete rotor, engines, clutches, and rotor-air compressors (Fig. 14) were to have been identical to the units then under development for the XHRH-1 assault helicopter. Upon cancellation

of the XHRH-1 in 1953, all rotor development was transferred to the XHCH-1 program. Funds for the XHCH-1 were cut back during the mid-1950s, with development then restricted to powerplant and rotor design and testing. A mockup of the XHCH-1 was built (Fig. 15), and a full-scale (75 ft diameter) rotor was eventually hot-whirled (Fig. 16), but the XHCH-1 contract was ultimately canceled in January 1959 with none of the three intended prototypes having been built.

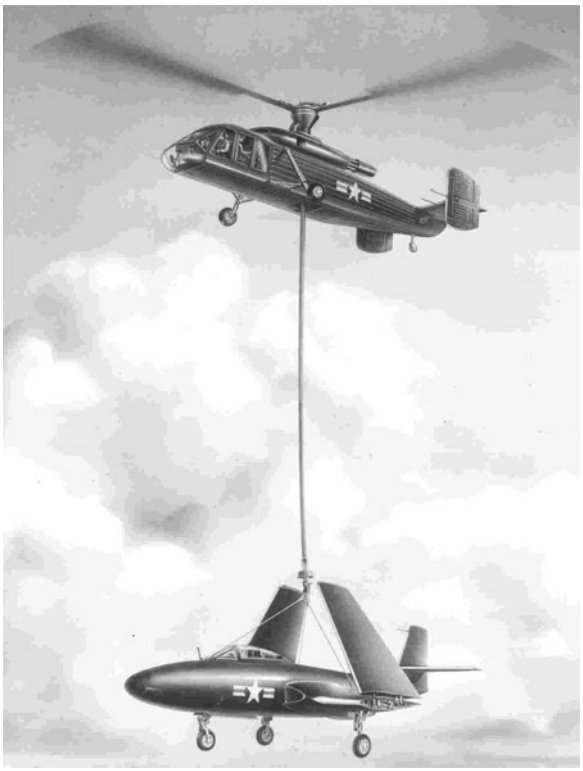

Fig. 13. Artist's vision of XHCH-1 at work.

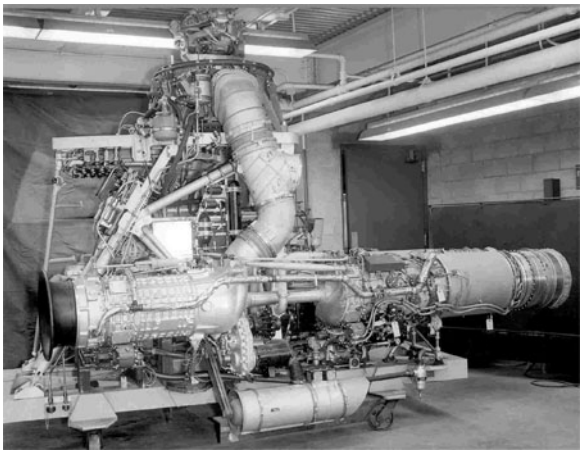

Fig. 14. XHCH-1 power assembly.

Fig. 15. XHCH-1 mockup (showing rotor fold).

Fig. 16. Full-scale XHCH-1 rotor hot-whirl rig.

MODEL 113

During the mid-1950s, McDonnell studied a variety of configurations based on the "Unloaded Rotor Principle", all quite similar in overall concept to the XHRH-1 (Model 78) of 1951. For example, the Model 113 (which did not win any development contracts) was offered as a light or medium cargo-and-troop transport and as a long-range rescue vehicle. As shown in Fig. 17, it would have had the McDonnell pressure-jet driven rotor, but versions with a shaft-driven rotor were also considered. The version shown here would have had four GE T58 turboshaft engines, two in each nacelle, alternately driving the compressors for rotor-drive air or turning the fixed-pitch propellers for forward flight.

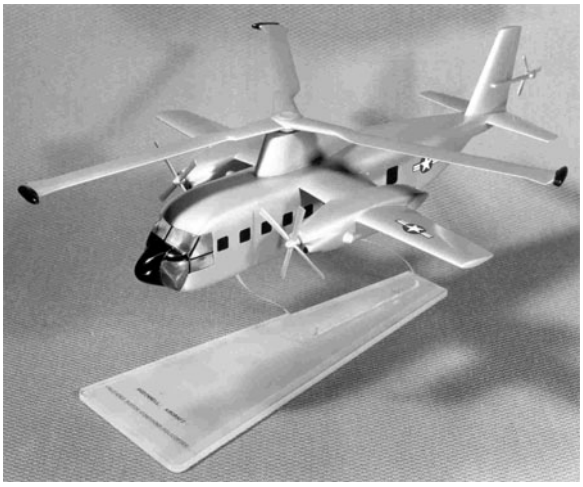

Fig. 17. Proposed Model 113P (desktop model).

MODEL 120

The penultimate chapter in the McDonnell helicopter story concerns the Model 120, a privately developed helicopter originally intended to be a utility vehicle for the Army. Begun in 1956, the Model 120 used the 31-ft pressure-jet rotor developed for the XV-1, with power provided by three small AiResearch gas turbine compressor units (Fig. 18). First flown on 13 November 1957, the Model 120 (Fig. 19) was widely publicized as the first helicopter cabable of lifting a payload greater than its own weight. In fact, the Model 120 demonstrated the ability to carry a load equal to 62% of the gross weight! Nevertheless the Model 120 went the way of previous McDonnell helicopters, failing to win either military or civilian orders.

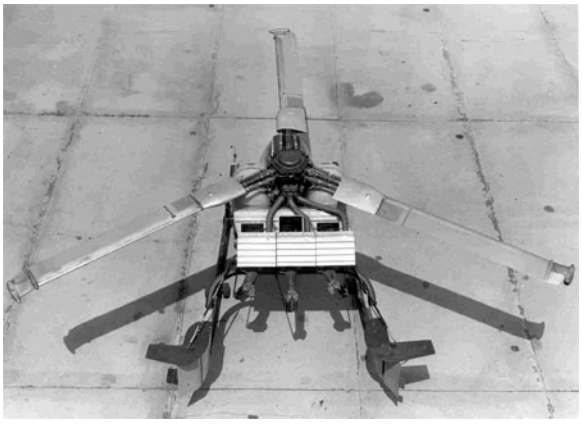

Fig. 18. Top view of Model 120 rotor and power systems.

Fig. 19. Model 120 in flight with personnel pod.

Although the McDonnell Helicopter Engineering Division continued to generate design proposals for several more years, the closeout of the Model 120 program in February 1960 in effect marked the end of the line for McDonnell's indigenous helicopter work.

CONCLUSION

McDonnell's eventual success in the rotary-wing world would finally come when, on 6 January 1984, the McDonnell Douglas Corporation acquired Hughes Helicopters, Inc. as part of its product diversification efforts. This acquisition brought into the company the MD500 helicopter line (originally the Hughes 500, based on the Army OH-6A *Loach*), Fig. 20, as well as the AH-64 *Apache* attack helicopter

Fig. 20. McDonnell Douglas *NOTAR* civil helicopters.

(Fig. 21). The *Apache* continues as a strong element of Boeing's military helicopter line, while the civil helicopter activity has been spun off as MD Helicopters, Inc.

Fig. 21. Hughes/McDonnell Douglas/Boeing AH-64D *Apache* attack helicopter.

Sadly, company founder and helicopter advocate J.S. McDonnell, or Mr. Mac, did not "enjoy" this ultimate development, having died on 22 August 1980.

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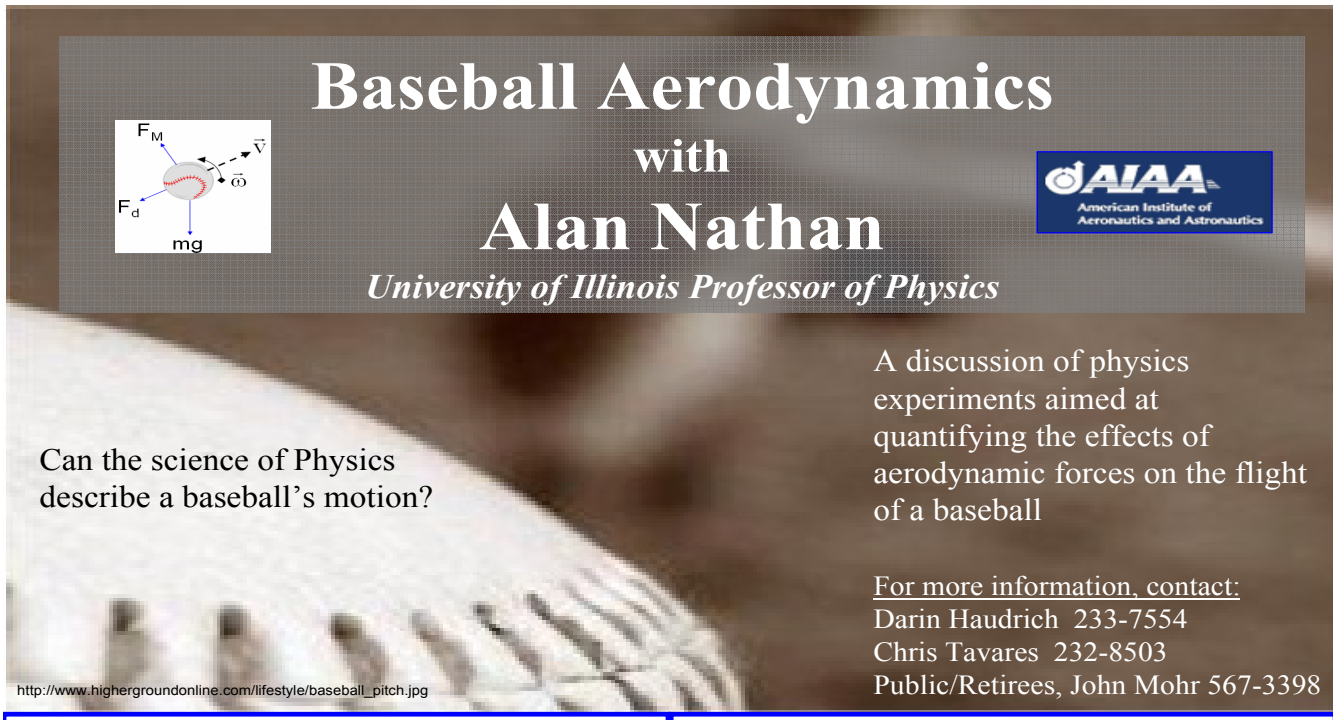

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