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TECHNICAL REPORT NO. 66-07

VENTILATED FLIGHT SUIT

Final Report

By
Frederic G. Hardenbrook
Environment and Survival Branch

December 1966

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U. S. ARMY LIMITED WAR LABORATORY
Aberdeen Proving Ground, Maryland 21005

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ABSTRACT

The purpose of this development is to increase the efficiency of the pilot and co-pilot of the Mohawk aircraft when operating in hot climates by using the principle of evaporative cooling. To do so, a Ventilated Flight Suit was developed through which ambient air could be forced by using a small blower and flexible tubing conducting the ambient air to the suit using the perspiration of the individual to achieve the cooling.

Service Tests made in South Vietnam proved the Ventilated Flight Suit inadequate when the aircraft cooling system was not in operation unless a supplementary lightweight, portable cooling system is provided.

PREFACE

The U. S. Army Limited War Laboratory, with the cooperation of representatives of the following Agencies and Laboratories, developed a Ventilated Flight Suit which, using ambient air, was able to reduce the heat stress on the pilot and co-pilot of the Mohawk aircraft to an acceptable level.

U. S. Naval Aerospace Medical Institute
U. S. Naval Aviation Medical Center
Pensacola, Florida

U. S. Army Natick Laboratories
Natick, Massachusetts

U. S. Army Aeromedical Research Unit
Fort Rucker, Alabama

U. S. Army Aviation Test Board
Fort Rucker, Alabama

U. S. Army Aviation Command
St. Louis, Missouri

Mohawk Project Office
Washington, D. C.

U. S. Army Board of Aviation Accident Research
Fort Rucker, Alabama

U. S. Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland

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Figure 2. Ventilating liner with ram air inlet and air hose attached.

Figure 3. Ventilated flight suit complete with adapted flight suit, ventilating liner and air inlet hose.

Figure 4. Quick disconnect for ram air hose.

Figure 5. Components of ventilating system including air inlet hoses, connections and brackets.

INTRODUCTION

A request was received on 7 September 1965 from the Chief of Research and Development to develop a method for reducing thermal stress on the pilot and co-pilot of the Mohawk aircraft when operating in warm climates so as to increase pilot efficiency. At present, because of power limitations, it is not feasible to air condition the cabin and therefore some method of cooling the pilot and co-pilot on an individual basis had to be developed.

CONCLUSION

During informal tests conducted by the U. S. Army Limited War Laboratory at Fort Rucker, Alabama, it was learned that the use of a Ventilated Flight Suit developed by the U. S. Army Limited War Laboratory, in cooperation with the U. S. Army Natick Laboratories, substantially reduced pilot stress due to heat. On receipt of approval of the U. S. Army Aeromedical Research Unit, Fort Rucker, Alabama, the U. S. Army Aviation Test Board, Fort Rucker, Alabama and with the knowledge and consent of the U. S. Army Aviation Commission, St. Louis, Missouri and the U. S. Army Test and Evaluation Command and with the certification that the suit met the safety standards of the U. S. Army Limited War Laboratory, five systems (10 suits and 5 air conducting systems with necessary hoses, brackets, and clamps) were shipped to South Vietnam for field evaluation.

PROBLEM

The problem is to reduce the effect on the pilot and co-pilot of high temperatures that develop in the cabin of the Mohawk aircraft when operating in tropical areas. The cabin temperatures often exceed ambient temperature by 30°F to 35°F and result in a decrease in efficiency of the pilot and co-pilot.

SOLUTION

During the course of the development a series of meetings were held with interested Agencies. The initial meeting to define the problem and possible solution was held at the Pensacola Naval Air Station on 17 September 1965. This meeting was attended by representatives of the U. S. Naval Aerospace Medical Institute, Pensacola, Florida, the U. S. Army Aviation Test Board, Fort Rucker, Alabama, the U. S. Army Aeromedical Research Laboratory, Fort Rucker, Alabama and the U. S. Army Limited War Laboratory, Aberdeen Proving Ground, Maryland. During this meeting it was decided that the U. S. Naval Aerospace Medical Institute and the U. S. Army Limited War Laboratory would cooperate on the project. The responsibility to develop a cooling suit for the pilot to increase his efficiency would be the responsibility of the U. S. Army Limited War Laboratory.

A second meeting was held at the U. S. Army Natick Laboratories on 24 September 1965. This meeting was attended by representatives of the Advanced Project Office, Clothing & Organic Materials Division of the U. S. Army Natick Laboratories, the U. S. Naval Aerospace Medical Institute, Pensacola, Florida and the U. S. Army Limited War Laboratory. At this meeting it was determined that cooling systems at present available were inadequate because of the inability of the systems to distribute sufficient air to the areas of the body most needing cooling (i.e., the torso and the groin). It was also determined that an adaptation of the air cooled suit developed for the Space Flight Center, Huntsville, Alabama should be used. The garment, to be worn under an adapted flight suit, was to consist of three layers (reference Figures 1, 2, and 3):

1. A loosely woven elastic material near the body.

2. A three dimensional textile to allow free circulation of air.

3. A closely woven hot calendered spinnaker cloth.

Using this combination of layers, air forced into the three dimensional layer will seek the path of least resistance and flow through the loosely woven material to the body of the wearer. As the middle layer is non-crushable, air circulation will not be impeded by the weight of the wearer's body or harness when seated and belted into the seat of the Mohawk aircraft.

A third meeting was held at the Grumman Aircraft Engineering Corporation on 15 October 1965 to discuss the compatibility of the Ventilated Flight Suit system to the Mohawk aircraft. The meeting was attended by representatives of the U. S. Army Aeromedical Research Laboratory, Grumman Aircraft Engineering Corporation, U. S. Army Natick Laboratories, AMC Mohawk Project

Figure 1. Adapted flight suit and ventilating liner (white) illustrating ram air inlet and adaptation of standard flight suit.

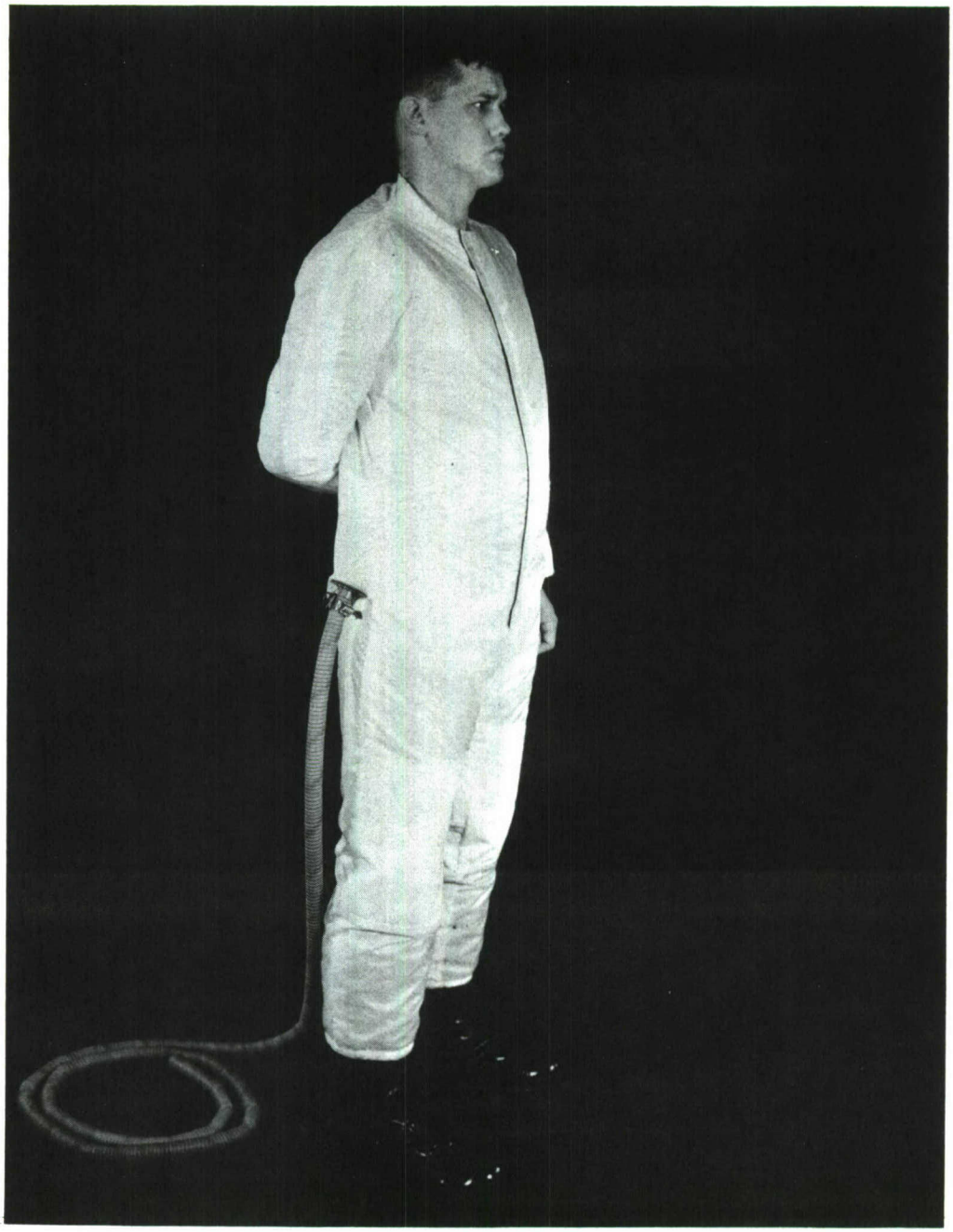

Figure 2. Ventilating liner with ram air inlet and air inlet hose.

Figure 3. Ventilated Flight Suit complete with adapted flight suit, ventilated liner and air inlet hose.

Manager's Office, Hamilton Standard Company and the U. S. Army Limited War Laboratory. It was determined that there was sufficient electrical power in the aircraft to activate the blower to circulate the air.

A fourth meeting was held at the Cumberland Army Depot on 26 October 1965. Using a Mohawk aircraft and a pilot, the determination was made as to the best location to attach the air input hose to the coverall and the best location in the aircraft for the air blower. It was decided that air input attachments should be placed on each side of the ventilated liner just below the hip bone. This was done so as to accommodate both the pilot and co-pilot. The flight suit was to be adapted to allow admission of the air input hose. A standard quick-release attachment needing a ten-pound pull to disconnect was used to connect the blown tube to the ventilation unit of the suit, Figure 4. The Mohawk aircraft at the Cumberland Army Depot had no armor in the nose. The most efficient location for the blower was then determined to be attached to the upright support struts just behind the hinges that allow the nose of the aircraft to be lifted. The meeting was attended by representatives of the U. S. Army Natick Laboratories and the U. S. Army Limited War Laboratory.

A fifth meeting was held at Fort Rucker, Alabama from 29 November to 2 December 1965 during which informal tests were made on the installation of the blower mechanism and the ventilated flight suit system. A blower system was installed in a Mohawk aircraft, Figure 5. A pilot was dressed in his underwear consisting of cotton T-shirt and shorts, the proposed ventilated flight suit, a flack vest and flight helmet. So dressed he was strapped in as if in flight. Another pilot dressed in similar underwear, a standard flight suit, lightweight flight vest and baseball cap was not strapped in the seat but sat free. Air at a temperature of 104°F was fed into the ventilated flight suit and the cabin of the Mohawk aircraft for thirty-five minutes. At the end of this time, the pilot dressed in the ventilated flight suit was comfortable. The other pilot was soaked with perspiration and extremely uncomfortable. This meeting was attended by representatives of the U. S. Army Natick Laboratories, the U. S. Army Aviation Test Board, the U. S. Army Aeromedical Research Laboratory and the U. S. Army Limited War Laboratory.

A final conference was held at Fort Rucker, Alabama on 20 December 1965. This meeting was attended by representatives of the U. S. Army Aviation Command, the U. S. Army Aviation Test Board and the U. S. Army Limited War Laboratory. At this meeting two locations for the installation of the blower were determined. The preferred location is just behind the nose armor astride a flat air duct. The alternate location, usable only if the nose armor has not been installed, is to have the blower attached to a mount bolted to uprights amidship. In use, ambient air is forced through

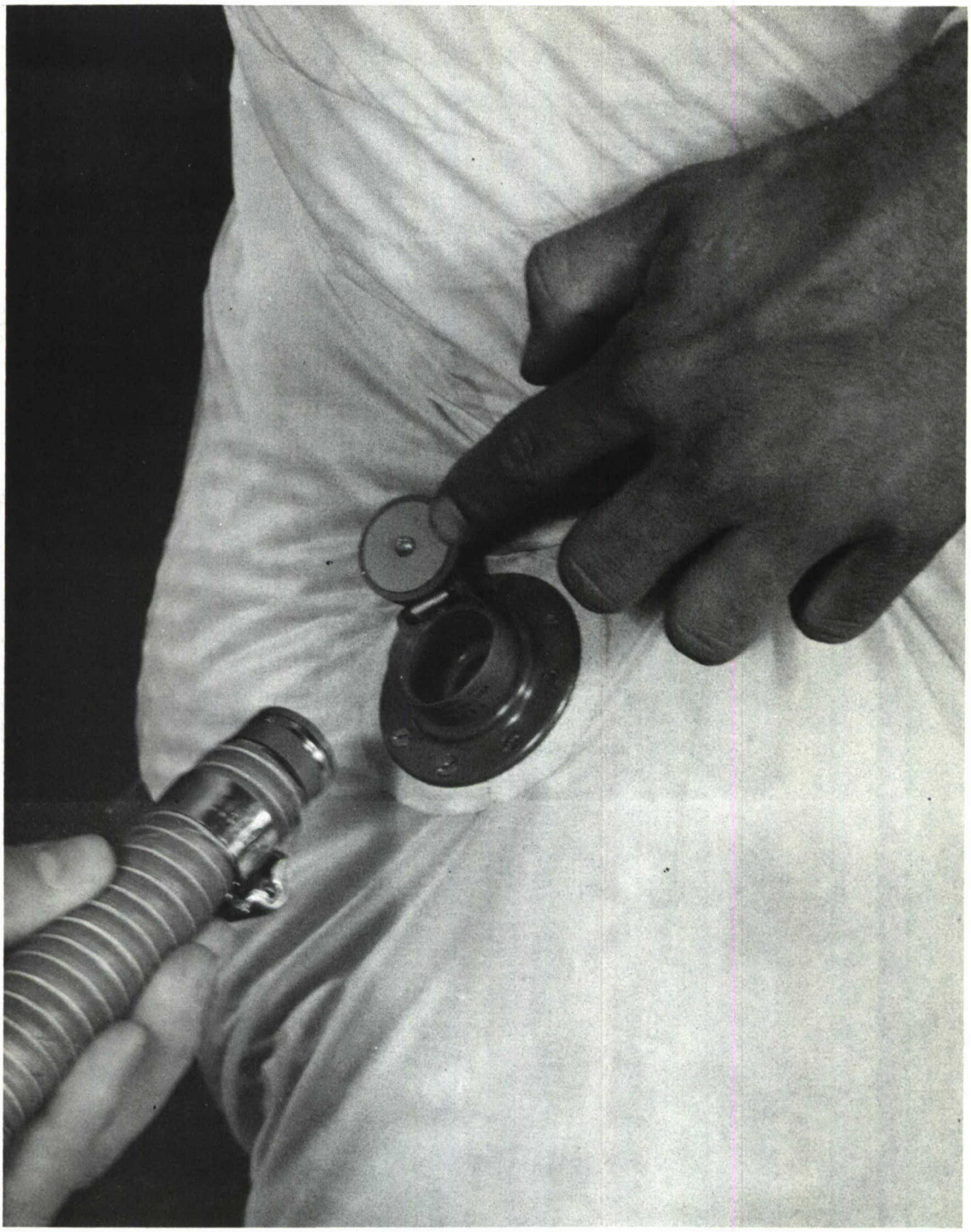

Figure 4. Quick disconnect for ram air hose.

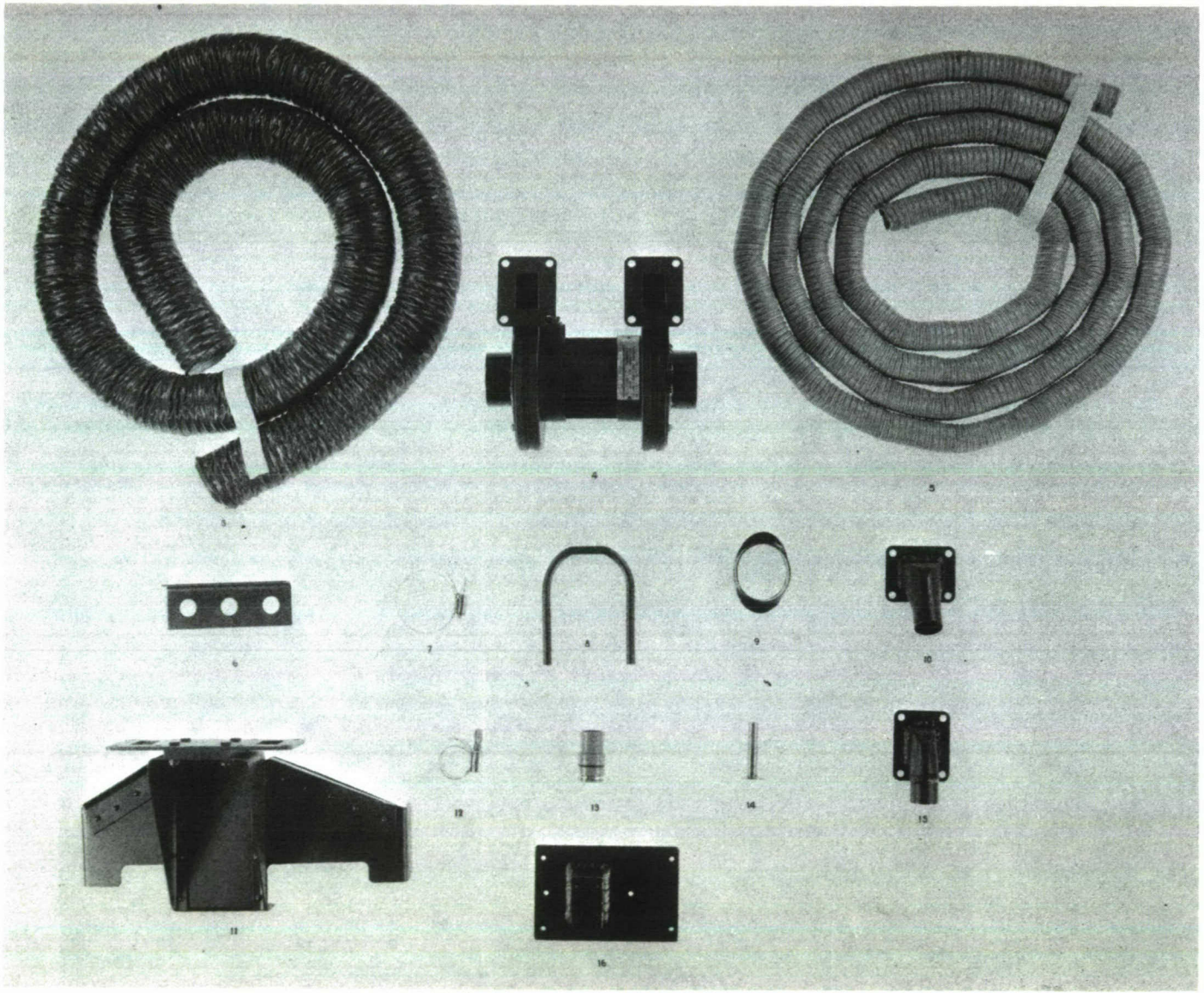

Figure 5. Components of ventilating system including air inlet hoses, connections and brackets.

the ram air inlet under the nose of the Mohawk aircraft and through a two-inch flexible hose to a blower mounted in the nose of the aircraft. From the blower air is fed through one-inch flexible hoses positioned between the pilot and co-pilot to the hose attachment in the ventilated flight suit. From there it circulates through the three dimensional textile layer over the wearer's body. The air escapes at the openings of the suit at the wrist, neck and ankle. At no time does the volume or force of escaping air become objectional to the wearer. The flow of air can be adjusted or discontinued entirely by adjusting the aperture of the ram air inlet. When flying in cool air a sufficient volume of air to cool the wearer can be fed through the suit by opening the ram air inlet and not activating the blower.

POTENTIAL HAZARDS

The material used in the Ventilated Flight Suit has been used successfully in garments designed to provide protection against thermal radiation emitted by nuclear weapons. There are two layers of cotton fabric, the pilot's underwear and spandex, between the nylon materials and the body. Therefore, the possibility of molten nylon contacting the skin is remote. In the event of rips or tears of the three thicknesses of material, there may be the possibility of skin irritation from the stiff ends of the three dimensional textile. The stiffened fibers in this cloth form the air chambers which allow the free flow of air that cools the body. The irritation that may come from the ends of the torn cloth is only an abrasion and is not from any toxicity inherent in the cloth.

RESULTS

On 14 February 1966 five (5) systems were shipped to Vietnam for tests. Service Tests were made in Vietnam by the 173rd Aviation Company in May 1966. A report was received from the Limited War Laboratory Liaison Officer in South Vietnam that the Ventilated Flight Suit was considered unsatisfactory for the following reasons:

1. Too bulky.

2. Restricted the movements of the pilot.

3. Should be of camouflage material.

4. Provided no cooling outside the aircraft.

It was the decision of the test group to use no system of personal cooling but await air conditioning of the Mohawk aircraft cabin.

Continued interest is being shown by the U. S. Naval Aerospace Medical Institute and the U. S. Naval Aviation Medical Center, Pensacola, Florida.

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13. ABSTRACT

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