U. S. ARMY
TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

TRECOM TECHNICAL REPORT 64-17

FULTON AIR-TO-GROUND PICKUP SYSTEM FOR CARIBOU AIRCRAFT

Task 1D141812XXX02

Contract DA 44-177-TC-804

February 1964

prepared by:

ROBERT FULTON COMPANY
Newtown, Connecticut

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HEADQUARTERS
U S ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

The Robert Fulton Company has successfully designed and developed an airborne pickup system for the Office of Naval Research. The contractor herein reports on the redesign and testing of this system that was installed on a CV-2 (Caribou) aircraft.

The U. S. Army Transportation Research Command concurs in the conclusions and recommendations contained in this report with the exception of recommendation six, wherein the contractor recommends the use of the snubber-snatch-block technique during normal entry of the load aboard the aircraft. As a result of the service tests discussed in this report, the U. S. Army adopted the technique of using an A-frame for load entry; the Army uses the snubber-block technique for the recovery of loads only as an emergency procedure.

The U. S. Army is currently procuring several of the Fulton air-to-ground pickup systems for use on Caribou aircraft, and action is being initiated to type classify the system.

A follow-on program that will use this same principle to retrieve litter patients from inaccessible areas is contemplated.

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APPROVED.

FOR THE COMMANDER:

for LARRY M. HEWIN
Technical Director

Task 1D141812XXX02
(Formerly Task 9R96-11-001-02)
Contract DA 44-177-TC-804
TRECOM Technical Report 64-17
February 1964

FULTON AIR-TO-GROUND PICKUP SYSTEM
FOR
CARIBOU AIRCRAFT
(Contractor's Observations During Joint Engineer-User Test)

Prepared by
Robert Fulton Company
Newtown, Connecticut

for
U.S. ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

PREFACE

The following report relates to contractor's observations regarding joint engineer/user tests of the Fulton Air-To-Ground Pickup system applied to the Army's Type CV-2 (CARIBOU) aircraft.

Tests were conducted jointly by the Airborne, Electronics and Special Warfare Board (AESW Board), Fort Bragg, North Carolina, and the U. S. Army Transportation Research Command (USATRECOM), Fort Eustis, Virginia. The Robert Fulton Company participated in these tests under the terms of this contract.

Facilities of the U. S. Marine Corps at New River, North Carolina, were used for water operations. Land operations were conducted both by day and by night at Fort Bragg.

CONTENTS

LIST OF ILLUSTRATIONS

SUMMARY

In accordance with U. S. Army Transportation Research Command contract DA 44-177-TC-804, the Robert Fulton Company installed aerial recovery equipment on Army type CV-2 (CARIBOU) Aircraft No. 573083. To evaluate the system, engineering and user tests were conducted at Fort Bragg, North Carolina. Sixty-four pickups were performed of which seven were successful personnel pickups. Figures 1 through 4 illustrate various steps in a pickup.

During the test program, only two operations were unsatisfactory. These were conducted in the early training phase of the program and, in both cases, previously used lift-lines were employed. One had been spliced defectively by inexperienced personnel and the other had been used five times and subjected to an unusual and severe load.

Emergency procedures as well as simulated operational pickups were tested with good results.

Pilots experienced little difficulty during daylight in maneuvering the aircraft to intercept the lift-line at the proper place. There were only three unintentional misses: one when the airplane flew too high and two when it was too far to one side. These were made by pilots unfamiliar with the technique.

Nine night operations were successfully conducted and various combinations of lighting systems were used individually and collectively for evaluation by the pilots. With the proper combination and adequate pilot training, night pickups can be made as regularly as daylight ones.

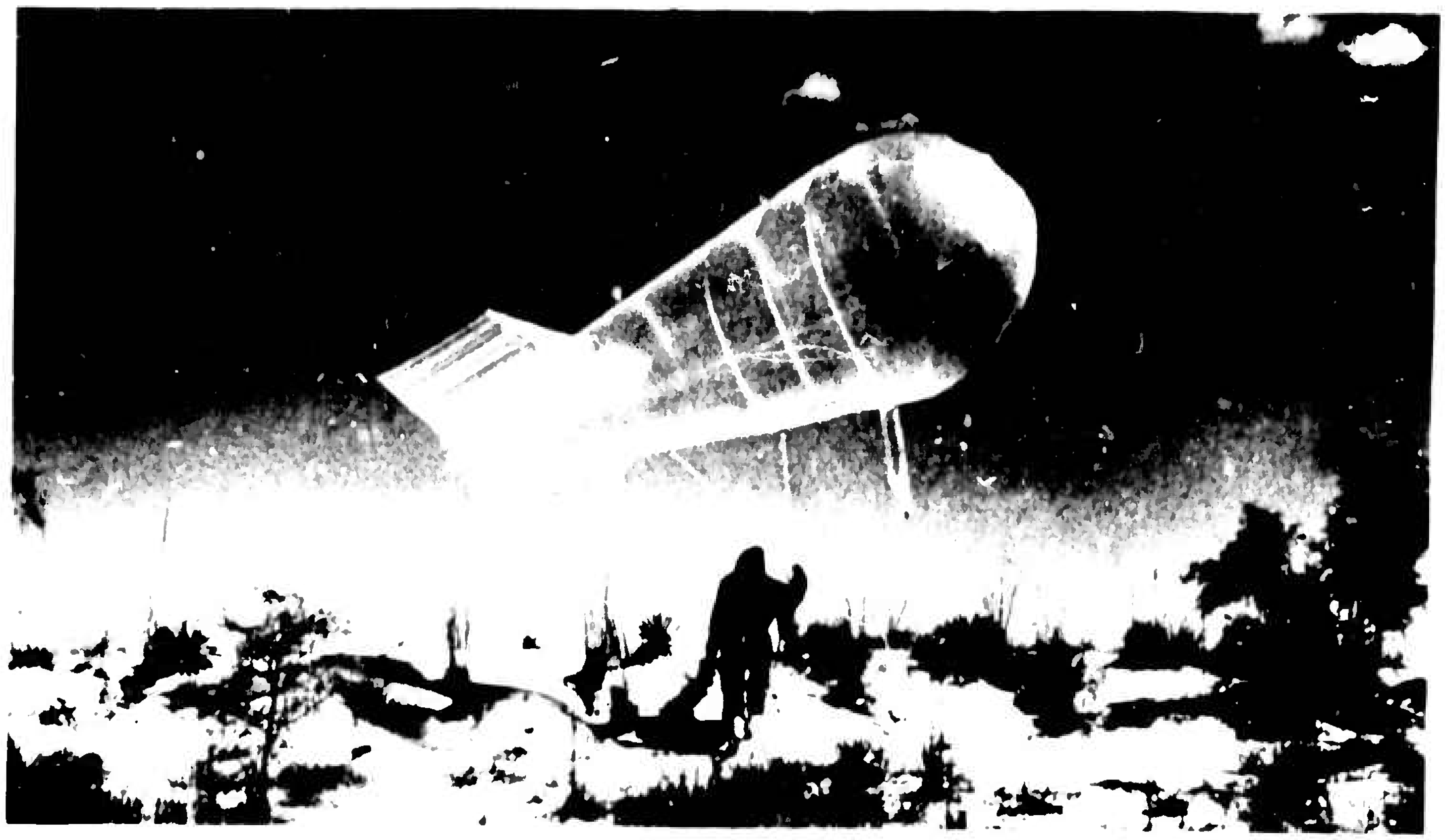


Figure 1. Releasing Balloon To Raise Lift-Line.

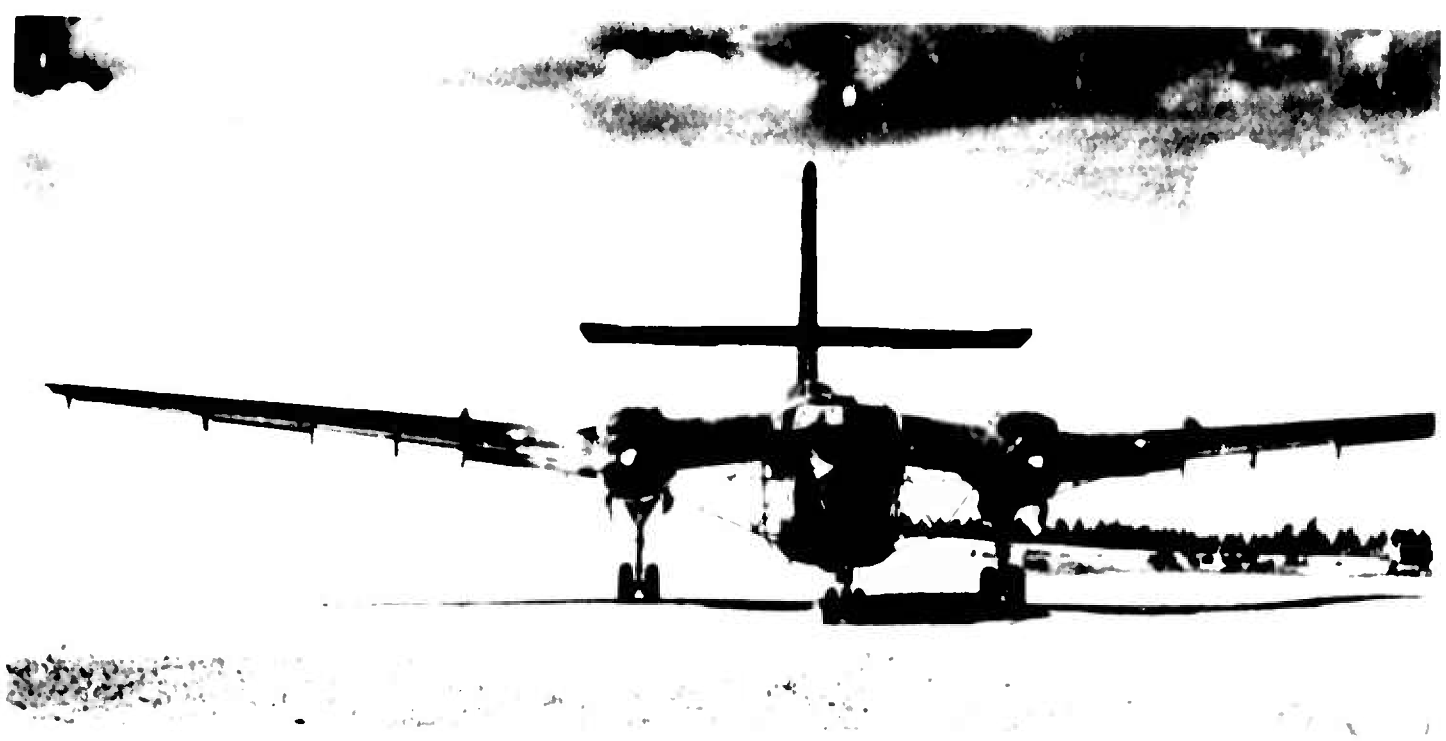


Figure 2. Caribou Preparing To Take Off for Rescue. (Note yoke attached to nose of plane.)

Figure 3. One of Seven Live Pickups at Fort Bragg.

Figure 4. Bringing "Survivor" Aboard Aircraft.

CONCLUSIONS

The test series was satisfactorily completed and justifies the following conclusions:

1. The recovery system is safe, reliable, and ready for operational use with the CARIBOU aircraft.

2. The system will recover personnel and equipment from the land as well as from the water.

3. A properly trained crew that is familiar with the equipment and procedures is a mandatory operational factor.

4. Where a live pickup is involved, it is essential that a new lift-line be used. Lift-lines may be reused only for cargo pickups and after proper inspection and rigging in accordance with the instruction manual.

5. Additional testing should be carried out in order to extend the capability to heavier loads and multiple pickups with the CARIBOU aircraft.

6. Night operations can be accomplished but require more training (particularly for the pilot) than is necessary for daylight operations.

RECOMMENDATIONS

It is recommended:

1. That stronger deflection lines be provided for wing and tail surfaces. (A new type of Teflon braided line is now available and has proven to be highly successful in recent tests on other aircraft.)

2. That the extension cord attaching the lift-line to the balloon be lengthened approximately 50 feet, since the increased height of the balloon above the aircraft on intercept would reduce the angle between the aircraft and the line and would provide adequate clearance from the propeller.

3. That it be standard procedure to coat the balloon filler nozzle with silicone to prevent its freezing into the balloon's neck during inflation.

4. That the lower rotating beacon on the CARIBOU be equipped with a guard to protect it from the lift-line.

5. That the parahook (instead of the J-hook) be used as standard equipment on the CARIBOU.

6. That the snubber-snatch-block technique be used to provide the safest entry of the load aboard the aircraft.

7. That training of the crew be considered as important to the success of a pickup mission as is the pickup hardware itself.

8. That small red lights be added to the yoke tips to make them readily visible to the pilot during night operations.

Figure 5. Navy P2V NEPTUNE on Rescue Mission in North Atlantic.

(The aircraft is fitted with a yoke, intercepts the balloon supported line, lifts the man out of the raft, hauls him into the aircraft.)

INTRODUCTION

PURPOSE

The test program described in this report was conducted to determine suitability of the Fulton Air-To-Ground Pickup System for Army use.

HISTORICAL BACKGROUND

The original concept of the system was presented to the U. S. Navy in 1954 for use in long-range air-to-sea rescue work beyond the range of helicopters. After extensive testing (over 100 pickups) with a small aircraft belonging to Mr. Robert E. Fulton, Jr., of Newtown, Connecticut, the system was installed on a Navy P2V-2 NEPTUNE, and feasibility of its use was proved on a large aircraft. Figure 5 shows the Navy aircraft about to make an intercept. Figure 6 illustrates a "survivor" preparing for a pickup.

Under the title "Fulton Skyhook Aerial Recovery System" installations were subsequently made on a variety of aircraft including P2V-7's, C-45's, B-17's, P2V-5's and C-130's.

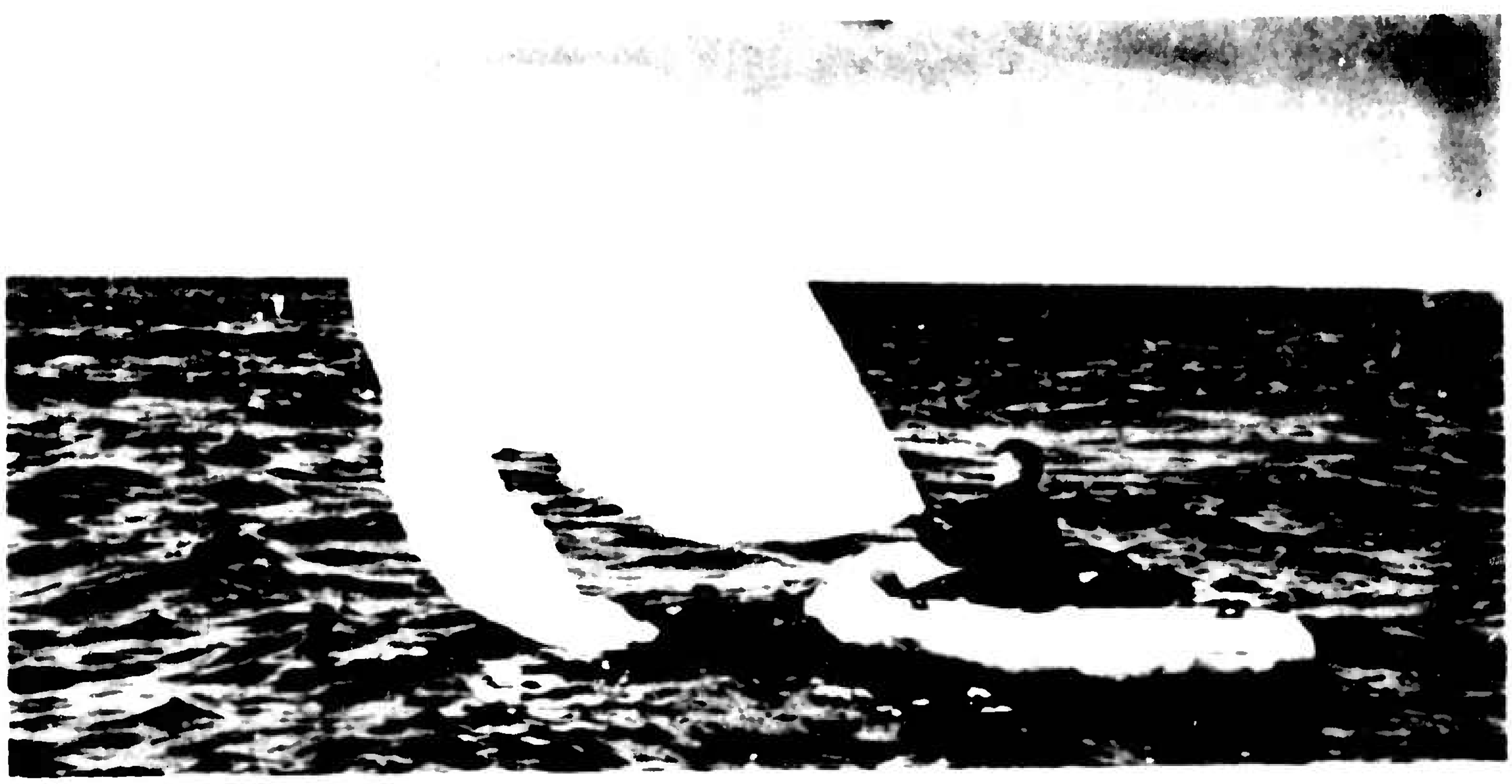


Figure 6. Inflating Balloon From Raft.

(Sea drop kit contains all necessary gear. Similar operations were included in the Army's test program.)

Figure 7. Airborne From a Raft.

(With this system, the man rises almost straight up out of the raft. The movement is so slow that it works equally well out of the water.)

Figure 8. "Survivor" Safely Winched Aboard Long-Range Aircraft Within 4 to 6 Minutes.

Extensive test programs were conducted. Over 1,000 recoveries were made using inanimate loads, animals and personnel. Pickups were accomplished at sea level out of the water, out of rafts, off the beach, out of the woods, and from mountain tops above 12,000 feet. Some of these are illustrated in Figures 7 through 9.

By means of special built-in lighting equipment, operations have been conducted in the dark. Figure 10 illustrates a 200-pound dummy being picked up at night. High above the dummy are four flashing lights attached to the lift-line. The equipment on the ground supplies the power and controls the flashing.

The system has been tested in the tropics as well as the Arctic and since 1961 has been operationally employed on scientific research projects in a number of inaccessible areas of the world.

More than 200 carefully instrumented pickups have been accomplished, proving the acceleration forces to be well within human tolerance. (See Figure 13.)

Making multiple pickups -- where two or more loads are simultaneously attached to the lift-line -- has proven an effective way to bring loads of over 500 pounds aboard an aircraft.

Figure 9. Scientists and Eskimos Preparing for a Pickup in Alaska.

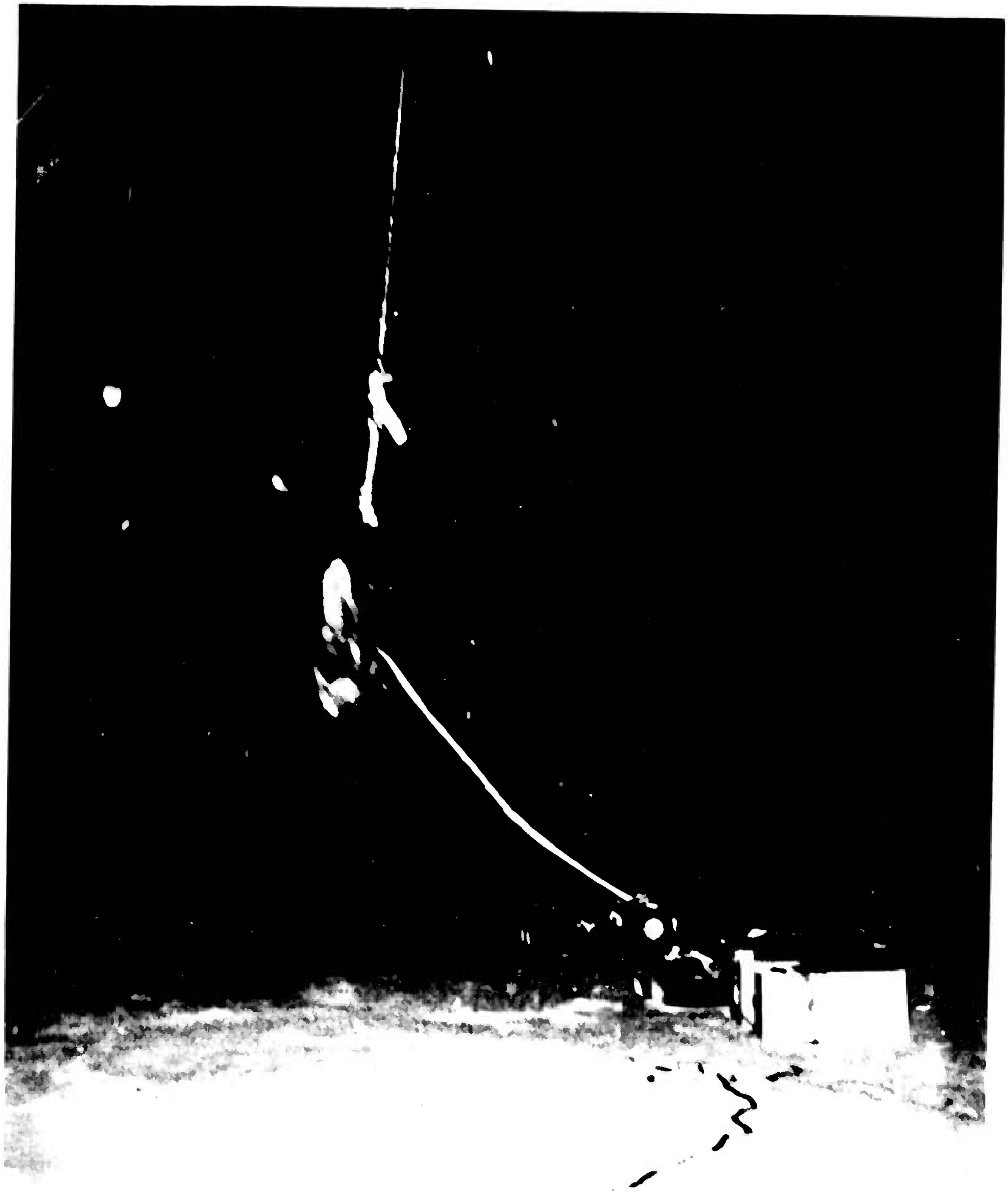


Figure 10. Night Pickup Test.

An extensive test program proved operational capability of the pickup system at high altitudes. Figure 11 shows a 250-pound load picked up from a 12,700-foot ridge, high above the tree line.

It is considered that the basic system has proven its operational capability and can be adapted to appropriate aircraft with only minor hardware modifications.

In October 1961, the U. S. Army Transportation Research Command, after evaluating several pickup systems, issued Contract Number DA44-177-TC-804 to the Robert Fulton Company for installation of one of the Fulton Aerial Recovery Systems on an Army Type CV-2 (CARIBOU) aircraft for test and evaluation purposes.

Difficulties in obtaining an aircraft with which to conduct the program caused considerable delays, and the work was not completed until January 1963.

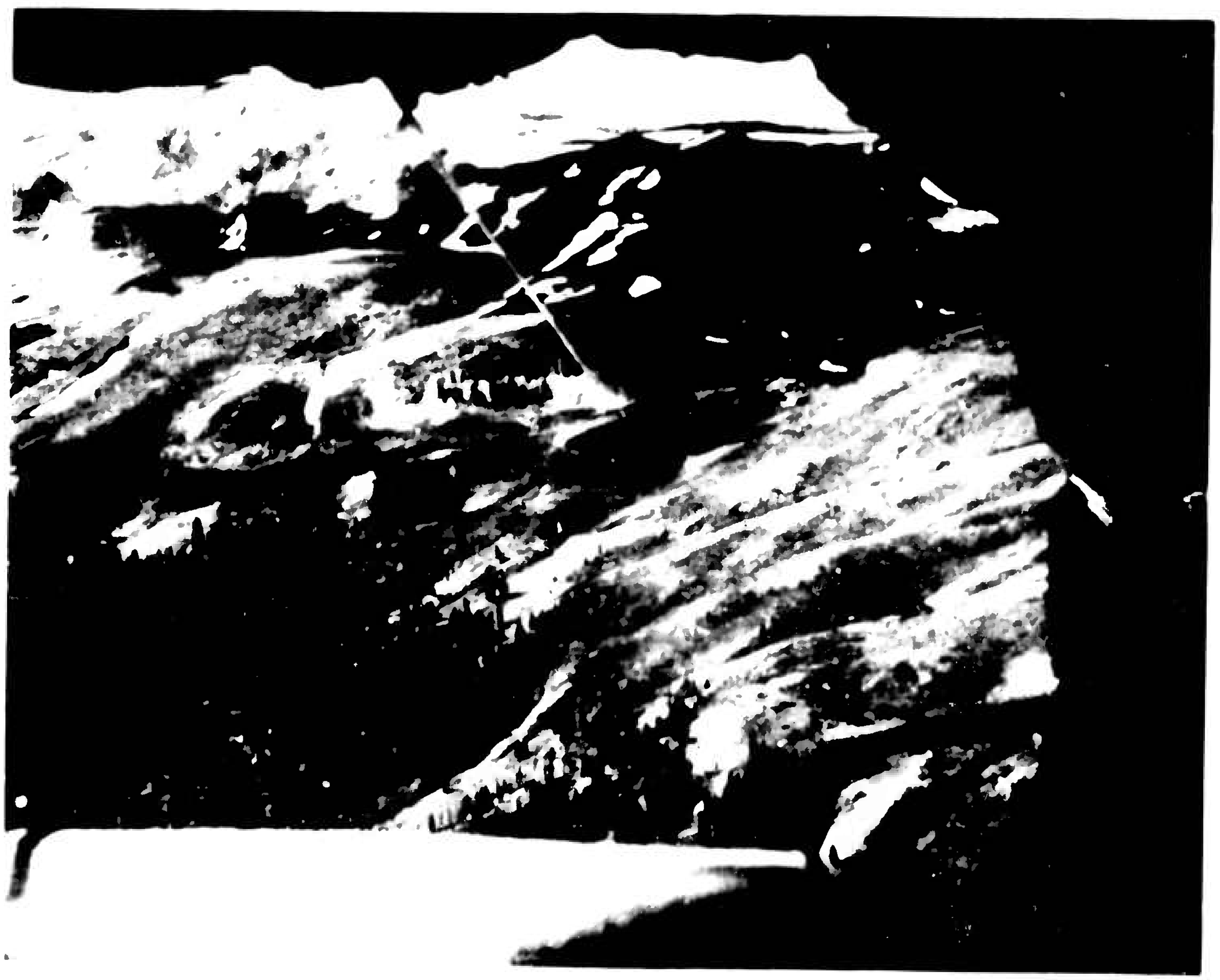
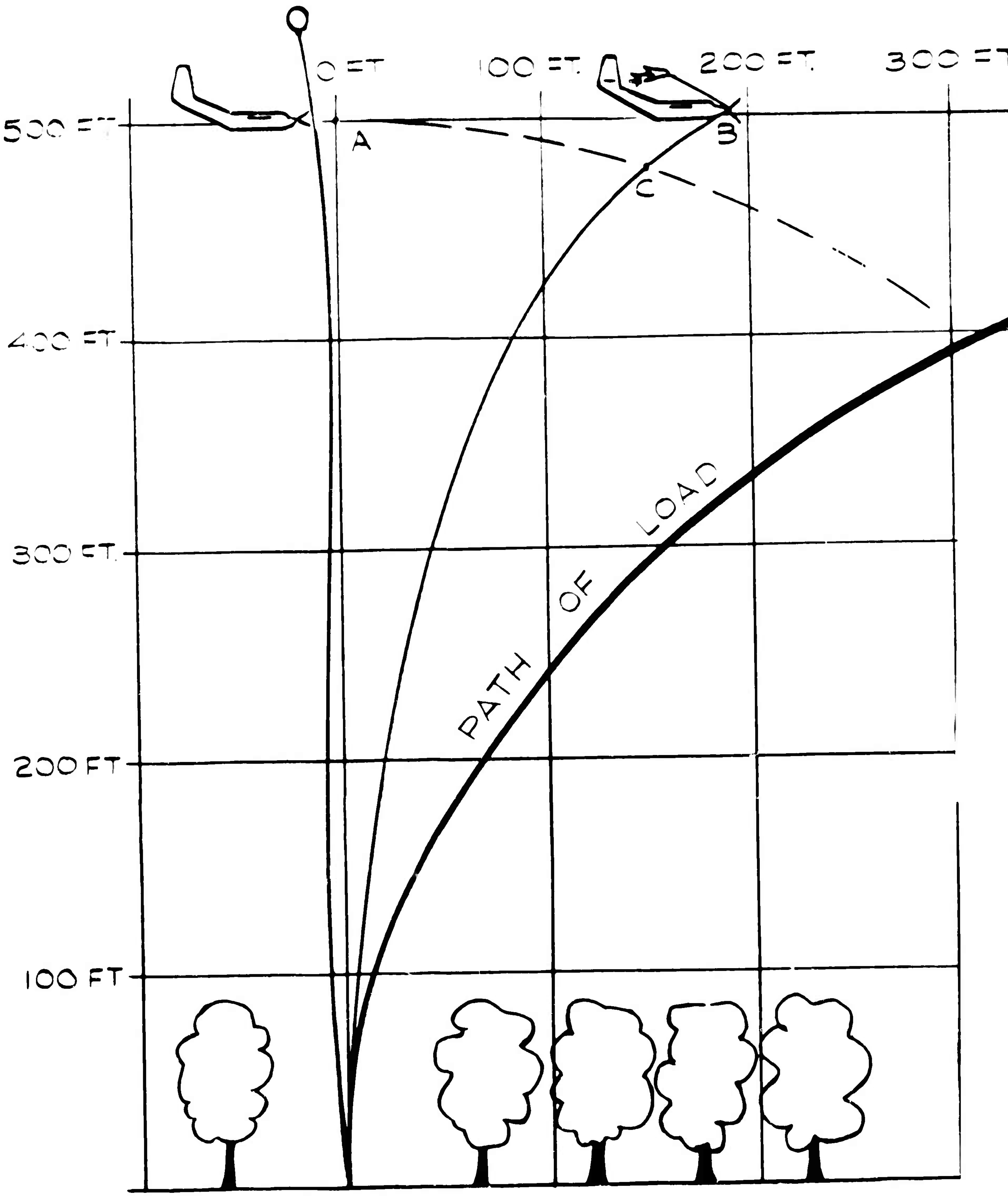
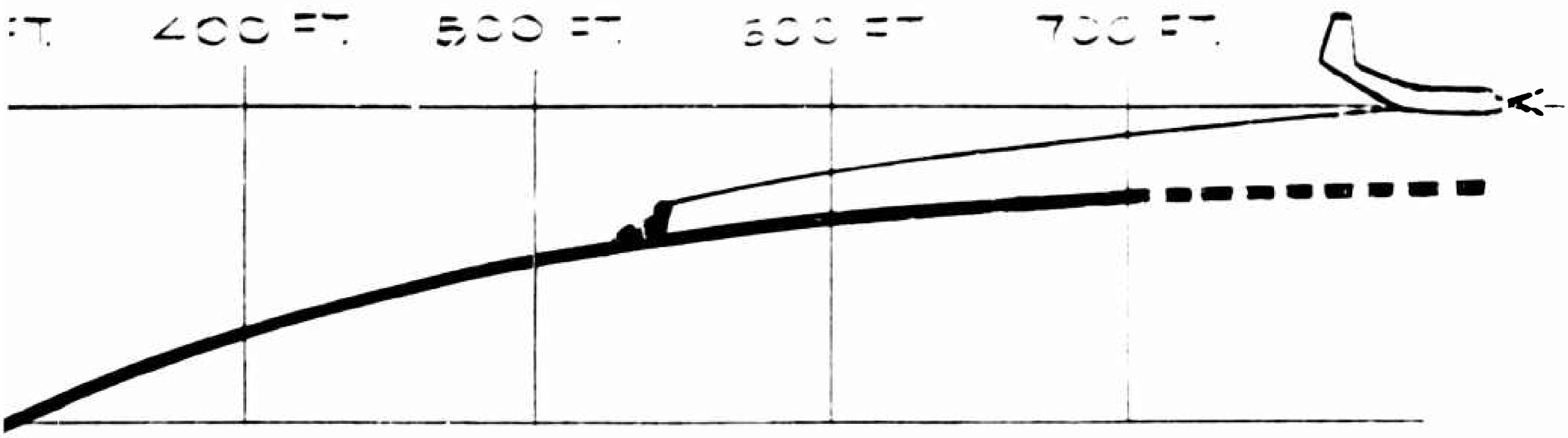


Figure 11. High Altitude Pickup



0 FT
100 FT.
200 FT.
300 FT
500 FT.
400 FT.
300 FT.
200 FT
100 FT
A
B
C
PATH OF LOAD



HOW THE SYSTEM WORKS

Designed for long-range, high-speed aerial recovery of men and materials, the system uses fixed-wing aircraft, yet achieves low G-forces by virtue of its simple geometry.

The aircraft is equipped with a "yoke", or wide fork, horizontally mounted on its nose. At an altitude of approximately 500 feet above the surface, it flies straight and level into a nylon line suspended below a balloon. Upon contact, the balloon tears loose and the line locks to the nose of the plane.

During the time that the aircraft travels from Point A (see sketch) to Point B, the man at the bottom of the line travels only the equivalent of the distance from Point B to Point C.

Thus, although the plane may be traveling at 125 knots or more, the man initially moves very slowly, gradually and smoothly accelerating until he reaches the speed of the airplane.

And since the lift-line can only pull, the initial direction of travel of the load will be vertical, only gradually becoming horizontal as the line leans over to follow the aircraft.

Attached as it is to the nose of the aircraft, the line lies along the bottom of the fuselage and is readily accessible through a bottom or side hatch. By means of a boathook it is quickly attached to a winch and the load is readily brought aboard.

The accompanying sketch was obtained directly from a motion picture of a SKYHOOK pickup. Note how the load rises 200 feet vertically before it travels 80 feet horizontally. Not only is the man safely picked up from among high obstructions, but the plane is also at a safe altitude and traveling at a maneuverable speed.

Figure 12. Geometry of the System

ENGINEERING ANALYSIS

Prior to installation of the recovery equipment in the CV-2 CARIBOU aircraft, a detailed design analysis was conducted. Determination was made regarding introduction of the pickup loads into the structure of the aircraft. Stresses were analyzed and supports and reinforcements were designed.

Complete details of this analysis can be found in "Design Analysis and Static Test Report Relating To Installation Of Fulton SKYHOOK On Army AC-1 (CARIBOU) Aircraft", which was compiled by the Robert Fulton Company under the terms of Contract DA 44-177-TC-804 with USATRECOM. (Although this report has not been published and distributed, the information is available at USATRECOM, Fort Eustis, Virginia.)

Installation of the equipment was carried out on the basis of the work described therein and its validity was confirmed by the success of the operation.

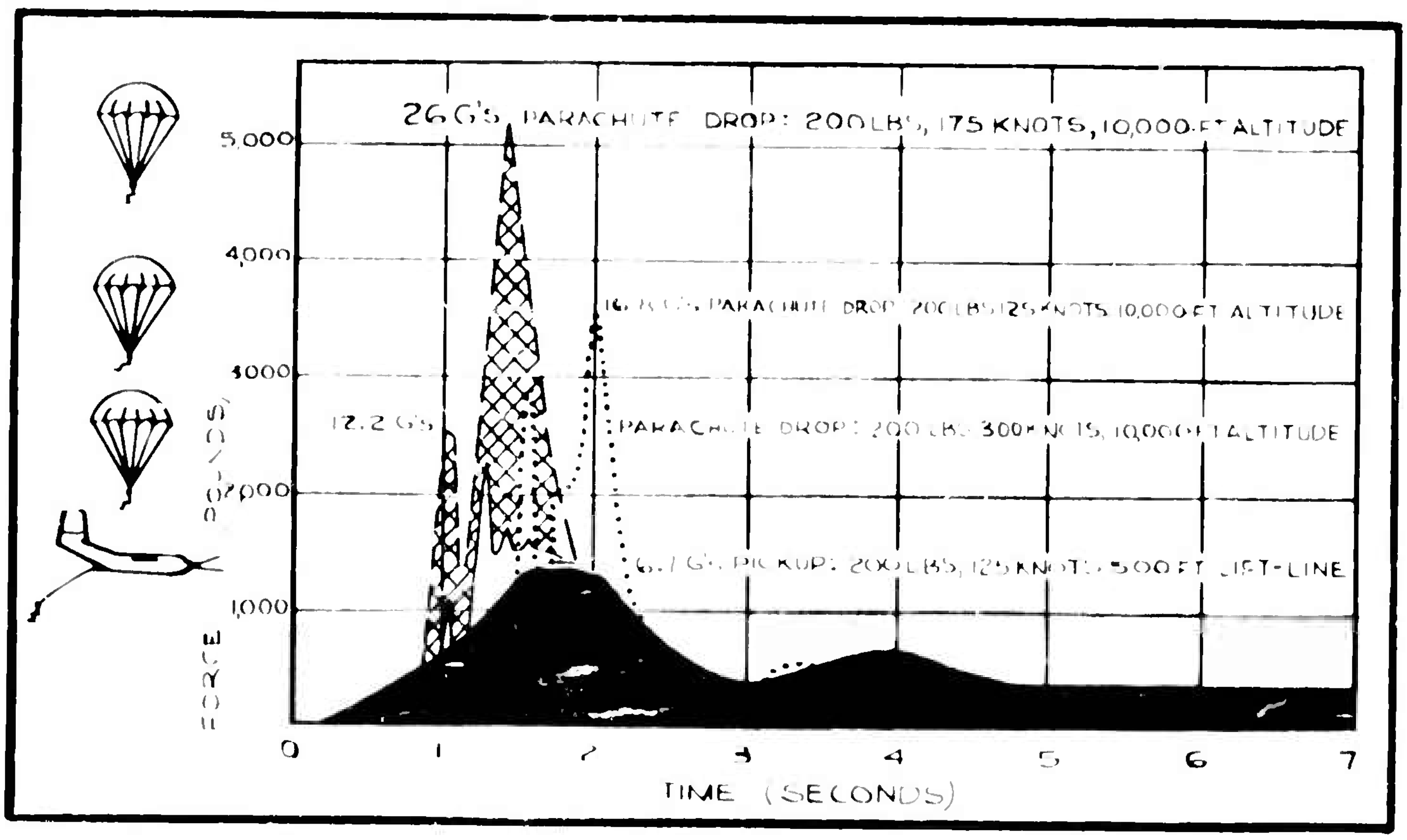


Figure 13. Comparison of Acceleration Forces Between Three Average Parachute Jumps and a Typical Pickup. (Some parachute jumps exceed 30 G's. Maximum vertical pickup force recorded was 10.5 G's, minimum 4.5; transverse and lateral G's proved negligible (below 2 G's) - Note that parachute jumps all exceed time duration of pickup at its peak acceleration level.)

DESCRIPTION OF EQUIPMENT

GENERAL ARRANGEMENT

The equipment used to perform aerial pickups with this system falls into two catagories:

1. Aircraft Components
2. Drop Kit Components

The former are items attached to the aircraft to give it the pickup capability and vary slightly according to the type of aircraft. The latter are items used by ground personnel who are either to be picked up themselves or who have inanimate loads to be picked up; these vary according to the recovery operation, whether it is from land or water, by day or night. Figure 16 (page 27) illustrates the location and use of the equipment.

AIRCRAFT COMPONENTS

Yoke

The yoke is a V-shaped structure attached to the nose of aircraft and guides the lift-line into a locking device located at the center of the V. It is constructed of chrome molybdenum steel tubing and is 26 feet wide across the opening of the V.

Skyanchor

The skyanchor is a locking device located at the apex of the V formed by the yoke. It locks the lift-line to the nose of the aircraft by winding the line around a shaft. A powerful main spring rotates the shaft. Ratchets prevent the line from unwinding when the pickup load is applied. Cocking and "charging" the skyanchor are accomplished electrically by controls located within the aircraft. "Firing" occurs automatically as a result of lift-line impact against the skyanchor's trigger.

Defelction Lines

A deflection-line extends from each tip of the yoke to the wing tips. If the pilot should fail to catch the lift-line in the yoke, the deflection-line guides the lift-line around the wing tips thus enabling the pilot to make another approach. The deflection-line is a special combination of phosphor-bronze wire with a braided nylon outer covering.

Reel-In Winch

The reel-in winch is mounted on the floor of the aircraft just forward of the aft opening. The winch is capable of hauling a 300-pound load on the end of a 500-foot line into the airplane in approximately 3 minutes. It is electrically driven and obtains its power from the aircraft's electrical system.

Miscellaneous Recovery Equipment

The recovery operation also requires a few pieces of miscellaneous hardware. A pulley is mounted overhead on an A-frame in the cabin and two cleats and a snubber-block eye are screwed to the floor. A fairing is attached to the tail ramp to eliminate its sharp edges. The recovery crew employs a J-hook, a snatch-block, and two line clamps (called "anchor clamps") to transfer the lift-line from the nose of the aircraft to the winch.

Emergency Load Handling Equipment

In case of power or winch failure within the aircraft, three alternate methods of handling the load are available: (1) a hand crank to operate the winch, (2) block-and-tackle equipment to haul in the load, and (3) a parachute to put down the load.

DROP KIT COMPONENTS

Land Drop Kit

Two containers hold the helium bottles, harness, balloon, and lift-line required for the ground end of the pickup operation. Each container is a conically shaped, heavy canvas bag suitably reinforced with webbing and shockproof padding. Zippers provide access to the inside. Figure 14 illustrates a land drop kit.

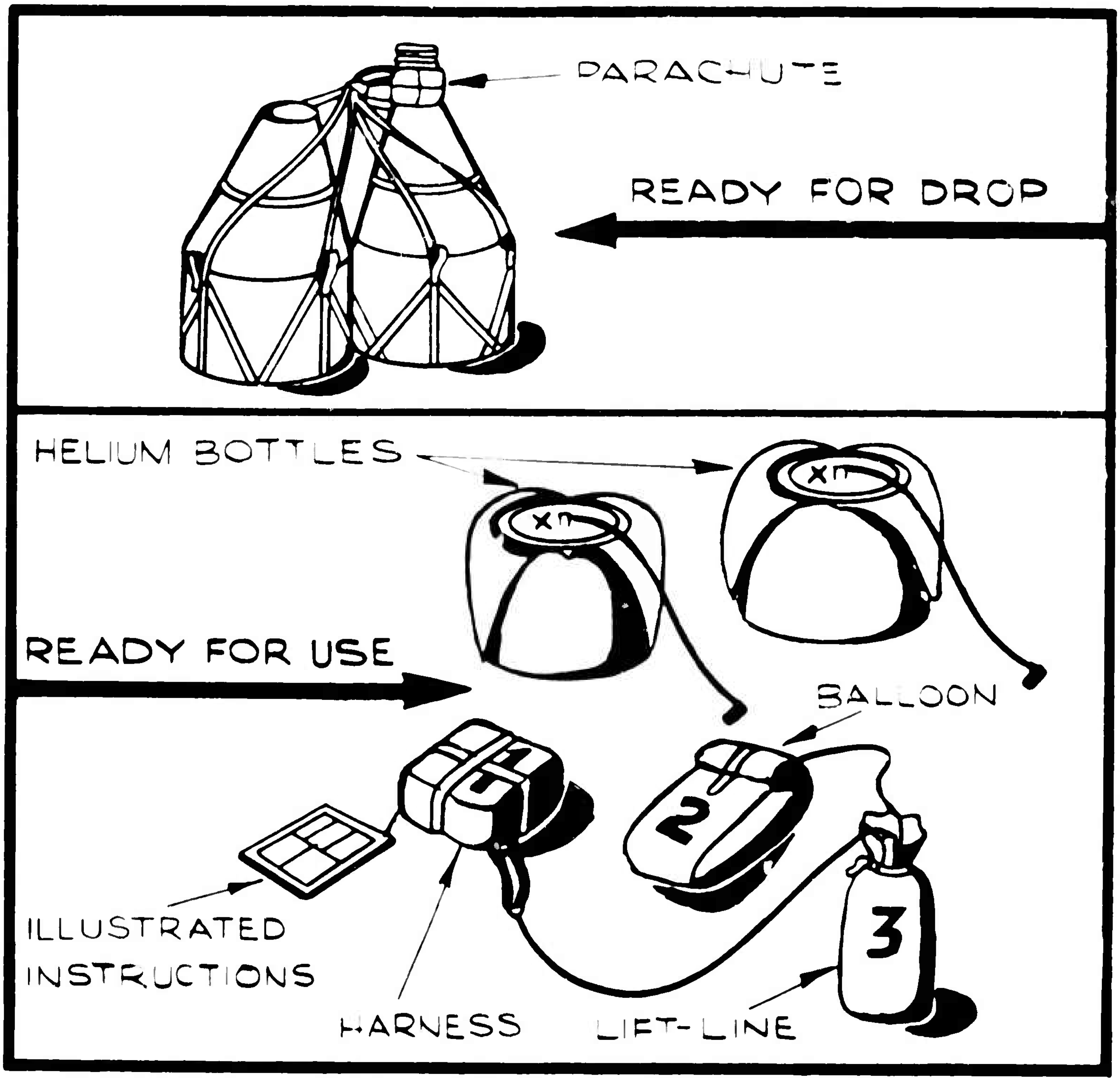


Figure 14. Land Drop Kit

(Items are numbered in their order of use.)

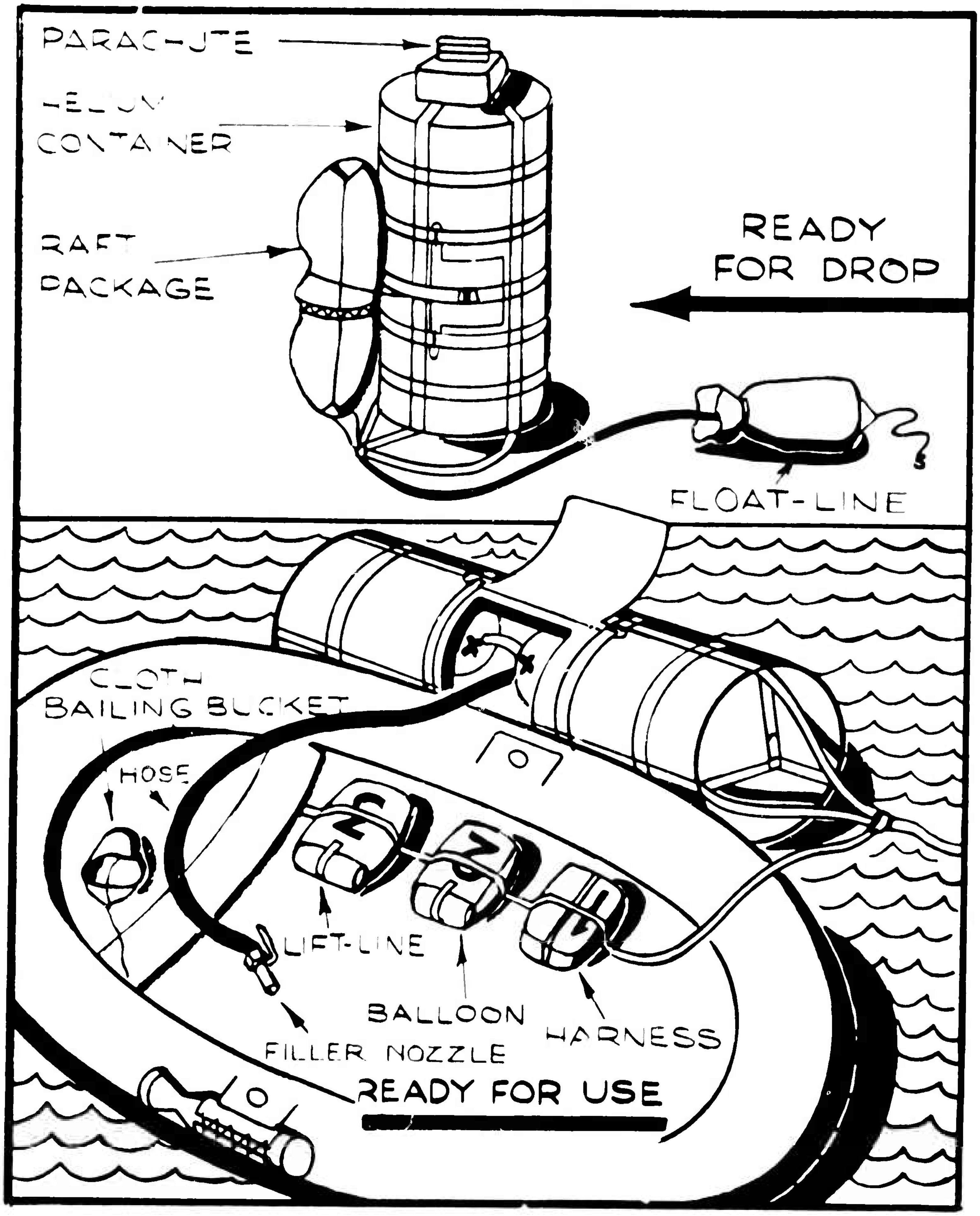


Figure 15. Sea Drop Kit.

(All items are attached together for easy handling. A cloth bailing bucket is also provided.)

Sea Drop Kit

A sea drop kit consists of a single floatable container housing the helium supply and an attached raft-package containing a raft, a pickup harness, a balloon, and a lift-line. The helium supply container is constructed of polyvinylchloride reinforced with a web harness. The raft package is contained in a rubber cover and tightly secured in a quickly releasable harness. All items are secured together so they cannot drift apart or fall overboard and sink. Figure 15 illustrates a sea drop kit.

Pickup Harness

The pickup harness functions essentially as a parachute harness. Its design, however, differs in two important respects. First, it is integrated into a wool-back nylon suit which makes the harness much easier to put on and provides protection against the wind and weather while its wearer is being winched up to the aircraft. Second, it automatically adjusts to the size of the wearer. Channels in the suit permit the webbing to slide and adapt itself to the occupant, whether he be 5 feet or 6 feet 6 inches tall. Four risers terminate in a D-ring above the wearer's head, and the lift-line is snapped to the D-ring.

The person being rescued is assumed to be wearing clothing appropriate to the local environment and the harness suit is designed primarily to ward off the air blast. A sheepskin lined hood is permanently attached and is trimmed with fur. A hard helmet is worn under the hood.

Four pockets are provided to hold a flashlight, a pocket knife, a transistorized switch, and a power supply. The latter two are used to operate lights on a night lift-line. The pickup harness is packaged in a canvas bag with instructions on the outside of the bag. For sea operations, the canvas bag is enclosed in a polyethylene bag and sealed with tape to make it waterproof.

Balloon

The balloon supports the lift-line and is aerodynamically shaped for stability in high winds. It is constructed of heat-sealed polyethylene and requires 680 cubic feet of helium for full inflation. In its deflated state, the balloon is packaged in a canvas bag.

Helium Storage Bottle

Two helium storage bottles are required to inflate the balloon. They are housed in the drop containers as shown in Figures 14 and 15. Each is constructed in a spherical shape by running fiberglass filament coated with an epoxy resin around a rubber liner. A bottle will hold 400 cubic feet of helium gas at a rated pressure of 4,000 psi. Each bottle is equipped with a valve and hose assembly which is plugged into the balloon during the filling operation.

Day Lift-Line

The lift-line is made of tubular nylon cord with a breaking strength of 4,000 pounds. Secured to the line are three items: (1) A 5,000-pound snap is spliced onto the bottom of the line for attachment to the load. (2) A 35-foot extension cord is secured to the top of the line for attachment to the balloon. (3) A large, red, Mylar marker is attached to the line 25 feet below the top. Two smaller markers are attached at 25-foot intervals below the large marker. These markers aid the pilot during his approach.

The top 100 feet of the lift-line is increased in strength from 4,000 pounds to 5,000 pounds. This is accomplished through a 20-foot tapered length. The bottom 25 feet of the line is dyed international orange. The overall length of the lift-line is 500 feet. It is packaged in a canvas bag with a log sheet. Each line bears a serial number adjacent to the bottom snap, and the log sheets are numbered accordingly.

Night Lift-Line

In addition to the items attached to the day lift-line, the night lift-line is equipped with an electrical connector at the bottom, three internal wires, and four small stroboscopic lights. The lights are attached to the line at 25-foot intervals starting 5 feet below the top of the line. The lights flash in unison about twice a second.

Lighting Equipment

The lighting equipment is used with the night lift-line and consists of a power supply and a transistorized switch unit. Each unit is approximately 3 inches by 5 inches by 8 inches. The power supply is a sealed unit providing energy to the switch unit and capable of operating the four lights attached to the line for more than one hour. The switch unit is also sealed and has an external ON/OFF switch and a cable to connect it with a receptacle located at the bottom of the night lift-line.

Float-Line

A float-line is included with sea drop kits and is constructed of polypropylene material braided into a hollow cone. The line is spliceable and is 500 feet long. A snap on one end hooks to the sea drop kit. The other is secured to a nylon sea anchor which helps it to stream across the water.

The line is supplied in a special canvas bag with a reinforced bottom, a tie-line secured to the bottom, and a closing strap at the top. When the kit is dropped, the float-line comes out of its canvas bag and spreads across the water. This makes it easy for the survivor in the water to reach the kit.

DIMENSIONS AND WEIGHTS

TABLE 1

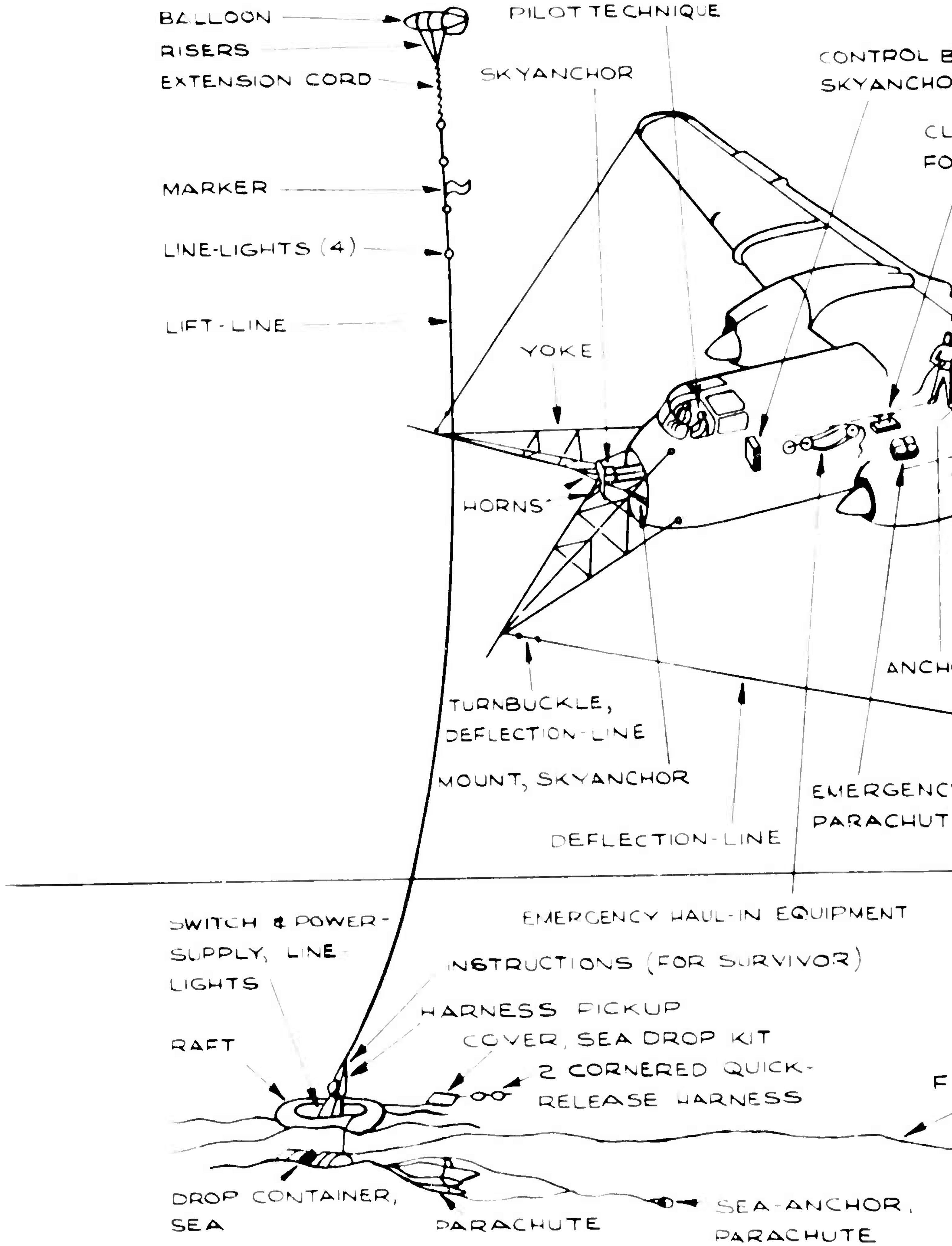
AIRCRAFT COMPONENTS

Item	General Dimensions	Weight (lbs)
Yoke	26-ft wide opening 21-1/2 ft long	148
Mount Yoke	29-3/4"x6-1/4"x4-1/4"	26-1/2
Skyanchor	54"x9-1/2"x7-1/2"	127-1/2
Control Box, Skyanchor	12"x7"x3-3/4"	3-1/2
Deflection System	40 ft long	12
Winch, Palletized	33-1/4"x28"x17-1/2"	200
Cleat Bar (2 req'd)	26"x2"x3"	6-3/4
Pulley, Overhead	12-3/4"x4-1/2"x4-1/2"	2-3/4
Snubbing Block	2-1/2"x1"x1"	1/4
Ramp Fairing	10"x12"x61-1/4"	44
Parahook	18"x12"x6" with 30-ft line	26
Anchor Clamp	10-3/4"x4-1/4"x1" with 15-ft line	2
Snatch-Block	5"x3"x2-1/2" with 20-ft line	2
A-Frame	7 ft	30-1/2

TABLE 2

DROP KIT COMPONENTS

Item	Overall Dimensions	Weight (lbs)
Drop Container, Land Including Helium Bottle (2 Containers Req'd For 1 Land Drop Kit)	46-1/6 in. high 22 in. dia	87
Drop Container, Sea	49 in. long 25-1/2 in. dia	180
Raft Kit (Complete With Raft, Harness, Balloon and Lift-Line)	20"x14"x4"	106
Harness, Personnel Pickup	7-1/2'x6'	14
Balloon (680 cu ft)	22'x7-1/2'x7-1/2'	12
Lift-Line, Day	500 ft long	19
Lift-Line, Night	500 ft long	20
Transistorized Switch Night Lighting	3"x5"x8"	5
Power Supply Night Lighting	3"x5"x8"	6
Float-Line	500 ft long	9



BALLOON
RISERS
EXTENSION CORD
MARKER
LINE-LIGHTS (4)
LIFT-LINE
PILOT TECHNIQUE
SKYANCHOR
CONTROL B
SKYANCHO
YOKE
HORNS
TURNBUCKLE, DEFLECTION-LINE
MOUNT, SKYANCHOR
DEFLECTION-LINE
ANCH
EMERGENC
PARACHUT
EMERGENCY HAUL-IN EQUIPMENT
SWITCH & POWER-SUPPLY, LINE-LIGHTS
INSTRUCTIONS (FOR SURVIVOR)
HARNESS PICKUP
COVER, SEA DROP KIT
2 CORNERED QUICK-RELEASE HARNESS
RAFT
DROP CONTAINER, SEA
PARACHUTE
SEA-ANCHOR, PARACHUTE

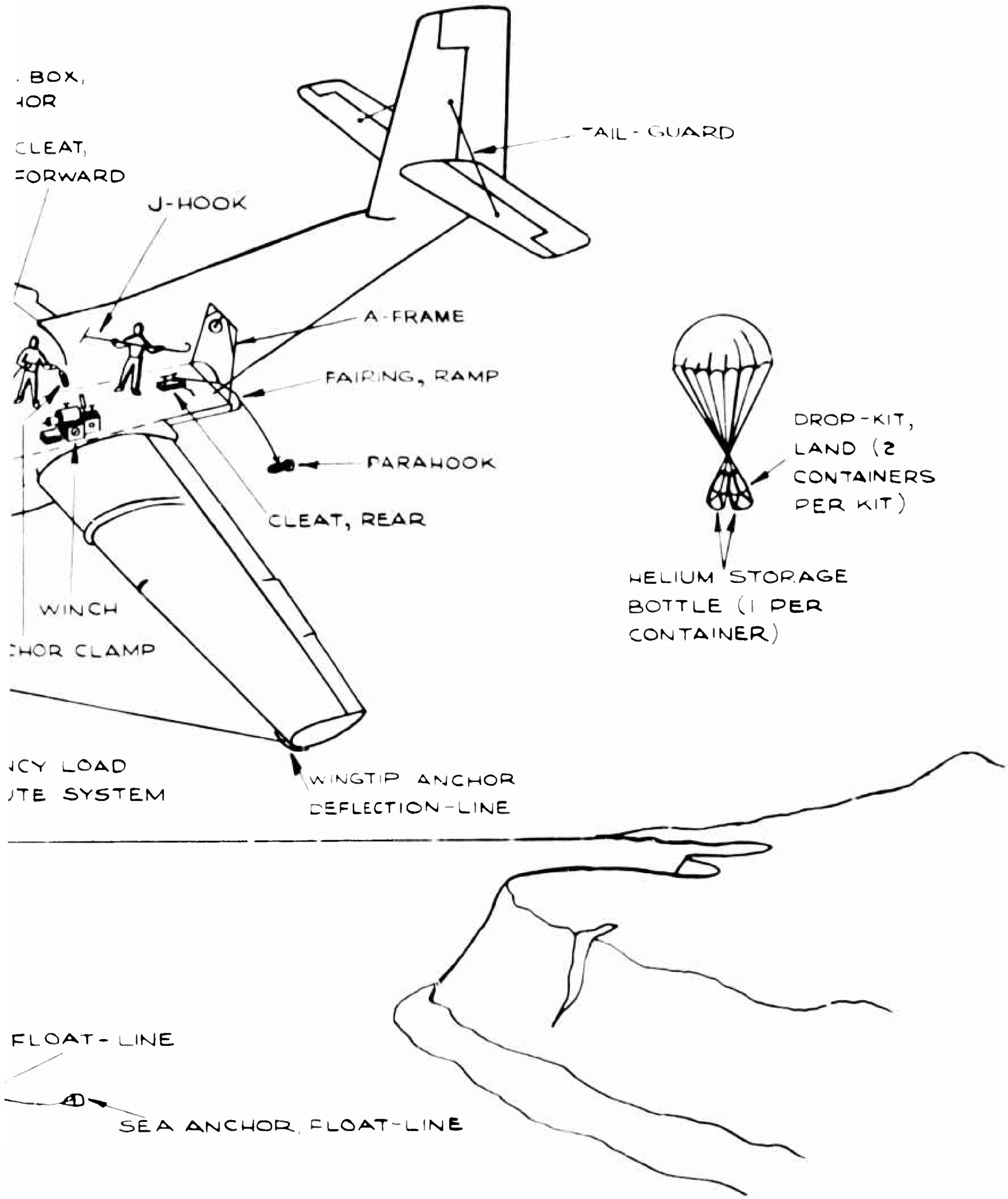


Figure 16. Pictorial Index of Equipment.

EFFECT OF EQUIPMENT INSTALLATION ON AIRCRAFT CENTER OF GRAVITY

Installation of the recovery system's aircraft components results in a slightly forward movement of the aircraft's center of gravity. The exact amount will depend upon the configuration and gross weight of the individual aircraft and can readily be computated using Chart E of the Type CV-2 (CARIBOU) Aircraft Manual wherein the datum line is considered to be 310.0 inches ahead of the leading edge of the wing.

Total weight of the equipment is 688.47 pounds applied at an arm of 258.22 inches aft of the datum (with a resulting moment of 177,778.81).

Table 3 gives a breakdown for the individual components.

Drop kit components are not included in the computation since they will vary in number, configuration and weight with the mission and are not fixed to the aircraft.

TABLE 3

WEIGHT AND BALANCE INFORMATION RELATING TO INSTALLATION OF AERIAL PICKUP EQUIPMENT ON ARMY TYPE CV-2 (CARIBOU) AIRCRAFT

(Based on Datum Line Located 310.0 Inches Ahead of Leading Edge of Wing, Per Chart E of CARIBOU Manual)

Item	Arm	Weight (lbs)	Moment
Yoke	41.30	148.00	6,112.40
Horns	46.60	17.50	815.50
Spacers and Shims for Horns .	54.00	9.00	486.00
Plate, Front, Strike	55.00	5.47	300.85
Skyanchor	81.50	127.50	10,391.25
Beam, Skyanchor Supporting ..	71.10	17.00	1,208.70
Frame, Beam Supporting	81.00	11.00	891.00
Shaft, Frame Supporting, Nose Gear, (and Bushings)	89.75	3.50	314.12
Fairing, Nose, Fiberglass			
(After)	(79.50)	(15.00)	(1,192.50)
(Before)	(86.00)	(9.00)	(774.00)
Resultant Change	69.75	6.00	418.50
Control Box, Skyanchor	194.80	3.45	672.06
Power Line, Control Box to Skyanchor	125.00	3.60	450.00
Deflection Lines (and Turnbuckles)	150.00	12.00	1,800.00
Wing Tip Guards	305.00	4.25	1,296.25
Winch, Drum and Oil, and Mounting Plate	455.50	200.00	91,100.00
Fuse and Mount in Relay Box .	195.00	.50	97.50
Power Line, Winch	345.00	28.65	9,884.25
Cleat Bars (Forward)	340.00	6.75	2,295.00
(Aft)	500.00	6.75	3,375.00
Pulley, Overhead	593.25	2.75	1,631.43
Fairing, Ramp	596.25	41.60	24,804.00
A-Frame	587.00	30.50	17,903.50
	257.00	685.77	176,247.31

TEST PROCEDURES AND CONTRACTOR'S OBSERVATIONS

GENERAL

During the test program, sixty-four operations were conducted. Fifty-seven of them used dummy loads, seven were personnel pickups. Of this total only twelve were unusual in any way. The remaining fifty-two were routine for this system, the load rising essentially vertically to a height of from 50 to 150 feet, then gradually arcing to follow the aircraft.

Based on past experience, the acceleration force averaged between five and eight G's with a maximum duration of 1/2 second.

The following are contractor's observations regarding these tests, with particular emphasis on their unusual aspects:

OBSERVATION 1. PROPER USE OF BALLOONS

Two catagories of balloons are available for use with this pickup system: aerodynamically shaped balloons and unaerodynamically shaped balloons. Configured like small dirigibles, the former have good static lift in a calm as well as aerodynamic lift in a wind. They also have good stability, pointing directly into the wind and having little tendency to oscillate.

While the unaerodynamically shaped balloons (most often round) also have good static lift, they behave badly in any wind over 12 knots, tending to "excursion" back and forth and to lie down.

Figure 12 in this report indicates that the high trajectory of the load, when picked up by this system, is a result of the geometry of the system. If the balloon permits the line to lie down below 45 degrees, both the acceleration force applied to the load and the trajectory of the load will be materially affected. The line will also be considerably more difficult for the pilot to intercept. Since the unaerodynamic balloons are apt to cause this condition, their only material advantage is their cheaper cost--about half that of the dirigible type.

Both types were used during this test program and the comparative performance was obvious.

It is the purpose of this observation to emphasize that round balloons should not be used in winds over 10 knots and that they should be used for training purposes only. Only in an extreme emergency and calm wind should they be used for operational purposes. Dirigible balloons will permit performing rescues in winds as high as 35 knots.

It is important that user personnel understand these facts and their bearing on the success of an operational mission.

OBSERVATION 2. EFFECT OF AIRSPEED ON LOAD ACCELERATION FORCE AND TRAJECTORY

The slower the pickup airplane flies, the less will be the acceleration force, but also the lower will be the load trajectory.

This was forcefully demonstrated during the early part of the test program. Unbeknown to the pilot, the ground crew placed the load very close to the trunk of a tree in an effort to observe its vertical travel. Simultaneously, the flight crew decided to test a very slow-speed intercept. The exceptionally slow-speed capability of the Caribou easily permitted it to be flown at 75 knots. In addition, there was a 15-knot wind blowing, further reducing the ground speed to 60 knots. The standard 500-foot length of lift-line was used.

The result was that instead of swinging slightly backward and following the initial angle of the lift-line, the load slowly rose upward into the branches of the tree which hung over it. There it lodged until the line tension built up enough to tear it loose. This meant that the line was excessively stretched. Consequently, the load was released like a shot and oversped the aircraft. Being thus unsupported, it fell, struck and tangled in another tree, and was again shot into the air. After this, it struck open ground and was then lifted clear by the aircraft.

Aboard the aircraft, the only noticeable effects were that a thud was felt and that the lift-line could not be released from the skyanchor. After the line was secured in the aft station, the fouled end of the line was cut and the load was brought aboard in normal fashion. It was later found that the excessive line tension had wedged the lift-line into the crack of the aircraft's nose wheel door.

The above described operation was the result of a lack of coordination among the personnel involved as well as a lack of understanding of the system.

A subsequent series of tests undertook to determine the effect of aircraft speed on load trajectory and G-force. A 35-foot pole was erected and the loads were placed downwind of the pole. The aircraft flew at various speeds at right angles to the pole. Motion picture cameras recorded the path of the load.

Tests were made at ground speeds of between 80 and 125 knots. A ground speed of 105 to 110 knots provided a vertical rise in excess of 50 feet which was considered to be satisfactory. Loads from 3.5 to 7 G's were experienced, the higher readings corresponding to the higher air speeds.

It is this contractor's opinion that these tests were too meager to cover the parameters of the condition. Too few tests were conducted. Due to the partial use of round balloons, the lift-lines lay at such varied angles that the trajectories cannot rightly be compared. The length of the lift-line was consistently 500 feet.

It is our observation that a good combination of acceleration force and load trajectory can be obtained, taking advantage of the Caribou's remarkable ability to fly as slowly as 65 knots, by shortening the length of the lift-line. Since it is possible that this might have advantages for certain types of operational missions, it is felt that this subject should be further investigated.

OBSERVATION 3. BOARDING TECHNIQUES

In the early stages of the tests, it was noted that when the load was being brought aboard, it sometimes struck the ramp edge or, if the load was unstable, it struck the side of the door frame. Some of the difficulty lay with the aerodynamic character of the loads and some with the air turbulence around the opening of the cargo doors. Various angles of the ramp and various air speeds were tried. Slower speeds improved the situation but did not entirely eliminate it.

An A-frame was jury-rigged in the aft station so that the overhead pulley was positioned above the ramp edge. This appeared somewhat to improve the load-landing characteristics, so a refined version of the A-frame was fabricated and installed.

At this time, a smoothly curved, fiberglass fairing was also attached to the rear face of the ramp. This unit could be installed or removed while the aircraft was in flight. It covered the sharp edges which could be uncomfortable to a person being brought aboard.

Neither of these solutions, however, completely eliminated the problem, since the load was still free to swing about and, if the period of oscillation was just wrong, to crash against the fairing.

As any boxer will attest, the way to avoid getting hit is not to move a few inches further away from his opponent but to move closer, so close in fact that he is right against his assailant--hence the clutch. In this case it merely meant the addition of a snubbing pulley to retain the lift-line close against the ramp fairing and always at the center. This automatically forced the load to come to the center and then slide smoothly over the ramp and come aboard the aircraft.

It is this contractor's observation that use of the snubbing pulley is an entirely adequate and simple solution to the boarding problem. It also renders the A-frame redundant, for it is easier to operate the system with the overhead pulley in its original position (at the aft static line anchor point rather than at a more rearward position). If it is felt that the A-frame had advantages as a handhold, better grips can be designed.

OBSERVATION 4. LIVE PICKUPS

A total of six personnel pickups was made during the engineer and user tests. (A seventh "demonstration" live pickup was performed immediately thereafter at Special Forces Headquarters, Fort Bragg, North Carolina.

Five military personnel associated with the project volunteered and were picked up "without a scratch".

The project officer of the U. S. Army Airborne, Electronics and Special Warfare Board for the air-to-ground pickup system was picked up twice.

In watching the aircraft approach for his first pickup, he leaned his head back to the extent that his helmet passed between the risers of the pickup harness. When the pickup occurred, the tension in the risers held his head back until he reached up and spread them to release the side pressure and was thus able to return his head to a normal position.

Slowly, he spun around three times and then stabilized facing aft. It took just under 6 minutes to bring him aboard the plane. He felt no ill effects and stated that the G-loading was negligible. On his second ride, he found that if he held his head forward there was much less tendency to spin just after intercept.

To gain personal experience at both ends of the system, three members of the flight crew volunteered. The pilot who flew most of the operations and two of the aft station recovery crew were picked up.

Simulated Operational Pickups

Two of the personnel pickups were intended to be simulated operational missions, one from land, one from sea.

Pickup From Land

For the land operation the kit was assumed to have been dropped. The man to be picked up unpacked the gear and prepared himself without assistance. He donned the pickup harness, inflated the balloon, attached the lift-line, and was ready for pickup in 22 minutes.

The pickup was entirely normal. Some turbulence was experienced during the final boarding stage, but the man landed on the ramp without discomfort. (The snubber block was not used in this case. It is strongly recommended that it be used at all times.)

Pickup From Sea

A sea drop kit was released from the aircraft but the parachute failed to open when the raft-package fouled the static line due to improper layout of the equipment prior to drop. The resultant free fall damaged one gas bottle, but the bottle did not rupture. Both bottles were discharged and condemned for future use.

The "survivor" in the water (near the Marine Corps Air Station, New River, North Carolina), swam to the drop equipment, inflated the life raft, climbed aboard, donned the pickup harness and released a balloon with attached lift-line. The balloon was inflated from a helium tanker on the dock since it was considered inadvisable to handle any more than necessary the helium bottles that crashed into the water.

The pickup was normal except that the "survivor" was soaking wet and barefooted (to facilitate swimming). The harness kept him warm except for his exposed feet which stayed wet as the water drained off the harness. The ambient temperature was approximately 55°F.

For sea operations, the personnel pickup harness, the balloon and the lift-line, in addition to being packed in their own individual canvas bags, are normally wrapped and sealed in polyethylene bags. This was not done in this case but should be considered normal operating procedure.

Comments Of Picked Up Personnel

All personnel picked up concurred that the G-forces were lighter than those encountered in parachute jumping, that there was no problem in breathing, and that they enjoyed the ride.

All agreed that the crash helmet which they wore under the hood was unnecessary. They felt that the heavy sheepskin lining in the hood itself supplied ample protection. Some felt that the fur trim on the hood hindered their seeing while being towed behind the aircraft.

Several made the comment that they were uncomfortably warm in the harness waiting for the pickup to occur. In most cases the cuffs of their arms and legs were taped to prevent flapping. They were also provided with a two-way radio so that they could talk to the aircraft. The combination transmitter-receiver was packed in a roll and strapped to their waists. The microphone was strapped to their mouths with adhesive tape--a most uncomfortable condition. Earphones were incorporated in the helmets.

Furthermore, each wore a parachute. This involved putting on a standard parachute harness over the pickup harness. Since a parachute harness must be snugly fitted to the wearer, the normally somewhat loose pickup suit became tightly strapped to their bodies. With the heavy parachute added on top plus the warm weather and bright sun, it is not surprising that they were uncomfortable.

Contractor's Observations Regarding Live Pickups

A total of 21 live pickups have been made with this system with consistently successful results. As a result of the comments of those picked up during this test program and others, this contractor concurs that the crash-helmet is unnecessary. However, he recommends that the hood be slightly modified, reducing it in size (since it will no longer be worn over a bulky helmet) and incorporating within the lining (behind the sheepskin) a cushioning material (such as polyvinylchloride).

There is no necessity to tape the pickup suit onto the wearer's arms and legs. Heel straps are provided to prevent the legs from riding up and, by closing the zippers on the sides, the legs narrow down to a comfortable fit at the ankles. Internal cuffs provide a good fit at the wrists. It is not only unnecessary but it would also be impractical to expect a survivor to go through such taping operations prior to being rescued.

The pickup harness is undoubtedly warm when worn as described above. However, is it not better to be too warm than too cold? The soldier picked up soaking wet might have been seriously chilled had the coveralls been less warm. Night operations also require more temperature protection than those in the bright sun.

The present material was selected in order to make the harness as universally useable as possible. This contractor feels that it is satisfactory for all except extremely cold conditions. For Arctic operations a silicon rubberized material is used.

This contractor does not favor the use of a parachute for personnel pickups. There is too much possibility of the parachute being accidently deployed and the survivor failing to survive because of a device mistakenly intended to save him. While the aircraft pulled at him in one direction, the parachute would tug the other way. Either or both could give way with disasterous results when nothing was the matter in the first place.

The maximum pickup force occurs when the man is between 50 and 150 feet off the ground. If the pickup line were to fail at this point, there would not be time or space for the parachute to deploy. If something went wrong inside the aircraft and it became impossible to winch the man aboard, a standard emergency put-down procedure is available whereby a parachute can be rigged to the top of the lift-line and the man safely parachuted back to earth using a static line deployment system.

A good walkie-talkie for use of the survivor on the ground to talk to the aircraft is considered essential. Its use during the reel-in operation is impractical. It has been tried several times without success. Wind-noise is too great and even throat microphones taped to the lips are not satisfactory.

Furthermore, once the man has been picked up and is in tow, there is no need for conversation between him and the airplane. All the rest is being done for him and the imperfect signals which he emits might well be misunderstood and lead to trouble. A small, hand-held walkie-talkie, without encumberance of the microphone or earphones, should be sufficient for the rescue operation. Lack of a closely fitting helmet (requiring built-in earphones) also makes such a simple radio satisfactory.

<u>Recap Of Contractor's Observation Pertaining To Live Personnel Pickups.</u>

1. Do not use a crash helmet, but do modify the pickup suit's hood to reduce its size and incorporate built-in padding for head protection.

2. Permit the "survivor" to use the pickup harness as it is, without additional taping or securing it to his person.

3. The present pickup harness material (woolback nylon) is satisfactory. A less warm material would frequently prove unsatisfactory and seriously complicate the logis-

tic's problem by requiring an additional weight of suit.

4. Do not use a parachute when making personnel pickups. It is more of a hazard than a safety precaution.

5. A good walkie-talkie should be provided in each drop kit for communication while the man is on the ground and the aircraft is preparing to accomplish the pickup. There is no need for further conversation between the survivor and the airplane once the pickup has been accomplished.

OBSERVATION 5. LINE RECOVERY PROCEDURE

During the test program, a number of instances were encountered where the aft station crew had difficulty getting hold of the lift-line streaming back under the fuselage of the aircraft.

The position of the lift-line in relation to the bottom of the plane is a function of the speed and attitude of the airplane as well as the weight and configuration of the load on the end of the line. If the load is heavy and compact, it will tend to hang lower than if it is light and bulky.

By increasing air speed, the load will ride higher, and if the pilot simultaneously pulls the nose of the plane up, it is normally easy to acquire the line.

Heretofore, a J-hook has been used for this purpose. It is essentially a boathook with a 10-foot-long handle and a generous opening at the bottom. However, since this proved to be too short on a number of occasions, a parahook was added to the equipment. This consists of a streamlined trailing weight fitted with tail fins to give it directional stability. A W-shaped hook is attached to the top of the unit and is secured to a line whereby it can be lowered from the aircraft.

The procedure is to lower the hook below the level of the line and then to move it sideways until the hook-line and the lift-line contact one another. Raising the hook causes the lift-line to enter one side or the other of the W, whereupon it can readily be brought to the level of the ramp for attachment to the reel-in winch.

Since the parahook will work under all conditions whereas the J-hook is limited, it is recommended that the latter be eliminated and the former exclusively employed.

Standard procedure calls for tying the end of the parahook line inside the aircraft to prevent inadvertant loss. However, since it is still possible that it might accidently be dropped overboard, it is recommended that a spare parahook be carried aboard the aircraft at all times.

A strictly emergency method of acquiring the lift-line when it cannot be reached from the tail ramp is to open the floor hatch in the cockpit. Being so near the nose of the aircraft, the lift-line is invariably close to the bottom at this point. A spare piece of line can readily be tied in a generous loop around the lift-line. The other end of the line can then be paid out through the hatch and, since it is carrying no load, will stream aft tight up against the bottom of the aircraft. It is thus easy to catch it at the ramp. If the loop is now permitted to slide back along the lift-line, the latter can readily be raised to the level of the ramp for transfer to the winch.

This emergency method should be described in the operations manual for the system.

OBSERVATION 6. BEACON LIGHT GUARD

Mounted on the centerline of the bottom of the aircraft is a rotating beacon. Before the lift-line was freed from the skyanchor following one of the pickups, the line apparently applied enough pressure against the beacon to shatter its glass cover.

To prevent a recurrence, a simple welded tubular guard was placed around the beacon and no further difficulty was encountered.

It is recommended that such a guard be provided as standard installation equipment when the aircraft is to be used for pickup work.

OBSERVATION 7. GREASING OF BALLOON NOZZLES

When helium gas is released from the drop kit storage bottles in order to inflate the balloon which supports the lift-line, the expanding gas becomes extremely cold. If the atmosphere is moist, a considerable amount of frost collects around the filler stem where it is inserted into the neck of the balloon, thereby making it difficult to separate the two when the inflation process is completed.

Such an occurrence took place when the land drop kit was being tested for speed of operation.

The simple solution to this problem is the use of grease, preferably a silicone grease, to act as a moisture barrier. It is completely effective and has been regularly used heretofore but was somehow omitted from a few of the balloons used during this test program. The grease is placed inside the filler valve in the neck of the balloon. This prevents its being accidentally rubbed off in handling.

For operational use it is recommended that the filler nozzle on the end of the hose from the helium bottle also be greased during the packing operation. This action will doubly insure elimination of this problem.

OBSERVATION 8. DEFLECTION-LINE AND EXTENSION CORD OPERATION

Running from the tips of the yoke to the wing tips are lines which deflect the lift-line if the pilot fails to steer it into the yoke opening.

Attached between the top of the lift-line and the bridle of the balloon is an extension cord which is crochet stitched throughout its length, the last stitch being secured with a piece of break cord. When the extension cord strikes the line, it causes the break cord to sever permitting the crochet stitches to unravel and thereby making an appreciable extra length of line available to reach around the wingtip. Without this extra length, the lift-line would tear loose from the balloon and fall to the ground.

The relationship between the length of the deflection-line and the stitched and unstitched extension cord is important to the success of the operation. To a large extent, these lengths depend upon the configuration of the aircraft being used. Extension cords originally supplied for this project had a stitched length of 25 feet which extended to 125 feet when the stitching was removed.

In all but two cases the deflection-line and extension-cord combination worked satisfactorily together, and the pilot was able to accomplish the pickup on the ensuing approach. This included misses at night where the lights continued to function despite the action of the deflection-line sliding along the lift-line.

During one night operation, a miss occurred when the lift-line became trapped between the leading edge of the wing and the outer deflection-line anchor. This was caused by insufficient tension in the deflection-line. The deflection-line was cut by the lift-line's sawing across it, but the load did not leave the ground.

During another night operation, a combination of events took place which cannot be described since no one could see what was happening. Both the lift-line and the deflection-line were cut by the propeller. It is possible that the extension cord attached to the top of the lift-line tore loose. This happened on an earlier occasion where inexperienced personnel made a poor splice while reworking one of the lines in the field. This could cause the top of the line to whip into the propeller blades. Although the blades immediately cut the line, they also can jerk it hard enough to break the deflection-line. It is more likely that the deflection-line was in need of replacement from having been subjected to a number of misses. Standard operating procedure calls for replacement of deflection-lines after each miss. (The average number of misses is one for every thirty approaches.)

After observing the results of this test program, it is this contractor's opinion that the proper length of extension cord for this aircraft is 30 feet stitched, which becomes 150 feet unstitched.

OBSERVATION 9. NIGHT OPERATIONS

The principal problem encountered here appeared to be one of night orientation for the pilots. The location where the pickups were performed was in the middle of a large, flat, completely unlit plain, and the nights were so dark that there was no indication of any horizon. These conditions are, of course, apt to prevail on an operational mission and are therefore ideal for testing. However, they also necessitate some training. Thus it becomes difficult to differentiate between the testing and training.

At first, the pilots experienced some difficulty in lining up the lift-line and the wind. Placing a light on the ground close to the load as a point of reference considerably improved the pilot's perspective and substantially reduced this problem.

The pilots also remarked that the brilliancy of the lights at close range (during the final stage of the approach) might be making it difficult for them due to the retentive capability of the human eye. Since the lights flash approximately twice per second, they felt they might be seeing new flashes on top of the after-effects of old ones. It was therefore decided to try two lights on the lift-line instead of four. The results of this concept were inconclusive since too few operations were conducted.

A better solution to the problem appeared to be use of the aircraft's landing lights during the last few seconds of the final approach. This illuminates the lift-line brilliantly against the black background and minimizes any retained image from the flashing lights by increasing the overall level of light with a resulting comparative reduction of brilliancy of the flashes.

Contractor's opinion in this matter is that the brilliancy of the lamps is not the problem. At an air speed of 125 knots, the aircraft is travelling more than 200 feet per second. At 200 feet the lights are still very small and are not so bright as to leave retained images on a normal pilot's eyes. Possibly the next flash at a distance of 100 feet might leave a trace, but it is at that time too late for the pilot to do anything to change the direction of the aircraft. If he is not lined up for the intercept at this moment, he is going to miss no matter what he does.

Use of the aircraft's landing lights during the last moments of the approach makes night pickups almost easier than day ones. The flashing lights tell him exactly where the line is even when he is far out on his approach and the landing lights make the lift-line stand out brilliantly at the moment when he needs to see it the most.

The nature of some missions, however, will not permit the use of landing lights. For these operations two things are important. First, a well trained pilot is essential and second, installation of a small red light at the tip of each yoke arm is beneficial. The light can be hooded so as to be visible only from the cockpit. Such lights were experimented with during the course of this test program and were found to be of substantial aid to the pilot. During daylight operations he apparently unconsciously uses the yoke tips as a frame of reference during his approach. The red lights make them available to him at night also. It is recommended that they be made a standard part of the systems equipment.

OBSERVATION 10. MULTIPLE PICKUP HARDWARE

Although not originally contemplated in the test program on two occasions multiple pickups were accomplished. One load was attached to the end of the line in the normal fashion while the second load was attached to a pigtail spliced into the line approximately 10 feet ahead of the other.

The loads rise in the same manner as single pickups, almost vertically at first, then arcing to follow the line of flight of the aircraft. They are winched aboard the plane in the normal manner.

The only change in the procedure occurs during the boarding operation. When the first load is brought aboard the plane, it is unsnapped from the lift-line and the second load should now be winched over the tail gate. However, the snap on the end of the pigtail which was attached to the first load is too large to pass through the overhead pulley. In addition, even if it would go through the pulley, it would be unsafe to have it flailing around the winch drum.

The procedure employed was therefore to cut the pigtail off with a knife.

This contractor does not consider this to be a satisfactory operation. Handling knives in an aircraft, possibly flying in rough air, is not recommended. In addition, there is too much danger of cutting the lift-line instead of the pigtail and thus losing the second load.

NOTE

While working on another project since the completion of the test program which is the subject of this report, the contractor has developed a special piece of hardware which solves this problem.

It is essentially a quick-detachable snap. On one end is a standard 5,000-pound parachute snap. The other end is formed like a large clevis with ample room for the lift-line to fit between the open sides. A 1/2-inch bolt passes through a hole in the two sides of the clevis and is retained by a nut. Both the bolt and the nut have knurled heads for easy turning and an annular groove with a line in it secured to the ring in the snap to prevent the parts from becoming lost.

The load is attached to the snap which is rigged to the lift-line by splicing an eye in the pigtail and securing it in the clevis by means of the bolt.

When the first load reaches the aircraft, it is easy to detach the load from the snap and then to detach the entire snap assembly from the pigtail. It is then immediately possible to operate the winch and bring the second load aboard. The pigtail passes through the overhead pulley without difficulty and readily winds onto the winch drum.

By using two such quick-detachable snaps, three separate loads can be brought aboard. Three snaps make it possible to pick up four loads at a time.

It is recommended that these quick-detachable snaps be used and that the multiple pickup capabilities of the Caribou aircraft be further explored with this aerial recovery system.

OBSERVATION 11. IMPORTANCE OF A TRAINING PROGRAM

The equipment and techniques used with this aerial pickup system long ago reached operational standards. Every detail has been carefully considered and integrated into the recovery task as a whole. The purpose of the operations described in this report was primarily to adapt the system to the Army's Type CV-2 aircraft and to provide Army personnel a first hand opportunity to utilize and observe it.

The inevitable result is a cross between an engineering and a training program. The satisfactory results of the former generally tend to hide the importance of the latter. It is the purpose of this observation to emphasize the need to qualify personnel for recovery operations.

Almost invariably, when failures occur in the field, they prove to be the result of either lack of understanding of the overall capability on the part of those setting up the operation or lack of attention to detail on the part of those executing it.

Pickup operations are essentially parachuting in reverse. The man simply goes up to the airplane instead of coming down from it. If those conducting a parachute operation knew so little about it that they permitted people to make jumps at a 50-foot altitude or in a 40-knot wind and allowed persons to pack the parachutes without any training, the results would certainly be undesirable to say the least. Similarly, if pickup missions are undertaken by untrained personnel, no better results can be expected.

A successful pickup operation is the result of good administration, coordination, and teamwork. It is essentially the combination of a number of pieces of equipment properly prepared and properly applied to the job.

It is therefore essential that responsibility for preparation of the equipment and its correct application be fixed from the start.

Those planning the mission must understand the capabilities of the system as well as its limitations. Those carrying it out must know how to select and prepare the necessary equipment, how to use it, and how to coordinate their efforts. They must also know when NOT to carry out the mission.

This contractor has observed that the very simplicity of this system has a tendency to induce personnel to put it to work without first acquainting themselves with the facts. Certainly a parachute also is simple enough; yet the details of its preparation and use are important enough to warrant special ratings for parachute riggers and special distinction for jumpers.

Since preparing parachutes requires the same sort of attention to detail as preparing pickup equipment, it seems logical to add this capability to that of parachute riggers and to train Jump Masters also to act as Pickup Masters -- possibly simultaneously adding a new rating.

The establishment of a coordinated training program should be implemented concurrently with introduction of this new capability and of its equipment at operational levels.

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Unclassified Report

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1. Air-To-Ground Pickup System

2. Contract DA 44-177-TC-804

Robert Fulton Co., Newtown, Conn., FULTON AIR-TO-GROUND PICKUP SYSTEM FOR CARIBOU AIRCRAFT - Robert E. Fulton, Jr., TRECOM Technical Rept 64-17, February 1964, Contract DA 44-177-TC-804, USATRECOM Task 1D141812XXX02 (Formerly Task 9R96-11-001-02), 51 pp. incl illus. tables.

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Robert Fulton Co., Newtown, Conn., FULTON AIR-TO-GROUND PICKUP SYSTEM FOR CARIBOU AIRCRAFT - Robert E. Fulton, Jr., TRECOM Technical Rept 64-17, February 1964, Contract DA 44-177-TC-804, USATRECOM Task 1D141812XXX02 (Formerly Task 9R96-11-001-02), 51 pp. incl illus. tables.

Unclassified Report

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The report contains the contractor's observations, recommendations, and conclusions regarding the joint engineer-user tests of the Fulton Air-To-Ground Pickup System. Also included are the historical background of the system, the principle of operation, and a description of the equipment employed. The test series was satisfactorily completed and justifies concluding the recovery system is safe, reliable, and ready for use with the CARIBOU aircraft to recover personnel and equipment from land and from water.

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