



TECHNICAL REPORT
 NATICK/TR-91/010

AD A 230 995

**EVALUATION OF AN ALTERNATIVE
 ROTORCRAFT CARGO LOWERING DEVICE
 FOR THE DELIVERY
 OF 500-LB AMMUNITION LOADS**

By
 Glenn Doucet

December 1990

Final Report
 October 1987-August 1989

TECHNICAL LIBRARY
 U.S. ARMY NATICK RD&E CENTER
 NATICK, MA 01760-5000



APPROVED FOR PUBLIC RELEASE;
 DISTRIBUTION UNLIMITED

UNITED STATES ARMY NATICK
 RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
 NATICK, MASSACHUSETTS 01760-5000

ADVANCED SYSTEMS CONCEPTS DIRECTORATE

DISCLAIMERS

The findings contained in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

DESTRUCTION NOTICE

For Classified Documents:

Follow the procedures in DoD 5200.22-M, Industrial Security Manual, Section II-19 or DoD 5200.1-R, Information Security Program Regulation, Chapter IX.

For Unclassified/Limited Distribution Documents:

Destroy by any method that prevents disclosure of contents or reconstruction of the document.

REPORT DOCUMENTATION PAGE			Form Approved OMB No 0704-0188	
<small>The time for preparing this report is estimated to average 3 hours per report including the time for making illustrations, preparing tables, etc. The time for reviewing the data needed and comparing and reviewing the material of information. Send comments regarding this burden estimate or any other aspect of this report including suggestions for reducing this burden to Washington Headquarters Service, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503</small>				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE December 1990	3. REPORT TYPE AND DATES COVERED Final Report October 1987 to August 1989		
4. TITLE AND SUBTITLE Evaluation of an Alternative Rotorcraft Cargo Lowering Device for the Delivery of 500-lb Ammunition Loads			5. FUNDING NUMBERS PE 62786 PR D283 TA AB WU N/A	
6. AUTHOR(S) Glenn Doucet			7. PERFORMING ORGANIZATION REPORT NUMBER NATICK/TR-91/010	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Natick RD&E Center ATTN: STRNC-AA Natick, MA 01760-5015			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION AVAILABILITY STATEMENT Approved for public release; distribution unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The focus of this analysis was to investigate a commercial lowering device called the <i>Sky Genie</i> for rotorcraft delivery of 500-lb ammunition loads. This item, similar to the presently used cargo and personnel rappelling device, uses the friction of rope on metal to control the payload's descent. Reduction in payload descent time, which translates into improved troop and aircraft survivability, was sought. This report describes the functional and operational tests performed on this item. Based on these tests, it was concluded that the <i>Sky Genie</i> represents an effective, predictable means of delivering up to 500-lb payloads from altitudes up to 100 ft with no user input once the load leaves the rotorcraft. (25) * Air drop operations,				
14. SUBJECT TERMS Airdrop Lowering Devices, Resupply,			15. NUMBER OF PAGES 40	
Ammunition Loads, Rappelling Devices, Rotorcraft,			16. PRICE CODE	
17. SECURITY CLASSIFICATION UNCLASSIFIED	18. SECURITY CLASSIFICATION UNCLASSIFIED	19. SECURITY CLASSIFICATION UNCLASSIFIED	20. LIMITATION OF ABSTRACT SAR	

TABLE OF CONTENTS

	<u>Page</u>
LIST OF FIGURES	iv
LIST OF TABLES	v
SUMMARY	vi
INTRODUCTION	1
Background	1
Objective	2
Approach	2
CONCEPT DESCRIPTION	4
Lowering Device	4
Rope	4
A7-A Sling	4
Roller	4
Energy Absorber	4
Rope Bag	5
Manportable Harnesses	5
System Operation	5
TESTING	6
Functional Performance Test	6
Purpose	6
Procedure	6
Instrumentation and Data Collection	6
Observations	6
Data	8
Results	10
Summary	12
Operational Test	12
Purpose	12
Procedure	12
Acceptability Criterion	12
Photographic Account and Observations	13
Summary	19
CONCLUSIONS AND RECOMMENDATIONS	22
APPENDIXES	23
A. <i>Sky Genie</i> Patent	23
B. Airworthiness Release	31

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	



LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. 500-lb Cargo and Personnel Lowering Device.	3
2. <i>Sky Genie</i> Descent Control Device.	3
3. Typical Data Printout From 5-ft Test Drop.	7
4. Typical Data Printout From 65-ft Test Drop.	9
5. Six 5.56mm Ammunition Cases Being Rigged on Special Forces UH-60 Helicopter Showing Top of Load.	14
6. Six 5.56mm Ammunition Cases Being Rigged on Special Forces UH-60 Helicopter Showing Bottom of Load.	15
7. Load Being Lowered From 40 ft and 20 Knots Forward Air Speed.	16
8. Load Impacting Ground With 20 Knots Forward Air Speed.	17
9. Load After Coming to Rest.	18
10. Load On Ground After Being Dropped From 100 ft and 0 Knots Forward Air Speed.	20
11. Manportable Modules Being Used After Test Drop.	21

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Maximum Forces on Load Cell for 5-ft Drop.	8
2. Data From 65-ft Drops With 450 lb and 2 ft of Slack.	10
3. Acceleration Versus Turns for 450-lb Load.	10
4. Force Exerted by <i>Sky Genie</i> With Varying Turns.	11
5. Predicted Versus Actual Values For Acceleration, Time of Descent, and Impact Velocity.	12

SUMMARY

The objective of this project was to investigate current methods of helicopter resupply of small arms ammunition and to develop alternative airdrop techniques. The maximum load range was set at 500 lb. The goals were to decrease drop zone litter and rigging time and to increase troop/aircraft survivability and the accuracy of delivery.

To meet these requirements, a system was developed that used a commercial item called the *Sky Genie*[®] as the central piece of hardware. This device works similar to a rappelling device in that it uses the friction of rope on metal to control descent. The difference in this concept is that the *Sky Genie* is attached to the helicopter and the rope is attached to the load. The load is allowed to fall without user input and accelerates at a uniform and preset rate. When it impacts, the helicopter pulls away and any remaining rope falls to the ground with the load.

Both functional and operational tests were performed. Functional tests were conducted to determine the characteristics of the device, such as maximum force on the mounting position, velocity profiles, and operating ranges (maximum and minimum amounts of control that can be placed on a load). These tests were instrumented and performed from a fixed height of 65 ft. The non-instrumented operational tests involved lowering six cases of 5.56mm ammunition filled with sand from a UH-60 helicopter from altitudes of 100, 75, and 40 ft.

Based on these tests, it was concluded that the *Sky Genie* represents an effective, predictable means of delivering up to 500-lb payloads with no user input from a height of up to 100 ft. This hands-off approach, once the load leaves the helicopter, results in a significant reduction in payload descent time. This translates into improved troop/aircraft survivability. These system characteristics commend the *Sky Genie* for use as a replacement for the present 500-lb cargo and personnel lowering device in the delivery of small arms ammunition.

Sky Genie[®] is a registered trade name of Descent Control Incorporated, Fort Smith, Arkansas. Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

EVALUATION OF AN ALTERNATIVE ROTORCRAFT CARGO LOWERING DEVICE FOR THE DELIVERY OF 500-LB AMMUNITION LOADS

INTRODUCTION

Background

Presently, there are many methods to deliver ammunition by helicopter. The four groups which almost all methods fall into are 1) airdrop using parachutes, 2) sling loading underneath aircraft, 3) landing and unloading, and 4) using a cargo and personnel lowering device. Each of these techniques have very distinct advantages. Parachute airdrop allows the craft to stay out of the range of small arms fire and can deliver up to 500-lb in a door bundle configuration. Sling loading is very useful for heavy and bulky loads because a helicopter can generally carry more weight externally than internally; however, this decreases the performance of the aircraft. Sling loading will not be addressed further in this report because the weight ranges exceed the range of interest for this project. Landing and unloading is certainly the easiest for small items in a secure area.

The two categories of parachute delivery are high velocity and low velocity. In a high velocity airdrop, the load impacts the ground between 70 and 90 ft/sec; the impact speed in low velocity airdrop is approximately 28 ft/sec. There are variations that can be made when using parachute delivery. Changing the parachute type is the main method used to achieve variations based on the load weight, drop zone condition, desirable aircraft height, and desirable impact velocity. One of the more common parachutes used for low velocity is the T-10 personnel parachute.

However, each of the above methods has its shortcomings. Loads airdropped by parachute cannot be delivered with pinpoint accuracy. The helicopter must be sufficiently high to allow parachute deployment; this increases its vulnerability to surface-to-air missiles but does afford a measure of protection from small arms fire. Unofficially, high velocity airdrop can be accomplished from altitudes as low as 300 ft. Airdrops are usually made in clearings; this increases the vulnerability of ground troops that must retrieve the supplies. Other points of consideration are the cost and time associated with packing the parachute and rigging the loads.

Airdrops can be performed over wooded areas, but there is a problem with the parachute getting caught in the trees. This could stop the load from reaching the ground. One method used to alleviate this problem is increasing the length of the parachute risers. However, this method does not help retrieve the chute from the trees. If concealment of the ground troops is important, the parachute must be recovered and hidden. This operation could be very difficult and, at the very least, time-consuming.

Landing and unloading is a reasonable method for delivery to a secure area. However, when flying into a hostile landing zone, the time required to

hover, descend, unload, and then gain altitude and speed leaves the aircraft very vulnerable to enemy attack. This operation must occur in a clearing, which requires the ammunition to be carried away for distribution under extremely adverse conditions.

The 500-lb cargo and personnel lowering device being used today, as described in TM10-1670-251-12, "Operator and Organizational Maintenance Manual Including Repair Parts and Special Tools List, Lowering Device, Cargo and Personnel, 500-lb Capacity" (FSN 1670-999-0758), is similar to the item that will be proposed in this report. The current item is used by looping a rope through a device that controls the descent of the load by friction (Figure 1). The friction is controlled by the number of loops and the force applied to the rope being fed into the device by a soldier in the helicopter. Loads exceeding 300 lb are not to be allowed to descend faster than 8 ft/sec when using this lowering device, as noted in the above-mentioned technical manual.

Objective

This project was initiated to 1) investigate present methods of helicopter resupply for light infantry rifle companies, special forces, and similar quick strike forces that require resupply of small arms ammunition; and 2) develop alternate airdrop techniques. Maximum load weight was set at 500 lb. With this limit, up to six cases of small arms ammunition can be delivered. This concept is also in line with present weight limits for door bundles airdropped using an A7 sling.

Improvements over present systems were sought in the areas of drop zone litter, rigging time, aircraft survivability, troop survivability and concealment, cost, ease of operation, load survivability, accuracy of drop, etc.

After initially exploring a variety of possibilities, the decision was made to concentrate this analysis on a commercial item called the *Sky Genie* (Figure 2). As shown on the left in the figure, this lowering device consists of a center shaft with eyelets on each end, around which the rope is wound. After setting the *Sky Genie*, a cylindrical metal cover is placed over the rope and shaft to prevent the rope from slipping off the shaft. This cover is secured to the shaft by means of a bullet catch and thumb nut as shown on the right in the figure. Through use of the *Sky Genie*, the speed of descent is controlled by the friction created between the rope and shaft. Thus, the speed of descent depends on the number of turns around the shaft and the distance to ground level. Therefore, the number of turns used is determined by the payload weight and desired rate of descent.

Approach

A series of functional and operational tests were performed on the *Sky Genie* lowering device in order to determine the item's suitability for application in the rotorcraft delivery of ammunition. Functional performance tests, conducted under controlled conditions, were first performed to establish the energy-dissipating characteristics of the device. Operational tests were then conducted from a UH-60A Black Hawk helicopter to check system performance under actual conditions and identify potential hardware/procedural problems.

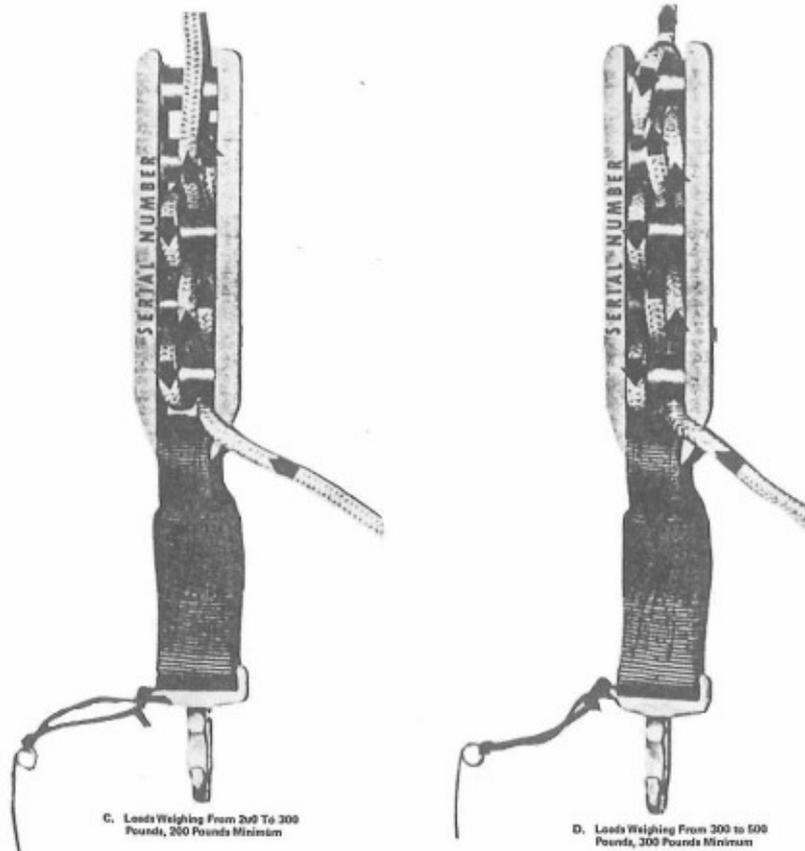


Figure 1. 500-lb Cargo and Personnel Lowering Device.

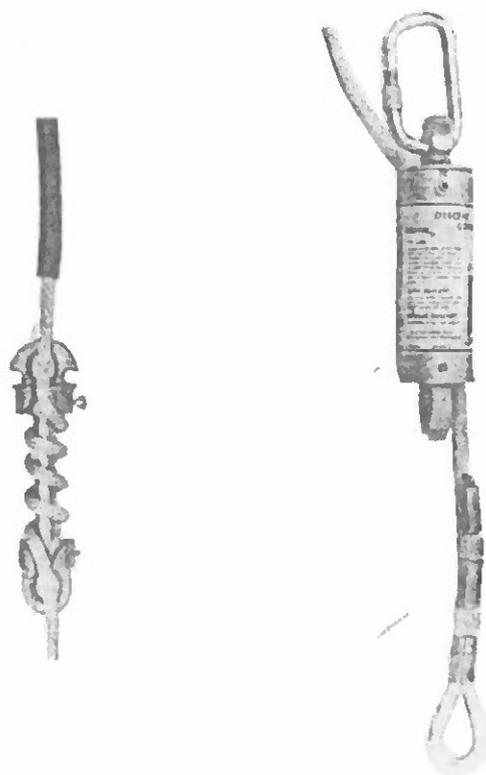


Figure 2. Sky Genie Descent Control Device.

CONCEPT DESCRIPTION

The concept system developed for this project consists of seven parts: the lowering device, rope, A7-A sling, rollers, energy absorber, rope bag, and manportable harnesses. These individual parts make up the complete concept. However, not all of the parts are necessary for system operation. The necessary items include the lowering device, rope, A7-A sling, and rope bag. The other items are optional and enhance the effectiveness of the system under certain conditions.

Lowering Device

As previously noted, the lowering device proposed for use in this system is a commercial item known as the *Sky Genie*. This is a descent control item designed for lowering personnel in much the same way rappelling devices work. This item was innovative enough to be awarded a patent on 10 May 1966, Number 3,250,515 (Appendix A). This item is more easily adjusted than the cargo and personnel lowering device because the ends of the rope need not be free and fed through slots but simply wrapped around a cylinder, which controls the "hands off" acceleration. The payload descends at slightly less than 1-g constant acceleration. Also, the way the item is used as part of a descent system makes it safer for the helicopter and ground crew as compared to other load-lowering devices that use rope. The main difference is the time required to lower the load. Because the load descends quickly, the helicopter is not in a vulnerable hover for as long a period of time.

Rope

The rope used for this test was braided nylon. This type or similar rope must be used for heat resistance, strength, and consistency of friction.

A7-A Sling

The sling used is a standard airdrop sling rated at 500-lb. It consists of three straps to hold the load together, but more can be used if necessary. D-rings are placed at the strap intersections for attachment of the suspension lines.

Roller

The type of roller used is commercially available as a standard conveyor and costs approximately \$100.

Energy Absorber

The energy absorber used is standard airdrop paper honeycomb. The amount used is determined by equations given in the operational test section of this report. End boards are used under the honeycomb to prevent it from crushing when the slings are tightened.

Rope Bag

The rope bag is constructed of rip-stop nylon with a 1/2-inch webbing loop at the mouth of the bag. This loop is just large enough to attach to the same carabiner to which the *Sky Genie* is attached. It is a cylinder with a 6-inch diameter and a 12-inch length.

Manportable Harnesses

If required, the loads can be rigged using the manportable harnesses. These harnesses allow a soldier to carry a case of ammunition much easier than with his hands. The harness encircles the ammunition case with three straps connected with quick release buckles. It is also equipped with a shoulder strap that can be used over the shoulder or to drag the case. These would be used if the troops had no vehicles and they must move from the drop zone before distribution of the ammunition can take place.

System Operation

This concept was designed to operate without user input once the load is thrown out of the helicopter. The load descends to the ground at a constant acceleration, impacting the ground at a predetermined velocity. The setup of the system is as follows: The rope bag holds a 100-ft length of rope (this could be longer or shorter if the situation requires). The rope need not be placed in the bag in any special way, simply stuffing it in has performed properly in every test thus far. The bag and the *Sky Genie* are hung from a snap hook (carabiner) connected to a ring inside the helicopter. The rope is fed through the snap hook and then through the *Sky Genie*. This is a very important step because any extra tension above the *Sky Genie* will dramatically decrease the rate of descent. The load will impact at a slower rate under this condition and the helicopter must maintain its position longer while the load descends.

The impact velocity is determined by knowing the altitude of the aircraft and the load weight. These two variables determine the number of turns placed within the *Sky Genie*, thereby increasing or decreasing the amount of frictional force on the rope. This will be discussed in more detail. The rope is then connected to a load rigged with an A7-A sling and an appropriate amount of energy absorber. Although using paper honeycomb as an energy absorber increases the time required to rig the load, it drastically decreases the amount of time over the drop zone because of the higher impact velocities that can be tolerated. To decrease the amount of effort required to get the load out of the aircraft, the load is placed on an 8-ft section of rollers. Two 500-lb loads will fit on one roller set.

Once over the drop zone, the helicopter hovers at an altitude of at least 10 feet less than the length of the rope. The load is then pushed out of the aircraft and it descends until it impacts the ground. At this point, there is still rope remaining in the bag. The helicopter can take off and any remaining rope will play out through the *Sky Genie* and fall to the ground. The drop is then complete.

TESTING

This device has been functionally tested as part of a system that can deliver up to 500-lb loads from a UH-60 helicopter at altitudes up to 100 feet. The testing included initial functional performance tests at the U.S. Army Natick Research, Development and Engineering Center (Natick) using a crane for altitude; operational testing was performed at the Natick/Sudbury Annex using a UH-60 Black Hawk helicopter from Ft. Devens Special Forces Unit.

Functional Performance Test

This testing was performed at Natick during April 5-19, 1988.

Purpose. This test was to determine the functional performance characteristics of the *Sky Genie*. Namely, how much energy it could absorb on a per turn basis.

Procedure. This test consisted of two subtests. The first procedure was to determine the maximum loads that could be placed on the mounting provision and to calibrate and test the equipment in a more easily controlled environment. It was performed inside from a 2-ton overhead crane at a height above the floor of approximately 5 ft. The load weight was 450 lb. The variables were the number of turns on the *Sky Genie* and the amount of slack in the rope. The slack in the rope was allowed to vary from 0 to 2 ft. Drops were made with rope turns of 3.5, 4.0, 5.0 and 6.0 around the *Sky Genie*.

The second part of this test was performed from a height of 65 feet using a mobile crane to lift the load. Two weights, 300 lb and 450 lb, were tested. The *Sky Genie* and rope holding bag were suspended from a sling and the load was attached to the crane hook by means of a sling and a remote release mechanism. Two feet of slack were left in the rope between the *Sky Genie* and the load for two reasons. First, initial testing indicated that the load tended to hang up and start slowly if there were no slack. Also, by providing slack in the rope, the *Sky Genie* would offer no resistance during the payload extraction phase of an actual airdrop. Hence, the load would move more easily over the rollers and out of the aircraft. The number of rope turns was varied between 4 and 6 in half-turn increments in these drop tests.

Instrumentation and Data Collection. Instrumentation included a load cell between the *Sky Genie* and the crane hook, an accelerometer on the load, and a velocity meter that measured the velocity of the load relative to the crane hook. Data was recorded using a Yokogawa analyzing recorder.

Observations. The only usable information obtained from the first subtest, consisting of drops from a height of 5 ft, was the maximum force on the mounting provision. Loads dropped from this height did not have time to stabilize before impacting the floor. A typical printout of one of these drops is shown in Figure 3. Although the second subtest consisted of 300-lb and 450-lb loads dropped from 65 ft, only the 450-lb drops conducted on the last day were analyzed for the conclusions because of the learning curve associated with operating the system. This day included 15 drops of varying turns, with approximately 2 ft of slack provided. The remaining observations were based on the 300-lb drops.

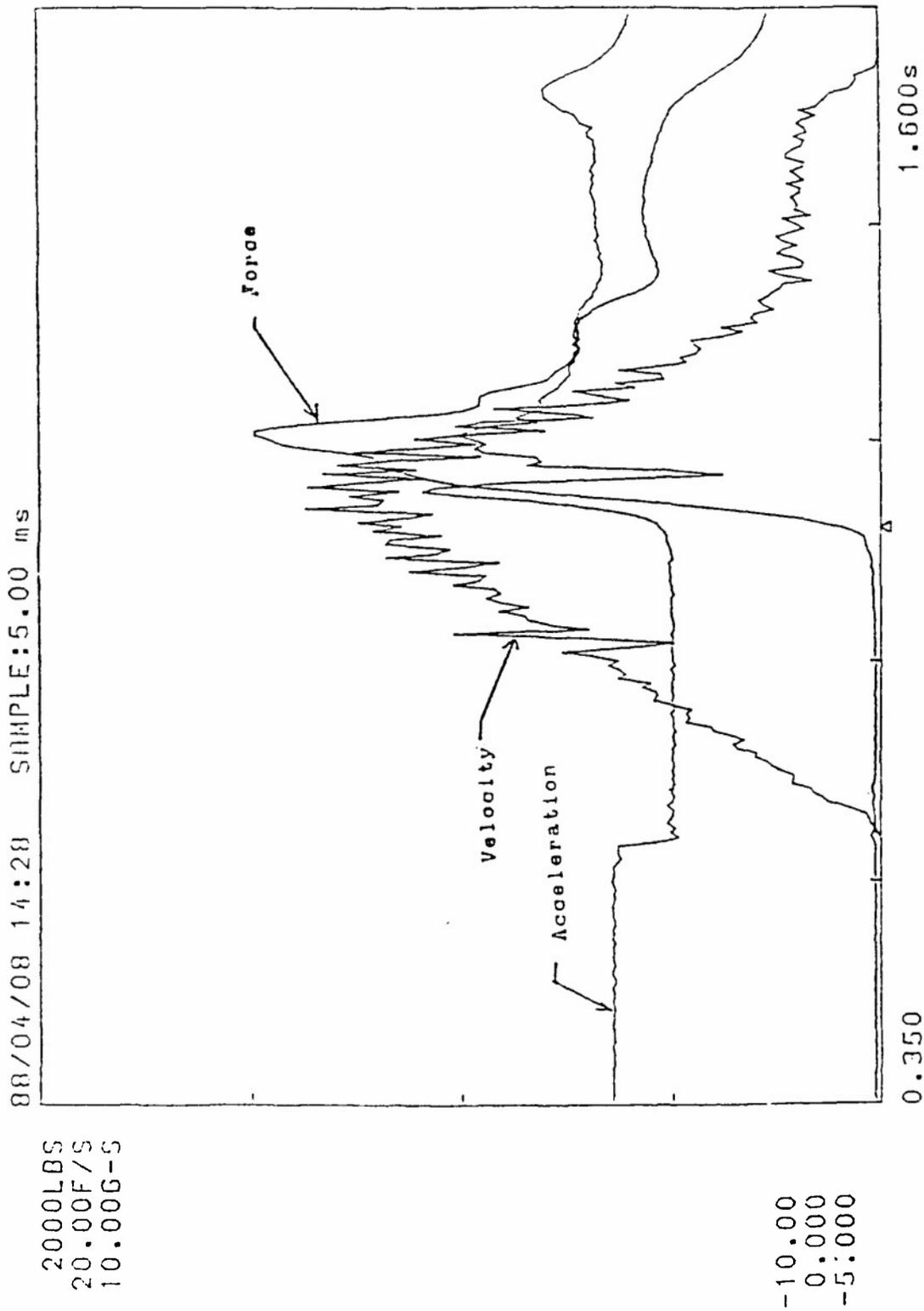


Figure 3. Typical Data Printout From 5-ft Test Drop.

The *Sky Genie* rotated as the load lowered. This problem would not exist in a helicopter because it would be attached to a fixed ring, but this did cause difficulty during testing. This problem did not present itself during the 5-ft drops.

Initially the rope was allowed to hang freely from the entrance hole of the *Sky Genie*. This technique caused the rope to jam and lower in a very erratic manner. Stuffing the rope in a small bag and supporting it next to the *Sky Genie* solved this problem.

If too many turns are placed on the *Sky Genie*, the rope will actually melt and form a plastic film on the center rod of the device. This film causes the rope to stick, and the load will descend very erratically and slowly and sometimes stop. Too many turns of rope would also heat the *Sky Genie* to a point where it was too warm to handle.

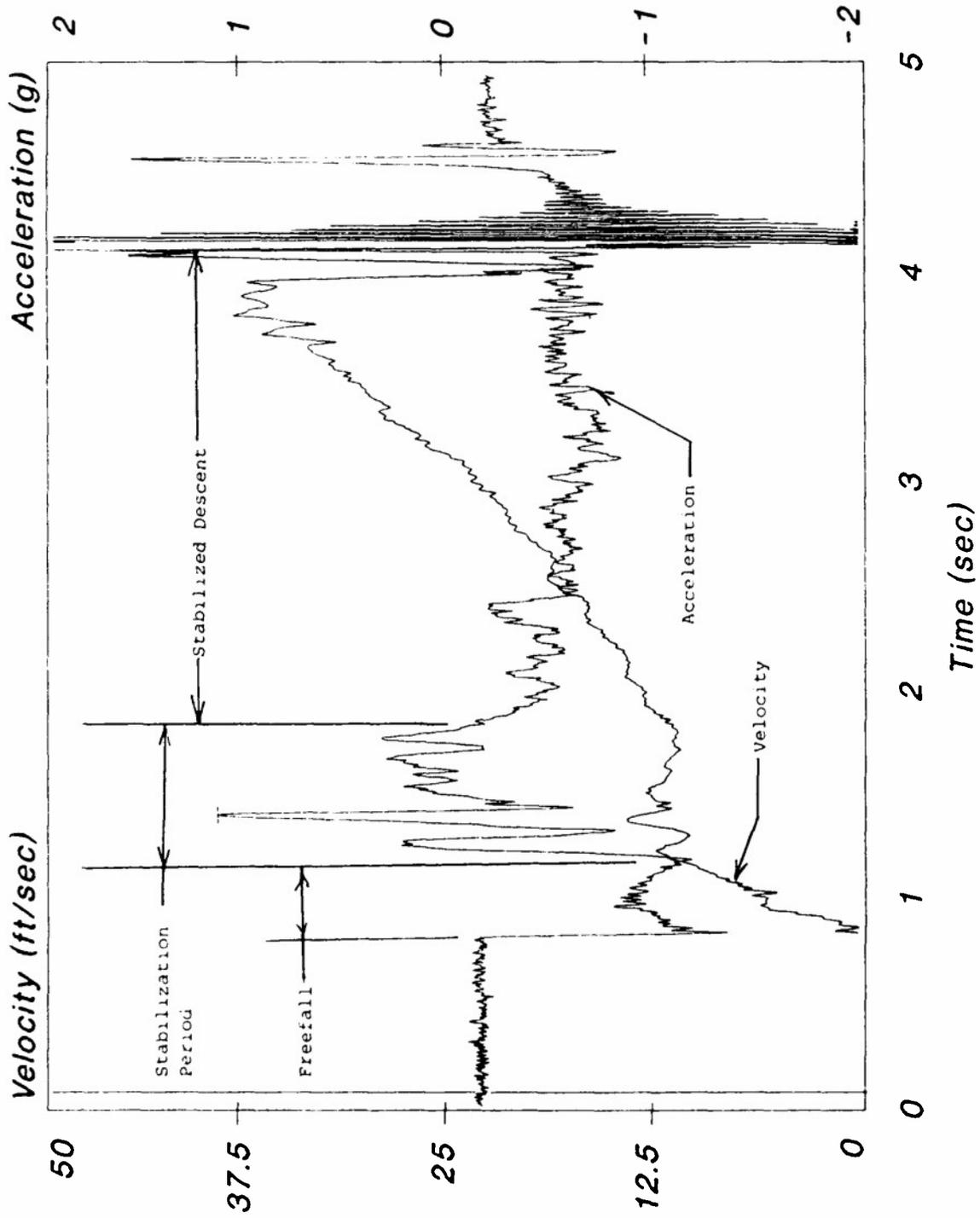
Instrumentation data showed that there were three phases to the descent. The initial freefall, a stabilization period, and the constant acceleration phase (Figure 4).

Data. Although velocity, acceleration, and force were collected during the 5-ft drops, only the data taken from the load cell was usable because there was no time for the load to stabilize. The load cell recorded the maximum snatch force after an initial freedrop of 0 to 2 ft. These values, given in Table 1, were measured from the instrument printout. These drops were conducted on April 8 and 11, 1988.

TABLE 1. Maximum Forces on Load Cell for 5-ft Drop.

Weight (lb)	Turns	Slack (ft)	Force (lb)
450	5.0	0	730
450	5.0	0	660
450	5.0	0	580
450	4.0	0	290
300	4.0	0	270
450	3.5	1	510
450	5.0	2	1580
450	5.0	2	1310
450	5.0	2	1530
450	6.0	2	1500

The final date of testing was April 19, 1988. Data measured from the printouts are shown in Table 2. Examination of this table reveals that for constant drop height, weight and slack, an increase in the number of turns leads to a decrease in the level of acceleration during the stabilized portion of the descent. This, in turn, generally results in an increase in both maximum force and descent time, as well as a decrease in maximum impact velocity.



✓ Sample interval = 5 milliseconds

Figure 4. Typical Data Printout From 65-ft Test Drop.

TABLE 2. Data From 65-ft Drops With 450 lb and 2 ft of Slack.

Trial Number	Turns	Decent Time (sec)	Maximum Velocity (ft/sec)	Accel. ^a (ft/sec ²)	Accel. ^b (ft/sec ²)	Max. Force ^c (lb)
1	5.0	3.38	38.6	14.10	12.50	729
2	5.0	3.27	39.4	14.80	12.50	585
3	5.0	3.12	38.9	17.70	13.70	779
4	5.5	2.78	37.9	16.10	10.90	770
5	5.5	2.91	38.0	15.40	10.90	711
6	5.5	2.89	37.0	13.20	11.60	477
7	6.0	3.91	33.1	10.90	9.59	1090
8	6.0	4.97	31.7	9.98	8.85	1290
9	6.0	8.54	25.4	14.80	6.61	1500
10	4.5	2.53	44.0	9.01	15.30	563
11	4.5	2.61	42.6	10.30	15.50	833
12	4.0	2.18	51.1	16.40	20.70	401
13	4.0	2.27	50.9	13.20	20.10	360
14	4.0	2.24	50.0	14.40	20.20	360

^aAcceleration taken from acceleration curve.

^bCalculated acceleration (slope of velocity curve).

^cCalculated force from maximum acceleration multiplied by the load.

Results. Table 3 below summarizes the accelerations obtained for a 450-lb payload versus the number of rope turns placed around the shaft of the *Sky Genie* lowering device. Accelerations shown in this table correspond to the average of the Table 2 acceleration values computed from the slopes of the velocity-time curves. In computing the standard deviation, a divisor of two was used, or one less than the number of samples. The standard deviations listed, therefore, represent unbiased estimates, since they are based on the number of deviations about the mean that are free to vary.

TABLE 3. Acceleration Versus Turns for 450-lb Load.

Turns	Acceleration (ft/sec ²)	Standard Deviation
6.0	8.35	1.55
5.5	11.20	0.41
5.0	12.94	0.73
4.5	15.43	0.14
4.0	20.37	0.34

From the acceleration of the load the force exerted by the *Sky Genie* was calculated using equation 1:

$$\text{Equation 1. } \frac{(32.2 \text{ ft/sec}^2 - A) * 450 \text{ lb}}{g_c} = F$$

Where:

A = acceleration of load

g_c = gravitational constant

F = force exerted by *Sky Genie*

The acceleration was taken from Table 3 and the results of this calculation are shown in Table 4.

TABLE 4. Force Exerted by *Sky Genie* With Varying Turns.

<u>TURNS</u>	<u>FORCE (lb)</u>
6.0	333
5.5	293
5.0	269
4.5	243
4.0	165

From the total force exerted by the *Sky Genie*, the frictional force per turn was calculated by dividing the total force by the number of turns. The result of this calculation was

$$F_t = 51.5 \text{ +/- } 5.82 \text{ lb}$$

With these numbers we can now predict the behavior of the *Sky Genie* when the load and weight are varied. To check the validity of the predictions, the actual test trial values will be calculated using equations 2 and 3 (See Table 5):

$$\text{Equation 2. } 32.2 - (32.2 * F_t * T / 450) = a$$

$$\text{Equation 3. } y = (1/2)at^2$$

Where:

a = acceleration of load

T = number of turns

y = height of drop

t = time of drop

TABLE 5. Predicted Versus Actual Values for Acceleration, Time of Descent, and Impact Velocity.

Turns	a _p	a _a	%Err	t _p	t _a	%Err	v _p	v _a	%Err
4.0	17.4	20.3	14	2.72	3.22	16	47.6	50.7	6
4.5	15.5	15.4	1	2.89	2.57	12	45.0	43.3	4
5.0	13.7	12.9	6	3.07	3.26	6	42.2	39.0	8
5.5	11.9	11.2	6	3.30	2.86	15	39.4	37.6	5
6.0	10.0	8.4	20	3.59	4.44	19	36.2	32.4	12

Symbols

a = acceleration
t = time of descent
v = impact velocity

Subscripts

p = predicted
a = actual

Summary. This experiment showed that the *Sky Genie* does operate with predictability within a certain range. About 65-percent controlling force was the cutoff for this experiment, or 5.5 turns.

To predict the amount of turns using the *Sky Genie* to lower ammunition the following steps should be taken.

1. Decide on an altitude for the drop (Y in ft).
2. Determine an acceptable impact velocity (V in ft/sec).
3. Determine the weight of the load (W in lb).
4. Use equation 4 to calculate the number of turns (T).

$$\text{Equation 4. } T = (W/51.6) * (1 - (V^2/64.4Y))$$

5. Round up to the nearest half turn.

Operational Test

The operational test was performed at the Natick/Sudbury annex drop zone on January 18, 1989.

Purpose. The purpose of these tests was twofold: 1) to determine how the *Sky Genie* would perform in a less controlled, more realistic environment, and 2) to test the proposed method of operational employment to ascertain any hardware/procedural deficiencies with system.

Procedure. The test consisted of four drops at 100 ft. The first two drops were from a hovering position, and the other two 40-ft drops were performed with forward velocities of 10 and 20 knots indicated airspeed. Wind on the drop zone was light.

Acceptability Criterion. No instrumentation was used for this operational test. The honeycomb crush was used as an approximate gauge for load survivability. Because the crush rate of honeycomb can be predicted within

reasonable accuracy (its crush rate is 6300-lb/ft²+/- 100), and because the predicted acceleration of the load upon impact was within the ammunition strength ratings, the drop would be considered successful if the load impacted square on the honeycomb and did not bottom out the honeycomb. The airworthiness granted for this drop is supplied in Appendix B

The amount of honeycomb used was determined according to equations 5 and 6:

Equation 5. $a = ((AC/W)-1)$

Equation 6. $t = (V^2)/(2gae)$

Where:

- a = acceleration of load (g's), use 40 g as max loading
- A = surface area of honeycomb (ft²)
- C = crush rate of honeycomb (6300 lb/ft²)
- W = weight of load (lb)
- t = honeycomb thickness (ft)
- V = ground impact velocity (ft/sec)
- g = acceleration from gravity (32.2 ft/sec²)
- e = compressive efficiency of honeycomb (0.7)

Photographic Account and Observations. A photographic account of the test, including comments and observations on system operation and performance, follows.

Figure 5: Six 5.56mm ammunition cases being rigged on the special forces UH-60 Black Hawk helicopter. The ammunition cans were filled with sand, which made the total weight of the load approximately 350 lb. Note the *Sky Genie* mounting position and rollers used. Also, the orientation of the load is such that the bottom of the load exits the craft first. In view is the top of the load.

Figure 6: Same load as Figure 5. This shows the bottom skid board necessary to minimize the crush of the honeycomb during rigging. This photo gives an excellent view of the *Sky Genie* and rope holding bag. Note that the rope must be passed through the connecting link (carabiner) between the helicopter's ring and the *Sky Genie*. This is necessary to maintain constant (and minimal) tension in the rope between the *Sky Genie* and the rope containing bag. The load will exit from this side of the aircraft.

Figure 7: Load being lowered at 40 ft and 20 knots.

Figure 8: Load from Figure 7 impacting the ground. This load is quite deformed at this point and bounced and rolled approximately 20 ft before coming to rest. Note load at right. This load was dropped from 40 ft and 10 knots. It bounced 12 feet and landed on its side with no apparent damage.

Figure 9: This is the load dropped in Figure 7. Although it looks somewhat broken apart, there was actually only superficial damage. The only visible damage was to the case closest to the camera, and this damage was limited to the wooden outer case. The ground on the drop zone was hard and frozen. Ice can be seen scattered about in this picture.

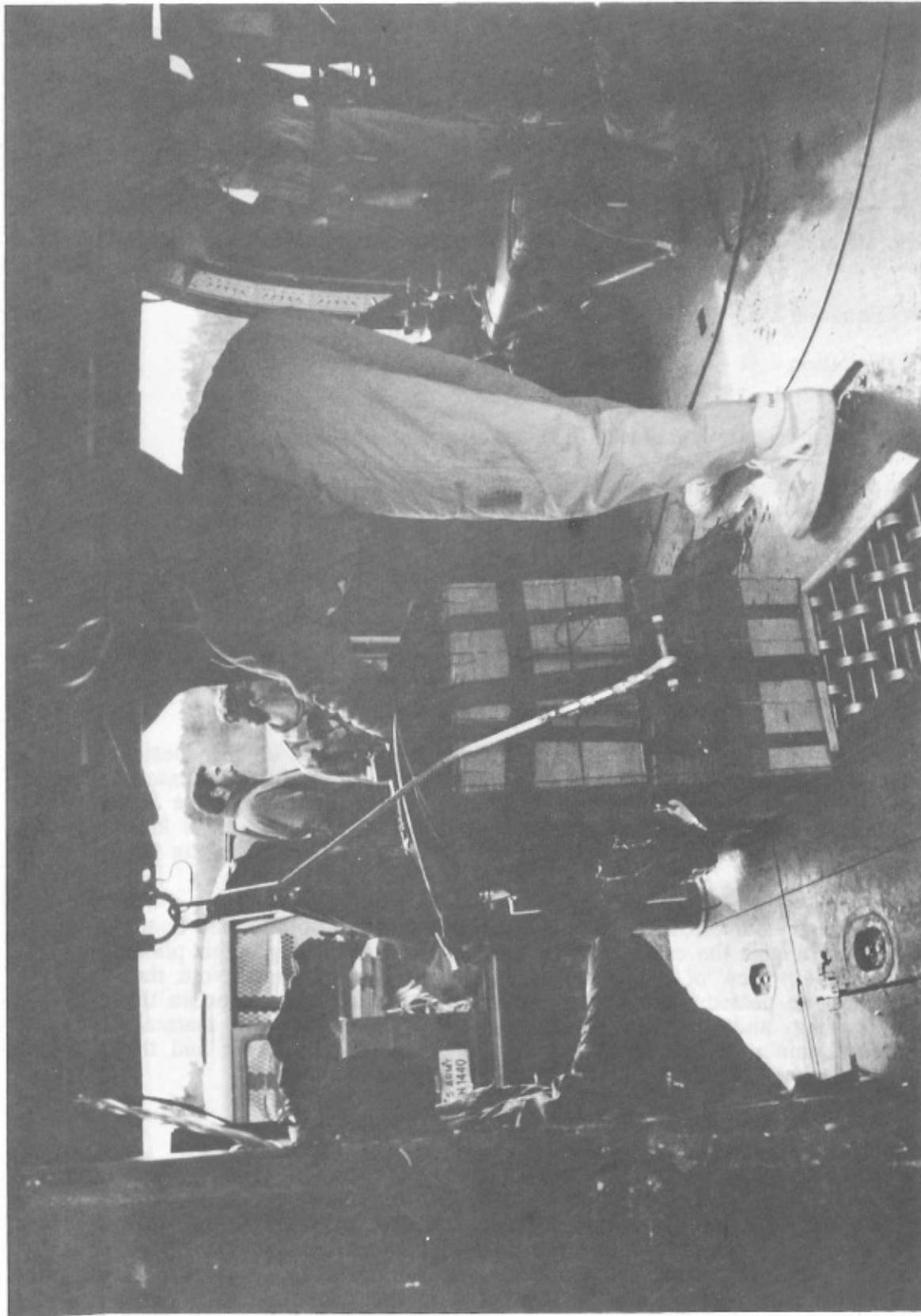


Figure 5. Six 5.56mm Ammunition Cases Being Rigged on Special Forces UH-60 Helicopter Showing Top of Load.

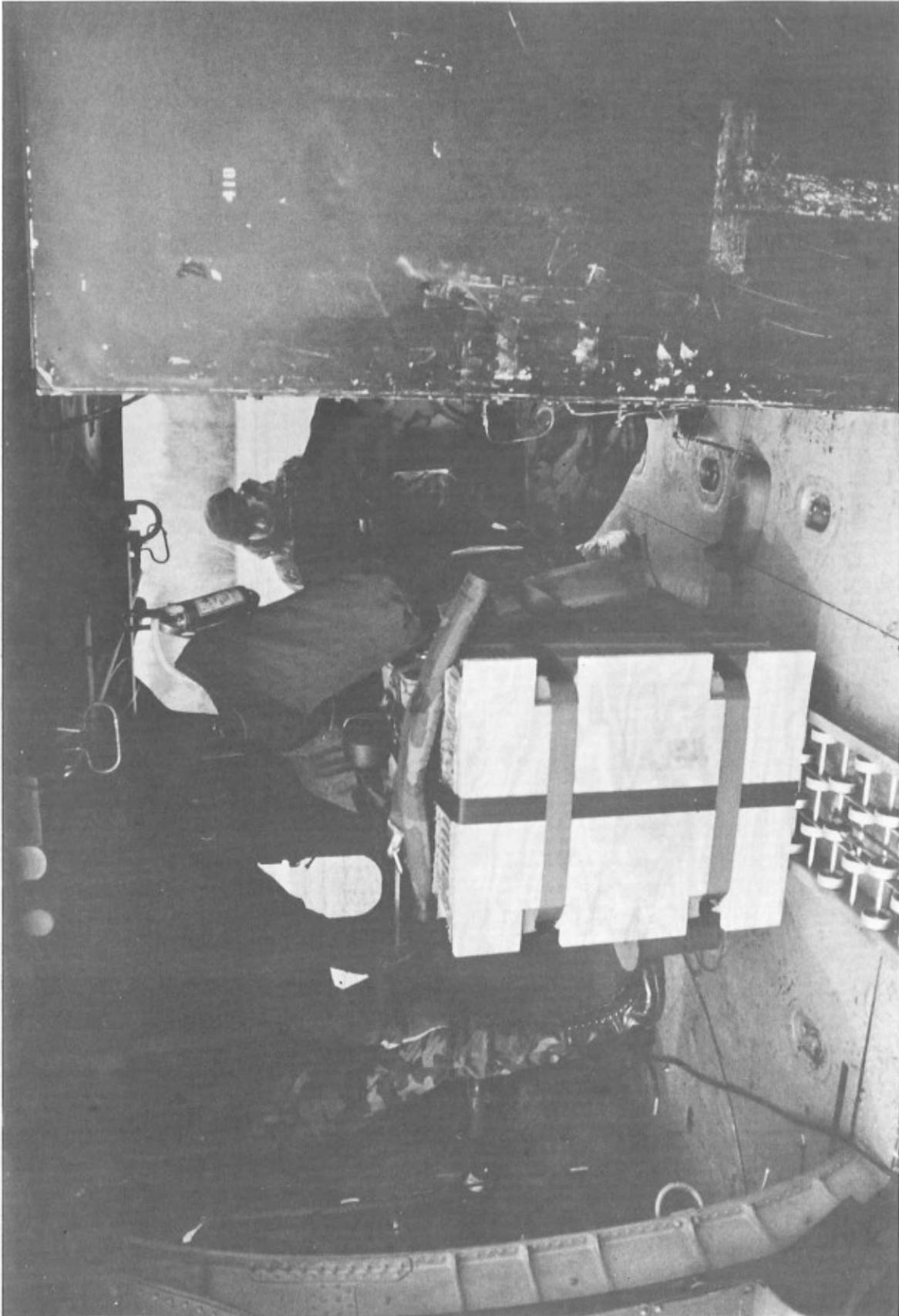


Figure 6. Six 5.56mm Ammunition Cases Being Rigged on Special Forces UH-60 Helicopter Showing Bottom of Load.



Figure 7. Load Being Lowered From 40 ft and 20 Knots Forward Air Speed.

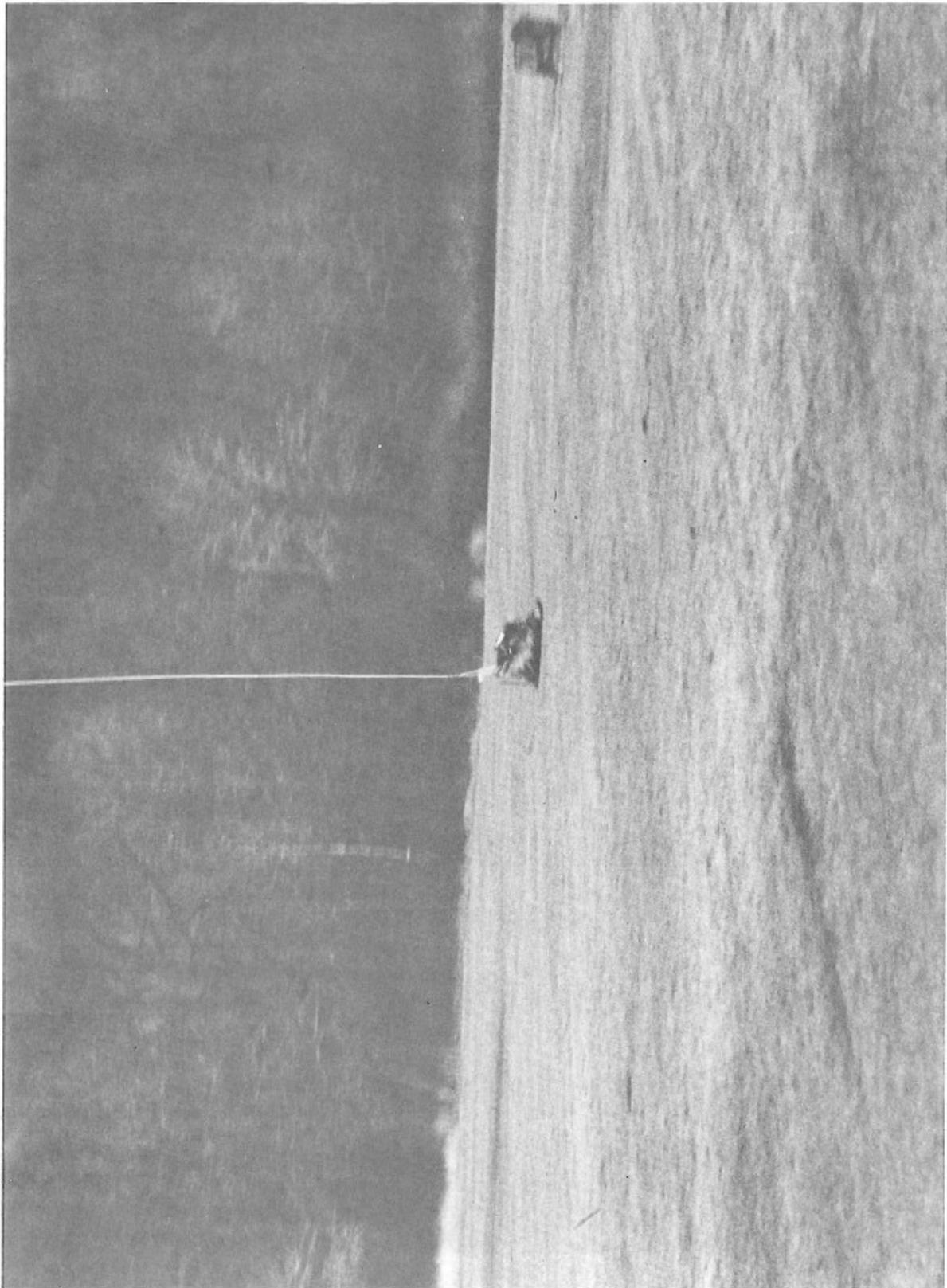


Figure 8. Load Impacting Ground With 20 Knots Forward Air Speed.



Figure 9. Load After Coming to Rest.

Figure 10: This load was dropped from 100 ft and 0 knots. This drop performed as predicted and the honeycomb crushed almost as predicted. Note the manportable module harnesses on each case.

Figure 11: These are the manportable modules. With these harnesses, it is easy to carry two cases a short distance. At 57 lb each, these cases were lighter than the actual cases filled with ammunition which range from 60 to 77 lb. The harnesses in this picture had adjustable shoulder straps which were let out too much. As a consequence, the cases were hanging much too low. However, because of the short distances that they would be transported in this manner, a one-size-fits-all harness would be much cheaper and provide a better fit. Also, the padding on the strap could be deleted because the difficulty added to rigging the load may not be worth the extra comfort and cost.

Summary. Based on these tests, it was concluded that the *Sky Genie* lowering device would perform as predicted in an operational environment.

Given the systems simplicity and ease of operation, it was further concluded that *Sky Genie* implementation as an ammunition delivery system and its integration into operational plans could be accomplished with minimal effort.



Figure 10. Load on Ground After Being Dropped From 100 ft and 0 Knots Forward Air Speed.



Figure 11. Manportable Modules Being Used After Test Drop.

CONCLUSIONS AND RECOMMENDATIONS

The *Sky Genie* can be very effective and predictable if used within its functional parameters. Its maximum load capacity is approximately 500 lb at 100 ft, if used as described (no user input). Once beyond these weight and height parameters, there may be problems with burning rope because of the increased time each element of the rope is in contact with the aluminum shaft when more turns are used. It could certainly handle much more weight if user input was allowed.

The hands-off approach is advantageous because of the speed at which the load reaches the ground. Drop times ranged from 2.5 to 4.5 sec from 65 ft as compared to the 8-ft/sec maximum rate of descent allowed for the present 500-lb cargo and personnel lowering device. This translates to 8 sec for a 65-ft drop. One of the reasons for the slow rate of descent for the present system is that an energy absorber is not specified for the loads. It would be very difficult for a user to judge the height above ground of the load from the helicopter, not to mention how difficult it would be to look over the edge of the aircraft while controlling the device. No user input also means that once the load is free of the craft, there is an extra person and pair of eyes that can defend the craft if necessary for the few seconds the load needs to descend.

The operation of the system is determined by equations 4, 5, and 6 in the previous section. All parameters of the drop are taken into account with these equations. Because these equations would not be used in the field, tables could be made to limit the number of variations possible.

One method, which could be pursued in order to speed the fielding of this system, might be by means of an ECP (engineering change proposal) to the present 500-lb cargo and personnel lowering device.

APPENDIX A.
Sky Genie Patent

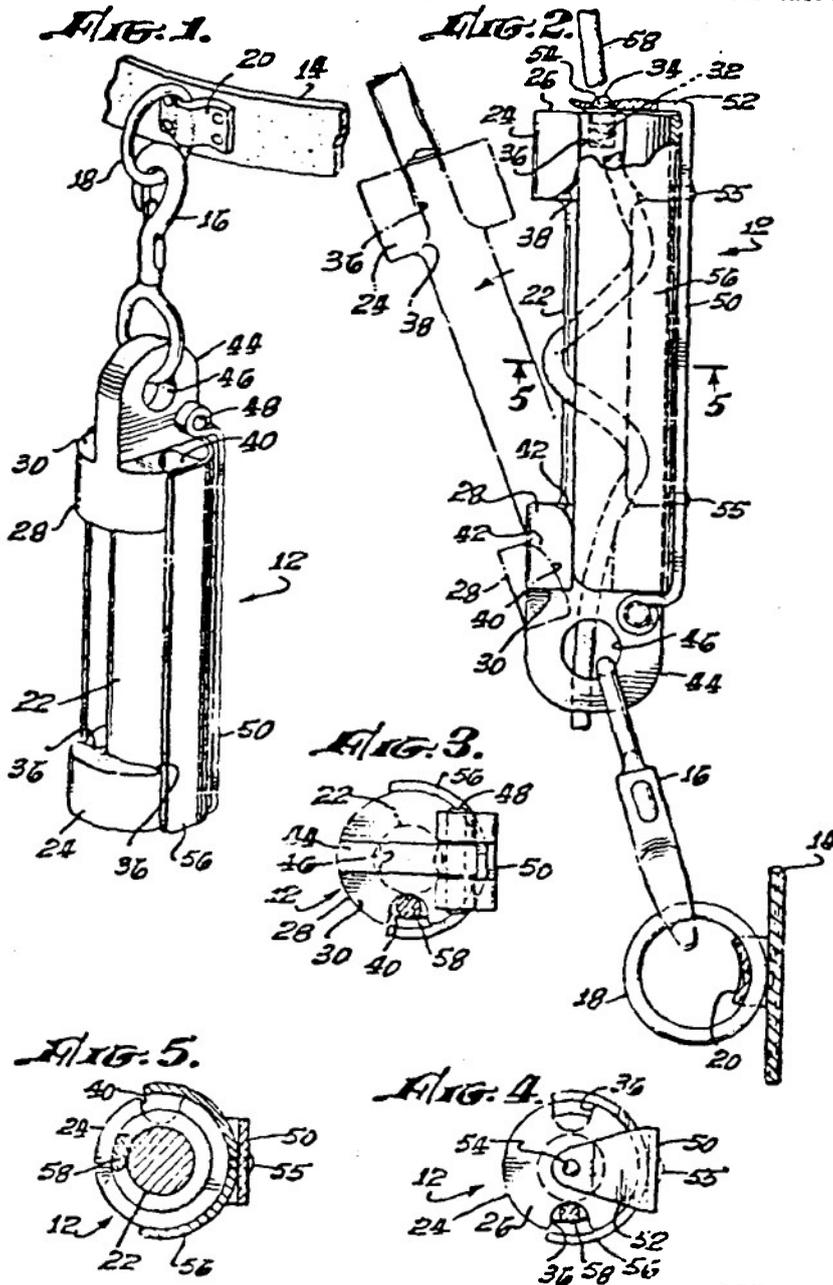
May 10, 1966

J. HUDNALL ETAL
MOVEMENT CONTROL DEVICE

3,250,515

Original Filed June 26, 1961

2 Sheets-Sheet 1



INVENTORS
JOHN HUDNALL,
ROBERT W. ADAMS,
EDGAR E. HOLMESVICK,
By THEIR ATTORNEYS
HARRIS, KIECH, RUSSELL & KERN

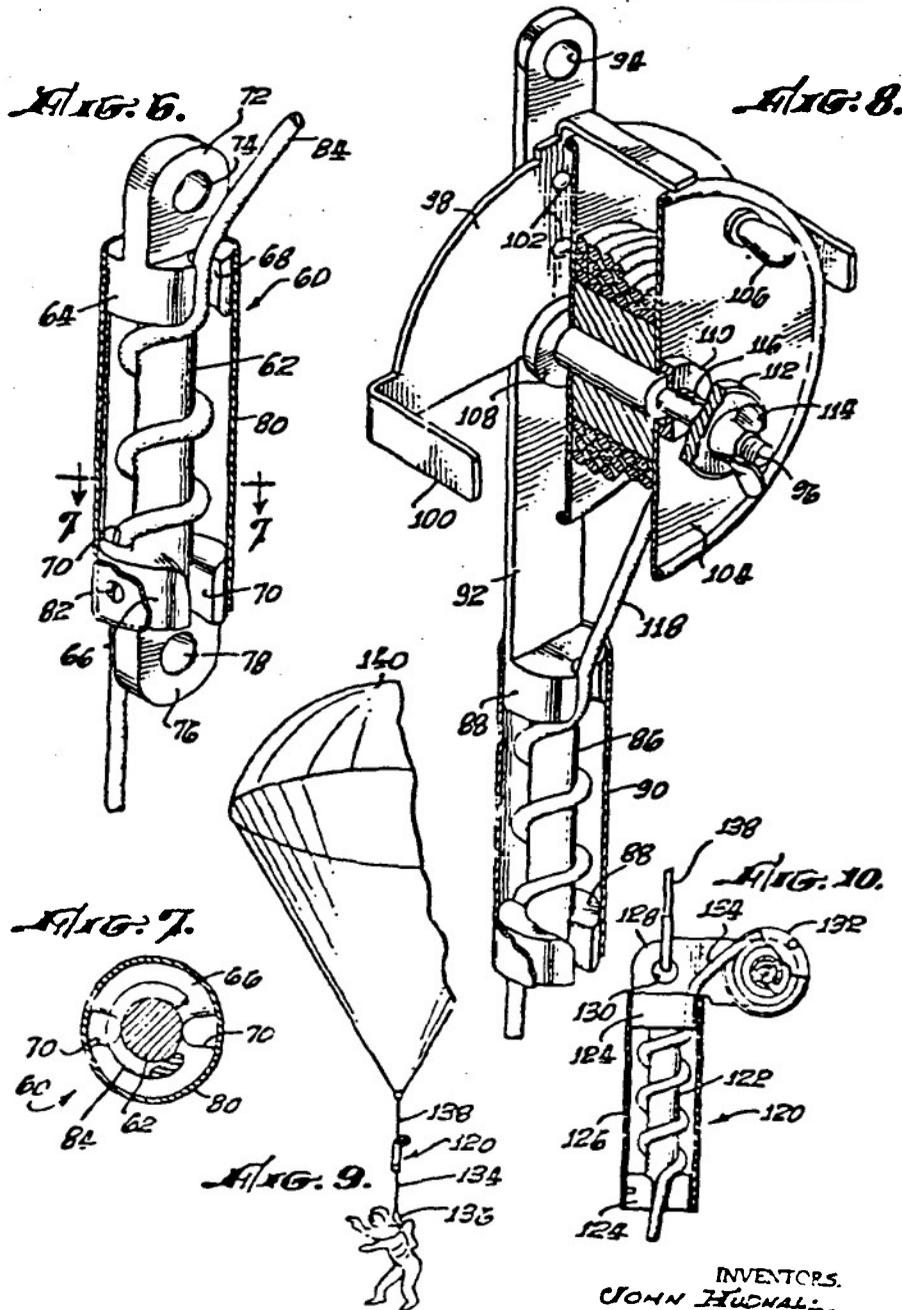
May 10, 1966

J. HUDNALL ETAL
MOVEMENT CONTROL DEVICE

3,250,515

Original Filed June 25, 1961

2 Sheets-Sheet 2



INVENTORS.
JOHN HUDNALL,
ROBERT W. ADAMS,
EDGAR E. HOLMESICK,
BY THEIR ATTORNEYS,
HARRIS, KACHN, RUSSELL & KERN

1

2

3,250,515

MOVEMENT CONTROL DEVICE

John Hudnall, Lynnwood, Wash., and Robert W. Adams, Los Angeles, and Edgar E. Holkesvick, Fullerton, Calif., assignors, by mesne assignments, to Lewis H. Himmelrich, Newport Beach, Calif.
Continuation of application Ser. No. 119,692, June 26, 1961. This application July 12, 1963, Ser. No. 296,834
13 Claims. (Cl. 254-156)

This application is a continuation of application Serial No. 119,692, filed June 26, 1961, now abandoned.

The present invention relates generally to the equipment handling art and more particularly to a novel movement control device for controlling the vertical movement of heavy objects and individuals and for the controlled braking of fast moving vehicles and the like.

Briefly stated, one embodiment of the present invention comprises a body member having a shaft portion with a hub at each end thereof. Axially extending slots are contained in each hub for slidably receiving a rope which is twisted around the shaft, and a removable cover member at least partially encloses the slots to prevent the rope from moving transversely out of the slots during the operation of the device. A bracket is provided at one end of the body member for attaching it to a load, a support, or to the belt of a person who is to use the device.

At the present time cumbersome and expensive hoists and winches are required for lowering heavy objects from a height on construction projects and the like. In other situations, as for example in the trimming of trees, heavy limbs are permitted to fall freely to the ground with possible damage to property and persons nearby.

Turning to another field, at the present time construction workers, firemen, tree trimmers, steeple jacks, high-line workers, and the like must descend from elevated positions by means of ladders, bosons chairs, and the like, or by laboriously climbing down a steel tower, wood pole, or tree trunk.

During rescue operations by helicopters and low flying aircraft, as when rescuing downed flyers from the ocean, the rescued person is often injured by the sudden shock which occurs when he is suddenly lifted from the water.

In still another field, the movement of aircraft on carriers and the movement of sleds used in testing rocket propulsion units is arrested by means of complicated expensive devices.

It is an object of the present invention, therefore, to provide a novel movement control device which is relatively inexpensive, extremely simple in construction and operation, and small in size, and which can be used for safely raising or lowering heavy objects under a controlled rate of speed or for slowing down the movement of vehicles and the like. More particularly, it is an object to provide such a device which can be used in combination with a rope for controlling the rate of movement of the rope therethrough. Specifically, it is an object to provide such a device for mounting on a rope or through which a rope can be moved, whereby the rate of relative movement between the device and the rope is controlled by the amount of frictional engagement therebetween.

Another object is to provide a novel descent control device which can be carried by individuals who work on elevated structures to be used by them in descending a rope at a controlled rate of speed under either normal or emergency conditions. More particularly, it is an object to provide such a device which is small and light in weight, and which can be carried on a workman's belt without interfering with his normal activities. Specifically, it is an object to provide such a device which can be carried on the belt of a workman

and which can be easily and quickly connected to a rope which has its upper end fastened to a support, whereby the workman can quickly and safely descend to the ground under emergency conditions.

Yet another object is to provide a novel device of this type which can be used for safely braking fast-moving devices and objects. More particularly, it is an object to provide such a device, which, under braking conditions, provides for initial fast relative movement between the rope and the device (either of which can be attached to the vehicle being braked), followed by a reduced rate of relative movement therebetween.

Another object is to provide a novel descent control device which can be used for easing or reducing the impact or shock caused by the sudden opening of a parachute or the like. More particularly, it is an object to provide such a device which will provide an initial fast relative movement between the parachute and the object suspended therefrom followed by a relatively slow movement therebetween for a predetermined period of time, and then a simultaneous descent of the parachute and object supported thereby.

An additional object is to provide a novel device of this type which will reduce the amount of shock which occurs when a person is being rescued by a helicopter or slow flying aircraft.

Further objects and advantages of the present invention will be apparent from the following detailed description, reference being had to the accompanying drawings wherein preferred embodiments of the present invention are shown.

In the drawings:

FIG. 1 is a perspective view of a descent control device embodying the teachings of the present invention, said device being of the type which can be worn by individuals who work on elevated structures, the device being shown in operative position;

FIG. 2 is an enlarged front elevational view of the device of FIG. 1, shown in the operative position with the cover member closed;

FIG. 3 is a bottom plan view of the device shown in FIG. 2;

FIG. 4 is a top plan view of the device shown in FIG. 2;

FIG. 5 is a horizontal sectional view taken on the line 5-5 in FIG. 2;

FIG. 6 is a perspective view (partially in cross section) of a modified construction for general useage, as for lowering heavy objects from buildings and the like, and with aircraft;

FIG. 7 is a horizontal sectional view taken on the line 7-7 in FIG. 6;

FIG. 8 is a perspective view (partially in cross section) of another modified construction which includes means for mechanically controlling rate of descent;

FIG. 9 is a somewhat schematic perspective view of yet another modified construction shown in combination with a parachute; and

FIG. 10 is an enlarged front elevational view (partially in section) of the device shown in FIG. 9.

Referring to the drawings more particularly by reference numerals, specifically FIGS 1 through 5, 12 indicates generally a descent control device constructed in accordance with the teachings of the present invention, shown removably attached to a workman's belt 14 by means of a hook catch 16 of conventional construction the latter engaging a ring 18 fastened to the belt by means of a tab 20.

The descent control device 12 includes a central elongated shaft portion 22 of circular cross section, the outer surface of which is preferably polished, and having a lower hub 24 with an end face 26 at one end and an

3

upper hub 28 with an end face 30 at the other end thereof.

Formed in the center of the end face 26 is a cavity 32 (FIG. 2) which receives a spring biased detent 34. Generally axially extending, diametrically opposed grooves or slots 36 with smooth inner surfaces are formed in the hub 24, the bottom portions of the slots 36 being co-extensive with the outer surface of the shaft portion 22, and the innermost ends of the slots being flared outwardly as at 38 (FIG. 2) for a purpose to appear.

The upper hub 28 contains a single, axially extending groove or slot 40 which is preferably in axial alignment with one of the slots 36 for ease of machining and which also has a smooth inner surface co-extensive with the outer surface of the shaft portion and which has the inner end thereof flared outwardly as at 42. As will be discussed more fully hereinafter, the hub 28 could be provided with two such slots but there is no particular advantage in doing so.

Extending from the end face 30 of the hub 28 in a plane normal to the plane of the slots is a flange 44 which contains an opening 46 for receiving one part of the hook catch 16. A pin 48 extends transversely through the flange 44 so as to pivotally support one end of a U-shaped bar-like bracket 50, the free end of the bracket containing a tongue 52 which is provided with an opening 54 for receiving the end of the detent 34. As shown in FIG. 2, the tip of the tongue 52 is curved slightly away from the hub so as to ride over the end of the detent 34 when the bracket is moved to the closed position. Fastened to the inner face of the bracket as by rivets 55 is a trough-like cover member 56 of arcuate cross section which extends from the outer face 30 of one hub to the outer face 26 of the other hub, the diameter of the cover member 56 being only slightly greater than the diameter of the hubs.

As shown in FIG. 2, and as will be discussed more fully hereinafter, the device is used with a rope 58 which is wrapped around the shaft 22 and positioned in the slots 36 and 40, and consequently it is only necessary that the cover member 56 be of a size and shape to at least partially enclose the slots and prevent the rope 58 from slipping radially or transversely therefrom.

Assuming for example that the device is being worn on the belts of firemen who are called to work on a multi-story building, the first fireman on the scene would suspend a number of ropes from the top of the building in position to hang downwardly adjacent the windows in the building. Thereafter, if the fireman found it necessary to quickly leave one of the upper floors of the building, he would merely raise the descent control device to the position shown in FIG. 2, raise the tongue 52 with one finger so as to release the bracket from the end of the hub to permit the shaft and hub assembly to swing to the position shown in broken lines in FIG. 2, pull a portion of the rope into the room, position the rope in the slot 40, wrap it around the shaft 22 a predetermined number of times, position it in one of the slots 36, and then re-engage the tongue 52 with the detent 34 so as to return the cover member to the closed position. Thereafter, the fireman could step out of the window and descend to the ground at a predetermined slow rate of speed, his descent down the rope being controlled by the number of turns of the rope around the shaft and therefore the friction between the device and the rope as the latter slips through it.

If the fireman wished to arrest this descent at any point, it would only be necessary for him to grasp the rope below the device and his movement would stop.

As mentioned hereinabove, the fireman would wind the rope 58 around the shaft 22 a predetermined number of times depending upon the desired rate of descent. Obviously, the number of turns required would depend on the weight of the fireman as well as the desired rate of descent, and would be determined by experiment before

4

the device would be used under emergency conditions. The two slots 36 in the one hub permit a one-half turn adjustment, and the flared inner ends of the slots permit the rope to slide smoothly through the device without any abnormal stresses or friction developing at the corners of the slots.

Inasmuch as considerable heat is developed when the rope slides through the slots and around the shaft, it has been determined that it is very important to make at least the shaft and hub portions, and preferably the cover 56, from a non-ferrous material having a relatively high rate of heat conductivity, as for example aluminum, copper, brass, or magnesium. In short, it is necessary to use a material in which the heat produced at the slots and shaft will be quickly conducted through the material to the outer surfaces of the device where it can be quickly dissipated to the surrounding atmosphere by convection. It is also desirable that the material be non-corrosive relative to water or other types of vapors or liquids which may come in contact with it so as not to adversely affect the smooth surfaces of the shaft portion 22 and the slots 36 and 40.

It is also very important to use a rope which is of braided construction and which is made from a high strength, heat-resistant material such as nylon, or one of the other synthetic fibers sold under the trademarks "Dacron" and "Mylar." These materials are also advantageous in that they are rot and mildew resistant. The braided construction permits the user to descend without turning about the rope and also provides a smooth, constant, frictional drag, and, the heat-resistant feature is necessary to prevent the rope from being burned and charred during usage. Obviously, the charring of the outer surface of the rope would change the coefficient of friction, and, if it were burned sufficiently, it might even break under the weight of the user.

As mentioned hereinabove, the cover member 56 should be of a shape and size to at least partially enclose all of the slots to prevent the rope 58 from moving transversely therefrom during usage. It is also necessary to have it open on one side to permit the shaft and hub assembly to be pivoted away from it, and the open side also permits a better circulation of air to further dissipate the heat developed during usage.

Turning to a consideration of FIGS. 6 and 7, the modified movement control device 60 shown therein is primarily for use in other than so-called emergency situations and can be employed where the device may either descend with the load or be anchored at the support and the load fastened to the rope, or it may be used when the rope is being trailed from a helicopter or slow flying aircraft for rescue purposes.

It includes a shaft 62 with an upper hub 64 at one end and a lower hub 66 at the other end thereof. The upper hub is provided with a single axially extending slot 68 and the lower hub is provided with two diametrically opposed axially extending slots 70, one of which is preferably in axial alignment with the slot 68 for ease in machining. As in the construction previously described, the surface of the shaft and the inner surfaces of the slots are smooth and coextensive and the inner ends of the slots are also flared outwardly to provide a smooth arcuate surface to receive the rope which has been wrapped around the shaft.

An upper flange 72 with an aperture 74 therein extends from the end of the upper hub 64, and a similarly constructed lower flange 76 with an aperture 78 depends from the end of the lower hub 66.

A cylindrical sleeve 80 is slidably mounted on the hubs and is removably attached thereto by means of a screw 82 which engages one of the hubs.

In use, the sleeve 80 is removed from the device, a length of rope inserted through the sleeve, wrapped around the shaft 62 and positioned in the slots 68 and 70, and the sleeve then repositioned on the shaft and

5

cured in place. Thereafter, the upper end of the rope 84 can be secured to a support and the load fastened to the lower flange 76, or, the upper flange 72 can be secured to a support and the load fastened to the lower end of the rope which extends through the device. The latter method of usage is preferred because it permits the user to completely control the movement of the load, whereas when using the first-mentioned method, the rate of descent would have to be predetermined based on the weight of the load.

The embodiment shown in FIGS. 6 and 7 is especially suitable for use on construction jobs, in load lowering and raising operations, and in similar situations where speed of attachment is not essential and where the device may travel with the load or remain with the support. It also may be preferred because of the relatively inexpensive and simple construction.

FIG. 8 shows another embodiment of the present invention which includes a shaft 86 provided with hubs 88 similar in construction to the ones previously described, and which also includes a removable cylindrical cover 90. It differs from the modification shown in FIG. 6, however, in that an elongated supporting bracket 92 extends axially upwardly from the upper hub 88 and contains an aperture 94 at the upper end thereof.

Projecting transversely from the supporting member 92 adjacent the center thereof is a shaft 96 with a threaded outer end. A semicircular guard member 98 with projecting fingers 100 is fastened to the supporting bracket at the inner end of the shaft 96 as by rivets 102. A reel 104 with a handle 106 is rotatably mounted on the shaft and washers 108 and 110 are provided at opposite sides thereof. Mounted on the outer end of the shaft is another washer 112 and a thumb nut 114, and a coiled spring 116 is positioned between the two washers 110 and 112.

In use, a rope 118 is wound on the reel 104 in a conventional manner (with the inner end of the rope fastened to the reel) and the free end thereof is positioned around the shaft 86 and in the slots in the end hubs 88 in the manner previously described. Thus, with the supporting bracket fastened to a hook or the like, as by means of the aperture 94, a load can be fastened to the lower end of the rope 118 and lowered at a predetermined rate by permitting the rope 118 to pass freely through the slots and around the shafts as previously described. However, if it is desired to automatically decrease the rate of descent after the load has started downwardly, this can be accomplished by merely rotating the wing nut 114 so as to further compress the spring 116 and thereby increase the frictional resistance of the washer 110 against the outer face of the reel 104. Thus, for example, it may be advantageous to have a relatively rapid descent at first, followed by a relatively slow descent as the load approaches the ground. This can be accomplished by merely rotating the wing nut 114 in the manner previously described.

After the load has been released, the wing nut 114 can be loosened and the rope 118 quickly and easily rewound on the reel by rotating it by means of the handle 106. Although the guard member 98 and the fingers 100 are not absolutely necessary, they do prevent the rope from coming off the reel 104 during the usage thereof.

Yet another embodiment of the present invention is shown in FIGS. 9 and 10, and is used to reduce the shock caused by the opening of a parachute or the like. Thus, a device 120 is provided with a shaft 122 having hubs 124 at each end thereof, each of said hubs containing one or more slots or grooves formed and shaped in the same manner as previously described. A cylindrical sleeve 126, similar to the construction previously described, is also removably mounted on the hubs 124.

Extending from the outer end of the upper hub is a plate-like flange or bracket 128 which contains an aper-

6

ture 130 in axial alignment with the shaft and which also rotatably supports a small reel 132 positioned transversely of the aperture 130. A rope 134 has one end portion wound about the reel and the end fastened to the reel or reel shaft. The remaining portion of the rope is positioned about the shaft 122 and in the slots in the hubs in the manner previously described, and the portion of the rope which extends from the device is fastened to the parachute harness 136 of the user. A short line 138 has one end connected to the device 120 by means of the aperture 130 and the other end thereof is connected to the shroud lines of a parachute 140.

One of the surprising and interesting characteristics of this device is that when a force is suddenly applied to the portion of the rope which depends from it, the rope will pass through the device at a relatively rapid rate of speed until several feet of rope have passed therethrough, and then the speed will be smoothly and steadily reduced to the relatively slow rate of relative movement between the rope and the device which will continue thereafter. Consequently, when the chute 140 opens and the descent of the jumper is suddenly arrested, the rope 138 will at first pass through the device at a relatively high rate of speed, and then, after several feet of rope have passed therethrough, the speed of the rope passing through the device will gradually decrease to a relatively slow rate until all of the rope has been paid from the reel 132. By this time, however, the jumper and parachute are descending at substantially the same rate and there is no reason for relative movement between them.

It will be readily apparent from the above description of the device 120 that the invention embodied in the various modifications disclosed herein is not limited to arresting the descent of a person or a load, but that it can also be used in arresting the movement of aircraft landing on carriers, stopping speeding automobiles without injuring the occupants, and in arresting the movement of sleds and the like used in testing rocket propulsion devices.

In addition, it can also be used where the load is being moved upwardly as in rescue operations. Thus, a device of the type described can be used for trailing a rope from a helicopter or slow flying aircraft so that when the person being rescued from the water, for example, grasps the rope, the rope initially slides through the device at a relatively rapid rate so as to reduce the amount of shock.

Thus, it is apparent that there has been provided several modifications of a movement control device which fulfill all of the objects and advantages sought therefor.

The device is relatively simple in construction and operation, and because of the limited number of parts it is also relatively inexpensive to manufacture. It can be used for the controlled descent or ascent of loads or individuals, and because it is relatively small and light in weight, it can be carried by individuals who work on high structures and who may have to quickly descend from those structures under emergency conditions.

It is to be understood that the foregoing description and the accompanying drawings have been given only by way of illustration and example and that changes and alterations in the present disclosure which will be readily apparent to one skilled in the art are contemplated as within the scope of the present invention.

We claim:

1. A movement control device for use with a length of rope, comprising:
 - a body member including a shaft portion with a hub portion adjacent each end thereof;
 - at least one generally axially extending slot in each hub portion of a size to slidably receive said rope;
 - an attachment bracket extending from one of said hub portions; and
 - a trough-like cover member pivotally mounted on the body member adjacent said one hub portion and

7

movable between an open position in which the slots are exposed and a closed position in which the slots are at least partially enclosed to prevent the rope from moving transversely out of said slots during usage.

2. A movement control device for use with a length of rope, comprising:

a body member including a shaft portion with a hub portion adjacent each end thereof;
at least one generally axially extending slot in each hub portion of a size to slidably receive said rope;
an attachment bracket extending from one of said hub portions;
releasable detent means adjacent the other of said hub portions; and

a trough-like cover member pivotally mounted on the body member adjacent said one hub portion and movable between an open position away from said hub portions and a closed position adjacent said hub portions, said cover member including means for engagement with the detent means for releasably maintaining the cover member in the closed position.

3. A movement control device for use with a rope, comprising:

an elongated shaft portion of substantially uniform cross section with a smooth outer surface free of recesses, said shaft portion being of a length to receive varying turns of rope thereabout;

a hub portion adjacent each end of the shaft portion; at least one slot with an inner surface contained in each hub portion, each of said slots being of a size to slidably receive a rope and having the inner surface thereof coextensive with the outer surface of the shaft portion; and
attachment means connected to at least one hub portion.

4. A movement control device for use with a rope, comprising:

a body member made from a non-ferrous material which has a relatively high rate of heat conductivity so as to quickly dissipate heat produced therein,

said body member including an elongated shaft portion of substantially uniform cross section with a smooth outer surface free of recesses and being of a length to receive varying turns of rope thereabout, and a hub portion adjacent each end of the shaft portion;

at least one slot with an inner surface provided in each hub portion,

each of said slots being of a size to slidably receive a rope and having the inner surface thereof co-extensive with the outer surface of said shaft portion; and attachment means connected to at least one hub portion.

5. In combination:

a movement control device for use with a rope, having an elongated shaft portion with an outer surface free of recesses, and a hub portion adjacent each end of the shaft portion;

at least one slot with an inner surface provided in each hub portion, each of said slots being of a size to slidably receive the rope and having the inner surface thereof coextensive with the outer surface of the shaft portion so as to guide the rope directly onto said last mentioned surface;

attachment means at one hub portion for suspending a load from the movement control device;

a rope extending through one slot in each hub portion and around the elongated shaft portion the number of turns required to provide the selected rate of descent of the control device relative to the rope,

said rope being of braided construction to prevent the control device and the load supported there-

8

by from rotating about the rope during the descent; and

removable means at least partially enclosing said slots to prevent the rope from moving transversely therefrom.

6. The combination set forth in claim 5 in which the strands of the braided rope are made from high strength, heat resistant, synthetic fibrous material.

7. A movement control device for use with a rope, comprising:

an elongated shaft portion of a length to receive varying turns of rope thereabout;

a hub portion adjacent each end of the shaft portion; at least one generally axially extending slot in each hub portion of a size to slidably receive the rope;

an attachment bracket extending from one of said hub portions; and

a cover member having one end thereof pivotally mounted adjacent one of said hub portions and movable between an open position in which the cover member is positioned away from the shaft portion and the slots are exposed and a closed position in which said slots are at least partially enclosed to prevent the rope from moving transversely out of the slots.

8. A movement control device as set forth in claim 7 which includes detent means engageable by the end of the cover member opposite to the pivotally mounted end for releasably maintaining the cover member in the closed position.

9. A movement control device for use with a rope, comprising:

an elongated shaft portion with a smooth, polished outer surface free of recesses,

said shaft portion being of uniform size throughout its length;

a hub portion adjacent each end of the shaft portion; at least one generally axially extending slot in each hub portion, of a size to slidably receive the rope,

said slots having innermost ends and bottom surfaces,

the innermost ends being flared outwardly to provide smooth arcuate surfaces and the bottom surfaces being coextensive with the outer surface of the shaft portion, whereby the rope slides freely between the slots and the outer surface of the shaft portion without binding; and

removable means for at least partially enclosing said slots to prevent the rope from moving laterally therefrom.

10. A movement control device for use with a rope, comprising:

an elongated shaft portion with a smooth outer surface free of recesses, said shaft portion being of a length to receive varying turns of rope thereabout;

a hub portion adjacent each end of the shaft portion;

a generally axially extending slot with an inner surface provided in one hub portion,

said slot being of a size to slidably receive the rope and having the inner surface thereof coextensive with the outer surface of the shaft portion;

two diametrically opposed, generally axially extending slots in the other hub portion, one of said slots being in axial alignment with the slot in said one hub portion,

each of the slots in said other hub portion being of a size to slidably receive the rope and having an inner surface co-extensive with the outer surface of the body portion; and

removable means for at least partially enclosing all of said slots to prevent the rope from moving laterally therefrom.

9

11. A movement control device for use with a length of rope, comprising:
 a body member including a shaft portion with a hub portion adjacent each end thereof;
 at least one slot with an inner surface contained in each hub portion each of said slots being of a size to slidably receive a rope and having the inner surface thereof coextensive with the outer surface of the shaft portion;
 means for at least partially enclosing each slot to prevent the rope from moving transversely out of the slots during usage;
 an elongated bracket extending from one hub portion; a reel member rotatably mounted on said bracket; and means for selectively retarding the rotation of said reel member.
 12. A movement control device for use with a length of rope, comprising:
 a body member including a shaft portion with a hub portion adjacent each end thereof;
 at least one slot with an inner surface contained in each hub portion each of said slots being of a size to slidably receive a rope and having the inner surface thereof coextensive with the outer surface of the shaft portion;
 means for at least partially enclosing each slot to prevent the rope from moving transversely out of the slots during usage;
 an elongated bracket extending from one hub portion; a reel member rotatably mounted on said bracket; and frictional means for engagement with said reel member for retarding the movement thereof.
 13. A movement control device for use with a length of rope, comprising:

10

- a body member including a shaft portion with a hub portion adjacent each end thereof;
 at least one slot with an inner surface contained in each hub portion each of said slots being of a size to slidably receive a rope and having the inner surface thereof coextensive with the outer surface of the shaft portion;
 means for at least partially enclosing each slot to prevent the rope from moving transversely out of the slots during usage;
 a bracket extending from one of said hub portions and containing means for attaching a line thereto; and means for supporting said length of rope on said bracket in a coiled position with one end thereof in frictional engagement with said body member.

References Cited by the Examiner

UNITED STATES PATENTS

20	386,237	7/1888	Budd	188-65.4
	536,866	4/1895	Fitzgerald	188-65.3
	1,103,849	7/1914	Stenborg	182-5
	1,115,603	11/1914	Smith	188-65.4
	1,187,754	6/1916	Lyra	188-65.4
25	2,482,052	9/1949	Zachary	132-40
	2,680,577	6/1954	Frieder	188-65.5
	2,682,272	6/1954	Hopkins	132-41

FOREIGN PATENTS

30	800,862	5/1936	France.
----	---------	--------	---------

HARRISON R. MOSELEY, *Primary Examiner.*

R. P. MACHADO, *Assistant Examiner.*

APPENDIX B.
Airworthiness Release



DEPARTMENT OF THE ARMY
HEADQUARTERS, US ARMY AVIATION SYSTEMS COMMAND
4300 GODFELLOW BOULEVARD, ST. LOUIS, MO. 63120-1798

REPLY TO
ATTENTION OF

AMSAV-E

16 AUG 1988

MEMORANDUM FOR:

Commander, U.S. Army Troop Support Command, Natick Research,
Development and Engineering Center, ATTN: STRNC-AA, Natick, MA
01760-5015
Commander, 10th Special Forces Group, ATTN: CPT Bosnowski, Ft.
Deven, MA 01433

SUBJECT: Airworthiness Release for UH-60A Helicopters 85-24390,
85-24417, 85-24418, and 85-24392 for Conducting a Test of a New
Air Delivery Concept

1. Reference:

a. Memorandum, STRNC-AA, 18 Jul 88, subject: Worthiness
Release for Airdrop Loads in UH-60 Helicopters.

b. Instruction Manual and Technical Bulletin, Sky Genie
Variable Descent System, Descent Control Inc, 1985.

c. TM 55-1520-237-10, 8 Jan 88, with Change 1, 29 Mar 88,
Operator's Manual UH-60A Helicopter.

2. This memorandum constitutes an Airworthiness Release in
accordance with AR 70-62 for the operation of the UH-60A
helicopter S/N 85-24390, 85-24417, 85-24418, and 85-24393 with the
Sky Genie Variable Descent System installed at the aircraft
tiedown assembly at Station 312 or 344 as outlined in references
1a and 1b.

3. The UH-60A helicopter is defined in the reference 1c
manual with exceptions note in the respective DD 250 acceptance
document. Modifications to the aircraft are defined in reference
1a memorandum and meet the constraint criteria of reference 1c.

4. The operating instructions, procedures, and limitations shall
be IAW reference 1c, UH-60A Operator's Manual except as modified
herein.

a. All flights will be day, VFR only.

b. The Sky Genie installation shall be inspected prior to
each flight for security and to assure that the host helicopter is
not damaged.

16 AUG 1988

AMSAV-E

SUBJECT: Airworthiness Release for UH-60A Helicopters 85-24390, 85-24417, 85-24418, and 85-24392 for Conducting a Test of a New Air Delivery Concept

5. The aircraft shall be inspected and maintained IAW all applicable maintenance manuals and associated Maintenance Advisory and Safety of Flight Messages. Any discrepancies shall be evaluated/repared prior to the next flight to ensure continued Airworthiness Release.

6. Parts needed for this modification may not be available in supply system. Your activity/facility must locally procure/manufacture the modification parts. This Airworthiness Release is not authorization to procure any material or services "Sole Source."

7. Aircraft Logbook Entries:

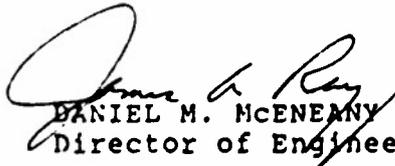
a. In accordance with the provisions of DA PAM 738-751, the following entries shall be made on DA Form 2408-13 and will be perpetuated on each Form until the Airworthiness release is terminated.

(1) Block 17 - Operate within the limitations prescribed in the enclosed Airworthiness Release dated **16 AUG 1988**

(2) The above entry will be preceded by the entry of a circle red "X" within block 16 and block 7 adjusted when appropriate.

b. A copy of this Airworthiness Release shall be placed in the aircraft logbook.

FOR THE COMMANDER:


DANIEL M. MCENEANEY
Director of Engineering