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NEWTOWN, CONNECTICUT

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REPORT NUMBER A (/,I,II,III) Nonr. 1125(00)

DATE 30 May, 1953.

REPORT

ON

PRELIMINARY STUDY AND RESEARCH RELATED TO IN-FLIGHT PICK-UP OF MEN AND MATERIALS WITH HIGH-PERFORMANCE AIRCRAFT

under

OFFICE OF NAVAL RESEARCH CONTRACT Nonr. 1126(00)

This do[illegible] been reviewed in acc[illegible] with [illegible]0.17, paragraph [illegible] curity [illegible] signed [illegible] to is [illegible]

Date 11/13/53 [signature] By direction of Chief of Naval Research (Code 461)

ROBERT E. FULTON, JR. NEWTOWN, CONNECTICUT.

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THIS REPORT IS A RESULT OF WORK
BY THE FOLLOWING GROUP .....

Robert E. Fulton, Jr., Chairman

O. J. Alvarez.

Leopold S. Godowsky.

Karl K. Sohakel

ROBERT E. FULTON, JR.
NEWTOWN, CONNECTICUT.

Project No. A (/) NONR.1128(00) dated (x) May, 1953. A

Project title: HIGH-PERFORMANCE PICK-UP.

NOTE

This REPORT is divided into 3 main sections:

SECTION I presents essentially the positive conclusions of the project with descriptive notes.

SECTION II consists of the work-papers (which include both positive and negative data and records of tests) upon which the conclusions of Section I are based.

SECTION III consists of motion picture films of a number of the tests described in Section II.

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REPORT TITLE HIGH PERFORMANCE PICK-UP.

INDEX

SUBJECT — PAGE

SECTION II

This Section consists of a MICROFILM record of work-papers and data collected in arriving at conclusions presented in Section I.

This material is both positive and negative, shows why some ideas may work, others may not.

For complete Index of this material see page..... 93.

SECTION III

This Section consists of a MOTION PICTURE record of a few of the preliminary tests conducted to determine feasibility of various techniques and supporting conclusions presented in Section I.

For complete Index of this material see page..... 98.

ROBERT E.
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PURPOSE

The PURPOSE of this REPORT is....

1. ....to study the problems related to picking up materiel and personnel from the grouna by means of high-performance aircraft.

2. ....to propose practical methods of accomplishing such pick-up.

3. ....to recommend a program of field testing which will prove and perfect the methods proposed.

CONCLUSIONS

The SKYHOOK, LONG-LINE, and MID-AIR techniques outlined below all appear to be potential solutions to the problem.

Preliminary tests have already indicated the feasibility of these three methods. (See Section II -test records-, and Section III -motion pictures-, of this Report for detailed data).

Since different circumstances of weather, light, geographical location, etc., prevailing at time of pick-up strongly affect the situation, one of these three techniques may sometimes be better than another.

It is therefore considered important to have as many solutions to the problem as possible. This increases the insurance of success of any pick-up operations which may be undertaken.

RECOMMENDATION

That a program of field testing of these three techniques be initiated to render them operational.

(See Page of this Report for details of Suggested Field Test Program).

Emphasis throughout this project has been placed on SIMPLICITY.

It is realized that operations will sometimes have to be conducted under conditions of poor weather, darkness, high winds and difficult terrain.

Furthermore personnel being picked up will not always be familiar with procedures and details of the equipment.

Under such circumstances complication of any kind cannot be tolerated.

If the processes described herein appear simple it is because all complication has been hammered out of them. It is indicative of their better chances of success.

The techniques described on the following pages are selected from a great many which have been thought of, both by this group and others. Some have been tried, most have not.

In the case of the three methods presented below, some preliminary tests have been conducted by this group*. The results have been sufficiently encouraging so that, combined with all considerations, these three techniques appear to have the best chance of proving practical.

---

* The results of these tests are only briefly referred to herein. More detailed data is available by reference to Sections II and III of this Report.

ROBERT E.
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REPORT TITLE HIGH PERFORMANCE PICK-UP.

TERSE TECHNIQUES

WHICH APPEAR

MOST PROMISING .....

"SKYHOOK" TECHNIQUE

EQUIPMENT

* A "skyhook", such as a small balloon, is provided to support approximately 200 to 1,000 feet of cable with multiple "knots" (swaged fittings) toward the top.
* A bag or harness is provided for the person to be picked up.
* The rescuing aircraft is fitted with a "yoke" or "yokes" on its nose and a reel-in mechanism inside.

SEQUENCE -

1. Aircraft intercepts cable.
2. "Knot" locks in "eye" of yoke.
3. Top of cable moves forward, bag moves upward, balloon bursts.
4. Bag is hauled into aircraft.

REMARKS

* Intercepting cable is easy because yoke is on nose of plane directly in front of pilot (not somewhere down under the tail) and its arms are widely spread. Numerous "knots" on cable also provide plenty of vertical latitude.
* With 400 feet of cable and aircraft speed of 150 knots, cargo will be subjected to approximately 5 G's for less than 2 seconds. Doubling cable length halves G's.
* Cargo will easily clear 100 foot obstacle less than 100 feet away.
* Preliminary tests of this technique have already been successfully conducted. (More details later).

"LONG-LINE" TECHNIQUE

EQUIPMENT

* Aircraft is fitted with a reel-in mechanism and is loaded with a "long-line bomb".

* "Long-line bomb" consists of a bag with several thousand feet of line in it.

SEQUENCE

1. Aircraft "bombs" appointed spot, holding onto one end of line. As bomb-bag drops line runs out of it.

2. Aircraft circles overhead until bag is on ground and person to be rescued gets into it.

3. Person in bag fires "ready" signal and plane starts climbing and flying away.

4. Bag rises virtually straight up (follows path of line which, at bottom, is hanging almost straight down).

5. Bag is reeled into aircraft.

REMARKS

* All equipment is in plane.

* Rescued person needs only to get to and enter the bag, fire the "ready" signal.

* Lift is practically vertical with virtually no G's.

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REPORT No. A(I)NONR 1126(00) DATE 30 MAY 1953

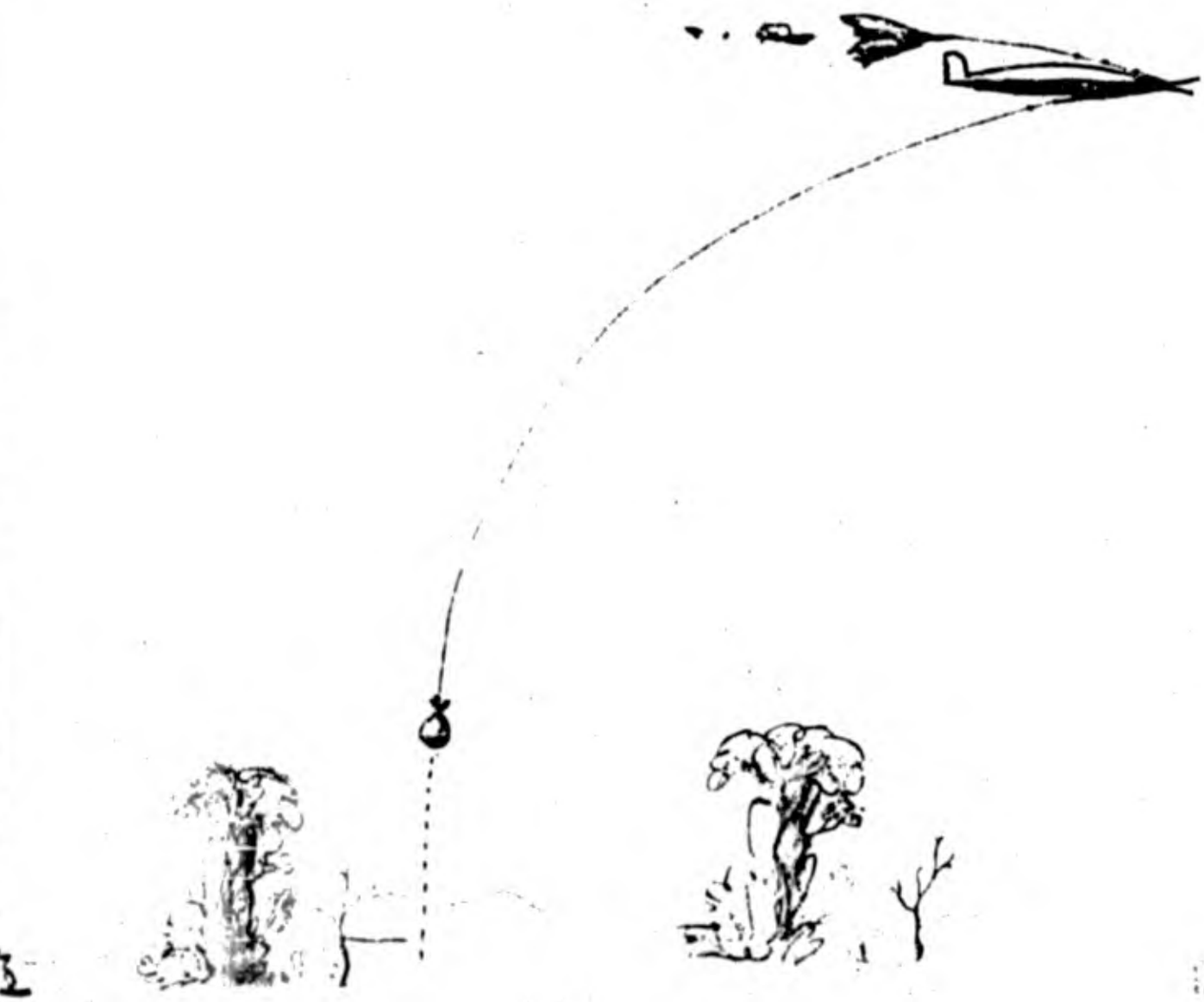
REPORT TITLE HIGH PERFORMANCE PICK-UP
'SKYHOOK' TECHNIQUE

12-A

30 MAY 1953

PICK-UP

IQUE



12-B

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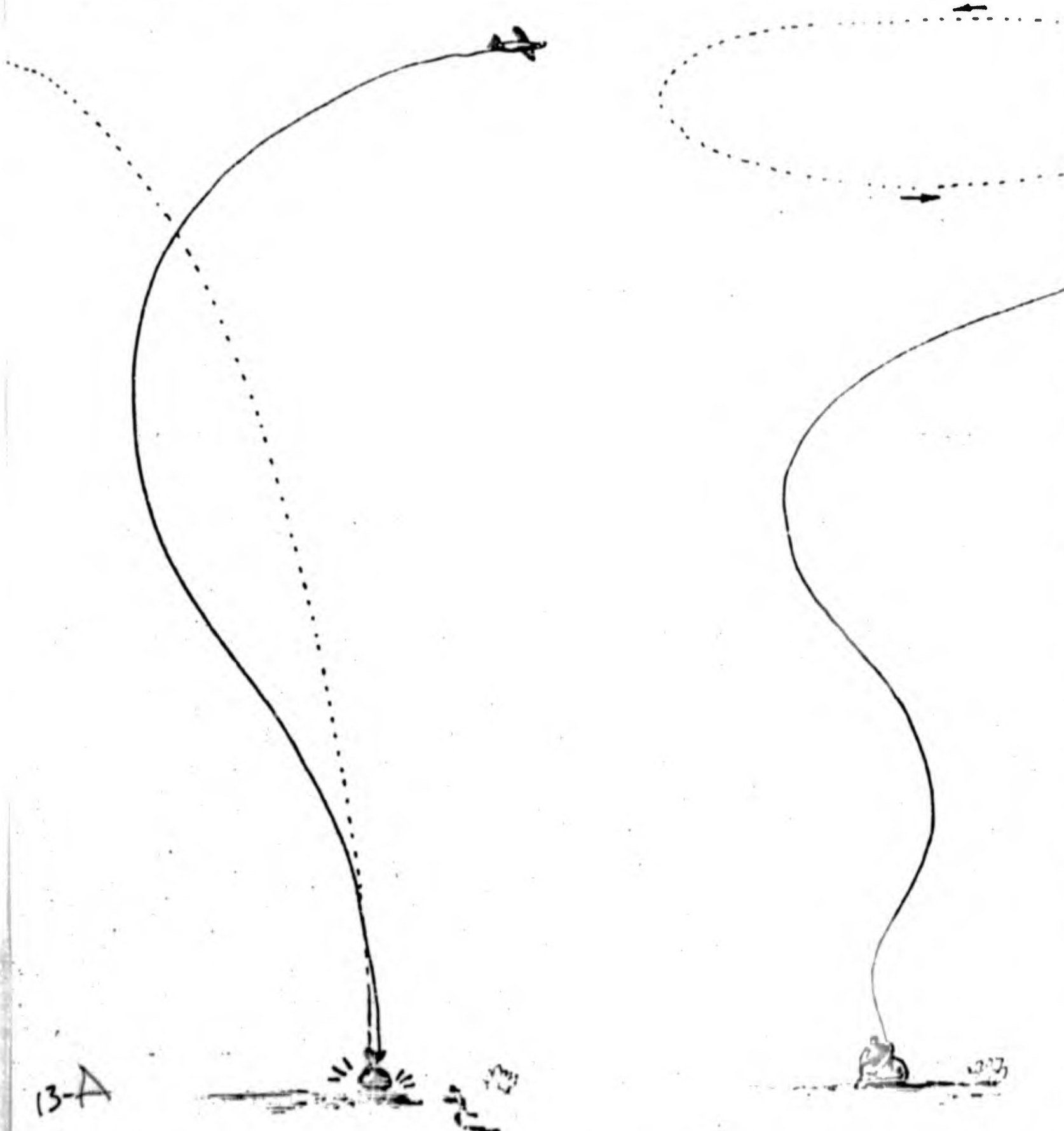
REPORT No. A(E)NONE 1[illegible]00) DATE 30 MAY 1953 PAGE

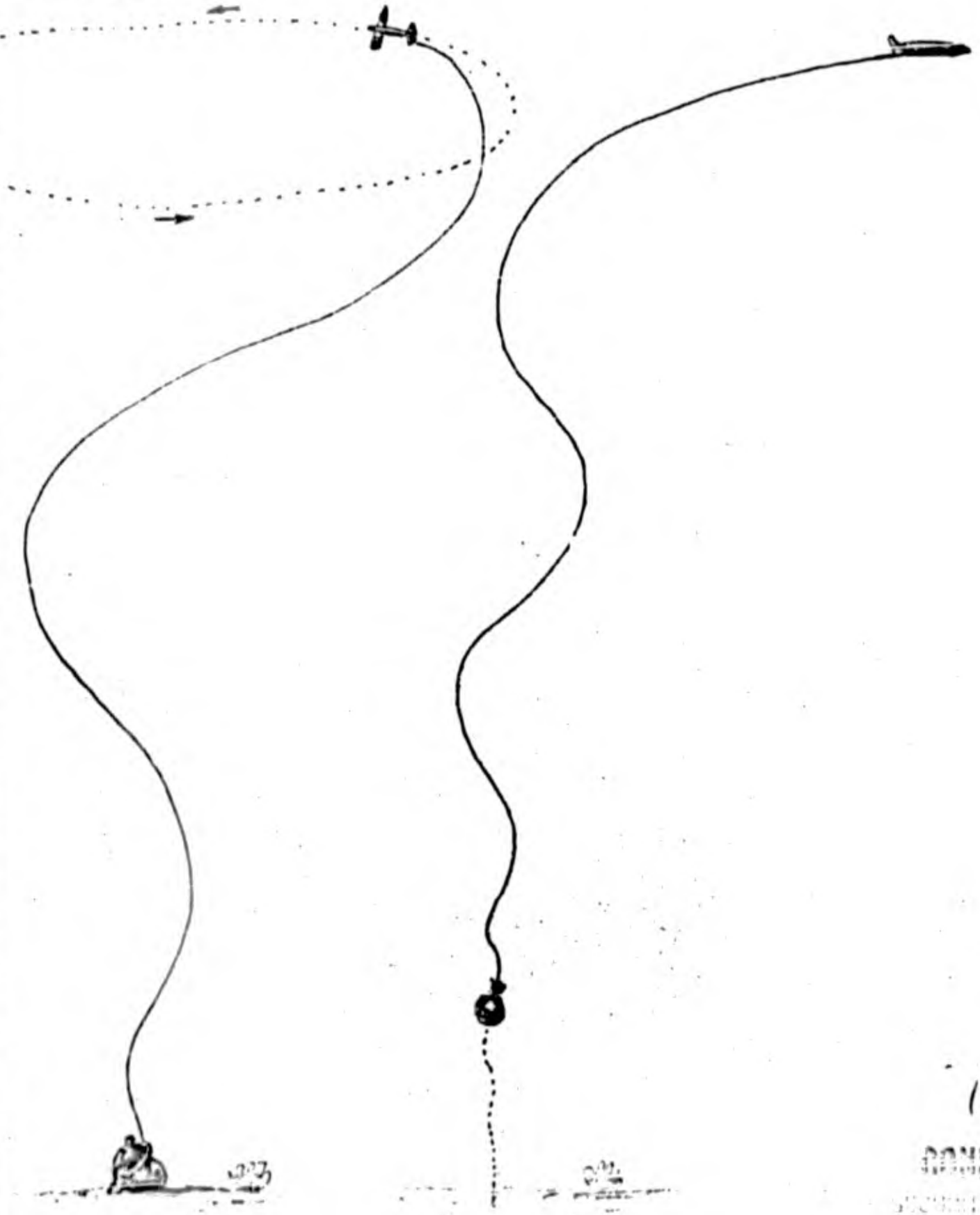
REPORT TITLE HIGH PERFORMANCE PICK-UP
"LONG-LINE TECHNIQUE



13-A

P

UE



13-B

"MID-AIR" TECHNIQUE

EQUIPMENT

* Man-carrying balloon.
* Cable with "knots".
* Bag.
* Lowering mechanism inside bag.
* Aircraft fitted with yoke and reel-in mechanism.

SEQUENCE

1. Balloon goes aloft with bag suspended closely under it so occupant can control vertical flight path.
2. Shortly prior to pick-up occupant lowers self and bag full length of cable (400 to 1,000 feet).
3. Yoke engages line and "knot" looks in eye.
4. Top of cable moves forward, bag moves upward, balloon bursts.
5. Bag is hauld into aircraft.

REMARKS

* This technique essentially the same as "SKYHOOK" except that balloon is bigger and bag is already in the air.
* Success of the principle has already been proven by preliminary tests of the SKYHOOK technique.
* G-loads can be even less than with the SKYHOOK technique because it is easier to use a longer cable.

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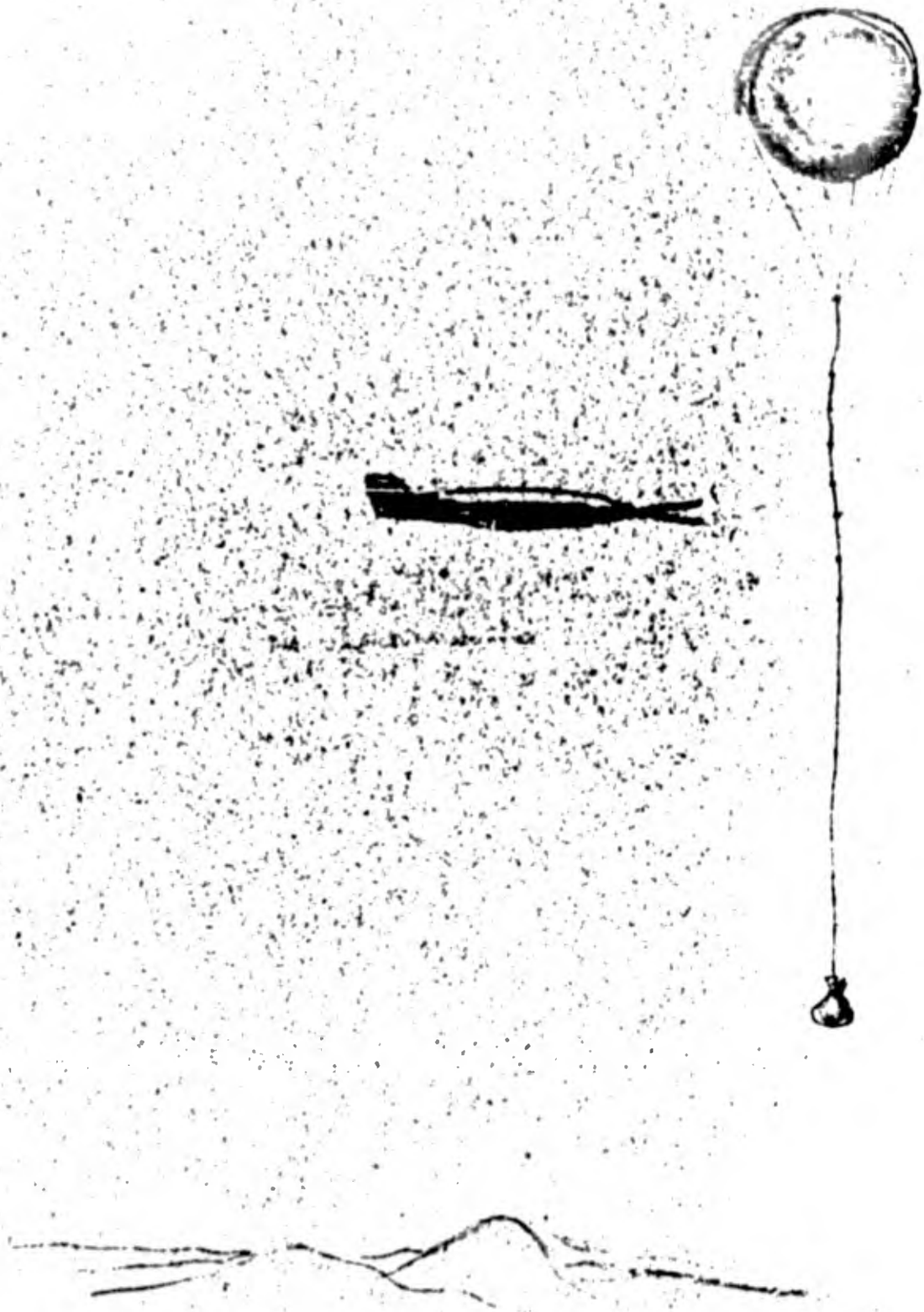
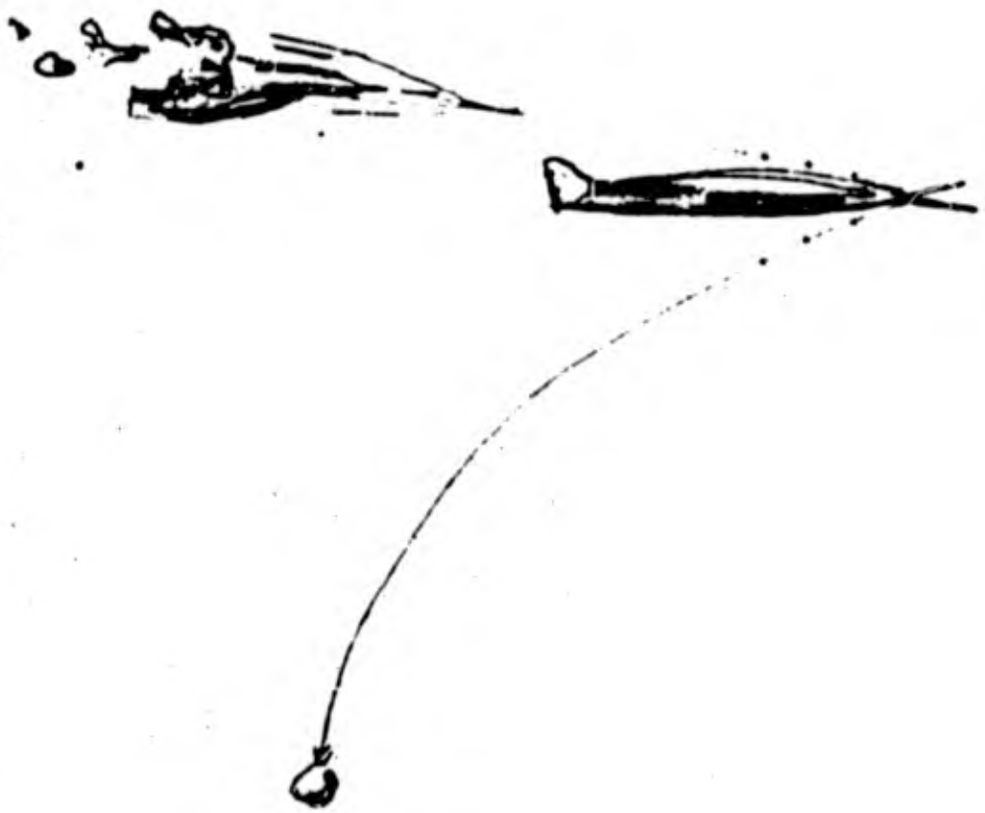
[illegible] dtd 30 MAY 1953 pg 11.

about the HIGH-PERFORMANCE PICK-UP

"MID-AIR" TECHNIQUE



15-A



FURTHER

"SKYHOOK"

DATA .....

(See Sections II & III for greater detail).

FILM-PLOT OF "SKYHOOK" TECHNIQUE

Material presented on facing page was obtained directly from motion picture record of an actual pick-up accomplished by "SKYHOOK" technique.

The film was projected frame-by-frame and the trace exactly follows the photographed flight path. Known speed of the camera provided accurate timing information.

Camera was located approximately 500 feet from the bottom of the lift-line and it was about another 200 feet to the trees.

Note extent to which cargo would clear high surrounding obstacles.

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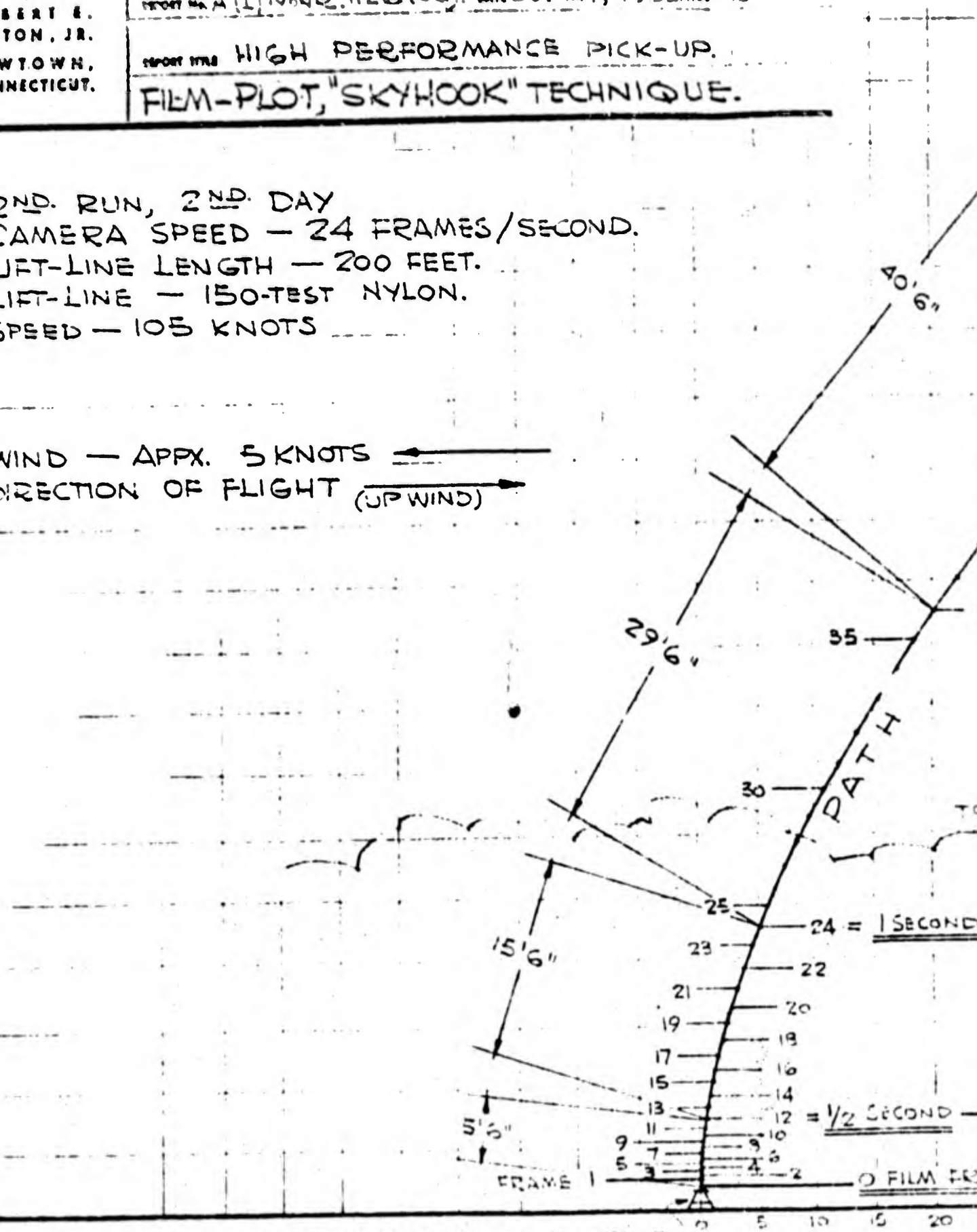
REPORT NO. A (I) No. R. 1126 (00). DATE 30 MAY, 1953 PAGE 13.

REPORT TITLE HIGH PERFORMANCE PICK-UP.

FILM-PLOT, "SKYHOOK" TECHNIQUE.

2ND. RUN, 2ND. DAY
CAMERA SPEED — 24 FRAMES/SECOND.
LIFT-LINE LENGTH — 200 FEET.
LIFT-LINE — 150-TEST NYLON.
SPEED — 105 KNOTS

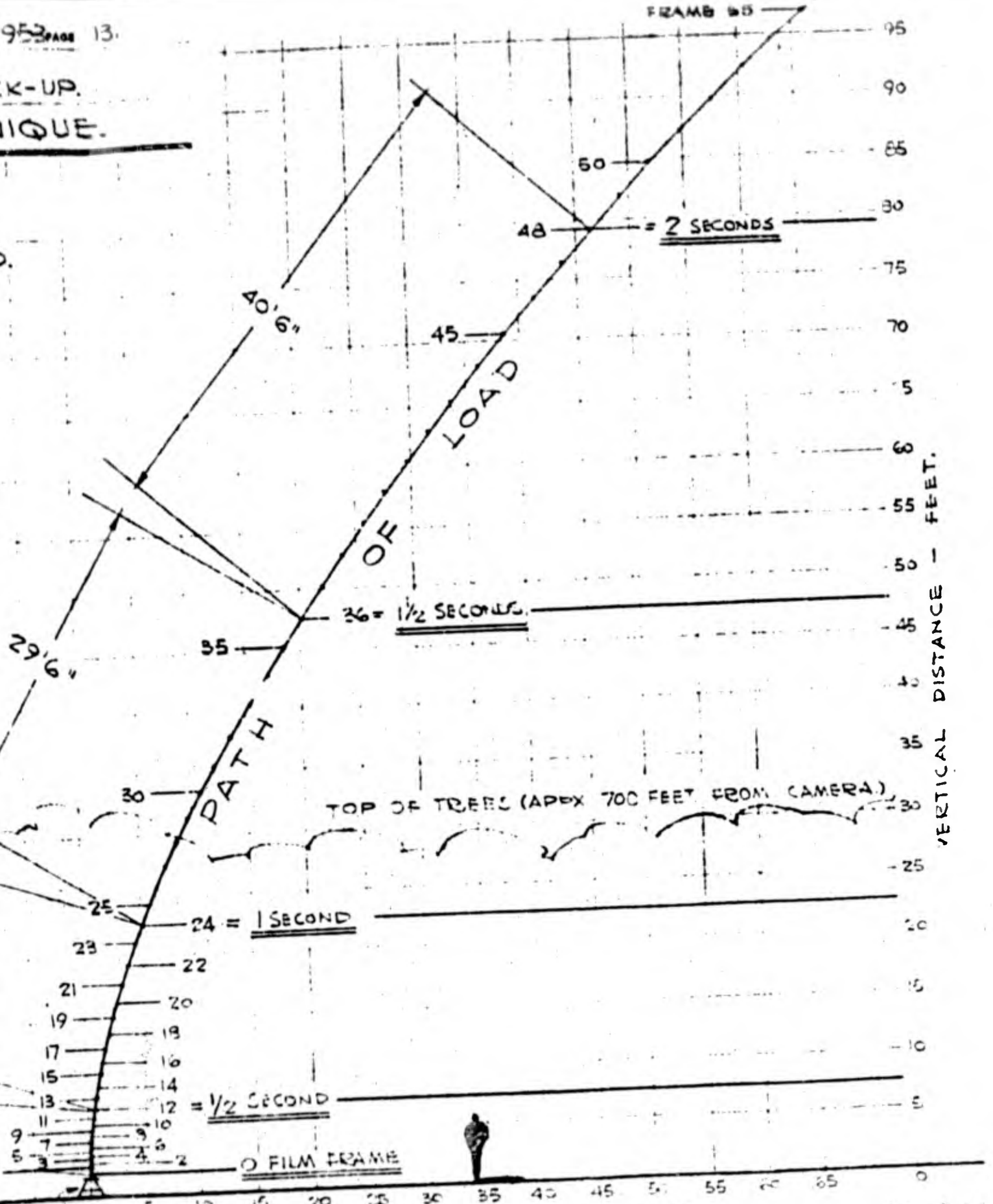
WIND — APPX. 5 KNOTS
DIRECTION OF FLIGHT (UP WIND)



18-A

K-UP.

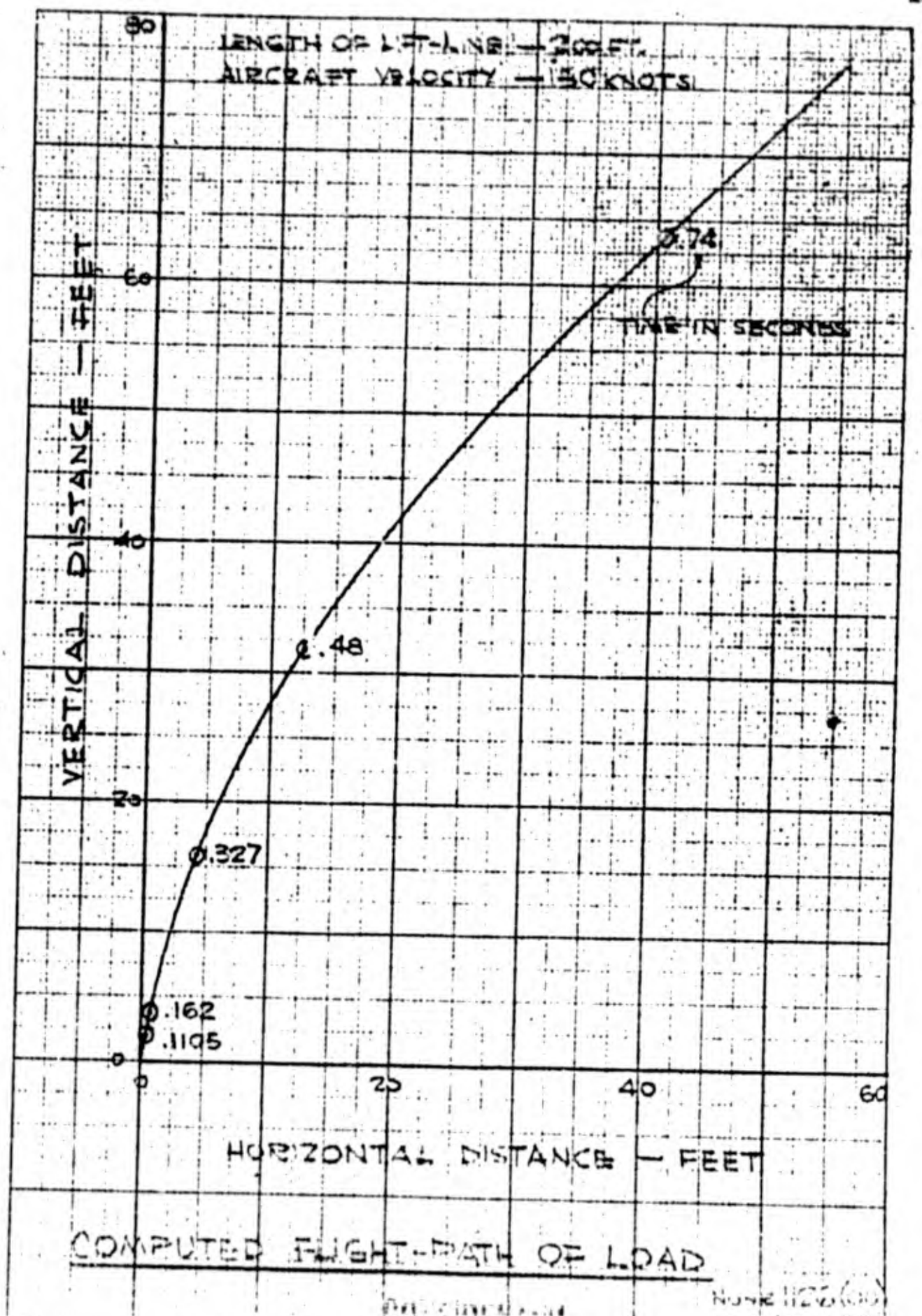
IIQUE.



18-B

COMPUTED FLIGHT PATH

Accompanying plot of mathematically computed flight path of the picked-up load agrees substantially with actuallity as recorded by motion picture and shown on the preceeding page.



COMPUTED FLIGHT-PATH OF LOAD

"G" - L O A D C O M P U T A T I O N S

Figures shown herewith are computed for various loads, line lengths, aircraft speeds, etc.

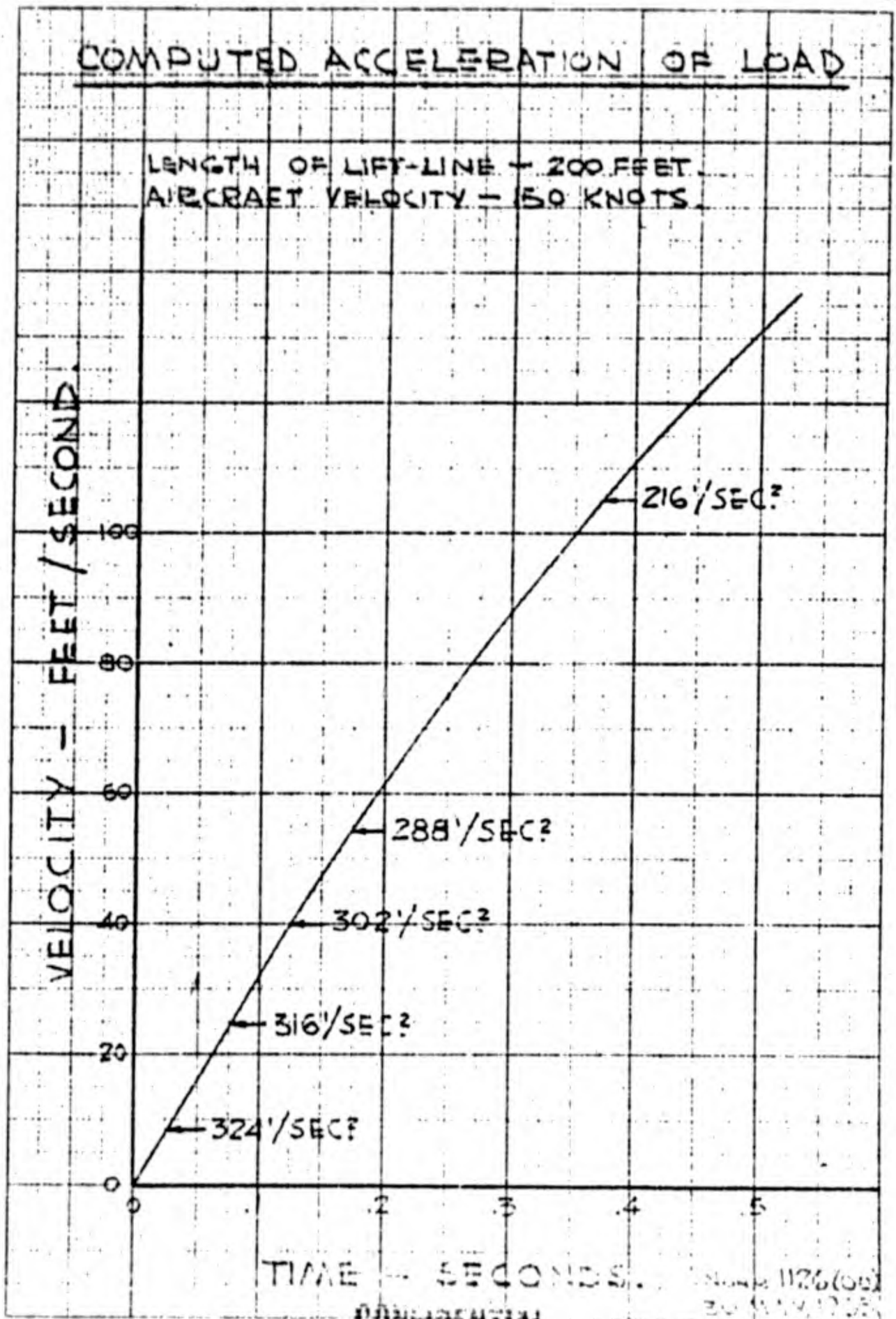
Line is taken as steel and considered as having no stretch.

Speed of 150 knots should provide ample controllability with any type aircraft.

G - L O A D C O M P U T A T I O N

LOAD #	LINE LENGTH Ft.	SPEED KNOTS	AVERAGE G's OVER .2 Secs.	VERTICAL DISPLACE-MENT, Ft.	ROPE LOAD #
200 #	200'	150	10.1	6.5'	2,200#
200	400	150	4.97	3.2	1,195
200	1,000	150	2.02	1.3	604
150	400	150	4.97	3.2	895
200	400	200	8.7	5.6	1,940

Maximum acceleration occurs at instant of start but is almost constant for most of the rise.


COMPUTED ACCELERATION OF LOAD
LENGTH OF LIFT-LINE = 200 FEET.
AIRCRAFT VELOCITY = 50 KNOTS.
VELOCITY - FEET/SECOND.
100
80
60
40
20
0
216'/SEC²
288'/SEC²
302'/SEC²
316'/SEC²
324'/SEC²
0
.1
.2
.3
.4
.5
TIME - SECONDS.

"G" RECORDER

In conducting preliminary tests a nylon line was used and a simple recording spring-scale was inserted above the load.

At 105 knots with 200 feet of line it recorded 5 G's which is in line with the computed results.

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B A L L O O N "H O O K"

The easiest type of hook to put up is perhaps the small balloon.

Since 100 feet of 7x19 construction, 1/8th. inch diameter cable (with a breaking strength of 2,000 pounds) weighs 2.9 lbs., a balloon with 250 cubic feet capacity will provide good lift for 300 to 400 feet of cable.

Such a balloon is relatively easy to handle, easy to see from the aircraft, and harmless if accidentally run into.

Its biggest shortcoming is its poor performance in winds over 15 to 20 knots. With winds ranging from 0 to 15 knots it is undoubtedly the best form of skyhook.

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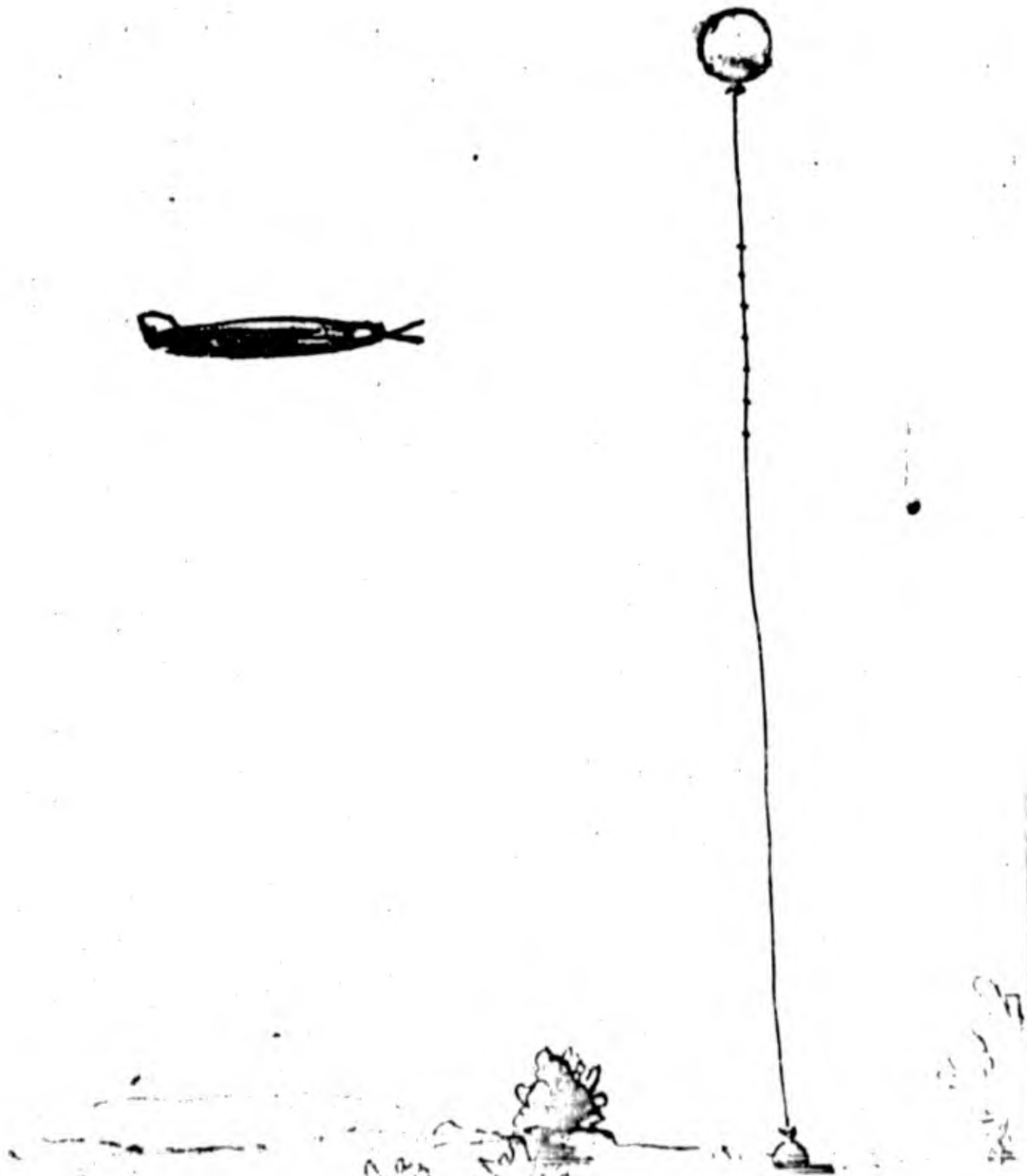
REPORT No. A(I) NONR 1126(00) DATE 30 MAY 1953 PAGE 22.

REPORT TITLE HIGH PERFORMANCE PICK-UP.

BALLOON HOOK



ACCOMPANYING PHOTOGRAPH SHOWS A DENNY & ALMY
B-4, 40 CUBIC FOOT CAPACITY, 5 FOOT DIAMETER
BALLOON 200 FEET ABOVE THE TERRAIN.

UNFORTUNATELY BY DAY IT IS AS EASY TO SEE
FROM THE GROUND AS FROM THE AIR. UNDER SOME
OPERATING CONDITIONS IT SHOULD PROBABLY BE
KEPT LOWERED OR UNINFLATED UNTIL SHORTLY
BEFORE INTERCEPT TIME OR UNTIL AFTER DARK.


SECURITY INFORMATION

MARKERS AND "KNOTS"

WHEN THIS PHOTOGRAPH WAS TAKEN EXPEDIENT OF STRINGING LINE WITH MARKERS AT TOP AND BOTTOM OF "KNOTTED" LENGTH HAD NOT BEEN CONCEIVED.

SUCH MARKERS MAKE LINE READILY APPARENT TO PILOT, EASY TO CATCH. (SEE "ATTRACTING DEVICES" BELOW).

"KNOTTED" LENGTH NEED NOT BE LONGER THAN 25 FEET, CAN BE 50 OR MORE IF DESIRED. THE MORE "KNOTS" THE MORE VERTICAL LATITUDE FOR THE PILOT BUT POSSIBLY THE LESS LINE FOR THE CARGO IF THE YOKE ENGAGES NEAR THE LOWEST KNOT.

SO-CALLED "KNOTS" WILL PROBABLY BE STANDARD AIRCRAFT FITTINGS FOR SWAGING TO CABLE PER SPECIFICATION AN-T-2.

B A L L O O N - I N F L A T I N G G A S

Can be fairly easily provided for up to a 250 cubic foot balloon either by....

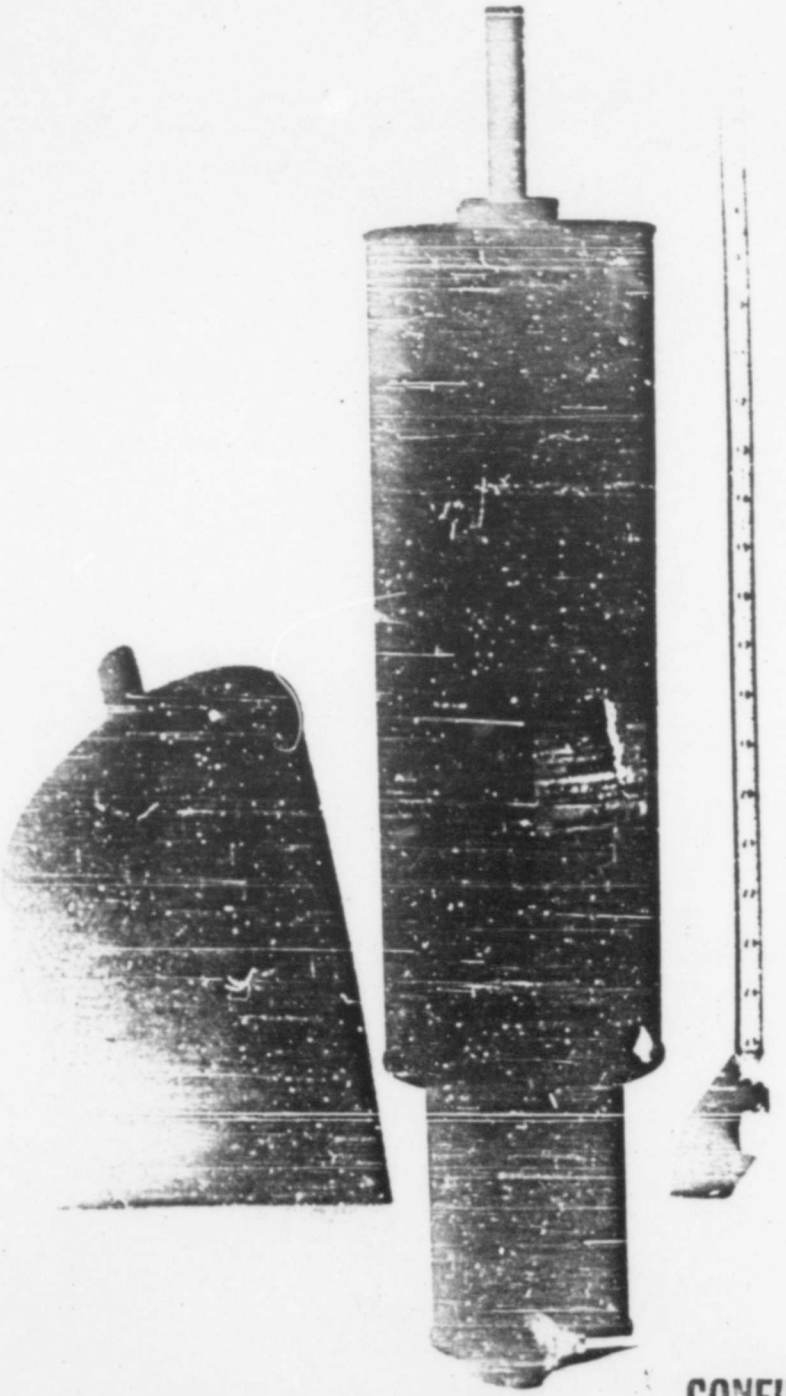
* ....lithium or calcium hydride and a tin-can type generator as illustrated (needs only water added)

or

* ....storage tanks (two at a weight of approximately 33 pounds each).

Both of the above are essentially stock items.

A ready, convenient and dependable gas supply is as important to success of the balloon hook as the balloon itself!



KITE "HOOK"

The more a balloon goes down with increasing wind the more a kite rises.

For winds above 15 to 20 knots a kite is probably preferable to a balloon.

Box kites appear to have the most stability and to be easy for anyone to fly. They are simple to assemble and launch and have ample lift to hold up more than 200 feet of cable.

Since the aircraft should always make its approach in an up-wind direction, a 15 knot wind would reduce the aircraft's ground speed approximately 10%, thereby decrease the G-loading on the bag and its contents.

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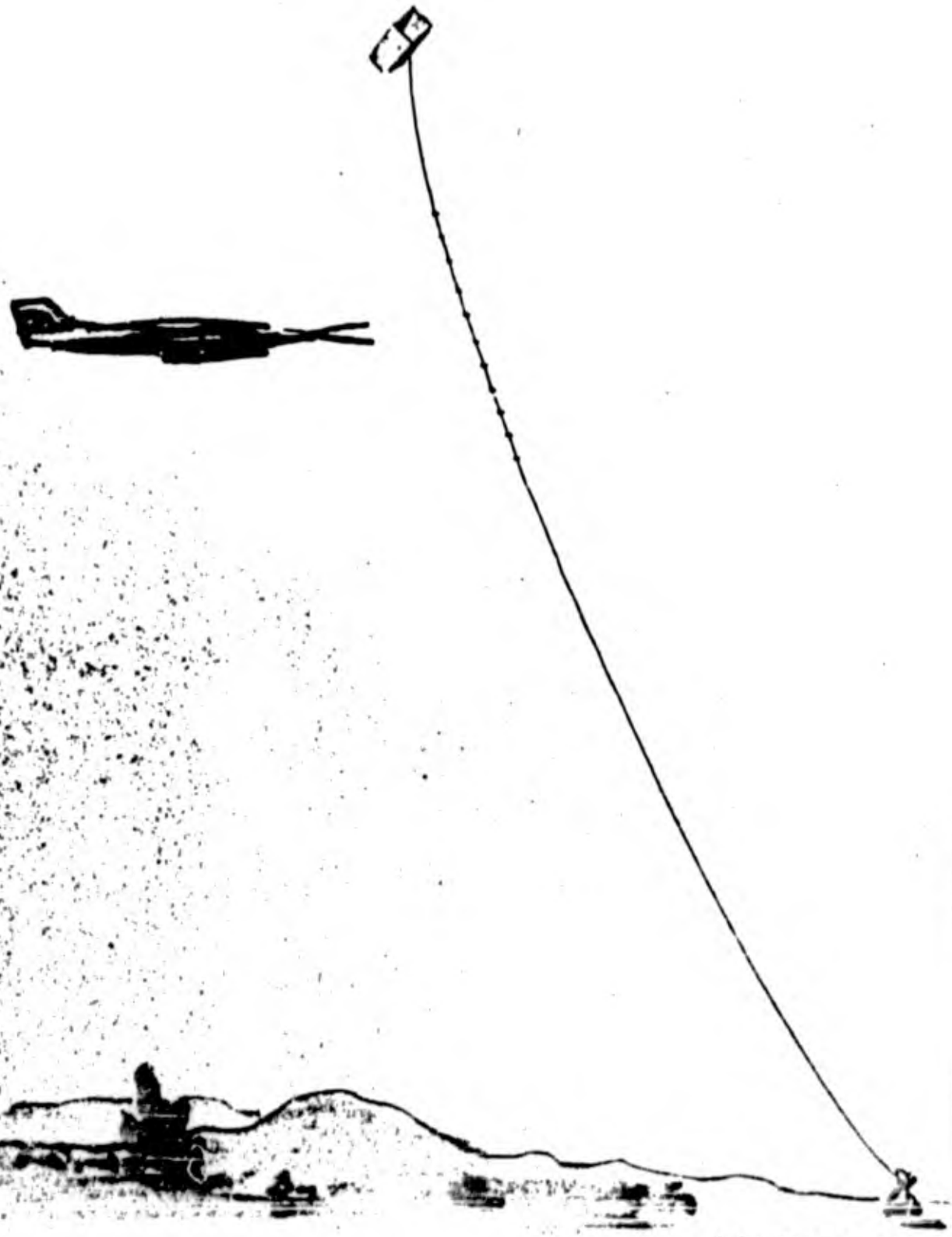
NEWTOWN, CONNECTICUT.

REPORT TITLE HIGH PERFORMANCE PICK-UP

KITE HOOK



PHOTOGRAPH SHOWS COMPARATIVE ELEVATION OF BALLOONS VERSUS KITE UNDER 30-KNOT WIND CONDITION.

BOTH K-4 BALLOONS AND THE KITE ARE HELD WITH LINES OF EQUAL LENGTH AND ARE ANCHORED TO GROUND AT APPROXIMATELY SAME POINT IN FRONT OF BUILDING.

AT TIMES WHEN WIND DIMINISHED BALLOONS WOULD SOMETIMES RISE TO KITE, OCCASSIONALLY GO ABOVE IT ----BUT KITE ALWAYS MAINTAINED GOOD ELEVATION AND WAS SATISFACTORILY STABLE.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K I T E - B A L L O O N "H O O K"

A combination might provide the advantages of each and eliminate their separate shortcomings.

Preliminary tests with a "Kytoon" have not proved too encouraging in this regard but there may be possibilities of successfully assembling and operating a flat type of flying mattress, polyethelene kite-balloon combination.

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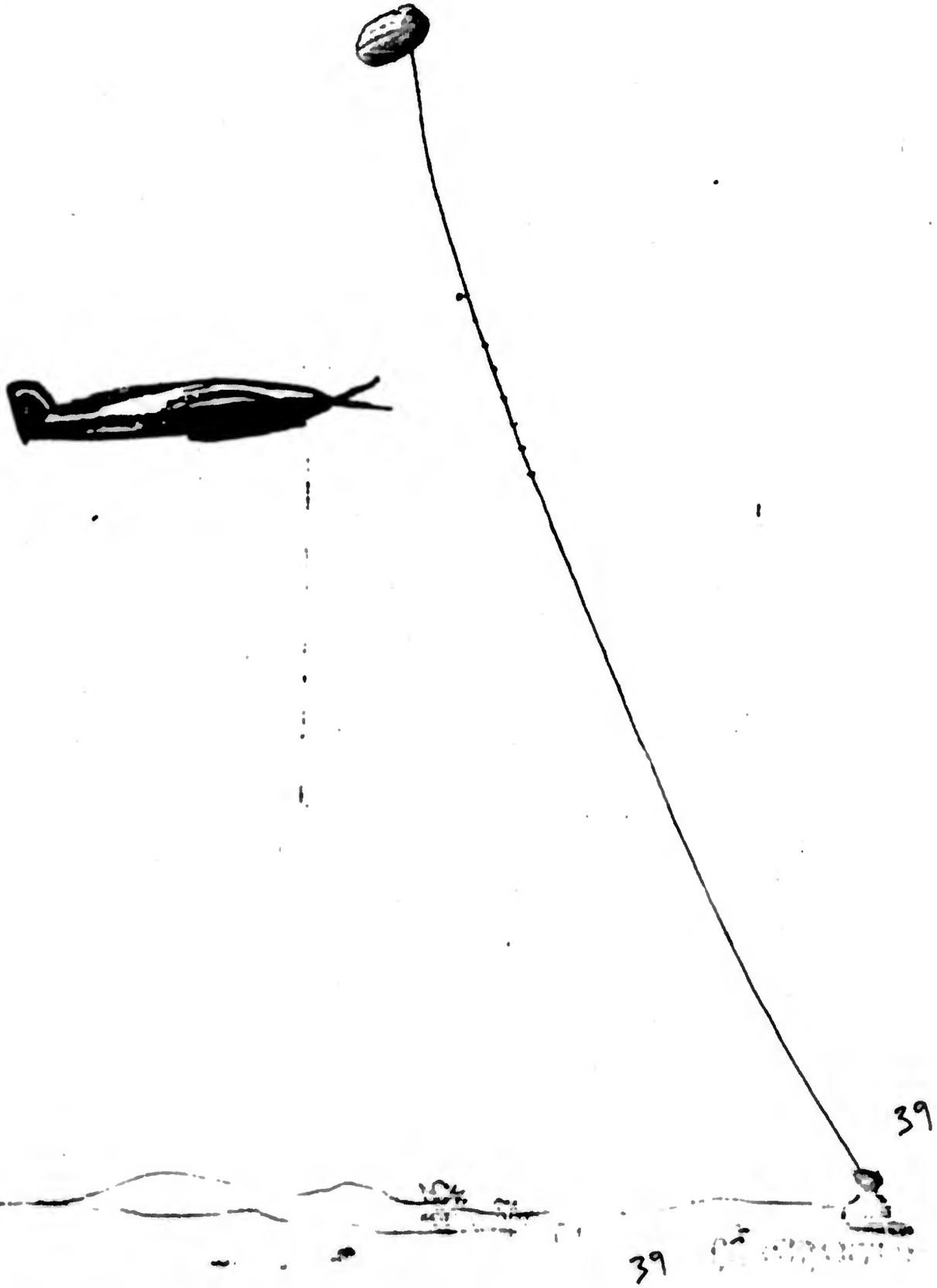
REPORT TITLE HIGH PERFORMANCE PICK-UP

KITE-BALLOON HOOK



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W I N D M I L L " H O O K "

Several experimental designs of contra-rotating propeller devices have already been developed.

They can be driven by electric motors, small jets, or other methods.

Stability appears to be the principle problem. Lifting capacity is ample for skyhook purposes.

This is a possibility but the probable complication would be justified only if balloons and kites prove totally unfeasable.

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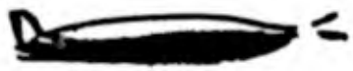
REPORT No. A(I) NONR 1126(00) DATE 30 MAY 1953 PAGE 34.

REPORT TITLE HIGH PERFORMANCE PICK-UP

WINDMILL HOOK



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ROCKET "HOOK"

Modern rocket design has reached the stage where it could produce a unit capable of sustaining a cable of as much as 1,000 feet in length for a period of 1/2 to 1 second and still be light enough for one man to handle.

Such a unit would be highly expensive, partly due to the intricate internal mechanism it would require to provide it with stability.

Inasmuch as its sustaining power would be very limited in time, it would probably also require remote control from the aircraft to fire it at the right moment to avoid striking the plane yet be aloft when the yoke passed over the target.

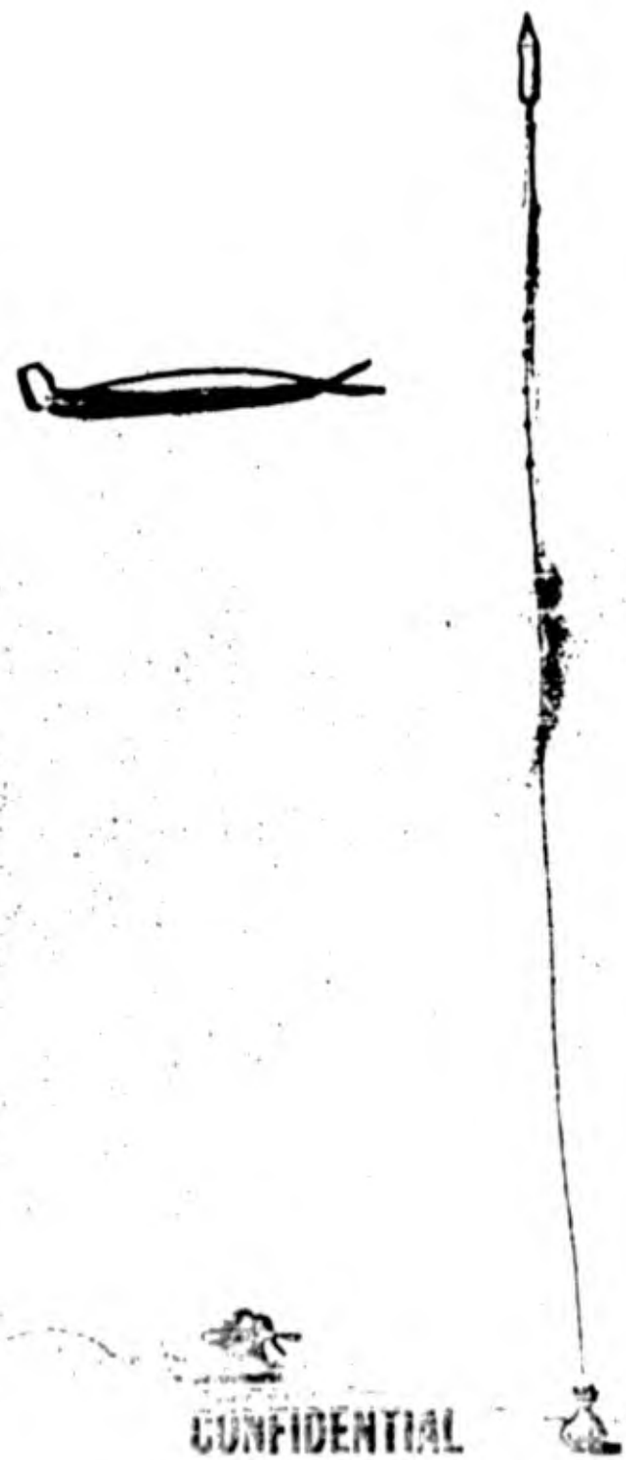
Its main asset would probably be its ability to hold the cable almost vertical regardless of wind direction or velocity.

It too seems justified only if the balloon and/or kite combination proves inadequate.

ROBERT E. FULTON, JR.
NEWTOWN, CONNECTICUT.

REPORT TITLE HIGH PERFORMANCE PICK-UP

ROCKET HOOK



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W I N D - L I N E

A possible solution to excessive lift-line-angle resulting from too much wind would be a light WIND-LINE anchored to windward.

This would permit the lift-line to hang vertically.

Since the aircraft always approaches up-wind there would be no interference with the balloon or lift-line at instant of contact.

Preliminary tests have already indicated that lift-line angles up to 20 to 30 degrees have no ill effect on the operation. The load seems initially to follow a path in the direction in which the line is inclined.

This is actually an advantage if there are close-by obstacles on the up-wind side for the load would initially swing away from them and probably be above them before it swung back.

Only actual testing can determine the exact lift-line angle that can be tolerated and the proficiency of the wind-line.

ROBERT E.
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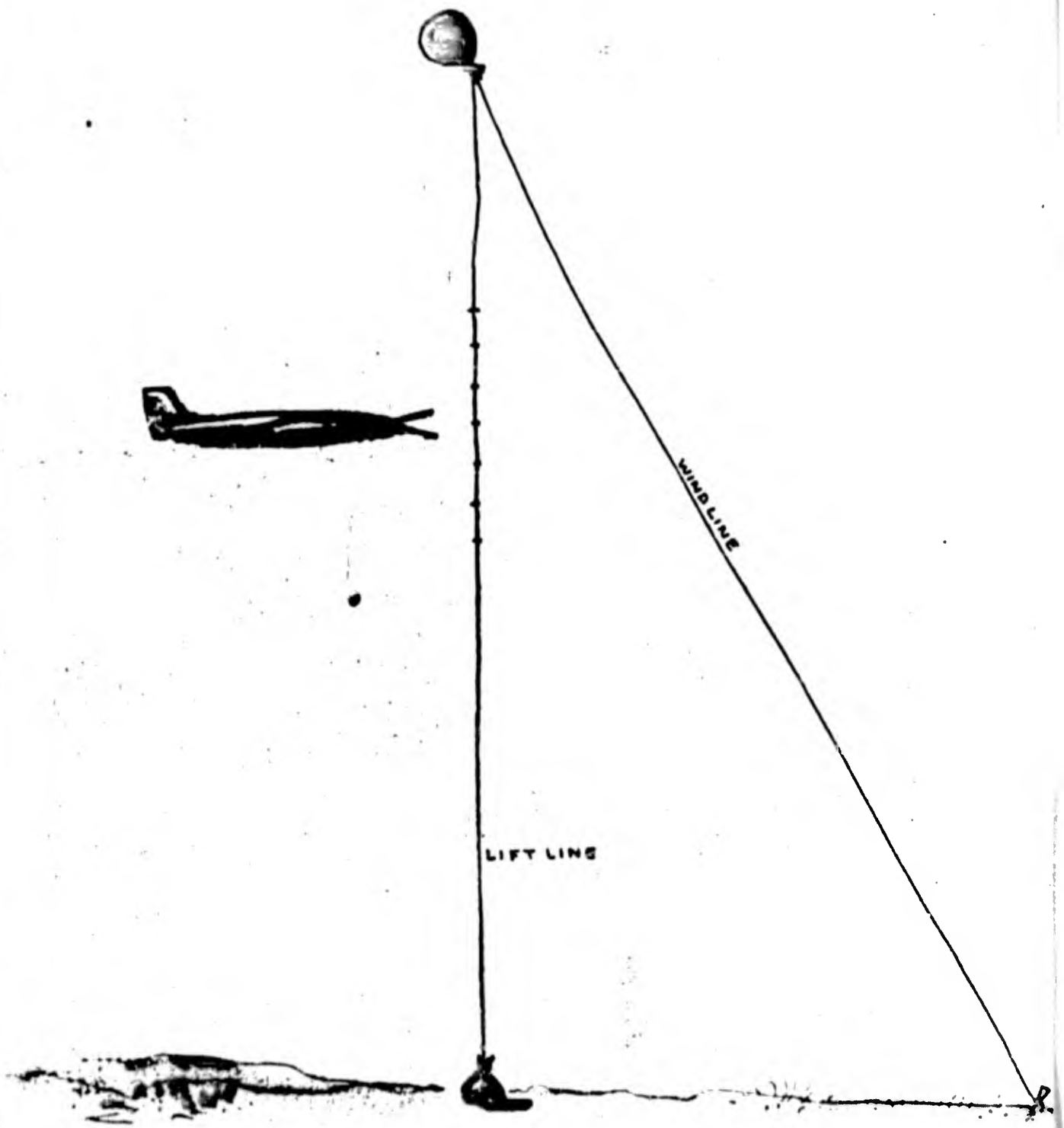
SUBJECT: HIGH PERFORMANCE

WIND-LINE



H I G H - S E A S O P E R A T I O N

Personnel, materiel, mail, etc., may be picked up at sea from any vessel by SKYHOOK technique.

Operation can be conducted at altitude well above superstructure, masts, antennas, etc. and in a direction that will immediately clear all obstacles.

Wind can be eliminated, created or disregarded by controlling the vessel's speed and direction or by standing still.

If windy, vessel could make way down-wind, if possible at speed equal to that of wind. Balloon skyhook would then stand vertically, effectively in still air.

If no natural wind, vessel could create its own relative wind by its speed and "kite hook" could be used ----or ship can stand still and use "balloon hook".

If light-weight objects (messages, charts, etc.) are to be picked up, nylon line may be used instead of cable.

THIS TECHNIQUE COULD WORK FOR A BATTLE CRUISER, A RUBBER RAFT, OR A MAN IN THE WATER.

ROBERT F
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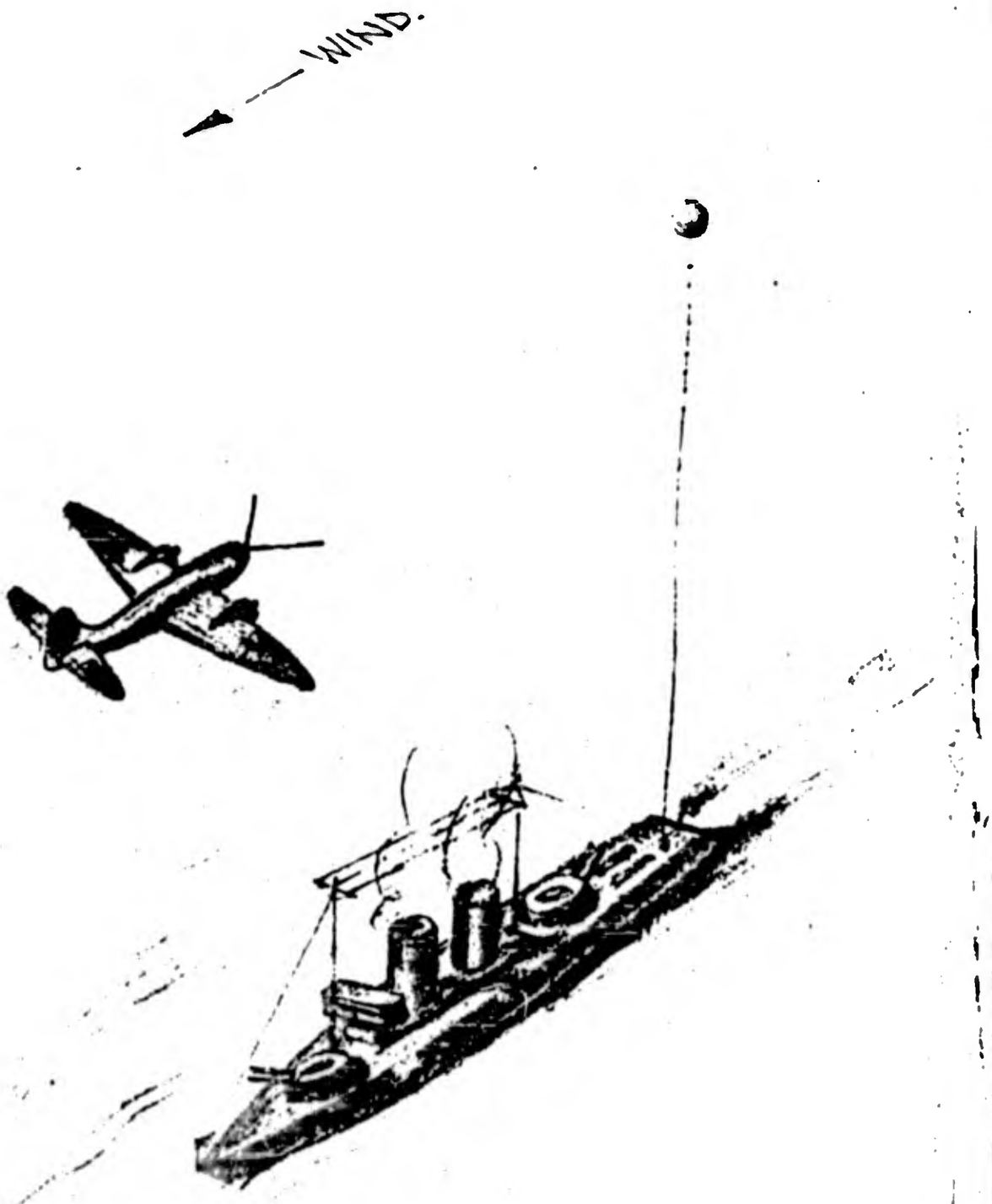
REPORT No. 4(1)ONR.112e(20). DATE 30 MAY, 1953 PAGE 47

REPORT TITLE HIGH PERFORMANCE PICK-UP.
HIGH-SEAS OPERATION.



ROBERT E. FULTON, JR. NEWTOWN, CONNECTICUT.	REPORT No. A (I) Memr. 1128(00). DATE 30 May, 1953. PAGE 39.
	REPORT TITLE HIGH PERFORMANCE PICK-UP.

FURTHER

"LONG - LINE"

DATA .....

(See Sections II & III for greater detail).

LONG-LINE DIMENSIONS

Accompanying sketch shows estimate of length of line required.

While the amount may at first seem great it is primarily because one is not accustomed to thinking in such lengths.

Actually it is negligible compared to the hundreds of miles the mission may fly reaching and returning from the pick-up.

Also some standard tow-target equipment is right now capable of handling as much as 12,000 feet of cable.

Even twice the proposed length is not unreasonable if the technique works.

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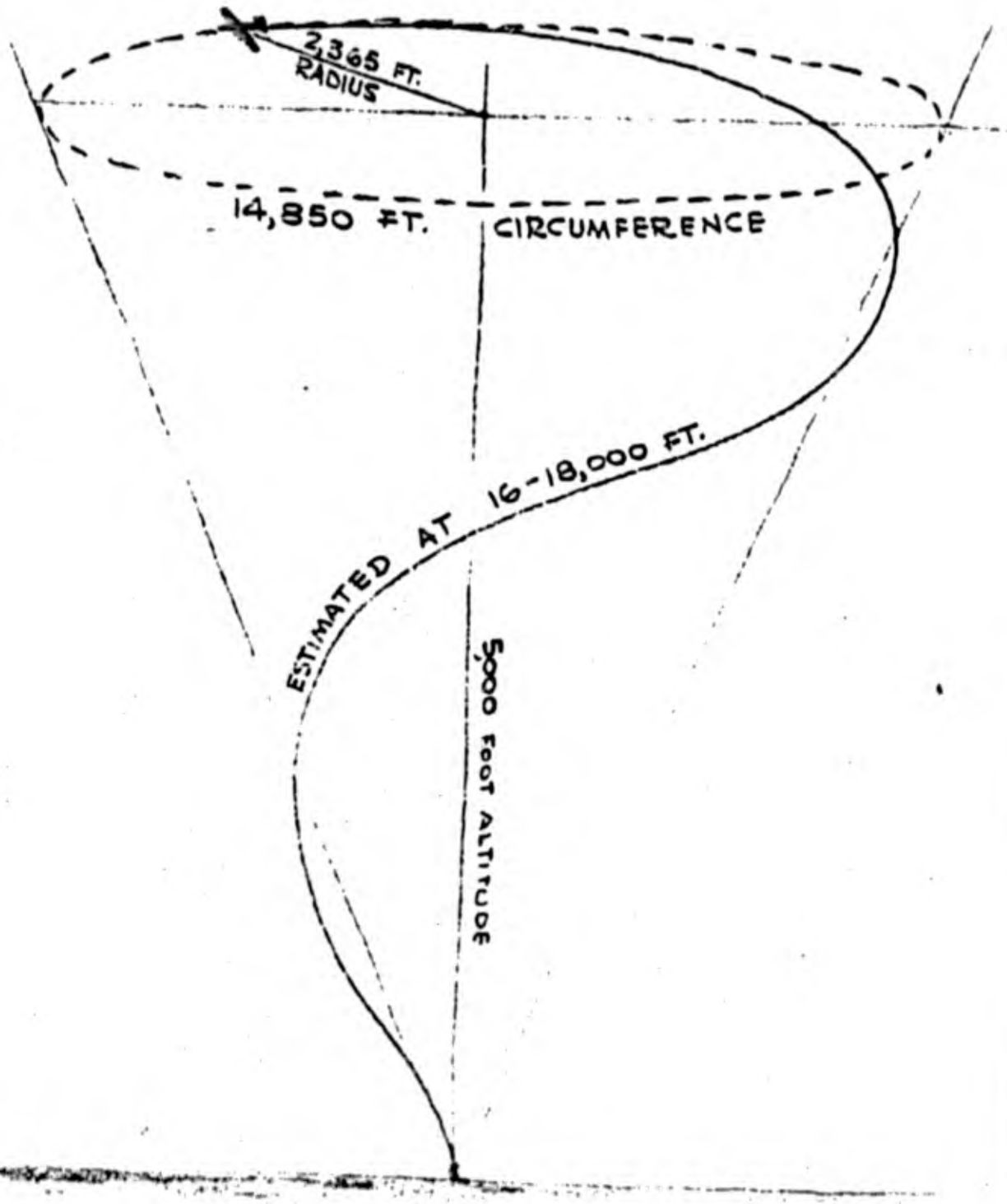
REPORT No. A(I)NoNR.1126(00). DATE 30 MAY 1953. PAGE 42.

REPORT TITLE HIGH PERFORMANCE PICK-UP

LONG-LINE DIMENSIONS

150 KNOT SPEED. 1-MINUTE RATE OF TURN.



CENTERING VANE

An alternate method of accomplishing the "LONG-LINE" technique is gradually to pay the line out from the aircraft (instead of dropping it in a bomb).

The problem is to make it go down and to the center of the airplane's turning radius.

If the end of the line is carrying a heavy weight it will respond to the centrifugal force set up by the plane's turning motion and tend to swing away from the turning center instead of toward it.

If instead of a heavy weight, a strong drag-load is applied to the end of the line this centrifugal force problem can be largely overcome.

The addition of a turning vane will still further direct the end of the line toward the center.

The more the line is paid out the more it should move toward the center. The closer it gets to the center the more it should drop.

When the forces of air drag on the line, the airplane's turning radius, the action of the turning vane and drag unit on the end of the line, and the length of the line are all in proper relationship, the line should be capable of coming to rest on the ground.

Experimentation is the only practical way of arriving at the desired values.

Raising the load would be accomplished as previously described.

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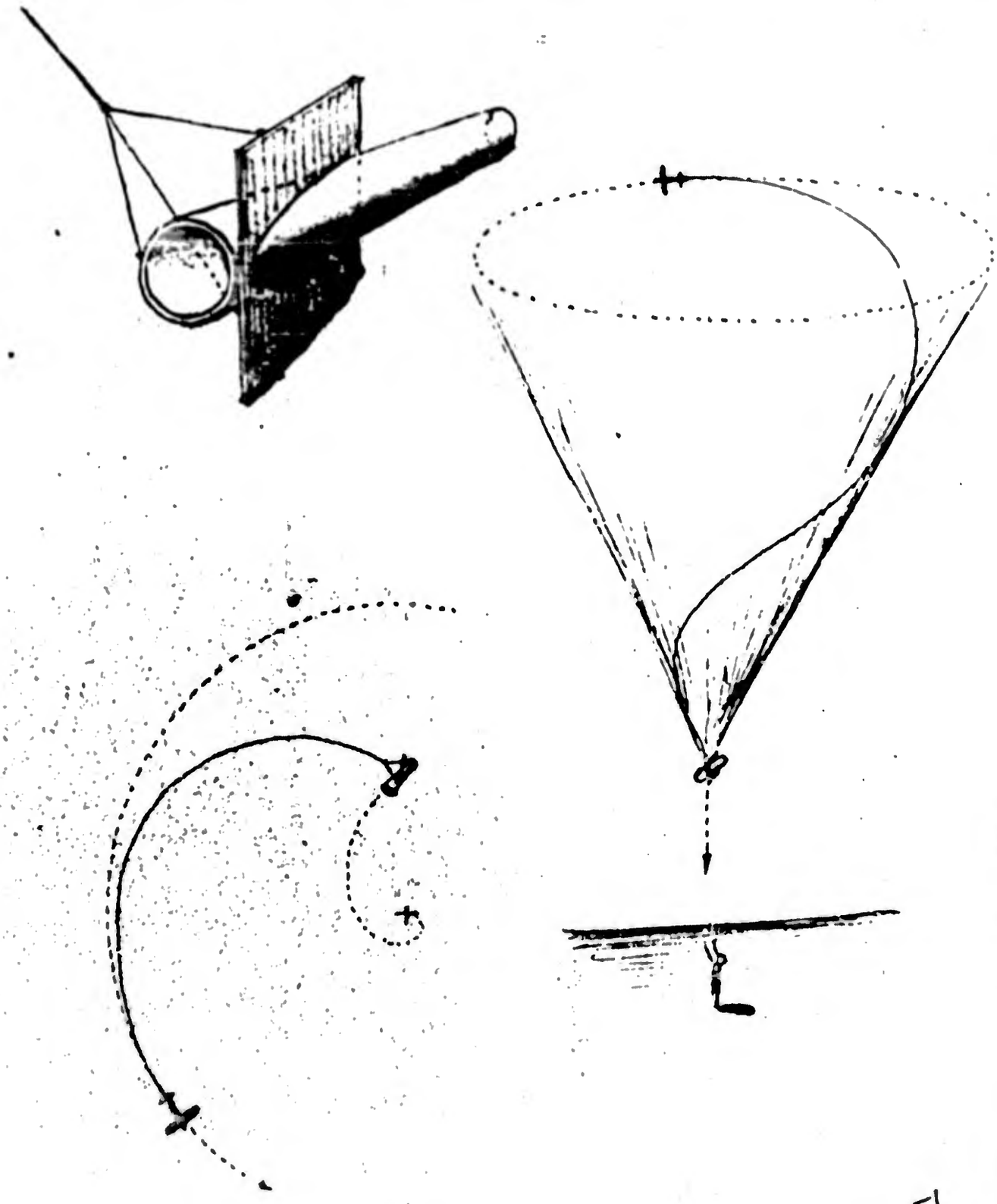
REPORT TITLE HIGH PERFORMANCE PICK-UP
CENTERING VANE



WATER TECHNIQUE

A possible application of the "LONG-LINE" technique to water operations is illustrated herewith.

EQUIPMENT

* Raft with sea-anchor and dump-valve built into bottom.
* Floatable line attached to raft and a flag-float.
* Airplane equipped with hook-bearing pole, dispenser cylinder with long lift-line wound in it, reel-in mechanism.

SEQUENCE

1. Man in raft permits sea-anchor to fill and pays out line and flag-float. (If calm, he paddles to keep float away from raft).
2. Plane, dragging hook in water, intercepts floating line.
3. As dispenser pays out long line, plane circles and climbs. Sea-anchor holds raft essentially stationary on the water.
4. When line is substantially straight up, man in float opens dump-valve. As bag slowly lifts, more water runs out of hole in bottom, bag gets lighter and progressively rises more easily.
5. Plane reels in line and load.

REMARKS

* This system could work despite fairly rough seas.
* Water is good to operate over since it usually provides a large unobstructed area easily located from the air.
* Success of this system is predicated upon success with the basic "LONG-LINE" technique. It is essentially another way to make it work over the water.

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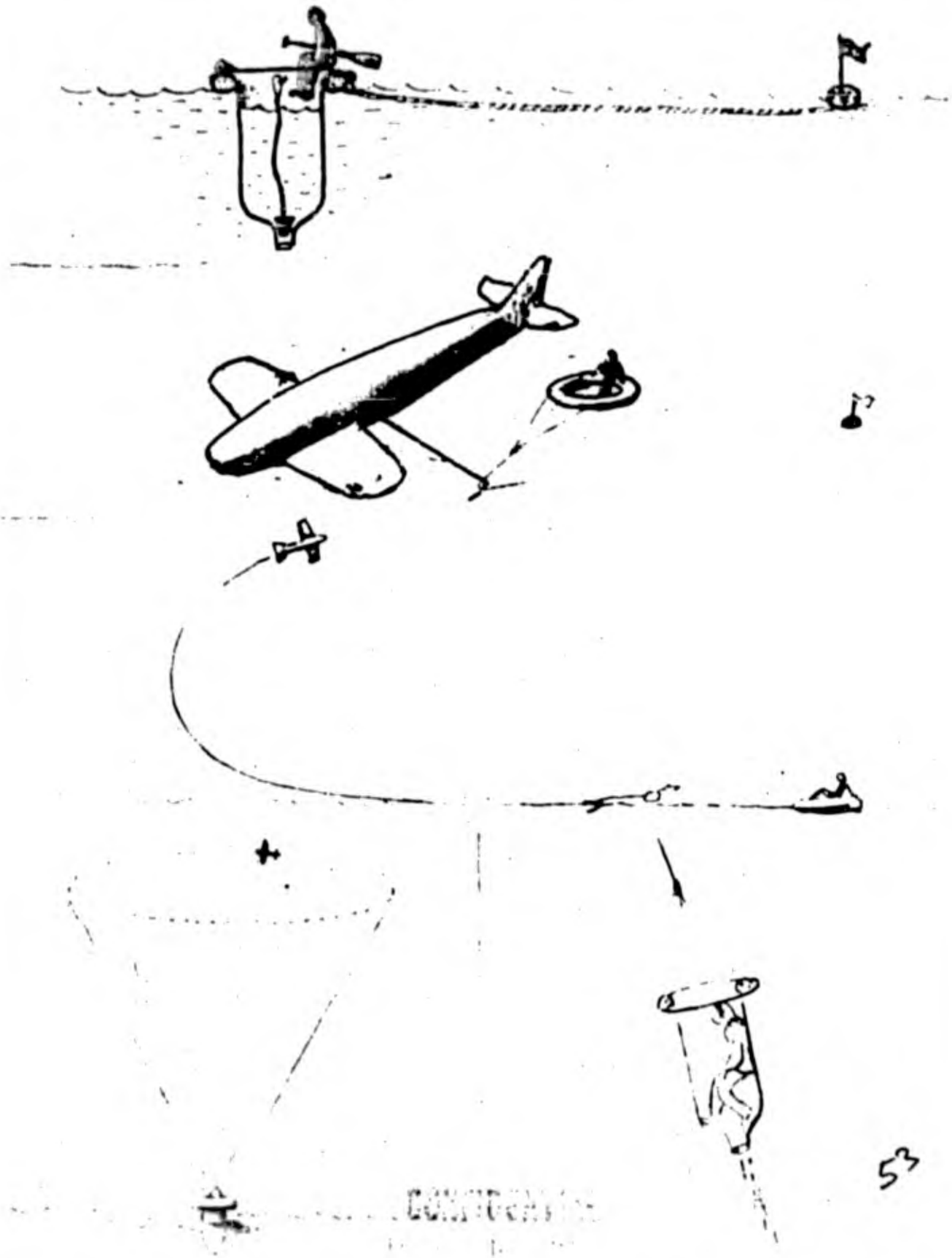
REPORT No. A(I)NONR 1126(00) DATE 20 MAY 1953 PAGE 45.

REPORT TITLE HIGH PERFORMANCE PICK-UP.

WATER TECHNIQUE



FURTHER

"MID - AIR"

DATA .....

(See Sections II & III for greater detail).

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M I D - A I R P I L O T - B A L L O O N

Instead of the balloonis passenger having to lower himself in order to provide a knotted line of sufficient length for successful SKYHOOK type of operation, a "pilot-balloon" is provided to support the lift-line.

Thus the aeronaut stays close to his gas control valve and no special equipment or procedure is necessary for him to position himself in relation to the balloon which carries him.

Under these circumstances 1,000 feet of lift-line could easily be handled. This would also reduce the resulting G-loads at time of pick-up to a very small amount (2 or 3 G's).

The only question seems to be "what will the balloon do?" Its shroud lines will carry the load and the bag will probably break, possibly even acting as a shock absorber and further reducing the G-loads.

This system could readily be tested at the same time as the previously described MID-AIR technique.

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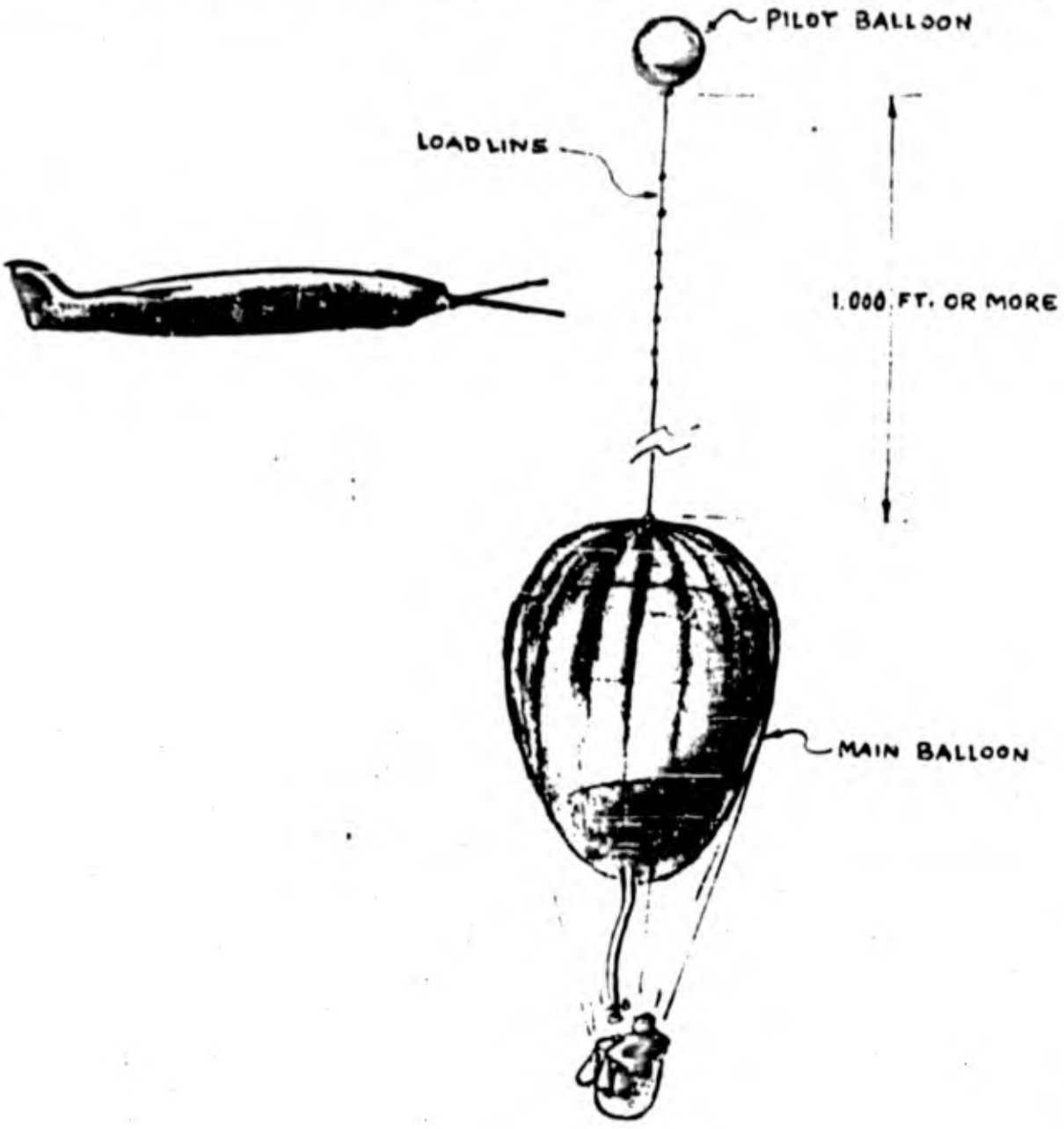
REPORT TITLE HIGH PERFORMANCE PICK-UP

MID-AIR PILOT BALLOON



MID-AIR PILOT-PARACHUTE

This technique simply substitutes parachutes for the balloons used in the foregoing description.

NOTE

This technique could regularly be used for rescuing combat pilots whose planes have been shot from under them.

A stand-by rescue plane (or possibly several of the planes in each squadron could be equipped with yokes and could retrieve them before they ever reached the ground (in enemy territory).

The technique is particularly suitable for use with jet propelled aircraft.

(Such an application would quickly deprive it of its possible surprise value).

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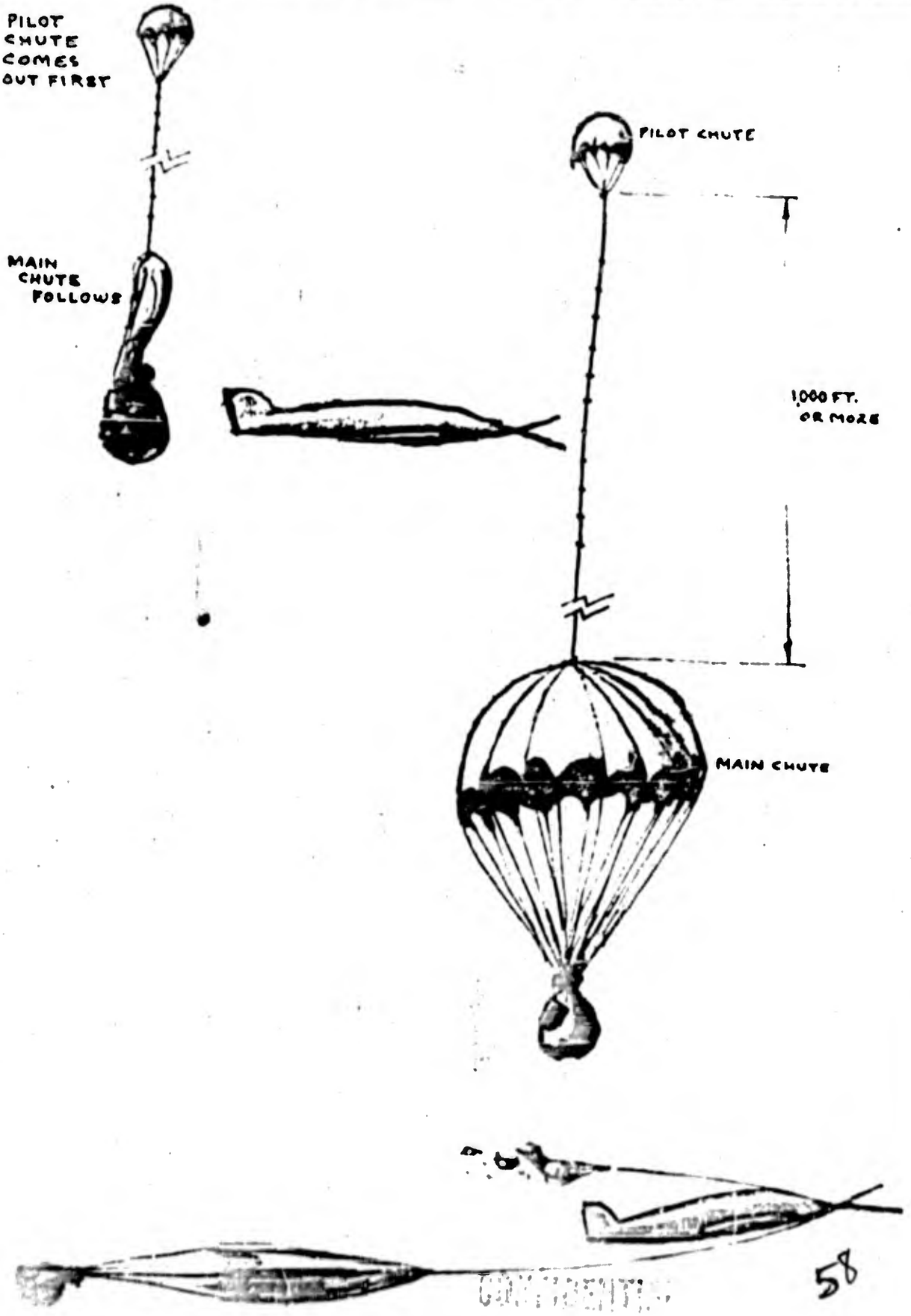
REPORT TITLE HIGH PERFORMANCE PICK-UP

MID-AIR PILOT PARACHUTE



ATTACHING

DEVICES .....

Y O K E - E Y E - K N O T S

"SKYHOOK" and "MID-AIR" techniques require a "yoke" attached to nose and/or wings of plane.

Bird's eye view of set-up shows yoke attached to nose with arms outspread, "eye" in which lift-line looks at apex of arms, "knots" near top of cable.

Cable would probably be equivalent of 1/8th. inch diameter, 7x19 construction aircraft control cable. "Knots" would then be double or single-shank ball terminals swaged onto the cable.

If nylon lift-line is used actual knots would probably suffice. (Such were used in the successful preliminary tests of this technique).

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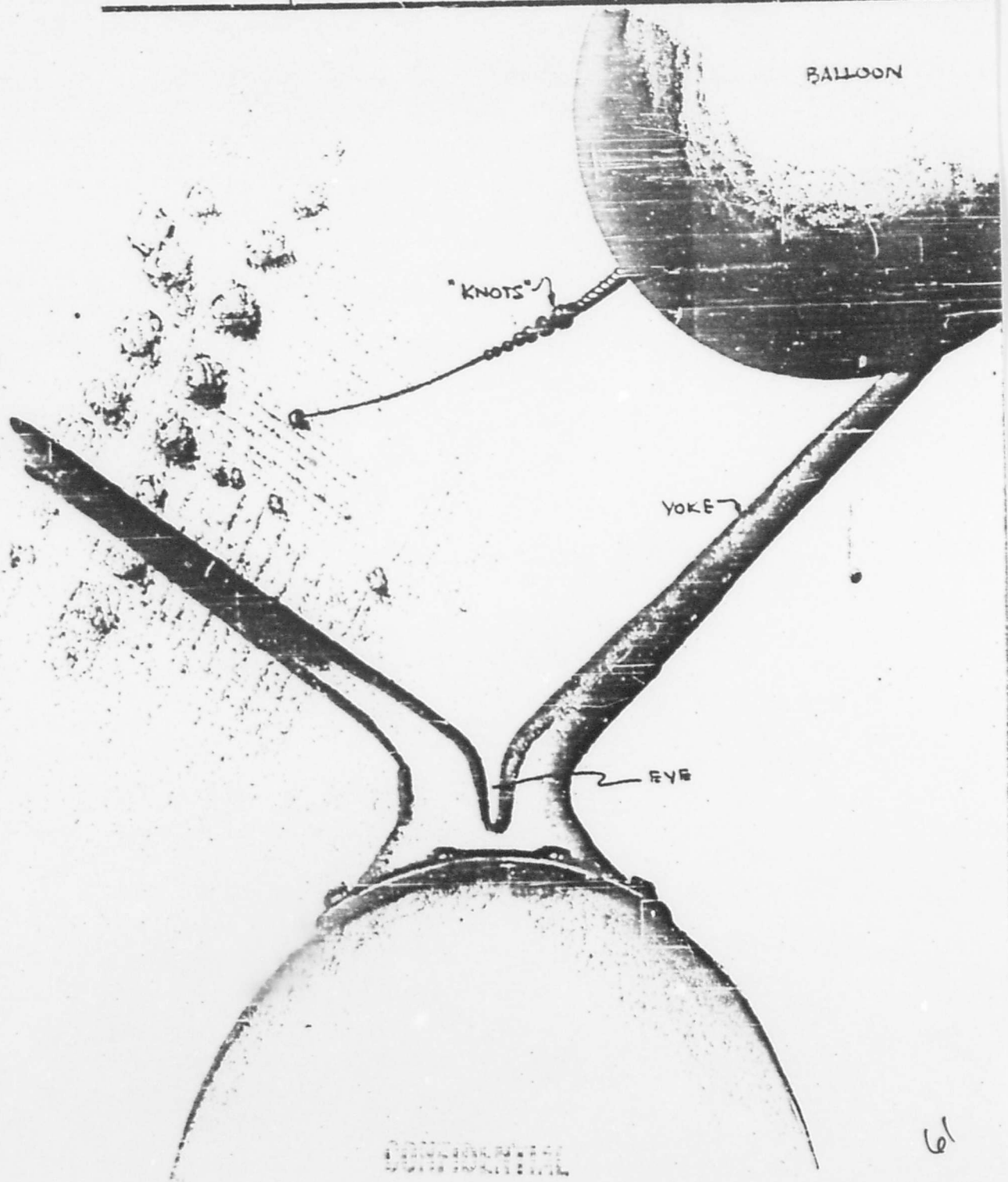
REPORT TITLE HIGH PERFORMANCE PICK-UP

YOKE-EYE-KNOTS



Y O K E S (plural)

To increase the horizontal latitude of the plane's operation in intercepting the lift-line, multiple yokes should be installed all the way across the front of the aircraft.

With propeller driven planes this gives added anti-propeller protection.

Note that the skyhook technique in general is especially applicable to high performance jet type aircraft which present no propeller problem.

Design of the yoke installation would somewhat depend upon the type of aircraft employed for the operation.

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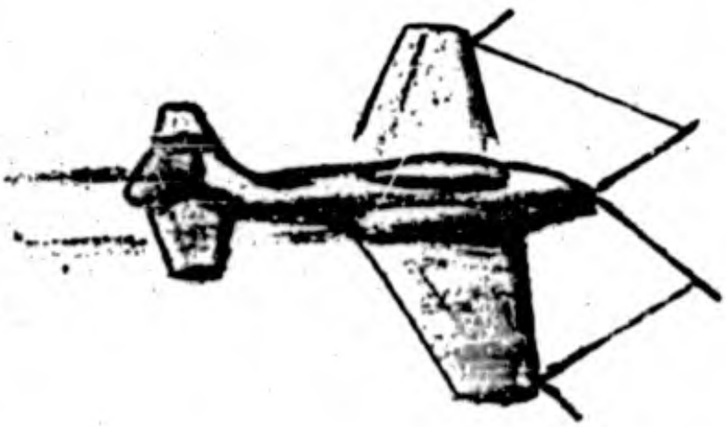
REPORT No. A(I)NONR 1126(00) DATE 30 MAY 1953 PAGE 55.

REPORT TITLE HIGH PERFORMANCE PICK-UP YOKES (PLURAL)



63

THIS ELEMENTARY INSTALLATION WAS USED FOR PRELIMINARY TESTING OF THE "SKYHOOK" TECHNIQUE. YOKE WAS LOCATED NEAR WING TIP SINCE PROPELLER WAS ON CENTERLINE.

YOKE HAD A SPREAD OF ONLY 5 FEET (SHOULD BE MADE AS WIDE AS POSSIBLE FOR OPERATIONAL USE). ARMS WERE HORIZONTALLY ANGLED 45 DEGREES TO AIRCRAFT'S LONGITUDINAL AXIS.

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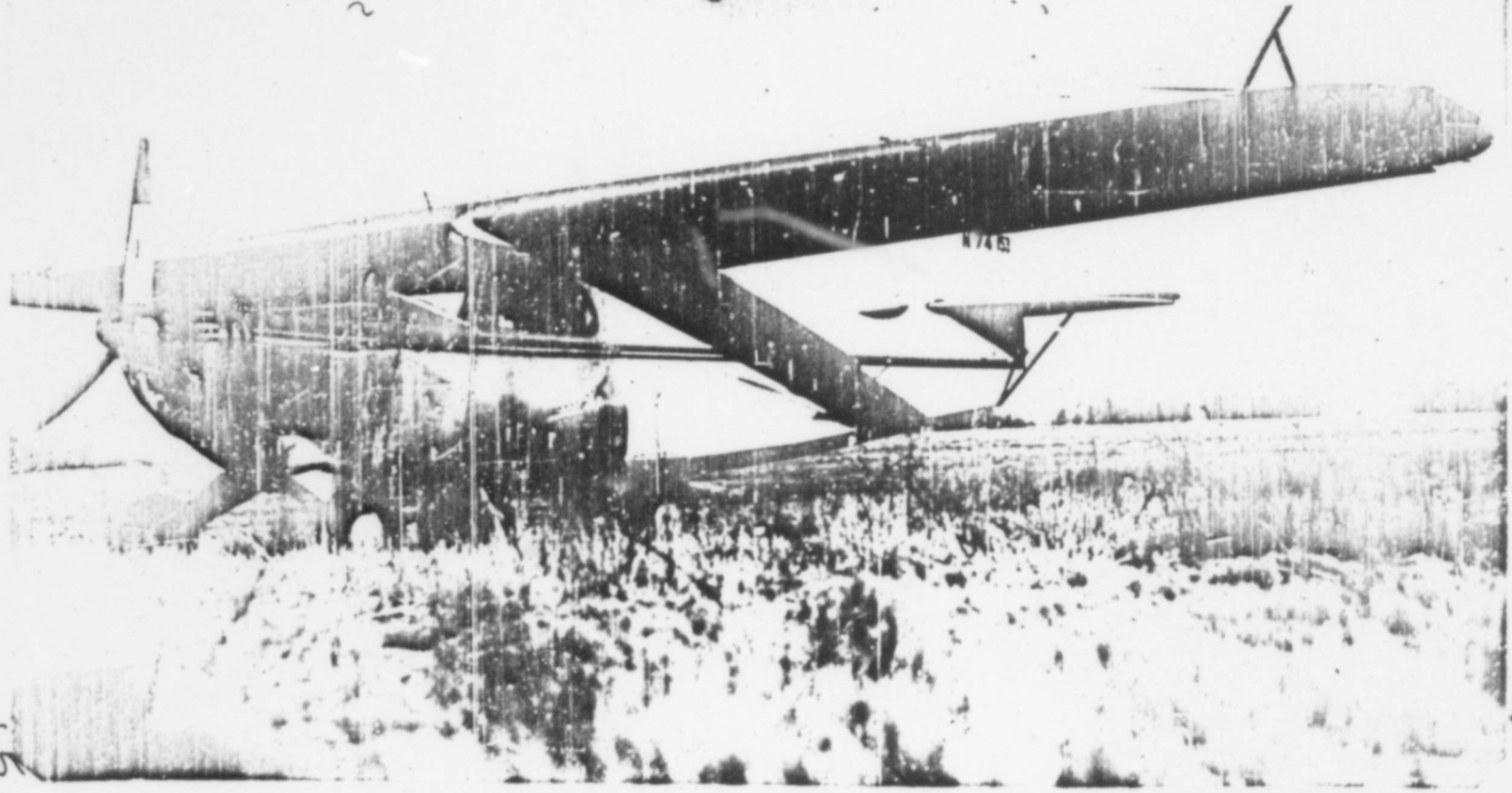
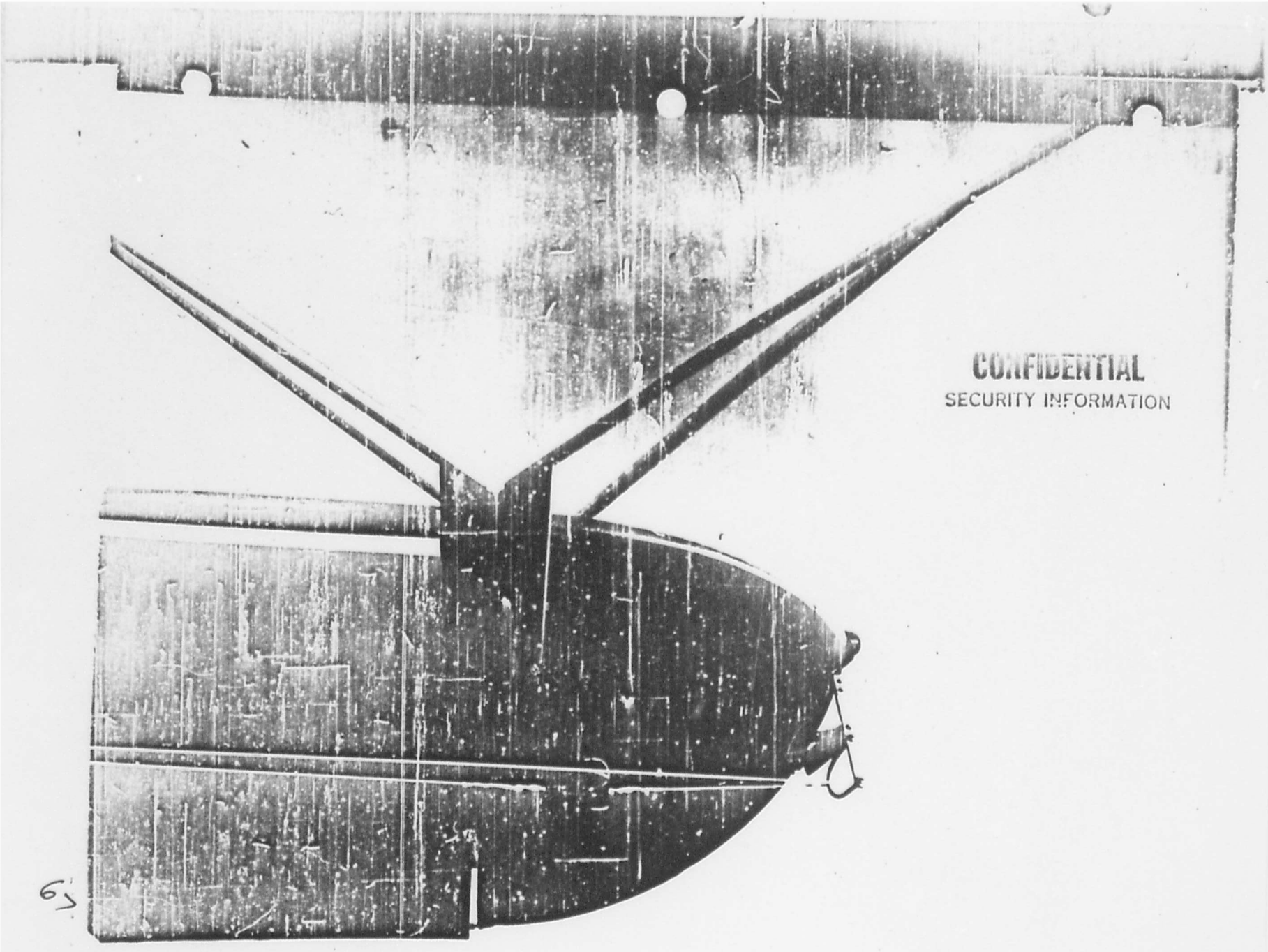
SECURITY INFORMATION



EYE OF YOKE IN WHICH ACTUAL KNOT IN A NYLON LINE CAUGHT AND RAISED LOAD.

GRAPPLING HOOK WAS USED TO HAUL LINE OVER TO COCKPIT SO THAT 3-MEASURING SCALE AT BOTTOM OF LIFT-LINE COULD BE HAULED INTO AIRPLANE AND READ.



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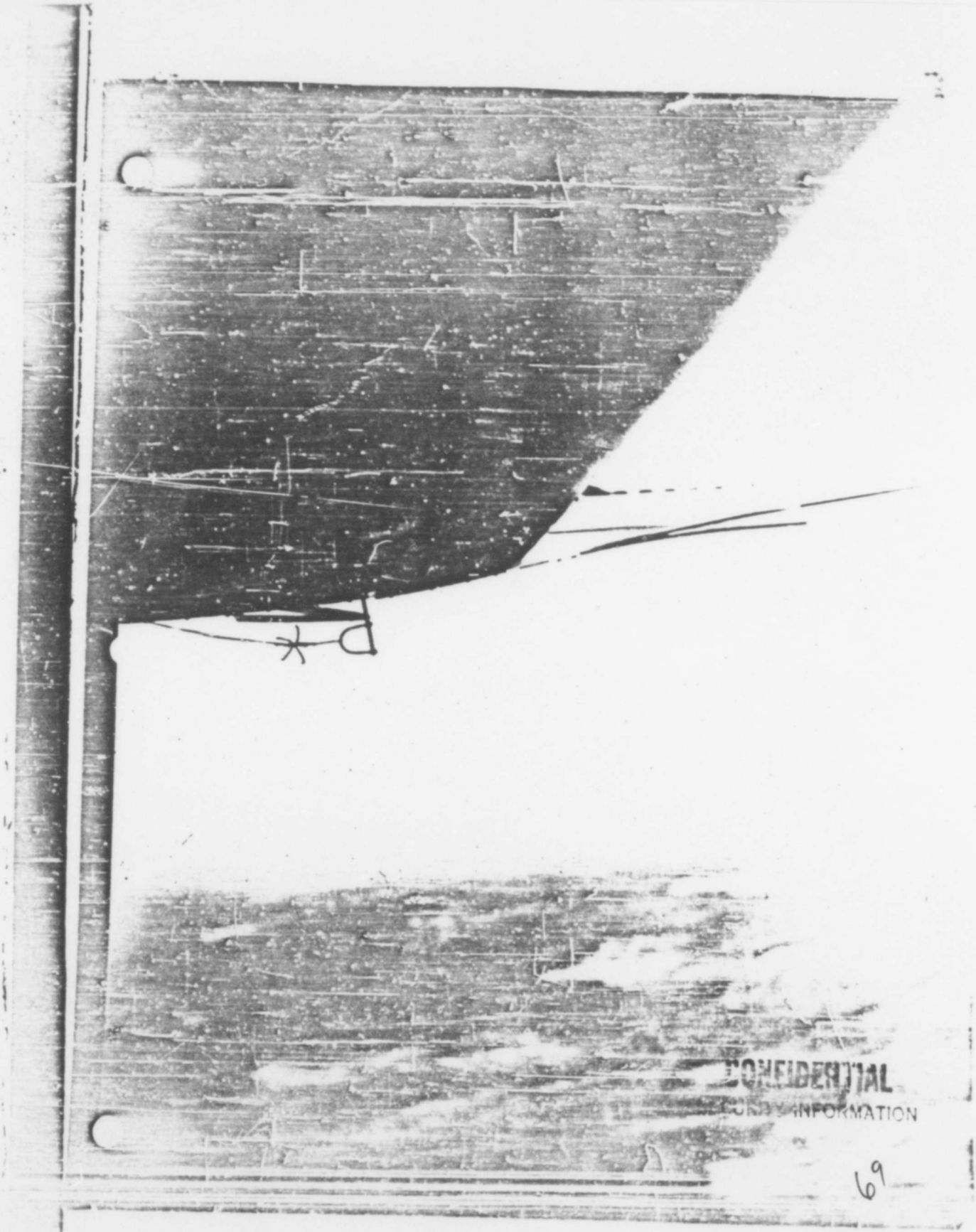
63

YOKE AND GRAPPLING HOOK SHOWN IN FLIGHT DURING PRELIMINARY TESTS. OTHER PROJECTION (STRIPED) ON FRONT OF WING IS PITOT TUBE.

ALTHOUGH YOKE WAS ONLY 8 FEET WIDE AND WAS MOUNTED AT WING TIP APPROXIMATELY 20 FEET FROM COCKPIT CENTERLINE, IT WAS STILL RELATIVELY EASY TO FLY THE LIFT-LINE INTO IT.

OPERATIONAL TECHNIQUE, HOWEVER, SHOULD IF POSSIBLE PROVIDE FOR YOKE BEING MOUNTED ON NOSE OF AIRCRAFT DIRECTLY IN FRONT OF COCKPIT.



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B A G (super)

Acceleration forces, high-speed air forces, temperature and atmospheric conditions require providing adequate protection for rescued personnel.

Considerations include:

* Ease of ingress and egress.
* Stretcher for wounded. (Prone position also helps distribute G-loads over body).
* Parachute outside with rip-cord inside.
* Waterproofing necessary, water floatation desirable.
* Adequate and controllable ventilation.
* Interior illumination.
* Possible interior heating.
* Sufficient room to stand up (with handles) in case of parachute landing.
* Automatic closing when lifting load is applied.
* Plenty of visibility (for psychological as well as operational reasons).
* [illegible] concealment.
* Possibly telephone or radio communication directly to the pick-up plane after physical contact is made with the lift-line.

Accompanying illustrations roughly show some of these considerations.

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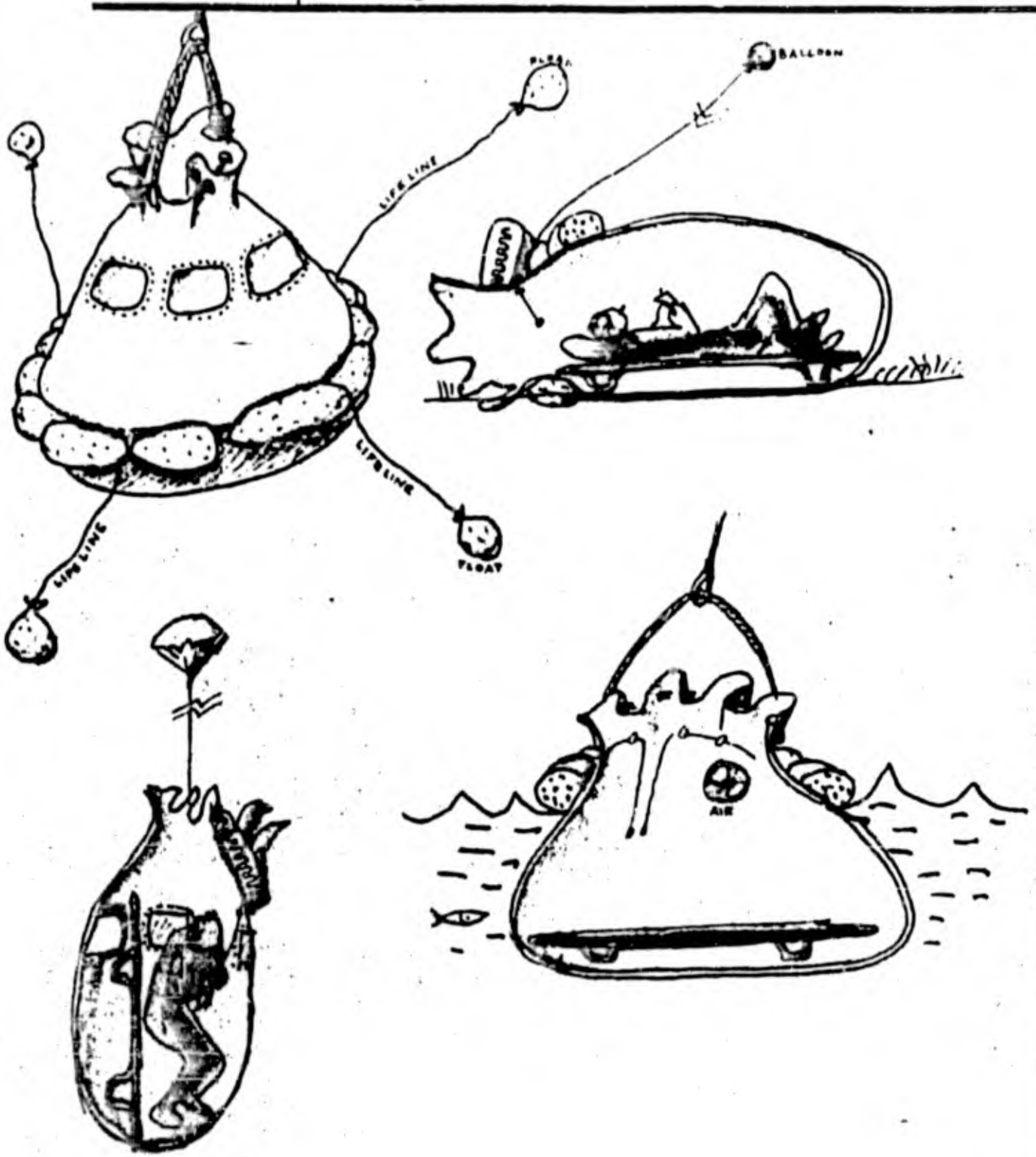
REPORT No. A(I)-NONE-112(60) DATE 30 MAY 62 PAGE 60.

REPORT TITLE HIGH PERFORMANCE PICK-UP.

SUPER BAG



71

B A G

Man-sized "duffle bag" might prove most practical.

Construction should be such as automatically to support occupant to withstand G-loads.

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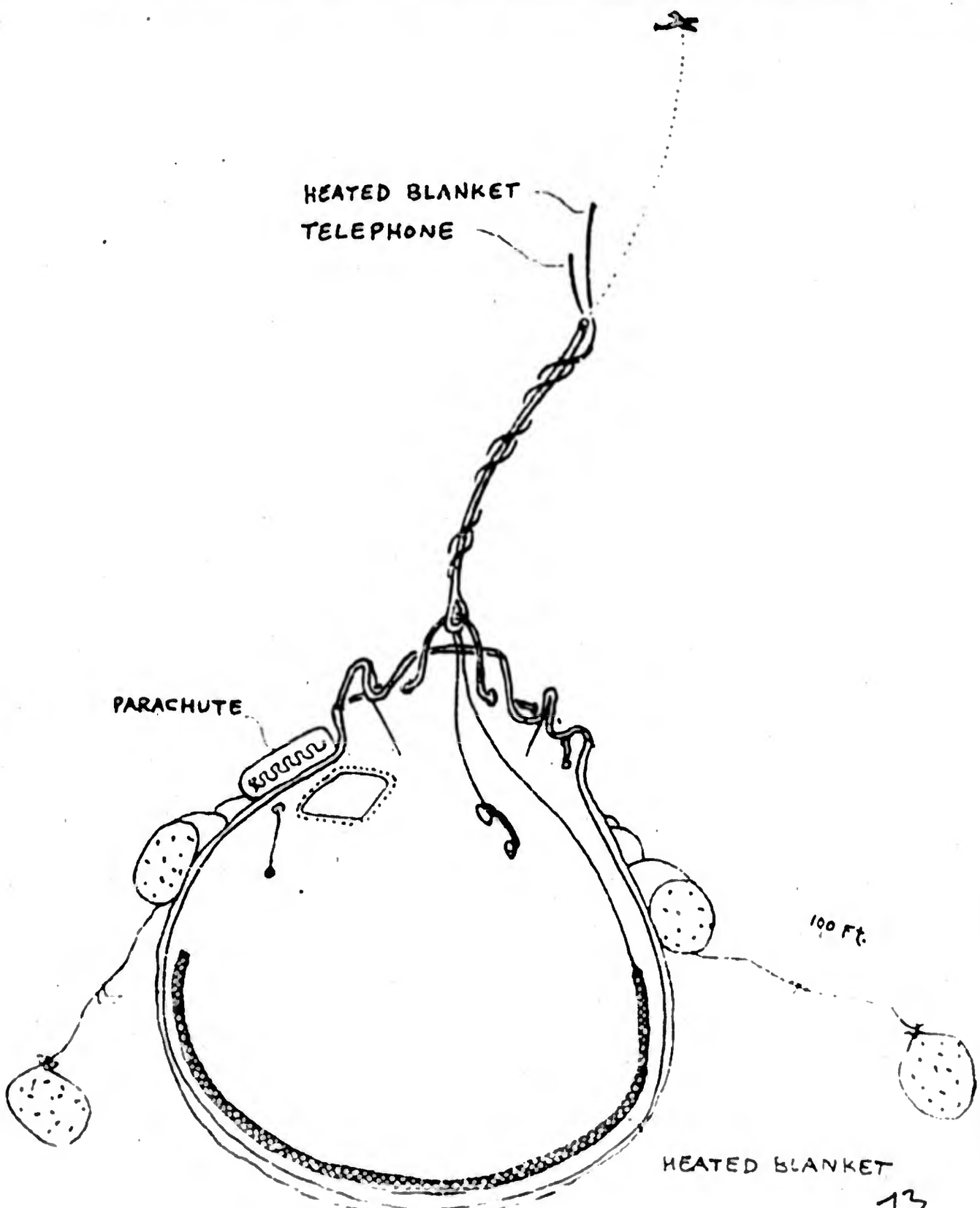
REPORT TITLE HIGH PERFORMANCE PICK-UP

BAG



W I N D - B A G

Such a "bag" as this would simultaneously act as a decelerator, reduce G-loads.

As the lift-load is applied the lines will run thru the rings around the perifery of the bag, gradually lift and close it at the same time.

It would also provide ample freedom of action, avoid claustrophobia.

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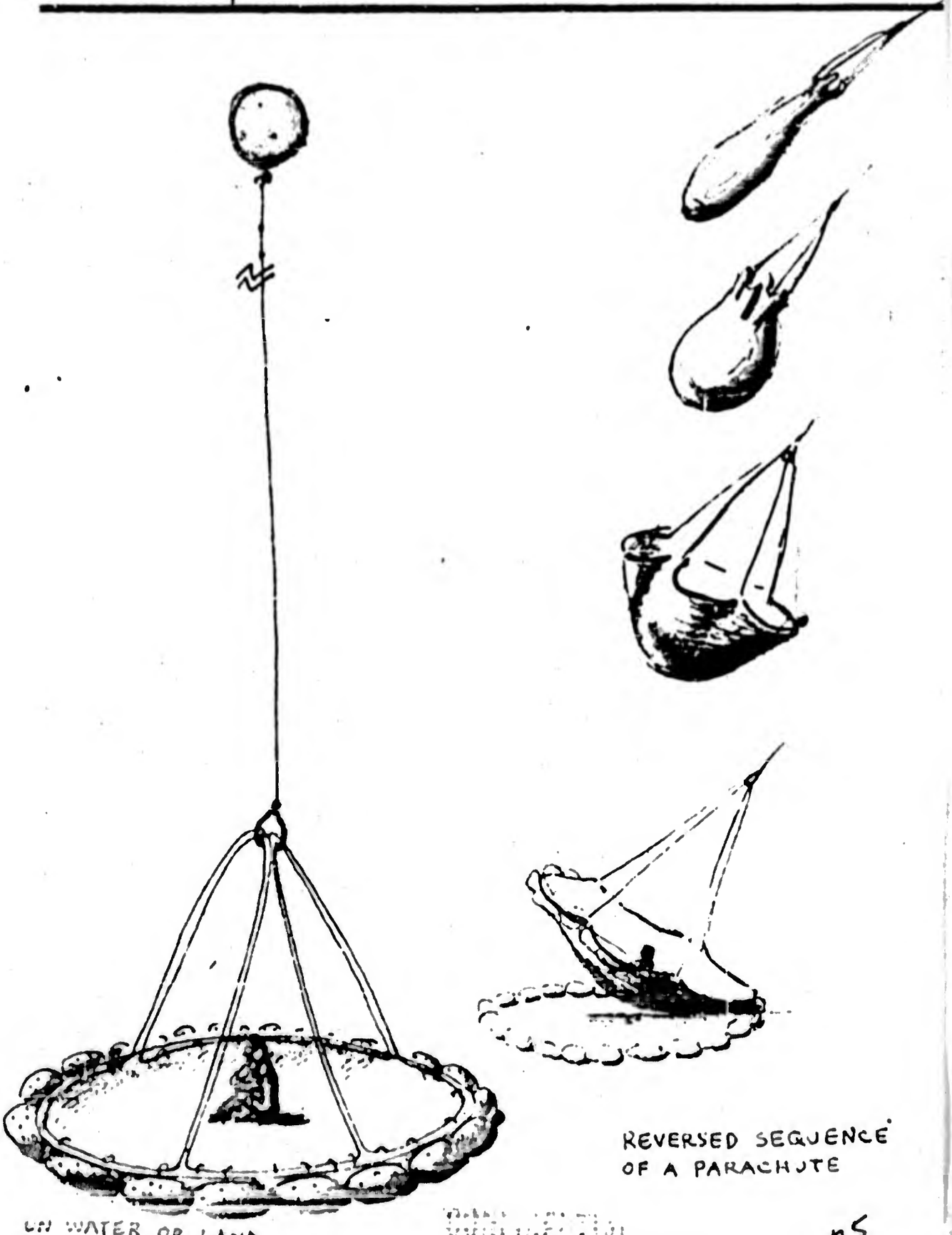
REPORT No. A(I) NONR 1126(00) DATE 30 MAY 1953 PAGE 84.

REPORT TITLE HIGH PERFORMANCE PICK-UP

WIND-BAG.



REVERSED SEQUENCE
OF A PARACHUTE

ON WATER OR LAND

ROBERT E. FULTON, JR.
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REPORT TITLE HIGH PERFORMANCE PICK-UP.

A C C E L E R A T I N G

D E V I C E S .....

(See Section II for greater detail).

CONICAL SNUBBER

If lift-line is shorter than 500 feet and speeds above 150 knots prove necessary with the SKYHOOK and MID-AIR techniques, some form of acceleration device may prove desirable.

A snubber of the type illustrated can be provided to cut the acceleration loads as much as in half.

It is considerably simpler, lighter and more effective than an accelerated drum-type unit by virtue of being located at the bottom of the lift-line just above the bag.

Note that use of any snubber will somewhat decrease the vertical lift vector and increase the horizontal one.

Simplicity of the overall system also speaks for elimination of any snubber if possible.

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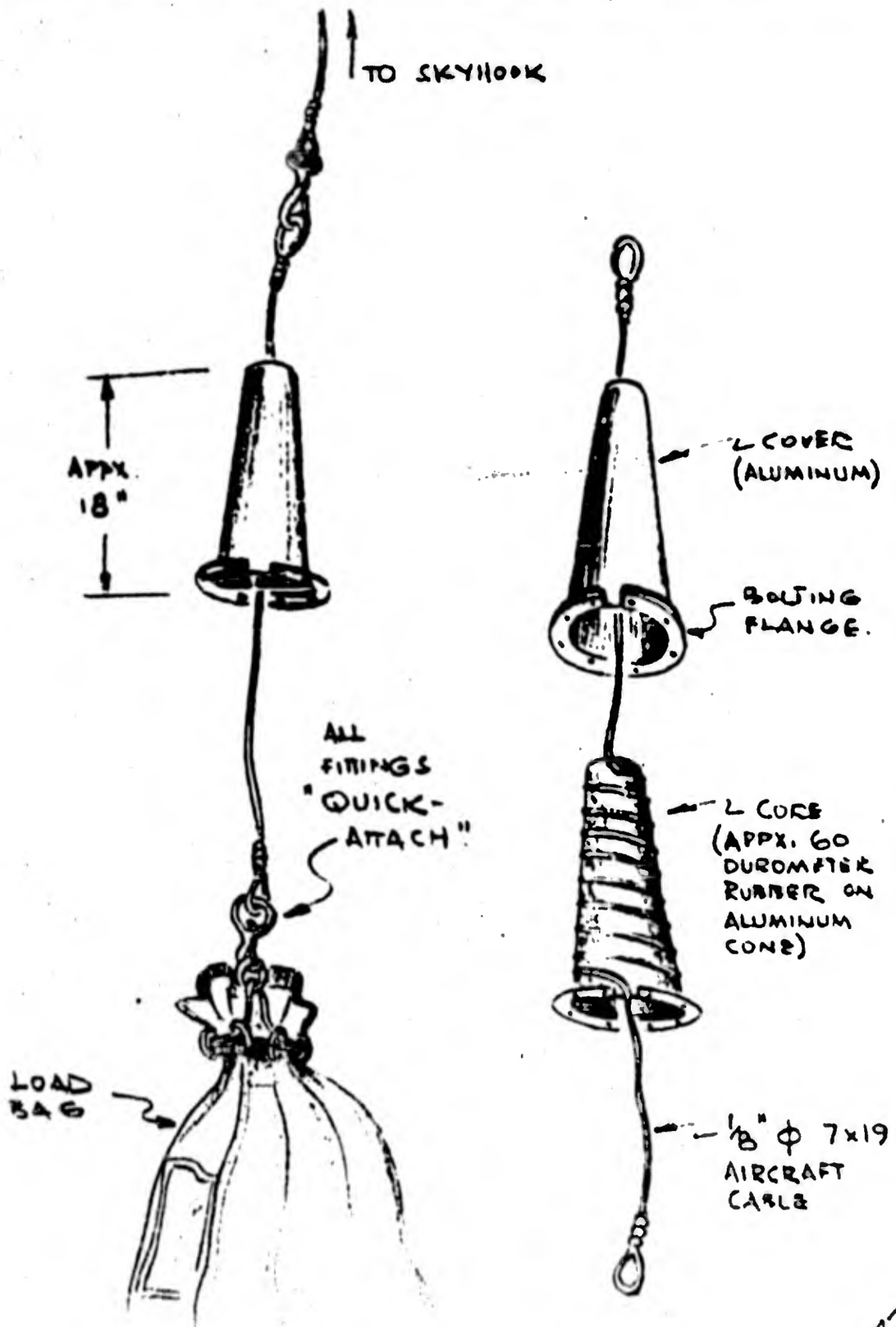
REPORT NO. A (I) NONR 1126(00) DATED 30 MAY 1953 PAGE 67.

REPORT TITLE HIGH PERFORMANCE PICK-UP.

CONICAL SNUBBER



NYLON SNUBBER

The use of a plain nylon lift-line would automatically insert a G-load softener into the system. However to carry the lift-loads developed the nylon line would have to be much heavier than steel cable of equal strength.

A satisfactory nylon snubber can nevertheless be made by tying a nylon line as indicated herewith.

As the load is applied it progressively snaps the tie-lines and thus absorbes the energy.

This is a simple expedient which can be created anywhere on short notice.

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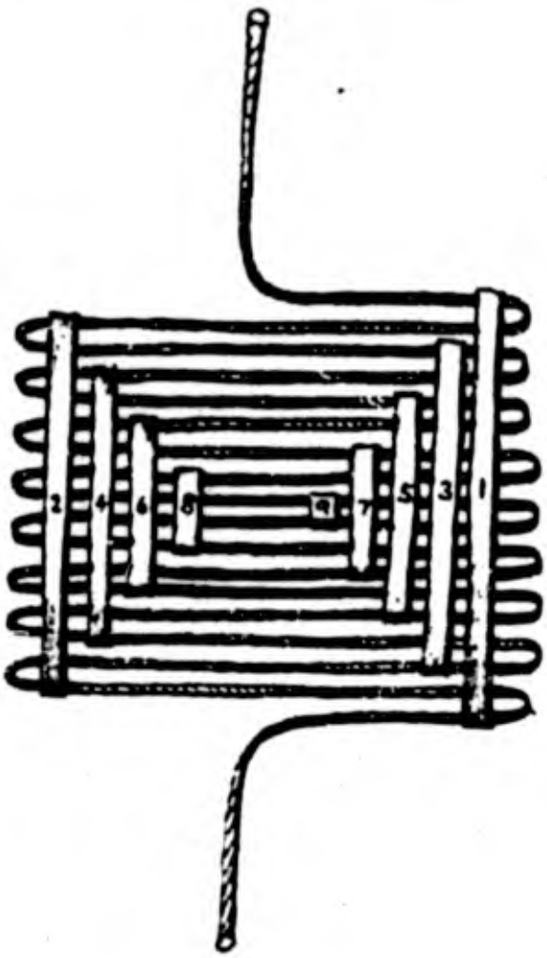
REPORT No. A (I) NONR 1126(00) DATE 30 MAY 1953 PAGE 69.

REPORT TITLE HIGH PERFORMANCE PICK-UP

NYLON SNUBBER



CROCHET RUBBER

A familiar crochet stitch, probably of nylon then rubberized to make it pull apart gradually.

By the time the lead is absorbed most of the stitches would be gone.

Another simple expedient.

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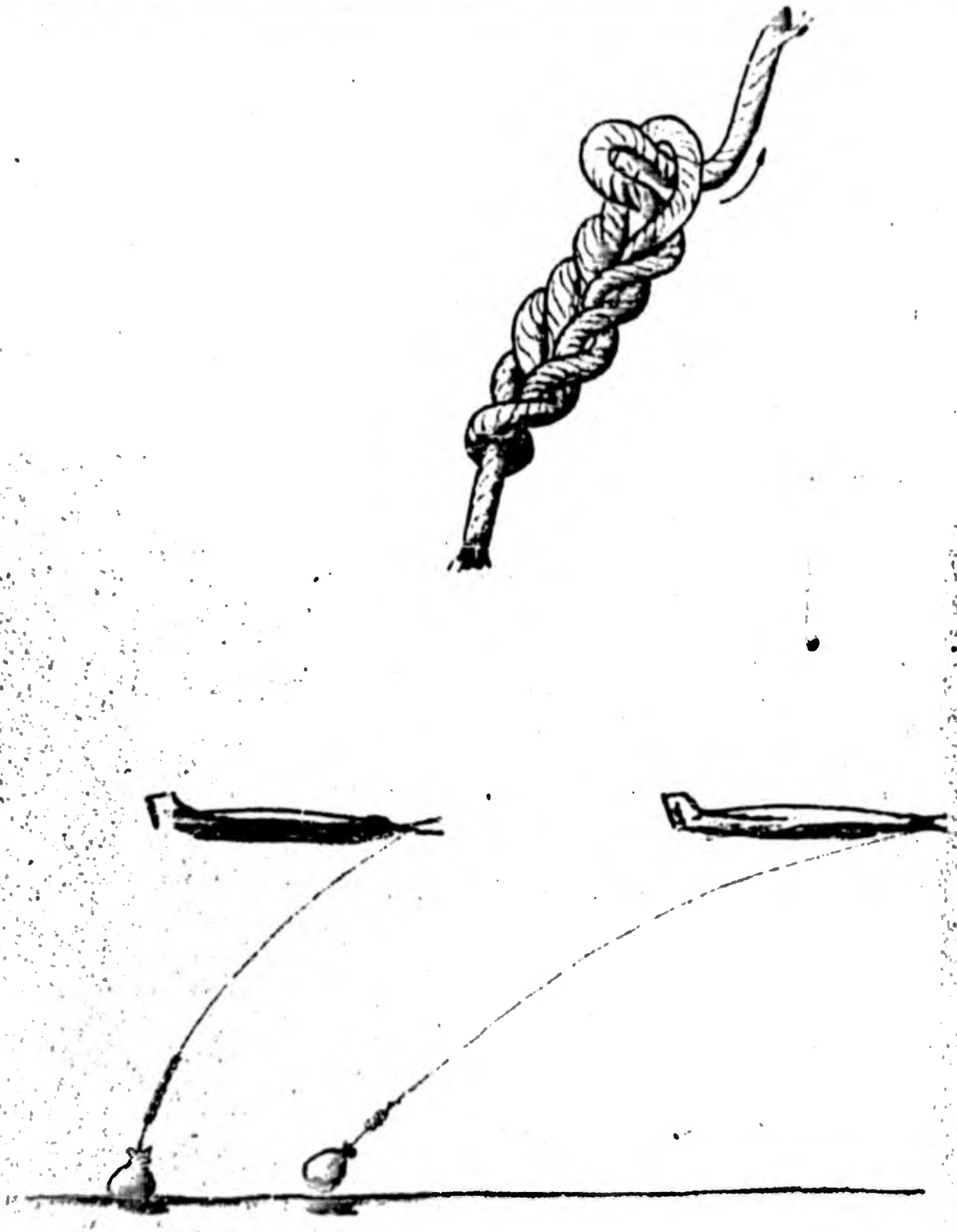
REPORT TITLE HIGH PERFORMANCE PICK-UP

CROCHET - SNUBBER



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REPORT No. A (I) Monr. 1126(00). DATE 30 May, 1953. PAGE 72.

SUBJECT TITLE HIGH PERFORMANCE PICK-UP.

ATTRACTING DEVICES .....

82

ATTRACTING DEVICES

Although it is not a formal part of this immediate project, the problem of leading the aircraft to the pick-up point must be satisfactorily solved or the rest of the operation cannot be performed.

For those who are concerned with this problem the following are mentioned as being of potential value:

- With the SKYHOOK and MID-AIR techniques the lift-line could be made [illegible] to serve as a homing radio antenna.

- Lift-line, balloons and parachutes can be coated with paint which responds only to lights carried in the pick-up plane.

- "Cat's eye" prisms should be mounted on the lift-line to mark the length where the knots occur.

  These prisms have the unique quality of reflecting light straight back to its source only and not being visible to anyone who is not directly behind the light.

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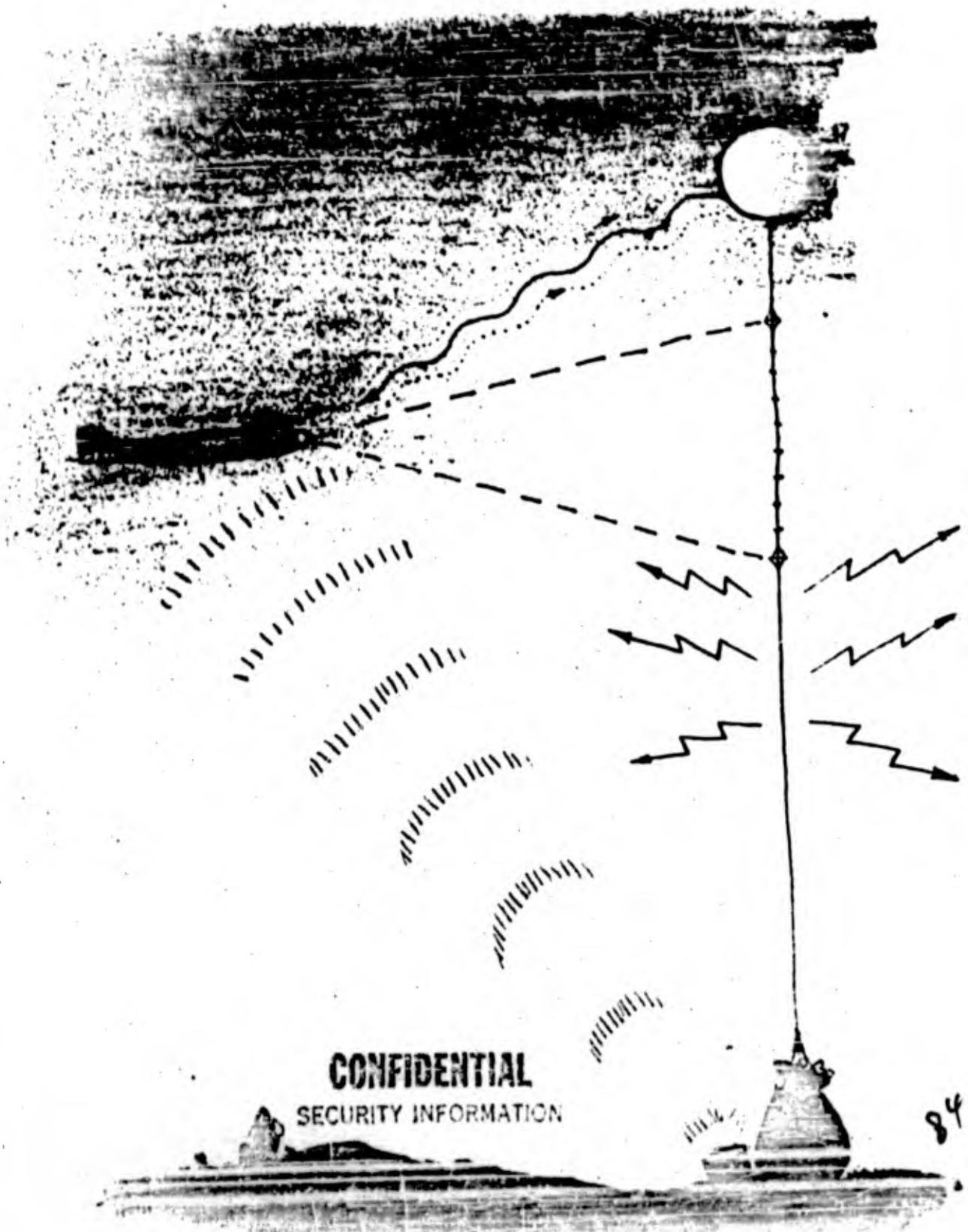
REPORT No. [illegible] DATE [illegible]

REPORT TITLE HIGH PERFORMANCE PICK-UP
ATTRACTING DEVICES



ALPINE SIGNAL LIGHT

Once the target is close at hand a standard type of alpine signal light, such as is schematically illustrated herewith, with its rotating disc and resulting changing colors would be a helpful marker distinguishable from the air.

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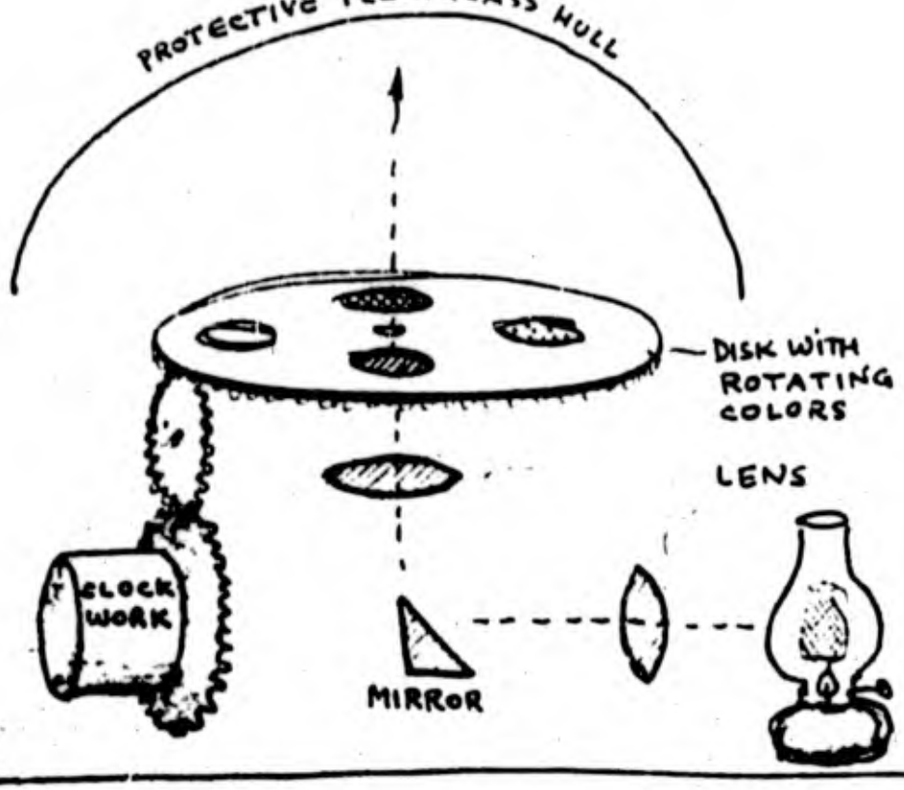
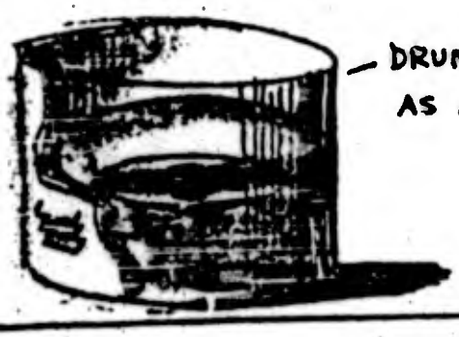
REPORT No. A (I) [illegible]

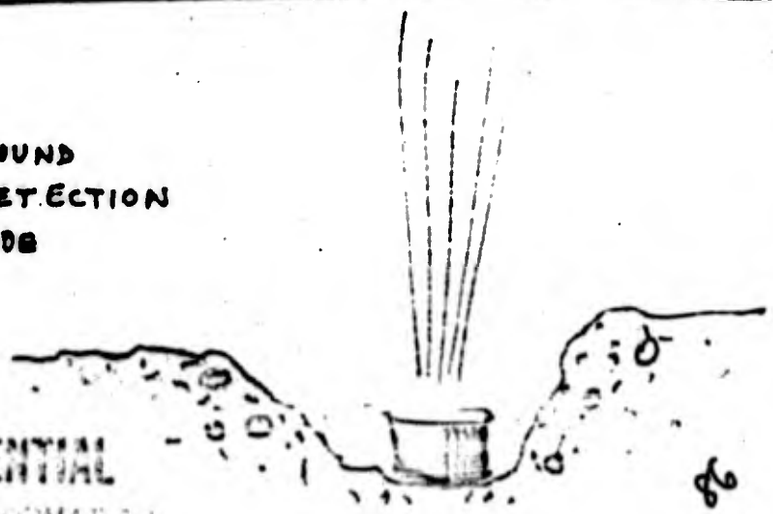
REPORT TITLE HIGH PERFORMANCE PICK-UP

ALPINE SIGNAL LIGHT





BURY IN GROUND
AGAINST DETECTION
FROM THE SIDE



B O A R D I N G

D E V I C E S .....

(See Section II for greater detail).

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SECURITY INFORMATION

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B R I D L E

Once the lift-line is engaged in the eye of the yoke it will trail back under the aircraft's fuselage or, if it is caught by one of the wing yokes, under the wing.

Getting it into the fuselage so that the load can be raised into the plane can be accomplished by means of a ring which closes around the cable at the eye and then slides back along it with a bridle to pull it into the bomb-bay or side door.

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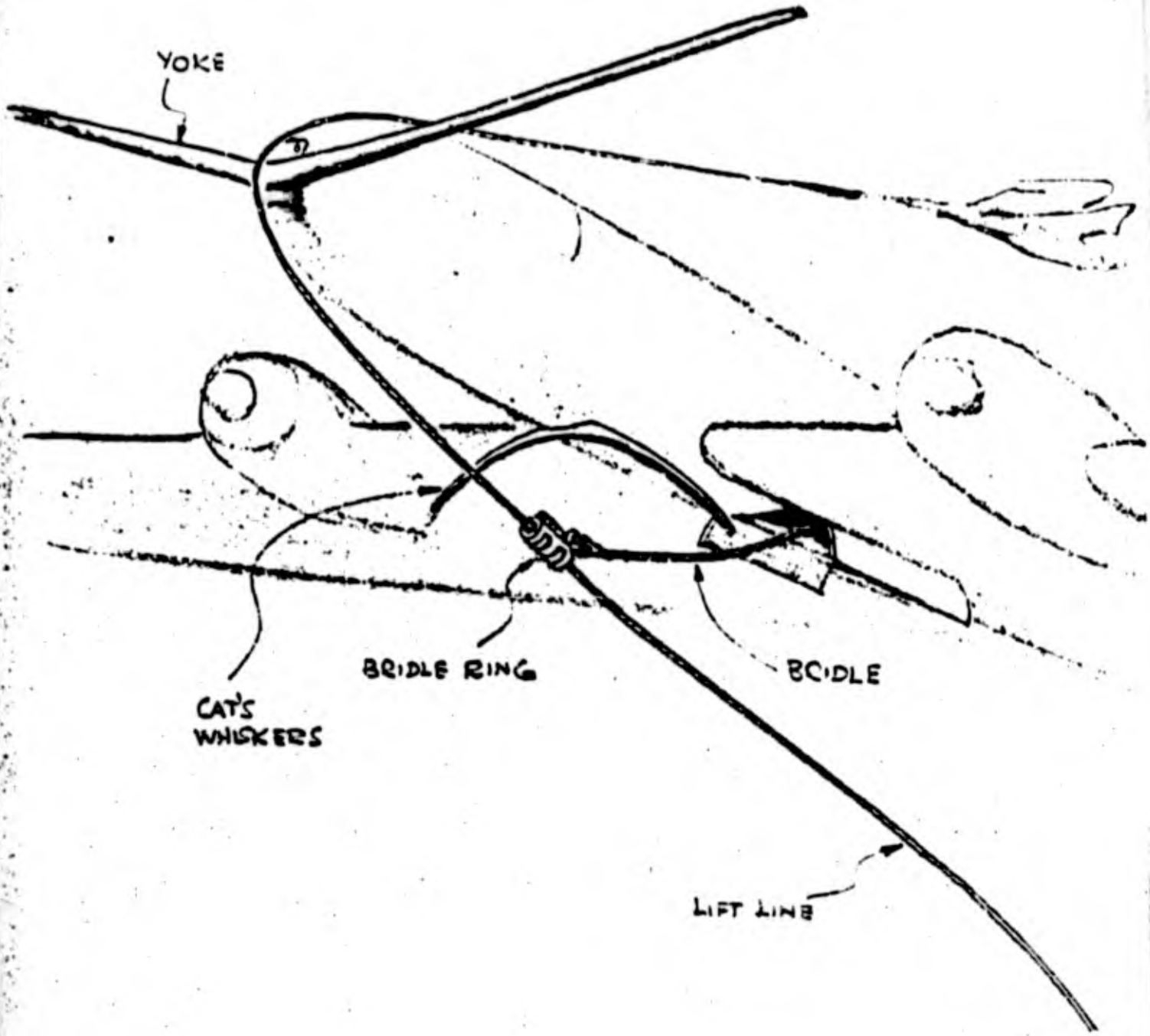
REPORT TITLE HIGH PERFORMANCE PICK-UP BRIDLE



REEL-IN DEVICES

A number of standard units of a type that could accomplish the job of pulling in the lift-line already exist.

The Navy's Mark V Anti-Aircraft Target Reel is already capable of handling more than 7,000 ft. of 1/8th. inch cable travelling in or out at considerable speed.*

It is air driven by an impeller rotated by the aircraft's air speed and may require modification to give it sufficient power to pull in a man. It may also require more spool capacity.

* Note that oiled cable of any kind must not be used! Centrifugal force throws off the oil creating an explosive vapor.

ROBERT E.
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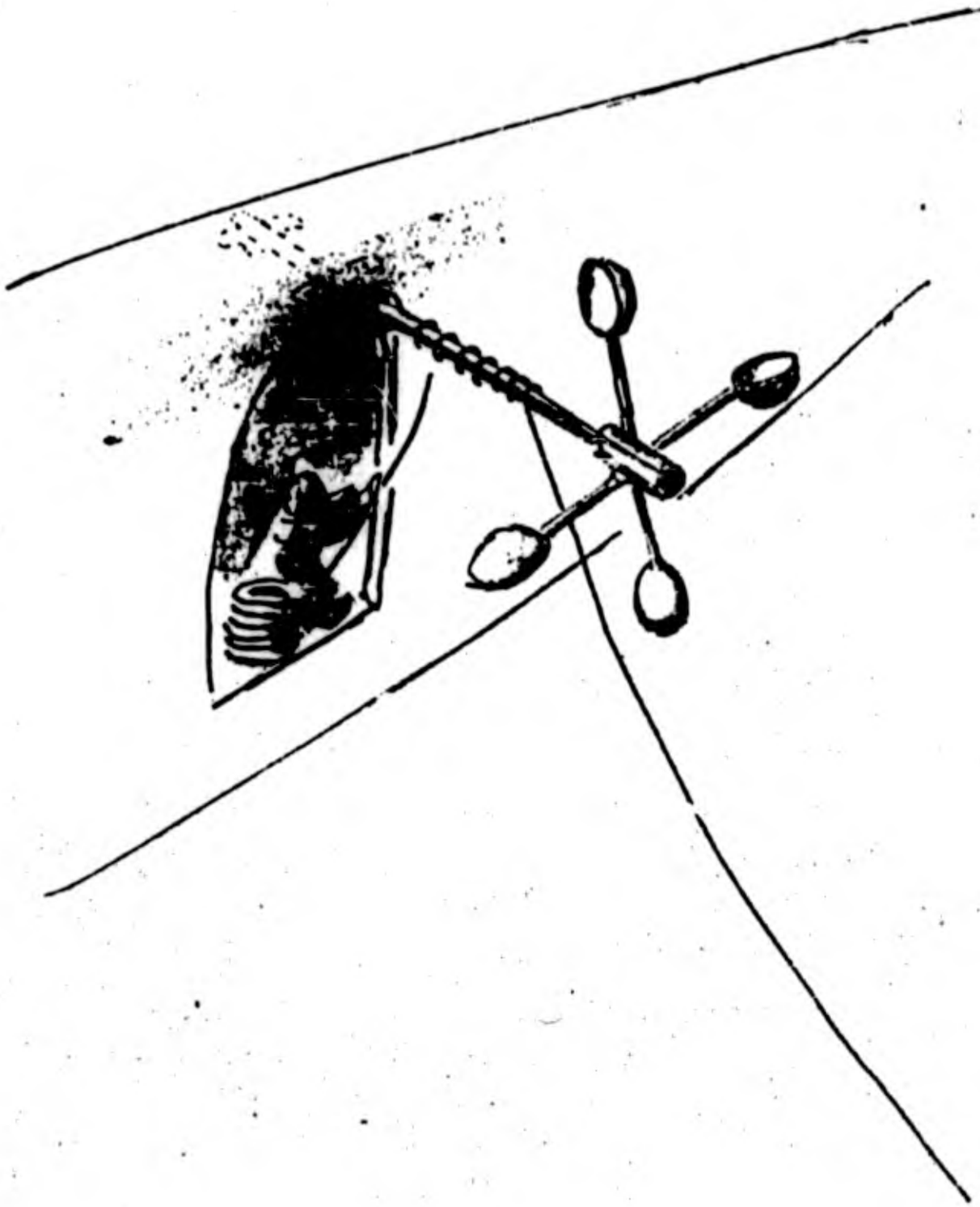
NEWTOWN,
CONNECTICUT.

REPORT TITLE HIGH PERFORMANCE PICK-UP REEL-IN DEVICE



VARIABLE-POWER PARACHUTE

With the LONG-LINE technique it is important to have some form of rapid reel-in mechanism to raise the bag the appreciable distance to the aircraft.

A "controllable-power parachute" such as that schematically illustrated could accomplish this as follows:

1. When the bag is ready to be raised, a parachute attached to the top end of the lift-line is released behind the airplane.

2. The parachute's "diameter-control line" is set to pay out just a certain number of feet depending upon the reeled out length of lift-line.

3. When this length is reached the parachute's diameter is automatically reduced and it stops raising the load.

4. Thereafter the operator can slowly raise the load at his discretion by gradually paying out the parachute's diameter-control line.

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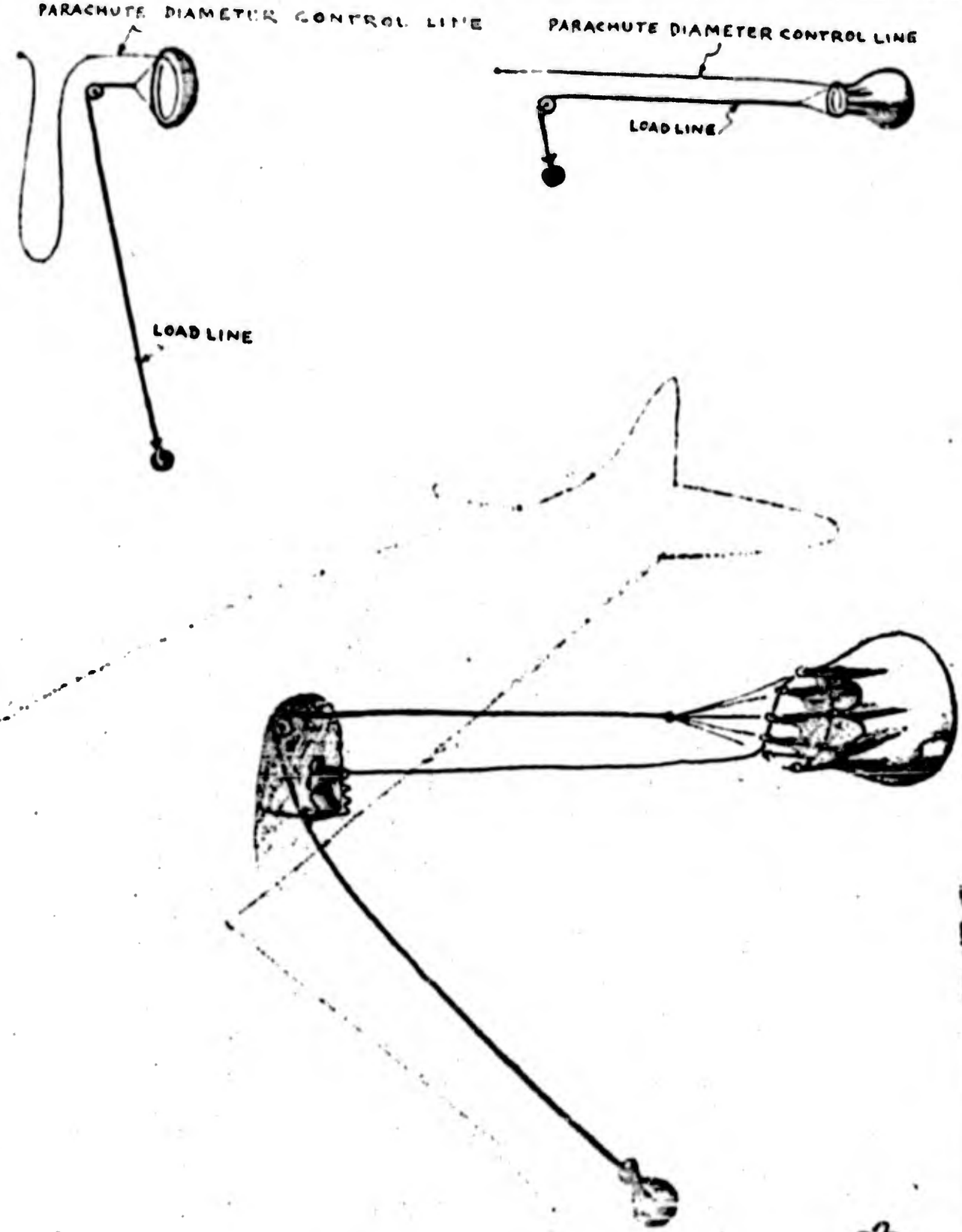
REPORT TITLE HIGH PERFORMANCE PICK-UP VARIABLE POWER PARACHUTE



"P A C K A G E D"

T E C H N I Q U E S

The following three sketches and accompanying lists integrate the various components into complete technique "packages".

Endeavor has been made to be specific in listing s··ial items and their general sources.

Some items, such as the yoke, are not available from stock and cannot be designed until a specific type of aircraft is selected.

These packages represent the combinations of technique and individual items which together appear to be the most promising solutions.

"SKYHOOK PACKAGE"

	ITEM	PART No.	MFGR/SUPPLR.	REMARKS
	BALLOON	M-1000.	Dewey & Almy.	---
	KITE	---	---	Box-type. To be designed.
*	ROCKET	---	Reaction Mtrs.	have made prelim. study.
*	WINDMILL	---	Miller	Signal Corps has proposal.
	YOKE) BRIDLE)	---	---	To be designed to specific aircraft.
	CABLE (Lift-Line)	1/8"Dx10 steel	Navy stock.	---
	"KNOTS"	Ball and shank terminal	Navy stock.	To be swaged onto cable in Navy shop.
	REEL-IN MECHANISM	MK-V anti Aircraft tow reel	Navy stock.	Could use All-Am. Model 15 with motor. (Not applicable to "LONG-LINE" tech.)
*	MARKER LIGHT	---	---	Requires investigation.
*	"CAT'S EYE" PRISM	---	---	Mfgr. can be ascertained from Bureau of Standards.
*	RADIO	---	---	Requires investigation.
*	CONICAL SNUBBER	---	Wallcome Devices.	To be tailored to job.
*	TIED NYLON SNUBBER	---	Columbia Rope.	Can be assembled with stock nylon line.
	GAS	---	Navy stock.	Helium or hydrogen.
*	GAS CYLINDER	Dwg. No. 240665	Walter Kidde Co.	Stock rocket charge bottle somewhat modified.
*	GAS GENERATOR	ML-303/TM	Signal Corps.	---
*	GAS CHARGE	ML-305A /TM	Metal Hydrides.	---
*	ATTRACTING DEVICES	---	---	Requires investigation.
	BAG	---	---	To be designed.

* See comment under "SUGGESTED FIELD TEST PROGRAM"

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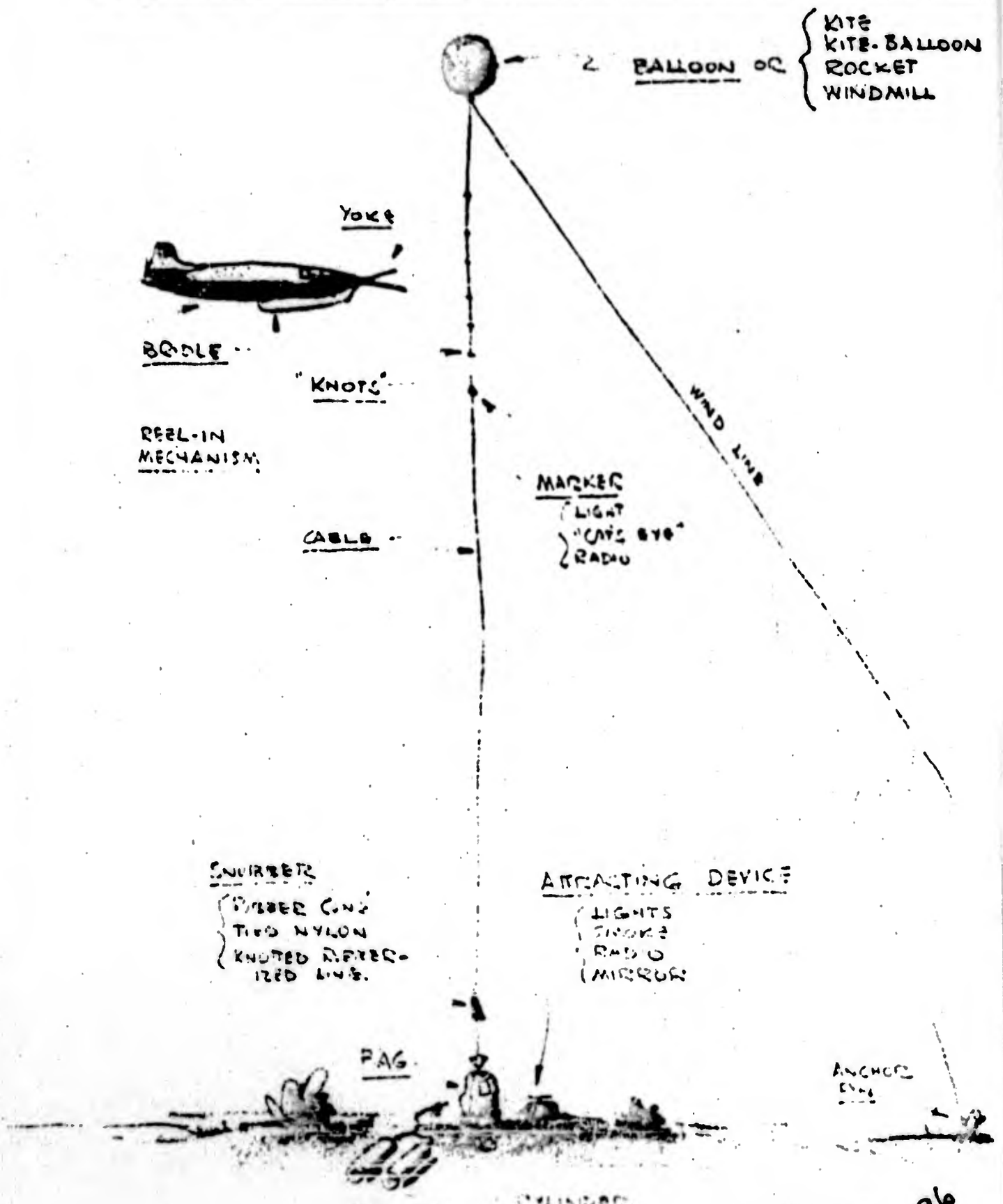
REPORT No. A(I)NONR 1126(00) DATE 30 MAY 1953 PAGE 86.

REPORT TITLE HIGH PERFORMANCE PICK-UP "SKY-HOOK" PACKAGE



"LONG-LINE PACKAGE"

ITEM	PART No.	MFGR/SUPPLR.	REMARKS
DISPENSER	---	Wellcome Devices.	Must be designed to contain requisite footage of cable.
CABLE (Long lift-line).	1/8", 7x19, steel.	Navy stock.	Unoiled!
REEL-IN MECHANISM	MK-V anti aircraft tow reel	Navy stock.	Must be capable of handling requisite cable footage.
* VARIABLE-POWER PARACHUTE	---	---	Would require research and design.
BAG	---	---	To be designed.
* ATTRACTING DEVICES	---	---	Requires investigation.

* See comment under "SUGGESTED FIELD TEST PROGRAM"

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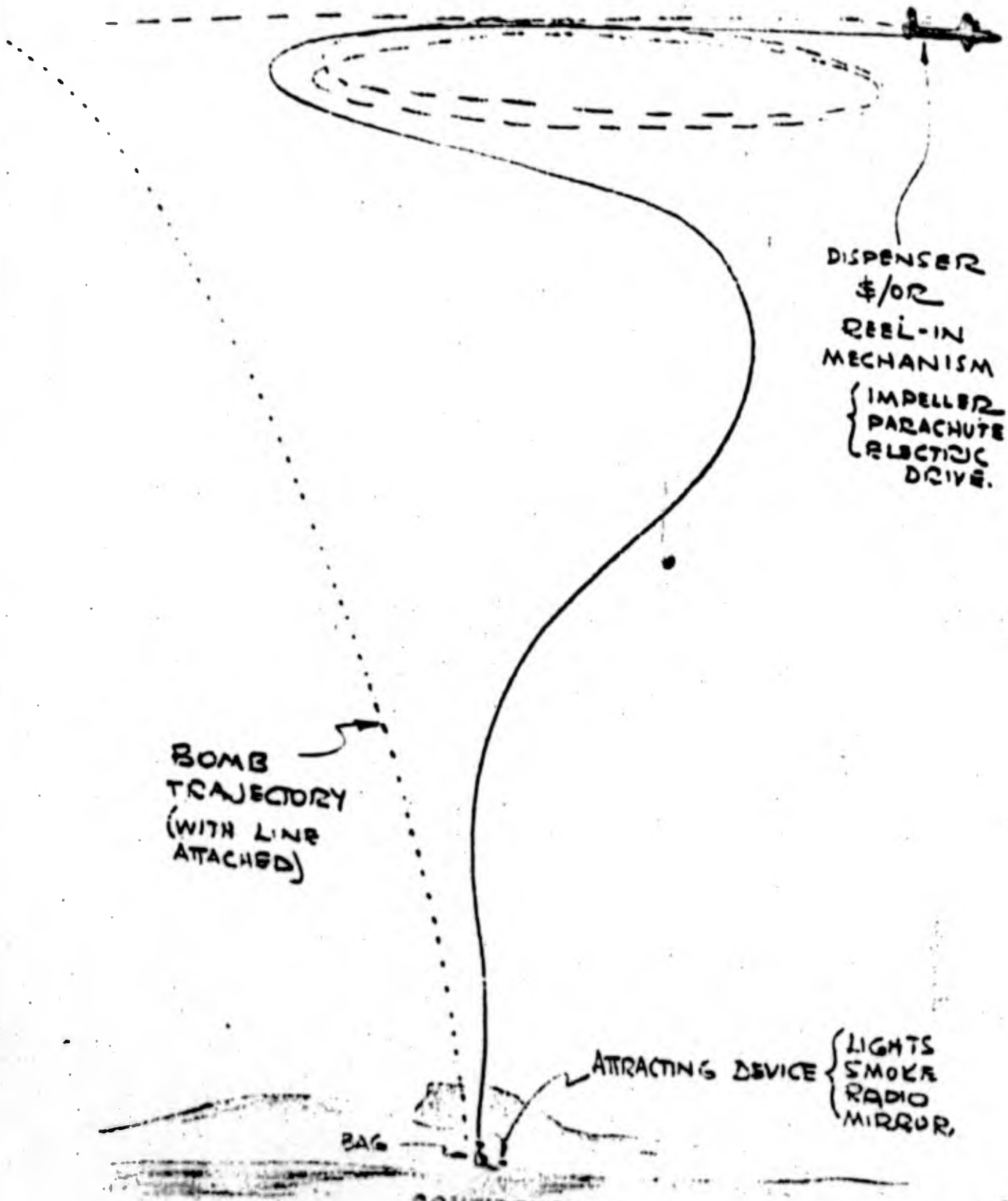
REPORT TITLE HIGH PERFORMANCE PICK-UP
LONG-LINE PACKAGE



"M I D - A I R P A C K A G E"

	ITEM	PART No.	MFGR/SUPPLR.	REMARKS
	BALLOON	---	---	Navy to supply.
	GAS	---	---	ditto
*	MARKER	---	---	See SKYHOOK technique.
	"KNOTS"	---	---	ditto
	CABLE (Lift-Line)	---	---	ditto
*	SNUBBERS	---	---	ditto
	LOWERING WINCH	---	---	Friction-block inside bag.
	BAG	---	---	See SKYHOOK technique.
*	ATTRACTING DEVICES	---	---	ditto

"M I D - A I R P I L O T B A L L O O N P A C K A G E"

	ITEM	PART No.	MFGR/SUPPLR.	REMARKS
	PILOT BALLOON	M-1000	Dewey & Almy	or equivalent.
*	---	---	---	Eliminate lowering winch.

"M I D - A I R P I L O T P A R A C H U T E P A C K A G E"

	ITEM	PART No.	MFGR/SUPPLR.	REMARKS
	PILOT PARACHUTE	---	Navy stock	Large enough to keep 1,000 feet of lift-cable taut above main parachute.
	MAN-CARRYING PARACHUTE	---	Navy stock	Must drop faster than pilot-parachute.
*	---	---	---	Eliminate pilot- and
*	---	---	---	man-carrying balloons.

* See comment under "SUGGESTED FIELD TEST PROGRAM"

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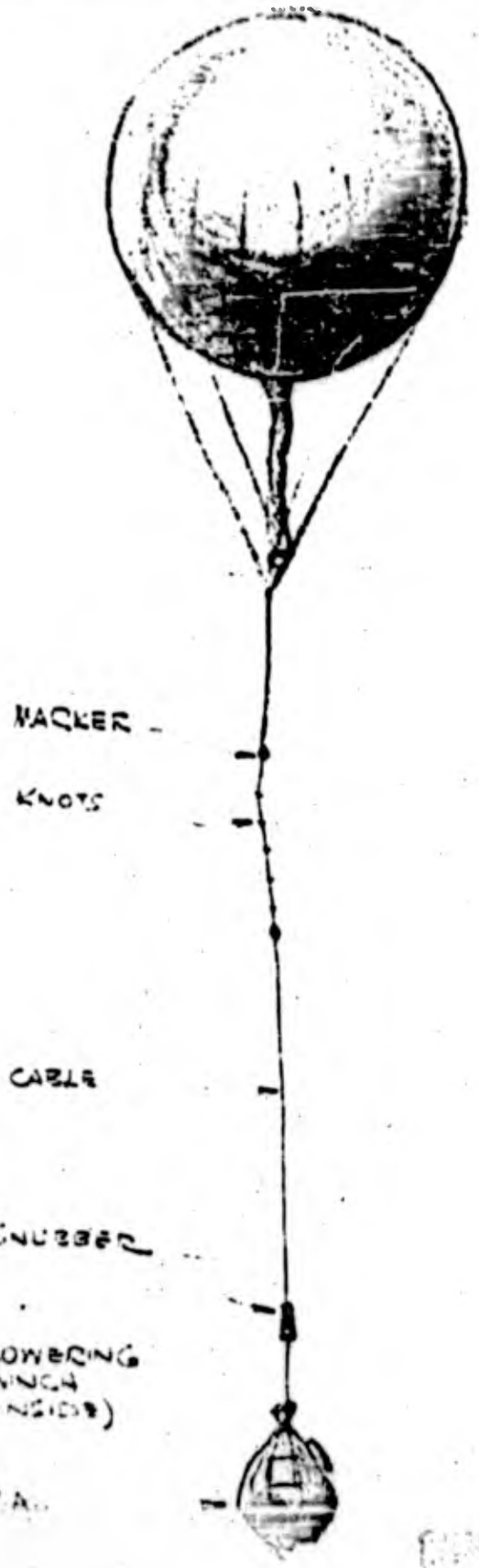
REPORT No. A (I) NONR 1126(00) DATE 30 MAY 1953 PAGE NO.

REPORT TITLE HIGH PERFORMANCE PICK-UP MID-AIR BALLOON PACKAGE



EXCEPT FOR LOWERING-WINCH THIS TECHNIQUE IS SAME AS "SKYHOOK."

IF PILOT-BALLOON IS USED WINCH IS ELIMINATED.

SUGGESTED FIELD TEST PROGRAM

While a number of preliminary tests have actually been conducted to prove the general feasibility of the techniques outlined herein, it has not technically been part of Phase I of this project to go beyond the idea stage.

The process of rendering them "operational" becomes Phase II of the undertaking.

Essentially this is a matter of taking the "packaged techniques" outlined in the immediately preceeding pages and putting them into action.

It is suggested that the program of Phase II be divided into the following steps:

1. Obtain the items which are not marked with an asterisk on the foregoing listing of packaged techniques.

   These are the basic components of each technique and will quickly serve to demonstrate how well each technique can be expected to work operationally.

2. If and as these basic concepts prove their worth, procure the asterisked items and proceed with integrating them into the operational systems as the need for them logically unfolds.

3. As the techniques develop conduct the tests under increasingly severe conditions to obtain operational experience.

SECTIONS

II & III

- INDEX -

N O T E

This Section is a MICROFILM record of work-papers and data collected in arriving at the conclusions presented in Section I of this Report.

The material it contains is both positive and negative, shows why some ideas may work, why others may not.

It is recorded on a continuous 35mm strip of film entitled:

SECTION II
(Work-papers & Data)
of REPORT on
PRELIMINARY STUDY AND RESEARCH
RELATED TO IN-FLIGHT PICK-UP
OF MEN AND MATERIALS WITH
HIGH PERFORMANCE AIRCRAFT

under

OFFICE OF NAVAL RESEARCH
CONTRACT Nonr. 1126(00)

This material is under the general headings given below and is recorded in the order of its listing.....

GENERAL DATA (Pertaining to the over-all subject).

* Articles illustrating conditions under which pick-up must be accomplished.
* Articles on air-to-air in-flight refuelling.
* "Night Vision Sense" Navy Bulletin (Navaer 00-80Q-33) USN 1950.
* Article illustrating details of in-flight refuelling mechanism.
* CAA Preliminary Report on "Determination of Centers of Gravity of Man" (CAA Project # 53-203; USN Contract NAonr 104-51; March, 1953).

"HISTORICAL" TECHNIQUES

* All American Aviation, Inc. "Air Pick-up" description and comments.
* Ships-at-sea mail pick-up experiments (Buair test program).

PATENT DATA

* Classification information.
* Partial list of relevant patents.
* Comments regarding methods set forth in these patents.

MISCELLANEOUS POSSIBLE TECHNIQUES

* Sketches and notes on a variety of techniques ---most of which probably would not work satisfactorily.

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SECTION III INDEX.

N O T E

This Section is a 16mm Kodachrome MOTION PICTURE of a few of the preliminary tests conducted to determine feasibility of various techniques and supporting the conclusions presented in Section I of this Report.

The film has a leader bearing the following inscription:

"PRELIMINARY SKYHOOK TESTS, Nonr. 1126(00), PHASE I"

The individual scenes have no titles but are numbered with india ink consecutively from the beginning. These scenes depict the following:

CAMERA SPEED (frames per sec).	SHOT No.	SHOT
24	1.	N-4 Dewey & Almy balloon (50" diameter, 40 cubic feet capacity, 2 to 3 lb. lifting power) attached to 400 ft. of 150 lb. test nylon line. Wind approx. 5 knots.
24	2.	Medium shot of load-bags attached to bottom of line. Shot pans up to balloon.
24	3.	CU of load-bags.
24	4.	Medium shot of load-bags with cloth streamer attached.
24	5.	Balloon aloft.
24	6.	Aircraft approaching on "dry run".

CAMERA SPEED (Frames per sec.)	SHOT NO.	SUBJECT.
24	7.	Aircraft passing on "dry run".
24	8.	Panning up from ground and showing aircraft making another "dry run".
24	9.	Live run with aircraft striking but not catching lift in yoke. Note load flies into air about 40 feet then drops back to ground. End 1st. day.
24	10.	Start of 2nd. day of tests. Balloons aloft, markers on line, aircraft making "dry run". Wind [illegible] 5 to 10 knots. All runs up-wind.
24	11.	Ditto shot 10.
24	12.	Ditto shot 10.
24	13.	Aircraft catching lift-line in yoke, line flying thru air, camera panning to follow it.
24	14.	Long shot of lift-line and load on sawhorse. No action.
24	15.	Long shot of lift-line and load on sawhorse. First snatch on 2nd. day. This shot plotted on paper.
64	16.	Medium CU of load on sawhorse. Load rises out of picture. This is CU of same shot as No. 15. Note holding-line following exact track of lift-line.
24	17.	Medium CU, lift-line, legs, G-meter, sawhorse.
24	18.	CU G-meter.
64	19 thru 23.	Medium CU lift-line and load on sawhorse. No action.
64	24.	Ditto Shot 19 but load rises. This is 2nd. pick-up on 2nd. day.