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HOLLOMAN
AIR DEVELOPMENT CENTER

SUMMARY REPORT ON
PROJECT MOBY DICK
COVERED WAGON BALLOON LAUNCHER
DEVELOPMENT AND TEST RESULTS

6 December 1951 To 15 September 1952

HOLLOMAN
AIR FORCE BASE, NEW MEXICO

REPORT NO. HDT-21   COPY NO. 10

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SUMMARY REPORT

PROJECT MOBY DICK

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6 December 1951 to 15 September 1952

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TABLE OF CONTENTS

Abstract

As a solution to the problem of inflating and launching large Moby Dick plastic balloons in adverse weather conditions, a "covered wagon" was built. It employs a 40-foot flatbed as a base with a headboard and side framework constructed of pipe and angle iron, covered with canvas. An airplane cloth cover forms the top piece. The gas bubble is inflated inside the covered wagon and released by removing one side and the headboard connections of the top cover. Thirty-two test flights and 20 operational flights have been made, employing this vehicle. The covered wagon has proved to be highly satisfactory. Balloons can now be launched in winds about three times as strong (20 to 25 knots) compared to launching with the previous launch platform technique.

SUMMARY REPORT

PROJECT MOBY DICK

COVERED WAGON BALLOON LAUNCHER

DEVELOPMENT AND TEST RESULTS

6 December 1951 to 15 September 1952

Introduction:

1. General:

a. One of the Moby Dick project problems assigned to the
Electronic and Atmospheric Balloon Sonde Sub-Unit was the development
of a launching system which would provide successful launchings of
large, plastic balloons under adverse weather conditions.

b. The Moby Dick balloons are polyethylene, 2.5-mil thick,
constant level vehicles, ranging from 45 to 72.8 feet in diameter, and
from 75 to 120 feet in length. The payload is approximately 10 cubic
feet in size, and weighs from 270 to 360 pounds. The problem of suc-
cessfully launching this assemblage in unfavorable wind velocities
are two-fold:

(1) The balloon must be protected from damage during the
30 minute inflation process.

(2) The payload must be launched without shock or damage.

2. Previous Reference:

A preliminary discussion of this problem, with solutions and
early tests, may be found in a Holloman Air Force Base Summary Report by

Mr. T. W. Kelley, "Balloon Launching Techniques in Adverse Winds", 6 December 1951 to 8 February 1952.

History and Development:

Until the time of this new requirement, plastic balloons had been flown at Holloman Air Force Base, employing a launch platform and a simple hold-down system. (See Figure 1) This combination provided adequate facilities for launchings in winds only up to 8 knots.

The first suggested solution to the inflation problem in stronger winds was a wind screen. New York University and General Mills balloon groups had employed wind screens with moderate success. An installation with walls 40 feet high, in 3-direction sectors, was ordered for Holloman Air Force Base and is now almost completed. This unit should make platform inflations feasible in winds up to at least 15 knots. However, it is known from experience that in velocities much above this figure, turbulent eddies at the top of the screen result in buffeting of the balloon bubble. In addition, any shift in direction of a strong wind occurring while the bubble is being inflated, would probably result in failure. Although, the wind screen would constitute an improvement in inflation techniques, it would be immobile and would not adequately protect the balloon in shifting winds.

As a solution to the actual launching of the payload, three actions were taken:

1. The 24-foot personnel parachute was flown packed, rather than opened. This shortened the balloon train, which allows a quicker and more vertical pick-up of the payload.

2. With payloads of up to 150 pounds and in winds of 5 knots or less, the payload was carried by hand, for a person could change direction faster than a vehicle. However, in greater wind velocities with the heavy Moby Dick load, this system is totally inadequate. Consequently, a three-wheeled front wheel castered cart with handles for pushing was constructed. (See Figure 2). This vehicle has proved to be extremely versatile, having been successfully employed with loads up to 600 pounds and in winds up to 18.5 knots.

3. The Moby Dick payload was redesigned, so that it was extremely well balanced, with a low center of gravity and a minimum of protuberances. Since these three elements have been combined, 23 out of 25 launches of the payload were successful. The failures were due to weaknesses in the release mechanism, which have since been remedied.

With reference to the inflation problem, a wind screen would be only partially successful, because it only partially shields the bubble. Thus, it appeared that the final solution would be to completely inclose the bubble in a shelter.

Variations of the shroud method were discussed. This system already used with rubber and small plastic balloons, consisted of a fabric cover draped over the balloon during inflation, and secured by lines to the

ground. For the large Moby Dick balloons, however, a tremendous cover
would be needed, with complex rigging problems involved.

It was suggested that the bubble of the balloon be completely in-
serted and inflated within a tubular, canvas bag. The cross sectional
area of the bag was to be small and the length considerable, so that there
would be less resistance to the wind. The release was to be made by a
zipper or lacing system.

The obvious advantage of this system was that the bubble could be
inflated in any sort of wind. In addition, it made a neat package which
entailed no handling of the balloon after it was inclosed. If precipita-
tion occurred, for instance, the inflated bubble could be left within the
bag, until the precipitation ceased. A final advantage was that the con-
tainer was fabric and flaccid, thus making it easy to roll up and store, or
ship.

The principal objection, which nullified this prototype suggestion, was
the shape. As soon as the bubble was freed from the bag, it would tend
to assume its natural shape, a tear-drop configuration. Consequently, as
the balloon is released from the narrow, tubular container, there would
be dangerous contortions of the balloon material due to the rushing gas.

In addition, there is the problem of size and wind shifts. A long
tubular bag, which would contain the entire balloon with the maximum volume
needed to fly the maximum weight Moby Dick load without actually com-
pressing the gas, would have to be 135 feet long, with a cross sectional

area 10 feet in diameter. The proportions of such a structure make the task of moving it, in case of wind shifts, almost impossible. Adding a mobility feature would nullify the advantages of this prototype.

To provide the needed mobility, a 40-foot, flatbed trailer was suggested as a base for the inflation system.

The advantages of this vehicle were:

1. It represented one of the lengthiest, movable structures available.

2. It was easy to move for wind shifts.

3. It represented a good vehicle for transportation and equipment portage between launching sites.

Because the flatbed length was so much shorter than that of the proposed prototype bag, the cross sectional area had to be much greater. Flaccid sides, 20 feet high or more, would be apt to subject the balloon to considerable buffeting by the wind, so rigid supports were suggested. Considerations for the maximum volume needed, plus the basic size of the 40-foot flatbed, soon determined the configuration of the covered wagon balloon launcher. The present models are very similar to the initial vehicle, constructed in November 1951. (See Figure 3)

Physical Description:

    1. General:

        The covered wagon can best be introduced physically by inspection of the blueprint (See Figure 4) and pictures (See Figure 5). Mounted on a 40-foot flatbed, the side and headboard frameworks are constructed of

5

angle iron, channel iron, and pipe, covered with 3/4-inch plywood. The floor is covered with canvas, and the top covers have been canvas and airplane cloth.

2. The Release System:

On each side of the covered wagon, there is a horizontal sliding bar along the top of the side framework. The sliding bar has pins every eight inches and is connected to a cable which has nails attached at the same intervals. These nails and pins slip into loops which are passed from the canvas cover through the holes of the angle iron attached to each side. There is a safety pin which has to be pulled from the last nail in the cable before release can be made. Then a release arm (See Figure 5) which dangles from the end of this cable and sliding bar arrangement down to within arm reach of the ground, is pushed forward. This pulls the pins and nails from the loops, releasing the cover.

The headboard release consists of a cable with nails which is released by a direct pull on the cable. The cable moves inside a channel, which is run along the circumference of the headboard.

In actual practice, only one (the upwind) side is released, with the headboard activated immediately afterwards. In one case, where both sides were accidentally simultaneously released, the cover remained on top of the balloon for a time, destroying the lift needed to pick up the load cleanly. The center release, which has been tried, is a much simpler system; but it is felt that there is too much contact of the release

6

rigging with the balloon material (which, after inflation, was pressed rather tightly against the center release mechanism). Despite the fact that the side release system appears more complicated, only one failure has occurred out of approximately 45 releases that have been made since the system has been modified to its present form.

3. Modifications:

The following list comprises the modifications which have been initiated since the first prototype (model No. 1) was constructed in November 1951.

a. The size of the floor, sides and headboard have all been increased.

b. The top of the leading edge of the open end of the trailer has been rounded off in order to prevent the possibility of balloon material catching there.

c. A center release cover has been constructed and tested.

d. The studs located at the junction of the sides and the floor have been replaced by U bolts.

e. The canvas covering the sides and the floor has been made of one piece, in place of the sections formerly used.

f. Platforms with stairs have been added to the back of the headboard, so that personnel may more easily work on that section.

g. The handle of the release arm was enlarged.

h. The top cover was redesigned so that with a fully inflated balloon inside, the canvas appeared bread-loaf shaped (See Figure 5). On

7

the first model, the canvas sloped down from the headboard circumference to the tail-gat- of the flatbed. (See Figure 3)

i. The floor canvas has had matching eyelets installed, so that it may be connected to the sides.

Test Operations:

1. General Discussion:

The covered wagon trailer was subjected to the following type of tests in the order listed below:

a. Mechanical operation of the release mechanism in light winds.

b. Mechanical operation of the release mechanism in moderate or heavy winds.

c. Effect of the various physical contacts with the covered wagon upon the balloon. Large scale damage could be determined from any of the former tests. However, very minor holes or abrasions could be detected only by long duration flights of one day or more.

d. Miscellaneous tests, such as maximum capacity, or use with supplementary devices.

Some of the tests had to be repeated as modifications to the wagon were introduced.

2. Outline of Tests:

a. Test No. 1, 6 December 1951

Purpose of Test: To check the general operation of the covered wagon balloon launcher, Model No. 1.

8

Balloon: General Mills, 1.5-mil, 20-foot diameter.

Launch Winds: 20 knots.

Flight Duration: Balloon held down after release.

Results: Some difficulty occurred with the release of the cover, but the 40-pound load was successfully launched.

b. Test No. 2, 12 December 1951

Purpose of Test: To test the release mechanism.

Balloon: Winzen, 45-foot diameter, 2.5-mil.

Launch Winds: 3 knots.

Flight Duration: Hold down.

Results: Successful.

c. Test No. 3, 17 December 1951

Purpose of Test: To test the release mechanism.

Balloon: Winzen, 45-foot diameter, 2.5-mil.

Launch Winds: 2 knots.

Results: Successful.

d. Test No. 4, 20 December 1951

Purpose of Test: To check mechanical operation in moderate winds.

Balloon: Winzen, 72.8-foot diameter, 1.5-mil.

Launch Winds: 5 knots.

9

Flight Duration: 10 minutes.

Results: Successful.

e. Test No. 5, 28 December 1951

Purpose of Test: To determine the maximum volume capacity

of the covered wagon.

Balloon: General Mills, 85-foot diameter, 1.3-mil.

Launch Winds: Calm.

Flight Duration: Hold down.

Results: Successful.

f. Test No. 6, 2 May 1952

Purpose of Test: To check the mechanical operation of

Model No. 2 in light winds.

Balloon: Winzen, 72.8-foot diameter, 1.0-mil.

Launch Winds: 5 knots.

Flight Duration: Hold down.

Results: Release mechanism jammed momentarily. After the

balloon cleared the wagon, an 8-inch-long rip was

seen in the balloon.

g. Test No. 7, 6 May 1952

Purpose of Test: To check the mechanical operation in light

winds.

Balloon: Winzen, 45-foot diameter, 2.5-mil.

10

Launch Winds: 7 knots.

Flight Duration: Hold down.

Results: Release mechanism again jammed. Small hole was
observed in balloon; the balloon had been used
twice before.

h. Test No. 8, 8 May 1952

Purpose of Test: To check the mechanical operation in
moderate winds.

Balloon: Winzen, 45-foot diameter, 2.5-mil.

Launch Winds: 15 knots.

Flight Duration: Hold down.

Results: The actual releasing process was successful. How-
ever, both sides and the headboard section were
unintentionally released simultaneously. As a
result, the balloon rose for a short time with the
cover on its cap.

i. Test No. 9, 15 May 1952

Purpose of Test: A duration flight to check for minor damage
to the balloon inflicted by the covered
wagon.

Balloon: General Mills, 85-foot diameter, 1.3-mil.

Launch Winds: 17 knots.

Flight Duration: 24 hours.

Results: Successful; the balloon remained aloft for one

day, exhibiting the performance of a normal, un-

ballasted vehicle.

j. Test No. 10, 5 June 1952

Purpose of Test: To check the maximum capacity of the

covered wagon, Model No. 2

Balloon: Winzen, 72.8-foot, 2-mil.

Launch Winds: 2 knots.

Flight Duration: 1 hour.

Results: Successful; maximum capacity proved to be 14,500

cubic feet, or 800 pounds of gross inflation.

This figure is 100 pounds in excess of the maximum

Moby Dick gross inflation.

k. Test No. 11, 12 June 1952

Purpose of Test: To test the operation of a center release

on the covered wagon.

Balloon: General Mills, 20-foot diameter, 1.5-mil.

Launch Winds: Calm.

Flight Duration: 2 hours.

Results: The center release worked satisfactorily.

l. Test No. 12, 19 June 1952

Purpose of Test: To test the center release of the covered

wagon.

Balloon: Winzen, 45-foot diameter, 4-mil, valve top.

Launch Winds: Calm.

Flight Duration: Hold down.

Results: Under stress of 10 times the amount of lift as the previous test, the center release was operated only with great difficulty.

m. Test No. 13, 1 July 1952

Purpose of Test: To test the center release.

Balloon: Winzen, 45-foot diameter, 2.5-mil.

Launch Winds: 4 knots.

Flight Duration: Hold down.

Results: Successful.

n. Test No. 14, 11 July 1952

Purpose of Test: Originally, to check the operation of the Moby Dick reel and packed parachute in conjunction with the covered wagon. However, since payload separation by timer failed, the flight was extended, and proved to be a good duration test of the covered wagon.

Balloon: Winzen, 45-foot diameter, 2.5-mil.

Launch Winds: 3 knots.

Flight Duration: 15 hours.

13

Results: The barograph height-time curve exhibited normal

performance of an undamaged, unballasted balloon.

o. Test No. 15, 14 July 1952

Purpose of Test: To evaluate high wind launching techniques.

Balloon: General Mills, 30-foot diameter, 1.5-mil.

Launch Winds: 15 knots.

Flight Duration: 9 minutes.

Results: Successful.

p. Test No. 16, 17 July 1952

Purpose of Test: To evaluate high wind launching techniques.

Balloon: Winzen, 45-foot diameter, 1.5-mil.

Launch Winds: 17 knots.

Flight Duration: 0.

Results: Successful.

q. Test No. 17, 23 July 1952

Purpose of Test: To determine the amount of helium lost,

in terms of pounds of lift, from an in-

flated balloon held captive inside the

covered wagon for a specified period of

time.

Balloon: Winzen, 45-foot diameter, 2.5-mil.

Launch Winds: Calm.

Flight Duration: Hold down.

Results: The total loss in lift for 183 hours was 232 pounds, 1.3 pounds per hour.

r. Tests No. 18 through No. 32

Purpose of Tests: These Moby Dick flights, which were flown as standard field operations (one per day, under any weather conditions) served as further tests for wind launchings, and as the final checks on long duration tests of the covered wagon launching techniques. All of the launchings were successful.

Test No.	Moby Dick Designation	Balloon	Launch Winds	Duration
18	S-29	Winzen, 45 ft., 2.5-mil	3 knots	22.5 hours
19	S-30	Winzen, 45 ft., 2.5-mil	3 knots	60 hours
20	S-31	Winzen, 61 ft., 2.5-mil	2 knots	80 hours
21	S-32	Winzen, 61 ft., 2.5-mil	3 knots	80 hours
22	S-33	Winzen, 61 ft., 2.5-mil	6 knots	78 hours
23	S-34	Winzen, 45 ft., 2.5-mil	12 knots	32 hours
24	S-35	Winzen, 45 ft., 2.5-mil	2 knots	62 hours
25	S-36	Winzen, 45 ft., 2.5-mil	0	53 hours
26	S-37	Winzen, 72.8ft., 2.5-mil	2 knots	71 hours
27	S-38	Winzen, 72.8ft., 2.5-mil	3 knots	36 hours

Test No.	Moby Dick Designation	Balloon	Launch Winds	Duration
28	S-39	Winzen, 72.8ft.,2.5-mil	5 knots	71 hours
29	S-40	Winzen, 61 ft., 2.5-mil	15 knots	60 hours
30	S-41	Winzen, 61 ft., 2.5-mil	18.5 knots	44 hours
31	S-42	Winzen, 61 ft., 2.5-mil	16.5 knots	24.5 hours
32	S-43	Winzen, 61 ft., 2.5-mil	5 knots	40 hours

In addition to these tests, 20 standard operational flights of all sorts have been made from the covered wagon, making a total of over 50 flights, up to September 1952.

Conclusions:

1. With respect to the launching wind problem, it appears that the covered wagon is satisfactory for winds up to 20 knots, with respect to the 72.8-foot diameter balloon, and probably 25 knots for the smaller balloons. There have been seven successful launchings in winds of 15 knots or more. Since the limit for a successful launching from the platform without a wind screen is about 8 knots, the covered wagon's advantage is appreciable. The 20- to 25-knot range of the vehicle should come very close to fulfilling the one-a-day aim of the project, as far as the winds are concerned. Even during the course of an extremely adverse day, when the winds might average 40 knots for the 24-hour period, it should be possible to find a lull period for launching, when the winds are down to 25 knots.

2. Because of prevailing climatic conditions, it has not yet been possible for Holloman Air Force Base to check the launching abilities of the covered wagon during precipitation. It is obvious that the top cover will protect a balloon being inflated from almost any type or intensity precipitation, and the inflated balloon can be kept under cover until conditions improve. Actually, it is not known whether a balloon can ascend safely through various types of heavy precipitation.

3. Earlier it was thought that use of the covered wagon in launching might shorten the duration of a balloon flight because of the physical contact and possible abrasion between the fragile polyethylene and the airplane cloth cover on the wagon. (Use of the launching platform may shorten flight duration also because of the heavy pressure contact between the launching arms and the balloon.) Wind buffeting and winding of the balloon bubble may also weaken the polyethylene material. The following flight durations are listed for Moby Dick flights using approximately the same control instrumentation:

Launch Platform		Covered Wagon	
9.5 plus	Hours	22.5	
15.5		24.5	
35.0		36.0	
36.0 plus		40.0 plus	
40.0		44.0 plus	
43.3		53.0	
44.0		60.0	
47.3 plus		62.0	
48.0		71.0	
62.0		71.0	
92.0		78.0 plus	
		80.0	
		80.0 plus	

This is primarily a check for small scale, gradual weakening processes, such as might be induced by contact of the polyethylene with the top cover of the wagon. The several flights which came down in a few hours, because of large scale damage, were omitted. There are other factors, however, which deter direct comparison of these columns.

a. All of the figures not labeled plus, are hours duration from take-off to impact, or from take-off to the time at which the last data from the tracking network indicated the balloon was on its way down. Those labeled plus are durations from take-off to last reported contact with the network, at which time there was no positive indication that the balloon was descending rapidly. Since, however, the proportion of pluses under each method were approximately the same (within 4 per cent), they were omitted in the statistical calculations.

b. Because most of the covered wagon flights were made during a season of the year when the upper atmospheric flow was light, the balloons had a better chance to remain over the tracking network for a longer period.

c. The balloon-borne control instrumentation used with each of these two launching methods was slightly different. This, combined with the possibility of seasonal variations in turbulence at floating altitudes, could cause significant variations in ballast performance and, consequently, in total duration.

18

d. The list under discussion contains a mixture of three different sized balloons. Any significant variation in the performance of the individual balloons would bias the launching method comparison. Following is the breakdown in durations for the various diameter balloons:

45-foot	61 foot	72.8 foot
9.5	24.5	36.0
15.5	40.0	40.0
22.5	44.0	44.0
32.0	78.0	48.0
35.0	80.0	62.0
36.0	80.0	71.0
43.3		71.0
47.3		
53.0		
60.0		
62.0		
92.0		

Mean = 42.3 hours   57.7 hours   51.7 hours
Standard deviation - 22.7 hours   24.5 hours   14.1 hours

Considering these limitations, the statistical significance of the difference between the observed means of the two columns is indicated by:

$$T = \frac{N_2 \Sigma X_1 - N_1 \Sigma X_2}{\left[(N_2 A_{11} - N_1 A_{22}) \frac{(N_1 + N_2)}{(N_1 + N_2 - 2)} \right]^{\frac{1}{2}}}$$

where T is a two tailed Student-Fischer T distribution

where $A_{xx} = N \Sigma X^2 - (\Sigma X)^2$

	N	ΣX	ΣX^2	A_{xx}
(1) Launch platform	11	472.6	25111.68	52877.72
(2) Covered wagon	13	722.0	45157.50	65763.50

4. Entering the Student T Distribution Table with T equal to 1.45 and 22 degrees of freedom, we find that the probability is .2, which means that the odds are 1 in 5 that the difference in the observed means is due to chance. The rigorous standards of classical statistics choose a significant level of 95 per cent, which would make the observed difference insignificant.

5. Because of the newness of the constant level balloon field, however, data are relatively sparse. Many previous decisions have been based on indications decidedly less obvious than this 80 per cent chance that the average duration of flights from the covered wagon is higher than those from the launch platform.

6. This 80 per cent figure, nevertheless, does not take into consideration the variables listed above. Applying the same Student Fischer T distribution to the three columns listed above, we find an 80 per cent chance that the mean duration of the 61-foot diameter balloon is greater than the mean duration of the 45-foot balloon. (None of the other relationships between the three balloons turned out to be more than 65 per cent.) Inspection of the columns comparing the two launching methods shows that the covered wagon column is comprised of three less 45-footers and two more 61-footers. With regard to factor d., therefore, the 80 per cent figure is considerably biased. The difference due to factor a., is probably small, as indicated by the 4 per cent difference. Since all the 61-footers were flown during the one season and in the covered wagon, the

significant difference between its performance and that of the 45-footer
is probably due to factors b. and c.

7. In the final analysis, therefore, we are not sure that the covered
wagon provides longer duration flights. (If the collection of more data
in the future proves this to be correct, however, it will be a pleasant
surprise for such an advantage was not originally apparent.) We are much
more sure that the covered wagon does not provide significantly shorter
duration flights than the launching platform technique. The latter con-
sideration can be verified by assuming that there is an 80 per cent chance
that the covered wagon durations are significantly less than the launch
platform performances. Now we have:

		N	ΣX	ΣX^2	A_{xx}
a.	Launch Platform	11	472.6	25111.68	52877.72
b.	Covered Wagon	13	Z	Y	$13Y-Z^2$

Assuming T equals -1.45, we get an equation with the unknowns Z and Y:

$$146Z^2 - 135163.6Z - 328Y - 39321073 = 0$$

Assuming the same standard deviation for the covered wagon, we get another
equation. $S = \left(\dfrac{X^2}{n} - X^2\right)^{1/2} = 20.5$

or $13Y-Z^2 \cong 71022$

Solving these two equations simultaneously, we obtain Z or ΣX
equal to 302.8. This represents a mean duration for the 13 flights of
23.3. Since the latter figure is less than half of the true mean (55.5 hours)

we are confident that the covered wagon does not afford flights of significantly less hours duration than the launch platform.

8. Summarizing, it appears that the covered wagon is the answer to successful balloon inflations in most adverse weather conditions. The limiting factor of 20- to 25-knots is a result of the problem which occurs after inflation, the actual releasing process. This problem may be solved by supplementary methods such as the reel device.

In general, the advantages of the covered wagon are:

a. The balloon can be inflated in very high winds.

b. The lay-out of the balloon is less complicated, and takes less time than in the launching platform technique.

c. No hold-down line is needed to keep the balloon under tension during inflation.

d. The inflated balloon can be left in the covered wagon for long periods of time, while waiting for more favorable weather conditions.

e. The inflation tube is comparatively easier to withdraw.

f. The covered wagon is a convenient vehicle for reorientating in case of wind shifts.

g. No bubble length has to be computed, as in the case of a platform launching.

h. The covered wagon is easily dismounted and adapted for transportation.

1. Less handling of the bubble is needed.

The limitations of the covered wagon are:

a. The bubble lies in a position perpendicular to the rest of the balloon. In reverting to a totally vertical position, the payload is often pulled in toward the base of the wagon.

b. The present configuration of the wagon indicates that any considerable enlargement for the purposes of containing greater gross inflations would result in a formidable structure.

c. The covered wagon at HAFB has withstood winds up to 60 mph. It is conceivable, however, that higher winds could be damaging.

d. The covered wagon, by itself, does not represent a successful take-off technique. It has only solved the inflation problem.

Recommendations:

1. Although the covered wagon is highly satisfactory, as regards ease of handling, economy, and as a solution to most balloon inflation problems, it is recommended that further techniques be evaluated.

2. The 25-knot launching wind limitation should not lessen the number of successful flights, from even the windiest Moby Dick site, by more than 10 per cent. At Holloman Air Force Base, for instance, standard Moby Dick flights were flown successfully on 12 consecutive days, including 1 day when the wind averaged 15 knots. Further need for investigating additional techniques is indicated by the possibility that future

23

Moby Dick launch sites may have surface winds considerably above average.

3. Another possibility is that a larger amount of accumulated data might indicate a direct relationship between short duration flights and high wind launchings from the covered wagon. Thus far, this is not the case, but as noted in Conclusions, the statistical sample is not yet indicative.

4. There are two high wind launch techniques upon which some work has already been done. It is recommended that these and other ideas be pursued further.

5. The first technique involves the Moby Dick reel, a device which supplements the covered wagon. All of the balloon material, except the bubble, is wound about a reeling device (See Figure 6). A modified balloon, with an extra appendix for inflation, located near the balloon equator, must be used in conjunction with this method. Winzen Research, Inc., has already supplied these side inflation balloons in the 45- and 72.8-foot diameter sizes.

6. The reel is geared and the rpm can be regulated by the weight of oil employed. By combining this device with the use of a packed parachute, the load can be set very close to the bubble, eliminating the lag which otherwise occurs between the release of the balloon and the pick-up of the package.

7. The individual advantage of the reel, therefore, is in the release of the flight. Used in conjunction with the covered wagon, balloons could

probably be launched in winds up to 35 knots.

8. The brake on the reel is not released until the flight is at least 10 feet off the ground. (If the gears were released while the reel was held to the ground, the primary advantage would be nullified.) In order to carry the reel back to earth, a 20-foot diameter balloon with a small negative free-lift is employed.

9. The reel has promise, but its primary limitations and complications are directly concerned with the use of this additional balloon.

10. If the reel were perfected and adopted, the covered wagon would no longer be the most practical inflation shelter. Mr. T.W. Kelly has suggested and built a model of a device which is designed to fit the more vertical configuration of an inflated balloon on a reel. It resembles a circus tent, rather than a covered wagon. The base is on a turntable, the most functional solution to wind shifts. The top cover has a center release. The load within the launcher is positioned at the top of an inclined plane, which runs out the side opening. This effect allows the load to become airborne more quickly, and gives the launch cart an extra momentum which is often needed in high wind launchings. Any disadvantages of this method would appear to be directly related to the disadvantages of the reel method.

11. Another method to be recommended for further thought is one that is based upon the covered wagon in its present form with very minor modifications. The procedure is simply to tow the covered wagon down wind at

a speed two to three knots greater than the prevailing wind. At this time, the inflated balloon will be released. The Electronic and Atmospheric Balloon Sonde Sub-Unit is preparing to make a test of this type very shortly. Initially, only a 30-foot diameter balloon will be used with the load sitting at the open end of the trailer. If results are promising, some sort of a small trailer will have to be added to accommodate the payload on the larger balloons. This procedure might well be the most simple method of extending the versatility of the covered wagon to cover most of the launching problems. The only limitation that can be envisioned at this time is the amount of skill involved to properly control the orientation and speed of the covered wagon. This and other problems which might be introduced will be discussed after the actual tests.

12. The ideal combination of classic launching techniques would be a steel framework tower, approximately 150-feet high, with canvassed sides and a roof. The inflation is vertical. The advantages are outstanding:

a. The inflation is ideal in a completely inclosed shelter with no surfaces contacting the balloon, as in the covered wagon. There are no external forces acting on the balloon, other than what it would be subjected to as a free vehicle (as opposed to the launching arms method).

b. No device such as a reefer is needed, a complication involved with any other type of vertical inflation.

26

c. There is no transition from an inflation position to the final vertical position. This is the classic advantage of a vertical inflation.

d. The inflation would be the most accurate possible, for in a dead calm and with the balloon in a vertical position the exact free-lift could be weighed off. Thus, the necessity for computing inflations is eliminated. This in turn eliminates the time, effort and danger of human errors involved in reading the pressure gauges and temperature, in calibrating the pressure gauges, installing the thermocouples, and performing the actual computations.

e. An additional advantage in this connection would be that the balloon could be left in an inflated position for as long as a day. Long delays after inflation have been experienced with the covered wagon, but the amount of gas lost is not accurately known, so that the success of the launching is jeopardized. In the case of the "covered tower", however, more gas is inserted, if necessary, until dummy load shot bags indicate the exact needed free-lift. It is the experience of the Electronic and Atmospheric Balloon Sonde technical staff that even very tiny holes in the balloon can be detected by checking weights on a vertical balloon for several hours. By employing this technique before launching, bad balloons could be weeded out and the chances of a three-day flight considerably enhanced.

f. The actual release would have all the advantages of a vertical release, the system which has the least complications, and subjects the balloon to less shock than any other method.

In this case, the down wind canvas is opened, and the load plus shot bags wheeled out of the tower on the Moby Dick cart. As soon as the balloon is clear of the tower, the shot bags are removed, and the release is negotiated.

13. The limitations of a "covered tower", of course, are complexity and size of structure. Since at least three sides of the tower have to be free of bracing material, the structural design problem is imposing. A tower could be built with only one side open, mounted on a turntable. The cost, however, would be considerable. A fixed structure, with only one side open to the most predominant down wind direction, would be reasonable in cost (probably $20,000 or less, according to Holloman Air Force Base engineers' estimate, based on current local materials prices). In the Tularosa Basin, for instance, the wind blows from the east less than five per cent of the time. It is not known, however, how much trouble it would be to release the balloon through the eastern opening with a good south-easterly wind blowing.

14. Another method would be to build a composite of three towers, each with one opening. Once again, the cost would be considerable. It is conceivable, however, that some clever method, such as releasing the bracing elements on any side for a short period during launching, could

28

be devised to make the relative cost and advantages of a covered tower highly desirable.

15. The "covered tower" has been described in detail because, step by step, it represents the classic launching technique. If new methods are to be considered, it is recommended that they be developed with these steps in mind.
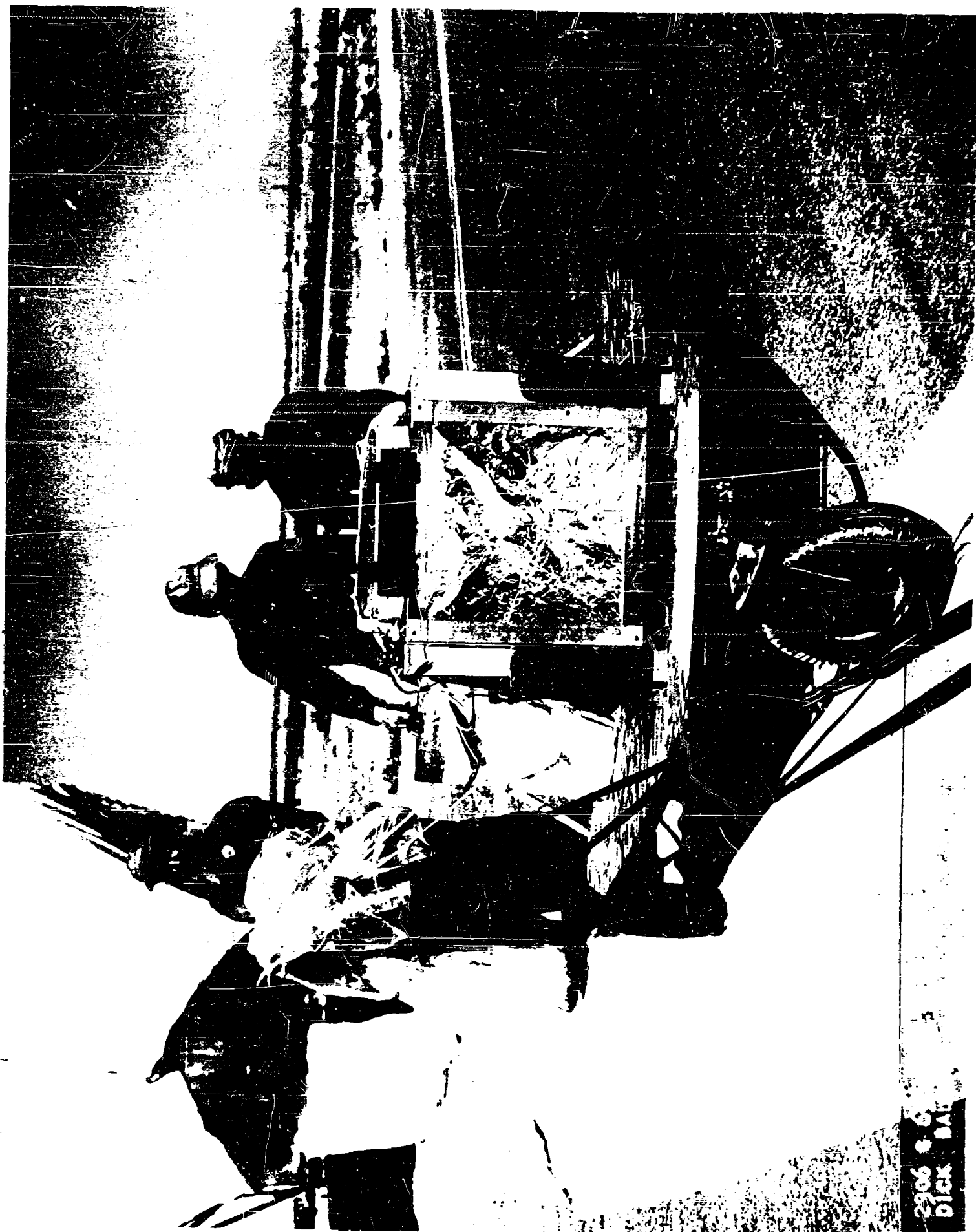
FIGURE 1

THE LAUNCH PLATFORM PLUS A SINGLE HOLD-DOWN LINE SYSTEM

FIGURE 2

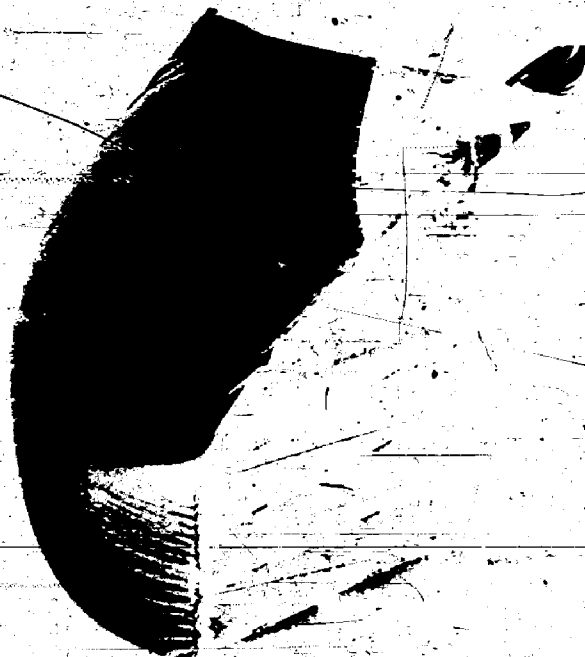MOBY DICK LAUNCHING CART

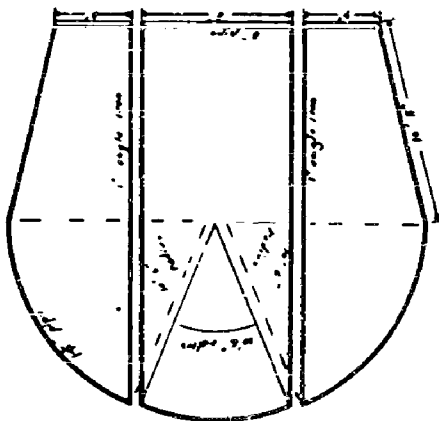FIGURE 3

COVERED WAGON MODEL NO. 1

FIGURE 4

COVERED WAGON BLUEPRINT

FIGURE 5

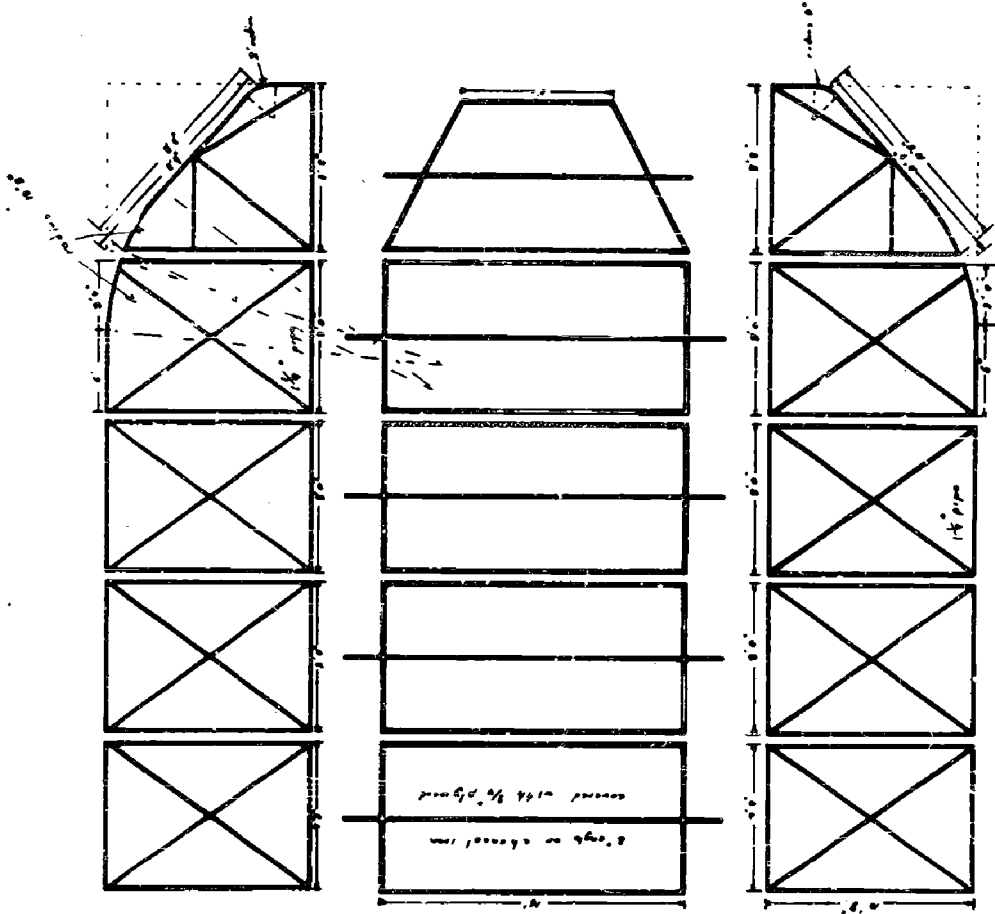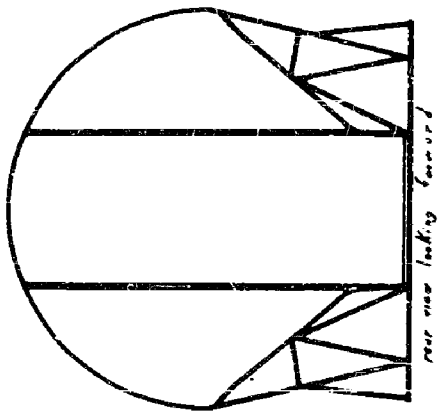COVERED WAGON MODEL NO. 2

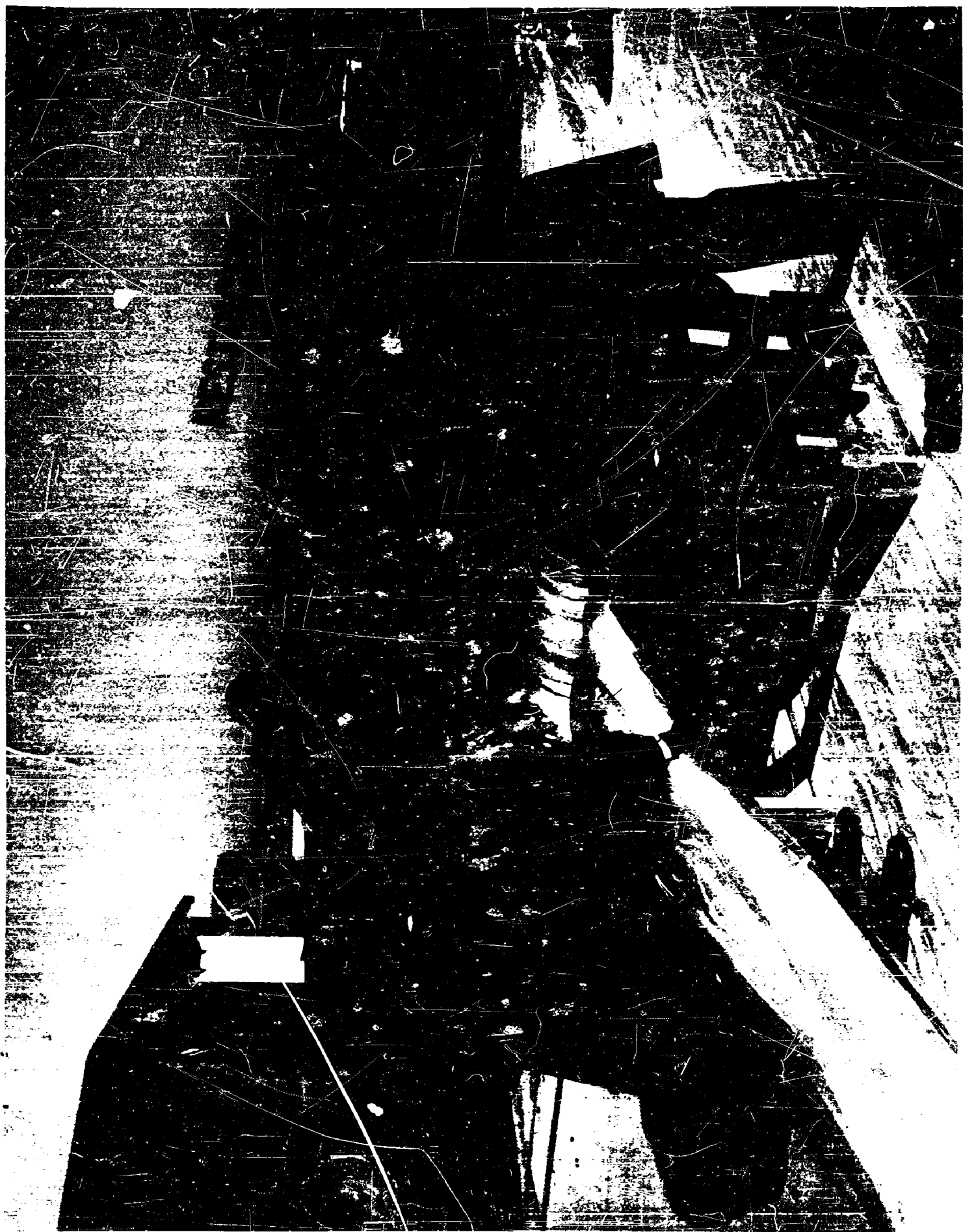FIGURE 6

RELEASE ARM

FIGURE 7

REELED BALLOON

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