MAR 1959

HANDBOOK OF LEAFLET DISPERSION VIA BALLOONS

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ED-134H BALLOON LEAFLET MANUAL
"HANDBOOK OF LEAFLET DISPERSION VIA BALLOONS"

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INTRODUCTION

This handbook describes the process of delivering leaflets to specified target areas via balloons. It covers the technical aspects of sending up balloons from different types of launching sites, the calculations which must be made to deliver the payload to its destination and dispersal in a desired pattern. A section is included which describes the characteristics of leaflet descent and dispersion. The effects of long and short range drift, and considerations of altitude and weather conditions as they apply to the various balloon delivery systems are detailed along with instrument checkout and launching instructions.

Meterology - Given detailed knowledge of the winds and air currents, controlled leaflet coverage of a target is entirely feasible by carefully selecting the balloon and leaflet load variables which are under the control of the operating personnel. Without such knowledge of the air currents, any attempt at controlled leaflet coverage is entirely in vain. For the purposes of this handbook it is assumed that adequate knowledge of the winds will be provided for use of the operating personnel whose job it is to select the appropriate balloon and leaflet characteristics to attain the desired leafleting dispersal pattern at the target destination.

A detailed discussion of meteorological problems is beyond the scope of this handbook, but there are certain basic meteorological factors which must be recognized in order to successfully launch leaflet dispensing balloons.

To begin with, a weather study of the wind pattern from the proposed launching area into the intended target area must be made. Since balloons are carried aloft and borne to destination by winds and air currents, a strong steady air stream in the correct direction is the most desirable and reliable form of transportation for predictable results. An illustration of such an ideal air stream is seen in the prevailing westerly winds generally found in the middle latitudes at heights varying from a few thousand feet above the ground to the beginning of the stratosphere.

If the weather study indicates that a favorable percentage of launching winds may be expected, then the problem of forecasting the weather arises. Here, the services of a qualified meteorologist who is familiar with the requirements of the operation are an absolute must! The meteorologist with his knowledge of local meteorological conditions, will prepare weather maps that enable him to make preliminary long range forecasts. The long range forecasts alert the operation to any approaching opportunities for launching balloons. Arrangements also should be made with as many radiosonde stations as possible to obtain their data promptly. With this information the progress of developing wind patterns can be monitored, and preliminary trajectories can be worked up.

Finally, if the weather situation develops as predicted, the winds at the launching site should be verified with a theodolite.

Three Ranges of Delivery - The technical considerations involved in delivering leaflets by balloon differ according to the distance to be traversed to reach the target. This necessitates treatment of the problems in three categories:

1. Short range leafleting operations (under 250 miles)

2. Mid range leafleting operations (250 to 600 miles)

3. Long range leafleting operations (up to 1500 miles)

It should be noted that the type of wind information needed and the amount of control attempted over the balloon and leaflets is not at all the same for each of these three different leafleting operations.

For the short range leafleting effort, a detailed study of the winds over a comparatively brief time interval is sufficient. In contrast, the problem of long range penetration requires forecasting the characteristics of general weather movement over an adequately longer span of time. In addition, the variations inherent in windflow limit the effectiveness of the controls which can be exercised to direct a leaflet balloon over long distances. The mid range effort requires weather observations over a period of time that falls somewhere in between the times for short and long range observations.

Impact and Dispersal - The "rule of thumb" for leaflet dispersion is that actual impact may vary from the predicted impact by as much as 10 percent of the distance the balloon travels. This means that for a short range target of 150 miles, the center of impact could be as much as 15 miles away from the predicted center of impact. However, this does not necessarily mean failure of the attempt because the dimensions of the leaflet pattern itself generally will be large enough to assure substantial coverage of the chosen target. It therefore follows that the efforts made to control the rise and burst of the balloon are fully warranted in short range leafleting.

Applying the same rule to mid range leafleting; a target 400 miles distant might have a center of impact as much as 40 miles away from the target area (and it also could be nearer than this to the target) so here again an effort at control is warranted.

The long range target 1000 miles distant presents quite a different problem. In this case an error of 10 percent amounts to 100 miles, thus it is impractical to attempt to leaflet any but a very general area.

The Systems - In this handbook the balloon systems for leaflet dispersion will be described with differing emphasis in accordance with each system's range capability and technical aspects.

The J-100 balloon, a short range system, will be described with intensive treatment of its performance characteristics under various conditions of load and free lift. Only brief attention will be given to the rigging and launching of this relatively simple balloon system. In connection with this J-100 system the section on "Characteristics of Leaflet Descent and Dispersion" should receive careful study since those characteristics are most important for short range leafleting and impact predictions. Also, these characteristics should be well understood for profitable application to the longer range problems.

The Pillow balloon constitutes a mid range capability (250 to 600 miles) where control of the payload can be used to select the desired floating level, but where free lift control is ineffective. The basic mechanism is somewhat more involved in this case, consequently this aspect will receive greater emphasis.

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The 170 and 180 balloons are long range systems, and no control through varying either the load or free lift will be attempted here. Instead, detailed instrument check out and launching instructions will be given for these more sophisticated systems.

Characteristics of Leaflet Descent and Dispersion

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CHARACTERISTICS OF LEAFLET DESCENT AND DISPERSION

Abstract - In order to blanket a target area with leaflets they must be released at a point in space where they will disperse and descend in a predictable pattern. To attain this objective there are two requisites:

1. A transport delivery system to the point of release.

2. A knowledge of leaflet descent and dispersion characteristics, and their calculation.

This section analyzes the behavior of leaflets when released in space and the factors which influence them in their descent to the ground. In this section there is a description of the types of motion assumed by leaflets when descending, and how the type of motion influences the rate of descent and dispersal. Wind drift at different altitude increments, and resulting ground patterns are discussed. Changing the rate of fall and dispersion of leaflets by varying the size and weight of paper is explained with a view to aid in the selection of leaflets.

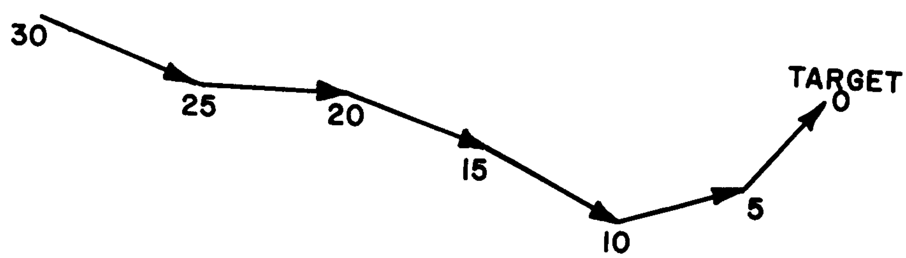
The fundamental principles of leaflet descent and dispersion discussed here include the basic mathematical equations and computations for a full understanding of their derivation. However, a full set of tables is included for ready reference to obviate the necessity of making extensive calculations in the field.

Following the tables there are a number of examples to illustrate the method of computing release points, drift, ground coverage patterns and density of coverage with coefficients of variation.

A thorough understanding of the characteristics of leaflet descent and dispersion covered in this section is a must for short range leafleting operations. It is an invaluable background for making the computations and predictions necessary to successful leafleting at any range of operation.

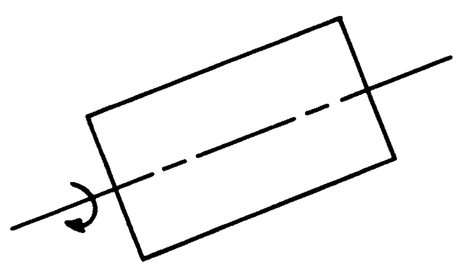
Target Coverage - Calculation of leaflet descent and dispersion patterns depends on a knowledge of wind speed and direction within each 5000-foot increment of altitude, and a knowledge of leaflet descent characteristics and rate of fall within each increment.

Given data on these factors, a horizontal leaflet pattern can be worked back in space from the target. The pattern will be a series of vectors* such as shown here. Viewpoint is from above looking towards the ground, at 5000-foot intervals.



Obviously, release of the leaflets at any point on these vectors could result in target coverage. But the important consideration here is the characteristics of the leaflets when released in free fall. What general rules of behavior do they obey; does the action of selected leaflets differ; how can their motion be computed; can ground patterns be predicted?

Basic Leaflet Descent - A basic difference between falling leaflets is the type of motion they assume during descent. This can be one of two forms: an autorotating motion or a non-autorotating motion. An autorotating leaflet is one which exhibits a very stable fall with the leaflet rotating about its longest axis.



* The term vector is applied to quantities which have both direction and magnitude. Any vector quantity may be represented by an arrow drawn in the appropriate direction and having a scaled length which depicts the numerical value of the quantity.

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The other types of fall (flip-flop, spiraling, etc.) can be grouped together for purposes of analysis. In general, these have a somewhat more rapid and less stable type of descent than the autorotators.

Empirical descent rate equations have been derived for each of these two general forms of motion:

Autorotation $$V = V_o(1-0.051H)^{-1/3} e^{0.105H^{1.4}}$$

Non-autorotation $$V = V_o(1-0.051H)^{-2/3} e^{0.0525H^2}$$

where V = descent rate at any height H (in ft/sec)
V_o = ground rate of descent (in ft/sec)
H = altitude (in feet)

Knowing the type of motion which any particular leaflet assumes and having measured its ground rate of descent (V_o), it is now possible to calculate the rate of descent (V) at any altitude (H) by simply plugging the values of V_o and H into the appropriate equation and solving. The more important use of the descent rate equation, however, is in calculating the time down. This can be obtained by performing an integration of the integral:

$$T = \int_{H_1}^{H_2} 1/V \, dH$$

The tables included in this handbook make it unnecessary for the operator to perform the integration himself; the method has been outlined to show the basic calculations.

Knowing the time spent within successive increments of altitude, and having the wind velocity and direction for these same altitude increments, it is simply a process of plotting vectors in order to determine the leaflet drift from release to impact.

One further measure of basic leaflet fall is necessary in order to determine dispersal. This is the coefficient of variation, which is the ratio of the descent time for 90% of the leaflets to the average descent time, which is designated by the symbol $R_T/\bar{T}_o$. This coefficient can be obtained at the same time the ground rate of descent (V_o) measurements are made. A high coefficient (anything above 0.50) means that there is a considerable variation in the rate at which the leaflets fall, while a low coefficient (below 0.50) means that the leaflets tend to fall much at the same rate.

Impact Pattern - Having plotted the drift vectors and knowing the variation coefficient for the particular leaflets of interest, it is now possible to calculate the size of the impact area for a single-point release.

An elliptical ground pattern results from a single-point release, the long or major axis of the ellipse being along the resultant drift vector $\vec{S}$ and the minor axis being normal to it. Not only is the major axis directed along the horizontal drift vector, but it is proportional to it also, the proportionality factor being the variation coefficient $R_T/\bar{T}_o$. The relationship of the difference of drift to the total drift from release to center of impact is:

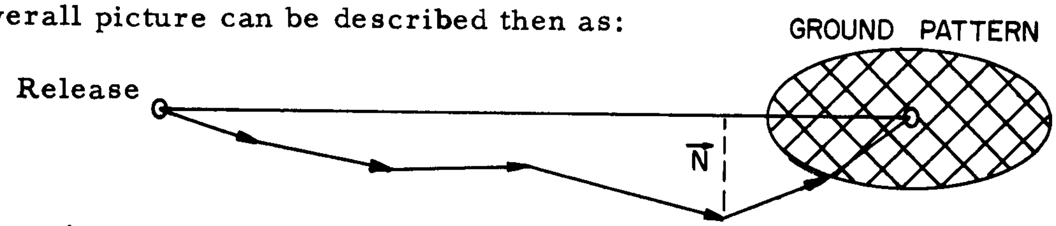
$$\Delta\vec{S} = (R_T/\bar{T}_o)\,\vec{S}$$

This constitutes the major contribution to the major axis. To this should be added one-half the release altitude for the leaflets, which is about the amount of natural dispersion for leaflets in still air. However, the latter is usually a minor factor.

The minor axis of the ellipse is the sum of the natural dispersion (one-half the release altitude) and the product of the coefficient of variation times the net maximum distance $\vec{N}$ - that the vector increments deviate in the normal from the horizontal drift vector. That is:

minor axis $= 1/2\,H + (R_T/\bar{T}_o)\,\vec{N}$

The overall picture can be described then as:



major axis $\cong \Delta\vec{S} = (R_T/\bar{T}_o)\,\vec{S}$

minor axis $= 1/2\,H + (R_T/\bar{T}_o)\,\vec{N}$

Knowing the major and minor axes of the ellipse which includes 90 percent of the leaflets released, permits calculation of the average density. The area of the ellipse is given by the formula $A=\frac{\pi}{4}ab$ where a and b are the major and minor axes. Dividing the number of leaflets released by this area figure, and multiplying the result by 0.90 (since the area includes only 90 percent of the leaflets) yields the average density. The factor 0.90 can be ignored without serious error, however, in which case the average density is simply the number of leaflets released divided by the area of the ground pattern.

To summarize, the following information is needed in order to determine the wind drift and ground pattern of any given type of leaflet.

1. A breakdown of the wind by velocity and direction for each 5000-foot increment of altitude through which the leaflet will fall.

2. The release height.

3. Class of leaflet: autorotator or non-autorotator.

4. The ground rate of descent (V_O).

5. The variation coefficient ($R_T/\overline{T}_o$).

Performance Tables - A computation form sheet plus a series of leaflet performance tables and illustrative examples follow. Adopting a standard approach to working up the leaflet descent and dispersion information will save considerable time for the operator. The technique proposed need not be followed rigorously; but, it is a useful one and is recommended until the operator develops considerable familiarity with the tables and the problem solving process.

General Leaflet Tables - The leaflet performance tables are described below. The first set of tables are General Leaflet Tables (or "G" Tables).

Table G-1 - Width and Areas of Leaflets with Different Length-Aspect Ratio Combinations.

As a convenience in presenting data on leaflets in some of the succeeding tables, leaflet sizes are identified by length and aspect

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ratio, the aspect ratio being the ratio of the length to the width. The width and area of these different length-aspect ratio combinations are presented in Table G-1. The operator can therefore readily select the size of leaflet that he would like to work with from this table and then procede to identify it by its appropriate length-aspect ratio designation for the remainder of his computations.

Table G-2 - Leaflets per Pound

In planning leaflet operations, it is necessary to know the number of leaflets per pound. The number of leaflets per pound for 40 different leaflet sizes in 4 different paper weights are listed in this table. It should be recalled that the paper weight is the weight of 2000 leaflets of 8-1/2 x 11 inch size, and that the number of leaflets per pound can be calculated from the formula:

$$\text{No. of leaflets/lb.} = \frac{2000 \times 11'' \times 8\text{-}1/2''}{\text{Paper length} \times \text{paper width} \times \text{paper weight}}$$

Table G-3 - Ground Level Descent Rates

Having selected the paper size and weight to work with, it is now necessary to establish whether the leaflet is an autorotator or non-autorotator, and its ground level rate of descent. The ground rates of descent are listed in this table with the underlined values designating those leaflets which are autorotators.

Table G-4 - Variation Coefficients ($R_T/\bar{T}_o$)

The variation coefficient which is used to calculate the leaflet dispersion is listed here for each leaflet size and weight.

Table G-5 - Ground Pattern Areas

This table is provided as a convenience in computing ground pattern areas. It is assumed that the patterns are elliptical, and, if a and b are the major and minor axes, then the area is

$$A = \frac{\pi}{4} ab$$

where π is 3.14. It is almost as easy to perform the multiplication itself as it is to refer to the tables, but they are included for convenience.

Descent Data - The following tables provide descent data on the autorotating and non-autorotating leaflets. The autorotating tables are designated as "A" Tables. The non-autorotating tables are designated as "NA" Tables.

Tables A-1 and NA-1 - Total Descent Times (hours)

Values in these tables present the total descent times for leaflets with various V_o values and release heights for each of the two classes of leaflets. They are listed for use in planning leaflet operations.

Tables A-2 and NA-2 - Time Factors (hours) for the Descent of Leaflets through 5000-foot Increments

These tables present times in hours that autorotating and non-autorotating leaflets with different ground descent rates remain within 5000-foot height intervals. The tables are most commonly utilized for computing vectorially the leaflet drift from release to impact.

Tables A-3 and NA-3 - Time Factors (hours) for the Descent of Leaflets to be Used with Standard Wind Data

Time factors in these tables are designed for direct use with wind measurements which have been transmitted in the standard form from a meteorological observing station. Plotting the horizontal drift vector using this method, as compared to that for 5000-foot increments, may be somewhat more laborious, but the individual operator can decide this.

Tables A-4 and NA-4 - Descent Rates at Different Altitudes

These values do not enter directly into any of the computations but are included as a source of information where needed in planning operations.

TABLE G-1

WIDTH AND AREAS OF LEAFLETS WITH
DIFFERENT LENGTH-ASPECT RATIO COMBINATIONS

Paper Length		Aspect Ratio 1.00	1.25	1.50	1.75	2.00	2.50	2.75	3.00	3.25	4.00
4"	Width (in.)	4.00	3.20	2.67	2.29	2.00	1.60	1.45	1.33	1.23	1.00
	Area (in.^{2})	16.00	12.80	10.70	9.20	8.00	6.40	5.80	5.30	4.90	4.00
6"	Width (in.)	6.00	4.80	4.00	3.43	3.00	2.40	2.18	2.00	1.85	1.50
	Area (in.^{2})	36.00	28.80	24.00	20.60	18.00	14.40	13.10	12.00	11.10	9.00
8½"	Width (in.)	8.50	6.39*	5.67	4.86	4.25	3.40	3.09	2.83	2.62	2.13
	Area (in.^{2})	72.30	54.30	48.20	41.30	36.10	28.90	26.30	24.10	22.30	18.10
11"	Width (in.)	11.00	8.80	7.33	6.29	5.50	4.40	4.00	3.67	3.38	2.75
	Area (in.^{2})	121.00	96.80	80.60	69.20	60.50	48.40	44.00	40.40	37.20	30.30

*Aspect Ratio = 1.33

TABLE G-2

LEAFLETS PER POUND

Paper Weight	Paper Length	Aspect Ratio (Ratio of Length to Width) 1.00	1.25	1.50	1.75	2.00	2.50	2.75	3.00	3.25	4.00
9 lb	4"	1299	1623	1948	2273	2597	3247	3571	3896	4220	5194
	6"	577	721	866	1010	1154	1443	1587	1731	1876	2309
	8½"	288	382*	431	503	575	719	791	863	935	1150
	11"	172	215	258	301	343	429	472	515	558	687
13 lb	4"	899	1124	1349	1573	1798	2248	2472	2697	2922	3596
	6"	400	499	599	699	799	999	1099	1199	1299	1598
	8½"	199	265*	299	348	398	498	548	597	647	796
	11"	119	149	178	208	238	297	327	357	386	476
16 lb	4"	730	913	1096	1278	1461	1826	2009	2191	2374	2922
	6"	325	406	487	568	649	812	893	974	1055	1299
	8½"	162	215*	243	283	324	404	445	485	526	647
	11"	97	121	145	169	193	241	266	290	314	386
20 lb	4"	584	730	877	1023	1169	1461	1607	1753	1899	2338
	6"	260	325	390	455	519	649	714	779	844	1039
	8½"	129	172*	194	226	259	324	356	388	421	518
	11"	77	97	116	135	155	193	212	232	251	309

*Aspect Ratio of 1.33

TABLE G-3

GROUND LEVEL DESCENT RATES
(V_o, ft/sec)

Paper Weight	Paper Length	Aspect Ratio (Ratio of Length to Width) 1.00	1.25	1.50	1.75	2.00	2.50	2.75	3.00	3.25	4.00
9 lb	4"	2.0	2.2	2.2	2.2	2.1	1.3**	1.0	1.3	1.3	1.3
	6"	2.4	2.2	2.3	2.6	3.1	2.5	2.6	2.3	2.2	1.8
	8½"	2.9	2.1*	2.2	2.4	2.7	3.0	3.0	2.0	2.9	1.7
	11"	2.5	2.6	2.6	2.5	2.9	2.8	2.8	2.8	2.6	2.5
13 lb	4"	2.2	2.4	2.6	2.6	1.8	1.3	1.3	1.3	1.5	1.6
	6"	2.3	2.4	2.7	2.9	3.6	2.4	1.5	1.3	1.5	1.5
	8½"	2.5	2.2*	3.0	2.8	3.4	3.4	3.2	2.3	2.9	2.0
	11"	3.1	2.6	2.8	2.7	3.0	3.5	3.6	3.0	2.9	2.1
16 lb	4"	2.4	2.6	2.8	2.3	1.5	1.4	1.5	1.5	1.6	1.9
	6"	2.7	2.8	3.3	4.5	4.7	1.4	1.4	1.6	1.9	2.1
	8½"	2.7	2.6*	3.2	3.4	3.8	4.4	3.6	1.8	2.2	1.8
	11"	3.3	2.8	3.0	2.7	4.5	4.1	3.9	4.0	2.9	1.7
20 lb	4"	2.6	3.0	3.1	2.1	1.7	1.7	1.7	1.7	1.6	2.1
	6"	2.7	3.0	4.0	4.7	2.5	1.5	1.6	1.7	1.8	2.1
	8½"	2.8	2.8*	4.0	3.7	5.2	4.0	1.9	2.2	2.2	2.2
	11"	2.9	3.2	3.3	3.7	5.0	5.8	5.9	3.5	2.0	1.8

*Aspect Ratio = 1.33

** Underlined figures indicate autorotators

TABLE G-4

VARIATION COEFFICIENTS ($R_T/\bar{T}_o$)

Paper Weight	Paper Length	Aspect Ratio (Ratio of Length to Width) 1.00	1.25	1.50	1.75	2.00	2.50	2.75	3.00	3.25	4.00
9 lb	4"	.31	.18	.30	.14	.13	.56	.45	.33	.24	.18
	6"	.33	.56	.26	.51	.48	.34	.49	.67	.56	.30
	8½"	.24	.22	.42	.37	.20	.16	.15	.34	.24	.80
	11"	.37	.32	.25	.16	.18	.21	.12	.12	.19	.18
13 lb	4"	.12	.12	.13	.14	.27	.16	.34	.25	.34	.50
	6"	.44	.23	.37	.55	.89	.87	.52	.59	.27	.09
	8½"	.31	.24	.31	.26	.25	.36	.27	.36	.60	.36
	11"	.36	.22	.24	.40	.34	.26	.19	.33	.34	.56
16 lb	4"	.20	.11	.20	.32	.05	.23	.42	.23	.28	.63
	6"	.32	.20	.63	.95	1.04	.28	.26	.36	.24	.17
	8½"	.26	.30	.27	.69	.68	.69	.65	.91	.50	.30
	11"	.31	.21	.29	.23	.20	.30	.25	.46	.18	.49
20 lb	4"	.19	.16	.16	.52	.05	.05	.07	.12	.65	.59
	6"	.26	.13	.46	1.00	1.11	.23	.21	.22	.30	.22
	8½"	.35	.15	.58	.63	.71	1.01	.42	.23	.27	.40
	11"	.24	.23	.42	.78	.58	.61	.62	.78	.57	.41

TABLE G-5

TABLE OF GROUND PATTERN AREAS (ELLIPSES)

Major Axis (mi)	Minor Axis (mi)								
	4	6	8	10	12	14	16	18	20
5	16	24	31	39	47	55	63	71	79
10	31	47	63	79	94	110	126	141	157
15	47	71	94	118	141	165	188	212	236
20	63	94	126	157	188	220	251	283	314
25	79	118	157	196	236	275	314	353	393
30	94	141	188	236	283	330	377	424	471
35	110	165	220	275	330	385	440	495	550
40	126	188	251	314	377	440	503	565	628
45	141	212	283	353	424	495	565	636	707
50	157	236	314	393	471	549	628	707	785
55	173	259	346	432	518	605	691	778	864
60	188	283	377	471	565	660	754	848	943
65	204	306	408	511	613	715	817	919	1021
70	220	330	440	550	660	770	880	990	1100
75	236	353	471	589	707	825	943	1060	1178
80	251	377	503	628	754	880	1005	1131	1257

TABLE A-1

TOTAL DESCENT TIMES (HOURS) - AUTOROTATORS

Ground Descent Rate (ft/sec)	Altitude Interval (thsds of ft)				
	10	20	30	40	50
1.0	2.64	4.89	6.71	8.13	9.21
1.1	2.40	4.44	6.09	7.38	8.36
1.2	2.19	4.06	5.57	6.75	7.65
1.3	2.03	3.76	5.16	6.25	7.07
1.4	1.88	3.48	4.78	5.79	6.56
1.5	1.76	3.25	4.46	5.40	6.12
1.6	1.65	3.06	4.20	5.08	5.75
1.7	1.55	2.87	3.94	4.78	5.41
1.8	1.47	2.71	3.72	4.51	5.11
1.9	1.39	2.57	3.53	4.28	4.84
2.0	1.32	2.44	3.35	4.06	4.60
2.1	1.26	2.33	3.20	3.88	4.40
2.2	1.20	2.22	3.05	3.69	4.18
2.3	1.15	2.13	2.92	3.54	4.01
2.4	1.10	2.04	2.80	3.40	3.85
2.5	1.05	1.95	2.67	3.24	3.67
2.6	1.01	1.87	2.57	3.12	3.53
2.7	0.97	1.81	2.49	3.02	3.42
2.8	0.95	1.75	2.40	2.91	3.30
2.9	0.91	1.69	2.32	2.81	3.18
3.0	0.88	1.63	2.24	2.71	3.07

TABLE A-1 (Cont'd)

TOTAL DESCENT TIMES (HOURS) - AUTOROTATORS

Ground Descent Rate (ft/sec)	Altitude Interval (thsds of ft)				
	10	20	30	40	50
3.1	0.85	1.58	2.17	2.62	2.97
3.2	0.83	1.53	2.10	2.55	2.89
3.3	0.80	1.48	2.03	2.46	2.79
3.4	0.78	1.44	1.97	2.39	2.71
3.5	0.75	1.40	1.91	2.32	2.63

TABLE A-2

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS THROUGH 5,000 FT INCREMENTS - AUTOROTATORS

Ground Descent Rate (ft/sec)	Altitude Interval (thsds of ft)									
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
1.0	1.36	1.28	1.18	1.07	0.96	0.86	0.76	0.66	0.58	0.50
1.1	1.24	1.16	1.07	0.97	0.87	0.78	0.69	0.60	0.53	0.45
1.2	1.13	1.06	0.98	0.89	0.80	0.71	0.63	0.55	0.48	0.42
1.3	1.05	0.98	0.91	0.82	0.74	0.66	0.58	0.51	0.44	0.38
1.4	0.97	0.91	0.84	0.76	0.69	0.61	0.54	0.47	0.41	0.36
1.5	0.91	0.85	0.78	0.71	0.64	0.57	0.50	0.44	0.39	0.33
1.6	0.85	0.80	0.74	0.67	0.60	0.54	0.47	0.41	0.36	0.31
1.7	0.80	0.75	0.69	0.63	0.57	0.50	0.45	0.39	0.34	0.29
1.8	0.76	0.71	0.65	0.59	0.53	0.48	0.42	0.37	0.32	0.28
1.9	0.72	0.67	0.62	0.56	0.51	0.45	0.40	0.35	0.30	0.26
2.0	0.68	0.64	0.59	0.53	0.48	0.43	0.38	0.33	0.29	0.25
2.1	0.65	0.61	0.56	0.51	0.46	0.41	0.36	0.32	0.28	0.24
2.2	0.62	0.58	0.53	0.49	0.44	0.39	0.34	0.30	0.26	0.23
2.3	0.59	0.56	0.51	0.47	0.42	0.37	0.33	0.29	0.25	0.22
2.4	0.57	0.53	0.49	0.45	0.40	0.36	0.32	0.28	0.24	0.21
2.5	0.54	0.51	0.47	0.43	0.38	0.34	0.30	0.27	0.23	0.20
2.6	0.52	0.49	0.45	0.41	0.37	0.33	0.29	0.26	0.22	0.19
2.7	0.50	0.47	0.44	0.40	0.36	0.32	0.28	0.25	0.21	0.19
2.8	0.49	0.46	0.42	0.38	0.34	0.31	0.27	0.24	0.21	0.18
2.9	0.47	0.44	0.41	0.37	0.33	0.30	0.26	0.23	0.20	0.17
3.0	0.45	0.43	0.39	0.36	0.32	0.29	0.25	0.22	0.19	0.17

TABLE A-2 (Cont'd)

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS THROUGH 5,000 FT INCREMENTS - AUTOROTATORS

Ground Descent Rates (ft/sec)	Altitude Interval (thsds of ft) 0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
3.1	0.44	0.41	0.38	0.35	0.31	0.28	0.24	0.21	0.19	0.16
3.2	0.43	0.40	0.37	0.33	0.30	0.27	0.24	0.21	0.18	0.16
3.3	0.41	0.39	0.36	0.32	0.29	0.26	0.23	0.20	0.18	0.15
3.4	0.40	0.38	0.35	0.31	0.28	0.25	0.22	0.20	0.17	0.15
3.5	0.39	0.36	0.34	0.31	0.27	0.24	0.22	0.19	0.17	0.14

TABLE A-3

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS
TO BE USED WITH STANDARD WIND DATA - AUTOROTATING

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 0	1	2	3	4	5	6	7	8	9	10	12
1.0	.14	.28	.27	.27	.27	.27	.26	.26	.25	.25	.37	.48
1.1	.13	.25	.25	.25	.24	.24	.24	.23	.23	.23	.33	.43
1.2	.12	.23	.23	.23	.22	.22	.22	.21	.21	.21	.30	.40
1.3	.11	.21	.21	.21	.21	.20	.20	.20	.20	.19	.28	.37
1.4	.10	.20	.20	.19	.19	.19	.19	.18	.18	.18	.26	.34
1.5	.09	.18	.18	.18	.18	.18	.17	.17	.17	.17	.24	.32
1.6	.09	.17	.17	.17	.17	.17	.16	.16	.16	.16	.23	.30
1.7	.08	.16	.16	.16	.16	.16	.15	.15	.15	.15	.21	.28
1.8	.08	.15	.15	.15	.15	.15	.15	.14	.14	.14	.20	.26

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 14	16	18	20	23	25	30	35	40	45	50
1.0	.46	.44	.42	.51	.48	.63	.81	.71	.62	.54	.24
1.1	.42	.40	.39	.46	.43	.57	.73	.64	.56	.49	.22
1.2	.38	.37	.35	.42	.40	.52	.67	.59	.52	.45	.20
1.3	.35	.34	.33	.39	.37	.48	.62	.55	.48	.41	.18
1.4	.33	.32	.30	.36	.34	.45	.58	.51	.44	.38	.17
1.5	.31	.29	.28	.34	.32	.42	.54	.47	.41	.36	.16
1.6	.29	.28	.27	.32	.30	.40	.50	.44	.39	.34	.15
1.7	.27	.26	.25	.30	.28	.37	.47	.42	.36	.32	.14
1.8	.25	.25	.24	.28	.27	.35	.45	.39	.34	.30	.13

TABLE A-3 (Cont'd)

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS
TO BE USED WITH STANDARD WIND DATA - AUTOROTATING

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 0	1	2	3	4	5	6	7	8	9	10	12
1.9	.07	.15	.14	.14	.14	.14	.14	.14	.13	.13	.19	.25
2.0	.07	.14	.14	.14	.13	.13	.13	.13	.13	.13	.18	.24
2.1	.07	.13	.13	.13	.13	.13	.12	.12	.12	.12	.17	.23
2.2	.06	.13	.12	.12	.12	.12	.12	.12	.12	.11	.17	.22
2.3	.06	.12	.12	.12	.12	.12	.11	.11	.11	.11	.16	.21
2.4	.06	.12	.11	.11	.11	.11	.11	.11	.11	.10	.15	.20
2.5	.06	.11	.11	.11	.11	.11	.10	.10	.10	.10	.15	.19
2.6	.05	.11	.11	.10	.10	.10	.10	.10	.10	.10	.14	.18
2.7	.05	.10	.10	.10	.10	.10	.10	.10	.09	.09	.14	.18

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 14	16	18	20	23	25	30	35	40	45	50
1.9	.24	.23	.22	.27	.25	.33	.42	.37	.33	.28	.13
2.0	.23	.22	.21	.25	.24	.31	.40	.35	.31	.27	.12
2.1	.22	.21	.20	.24	.23	.30	.38	.34	.30	.26	.11
2.2	.21	.20	.19	.23	.22	.28	.37	.32	.28	.24	.11
2.3	.20	.19	.18	.22	.21	.27	.35	.31	.27	.23	.10
2.4	.19	.18	.18	.21	.20	.26	.34	.30	.26	.22	.10
2.5	.18	.18	.17	.20	.19	.25	.32	.28	.25	.22	.10
2.6	.18	.17	.16	.19	.18	.24	.31	.27	.24	.21	.09
2.7	.17	.16	.16	.19	.18	.23	.30	.26	.23	.20	.09

TABLE A-3 (Cont'd)

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS
TO BE USED WITH STANDARD WIND DATA - AUTOROTATING

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 0	1	2	3	4	5	6	7	8	9	10	12
2.7	.05	.10	.10	.10	.10	.10	.10	.10	.09	.09	.14	.18
2.8	.05	.10	.10	.10	.10	.09	.09	.09	.09	.09	.13	.17
2.9	.05	.10	.09	.09	.09	.09	.09	.09	.09	.09	.13	.16
3.0	.05	.09	.09	.09	.09	.09	.09	.09	.08	.08	.12	.16
3.1	.04	.09	.09	.09	.09	.09	.08	.08	.08	.08	.12	.15
3.2	.04	.09	.09	.08	.08	.08	.08	.08	.08	.08	.11	.15
3.3	.04	.08	.08	.08	.08	.08	.08	.08	.08	.08	.11	.14
3.4	.04	.08	.08	.08	.08	.08	.08	.08	.07	.07	.11	.14
3.5	.04	.08	.08	.08	.08	.08	.07	.07	.07	.07	.10	.14

Ground Descent Rate (ft/sec)	14	16	18	20	23	25	30	35	40	45	50
2.7	.17	.16	.16	.19	.18	.23	.30	.26	.23	.20	.09
2.8	.16	.16	.15	.18	.17	.22	.29	.25	.22	.19	.09
2.9	.16	.15	.15	.17	.16	.22	.28	.24	.21	.19	.08
3.0	.15	.15	.14	.17	.16	.21	.27	.24	.21	.18	.08
3.1	.15	.14	.14	.16	.15	.20	.26	.23	.20	.17	.08
3.2	.14	.14	.13	.16	.15	.20	.25	.22	.19	.17	.08
3.3	.14	.13	.13	.15	.14	.19	.24	.21	.19	.16	.07
3.4	.13	.13	.12	.15	.14	.18	.24	.21	.18	.16	.07
3.5	.13	.13	.12	.14	.14	.18	.23	.20	.18	.15	.07

TABLE A-4

DESCENT RATES AT DIFFERENT ALTITUDES
FOR AUTOROTATING TYPE LEAFLETS
(ft/sec)

Ground Descent Rate (ft/sec)	Altitude (thsds of ft)									
	5	10	15	20	25	30	35	40	45	50
1.0	1.0	1.1	1.2	1.4	1.5	1.7	2.0	2.2	2.6	3.0
1.1	1.2	1.2	1.4	1.5	1.7	1.9	2.2	2.5	2.8	3.3
1.2	1.3	1.4	1.5	1.6	1.8	2.1	2.4	2.7	3.1	3.6
1.3	1.4	1.5	1.6	1.8	2.0	2.2	2.5	2.9	3.4	3.9
1.4	1.5	1.6	1.7	1.9	2.1	2.4	2.7	3.1	3.6	4.2
1.5	1.6	1.7	1.9	2.1	2.3	2.6	2.9	3.4	3.9	4.5
1.6	1.7	1.8	2.0	2.2	2.4	2.8	3.1	3.6	4.1	4.8
1.7	1.8	1.9	2.1	2.3	2.6	2.9	3.3	3.8	4.4	5.1
1.8	1.9	2.0	2.2	2.5	2.8	3.1	3.5	4.0	4.7	5.4
1.9	2.0	2.1	2.3	2.6	2.9	3.3	3.7	4.3	4.9	5.7
2.0	2.1	2.3	2.5	2.7	3.1	3.4	3.9	4.5	5.2	6.0
2.1	2.2	2.4	2.6	2.9	3.2	3.6	4.1	4.7	5.4	6.3
2.2	2.3	2.5	2.7	3.0	3.4	3.8	4.3	4.9	5.7	6.6
2.3	2.4	2.6	2.8	3.1	3.5	4.0	4.5	5.2	5.9	6.9
2.4	2.5	2.7	3.0	3.3	3.7	4.1	4.7	5.4	6.2	7.2
2.5	2.6	2.8	3.1	3.4	3.8	4.3	4.9	5.6	6.5	7.5
2.6	2.7	2.9	3.2	3.6	4.0	4.5	5.1	5.8	6.7	7.8
2.7	2.8	3.1	3.3	3.7	4.1	4.7	5.3	6.1	7.0	8.1
2.8	2.9	3.2	3.5	3.8	4.3	4.8	5.5	6.3	7.2	8.4
2.9	3.0	3.3	3.6	4.0	4.4	5.0	5.7	6.5	7.5	8.7

TABLE A-4 (Cont'd)

DESCENT RATES AT DIFFERENT ALTITUDES
FOR AUTOROTATING TYPE LEAFLETS
(ft/sec)

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 5	10	15	20	25	30	35	40	45	50
3.0	3.1	3.4	3.7	4.1	4.6	5.2	5.9	6.7	7.8	9.0
3.1	3.3	3.5	3.8	4.2	4.7	5.3	6.1	6.9	8.0	9.3
3.2	3.4	3.6	4.0	4.4	4.9	5.5	6.3	7.2	8.3	9.6
3.3	3.5	3.7	4.1	4.5	5.0	5.7	6.5	7.4	8.5	9.9
3.4	3.6	3.8	4.2	4.6	5.2	5.9	6.7	7.6	8.8	10.2
3.5	3.7	4.0	4.3	4.8	5.3	6.0	6.9	7.8	9.0	10.5

TABLE NA-1

TOTAL DESCENT TIMES (HOURS) - NON-AUTOROTATORS

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 10	20	30	40	50
2.0	1.35	2.52	3.43	4.07	4.48
2.1	1.27	2.38	3.25	3.86	4.25
2.2	1.22	2.28	3.11	3.69	4.06
2.3	1.17	2.18	2.98	3.54	3.89
2.4	1.12	2.09	2.85	3.38	3.72
2.5	1.07	2.00	2.73	3.24	3.56
2.6	1.03	1.93	2.63	3.12	3.44
2.7	1.00	1.86	2.53	3.00	3.30
2.8	0.96	1.80	2.45	2.91	3.20
2.9	0.92	1.72	2.35	2.79	3.07
3.0	0.90	1.68	2.29	2.72	2.99
3.1	0.86	1.61	2.20	2.62	2.88
3.2	0.84	1.57	2.14	2.54	2.79
3.3	0.82	1.53	2.09	2.47	2.72
3.4	0.79	1.48	2.02	2.40	2.63
3.5	0.76	1.43	1.95	2.31	2.54
3.6	0.74	1.39	1.89	2.25	2.48
3.7	0.72	1.35	1.85	2.20	2.42
3.8	0.71	1.32	1.80	2.14	2.35
3.9	0.69	1.28	1.75	2.08	2.29
4.0	0.67	1.26	1.72	2.04	2.24

TABLE NA-1 (Cont'd)

TOTAL DESCENT TIMES (HOURS) - NON-AUTOROTATORS

Ground Descent Rate (ft/sec)	Altitude (thsds of ft)				
	10	20	30	40	50
4.1	0.65	1.22	1.67	1.98	2.18
4.2	0.64	1.19	1.62	1.93	2.12
4.3	0.63	1.17	1.60	1.89	2.08
4.4	0.61	1.14	1.55	1.84	2.02
4.5	0.59	1.11	1.52	1.81	1.99
4.6	0.59	1.10	1.49	1.77	1.95
4.7	0.57	1.07	1.46	1.73	1.91
4.8	0.56	1.04	1.42	1.69	1.86
4.9	0.55	1.03	1.40	1.66	1.82
5.0	0.53	0.99	1.36	1.62	1.78

TABLE NA-2

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS THROUGH 5,000-FT INCREMENTS - NON-AUTOROTATORS

Ground Descent Rate (ft/sec)	Altitude Interval (thsds of ft)									
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
1.0	1.37	1.31	1.22	1.11	0.98	0.84	0.71	0.58	0.46	0.35
2.0	0.69	0.66	0.61	0.56	0.49	0.42	0.35	0.29	0.23	0.18
2.1	0.65	0.62	0.58	0.53	0.47	0.40	0.34	0.27	0.22	0.17
2.2	0.62	0.60	0.56	0.50	0.45	0.38	0.32	0.26	0.21	0.16
2.3	0.60	0.57	0.53	0.48	0.43	0.37	0.31	0.25	0.20	0.15
2.4	0.57	0.55	0.51	0.46	0.41	0.35	0.29	0.24	0.19	0.15
2.5	0.55	0.52	0.49	0.44	0.39	0.34	0.28	0.23	0.18	0.14
2.6	0.53	0.50	0.47	0.43	0.38	0.32	0.27	0.22	0.18	0.14
2.7	0.51	0.49	0.45	0.41	0.36	0.31	0.26	0.21	0.17	0.13
2.8	0.49	0.47	0.44	0.40	0.35	0.30	0.25	0.21	0.16	0.13
2.9	0.47	0.45	0.42	0.38	0.34	0.29	0.24	0.20	0.16	0.12
3.0	0.46	0.44	0.41	0.37	0.33	0.28	0.24	0.19	0.15	0.12
3.1	0.44	0.42	0.39	0.36	0.32	0.27	0.23	0.19	0.15	0.11
3.2	0.43	0.41	0.38	0.35	0.31	0.26	0.22	0.18	0.14	0.11
3.3	0.42	0.40	0.37	0.34	0.30	0.26	0.25	0.17	0.14	0.11
3.4	0.40	0.39	0.36	0.33	0.29	0.25	0.21	0.17	0.13	0.10
3.5	0.39	0.37	0.35	0.32	0.28	0.24	0.20	0.16	0.13	0.10
3.6	0.38	0.36	0.34	0.31	0.27	0.23	0.20	0.16	0.13	0.10
3.7	0.37	0.35	0.33	0.30	0.27	0.23	0.19	0.16	0.12	0.10
3.8	0.36	0.35	0.32	0.29	0.26	0.22	0.19	0.15	0.12	0.09
3.9	0.35	0.34	0.31	0.28	0.25	0.22	0.18	0.15	0.12	0.09

TABLE NA-2 (Cont'd)

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS
THROUGH 5,000-FT INCREMENTS - NON-AUTOROTATORS

Ground Descent Rate (ft/sec)	Altitude Interval (thsds of ft) 0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
4.0	0.34	0.33	0.31	0.28	0.25	0.21	0.18	0.14	0.11	0.09
4.1	0.33	0.32	0.30	0.27	0.24	0.21	0.17	0.14	0.11	0.09
4.2	0.33	0.31	0.29	0.26	0.23	0.20	0.17	0.14	0.11	0.08
4.3	0.32	0.31	0.28	0.26	0.23	0.20	0.16	0.13	0.11	0.08
4.4	0.31	0.30	0.28	0.25	0.22	0.19	0.16	0.13	0.10	0.08
4.5	0.30	0.29	0.27	0.25	0.22	0.19	0.16	0.13	0.10	0.08
4.6	0.30	0.29	0.27	0.24	0.21	0.18	0.15	0.13	0.10	0.08
4.7	0.29	0.28	0.26	0.24	0.21	0.18	0.15	0.12	0.10	0.08
4.8	0.29	0.27	0.25	0.23	0.20	0.18	0.15	0.12	0.10	0.07
4.9	0.28	0.27	0.25	0.23	0.20	0.17	0.14	0.12	0.09	0.07
5.0	0.27	0.26	0.24	0.22	0.20	0.17	0.14	0.12	0.09	0.07

TABLE NA-3

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS
TO BE USED WITH STANDARD WIND DATA - NON-AUTOROTATING

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 0	1	2	3	4	5	6	7	8	9	10	12
1.0	.10	.28	.28	.27	.27	.27	.27	.26	.26	.26	.38	.49
2.0	.05	.14	.14	.14	.14	.13	.13	.13	.13	.13	.19	.25
2.1	.05	.13	.13	.13	.13	.13	.13	.13	.12	.12	.18	.24
2.2	.04	.13	.12	.12	.12	.12	.12	.12	.12	.12	.17	.22
2.3	.04	.12	.12	.12	.12	.12	.12	.11	.11	.11	.17	.21
2.4	.04	.12	.11	.11	.11	.11	.11	.11	.11	.11	.16	.21
2.5	.04	.11	.11	.11	.11	.11	.11	.11	.10	.10	.15	.20
2.6	.04	.11	.11	.11	.10	.10	.10	.10	.10	.10	.15	.19
2.7	.04	.10	.10	.10	.10	.10	.10	.10	.10	.10	.14	.18

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 14	16	18	20	23	25	30	35	40	45	50
1.0	.48	.46	.44	.52	.49	.63	.78	.64	.52	.42	.16
2.0	.24	.23	.22	.26	.24	.31	.39	.32	.26	.21	.08
2.1	.23	.22	.21	.25	.23	.30	.37	.31	.25	.20	.08
2.2	.22	.21	.20	.24	.22	.28	.35	.29	.23	.19	.07
2.3	.21	.20	.19	.23	.21	.27	.34	.28	.22	.18	.07
2.4	.20	.19	.18	.22	.20	.26	.32	.27	.22	.18	.07
2.5	.19	.18	.18	.21	.19	.25	.31	.26	.21	.17	.07
2.6	.18	.18	.17	.20	.19	.24	.30	.25	.20	.16	.06
2.7	.18	.17	.16	.19	.18	.23	.29	.24	.19	.16	.06

TABLE NA-3 (Cont'd)

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS
TO BE USED WITH STANDARD WIND DATA - NON-AUTOROTATING

Ground Descent Rate (ft/sec)	Altitude (thsds of ft)											
	0	1	2	3	4	5	6	7	8	9	10	12
2.8	.03	.10	.10	.10	.10	.10	.10	.09	.09	.09	.14	.18
2.9	.03	.10	.09	.09	.09	.09	.09	.09	.09	.09	.13	.17
3.0	.03	.09	.09	.09	.09	.09	.09	.09	.09	.09	.13	.16
3.1	.03	.09	.09	.09	.09	.09	.09	.09	.08	.08	.12	.16
3.2	.03	.09	.09	.09	.09	.08	.08	.08	.08	.08	.12	.15
3.3	.03	.08	.08	.08	.08	.08	.08	.08	.08	.08	.12	.15
3.4	.03	.08	.08	.08	.08	.08	.08	.08	.08	.08	.11	.15
3.5	.03	.08	.08	.08	.08	.08	.08	.08	.07	.07	.11	.14
3.6	.03	.08	.08	.08	.08	.07	.07	.07	.07	.07	.11	.14

Ground Descent Rate (ft/sec)	Altitude (thsds of ft)										
	14	16	18	20	23	25	30	35	40	45	50
2.8	.17	.16	.16	.19	.17	.22	.28	.23	.18	.15	.06
2.9	.16	.16	.15	.18	.17	.22	.27	.22	.18	.15	.06
3.0	.16	.15	.15	.17	.16	.21	.26	.21	.17	.14	.05
3.1	.15	.15	.14	.17	.16	.20	.25	.21	.17	.14	.05
3.2	.15	.14	.14	.16	.15	.20	.24	.20	.16	.13	.05
3.3	.14	.14	.13	.16	.15	.19	.24	.19	.16	.13	.05
3.4	.14	.13	.13	.15	.14	.18	.23	.19	.15	.12	.05
3.5	.14	.13	.13	.15	.14	.18	.22	.18	.15	.12	.05
3.6	.13	.13	.12	.14	.14	.17	.22	.18	.14	.12	.05

TABLE NA-3 (Cont'd)

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS
TO BE USED WITH STANDARD WIND DATA - NON-AUTOROTATING

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 0	1	2	3	4	5	6	7	8	9	10	12
3.7	.03	.07	.07	.07	.07	.07	.07	.07	.07	.07	.10	.13
3.8	.03	.07	.07	.07	.07	.07	.07	.07	.07	.07	.10	.13
3.9	.02	.07	.07	.07	.07	.07	.07	.07	.07	.07	.10	.13
4.0	.02	.07	.07	.07	.07	.07	.07	.07	.07	.06	.10	.12
4.1	.02	.07	.07	.07	.07	.07	.07	.06	.06	.06	.09	.12
4.2	.02	.07	.07	.07	.06	.06	.06	.06	.06	.06	.09	.12
4.3	.02	.06	.06	.06	.06	.06	.06	.06	.06	.06	.09	.11
4.4	.02	.06	.06	.06	.06	.06	.06	.06	.06	.06	.09	.11
4.5	.02	.06	.06	.06	.06	.06	.06	.06	.06	.06	.08	.11

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 14	16	18	20	23	25	30	35	40	45	50
3.7	.13	.13	.12	.14	.13	.17	.21	.17	.14	.11	.04
3.8	.13	.12	.12	.14	.13	.16	.20	.17	.14	.11	.04
3.9	.12	.12	.11	.13	.12	.16	.20	.16	.13	.11	.04
4.0	.12	.11	.11	.13	.12	.16	.19	.16	.13	.11	.04
4.1	.12	.11	.11	.13	.12	.15	.19	.16	.13	.10	.04
4.2	.11	.11	.10	.12	.12	.15	.18	.15	.12	.10	.04
4.3	.11	.11	.10	.12	.11	.15	.18	.15	.12	.10	.04
4.4	.11	.10	.10	.12	.11	.14	.18	.15	.12	.10	.04
4.5	.11	.10	.10	.12	.11	.14	.17	.14	.11	.09	.04

TABLE NA-3 (Cont'd)

TIME FACTORS (HOURS) FOR THE DESCENT OF LEAFLETS
TO BE USED WITH STANDARD WIND DATA - NON-AUTOROTATING

Ground Descent Rate (ft/sec)	Altitude (thsds of ft)											
	0	1	2	3	4	5	6	7	8	9	10	12
4.6	.02	.06	.06	.06	.06	.06	.06	.06	.06	.06	.08	.11
4.7	.02	.06	.06	.06	.06	.06	.06	.06	.C6	.05	.08	.11
4.8	.02	.06	.06	.06	.06	.06	.06	.05	.05	.05	.08	.10
4.9	.02	.06	.06	.06	.06	.05	.05	.05	.05	.05	.08	.10
5.0	.02	.06	.06	.05	.05	.05	.05	.05	.05	.05	.08	.10

Ground Descent Rate (ft/sec)	Altitude (thsds of ft)										
	14	16	18	20	23	25	30	35	40	45	50
4.6	.10	.10	.10	.11	.11	.14	.17	.14	.11	.09	.04
4.7	.10	.10	.09	.11	.10	.13	.17	.14	.11	.09	.03
4.8	.10	.10	.09	.11	.10	.13	.16	.13	.11	.09	.03
4.9	.10	.09	.09	.11	.10	.13	.16	.13	.11	.09	.03
5.0	.10	.09	.09	.10	.10	.13	.16	.13	.10	.08	.03

TABLE NA-4

DESCENT RATES AT DIFFERENT ALTITUDES
FOR NON-AUTOROTATING TYPE LEAFLETS
(ft/sec)

Ground Descent Rate (ft/sec)	Altitude (thsds of ft)									
	5	10	15	20	25	30	35	40	45	50
2.0	2.1	2.2	2.4	2.7	3.0	3.6	4.3	5.4	6.9	9.0
2.1	2.2	2.3	2.5	2.8	3.2	3.8	4.6	5.7	7.2	9.5
2.2	2.3	2.4	2.6	2.9	3.3	3.9	4.8	5.9	7.6	9.9
2.3	2.4	2.5	2.7	3.0	3.5	4.1	5.0	6.2	7.9	10.4
2.4	2.5	2.6	2.8	3.2	3.6	4.3	5.2	6.5	8.3	10.9
2.5	2.6	2.7	3.0	3.3	3.8	4.5	5.4	6.7	8.6	11.3
2.6	2.7	2.8	3.1	3.4	4.0	4.7	5.6	7.0	9.0	11.8
2.7	2.8	2.9	3.2	3.6	4.1	4.8	5.9	7.3	9.3	12.2
2.8	2.9	3.1	3.3	3.7	4.3	5.0	6.1	7.6	9.6	12.7
2.9	3.0	3.2	3.4	3.8	4.4	5.2	6.3	7.8	10.0	13.1
3.0	3.1	3.3	3.6	4.0	4.6	5.4	6.5	8.1	10.3	13.6
3.1	3.2	3.4	3.7	4.1	4.7	5.6	6.7	8.4	10.7	14.0
3.2	3.3	3.5	3.8	4.2	4.9	5.7	6.9	8.6	11.0	14.5
3.3	3.4	3.6	3.9	4.4	5.0	5.9	7.2	8.9	11.4	14.9
3.4	3.5	3.7	4.0	4.5	5.2	6.1	7.4	9.2	11.7	15.4
3.5	3.6	3.8	4.2	4.6	5.3	6.3	7.6	9.4	12.1	15.8
3.6	3.7	3.9	4.3	4.8	5.5	6.4	7.8	9.7	12.4	16.3
3.7	3.8	4.0	4.4	4.9	5.6	6.6	8.0	10.0	12.7	16.7
3.8	3.9	4.1	4.5	5.0	5.8	6.8	8.2	10.2	13.1	17.2
3.9	4.0	4.3	4.6	5.2	5.9	7.0	8.5	10.5	13.4	17.6

TABLE NA-4 (Cont'd)

DESCENT RATES AT DIFFERENT ALTITUDES
FOR NON-AUTOROTATING TYPE LEAFLETS
(ft/sec)

Ground Descent Rate (ft/sec)	Altitude (thsds of ft) 5	10	15	20	25	30	35	40	45	50
4.0	4.1	4.4	4.7	5.3	6.1	7.2	8.7	10.8	13.8	18.1
4.1	4.2	4.5	4.9	5.4	6.2	7.3	8.9	11.1	14.1	18.5
4.2	4.3	4.6	5.0	5.6	6.4	7.5	9.1	11.3	14.5	19.0
4.3	4.4	4.7	5.1	5.7	6.5	7.7	9.3	11.6	14.8	19.4
4.4	4.5	4.8	5.2	5.8	6.7	7.9	9.5	11.9	15.2	19.9
4.5	4.6	4.9	5.3	6.0	6.8	8.1	9.8	12.1	15.5	20.3
4.6	4.7	5.0	5.5	6.1	7.0	8.2	10.0	12.4	15.8	20.8
4.7	4.8	5.1	5.6	6.2	7.1	8.4	10.2	12.7	16.2	21.3
4.8	4.9	5.2	5.7	6.4	7.3	8.6	10.4	12.9	16.5	21.7
4.9	5.1	5.3	5.8	6.5	7.4	8.8	10.6	13.2	16.9	22.2
5.0	5.2	5.5	5.9	6.6	7.6	9.0	10.8	13.5	17.2	22.6
5.1	5.3	5.6	6.1	6.8	7.8	9.1	11.1	13.8	17.6	23.1
5.2	5.4	5.7	6.2	6.9	7.9	9.3	11.3	14.0	17.9	23.5
5.3	5.5	5.8	6.3	7.0	8.1	9.5	11.5	14.3	18.3	24.0
5.4	5.6	5.9	6.4	7.2	8.2	9.7	11.7	14.6	18.6	24.4
5.5	5.7	6.0	6.5	7.3	8.4	9.9	11.9	14.8	18.9	24.9
5.6	5.8	6.1	6.6	7.4	8.5	10.0	12.1	15.1	19.3	25.3
5.7	5.9	6.2	6.8	7.6	8.7	10.2	12.4	15.4	19.6	25.8
5.8	6.0	6.3	6.9	7.7	8.8	10.4	12.6	15.6	20.0	26.2
5.9	6.1	6.4	7.0	7.8	9.0	10.6	12.8	15.9	20.3	26.7
6.0	6.2	6.5	7.1	8.0	9.1	10.7	13.0	16.2	20.7	27.1

MAKING THE COMPUTATIONS

Computation Sheet - The suggested computation sheet and illustrative examples of the use of the tables follow. The sheet is divided into three major sections. In the upper left are entered the wind speeds and azimuth angles of the predicted winds for the 5000-foot altitude increments of interest.[1] To this are added the time factors in hours for the leaflet type selected, with a column provided for the product of the appropriate time factor and the wind speed in each 5000-foot increment. In the upper right are listed the launch date, time, and site; the target; and the release altitude. Immediately below this are the data on the leaflet type selected. The bottom half of the sheet is for recording the computations of drift and determining the ground pattern area and leaflet density. A sheet of graph paper lined to a convenient scale (such as 10 squares to the inch) should be obtained also for plotting the vector results of the horizontal drift distance.

Example No. 1 - Example No. 1 is for 4 x 6 inch leaflets printed on 16-lb. paper released at a height of 37,000 feet, and with wind speeds and azimuth angles as indicated on the form. The first thing to do is to refer to Table G-1, where it is seen that this leaflet size corresponds to an aspect ratio of 1.5. The number of leaflets per pound as found in Table G-2 is 487. Referring to Table G-3, it is seen that a 16-lb. leaflet with a length of 6" and an aspect ratio of 1.5 has a ground rate of descent (V_O) of 3.3 ft/sec and falls with a non-autorotating motion. The coefficient of variation ($R_T/\bar{T}_o$) as found in Table G-4 is 0.63.

The time factors for a non-autorotating leaflet with a $V_O = 3.3$ ft/sec may be found in Table NA-2. These values are listed in the appropriate column in the upper left of the computation sheet, and the factors multiplied by the wind speed corresponding to that altitude increment give the horizontal drift distance through each 5000-foot interval. These drift distances are next plotted on graph paper to obtain the overall drift. The tail of the first vector represents the release

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[1] The azimuthal angles are the direction from which the winds are blowing on a 360 degree scale moving in a clockwise direction from due north. For example, a 90^o wind is blowing from east to west, a 180^o wind from south to north, a 270^o wind from west to east, and a 360^o wind from north to south.

LEAFLET COMPUTATION SHEET

Height Increments (thsds of ft)	Time Factor (hours)	Wind Speed (knots)	Horiz. Drift Distance (naut. mi.)	Azimuth Angle (deg)
50-45				
45-40				
40-35				
35-30				
30-25				
25-20				
20-15				
15-10				
10-5				
5-0				

Date ________

Time of Launch ______

Launch Site ________

Target ________

Release Altitude ______

Leaflet Data

Paper Weight ______

Size ________

Aspect Ratio ______

$\frac{R_T}{\overline{T}_o}$ ________

V_o ________

Autorotator ______

Non-autorotator ______

Leaflets/lb ______

Computations

Total horizontal drift vector from release to impact: ________

Maximum deviation normal to net vector: ________

Ground Dispersion Pattern:

- Major Axis
- Minor Axis
- Area

Payload

Number of leaflets

Mean density

Leaflets/mi^2 $\div$ 2800 = leaflets/10,000 ft^2

point. The vector is drawn along a line parallel to the azimuth angle of the wind, the length of the vector corresponding to the horizontal drift distance. The second vector has its tail at the head of the first vector and so forth until the last vector is plotted. In this case the release altitude was 37,000 feet, and therefore the first vector is only 2/5 of that shown on the form sheet, i.e., 4.0 miles rather than 10.2. The subsequent vectors are, of course, all full length with the possible exception of the last one, which will have to be shortened if the impact area is above sea level. In this example it is assumed that the elevation of the target is essentially the same as sea level, so no correction need be made.

Having plotted the vectors for each successive altitude increment, the resultant horizontal drift vector is now drawn from the release point (the tail of the first vector) to the impact point (the head of the last vector). Measuring the length and azimuth of the resultant vector yields the overall drift distance and direction, in this case 57 nautical miles and 282°, respectively. Finding the maximum deviation normal to the resultant is done simply by inspection. It turns out to be 8 nautical miles for this example.

It should be noted that, since the winds are reported in knots rather than in miles per hour, the distances plotted are nautical miles and must be multiplied by the factor 1.15 to convert them to statute miles. In other words, the resultant drift vector is 66 statute miles (1.15 times 57 nautical miles) and the maximum deviation normal to it is 9 statute miles (1.15 times 8 nautical miles).

Having obtained the total horizontal drift and the maximum deviation normal to it, these values are recorded in the section for computations. The size of the ground dispersion pattern can now be determined. The major axis of the ellipse is the total drift multiplied by the variation coefficient, while the minor axis is the sum of one-half of the release height (in miles)[1] plus the maximum normal deviation times the variation coefficient. The major axis here is 66 times 0.63, or 41 miles; the minor axis is 13 miles. The major and minor axes thus determined, the area is found from the formula $A = \frac{\pi}{4}ab$ to be 420 square miles.

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[1] This is the ratio of the release height in feet to 5280 feet, the result being the release height in miles.

Dispersion Density - Knowing the size of the payload and the number of leaflets per pound permits calculation of the total number of leaflets released, and this value divided by the above calculated area figure yields the average density in leaflets per square mile. The payload here was 400 pounds and the number of leaflets per pound was 487 giving a total of 195,000 leaflets released. The average density then is 195,000 ÷ 420, or 464 leaflets/mi^2.

A more meaningful figure, however, is the average number of leaflets in each square that is 100 feet on a side (i.e., in 10,000 square feet). This can be obtained by dividing the number of leaflets per square mile by 2800; thus 464 divided by 2800 yields a density of 0.16 leaflets per 10,000 square feet. In other words, there is only one leaflet per 60,000 square feet on the average. A reasonable density is between 1 and 10 leaflets per 10,000 square feet.

It is useful to draw the ground pattern on graph paper. The center of the ellipse is placed at the predicted point of impact and the major and minor axes measured out with the major axis being along the resultant drift vector and the minor axis normal to it. The ellipse can then be drawn and shaded in to show the general size of the ground pattern more distinctly.

Example No. 2 - The leaflet in Example No. 2 was selected because it has a slower ground level rate of descent (V_O) and a considerably smaller variation coefficient, while still being of the non-autorotating leaflet variety. The result of this choice is that (1) the leaflet spends more time between altitude levels than did the leaflet in Example No. 1, hence, the horizontal drift vector for any given altitude increment will be greater for this second leaflet than for the first, assuming wind conditions to be the same for both cases; and (2) the size of the ground pattern is much tighter than it is in Example No. 1.

The winds listed in the computation form sheet are identical to those found in Example No. 1. The procedure for making the calculations, plotting the vectors, and determining the pattern size and density is the same as that followed in Example No. 1. The steps involved are as follows:

(1) Find the aspect ratio in Table G-1.

(2) Determine the number of leaflets per pound in Table G-2.

(3) Find the ground rate of descent (V_O) and type of motion (autorotating or non-autorotating) in Table G-3.

(4) Find the variation coefficient ($R_T/\bar{T}_o$) in Table G-4.

(5) Find the time factors for this non-autorotating leaflet, with the V_o as determined in step 3, in Table NA-2[1]; list these values in the appropriate column of the computation sheet.

(6) Multiply the time factors by the corresponding wind speed to determine the horizontal drift distance in each altitude increment.

(7) Plot the horizontal drift distances as vectors on the graph paper, taking care that allowance is made for any partial drop heights in the first and last 5000-foot increments of the descent.

(8) Draw the resultant horizontal drift vector from the point of release to the point of impact, and measure the magnitude and direction of this vector.

(9) Determine and measure the point of maximum normal deviation from the net vector.

(10) Convert the measured distances of the resultant vector and the maximum normal deviation from nautical miles to statute miles, and list these values on the computation form.

(11) Determine the major axis of the ellipse by multiplying the magnitude of the resultant vector by the variation coefficient.

(12) Determine the minor axis by dividing the descent distance in feet by 5280 (to obtain the descent distance in miles) and adding to this the product of the maximum normal deviation and the variation coefficient.

(13) Determine the area of the ground pattern from the formula $A=\frac{\pi}{4}ab$ where a and b are the major and minor axes.

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[1] Were this an autorotating leaflet rather than a non-autorotating leaflet, the time factors would be found in Table A-2 rather than in Table NA-2.

(14) Multiply the weight of the payload by the number of leaflets per pound to obtain the total number of leaflets released.

(15) Divide the total number of leaflets obtained in step 14 by the area figure found in step 13 to get the average density in leaflets per square mile.

(16) Divide the average density found in step 15 by 2800 to obtain the average density in leaflets per 10,000 square feet.

(17) Draw and shade in the ground pattern on the graph paper.

As mentioned earlier, the descent rate is slower and the variation coefficient smaller for the leaflet selected in Example No. 2 in comparison with that in Example No. 1. Therefore, the horizontal drift is greater, and the ground pattern is smaller. In order to reduce the length of the drift vector to be approximately equal to that of Example No. 1, the release height is lowered from 37,000 to 34,000 feet. The ground pattern is, however, little affected by this change.

It is interesting to superimpose the two problems, i.e., Example Nos. 1 and 2, on the same sheet of graph paper for purposes of comparison. This is shown on one of the following graphs.

Example No. 3 - Example No. 3 is included as a further study, although there are no important differences in it from the previous two examples. An autorotating leaflet is selected for this problem, and a different set of wind conditions are used. The procedures for working up the drift and ground pattern are identical to those outlined under Example Nos. 1 and 2.

Example No. 1

LEAFLET COMPUTATION SHEET

Height Increments (thsds of ft)	Time Factor (hours)	Wind Speed (knots)	Horiz. Drift Distance (nauti. mi.)	Azimuth Angle (deg)
50-45				
45-40				
40-35	0.17	60	10.2	320
35-30	0.25	50	12.5	300
30-25	0.26	40	10.4	280
25-20	0.30	40	12.0	290
20-15	0.34	30	10.2	280
15-10	0.37	30	11.1	270
10-5	0.40	10	4.0	180
5-0	0.42	5	2.1	170

Date June 25, 1960
Time of Launch 0600
Launch Site # 2
Target X
Release Altitude 37,000 ft.

Leaflet Data
Paper Weight 16
Size 6" x 4"
Aspect Ratio 1.5
R_T/T_o 0.63
V_o 3.3 ft/sec
Autorotator
Non-autorotator X
Leaflets/lb 487

Computations

Total horizontal drift vector from release to impact: 282°, 57 naut. mi. 66 miles

Maximum deviation normal to net vector: 8 naut. miles = 9 miles

Ground Dispersion Pattern:

Major Axis $66 \times 0.63 = 41$ miles

Minor Axis $\frac{37,000}{5280} + 9 \times 0.63 = 13$ miles

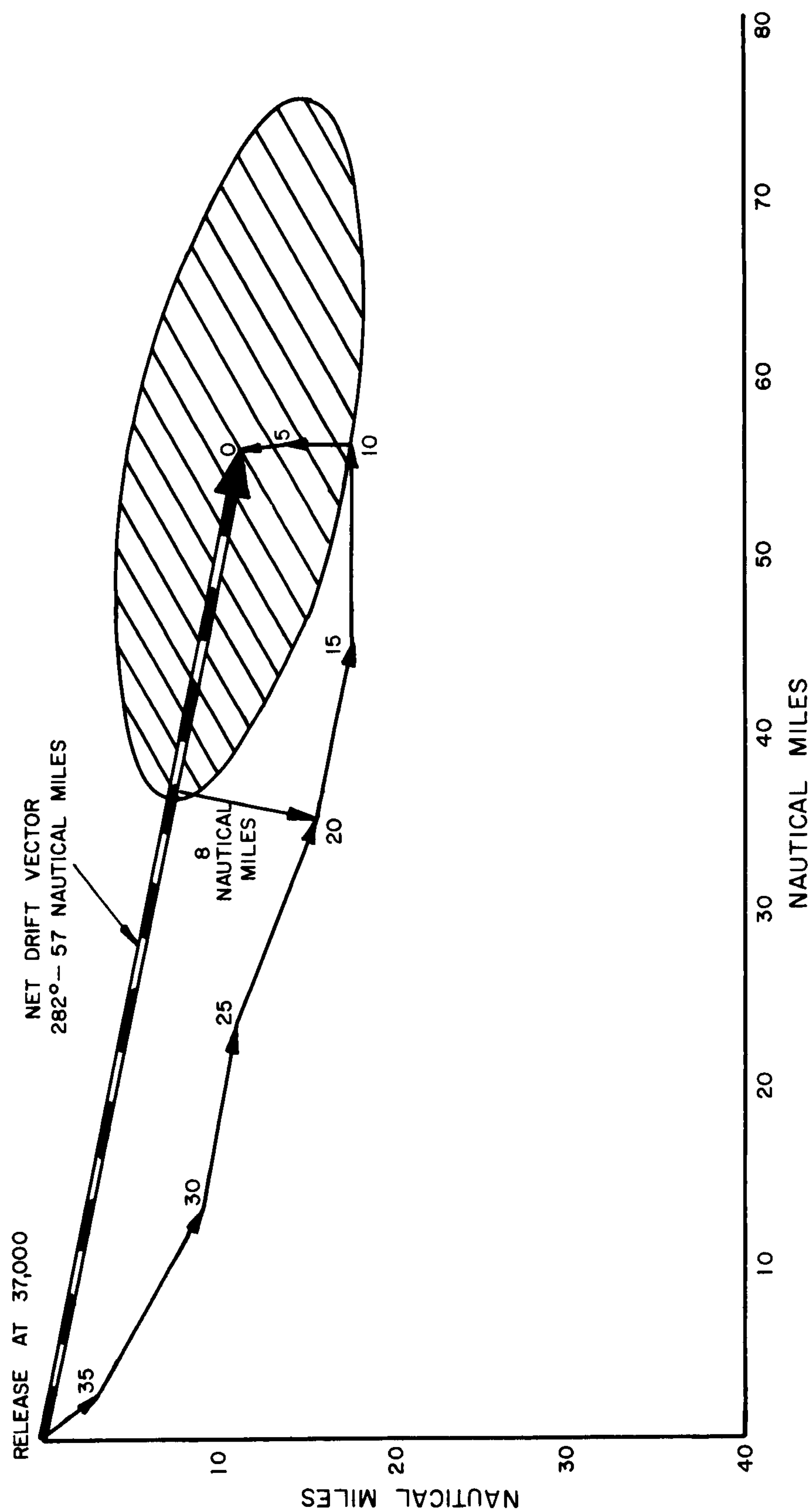
Area $\frac{\pi}{4} \times 13 \times 41 = 420$ square miles

Payload 400 pounds

Number of leaflets $400 \times 487 = 194,800$

Mean density $194,800 \div 420 = 464$ leaflets/mi^2

Leaflets/mi^2 $\div$ 2800 = leaflets/10,000 ft^2 = $464 \div 2800 = 0.16$ leaflets/10,000 ft^2



Example No. 1 VECTORS AND GROUND PATTERN

Example No. 2

LEAFLET COMPUTATION SHEET

Height Increments (thsds of ft)	Time Factor (hours)	Wind Speed (knots)	Horiz. Drift Distance (naut. mi.)	Azimuth Angle (deg)
50-45				
45-40				
40-35		60		320
35-30	0.25	50	12.5	300
30-25	0.30	40	12.0	280
25-20	0.35	40	14.0	290
20-15	0.40	30	12.0	280
15-10	0.44	30	13.2	270
10-5	0.47	10	4.7	180
5-0	0.49	5	2.5	170

Date June 25, 1960
Time of Launch 0600
Launch Site # 2
Target X
Release Altitude 34,000 ft.

Leaflet Data
Paper Weight 16
Size 6" x 4.8"
Aspect Ratio 1.25
$R_T/\bar{T}_o$ 0.20
V_o 2.8 ft/sec
Autorotator
Non-autorotator X
Leaflets/lb 406

Computations

Total horizontal drift vector from release to impact: 277°, 60 naut. mi. = 69 miles

Maximum deviation normal to net vector: 8 naut. miles = 9 miles

Ground Dispersion Pattern:

Major Axis $69 \times 0.20 = 14$ miles

Minor Axis $\frac{34,000}{5280} + 9 \times 0.20 = 8$ miles

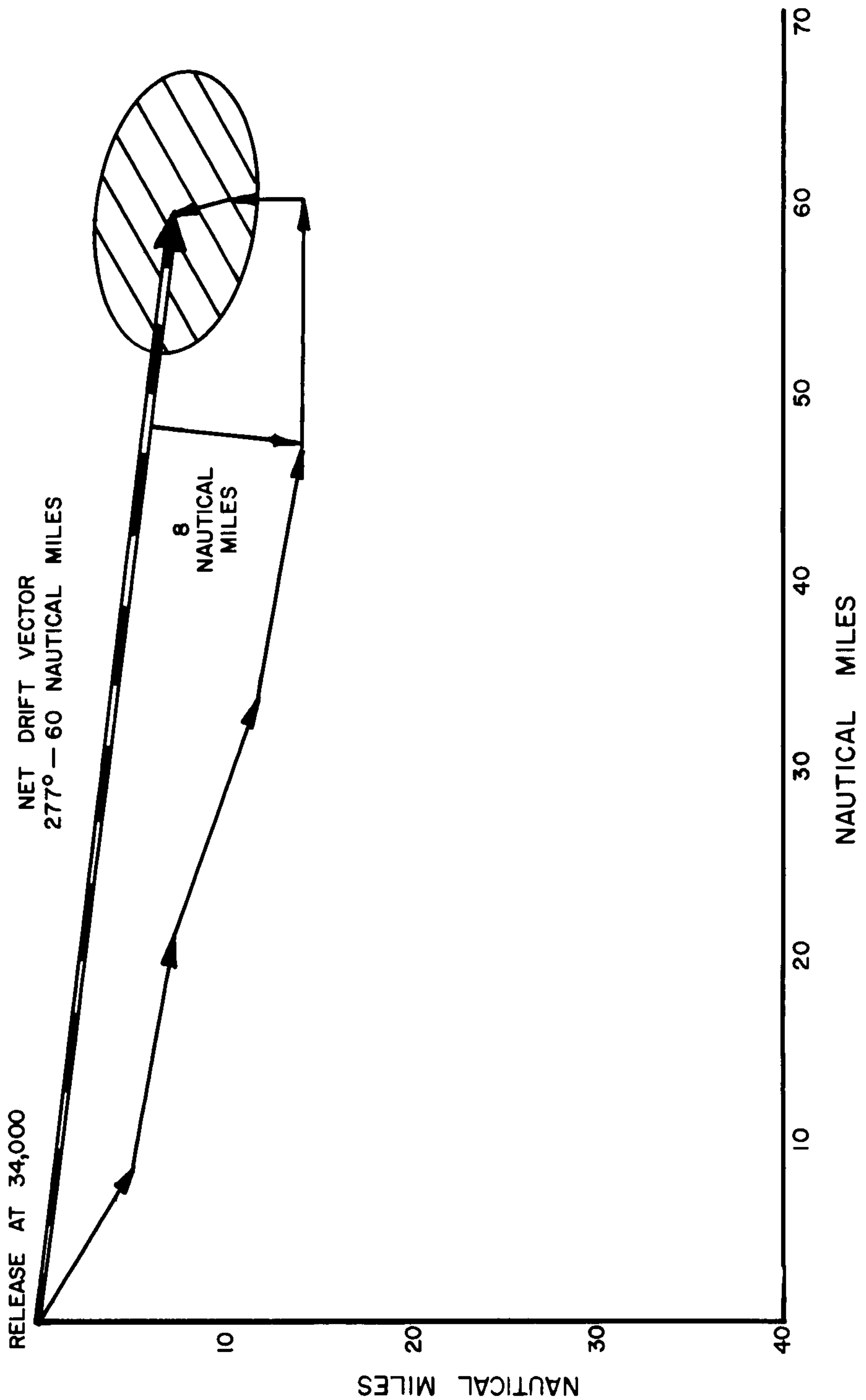
Area $\frac{\pi}{4} \times 14 \times 8 = 88$ square miles

Payload 400 pounds

Number of leaflets $400 \times 406 = 162,000$

Mean density $162,000 \div 88 = 1840$ leaflets/mi^2

Leaflets/mi^2 $\div$ 2800 = leaflets/10,000 ft^2 = $1840 \div 2800 = 0.66$ leaflets/10,000 ft^2



Example No. 2. VECTORS AND GROUND PATTERN

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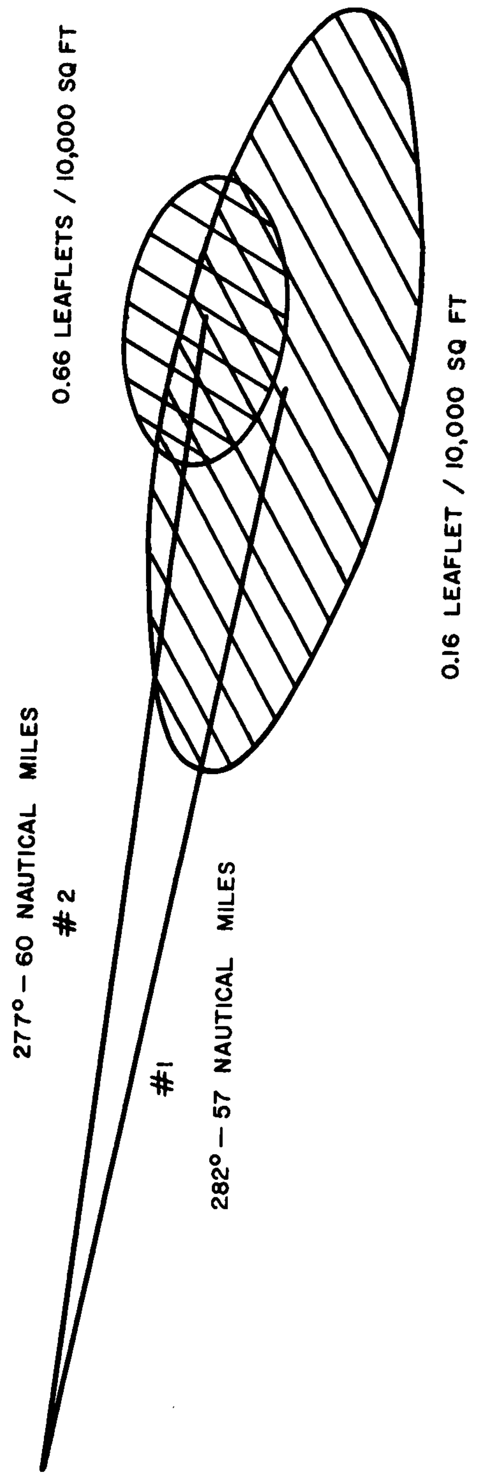


Examples No. 1 and 2. SUPERIMPOSED GRAPHS

Example No. 3

LEAFLET COMPUTATION SHEET

Height Increments (thsds of ft)	Time Factor (hours)	Wind Speed (knots)	Horiz. Drift Distance (naut. mi.)	Azimuth Angle (deg)
50-45				
45-40	0.29	60	17.4	290
40-35	0.33	70	23.1	270
35-30	0.38	70	26.6	260
30-25	0.43	50	20.5	240
25-20	0.48	40	19.2	230
20-15	0.53	30	15.9	210
15-10	0.59	10	5.9	330
10-5	0.64	10	6.4	360
5-0	0.68	5	3.4	010

Date July 8, 1961
Time of Launch 1530
Launch Site # 1
Target Y
Release Altitude 32,000 ft.

Leaflet Data
Paper Weight 13
Size 8-1/2" x 2.13"
Aspect Ratio 4.00
$R_T/\bar{T}_o$ 0.36
V_o 2.0 ft/sec
Autorotator X
Non-autorotator
Leaflets/lb 796

Computations

Total horizontal drift vector from release to impact: 245^o, 57 naut. mi. = 66 miles

Maximum deviation normal to net vector: 14 naut. miles = 16 miles

Ground Dispersion Pattern:

Major Axis $66 \times 0.36 = 24$ miles

Minor Axis $\frac{32,000}{5280} + 16 \times 0.36 = 12$ miles

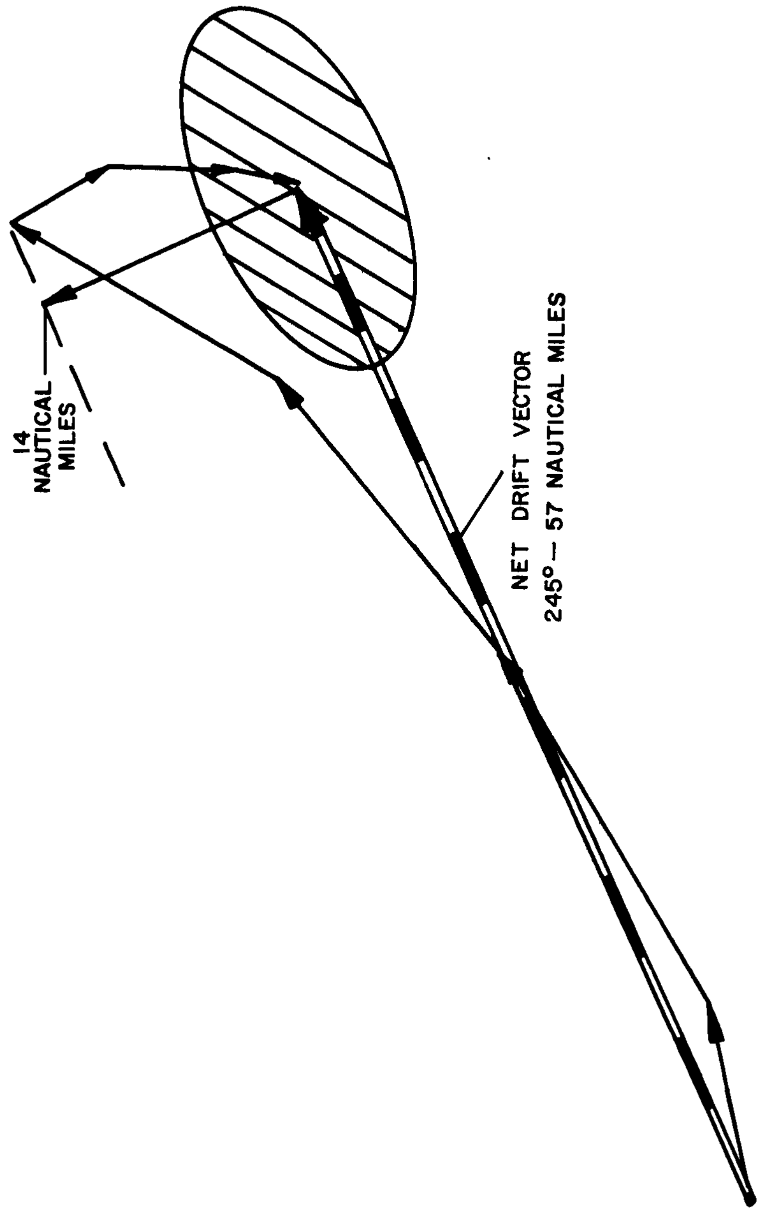
Area $\frac{\pi}{4} \times 24 \times 12 = 226$ square miles

Payload 400 pounds

Number of leaflets $400 \times 796 = 318,000$

Mean density $318,000 \div 226 = 1400$ leaflets/mi^2

Leaflets/mi^2 $\div$ 2800 = leaflets/10,000 ft^2 = 1400 $\div$ 2800 = 0.50 leaflets/10,000 ft^2



Example No. 3. VECTORS AND GROUND PATTERN

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Balloon Delivery System
J 100

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THE J-100 BALLOON DELIVERY SYSTEM

Abstract - The J-100 meteorological balloon is used as the delivery system for leafleting operations in the short range target areas up to 250 miles distant. The balloon with its payload rises at a fairly constant rate. As it passes through regions of successively lower air density, the gas in the balloon expands and stretches the balloon film. Finally, the film stretches to the point of rupture and releases the payload to drift down separately and disperse over the ground.

The J-100 is a versatile delivery system for these short ranges since the distance and height of flight can be altered by varying the payload-free lift combinations. These features, along with a knowledge of wind conditions and the principles of leaflet descent and dispersion, form the variables which are at the disposal of the operator to control the range and burst altitude for leafleting the target area.

This section of the handbook details the performance characteristics of the J-100 balloon, including charts, graphs and tables obtained from actual tests. Examples show how the best payload-free lift combination for a specific leafleting situation is selected, and matching leaflet drift to the balloon trajectory so the total problem from launch to impact is worked out.

Other considerations include launching sites, both fixed and mobile, computing and plotting balloon trajectories, the choice of leaflet size and weight, and performance characteristics of the J-100 when flying into clouds, on night flights, aged balloons, and the use of dissociated ammonia for the lifting gas in place of hydrogen.

At the end of this section will be found detailed operating instructions for the J-100 balloon delivery system (external load) arranged in sections covering assembly of the balloon, assembly and loading of the carrier, inflation, hydrogen handling, and launching.

J-100 Capability - The J-100 balloon is a neoprene meterological balloon. It is basically a wind sounding balloon but can be easily adapted for load carrying purposes. The balloon film is extensible; its flaccid diameter (i.e., the diameter before inflation) being 16 inches and the burst diameter being in the order of 80 inches.

A payload is attached to the balloon and the balloon is then inflated with a lighter-than-air gas[1] to the point where the system is just in equilibrium with the air. If now a small additional amount of gas is added to the balloon, the system will become buoyant and, if freed, begin to rise. This additional increment of gas is called the free lift, and the rate of rise is dependent on the amount of excess gas (free lift) imparted to the system.

The system rises at an essentially constant rate, the gas in the balloon expanding and stretching the balloon film as the system passes into regions of successively lower density. Finally the film is stretched beyond its elastic limit and the balloon ruptures, releasing its payload which drifts down separately to the target area.

In a very general way the delivery capability of the J-100 can be summarized by the following schematic:

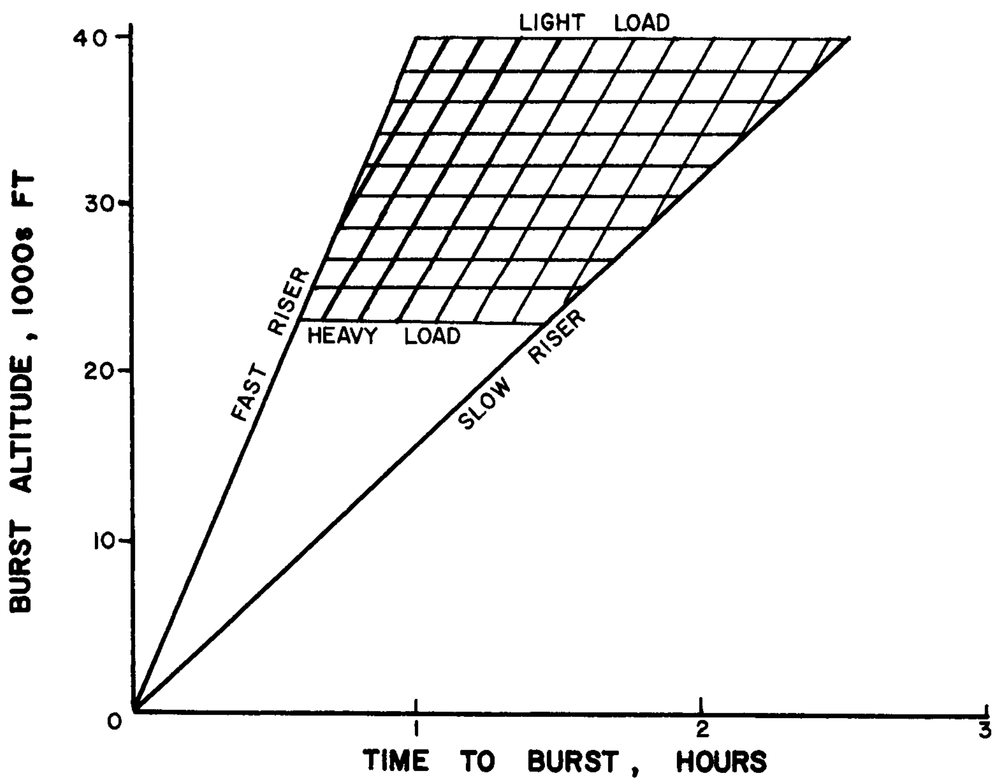

Figure 1. CAPABILITY OF J-100 BALLOON

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[1] Usually hydrogen is used as the lifting gas, although dissociated ammonia and coal gas have been used successfully.

The shaded area bordered by the four boundary lines "fast riser, light load, slow riser, and heavy load", represents the area into which a J-100 can be reliably used to carry a payload. The boundary limits chosen for this handbook are: fast riser - 500 grams free lift; light load - 2 pounds; slow riser - 50 grams free lift; heavy load - 6 pounds. Theoretically, any point within the boundary is attainable if the right payload and free lift are selected. In practice, the given series of recommended payload-free lift combinations will suffice, and for most purposes there will be no reason to use any other than these recommended values.

Referring to the schematic again, it is seen that the J-100 represents a rather versatile short range capability. It is able to deliver a light load to an altitude of 40,000 feet in a time period varying from about 1 to 2-1/2 hours depending on the free lift selected, or a heavy load to an altitude of 23,000 feet in a time period varying from 1/2 to 1-1/2 hours. Assuming an average wind of 40 mph[1] from ground to burst, the heavy load will be carried a distance from 20 to as much as 60 miles from the launch site, while the light load will be drifted from 40 to 100 miles[2] before releasing its payload. If a leaflet descent time of 2 hours is assumed for the 23,000 foot release and 3 hours for the 40,000 foot release altitudes[3], a leaflet drift of 40 miles in the case of the low release and 60 miles for the high release would result. A total drift vector from balloon launch to leaflet impact would then be as follows:

DRIFT VECTORS J-100

Load	Rise	Balloon drift	Leaflet drift	Total drift
heavy	rapid	20 miles	40 miles	60 miles
heavy	slow	60	40	100
light	rapid	40	60	100
light	slow	100	60	160

1 40 mph = 35 knots, an average wind condition at altitude.

2 The distances are obtained by multiplying the time to burst by the average wind, e.g., 1-1/2 hours x 40 mph = 60 miles.

3 This corresponds, for example, to an autorotating leaflet with a ground rate of descent (V_o) of 2.7 feet/second.

Under average wind conditions and using an "average" leaflet, it is seen that a distance of from 60 to 160 miles results. Under higher or lower wind conditions and with a leaflet having faster or slower rate of descent, the total distance could be easily altered to points between 50 and 250 miles, with distances on either side of this range attainable under special conditions. In general, however, the 50 to 250 mile range is considered to be the capability of the J-100 balloon, and for planning purposes a target area outside of these limits should be scrutinized carefully for means of delivery by a carrier other than the J-100[1].

Load Methods - There are two methods of using the J-100 as a load carrying vehicle: (1) placing the payload inside the balloon by stretching the balloon neck and inserting the load prior to inflation; (2) suspending the load outside of the balloon from the balloon neck. The first method is called internal loading, while the second is called external loading.

Early leaflet operations with the J-100 were internal-load operations. In this case the balloon simply rises to burst, at which point the load separates from the balloon and floats down independently. This method, however, suffered from such serious limitations as the following: the maximum load that could be delivered was 2 pounds; the premature burst rate[2] was excessive; the inflation rate could not be increased without encountering a prohibitively high premature burst rate; and the bursting of the balloons after release was erratic. In order to overcome these limitations, an external loading method has been devised which simply and economically permits flying larger loads, virtually eliminates prebursting[3], allows more rapid inflation, and eliminates erratic bursting[3].

---

1 For targets under 50 miles a simple leaflet drift by leaflets released from an airplane should be considered. For targets over 250 miles the Pillow balloon might be used.

2 A "premature" burst is a balloon rupture occuring during inflation due to a shifting and fluttering of the load which causes scoring and abrading of the balloon during the inflation operation.

3 A certain amount of prebursting (of the order of 1%) is due to defective balloons. This is also true for "erratic" bursting which is the bursting of balloons while airborne prior to reaching the intended volume. Very few balloons are defective in this sense, unless handled improperly.

It is therefore recommended that the external loading system be used rather than the internal load. The charts, graphs, and tables contained in this handbook were obtained from test results using external loads.

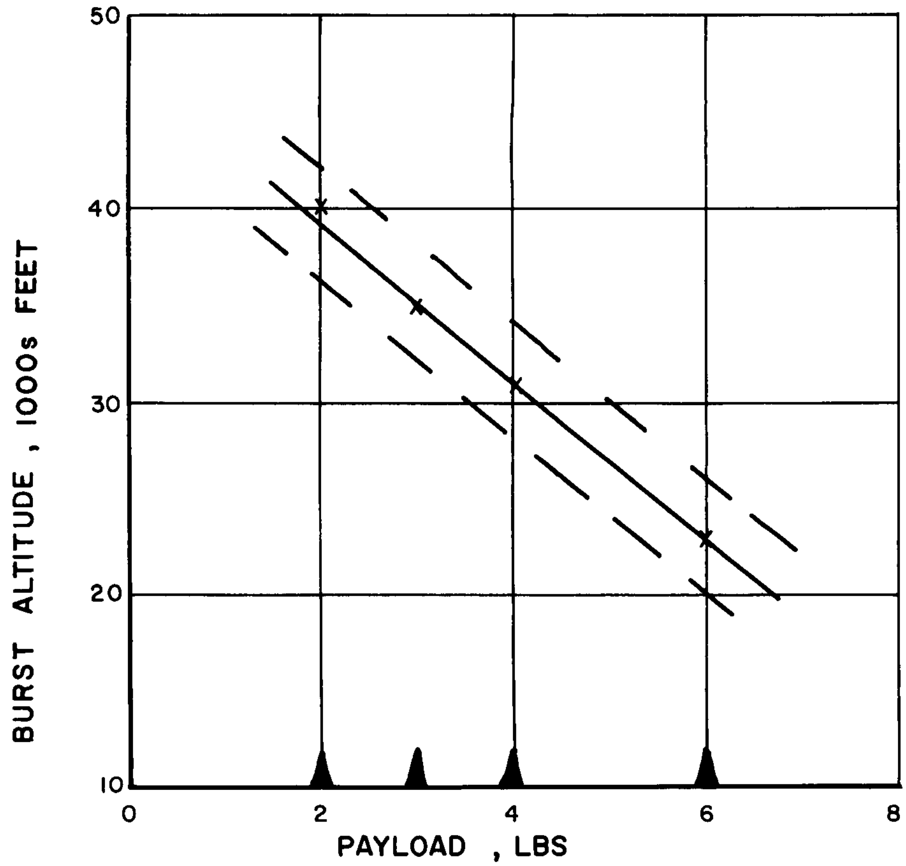
PERFORMANCE CHARACTERISTICS OF THE J-100

The performance characteristics of the J-100 can perhaps best be summarized by reference to four graphs.

Figure 2 shows the relationship of burst altitude to payload. It is seen that within the range of 2 to 6 pounds, the relationship can be represented as being linear. Release at any particular altitude between 20 and 40 thousand feet could be effected simply by choosing the appropriate payload from the graph and loading the balloon accordingly. It will usually be found, however, that one of the four payloads tested (2, 3, 4, and 6 pound loads) will satisfy the requirements of the operational situation. Nonetheless, the graph is useful in picturing how the burst altitude is effected by load. It is interesting to note also that the spread in the burst altitude is constant over the entire range of altitudes reported, i.e., ± 3000 feet. It might further be pointed out that burst altitude is essentially independent of the free lift.

Figure 3 shows the relationship of rate of rise to free lift. Here again, the relationship is seen to be linear between the range of 100 and 500 grams of free lift. For free lifts below 100 grams, the linearity does not appear to hold. Theoretically it would be possible to obtain any rate of rise desired simply by matching the rate of rise to its corresponding free lift. Practically, one of the five free lifts tested (50, 100, 200, 350, and 500 grams) will satisfy almost any operational requirement. However, the graph is useful for planning and orientation purposes. Rate of rise is seen to be largely independent of payload.

Figure 4 is particularly interesting when it is used in combination with the previous two graphs. A family of rate of rise curves is plotted on a graph which has "time to burst" as the ordinate and "burst altitude" as the abscissa. The result being that if a specific time to burst and burst altitude are desired (e.g., 1.5 hour air-time from launch to burst with a release at 35,000 feet), the required rate of rise can be obtained directly from the graph (for the example chosen, approximately 400 feet minute). Turning to Figure 3 it is seen that a free lift of 200 grams will yield a rate of rise of 400 feet per minute. From Figure 2, a payload of 3 pounds will cause a burst at 35,000 feet. A summary of the entire flight of a balloon is therefore described in these three graphs.

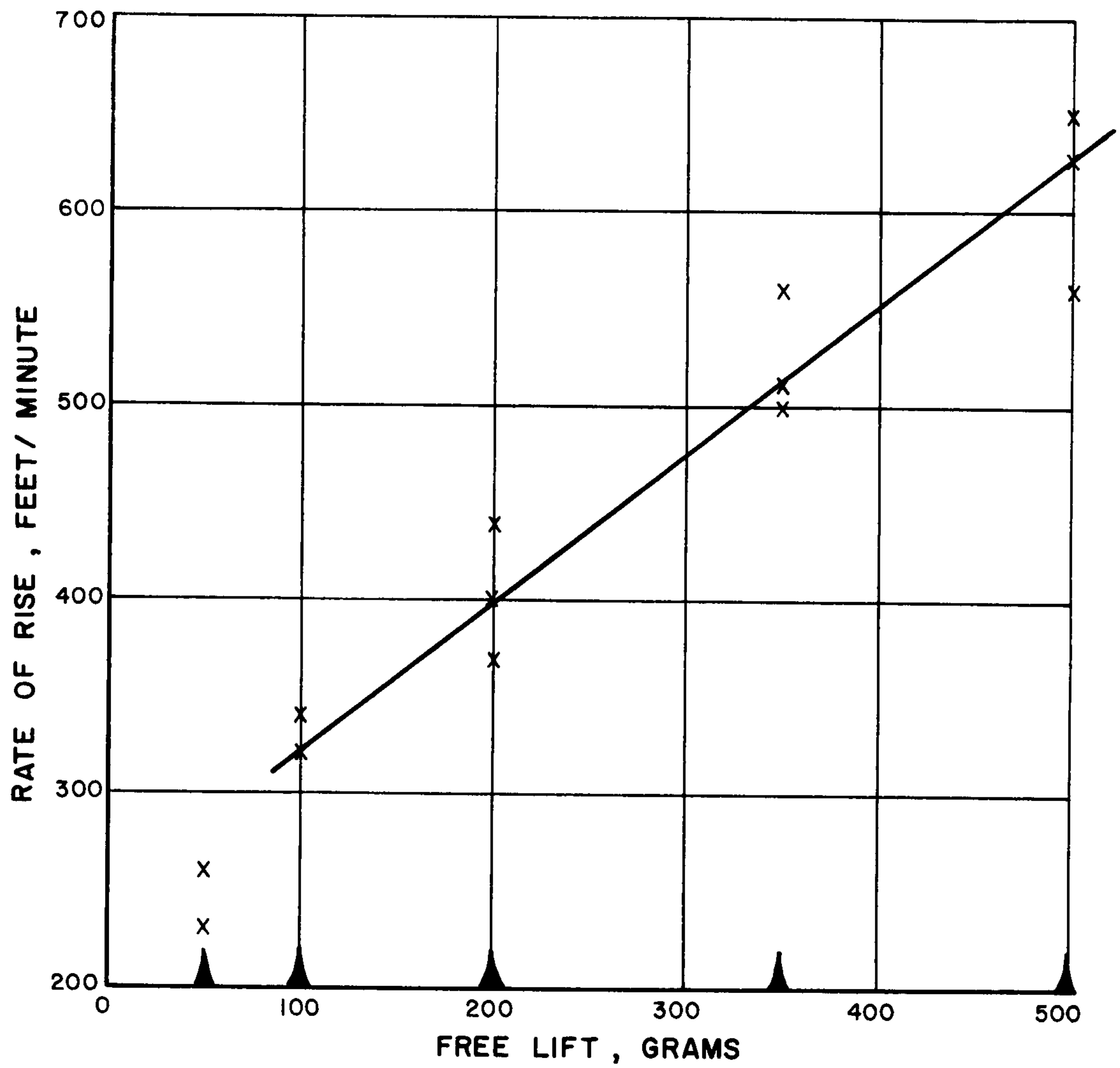


WITHIN THE RANGE 2 TO 6 POUNDS, $H \cong -4L + 47$
WHERE: H = BURST ALTITUDE
L = PAYLOAD

NOTES:

1. DASHED LINES INDICATE EXPECTED SPREAD ABOUT THE AVERAGE BURST ALTITUDE (± 3000 FEET) FOR 80% OF THE BALLOONS.
2. ARROW HEADS INDICATE FREE LIFTS TESTED.
3. X – INDICATES ACTUAL VALUES FROM FLIGHT TESTS.

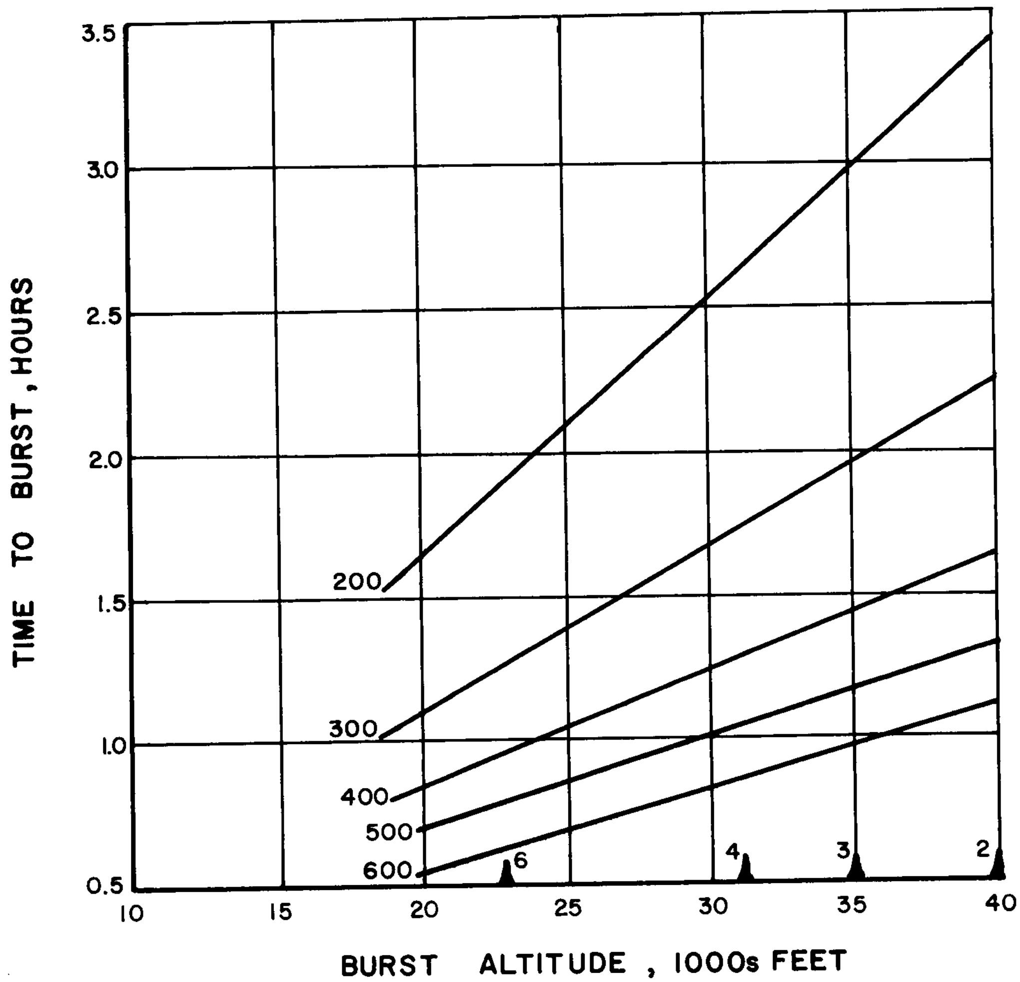
Figure 2. J-100 BALLOONS: RELATIONSHIP OF BURST ALTITUDE TO PAYLOAD



WITHIN THE RANGE 100 TO 500 GRAMS, R ≅ 0.77F + 246
WHERE: R = RATE OF RISE
F = FREE LIFT

NOTES:
1. ARROW HEADS INDICATE FREE LIFTS TESTED.
2. X – INDICATES ACTUAL RESULTS FROM FLIGHT TESTS.

Figure 3. J-100 BALLOONS: RELATIONSHIP OF RATE OF RISE TO FREE LIFT



NOTE:
1. ARROW HEADS INDICATE BURST ALTITUDES OF THE FOUR PAYLOADS TESTED.

Figure 4. AIRTIME FROM LAUNCH TO BURST FOR RATES OF RISE OF 200 TO 600 FEET/MINUTE

It should be pointed out that not only is it possible to start with the desired air time and burst altitude and work back to the required payload and free lift needed to satisfy the conditions, but the process can be worked in reverse as well. That is, one can start with the payload (say 4 pounds) and obtain the burst altitude (31,000 feet). Then choosing a free lift (350 grams) it is found that a rate of rise of approximately 500 feet/minute results. Going to Figure 4, for a burst altitude of 30,000 feet and a rate of rise of 500 feet/minute, an air time of just over 1 hour is required.

Figure 5 is a graphical summary of the payload-free lift combinations tested. This graph is actually the most useful one of the four. Not only does it report actual test results, but it is a summary of all the pertinent information on one graph. The load and free lift are directly related to the burst altitude and air time, and conversely.

Summary

(1) Burst altitude is directly proportional to payload and independent of free lift. A range in burst altitude from 23,000 to 40,000 feet results from payloads between 6 and 2 pounds.

(2) Rate of rise is directly proportional to free lift and largely independent of payload. A range in rate of rise from 250 to 600 feet/minute results from free lifts between 50 and 500 grams.

Performance Within 5000-Ft. Levels - Performance charts, breaking the flight up into successive 5000 feet increments, follow.

Table 1 summarizes the flight results for the various load and free lift conditions tested, showing the burst altitude, the rate of rise, the time to burst (in hours), and the time spent between altitude levels (also in hours). The time spent between successive 5000-foot altitude levels is the distinctive information presented in this table. This incremental break down of time is vital for working up balloon trajectories, and, once the operator familiarizes himself with the general characteristics of the J-100, Table 1 should be used almost exclusively for working up detailed flight trajectories.

Table 2 presents time to burst in minutes, and rate of rise between successive 5000-foot altitudes is reported in place of the time.

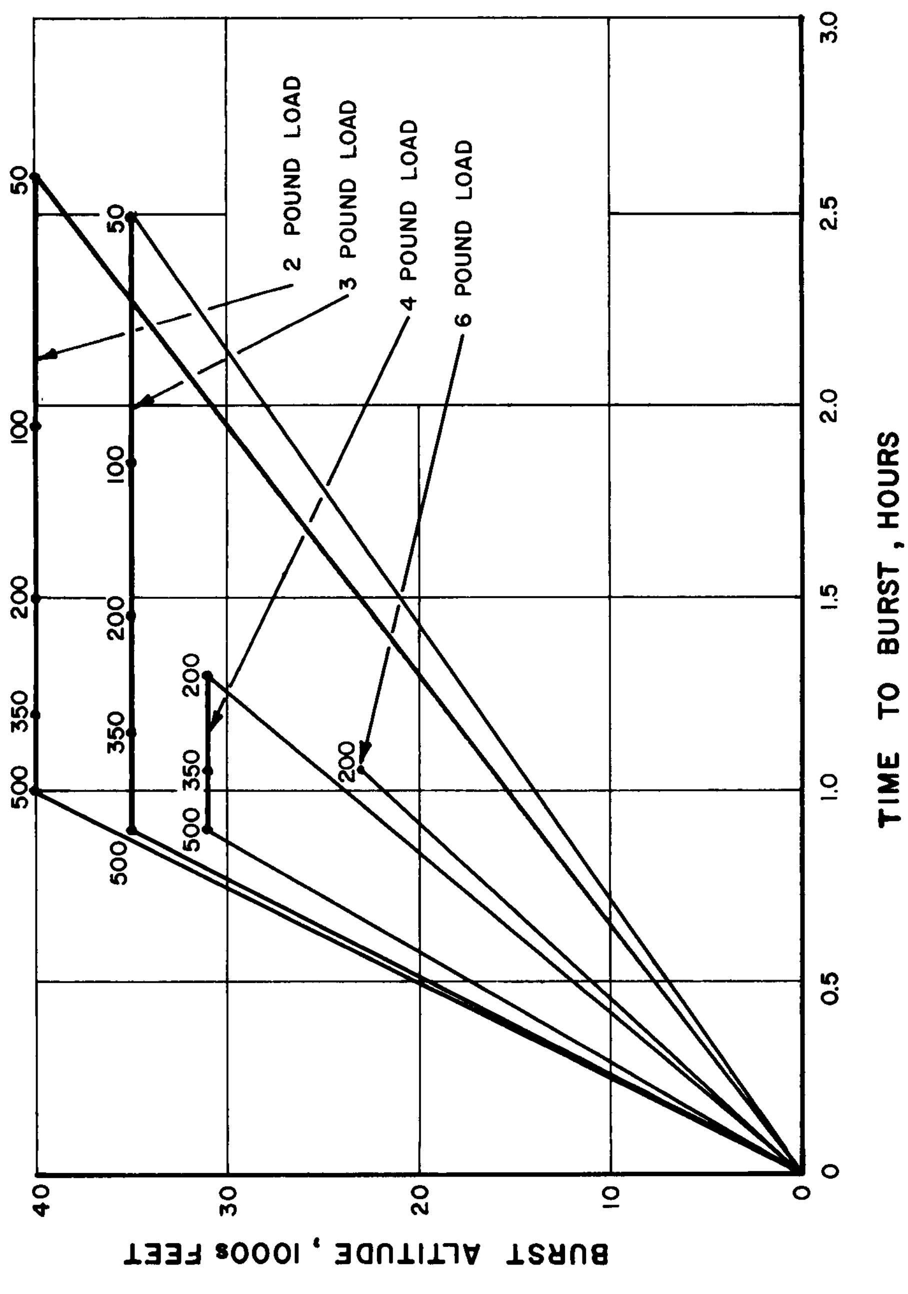


Figure 5. J-100 GRAPHICAL SUMMARY OF TIME TO BURST AND BURSTING ALTITUDE OF THE PAYLOADS AND FREE LIFTS REPORTED ON

Table 1. J-100 Performance Table
Incremental Time Factors

J-100 DAYTIME FLIGHTS

	Free Lift (Grams)	Burst Altitude	Rate of Rise (ft/min)	Time to Burst (hours)
	50	40,000	260	2.59
	100	40,000	340	1.95
2 Pound Load	200	40,000	440	1.52
	350	40,000	560	1.19
	500	40,000	650	1.03
	50	35,000	230	2.51
	100	35,000	320	1.84
3 Pound Load	200	35,000	400	1.45
	350	35,000	510	1.14
	500	35,000	630	0.92
	200	31,000	400	1.30
4 Pound Load	350	31,000	500	1.03
	500	31,000	560	0.92
6 Pound Load	200	23,000	370	1.04

J-100 NIGHT-TIME FLIGHTS

3 Pound Load	200	35,000	330	1.79

Table 1. J-100 Performance Table
Incremental Time Factors

J-100 DAYTIME FLIGHTS

Time Spent Between Altitude Levels (hours)

0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
0.42	0.38	0.36	0.33	0.31	0.29	0.26	0.24
0.24	0.28	0.27	0.25	0.24	0.23	0.23	0.21
0.19	0.21	0.20	0.20	0.19	0.18	0.18	0.17
0.14	0.16	0.16	0.15	0.15	0.15	0.14	0.14
0.10	0.13	0.14	0.14	0.13	0.13	0.13	0.13
0.44	0.42	0.38	0.36	0.33	0.30	0.28	
0.30	0.29	0.27	0.26	0.25	0.24	0.23	
0.21	0.21	0.22	0.21	0.21	0.20	0.19	
0.16	0.18	0.17	0.17	0.16	0.15	0.15	
0.11	0.13	0.14	0.14	0.14	0.13	0.13	
0.21	0.21	0.22	0.21	0.21	0.20	0.04	
0.16	0.17	0.17	0.17	0.17	0.16	0.03	
0.14	0.16	0.15	0.15	0.15	0.14	0.03	
0.21	0.22	0.23	0.23	0.15			

J-100 NIGHT-TIME FLIGHTS

0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
0.24	0.26	0.27	0.26	0.26	0.26	0.24	

Table 2. J-100 Performance Table
Incremental Rates of Rise

J-100 DAYTIME FLIGHTS

	Free Lift (Grams)	Burst Altitude	Rate of Rise (ft/min)	Time to Burst (min)
	50	40,000	260	155
	100	40,000	340	117
2 Pound Load	200	40,000	440	91
	350	40,000	560	71
	500	40,000	650	62
	50	35,000	230	150
	100	35,000	320	110
3 Pound Load	200	35,000	400	87
	350	35,000	510	68
	500	35,000	630	55
	200	31,000	400	78
4 Pound Load	350	31,000	500	62
	500	31,000	560	53
6 Pound Load	200	23,000	370	62

J-100 NIGHT-TIME FLIGHTS

3 Pound Load	200	35,000	330	107

Table 2. J-100 Performance Table
Incremental Rates of Rise

J-100 DAYTIME FLIGHTS

Incremental Rate of Rise (ft/min)

0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
200	220	230	250	270	290	320	340
340	300	310	330	340	360	370	390
440	400	410	420	430	450	470	500
580	520	530	540	550	560	580	590
800	650	610	610	620	630	640	640
190	200	220	230	250	280	300	
280	290	300	310	320	340	360	
400	400	380	390	400	410	430	
520	470	480	500	520	540	560	
750	640	580	600	610	620	630	
400	390	380	390	400	420	440	
520	480	480	480	500	530	560	
600	530	540	550	560	580	600	
400	380	370	370	370			

J-100 NIGHT-TIME FLIGHTS

350	330	310	320	320	340

MATCHING LEAFLET DRIFT TO BALLOON TRAJECTORY

To bring a balloon to a point in space is a useful accomplishment. However, it is not nearly so meaningful as to match a leaflet drift to a balloon trajectory such that the total problem from launch to impact is worked out. Since the balloon's trajectory begins at the launching site, a consideration of the types of launching possibilities is in order before taking up examples of the entire problem from launch to impact.

There are three distinct types of launching possibilities:

(1) Launching from a single fixed site

(2) Launching from the best suited one of several fixed sites

(3) Launching from a mobile unit which could be either land-based or ship-based.

Mobile Launch Site - The most adaptable type of launch is, of course, the mobile unit. This is particularly true for the ship-based operation which can range up and down the coast and closer or further away from the target as the case may require, all the time in a very nearly ready state to launch. The land-based mobile site will not have as much flexibility in choosing its launching site and may have to contend with certain environmental factors (such as a curious populace) as well. Also, the setup time will usually be longer than for the ship-based launch.

Both wind direction and magnitude are important for a mobile launch; however, if the magnitude is greater or less than can be conveniently compensated by altering the payload and free lift to suit[1], a change in distance between the launch site and target can readily be effected instead. Likewise, a change in position can be made to take best advantage of the wind direction.

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[1] This might occur in cases where the leaflet carriers were preloaded and it would not be easy to alter the payload quickly.

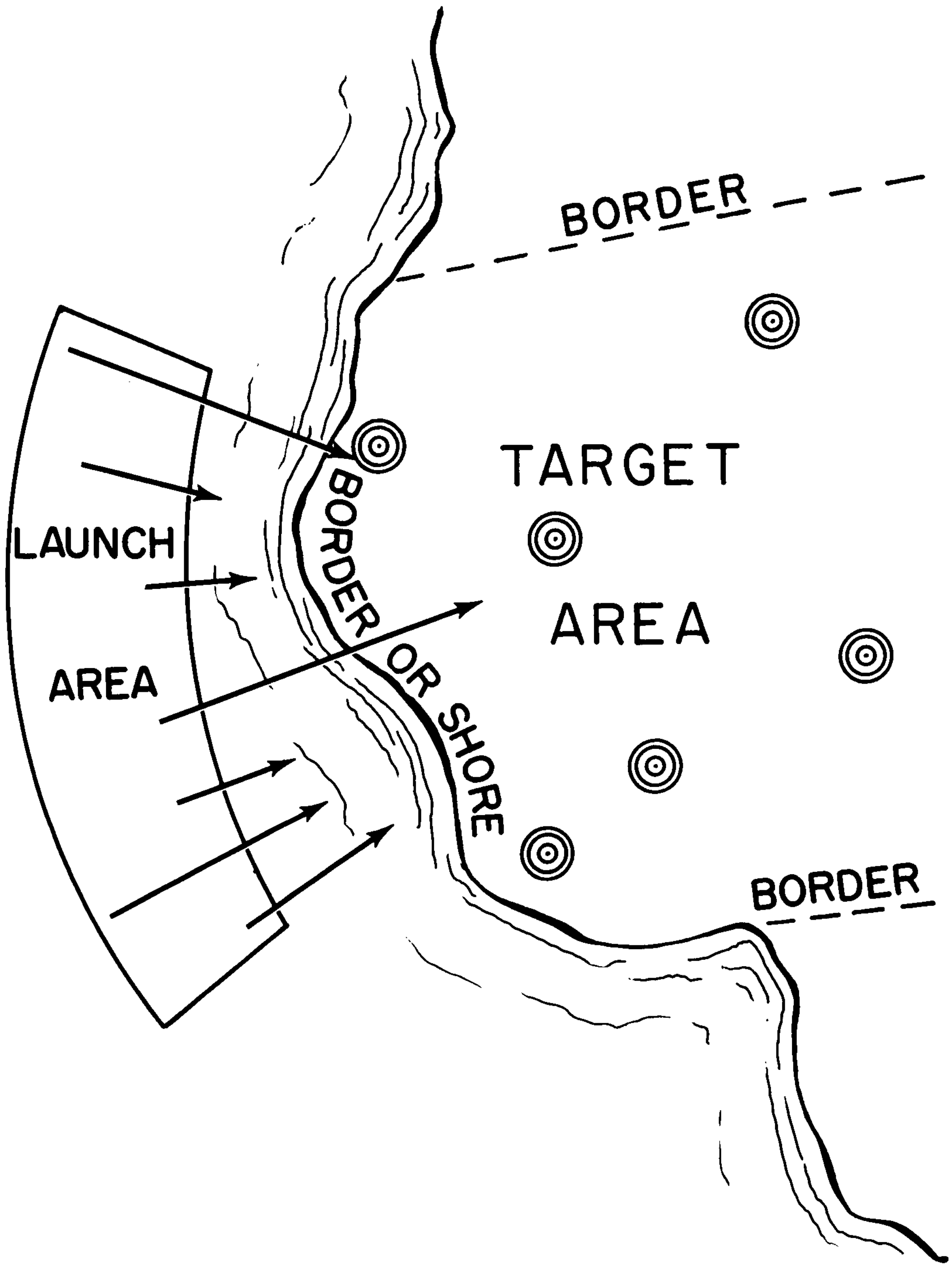


Figure 6. MOBILE LAUNCH UNIT AFFORDS DISTANCE AND DIRECTIONAL ADAPTABILITY

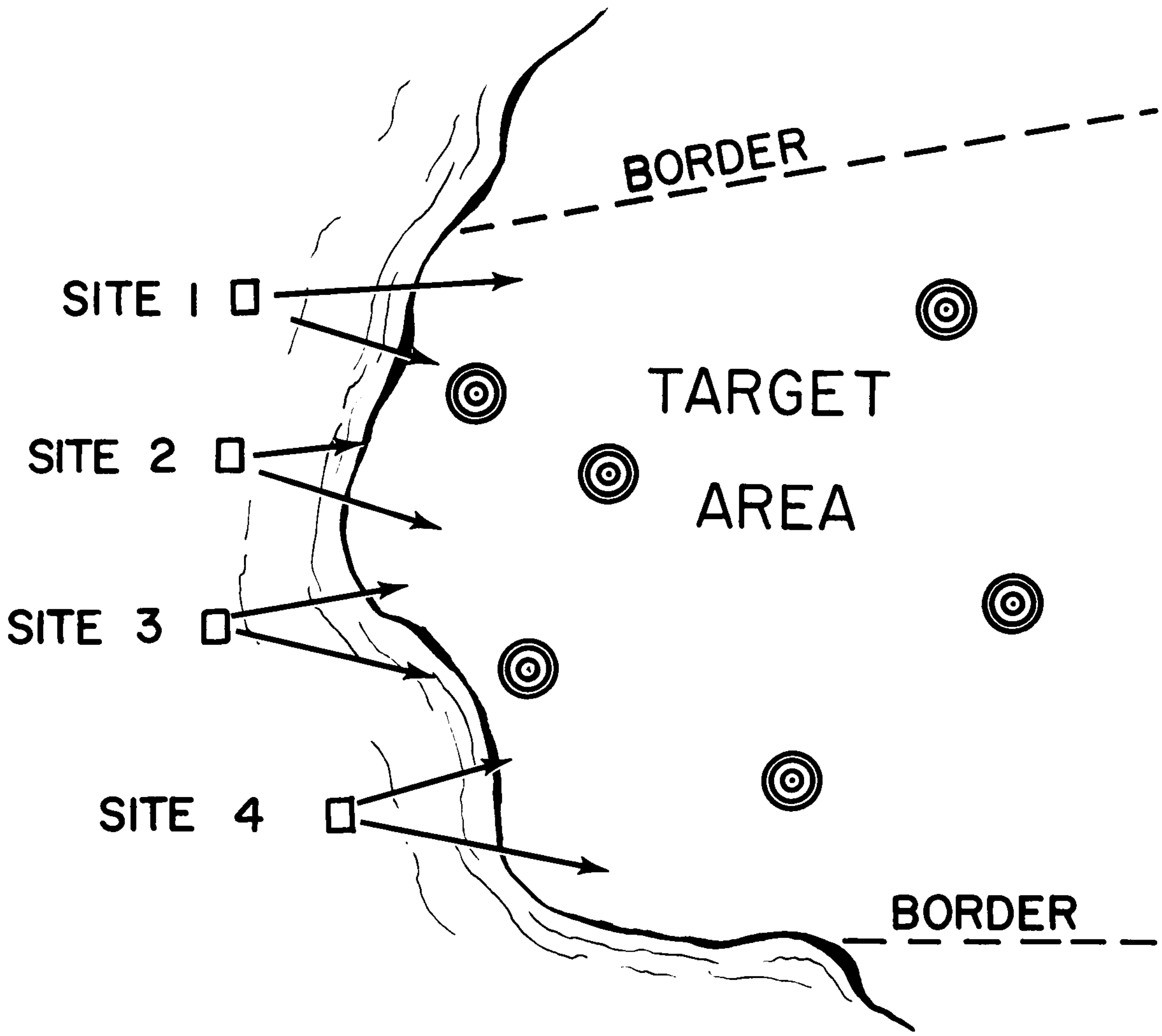


Figure 7. MULTIPLE LAUNCH SITES AFFORD DIRECTIONAL ADAPTABILITY

Multiple Fixed Launching Site - The next most adaptable arrangement is the multiple fixed site situation. The most common setup here is to have a series of sites strung out along the border but not appreciably set back from it. Directional versatility results from such an arrangement, with distance flexibility dependent upon intelligent choice of the payload, free lift, and leaflet.

Single Fixed Launching Site - Launching from a single fixed site is, of course, the most difficult problem. It is somewhat eased, however, if there is more than one target as is almost always the case. High winds can be used for the longer-distance targets, while low winds can be used for those nearer. Directionally, as long as the wind is blowing into the target area, a suitable target can probably be found. Moreover, the problem is not quite as severe as it may first appear since both the distance and direction may be altered, within limits, by selection of the most appropriate payload (which determines the burst altitude) and free lift (which controls rate of rise and therefore time to burst). This is illustrated by Figures 5 through 9, in which the leaflet characteristics are held constant, the purpose being only to show how a distance-directional versatility exists by using the balloon alone. Changing the leaflet would change the air time from release to impact and, consequently, the drift distance. The direction, however, would be virtually unaffected. Since the leaflet will usually be fixed well ahead of launch, alteration in the leaflet is not a real possibility for any given mission. Therefore, to emphasize achieving flexibility through change of the payload and/or free lift is more realistic.

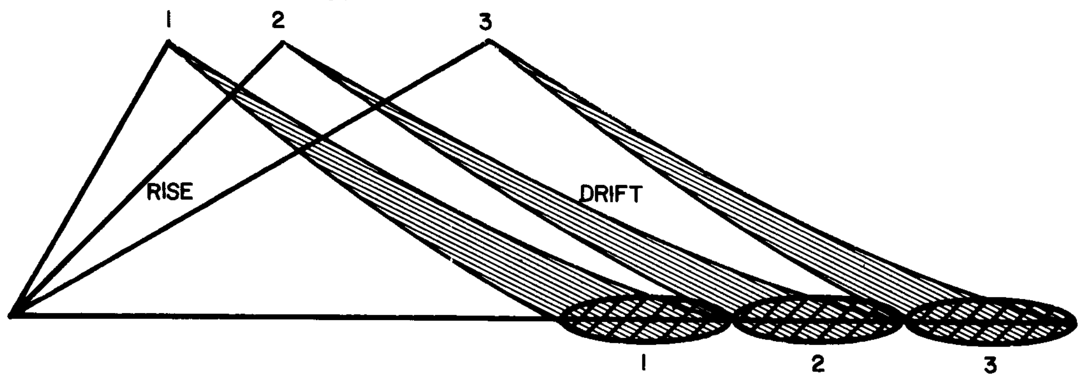
Figure 8 is a profile of the balloon rise to burst followed by the leaflet descent to impact. The burst altitude is held constant, and therefore the difference in the distance from launch to impact is seen to be solely a result of the longer or shorter time the balloon takes to reach the release altitude, depending on the free lift imparted to the system.

Figure 9 is again a profile of the balloon rise to burst followed by the leaflet descent to impact. Here, however, the rate of rise is held constant and the payload is varied. The balloon with the lighter load, of course, bursts at a higher altitude, resulting in a greater distance from launch to impact.

Figure 10 is a top view of the profile shown in Figure 8. The result is a difference in distance with no change in direction.

Figure 11 is a top view of the profile shown in Figure 9. It is seen here that due to the small amount of shear between the two release altitudes (in this case about 7^{o}), not only does a difference in distance result, but also a small change in direction.

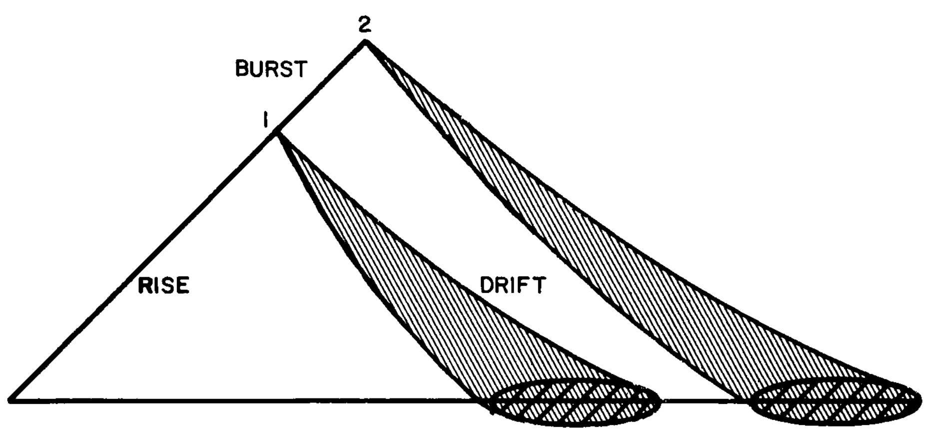
Figure 12 is also a top view of the profile shown in Figure 9. A change in wind direction between the two release altitudes of 30^{o} was selected for this example. This results in a significant change in overall direction. In addition, of course, the higher burst altitude yields a longer distance from launch to center of impact.



BALLOON BURST = CONSTANT

1 = FAST RISER
2 = AVERAGE RISER
3 = SLOW RISER

Figure 8. RATE OF RISE PROFILE



RATE OF RISE = CONSTANT

1 = HEAVY LOAD RELEASE
2 = LIGHT LOAD RELEASE

Figure 9. RELEASE ALTITUDE PROFILE

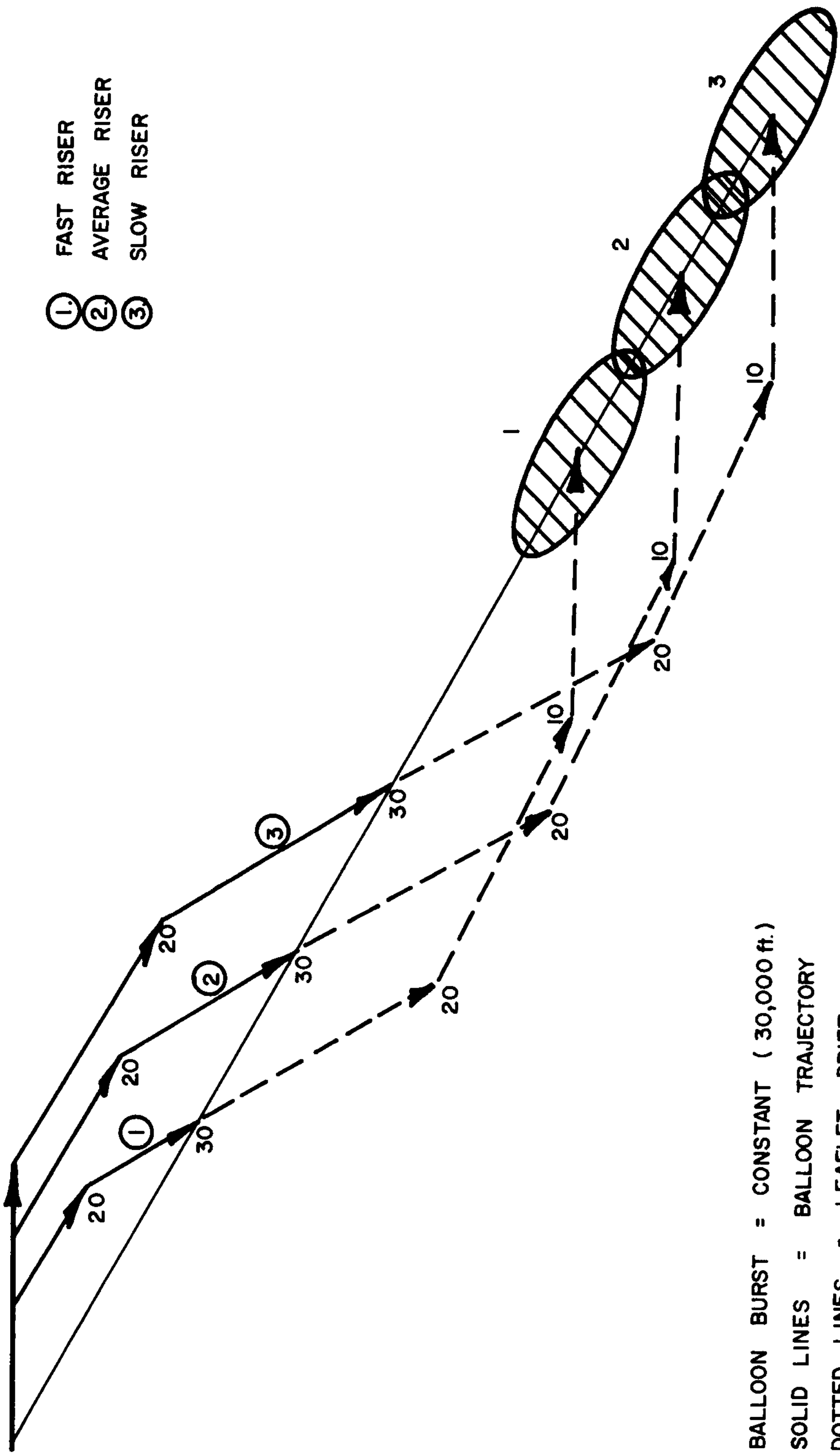


Figure 10. RATE OF RISE, TOP VIEW

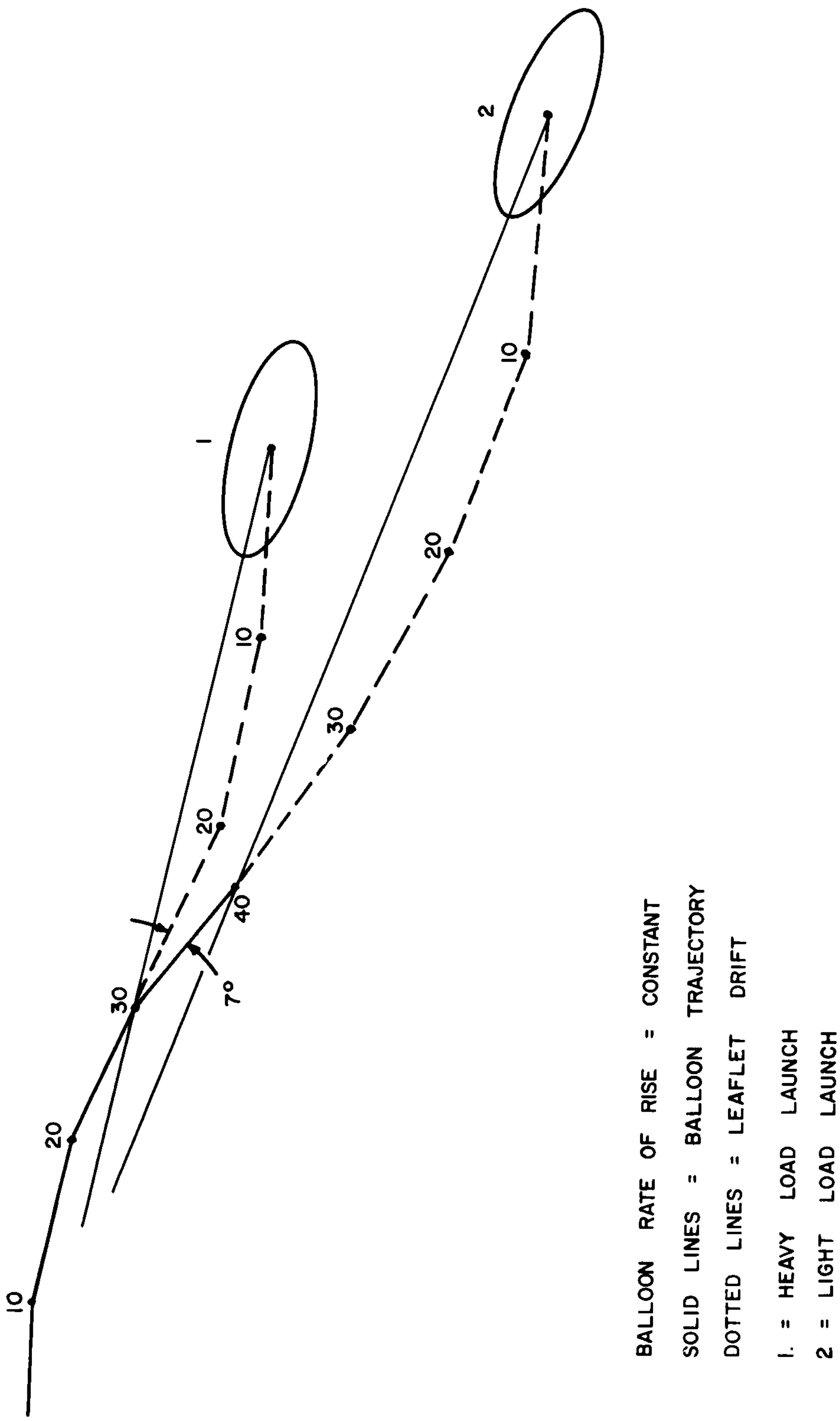


Figure 11. BALLOON BURST, TOP VIEW
(Wind in Negligible Shear, approx. 7 degrees)

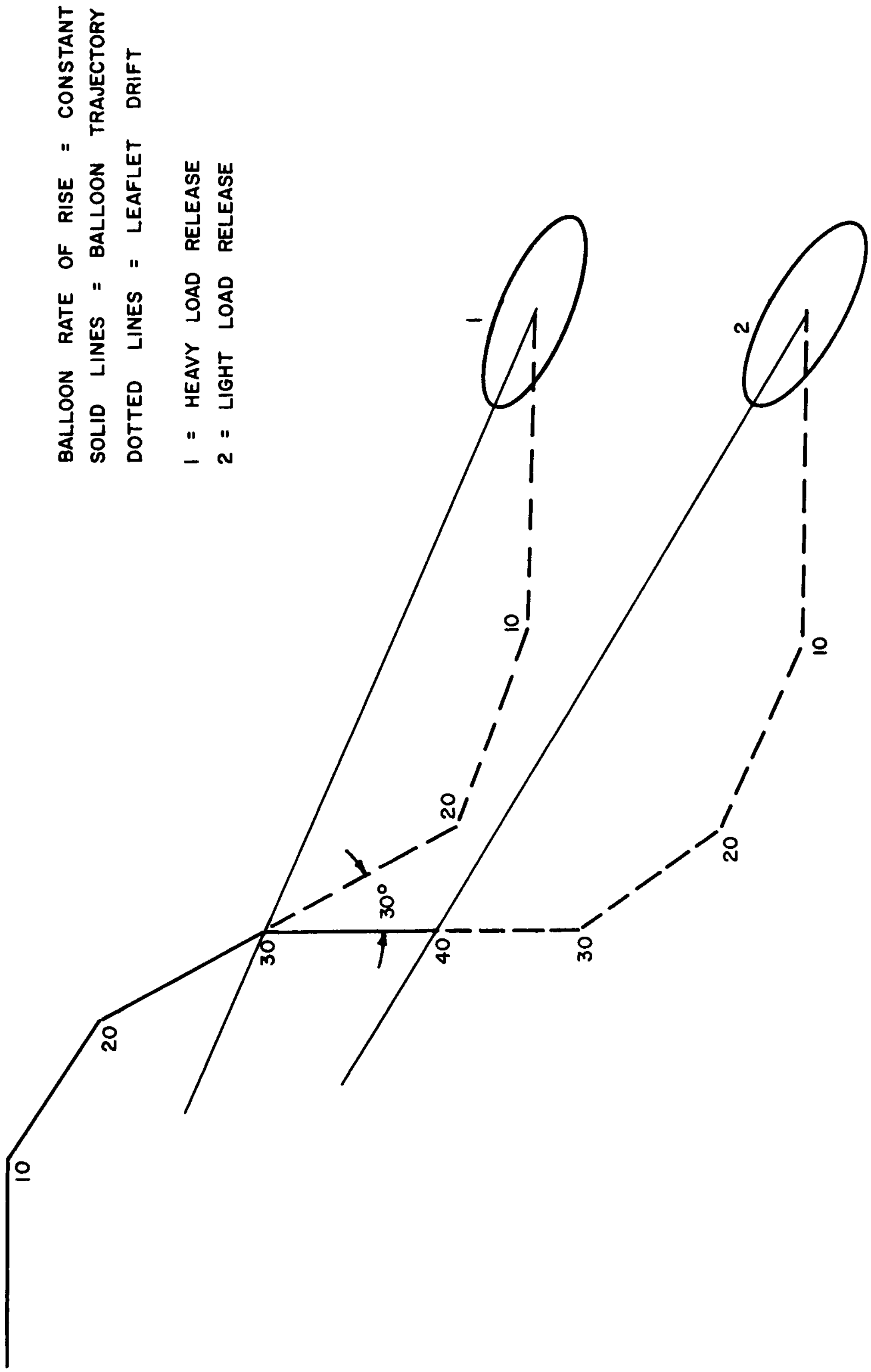


Figure 12. BALLOON BURST, TOP VIEW
(Wind in 30° Shear)

To summarize then:

(1) The slower the rate of rise, the longer the distance from launch to burst (and consequently impact).

(2) The smaller the payload the higher the burst altitude and consequently the longer the distance from launch site to point of burst and center of impact. (An exception would occur when there is a reversal in the winds in the higher altitudes. This is most unlikely for the great majority of cases, however.)

(3) When there is wind shear, a difference in release altitude will alter the direction. A difference in rate of rise, however, leaves the direction unaffected.

The launching possibilities described above apply to the multiple site and mobile unit launches as well. They are less critical for these, however, and therefore the examples which follow will be for the most difficult case, the single fixed site. Application of the method to the other two cases should be obvious.

Example 1 - As a first example, assume that an autorotating leaflet has been selected with a ground rate of descent (V_o) of 1.4 feet/second, aspect ratio of 2.75, length of 6 inches, and a paper weight of 16 pounds; and that the leaflets have been printed up and delivered to the site awaiting appropriate winds. It will be noted that this particular leaflet is a long air-time leaflet (see Leaflet Table A-1) and therefore suited to a long-distance drift. It is assumed that the choice was made deliberately, the target being 210 nautical miles from the fixed site at an angle of 70° measured from due North[1].

A computation form sheet corresponding to that which has been provided for working up leaflet drift is needed for working up balloon trajectories also.

The first step is to fill in the wind speeds and directions reported for each 5000-foot increment. This is done both on the balloon and leaflet computation form sheets.

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1 This corresponds to a wind blowing from 70° plus 180° or 250°

The next thing is to work up the leaflet drift, starting from the target and working it back in space. This is done by computing the horizontal drift distance in each 5000-foot altitude increment (by multiplying the time factors, in this case found in Table A-2, by the corresponding wind speed). Starting with the altitude increment 5-0 and proceding on up through 40-35, the successive drift vectors are plotted out, the head of the 5-0 vector being on the target and the subsequent vectors being laid out with their heads at the tail of the preceding one:

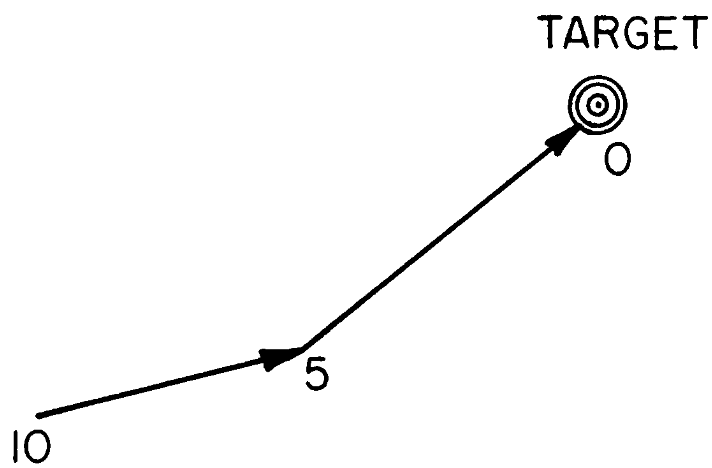

Figure 13. LEAFLET DRIFT VECTORS

If the target and the launch site have been connected by a straight line (that is, the vector of length 210 nautical miles at an angle of 70° measured from due north) on the same plot that the leaflet drift is worked up on, it is possible to roughly gauge the best release altitudes. The criterion for judging is this: the further any point on the drift vector is away from the line connecting target to launch site, the less attractive is that particular altitude level for leaflet release. The reason for this rule is that, again roughly speaking, the resultant balloon vector from launch to burst will have very nearly the same azimuth (i.e., direction) as will the resultant leaflet drift vector. So if a release altitude is selected which has its vector tail close to the launch-target connecting line, substantial target coverage will result.

In this example, release at either 30 or 35 thousand feet would ensure reasonable coverage, while the 40 thousand foot vector strays too far away from the connecting line. It would therefore be prudent to select either the 3-pound load (35,000-foot burst) or the 4-pound load (31,000-foot burst). But in order to make the choice it is necessary to consider the distances involved. Measuring from the launch site to these two possible release altitudes finds the 35,000-foot point just under 80 nautical miles from the site, and the 31,000-foot point about 100 nautical miles from the site. Looking now at the wind speeds and direction, it is seen that the winds in the 15-35 thousand foot levels are the only winds which have their direction primarily in the intended distance of travel. Moreover, the wind speeds in the lower altitudes are low enough in this case so as not to materially alter the situation if the 15-35 level is selected for particular emphasis. Focusing attention on the 15-35 winds then, it is seen that the average wind speed from 15-30 is 47 knots while from 15-35 it is 48 knots. The balloon then would have to spend over 2 hours (2 x 47 = 94 knots) in the 15-30 level to traverse the necessary 100 miles, while it would only have to spend slightly less than 1-1/2 hours (1.5 x 48 = 72 knots) in the 15-35 thousand foot level. Obviously the latter altitude level is the correct choice, and the 3-pound load is therefore the payload to fly.

Now the free lift must be selected. Focusing again on the 15-35 thousand foot levels, it is seen from J-100 Table 1 that only the 50-gram free lift will allow the balloon to remain at these altitudes for anywhere near 1-1/2 hours (50 grams of free lift will keep the balloon in these altitudes for 1.27 hours, while 100 grams of free lift reduce this to 0.98 hours). The choice is easily made then to fly a 3-pound load with 50 grams of free lift.

Returning to the balloon computation form sheet, the time factors are filled in for this payload - free lift combination and the horizontal drift distance computated for each altitude increment by multiplying the time factor by the corresponding wind speed.

This done, the balloon trajectory may be plotted.[1] Plotted out it is found that the balloon will burst at a distance of 65 nautical miles from the launch site and at an angle of about 70° from true north.

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[1] It is suggested that this be done on a fresh map, piece of graph paper, or overlay, rather than on the same sheet the leaflet descent vectors were worked on.

Now the leaflet drift vector may be added to the balloon drift to find the center of impact. Rather than re-plot the entire leaflet descent for the various levels, it is easier to measure the distance and direction of the resultant leaflet drift vector and draw it in. In this case, the resultant is 132 nautical miles at an angle of 253° (73° from true north). The overall distance from launch to impact is therefore 195 nautical miles at an angle of 72° from true north.

By working up the ground pattern dimensions from the incremental plot of the leaflet drift vectors and according to the instructions in the Chapter on Leaflet Release Specifications, it is found that an ellipse with major axis of 34 nautical miles (39 statute miles) results. Drawing this in, it is seen that the target will largely be covered although the center of impact will be somewhat short of the target center.

Example 2 - As a second example, assume that a non-autorotating leaflet with a ground rate of descent of 3.0 feet/second, length of 8-1/2 inches, aspect ratio of 1.50, and paper weight of 13 pounds has been selected. It will be noted that this represents a medium-fast descending leaflet and is therefore most appropriate for reasonably close targets. Assume that the target meets this requirement of proximity, it being 105 nautical miles from the fixed site. The azimuth is 130° from true north[1].

The winds are recorded on the J-100 computation Form Sheet and the Leaflet Form Sheet. The procedure for making the calculations, plotting the vectors, selecting the payload and free lift, and determining the pattern size are as follows:

(1) Follow steps 1-6 as described in the Section entitled Leaflet Descent and Dispersion which covers recording of the leaflet characteristics and computing the horizontal drift in each altitude increment.

(2) Plot the horizontal drift vectors on the graph paper, starting from the target (the 5-0 vector) and working back to altitude (ending with the 40-35 vector).

(3) It is seen that for this example the closest approach to the target-launch site connecting line are the drift vectors between the 35 and 25-thousand foot altitudes. The choice is

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1 Corresponding to a wind blowing from 130° + 180°, = 310°

therefore between the three-pound load (35,000-foot burst), the four-pound load (31,000-foot burst) and the six pound load (23,000-foot burst).

(4) Measure the distance from launch to burst for the three possible burst altitudes. This turns out to be 40, 47, and 71 nautical miles for the three burst altitudes of 35, 31, and 23 thousand feet, respectively. As most of the balloon drift in the direction of the target will be in the altitudes above 15 thousand feet (the average winds here being about 50 knots), it is on this part of the flight that attention must be focused as far as selection of the payload and free lift is concerned. For the six-pound load, the balloon would have to spend about 1-1/2 hours (1-1/2 x 50 = 75) in the 15-23 thousand foot levels to get the necessary distance; the four-pound load would need to spend just 1 hour (1 x 50 = 50) in the 15-31 thousand foot levels to drift the needed distance; and the three-pound load would require just over 3/4 of an hour (3/4 x 50 = 37) to drift the needed distance.

(5) Looking to the J-100 Performance Tables it is seen that the six-pound load falls far short of the required time, the four-pound load falls somewhat short, and the three-pound load with 200 grams of free lift yields just the necessary time.

(6) Fill in the time factors for the three-pound load, 200-gram free lift combination on the balloon computation form sheet, and compute the balloon drift for each successive altitude increment.

(7) Plot the balloon trajectory on a new sheet of graph paper, and measure the resultant balloon vector from launch to burst (in this case 44 nautical miles at 313°) and record this value on the balloon computation form sheet.

(8) Measure the leaflet net drift vector and azimuth from release to impact (66 nautical miles - 312°), and lay out this vector from the point of balloon burst on the new graph paper.

(9) Measure the maximum deviation of the leaflet drift normal to the net drift vector (8.5 nautical miles), and record this value together with the leaflet net drift vector on the leaflet computation form sheet.

(10) Compute the major axis and minor axis of the ground pattern ellipse (major axis = 20 nautical miles, minor axis = 9 nautical miles), and draw the impact area in with the center of the ellipse at the point of impact. It is seen that the target is partly but not completely covered by the leaflet pattern.

To recapitulate the entire J-100 balloon[1] - leaflet drift problem, the procedures involved are as follows:

A. Choice of the leaflet

The leaflet size and weight are selected on the basis of the air time[2] desired, what dispersion is wanted, and how much space is needed to print the leaflet message.

Generally speaking, leaflets with a long air-time are those which have a ground rate of descent (V_o) of 2.0 feet/second or less. This corresponds to the autorotating type of leaflet. Leaflets with a medium air time are those with a ground rate of descent (V_o) between 2.0 and 3.0 feet/second. Many non-autorotators and a few autorotators fall in this category. Finally, a short air time results from leaflets with a ground rate of descent (V_o) of 3.0 feet/second and greater. Only non-autorotating leaflets fall in this category.

Knowing generally what rate of descent and leaflet size and weight are desired, a particular leaflet possessing the desired characteristics can be quickly selected by reference to the Leaflet Drift and Dispersion instructions. Table G-3 lists the ground rate of descent for

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1 Or other rubber balloon such as the J-9-10-300

2 Drift distance is equal to the product of the wind velocity and the air time. Holding wind velocity constant then, a long drift distance will result from a long air time and a short drift from a short air time.

various leaflet sizes and weights and distinguishes between autorotators and non-autorotators as well. Table G-4 lists the variation coefficient ($R_T/\bar{T}_o$) for each leaflet size and weight combination, and, consequently, the desired dispersion can be selected as well. A reasonably tight leaflet pattern results from a coefficient of variation of less than 0.40, and a broad dispersion results from a coefficient greater than 0.40.

In actual practice, the size-weight-air time-dispersion characteristics will have to be compromised somewhat in order to choose the optimum leaflet. As long as the general requirements of each is satisfied, however[1], the problem can be solved.

Once the leaflet is selected, the characteristics are recorded on the leaflet computation form sheet.

B. Obtain the Forecast of the Winds

As pointed out earlier, the meteorological problems of forecasting are outside the scope of this handbook. It should be obvious, however, that good, accurate forecasting is essential. To attempt to conduct a controlled leafleting operation without this knowledge of the winds is a waste of time and effort. It is presumed throughout this handbook that provision for the meteorological problem is made. The forecast winds are recorded both on the leaflet computation as well as the balloon computation form sheet.

C, D, E, and F are combined in a stepwise procedure as each succeeding step is related to those preceeding. The procedures involved are:

C. Work out the leaflet drift (steps 1-4)

D. Select the balloon payload and free lift (steps 5-8)

E. Work up the balloon trajectory, and affix the net leaflet drift vector to the point of balloon burst (steps 9-11)

F. Compute the ground pattern dimensions, and draw in the ellipse (steps 12-13)

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[1] Usually this will not be a serious problem as there will be a choice between several possible leaflets for most every requirement.

PROCEDURE

(1) List on the leaflet computation form sheet the appropriate time factors for the leaflet selected as found in Table A-2 or NA-2 depending on whether the leaflet is an autorotaror or non-autorotator.

(2) Compute the horizontal drift distance for each altitude increment by multiplying the wind speed by the time factor.

(3) Starting from the target, plot the horizontal drift vectors from the ground back to altitude.

(4) Find the points of closest approach of the leaflet drift vectors to the line connecting the launch site and target. If these points are in the 23,000 to 40,000 foot levels, they represent possible release altitudes for the leaflets.

(5) Measure the distances from the launch site to the possible release levels found in step 4.

(6) Compute the average wind in the direction of the target (these might be called the "primary" winds), and calculate the amount of time the balloon would have to spend in the altitudes of the primary winds for each of the distances measured in step 5. (It might be useful to recall here that: distance ÷ primary wind = time required.)

(7) Looking to the J-100 Performance Tables, select that combination of load and free lift which gives: (a) a desired release altitude as found in step 4 and (b) a corresponding necessary air time to achieve the necessary flight distance as computed in step 6.

(8) Record the time factors for the load and free lift combination selected on the balloon computation form sheet, and compute the balloon drift for each successive altitude increment.

(9) Plot the balloon trajectory on a new sheet of graph paper, beginning, of course, with the launch site and ending with burst.

(10) Measure the distance and azimuth of the net leaflet drift vector from release altitude to impact and lay out this vector with the tail being at the point of balloon burst and the head being the actual center of impact.

(11) Measure the maximum deviation normal to the net drift vector (as found on the first plot of the leaflet drift), and record this value together with that of the net leaflet drift vector (as found in step 10) on the leaflet computation form sheet.

(12) Compute the length of the major axis and minor axis of the ground pattern ellipse. Calculate the mean leaflet density.

(13) Draw out the size of the impact area as computed in step 12. The center of the ellipse is the center of impact.

Example No. 1

BALLOON COMPUTATION FORM SHEET

Date July 26, 1960
Time of launch 0700

Launch site 1
Target U

Height Increments (thsds of ft)	Time Factor (hours)	Wind Speed (knots)	Horiz. Drift Distance (naut. mi.)	Azimuth Angle (degree)
45-50				
40-45				
35-40		40		270
30-35	0.28	50	14.0	260
25-30	0.30	60	18.0	270
20-25	0.33	50	16.5	280
15.20	0.36	30	10.8	270
10-15	0.38	20	7.6	200
5-10	0.42	20	8.4	190
0-5	0.44	10	4.4	180

Payload 3 pounds
Free lift 50 grams

Burst altitude 35,000
Rate of rise 230 ft/min

No. of balloons launched 400
Total load launched 1200 pounds

Total horizontal drift vector, launch to burst 65 naut. mi., 250°

Example No. 1

LEAFLET COMPUTATION FORM SHEET

Height Increments (thsds of ft)	Time Factor (hours)	Wind Speed (knots)	Horiz. Drift Distance (naut. mi.)	Azimuth Angle (degree)
50-45				
45-40				
40-35	0.47	40	18.8	270
35-30	0.54	50	27.0	260
30-25	0.61	60	36.6	270
25-20	0.69	50	34.5	280
20-15	0.76	30	22.8	270
15-10	0.84	20	16.8	200
10-5	0.91	20	18.2	190
5-0	0.97	10	9.7	180

Date July 26, 1960
Time of launch 0700
Launch site 1
Target U
Release altitude 35,000 ft

Leaflet Data
Paper weight 16
Size 6" x 2.18"
Aspect ratio 2.75
$R_T/\overline{T}_o$ 0.26
V_o 1.4 ft/sec
Autorotator X
Non-autorotator
Leaflets/lb 893

Computations
Total horizontal drift vector from release to impact: 253^o, 132 naut. mi.
Maximum deviation normal to net vector: 35 naut. miles
Ground Dispersion Pattern:

Major Axis: 132 x 0.26 = 34 naut. mi. = 39 statute miles

Minor Axis: $\frac{35,000}{5280} + 35 \times 0.26$ = 16 naut. mi. = 18 statute miles

Area: $\frac{\pi}{4} \times 39 \times 18$ = 550 square miles

Payload 1200 pounds
Number of leaflets 1200 x 893 = 1,070,000
Mean density 1,070,000 ÷ 550 = 2000 leaflets/mi^2
Leaflets/mi^2 ÷ 2800 = leaflets/10,000 ft^2 = 2000 ÷ 2800 = 0.71 leaflets/10,000 ft^2

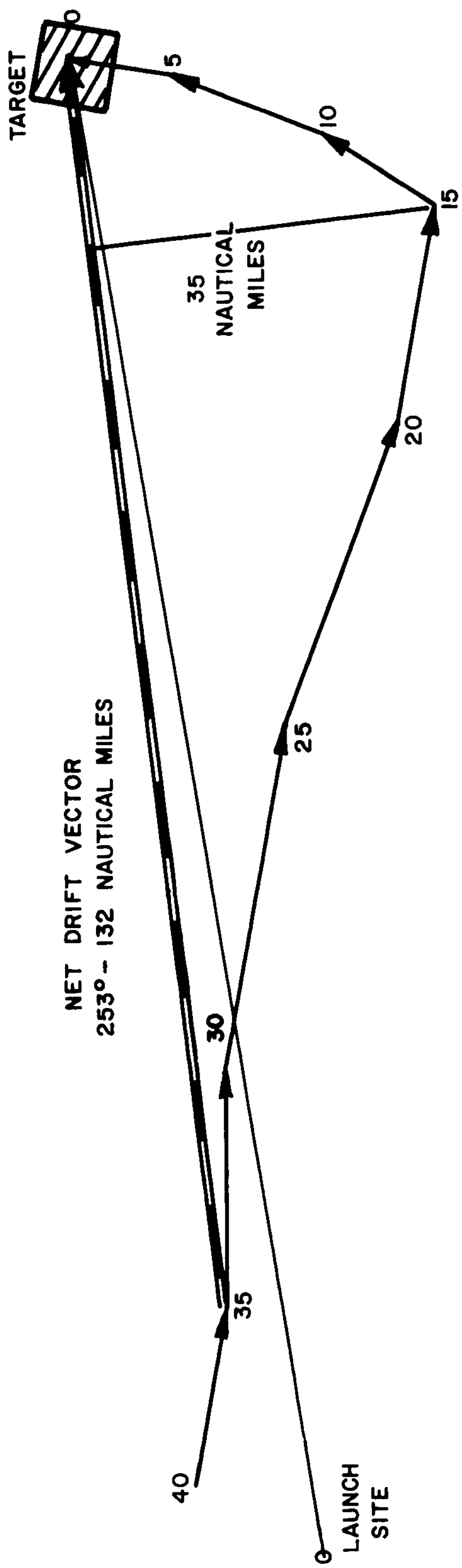


Figure 14. NET DRIFT VECTOR Example No. 1

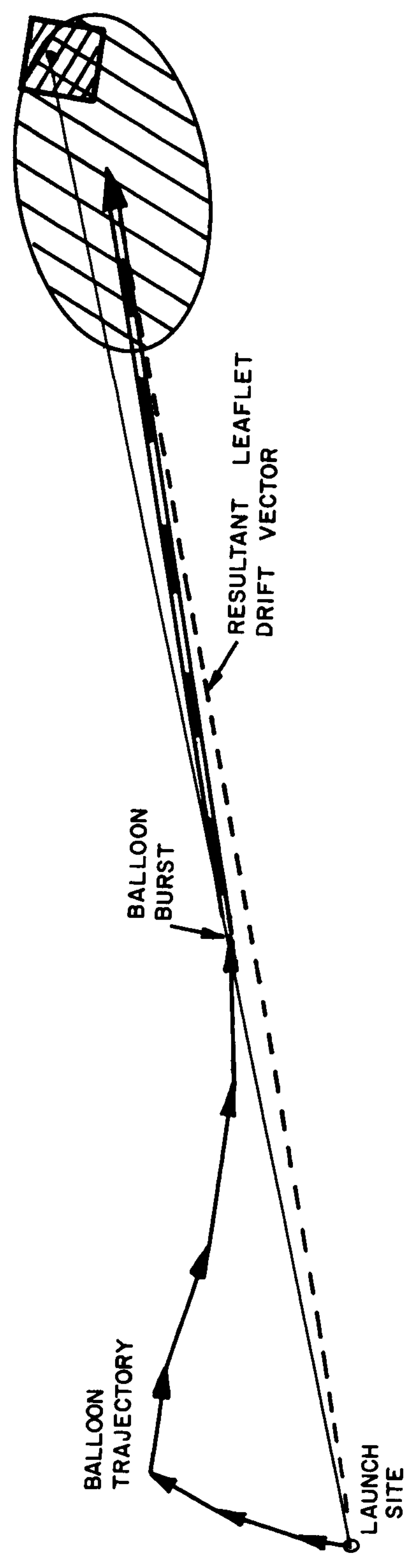


Figure 15. BALLOON TRAJECTORY AND LEAFLET DRIFT Example No. 1

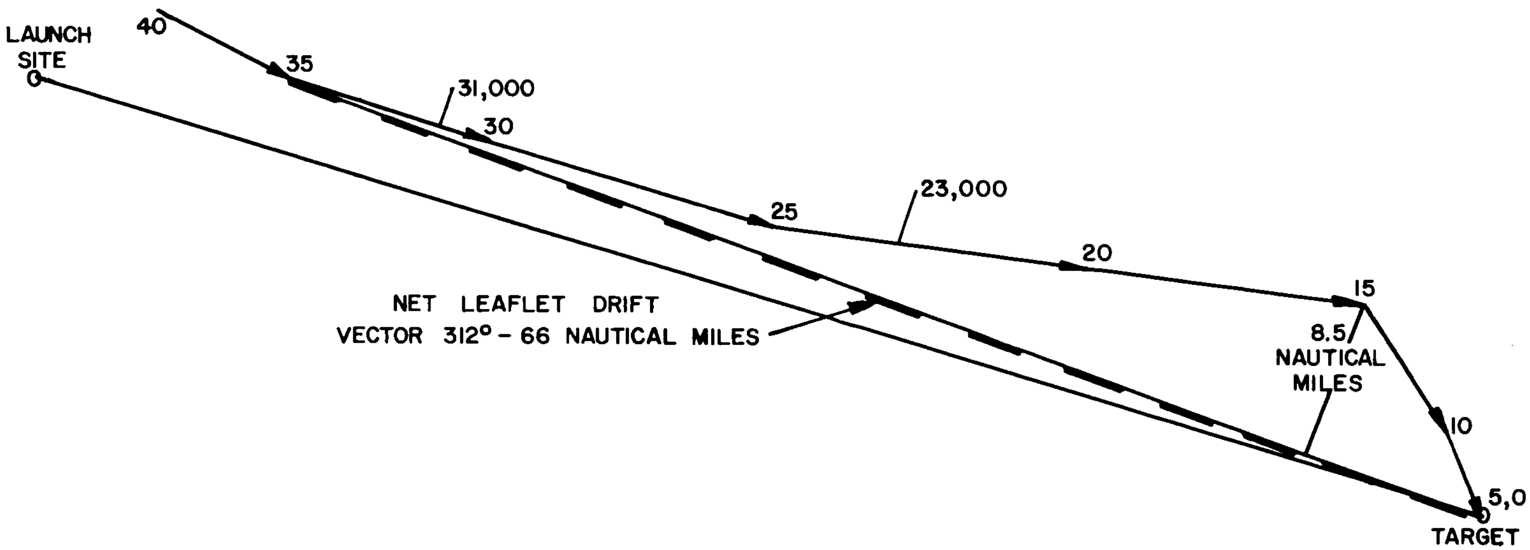


Figure 16. NET LEAFLET DRIFT VECTOR Example No. 2

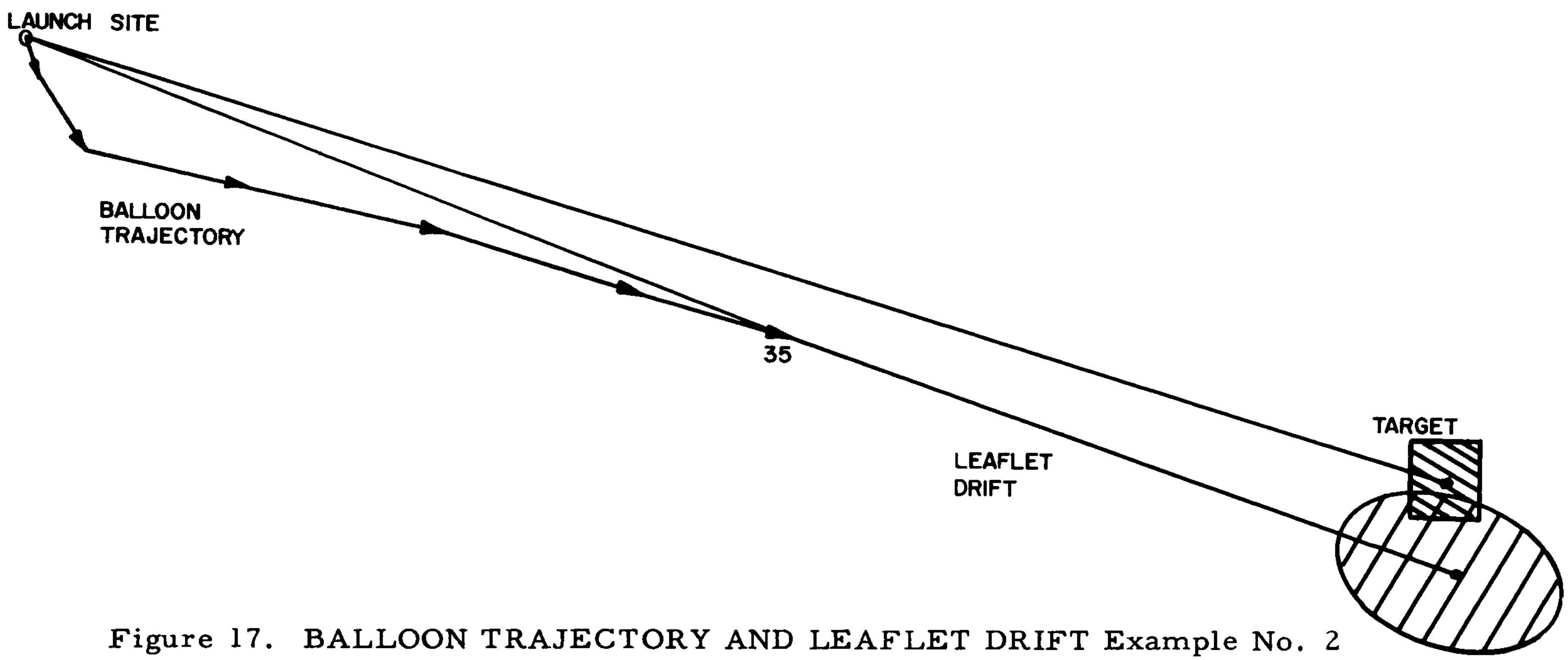


Figure 17. BALLOON TRAJECTORY AND LEAFLET DRIFT Example No. 2

Example No. 2

BALLOON COMPUTATION FORM SHEET

Date October 3, 1962
Time of launch 1200

Launch site # 1
Target Y

Height Increments (thsds of ft)	Time Factor (hours)	Wind Speed (knots)	Horiz. Drift Distance (naut. mi.)	Azimuth Angle (degree)
45-50				
40-45				
35-40		40		320
30-35	0.19	40	7.6	310
25-30	0.20	60	12.0	310
20-25	0.21	50	10.5	300
15-20	0.21	40	8.4	300
10-15	0.22	20	4.4	350
5-10	0.21	10	2.1	360
0-5	0.21	0	-	-

Payload 3 pounds
Free lift 200 grams

Burst altitude 35,000
Rate of rise 400 ft/min

No. of balloons launched 550
Total load launched 1650 pounds

Total horizontal drift vector, launch to burst 44 naut. mi., 313°

Example No. 2

LEAFLET COMPUTATION FORM SHEET

Height Increments (thsds of ft)	Time Factor (hours)	Wind Speed (knots)	Horiz.Drift Distance (naut.mi.)	Azimuth Angle (degree)
50-45				
45-40				
40-35	0.19	40	7.6	320
35-30	0.24	40	9.6	310
30-25	0.28	60	16.8	310
25-20	0.33	50	16.5	300
20-15	0.37	40	14.8	300
15-10	0.41	20	8.2	350
10-5	0.44	10	4.4	360
5-0	0.46	-	-	-

Date October 3, 1962
Time of launch 1200
Launch site # 1
Target Y
Release altitude 35,000 ft

Leaflet Data
Paper weight 13
Size 8-1/2" x 5.67"
Aspect ratio 1.50
$R_T/\bar{T}_o$ 0.31
V_o 3.0 ft/sec
Autorotator ____
Non-autorotator X
Leaflets/lb 299

Computations
Total horizontal drift vector from release to impact: 312°, 66 naut. mi.
Maximum deviation normal to net vector: 8.5 naut. miles
Ground Dispersion Pattern:

Major Axis 66 x 0.31 = 20 naut. mi. = 24 statute miles

Minor Axis $\frac{35,000}{5280} + 8.5 \times 0.31 = 9$ naut. mi. = 10 statute miles

Area $\frac{\pi}{4} \times 24 \times 10 = 190$ square miles

Payload 1650 pounds
Number of leaflets 1650 x 299 = 493,000
Mean density 493,000 ÷ 190 = 2590 leaflets/mi^2
Leaflets/mi^2 ÷ 2800 = leaflets/10,000 ft^2 = 2590 ÷ 2800 = 0.92 leaflets/10,000 ft^2

J-100 SPECIAL SITUATIONS

Several minor problems remain to be covered on the performance characteristics of the J-100; namely, flying into clouds, night flights, aged balloons, and use of dissociated ammonia for the lifting gas. These are discussed below.

Flying into Clouds - There is no important change in balloon performance for daytime flights in cloudy weather. The initial rate of rise is usually somewhat reduced, but the rate of rise during the latter part of the flight generally increases to yield an average rate of rise identical to that of a flight in clear sky.

Night Flights - There is no change in the burst altitude. The rate of rise is about 20 percent less than for daytime flights, therefore, the time spent between altitude levels should be multiplied by 1.2 to get the corrected time.

Aging - Balloons less than a year old do not exhibit any significant change in performance due to aging. For balloons over a year old, the process of crystallization becomes serious, and the film undergoes a stiffening and decrease in extensibility. The film may be reconditioned by immersing it in hot water (200°F) for several minutes. The reconditioned balloon should be suitable for use for over a month after the heating.

Use of Dissociated Ammonia - The burst altitude and rate of rise are about 20 percent less when dissociated ammonia is used for the lifting gas in place of hydrogen. The net result is that, while the bursting altitude is reduced, the total air time is unchanged.

BALLOON DISPERSION AND LEAFLET COVERAGE

Generally speaking, the J-100 can be expected to burst within ± 3000 feet of the reported burst altitude and to rise at a rate within ± 5 percent of the reported rate of rise. The result is that, rather than having a single point release, as is assumed in all of the example problems worked out, a variety of point releases actually develop. This tends to increase the leaflet spread beyond that described in the examples cited and consequently a lower leaflet density also results. The magnitude of the difference is shown schematically below:

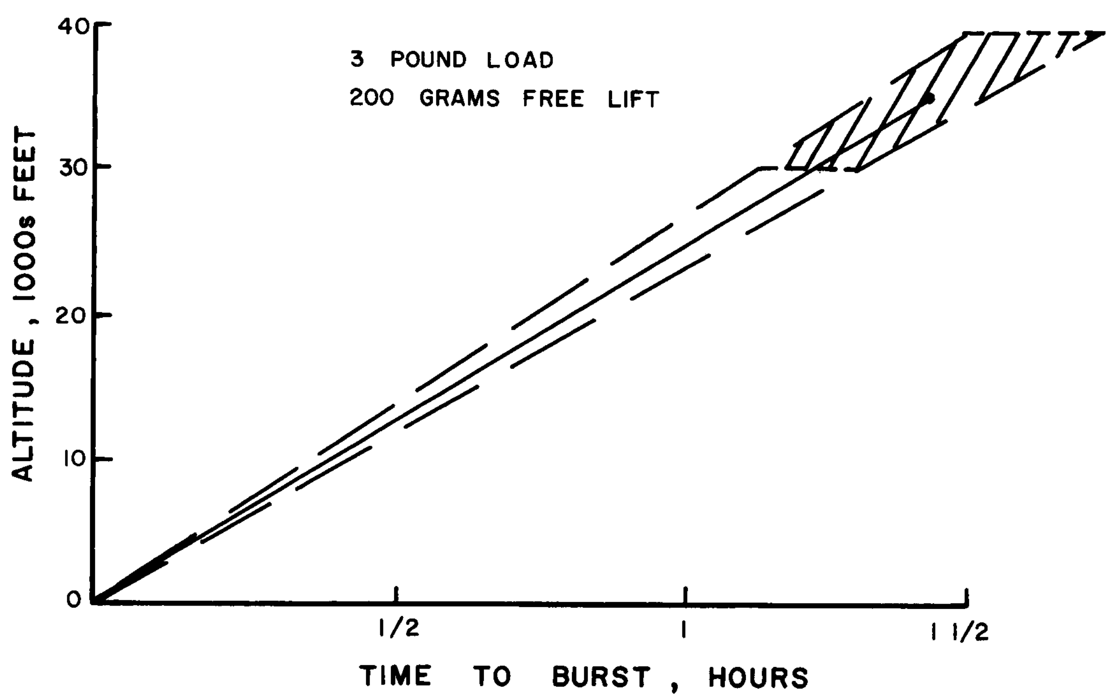


Figure 18. ZONE OF MULTIPLE RELEASE POINTS

It is seen that, for a slow riser, high burster, the time to burst may be increased by as much as 15 minutes; while for the low burster, fast riser, the time is 15 minutes less than the average. For an average wind at altitude of 40 knots, this will bring the far-bursting balloons some 10 nautical miles beyond the average release point, while the closer burster will be 10 nautical miles short of the average. The major axis of an ellipse calculated on the basis of a point release at 30 nautical miles must therefore be increased to 50 nautical miles (although the majority of the leaflets will probably be found within an axis length of 40 nautical miles).

Furthermore, variations in the wind speed and direction will probably occur while the launching is in progress. This will tend to increase the size of the ground pattern and decrease the leaflet density by spreading out the balloon bursts over a greater area. A variation of 3 degrees on both sides of the average wind vector would, for a balloon bursting 60 nautical miles from the launch site, cause a release variation of 3 nautical miles on either side of the average.

The minor axis of an ellipse calculated on the basis of a point release at 10 nautical miles should therefore be increased to 16 nautical miles (although the majority of the leaflets would be found within 13 nautical miles).

It might be taken as a general rule that the actual coverage will exceed the calculated coverage from a point release by about 30 percent in both the length and width of the ground pattern. This in turn yields an area 70 percent greater than the single point release ($1.3 \times 1.3 = 1.69$).

There is sometimes a tendency to use several payload-free lift combinations during the same mission in the hope of more effectively leafleting a target area. Except for very large missions this is probably inadvisable since the actual result will be a leaflet density so low that nowhere will there be a significant return, the leaflets being so widely scattered as to discourage any effort to find them. If the operator realizes that he has built into the system an inherent feature in this tendency toward spread discussed above, he should be less anxious to increase this still more, but rather should concentrate on adequate coverage of a single area on each specific mission.

BALLOON DELIVERY SYSTEM

J-100

(External Load)

OPERATING INSTRUCTIONS

Operating Instructions for BALLOON DELIVERY SYSTEM J-100 (EXTERNAL LOAD)

Introduction

This relatively simple system will deliver a payload varying from 2 to 6 pounds of leaflets at free lifts varying from 50 to 500 grams. A leafleting range from 50 to 250 miles is considered to be the capability of the J-100.

The instructions which follow are to guide you in the preparation of the J-100 System for launching. They should be followed exactly in step-by-step sequence for a successful flight. The steps are numbered serially and should be performed in the indicated order, particularly within each section.

Section 1 (Steps 1 to 5) describes the assembly of the balloon.

Section 2 (Steps 6 to 9) gives directions for the assembly and loading of the leaflet carrier.

Section 3 (Steps 10 to 13) deals with the inflation of the balloon.

Section 4 (Step 14) gives final directions for launching.

Section 5 is concerned with the handling of hydrogen.

CONTENTS

Section 1.

ASSEMBLY OF BALLOON

Section 2.

ASSEMBLY AND LOADING OF CARRIER

Section 3.

INFLATION OF BALLOON

Section 4.

LAUNCHING

Section 5.

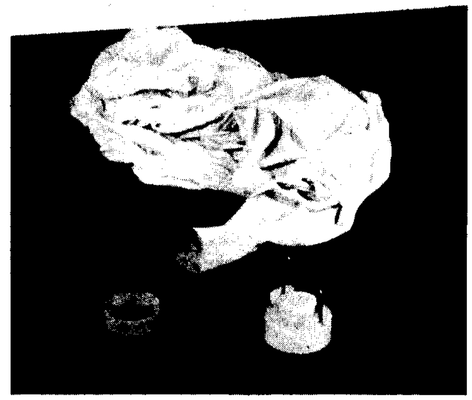
HYDROGEN HANDLING

Section 1.

ASSEMBLY OF BALLOON

STEP 1.

THE J-100, before assembly, consists of the neoprene balloon, the polyethylene ring, and the polyethylene closure. A cap is provided (shown in the right foreground attached to the closure) which can be readily snapped onto the closure or removed therefrom.

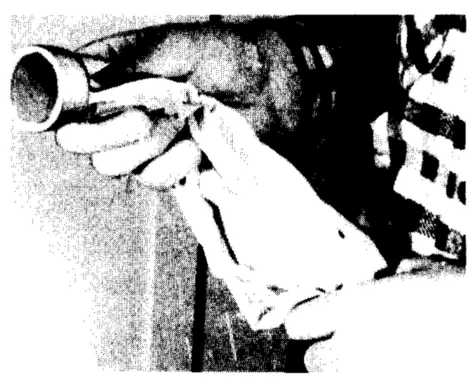


STEP 2.

SLIDE the ring over the neck of the balloon, as shown.

STEP 3.

FOLD the balloon neck back over the ring, as shown.



STEP 4.

FIT THE CLOSURE over the ring and folded-back skin of balloon, as shown, and snap the closure into place.

Insert a length of string through the two clearly visible load suspension hooks which are attached to the closure, and pull to make sure that the closure is snapped securely in place. When the fit is tight, remove this string.

STEP 5.

REMOVE the cap from the inflation opening, as shown.

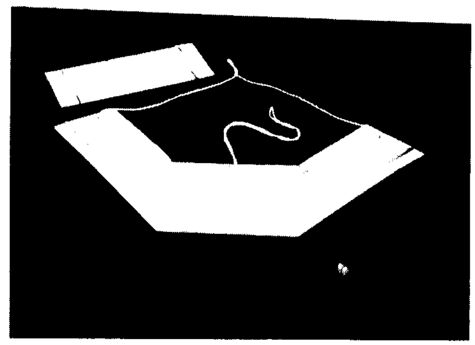
Section 2.

ASSEMBLY AND LOADING OF CARRIER

STEP 6.

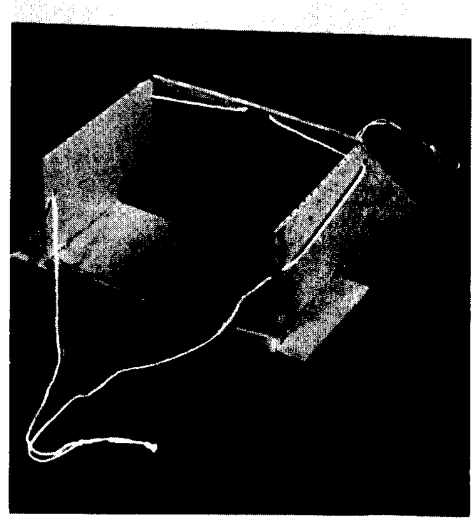
THE TWO CARDBOARD pieces of the leaflet carrier, with load suspension strings attached, are shown as received. Note the slots in these two pieces.

Fold the larger piece of cardboard along the two bend lines. Fold the smaller, rectangular piece of cardboard along the one bend line to form a small lip.



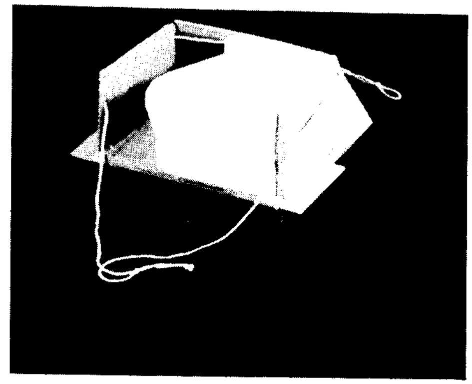
STEP 7.

ASSEMBLE the carrier by inserting the rectangular piece of cardboard into the slots in the folded larger piece. The carrier is shown completely assembled, and the small lip along the backside of the base is clearly visible. This lip is necessary to prevent loss of the load during severe oscillations of the carrier.



STEP 8.

LOAD the leaflets in the carrier. The carrier is shown partially loaded.



STEP 9.

SUSPEND the loaded carrier from the closure by inserting the suspension strings through the load suspension hooks as shown.

Attach the appropriate free-lift weight to the carrier.

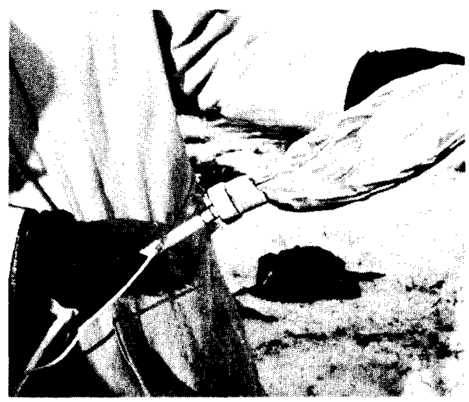
Section 3.

INFLATION OF BALLOON

STEP 10.

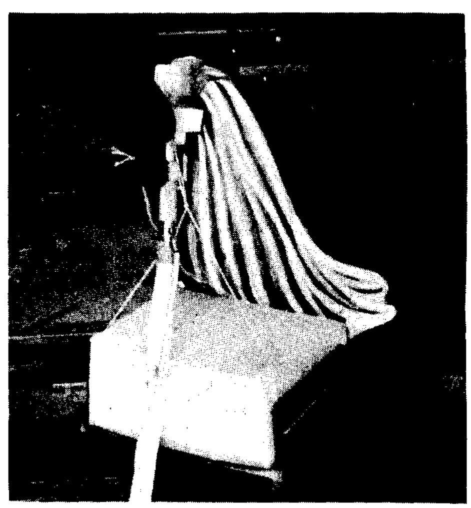
INSERT THE inflation nozzle into the inflation opening of the closure. This is simply a friction fit. The inflation nozzle is shown about to be inserted into the opening and, also, after insertion is complete.

Note the electrical grounding of the inflation nozzle shown in both pictures. This safety precaution is essential when using flammable gas such as hydrogen.



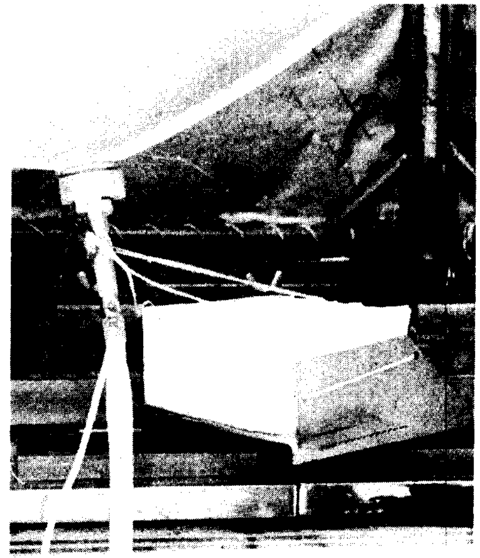
STEP 11.

THE balloon should be in the inflation shield during inflation if this operation is conducted outdoors. The balloon is shown as inflation is about to begin.



STEP 12.

REGULATE THE flow of gas from the cylinder into the balloon by means of the foot-operated valve. Gas flow can be fairly rapid, but violent fluttering of the tubing should be avoided. The balloon as shown, requires no attention once sufficient gas has been introduced to support it.

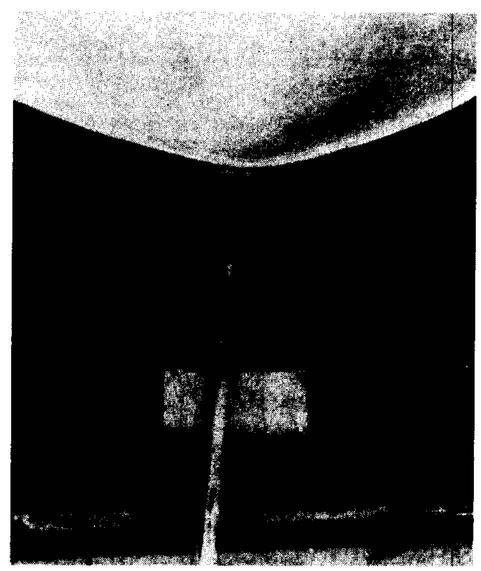


STEP 13.

ADD GAS SLOWLY when the balloon begins to pick up the load prior to equilibrium. The balloon is shown just beginning to pick up the load prior to equilibrium.

Stop adding gas once the balloon is in equilibrium, i.e., when it supports the load. Exercise caution to prevent over-inflation.

Remove the inflation nozzle from the inflation opening, and immediately press the cap securely over the inflation opening.



Section 4.

LAUNCHING

STEP 14.

LAUNCH the balloon by removing the free-lift weight. The balloon is shown just prior to release.

Section 5.

HYDROGEN HANDLING

Hydrogen can be very dangerous if not handled properly. An air-hydrogen mixture containing between 7 and 72 percent hydrogen by volume is explosive, and in the higher ranges will burn vigorously. On the other hand, as long as air is excluded from mixing with the hydrogen, and no flames, sparks, or hot surfaces in excess of 400°F are permitted near the gas, there is no danger.

SMOKING MUST NOT BE ALLOWED
in the area when using hydrogen. To minimize the chances of generating static sparks during inflation, the
HYDROGEN CYLINDER AND INFLATION NOZZLE
MUST BE ELECTRICALLY GROUNDED.

Immediate capping of the inflation opening after removal of the inflation nozzle will minimize the introduction of air into the balloon.

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Balloon Delivery System
170 F

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CONTENTS

Section 1.

LEAFLET CONTAINER PREPARATION

Section 2.

BALLAST PREPARATION

Section 3.

CHECK-OUT AND PREPARATION OF INSTRUMENT SYSTEM CIRCUITS

Section 4.

RIGGING, INFLATION AND CAP INSTALLATION

Section 5.

LAYOUT OF BALLOON AND EQUIPMENT

Section 6.

INFLATION OF BALLOON

Section 7.

HYDROGEN HANDLING

Section 8.

LAUNCHING

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Operating Instructions

for

BALLOON DELIVERY SYSTEM 170F

This system has been very carefully designed to deliver a payload of 88 pounds (40 kilograms) of leaflets. The leaflets can be dropped in any one of several selected patterns. In case of failure of the balloon to operate as desired, emergency measures have been provided which will insure spreading of the payload over a wide area even if it is not the one selected.

The success of any balloon flight depends mainly upon careful preparation and launching after study of meteorological conditions which will govern flight. The instructions which follow are to guide you in the preparation of the 170F System for launching. They should be followed exactly in step-by-step sequence for a successful flight.

Preparation and check-out steps are serially numbered and should be performed in the indicated order, at least within each section. Section 1 (Steps 1 to 8) deals with the preparation of the leaflet containers. Section 2 (Steps 9 to 11) tells how to prepare the balloon ballast. Section 3 (Steps 12 to 29) gives directions for check-out of instruments. Section 4 (Steps 30 to 33) describes rigging and inflation. Section 5 describes the layout of the balloon and equipment; Section 6 gives instructions for inflation of the balloon; Section 7 deals with the handling of hydrogen, and Section 8 gives final direction for launching.

WEIGHT SCHEDULE

Balloon Weight	20 pounds	9.15 Kilograms
Gondola Assembly	27 "	12.25 "
Ballast for 60 hours	50 "	22.65 "
Payload of Leaflets	88 "	40.00 "
Gross Weight	185 pounds	84.05 Kilograms

Free lift for weigh-off weight:

Daylight launching: 14% of the gross weight or 26 pounds (11.6 kgs)

Night launching: 17% of the gross weight or 31 pounds (13.6 kgs)

Balloon volume: 7,925 cubic feet.

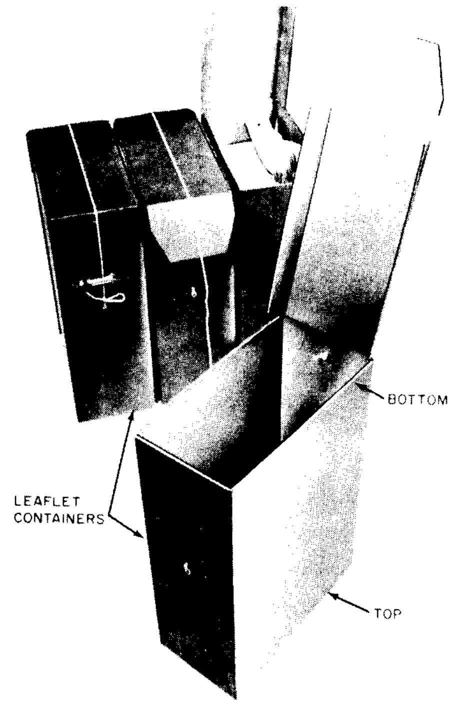
Theoretical altitude with gross weight of 185 pounds: 30,000 feet (9200 m)

Section 1

LEAFLET CONTAINER PREPARATION

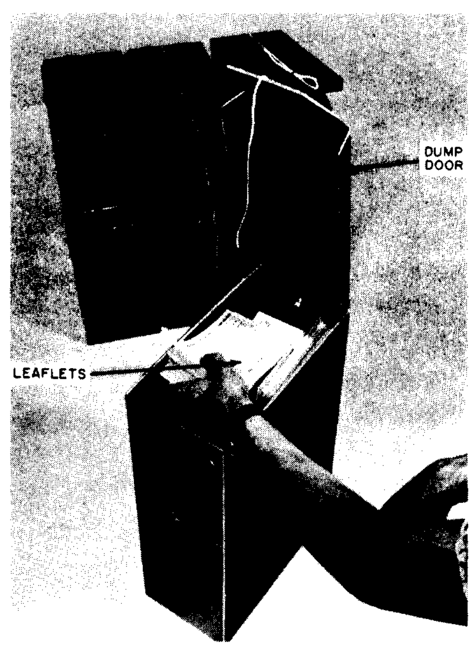
STEP 1.

FILL LEAFLET CONTAINERS. To do this, place the container to be filled on the floor or table in an inverted position and open the dump door. The containers are filled from the bottom as shown.



STEP 2.

FILL each of the four containers with 22 pounds (10 kilograms) of leaflets as shown.



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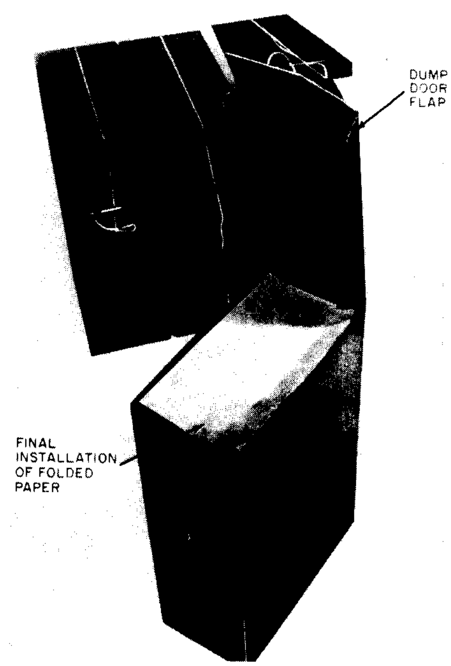
STEP 3.

OBTAIN A SHEET of paper, fold as shown and install around leaflets. This will prevent leaflets from escaping from between the dump door flap and container wall when the dump door is closed.

STEP 4.

BE SURE that paper is neatly fitted as shown. This shows completion of the operation started in Step 3.



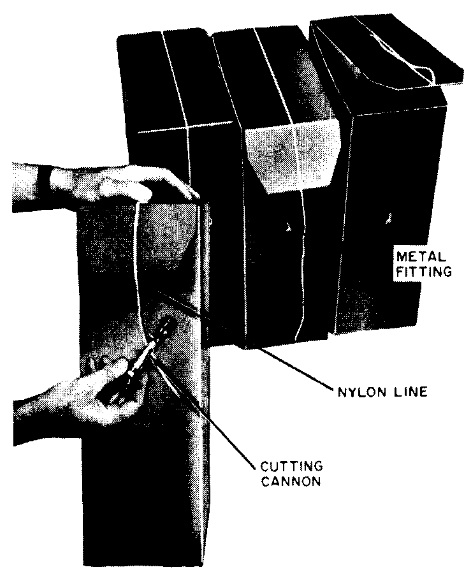
STEP 5.

CLOSE the dump door with the side flaps on the inside of container as shown.

STEP 6.

INSERT NYLON LINE through the cutting cannon as shown. Be sure that the color marked on the cutting cannon is the same as that on the top of the container.

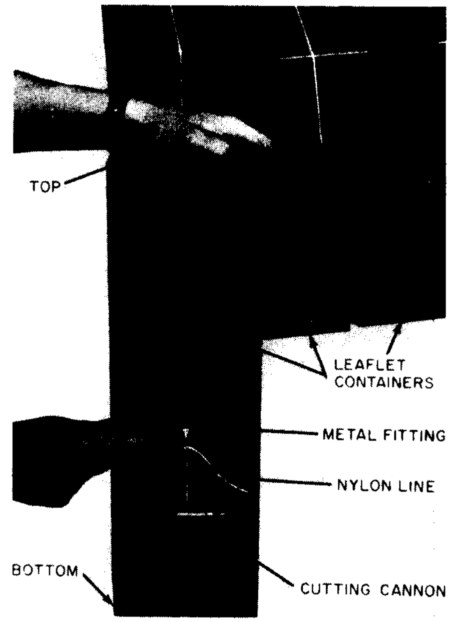
Caution: Never connect cutting cannon to plugs before installing. This is not done until Step 43.



STEP 7.

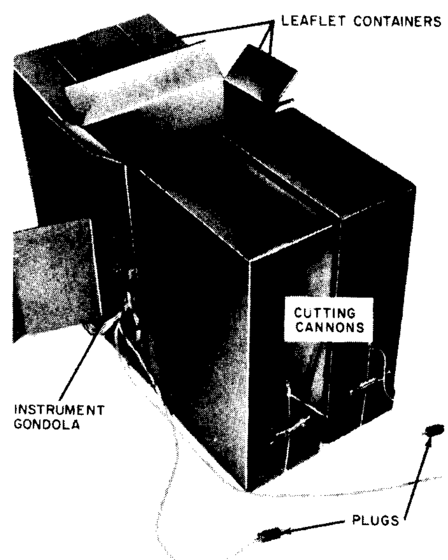
INSERT nylon line through metal fitting on leaflet container and tie securely as shown.

Note: Nylon lines may be tied before inverting containers.



STEP 8.

INVERT ALL containers so that the dump doors are on the bottom as shown. The nylon harness used to attach containers to the load bars is not shown in this picture. (See Step 32)



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Section 2.

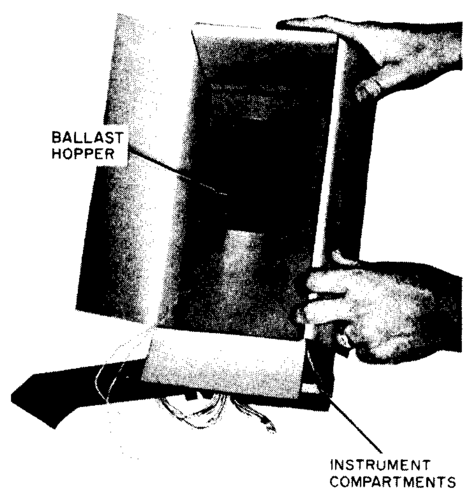
BALLAST PREPARATION

STEP 9.

TAKE OUT THE BLOCKS OF white insulation from the top of the instrument gondola (container) so that the opening into the ballast hopper is exposed.

Caution: Before removal of this insulation notice the position of each piece so it may be replaced in the same pattern.

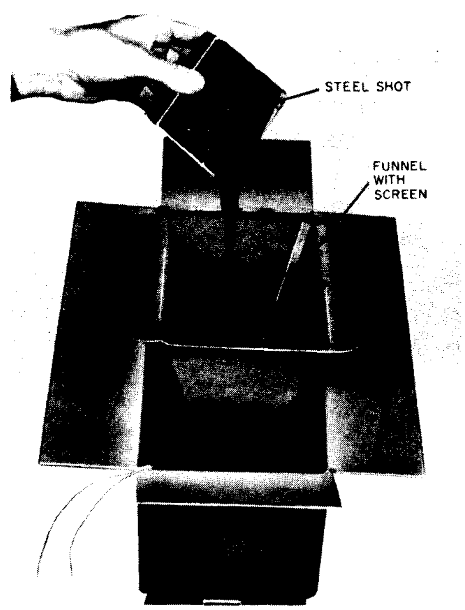
The rectangular hole at the bottom of the battery compartment is the opening into the ballast hopper.



STEP 10.

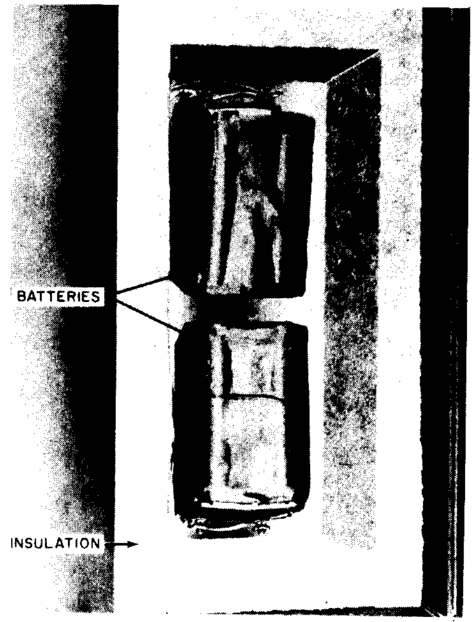
POUR 50 POUNDS OF steel shot through screen into ballast hopper as shown.

Caution: Do not pour steel shot into ballast hopper without screening. A funnel with a screen in its bottom have been provided for this purpose.



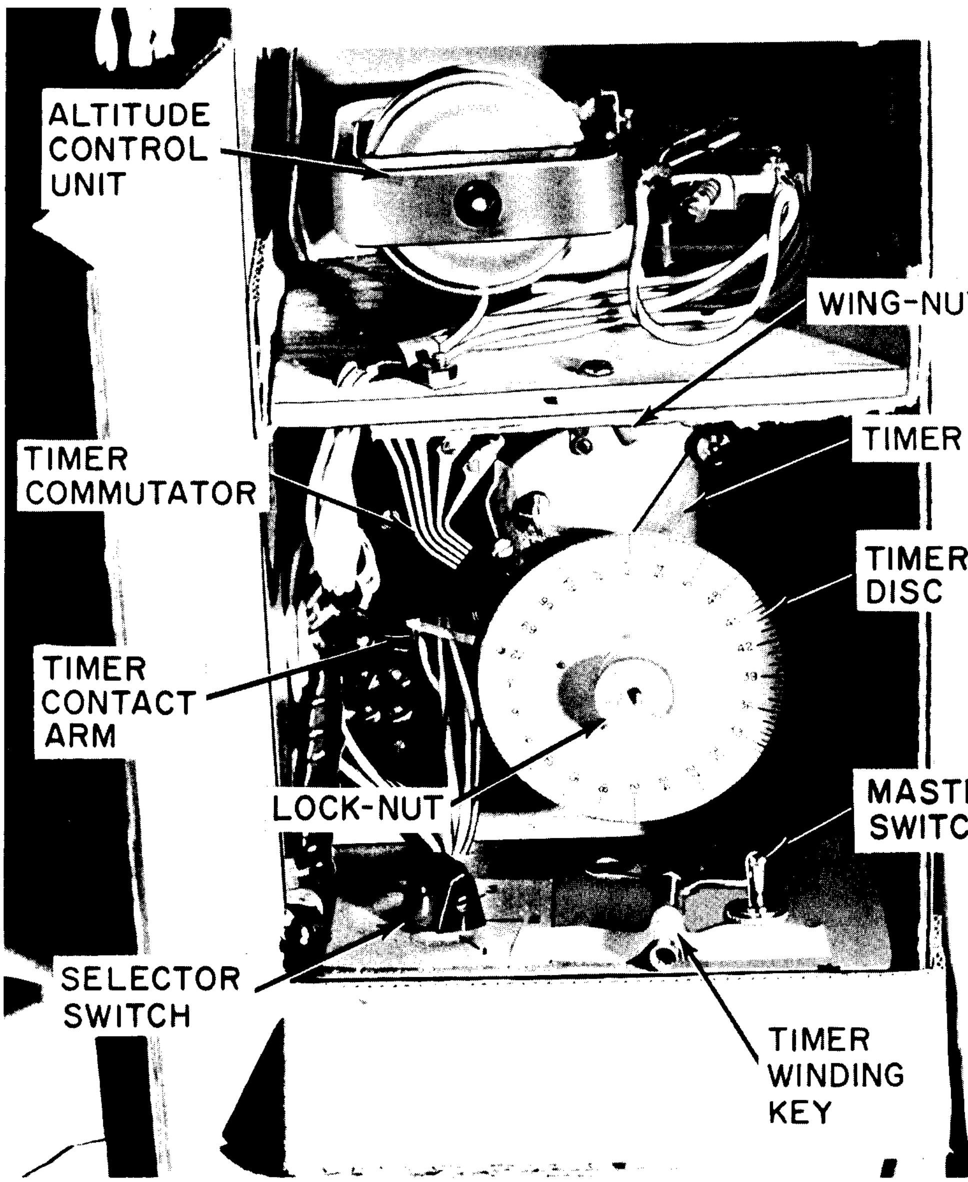
STEP 11.

RE-INSTALL insulation over ballast hopper and around battery compartment as shown. (See also Steps 26, 27 and 28.)

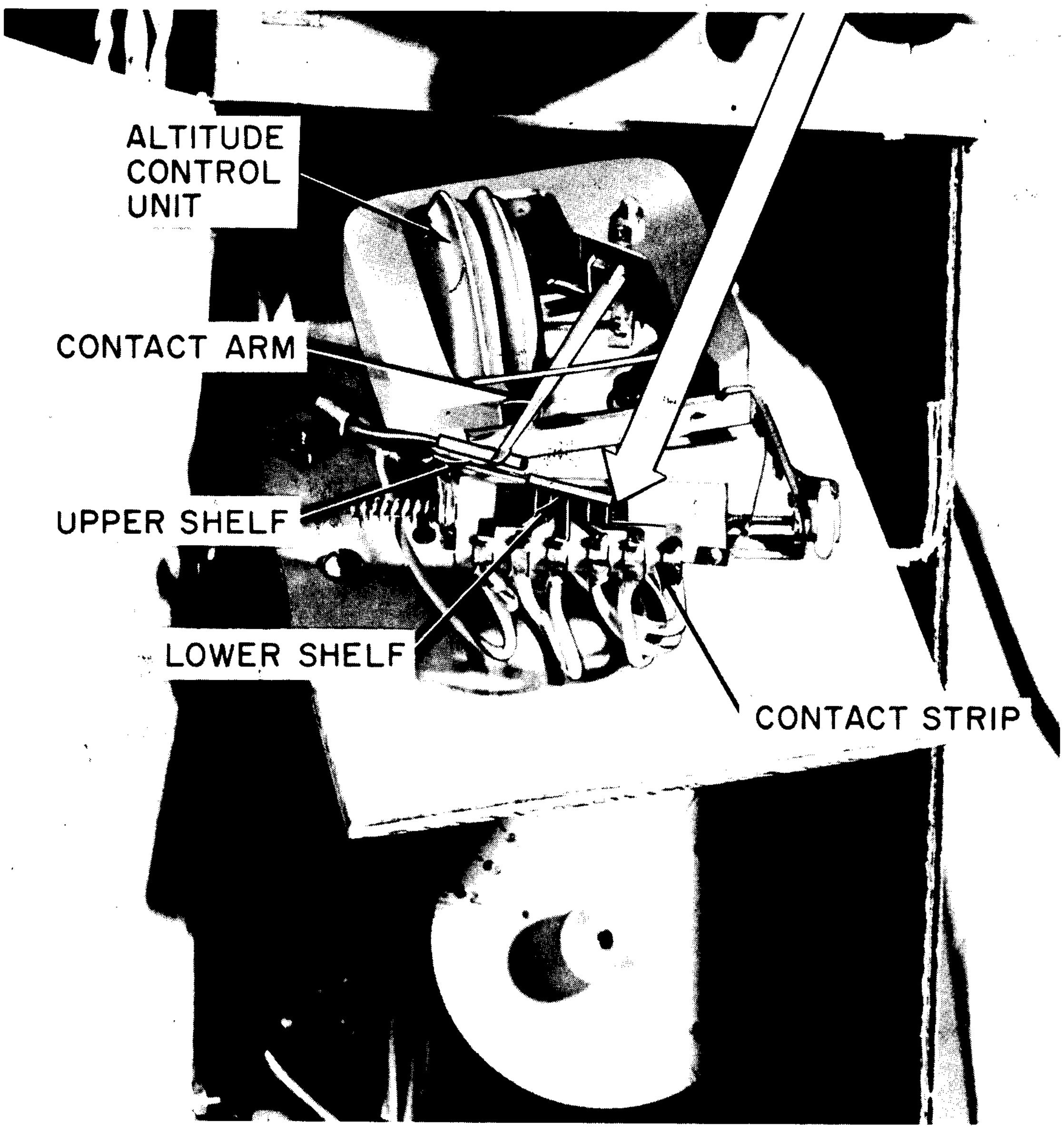


Section 3.

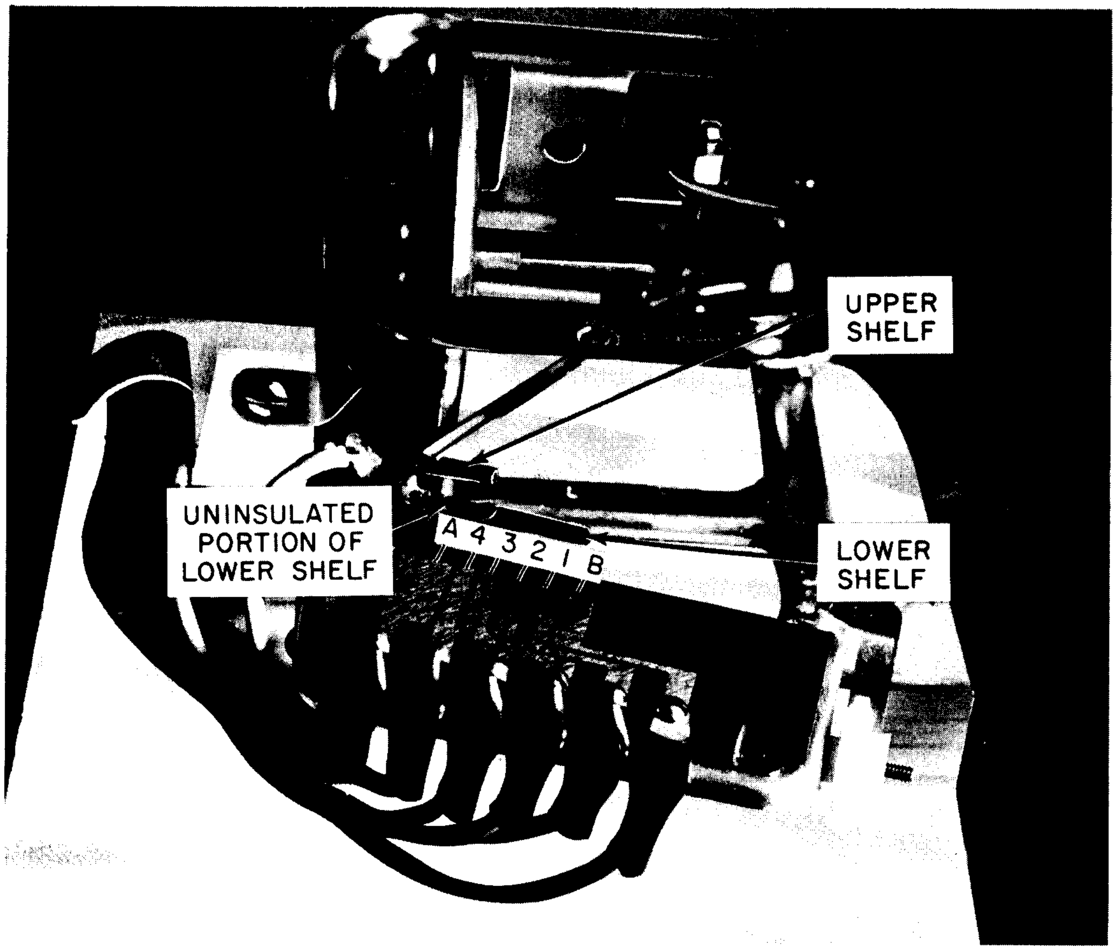
CHECK-OUT AND PREPARATION OF INSTRUMENT SYSTEM CIRCUITS



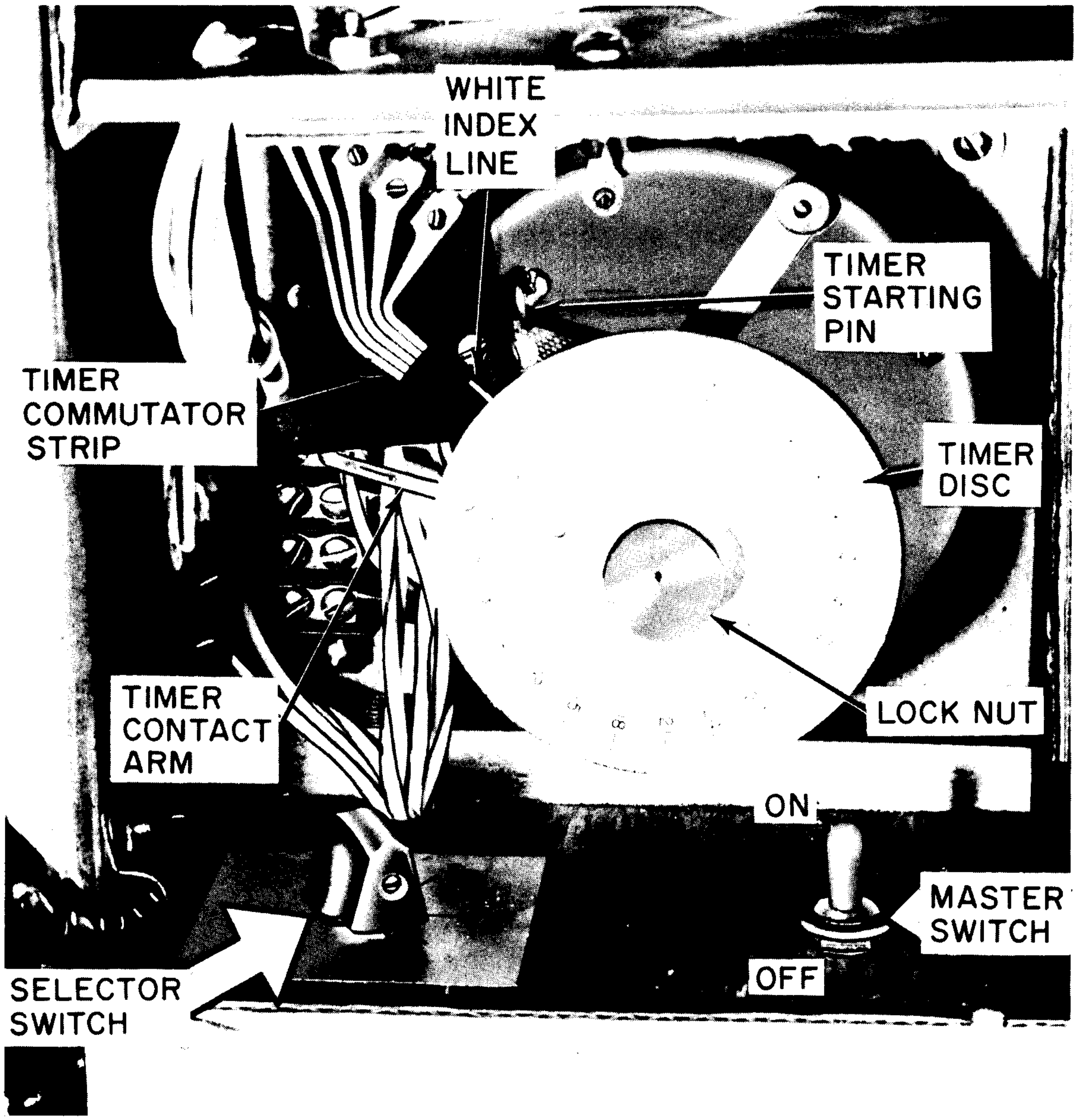
STEP 12. OPEN THE DOOR WHICH covers instrument compartments. Illustration shows the arrangement of both instrument compartments as they may appear when first unpacked.



STEP 13. TO PERFORM NECESSARY tasks and checks, first unfasten the wingnut which holds the plywood base of the altitude control unit firmly to the shelf of the upper compartment. Grasp the plywood base (not the instrument) and move the unit out as shown. The arrow points to the first contact on the contact strip. This is designated as contact "B" in the circuit schematic, Plate I.



STEP 14. CLEAN ALL SIX CONTACTS on altitude control system commutator. Commutator strip is shown. Contacts are numbered as shown. When cleaning, use a good grade of silver polish. Wipe very gently parallel to the long dimension of the contacts. Do not use too much polish so that a residue is left. Do not touch shelves above commutator strip while cleaning contacts. Wipe contacts clean with chamois or cloth after cleaning.



STEP 15. CLEAN THE FIVE CONTACTS on the timer commutator strip shown. As for Step 14, use a good grade of silver polish. Wipe very gently parallel to the long dimension of the contacts. Wipe contacts clean with a chamois or cloth after cleaning.

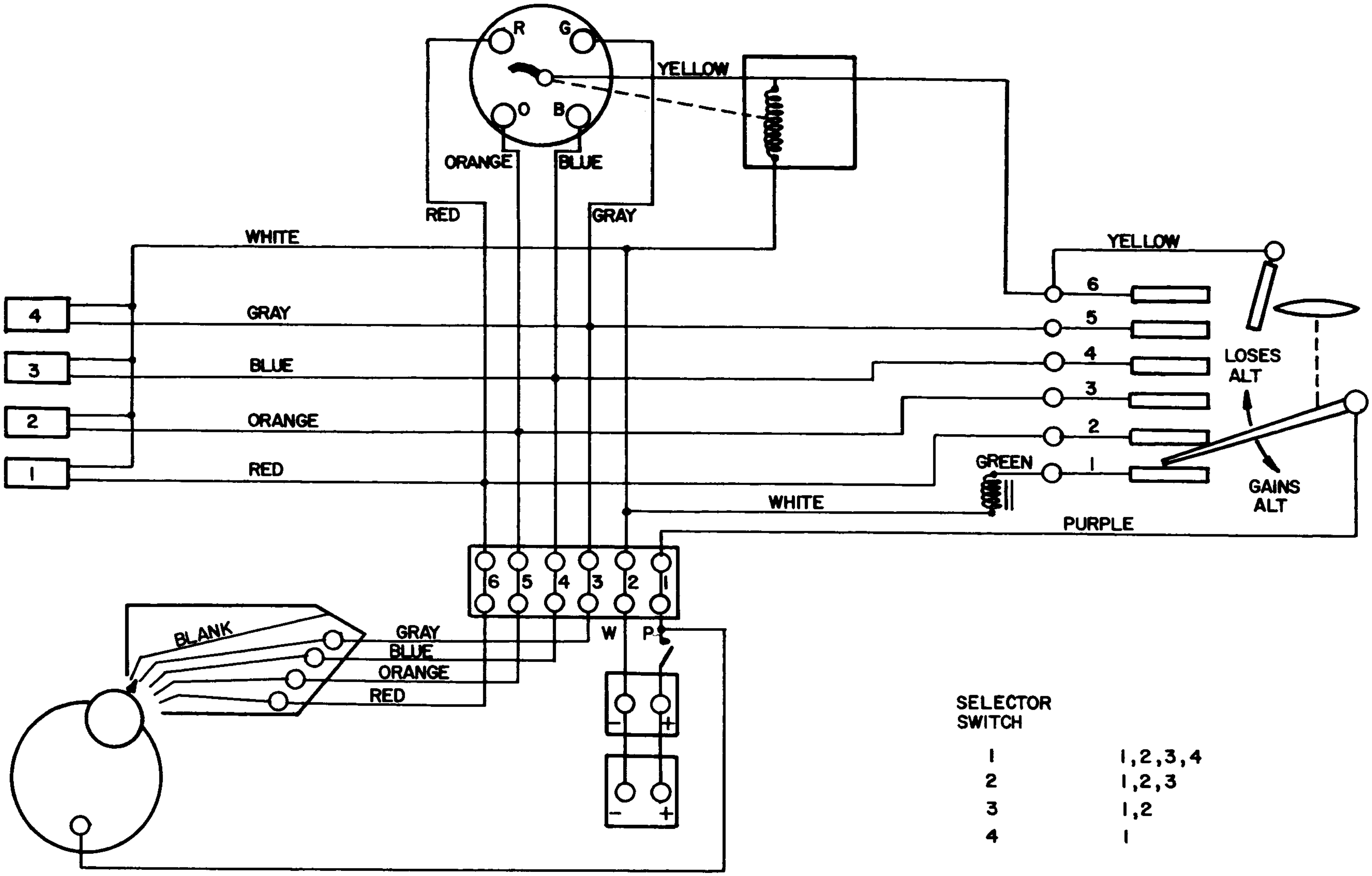
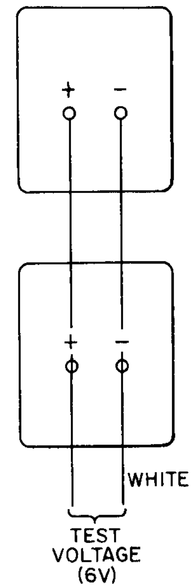


Plate I -- SCHEMATIC DIAGRAM OF INTERCONNECTION OF CONTROL UNITS.

The numbered and lettered contacts (check points) shown above will assist in the check-out of Instrument System Circuits. Check points are referred to in the step-by-step instructions.

STEP 16.

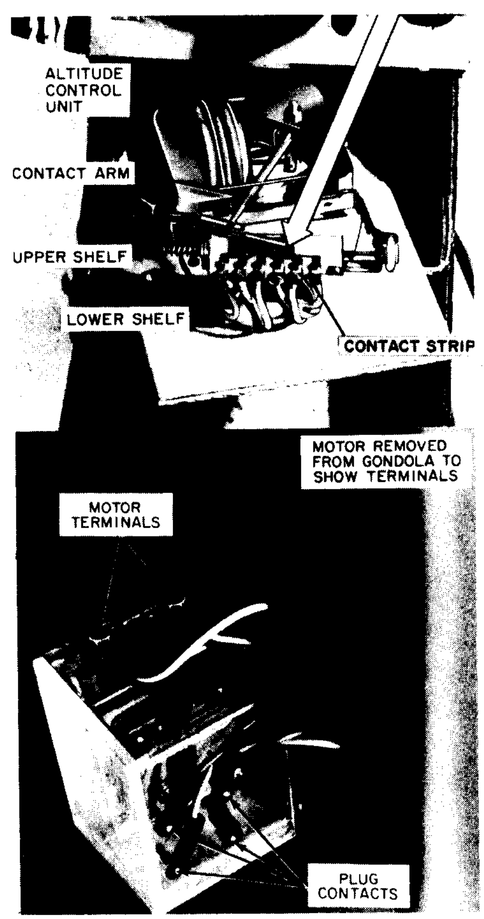
USE TWO SIX-VOLT test batteries for the circuit checks described in the following steps (Steps 17 to 25). Connect the colored wire (purple) to the positive terminal of both batteries (terminals are marked). Connect the white wire to the negative terminal of both batteries as shown.



STEP 17.

CHECK FIRST emergency circuit.

a. Put Master Switch ON. See Step 15.
b. With a light wire and clips connect the uninsulated part of the lower shelf to the frame of the altitude control unit. Uninsulated part of lower shelf, on which altitude control arm rests during last half of ascent to calculated flight pressure level, is the contact for the first emergency circuit. (See Step 13) For this test the arm should rest on the upper insulated shelf.
c. With voltmeter provided, check voltage across the terminals of the motor as shown. The voltage should read 6 volts.
d. Remove wire and clips.

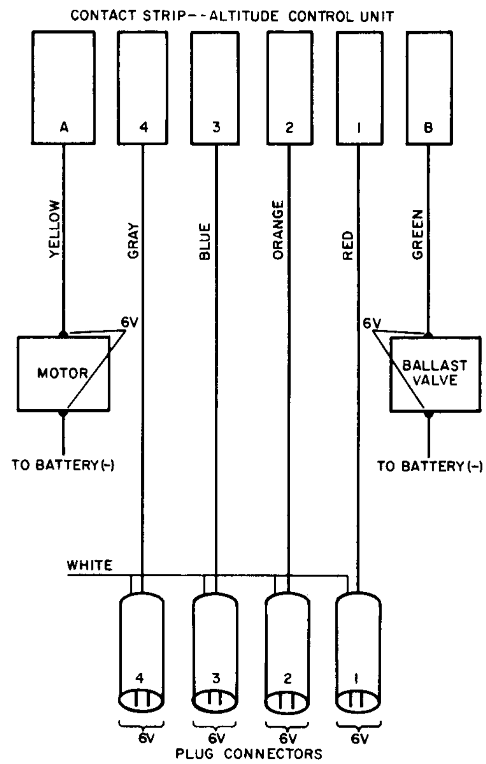


STEP 18.

CHECK ALTITUDE control circuit.

a. Put Master Switch ON.
b. With ballast valve at eye level, using test wire, momentarily ground contact B of altitude control commutator strip (See Step 14 and Plate I) to frame of altitude control unit. Ballast should flow as contact is made and stop immediately when contact is broken. Ballast valve is shown.

Note: Drawing shows location of ballast valve in bottom of instrument gondola.



STEP 19.

CHECK STANDARD emergency circuit.

a. Put Master Switch ON.
b. With a light wire and clips, successively ground contacts 1, 2, 3, 4, and A on the Altitude Control Unit commutator strip to the instrument frame. Check each corresponding plug and motor contacts in turn with the voltmeter. Voltage in each instance should read six volts. Illustration is a partial schematic to show check points.

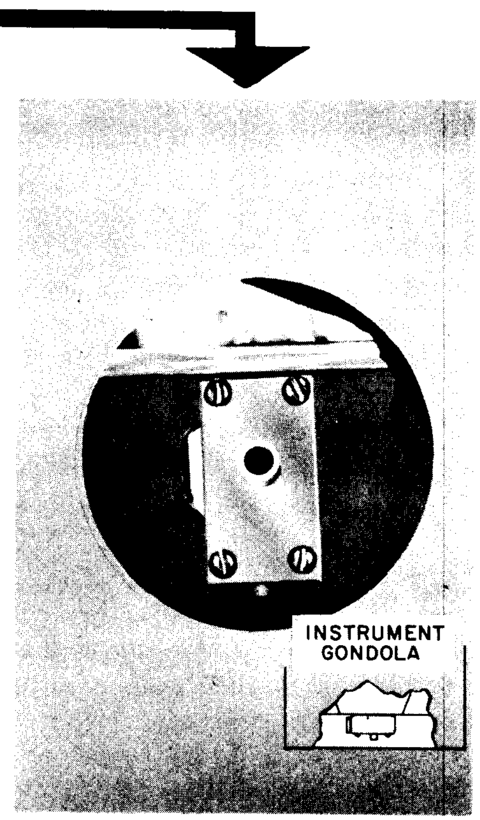
Contact No. 1 activates circuit for Plug No. 1.

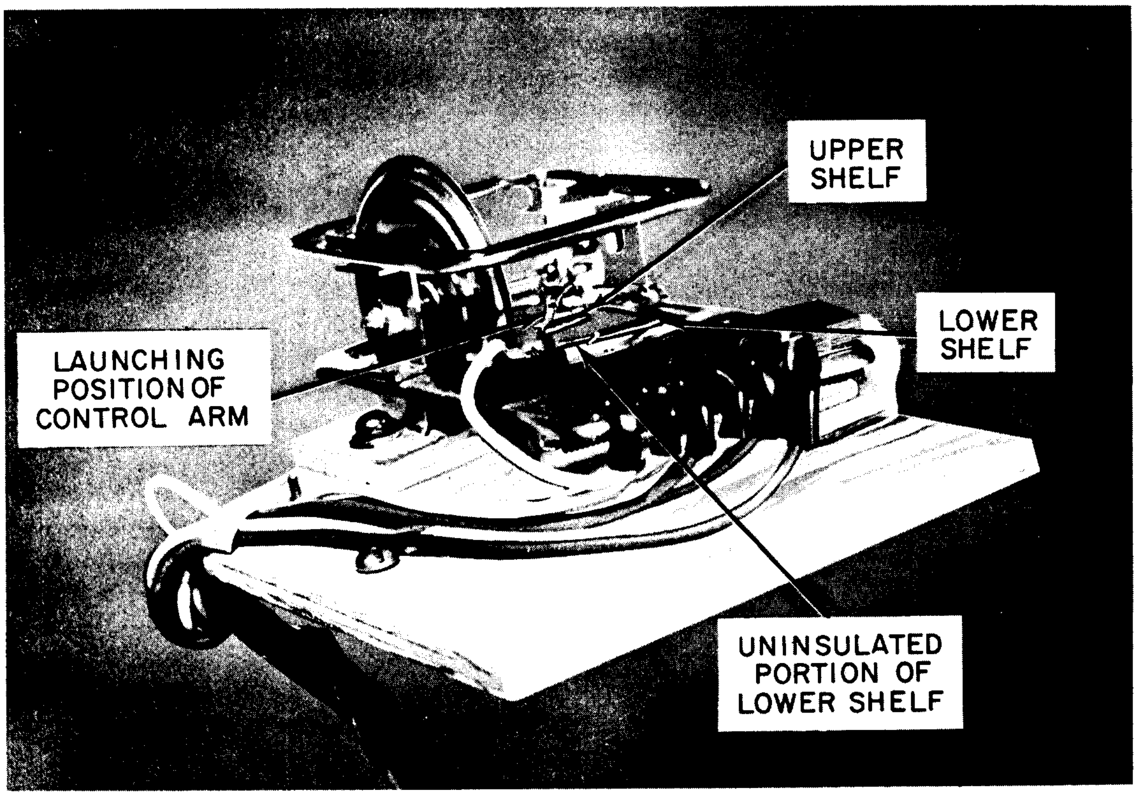
Contact No. 2 activates circuit for Plug No. 2.

Contact No. 3 activates circuit for Plug No. 3.

Contact No. 4 activates circuit for Plug No. 4.

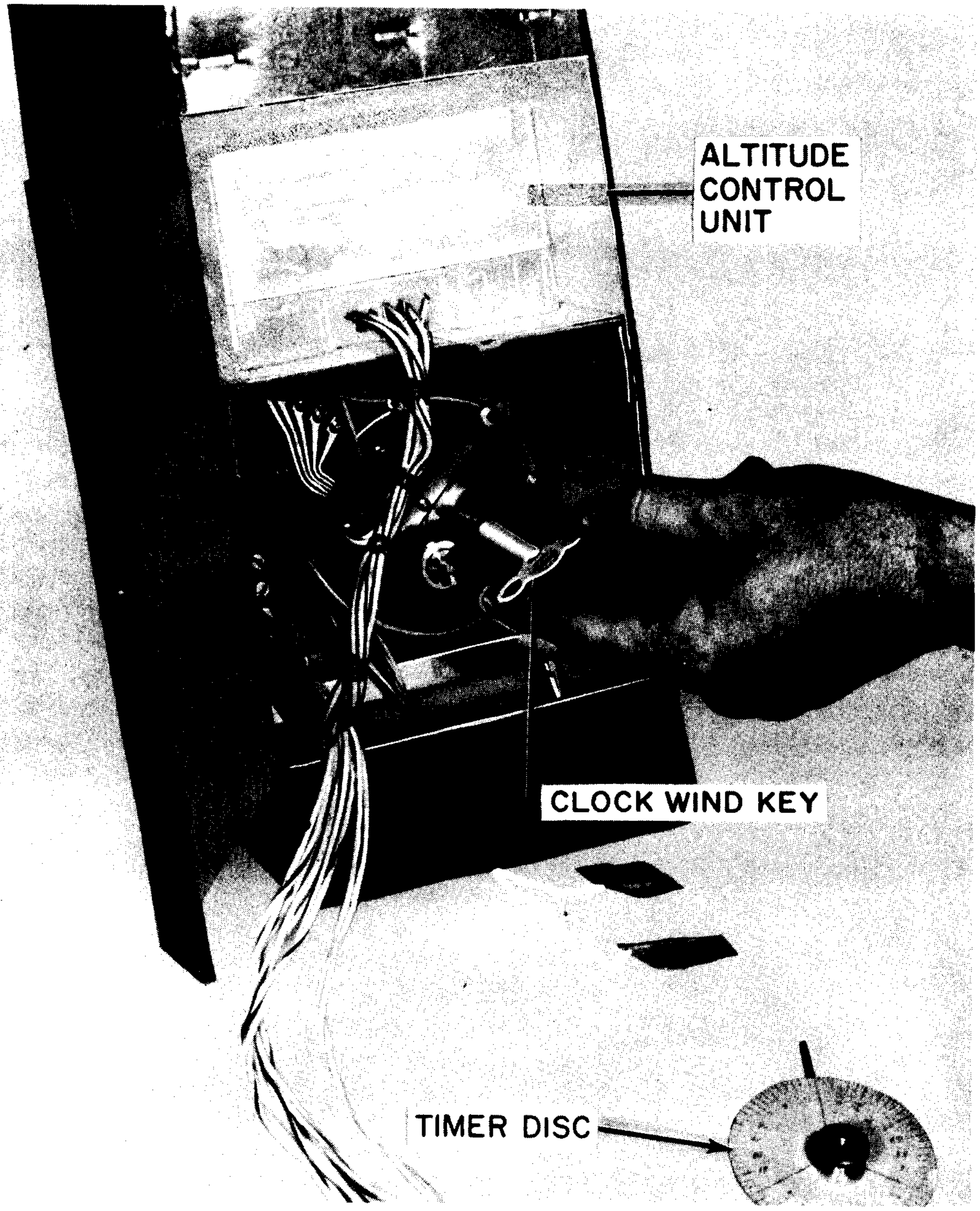
Contact A activates circuit for Motor Contact MA.





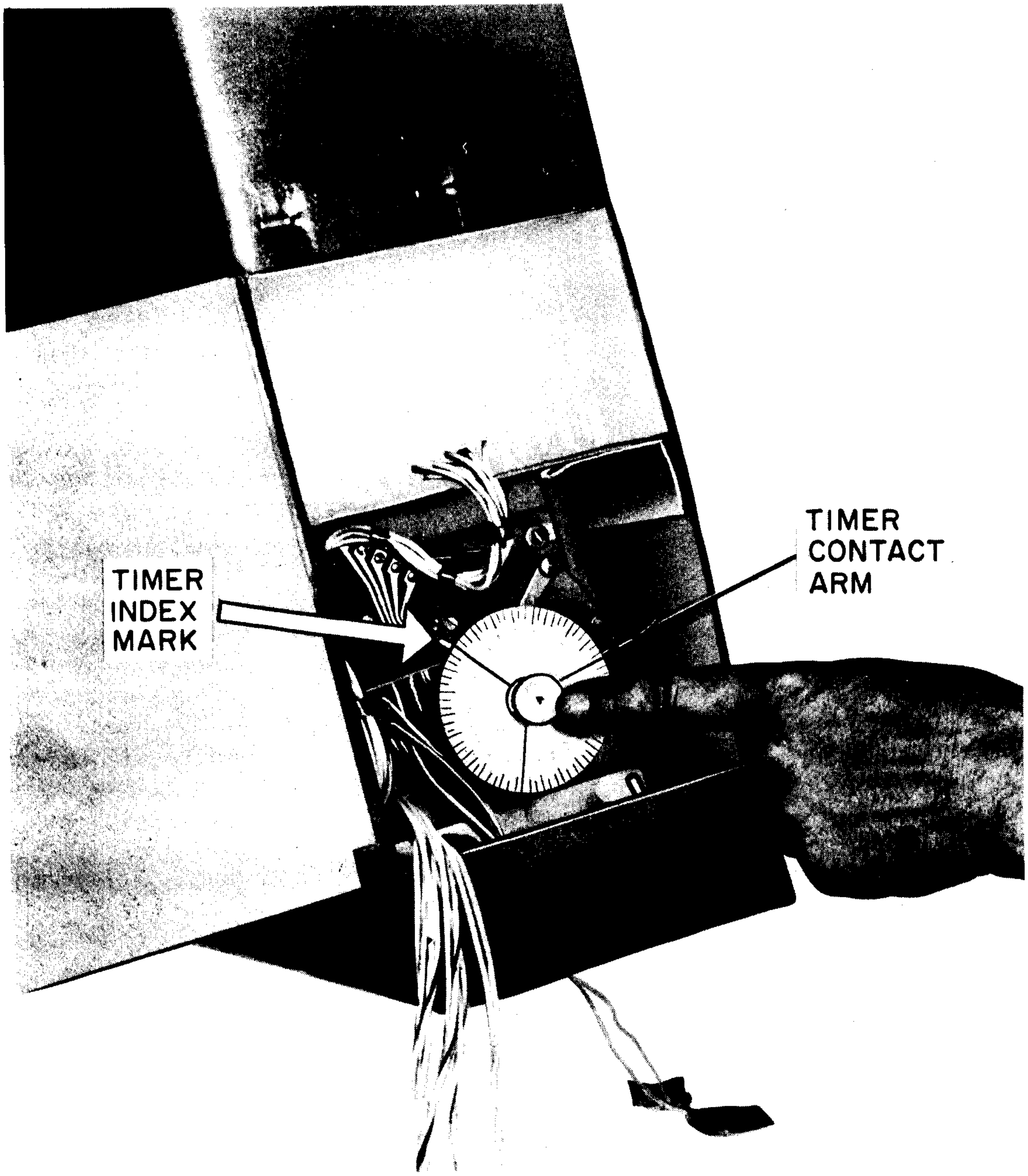
STEP 20. CHECK THE POSITION OF the altitude control arm as shown. This arm must be riding on the upper short shelf at launching. If this arm touches the uninsulated part of the lower shelf when the Master Switch is on, the motor will be activated and the plugs will fire in sequence. Step 13 also shows the proper launching position of the control arm.

After satisfactory check, replace and refasten the Altitude Control Unit in the upper instrument compartment with the wing nut as shown in Step 12.



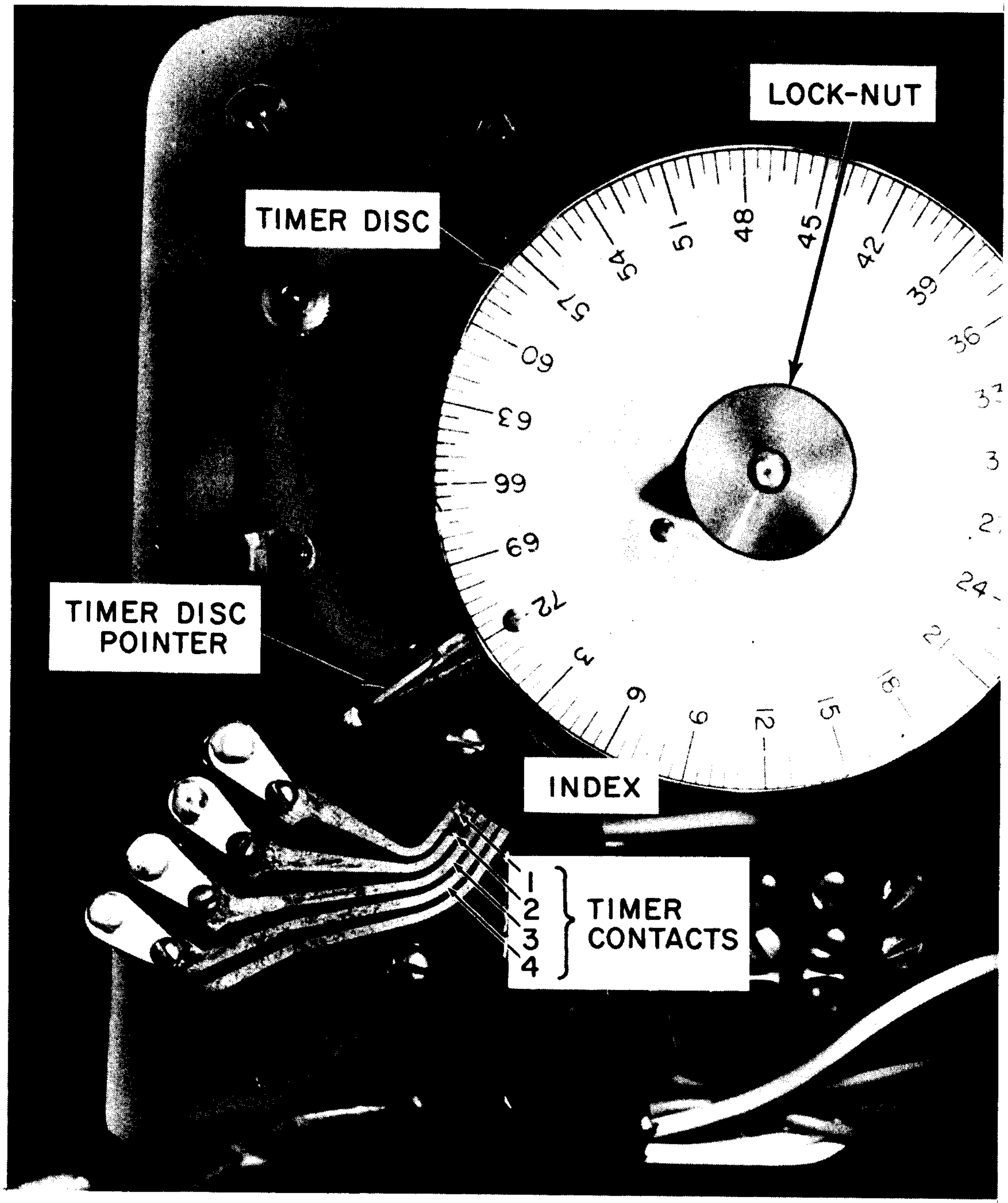
STEP 21. CHECK TIMER control circuit. (Steps 21 - 24 inc.)

a. Remove timer disc.
b. Wind clock with key provided.
c. Replace timer disc.



STEP 22. REPLACE TIMER DISC lock nut but do not tighten. The nut must be loose so that the timer disc may be moved easily. Lock nut is shown by finger.

The timer disc has a pointer attached at the zero reading. Test the contact of the pin on the timer disc pointer with the timer commutator strip. Make certain that the pointer makes good contact. If the contact is not good, the pointer can be bent in or out by hand until the correct adjustment is made.



STEP 23. TURN TIMER DISC pointer counterclockwise until pointer contacts No. 1 contact on the timer commutator strip. Contact No. 1 is the first contact reached by the timer disc pointer as it travels counterclockwise.

STEP 24.

PUT MASTER SWITCH ON.

Set Selector Switch on Position 1; check plugs 1, 2, 3 & 4 for 6 volts.

Set Selector Switch on Position 2; check plugs 1, 2 & 3 for 6 volts.

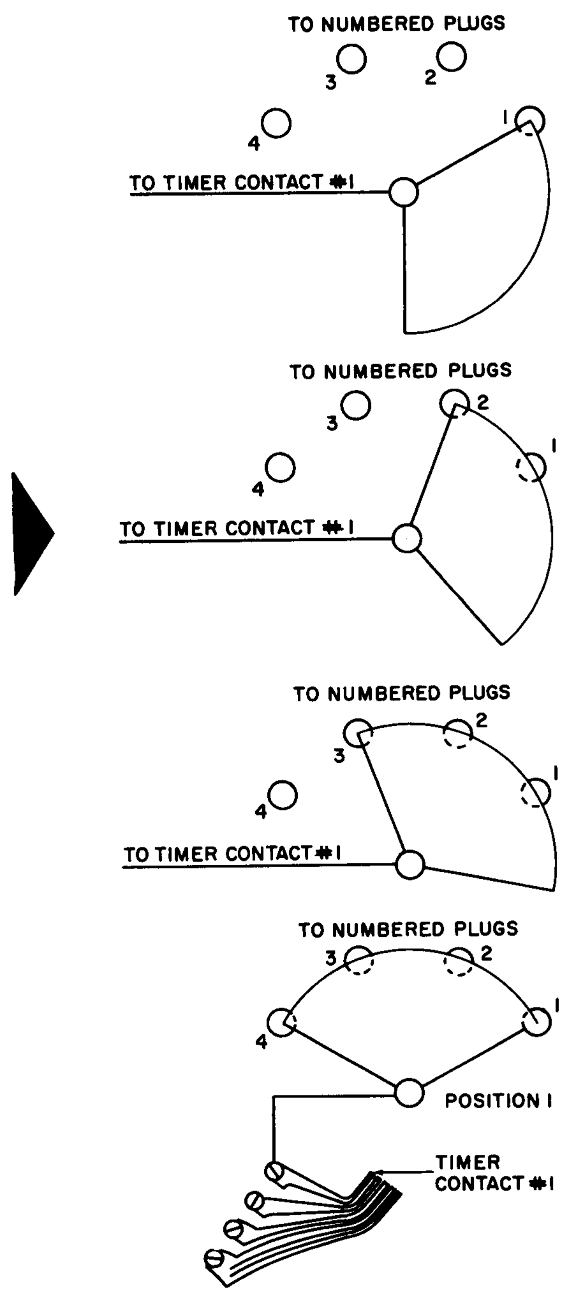
Set Selector Switch on Position 3; check plugs 1 & 2 for 6 volts.

Set Selector Switch on Position 4; check plug 1 for 6 volts.

Move timer disc pointer counterclockwise to Contact No. 2; check plug 2 for 6 volts.

Move timer disc pointer to Contact No. 3; check plug 3 for 6 volts.

Move timer disc pointer to Contact No. 4; check plug 4 for 6 volts.



STEP 25.

SET THE LEAFLET drop timer. Select the required flight duration hour number plus an estimated time required for rigging and inflation.

Place this number opposite the white index mark (shown in Step 23) on the timer commutator strip. Tighten lock nut.

Set drop circuit Selector Switch in accordance with table.

Selector Switch Position	Live Plug
1	1-2-3-4
2	1-2-3 (#4 fires approx. 60 min. later)
3	1-2 (#3 fires approx. 40 min. later; #4 fires approx. 60 min. later)
4	1 (#2 fires approx. 20 min. later; #3 fires approx. 40 min. later; #4 fires approx. 60 min later)

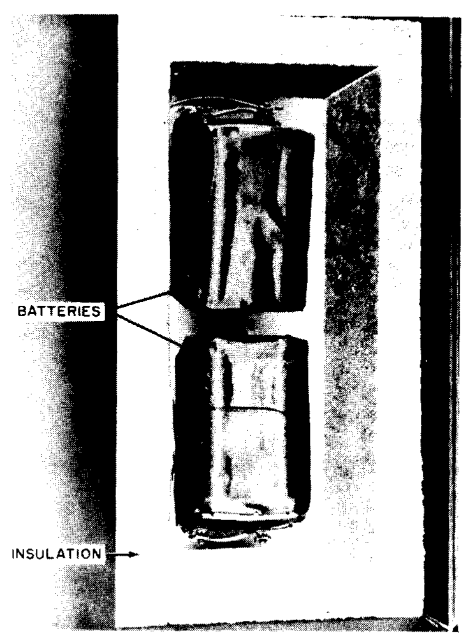
STEP 26.

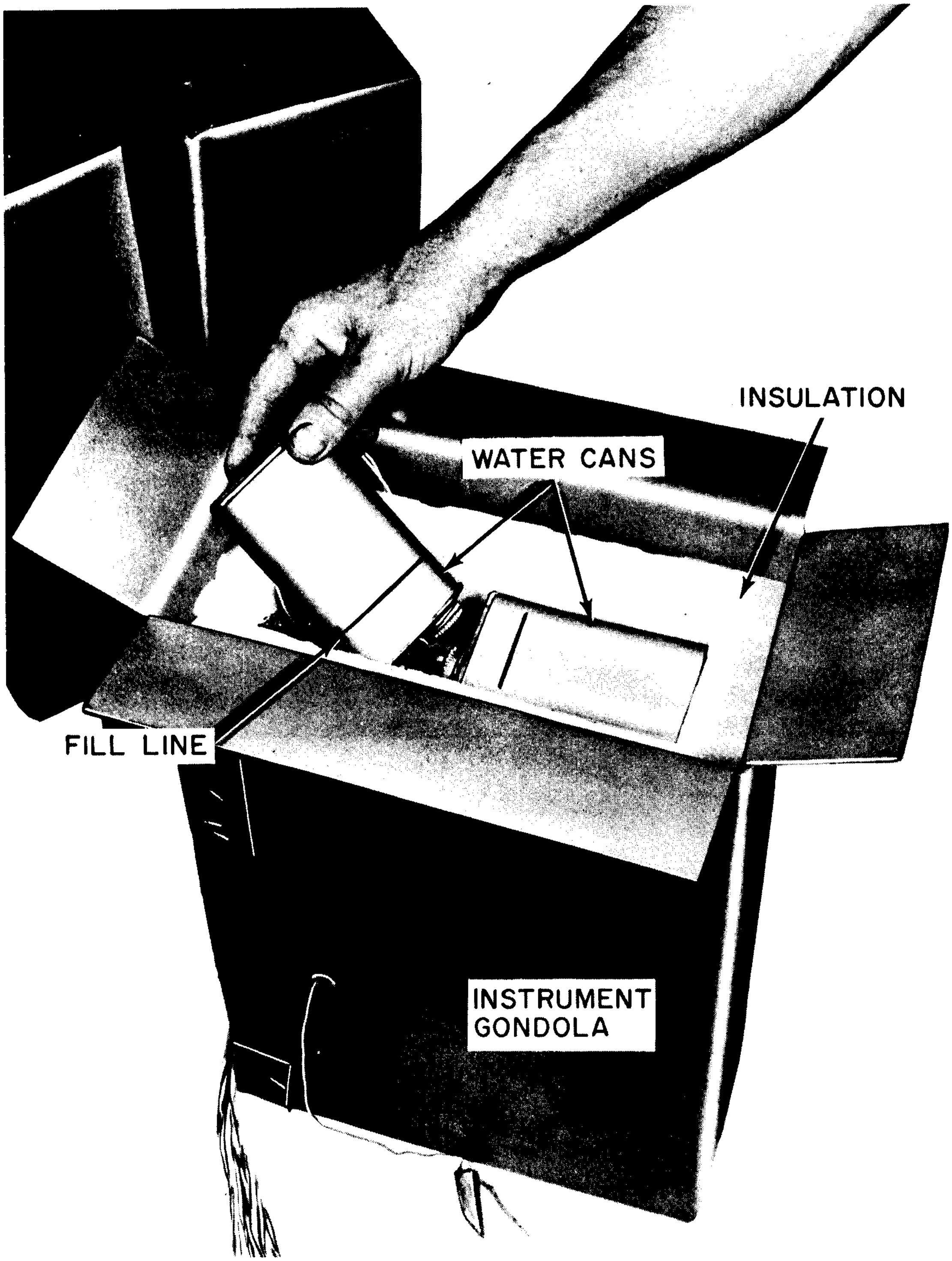
INSTALL THE TWO 6-volt batteries in the flat position as shown.

Connect the colored wire to the positive terminals of both batteries.

Connect the white wire to the negative terminals of both batteries.

Make sure that the batteries are placed so that the terminals are at opposite ends of the battery compartment as shown. This will prevent short circuits caused by the touching of battery terminals.



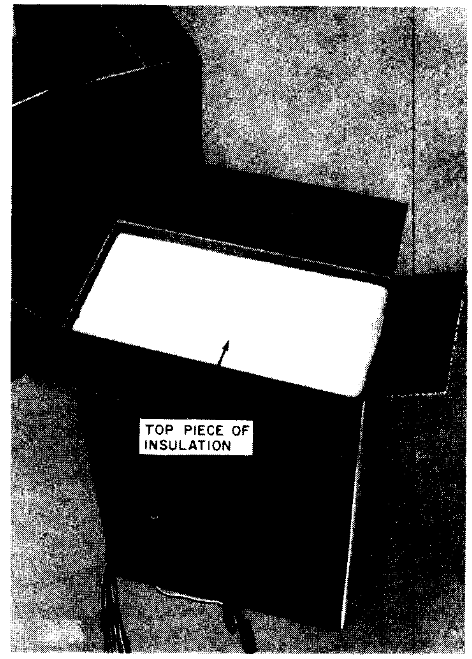


STEP 27. TWO SMALL WATER cans are provided. Fill these cans with water to the black line marked on each. Screw the caps on securely.

Place the cans of water over the batteries as shown.

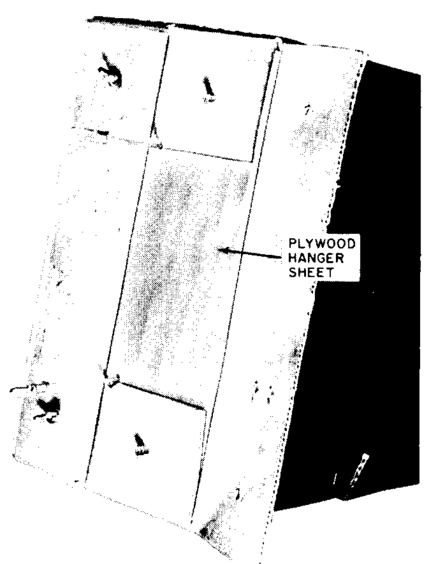
STEP 28.

INSTALL top piece of insulation over the batteries and water cans as shown.



STEP 29.

INSTALL plywood hanger sheet in place, close flaps and install washers and wing nuts as shown.



Section 4.

RIGGING, INFLATION AND CAP INSTALLATION

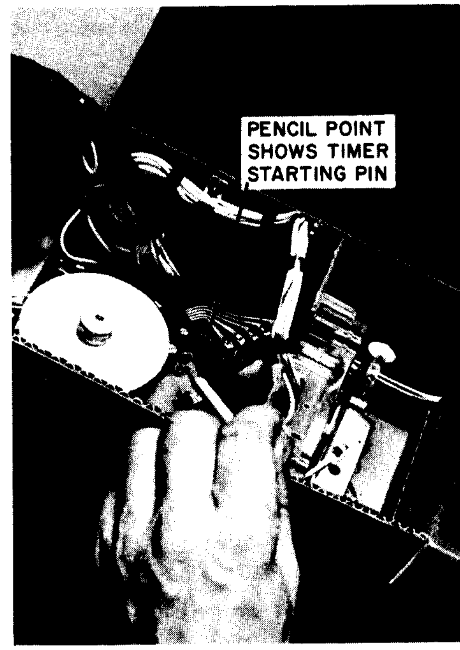
STEP 30.

AT THE LAUNCHING site, concurrent with balloon layout:

Check the position of the altitude control arm (Step 13). This arm must be riding on the upper, short insulated shelf at launch.

Re-check setting of the leaflet drop timer. (Step 15).

Pull pin to start timer. Note time allowed for launch.



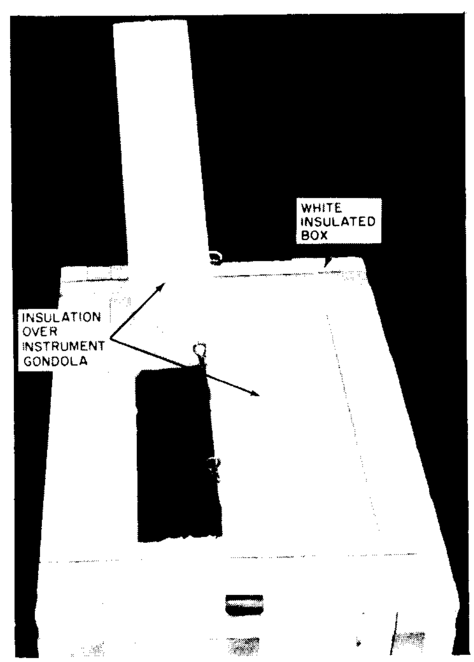
STEP 31.

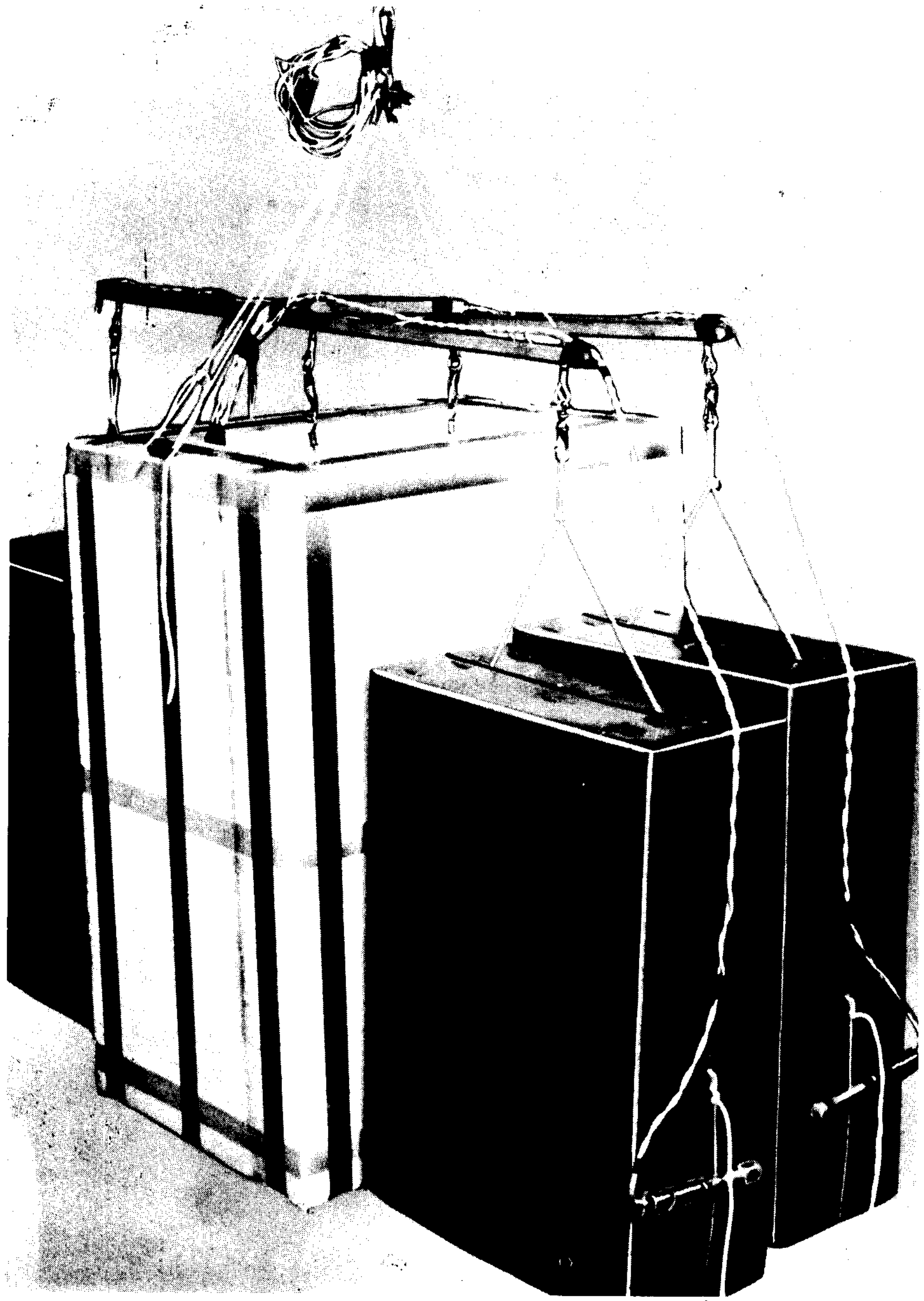
TURN MASTER SWITCH ON. (Step 15)

Close instrument compartment door.

Insert instrument gondola in white insulated box as shown.

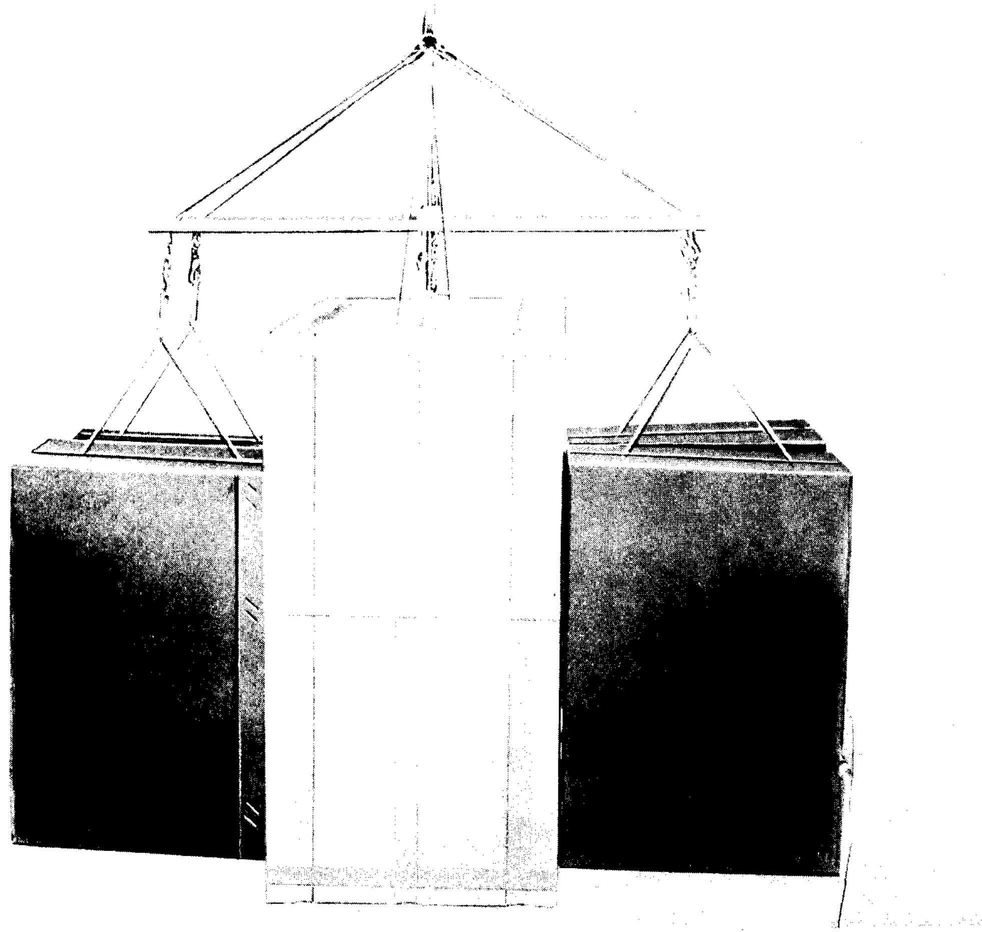
Install the two top insulation pieces as shown. The five circuit wires will protrude from one side between the two pieces of insulation.





STEP 32. ATTACH LOAD BAR ASSEMBLY as shown. The nylon support line for the insulated box goes from one side to the other side of the box through the ring of the snap at the upper part of the load bar assembly. (Note: Insulating blocks have been removed for this photograph.)

Attach the leaflet containers to the outer points of the load bars as shown, matching the corresponding color codes of the container and the load bar marking.



STEP 33. TAPE THE LEAFLET containers and the insulated box together in the positions shown.

Connect the top hooks of the load bar assembly to the balloon suspension.

Attach appropriate free-lift weight.

Section 5.

LAYOUT OF BALLOON AND EQUIPMENT

STEP 34.

UPON ARRIVAL AT the launching site, the ground cloth should be laid out in the down-wind direction. The gondola, loaded with ballast, leaflets and free-lift weight makes an excellent anchor and should be placed on the up-wind end of the ground cloth.

STEP 35.

PLACE THE BOX containing the balloon adjacent to the ground cloth at the up-wind end. Open the top of the box and split it down the sides to make it lie flat.

STEP 36.

PICK THE BALLOON up gently and place it on the ground cloth. The balloon is now in position to be rolled out to its full length.

STEP 37.

ROLL OUT THE balloon. Two men, one on either side, should do this. In handling the balloon, get underneath to lift it. Do not pull or grip the material with the fingers. Light-weight, metal-free gloves should be worn to prevent the fingernails from damaging the fragile balloon material. Every precaution must be taken in handling the balloon to insure that no damage will occur that could result in a leaky balloon. During this operation a third person should place the harness and accessories in such a position that he can secure the gondola to the harness. Make sure that no twists occur in the suspension lines and gondola load bars.

STEP 38.

THE DIFFUSER CAN now be inserted into the inflation tube making sure that no twists are evident in the tubing. The inflation tubing should be taped tightly to the diffuser to prevent gas leakage.

STEP. 39.

BEFORE BEGINNING to inflate the balloon, the open appendix at the base of the balloon should be temporarily tied shut, being careful not to damage the skirt material in the process.

Section 6.

INFLATION OF BALLOON

STEP 40.

INFLATION REQUIRES A man to support the apex of the balloon until it is supported by the gas. This same man will regulate the reefing sleeve after there is enough gas in the balloon so that it is erect and can support itself. The reefing sleeve serves to protect the balloon and holds all the slack material of the balloon together on inflation, preventing the wind from making a big uncontrollable sail of it. Judgement should be used to prevent this and yet allow room for the gas to expand freely.

STEP 41.

ANOTHER MAN IS NEEDED TO regulate the flow of gas into the balloon through the duct inflation tube. Gas flow can be fairly rapid; however, violent fluttering of the tubing should be avoided. This man can also steer the inflation bubble to offset the effect of the wind, by keeping tension on the duct. Once the balloon is vertical, gas flow can be increased to maximum without ripping or violent flutter occurring in the inflation tube. During inflation, last minute checks on the rigging and equipment can be accomplished. With 14 German 6 cubic meter bottles turned on in the manifold, continue inflation until the gondola is weighed off and the free lift weight starts to become light. Decrease the rate of gas flow and holding the gondola in place, carefully determine if the balloon is light or heavy. Slowly add gas until the system is in equilibrium. After achieving initial balance, secure a closer check by lifting system approximately three feet in the air and check for settling. Add gas as necessary to achieve as close balance as possible. Once gas is introduced into the balloon there is no provision for release of excess gas. Consequently, caution is necessary to prevent over-inflation. Securely tie off inflation duct and cut off excess material approximately 20 cm below tie off point.

Section 7.

HYDROGEN HANDLING

STEP 42.

Hydrogen can be very dangerous if not handled properly. An air-hydrogen mixture containing between 7 and 72 percent hydrogen by volume is explosive, and in the higher ranges will burn vigorously. On the other hand, as long as air is excluded from mixing with the hydrogen, and no flames, sparks, or hot surfaces in excess of 400°F are permitted near the gas, there is no danger.

SMOKING MUST NOT BE ALLOWED
in the area when using hydrogen. To minimize the chances of generating static sparks during inflation, the
HYDROGEN CYLINDER AND INFLATION NOZZLE
MUST BE ELECTRICALLY GROUNDED.

There is no danger of air being sucked into the balloon during inflation with this type balloon with the appendix clipped, shut, or tied off. The standard German hydrogen cylinder has an expanded volume of gas of 6 cubic meters (211 cubic feet) and will provide (at 140 atmospheres or 2000 psi or better) at least 6.35 kilograms (14 pounds) of lift. A full German hydrogen cylinder weighs approximately 80 kilograms (176 pounds) and has left-hand threads.

Section 8.

LAUNCHING

STEP 43.

CHECK THE VOLTAGE across the terminals of plugs 1, 2, 3 and 4 with the voltmeter provided. The voltage should be zero in each case. After satisfactory test, remove the short from each cannon socket in turn and attach each plug to its respective cannon socket on a leaflet container, matching the color coding marked on plug and socket.

Mating of the plugs and sockets is shown in Step 32.

Await D-hour set on timer for launch.

Launch by cutting off free-lift weight.

Balloon Delivery System

J - 9 - 10 - 300

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J-9-10-300 BALLOON

Abstract - This balloon is a larger version of the J-100 balloon, and being larger it is able to carry greater loads to higher altitudes. This means that longer drift distances can be obtained using the J-9-10-300 than could be possible with the J-100. In general the J-9-10-300 has a capability of 250 to 400 miles distance, but the higher burst altitudes may complicate the problem of predicting flight and leaflet impact.

In this section the performance characteristics of the J-9-10-300 balloon are presented, with tables showing the rate of rise, and time spent within 5000-foot increments of altitude.

General Description - The J-9-10-300 is the big brother of the J-100. It has a nominal weight of 300 grams as compared with 100 grams for the J-100. The J-9-10-300 is used meteorologically as a load carrying balloon for the radiosonde. Being a larger balloon it is able to carry greater loads to higher altitudes. Two different payloads were tested for this study, a 5 and a 10 pound load. The burst altitudes resulting were 58,000 feet and 46,000 feet, respectively. It is readily apparent then that longer drift distances can be obtained using the J-9-10-300 than could be with the J-100. The higher burst altitudes may, however, complicate the prediction problem as winds at these higher altitudes are not as commonly reported as those for the lower altitudes.

If long drift distances are the objective, they are most easily obtained by selecting a leaflet with a slow rate of descent and releasing it at very high altitudes[1]. An example of such a leaflet is the autorotating leaflet with a ground rate of descent (V_0) of 1.3 feet/second. The time down of this leaflet from 58,000 feet is about 7.5 hours and from 46,000 feet, 6.7 hours. Using the slowest rate of rise reported here (300 grams free lift), the time to burst is 1.9 hours for the 58,000 foot burst and 1.5 hours for the 46,000 foot burst. These times are summarized on the following page.

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[1] This does not follow where there is a reversal of winds at the higher altitudes, causing the leaflets to drift first one way and then the opposite way.

J-300 BALLOON

Load (pounds)	Balloon time to burst (hours)	Leaflet time to impact (hours)	Total time (hours)
5	1.9	7.5	9.4
10	1.5	6.7	8.2

Assuming an average 40 mph[1] wind, these total air times of 9.4 and 8.2 hours from balloon launch to leaflet impact yield total drifts of 376 and 328 miles, respectively[2].

In general, then, the J-9-10-300 can be thought of as having a 250 to 400 mile capability, although it may be preferable to use the Pillow balloon for these distances, especially when winds at the very high altitudes are lacking.

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1 40 mph = 35 knots, an average wind condition at altitude.

2 The distances are obtained by multiplying the total air time by the average wind, e.g., 9.4 hours x 40 mph = 376 miles.

PERFORMANCE CHARACTERISTICS OF THE J-9-10-300

As mentioned under the section "General Description" this balloon is basically the J-100 in a larger size. The J-9-10-300 performs similarly to the J-100; the only important differences being the larger payloads carried and higher burst altitudes attained.

The problem solving techniques described for the J-100 are the same as those to be used for the J-9-10-300. It might be repeated that forecasts of the winds at higher altitudes are necessary to use this balloon system to best advantage, and that special arrangements may have to be made with the weather services to obtain the necessary information.

The performance characteristics of the J-9-10-300, with 5 and 10-pound payloads, are presented in the following tables.

Table 1 - provides the rate of rise of the balloon within each 5000-foot increment of altitude from 0 to 60,000 feet.

Table 2 - shows the time spent by the balloon between each 5000-foot increment of altitude from 0 to 60,000 feet.

Table 1. J-9-10-300 Performance Characteristics
Incremental Rates of Rise
DAYTIME FLIGHTS

Free Lift (grams)	Burst Alt. (ft)	Rate of Rise (ft/min)	Time to Burst (min)	Incremental 0-5	5-10	10-15	15-20
5 Pound Load							
300	58,000	520	112	540	510	480	480
1,000	58,000	820	71	1000	950	900	850
10 Pound Load							
300	46,000	510	91	650	600	500	460
700	46,000	690	67	1000	1000	850	650
1,000	46,000	880	52	1100	1100	1100	1000

Table 1. J-9-10-300 Performance Characteristics
Incremental Rates of Rise
DAYTIME FLIGHTS

Rate of Rise (ft/min)

20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
5 Pound Load							
480	480	490	500	520	550	590	630
800	750	800	800	800	800	800	850
10 Pound Load							
450	450	480	500	500	510		
600	600	600	600	650	650		
900	800	700	700	700	700		

Table 2. J-9-10-300 Performance Characteristics
Incremental Time Factors
DAYTIME FLIGHTS

Free Lift (grams)	Burst Alt. (ft)	Rate of Rise (ft/min)	Time to Burst (hours)	Time Spent 0-5	5-10	10-15	15-20
5 Pound Load							
300	58,000	520	1.87	0.15	0.16	0.17	0.17
1,000	58,000	820	1.19	0.08	0.09	0.09	0.10
10 Pound Load							
300	46,000	510	1.52	0.13	0.14	0.17	0.18
700	46,000	690	1.11	0.08	0.08	0.10	0.13
1,000	46,000	880	0.87	0.07	0.07	0.07	0.08

Table 2. J-9-10-300 Performance Characteristics
Incremental Time Factors
DAYTIME FLIGHTS

Between Altitude Levels (hours)							
20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
			5 Pound Load				
0.17	0.17	0.17	0.17	0.16	0.15	0.14	0.09
0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.06
			10 Pound Load				
0.18	0.18	0.17	0.17	0.17	0.03		
0.14	0.14	0.14	0.14	0.13	0.03		
0.09	0.11	0.12	0.12	0.12	0.02		