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RESEARCH MEMORANDUM

EXPECTED COST AND PAYOFF OF A HIGH INTENSITY BALLOON PIONEER RECONNAISSANCE CAMPAIGN OVER THE U.S.S.R. (S)

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I. INTRODUCTION

The original analysis of the feasibility and utility of a balloon pioneer reconnaissance system was completed at RAND in November, 1950, and almost immediately Project Gopher was established to develop the system. Since then RAND has continued to keep in touch with balloon developments as much as possible, and has from time to time made supplementary studies to bring the original work up to date and to investigate certain special features. The most extensive of these studies was RM-979, November, 1952, which went into the cost estimates and expected coverage of the system, based on information gained in the course of the work on Project Gopher.

One of the basic constraints on a balloon pioneer reconnaissance system is the need for using it during a season when the winds are most favorable. Without resorting to very large, high-altitude balloons, operating above about 80,000 ft (see RM-979, p. 47), it would be necessary to work during the winter months, when the westerly winds in the lower stratosphere at middle and high latitudes are fairly strong and steady. It was assumed in the previous system studies that the winter months could be considered as November, December, January, and February, and that there was therefore a period of roughly 100 days a year which would be favorable for the operation.

Nothing has come up in the way of wind data to really affect this assumption, but a criticism has originated based on quite a different consideration. It has been argued that the three-month period would be too long for the operation from a political standpoint, and that it would be better to get it over with much more rapidly. Granting that this might well be so, the political advantages should be weighed against the considerable increase in the difficulty and cost of compressing the operation into a shorter time. Without attempting to weigh the political aspects, the problems of running a "high intensity campaign" are spelled out below.

There are clearly two ways of shortening the duration of the operation without accepting a decrease in coverage.

- o It can be run with more effective arrays of balloon-borne, long focal length cameras, which will increase the data gathering ability of each balloon and thereby reduce the total number required for a given level of coverage, but will increase the weight and cost per balloon. (Sections II and III.)
- o It can be run at a higher rate of launching and recovery, resulting in greater cost for launching sites and recovery facilities to carry the increased load. (Section IV.)

These two avenues are both explored in this report, and it is shown where the practical limits occur in each case.

Another consideration which has been receiving some attention is the coverage as a function of the position of the launching point or points. The coverage calculations in RM-979 were based on one launching point (65°N Lat., 0° Long.) In order to demonstrate the effect of changing the launching points, the coverage calculations have been extended to show the coverage for a variety of launching patterns, using single or double launching sites.

Thus, this report is essentially a further extension of the original studies. However, an attempt will be made to present the material in such a way that its implications can be understood without reference to the other reports.

II. COVERAGE CALCULATIONS

As a reconnaissance balloon drifts cross-country during the daytime, its cameras will photograph a strip of ground. If an array of cameras is used it is possible to obtain pictures essentially from horizon to horizon. Furthermore, the focal lengths of these cameras can, in principle, be adjusted to give a scale which is suitable for photo-interpretation on large features out to as far as 50 miles. It should be noted, however, that as one looks over such a strip of photographs one would find long sections which would show only cloud tops, and there would be at least twelve hours out of each day's travel for which there would be no pictures because of darkness. (For more on this subject, see Section III.)

We say that a feature of the terrain is "covered" if it is photographed with a proper scale during a day with two-tenths cloud cover or less and a visibility of six miles or better. With this definition, it is possible to determine statistically the probability that a point in a given region will be covered as a function of the number of balloons launched and the position of the launching site. Clearly, a number of factors must be considered in arriving at these probabilities. The details are to be found in

RM-979 (Section II.D and Appendix D), so it will suffice here to summarize the factors briefly:

- The pattern of balloon trajectories, assuming a large number of balloons launched more or less regularly over the course of several days or weeks (in winter), will look like a smoke trail spreading out from the launching site and extending in the direction towards which the mean wind blows. By actually computing a number of such trajectories from upper air maps it is possible to arrive at an estimate of the spread of these trajectories and the point of maximum density along any given meridian downwind. This was done for three launching sites, corresponding to 60°, 65°, and 70°N Lat. along the Greenwich meridian. There will presumably be some variation from year to year and from month to month within the winter season, but the general features of the mean wind flow and the spread of the trajectory patterns will probably not be too different from those used in this study.

The question of altering the trajectory distribution by using trajectory forecasting methods cannot be ignored. It seems certain that by selecting certain times when the wind was "favorable" one could displace the pattern north or south, or could change the mean speed of travel. However, it is equally certain that one could not tell where a given balloon would go to better than some 20 to 30 percent of the distance traveled, so it would be quite impossible to direct individual balloons to individual targets more than a few hundred miles downwind. Thus, the concept of launching whenever possible appears to be the best scheme in the long run, and in a "high-intensity campaign" it would probably be quite impractical to hold up operations until the forecaster said, "Go."

- o The balloons which travel a high-latitude trajectory in winter will encounter fewer daylight hours per day, so will "cover" less area per mile traveled than those at lower latitudes. This darkness degradation factor, a function of latitude, is taken into account.
- o The distribution of cloudiness and obstructions to visibility will determine how many useable pictures are taken each day. The cloudiness factor was computed by the Air Weather Service.*
- o The probability of recovering a balloon payload, once it has been successfully launched, has been estimated to be about one-half, i.e., two balloons launched for each payload recovered.

There are so many variables that it has been difficult to devise a convenient and readily understandable way to present the melee of results. The following pictorial presentation has been found the most satisfactory, since it allows one to draw one's own conclusions without imposing preconceived

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*Areal and Altitudinal Variations of Cloud Conditions Favorable for Visual Photo-Reconnaissance Operations Over Eurasia, Directorate of Climatology, Headquarters, Air Weather Service, October, 1952 (Secret).

judgments as to just what is "optimum."

In Fig. 1 through 5 are presented maps showing the variation of coverage in western and central Russia for several launching points or combination of launching points. The lines are lines of constant coverage, referred to as "isopleths of coverage," and the number assigned to each isopleth will depend on two things:

- o The number of balloons launched, or balloon force.
- o The width of the strip which will yield useful information.

The values assigned to each isopleth for a given combination of balloon force and strip width are given in Table I.

TABLE I

Values (in Percent) to be Assigned to Isopleths in Coverage Figures for Various Combinations of Balloon Force and Strip Width

Number of Balloons Launched	Strip Width (Statute Miles)														
	40					60					100				
	Isopleth Label					Isopleth Label					Isopleth Label				
	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
1000	75	55	45	28	17	86	70	55	37	24	96	83	75	55	37
2000	95	80	68	47	30	100	90	80	60	40	100	97	93	80	60
4000	100	95	90	74	50	100	100	95	83	65	100	100	100	95	83
8000	100	100	100	90	73	100	100	100	97	83	100	100	100	100	97

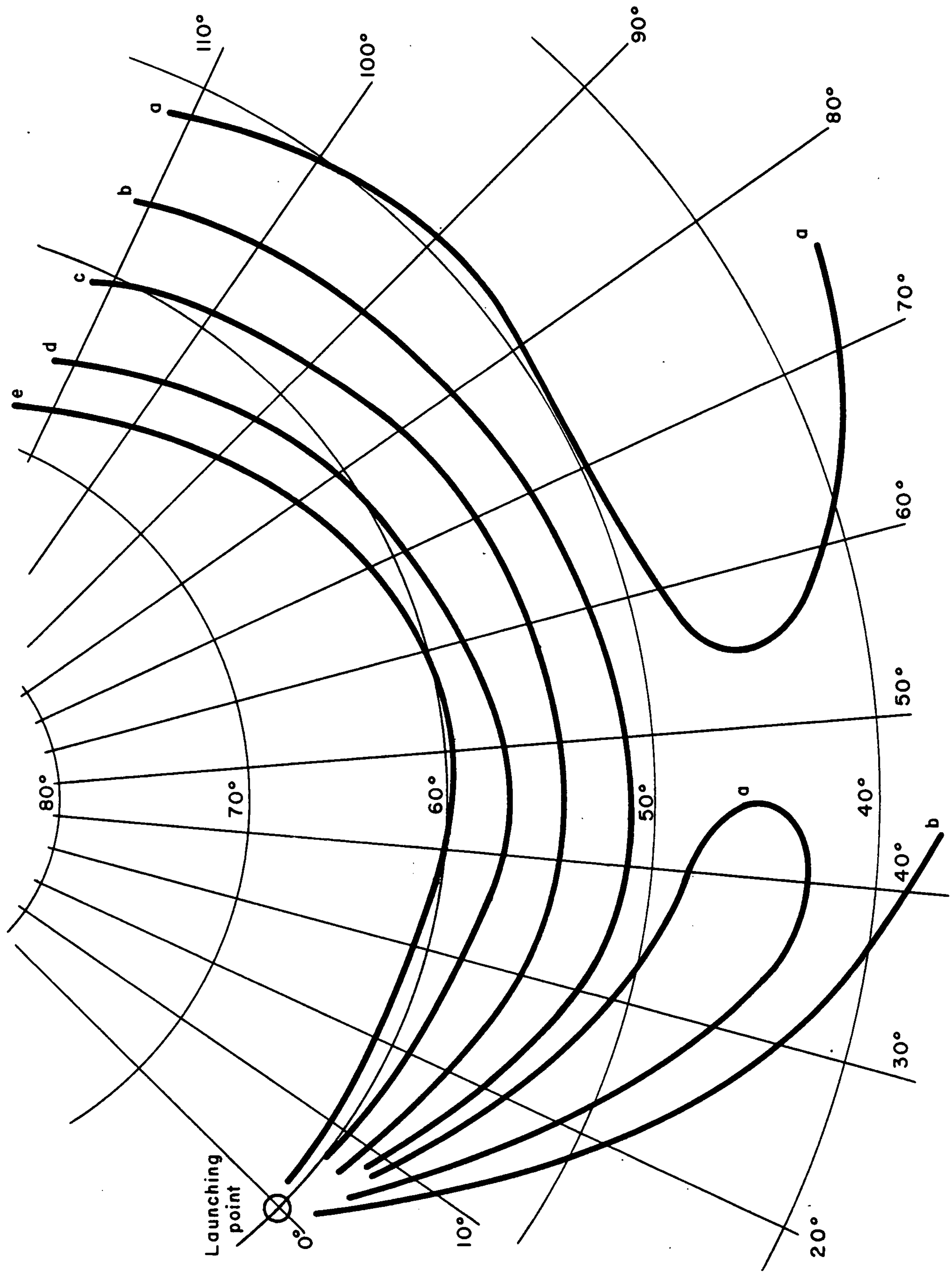

Fig. 1—Coverage pattern for balloons launched from 60°N, 0°E

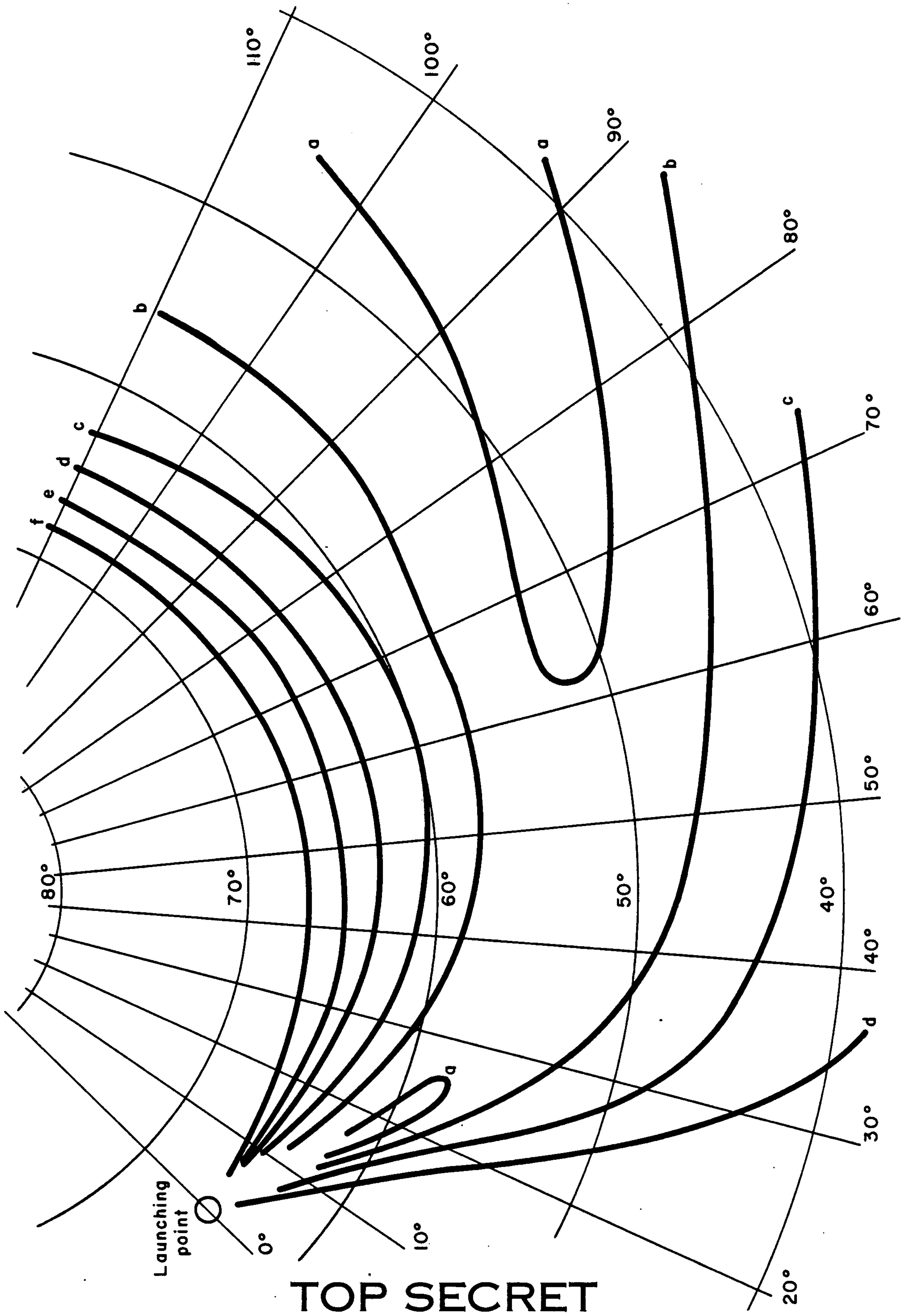

Fig. 2—Coverage pattern for balloons launched from 65°N, 0°E.

RM 1164-2

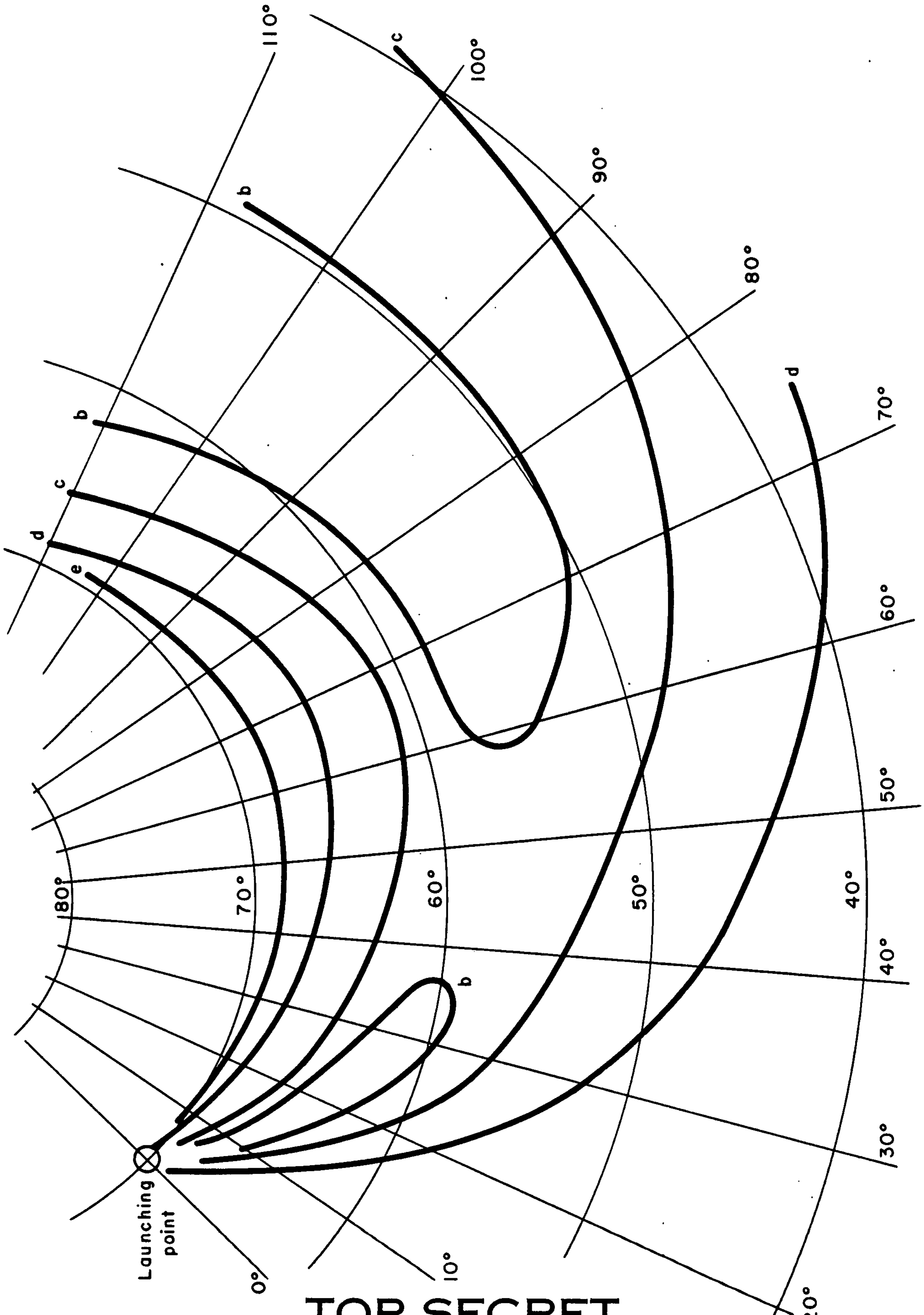

Fig. 3—Coverage pattern for balloons launched from 70°N, 0°E

RM 1164-3

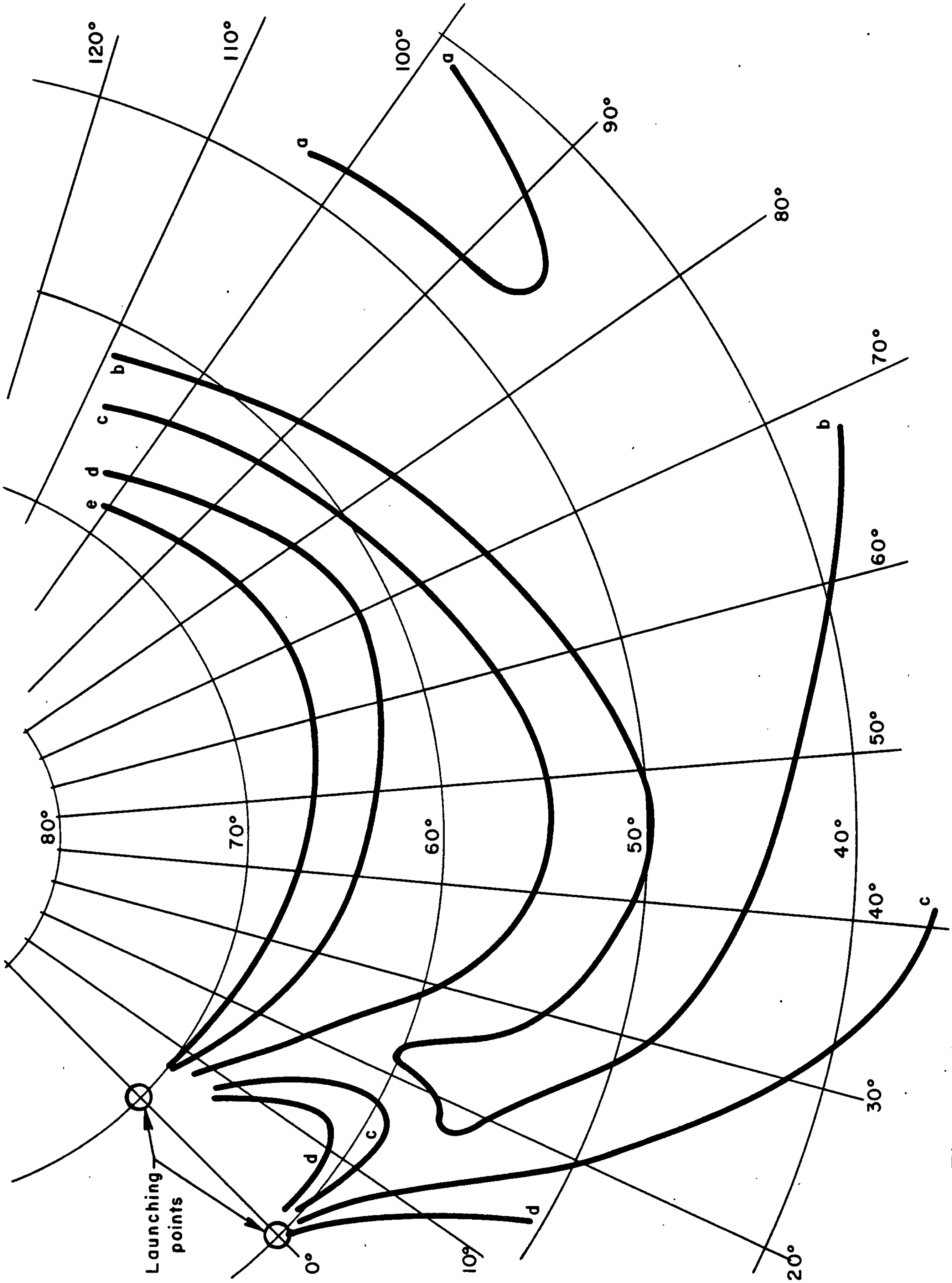

Fig. 4—Coverage pattern when equal numbers of balloons are launched from the 70° N point and the 60° N point (two launching sites)

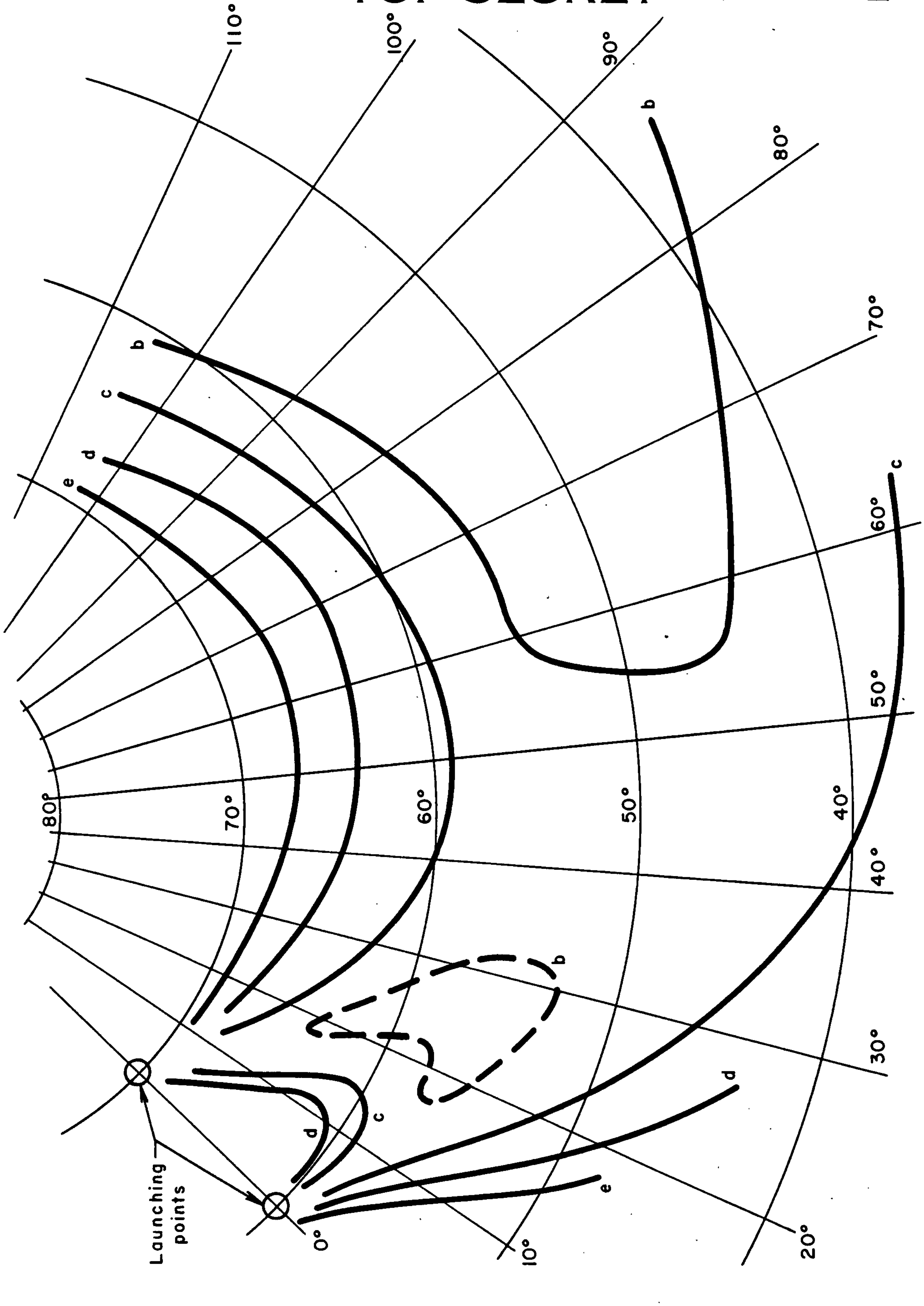

Fig. 5—Coverage pattern when twice as many balloons are launched from the 70°N point as from the 60°N point

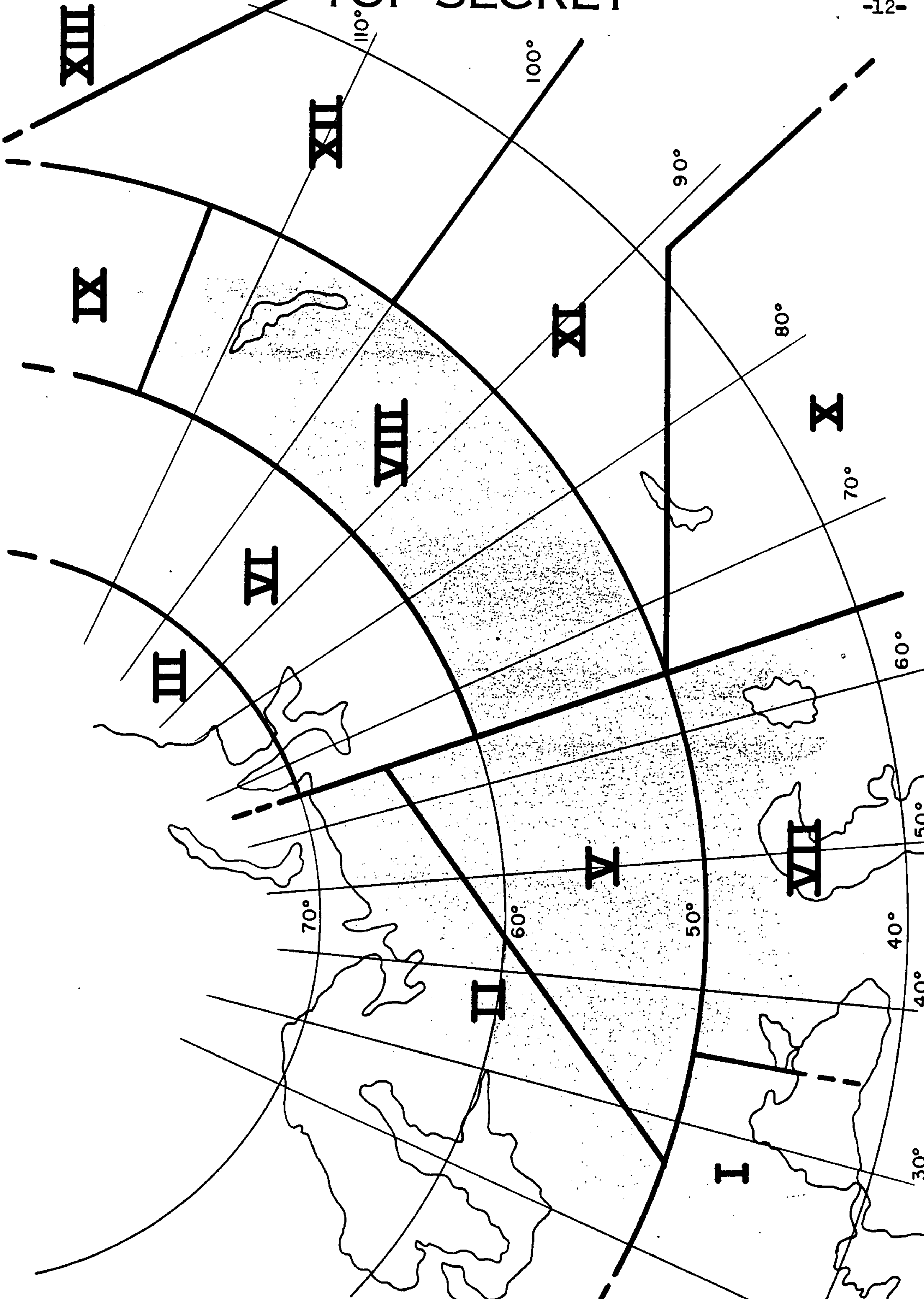

Fig. 6—Map of the USSR, showing the more important areas for pioneer reconnaissance (dark shading)

RM 1164-6

The coverage is expressed in terms of a percent, which can be interpreted in either of two ways:

- o A given percentage of the large features in a given region will be photographed.
- o A feature in a given region will have a given percentage probability of being photographed.

It will be noted that the coverage of the northern part, above about 60° to 65°N Lat., is rather poor due to the darkness degration. This means that relatively more balloons are required to obtain the same coverage in the northern part. Thus, the launching scheme shown in Fig. 5, where twice as many balloons are launched from the northern end of the launch line as from the southern end, seems to be somewhat the best in that it gives the broadest coverage of the whole region of interest.

In order to give a better idea of the orientation of the various patterns, Fig. 6 shows an outline map of Russia and some of the regions which, for one reason or another, are considered to be of interest for a pioneer reconnaissance operation. It is drawn to the same scale, so the coverage patterns can be used as overlays on this map.

It can readily be seen that an appraisal of the coverage must necessarily be rather subjective, due to the fact that the balloon coverage pattern is such that one cannot hope to get all of the areas of interest properly reconnoitered, and also due to the fact that one cannot specify the "target system" precisely. (See Fig. 6.) However, it may be of some interest to inquire how the <u>overall coverage</u> would vary with the various changes of strip width, overall coverage being rather arbitrarily defined as the fraction of the whole area of Russia west of 100°E Long. (A few rough checks indicate

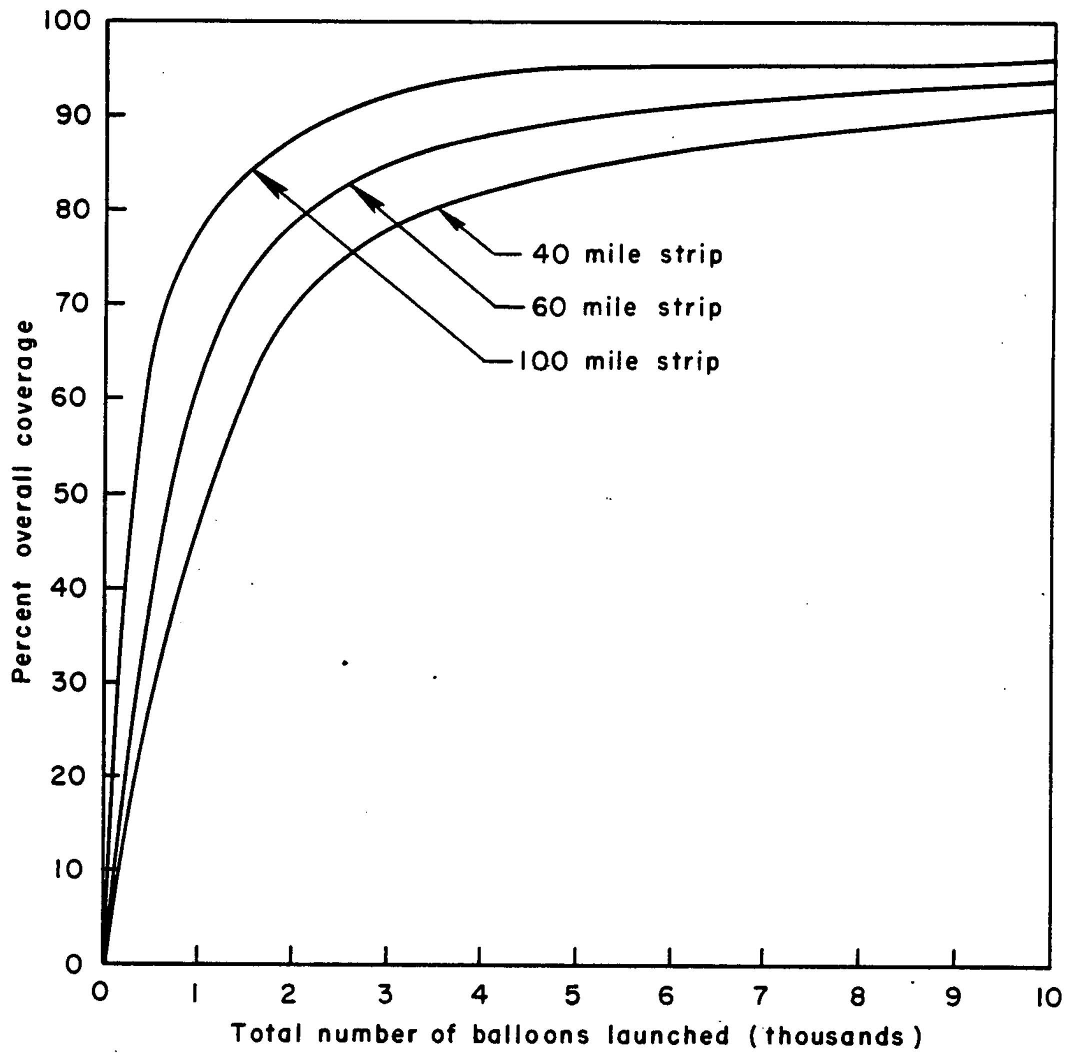

Fig. 7 — Coverage of the USSR west of longitude 100° E by balloons launched from 65° N latitude, 0° long

that the numbers for overall coverage would not be greatly altered by including all of the area of Russia and Communist China.) The overall coverage is shown in Fig. 7, where the case of a single launching point at 65°N Lat., 0° Long., is considered, and the 40, 60, and 100 mile strip widths are each treated. The numbers would be somewhat different for the different launching schemes, but the relative effect of changing the strip width would be about the same.

III. BALLOON-BORNE CAMERAS AND THEIR USE

The conception of a balloon photo-reconnaissance system is not new, but much remains to be learned about how to use it to best advantage. The present section will suggest how photographic equipment can be used to obtain more information than that which is ordinarily gathered from aerial strip photography.

It will be evident to anyone reading this section that some important decisions must be made with regard to the best way to use the balloon-borne cameras. Since special cameras and special lenses will have to be procured for this operation, and since relatively large numbers will be required, it is of the utmost importance that the camera payload and its output be given immediate attention.

Focal Lengths vs. Strip Widths

In Section II it was shown how much the coverage per balloon would be increased by increasing the width of the photographed strip which would reveal useful information. It should be remembered, however, that one does not arrive at an increased width without extending the range of the cameras, and this can be done by one of two methods. If one grants that photo interpreters must have a certain effective resolution on the ground in order to identify a feature such as a factory, airfield, population center, etc., then one can get greater range by going to either:

- Longer focal lengths in order to increase the scale at a given range.
- Greater resolution and/or contrast on the negative.

The question of the scale or resolution required for pioneer reconnaissance is far from settled, but a range of scales which would bracket the scale requirements would be:*

1:100,000 to 1:500,000

It is assumed here that the usual 10 to 14 lines per mm is the image resolution of the lens and film. If very fine lenses and fine grain film were used, the allowable scale would be somewhat smaller, but this is a complex question which will not be dealt with here. (See, for example, the Beacon Hill Report, Appendix C.) For the sake of illustrating the situation, let us adopt a scale of 1:250,000 as acceptable for pioneer reconnaissance.

For a balloon at 60,000 ft altitude, a 3 in. focal length camera would provide this scale in the vertical. However, for the same floating altitude, the range to the ground is greater for obliques, and there is also the problem of distortion of a horizontal feature due to the obliquity. For a balloon at 60,000 ft, a 12 in. focal length will be required to provide the effective scale for an object at a horizontal distance of about 30 mi.**

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*Personal discussion with Mr. Amrom H. Katz, Photo Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

** The horizontal and vertical scales in an oblique, S_x and S_y respectively, are not the same. For an object near the axis of the camera:

As one goes to still greater ranges, another factor enters, the degradation of contrast due to haze. The 30 mi horizontal distance corresponded to a depression angle of about 22°. To reach out 50 mi the depression angle would be less than 15°, and at such small angles of depression the required focal length on a day with average visibility may be two to four times greater than that which would be required on an ideally clear day. (See Beacon Hill Report, Appendix C.) Thus, to give the resolution required for pioneer reconnaissance, the focal length for a 50 mi horizontal range would probably have to be at least 36 to 48 in.

These trial calculations are not to be considered as final, but are intended to show how fast the focal length goes up as one tries to reach out to greater ranges. The weight of the camera would go up roughly as the cube of the focal length, and the weight of film would go up roughly as the square of the focal length. In a system where weight of payload is an important factor in determining the cost and reliability, this will run up the cost per balloon and will tend to decrease the reliability; but the increased cost per balloon could be about balanced by the increased coverage per balloon.

Nighttime Photography

In the preceding section it was pointed out that a very large degradation factor had to be introduced to take into account the short duration

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** $S_x = \frac{H}{f}\left[\frac{1}{\sin\theta}\right]$, $S_y = \frac{H}{f}\left[\frac{1}{\sin\theta}\right]^2$, and the effective scale is defined as $\overline{S}_e = \sqrt{S_x S_y}$, where H is altitude, f is focal length, and θ is angle of depression of the camera axis.

of daylight in winter at high latitudes. Thus, virtually no coverage is obtained north of 65° to 70°N Lat., a region along the arctic coast of Asia which may be of considerable interest.

It is usually assumed that only daylight photography will be practical, for with the motion of the balloon it would not be practical to take time exposures at night in order to pick up terrain features. There is an application of night photography which might give useful information, however:* Artificial lights on the ground, such as street lights, will leave faint "trails" on the film of a camera set for normal daylight exposure. If the camera were to be used with a larger aperture at night, fainter lights could be detected, and possibly the reflected illumination from shaded lights. (Exposures of around 1/25 to 1/50 of a second would probably be adequate for these, though longer exposures would make the trails on the film longer and easier to spot. The light from a moving point source falling on a film will make an exposure which is independent of the exposure time as long as the circle of confusion of the image moves a distance equal to its own diameter while the shutter is open.)

If a balloon destined for a northerly trajectory were set to operate continuously, day and night, the nighttime portions of its film strip could be analyzed to show signs of habitation and human activity, on the assumption that arctic installations would not be completely blacked out. The purpose of pioneer reconnaissance is to a large extent to determine the extent of enemy activity in a broad sense, and it is fairly certain that in the arctic any activity at all would be of strategic interest.

It should be noted that balloons with northern trajectories will tend

*The author is indebted to Professor James G. Baker, Harvard College Observatory, for suggesting this application.

to enter the recovery network in its extreme northern end, and recoveries would have to be made over the Arctic Ocean north of Alaska. This area is a difficult region in which to operate aircraft, particularly in winter, when the ground cold and short day multiply the normal difficulties many times. Thus, one should not expect a very high level of recovery in this region without a special effort.

IV. COST AND EFFORT REQUIRED TO INCREASE THE LAUNCHING AND RECOVERY RATE

Let us now examine what increases in cost and effort might be expected if we desire to drastically shorten the total time of operation, keeping the total number of balloons constant. In order to do this, we would have to step up the intensity of launching and recovery. In this case, we must still live with the fixed requirements of the launching and recovery methods. These will determine the increased cost and effort and, in the long run, the probability of success of the stepped-up operation.

Launching Requirements

The vehicle involved is considered to be a 73' diameter balloon. This balloon is composed of polyethelene material .001-.002 in. thick, and is expected to take off with a gross load of 1500 lbs. Being large and sail-like initially, it is very much affected by surface winds during the preparation period. Using unconventional methods, some of which are described in a previous report (RM-979), it has been found possible to launch these balloons in gust velocities up to 15 knots, but to date this remains as the upper limit. We are faced, then, with the problem of releasing a number of large, cumbersome, fragile vehicles that are greatly affected by ground conditions at the time of launching. There have been two basic philosophies developed on how best to get these balloons off the ground. One involves launching from a ground station, at which you take advantage of all the available wind shelter and launch only under the proper conditions. The second involves launching from a ship at sea (such as an aircraft carrier or seaplane tender), on which you steam downwind at a proper speed so as to eliminate a certain percentage of the adverse winds. Although each philosophy has its specific advantages, it was found, surprisingly enough, that when the 15 knot limitation is imposed, from the standpoint of winds alone, both types of launching bases are suitable for operation about 50 percent of the time during the winter months. The main differences between the two were those involving ease of setting-up, mobility, security, and replenishment of lifting gas supplies.

Although it is true that a ship is easier to launch from, more mobile, and certainly more secure than a land base, the supplying of lifting gas is a substantial problem, and in the long run could become the equalizing factor between the two systems. It has been estimated that an aircraft carrier can store 2×10^6 cubic feet of gas on its flight deck. At the usual rate of 2×10^4 cubic feet/balloon, this is enough for only 100 balloons. This gas can be replenished in two ways. One is by resupply, and the second is by installing gas generation equipment. (If helium is used rather than hydrogen, this second method is impossible.) Under the first method, let us suppose we are running a campaign of 2000 balloons, which would require in the order of 4×10^7 cubic feet of gas. Subtracting the 2×10^6 cubic feet already on the carrier, this would leave 3.8×10^7 cubic feet to be supplied. Put in more understandable terms, if it were necessary to transport this amount of gas over land it would require the use of 190 special railroad tank cars, or 1140 special tank trucks. This is certainly a substantial resupply problem, made even more difficult by the non-availability of this number of special tank cars or trucks.

It should be noted, however, that this tremendous resupply problem is generated by the assumption that the entire campaign is run from only one ship. If ten carriers were used as launching bases, they would be able to carry half of the gas needed, and each would have to be resupplied only once. Thus, the multiple launching site scheme, for this and a number of other reasons, will be shown to be preferable.

On land it is, of course, possible to store the entire necessary supply of gas at the various overseas bases that would be used. However, assuming that helium would be employed, this 4×10^7 cubic feet would still have to be transported from the U.S.

If we are allowed to use hydrogen as the lifting gas, there exists the possibility of generating this gas aboard ship. It has been estimated that a generator which had an output of 200,000 cubic feet/hour could be installed aboard a carrier, at a cost of about one million dollars. It is also estimated that a generator with an output of 40,000 cubic ft/hour could take care of 2 launchings/hour, and would cost about $500,000. The larger generator operated 20 hours a day would allow balloons to be launched from a single carrier at the rate of 200 per day. It is believed possible* to launch as many as 15 balloons at a time from the deck of an aircraft carrier. Allowing for aborts and decreased efficiency, each three crews could, with

*Lt. S. G. Malcolm Ross, USN, Summary of Feasibility: Report on Naval Usage of Plastic Balloons, 1952 (Secret).

proper assistance in preparing the balloons, launch 4 per hour or two crews could be capable of launching 2 balloons per hour. At this rate of 20 balloons per hour it would be possible to use up a day's generation of gas in about 10 hours. Since this proposed generator approaches the limit (in size) that can be placed aboard a carrier, this number of 200 launchings per day represents an upper limit to the number of launchings per carrier.

It should be noted at the outset, however, that due to the need for a certain degree of dispersal of the balloons, anything approaching 200 balloons per day from one base would result in the balloons being too closely bunched, and so it would be more advantageous to have several bases, both in the land and sea cases.

The Recovery Requirements

There are essentially four methods of affecting the recovery of a balloon payload. These are:

1. Snatch it from the air by a recovery plane.
2. Snatch it from the sea by a recovery plane.
3. Recover it from the sea by a surface craft.
4. Let it travel for a longer period of time and recover it from a land area.

We may eliminate the fourth possibility due to the strain that it imposes on the balloon system, and the haphazard and uncontrollable way that it must be carried out. Of the remaining three, it is estimated that the first, the "air snatch," would be most economical. On this assumption, such a system was field tested and was proven feasible.

In this section the probability of a payload being recovered by this method is not treated. The recovery probability only affects the total number of balloons launched to achieve a given coverage, a phase that was treated in an earlier section. Instead, we will examine the force requirements necessary for a given campaign, assuming that a recovery attempt will be made on every balloon launched, and estimate the resulting cost.

Quoting from RM-979, these are the pertinent force requirements:

1. Length of the recovery network, from Okinawa to Fairbanks is about 4000 n mi, extending in a curved line from SW to NE.
2. Bases at or near Okinawa, Tokyo, Shemya, and Fairbanks should be able to provide coverage for the area.
3. The fraction of aircraft out for maintenance at any one time is 1/3, and the abort rate is 0.2 (the usual factors considered in a bombing campaign). This means that 1.7 aircraft are needed for every aircraft required to be in operation.
4. The network is "saturated," i.e., there is always at least one balloon in the patrol area of each aircraft, so all sectors of the network must be continuously patrolled during the daylight hours.
5. Each aircraft can attempt to recover, on the average, five payloads in a day's operation. Thus, as the flux of balloons through the network increases there will be a point where more aircraft must be added to keep the average work load at five recoveries per aircraft per day. (The maximum number of recoveries for a given aircraft might be as much as ten or fifteen per day, if they were quite closely spaced, but the <u>average</u> work load is kept low to allow for the random

fluctuations in the number of balloons passing through a given sector.)

6. The plane that appears to be best suited for this job is the C-119H.
7. The cost of flying such an aircraft, including the cost of fuel, maintenance, and depreciation, is estimated to be roughly $500 per flying hour. Each of the recovery aircraft flies an average of ten hours per operational day.
8. The minimum number of operational aircraft over the entire recovery network is taken to be nine.
9. In all cases the network is designed for an estimated daily peak density. This peak density is assumed to be the number of balloons released per day.
10. Adverse weather grounds recovery aircraft 10 percent of the time.
11. Based on the minimum and maximum time for a balloon to cross Russia, it is assumed that the recovery operation will extend from three days after the first balloon is launched, to 10 days after the last balloon is launched.

Desired Launching Pattern

For the calculated coverage to have any validity, trajectories must be independent of each other. It is, of course, apparent that in any operation involving multiple launching sites, many balloons, and a limited time of operation, trajectories will be close together, and there will be a tendency for "clumps" of balloons to travel across Russia. It is imperative, therefore, that every effort be made to minimize this clumping by maximizing the initial spacing of the balloons, and thereby make them follow independent trajectories. This is especially true in the case under consideration, in which we are attempting to cram as many balloons as we can into as short a time as possible.

There are several ways in which this can be done. One such method would be to spread them far enough apart <u>in time</u> to insure independence, and the second would be to spread them far enough apart <u>in space</u>. Due to the fact that the area along the Greenwich meridian between 60°N and 70°N was found to be the most suitable launching line for a balloon survey of Russia, there will be a basic limitation to the spacing possible. Time spacing will be at a premium because of our desire to get the balloons across Russia in a short time. Some compromise will therefore have to be worked out. Based on assumptions about the persistence of the local wind vector, and the normal distribution of streamlines in the atmosphere, we have set up the following constraints on the space and time distribution of balloon launchings:

1. All stations (both land and sea) will be located between 60°N and 70°N.
2. The north-south spacing between stations will be no less than the useful width of the strip which is photographed from the balloon. This is to allow for the worst case of balloons launched at the same time from different stations having parallel trajectories. In this case there would be no overlap of photographed strips.
3. No more than 2 balloons/hour will be launched from each

station. There is no objective basis for this number. It is considered that if the trajectories do not fan out rapidly from a station there should not be too many balloons flying one behind the other, and if there is a tendency to fan out there should still be enough vehicles in the air to do the job.

For this short duration, intense campaign, we will assume the following two daily launching rates as being representative of "reasonable" and "extreme" levels of operation:

- o 200 total launchings per favorable day.
- o 500 total launchings per favorable day.

Let us examine what the above constraints mean in terms of space distribution of launching stations.

TABLE II

Number and Arrangements of Launching Sites

Balloons/day favorable for launching	Width of strip photographed from balloon	Number of stations needed	Number possible along a north-south line	Number of north-south lines needed
200	100 miles	10	8	1
	60 miles	10	12	1
500	100 miles	25	8	3
	60 miles	25	12	2

It can be seen almost immediately, from the above table, that one would be inclined to disregard the 500/day case due to the tremendous logistics problem that would be involved in maintaining 25 launching stations. Moreover, it is felt that, despite any spacing imaginable, we are still limited to an area approximately 10° on a side, and launching 500 balloons a day into this relatively small area can only result in a severe concentration of vehicles, which would mean many pictures of the same strip. For the sake of completeness, however, we shall continue to carry this case through the next section on costing.

Cost of the Intensive Campaign

Before tabulating the cost let us set down the approximate duration of the launching operation. As stated previously, consideration of the climate of the North Atlantic and northwestern Europe indicates that both on sea and land about half of the days will be favorable for launching.

TABLE III

Approximate Duration of Launching Operation

	Total Number of Balloons in Campaign				
Balloon/day	1000	2000	4000	6000	10,000
200	10 days	20	40	60	100
500	4	8	16	24	40

The table below lists the campaign requirements including dollar costs, equipment amounts, and personnel. It should be noted that, as in the previous report, the costs considered here are only the explicit costs of the expendable gear, the specially procured ground equipment, and the costs of operating the recovery aircraft. Actually, the total cost to the Department of Defense will be much more, since there will be an extensive training program (as indicated by the number of specially trained personnel), recovery aircraft and launching facilities to allocate and maintain, and the cost of transporting such a complex task force. These are not included in the dollar costing, but are indicated in the calculations and should be kept in mind when contemplating the level of effort required to mount a campaign of a given size.

In an effort to integrate all the material, a set of "ground rules" by which the campaign requirements were estimated are also given. In essence they reiterate the pertinent information presented in the preceding sections.

We will make one more basic assumption before starting: The campaign is run using hydrogen, and the hydrogen is procured by generation at the launching site.

TABLE IV

Campaign Requirements for 200 Balloons/Day Favorable for Launching

Requirements	Total Number of Balloons Launched in Campaign				
	1000	2000	4000	6000	10,000
1. Total number of launching stations	10	10	10	10	10
2. Number of balloons launched per station per day	20	20	20	20	20
3. Number of launching crews and associated gear required	20	20	20	20	20
4. Cost of gas generating equipment (millions of dollars)	5.0	5.0	5.0	5.0	5.0
5. Recovery aircraft which must be in air each day when weather permits	40	40	40	40	40
6. Total force of recovery aircraft	68	68	68	68	68
7. Total number of days of recovery operation	17	27	47	67	107
8. Approximate total number of flying hours spent on recovery missions	6800	9720	16920	24120	38520
9. Cost of operating and maintaining the aircraft (millions of dollars)	3.4	4.9	8.5	12	19.3
10. Total explicit cost of non-expendable equipment and operation of recovery aircraft (millions of dollars)	8.7	10.2	13.8	17.3	24.6
11. Cost of balloon and associated expendable gear (millions of dollars)	8.35	16.7	33.4	50.0	83.5
12. Total explicit cost (millions of dollars)	17.15	26.9	47.2	67.3	107.9
13. Number of specially trained personnel for launching, tracking and recovery	568	568	568	568	568

TABLE V

Campaign Requirements for 500 Balloons/Day Favorable for Launching

Requirements	Total Number of Balloons Launched in Campaign				
	1000	2000	4000	6000	10,000
1. Total number of launching stations	25	25	25	25	25
2. Number of balloons launched per station per day	20	20	20	20	20
3. Number of launching crews and associated gear required	50	50	50	50	50
4. Cost of gas generating equipment (millions of dollars)	12.5	12.5	12.5	12.5	12.5
5. Recovery aircraft which must be in the air each day when weather permits	100	100	100	100	100
6. Total force of recovery aircraft	170	170	170	170	170
7. Total number of days of recovery operation	11	15	23	31	47
8. Approximate total number of flying hours spent on recovery missions	9900	13500	20700	27900	42300
9. Cost of operating and maintaining the aircraft (millions of dollars)	5.0	6.8	10.4	14.0	21.2
10. Total explicit cost of non-expendable equipment and operation of recovery aircraft (millions of dollars)	18.25	19.95	23.55	27.15	34.35
11. Cost of balloon and associated expendable gear (millions of dollars)	8.35	16.7	33.4	50.0	83.5
12. Total explicit cost (millions of dollars)	26.55	36.65	56.95	77.15	127.85
13. Number of specially trained personnel for launching, tracking and recovery	1360	1360	1360	1360	1360

SUMMARY OF RULES FOR CALCULATING THE CAMPAIGN REQUIREMENTS

Items 1 and 2	Maximum number of balloons launched from a station not to exceed 20/day.
Item 3	It is assumed that two launching crews of four men each could launch 2 balloons/hour for a 10 hour day.
Item 4	It is assumed that a gas generation unit capable of supplying 20 balloons per day would cost $500,000. It should be noted that it was also assumed that the land stations would use this generator, whereas there is a possibility of obtaining the gas commercially at $100 per launching. If this is true, the gas cost for land launching will be a very small fraction of the cost as assumed.
Item 5	The number of aircraft on patrol is kept at a level to insure recovery of peak flow through network (number of balloons launched per day), at an assumed rate of 5 recoveries/aircraft/day.
Item 6	To take into account preventive maintainence and aborts, 1.7 aircraft are needed for every aircraft required in operation.
Item 7	It is assumed that the recovery operation will start three days after the first balloon is released, and end ten days after the last balloon is launched.
Item 8	Each operational aircraft flies, on the average, a daily ten hour mission. The operation lasts for the number of days as given. Ten percent of the time the aircraft are grounded due to weather, an average for the network.
Item 9	Fuel, oil, maintenance, and depreciation of the aircraft cost about $500 for each flying hour.
Item 10	The average launching equipment cost per crew (on sea or on land) is assumed equal to $10,000. Gas generation costs are as given. A DF tracking network (ground) is used to first pick up the balloons. This consists of four stations and has a total cost of $200,000
Item 11	Each complete set of flying gear (balloon, gondola, etc.) costs about $8350. None are recovered in time to be used over again in one campaign.
Item 12	Sum of items 10 and 11.
Item 13	Four men per launching crew. Two men per launching crew for readying the gondola. Ten men per DF tracking station, and four stations. Six trained men on each recovery aircraft, and the same number of crews as total aircraft.

CONCLUSIONS

With the information contained in the above section, it is now possible to evaluate the feasibility of increasing the launching and recovery rate. Let us first compare the cost in dollars and the requirements in trained men and aircraft needed for the short duration "high intensity" campaign and the 100 day campaign originally proposed. This is done in the following table:

TABLE VI

Summary of Campaign Requirements

	Total No. of Balloons in Campaign														
	1000			2000			4000			6000			10,000		
Type of campaign	at 200/day	at 500/day	in 100 days	at 200/day	at 500/day	in 100 days	at 200/day	at 500/day	in 100 days	at 200/day	at 500/day	in 100 days	at 200/day	at 500/day	in 100 days
Trained men needed	628	1510	148	628	1510	154	628	1510	232	628	1510	316	628	1510	520
Explicit total dollar costs (millions) of dollars	17.2	26.6	13	26.9	36.7	21	47.2	57.0	41	67.3	77.2	62	108	127.2	103
Aircraft needed	68	170	17	68	170	17	68	170	28	68	170	40	68	170	70
No of days needed to complete launchings	10	4	100	20	8	100	40	16	100	60	24	100	100	40	100

As can be seen, in the short duration campaign we fix the launching rate, and this immediately fixes the size of the launching and recovery establishments, regardless of the total number of balloons launched. As may be imagined, this is wasteful for small total numbers of balloons, but is effective in cutting down on the total time involved. It is surprising to note that dollar costs are not further apart for the various campaigns. However, we must remember that this is only the explicit cost (which is mainly dependent on the total numbers launched), and does not accurately reflect the total cost of a campaign requiring a given force level (aircraft, ships, men, etc.). It should be noted that the reason for disagreement between the 10,000 balloon, 100 day campaign and the 10,000 balloon, 200/day campaign, which also takes 100 days, is due to the original assumption that the former is run from only one launching station. The main differences between the systems are then:

- As can be seen from the table, the level of effort in terms of trained personnel and aircraft is much higher for the short duration campaign, and this will contribute to a much higher total cost to the Defense Department.
- The logistic problems are much greater for the short duration campaign because of the multiple launching sites, and would tend to completely rule out the 500 balloons/favorable day case.

We may conclude then that a short duration campaign (200 balloons/favorable day) is feasible but would require a high level of effort.

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SUMMARY OF A REVISED STUDY OF

PIONEER PHOTO RECONNAISSANCE BY BALLOONS (S)

I. COST VS. COVERAGE

A. Coverage vs. Number of Balloons Launched

The Gopher system is basically limited to pioneer reconnaissance. By altering the launching point and by trajectory forecasting it should be possible to improve the coverage of specific areas in Western Russia, but the trajectories are not sufficiently controllable to eliminate the essential randomness of the coverage pattern. Therefore, the "total coverage" is considered as a fraction of the entire area of Russia which could be photographed, with no weighting of specific areas for their military or economic importance.

In Fig. 1a is shown the total coverage of the whole of Russia west of longitude 100°E as a function of the number of Gopher balloons launched. (It would probably be essentially the same for all of Russia, since the completed trajectories go all the way across the country.) In calculating this total coverage account has been taken of the statistical distribution of the trajectories (Figs. 2, 3, 4 and 5), the degradation due to hours of darkness and cloud cover, which varies from place to place (Fig. 6), and an overall operational loss of 50 percent, or one balloon recovered for every two launched.

The total coverage is probably somewhat dependent on the launching point, since, as can be seen from Figs. 3, 4, and 5, the statistical distribution of the coverage by a certain number of "effective balloons" shifts with the launchin point, and this will bring different degradation factors to bear. The computation presented here should be considered as approximate only, and the coverage might be improved slightly by chosing an optimum launching point or by using

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multiple launching points.

It should be pointed out that the coverage is relatively poor in the northern part of Russia due to the long darkness and the frequent cloud cover. This will always be true in winter, which is the only time when the winds are favorable below about 80,000 feet. The degradation factors shown in Fig. 6 were estimated for January 15 conditions, based on hours of daylight between sunrise and sunset and the Air Weather Service study prepared for Project "Hope Chest."* They will definitely improve toward the end of the period, which may be around the vernal equinox in the latter part of March.

B. Cost vs. Number of Balloons Launched

The explicit cost of launching a specified number of balloons in one season's operation has been estimated, taking into account the purchasing of certain special fixed equipment (such as hydrogen generators, tracking stations, etc.) as well as the expendible equipment, and including the cost of operation of the recovery aircraft. The dollar costing does not include the cost of training and maintaining the military personnel, the cost of the launching base (whether aircraft carrier or ground base), the initial cost of the recovery aircraft, or the cost of transporting the task force. The probable cost as a function of number of balloons launched is shown in Fig. 1b, and a more detailed cost breakdown is given below.

It will be noted that the explicit cost of the non-expendible equipment which has to be specially procured, plus the cost of the aircraft recovery operation, seems to be about one-fifth of the cost of the expendible equipment over most of the range. This is due to the fact that, for an operation of more than

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* "Areal and Altitudinal Variations of Cloud Conditions Favorable for Visual Photo-Reconnaissance Operations over Eurasia," Hqs., Air Weather Service, Directorate of Climatology, October, 1952 (SECRET).

about 2000 balloons in a season, the launching and recovery costs will probably go up almost linearly with the number of balloons. The major part of the non-expendible cost comes from the lifting gas generation and the cost of operating the recovery aircraft (mostly the latter).

The problem of supplying enough lifting gas to operate thousands of large balloons (about 20,000 ft^3 per balloon at S.T.P.) is a very grave one, and it appears that the most satisfactory solution from a logistics standpoint is to manufacture it on the spot and to store only a limited amount (say, one to two days of operation). However, the generating equipment is expensive, and the best estimate seems to be $50,000 dollars for each 1000 ft^3 per hour generating capacity for the first 10,000 ft^3 per hour capacity, with a decrease in this figure as the capacity increases still further. (A very large $.75 \times 10^6$ ft^3 per hour plant, for example, was built at a cost of 1.7×10^6 dollars, which amounts to about 2,300 dollars for each 1000 ft^3 per hour capacity.)* To this must be added the cost of the compressing and storage equipment. To transport very large amounts of hydrogen from an industrial plant will mean procuring large quantities of tanks (either trailers or tank cars), and this would result in a saving in gas generating cost but a large logistics cost. There is, or course, the possibility that a land based launching site could be established within piping distance of an existing generating plant, which would cut the gas cost tremendously. For a shipboard launching operation it appears that generation on the spot and limited storage would be the only practical way for a large operation.

This matter will require much more study, and such a study would include a

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* "Lifting Gas Requirements of a Balloon Delivery System," Aeron. Res. Labs., General Mills, Inc., Rept. No. 1073, 21 March 1952 (SECRET).

a survey of available hydrogen in Europe, especially in England. An excellent preliminary survey of the problem of gas supply has been prepared by General Mills, Inc.*

It will be noted that the costing has been carried out separately for a land or a carrier based launching site. The difference in explicit cost between the two appears to be very small, however, since the larger cost of the lifting gas aboard a carrier is approximately offset by the cost of the launching facilities (wind screens, etc.) on land. The modifications required to make a carrier of the CVE type or seaplane tender fit for this operation would consist primarily of providing hydrogen generators and storage tanks aboard, and the difficulty of doing this has not been determined. For the smaller scale of effort, where, for example, a 2000 balloon operation would require a gas generation capacity of about 20,000 ft^3 per hour, plus a 2×10^6 ft^3 storage, it is estimated that such an installation would cost in the order of $600,000.

A carrier launching base is very attractive for a number of reasons. The primary advantage of such a platform is the ease with which a balloon can be inflated in winds up to the cruising speed of the carrier. The creation of a no-wind condition permits a vertical launching, which is by far the most reliable method. (A vertical launching probably requires less than 4 knots of wind against the balloon, even with a "reefing tube," and this is hard to obtain on land.) A second advantage of a carrier is the security of the operation.

It is urged that the use of carrier launching bases be considered in more detail than has been done here, in order to determine whether it would in fact be as advantageous as it appears at first sight.

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* "Lifting Gas Requirements of a Balloon Delivery System," Aeron. Res. Labs., General Mills, Inc., Rept. No. 1073, 21 March 1952 (SECRET).

1. Expendable Equipment

A reasonable estimate of the components of the Gopher package and their cost is as follows:

o 73 ft diameter, 2 mil laminated balloon, complete with lines, appendix, etc. (May be somewhat less in large production quantities.)	$1400
o Gondola (Developed by Stanley Aviation Co.; the cost is based on procurement in lots of 3000 and would be less in larger quantities.)	4500
o Cameras (Still being developed by Eastman, under contract with Photo Lab., WADC; 5 cameras per flight; 3" focal length lens, 4 1/2" x 4 1/2" negatives.)	1500
o Film	100
o Solar elevation angle recorder (Developed by Eastman, under subcontract from Stanley Aviation. Probably somewhat less in large quantities.)	500
o Hydrogen peroxide, 150 lbs.	150
o Government furnished equipment (parachutes, dye markers, etc.)	200
Total cost	$8350

2. Non-Expendable Items

The items which must be specially procured or turned over to the project are listed below, with a cost attached where an estimate is possible. The costs of transporting supplies, of maintaining the launching base, and of training and maintaining special personnel do not show up in the dollar costing, though they may be fairly large items.

o Launching base (An aircraft carrier of the CVE type, a seaplane tender, or a land base; one such base could be sufficient to launch over 10,000 balloons in a 3 to 4 mo. period.)	——
o Recovery aircraft (Presumably of C-119 type; number will depend on density of balloons, since each aircraft can probably make about 5 recoveries, on the average, per day.)	——
o Operation of recovery aircraft (A rough costing which estimates the expenditure for fuel, maintenance, and aircraft depreciation.)	$500/flying hour
o Launching equipment per launching crew:	
Carrier base	$1000
Land Base	$20,000

o Equipment at launching base for monitoring and cut-down	\$10,000
o Gas generating and storage equipment (Required for a carrier base, which can probably only store about 2 x 10^6 ft^3 or the equivalent of 10 railway tank cars. For a land base the generator can be reduced in capacity with larger storage facilities, or can be eliminated entirely if the base is close to an industrial generating plant.)	__Shipboard__: Minimum of \$500,000 Maximum of \$1,000,000 __Land__: \$100 per inflation
o Recovery DF stations (Four required as minimum. It is not yet decided whether adcock type will be adequate, but it will probably not be. For this costing, assumed \$200,000 for initial cost of network.)	\$5,000 - adcock \$25,000 to \$50,000 - rhombic

3. __Trained Personnel__

The military personnel which must be specially trained for the operation (in addition to base and maintenance personnel) are as follows (no further breakdown in terms of MOS or rank is attempted here):

o Launching, per crew:

Carrier base	4
Land base	6

o Loading and checking gondola, per crew	2
o DF stations, per station	10
o Recovery aircraft, per crew	6

4. Campaign Assumptions

The following rules have been established to permit the costing to be carried through. The various factors have been estimated from the best available information, but they are necessarily approximate. The whole operation period is taken as 100 days.

o Launching:

Carrier Base	Land Base
50 percent of days have favorable weather (winds $\lesssim$ 20 knots)	50 percent of days have favorable weather
10 hrs. available for launching on each favorable day (must steam back upwind)	10 hrs. available for launching on each favorable day
1/2 hr. required per launching	1/2 hr. required per launching
Can store 2×10^6 ft^3 of lifting gas. Can generate for 20 hrs. per day every day, and can launch the full quota of balloons each day for an indefinite period.	Cost of gas is $100 per launching, which implies an industrial source for the gas and a nominal cost for the transporting (or piping) of the gas to all the launching sites.

o Recovery (See Fig. 9):

Aircraft grounded due to weather 10 percent of time (an average for the network).

Each operational aircraft flies a 10 hour mission, and attempts to recover an average of 5 gondolas per mission.

There must be enough aircraft in the air each operational day to recover the total number launched per operational day, i.e. they may come in clusters, and there must be sufficient aircraft in the air to handle the maximum flux. It will usually not be possible to predict the flow of balloons through the network. For the smaller operation (less than about 2000 balloons) each aircraft will be able to take care of a sector about 500 miles long, and this will require a minimum of nine aircraft flying each day. As the operation becomes larger the force must be increased to maintain the average of five recoveries per mission.

There are four bases for the recovery aircraft (roughly, Okinawa, Tokyo, Shemya, Nome).

One third are out for maintenance at all times, plus one or two standby aircraft to replace aborts.

There are as many crews as there are aircraft, which permits each crew almost every other day off (about four missions per week).

No account has been taken of attrition of air craft.

II. THE INFLUENCE OF POSSIBLE ENEMY COUNTERMEASURES

It will be impossible to keep a full scale Gopher operation (over 500 to 1000 balloons) a secret. First, a certain number will be seen, since the balloon is visible to the naked eye, and some will probably be detected by radar. Then, in spite of all precautions, it is quite certain that a few will come down in enemy territory, and experience in the U.S. has shown that these will usually be spotted and recovered. It must therefore be assumed that the full intent of our reconnaissance effort will be revealed soon after it begins.

It is necessary to try to guess what the enemy may be able to do physically to prevent the operation from continuing. In what follows, there is no discussion of the political or psychological reaction of the U.S.S.R. and of the rest of the world.

A. Sabotage of the Launching Site

If a violent reaction is anticipated, then the operation would probably not be undertaken at all in peacetime. However, it would obviously be necessary to take measures to prevent attempts to sabotage the launching site if it were on land. A carrier should be immune from anything but an overt and fairly large scale attack.

B. Destruction of the Vehicle

The effects of enemy weapons on the Gopher balloon has not been determined. There are only a few facts which can be inferred from what little is known about Russian weapon capabilities.

- An extensive manned visual observation network, the observers being equipped with binoculars, could spot the balloons on clear days. This would mean a relatively low spotting efficiency in western Russia, because only about one day in five to seven, on the average, would be sufficiently clear.

- The Russian VHF radars may be able to track the present Gopher gondolas because of their antennas, the radar cross section being roughly as big as a bomber. Microwave radars, judging from experience in the U.S., would not be able to track them successfully. (It may be practical to retract the balloon antennas in flight over Russia, since they are not being used then, and this should be investigated.)

- If a balloon flies at an altitude below a fighter's ceiling, then it can probably be shot down (though it has not been tried yet). The present Gopher altitude of 60,000 to 70,000 feet is at least 5000 feet above the ceilings of any Russian fighters which have been reported in combat in Korea, even if these were equipped with afterburners. In the next two years the ceilings of operational fighters may be raised to 60,000 to 70,000 feet, and, if there is evidence that this has happened, it would be necessary to use a larger Gopher balloon which could fly higher (at an increase in cost).

- Anti-aircraft of the conventional type could not be effective against these balloons.

- o Anti-aircraft type rockets with some sort of guidance could be very effective against these balloons. The cost of bringing down the large number of balloons which is visualized would, however, be considerably more than the cost of the Gopher system, and this factor could be further increased by the use of balloon decoys. It seems probable, also, that there would be some time lag for the procurement of suitable missiles and setting up launching sites over a wide area, and the reconnaissance operation might be completed before the missile defense system could be brought up to a level of great effectiveness.

C. Hindering the Recovery

The recovery network should be set as close to the cost of Asia as possible in order to shorten the required duration of the balloons. However, this makes it possible for the enemy to hinder the recovery effort in certain ways.

There is the possibility that the recovery aircraft would be attacked. If this were the case, the recovery network would have to be moved back, since there would be no practical way of protecting it.

A more likely enemy countermeasure is the jamming of the balloon DF network, which, as it is now designed, receives CW signals at frequencies between about 3 and 15 MC. It would be impractical to increase the beacon power beyond about 5 (or possibly 10) watts, due to the limited power available in the gondola's batteries. There are methods which might improve the reception in the presence of jamming, one being the use of a pulse interrogation system, where the ground station triggers a HF pulse transmitter in the balloon. This also has the virtue of giving range as well as azimuth. The cost of such a system would probably be greater, however, and the components have not been developed.

A more simple "quick fix" to overcome enemy jamming would be the exclusive use of the VHF beacon on the balloon, in conjunction with VHF-DF receivers on the recovery aircraft. This would give a potential range of some 200 to 300 miles to the aircraft (as compared to about 1000 for the HF ground based system), and this would almost be sufficient to permit an aircraft to locate the balloons in its sector of operation, even without the help of the ground network. Development of a VHF pulse interrogation system for the aircraft would make this scheme work very well, since then a single aircraft could get a complete fix on each balloon which it could contact.

III. SPECIAL RECOMMENDATIONS

A. Central Balloon Authority

The development of a balloon system of any kind will require the coordination of a large number of functions, and there seems to be general agreement among those who are working with the balloon development program that such coordination will require a central authority, presumably at the level of the JCS. Such an organization should have control over:

- Research and development on the balloon vehicle
- Balloon launching facilities
- Radio tracking networks
- Recovery facilities
- Planning for the use of the balloon as an operational vehicle, e.g., design of the gondola, processing of reconnaissance films, SOP for BW dispersal, etc.

B. Use of Available and Tested Components for Gopher in an Operational Service Test

The consensus of opinion is that, with one possible exception, the components of the Gopher system have been developed to the point where an operation could get underway now with a good chance for success. Technically, the system is feasible. The one possible exception is the air-snatch recovery technique, which has been successfully demonstrated but not yet proven.

The 73-foot diameter balloon (about 200,000 ft^3 volume) can lift the present Gopher gross load of 1500 lbs to an initial altitude of about 58,000 feet. With the components as they now are there will be about 700 to 900 lbs of ballast. The probable daily loss of lift for such a balloon, equipped with an improved type of appendix is about 6 to 7 per cent due to change in superheat (for a quasi-constant altitude flight, not taking advantage of the thermodynamic stability of a balloon) and, at most, 2 per cent for leakage. Such performance would give an endurance at altitude of about ten days. This provides a good margin of safety over the minimum required, which is about six days.

To show more clearly how such a balloon would perform, refer to Fig. 7. The daily loss of 8 per cent of the gross load remaining will result in a steady lightening of the weight on the balloon, so at each sunrise it will rise higher (assuming an air-tight appendix on the balloon). The initial altitude of 58,000 feet will only last until the first sunrise following a sunset, and each day it will rise from 1500 to 2000 feet, ending up at about 74,000 feet on the tenth day. Fig. 8 shows the performance of a rather poor balloon, with 15 per cent daily loss of lift. Such a balloon will show the same rise in altitude, but will only last for about six days. In this diagram is also shown the behavior of NH_3 as a "ballast." If some convenient and lightweight means can be devised for allowing it to vaporize from a liquid form into the balloon each night, then the performance of even such a "poor" balloon could be stretched to about eight (possibly nine) days.

The performance described above can be achieved without any major development in balloon design, but by merely fixing on the best features of balloons which have already flown successfully. It is reasonably certain that the University of Minnesota and General Mills, Inc., will in the course of their further research learn to improve balloon performance still more, but it is not necessary to postulate such further advances in order to guarantee success.

The performance of the present Gopher gondola is not yet proven, but there does not appear to be anything basicly inadequate in it. The radio beacons will require more power than they now have, and the special purpose cameras are still being developed, but both of these deficiencies will be remedied in time.

The generation of hydrogen poses a serious <u>cost</u> constraint on the system if there are not large local sources. This is particularly serious for shipboard launchings, but may also be a problem ashore. However, here again the technical knowhow certainly exists, and it is primarily a problem of procurement.

A satisfactory launching technique for the large Gopher balloons, permitting an operation on land in winds over 4 to 5 knots, has not been developed. The methods which are now being used generally involve some handling of the balloon, and the manufacturer feels that this is undesirable. An operation from a carrier would avoid this very serious handicap by permitting a vertical launching, and this is probably the method which will insure the greatest reliability of the balloon.

The question of the recovery technique is not so clear. The tests to date at El Centro of the air-snatch shows that a trained pilot can get his hook into the parachute between 80 and 90 per cent of the time, and that the parachute and aircraft gear can be built to stand the shock, even with 300 to 400 lbs hanging on the parachute. However, of all the components in the system, this is the least well-proven, and, since it is so crucial to the overall success, it should be urged that the test program of the air-snatch recovery be given more support.

It is recommended, therefore, that, if a Gopher operation is desired, the initial emphasis be placed on an <u>operational service testing of the complete system</u> (over the U.S.), with research and development of components being continued at the same time. This would provide:

- o A means for testing new components under operational conditions.
- o A training program for the launching, tracking, and recovery crews.
- o A means for properly assessing the overall utility of the system.

C. <u>Worldwide Moby Dick</u>

One of the chief advantages of the balloon reconnaissance system is that, on the face of it, it is not an instrument of aggression. There will be objections from the enemy, to be sure, but it can be argued that we have no control over the course of our balloons, and that they operate in an air space which is too high to endanger enemy aircraft operations and which is, in a sense, public domain.

In order to establish this contention to the world, it would be well to avoid the impression that there is a covert activity connected with our balloon operation, and the best way to avoid this is to give it full publicity under a different guise. It is likely that the enemy will not be fooled by this, but it will provide a valuable "talking point" for propaganda purposes.

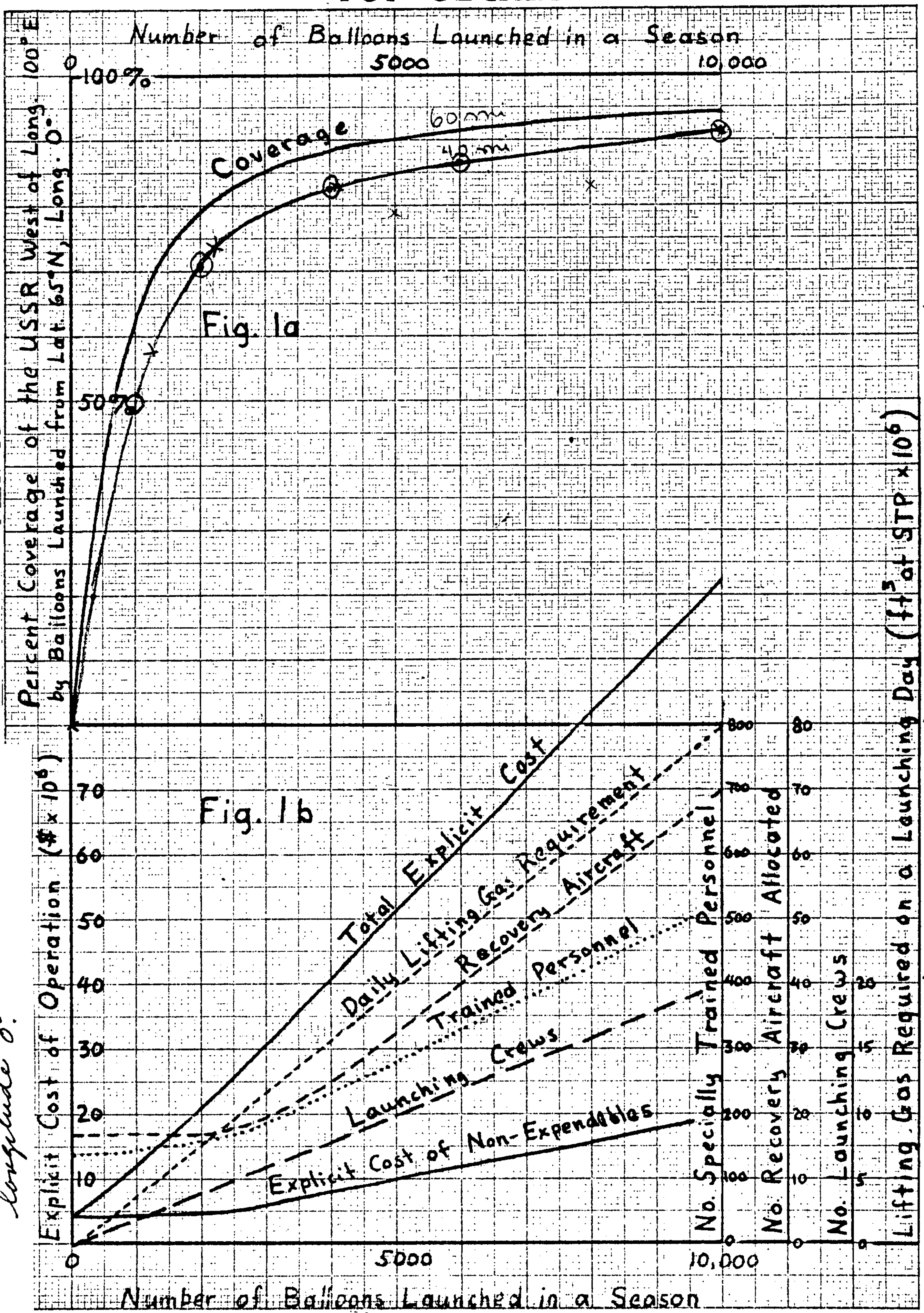
The different guise is obviously geophysical research. The Moby Dick project has already been given publicity, and there is no obvious reason why it should not be considered for a worldwide project. A suggested course of action would be:

- Propose to the International Meteorological Organization (IMO) that the upper air radiosonde network be supplemented by an upper air trajectory network. There are many sound reasons why data on upper air trajectories would be valuable to meteorologists. The flight equipment would be provided by the U.S., and all that would be required of the other participating countries would be tracking by radio DF networks. (These are probably already in existence, as are our own AACS and FCC networks.) The European countries should be willing to cooperate, since so little effort is required on their parts. The U.S.S.R. is also officially a member of the IMO, and would be asked to participate.
- Moby Dick gear with increased duration would be launched, then, and these would in some cases go for every great distances. With a six to eight day duration a good fraction will pass half way around the world. If the Russians find these (as they surely would) it would be clear what they are. (They would be identified by labels in various languages stating their mission, plus the clear intent of the telemetering equipment.)
- The enemy would possibly try to shoot these down. Perhaps this should be encouraged by setting the flight altitude at between 40,000 to 50,000 feet, so that his fighter aircraft would be effective with a large operational effort on his part.
- When the Gopher gondolas begin to be interspersed with the Moby Dick gondolas, these would fly higher and would be less susceptible to his weapons. Some would come down, however, and

the presence of the cameras could be explained as a project to study cloud formations and to determine, in retrospect, the path of the balloon--since the U.S.S.R. had been uncooperative in supplying the tracking information requested of them.

o The Russians will recognize this tongue-in-cheek attitude, since they adopt it so frequently themselves. However, it may sufficiently confuse the basic issue so that they will have difficulty in making valid their claims of aggression on the part of the U.S.

Note: The above is partly the outcome of a discussion with Major Thomas O. Haig, Geophysical Research Division, AFCRC, the Moby Dick Project Officer.



title - Coverage of USSR West of longitude 100° E by balloons launched from latitude 65° N, longitude 0°

side - percent coverage -

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C12-1

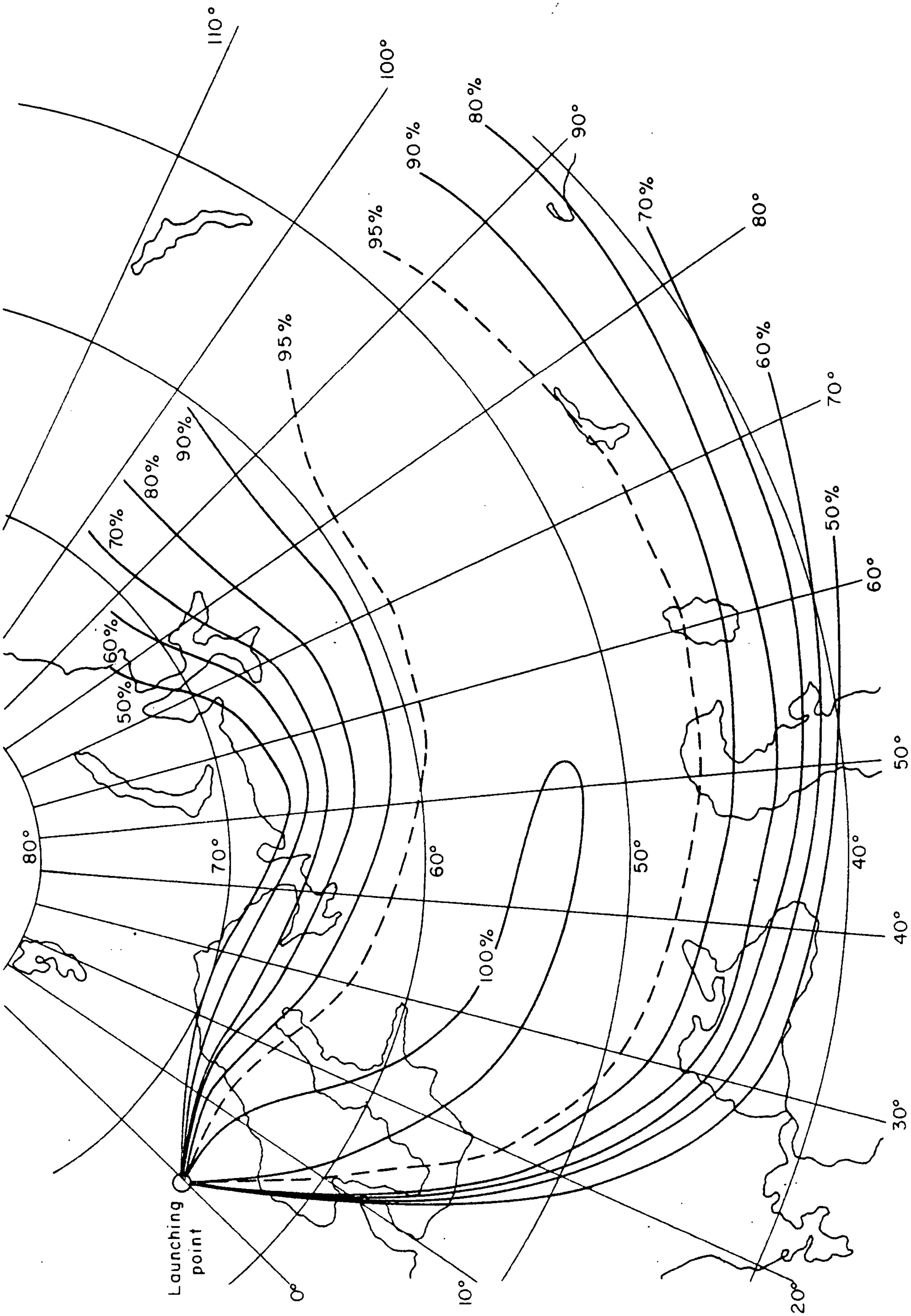

Fig. 2 —Coverage by 100 effective balloons

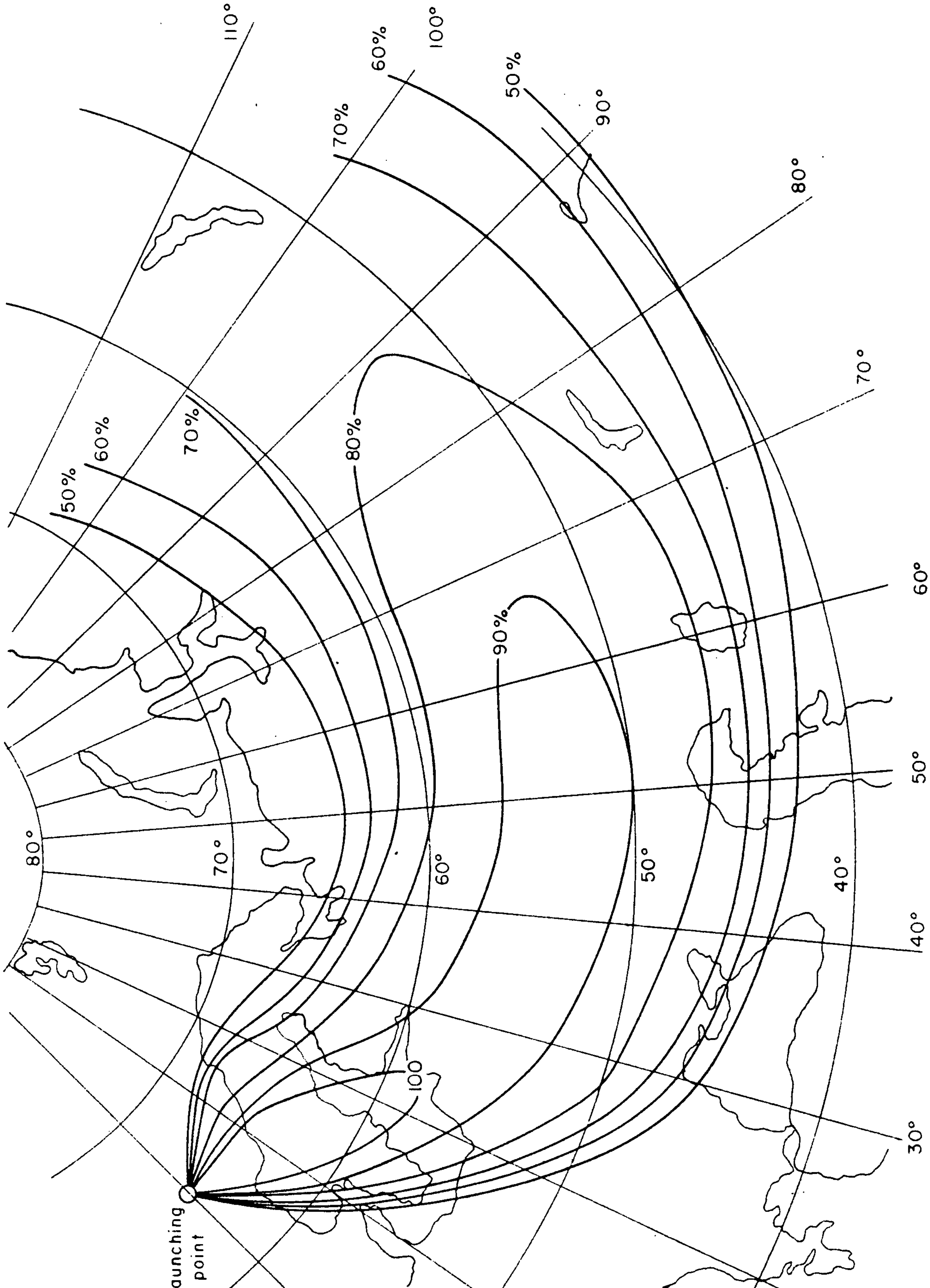

Fig. 3 —Coverage by 50 effective balloons

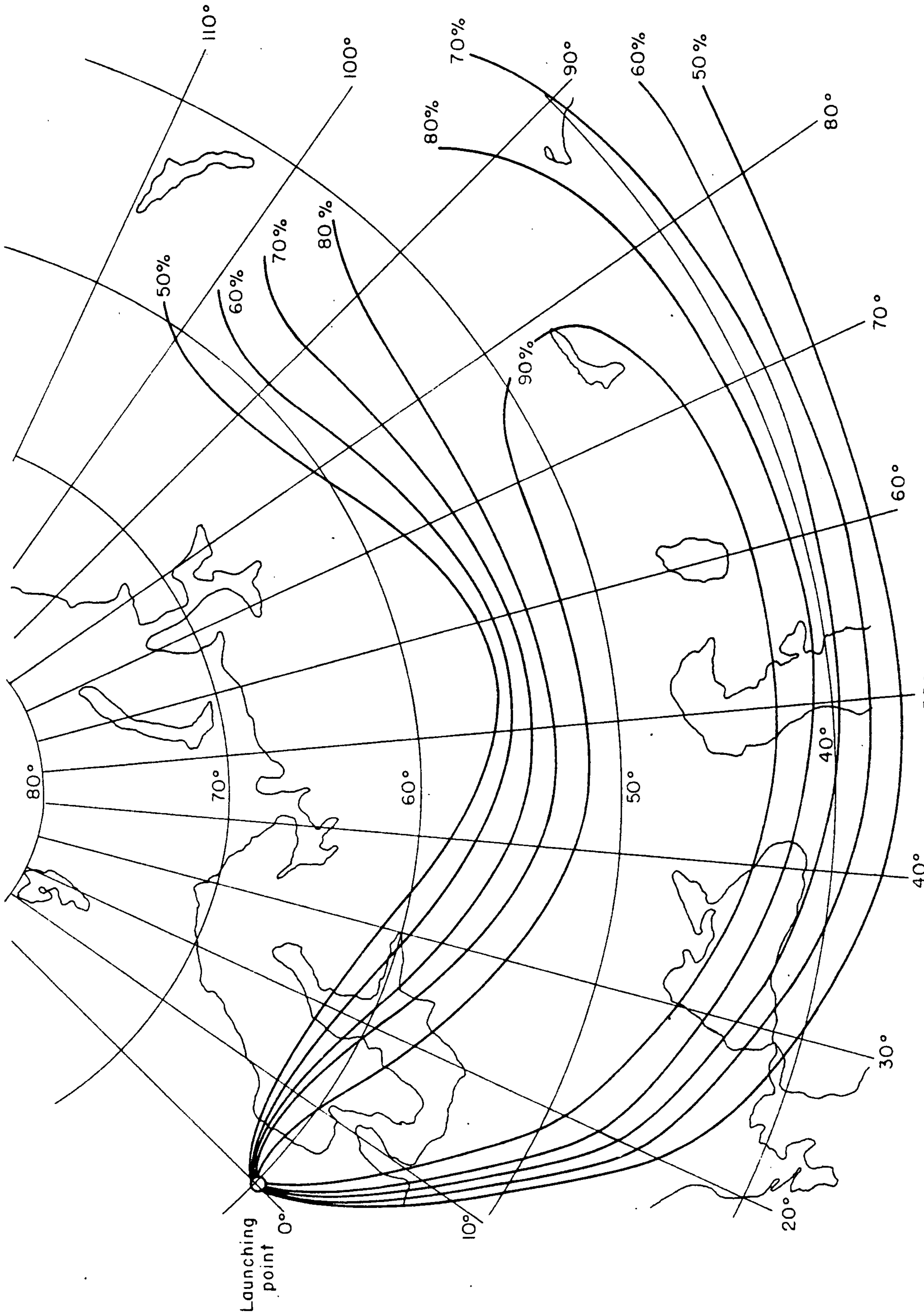

Fig. 4 —Coverage by 50 effective balloons

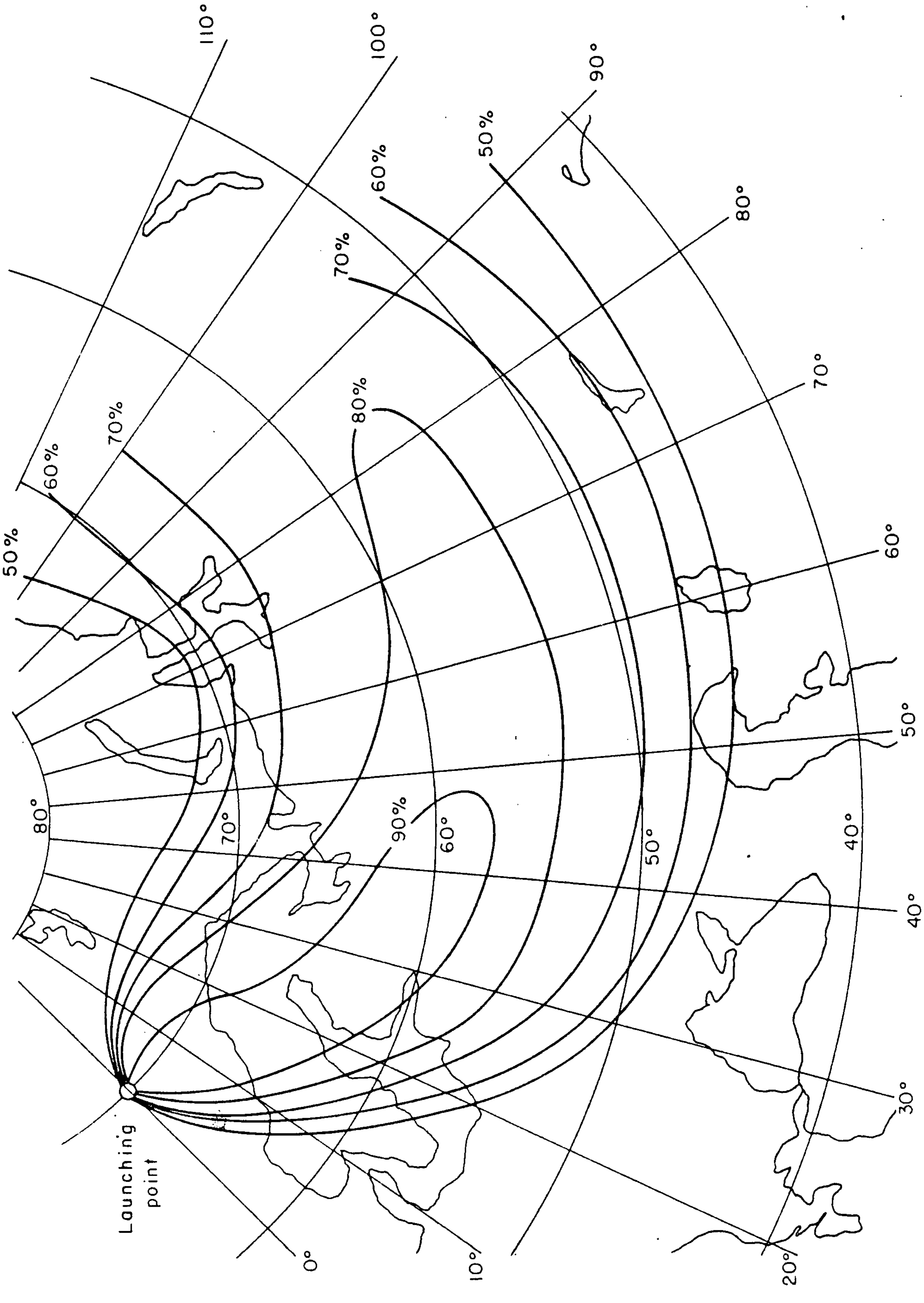

Fig. 5 — Coverage by 50 effective balloons

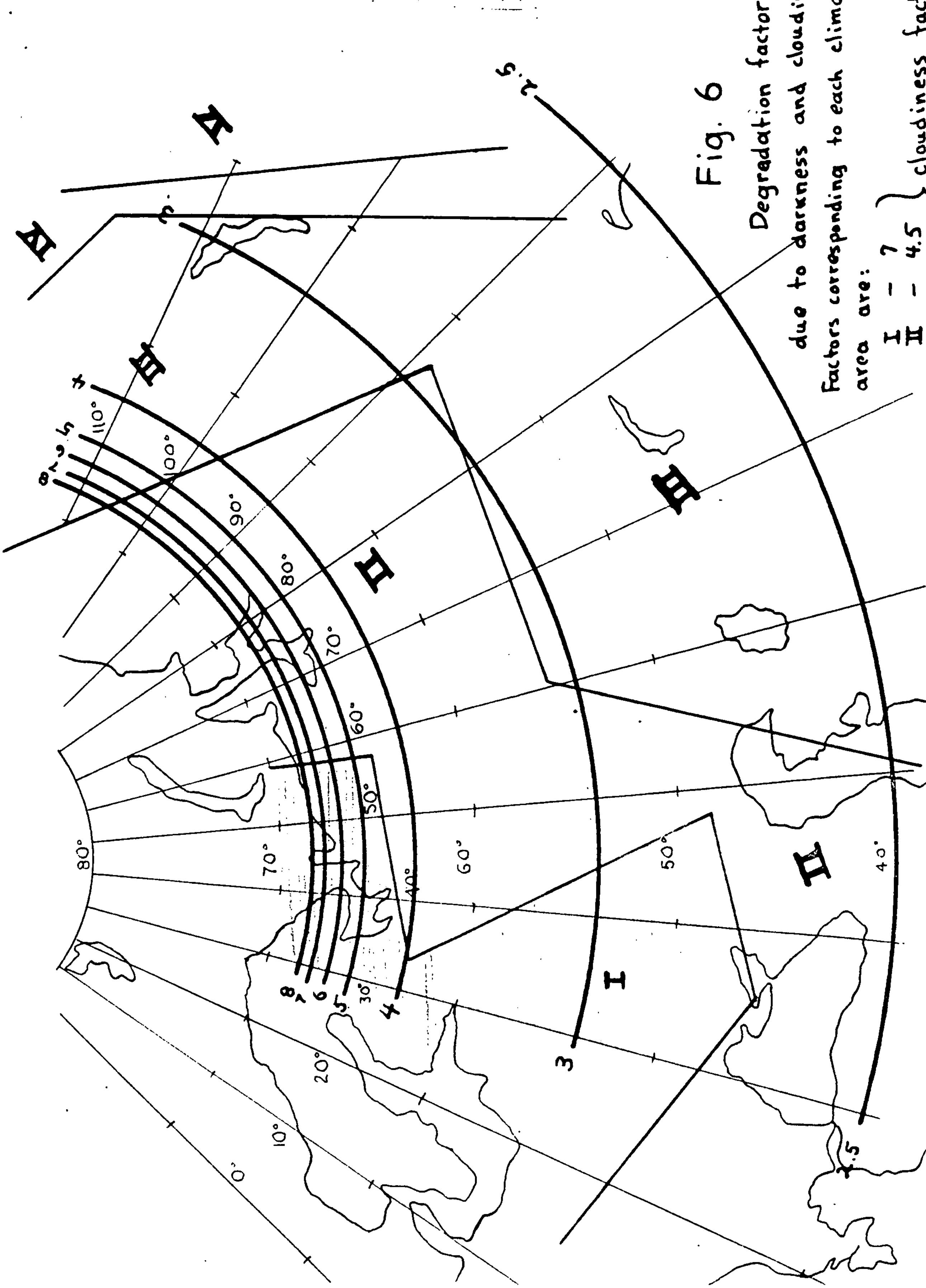

Fig. 6

Degradation factors due to darkness and cloudiness.

Factors corresponding to each climatic area are:

I – 7
II – 4.5
III – 3
IV – 2

} cloudiness factors

Winter Weather and Darkness

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SECURITY INFORMATION

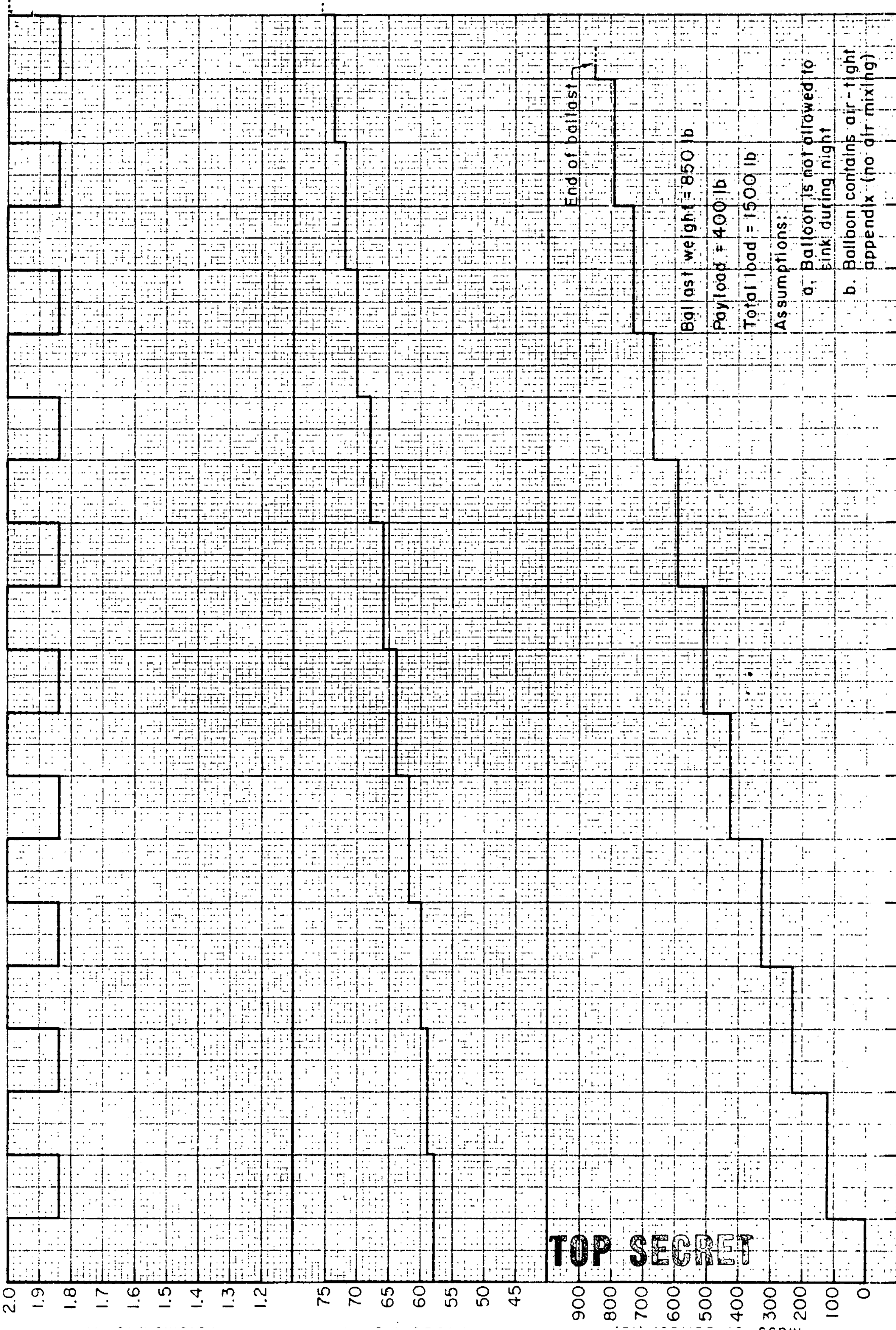

Fig. 7 Performance of a balloon with a daily fractional loss of lift = 8 % of gross load

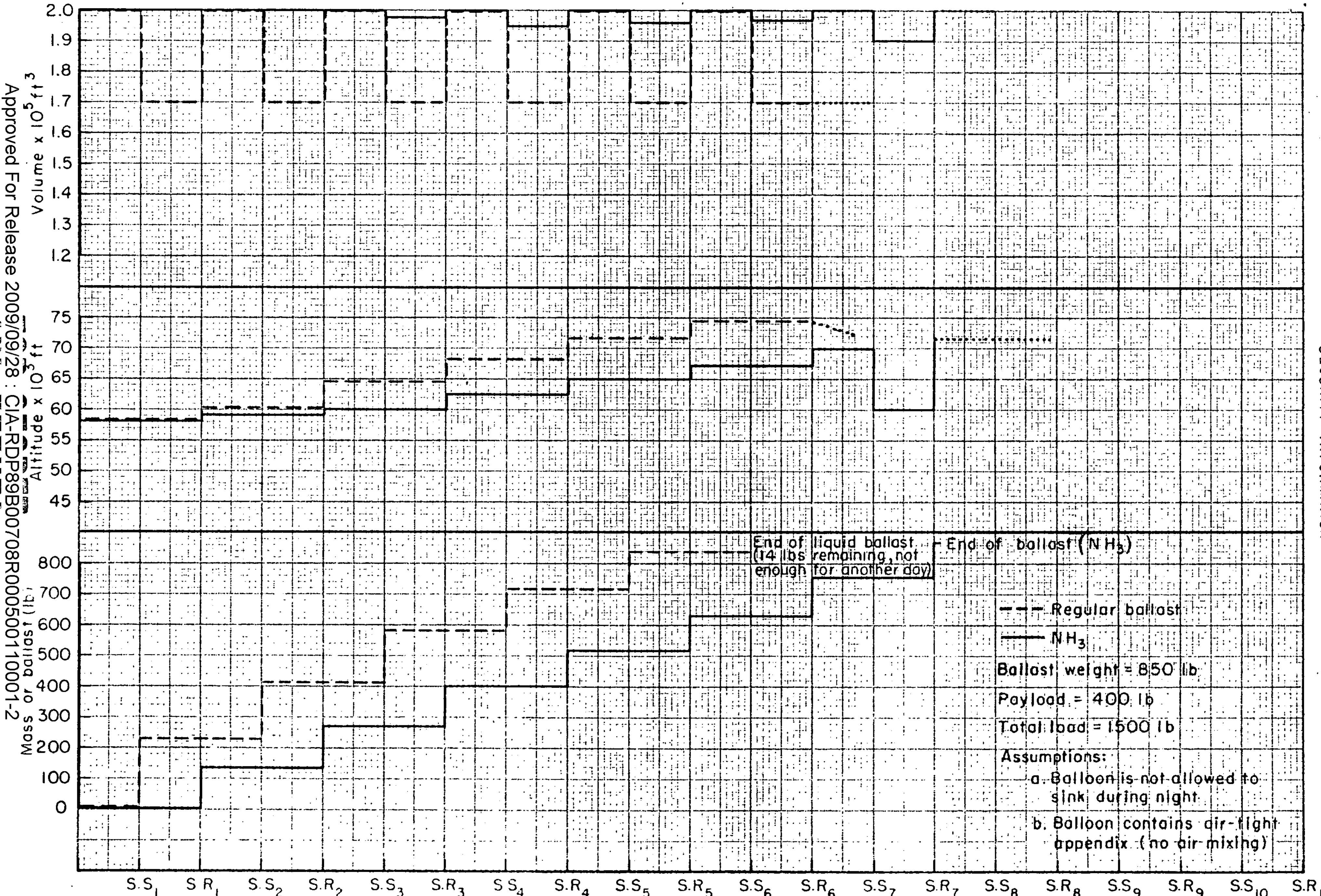

Fig. 8 Performance of a balloon with a daily fractional loss of lift = 15 % of gross load

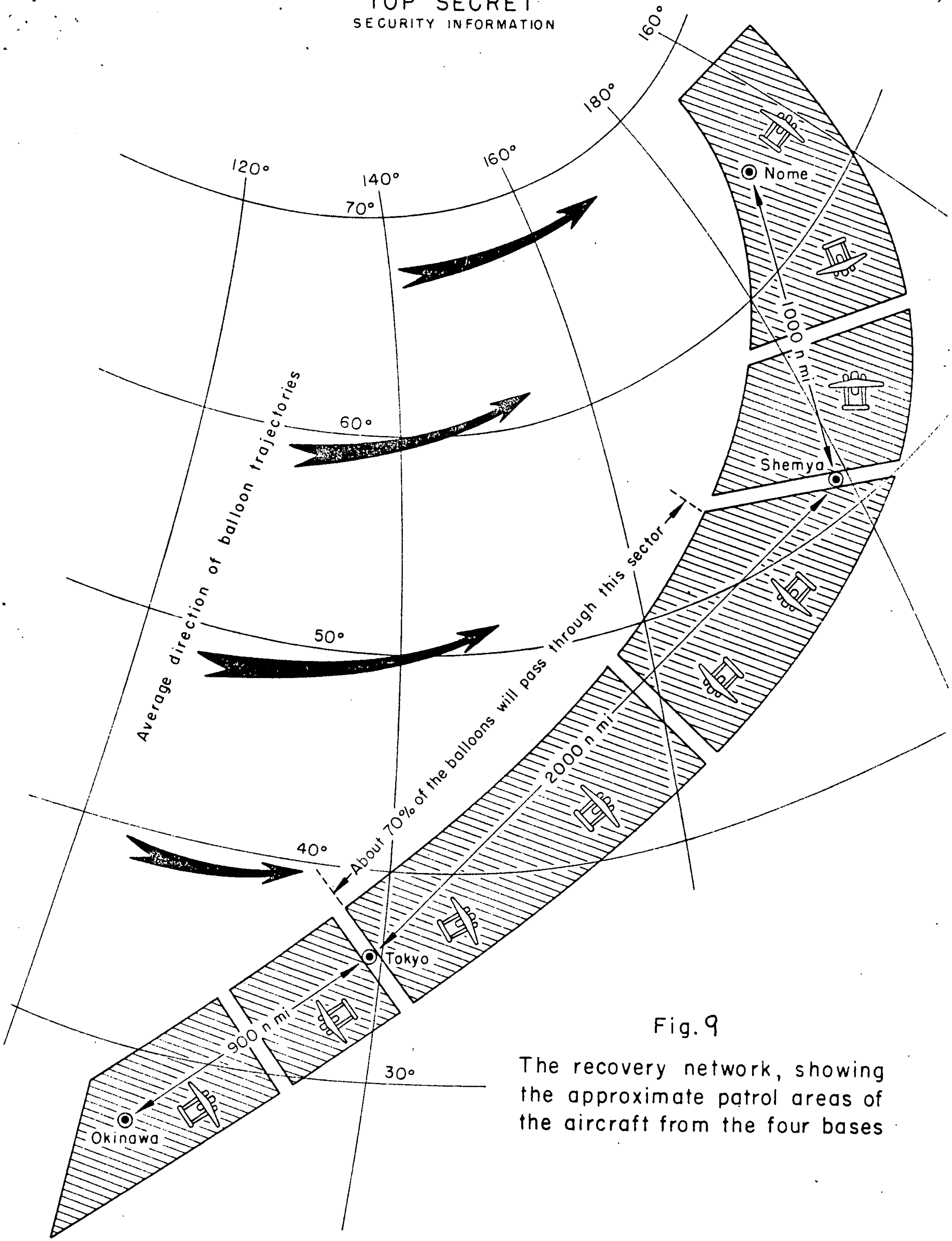

Fig. 9

The recovery network, showing the approximate patrol areas of the aircraft from the four bases

C12-4

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