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University of California, San Diego
Marine Physical Laboratory of the
Scripps Institution of Oceanography
San Diego 52, California

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A TIME SAVING METHOD FOR DETERMINING THE CHARACTERISTIC SHAPE AND STRIKE OF OCEANIC MAGNETIC ANOMALIES

Arthur D. Raff

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A TIME SAVING METHOD FOR DETERMINING THE CHARACTERISTIC SHAPE AND STRIKE OF OCEANIC MAGNETIC ANOMALIES

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INTRODUCTION

Magnetic surveys have revealed interesting patterns of peculiar character of magnetic anomaly in widely separated parts of the ocean. The practice of obtaining the magnetic anomaly picture for an area of ocean by means of a close grid, two-dimensional survey has been very expensive of ship and personnel time. In view of the expense, there has been hesitation ~~we have hesitated~~ to extend our surveys in many places of interest. Recently, in order to make better use of the limited time during the Risepac expedition, ~~the author tried~~ a semistatistical method was attempted for determining the anomaly character of a particular area. The method turned out to be quite satisfactory for obtaining a two-dimensional character picture of the anomaly along a ship's track between ports with little loss of "good" time to the ship's progress. About one day of "good" time is lost per thousand miles of track. This may vary by a factor of two either way depending on the particular stretch of ocean covered.

THEORY AND METHOD

When a recording magnetometer or any other recording survey instrument makes an abrupt change of track direction over a slope of an anomaly, the recorded anomaly slopes close to the point of turn give a unique solution to the strike of the anomaly's contour at the turn point. The jog method of determining anomaly strike gives a unique solution because it chooses the right angle turns to be over a selected part of each anomaly; the part or parts of maximum slope. The graphic method, as presented here, of determining the contour direction at the turn point over the slope is merely a specialized technique derived from the usual methods of contouring topographic data from a two-dimensional survey. Figure 1 serves to illustrate this.

The two contoured anomalies (Figure 1) represent the principal magnetic anomaly shapes encountered at sea; the elongated and the circular anomalies. Great areas of the ocean are characterized by such elongated anomalies all having their long axis in the same direction. It is this peculiarity that is of most interest when a jog line survey is being run. To give a correct statistical picture it is important that the jog survey show the proportion of the anomalies that are elongated and whether their strikes are random or favor a principal direction.

To illustrate the method, the magnetic intensity record from the track A to B, (Figure 1) is shown in Figure 2. The operator notices that the slope of the trace is steepening. The point of maximum slope is estimated to have arrived, and a jog is called for. In this case it happens to be to the right. The jog is continued for ten minutes; a sufficient time to establish the new slope, and then the ship makes a left-hand turn to continue its course. When the peak of the anomaly is passed and the down slope is about maximum, a similar left-hand jog is made. A solution to the strike of the contours can be obtained by noting the field intensity values along the track and contouring them, but a much quicker method is as follows:

At the turning points on the magnetometer record (Figure 2), slope lines GG and HH are drawn for each slope at the turning point. Then time interval lines $H'_1 H'_2$ and $G'_1 G'_2$ are drawn to show the time and consequent relative distance traveled during a magnetic intensity change of one arbitrary unit. This amounts to determining the distance spacing of the contour lines. Distance traveled G'_1 to G'_2 is picked off with a divider and marked on the corresponding piece of track line of Figure 3. Distance interval H'_1 to H'_2 is treated similarly. Finally a line joining G'_1 to H'_2 is drawn to complete the triangle.

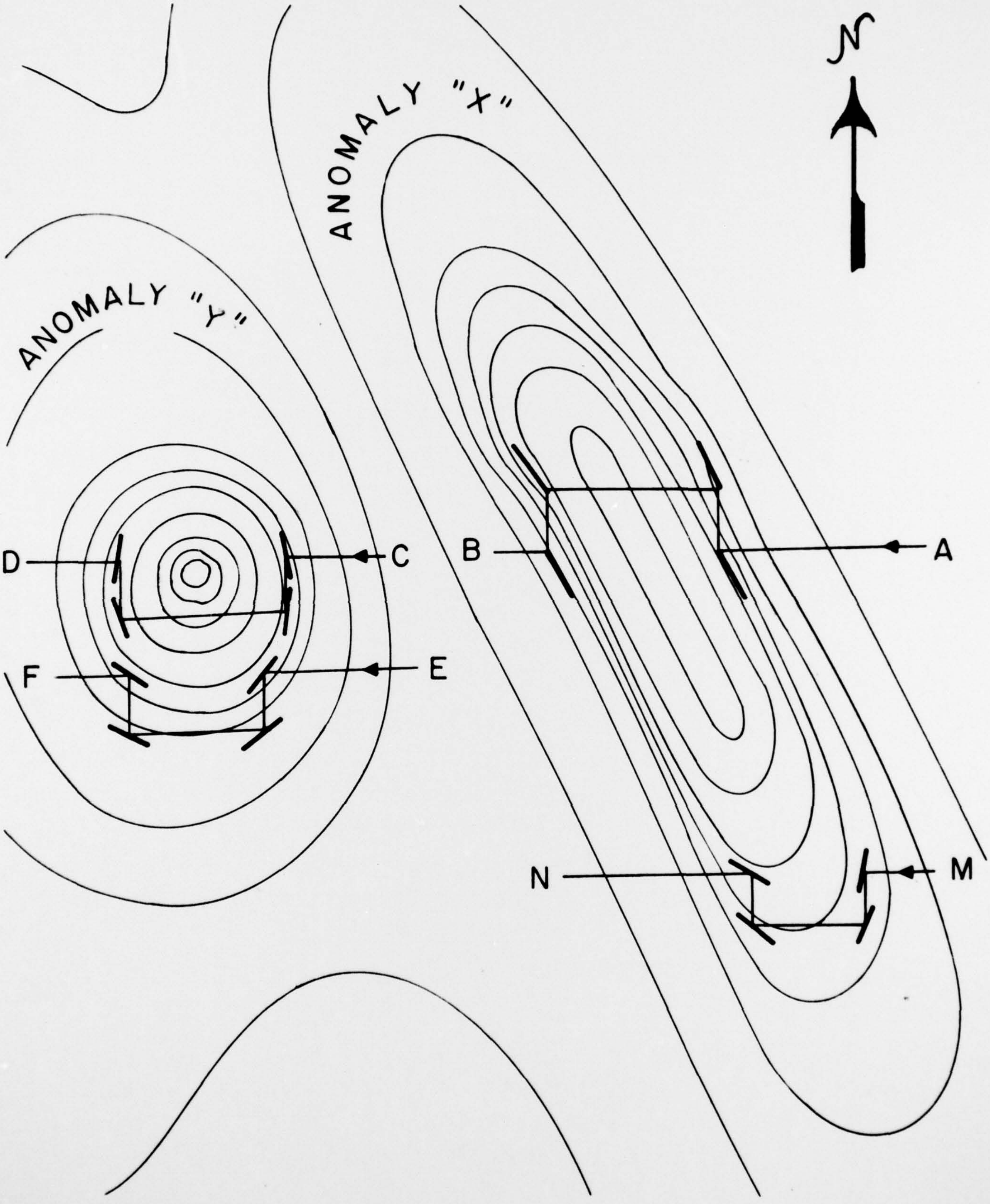

Figure 1. Typical anomalies and jogs

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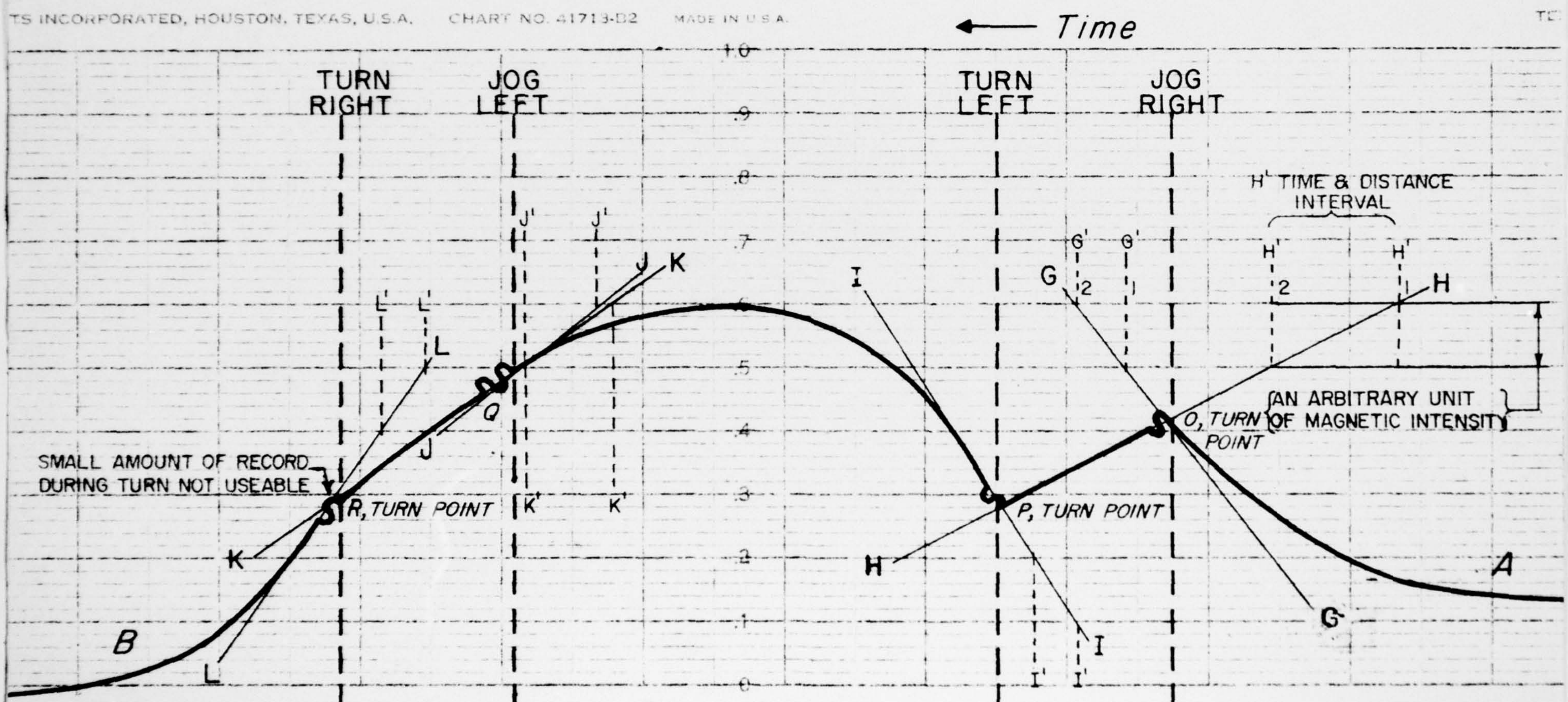

Figure 2 Typical magnetometer record

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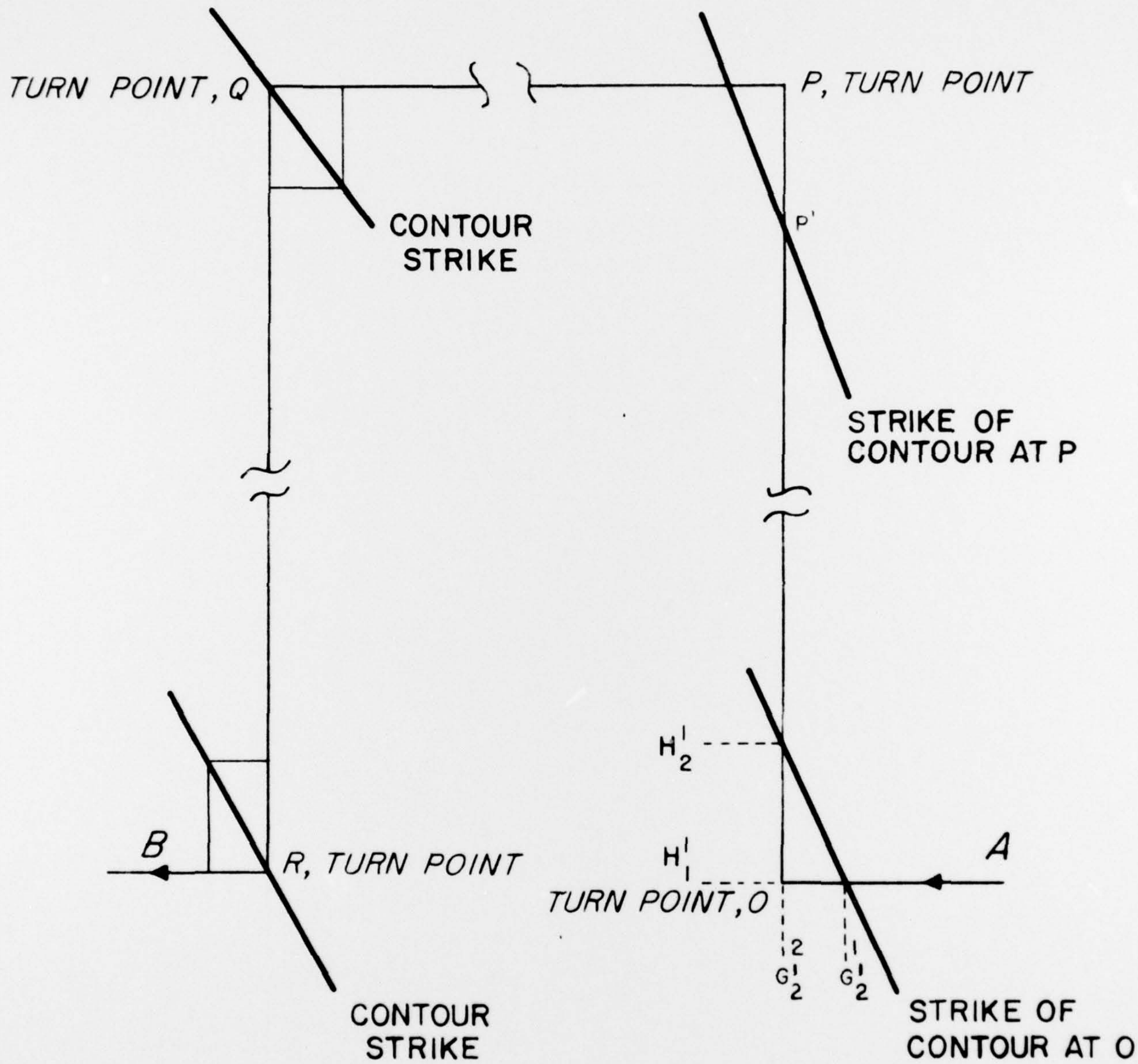

Figure 3. Solution to problem in Figure 2

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This diagonal line is parallel to the contour line passing through the turning point 0. The other turning points and slopes are treated the same way except that at turning points Q and R a parallelogram must be completed and the contour strike line drawn through opposite corners to give the correct strike. This is so because the slopes have the same sign at turning points Q and R, whereas at turning points 0 and P the turns cause the slope to reverse sign.

With a little experience one can learn to determine the strikes with sufficient accuracy using only a free-hand drawing or even with only a brief inspection and a mental sketch. The important thing to remember is that when slopes meeting at the turning point change sign, the strike line makes or completes a simple triangle, but when the slopes have the same sign the strike line is through the track corner and the newly formed corner of a completed parallelogram. An even simpler rule is that when the slopes change sign the strike line passes through the turn point without bisecting the track line at the turn, but when the slopes have the same sign the strike line bisects or cuts across the track line at the turning point.

It can be seen that with only two jogs making four right angle turns, four strike lines have been obtained, which give the strike of the elongated anomaly "X". This jog method determines the strike over a very limited area of a single anomaly. To determine the direction of lineation of an extensive area, nearly every suitable anomaly should have a jog track over it.

Figure 1 illustrates the principal errors that may arise. Anomaly "X" is a magnetic high and is quite elongated with a definite strike. But track A-B determines only that both sides of the anomaly at the line of crossing have the same strike and what it is. Track C-D over anomaly "Y" gives the same sort of solution with the exception that in this case, anomaly "Y" appears to have a strike at right angles to the main track, while anomaly "X" has a strike that is diagonal to the course track. This difference hints that anomaly "X" is elongated and that anomaly "Y" may possibly be circular. If track A-B had crossed anomaly "X" at right angles it too would be suspected of possibly being circular. If the ship had crossed anomaly "Y" by track E-F, the strike lines would more strongly suggest a circular anomaly. Anomaly "X" appears similarly circular when crossed with track M-N.

With multiple solutions to any one anomaly crossing, it is obvious that a conclusive solution for an area can only be determined statistically. It appears that a solution is most difficult when the anomalies of a particular area are both circular and elongated and the ship's main course is parallel to the predominant strike of the elongated anomalies. Just such a situation was encountered on the latter part of expedition Risepac in 1962 (Figure 4). By making a histogram of the many strikes determined over the area and comparing the real histogram to histograms of model areas with random distribution of anomalies, it was determined that the real histogram represented an anomaly pattern of both circular and elongated anomalies with the elongations parallel to the course track. A subsequent areal survey over the area disclosed that the conclusion was the correct one.

It is important that when finally evaluating the jog data, one determines the validity of the statistical results and the degree of uniformity of any detected lineation of anomaly. This has been accomplished satisfactorily by comparing the real histogram to histograms of various drawn models. One can quickly draw model anomaly charts with anomalies of various shapes and groupings, and then draw course tracks in several directions across the model chart. With this, one draws a line at each anomaly boundary showing the strike of the contour there. A histogram is made for each track across the model chart and comparisons made to the real histogram to determine its interpretation. (See Figure 5.) In areas where the course track is over a pattern of unusually well aligned and parallel anomalies that make a strike angle with the track of greater than about 15 degrees, it is quite unlikely that the pattern will escape detection by this jog method (Figure 6). When an area appears to have

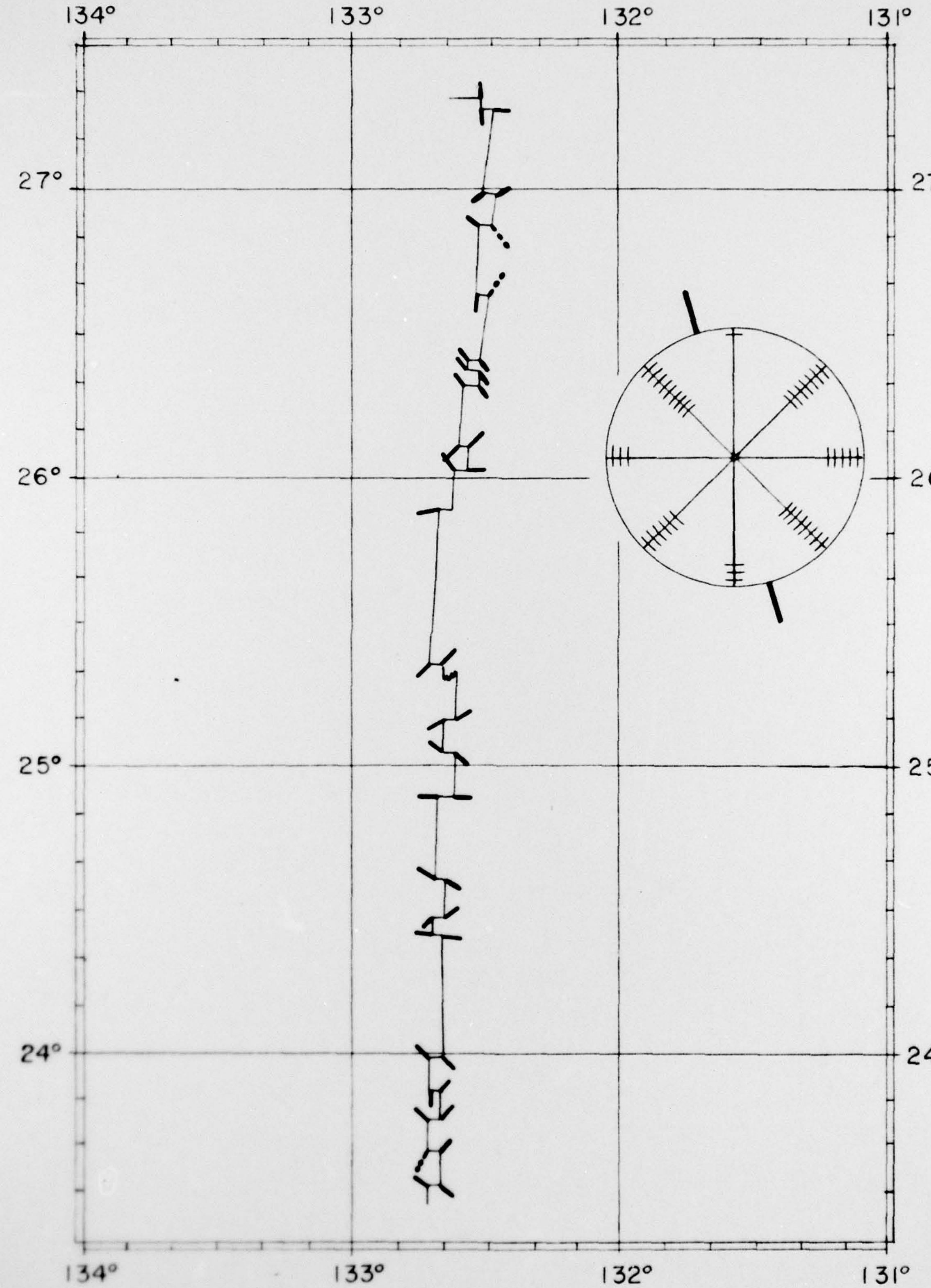

Figure 4. Jog track and solutions

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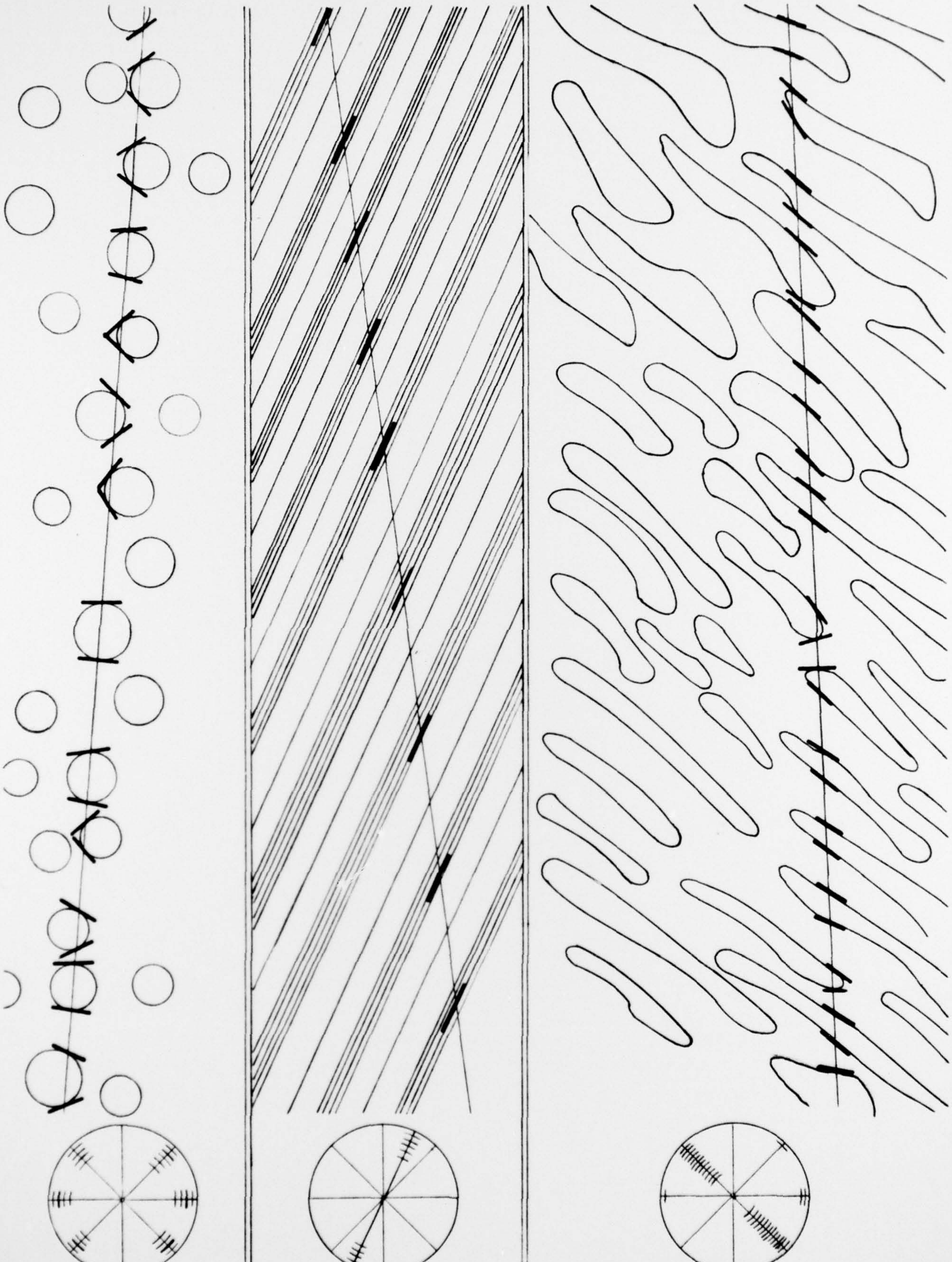

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Figure 5. Model anomaly patterns and histograms

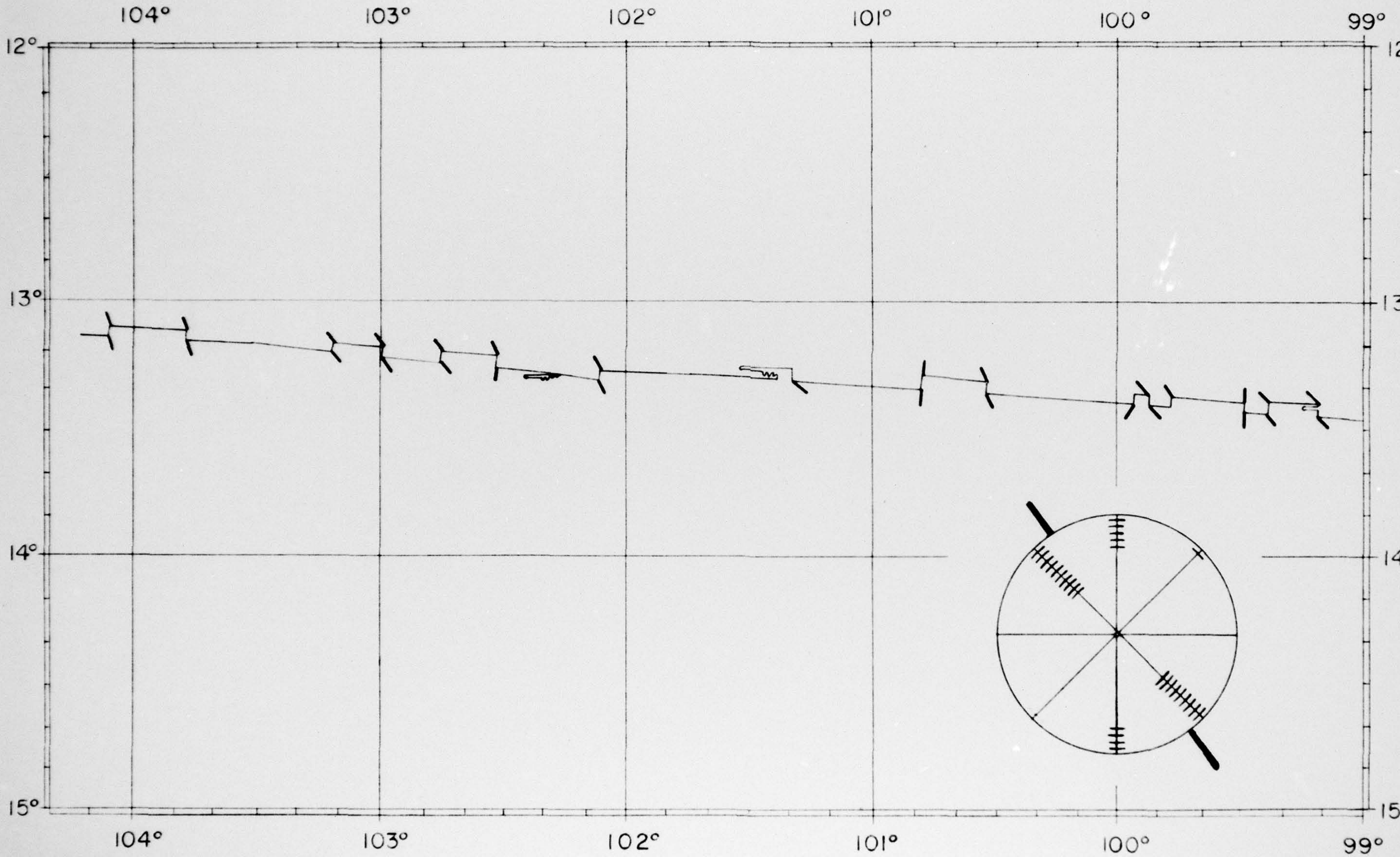

Figure 6. Jog track and solutions

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nearly random anomalies and only a hint of any uniform strike, the solution can be made firm by running a track through the area at approximately right angles to the first track.

Figure 7 is a chart of prevailing strike obtained from the jog track of expedition Risepac. When the entire jog track of Figure 7 was laid out so that all the individual strike lines could be observed at once it was immediately apparent that there were several provinces of different anomaly distribution and strike. It is important that each area of a particular characteristic was treated separately and studied by means of its histogram compared to that of models. If two or more areas of different character are treated with one histogram, the results will be an average and not really correct for any one area or combination of areas. The author feels that the Risepac jog track produced a considerable amount of reasonably accurate information with a minimum amount of time lost from the ship's progress from port to port.

SUGGESTIONS

A few operational rules gained from our experience are listed here:

The ship should maintain uniform speed during any one jog.

The galley should be alerted before each jog.

It is best if all the jog turns are right angle turns.

Jogs should be made on all slopes that are characteristic of the particular area or that are steeper.

Jog over both the up-slopes and down-slopes.

Either alternate the jogs left and right to keep the ship on its intended track, or let the bridge choose the direction of each jog and thereby make corrections for set.

Jogs that cause a reversal of slope usually are more informative. If a particular area has quite uniform strike of its anomalies, the jog directions can be chosen to give slope reversal on most of the turns.

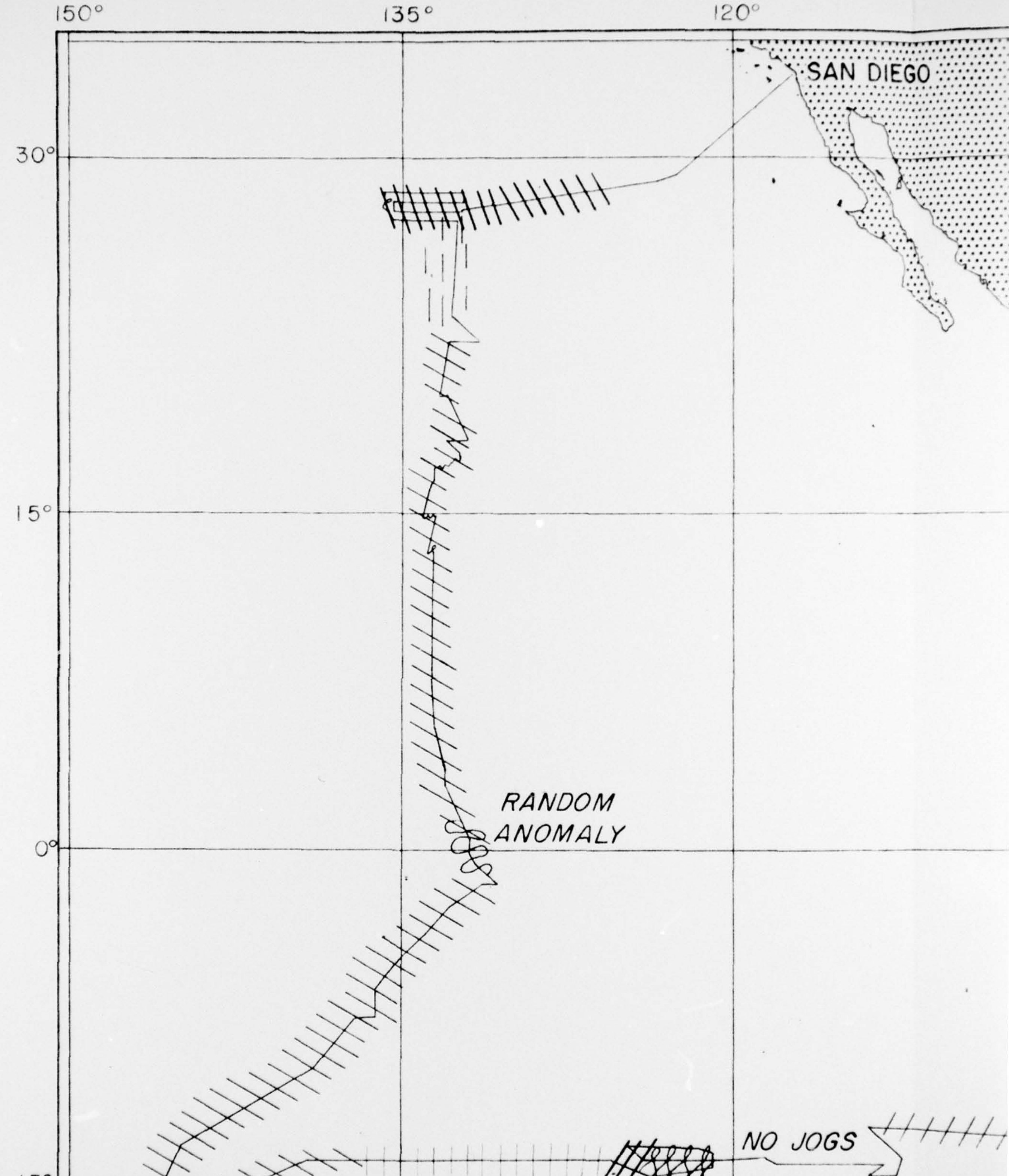

Figure 7. Risepac Ex

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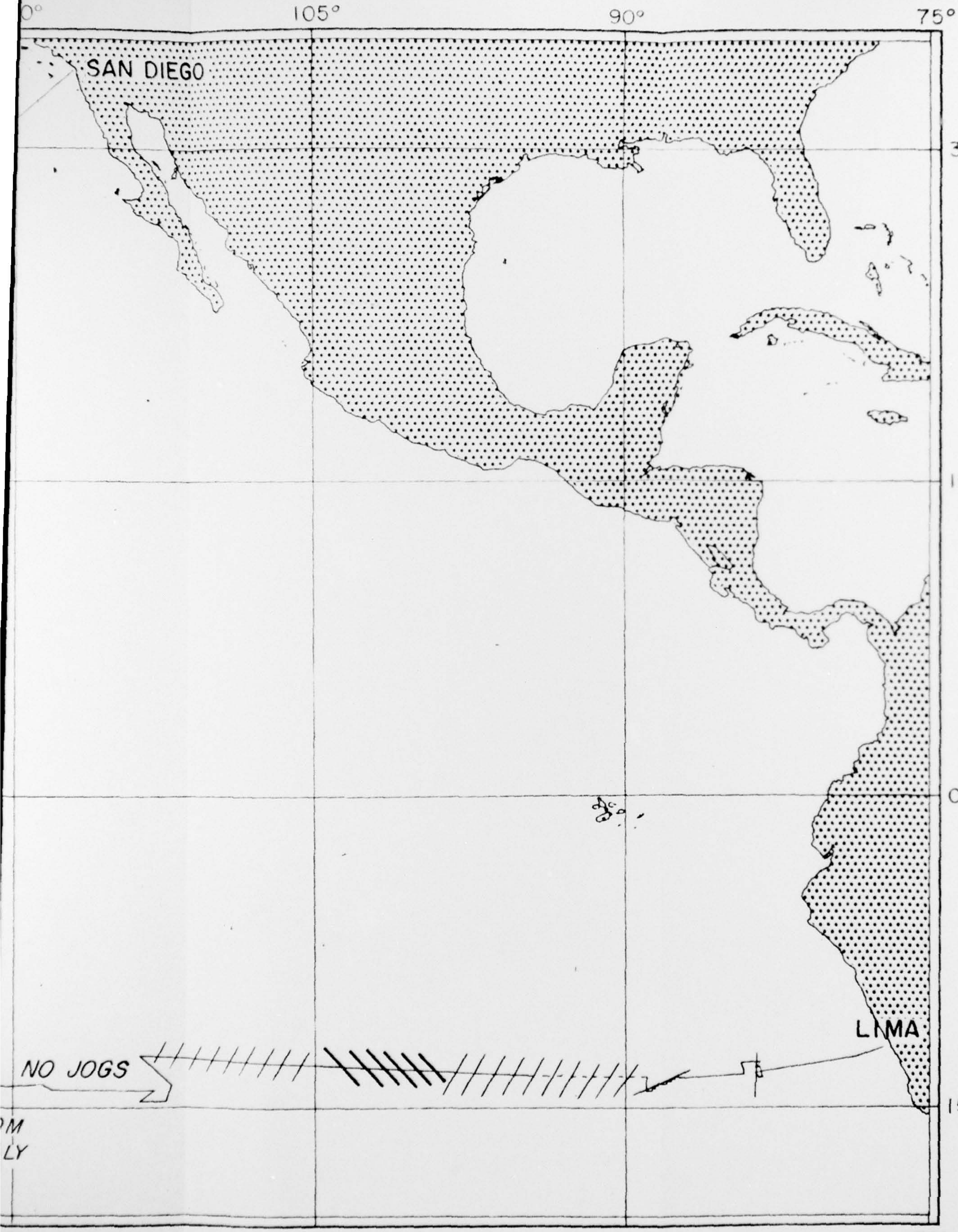

Figure 7. Risepac Expedition

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The best place on a slope to jog can be anticipated by noticing carefully the rate of slope change and curvature and by using one's experience.

At twelve knots the smallest satisfactory jog consists of a one minute turn, ten minutes of running at right angles to the course, and another one minute turn to put the ship back on its main heading. This makes for a total of about twelve minutes used from "good" time.

When a jog is mistakenly made over or near the crest or trough of an anomaly it is usually indeterminate of strike and useless.

The text of Technical Memo 127 fails to state that the method of determining anomaly contour strike by a jog track requires that the earth's smooth field gradient for the local area be removed from the record in order that the slopes be true for the anomaly only.

In some areas of low latitude the earth's smooth gradient is small enough compared to the gradient of the typical anomaly for it to be ignored. The anomaly slopes on the magnetometer record at the site of a jog can be quickly corrected by adding or subtracting the [illegible] for the particular area and track direction.

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