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National Weather Service

Forecasting Precipitation at Bakersfield, California, Using Pressure Gradient Vectors

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Western Region

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

NOAA Technical Memorandum NWSTM WR-78

FORECASTING PRECIPITATION AT BAKERSFIELD,
CALIFORNIA, USING PRESSURE GRADIENT VECTORS

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WESTERN REGION
TECHNICAL MEMORANDUM NO. 78

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TABLE OF CONTENTS

	<u>Page</u>
List of Table and Figures	iii
I. Introduction	i
II. Development of Objective Aid	1-2
III. Evaluation	2-3
IV. Conclusions	3
V. Acknowledgments	3
VI. References	3-4

LIST OF TABLE AND FIGURES

	<u>Page</u>
Table 1. Forecast Verification, Bakersfield, California, November - April, 1967-71	4
Figure 1. Location of Stations Used for Pressure Gradient Computations	5
Figure 2. Typical Surface Map and Resultant Pressure Gradient Vector for Low Probability of Precipitation at Bakersfield, California	6
Figure 3. Typical Surface Map and Resultant Pressure Gradient Vector for High Probability of Precipitation at Bakersfield, California	7
Figure 4. End Points of Resultant Vectors for Season November 1964-April 1965	8
Figure 5. Probability of Precipitation at Bakersfield (November-April) for Resultant Surface Pressure Gradient Vectors with Direction in Degrees and Magnitude in Millibars	9
Figure 6. Reliability Curves for Objective and Official PoP Forecasts, Bakersfield	10
Figure 7. Diagram of Vector Plotting Board	11

FORECASTING PRECIPITATION AT BAKERSFIELD, CALIFORNIA, USING PRESSURE GRADIENT VECTORS

I. INTRODUCTION

The purpose of this study was to find an objective method of forecasting precipitation probabilities in the Bakersfield area. In considering readily available predictors, it was decided to use surface-pressure gradient vectors to give an indication of the approach and strength of low-pressure systems. The direction and magnitude of the resultant vector, using gradients from four quadrants, appeared to give the best results. While an objective method for a forecast of measurable precipitation for a period of 12 to 24 hours based on observed data was the prime concern, this system should also be adaptable to use with National Meteorological Center (NMC) facsimile prognostic charts for longer range forecasts. It was also felt this same system should be applicable to forecasting other elements, such as winds, temperatures, etc.

Rain occurs infrequently in the southern San Joaquin Valley; therefore it is of great importance when even a small amount occurs. Mountains surround Bakersfield on all sides except the northwest, which frequently results in a rain shadow over this area while surrounding areas receive precipitation. With the introduction of probability forecasting, there was very little material available to use in formulating an objective forecast. Since small-scale analysis seemed advisable for local forecasting, some objective method of forecasting was desirable for this station. Forecasters at Los Angeles, among other stations, had been using pressure differences between selected stations to arrive at a rain forecast [1]. Some experimentation had also been done at Bakersfield with pressure gradients; however, results were not satisfactory.

II. DEVELOPMENT OF OBJECTIVE AID

Pressure gradient vectors were plotted during the winter of 1964 - 65 in connection with the fruit-frost forecasting program to determine clear nights when radiation would be at a maximum [2]. In plotting these pressure gradient vectors on the surface maps, it was noted that there was a good correlation between direction of vectors and precipitation. During the winter of 1965 - 66 a new pattern of pressure gradients was set up and resultant vectors plotted on a circular graph along with precipitation during the following 12- 24-hour period. Results were very satisfactory.

Computation of pressure gradients used in the study during the winters of 1964 - 65 and 1965 - 66 required four stations equidistant from Bakersfield and at angles of nearly 90 degrees. Stations that fit

this pattern best were Moffet Field (NUQ), Thermal (TRM), California, and Tonopah (TPH), Nevada. In the 4th quadrant, a point over the Pacific Ocean at 33 degrees north and 121 degrees west was selected (Figure 1). The pressure for this point was determined between NUQ and TRM, TPH, and 33N 121W in millibars and tenths. A resultant vector was obtained by the addition of these gradient vectors. A typical pressure pattern in which there was little chance of precipitation in the Bakersfield area is shown in Figure 2. It can be seen that with high pressure just to the north of Reno, the resultant pressure gradient vector points almost south. Thus, a resultant vector in this direction should give a very low probability of precipitation.

A typical rainy pressure pattern is shown in Figure 3. The resultant vector in this case was directed to about 330 degrees; this should be the direction for a high probability of precipitation at Bakersfield.

Resultant vectors were obtained from the 0400 PST and 1600 PST surface maps for each day of the 1964 - 65 season (November to April) and were then plotted on polar coordinate paper (Figure 4). Points at the end of each vector were marked either with an open circle showing no rain in the forecast period of 12 to 24 hours after maptime or a solid circle showing rain. Using this graph and counting the occurrences or nonoccurrences of precipitation for each forecast period in increments of 10 degrees of arc, the probability of precipitation (PoP) $\geq .01$ inch for the various portions of the chart was obtained. Average PoP values were then entered on the chart shown in Figure 5 for use in objective forecasting.

After examining data for the winter of 1966 - 67, it was decided there should be a correcting factor when the pressure was quite low or high in the Bakersfield area. When the pressure at Bakersfield at maptime was less than 1012 mbs, 10 percent was added to the objective forecast value and when pressure was above 1022 mbs, 10 percent was subtracted.

III. EVALUATION

A reliability curve for official Bakersfield WSO PoP forecasts for winter seasons 1965-66 and 1966-67 (November-April) is shown in Figure 6 (dashed line). Forecasts for this period were made before the objective aid was available. It can be seen that above 10 percent probability, the forecast curve is above the perfect reliability curve (underforecasting). No value greater than 60 percent was forecast for the 12 to 24 hour period. The reliability curve was then plotted for the objective method (solid line) for the November to April seasons from 1967 through 1971. It can be seen reliability was very good for PoP forecasts below 20 percent. Above this value there was a tendency for overforecasting of precipitation.

When evaluating objective forecasts with high PoP values, it was determined that when approaching low pressure systems were wet the objective method would provide reliable PoPs. When the systems were dry upstream, the objective method tended to overforecast precipitation. Forecasters at the station have used this information to subjectively improve the objective forecast over the past few years. The curve for the official forecasts (1967 - 71, dotted line) shows near-perfect reliability. This curve also gives a comparison against official forecasts made during the years of 1965 - 67 when no objective method was available (dashed line). The 1967 - 71 forecasts included several forecasts of seventy and eighty percent, while there were none above sixty percent when the objective method was not available.

A comparison between official and objective forecast scores for the period 1967 through 1971 is shown in Table I. It can be seen that official forecasts were better than objective forecasts--thus, forecasters were able to successfully modify the objective forecasts, using the criteria described earlier.

A plotting board for finding the resultant pressure gradient vector was devised as shown in Figure 7. The circular plastic scale shown at the bottom of the page was fastened to a plotting board and the circular plastic plate at the top of the page was mounted on top so it could rotate. Using this plotting board resultant pressure gradient vectors could be computed easily.

IV. CONCLUSIONS

In comparing the official forecast reliability curve before the objective forecast method was available against the curve afterwards, it can be seen that the objective method was a great help. I feel a similar objective method could be set up at other stations and would give more consistent forecasts and would be of great help when new men transfer into a station.

V. ACKNOWLEDGMENTS

Acknowledgments are due Mr. Ray Randall, MIC, Bakersfield, for his encouragement in this study; to Mr. Tom Crossan, MIC, Fresno, for his help in designing the vector plotting board and to the staff of the Bakersfield Weather Service Office for plotting the resultant pressure gradients during the years of study.

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TABLE I

FORECAST VERIFICATION, BAKERSFIELD, CALIFORNIA
NOVEMBER - APRIL, 1967 - 71

	Official Forecasts	Objective Forecasts
Percent correct	90%	88%
Postagreement	.57	.44
Prefigurance	.50	.36
Threat Score	.36	.25

N = 1450

Precipitation Occurrences = 157

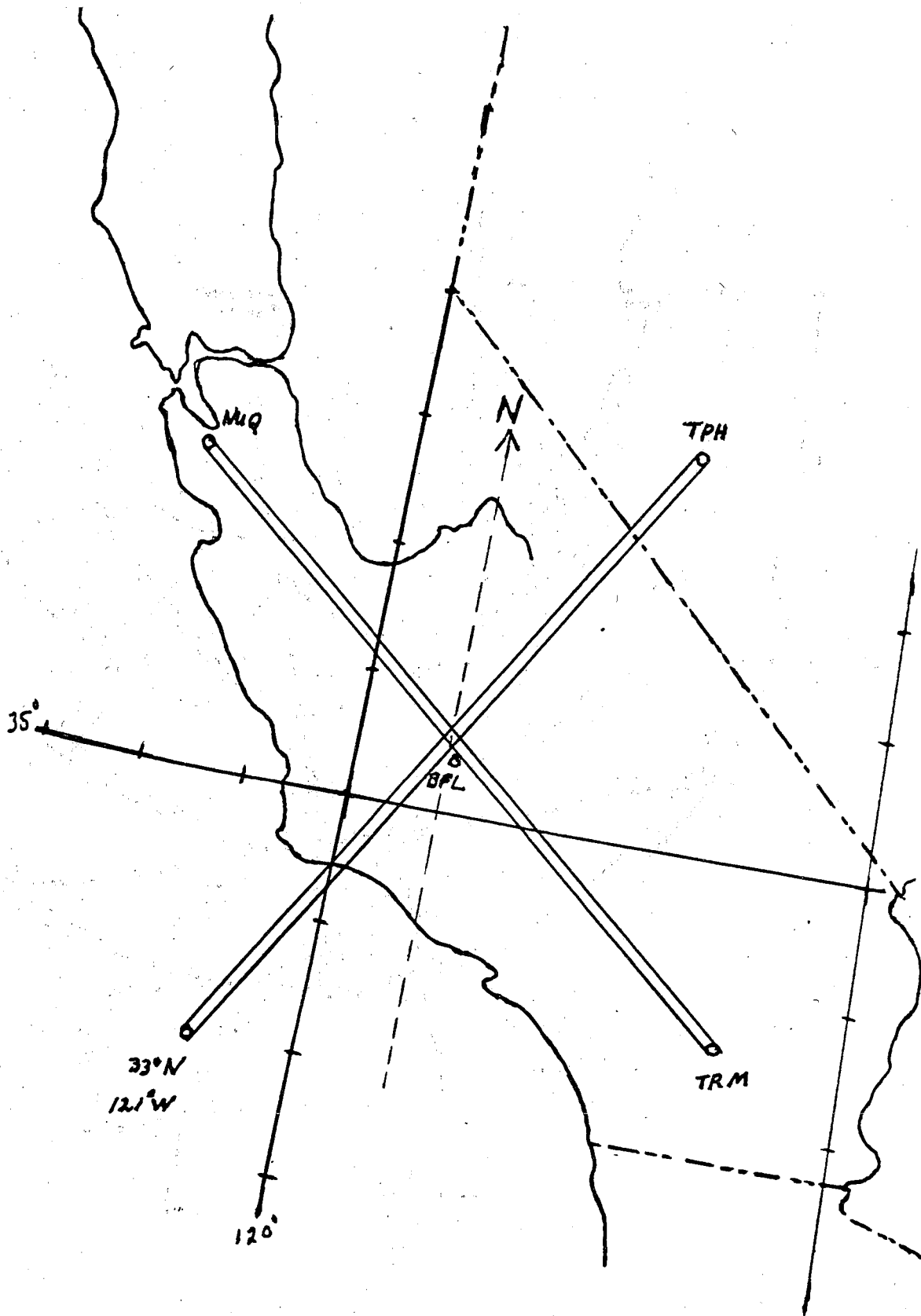


FIGURE 1. LOCATION OF STATIONS USED FOR PRESSURE GRADIENT COMPUTATIONS.

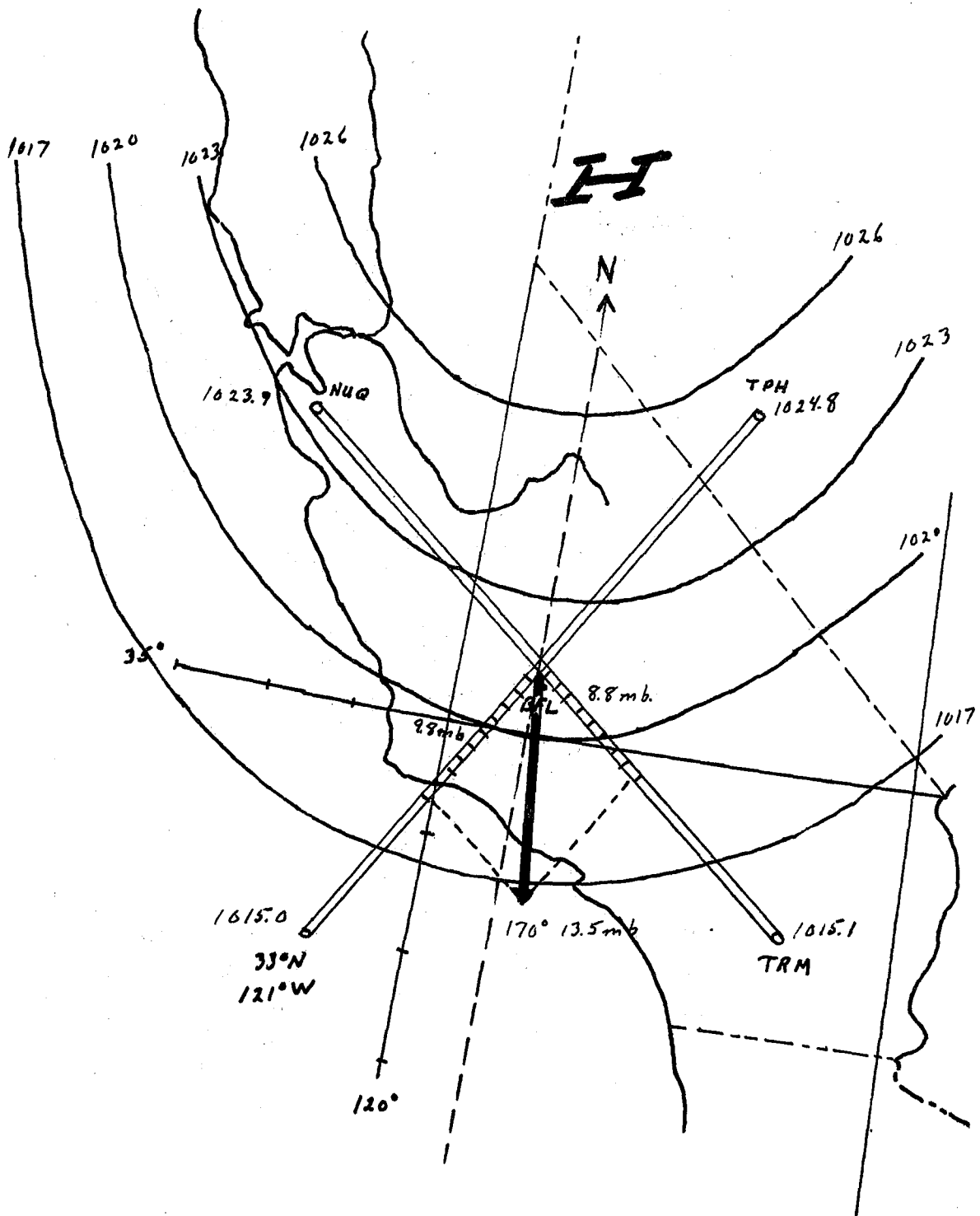


FIGURE 2. TYPICAL SURFACE MAP AND RESULTANT PRESSURE GRADIENT VECTOR FOR LOW PROBABILITY OF PRECIPITATION AT BAKERSFIELD, CALIFORNIA.

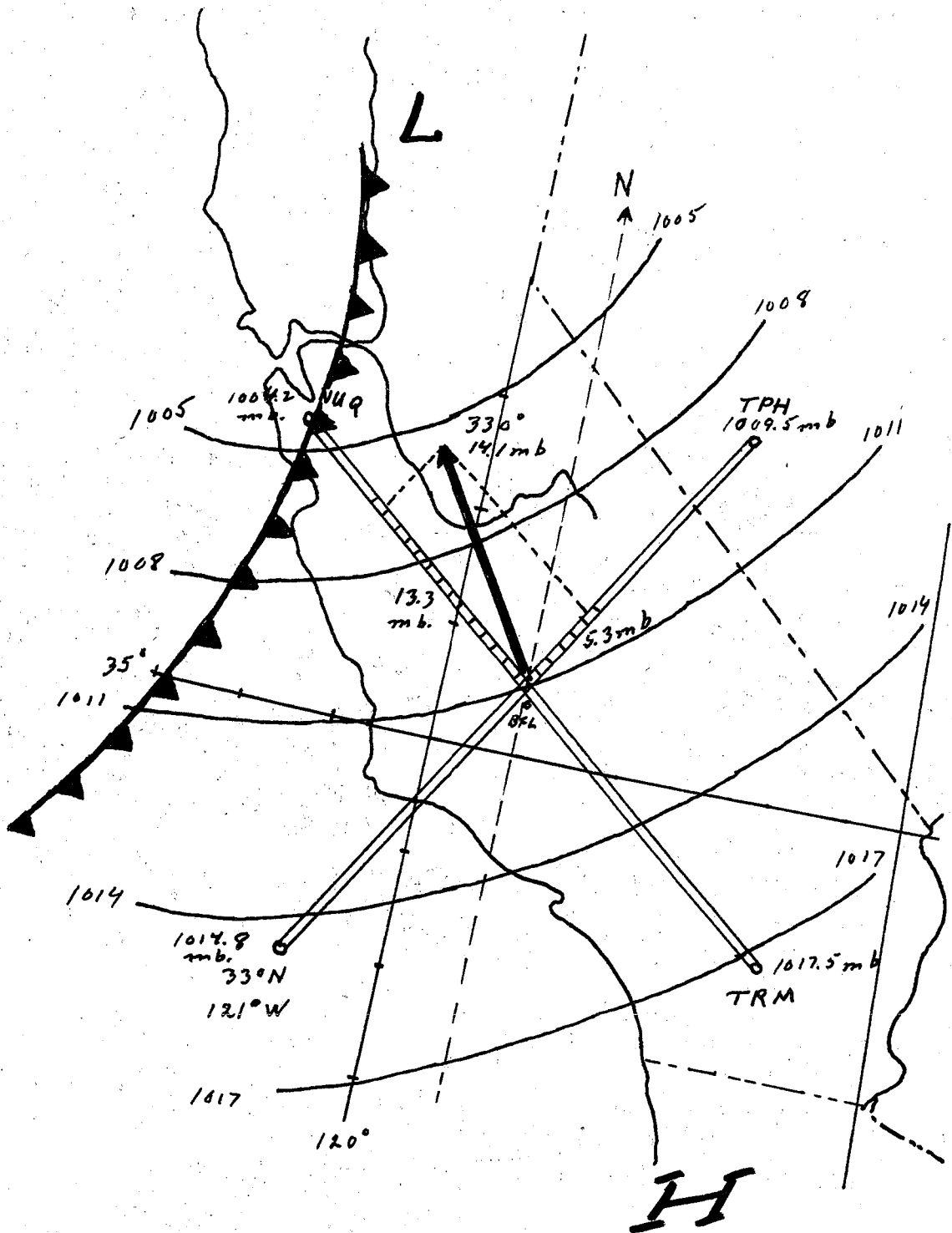


FIGURE 3. TYPICAL SURFACE MAP AND RESULTANT PRESSURE GRADIENT VECTOR FOR HIGH PROBABILITY OF PRECIPITATION AT BAKERSFIELD, CALIFORNIA.

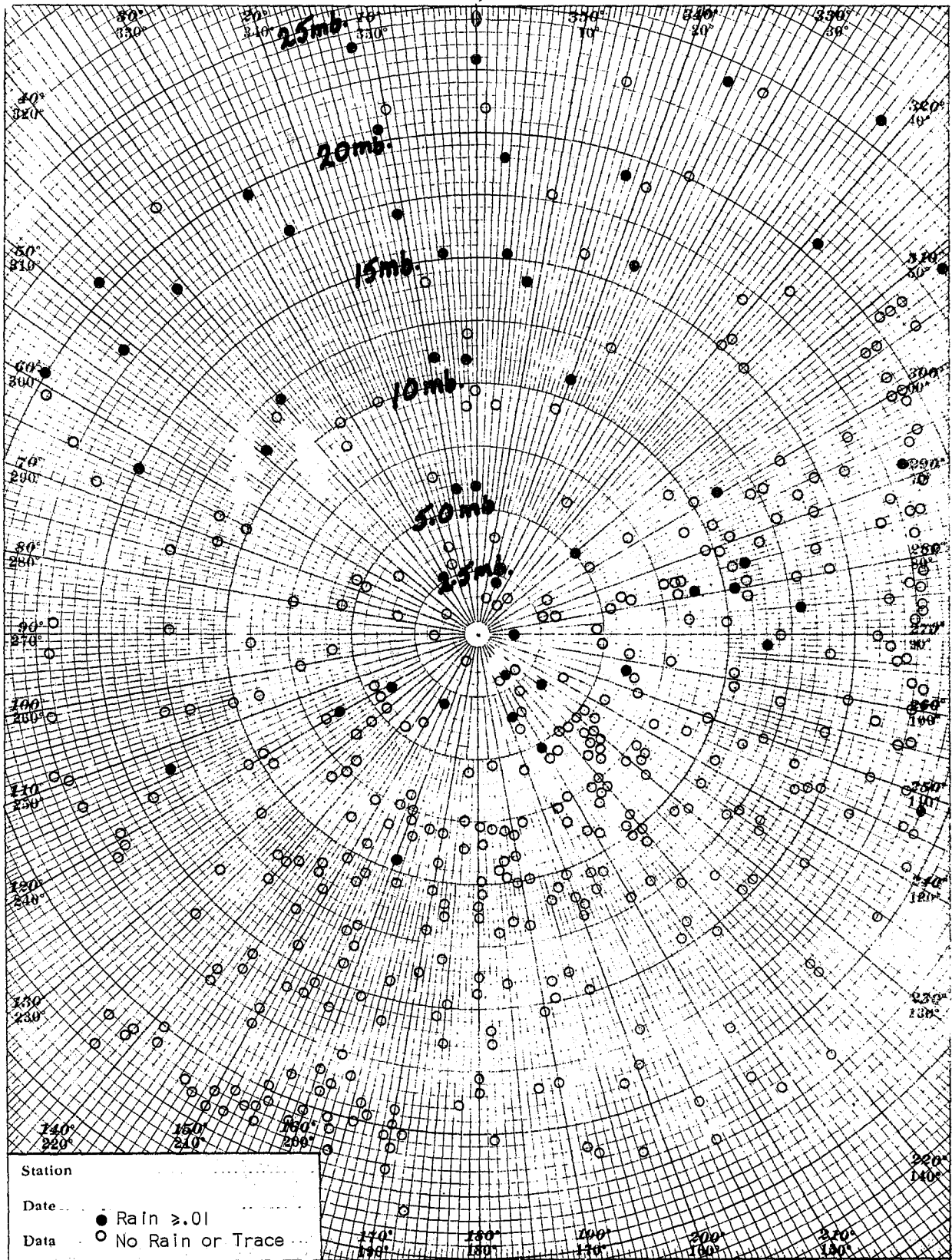


FIGURE 4. END POINTS OF RESULTANT VECTORS FOR SEASON NOVEMBER 1964-APRIL 1965. SOLID CIRCLE INDICATES RAIN FORECAST ($\geq .01$) FOR 12 - 24 HOUR PERIOD; OPEN CIRCLE, NO RAIN OR TRACE.

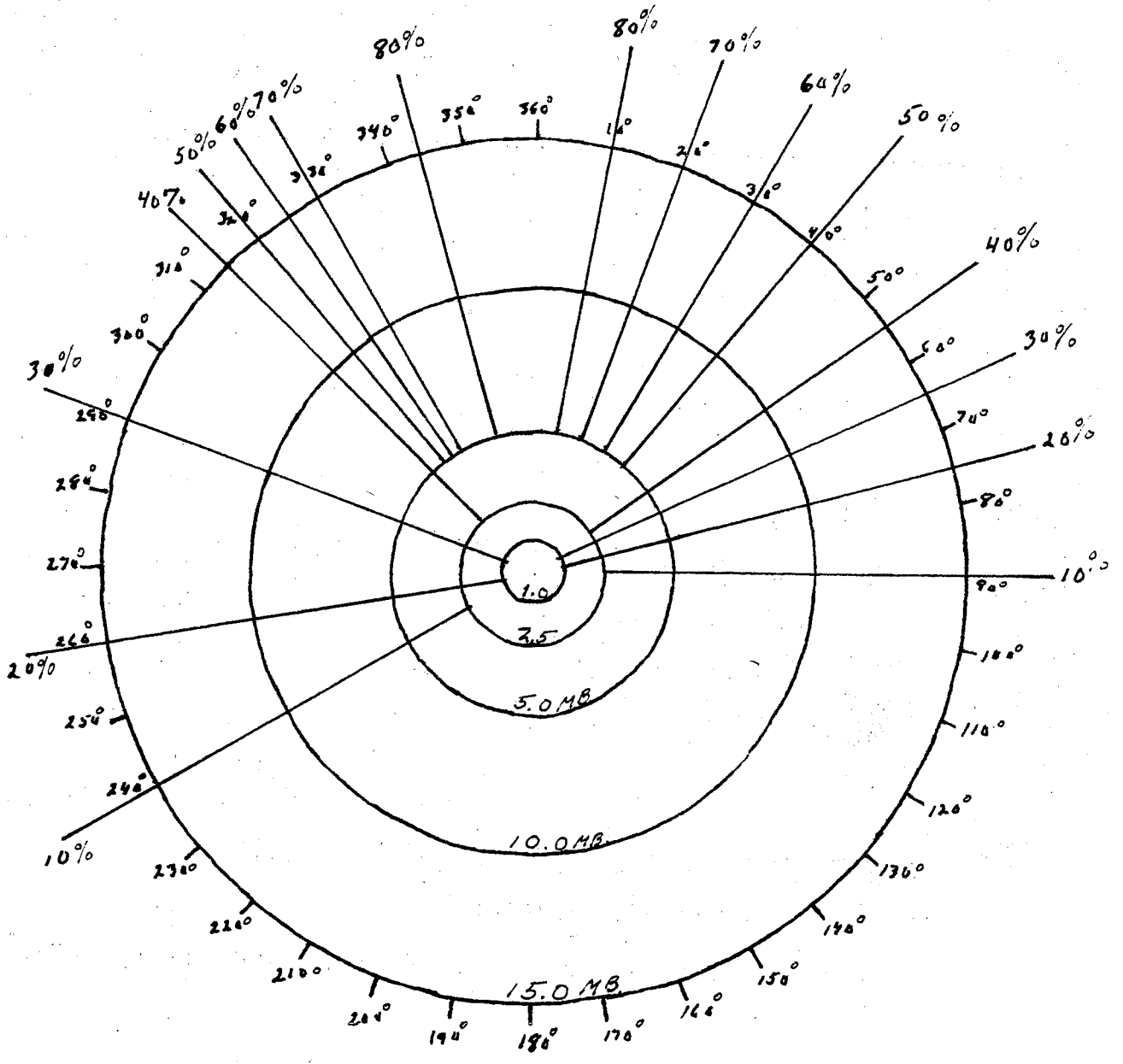


FIGURE 5. PROBABILITY OF PRECIPITATION AT BAKERSFIELD (NOVEMBER-APRIL) FOR RESULTANT SURFACE PRESSURE GRADIENT VECTORS WITH DIRECTION IN DEGREES AND MAGNITUDE IN MILLIBARS.

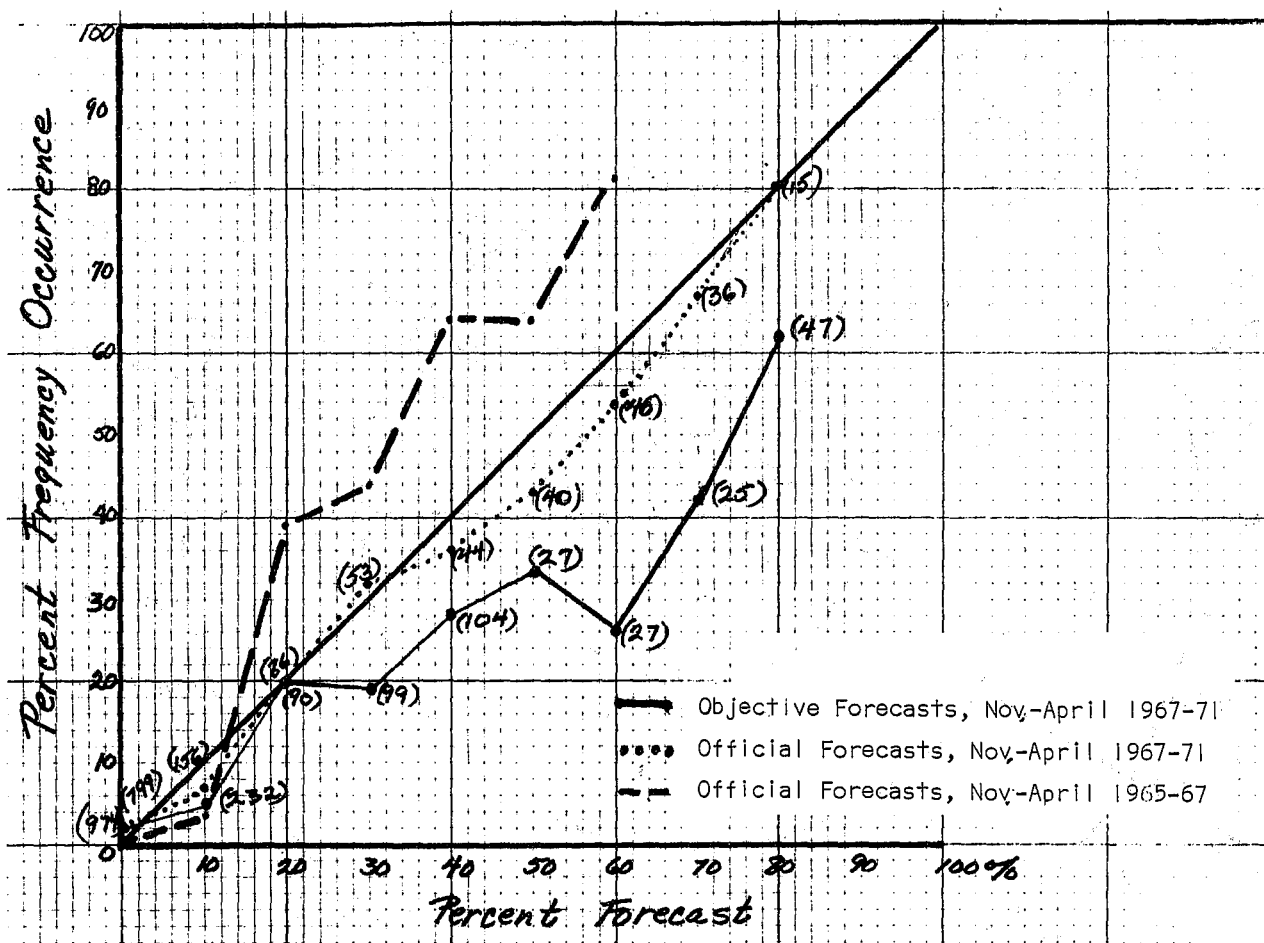
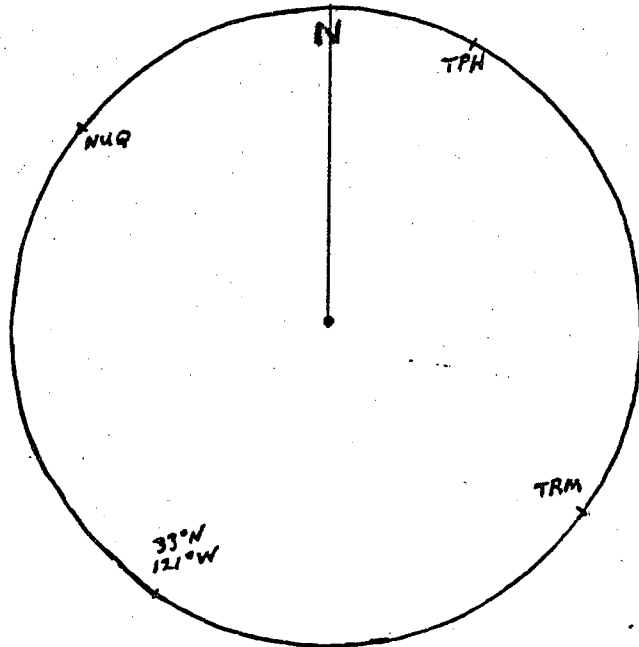


FIGURE 6. RELIABILITY CURVES FOR OBJECTIVE AND OFFICIAL PoP FORECASTS, BAKERSFIELD.



Top plate
rotating

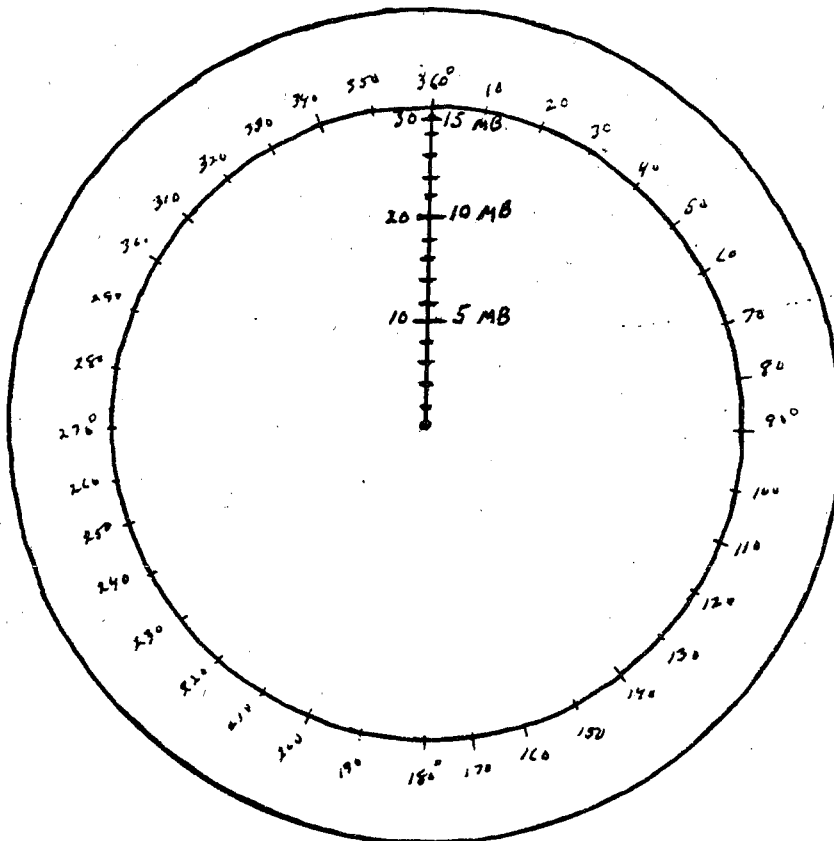


FIGURE 7. DIAGRAM OF VECTOR PLOTTING BOARD.

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