Streamlines

A tropical streamline analysis is a continuous representation of the wind field constructed from plotted wind observations (showing both speed and direction) taken on a horizontal plane. There are two horizontal levels commonly analyzed: 1. the gradient level (the level nearest the surface above the friction layer, usually at 2,000 ft. to 3,000 ft.). 2. the upper level (high level winds, usually at the 300-200 mbs. level.) The majority of this program will deal primarily with the GRADIENT LEVEL analysis. However, unless otherwise stated, the rules of analysis are applicable to all levels.

A forecaster's job is to describe and forecast the weather. In the mid-latitudes, this is generally accomplished by analyzing the pressure field and the heights of pressure surfaces. The forecaster must have knowledge of the different air masses and the discontinuity which occurs along their boundaries. However, in the tropics the forecaster quickly learns that he is dealing with a single air mass. Therefore, his major concern is with internal changes that occur within this single air mass. In the mid-latitudes the forecaster is concerned with a number of air masses and the weather that is generated along their frontal boundaries.

Since the tropics is considered to be a single air mass, the horizontal pressure and temperature gradients are ordinarily weak. Pressure and temperature variations frequently are due only to the DIURNAL EFFECT.

Due to weak horizontal gradients of pressure and temperature, another element must be used when analyzing tropical weather patterns. That element is the wind. An analysis of the wind field is called a tropical streamline analysis. The primary reason for constructing a tropical streamline analysis is due to weak horizontal gradients of pressure and temperature.

The tropical streamline analysis consists of two sets of lines: Streamlines and Isotachs.

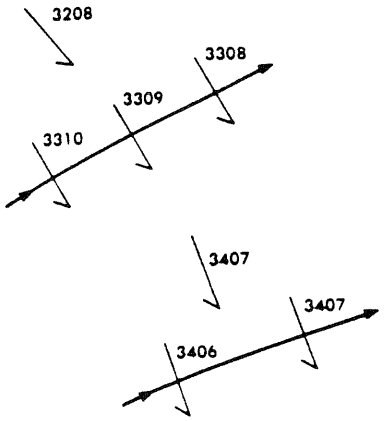
Streamlines represent the direction of the wind and are drawn as unending lines which may converge or diverge from one another (following certain rules).

Isotachs represent the speed of the wind and are drawn as dashed green lines which connect points of equal wind speed.

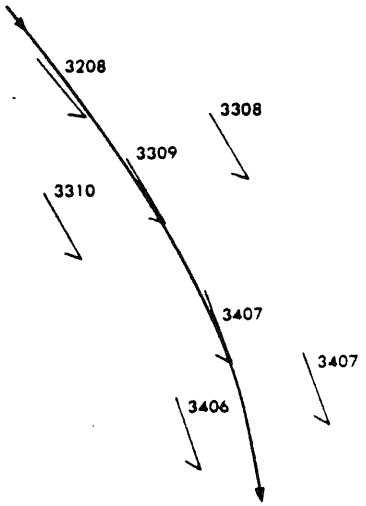
A complete analysis consists of two sets of lines, one superimposed upon the other. When superimposed, streamlines and isotachs give a continuous representation of the horizontal wind field. From this representation, the forecaster can normally determine wind direction and speed at any point on the chart. Streamlines are the first set of lines to be drawn. They are always drawn in sufficient numbers to accurately depict the direction of the flow.

Streamlines are first sketched in pencil. Beginning at the top of the chart and working from left to right or right to left (depending on the direction of the flow). Unlike isobars (which connect points of equal surface pressure), streamlines DO NOT connect points of equal wind direction. STREAMLINES are drawn roughly parallel to the reported wind direction.

Incorrect Method



Correct Method

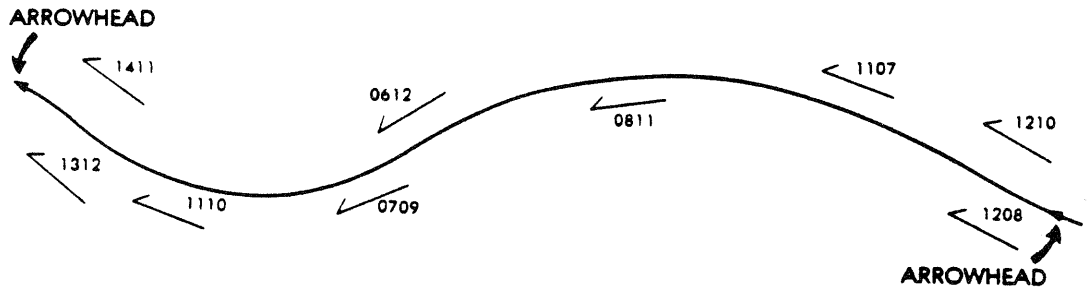


Note: All wind reports in this program will be plotted as shown.

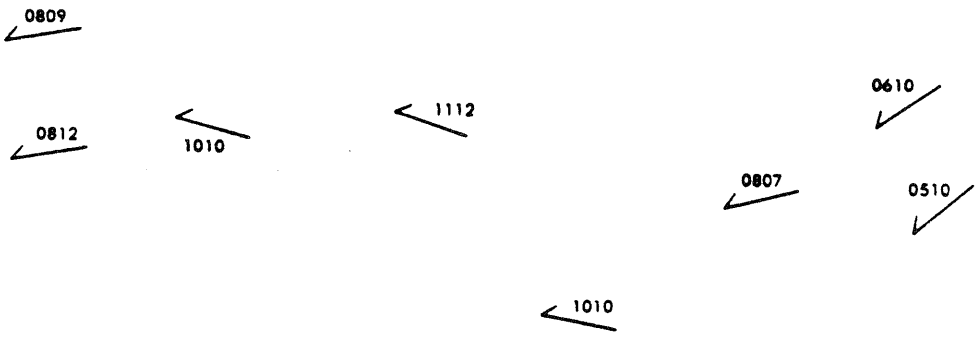
0914

In this example 09 indicates the direction from which the wind is blowing and 14 indicates the speed of the wind in knots.

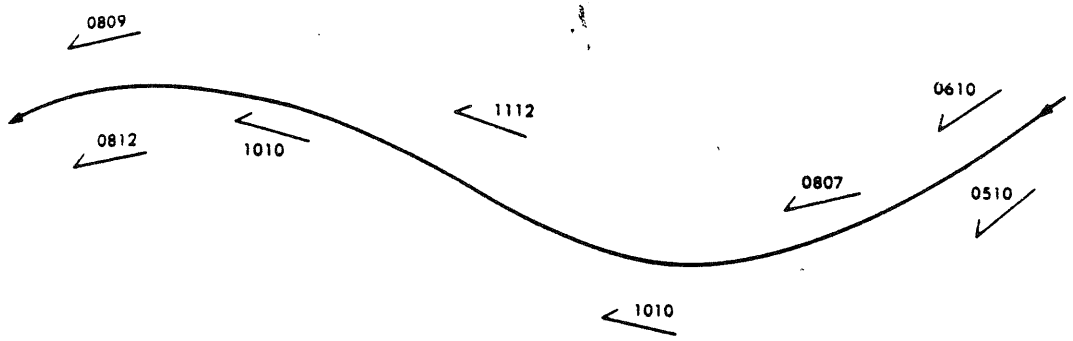
Streamlines should be drawn roughly parallel to the reported wind direction. Some interpolation may be required when data is not available along the path of the streamline. Interpolations of wind direction are carried out by eye and once the flow pattern is recognized, the streamline is drawn using a trial and error approach. In order to indicate that the streamline is continuous, arrowheads, pointing in the direction of the flow, are drawn at the beginning and ending of each streamline.



Using the following wind reports, sketch (in pencil) a single streamline from east to west. Remember to interpolate where necessary.



ANSWER:



FRAME 10

When drawing streamlines, keep the following guidelines in mind:

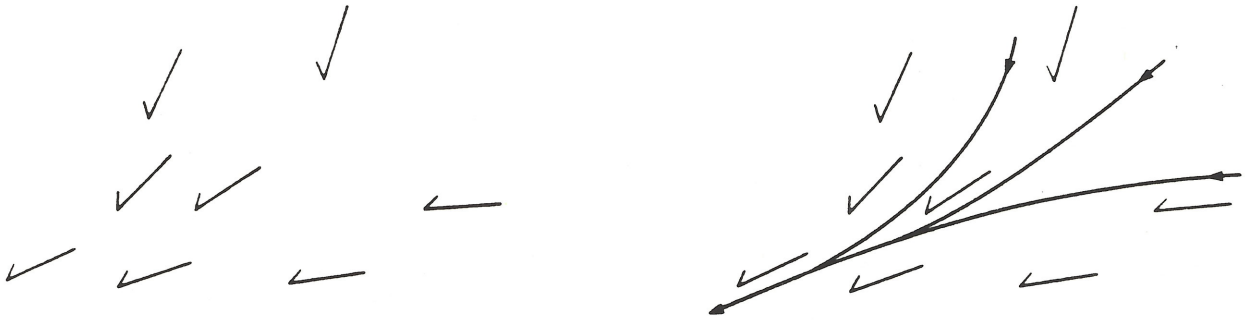
1. A streamline is drawn roughly parallel to the reported wind direction.
2. A single streamline represents a narrow channel of wind direction within the major flow, from one point on the chart to another.
3. Arrowheads are placed at the beginning and ending of each streamline.
4. Streamlines begin and end at the edges of the chart or at singular points.
5. Streamlines never cross.
6. Due to a limited number of wind reports, interpolation is sometimes necessary.
7. When enough streamlines have been drawn, a complete and continuous representation of wind direction should exist.

The spacing of parallel streamlines may be either <u>even</u> (to the extent possible) or <u>vary</u> according to the flow or density of the data (tighter spacing over a dense data area, and vice versa). Closer streamlines do not mean that the wind speed is higher.

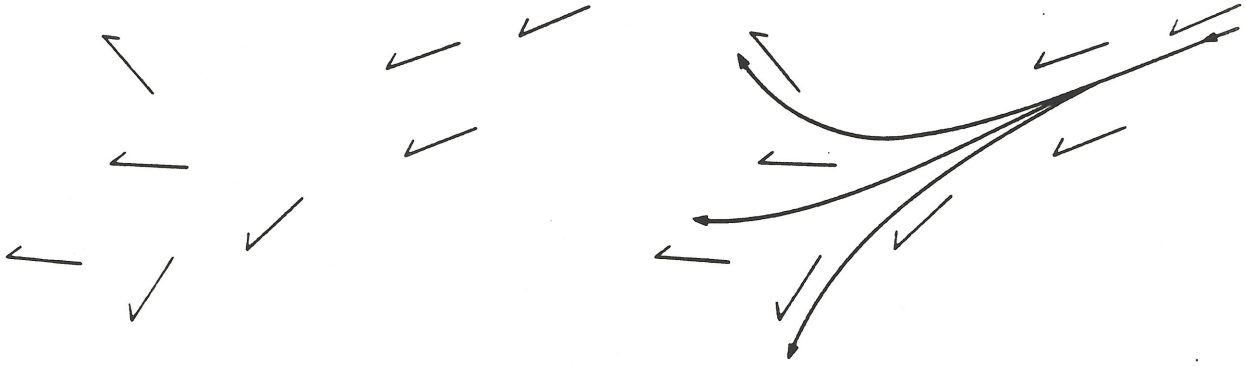
<u>CONVERGENCE and DIVERGENCE</u>

Frequently the forecaster will find areas on the chart where the wind direction from several reports indicates that the flow is spreading out or coming together (the indication of a diverging or converging flow). Since streamlines must be drawn parallel to the direction of the wind, it should follow that parallel streamlines should be drawn in such a way that a diverging or converging flow is easily visualized.

Example of <u>streamline CONVERGENCE</u>
Usually called directional convergence



Example of <u>streamline DIVERGENCE</u>
Usually called directional divergence

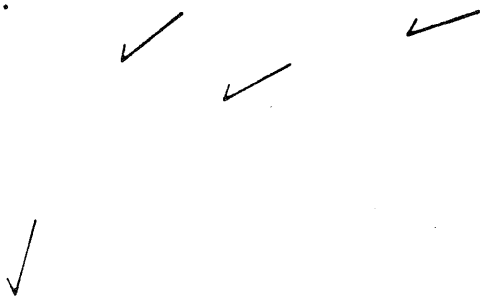


The axis of the diverging or converging flow is depicted by drawing a special streamline known as an asymptote. Asymptotes will be discussed later in the program.

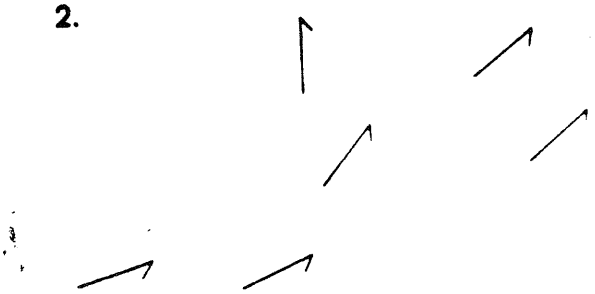
A single streamline can be visualized as an arrow (→) which points in the direction that the wind is blowing (downstream). An arrow has both a head and tail; however, in streamline analysis, we refer to both points as Arrowheads. This is because a streamline is continuous. In other words, the wind does not end at the edge of the chart; therefore, the tail is really a point indicative of a continuing streamline.

In each panel on the following page, draw (on a plastic covering) a sufficient number (1 or 2) of streamlines to accurately depict the flow.

1.

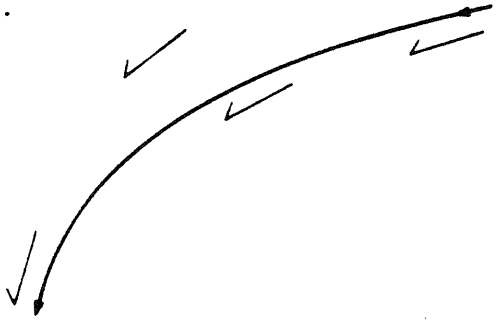


2.

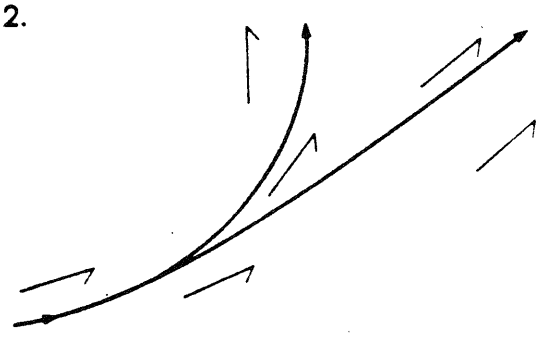


ANSWER:

1.



2.



INTERPOLATION and DISTORTION

Do not draw a streamline through every wind report as this leads to a cluttered appearance and prohibits proper spacing. Spacing should be at equal distance except in areas of converging or diverging streamlines. There is a tendency to distort streamlines to make them pass through data points which often leads to the violation of this basic rule.

Streamlines should roughly parallel the reported wind direction. On the other hand, try to refrain from distorting the analysis over too large an area on the basis of one wind report without substantial supportive data.

Insure that streamlines roughly parallel all wind reports which are considered accurate. An exception to this rule is permitted for reports of very light wind speed (less than 5 knots at the gradient level or less than 10 knots at upper levels). This rule usually applies to streamline construction which depicts major features of the analysis. Major features will be discussed later in this program.

Once the streamline pattern is complete, the next step is to complete the isotach portion of the analysis.

Previous frames discussed the construction of a "simple" streamline pattern. There are, however, several major features constantly occurring within the wind field which cause streamlines to assume characteristic patterns.

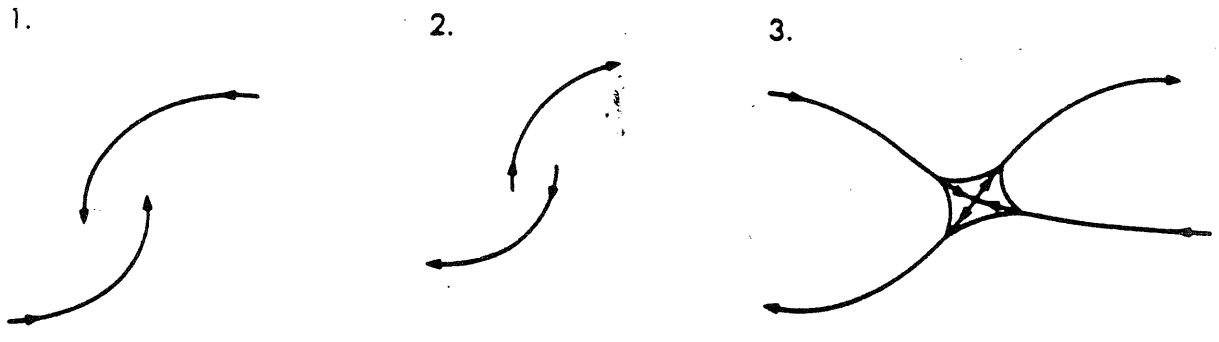
These major features are: (a) Singular Points, (b) Waves, (C) Asymptotes.

Frames 20 through 29 will define the major features and show their characteristic patterns.

FRAME 20

Singular Points are points on the chart into which more than one streamline can be drawn or about which streamlines form a closed curve.

Examples of a closed curve are shown on the following page. Example (1) shows two streamlines which depict a cyclonic turning of the wind. Example (2) shows the opposite condition (anticyclone), and Example (3) shows a point on the chart into which more than one streamline can be drawn.



In Example (3), an opposing flow is indicated. This type of singular point is called a NEUTRAL POINT.

FRAME 21

There are four types of singular points:

a. cyclonic circulation center or cyclone

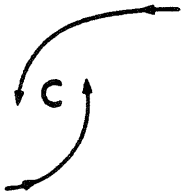
b. anticyclonic circulation or anticyclone

c. neutral point

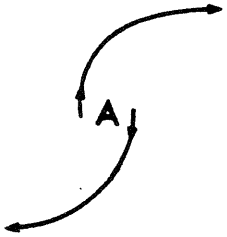
d. CUSP

Below are examples of singular points. The examples depict how special streamlines (asymptotes) are drawn to show the location of such singular points.

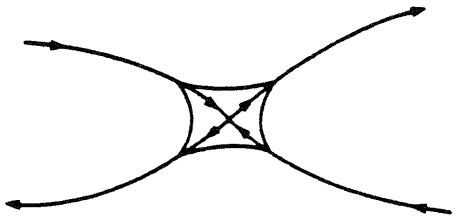
a. CYCLONE



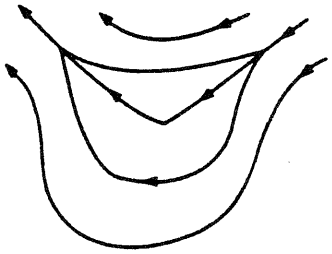
b. ANTICYCLONE



c. NEUTRAL POINT



d. CUSP

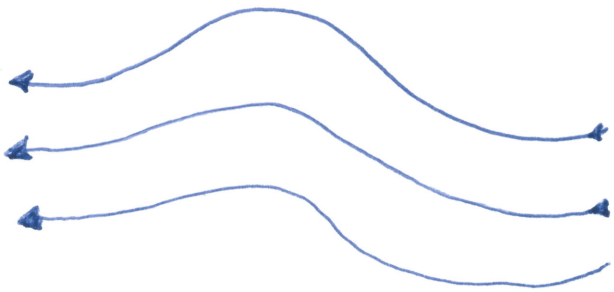


FRAME 22

Below are 4 types of singular points:

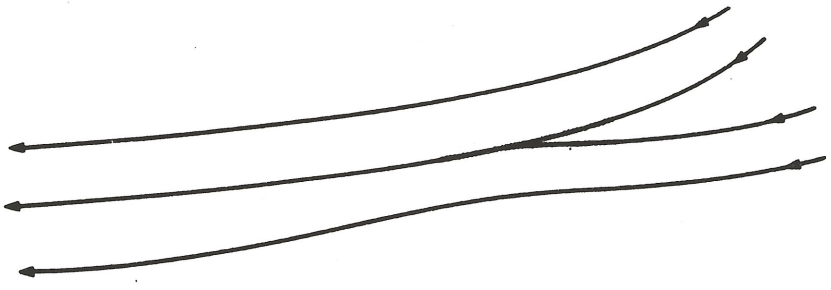
1. Cyclonic circulation center (cyclone) is any closed counter-clockwise circulation (Northern Hemisphere) within the wind field.
2. Anticyclonic circulation center (Anticyclone) is any closed clockwise circulation (Northern Hemisphere) within the wind field.
3. Neutral Point is a transition area between two like singular points or circulation patterns or between westerly and easterly flow.
4. CUSP is an intermediate pattern in the transition phase between a wave and a circulation center.

The second major feature to be defined is an oscillation in the streamline pattern called a tropical wave. These perturbations in the trade wind belt are migratory disturbances which move from east to west.



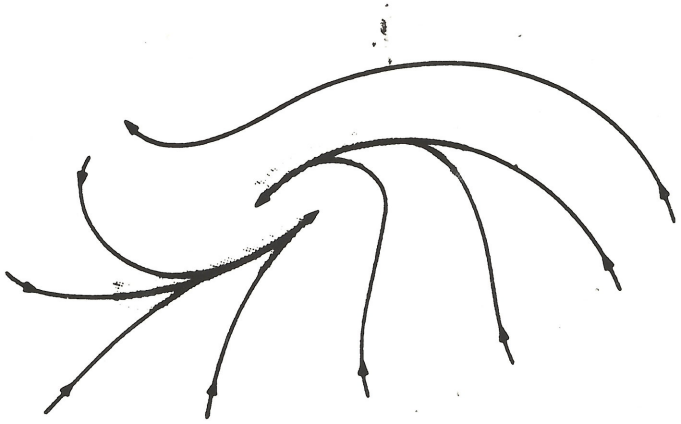
The third major feature to be discussed is an ASYMPTOTE. Asymptotes are defined as special streamlines which depict the axes within a region of ~~major~~ directional convergence or divergence. Since asymptotes depict regions of ~~major~~ directional convergence or divergence, it is understood that they are usually closely associated with singular points, however this is not always the case. Example 1 shows a converging asymptote within the streamline pattern not associated with a singular point.

EXAMPLE 1:

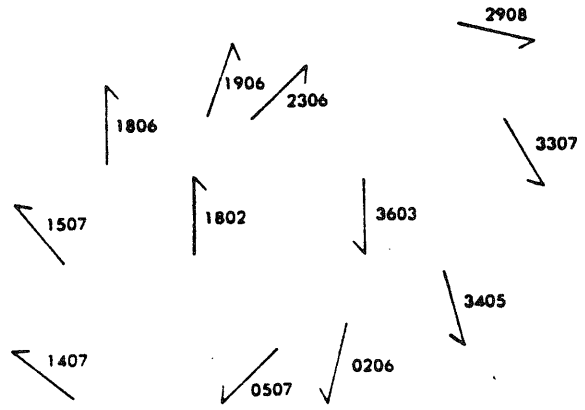


Example 2 shows two converging asymptotes associated with a cyclonic circulation center (singular point).

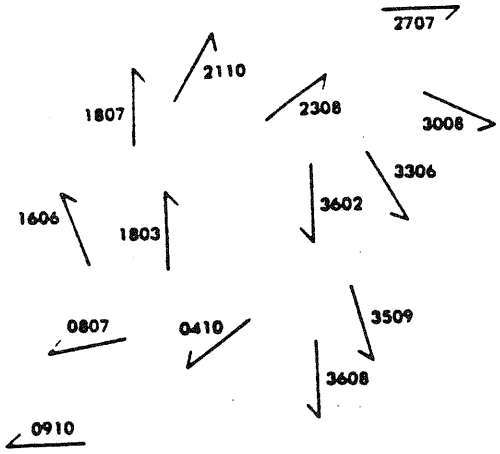
EXAMPLE 2:

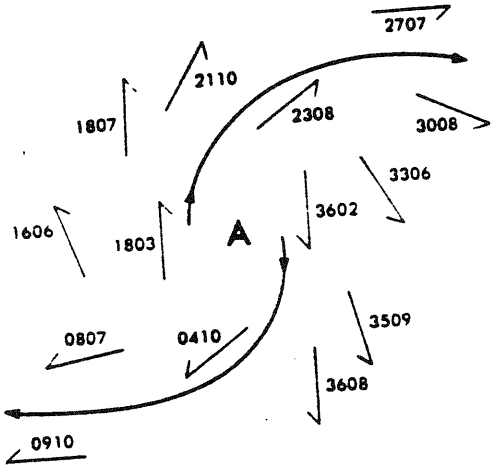


An anticyclone is any clockwise circulation (with a characteristic outflow of air from the center) in the Northern Hemisphere.



The examples on the following page (before and after analyzation) depict an anticyclonic circulation center (singular point) within the wind field.





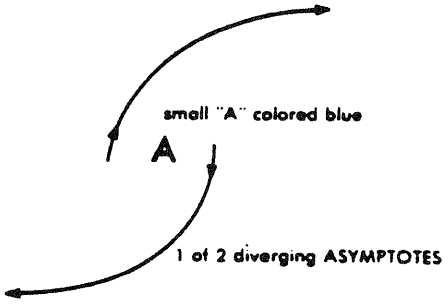
Note the outflow characteristic (clockwise) and the light winds near the center.

Two streamlines are drawn to depict the anticyclonic circulation center (closed curve).

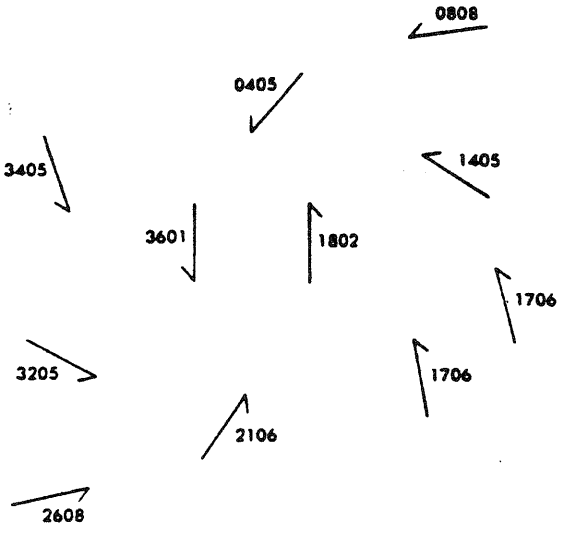
Standard rules for analyzing an ANTICYCLONE:

1. A minimum of two divergent asymptotes will denote a center. (Refer to the illustration in Frame 36)
2. Once the location of the center has been determined (thrbugh interpolation), it is labeled with a small blue "A" to denote an anticyclonic circulation center.

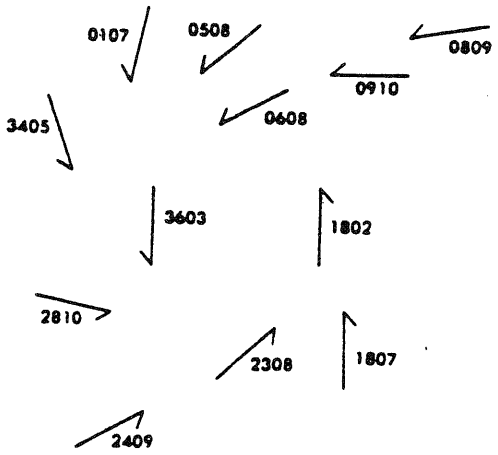
EXAMPLE:

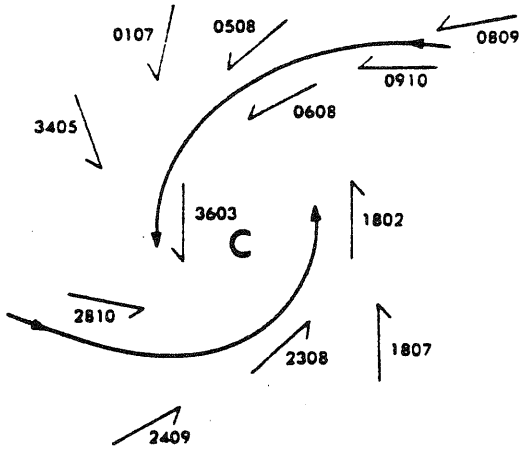


The second singular point to be discussed is the <u>cyclone</u>. Cyclones are normally located south of the subtropical ridge line axis. A cyclone is any closed counterclockwise circulation (with a characteristic inflow of air) in the Northern Hemisphere.



The examples below (before and after analyzation) depict a cyclonic circulation center (singular point) within the wind field.

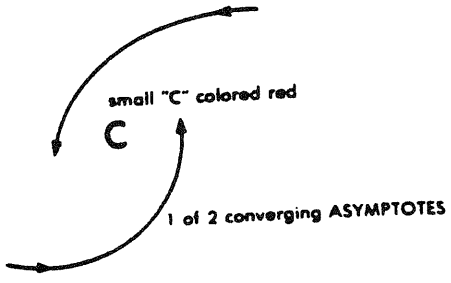




Standard rules for analyzing a <u>cyclone</u>:

1. A minimum of 2 convergent asymptotes will denote a center. (Refer to the illustration in Frame 39)
2. Once the location of the center has been determined (through interpolation), it is labeled with a small red "c" to denote a cyclonic circulation center.

EXAMPLE:



FRAME 41

On low-level (gradient level) charts - once the circulation centers have been located - work OUTWARD from anticyclonic centers and INWARD toward cyclonic centers. This procedure for drawing the streamlines insures that the diverging flow around anticyclones and the converging flow around cyclones are accurately depicted.

When doing a gradient level streamline analysis, the forecaster should work _____ from anticyclones and _____ toward cyclones.

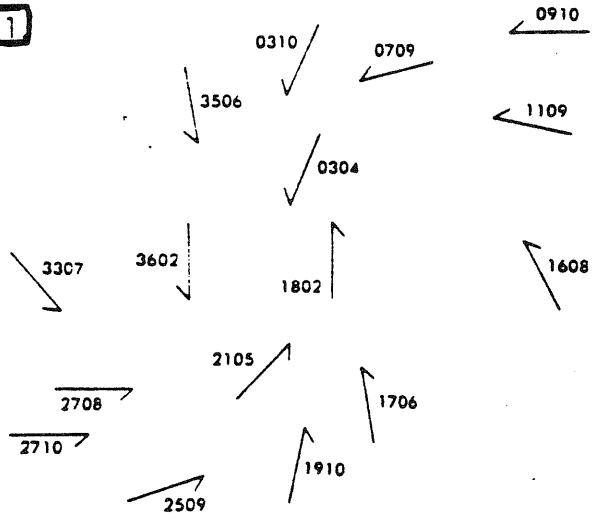
* *

ANSWER: outward, inward

FRAME 42

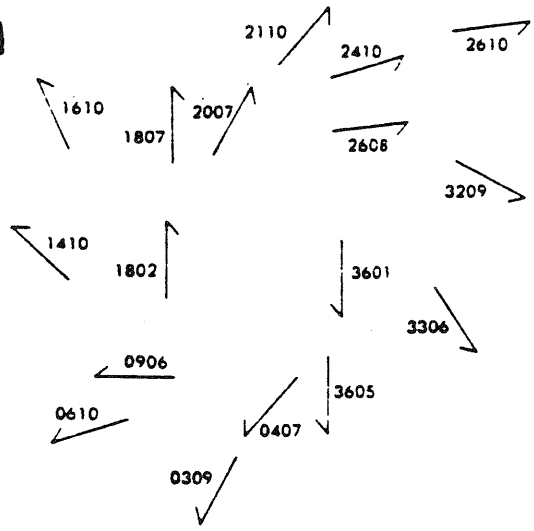
Consider the two wind fields illustrated in Blocks 1 and 2. Using two asymptotes and the proper letter designator, analyze and label the type of singular point in each block.

1



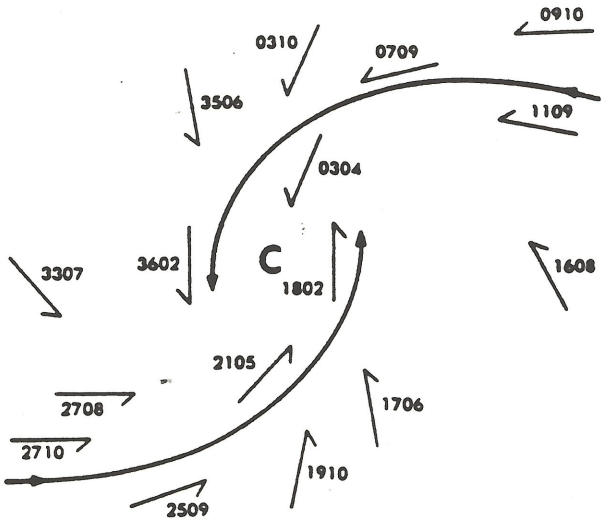
This singular point is known as _____

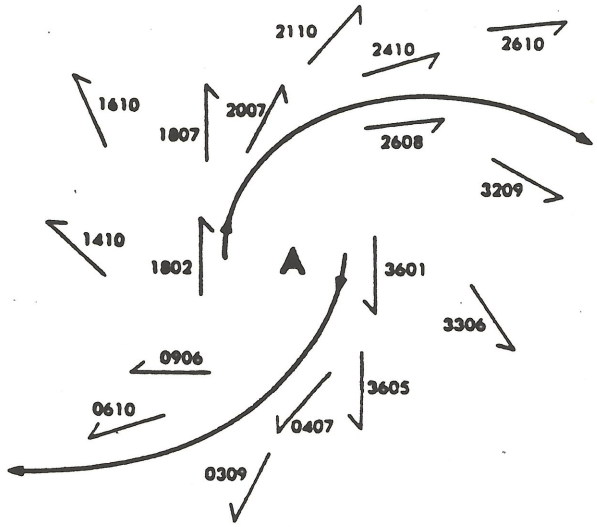
2



This singular point is known as _____

ANSWER:





This singular point is known as a:

cyclone

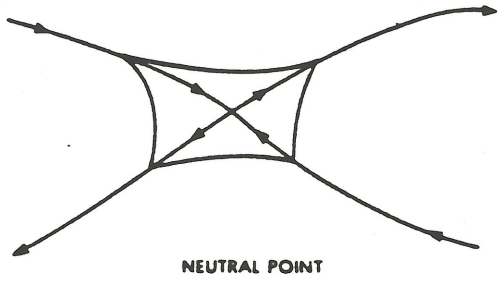
This singular point is known as an:

anticyclone

FRAME 43

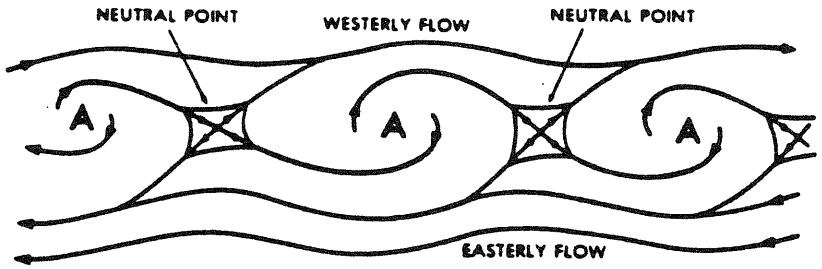
The third type of singular point to be located is called a NEUTRAL POINT. A neutral point is a transition area between two like singular points (cyclones or anticyclones) or circulation patterns or between westerly and easterly flow.

EXAMPLE 1:

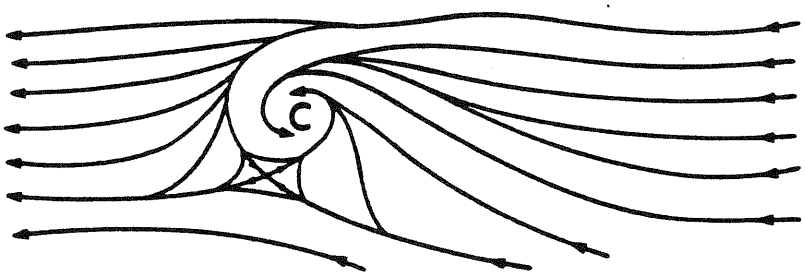


FRAME 43 (CONTD.)

EXAMPLE 2:



EXAMPLE 3:



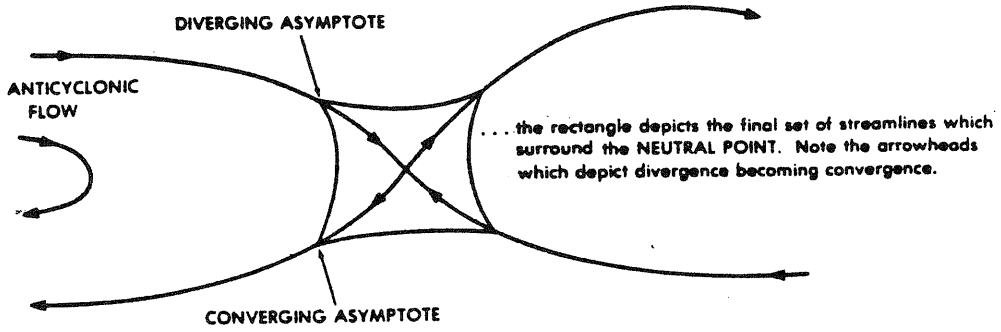
Example 1 shows the proper construction of a neutral point.

Example 2 shows neutral points that are located between two like singular points (in this case anticyclones). Note the westerly wind to the north and easterly wind to the south of each neutral point.

Example 3 shows a cyclone with a neutral point below it. The neutral point separates the westerly wind component of the cyclone from the otherwise easterly wind south of the cyclone.

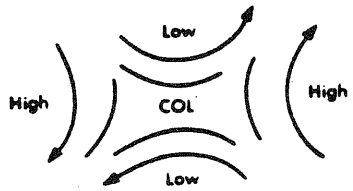
**********NO RESPONSE NECESSARY**********

A <u>neutral point</u> is further defined as that point where two divergent and two convergent asymptotes appear to intersect (as shown below).



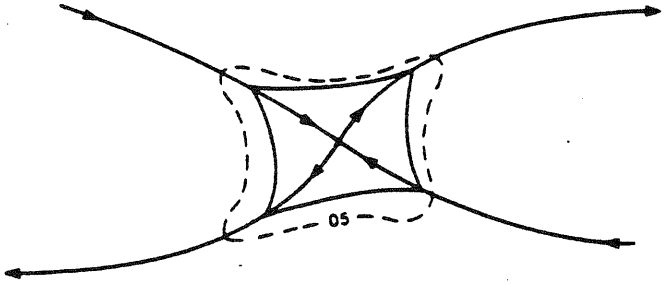
A neutral point can be compared to a "COL" area on a surface isobaric analysis, an area bounded by opposing high and low pressure.

EXAMPLE: (Surface Analysis)



Keep areas around the neutral points relatively small, the boundary around the center encased by the last two converging/diverging streamlines which flow from the asymptotes.

Example: gradient level neutral point.



20

FRAME 46 (CONTD.)

On the gradient level analysis, most of the area around the neutral point should be drawn inside the (yet-to-be drawn) 5-knot isotach. On the upper level chart, this area is contained within the 10-knot isotach. To accomplish this, draw the neutral point intersections first and then the bounding streamlines associated with the neutral points by considering the reported wind speed.

Most of the boundary which surrounds a neutral point is drawn inside the _____ knot isotach of the gradient level chart, and the _____ knot isotach of the upper level chart.

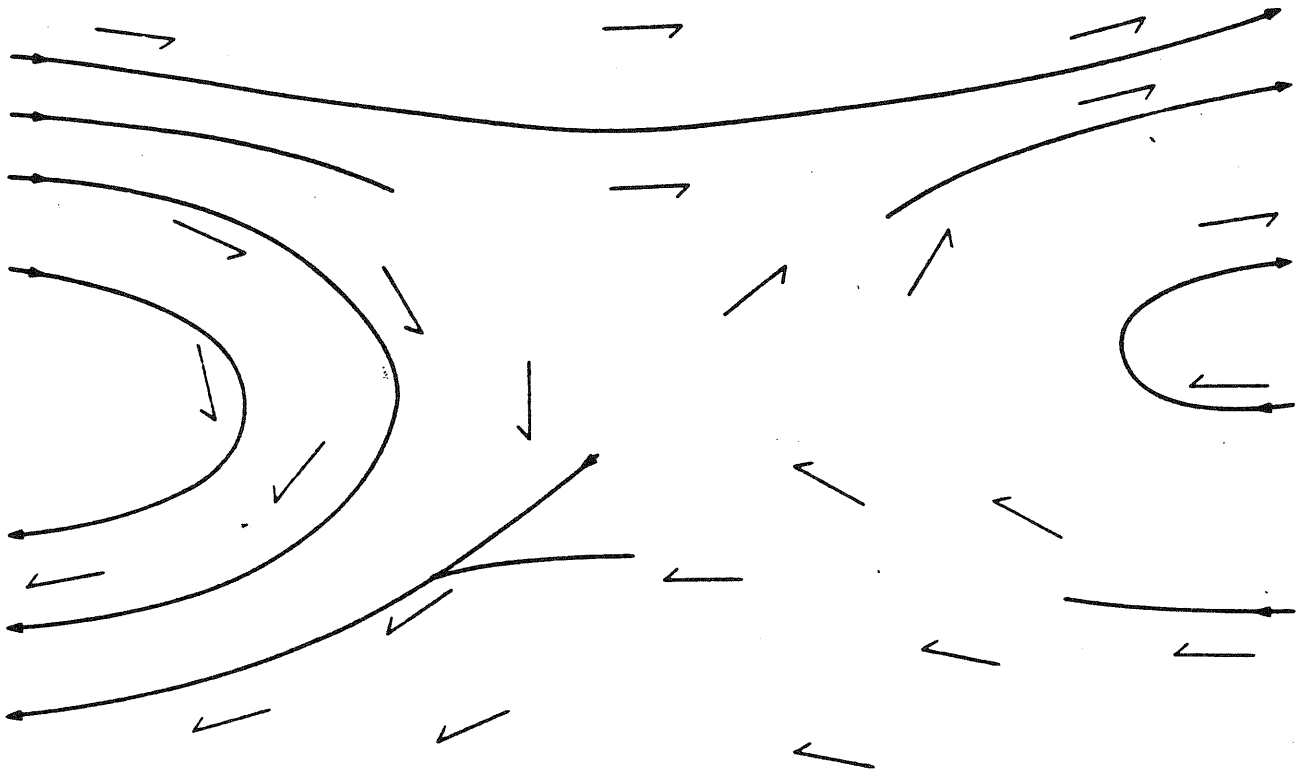
* *

ANSWER: 5, 10

FRAME 47

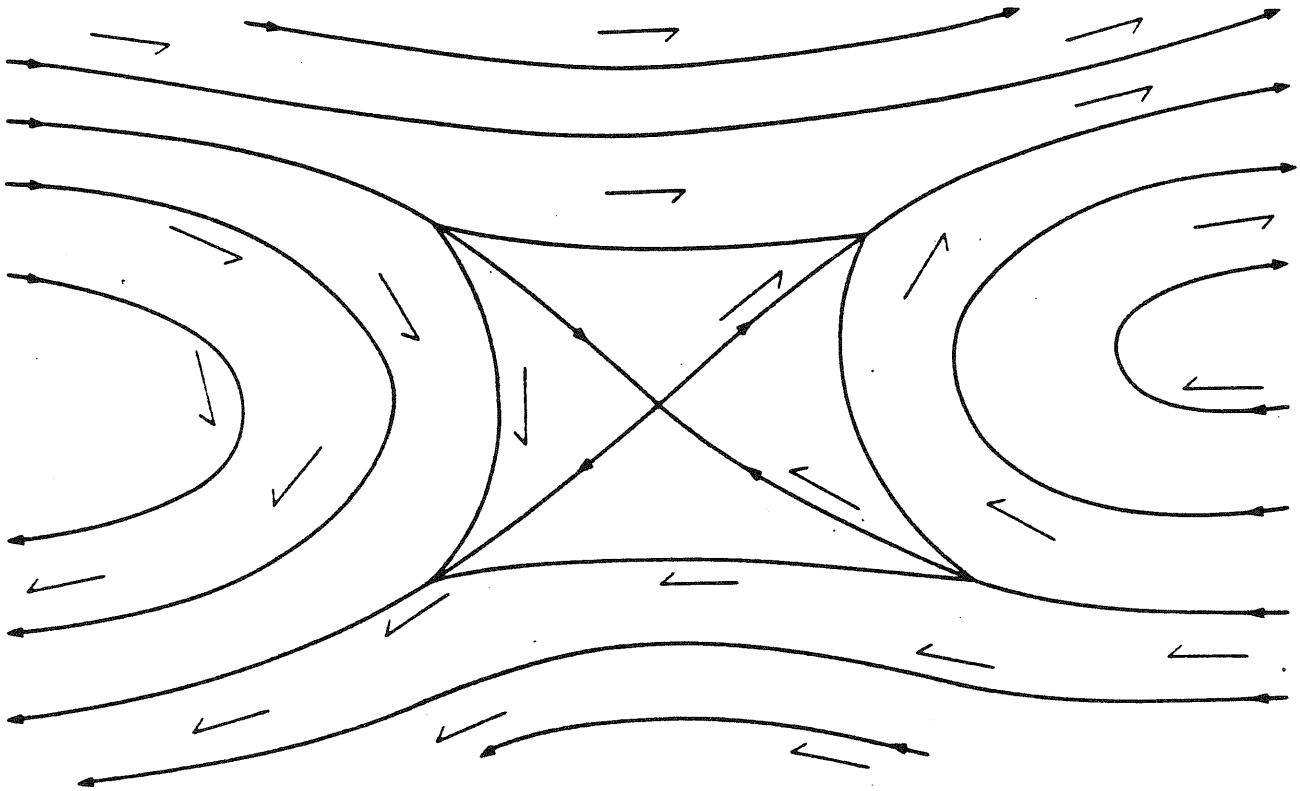
On the partially completed analysis on the following page, draw (on a plastic covering) sufficient streamlines to depict a neutral point using guidelines described in Frames 43 through 46.

FRAME 47 (CONTD.)



* *

ANSWER:

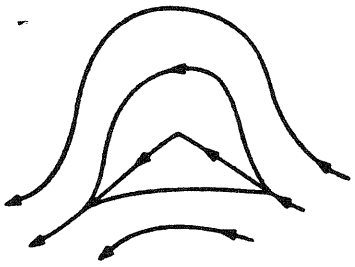


FRAME 48

The final singular point to be discussed within this program is known as a CUSP.

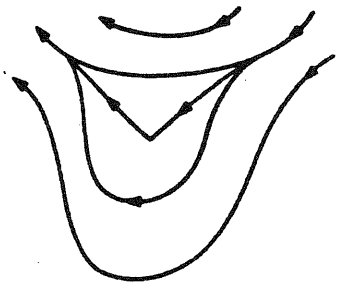
A CUSP is an intermediate pattern in the transition phase between a wave and a circulation center. It is relatively unimportant in synoptic wind analysis simply because of its short life. Below are two example variations of a CUSP.

1.



Cyclonic CUSP

2.



Anticyclonic CUSP

An intermediate pattern between a wave and a circulation center is called a _____.

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ANSWER: CUSP