TERMINAL FORECAST REFERENCE FILE

25 February 1970

Detachment 5, 17th Weather Squadron

McChord AFB, Washington

107

MCCHORD AIR FORCE BASE

TERMINAL FORECAST REFERENCE FILE

These files have been revised in accordance with 7WWM 55-1 dated 15 July 1968, by MSgt Dennis W Wixon and TSgt Thomas M Christoffer. The TFRF is for the purpose of the following:

1. Providing a written record of local forecasting information and problems, along with some solutions to these problems.

2. Acquainting newly assigned forecasters with the pertinent weather phenomena peculiar to the local area and with information accumulated through study and experience at this station.

3. Serving as a ready reference for local forecasting techniques and climatological data.

Prepared 25 February 1970

Detachment 5, 17th Weather Squadron

McChord AFB, Washington

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SECTION I

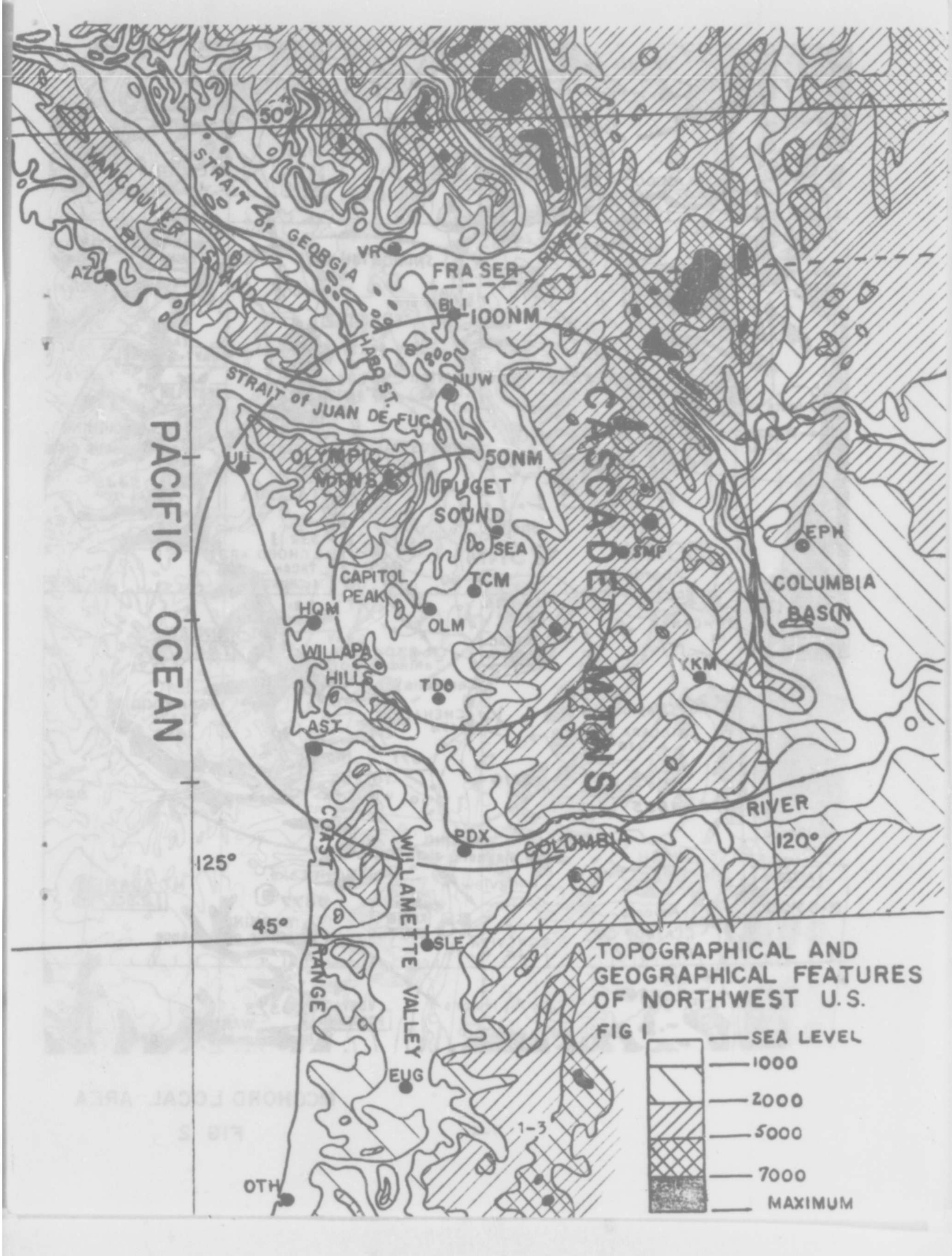
LOCATION AND TOPOGRAPHY

1000. LOCATION AND TOPOGRAPHY

1010. LOCATION OF MCCHORD AIR FORCE BASE (Figs 1-3)

a. Location of McChord AFB and Main Geographic Features: McChord AFB is located 1 mile south of Tacoma, Washington and 25 miles south-southwest of Seattle, Washington at 47 degrees 9 minutes north latitude and 122 degrees 29 minutes west longitude. The base is 80 miles east of the Pacific Ocean at an elevation of 322 feet MSL. The Cascade Mountain range starts to rise 25 miles east of the station. The Cascades are orientated north-south with numerous peaks rising above 7,000 feet. Mount Rainier, 40 miles southeast of the base, is the highest peak at 14,410 feet. Two main rivers cut though the Cascades. To the south, the Columbia River forms a commen border between Washington and Oregon and flows into the Pacific Ocean at Astoria (AST). To the north, the Fraser River drains central British Columbia and flows into the Strait of Georgia at Vancouver (VR). The most used route for low flying aircraft through the Cascades is Stampede Pass (SMP), which is 55 miles east-northeast at an elevation of 3800 feet. Forty-five miles northwest the Olympic Mountains range up to nearly 8,000 feet sheltering McChord AFB from any strong northwesterly winds. Finally, the Straits of Juan De Fuca, Haro, and Georgia form the natural northwest boundary of Washington.

b. Local Geographical Features: The area between the Olympics and the Cascades is dominated by Puget Sound, which has numerous in-



TOPOGRAPHICAL AND GEOGRAPHICAL FEATURES OF NORTHWEST U.S.

FIG 1

MCCHORD LOCAL AREA

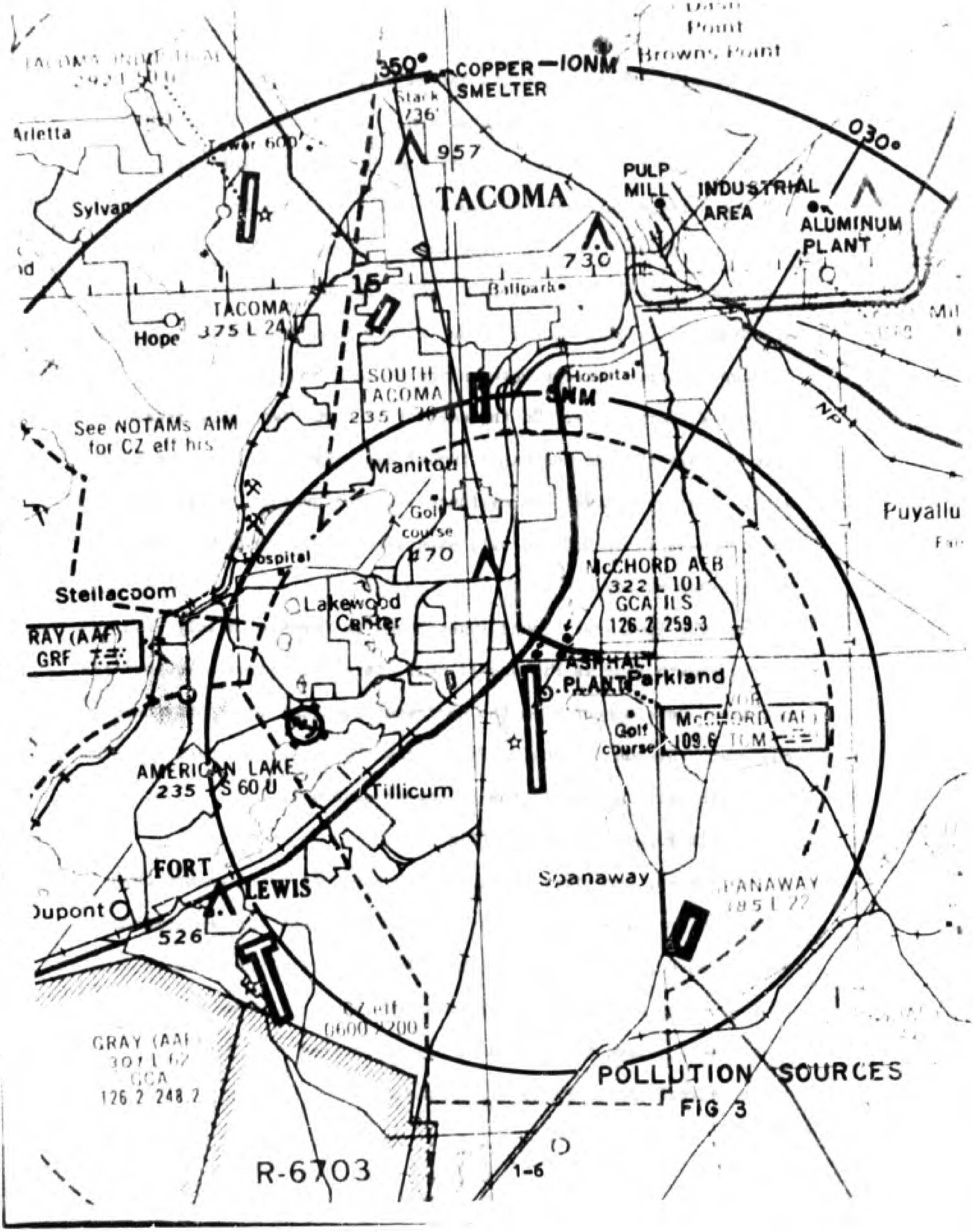
FIG 2

lets, canals, and bays, and is dotted by many islands. After cliffs that rise abruptly, the land area around Puget Sound is mainly flat at 200 to 600 feet elevation, with numerous small lakes and a few rolling hills. Guarding the southwest end of Puget Sound, Capitol Peak rises to 2658 feet 10 miles west of Olympia (OLM). Further southwest and south, the Willapa Hills rise up to 3110 feet. Moist air from the Pacific easily finds its way into the Puget Sound area through the open valleys between the Olympic Mountains, Capitol Peak, and the Willapa Hills. To the east of McChord, two small rivers form valleys that periodically funnel easterly winds into the sound area. The Green River valley funnels winds towards Seattle (SEA). On rare occasions, McChord will experience gusty winds from the White River valley.

c. The land area around Puget Sound is forested mainly with second growth Douglas Fir except near cities and towns. McChord AFB has urban development from the northwest quadrant to the northeast quadrant. Stands of Douglas Fir, broken by brushy patches, are from the southeast quadrant to the southwest quadrant.

1020. AIR POLLUTION SOURCES (Fig 3)

a. Smoke, sometimes combined with haze, is quite common when an inversion is present with a light north-northwest through northeast wind. The copper smelter and the pulp mill are major smoke sources with a lesser amount emanating from the industrial area and the aluminum plant. Also, three asphalt plants located just off runway 16 can be significant, especially during marginal foggy conditions,



POLLUTION SOURCES

FIG 3

R-6703

1-6

often thickening fog on runway 16.

1030. METEOROLOGICAL EQUIPMENT (Fig 4)

a. The Representative Observation Site (ROS) is located on the roof of hanger 3, 100 feet above ground level, and 1800 feet west of the half-way point of the runway. The spacious site (15X15 feet) has windows of non-glare glass and a ramp that extends around the building. Hanger 4 blocks the view of the observer and hides the southeast portion of the runway; however, the area beyond the runway is in sight. Otherwise, the observer has an unobstructed view.

b. Rotating Beam Ceilometer (AN/GMQ13)

(1) Projector, runway 16: The location is 1600 feet north of the approach end of runway 16 and 125 feet west of the center line.

(2) Detector, runway 16: The location is 1975 feet north of the approach end of runway 16 on the center line.

(3) Projector, runway 34: The location is 3200 feet south of the approach end of runway 34 and 150 feet west of the center line.

(4) Dectector, runway 34: The location is 2925 feet south of the approach end of runway 34 and 300 feet west of the center line.

c. Transmissometer (AN/GMQ10B)

(1) Projector, runway 16: The location is 900 feet south of the approach end of runway 16 and 1000 feet east of the center line.

(2) Receiver, runway 16: The location is 400 feet south of the approach end of runway 16 and 1100 feet east of the center line.

(3) Projector, runway 34: The location is 750 feet north of the approach end of runway 34 and 500 feet west of the center line.

(4) Receiver, runway 34: The location is 1250 feet north of the approach end of runway 34 and 600 feet west of the center line.

d. Anemometer (AN/GMQ 11/20)

(1) Transmitter, runway 16: The location is 875 feet south of the approach end of runway 16 and 500 feet east of the center line.

(2) Transmitter, runway 34: The location is 1100 feet north of the approach end of runway 34 and 500 feet west of the center line.

e. Temperature-Humidity (AN/TMQ11)

(1) The location is 4300 feet from the approach end of runway 34, 5800 feet from the approach end of runway 16, and 500 feet west of the center line.

f. Rain Guage (ML17)

(1) The location is 50 feet west of the base weather station in building 1172.

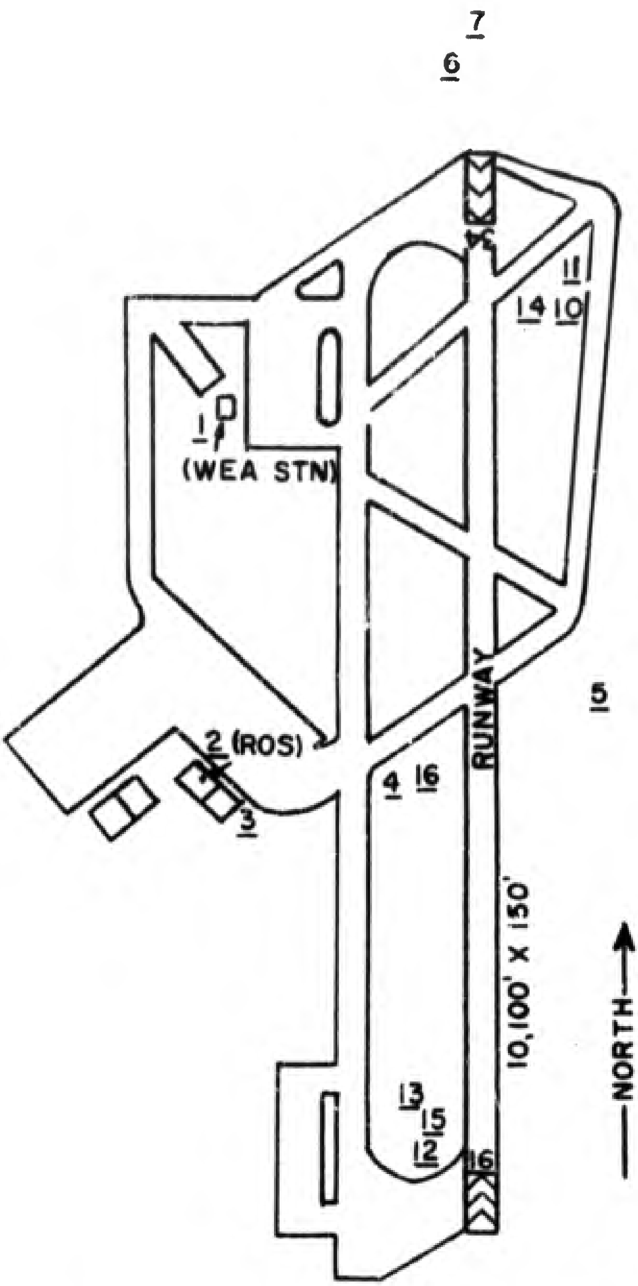
g. Radar (TPQ11)

(1) Transmitter-Receiver: The location is 50 feet west of the base weather station.

(2) Recorder: The location is in the base weather station.

h. Readouts and indicators of meteorological equipment are located in the ROS, except the TPQ11. The Control Tower also has one wind indicator; Radar Approach Control has four wind indicators; and Base Weather has one indicator. The ROS has a wind recorder.

i. FM1 RVR Computer: The location is in the ROS.



MCCHORD RUNWAY & WEA EQUIPMENT LOCATION

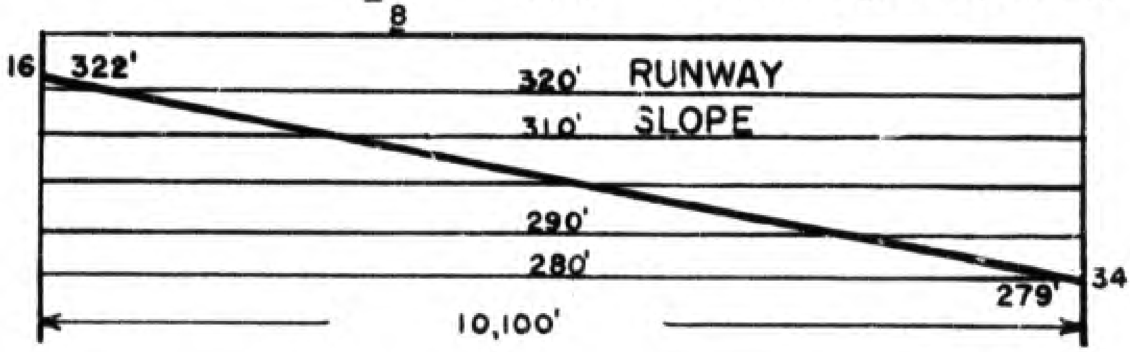
1. Base Wea-ACP-Base Ops
2. ROS
3. TWR-RAPCON-GCA
4. GCA Remote Radar
5. RAPCON Remote Radar
6. RBC Projector
7. RBC Detector
8. RBC Projector
9. RBC Detector
10. Transmissometer Projector
11. Transmissometer Receiver
12. Transmissometer Projector
13. Transmissometer Receiver
14. Anemometer Transmitter
15. Anemometer Transmitter
16. Temperature-Humidity

(Rain Guage and TPQ-11 Radar located 50 feet west of Base Wea Stn)

Local Dissemination By Teletype Pony Circuit

Station
1. ROS (Send-Receive)
2. Base Wea (Send-Receive)
3. TWR (Receive)
4. RAPCON-GCA (Receive)
5. Base Ops (Receive)
6. Airlift Command Post (Receive)
7. 318th Fighters (Receive)

FIG 4



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SECTION II

WEATHER CONTROLS

2000 WEATHER CONTROLS

2010. CONTROLLING FEATURES: (Ref. Figs. 5-8)

a. Pacific High: The semipermanent Pacific High migrates from a summer position of about 36 degrees north 153 degrees west to a mean winter position of 29 degrees north 138 degrees west. At its most northerly summer position, the high works as an effective block and causes the mean storm track to pass well north of McChord. As winter approaches, and the high migrates toward its most southern position, the storm track moves south allowing frequent frontal passages at McChord.

b. Aleutian Low: The position of the Aleutian Low, which has a mean winter position of about 49 degrees north 174 degrees east, has a decided effect on frontogenesis in the Eastern Pacific. Most cyclones affecting the Pacific Northwest are formed in the southwest flow around the southern periphery of the low. The position and intensity of the low affects the type and intensity of the spawned frontal system. For example, the low, or a break off from the low, often moves into the Gulf of Alaska. From this position it pulls cold Continental Polar Air (CP) off the Alaskan mainland. A front spawned under these conditions would be expected to bring a showery unstable air mass to the northwest. Conversely, when the low is in a more south and westerly position, the air mass being advected into the northwest is apt to be more stable and moisture laden. The Aleutian Low is mostly a fall, winter, and spring phenomenon and virtually disappears during the summer.

c. Thermal Trough: During summer months, a thermal low develops over the Southwestern U.S., and an associated trough often extends northward into the Columbia basin. When this takes place, the resulting pressure gradient generally causes on shore flow in Western Washington. With the advection of this moist maritime air, late night and early morning stratus is a common occurrence.

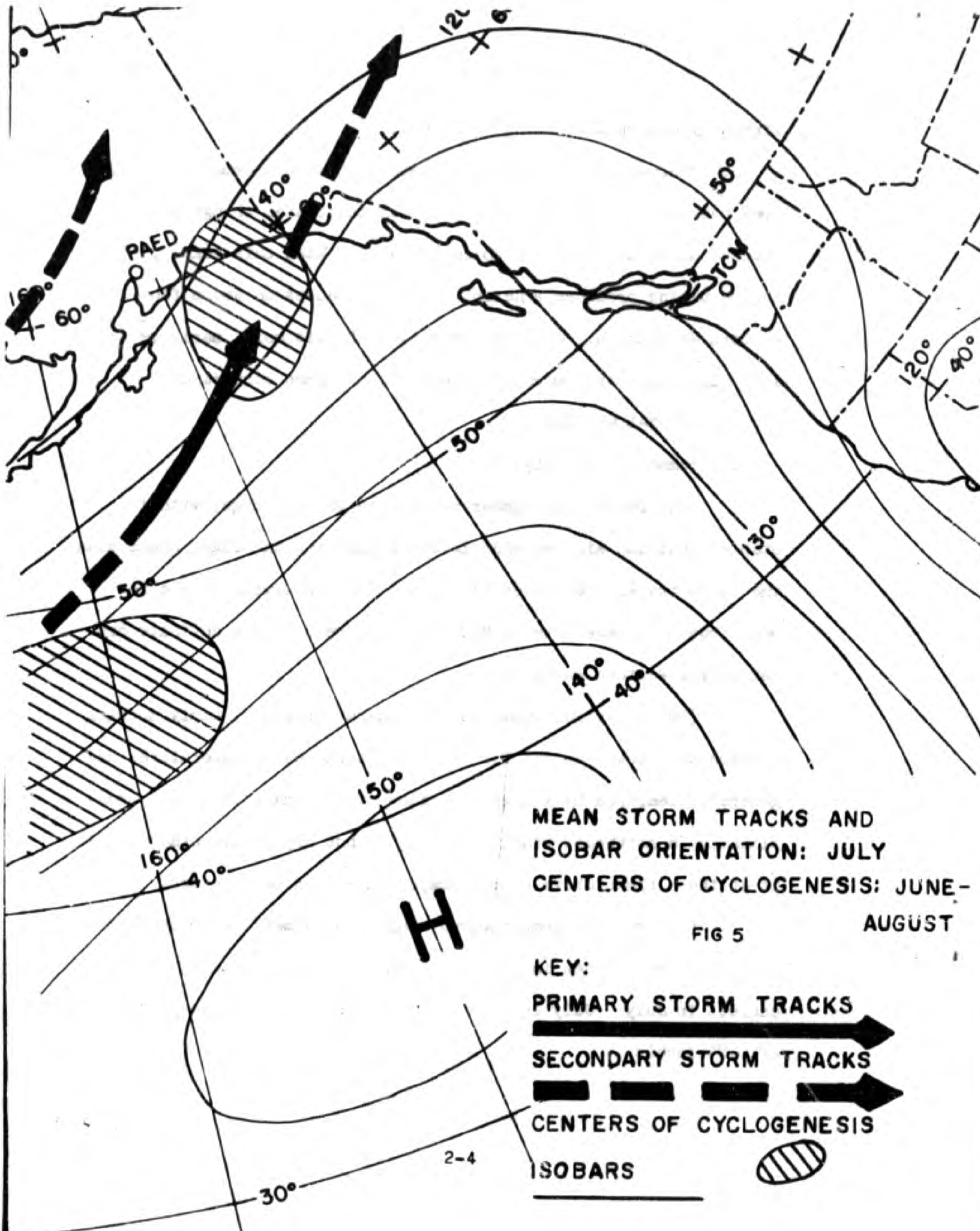
2020. SEASONAL WEATHER:

a. Summer: (Ref fig. 5)

(1) During the summer months the Pacific High, with its stable subsiding air, extends inland blanketing the Puget Sound area. The storm tracks are forced far to the north allowing only a few weak fronts to penetrate to McChord. The result is a definite dry season for Western Washington.

(2) A typical summer day is characterized by early morning stratus and clear, except for cirrus, afternoons. Temperatures are generally tempered by a low level flow of cool maritime air. occasionally, a northeast wind will bring in hot dry continental air. It is at these times above normal temperatures can be expected.

(3) McChord temperatures range from a mean of 59 degrees in June to 64 degrees in July. The maximum recorded was 100 degrees in July. July is also the driest month with a mean rainfall of 0.84 inches.



MEAN STORM TRACKS AND ISOBAR ORIENTATION: JULY
CENTERS OF CYCLOGENESIS: JUNE-AUGUST

FIG 5

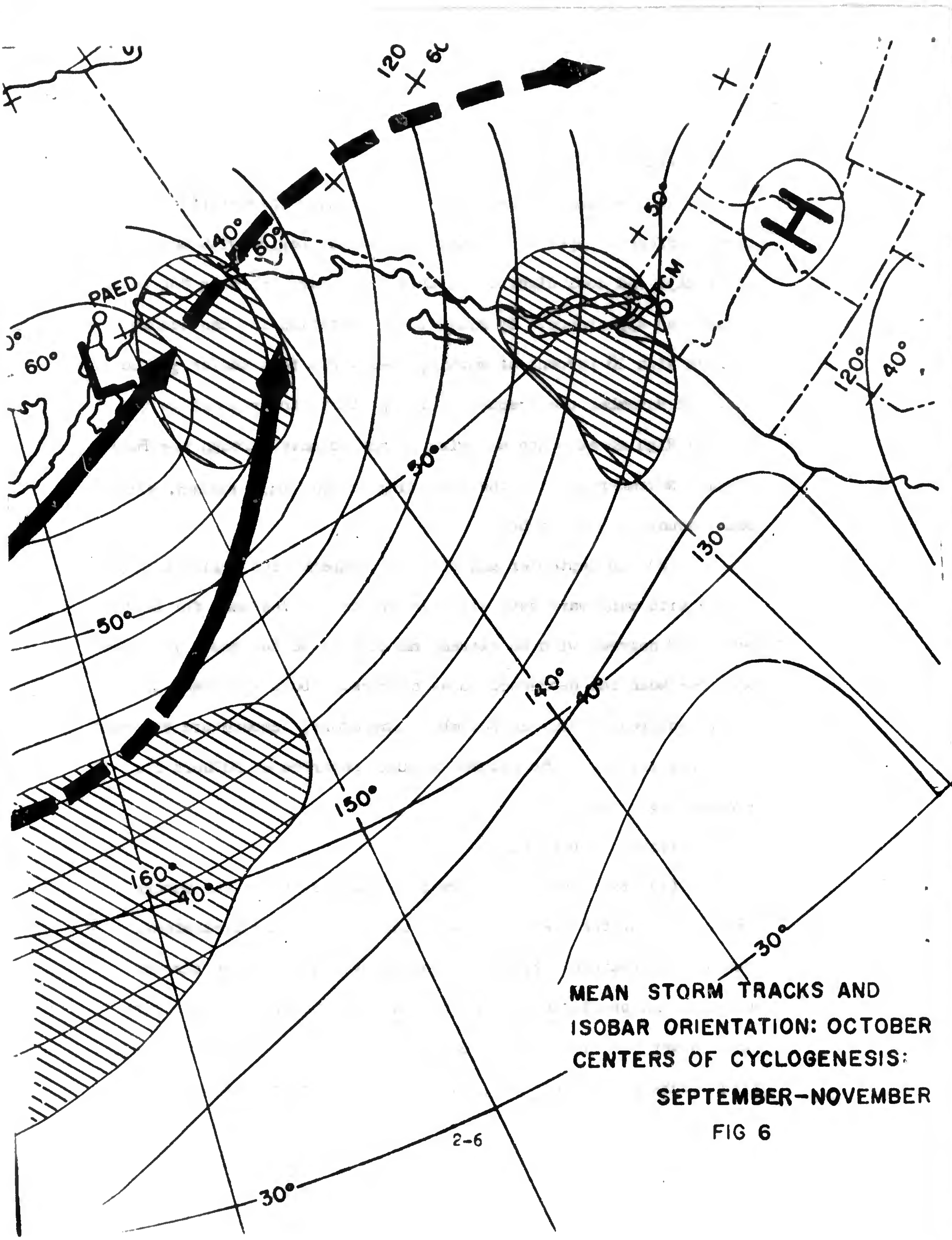
b. Autumn: (Ref. Fig. 6)

(1) Autumn in the Northwest is really characterized by three different types of weather. September begins with mostly clear days and cool nights. At this time, early morning fog begins to make an appearance. By mid-October radiation fog has become a problem with 18 percent of mornings below 200 feet and/or ½ mile in fog. In November the frequency of fog starts to drop off as the Pacific High moves south allowing storms to move through the Puget Sound. November is also the beginning of the rainy season, with a mean amount of 5.88 inches.

(2) In September and October, temperatures begin to cool slowly with many warm days still in evidence. The mean for September is 59 degrees with an extreme maximum of 96 degrees. By November, the mean has decreased to 44 degrees. About 4 percent of Arctic outbreaks occur in November; therefore, temperature extremes are a possibility. The extreme minimum recorded at McChord for November is 2 degrees.

d. Winter: (Ref. Fig 7)

(1) By midwinter the Pacific High has moved far enough south to allow the Aleutian Low to take over as the predominate controlling feature. Frequent frontal systems now move through McChord, and precipitation takes on a more steady character with less shower activity. Forty percent of the total yearly precipitation occurs during December, January, and February. A small



MEAN STORM TRACKS AND
ISOBAR ORIENTATION: OCTOBER
CENTERS OF CYCLOGENESIS:
SEPTEMBER–NOVEMBER
FIG 6

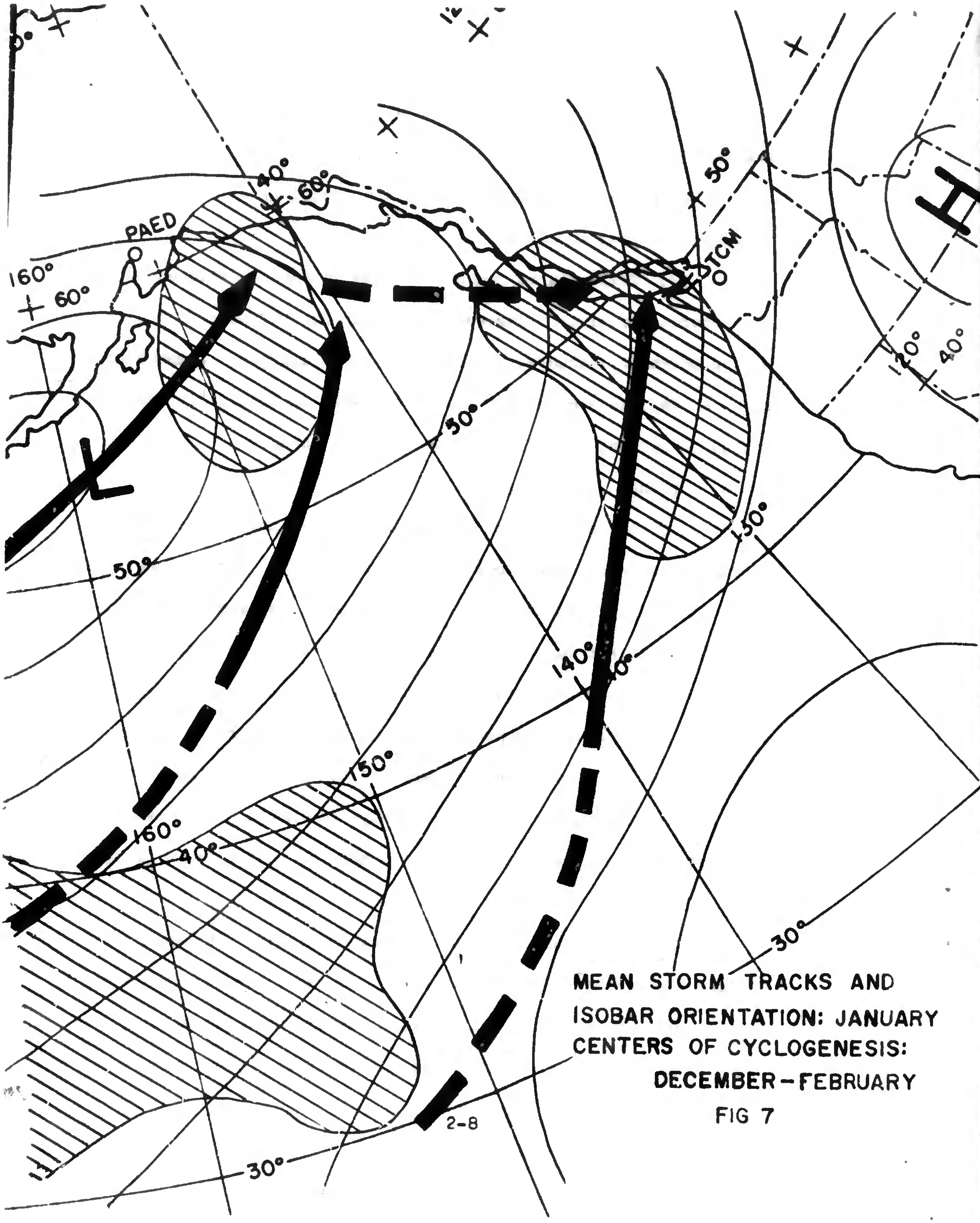
portion of this precipitation falls as snow. January has a mean snowfall of 4.2 inches, over twice as much as in any other month. Fog can still be a problem; however, the frequency of occurrence is much less than in autumn.

(2) Temperatures reach a minimum in January with an extreme low recorded of minus 6 degrees. The mean for the three month period December, January, and February is 40 degrees. Temperatures below 20 degrees are usually associated with an Arctic outbreak; of which, 50 percent occur during the month of January.

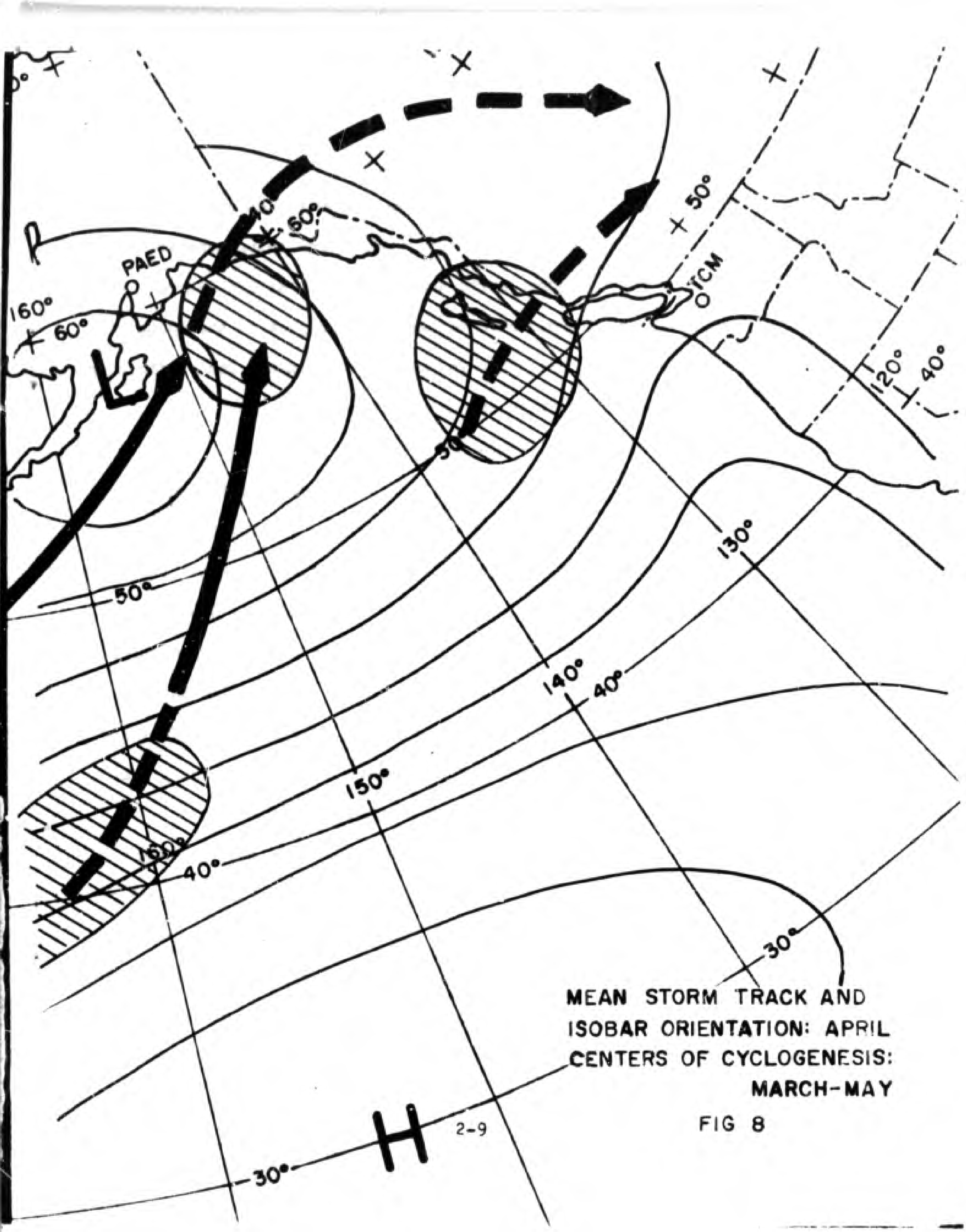
d. Spring: (Ref. Fig. 8)

(1) As the Pacific High begins to move north, the mean storm tracks take a more west to east trajectory. The cyclones originate at a higher latitude and therefore have unstable characteristics. This change in air mass source, coupled with warming of the land mass, results in a transition from the stratus and steady rain of winter to the cumulus and showery type weather of spring. Heavy cumulus clouds are sometimes accompanied by small hail; March has the greatest hail occurrence -- 1.58 days per month. Snow remains a threat in March, but tapers off to a mean of only a trace in April and May.

(2) Temperatures begin to moderate slowly. The mean temperature for March is 44 degrees, May 55 degrees. The chance of an Arctic outbreak, with its below normal temperatures, is about 6 percent in March and practically nil thereafter.



MEAN STORM TRACKS AND
ISOBAR ORIENTATION: JANUARY
CENTERS OF CYCLOGENESIS:
DECEMBER–FEBRUARY
FIG 7



MEAN STORM TRACK AND
ISOBAR ORIENTATION: APRIL
CENTERS OF CYCLOGENESIS:
MARCH-MAY

FIG 8

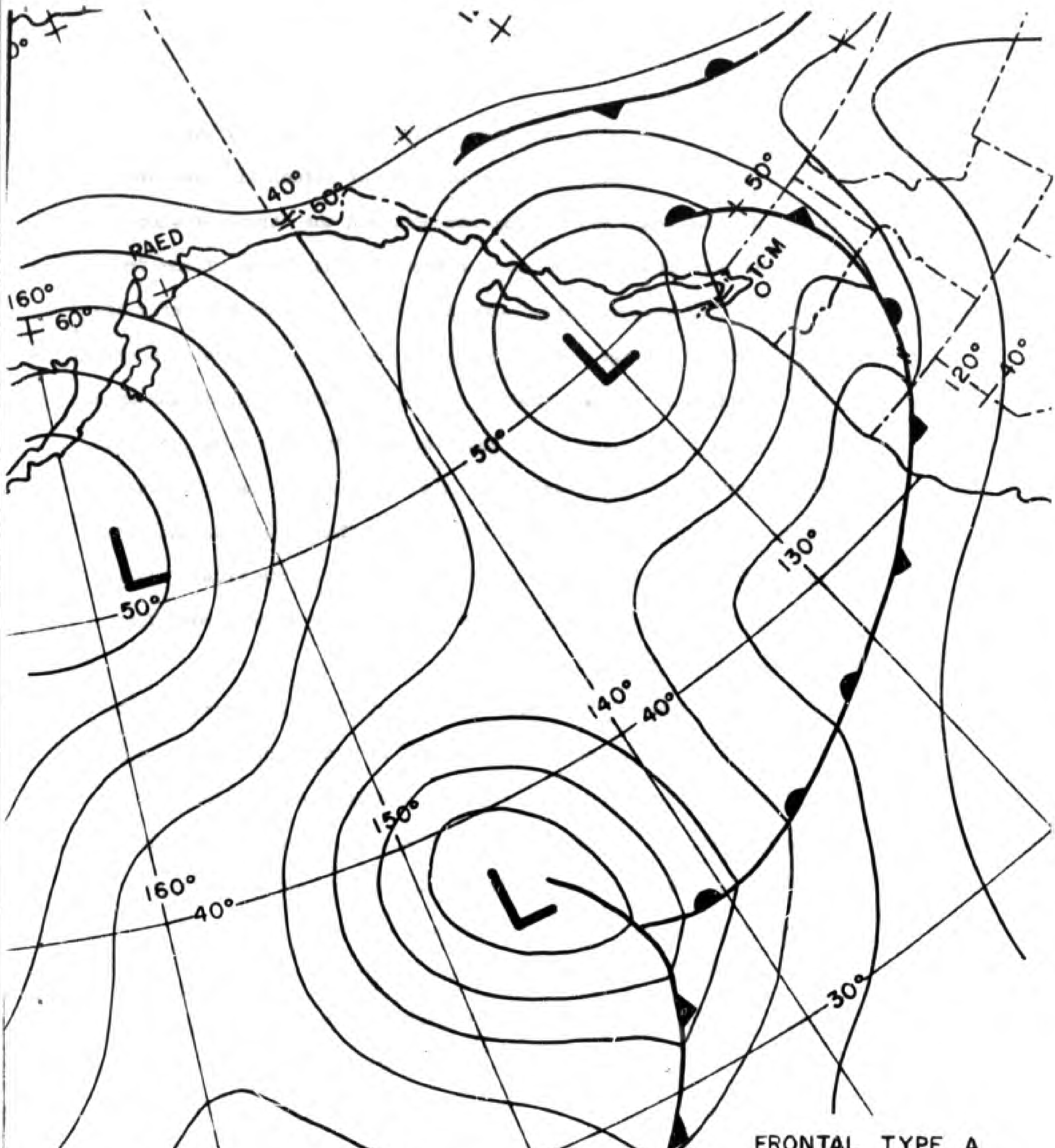
2030 CYCLONES: (Ref. Figs. 5-8)

Areas of mean cyclogenesis vary from season to season. During the winter there are four main areas, with storms being generated as far south as 30 degrees north and as far west as 175 degrees. By summer, the four areas have become two, one just to the south of the Aleutians and the other in the Gulf of Alaska. Their effect on McChord weather is discussed under fronts.

2040. FRONTS: (Ref. Figs. 9-11)

a. Type "A": (Ref. Fig. 9) As the areas of cyclogenesis change, so do the areas of frontal activity. During the winter months, a common frontal type is one that is generated to the northwest of Hawaii, hereafter referred to as type "A". These frontal waves, formed along the polar boundary, move northeast and enter the Pacific Northwest around Vancouver Island. By the time they reach land, they are gererally warm front type occlusions. If they are not already occluded, the occlusion process usually takes place upon contacting the colder air mass lying over the land.

(1) These storms bring moist-stable air into the Puget Sound area. Precipitation is steady with total fall being moderate to heavy. With the advection of this warm-moisture laden air over the colde[illegible] of the land mass, ceilings and visibilities of 400-500 feet and 1-2 miles are not unusual. Clouds are often layered to 35,000 feet and become solid just prior to passage of the upper front. Moderate to heavy aircraft icing is common and generally takes the form of rime.



FRONTAL TYPE A

FIG 9

(2) Winds with this type of system are usually strongest before passage; however, if a dense layer of colder air lies over the land, the winds may be dampened out, and the strongest winds occur after passage of the surface front. Winds ahead of the front are generally southeasterly, and shift to a south-southwesterly direction after passage. Wind speeds are usually 15-25 knots; however, very intense systems may produce 35-45 knots with isolated instances of gusts in the fifties. One gust has been recorded from the south at 76 knots. The forecaster must also be alert to the occurrence of rapid pressure rises behind the front. This is a good indicator that the maximum gusts will occur with and after the front. It is also an indication that the winds will continue quite strong for several hours after passage.

(3) Frontal frequency varies, but there is generally from 24-36 hours between passages. However, at times minor waves become sufficiently close together to give a passage every 12-18 hours. General clearing seldom occurs after passage; however, conditions do tend to improve slowly. Middle and high clouds are usually in evidence throughout the period between waves.

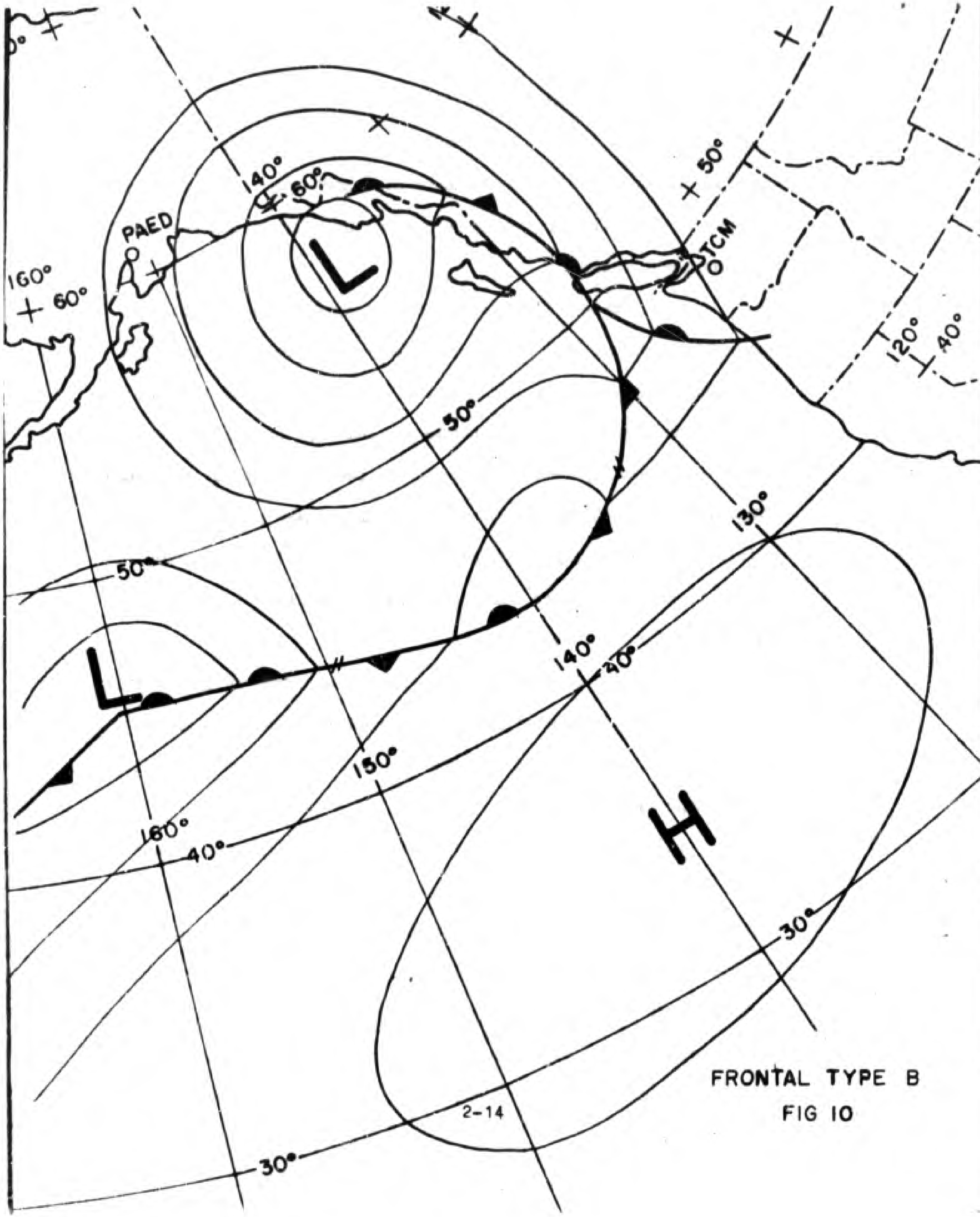
(4) As the Pacific High moves north in the spring, the effect of this type of system on McChord becomes less and less. By summer, the few storms that still bear a similarity to the ones described hit the coast of Southern Alaska and have no significant effect on McChord's weather.

b. Type "B": (Ref. Fig. 10) This type is associated with near zonal flow aloft. Break off lows occur near the Aleutians and in the Gulf of Alaska and move east-northeast into British Columbia. The trailing frontal systems usually affect Washington and Northern Oregon.

(1) These storms, with their origin further north than type "A", produce more unstable showery type weather. They are predominately cold type occlusions; although, warm occlusions and nonoccluded fronts are not uncommon. Ceilings average 2,000-3,000 feet, occasionally decreasing to 1,500 feet in the heavier showers. Tops vary from 25,000-30,000 feet and often have embedded cumulus. Visibility, generally good, decreases to 3-5 miles in showers. Light to moderate mixed icing is common. Rainfall is generally moderate with this type.

(2) With frontal passage, marked improvement is the rule. Timing can be achieved by monitoring coastal stations. Broken cumulus and shower activity along the coast are the first indication of an improving trend.

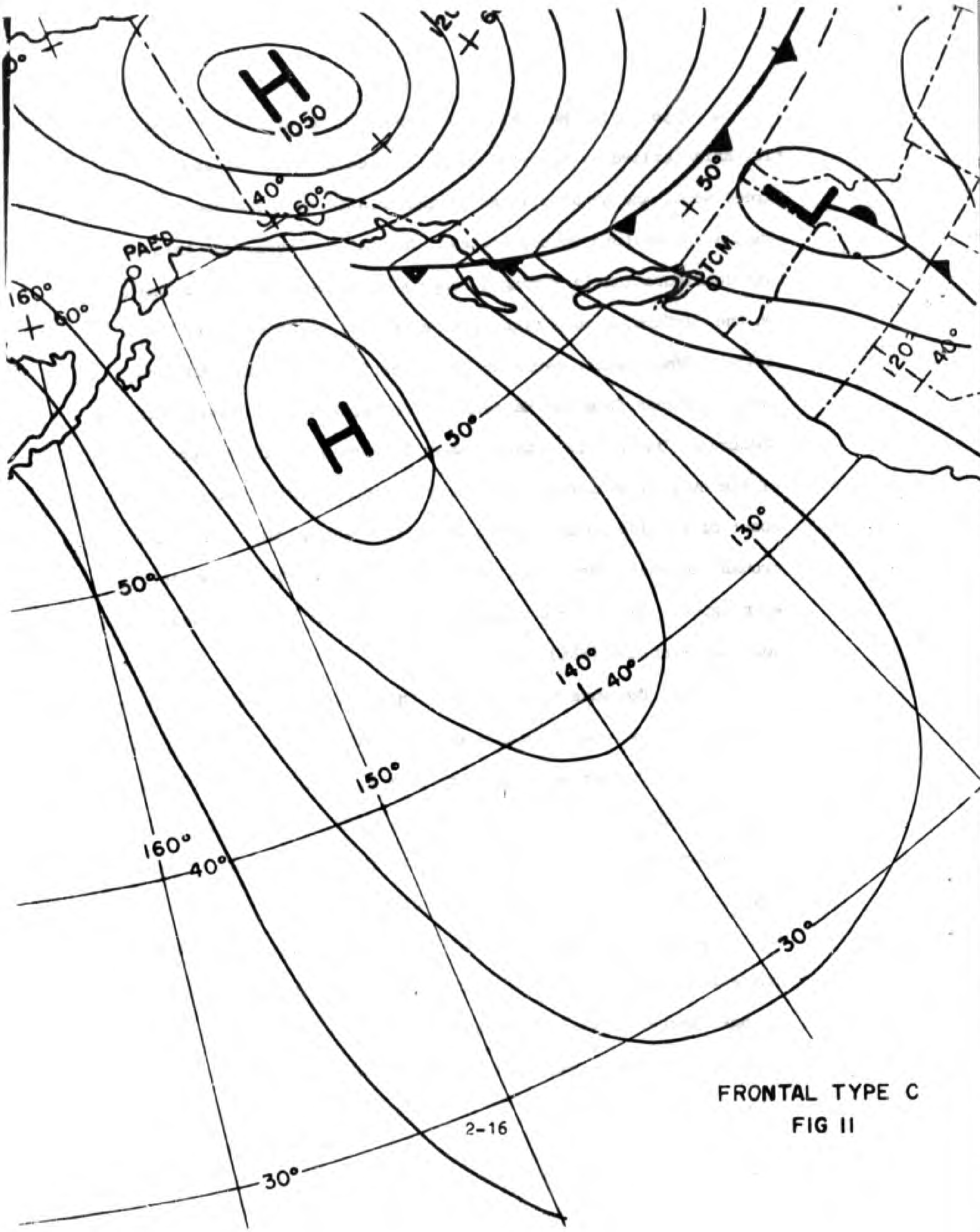
(3) Winds ahead of the front are generally out of the south 15-25 knots shifting to southwest after passage. Unlike type "A", winds are more likely to be stronger with and after passage than before. Gusts 35-45 knots occasionally occur with the more intense systems. If rapid rises are noted behind the front, strong winds can be expected to last 3-4 hours after passage, and the direction may vary from southwest to west.



FRONTAL TYPE B
FIG 10

c. Type "C": (Ref. Fig. 11) Type "C", or Arctic outbreak type, is characterized by an upper ridge located between 145 and 150 degrees west, and an associated trough located over the coast of Canada and Western United States. The natural result of this upper air configuration is strong northerly winds over British Columbia. On the surface, a cold high, with a central pressure of at least 1045-1050MBS, exists over the Yukon Territory; and an elongated trough extends from the Eastern Gulf of Alaska to Southern British Columbia. Under this setup, a wave is formed in the eastern portion of the Gulf of Alaska and then tracks south-southeastward along the coast of British Columbia into and across Washington. The winds around the back side of the low pull the Arctic Front down into Washington. Under these conditions, Arctic air often spreads as far south as Portland (PDX).

(1) The wave that preceeds the Arctic outbreak usually consists of a cold type occlusion and is of a very mild type. precipitation is light, and ceilings vary from 1,500-2,000 feet. Tops of clouds are likely to range from 20,000-25,000 feet. Light rain and drizzle are likely to reduce the visibility to 1-2 miles at times. Light, occasionally moderate, rime icing is usually present. winds will be generally light, 10-20 knots. The direction will vary from southeast ahead of the front to north-northwest after passage. With passage, temperatures can be expected to drop 3-5 degrees. No general clearing can be expected until well after the Arctic air has moved in.



FRONTAL TYPE C

FIG 11

(2) With passage of the Arctic Front, ceilings of 500-800 feet can be expected. Ceilings will often be reduced even further during periods of heavier snow. Cloud tops will vary from 8,000-12,000 feet. Visibilities are 3-5 miles on the average with short periods of below ½ miles in snow. Total precipitation is light, usually no more than 2-4 inches of snowfall. Light rime icing is normally present. Winds are likely to be light and variable before passage, becoming north-northeast 10-20 knots after passage. Some stations further north, eg. (BLI), may register gusty winds 35-45 knots; however, gusts to over 30 knots would be quite rare at McChord. Temperatures will begin dropping after passage and continue for at least 12 hours, as the cold air drains down the Fraser River Valley into Western Washington. A 20 degree drop over a 12 hour period would not be uncommon. As the cold air deepens, the cloud bases will slowly raise; however, no general clearing should be expected until 36-48 hours after frontal passage. Clearing may not occur at all if overruning from the west is present.

(3) Overruning of warm-moist-maritime air is the cause of the majority of snowfall at McChord. Often when Arctic air is present over Western Washington, small lows will form on

the fringe of the cold air, in the vicinity of Vancouver Island, and move very slowly down the coast of Washington. Snowfall in the range of 8-10 inches is not uncommon under these circumstances.

(4) Even though type "C", when compared to type "A" and "B", is relatively rare type, the severity of the associated weather requires a disproportionate amount of consideration be given it by the forecaster. Runway icing, snow removal, and low visibilities, all present a problem to aircraft operations. Furthermore, the abnormally low temperatures and snowfall play havoc with the activities of the surrounding communities. Transportation to and from work becomes difficult; and housing, not built for the temperature extremes, becomes hard to heat, resulting in many broken pipes and fires.

(5) However, many years pass without a single outbreak. From 1893-1962 about 40 percent of the years were completely free of Arctic outbreaks. During the same period, as many as six consecutive years passed without an outbreak. When they do occur, the most frequent duration is three days, but it is not unusual for an outbreak to last from 1-3 weeks. About 50 percent occur during January. The lowest temperature recorded with an outbreak at McChord was -6 degrees in January 1943.

(6) All things considered, an alert forecaster should not be taken by surprise. An indication of the type of synoptic situation to watch for can be acquired by referring to figure 11. Figure 11 is a composite of 10 different outbreaks. The occurrence of a situation similar to the one indicated should be sufficient to alert the forecaster of a possible outbreak. Some degree of timing can be achieved by watching the reporting stations in the Fraser Valley. As the Arctic air passes, their winds shift to a northerly direction and usually increase in speed. The strength of the winds after passage is a good indication of the magnitude of the cold push. Also, there will be a marked decrease in temperature and dewpoint. A distinguishing feature of the Arctic air is its exceptional dryness, indicated by its low dewpoints.

(7) There are many variations of type "C" that do not bring about an Arctic outbreak. For example, during summer months a minor wave occasionally moves southeastward from the Gulf into and through Washington. However, the lack of a cold high over the Yukon precludes any secondary frontal movement into the state. The result is generally 2-3 days of cooler temperatures and a few light showers with the wave associated frontal system. Quite often a layer of stratocumulus, 2,000-

3,000 feet, may become trapped in the Puget Sound Basin and last for a couple days. Also, during winter months the conditions are not always exact enough to force Arctic Air as far south as McChord. For example, the upper ridge may not have exactly the right configuration, or the Yukon High may not be strong enough. When this happens, the weather will be that which can be expected with the maritime wave.

d. Forecasting Frontal Phenomena: Forecasting frontal passage and associated weather is a particularly special problem at McChord. The surrounding terrain and position of McChord in relation to the Pacific Ocean are significant complicating factors.

(1) With the sparse data available over the Pacific, forecasting frontal movement and timing of passage at McChord becomes a challenge to even the most experienced forecaster. Of course, if he chooses, the forecaster can rely upon the National Meteorological Center (NMC) products. However, they do not always respond quickly enough to situation changes that become immediately known to the detachment forecaster. For example, a current satellite picture may indicate the NMC frontal position to be in error. It could be 3-6 hours before this is corrected and transmitted on the NMC product. Therefore, in order to make the best forecast the detachment forecaster must

immediately correct this deficiency. Also the NMC prognoses are on such a large scale they can not really be used for short period terminal forecasting.

(a) Assuming that all available data, including ships and satellite pictures, have been used in locating the front, a quick and acceptable over water movement forecast can be made by using 50 percent of the 500MB flow normal to the front. This method is adequate for use in forecasting for periods of more than 24 hours. As the front nears the coast, other methods should be utilized.

(b) When the front nears the Washington coast, factors inherent to the locale slow it considerable. Because of the interaction between air, water, and mountainous terrain, divergence aloft is the mean condition over the Northwest United States. Divergence in itself tends to slow a front down. Also, the terrain has the effect of slowing, and in some cases, depending on its original path, diverting it further north or south. Therefore, any objective method must be tempered by forecaster judgement. Extrapolation, adjusted by the forecaster for terrain and amount of divergence, is probably the best short range tool.

(c) Frontal passage is usually readily identifiable on the coast. Ceilings and visibilities improve along with a noticeable veer in wind direction. However, as the front moves inland, it again becomes difficult to track. Tracking the front from the coast to McChord is hampered by the lack of good indicator stations enroute. Usually the front is not noticed again until it passes McChord. Even then it is sometimes hard to detect. As a rough estimate, expect passage at McChord 3 hours after noting occurrence on the coast.

(d) During the colder months of the year, frontal systems approaching from the west are sometimes forced aloft over the colder air lying upon the land. This prevents any temperature change or significant wind shift as the front passes. However, passage of the upper front can usually be detected by a leveling off or rise in the barograph pressure trace, decrease in precipitation, and a decrease in amount of upper cloud detected on the radar. If the front is sufficiently strong, the cold air is eventually eroded away by the overrunning maritime air, allowing a wind shift, temperature rise, and general improvement to occur.

(2) The forecasting of specific weather conditions is made difficult by essentially the same factors: lack of data over the land, making it difficult to establish a trend;

temperature difference between land and water, conditions that occur with a front over water will not necessarily happen over land; and the modifying effect of uneven terrain between the coast and McChord.

(a) Coastal conditions, associated with a particular frontal system, are usually much more severe than what is expected with the same front at McChord. Minimum ceilings and visibilities along the coast are usually about 50 percent lower than what can be expected to occur at McChord, winds 50-60 percent higher than at McChord. These are rough averages and can vary considerably, depending on various factors including the amount of cold air present over the land.

(b) During the colder months, a dense layer of cold air sometimes exists over the land. This often shelters McChord from strong pre-frontal winds. The low clouds along the coast are also prevented from moving inland. However, with extensive and prolonged overrunning accompanied by pre-frontal rain, low stratus will often form within the cold air. Visibilities are also reduced when this occurs.

2050. SIGNIFICANT WEATHER PHENOMENA

a. Clouds:

(1) Stratus:

(a) Southwest Stratus: (Ref: Local Forecast Study, par 4040) Southwest stratus occurs mostly during summer but may occur during late spring and early fall. It reaches a maximum frequency of occurrence during August. The normal sequence of events leading to southwest stratus ceilings at McChord goes as follows: Over a period of about three days of warm clear weather, a thermal trough develops northward into Eastern Washington from the thermal low over California. During the three days that the trough is developing, a "tongue" of stratus begins moving northward from off the California coast. Satellite pictures and, or observations from weather stations along the coast help indicate the northward movement. The pressure gradient from North Bend (OTH) to Seattle (SEA) and from Portland (PDX) to Seattle are excellent indicators of whether or not the stratus will move inland to McChord. (Ref: Forecast Study) The arrival of maritime air at McChord may be marked by a quick drop in temperature of 10 to 20 degrees, a decrease of the temperature-dew-point spread, and occasionally gusty southwesterly winds. Wind gusts may reach 20 or 25 knots for a few hours. Stratus ceilings soon show up, unless the inland temperatures have been in the high eighties or higher. If the temperatures have been high, then stratus will not be advected inland but will quickly form after sufficient radiational cooling has taken place. Stratus advected from the southwest will generally have ceilings of 1500 feet or more with unrestricted visibilities. Tops will be near 2,000 to 4,000 feet and usually no other clouds will be present above the stratus, except sometimes cirrus. Infrequently, middle clouds ahead of a frontal system will be present. During the morning, stratus bases gradually lift, unless a strong on-shore flow exists. Breakup of stratus will be shortly after 1200L on the average. Thin layers tend to "burn off" sooner, unless a strong on-shore flow exists. Thicker stratus will usually take longer to "burn off". Radar and pilot reports of stratus tops are useful in timing dissipation; however, a strong on-shore flow may thicken the stratus. Occasionally, the stratus will not dissipate and just show a few breaks in the late afternoon, if any. Once southwest stratus is present in the late afternoon or early evening, it will almost always be present the next morning. Normally, stratus will repeat for several days. Cold fronts from the northwest will normally end the stratus for a while; however, weak fronts may create on-shore flow advecting stratus inland.

(b) Northwest Stratus: This stratus is much less frequent than the southwest variety. Northwest stratus occurs mostly during the late spring and during the summer. It is advected through the Straits of Juan De Fuca and eventually down Puget Sound to McChord AFB. It will take a day or more to reach McChord, if it does at all. When this stratus occurs, usually the synoptic situation is changing from a moist on-shore flow to a more northerly flow, and a dry off-shore flow may eventually be set up. When stratus is already present over the sound, checking pressure gradients between Olympia (OLM) and Seattle

(SEA) or between McChord and Seattle can be useful in determining whether or not the stratus will move over McChord. A north to south gradient would advect the stratus towards McChord. Ceilings will generally be about 500 feet and visibilities may be reduced to 2 miles or less. This stratus is fairly thin and is usually gone by noon.

(c) Local Stratus: Stratus sometimes forms locally and is advected over McChord. This type of stratus is infrequent, but it may occur during any season. Formation will often be near sunrise when a light pressure gradient causes moist air to drift towards McChord from Puget Sound or from Lake Washington, just east of Seattle. Stratus forms in the moist air as it is uplifted by the 200 to 600 foot high cliffs along the edge of Puget Sound or the few small rolling hills between Lake Washington and McChord. Also, local stratus may be formed from ground fog that is lifted by increased winds.

(2) Convective Clouds:

(a) Spring and Early Summer: During spring and early summer, fronts passing from the west bring increased cumulus activity because of the warmer ground and the relatively unstable air masses moving across the Gulf of Alaska. There is a diurnal variation of activity. Morning often begins with a stratocumulus ceiling near 2,000 to 3,000 feet. This stratocumulus may tend to dissipate during the morning, and then cumulus begins to form after 1000L often becoming broken by 1200L at 2,500 to 3,500 feet. As the cumulus continues to build, a subsidence inversion, if any, will cap the clouds and a high stratocumulus or low altocumulus ceiling will form. By this time the lower cumulus layer has normally gone scattered. If the upper air is unstable enough, as can be determined from soundings, the cumulus will continue to build. By mid-afternoon cumulonimbus clouds will have developed, especially over the mountains and sometimes near McChord. Usually by this time, the cumulus has become scattered, except for patches of broken ceilings near the heavier buildups. These ceilings are normally 3,000 to 4,000 feet. Radiational cooling after sunset will quickly dissipate the cumulus; however, cumulonimbus over mountains will continue building for a few hours, especially during summer. Towards midnight or later, stratocumulus ceilings often form again over the area if the flow remains on-shore.

(b) Summer: Cumulus activity during the summer tends to be of lesser frequency because of the subsidence inversion and on-shore flow of maritime air which often forms stratus; however, thunderstorm frequency at McChord reaches a maximum of occurrence. (Ref: par 2050b) Air mass Cumulonimbus frequency increases east of the Cascades and, with the upper flow from the interior, broken cirrus will often be advected over McChord. In cases when an upper trough is off-shore for several days, so that the upper winds are southerly, broken altocumulus with bases of near 10,000 to 14,000 feet will likely appear.

b. Thunderstorms: (Ref: Fig 12)

(1) Thunderstorms are relatively infrequent at McChord AFB. The annual average is about 5 days. There is a definite summer maximum of about 3 days and a winter minimum of less than 1 day.

(2) Thunderstorms that occur at McChord can be grouped into

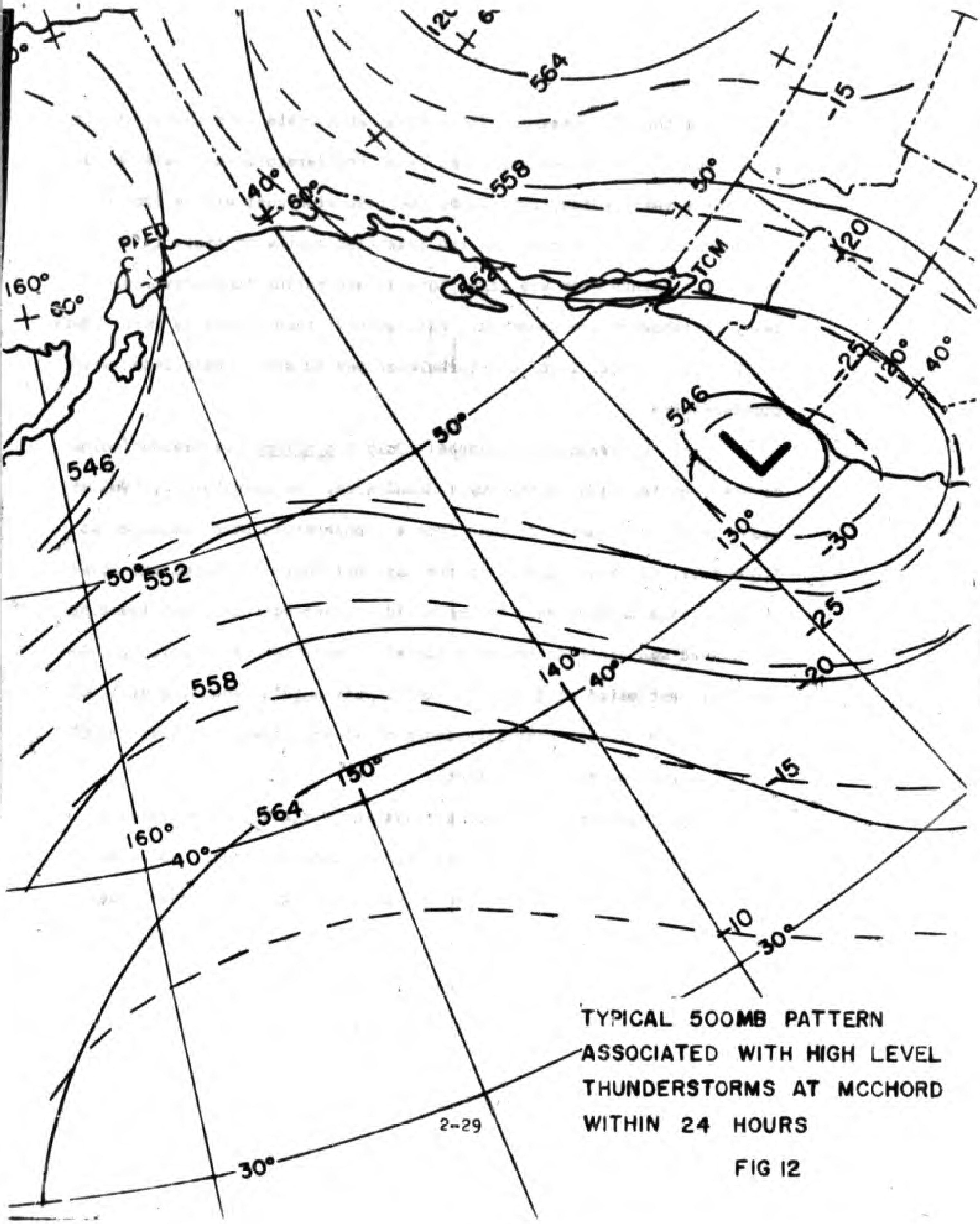
three types:

(a) High Level: (Ref: Fig12) These thunderstorms occur in summer when the winds aloft have been from the south for about 3 days. A 500MB cold trough or even closed low will sometimes produce this situation. Most of them arrive at McChord in the evening or near midnight. Altocumulus castellatus is a good indicator that either thunderstorms are present, or about to develop. These thunderstorms have high bases of 5,000 to 8,000 feet or even higher.

(b) When a strong advection of maritime air occurs in summer, thunderstorms may be produced. These thunderstorms are of short duration and occur only once, since the maritime air quickly stabilizes the lower layers. A trough aloft is usually associated with these thunderstorms. Once these thunderstorms are touched off, they will sweep across Western Washington to the Cascades in only a few hours time.

(c) Frontal: These thunderstorms are normally observed during the spring and fall. Polar outbreaks frequently move out of Alaska, move across the Gulf of Alaska, and eventually move across Western Washington. The lower layers are modified by this time; however, the upper layers are relatively unmodified, resulting in heavy cumulus buildups. Thunderstorms are produced along the stronger fronts, or associated with the cold upper trough behind the stronger fronts. Tops of these thunderstorms average 20,000 to 25,000 feet but they can be much lower.

(3) Effects of thunderstorms at McChord are mild, with light-



TYPICAL 500MB PATTERN ASSOCIATED WITH HIGH LEVEL THUNDERSTORMS AT MCCHORD WITHIN 24 HOURS

FIG 12

ning being the main hazard. The maximum wind gusts with thunderstorms are normally 15 to 20 knots. High lev‹ › thunderstorms may have no gust. In a three year period, 1955-1958, the peak wind gust with a frontal thunderstorm was 32 knots, and the peak wind gust with other types was 26 knots. Rainshowers are light to moderate during thunderstorms. Heavy rainshowers are uncommon. Hail greater than ¼ inch is rare. (Ref: par 2050d4) Aloft, icing and turbulence may be severe associated with thunderstorms.

(4) Waterspouts/Tornadoes: Only 1 confirmed waterspout/tornado has been recorded in the Puget Sound area. On December 12, 1969 at about 1420L, the funnel dropped from a thunderstorm base estimated at 3,000 feet. It touched down in the bay just north of Tacoma and moved on-shore as a tornado near Boeing Field. A second funnel not touching the ground was close to the main funnel. Injuries were minor, but damages were estimated at $500,000. Quillayute's (UIL) sounding at 1600L indicated a Showalter stability index of +1 and showed a jet at 29,000 feet from 240 degrees at 110 knots.

(5) When thunderstorms are within 50 miles, Radar Approach Control (RAPCON) can furnish: direction, distance, shape, and size. The intensity, to a certain extent, can also be given; however, they can not determine tops from their radar. Several reports over a short period can also determine movement and development.

c. Various Restrictions of Visibility:

(1) Fog: (Ref: Local Forecast Study, par 4030)

(a) Time and Season of Occurrence: Fog becomes the number one weather problem for flight operations during the fall at McChord. Of the below minimum fog cases, most occur from September through January with October being the peak month. Eighteen percent of the hours 0600 to 0800L during October are below the field minimums of 200 feet and, or ½ mile. (Ref: Fig 39) In November, Pacific storms show up more often, and the number of fog cases declines gradually. Early in the fog season, fog is a factor usually only from 0400 to 0900L. Later in the fog season, fog may be a factor at any time; however, there is a minimum during the afternoons and a maximum during the mornings. Pre-frontal fog is occasionally observed during extended periods of precipitation in advance of warm occlusions and, sometimes, warm fronts. Fog is rare during summer months.

(b) Optimum Synopic Conditions: The best situation for radiational fog at McChord is a stagnate high pressure system over Washington or British Columbia producing a light northerly pressure gradient. Smoke from Tacoma's pollution sources (Ref: Fig 3) will then concentrate over McChord trapped by the subsidence inversion associated with the high. Radiational cooling re-enforces the subsidence inversion, and the smoke thickens after sunset. After sufficent cooling, water vapor can then condense on the smoke particles. Unless there is a change in the synopic situation, such as a frontal system approaching, once fog forms during the night, then the visibility and ceiling will often drop below minimums and stay below until mid-morning or later.

(c) Occasionally, fog will "frost out" when the temperature drops to near or below freezing; however, if other conditions are right when the temperature rises above freezing in the morning, the air will be saturated by water vapor from the melting of frost and fog will form. Carefully watching other stations in the area can be useful in this case. The fog at Seattle (SEA) and Olympia (OLM) often will not "frost out" when the fog at McChord does. Also the presence of fog banks may be visible in the distance from the base.

(2) Smoke: (Ref: Pollution Sources par 1020, Fig 3) Smoke is significant because it aids fog formation. Also, the visibility can be reduced occasionally to about 2½ to 5 miles without fog formation, such as during summer mornings when insufficient moisture is available. Normally, smoke will be present with a light northerly pressure gradient and stable air. Tacoma's pollution sources pour out tons of pollutants, such as sulfur dioxide which is a good hygroscopic condensation nuclei. When sunlight is present, sulfur dioxide will chemically change to sulfur trioxide. Since sulfur trioxide is an even better hygroscopic condensation nuclei, the visibility will usually drop after sunrise as the fog and smoke combination thickens. During the fall, smoke will be present when fog dissipates. Usually the visibility will increase to 6 miles or better by 1500L. If a strong subsidence is present trapping the smoke, the visibility will drop near sunset to about 2½ to 5 miles if a northerly pressure gradient keeps the smoke concentrated over McChord. During winter, a weak warm occlusion or warm front, orientated west-east and approaching McChord from the south, will create a light northerly gradient and the visibility will often decrease to 2 or 3 miles in smoke or lower if fog forms.

(3) Haze: Haze is seldomly observed without smoke, and then smoke is predominant.

d. Precipitation: (Ref: Figs 14 & 15)

(1) Rain: Rainfall at McChord is mostly associated with frontal systems, which are discussed in paragraph 2040. In addition, the timing of the start or end of rain over a short period can be made more accurate by watching coastal stations. When frontal systems are approaching from the west or northwest, rain will begin at Quillayute (UIL) about 5 hours before beginning at McChord. Also, rain will begin at Hoquiam (HQM) about 3 hours before beginning at McChord. The descent rate of pre-frontal precipitation bases, as determined by radar, is a useful aid in timing the start of rain. Since the descent rate can vary over a short period of time, use one hour or more to determine the average rate. Rain usually begins shortly after the base lowers below the freezing level, because rain has a rate of fall about 5 times that of snow.

(2) Snow: Snowfall at McChord occurs from November through March and averages 9.6 inches. January is the peak month with an average of 4.2 inches. Three types of snow situations can be identified:

(a) Arctic Outbreak: The heavier and longer lasting snowfalls depend upon Arctic Outbreaks, which are discussed in paragraph 2040. If an Arctic outbreak has occurred over Western Washington, and a stationary low develops off the mouth of the Columbia River, then overrunning of the Arctic air takes place and heavy snow falls. If the low deepens rapidly, usually the snow will change to mixed rain and snow, and eventually to rain. If pockets of Arctic air remain, some form or combination of freezing and frozen precipitation is likely.

(b) If a relatively small tight cold low remains long enough off the Washington coast, eventually cold air from British Columbia will reach the McChord area. With temperatures at or near freezing, snow showers will occur.

(c) Another type is a larger cold low with moist on-shore flow and generally with temperatures just above freezing. Snow occurs at night or early in the day and then changes to mixed precipitation or just rainshowers.

(3) Drizzle: Drizzle at McChord occurs under moist and stable conditions such as during summer. Thick stratus is usually present and lowers during the night if the pressure gradient weakens. Drizzle falls from the stratus mostly during the morning hours and is usually light and intermittent. Fog may be present with drizzle. Drizzle may also fall from pre-frontal clouds when the air mass is stable and close to saturation.

(4) Hail: Hail falls on about 6 days annually at McChord, mostly during the spring with maximum occurrence in March. It is soft and of the small variety, rarely exceeding ¼ inch in diameter. Cumulus buildups with tops of only 12,000 to 17,000 feet may produce hail. Thunderstorms may or may not produce hail. During the spring, the freezing level is low allowings small hail to reach the ground without melting.

During the summer, the freezing level is high (12,000 to 14,000feet) and hail is rare. Hail has not been reported at McChord during July and August.

e. Winds: (Ref: Figs 17-29)

(1) Gusty Winds: Normally, strong gusty winds at McChord are associated with the frequent frontal passages occurring from fall through spring. Gusty winds with various types of frontal systems are discussed in paragraph 2040.

(2) Extreme Wind Gusts: The average wind speed is below 22 knots over 99 percent of the time; however, 40 percent of the months from 1946 through 1966 have reported a daily peak gust of 35 knots or more. Eighty percent of these gusts have occurred from November through April. None have been reported in July and August, and only one case was reported in June. The extreme was 76 knots from the south during the "Columbus Day" storm of October 1962. The second highest extreme was 56 knots, which happened twice. Most of the wind gusts above 34 knots have been from SSE through W. During the period of record, no gust above 34 knots has been reported from NW, ENE, and E. This is because of the sheltering effect of the Olympics and the Cascades. Wind gusts over 34 knots from other directions than SSE through W have only occurred from September through March.

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SECTION III

CLIMATIC AIDS

3000 CLIMATIC AIDS

The majority of information contained in this section was extracted from the Uniform Summary of Surface Observations for McChord Air Force Base, Wa, issued 27 March 1969. The source of all other information is noted ajacent to the data.

3010 TEMPERATURE DATA -- means and extremes based on data from Aug 1940 - Dec 1966 for McChord AFB, Wa.

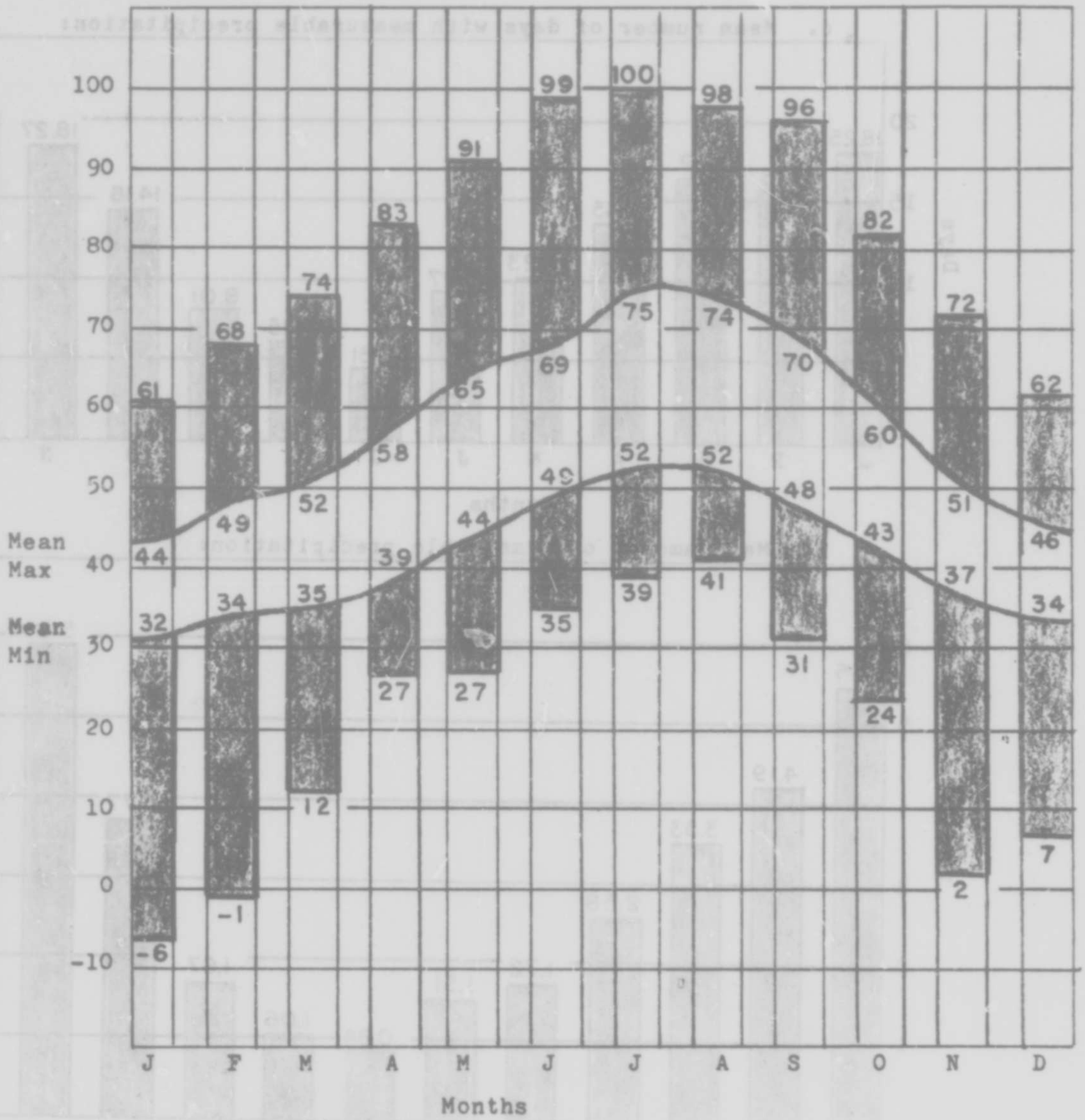


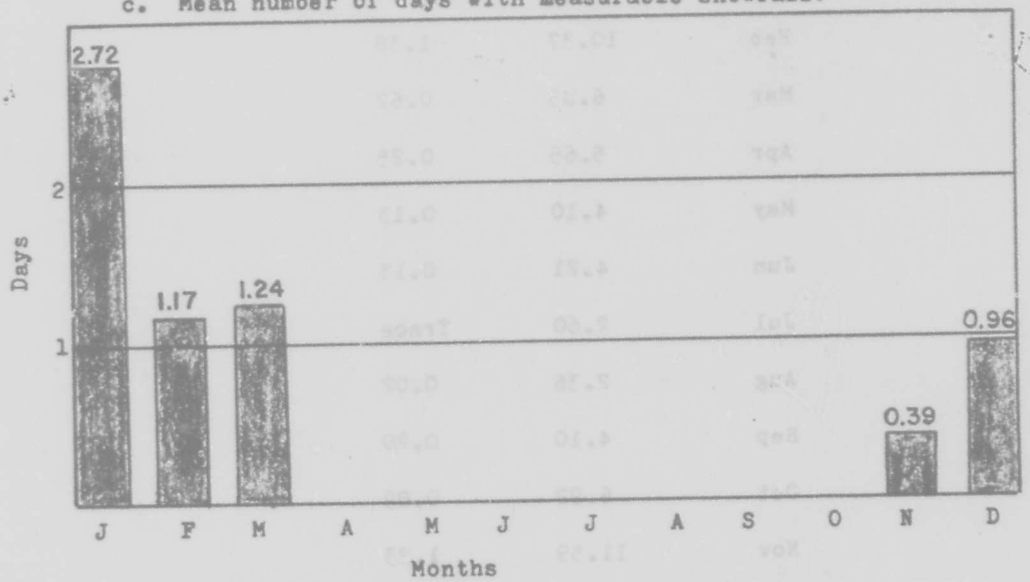
FIG 13

3030 SNOWFALL STATISTICS -- based on data from Jan 1946 - Dec 1966 for McChord AFB, Wa.

a. Annual mean 9.6 inches

b. Extreme 24hr fall 8.4 inches, Jan 1950

c. Mean number of days with measurable snowfall:



d. Mean amount of measurable snowfall:

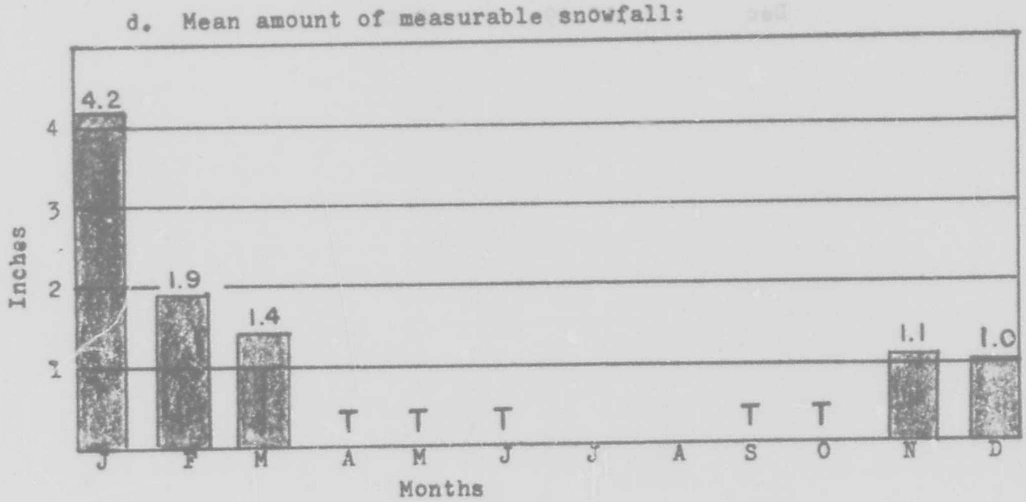


FIG 15

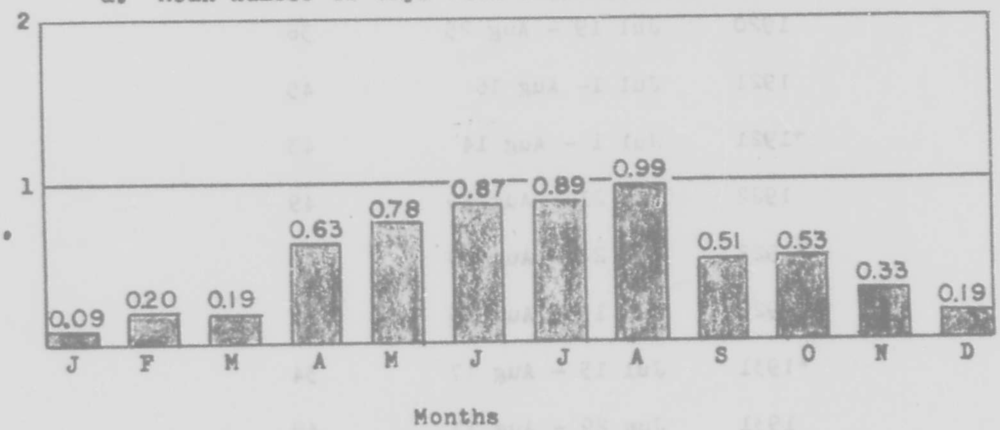
3040 DAYS WITHOUT MEASURABLE PRECIPITATION -- Tacoma, Washington. Data source: Tacoma News Tribune, Aug 1967.

YEAR	PERIOD	DAYS
1920	Jul 19 - Aug 25	36
1921	Jul 1- Aug 16	45
*1921	Jul 1 - Aug 14	43
1922	Jun 21 - Aug 10	49
*1922	Jun 22 - Aug 10	48
1925	Jun 13 - Aug 13	60
*1931	Jul 13 - Aug 17	34
1931	Jun 29 - Aug 17	48
*1936	Jul 10 - Aug 23	43
1936	Jul 10 - Aug 23	43
1939	Jul 19 - Aug 25	36
*1952	Sep 8 - Oct 20	41
1952	Sep 8 - Oct 20	41
*1955	Jul 31 - Sep 13	43
1955	Jul 31 - Sep 13	43
1960	Jun 6 - Aug 14	51
1961	Jul 7 - Aug 13	38
1962	Jul 13 - Jul 30	18
1963	May 13 - Jun 2	20
1964	Aug 5 - Aug 18	14
1965	Jun 15 - Jul 8	24
1966	Jul 15 - Aug 26	43

*Seattle Washington

3050 THUNDERSTORMS AND HAIL -- data from Jan 1946 - Dec 1966 for McChord AFB, Wa.

a. Mean number of days with thunderstorms:



b. Mean number of days with hail:

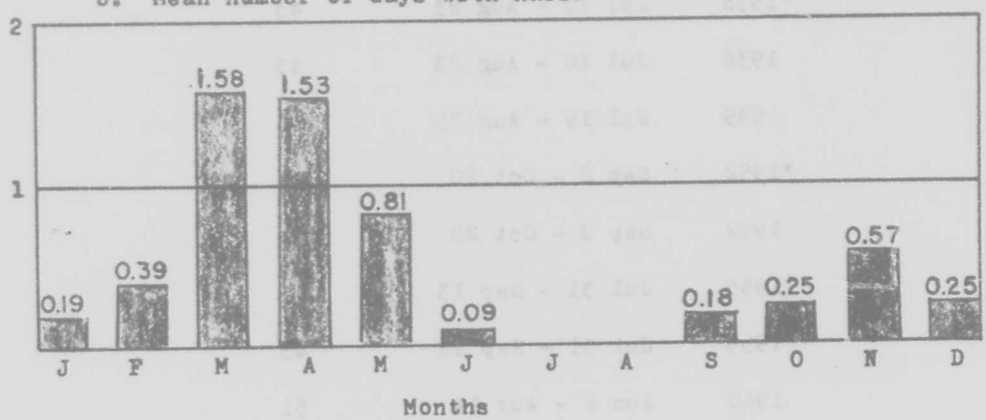


FIG 16

3060 WIND ROSES (Figures

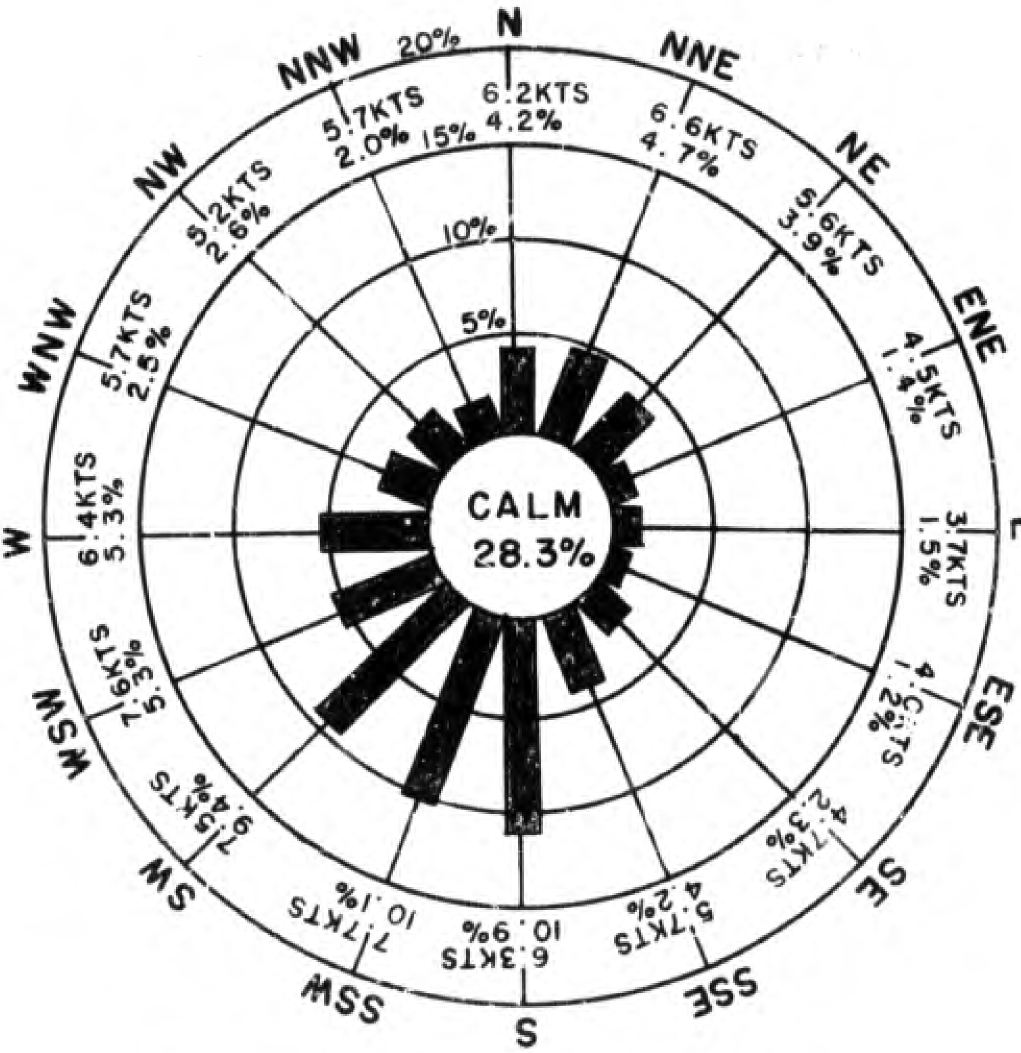
Annual and monthly wind roses are shown depicting percentage frequency of occurrence for sixteen points of the compass, mean wind speed, and percentage frequency of calm. Peak gusts for the year and month are also given. The period of data for peak gusts was from January 1946 - December 1966. Data periods for the wind roses vary; therefore, the data period for each rose is given separately.

ALL MONTHS WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1940 - Dec 1967.

b. Baru indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: S 76KTS

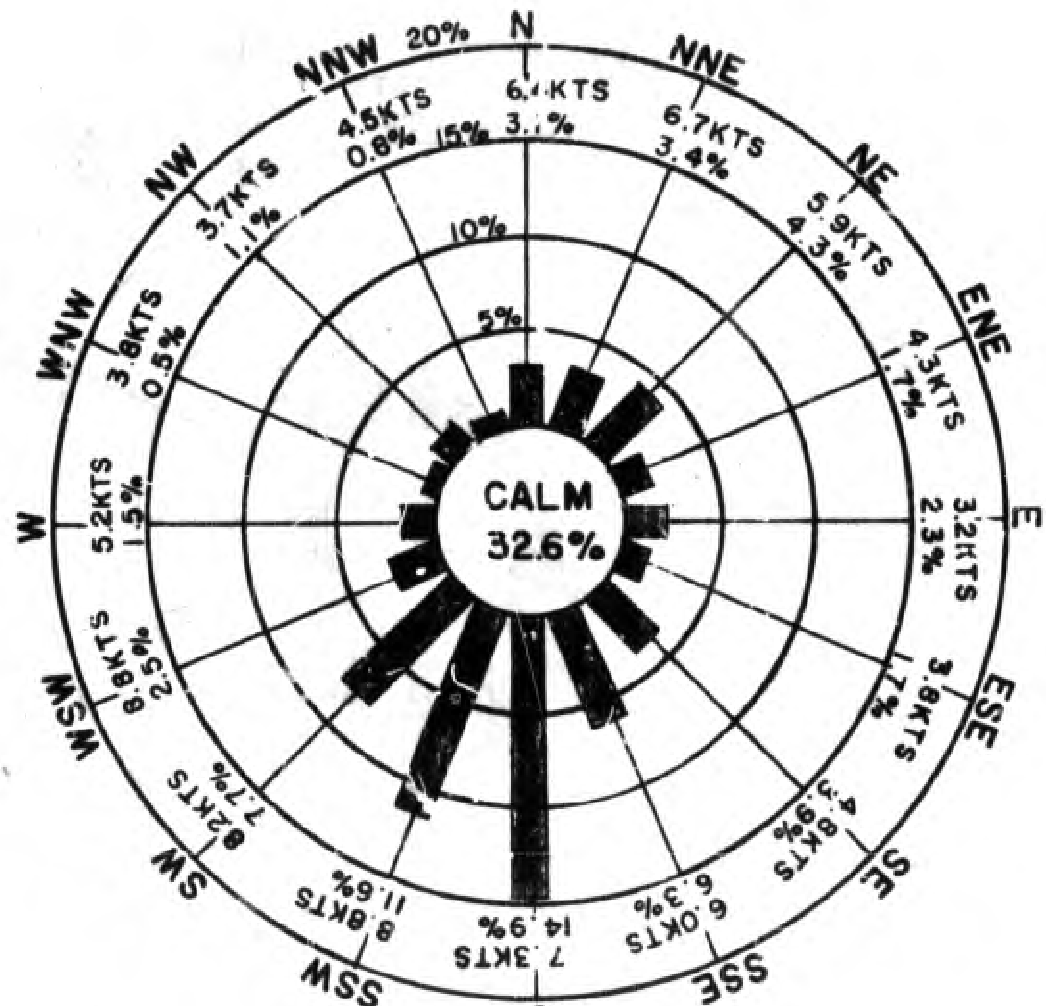
FIG 17

JANUARY WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1941 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: SSE 56KTS

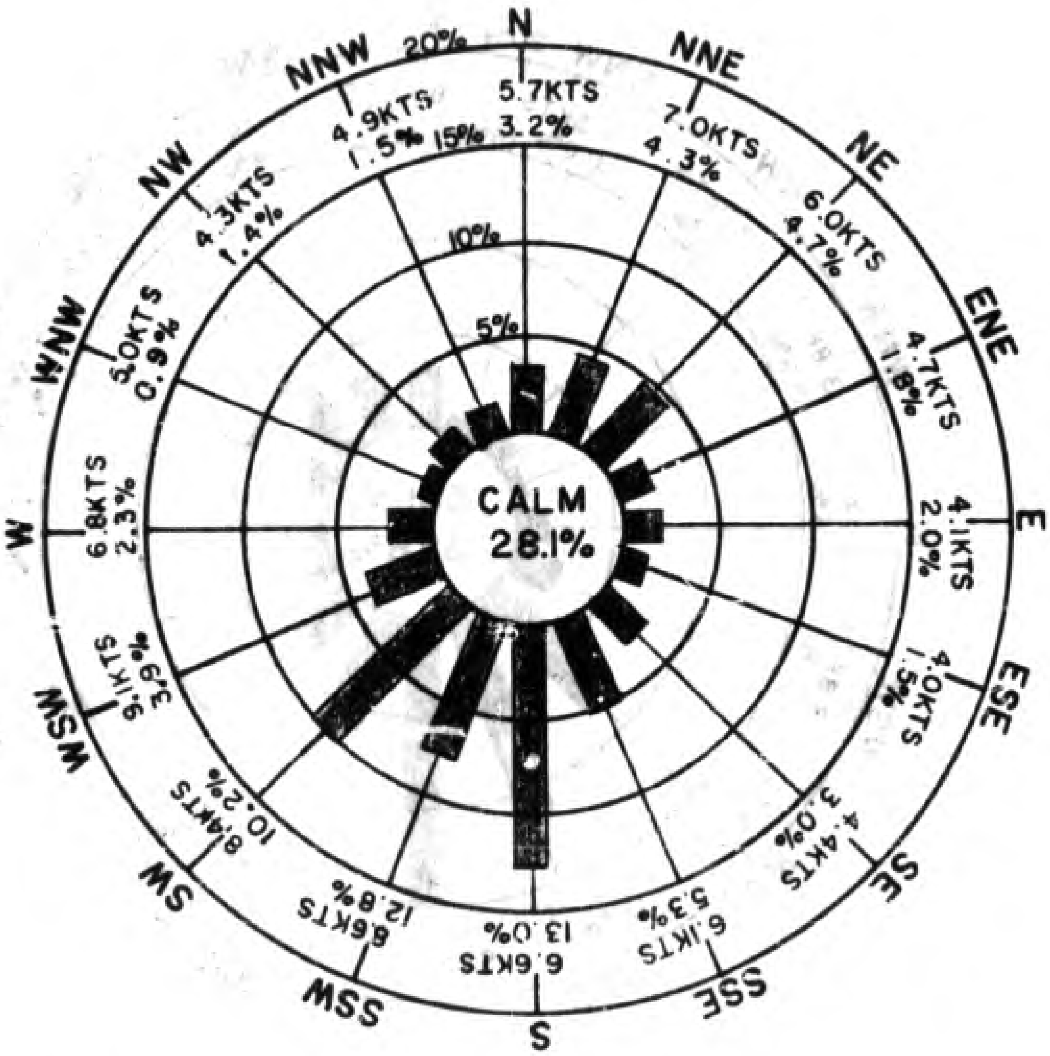
FIG 18

FEBRUARY WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1941 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gusts SW 49KTS

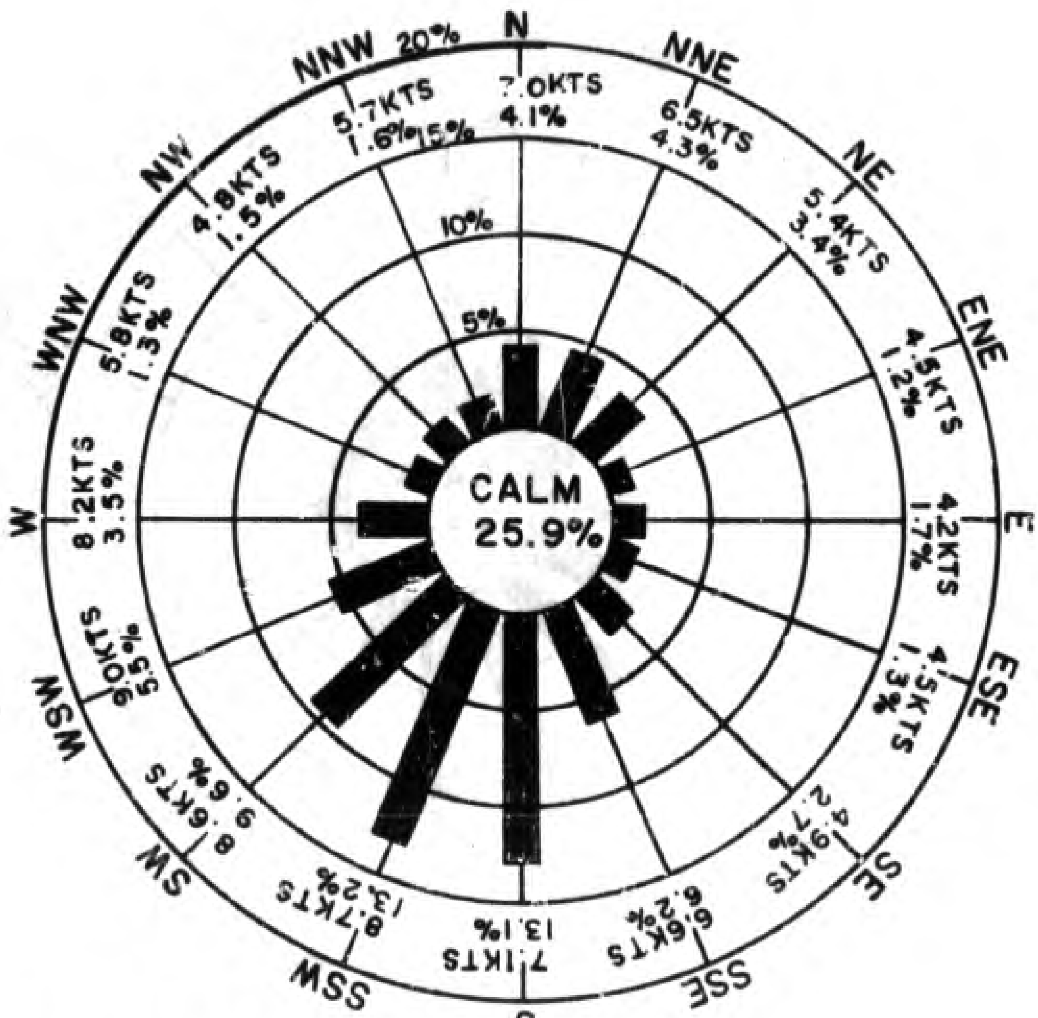
FIG 19

MARCH WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1941 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: WSW 56KTS

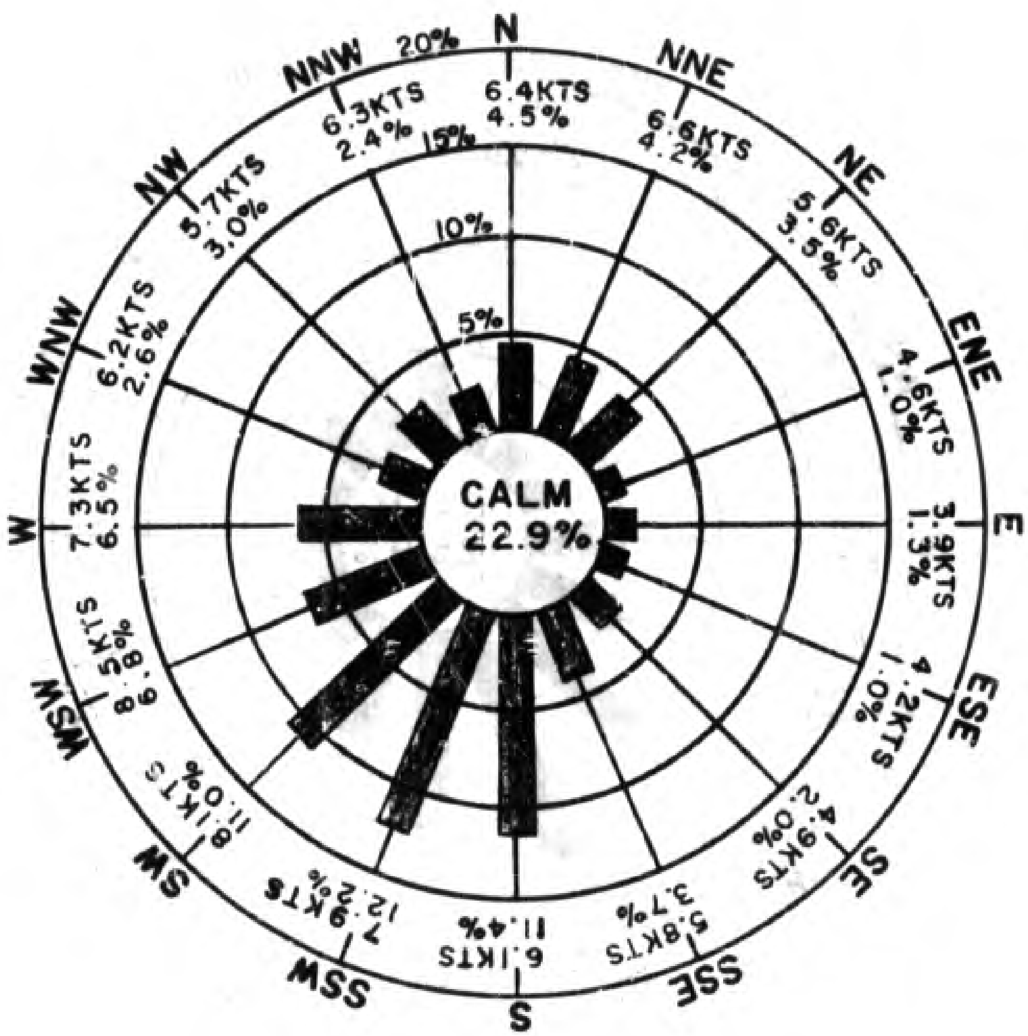
FIG 20

APRIL WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1941 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: WSW 49KTS

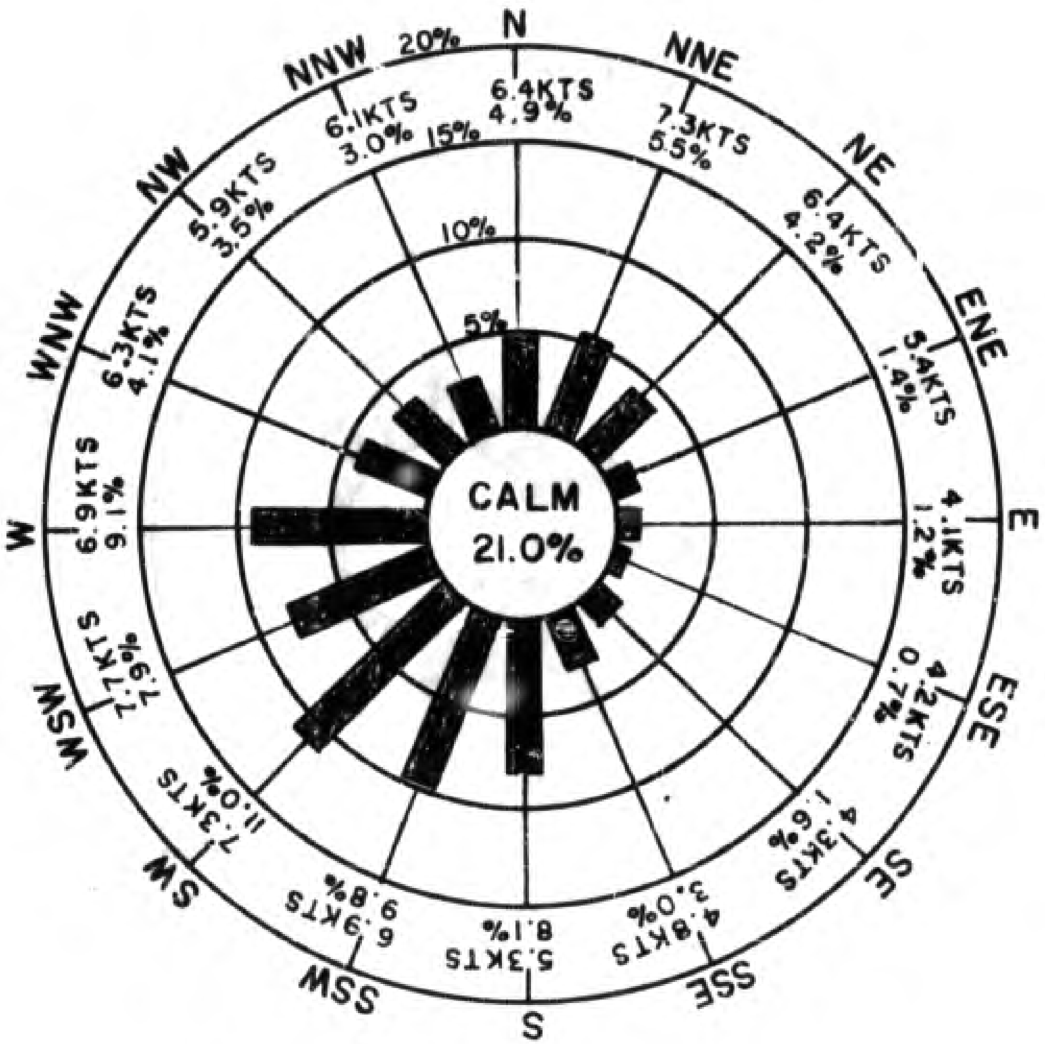
FIG 21

MAY WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1941 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: SSE 39KTS

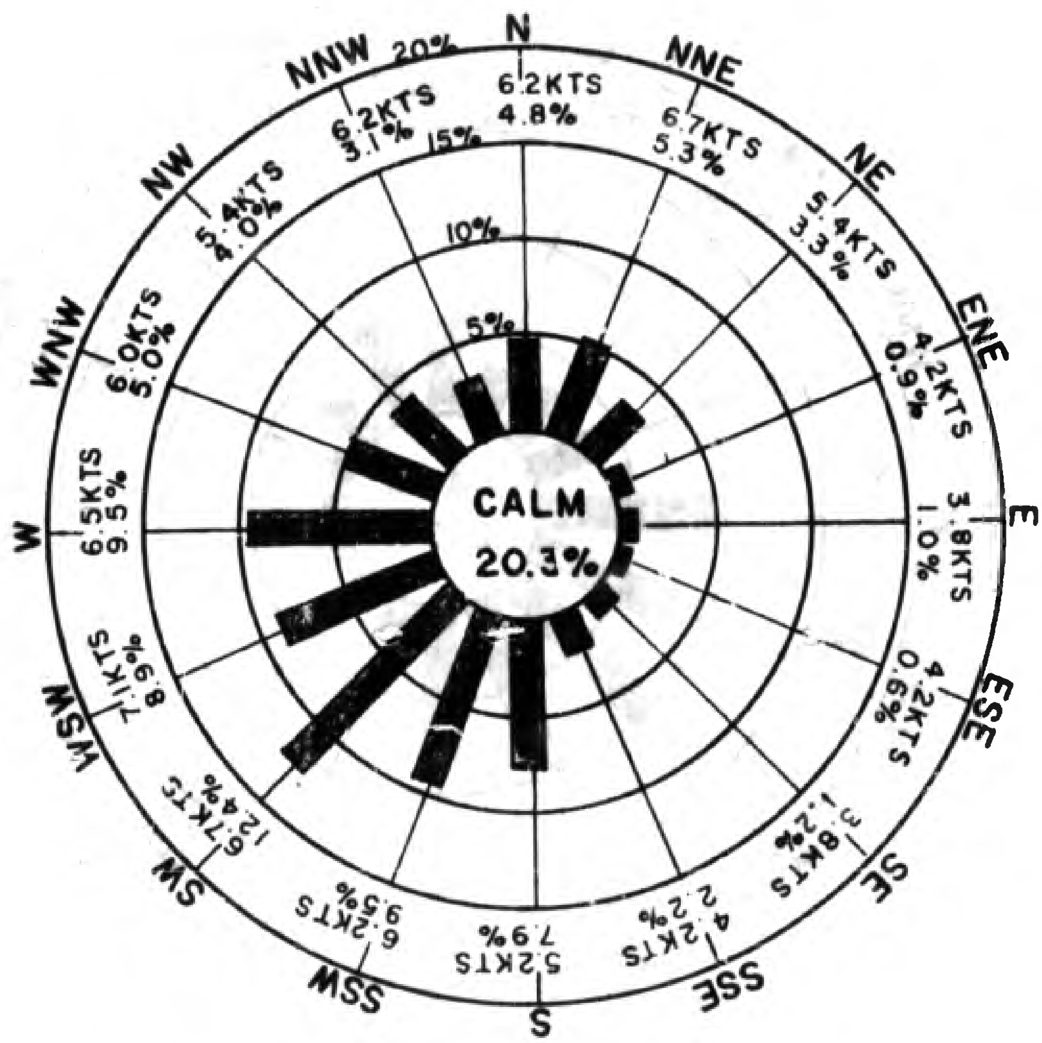
FIG 22

JUNE WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1941 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: SSW 40KTS

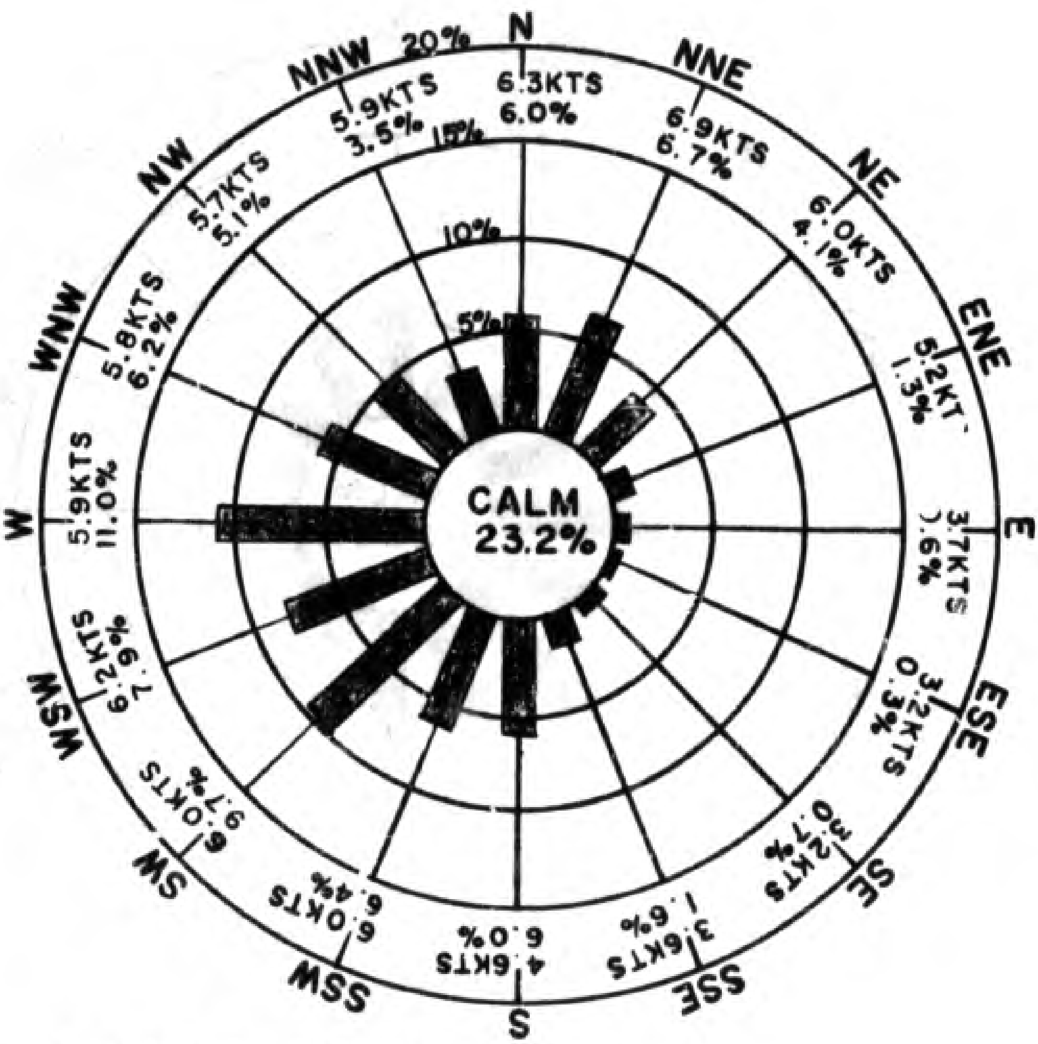
FIG 23

JULY WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1941 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: NNW 34KTS

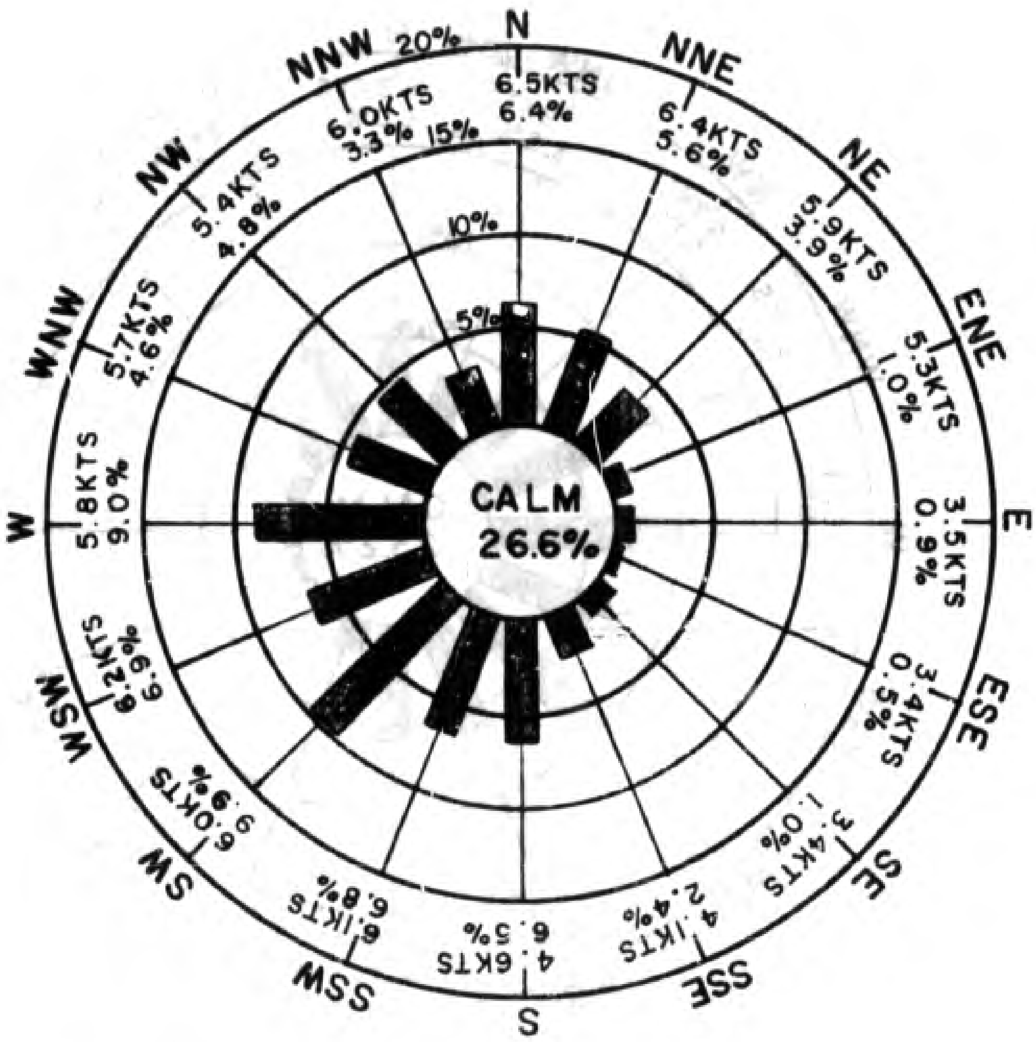
FIG 24

AUGUST WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1940 - Dec 1967.

b Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. **Peak Gust: W 32KTS**

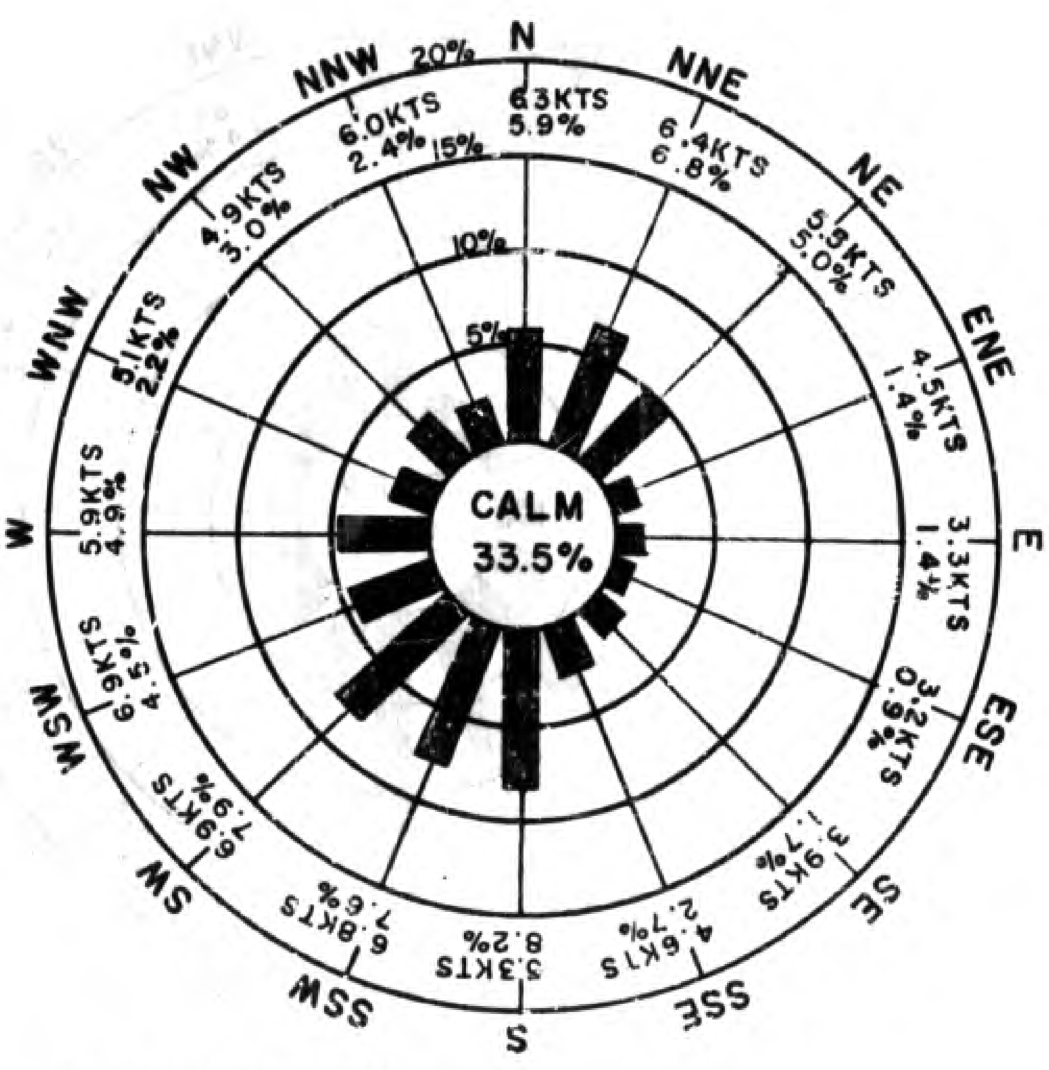
FIG 25

SEPTEMBER WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1940 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: SW 44KTS

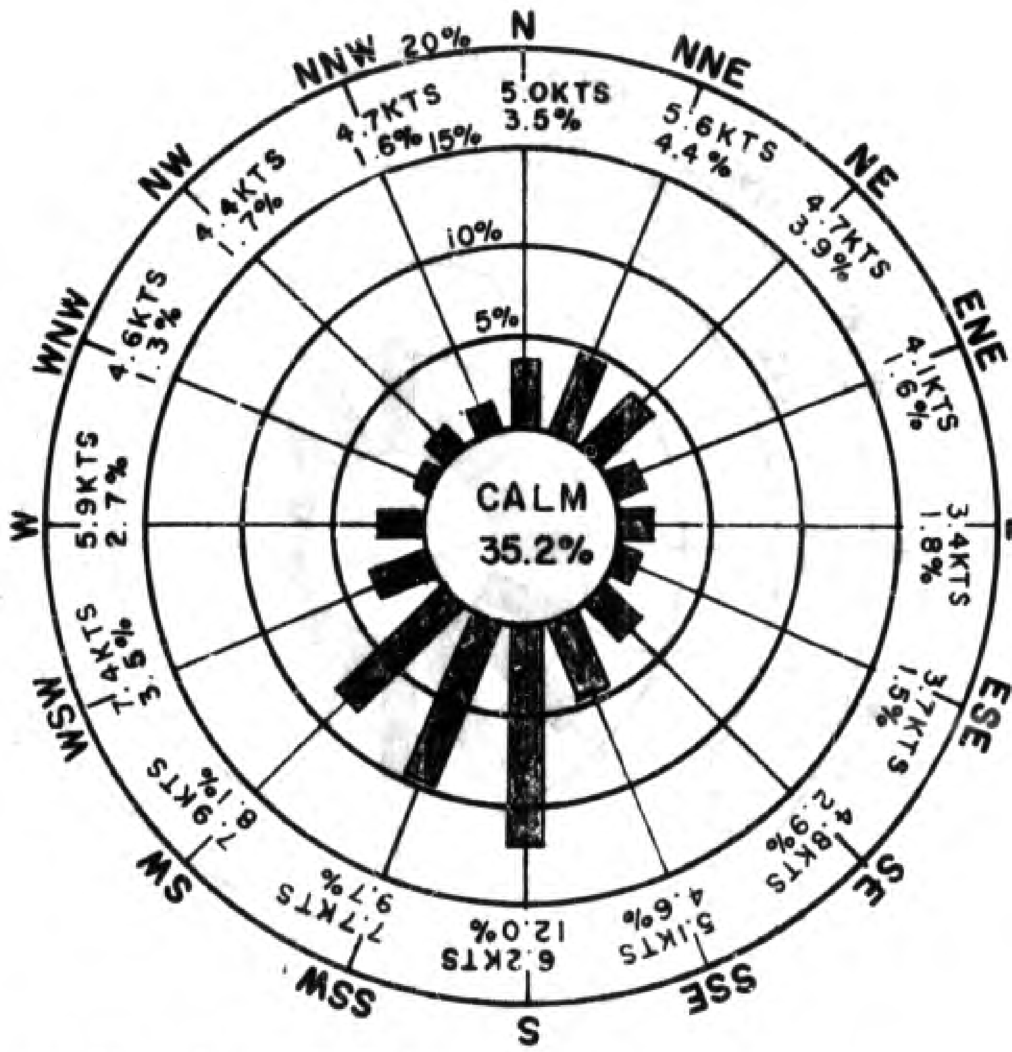
FIG 26

OCTOBER WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1940 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: S 76KTS

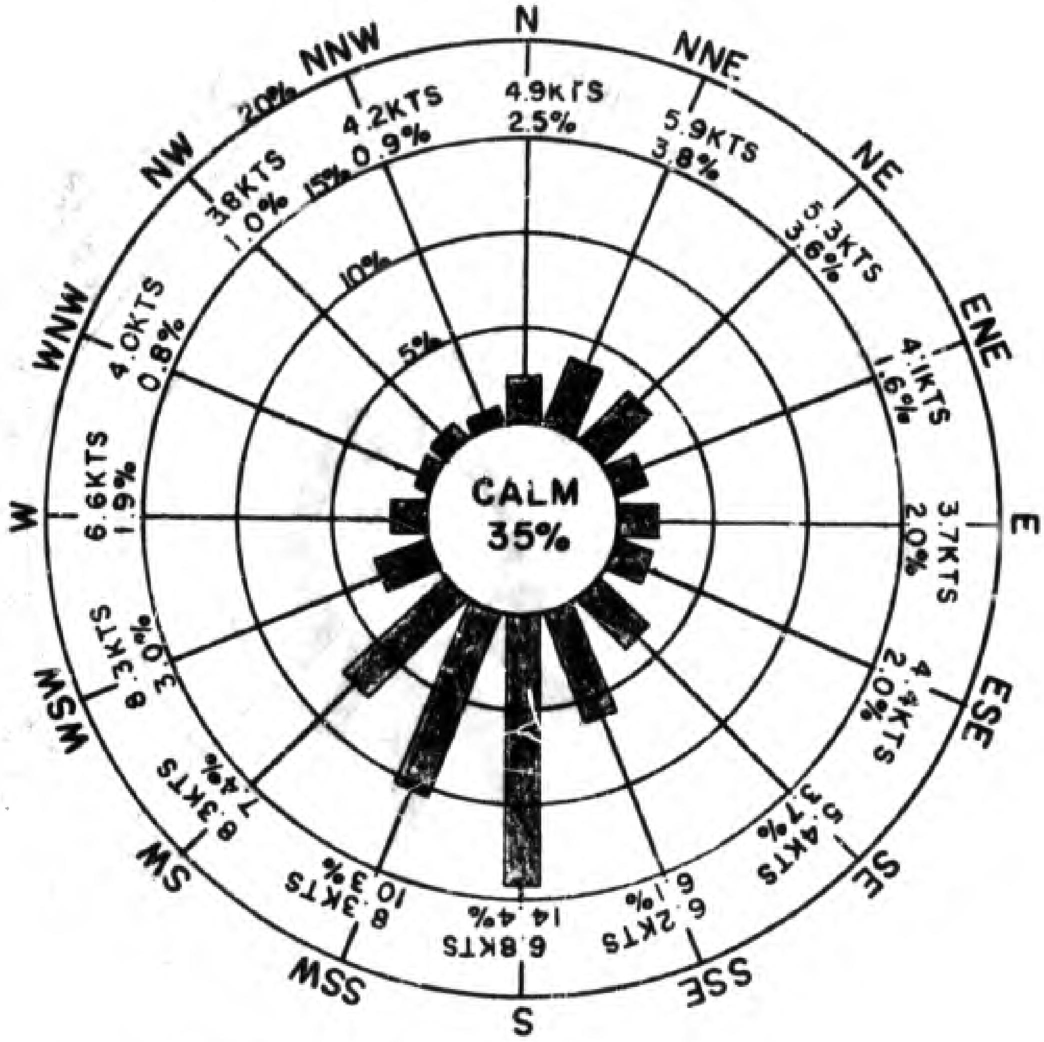
FIG 27

NOVEMBER WIND ROSE

a. Data period Aug 1940 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gust: S 48KTS

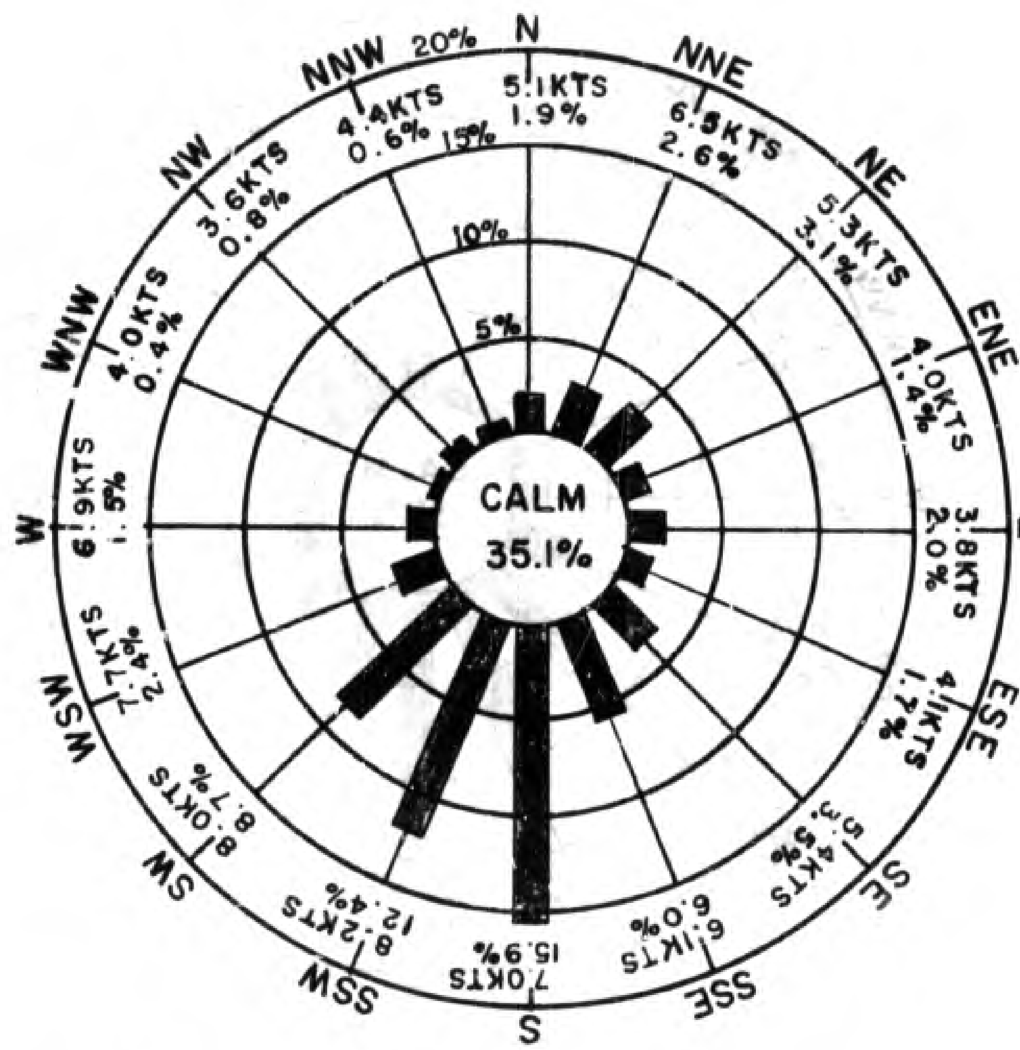
FIG 28

DECEMBER WIND ROSE (McChord AFB, Wa)

a. Data period Aug 1940 - Dec 1967.

b. Bars indicate percentage frequency of occurrence. Exact percent is given at the bar ends.

c. The value in knots represents the mean wind speed for the direction indicated by the bar.



d. Peak Gusts S 45KTS

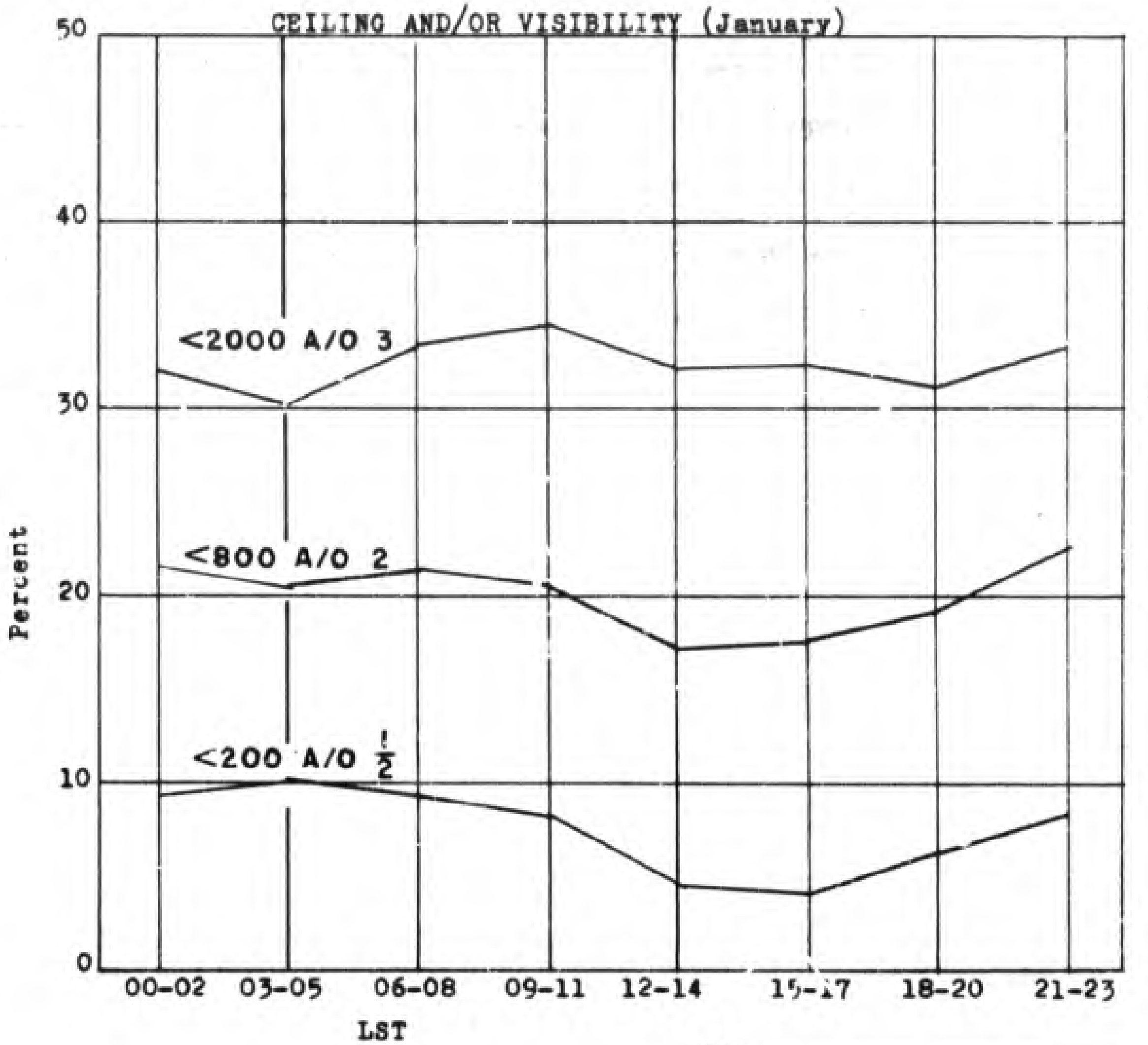
FIG 29

3070 CEILING AND/OR VISIBILITY AND SKY CONDITION (Figures

Frequency of occurrence of ceiling and/or visibility and sky condition are portrayed for each month. The choice of ceiling and visibility categories was governed by operational significance.

PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.



PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

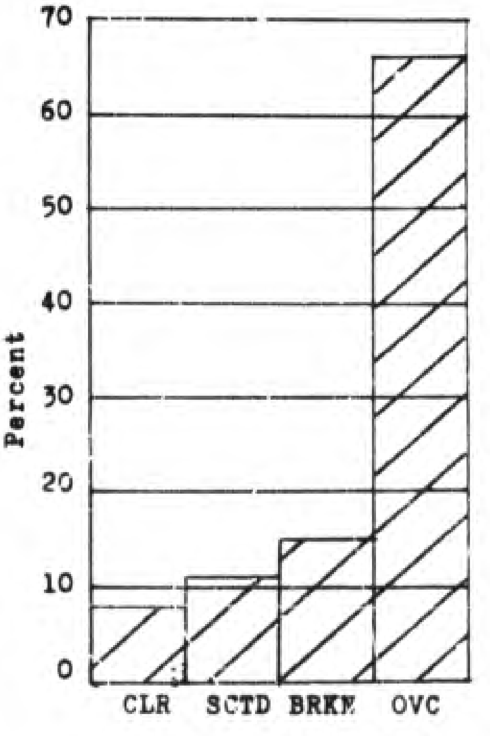
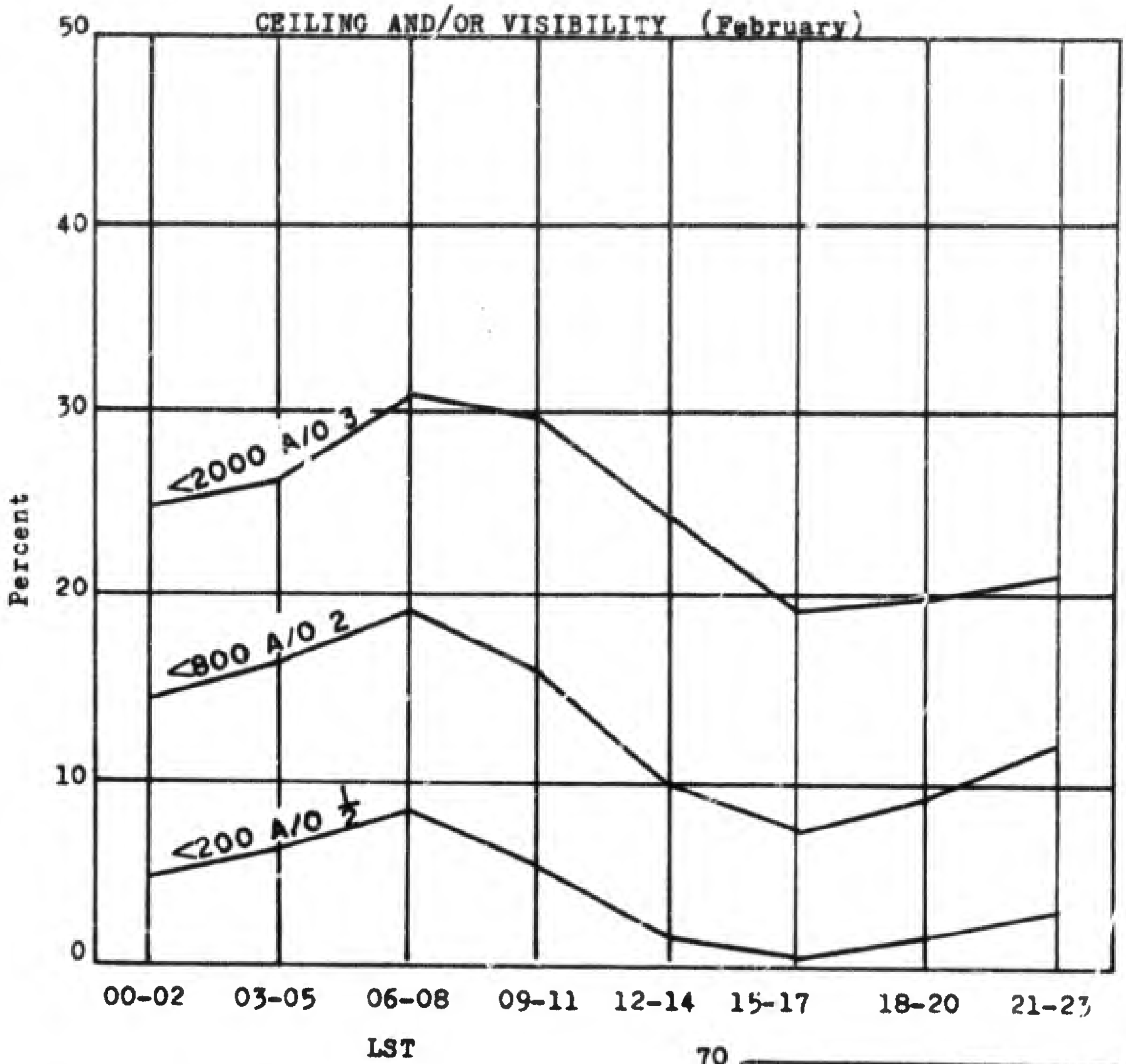


FIG 30

PERCENTAGE FRQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.



PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

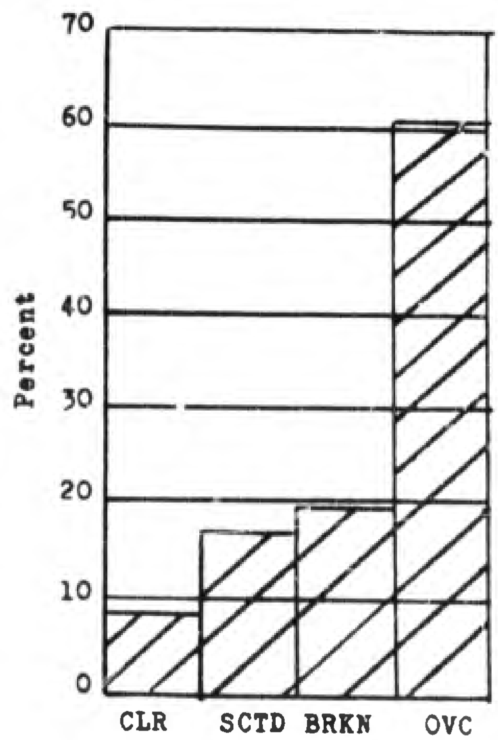
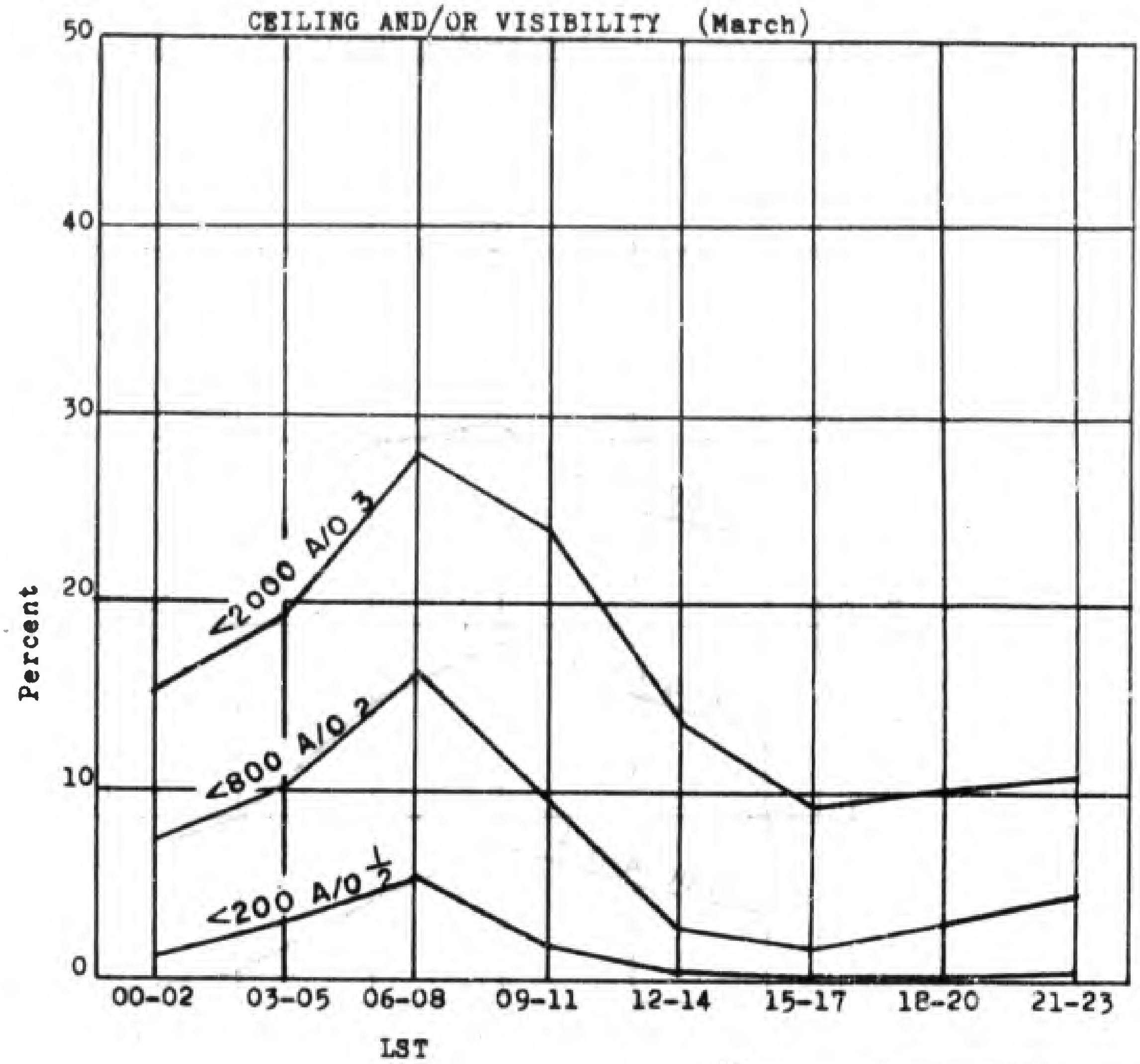


FIG 31

PERCENTAGE FREQUENCY OCCURRENCE

Data based on period January 1941 - December 1967.

CEILING AND/OR VISIBILITY (March)

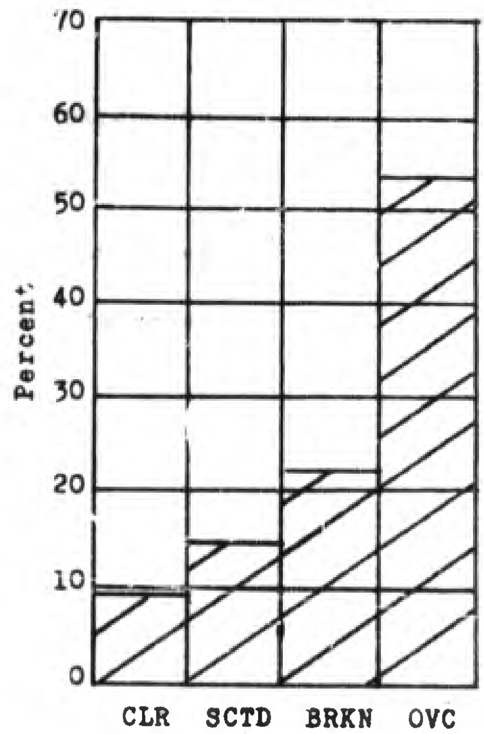


PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

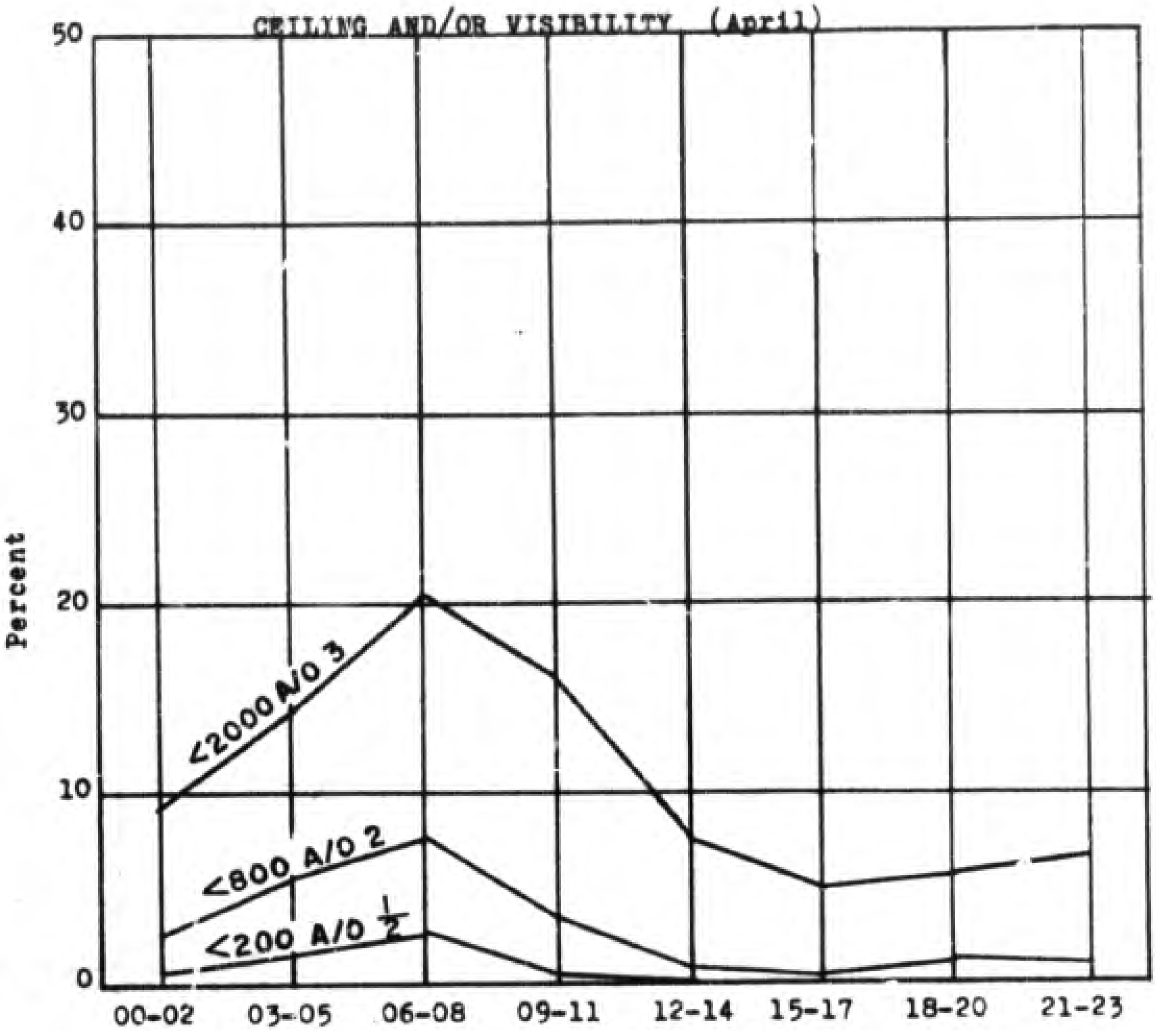
FIG 32



PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.

CEILING AND/OR VISIBILITY (April)



PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

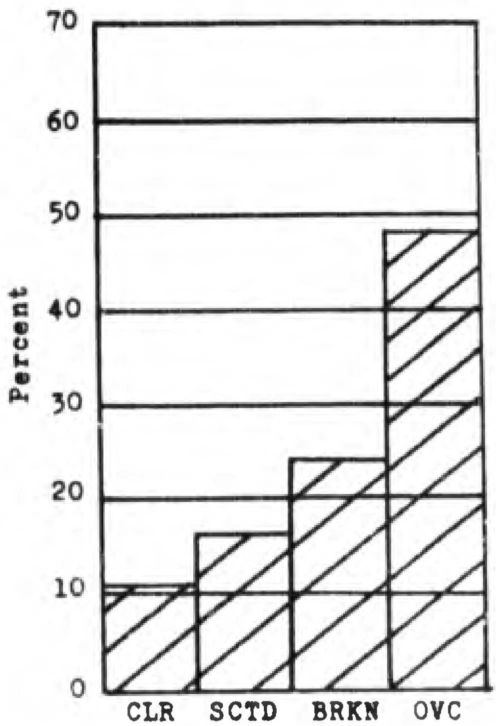
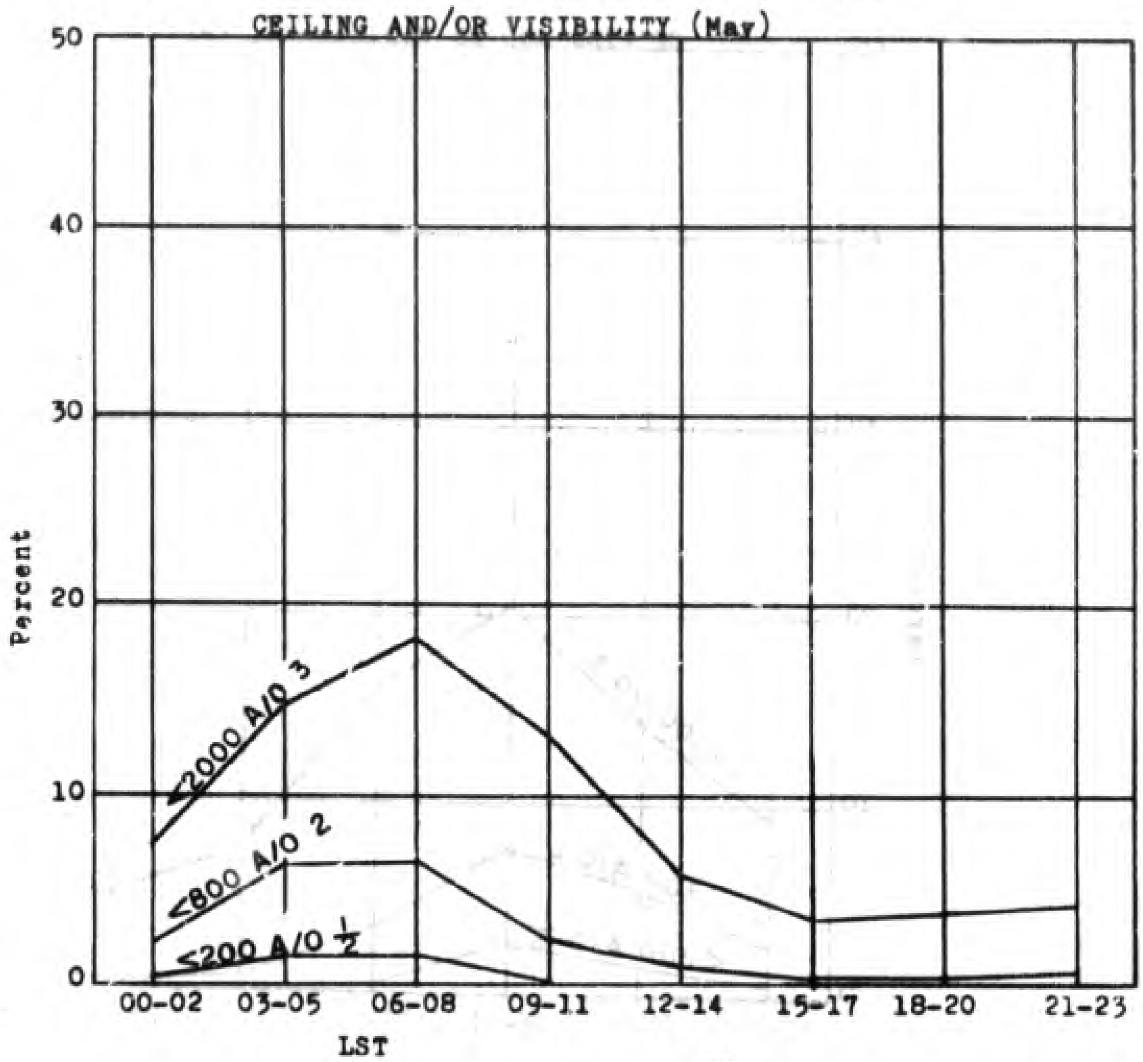


FIG 33

PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.

CEILING AND/OR VISIBILITY (May)

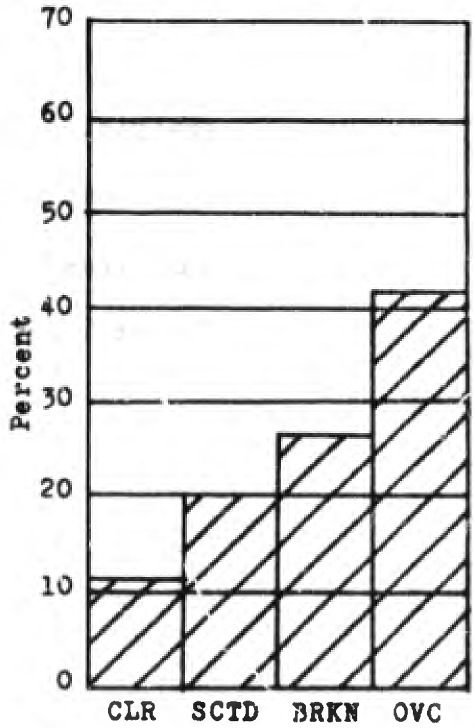


PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

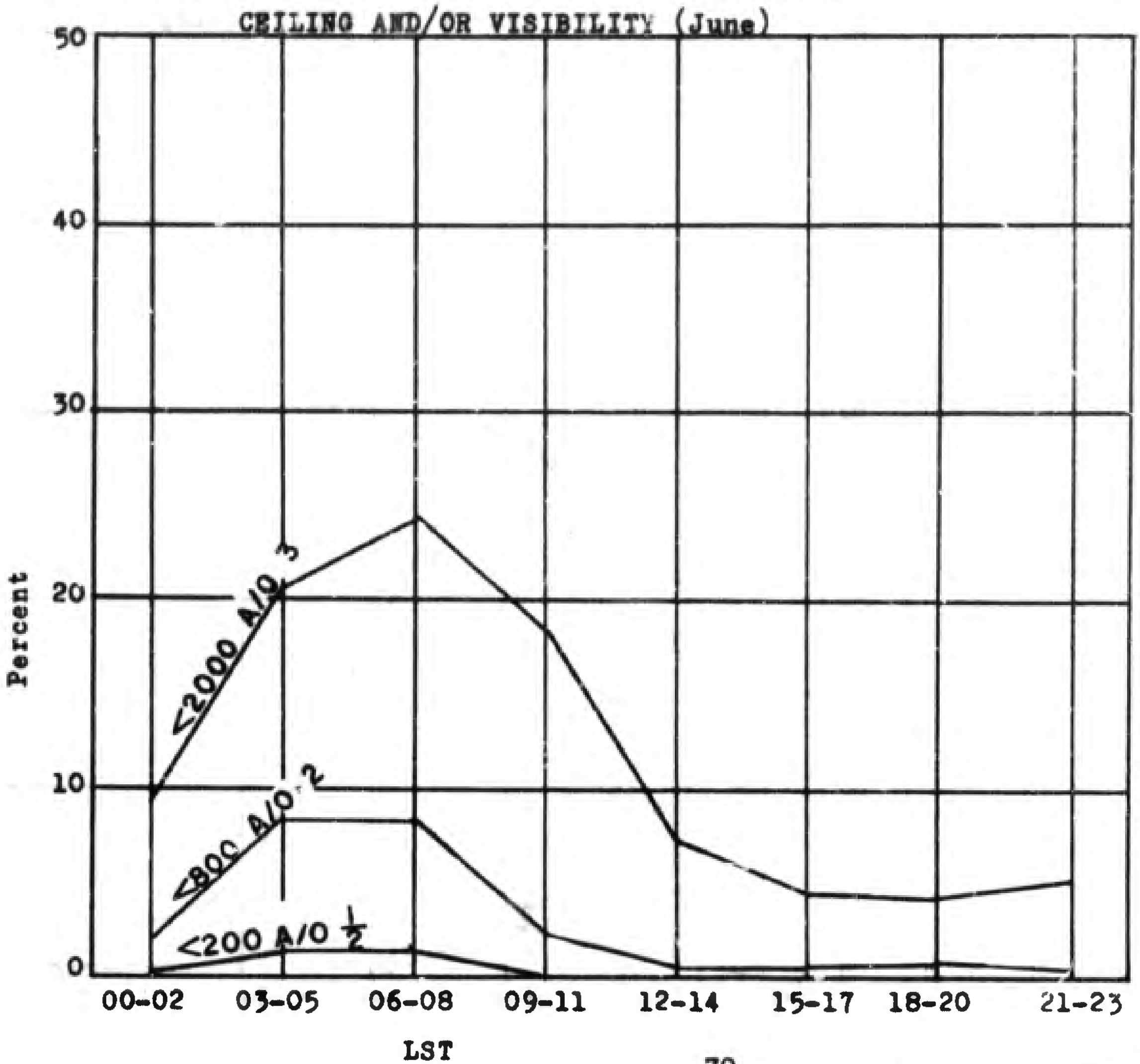
FIG 34



PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.

CEILING AND/OR VISIBILITY (June)



PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

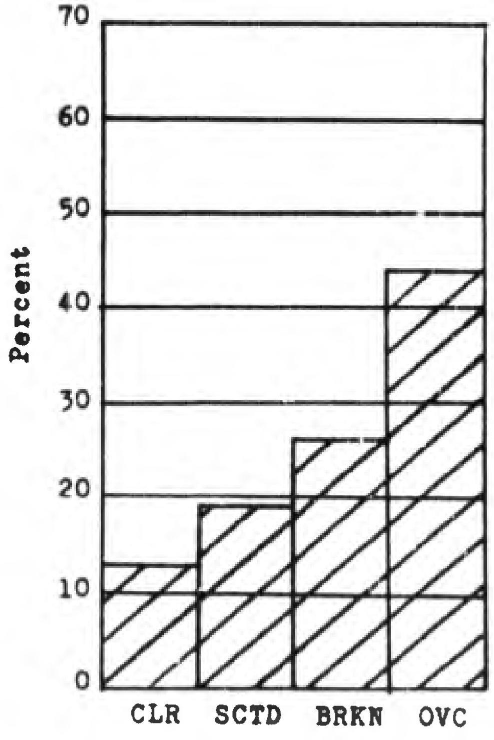
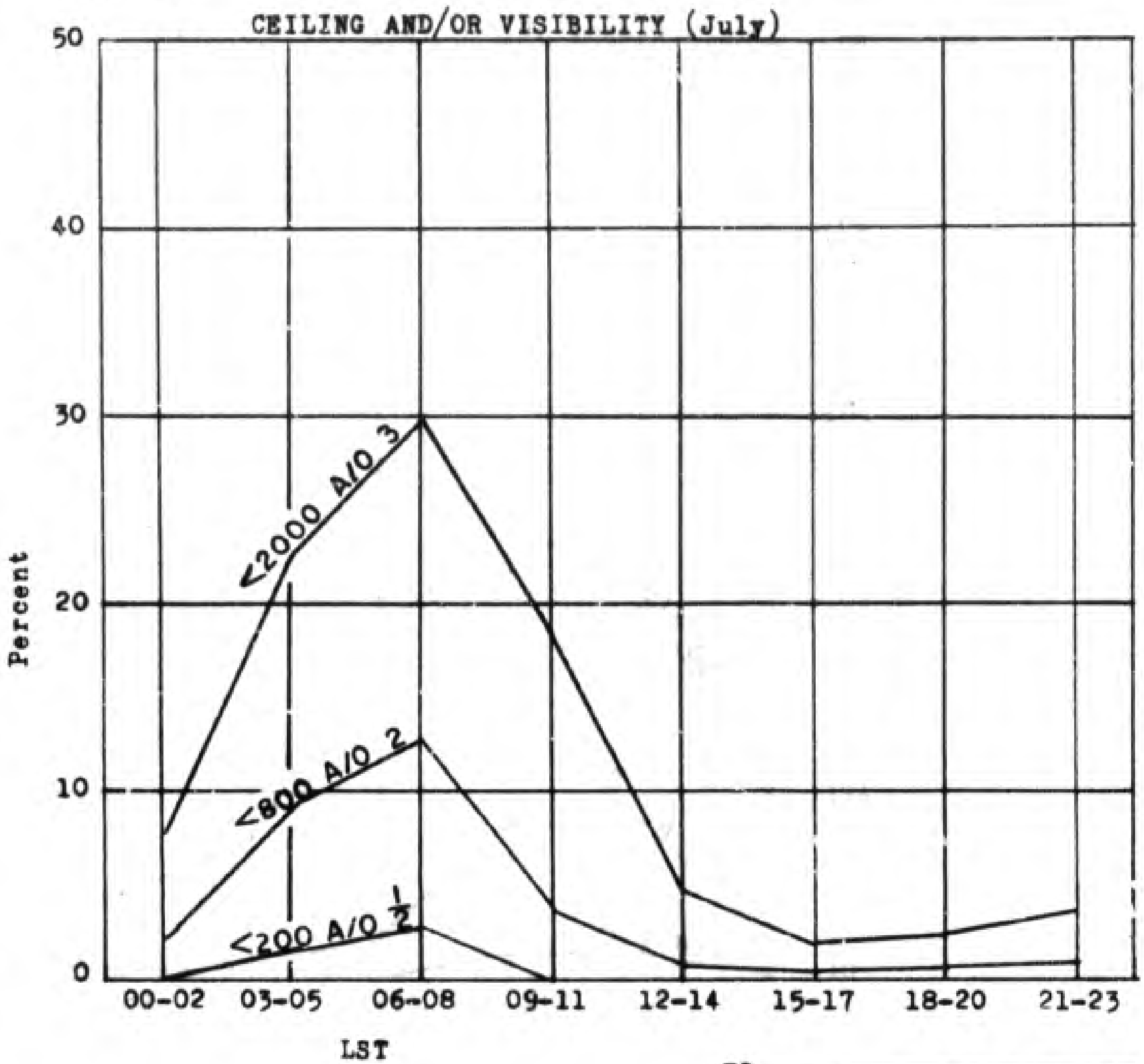


FIG 35

PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.

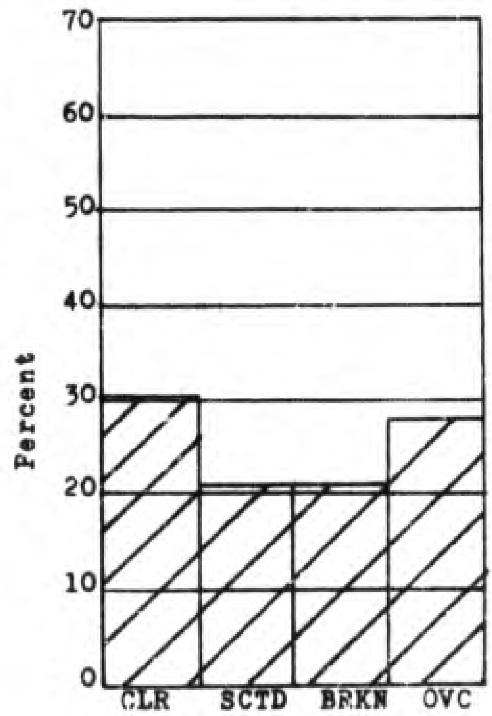


PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

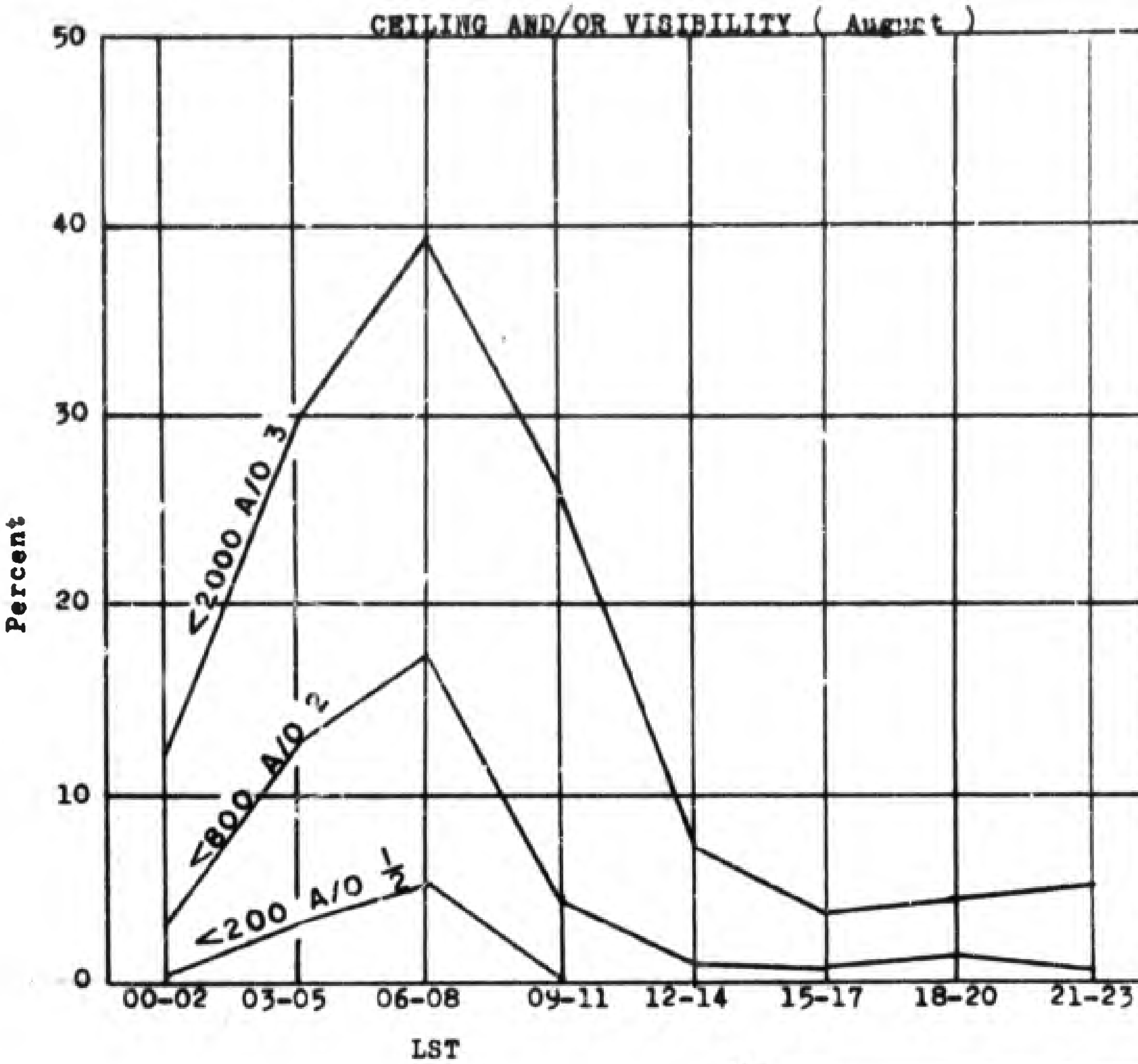
Data based on period January 1946 - December 1967

FIG 36



PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.



PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

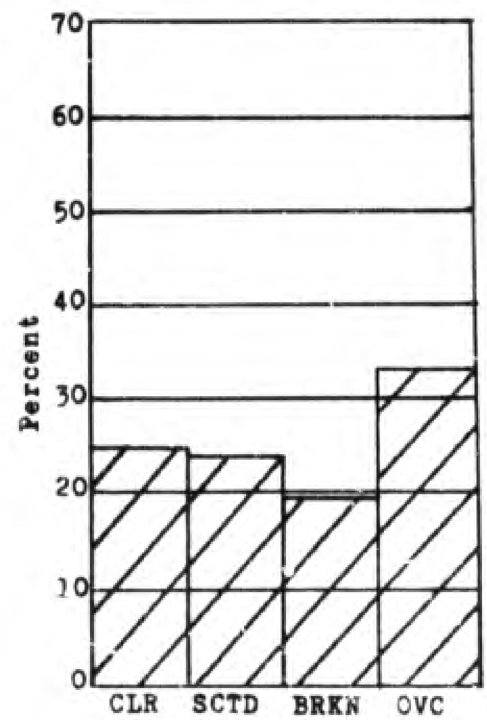
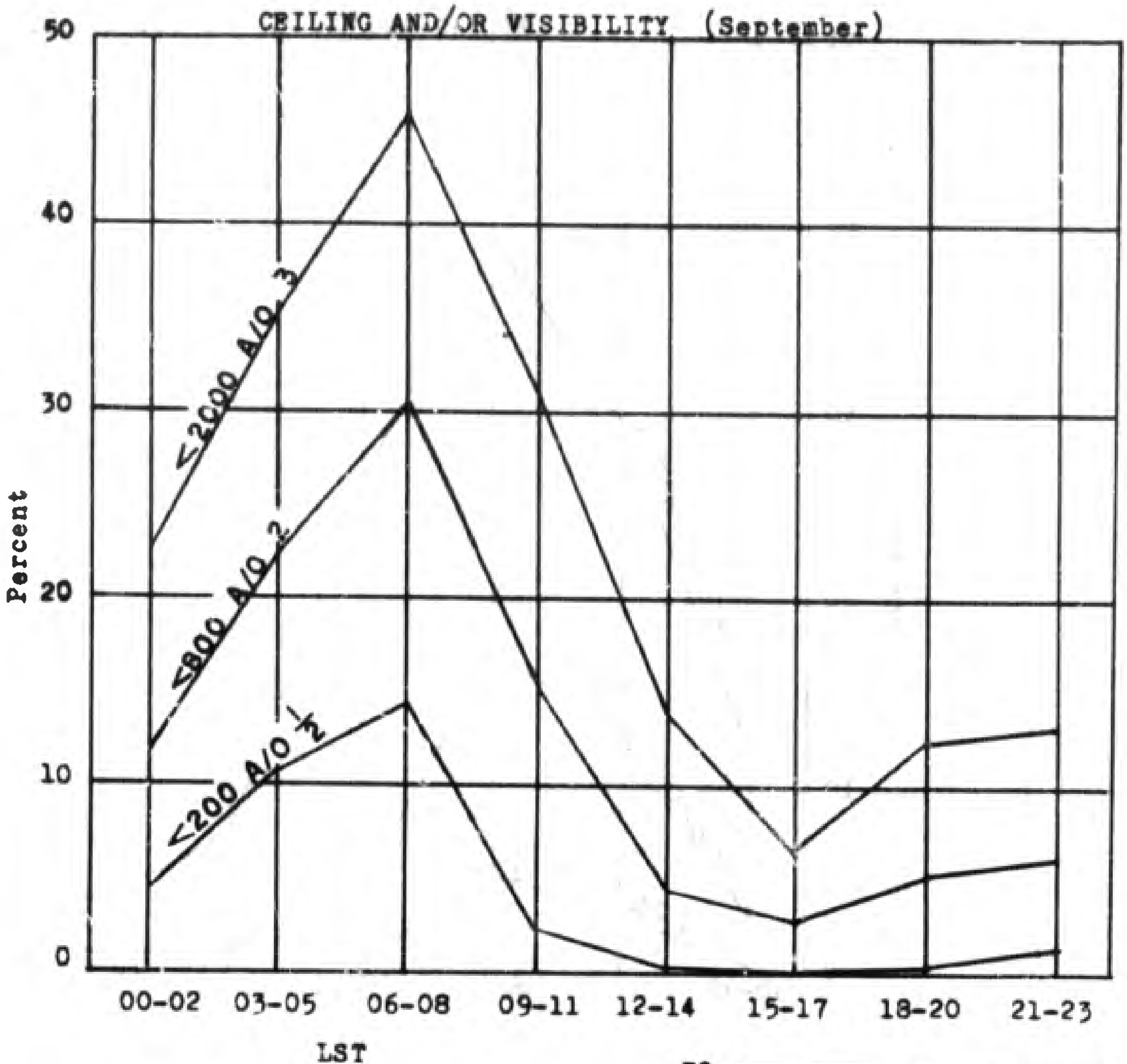


FIG 37

PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.

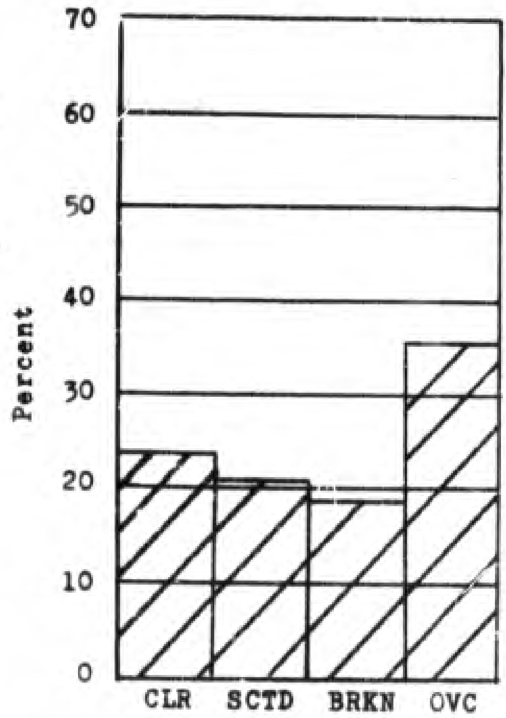


PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

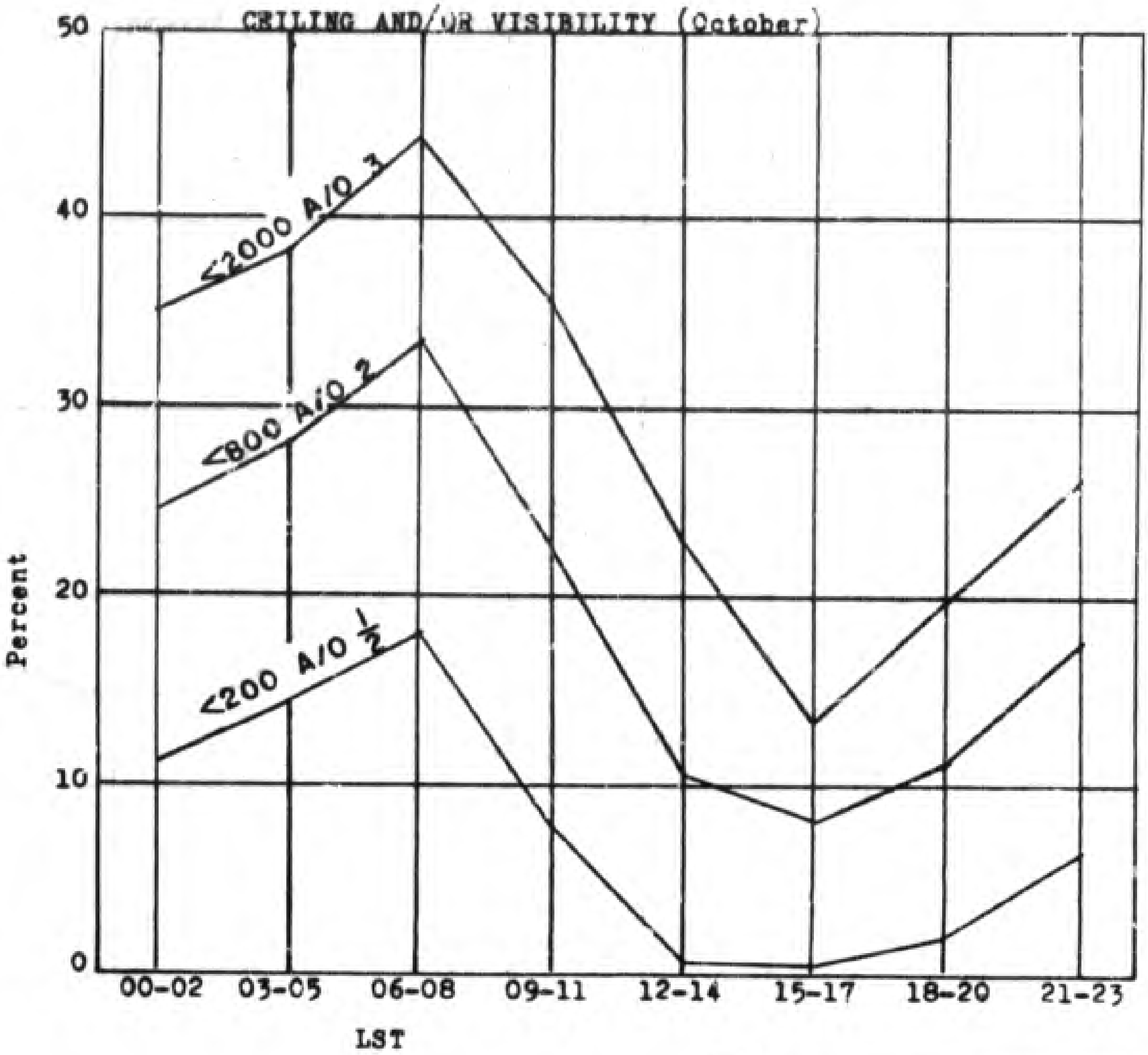
FIG 38



PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.

CEILING AND/OR VISIBILITY (October)



PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

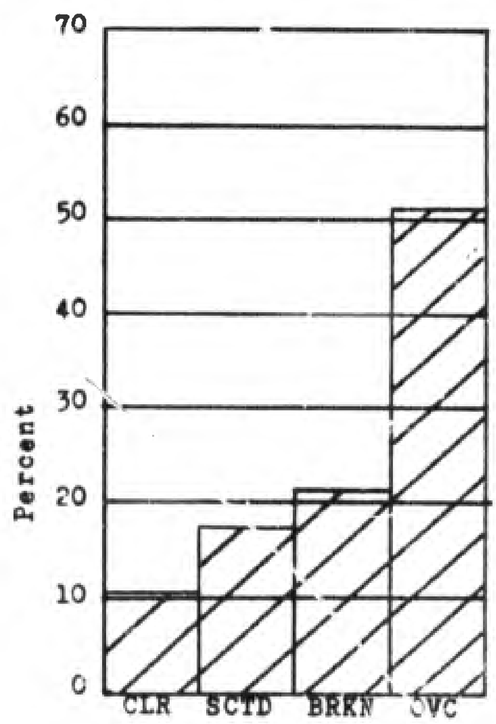
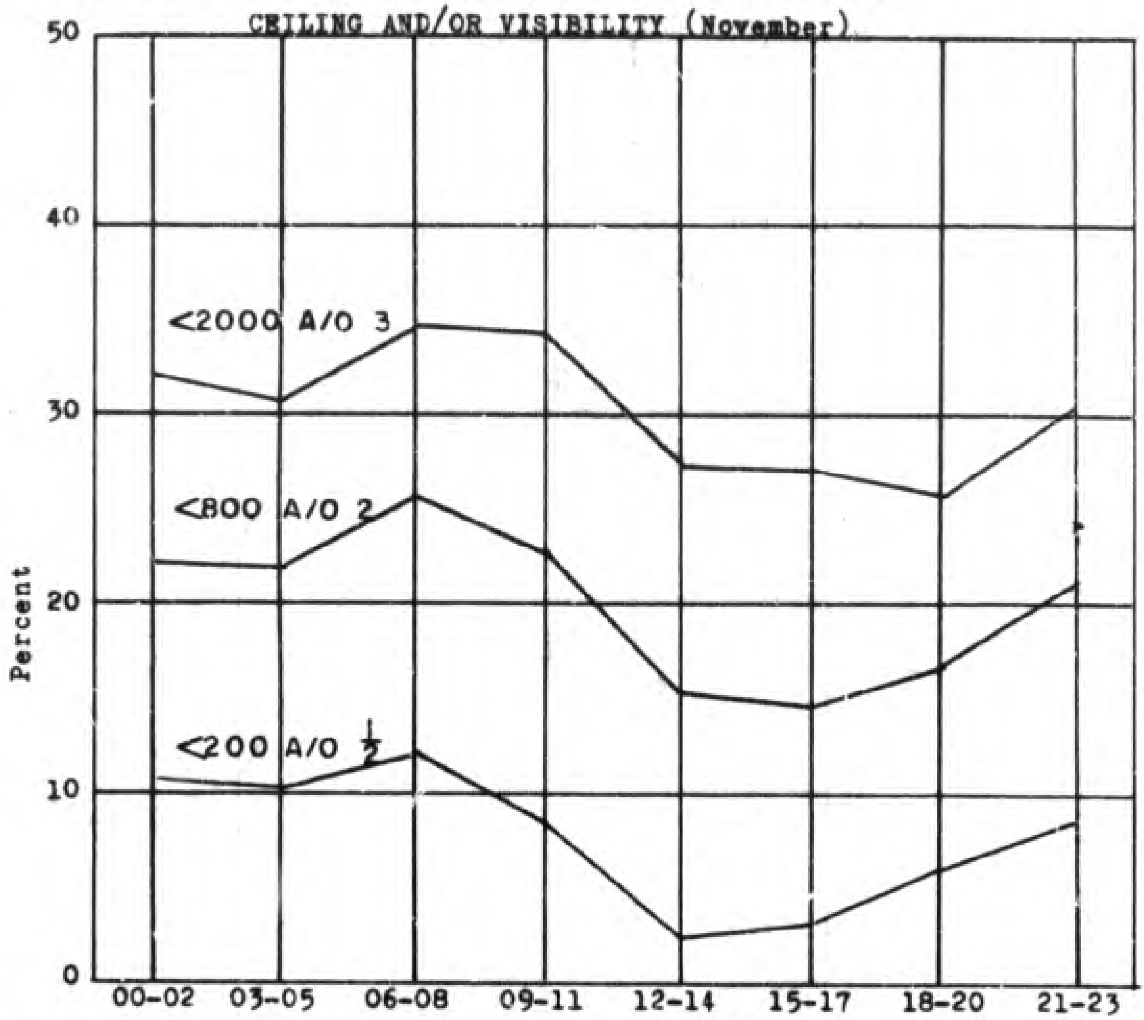


FIG 39

PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 - December 1967.

CEILING AND/OR VISIBILITY (November)

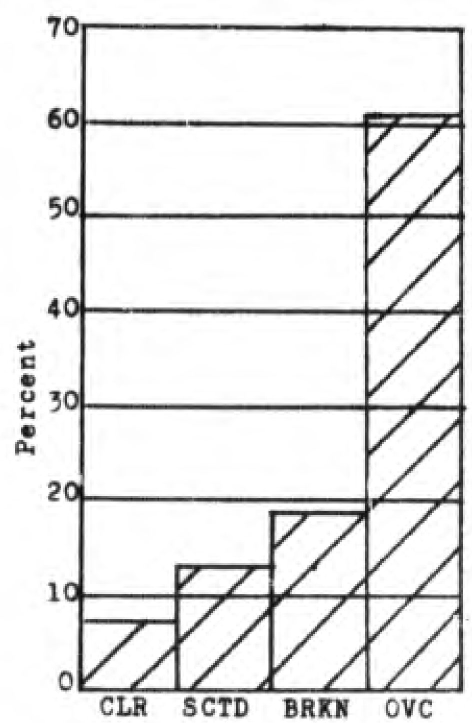


PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

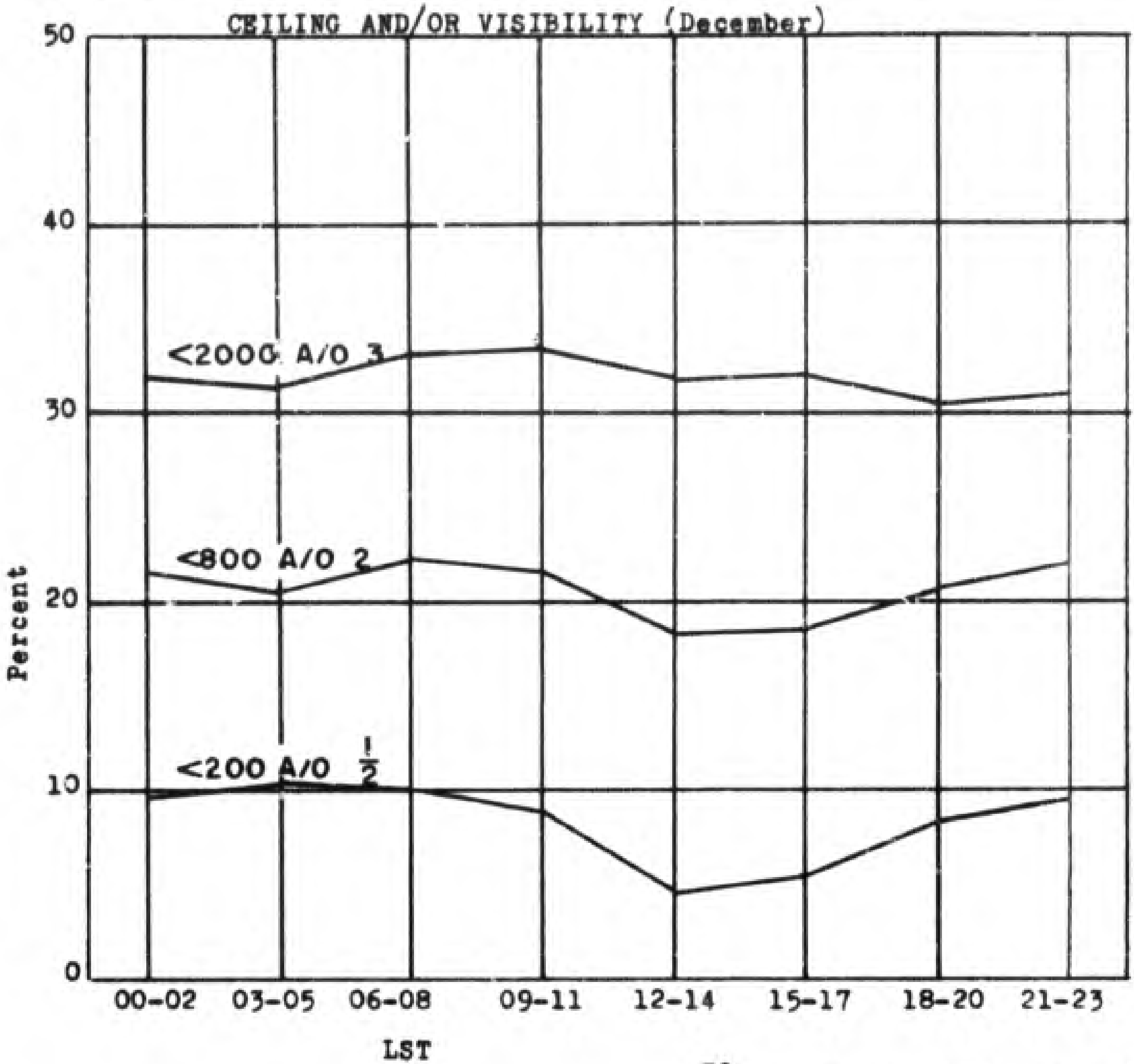
FIG 40



PERCENTAGE FREQUENCY OF OCCURRENCE

Data based on period January 1941 -- December 1967.

CEILING AND/OR VISIBILITY (December)



PERCENTAGE FREQUENCY OF OCCURRENCE

SKY CONDITION

Data based on period January 1946 - December 1967

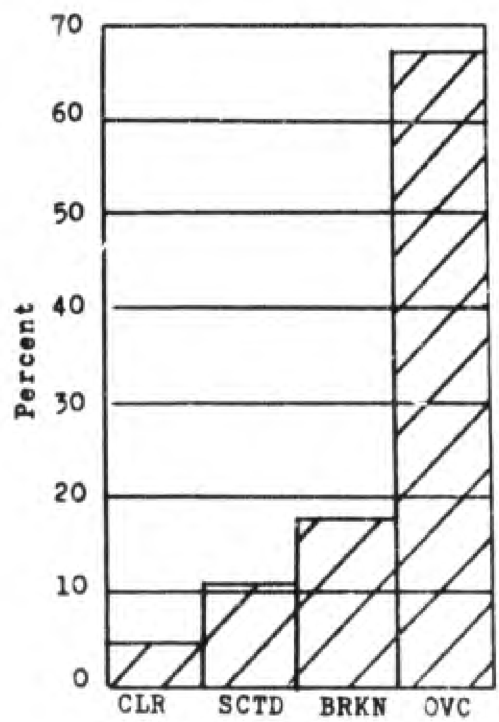


FIG 41

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SECTION IV

LOCAL FORECAST STUDIES

4000 LOCAL FORECAST STUDIES

4010 OPERATIONAL WEATHER REQUIREMENTS FOR MCCHORD AIR FORCE BASE ARE:

a. 200 ft. a/o ½ mile (Runway 34 ILS-GCA minimums)

b. 300 ft. a/o ¾ mile (Runway 16 GCA minimums)

c. 500 ft. a/o 1 mile, 500 ft. a/o 1½ mile, and 600 ft. a/o 2 miles (Circling minimums depending upon type of aircraft, C-141 600 ft. a/o 2 miles)

d. 2200 ft. a/o 3 miles (IFR-VFR change over jet aircraft)

e. 1700 ft. a/o 3 miles (IFR-VFR change over all other aircraft)

f. Zero a/o ¼ mile (MAC takeoff minimums with suitable takeoff alternate)

g. 800 ft. a/o 2 miles (MAC alternate minimums)

4020 CRITICAL FORECASTING PROBLEMS: Forecasting the occurrence and breakup of fog is the most critical problem at McChord. The fog season is from September through January with the highest frequency of occurrence in October. A problem of secondary importance is forecasting the occurrence and break-up of summertime stratus. The season is from May through September. Precipitation forecasting is not operationally significant, except when occurring in the form of freezing precipitation or snow; however occurrence of these forms are infrequent. Strong surface winds and thunderstorms are in the same category. They are significant when they occur, but occurrence is relatively small.

4030 AN OBJECTIVE METHOD OF FORECASTING LOW VISIBILITIES DUE TO FOG AT MCCHORD AFB

a. Statement of the Problem: Because of the nature of most flying done at McChord (MAC flights are scheduled far in advance), it becomes imperative that an accurate planning forecast be available. Therefore, with the main weather problem at McChord being fog, it follows that a method of forecasting below minimums due to fog, sufficiently far enough in advance to aid planning, is essential.

b. Purpose: This study is to provide , at 1300P, a yes or no type forecast for the occurrence of visibilities below $\frac{1}{2}$ mile due to fog. The valid time is for a period of 1 or more hours from 2200P to 1000P the following day. This study was designed for use during October and November; however, it can be used as guide for other fall and winter months.

c. Procedures:

(1) Enter chart I with McChord average hourly wind speed 1000 - 1300P, McChord 1300P wind direction:

(a) If point falls in area A, forecast "NO" and stop.

(b) If point falls in area B, proceed to chart II.

(2) Enter chart II with TCM 1300P pressure and dew point:

(a) If point falls in area A, forecast "NO" and stop.

(b) If point falls in area B, proceed to chart III.

(3) Enter chart III with the McChord 1300P sky condition ceiling, or ceiling, and McChord 1300P dew point spread:

(a) If point falls in area C, forecast "NO" and stop.

(b) If point falls in area A, forecast "YES".

(c) If point falls in area B, proceed to chart IV.

(4) Enter chart IV with the McChord 1300P 24 hour change in pressure 1300P to 1300P, and the 3 hour change in pressure:

(a) If point falls in area A, forecast "NO".

(b) If point falls in area B, forecast "YES".

VISIBILITY STUDY VERIFICATION RESULTS

(Data period 13 Sep thru 30 Nov 1969)

OBSERVED

FORECAST		YES	NO	
	YES	14	6	20
	NO	3	57	60
		17	63	80

HEIDKE SKILL SCORE .68

% CORRECT 89

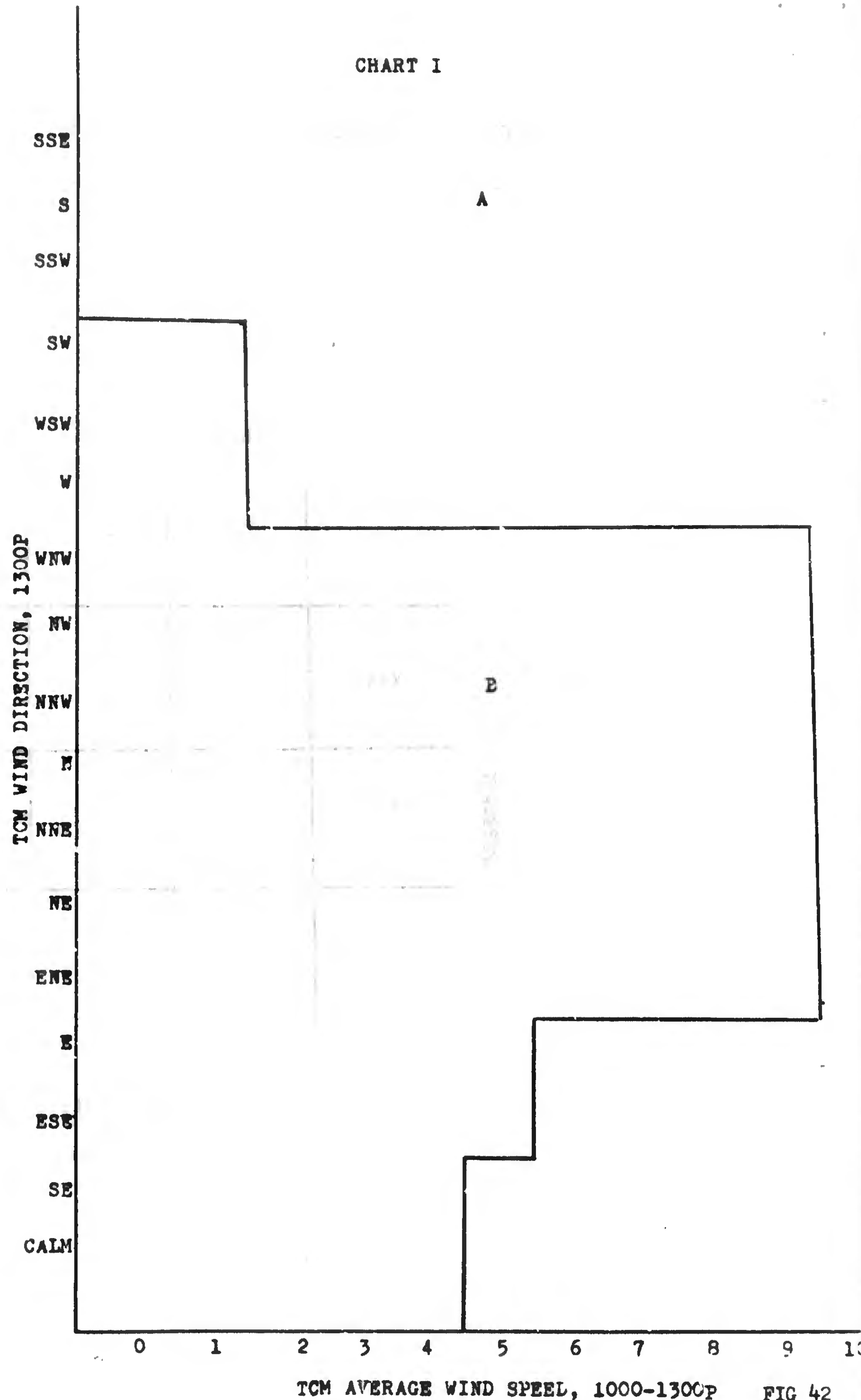
CHART I
A
B
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
N
NNE
NE
ENE
E
ESE
SE
CALM
TCM WIND DIRECTION, 1300P
0
1
2
3
4
5
6
7
8
9
10
TCM AVERAGE WIND SPEED, 1000-1300P

FIG 42

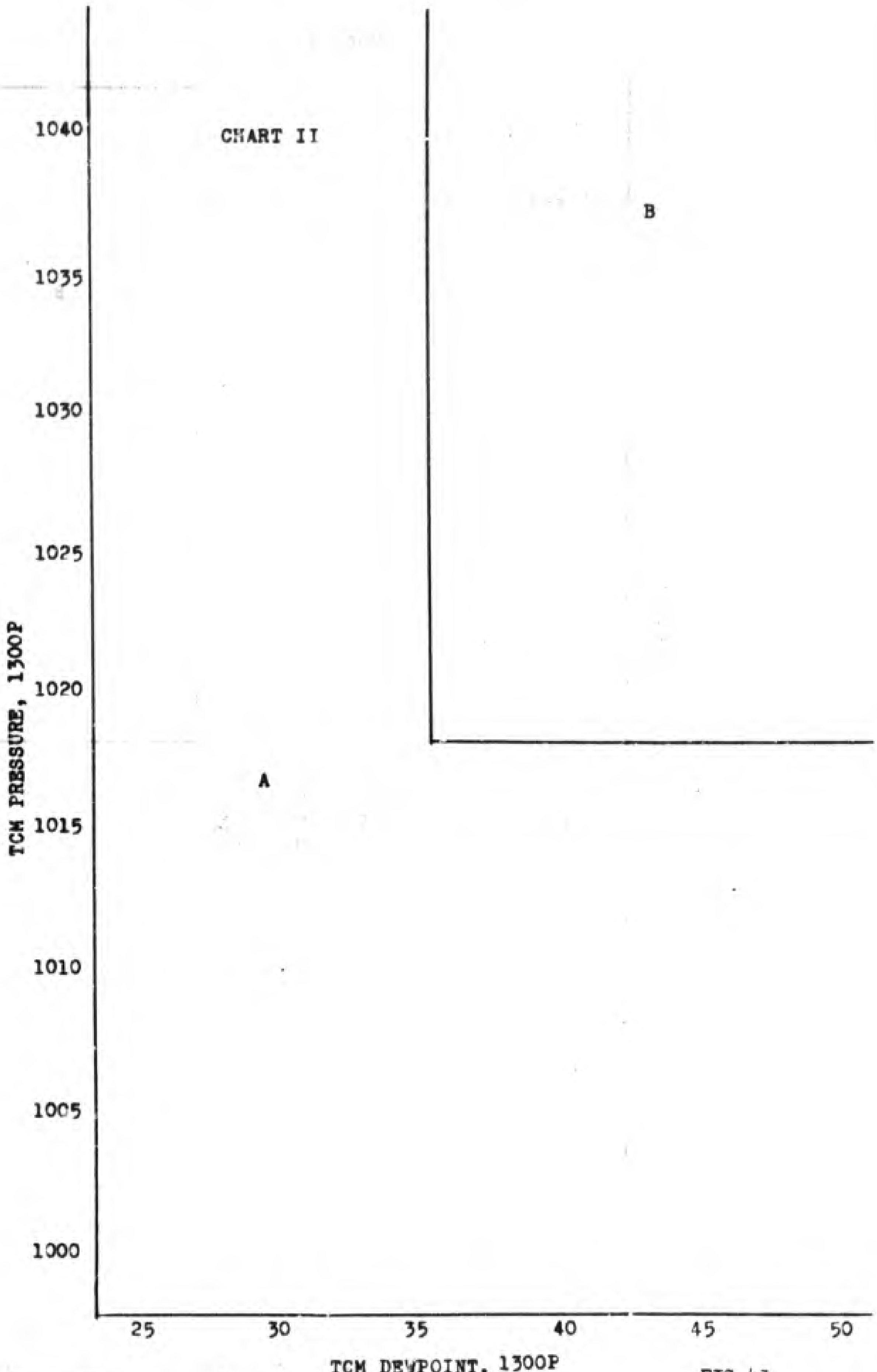
CHART II
B
A
1040
1035
1030
1025
1020
1015
1010
1005
1000
TCM PRESSURE, 1300P
25
30
35
40
45
50
TCM DEWPOINT, 1300P

FIG 43

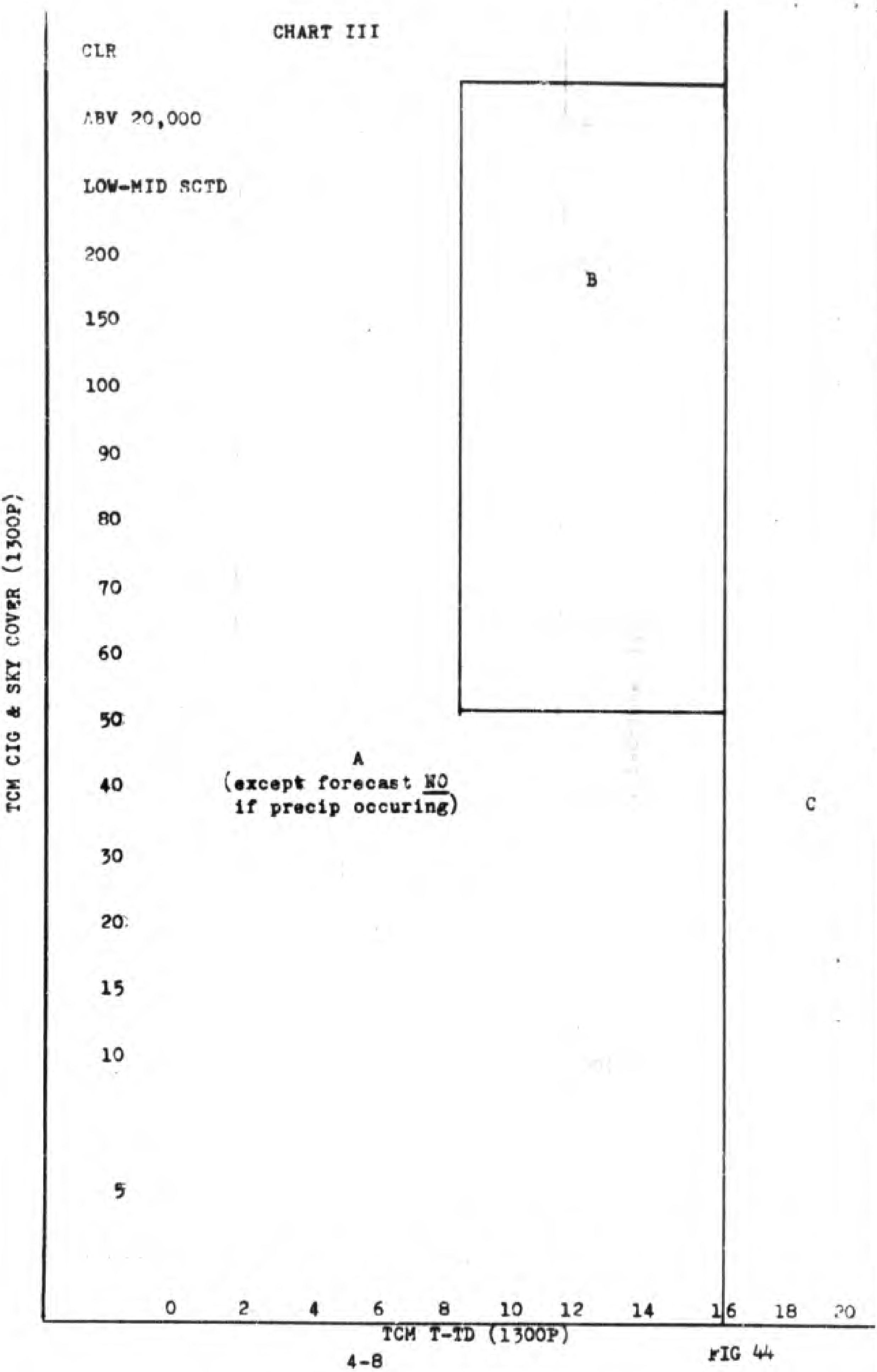
CHART III
CLR
ABV 20,000
LOW-MID SCTD
200
150
100
90
80
70
60
50
40
30
20
15
10
5
B
A
(except forecast NO if precip occuring)
C
TCM CIG & SKY COVER (1300P)
0
2
4
6
8
10
12
14
16
18
20
TCM T-TD (1300P)

FIG 44

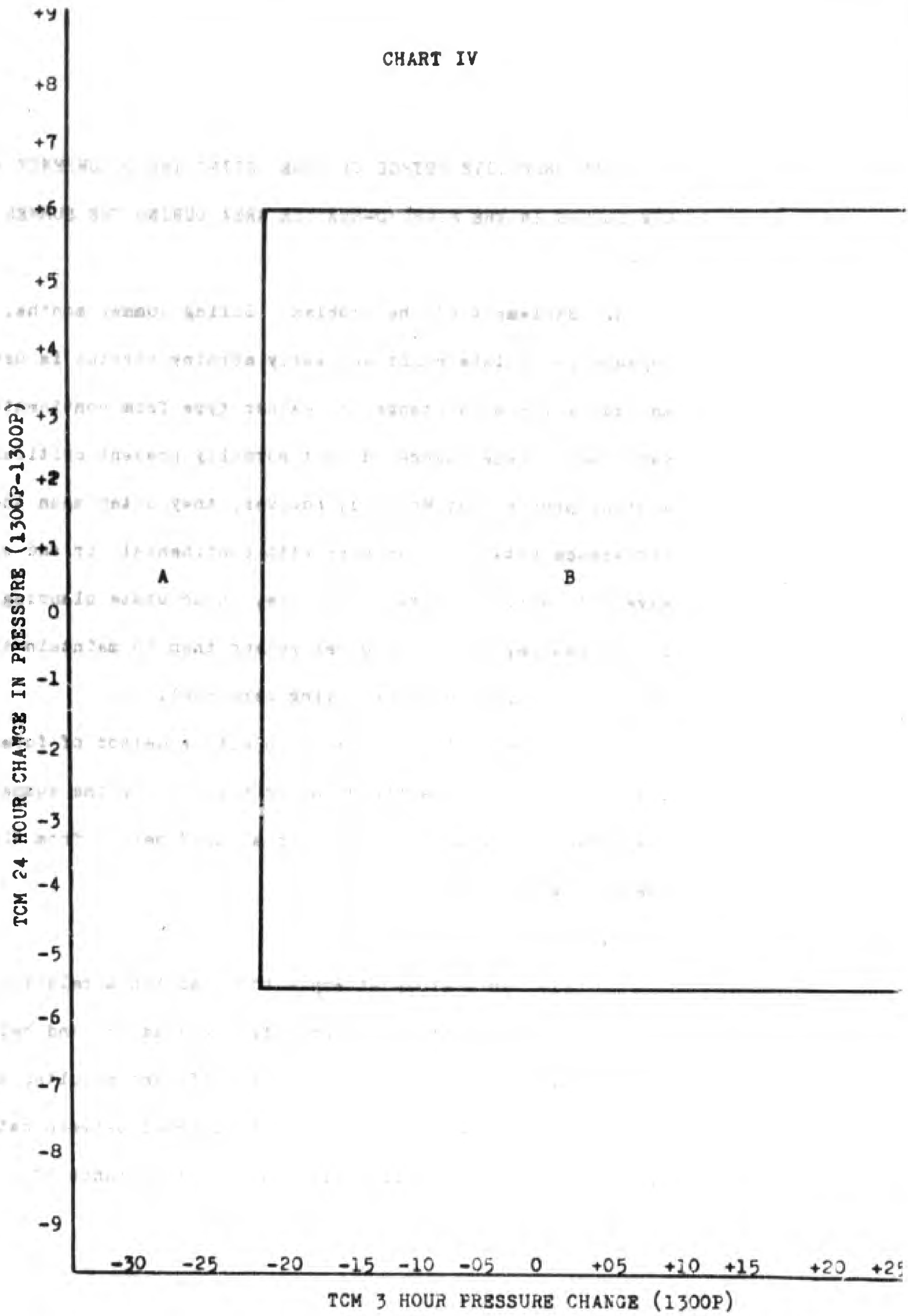
CHART IV
+9
+8
+7
+6
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
TCM 24 HOUR CHANGE IN PRESSURE (1300P-1300P)
A
B
-30 -25 -20 -15 -10 -05 0 +05 +10 +15 +20 +25
TCM 3 HOUR PRESSURE CHANGE (1300P)

FIG 45

4040 AN OBJECTIVE METHOD OF FORECASTING THE OCCURRENCE OF LOW CLOUDS IN THE MCCHORD-SEATTLE AREA DURING THE SUMMER MONTHS

a. Statement of the Problem: During summer months, the appearence of late night and early morning stratus is usually an indication of a change in weather type from continental to maritime. These changes do not normally present critical weather problems at McChord; however, they often mean the difference between clear skys with continental air and overcast skys with maritime air. Therefore, an accurate planning forecast is desireable, if for no other reason than to maintain the professional respect of base flying personnel.

b. Purpose: To provide an objective method of forecasting the occurrence of low clouds at McChord during the summer months. The time of forecast is 1300P for a valid period from 2200-1200P the following day.

c. Comments:

(1) This study attempts to establish a relationship between the strength of on shore flow and amount and height of cloud cover at McChord. The most significant results, as seen on chart II (Fig 47), is the direct contrast between category I and catefories V and VI, reflecting the importance of a strong

onshore or offshore flow relative to cloud cover and ceiling heights. Comparing category I with category VI, category I had 83 percent occurrence of greater than 5,000 feet while category VI had 94 percent 5,000 feet or less. On the other hand, clouds below 500 feet show a reverse in occurrence with category VI indicating only 1 percent while category 1 indicates 6 percent.

(2) This is not a yes or no type study; however, it does give the percentage frequency of occurrence of 5 different ceiling categories; and therefore, can be used in much the same manner. For example, if after entering the charts with the necessary data an 85 percent frequency of ceilings of 5,000 feet or less is obtained, the forecaster would have to have a very substantial reason for forecasting above 5,000 feet. In essence, these charts provide the forecaster with a useful tool to be used in preparing a more objective type forecast.

c. Procedures:

(1) Enter Chart I with the 1300P (2100Z) OTH-SEA and PDX-SEA pressure difference. Note category number (if on line use next highest category).

Note: For use at other hours, forecast the pressure for 1300P.

(2) Enter Chart II with category number and read the percent probability of occurrence of specified ceiling classifications on the vertical column. For example; in category I there is an 83 percent chance of ceilings above 5000 feet or clear, a 9 percent chance of ceilings 1500 feet to 5000 feet, etc. (Note that in Category VI, by adding the two cloud category percentages together, there is a 94 percent chance of cloudiness as opposed to a 5 percent chance of over 5000 feet or clear).

(3) As a guide in forecasting time of occurrence and/or breakup of specified ceiling categories, refer to Charts IV, V, or VI for the appropriate month.

Note: Chart III is not to be used in making the forecast. it shows 1969 independent test results.

CHART 1

(Dependent Data - Jun, Jul, and August 1958-63 Inc.)

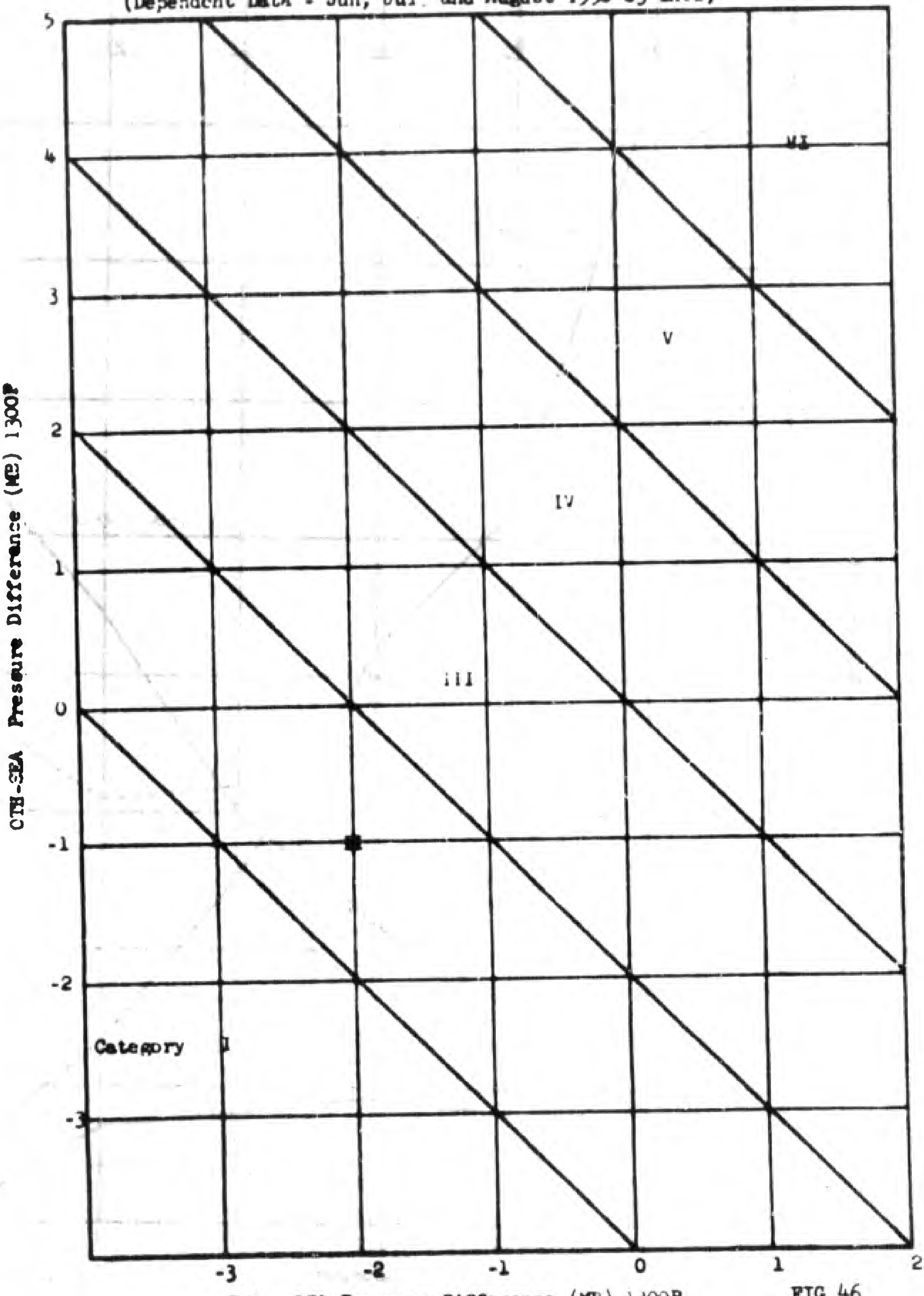

FIG 46

CHART II

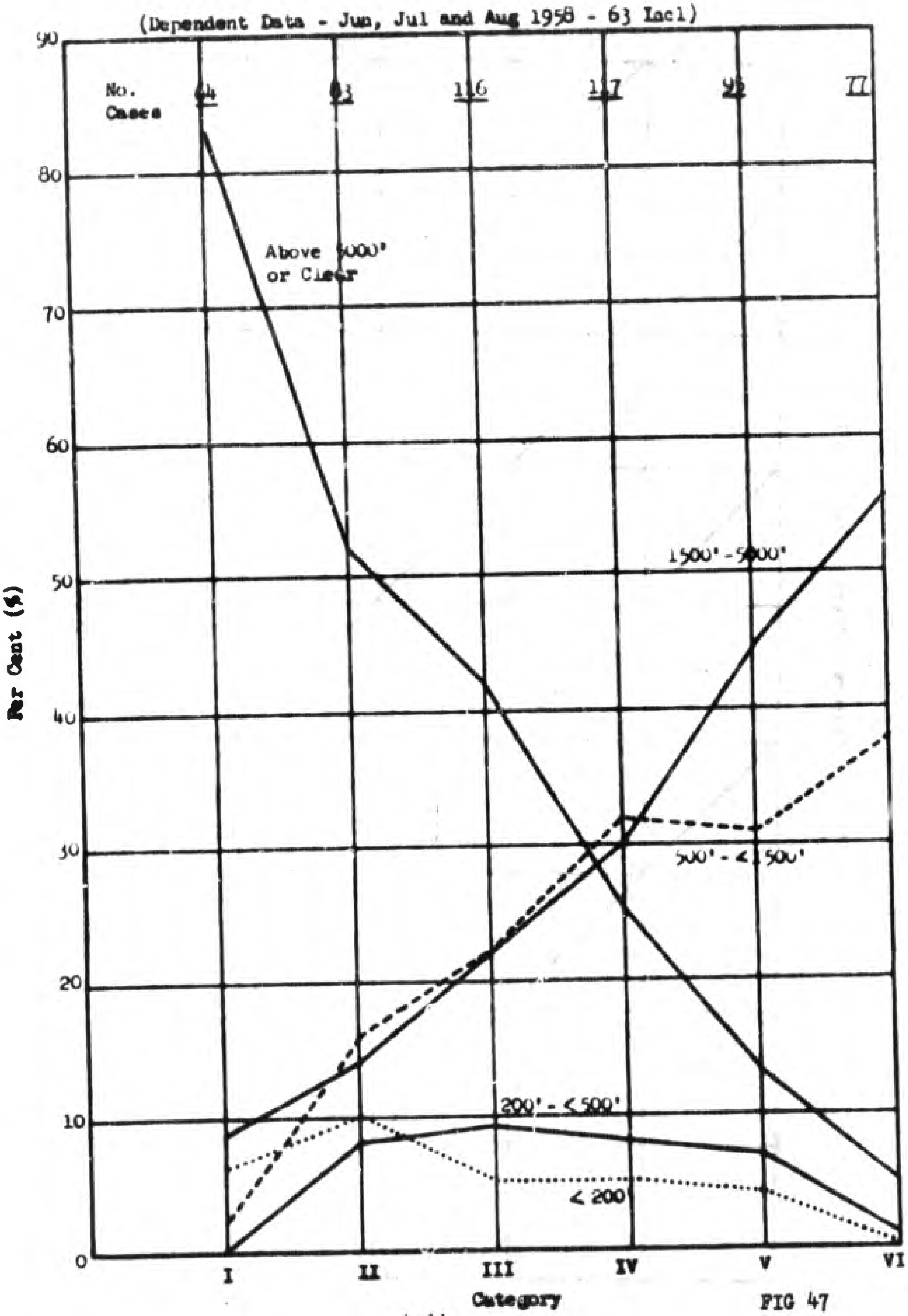

FIG 47

CHART III

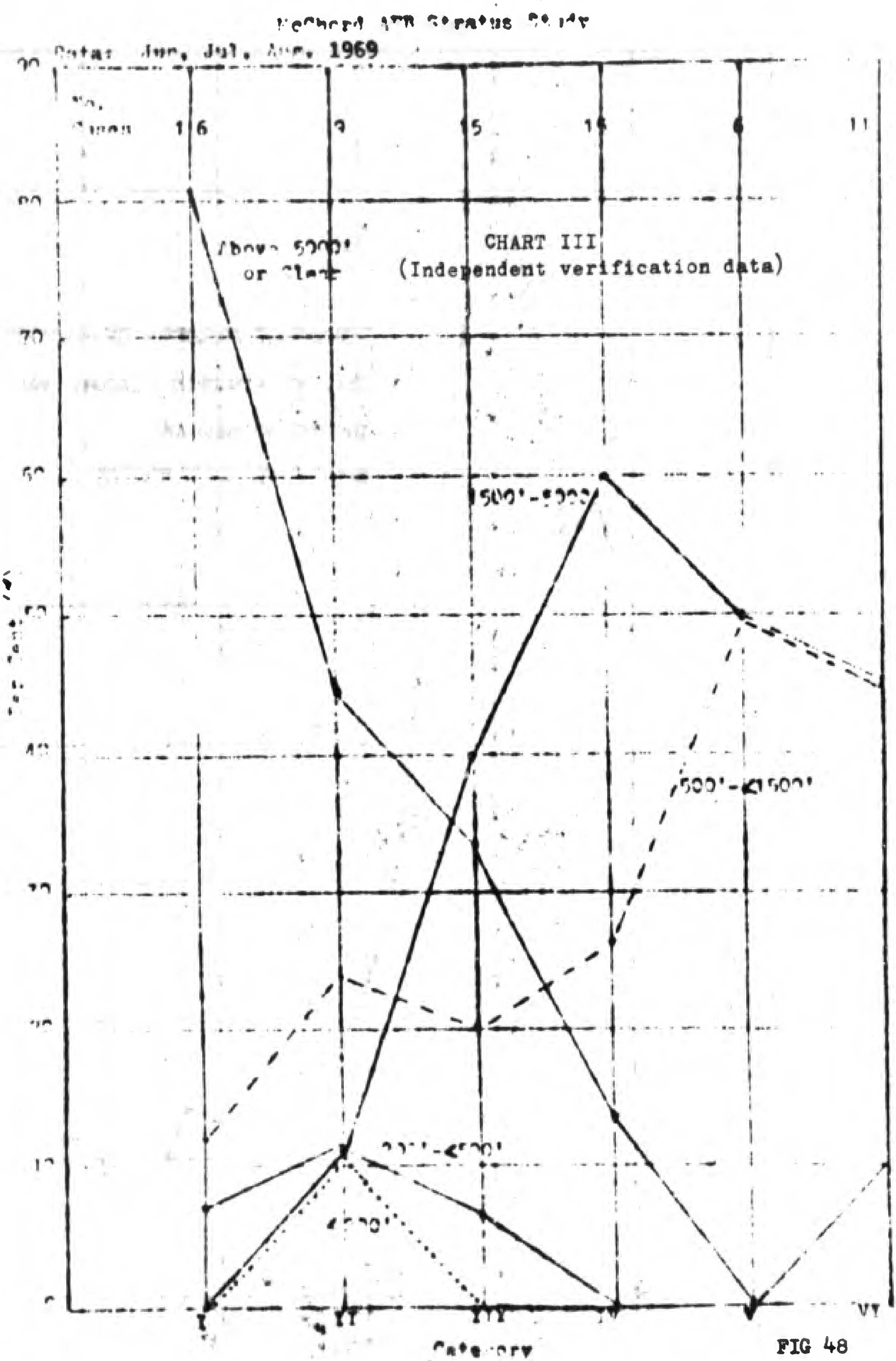
Data: Jun, Jul, Aug, 1969
CHART III
(Independent verification data)
1969
16
15
6
11
0
I
VI
FIG 48

CHART IV

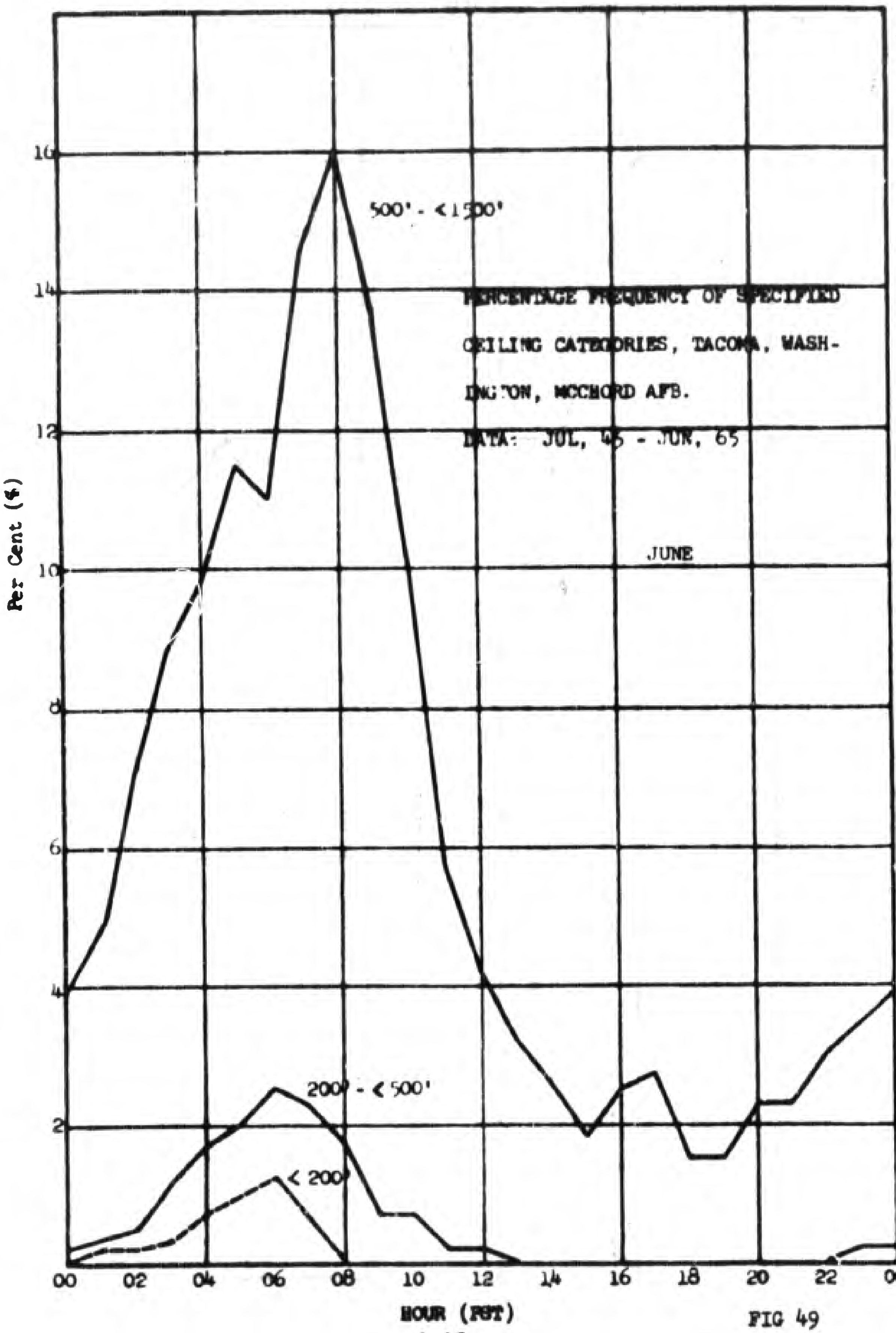

FIG 49

CHART V (13)

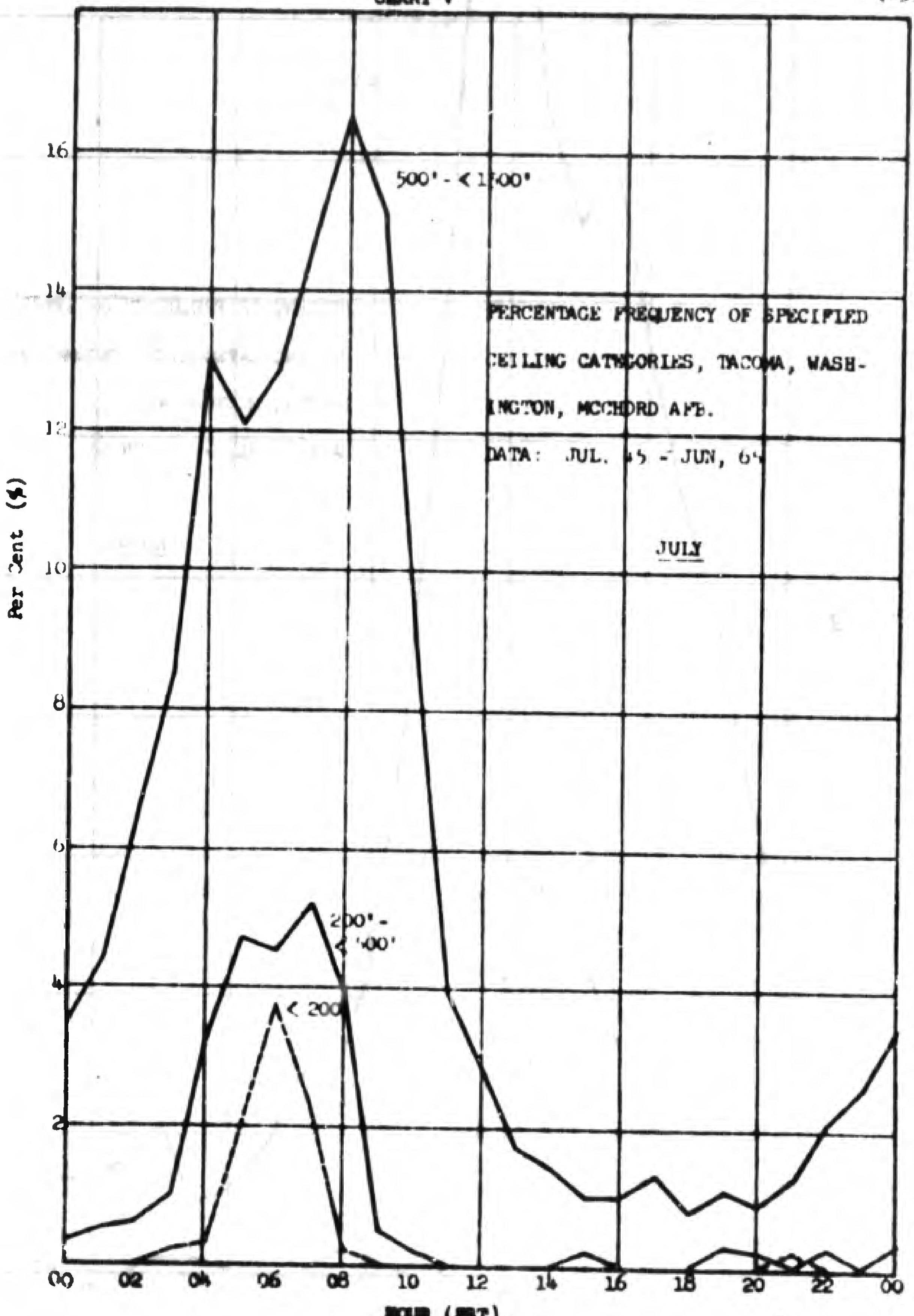

FIG 50

CHART VI

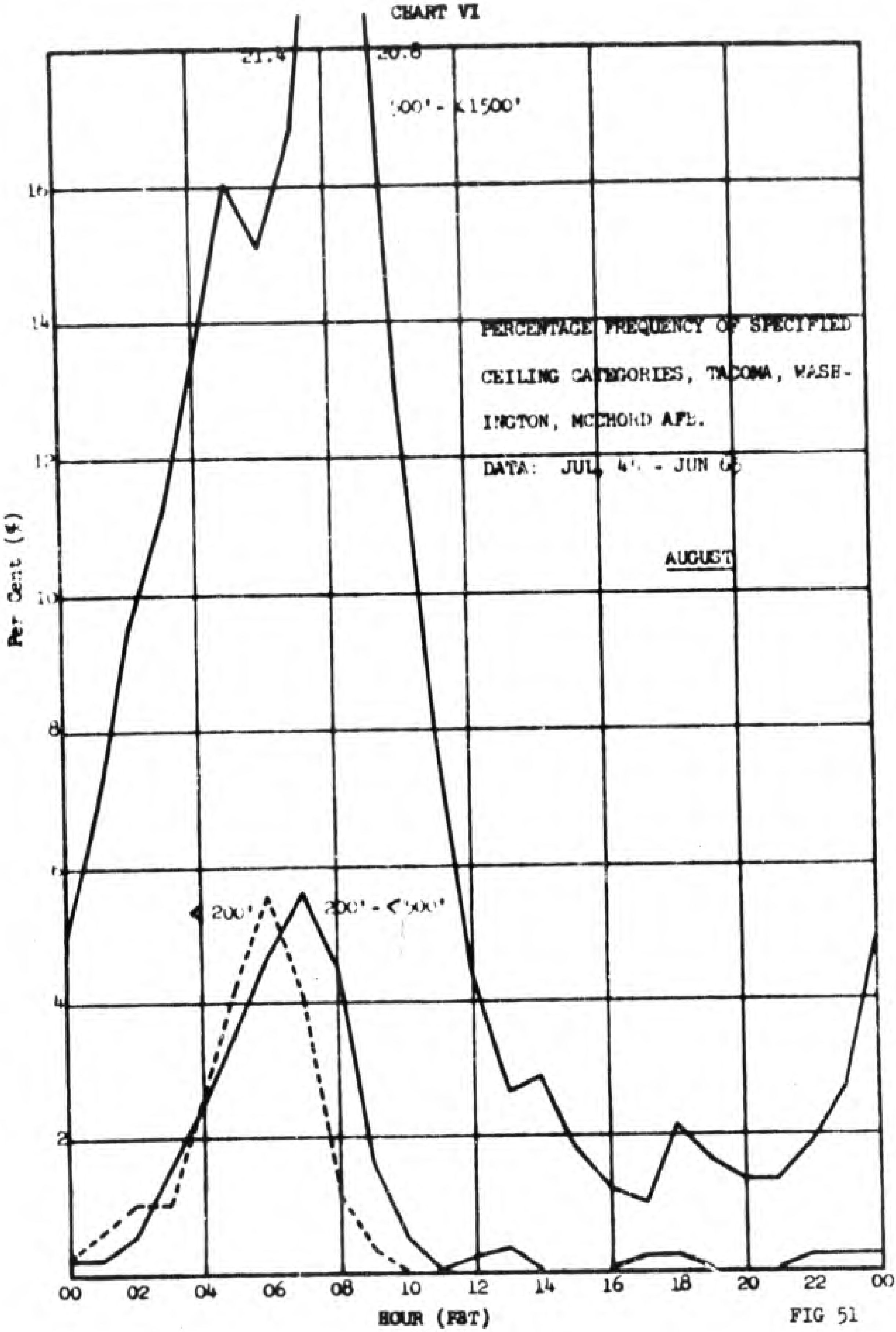

FIG 51

4050 AN OBJECTIVE AID FOR FORECASTING STRONG AND GUSTY SURFACE WINDS AT MCCHORD AFB

a. Statement of the Problem: Although not a frequent occurrence, winds of sufficient strength to represent an operational hazard do occur at McChord. These winds are usually out of a southerly direction and associated with a cyclone.

b. Purpose: To provide an objective method of forecasting surface winds of 25 knots or greater with a southwesterly component. Forecasts are made from the 0000Z and 1200Z observations and are valid for a period of 6 to 12 hours.

c. Procedures: Steps in this procedure are sequential and must be followed in the order listed.

(1) If ZT pp $>$ 1021.5MBS, forecast "NO" and stop

(2) If (PDX - TCM) pp $<$ +0.4MBS, forecast "NO" and stop

(3) If (TCM - TTI) pp $<$ +2.1MBS, forecast "NO" and stop

(4) If none of the above criteria are satisfied, use Diagram I (Fig 52). If case falls in area "A , forecast "YES", if in area "B", forecast "NO".

WINDS STUDY VERIFICATION RESULTS

(Data period 1 Oct 1969 thru 20 Feb 1970)

FORECAST

OBSERVATION	YES	NO	
YES	3	2	5
NO	6	120	126
	9	122	131

HEIDKE SKILL SCORE .40

%CORRECT 94

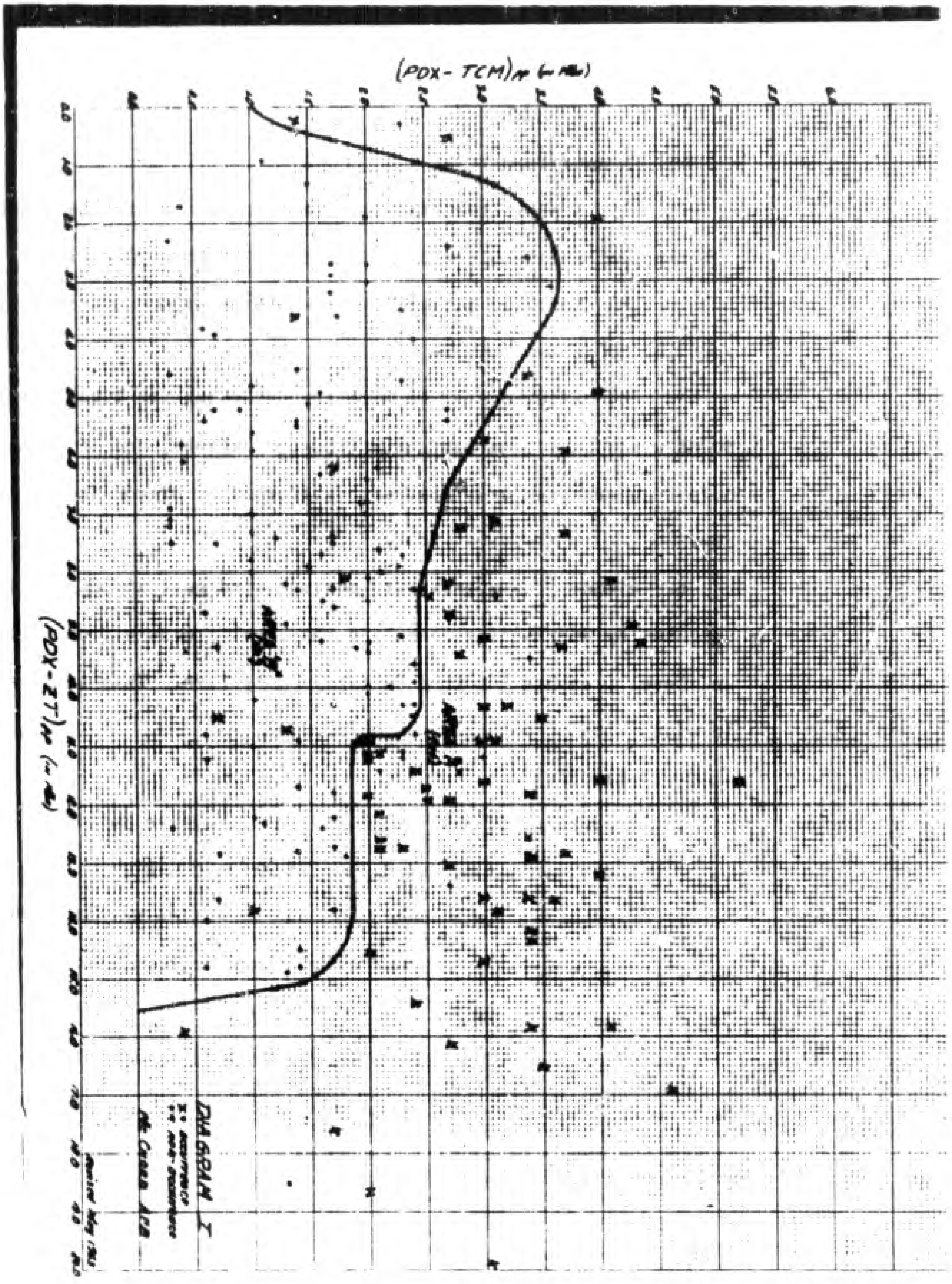

FIG 52

 DIAGRAM I

4060 RULES OF THUMB

a. Thunderstorms:

(1) A showalter stability index of +2 or less is a good indicator of thunderstorm development in the McChord vicinity.

(2) Most, if not all, thunderstorms at McChord develop when the 500MB temperature is -23 or colder.

(3) Afternoon or evening thunderstorms are likely if the 500MB winds have been southerly (150-190 degrees) and if thunderstorms have been observed over Northern California or Oregon the previous day.

b. Winds: The approximate maximum wind gust at McChord can be computed by subtracting Seattle's sea level pressure from Portland's sea level pressure and then multiplying by five. This applies only to winds with a southerly component.

4070 BIBLIOGRAPHY

a. Kinzebach, R. M.: July 1963, 'An Objective Method of Forecasting Low Visibilities Due to Fog at McChord AFB'.

b. Kinzebach, R.M.: May 1967, 'An Objective Method of Forecasting the Occurrence of Low Clouds in the McChord-Seattle Area During the Summer Months--A Further Study'.

c. Simmonds, T.H.: May 1963, 'An Objective Aid for Forecasting Strong and Gusty Surface Winds at McChord AFB, Washington'.

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Security Classification

DOCUMENT CONTROL DATA - R & D

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13. ABSTRACT

This reference file discusses factors affecting the Weather at McChord AFB, WA. Included are location and topography, weather controls, climatic aids, and local forecast studies.

DD FORM 1 NOV 65 1473

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Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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Climatic Data						
McChord AFB, WA						
Local Forecast Studies						

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Security Classification

14 Feb 72

SUBJECT: Change #1 to Terminal Forecast Reference File (TFRF) McChord AFB, Wa

TO: Holders of McChord TFRFs

1. Page changes:

REMOVE	INSERT
Pages 4-3 thru 4-18	Pages 4-3 thru 4-18.1

2. After posting, file this change sheet in back of TFRF.

PHILLIP W. GOERTZ, Major, USAF
Commander

20

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3. REPORT TITLE

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
N/A	Hq 7th Weather Wing Scott AFB, IL 62225

13. ABSTRACT

This change revises and updates the following OBJECTIVE FORECAST STUDIES:

1. "AN OBJECTIVE METHOD OF FORECASTING BELOW MINIMUM VISIBILITIES AT MCCHORD AFB DURING THE FALL AND WINTER MONTHS".

2. "AN OBJECTIVE METHOD OF FORECASTING THE OCCURRENCE OF LOW CLOUDS IN THE MCCHORD-SEATTLE AREA DURING THE SUMMER MONTHS".

DD FORM 1 NOV 65 1473

UNCLASSIFIED

Security Classification

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UNCLASSIFIED

KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Meteorology						
Visibility						
Clouds						
McChord AFB, WA						

UNCLASSIFIED

Security Classification

precipitation or snow; however occurrence of these forms are infrequent. Strong surface winds and thunderstorms are in the same category. They are significant when they occur, but occurrence is relatively small.

4030 AN OBJECTIVE METHOD OF FORECASTING LOW VISIBILITIES DUE TO FOG AT MCCHORD AFB

a. Statement of the Problem: Because of the nature of most flying done at McChord (MAC flights are scheduled far in advance), it becomes imperative that an accurate planning forecast be available. Therefore, with the main weather problem at McChord being fog, it follows that a method of forecasting below minimums due to fog, sufficiently far enough in advance to aid planning, is essential.

b. Purpose: This study is to provide , at 1300P, a yes or no type forecast for the occurrence of visibilities below ½ mile due to fog. The valid time is for a period of 1 or more hours from 2200P to 1000P the following day. This study was designed for use during October and November; however, it can be used as guide for other fall and winter months.

c. Procedures:

(1) Enter chart I with the McChord average hourly wind speed 1000-1300P, and the 1300P wind direction:

(a) If the result is "NO", forecast "NO" and stop.

(b) Otherwise proceed to chart II.

(2) Enter chart II with the McChord 1300P sea level pressure and dewpoint:

(a) If the result is "NO", forecast "NO" and stop.

(b) Otherwise proceed to chart III.

(3) Enter chart III with the McChord 1300P sky condition and the temperature-dewpoint spread:

(a) If the result is "NO", forecast "NO" and stop.

(b) If the result is "YES", forecast "YES" and stop.

(c) Otherwise proceed to chart IV.

(4) Enter chart IV with the McChord 1300P 24 hour pressure change and the 3 hour pressure change.

(a) If the result is "YES", forecast "YES".

(b) If the result is "NO", forecast "NO".

VISIBILITY STUDY VERIFICATION RESULTS

(Data period: 1 Oct 68 - 30 Nov 70)

OBSERVED

FORECAST		YES	NO	
	YES	31	6	37
	NO	6	140	146
		37	146	183

HEIDKE SKILL SCORE .80

% CORRECT 93

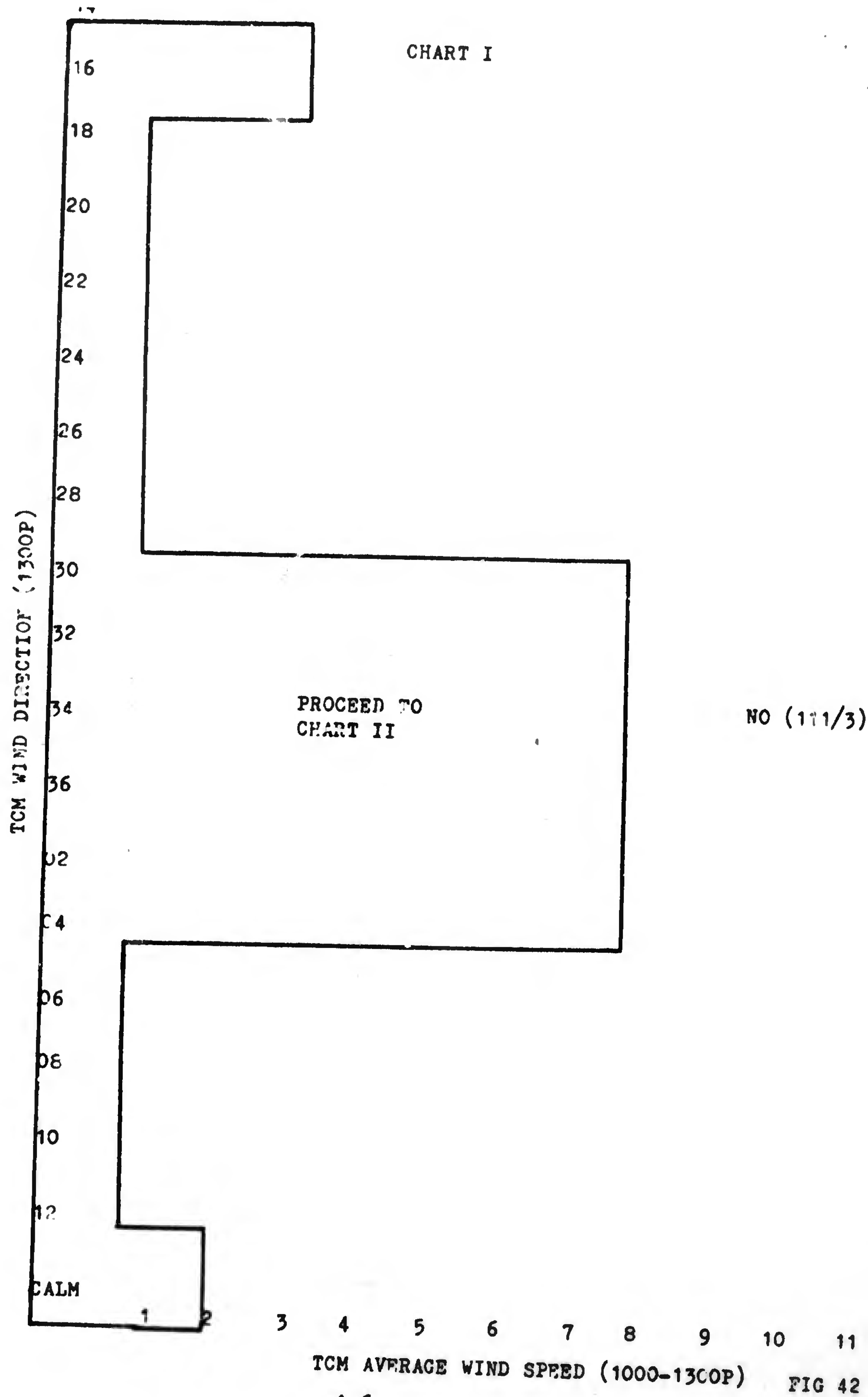


CHART I
16
18
20
22
24
26
28
30
32
34
36
02
04
06
08
10
12
CALM
PROCEED TO
CHART II
NO (111/3)
1
2
3
4
5
6
7
8
9
10
11
TCM AVERAGE WIND SPEED (1000-1300P)
TCM WIND DIRECTION (1300P)

FIG 42

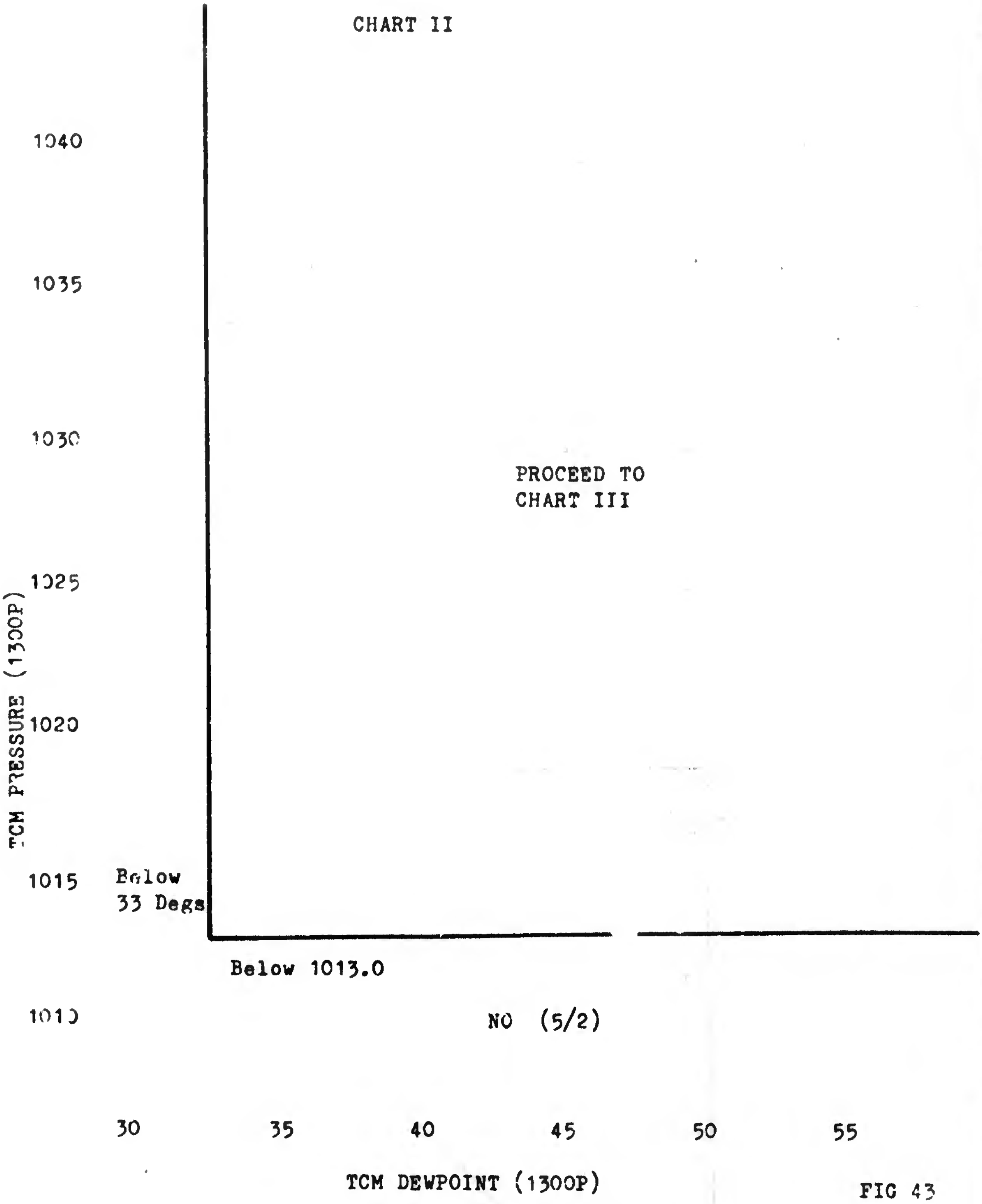


CHART II
1040
1035
1030
PROCEED TO
CHART III
1025
TCM PRESSURE (1300P)
1020
1015
Below
33 Degs
Below 1013.0
1010
NO (5/2)
30
35
40
45
50
55
TCM DEWPOINT (1300P)

FIG 43

CHART III

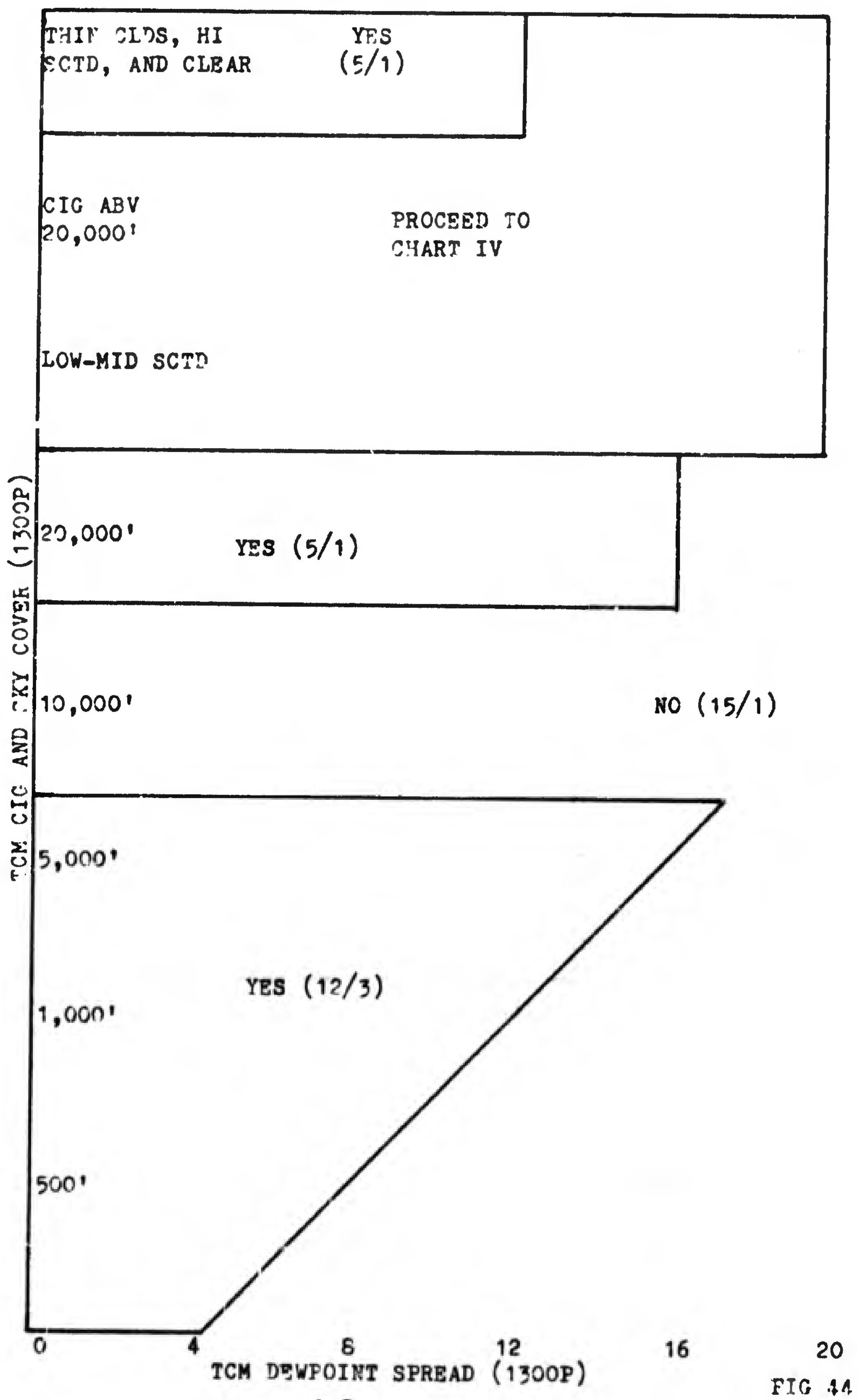


FIG 44

CHART IV

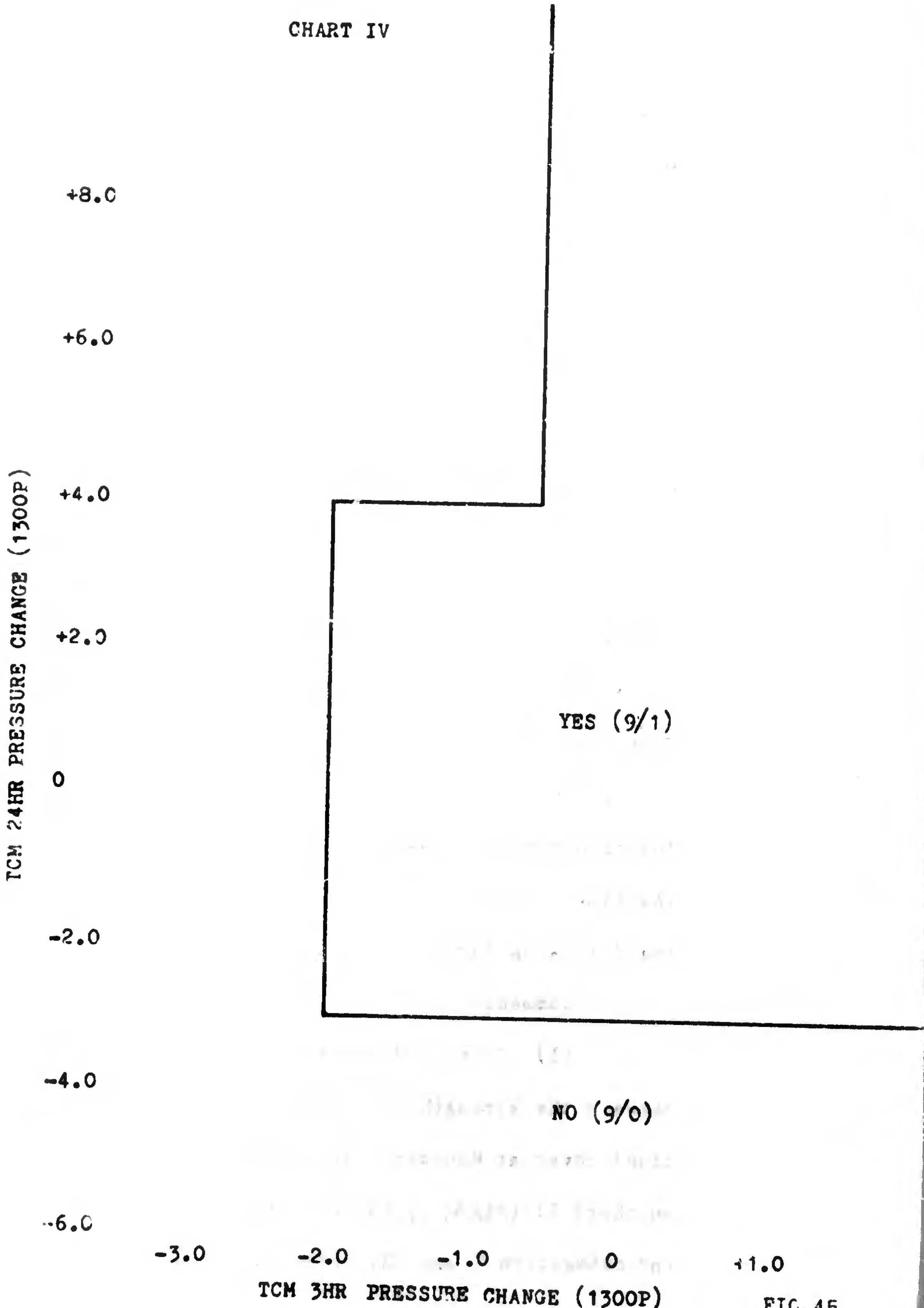


FIG 45

4040 AN OBJECTIVE METHOD OF FORECASTING THE OCCURRENCE OF LOW CLOUDS IN THE MCCHORD-SEATTLE AREA DURING THE SUMMER MONTHS

a. Statement of the Problem: During summer months, the appearence of late night and early morning stratus is usually an indication of a change in weather type from continental to maritime. These changes do not normally present critical weather problems at McChord; however, they often mean the difference between clear skys with continental air and overcast skys with maritime air. Therefore, an accurate planning forecast is desireable, if for no other reason than to maintain the professional respect of base flying personnel.

b. Purpose: To provide an objective method of forecasting the occurrence of low clouds at McChord during the summer months. The time of forecast is 1300P for a valid period from 2200-1200P the following day.

c. Comments:

(1) This study attempts to establish a relationship between the strength of on shore flow and amount and height of cloud cover at McChord. The most significant results, as seen on chart II (Fig 47), is the direct contrast between category I and categories V and VI, reflecting the importance of a strong

onshore or offshore flow relative to cloud cover and ceiling heights. Comparing category I with category VI, category I had 83 percent occurrence of greater than 5,000 feet while category VI had 94 percent 5,000 feet or less. On the other hand, clouds below 500 feet show a reverse in occurrence with category VI indicating only 1 percent while category I indicates 6 percent.

(2) This study becomes a yes or no type forecast study with the use of charts III and IV which further break down category III with the use of additional parameters.

c. Procedures:

(1) Enter Chart I with the 1300P (2100Z) OTH-SEA and PDX-SEA pressure difference. Obtain category number (if on line use highest category). Note: For use at other hours, forecast the pressure for 1300P.

(2) Enter Chart II with the category number and read the percent probability of occurrence of specified ceiling classifications on the vertical column for a confidence factor. If the category is I or II forecast NO ceiling of 5,000' or below. If the category is IV, V, or VI forecast YES. If the category is III continue to Chart III.

(3) Enter Chart III with the TCM 1300P Ceiling and Sky Cover, and the TCM 1300P Temperature. If the result is YES, fore-

YES and stop. Otherwise continue to Chart IV.

(4) Enter Chart IV with the TCM 1300P wind direction, and the TCM 1300P Temperature-dewpoint spread. If the result is NO forecast NO. If the result is YES forecast YES.

LOW CLOUD STUDY VERIFICATION RESULTS

(Data period: 1 JUN 69 - 30 AUG 71)

OBSERVED

FORECAST	YES	NO	
YES	127	18	145
NO	31	75	106
	158	93	251

HEIDKE SKILL SCORE .59

% CORRECT 80.6

CHART I

(Dependent Data - Jun, Jul, and August 1958-63 Inc.)

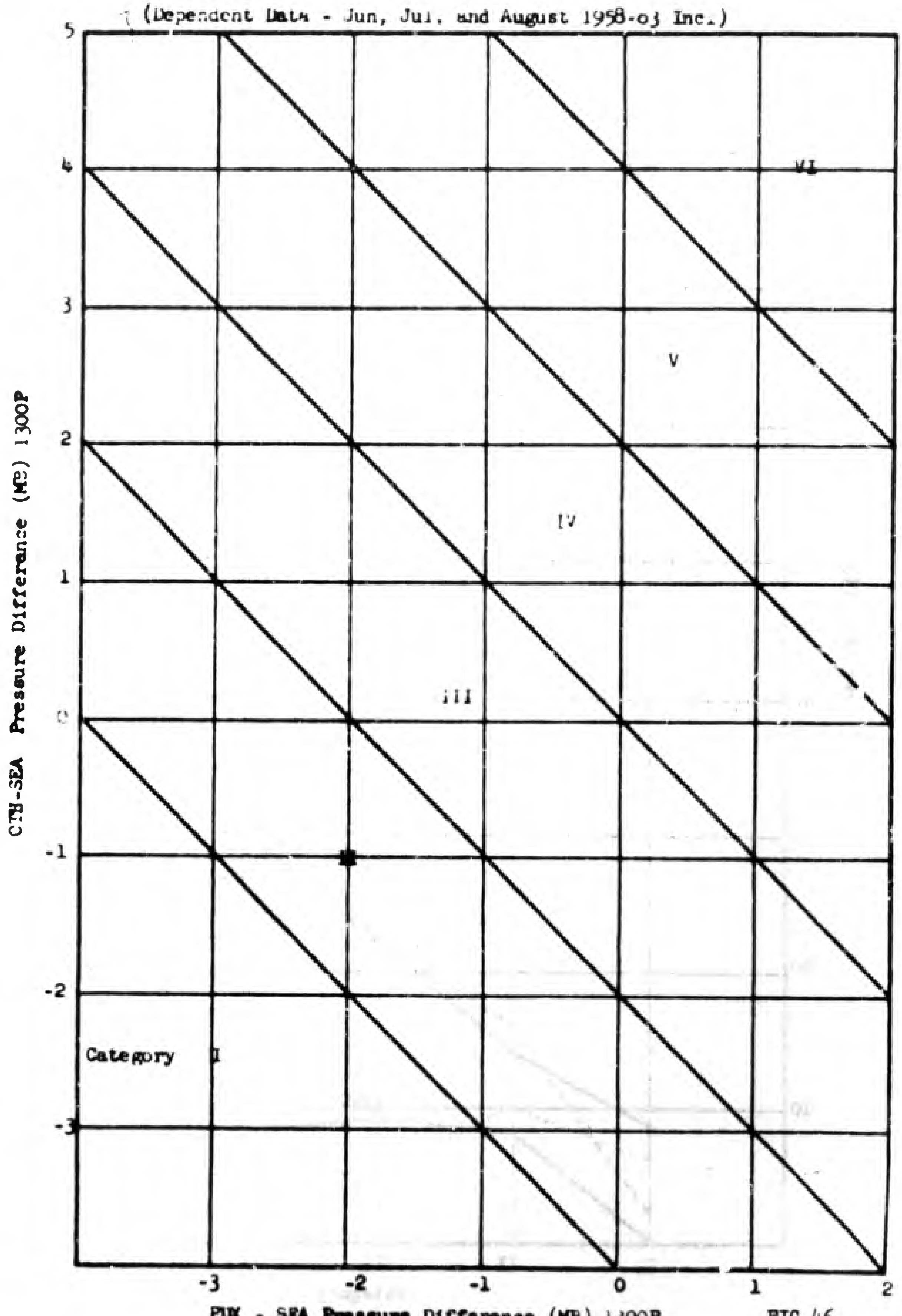


FIG 46

CHART II

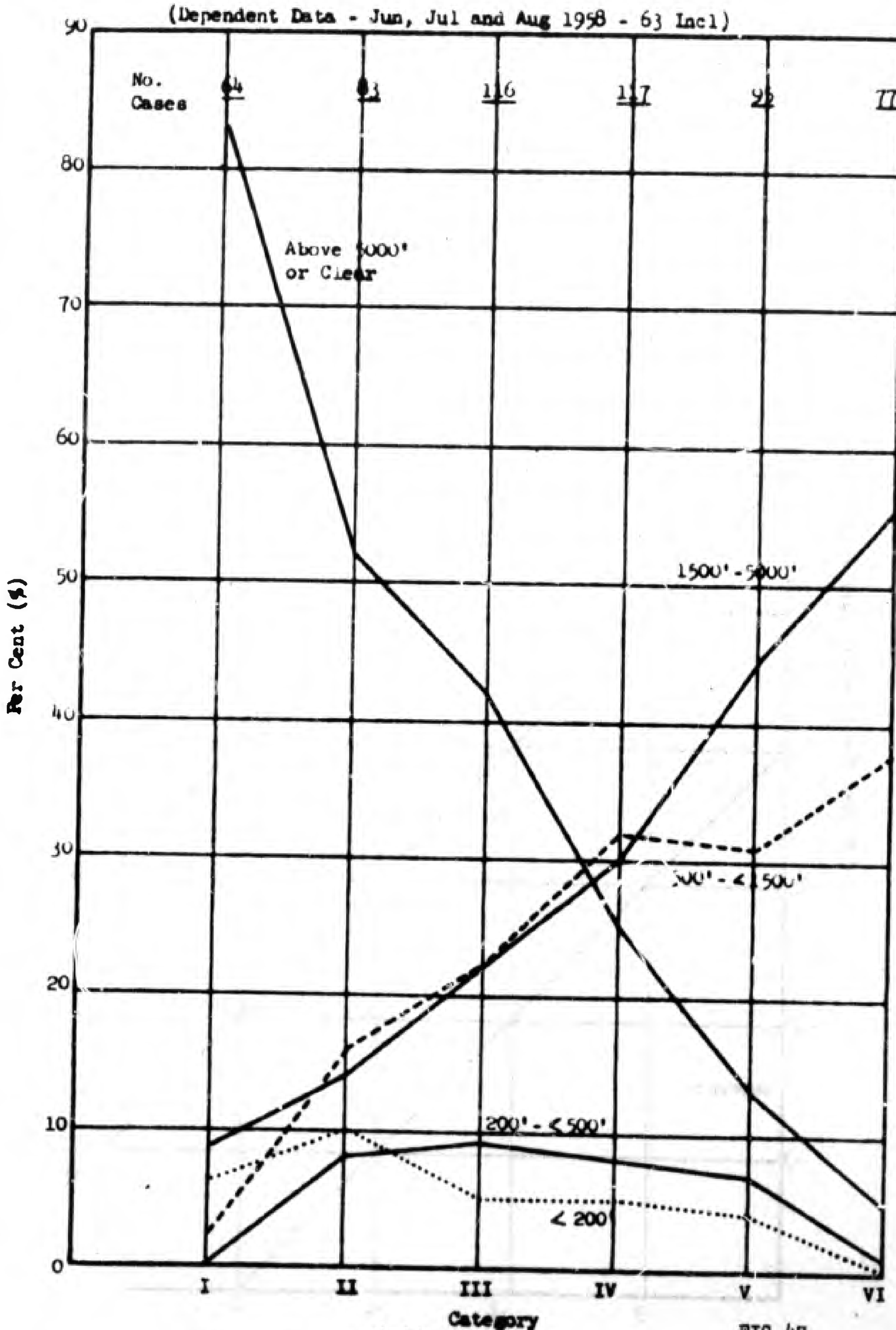


FIG 47

CHART III

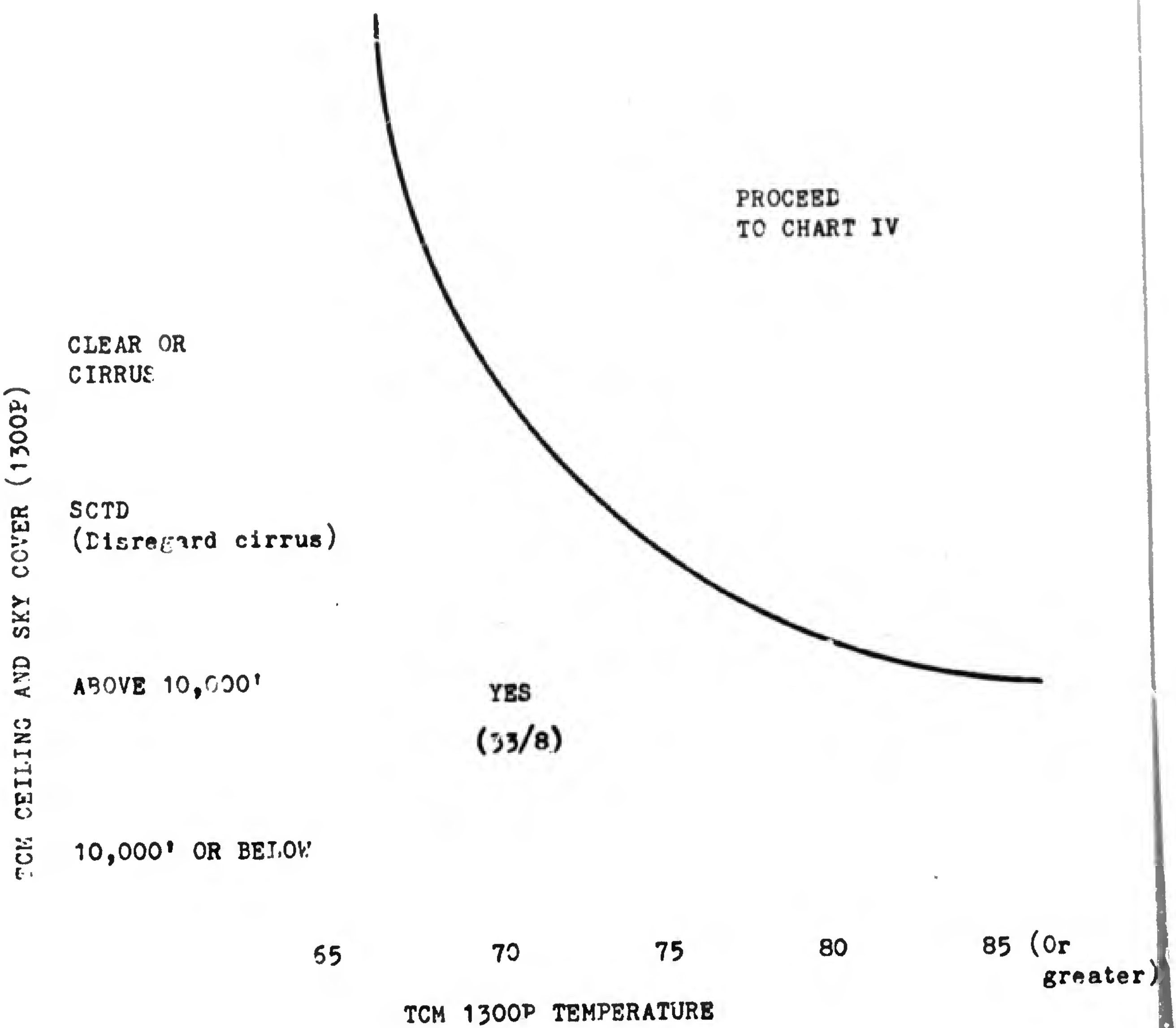


FIG 48

CHART IV

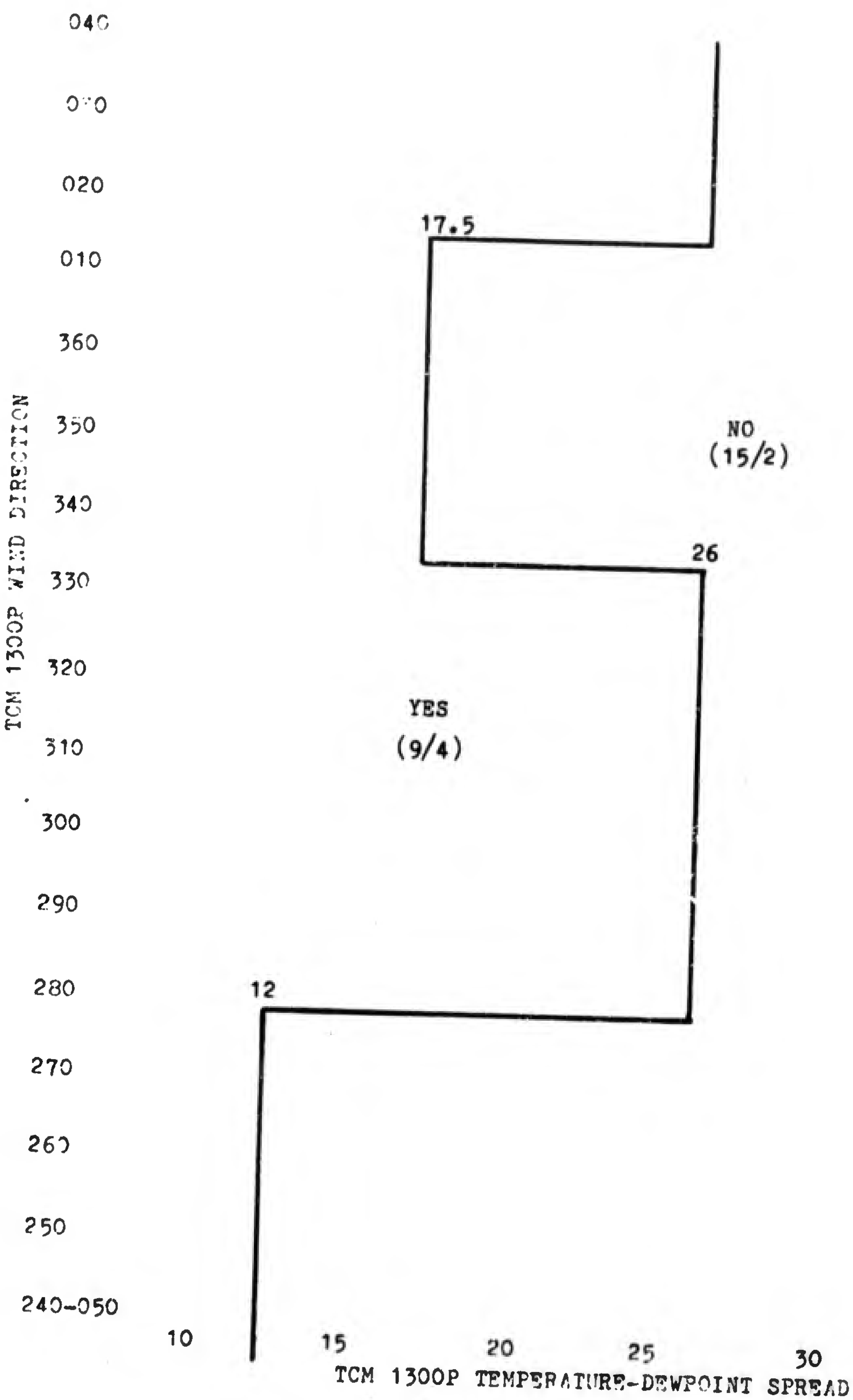


FIG 49

CHART V

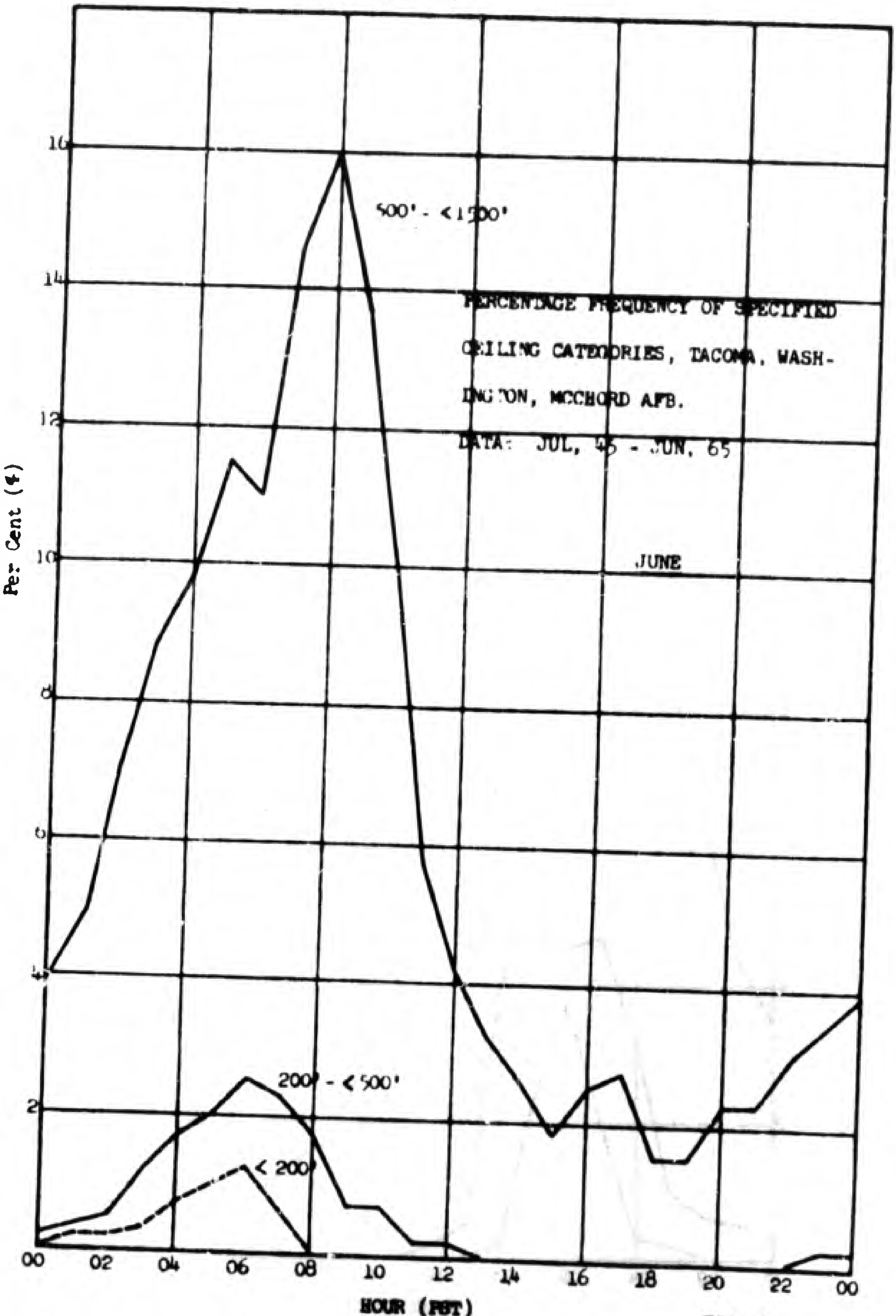


FIG 50

CHART VI

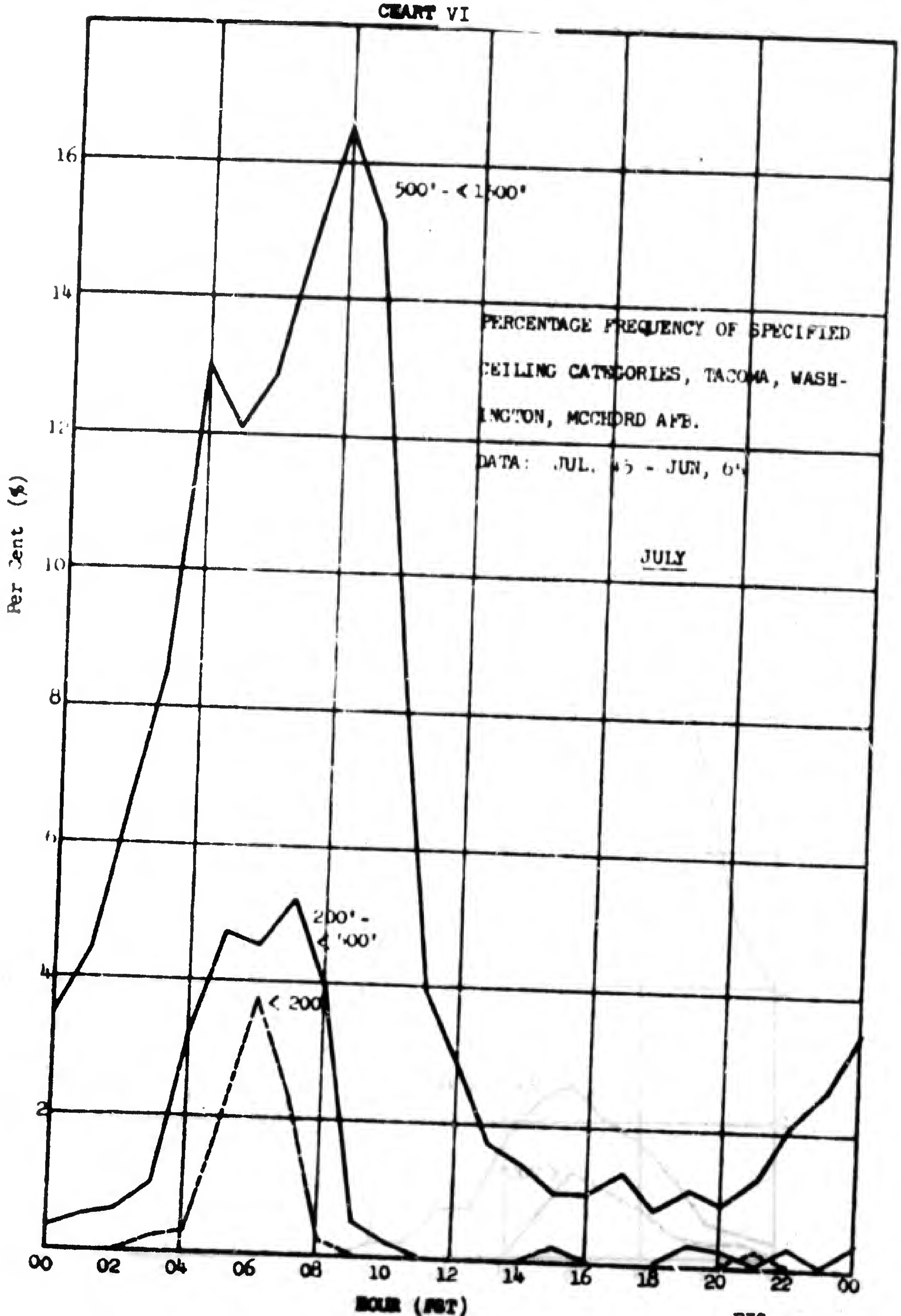
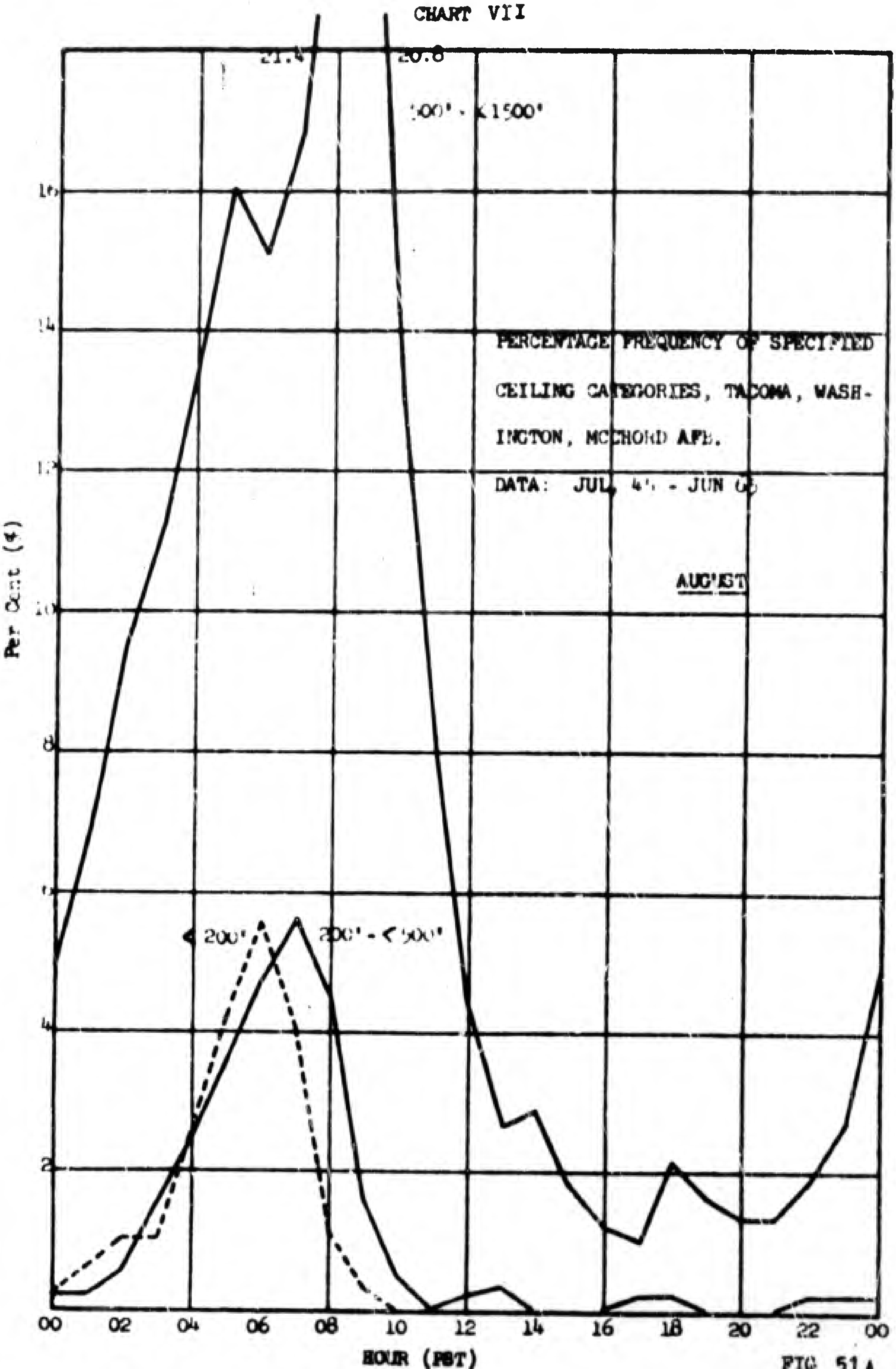


FIG 51

CHART VII


21.4
20.8
500' - < 1500'
PERCENTAGE FREQUENCY OF SPECIFIED CEILING CATEGORIES, TACOMA, WASHINGTON, MCCHORD AFB.
DATA: JUL 4? - JUN 6?
AUGUST
< 200'
200' - < 500'
Per Cent (%)
2
4
6
8
10
12
14
16
00
02
04
06
08
10
12
14
16
18
20
22
00
HOUR (PST)
FIG 51 A